

**OCAS-DRI-DBS-19-07
NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT CONFIRMATION TEST**

2019 Chevrolet Silverado Crew Cab

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Final Report

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Office of Crash Avoidance Standards
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16. Abstract These tests were conducted on the subject 2019 Chevrolet Silverado Crew Cab in accordance with the specifications of the Office of Crash Avoidance Standards 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 false positive scenarios but failed every other scenario. Therefore the vehicle failed the overall test.			
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TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
I. OVERVIEW AND TEST SUMMARY	1
II. DATA SHEETS	2
A. Data Sheet 1: Test Summary.....	3
B. Data Sheet 2: Vehicle Data.....	4
C. Data Sheet 3: Test Conditions	6
D. Data Sheet 4: Dynamic Brake Support System Operation.....	8
III. TEST PROCEDURES.....	11
A. Test Procedure Overview.....	11
B. General Information.....	16
C. Principal Other Vehicle.....	19
D. Foundation Brake System Characterization.....	20
E. Brake Control.....	21
F. Instrumentation.....	22
Appendix A Photographs	A-1
Appendix B Excerpts from Owner's Manual.....	B-1
Appendix C Run Logs	C-1
Appendix D Brake Characterization.....	D-1
Appendix E Time Histories.....	E-1

Section I OVERVIEW AND TEST SUMMARY

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 2019 Chevrolet Silverado Crew Cab. 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

(Page 1 of 1)

2019 Chevrolet Silverado Crew Cab

SUMMARY RESULTS

VIN: 1GCPWEED3KZ1xxxx

Test Date: 10/25/2018

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

SV 25 mph: Fail

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

SV 25 mph POV 10 mph: Fail

SV 45 mph POV 20 mph: Fail

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

SV 35 mph POV 35 mph: Fail

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

SV 25 mph: Pass

SV 45 mph: Pass

Overall: Fail

Notes:

DYNAMIC BRAKE SUPPORT
DATA SHEET 2: VEHICLE DATA

(Page 1 of 2)

2019 Chevrolet Silverado Crew Cab

TEST VEHICLE INFORMATION

VIN: 1GCPWEED3KZ1xxxx

Body Style: Pickup Truck

Color: Summit White

Date Received: 10/15/2018

Odometer Reading: 29 mi

Engine: 5.3 L V-8

Transmission: Automatic

Final Drive: 2WD (RWD)

Is the vehicle equipped with:

ABS	<u>X</u>	Yes	<u> </u>	No
Adaptive Cruise Control	<u> </u>	Yes	<u>X</u>	No
Collision Mitigating Brake System	<u>X</u>	Yes	<u> </u>	No

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: General Motors LLC

Date of manufacture: 09/18

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: 275/60R20

Rear: 275/60R20

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

Rear: 240 kPa (35 psi)

DYNAMIC BRAKE SUPPORT
DATA SHEET 2: VEHICLE DATA

(Page 2 of 2)

2019 Chevrolet Silverado Crew Cab

TIRES

Tire manufacturer and model: Bridgestone Alenza A/S 02

Front tire size: 275/60R20

Rear tire size: 275/60R20

VEHICLE ACCEPTANCE

Verify the following before accepting the vehicle:

- All options listed on the “window sticker” are present on the test vehicle
- Tires and wheel rims are the same as listed.
- There are no dents or other interior or exterior flaws.
- The vehicle has been properly prepared and is in running condition.
- Verify that spare tire, jack, lug wrench, and tool kit (if applicable) is located in the vehicle cargo area.

DYNAMIC BRAKE SUPPORT
DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2019 Chevrolet Silverado Crew Cab

GENERAL INFORMATION

Test date: 10/25/2018

AMBIENT CONDITIONS

Air temperature: 26.7 C (80 F)

Wind speed: 1.5 m/s (3.5 mph)

X Windspeed \leq 10 m/s (22 mph)

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

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

VEHICLE PREPARATION

Verify the following:

All non consumable fluids at 100 % capacity : X

Fuel tank is full: X

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

Front: 240 kPa (35 psi)

Rear: 240 kPa (35 psi)

DYNAMIC BRAKE SUPPORT
DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2019 Chevrolet Silverado Crew Cab

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front: 708.1 kg (1561 lb)

Right Front: 677.7 kg (1494 lb)

Left Rear: 517.5 kg (1141 lb)

Right Rear: 514.8 kg (1135 lb)

Total: 2418.1 kg (5331 lb)

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 1 of 3)

2019 Chevrolet Silverado Crew Cab

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

Low Speed Forward Automatic Braking (RPO Code = UHY) included in Safety Package II (RPO Code = PDJ) which is available on LTZ Premium Package and included with High Country Deluxe or High Country Premium Package

System setting used for test (if applicable):

Alert & Brake

Brake application mode used for test:

Constant pedal displacement

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

5 mph (Per manufacturer supplied information)

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

50 mph (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure?

_____ Yes
 X No

If yes, please provide a full description.

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

_____ Yes
 X No

If yes, please provide a full description.

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

Section III TEST PROCEDURES

A. TEST PROCEDURE OVERVIEW

Four test scenarios were used, as follows:

- Test 1. Subject Vehicle (SV) Encounters Stopped Principal Other Vehicle (POV)
- Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle
- Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle
- Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

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

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

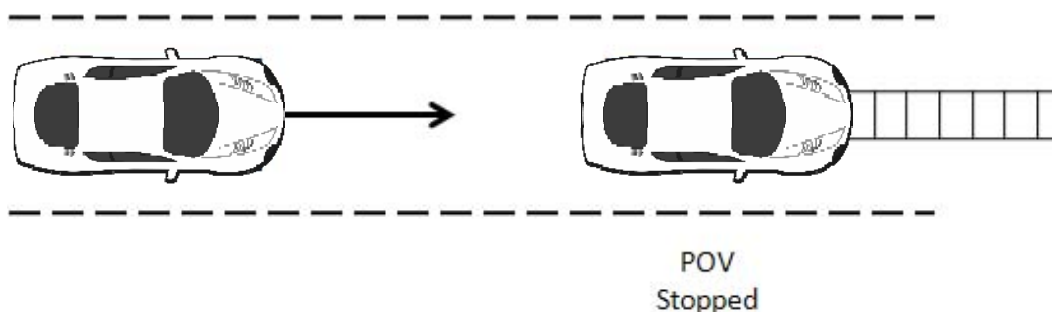


Figure 1. Depiction of Test 1

a. Procedure

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

The SV ignition was cycled prior to each test run. The SV was driven at a nominal speed of 25 mph (40.2 kph) 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 kph) 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 kph)	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. TEST 2 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE

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

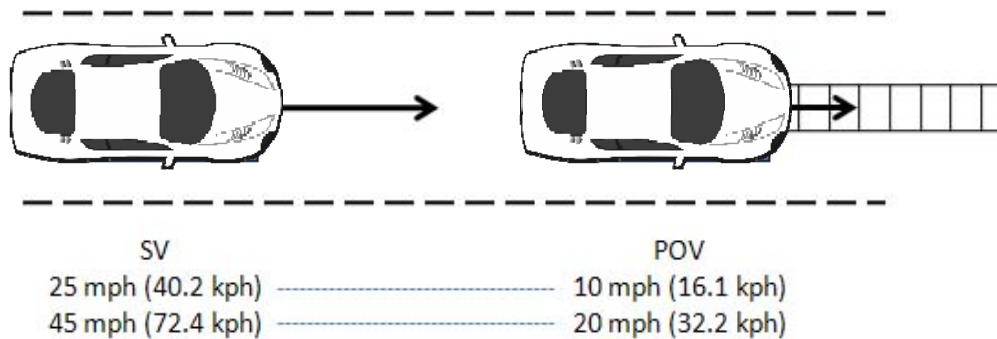


Figure 2. Depiction of Test 2

a. Procedure

The SV ignition was cycled prior to each test run. The tests were conducted two ways. In the first, the POV was driven at a constant 10.0 mph (16.1 kph) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2 kph), 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 kph) in the center of the lane of travel while the SV was driven at 45.0 mph (74.4 kph), 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 kph) 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 kph) 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 kph)	10 mph (16 kph)	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 kph)	20 mph (32 kph)	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.

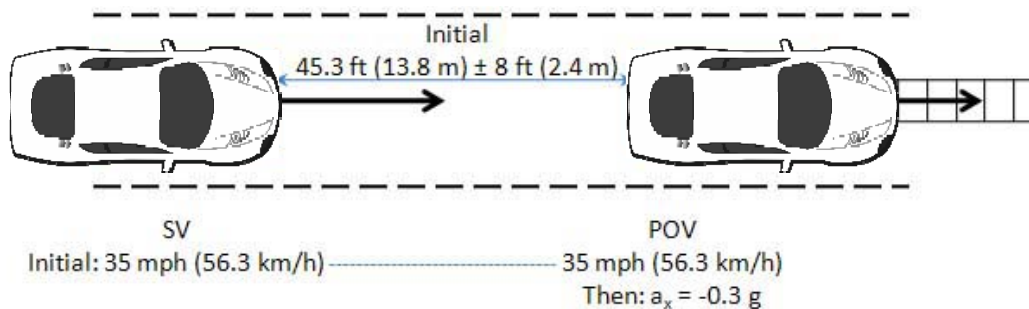


Figure 3. Depiction of Test 3 with POV Decelerating

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 kph) in the center of the lane, with headway of 45 ft (14 m) \pm 8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve 0.3 \pm 0.03 g. The SV throttle pedal was released within 500 ms of t_{FCW} , and the SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

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

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the POV and the center of the travel lane could not deviate more than \pm 1 ft (0.3 m) during the validity period.
- The headway between the SV and POV must have been constant from the onset of the applicable validity period to the onset of POV braking.
- The SV and POV speed could not deviate more than \pm 1.0 mph (1.6 kph) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than \pm 0.03 g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

Table 3. Nominal Decelerating POV DBS Test Choreography

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

b. Criteria

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

4. TEST 4 – FALSE POSITIVE SUPPRESSION

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

a. Procedure

This test was conducted at two speeds, 25 mph (40.2 kph) and 45 mph (72.4 kph). 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 bandpass 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	Pass-Band Frequency Range
Audible	5 th	3 dB	60 dB	Identified Center Frequency \pm 5%
Tactile	5 th	3 dB	60 dB	Identified Center Frequency \pm 20%

2. General Validity Criteria

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

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

- POV element, whose requirements 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.

- POV delivery system, whose requirements are to:
 - Accurately control the nominal POV speed up to 35 mph (56 kph).
 - 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.

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.

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. POV Automatic Braking System

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

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

F. INSTRUMENTATION

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

TABLE 5. TEST INSTRUMENTATION AND EQUIPMENT

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and	Omega DPG8001	17042707002	By: DRI Date: 6/21/2018 Due: 6/21/2019
Platform Scales	Vehicle Total, Wheel, and Axle Load	1200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 2/1/2018 Due: 2/1/2019
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	43020490	By: DRI Date: 5/1/2018 Due: 5/1/2019
Load Cell	Force applied to brake pedal					By: DRI
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 8/28/2018 Due: 8/28/2019
		0 - 250 lb 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 8/28/2018 Due: 8/28/2019
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 kph	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;	Accels $\pm 10g$, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
	Lateral, Longitudinal and Vertical Velocities;				2182	Date: 10/16/2017 Due: 10/16/2019
	Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles				2258	Date: 3/8/2017 Due: 3/8/2019
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: ± 0.02 m/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)	$\pm 5g$	$\leq 3\%$ 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: Due:
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).			D-Space Micro-Autobox II 1401/1513		
				Base Board	549068	
				I/O Board	588523	

APPENDIX A

Photographs

LIST OF FIGURES

	Page
Figure A1. Front View of Subject Vehicle.....	A-3
Figure A2. Rear View of Subject Vehicle.....	A-4
Figure A3. Window Sticker (Monroney Label)	A-5
Figure A4. Vehicle Certification Label.....	A-6
Figure A5. Tire Placard.....	A-7
Figure A6. Rear View of Principal Other Vehicle (SSV).....	A-8
Figure A7. Load Frame/Slider of SSV.....	A-9
Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track.....	A-10
Figure A9. Steel Trench Plate.....	A-11
Figure A10. Two-Rail Track and Road-Based Lateral Restraint Track.....	A-12
Figure A11. Steel Trench Plate.....	A-13
Figure A12. DGPS, Inertial Measurement Unit and MicroAutoBox Installed in Subject Vehicle.....	A-14
Figure A13. Sensors for Detecting Auditory and Visual Alerts.....	A-15
Figure A14. Computer and Brake Actuator Installed in Subject Vehicle.....	A-16
Figure A15. Brake Actuator Installed in POV System.....	A-17
Figure A16. Heads-Up Visual AEB Alert.....	A-18
Figure A17. AEB Setup Menus (1 of 2).....	A-19



Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle



CHEVROLET

2019 SILVERADO 2WD LTZ CREW

EXTERIOR: SUMMIT WHITE
INTERIOR: JET BLACK

ENGINE, 5.3L ECOTEC3 V8 WITH
TRANSMISSION, 8-SPEED AUTOMATIC

STANDARD EQUIPMENT

ITEMS FEATURED BELOW ARE INCLUDED AT NO EXTRA CHARGE IN THE STANDARD VEHICLE PRICE SHOWN

- 3 YR/36,000 MILES BUMPER-TO-BUMPER WARRANTY
- 5 YR/60,000 MILES POWERTRAIN LIMITED WARRANTY
- ROADSIDE ASSISTANCE
- COURTESY TRANSPORTATION
- FIRST MAINTENANCE VISIT
- OIL CHANGE AND TIRE ROTATION
- MULTI POINT VEHICLE INSPECTION
- SEE CHEV.COM OR DEALER FOR TERMS, DETAILS & LIMITS

MECHANICAL

- CAPLESS FUEL FILL
- TRAILERING PACKAGE
 - TRAILER HITCH
 - 7 PIN AND 4 PIN CONNECTORS
 - HITCH GUIDANCE
- ADVANCED TRAILERING SYSTEM
- AUTO LOCKING REAR DIFFERENTIAL

- TRAILER BRAKE CONTROLLER

SAFETY & SECURITY

- HD REAR VISION CAMERA
- TEEN DRIVER MODE
- STABILITRAK W/ TRAILER SWAY CONTROL & HILL START ASSIST
- ONSTAR (R) SERVICES CAPABLE (SUBJECT TO TERMS SEE ONSTAR.COM)

EXTERIOR

- TAILGATE WITH LIFT ASSIST, POWER LOCK, AND RELEASE
- 12 FIXED DURABLE TIE DOWNS W/ EACH CORNER RATED AT 600LBS
- LED DURABLE LIGHTING
- CORNERSTEP REAR BUMPER
- REAR WHEELHOUSE LINERS
- POWER HEATED/FOLDING OUTSIDE MIRROR W/ PERIMETER LIGHTING, PUDDLE LAMPS & MEMORY SETTING
- LED REFLECTOR HEAD LAMPS
- LED SIGNATURE TAIL LAMPS
- LED FRONT FOG LAMPS

- LED DAYTIME RUNNING LAMPS
- ALL SEASON TIRES

INTERIOR

- LEATHER APPOINTED 40/20/40 SPLIT BENCH FRONT SEATS W/ 10-WAY ADJUST INCLUDING LUMBAR SUPPORT
- DRIVER SEAT W/ MEMORY SETTING
- HEATED, LEATHER APPOINTED 60/40 FOLDING REAR BENCH SEATS WITH SEATBACK AND UNDERSEAT STORAGE
- REAR SEAT REMINDER
- HEATED LEATHER STEERING WHEEL
- KEYLESS OPEN AND START
- POWER WINDOWS: EXPRESS UP & DOWN FRONT, EXPRESS DOWN REAR
- REAR WINDOW DEFOGGER
- REAR HVAC VENTS
- STEERING WHEEL AUDIO CONTROLS
- TILT AND TELESCOPING STEERING COLUMN
- AUTO DIMMING REAR VIEW MIRROR

- DUAL ZONE CLIMATE CONTROL
- 120V POWER OUTLET IN BEDSIDE AND INSTRUMENT PANEL
- CHEVROLET INFOTAINMENT 3 PLUS 8" DIAG HD COLOR TOUCHSCREEN VOICE RECOGNITION
- BLUETOOTH AUDIO STREAMING APPLE CARPLAY & ANDROID AUTO CAPABLE, IN-VEHICLE APPS AND PERSONALIZATION CAPABLE
- SIRIUSXM ALL ACCESS + SERVICE SUBSCRIPTION SOLD SEPARATELY BY SIRIUSXM AFTER 3 MTHS
- 4G LTE WI-FI (R) HOTSPOT CAPABLE (SUBJECT TO TERMS SEE ONSTAR.COM)
- HD RADIO
- 6-SPEAKER AUDIO SYSTEM

OPTIONS & PRICING

MANUFACTURER'S SUGGESTED RETAIL PRICE

STANDARD VEHICLE PRICE \$45,400.00

Visit us at www.chevy.com

OPTIONS INSTALLED BY THE MANUFACTURER (MAY REPLACE STANDARD EQUIPMENT SHOWN)

- LTZ PREMIUM PACKAGE 6,310.00
- SEATS, FRONT BUCKET WITH CENTER CONSOLE
- SEATS, VENTILATED DRIVER AND FRONT PASSENGER
- REAR SLIDING POWER WINDOW
- UNIVERSAL HOME REMOTE
- 2 USB PORTS
- SEATS, HEATED SECOND ROW OUTBOARD SEATS
- NAVIGATION
- BOSE PREMIUM SOUND SYSTEM
- WIRELESS CHARGING
- FRONT AND REAR PARK ASSIST
- LANE CHANGE ALERT WITH SIDE BLIND ZONE ALERT
- REAR CROSS TRAFFIC ALERT
- FORWARD COLLISION ALERT
- LANE KEEP ASSIST WITH LANE DEPARTURE WARNING
- LOW SPEED FORWARD AUTOMATIC BRAKING

- FRONT PEDESTRIAN BRAKING
- INTELLIBEAM, AUTO HIGH BEAM
- FOLLOWING DISTANCE INDICATOR
- SAFETY ALERT SEAT
- RECOVERY HOOKS, BLACK
- SUNROOF, POWER
- 20" ULTRA BRIGHT WHEELS
- BLACK BOWTIE EMBLEM - FRONT (DEALER-INSTALLED) 135.00
- GWR, 6,900 LBS. (3,130 KG) INC.
- REAR AXLE 3.23 RATIO INC.
- ENGINE, 5.3L ECOTEC3 V8 WITH DYNAMIC FUEL MANAGEMENT INC.

TOTAL OPTIONS	\$6,445.00
TOTAL VEHICLE & OPTIONS	\$51,845.00
DESTINATION CHARGE	1,495.00
TOTAL BEFORE SAVINGS	\$53,340.00
LTZ PREMIUM PACKAGE DISCOUNT	-1,000.00

TOTAL VEHICLE PRICE* \$52,340.00

EPA DOT Fuel Economy and Environment

Fuel Economy

19 MPG
combined city/hwy

17 city
23 highway

5.3 gallons per 100 miles

Standard pickup trucks range from 14 to 22 MPG. The best vehicle rates 136 MPGe.

You spend \$3,000

more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel Cost \$2,000

Fuel Economy & Greenhouse Gas Rating (tailpipe only)

3

This vehicle emits 467 grams CO₂ per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions. Learn more at fuelconomy.gov.

Smog Rating (tailpipe only)

5

Best 10

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs \$7,000 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$2.55 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fuelconomy.gov
Calculate personalized estimates and compare vehicles



GOVERNMENT 5-STAR SAFETY RATINGS

This vehicle has not been rated by the government for overall vehicle score, frontal crash, side crash or rollover risk.

Source: National Highway Traffic Safety Administration (NHTSA)
www.safercar.gov or 1-888-327-4236



Equipped with the safety and connectivity of OnStar.

Visit onstar.com for details.
onstar.com/forwarranty

PARTS CONTENT INFORMATION

FOR VEHICLES IN THIS CARLINE:
U.S./CANADIAN PARTS CONTENT: 42%
MAJOR SOURCES OF FOREIGN PARTS CONTENT: MEXICO 46%

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

FOR THIS VEHICLE:
FINAL ASSEMBLY POINT: ROANOKE, IN U.S.A.
COUNTRY OF ORIGIN: ENGINE: UNITED STATES
TRANSMISSION: UNITED STATES

This label has been spotted pursuant to Federal law - Do not remove prior to delivery to the ultimate purchaser. *Includes Manufacturer's Recommended Pre-Delivery Service. Does not include dealer installed options and accessories not listed above, local taxes or license fees.

© 2019 General Motors LLC
GM/IL, PROD, 0038 - 07/20/2018

ORDER NO W14721 SALES CODE E
SALES MODEL CODE CC10543
DEALER NO
FINAL ASSEMBLY:
ROANOKE, IN U.S.A.
VIN 1GCPWEED3KZ12
DEALER TO WHOM DELIVERED



LM

Figure A3. Window Sticker (Monroney Label)



MFD BY GENERAL MOTORS LLC

09/18

GVWR
3130 KG
6900 LB

GAWR FRT
1678 KG
3700 LB

GAWR RR
1724 KG
3800 LB



8624

THIS VEHICLE CONFORMS TO ALL
APPLICABLE U.S. FEDERAL MOTOR
VEHICLE SAFETY STANDARDS IN EFFECT
ON THE DATE OF MANUFACTURE
SHOWN ABOVE.

1GCPWEED3KZ12

TYPE: TRUCK

MODEL: 30CC10543

	TIRE SIZE	
FRT	275/60R20	S
RR	275/60R20	S
SPA	255/80R17	S

RIM
20X9J
20X9J
17X8J

Figure A4. Vehicle Certification Label



TIRE AND LOADING INFORMATION



SEATING CAPACITY | TOTAL 5 | FRONT 2 | REAR 3

The combined weight of occupants and cargo should never exceed **827** kg or **1822** lbs.

TIRE	ORIGINAL SIZE	COLD TIRE PRESSURE	SEE OWNER'S MANUAL FOR ADDITIONAL INFORMATION
FRONT	275/60R20 S	240 kPa, 35 PSI	
REAR	275/60R20 S	240 kPa, 35 PSI	
SPARE	255/80R17 S	240 kPa, 35 PSI	

1GCPWEED3KZ12

Figure A5. Tire Placard



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



Figure A7. Load Frame/Slider of SSV

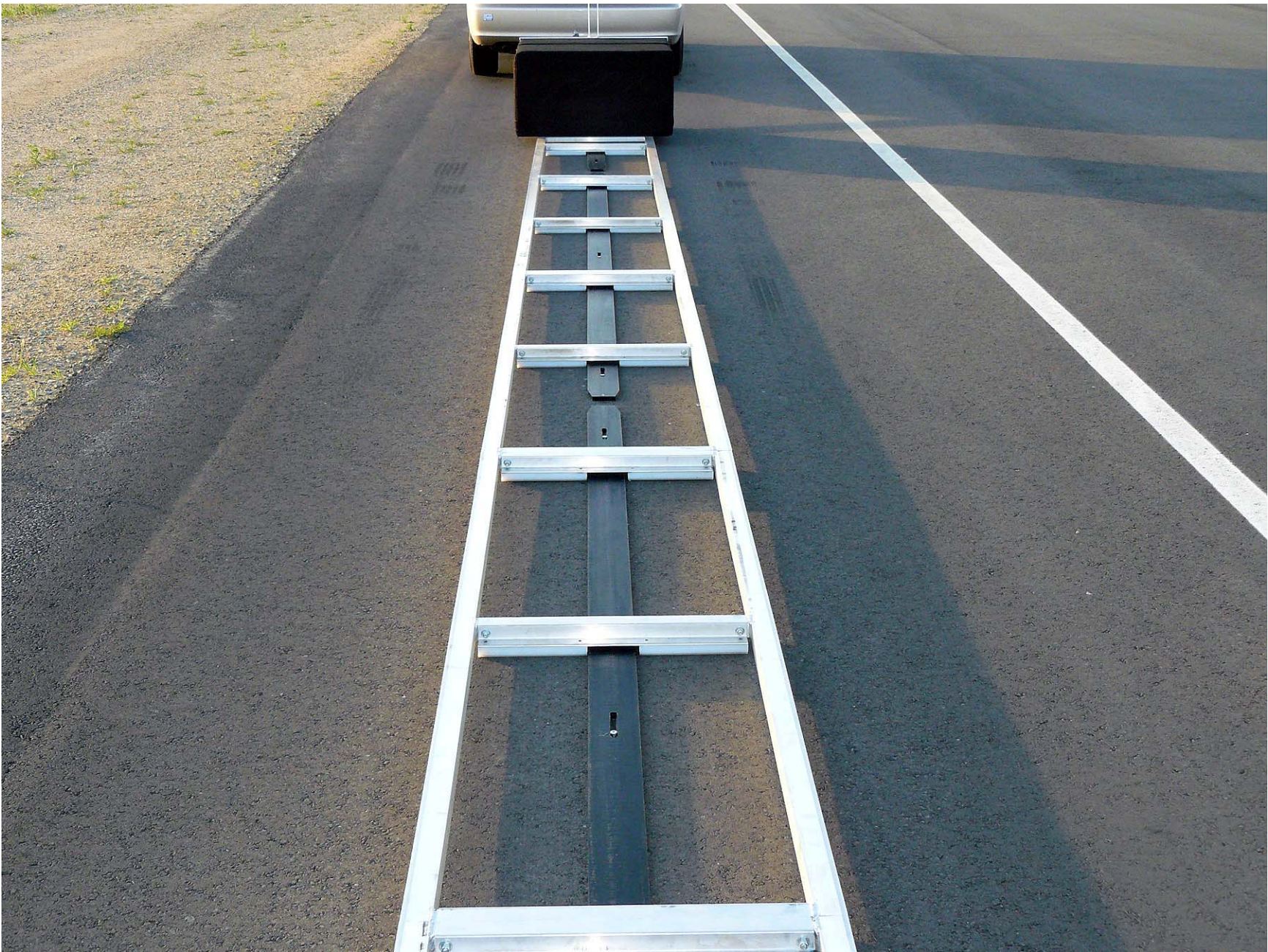


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track



Figure A9. Steel Trench Plate



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



Figure A11. Sensors for Detecting Auditory and Visual Alerts



Figure A12. Computer and Brake Actuator Installed in Subject Vehicle



Figure A13. Brake Actuator Installed in POV System



Figure A14. Heads-Up Visual AEB Alert



Figure A15. AEB Setup Menus (1 of 2)



Figure A16. AEB Setup Menus (2 of 2)



Figure A17. AEB/FCW System Range Setting Control Button

APPENDIX B

Excerpts from Owner's Manual

⚠ Danger

Danger indicates a hazard with a high level of risk which will result in serious injury or death.

⚠ Warning

Warning indicates a hazard that could result in injury or death.

Caution

Caution indicates a hazard that could result in property or vehicle damage.



A circle with a slash through it is a safety symbol which means "Do Not," "Do not do this," or "Do not let this happen."

Symbols

The vehicle has components and labels that use symbols instead of text. Symbols are shown along with the text describing the operation or information relating to a specific component, control, message, gauge, or indicator.

: Shown when the owner's manual has additional instructions or information.

: Shown when the service manual has additional instructions or information.

: Shown when there is more information on another page — "see page."

Vehicle Symbol Chart

Here are some additional symbols that may be found on the vehicle and what they mean. See the features in this manual for information.

: Air Conditioning System

: Air Conditioning Refrigerant Oil

: Airbag Readiness Light

: Antilock Brake System (ABS)

: Brake System Warning Light

: Dispose of Used Components Properly

: Do Not Apply High Pressure Water

: Engine Coolant Temperature

: Flame/Fire Prohibited

: Flammable

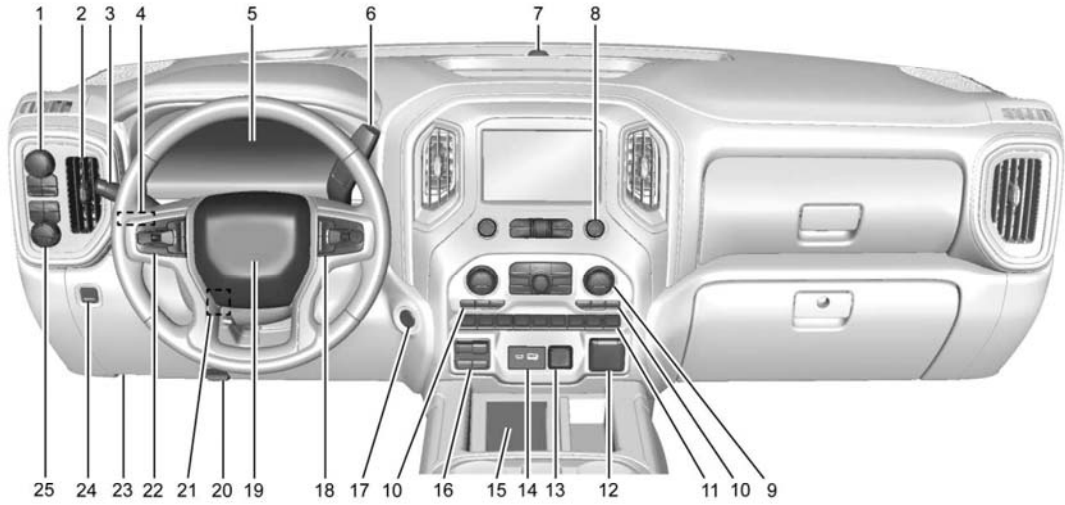
: Forward Collision Alert










: Fuse Block Cover Lock Location

: Fuses

: ISOFIX/LATCH System Child Restraints

Instrument Panel



- | | | |
|--|--|---|
| <ol style="list-style-type: none"> 1. Tow/Haul Mode (On Some Models). See <i>Driver Mode Control</i> ⇨ 244.
Automatic Transfer Case Control (If Equipped). See <i>Four-Wheel Drive</i> ⇨ 233.
<i>Driver Mode Control</i> ⇨ 244 (If Equipped). 2. <i>Air Vents</i> ⇨ 192. 3. Turn Signal Lever. See <i>Turn and Lane-Change Signals</i> ⇨ 179.
<i>Windshield Wiper/Washer</i> ⇨ 129. 4. <i>Head-Up Display (HUD)</i> ⇨ 161 (If Equipped). 5. <i>Instrument Cluster</i> ⇨ 136. 6. Shift Lever. See <i>Automatic Transmission</i> ⇨ 227.
Range Selection Mode. See <i>Manual Mode</i> ⇨ 230. 7. Light Sensor. See <i>Automatic Headlamp System</i> ⇨ 177. 8. <i>Infotainment</i> ⇨ 185. | <ol style="list-style-type: none"> 9. <i>Climate Control Systems</i> ⇨ 186 (If Equipped).
<i>Dual Automatic Climate Control System</i> ⇨ 188 (If Equipped). 10. <i>Heated and Ventilated Front Seats</i> ⇨ 74 (If Equipped). 11.  Park Assist Switch (If Equipped). See <i>Assistance Systems for Parking or Backing</i> ⇨ 252.
 <i>Traction Control/Electronic Stability Control</i> ⇨ 241.
 <i>Hazard Warning Flashers</i> ⇨ 178.
 <i>Lane Keep Assist (LKA)</i> ⇨ 267 (If Equipped).
 Hill Descent Control Switch (If Equipped). See <i>Hill Descent Control (HDC)</i> ⇨ 243.
 <i>Power Assist Steps</i> ⇨ 51 (If Equipped).
 Power Release Tailgate (If Equipped). See <i>Tailgate</i> ⇨ 47. | <p>DC/AC Switch. See <i>Power Outlets</i> ⇨ 130.</p> <p> Auto Stop Disable Switch (If Equipped). See <i>Stop/Start System</i> ⇨ 220.</p> <p> Express Window Down Button (If Equipped). See <i>Power Windows</i> ⇨ 61.</p> <p>Tow/Haul Mode (On Some Models). See <i>Driver Mode Control</i> ⇨ 244.</p> <ol style="list-style-type: none"> 12. Power Outlet (Alternating Current) (If Equipped). See <i>Power Outlets</i> ⇨ 130. 13. <i>Power Outlets</i> ⇨ 130. 14. USB Port. See the infotainment manual. 15. <i>Wireless Charging</i> ⇨ 132 (If Equipped). 16. Trailer Brake Control Panel (If Equipped). See “Integrated Trailer Brake Control System” under <i>Towing Equipment</i> ⇨ 284. |
|--|--|---|

8 In Brief

17. ENGINE START/STOP. See *Ignition Positions (Key Access)* ⇨ 215 or *Ignition Positions (Keyless Access)* ⇨ 217.
18. *Steering Wheel Controls* ⇨ 129 (If Equipped).
Driver Information Center (DIC) Controls.
See *Driver Information Center (DIC) (Base Level)* ⇨ 157 or *Driver Information Center (DIC) (Midlevel and Uplevel)* ⇨ 158.
19. *Horn* ⇨ 129.
20. Hood Release. See *Hood* ⇨ 312.
21. *Steering Wheel Adjustment* ⇨ 128 (Out of View).
22. *Cruise Control* ⇨ 248.
Forward Collision Alert (FCA) System ⇨ 258 (If Equipped).
23. Data Link Connector (DLC) (Out of View). See *Malfunction Indicator Lamp (Check Engine Light)* ⇨ 147.
24. *Electric Parking Brake* ⇨ 239.
25. *Fog Lamps* ⇨ 179 (If Equipped).
Instrument Panel Illumination Control ⇨ 181.
Exterior Cargo Lamps ⇨ 180.
Exterior Lamp Controls ⇨ 174.
Task Lighting ⇨ 180 (If Equipped).

Initial Drive Information

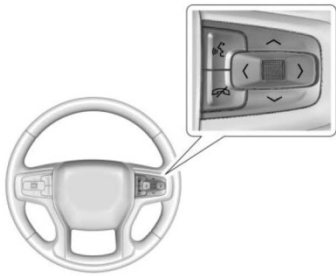
This section provides a brief overview about some of the important features that may or may not be on your specific vehicle.

For more detailed information, refer to each of the features which can be found later in this owner's manual.

Stop/Start System

If equipped, the Stop/Start system will shut off the engine to help conserve fuel. It has components designed for the increased number of starts.

When the brakes are applied and the vehicle is at a complete stop, the engine may turn off. When stopped, the tachometer displays AUTO STOP. See *Tachometer* ⇨ 141. When the brake pedal is released or the accelerator pedal is pressed, the engine will restart. See *Stop/Start System* ⇨ 220.




^ or v : Use the thumbwheel to scroll up or down in a list. Press the thumbwheel to select.

< or > : Press to move between the interactive display zones in the cluster. Press the thumbwheel to select.

See *Driver Information Center (DIC) (Base Level)* ⇨ 157 or *Driver Information Center (DIC) (Midlevel and Uplevel)* ⇨ 158.

Forward Collision Alert (FCA) System

If equipped, FCA may help avoid or reduce the harm caused by front-end crashes. FCA provides a green indicator, , when a vehicle is detected ahead. This indicator displays amber when following a vehicle much too closely. When approaching a vehicle ahead too quickly, FCA provides a flashing red alert on the windshield and rapidly beeps or pulses the driver seat.

See *Forward Collision Alert (FCA) System* ⇨ 258.


Forward Automatic Braking (FAB)

If the vehicle has Forward Collision Alert (FCA), it also has FAB, which includes Intelligent Brake Assist (IBA). When the system detects a vehicle ahead in your path that is traveling in the same direction that you may be about to crash into, it can provide a boost to braking or automatically brake the

vehicle. This can help avoid or lessen the severity of crashes when driving in a forward gear.

See *Forward Automatic Braking (FAB)* ⇨ 261.

Front Pedestrian Braking (FPB) System

If equipped, the FPB system may help avoid or reduce the harm caused by front-end crashes with nearby pedestrians when driving in a forward gear. FPB displays an amber indicator, , when a nearby pedestrian is detected directly ahead. When approaching a detected pedestrian too quickly, FPB provides a red flashing alert on the windshield and rapidly beeps or pulses the driver seat. FPB can provide a boost to braking or automatically brake the vehicle.

See *Front Pedestrian Braking (FPB) System* ⇨ 262.

152 Instruments and Controls

without using the turn signal in that direction. The LKA light will turn amber.

This light is amber and flashes as a Lane Departure Warning (LDW) alert, to indicate that the lane marking has been crossed.

See *Lane Keep Assist (LKA)* ⇨ 267.

Vehicle Ahead Indicator



If equipped, this indicator will display green when a vehicle is detected ahead and amber when you are following a vehicle ahead much too closely.

See *Forward Collision Alert (FCA) System* ⇨ 258.

Pedestrian Ahead Indicator



If equipped, this indicator will display amber when a nearby pedestrian is detected directly in front of the vehicle.

See *Front Pedestrian Braking (FPB) System* ⇨ 262.

Traction Off Light



This light comes on briefly while starting the engine. If it does not, have the vehicle serviced by your

dealer. If the system is working normally, the indicator light then turns off.

The traction off light comes on when the Traction Control System (TCS) has been turned off by pressing and releasing the TCS/ESC button.

This light and the Electronic Stability Control (ESC) OFF light come on when ESC is turned off.

If the TCS is off, wheel spin is not limited. Adjust driving accordingly.

See *Traction Control/Electronic Stability Control* ⇨ 241.

Traction Control System (TCS)/Electronic Stability Control Light



- Brakes
- Steering
- Ride Control Systems
- Driver Assistance Systems
- Cruise Control
- Lighting and Bulb Replacement
- Wiper/Washer Systems
- Doors and Windows
- Seat Belts
- Airbag Systems
- Engine and Transmission
- Tire Pressure
- Battery

Engine Power Messages

ENGINE POWER IS REDUCED

This message displays when the vehicle's propulsion power is reduced. Reduced propulsion power can affect the vehicle's ability to accelerate. If this message is on, but there is no observed reduction in performance, proceed to your destination. The performance may

be reduced the next time the vehicle is driven. The vehicle may be driven while this message is on, but maximum acceleration and speed may be reduced. Anytime this message stays on, or displays repeatedly, the vehicle should be taken to your dealer for service as soon as possible.

Vehicle Speed Messages

SPEED LIMITED TO XXX KM/H (MPH)




This message shows that the vehicle speed has been limited to the speed displayed. The limited speed is a protection for various propulsion and vehicle systems, such as lubrication, thermal, suspension, Teen Driver if equipped, or tires.

Vehicle Personalization

The following are all possible vehicle personalization features. Depending on the vehicle, some may not be available.

For System, Apps, and Personal features and functions, see "Settings" in the infotainment manual.

To access the vehicle personalization menu:

1. Touch the SETTINGS icon on the Home Page of the infotainment display.
2. Touch Vehicle to display a list of available options.
3. Touch to select the desired feature setting.
4. Touch  or  to turn a feature off or on.
5. Touch  to go to the top level of the Settings menu.

166 Instruments and Controls

The menu may contain the following:

Rear Seat Reminder

This allows for a chime and a message when the rear door has been opened before or during operation of the vehicle.

Touch Off or On.

Climate and Air Quality

Touch and the following may display:

- Auto Fan Speed
- Auto Defog
- Auto Rear Defog

Auto Fan Speed

This setting specifies the amount of airflow when the climate control fan setting is Auto Fan.

Touch Low, Medium, or High.

Auto Defog

This setting automatically directs air to the windshield to assist in defogging, based on temperature and humidity conditions.

Touch Off or On.

Auto Rear Defog

This setting automatically turns the rear defogger on based on temperature and humidity conditions.

Touch Off or On.

Collision/Detection Systems

Touch and the following may display:

- Alert Type
- Forward Collision System
- Front Pedestrian Detection
- Lane Change Alert
- Park Assist
- Rear Camera Park Assist Symbols
- Rear Cross Traffic Alert

Alert Type

This feature sets the type of alert from the driver assistance systems to help avoid crashes.

Touch Beeps or Safety Alert Seat.

Forward Collision System

This feature will turn on or off Forward Collision Alert (FCA) and Forward Automatic Braking (FAB). The Off setting disables all FCA and FAB functions. With the Alert and Brake setting, both FCA and FAB are available. The Alert setting disables FAB. See *Forward Automatic Braking (FAB)* ⇨ 261.

Touch Off, Alert, or Alert and Brake.

Front Pedestrian Detection

This feature may help avoid or reduce the harm caused by front-end crashes with nearby pedestrians. See *Front Pedestrian Braking (FPB) System* ⇨ 262.

Touch Off, Alert, or Alert and Brake.

Lane Change Alert

This allows the feature to be turned on or off. See *Lane Change Alert (LCA)* ⇨ 265.

Touch Off or On.

Driver Assistance Systems

This vehicle may have features that work together to help avoid crashes or reduce crash damage while driving, backing, and parking. Read this entire section before using these systems.

Warning

Do not rely on the Driver Assistance Systems. These systems do not replace the need for paying attention and driving safely. You may not hear or feel alerts or warnings provided by these systems. Failure to use proper care when driving may result in injury, death, or vehicle damage. See *Defensive Driving* ⇨ 196.

(Continued)

Warning (Continued)

Under many conditions, these systems will not:

- Detect children, pedestrians, bicyclists, or animals.
- Detect vehicles or objects outside the area monitored by the system.
- Work at all driving speeds.
- Warn you or provide you with enough time to avoid a crash.
- Work under poor visibility or bad weather conditions.
- Work if the detection sensor is not cleaned or is covered by ice, snow, mud, or dirt.
- Work if the detection sensor is covered up, such as with a sticker, magnet, or metal plate.

(Continued)

Warning (Continued)

- Work if the area surrounding the detection sensor is damaged or not properly repaired.

Complete attention is always required while driving, and you should be ready to take action and apply the brakes and/or steer the vehicle to avoid crashes.

Audible or Safety Alert Seat

Some driver assistance features alert the driver of obstacles by beeping. To change the volume of the warning chime, see "Comfort and Convenience" under *Vehicle Personalization* ⇨ 165.

If equipped with the Safety Alert Seat, the driver seat cushion may provide a vibrating pulse alert instead of beeping. To change this, see "Collision/Detection Systems" under *Vehicle Personalization* ⇨ 165.

258 Driving and Operating

Use caution while backing up when towing a trailer, as the RCTA detection zones that extend out from the back of the vehicle do not move further back when a trailer is towed.

RCTA is disabled when the trailer connection status is displayed.

RCTA can be turned off through "Collision/Detection Systems" under *Vehicle Personalization* ⇨ 165.

Turning the Features On or Off



Press **P** on the center stack to turn on or off the Front and Rear Park Assist. The indicator light next to the button comes on when the features are on and turns off when the features have been disabled.

Front and Rear Park Assist can be turned Off, On, or On with Towbar through vehicle personalization. See "Park Assist" under *Vehicle Personalization* ⇨ 165. If Park Assist is turned off through vehicle personalization, the Park Assist button will be disabled. To turn Park Assist on again, select On in the vehicle personalization menu. The On with Towbar setting allows for Park Assist to work properly with a trailer hitch. Some larger trailer hitches may not be compatible.

Turn off Park Assist when towing a trailer.

To turn the RPA symbols on or off, see "Rear Camera Park Assist Symbols" under *Vehicle Personalization* ⇨ 165.

Assistance Systems for Driving

If equipped, when driving the vehicle in a forward gear, Forward Collision Alert (FCA), Lane Departure Warning (LDW), Lane Keep Assist (LKA), Side Blind Zone

Alert (SBZA), Lane Change Alert (LCA), Forward Automatic Braking (FAB), and/or the Front Pedestrian Braking (FPB) System can help to avoid a crash or reduce crash damage.

Forward Collision Alert (FCA) System

If equipped, the FCA system may help to avoid or reduce the harm caused by front-end crashes. When approaching a vehicle ahead too quickly, FCA provides a red flashing alert on the windshield and rapidly beeps or pulses the driver seat. FCA also lights an amber visual alert if following another vehicle much too closely.

FCA detects vehicles within a distance of approximately 60 m (197 ft) and operates at speeds above 8 km/h (5 mph).

Warning

FCA is a warning system and does not apply the brakes. When approaching a slower-moving or stopped vehicle ahead too rapidly, or when following a vehicle too closely, FCA may not provide a warning with enough time to help avoid a crash. It also may not provide any warning at all. FCA does not warn of pedestrians, animals, signs, guardrails, bridges, construction barrels, or other objects. Be ready to take action and apply the brakes. See *Defensive Driving* ⇨ 196.

FCA can be disabled through vehicle personalization. See "Collision/Detection Systems" under *Vehicle Personalization* ⇨ 165.

Detecting the Vehicle Ahead



FCA warnings will not occur unless the FCA system detects a vehicle ahead. When a vehicle is detected, the vehicle ahead indicator will display green. Vehicles may not be detected on curves, highway exit ramps, or hills, due to poor visibility; or if a vehicle ahead is partially blocked by pedestrians or other objects. FCA will not detect another vehicle ahead until it is completely in the driving lane.

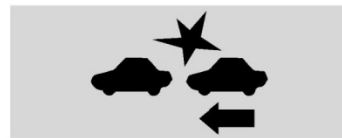
Warning

FCA does not provide a warning to help avoid a crash, unless it detects a vehicle. FCA may not detect a vehicle ahead if the FCA sensor is blocked by dirt, snow, (Continued)

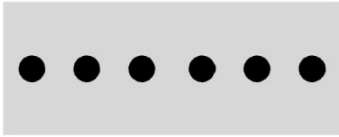
Warning (Continued)

or ice, or if the windshield is damaged. It may also not detect a vehicle on winding or hilly roads, or in conditions that can limit visibility such as fog, rain, or snow, or if the headlamps or windshield are not cleaned or in proper condition. Keep the windshield, headlamps, and FCA sensors clean and in good repair.

Collision Alert



With Head-Up Display



Without Head-Up Display


When your vehicle approaches another detected vehicle too rapidly, the red FCA display will flash on the windshield. Also, eight rapid high-pitched beeps will sound from the front, or both sides of the Safety Alert Seat will pulse five times. When this Collision Alert occurs, the brake system may prepare for driver braking to occur more rapidly which can cause a brief, mild deceleration. Continue to apply the brake pedal as needed. Cruise control may be disengaged when the Collision Alert occurs.

Tailgating Alert



The vehicle ahead indicator will display amber when you are following a vehicle ahead much too closely.

Selecting the Alert Timing

The Collision Alert control is on the steering wheel. Press  to set the FCA timing to Far, Medium, or Near. The first button press shows the current setting on the DIC. Additional button presses will change this setting. The chosen setting will remain until it is changed and will affect the timing of both the Collision Alert and the Tailgating Alert features. The timing of both alerts will vary based on vehicle speed. The faster the vehicle speed, the farther away the alert will occur. Consider traffic and weather conditions when selecting the alert

timing. The range of selectable alert timings may not be appropriate for all drivers and driving conditions.

Following Distance Indicator

The following distance to a moving vehicle ahead in your path is indicated in following time in seconds on the Driver Information Center (DIC). The minimum following time is 0.5 seconds away. If there is no vehicle detected ahead, or the vehicle ahead is out of sensor range, dashes will be displayed.

Unnecessary Alerts

FCA may provide unnecessary alerts for turning vehicles, vehicles in other lanes, objects that are not vehicles, or shadows. These alerts are normal operation and the vehicle does not need service.

Cleaning the System

If the FCA system does not seem to operate properly, this may correct the issue:

- Clean the outside of the windshield in front of the rearview mirror.
- Clean the entire front of the vehicle.
- Clean the headlamps.

Forward Automatic Braking (FAB)

If the vehicle has Forward Collision Alert (FCA), it also has FAB, which includes Intelligent Brake Assist (IBA). When the system detects a vehicle ahead in your path that is traveling in the same direction that you may be about to crash into, it can provide a boost to braking or automatically brake the vehicle. This can help avoid or lessen the severity of crashes when driving in a forward gear. Depending on the situation, the vehicle may automatically brake moderately or

hard. This forward automatic braking can only occur if a vehicle is detected. This is shown by the FCA vehicle ahead indicator being lit. See *Forward Collision Alert (FCA) System* ⇨ 258.

The system works when driving in a forward gear between 8 km/h (5 mph) and 80 km/h (50 mph). It can detect vehicles up to approximately 60 m (197 ft).

 **Warning**

FAB is an emergency crash preparation feature and is not designed to avoid crashes. Do not rely on FAB to brake the vehicle. FAB will not brake outside of its operating speed range and only responds to detected vehicles.

FAB may not:

- Detect a vehicle ahead on winding or hilly roads.

(Continued)

Warning (Continued)

- Detect all vehicles, especially vehicles with a trailer, tractors, muddy vehicles, etc.
- Detect a vehicle when weather limits visibility, such as in fog, rain, or snow.
- Detect a vehicle ahead if it is partially blocked by pedestrians or other objects.

Complete attention is always required while driving, and you should be ready to take action and apply the brakes and/or steer the vehicle to avoid crashes.

FAB may slow the vehicle to a complete stop to try to avoid a potential crash. If this happens, FAB may engage the Electric Parking Brake (EPB) to hold the vehicle at a stop. Release the EPB or firmly press the accelerator pedal.

Warning

FAB may automatically brake the vehicle suddenly in situations where it is unexpected and undesired. It could respond to a turning vehicle ahead, guardrails, signs, and other non-moving objects. To override FAB, firmly press the accelerator pedal, if it is safe to do so.

Intelligent Brake Assist (IBA)

IBA may activate when the brake pedal is applied quickly by providing a boost to braking based on the speed of approach and distance to a vehicle ahead.

Minor brake pedal pulsations or pedal movement during this time is normal and the brake pedal should continue to be applied as needed. IBA will automatically disengage only when the brake pedal is released.

Warning

IBA may increase vehicle braking in situations when it may not be necessary. You could block the flow of traffic. If this occurs, take your foot off the brake pedal and then apply the brakes as needed.

FAB and IBA can be disabled through vehicle personalization. See "Collision/Detection Systems" under *Vehicle Personalization* ⇨ 165.

Warning

Using FAB or IBA while towing a trailer could cause you to lose control of the vehicle and crash. Turn the system to Alert or Off when towing a trailer.


A system unavailable message may display if:

- The front of the vehicle or windshield is not clean.

- Heavy rain or snow is interfering with object detection.
- There is a problem with the StabiliTrak system.

The FAB system does not need service.

Front Pedestrian Braking (FPB) System

If equipped, the FPB system may help avoid or reduce the harm caused by front-end crashes with nearby pedestrians when driving in a forward gear. FPB displays an amber indicator, , when a nearby pedestrian is detected directly ahead. When approaching a detected pedestrian too quickly, FPB provides a red flashing alert on the windshield and rapidly beeps or pulses the driver seat. FPB can provide a boost to braking or automatically brake the vehicle. This system includes Intelligent Brake Assist (IBA), and the Forward Automatic Braking (FAB) system

APPENDIX C

Run Log

Subject Vehicle: **2019 Chevrolet Silverado Crew Cab**

Test Date: 10/25/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-9	Brake characterization and confirmation						See Appendix D
10	Static Run						
11	Stopped POV	Y	2.76	0.00	0.40	Fail	E-Brake Activation
12		N					Throttle Drop/Yaw Rate/E-Brake Activation
13		N					Brake Rate/E-Brake Activation
14		N					Yaw Rate/Lateral Offset/E-Brake Activation
15		N					Throttle Drop/E-Brake Activation
16		N					Lateral Offset/E-Brake Activation
17		Y	2.82	0.00	0.38	Fail	E-Brake Activation
18		N					Lateral Offset/Throttle Offset/E-Brake Activation
19		Y	2.76	0.00	0.38	Fail	E-Brake Activation
20		Y	2.76	0.00	0.38	Fail	E-Brake Activation
21		Y	2.83	0.00	0.38	Fail	E-Brake Activation
22	Static Run						

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
23	Slower POV, 25 vs 10	N					Lateral Offset
24		Y	2.61	0.00	0.44	Fail	
25		Y	2.53	0.00	0.42	Fail	
26		Y	2.72	0.00	0.42	Fail	
27		Y	2.83	0.00	0.40	Fail	E-Brake Activation
28		N					Throttle Drop / E-Brake Activation
29		Y	2.78	0.00	0.39	Fail	E-Brake Activation
30	Static run						
31	Slower POV, 45 vs 20	N					Brake Application Rate / E-Brake Activation
32		N					Lateral Offset/ Throttle Drop/ SV Speed
33		N					Throttle Drop
34		N					Throttle Drop
35		N					Throttle Drop
36		N					SV Speed / E-Brake Activation
37		N					Avg Decel / E-Brake Activation
38	STP - Static run						

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
39	Baseline, 25	Y			0.45		
40		Y			0.45		
41		Y			0.45		
42		Y			0.45		
43		Y			0.45		
44		Y			0.44		
45		Y			0.45		
46	STP - Static run						
47	Baseline, 45	N					SV Speed
48		Y			0.49		
49		Y			0.51		
50		Y			0.51		
51		Y			0.50		
52		Y			0.50		
53		Y			0.49		
54		Y			0.49		
55	STP - Static run						

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
56	STP - Static Run						
57	STP False Positive, 25	N					Throttle Drop
58		N					SV Speed
59		Y			0.44	Pass	
60		Y			0.44	Pass	
61		Y			0.44	Pass	
62		Y			0.44	Pass	
63		Y			0.45	Pass	
64		Y			0.44	Pass	
65		Y			0.44	Pass	
66	STP - Static run						
67	STP False Positive, 45	N					SV Speed/Yaw Rate/Lateral Offset
68		Y			0.44	Pass	
69		N					SV Speed
70		Y			0.43	Pass	
71		Y			0.43	Pass	
72		Y			0.42	Pass	

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
73		Y			0.41	Pass	
74		Y			0.42	Pass	
75		Y			0.43	Pass	
76	STP - Static run						
77	Static run						
78	Slower POV, 45 vs 20	Y	3.14	0.00	0.55	Fail	
79		N					Lateral Offset
80		N					Brake Application Rate
81		Y	3.19	0.00	0.58	Fail	
82		Y	1.94	0.00	0.55	Fail	
83	Static run						
84	Braking POV, 35	N					Yaw Rate/ Lateral Offset
85		Y	1.88	0.00	0.43	Fail	
86		N					SV Speed. No FCW, Infotainment system appeared to reset after vehicle was put into reverse. Cycled Ignition after that happened.

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
87		N					No warning, throttle release
88		Y	2.06	0.00	0.45	Fail	
89		Y	1.89	0.00	0.45	Fail	
90	Static run						

APPENDIX D

Brake Characterization

DBS Initial Brake Characterization				
Run Number	Stroke at 0.4 g (in)	Force at 0.4 g (lb)	Slope	Intercept
2	1.611701	21.79973	1.148799	0.174616
3	1.58013	21.38908	1.114955	0.215761
4	1.555788	20.94775	1.060585	0.251432

DBS Brake Characterization Confirmation								
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
5	Displacement	35	Y	0.437	1.58		1.45	
6	Displacement	35	Y	0.370	1.47		1.59	
7	Displacement	35	Y	0.390	1.51		1.55	
8	Displacement	25	Y	0.417	1.51		1.45	
9	Displacement	45	Y	0.422	1.51		1.43	

Appendix E

TIME HISTORY PLOTS

LIST OF FIGURES

	Page
Figure E1. Example Time History for Stopped POV, Passing	10
Figure E2. Example Time History for Slower POV 25 vs. 10, Passing	11
Figure E3. Example Time History for Slower POV 45 vs. 20, Passing	12
Figure E4. Example Time History for Braking POV 35, Passing	13
Figure E5. Example Time History for False Positive Baseline 25, Passing.....	14
Figure E6. Example Time History for False Positive Baseline 45, Passing.....	15
Figure E7. Example Time History for False Positive Steel Plate 25, Passing	16
Figure E8. Example Time History for False Positive Steel Plate 45, Passing	17
Figure E9. Example Time History for DBS Brake Characterization, Passing	18
Figure E10. Example Time History Displaying Various Invalid Criteria.....	19
Figure E11. Example Time History Displaying Various Invalid Criteria.....	20
Figure E12. Example Time History for a Failed Run.....	21
Figure E13. Time History for DBS Run 11, SV Encounters Stopped POV	22
Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV	23
Figure E15. Time History for DBS Run 19, SV Encounters Stopped POV	24
Figure E16. Time History for DBS Run 20, SV Encounters Stopped POV	25
Figure E17. Time History for DBS Run 21, SV Encounters Stopped POV	26
Figure E18. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph	27
Figure E19. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph	28
Figure E20. Time History for DBS Run 26, SV Encounters Slower POV, SV 25 mph, POV 10 mph	29
Figure E21. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph	30
Figure E22. Time History for DBS Run 29, SV Encounters Slower POV, SV 25 mph, POV 10 mph	31
Figure E23. Time History for DBS Run 78, SV Encounters Slower POV, SV 45 mph, POV 20 mph	32
Figure E24. Time History for DBS Run 81, SV Encounters Slower POV, SV 45 mph, POV 20 mph	33
Figure E25. Time History for DBS Run 82, SV Encounters Slower POV, SV 45 mph, POV 20 mph	34
Figure E26. Time History for DBS Run 85, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph.....	35

Figure E27. Time History for DBS Run 88, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph.....	36
Figure E28. Time History for DBS Run 89, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph.....	37
Figure E29. Time History for DBS Run 39, False Positive Baseline, SV 25 mph.....	38
Figure E30. Time History for DBS Run 40, False Positive Baseline, SV 25 mph.....	39
Figure E31. Time History for DBS Run 41, False Positive Baseline, SV 25 mph.....	40
Figure E32. Time History for DBS Run 42, False Positive Baseline, SV 25 mph.....	41
Figure E33. Time History for DBS Run 43, False Positive Baseline, SV 25 mph.....	42
Figure E34. Time History for DBS Run 44, False Positive Baseline, SV 25 mph.....	43
Figure E35. Time History for DBS Run 45, False Positive Baseline, SV 25 mph.....	44
Figure E36. Time History for DBS Run 48, False Positive Baseline, SV 45 mph.....	45
Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 45 mph.....	46
Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 45 mph.....	47
Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 45 mph.....	48
Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 45 mph.....	49
Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 45 mph.....	50
Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 45 mph.....	51
Figure E43. Time History for DBS Run 59, SV Encounters Steel Trench Plate, SV 25 mph.....	52
Figure E44. Time History for DBS Run 60, SV Encounters Steel Trench Plate, SV 25 mph.....	53
Figure E45. Time History for DBS Run 61, SV Encounters Steel Trench Plate, SV 25 mph.....	54
Figure E46. Time History for DBS Run 62, SV Encounters Steel Trench Plate, SV 25 mph.....	55
Figure E47. Time History for DBS Run 63, SV Encounters Steel Trench Plate, SV 25 mph.....	56
Figure E48. Time History for DBS Run 64, SV Encounters Steel Trench Plate, SV 25 mph.....	57
Figure E49. Time History for DBS Run 65, SV Encounters Steel Trench Plate, SV 25 mph.....	58
Figure E50. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 45 mph.....	59
Figure E51. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 45 mph.....	60
Figure E52. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 45 mph.....	61

Figure E53. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 45 mph	62
Figure E54. Time History for DBS Run 73, SV Encounters Steel Trench Plate, SV 45 mph	63
Figure E55. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph	64
Figure E56. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph	65
Figure E57. Time History for DBS Run 2, Brake Characterization Initial	66
Figure E58. Time History for DBS Run 3, Brake Characterization Initial	67
Figure E59. Time History for DBS Run 4, Brake Characterization Initial	68
Figure E60. Time History for DBS Run 5, Brake Characterization Determination 35 mph	69
Figure E61. Time History for DBS Run 6, Brake Characterization Determination 35 mph	70
Figure E62. Time History for DBS Run 7, Brake Characterization Determination 35 mph	71
Figure E63. Time History for DBS Run 8, Brake Characterization Determination 25 mph	72
Figure E64. Time History for DBS Run 9, Brake Characterization Determination 45 mph	73

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)
- Braking 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.

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., $0.30\text{ g} \pm 0.03\text{ g}$). 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.

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. The yellow envelope in this case is used only to visualize the target average brake force necessary for the test 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
- 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

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

Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure E13.

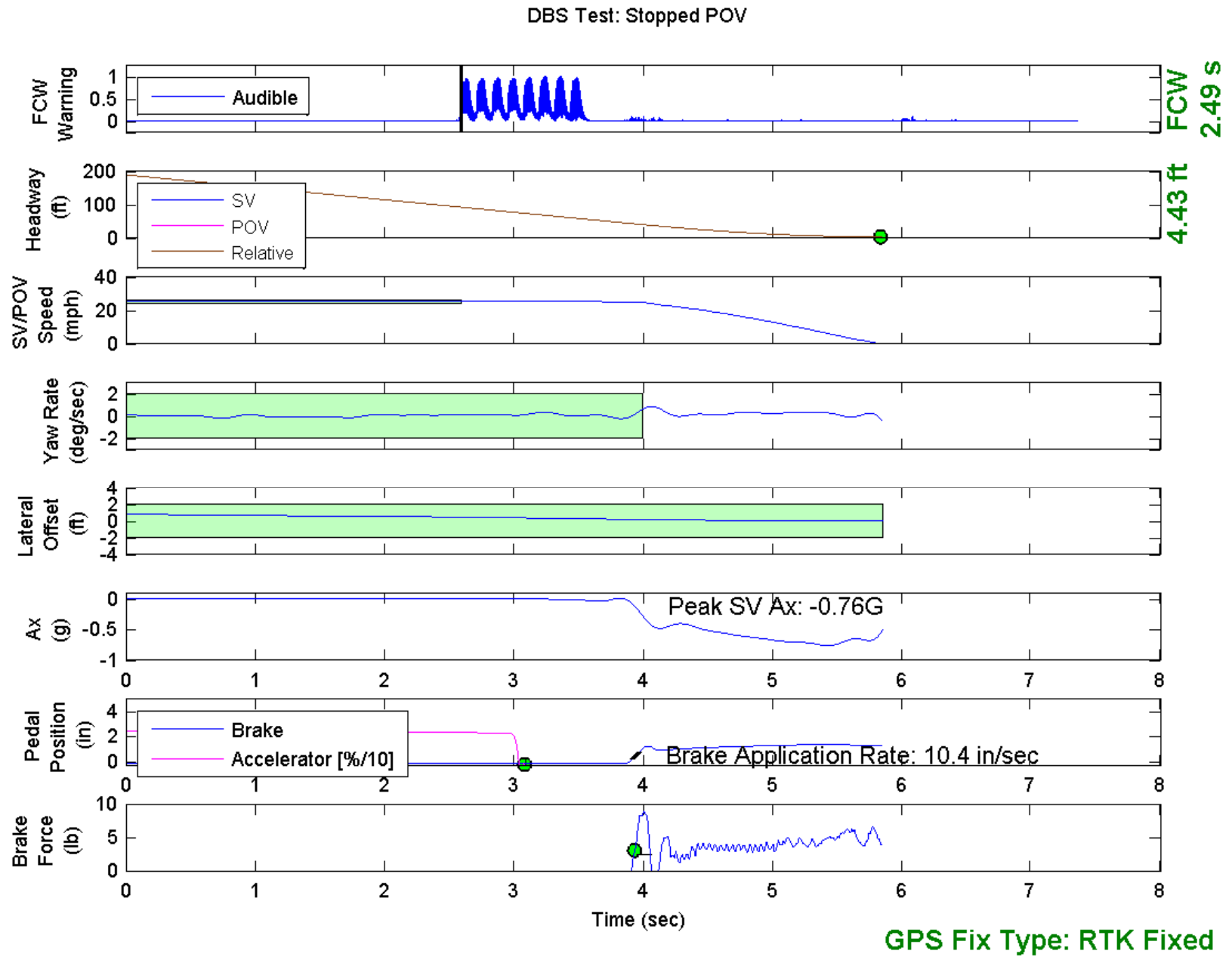


Figure E1. Example Time History for Stopped POV, Passing

DBS Test: Slower POV 25/10 mph

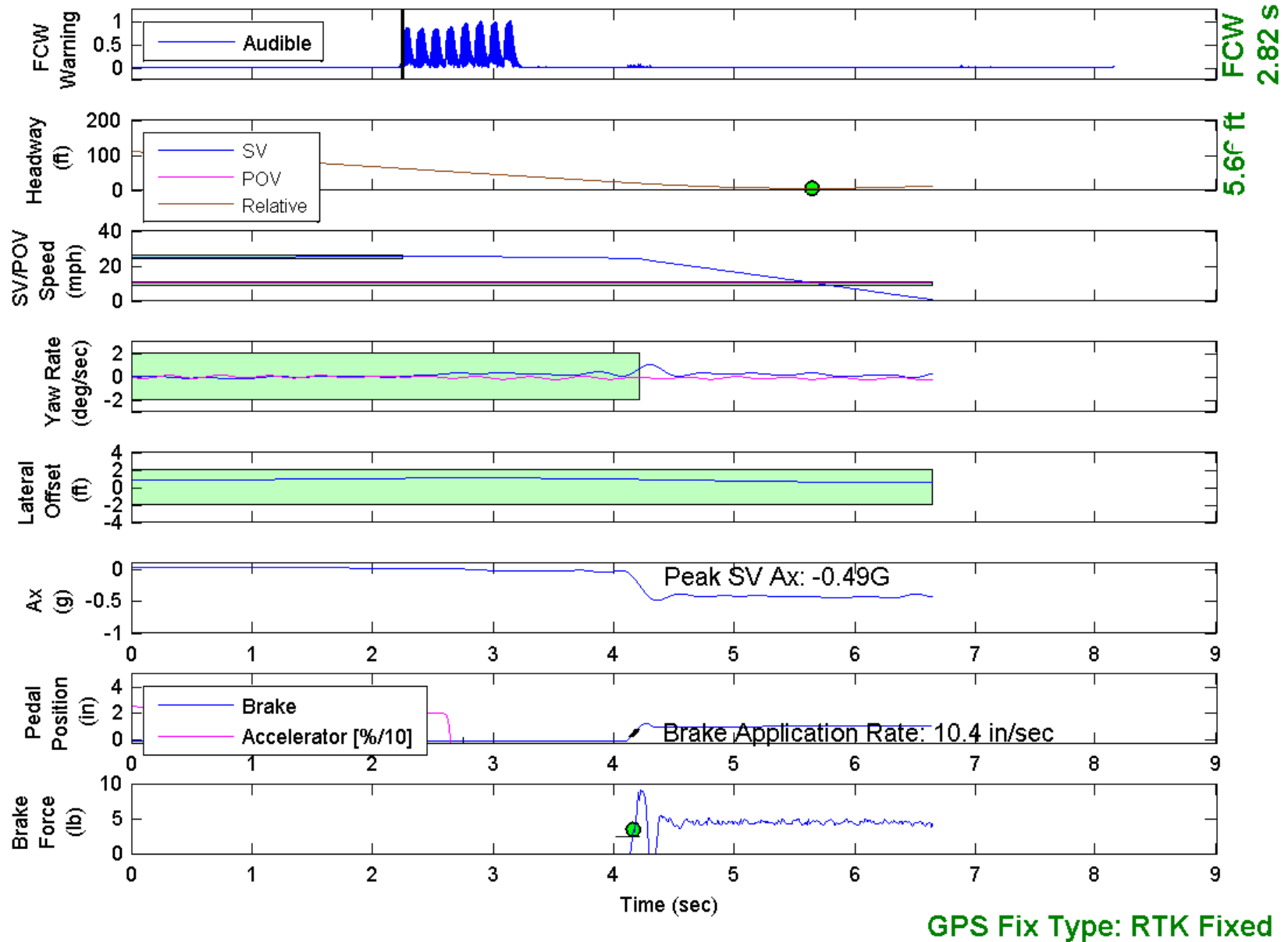


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

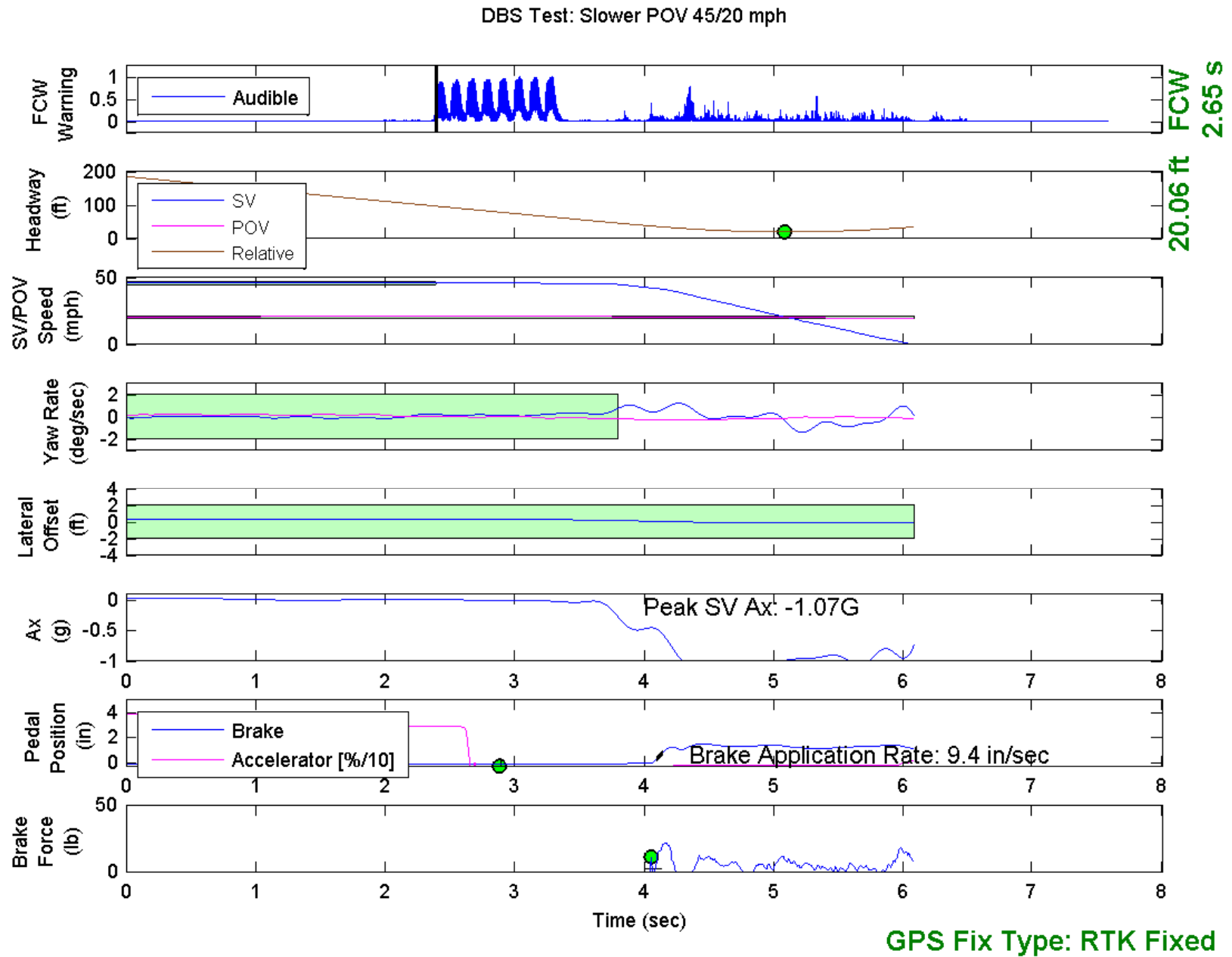


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

DBS Test: Braking POV 35 mph

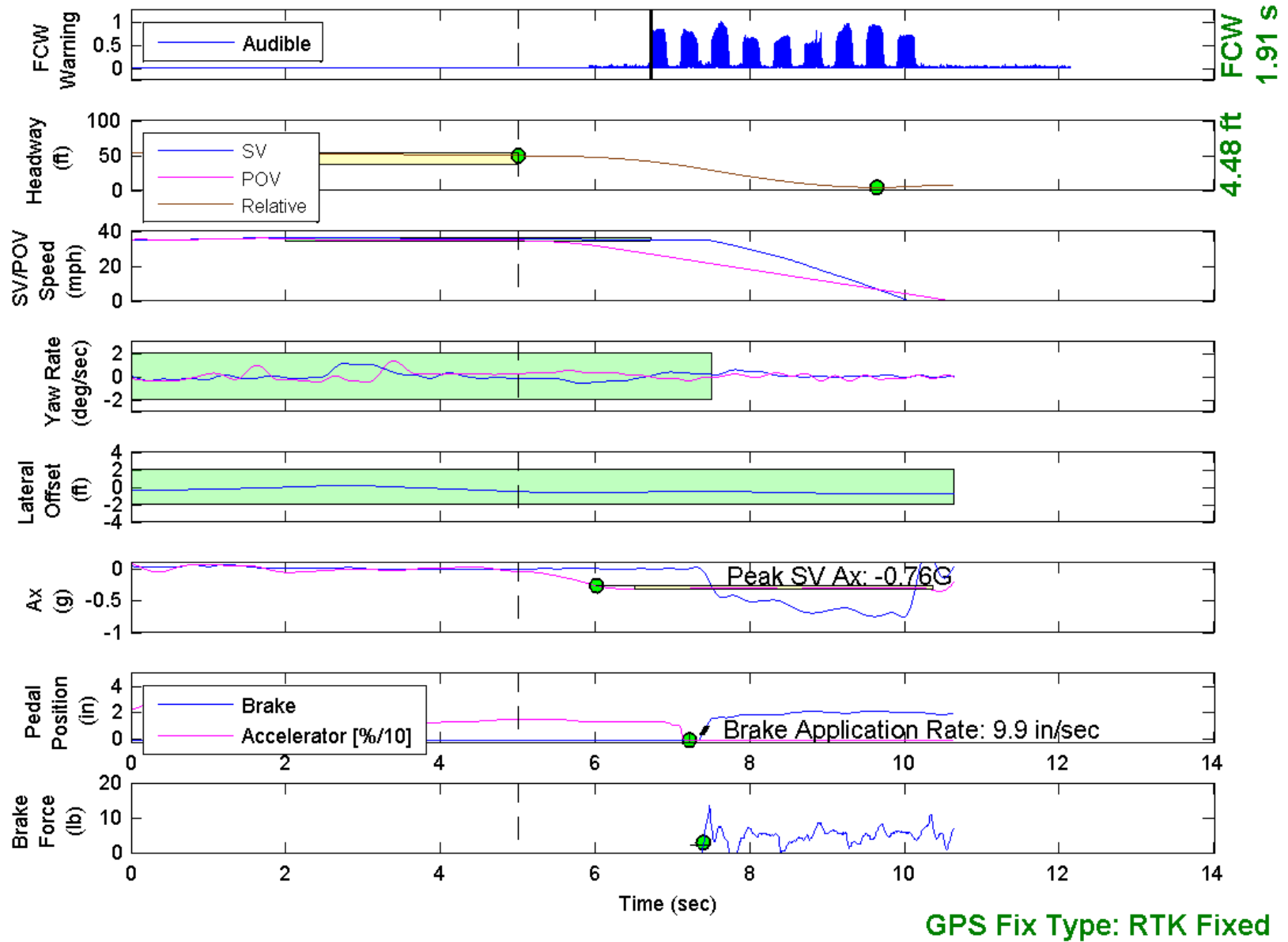


Figure E4. Example Time History for Braking POV 35, Passing

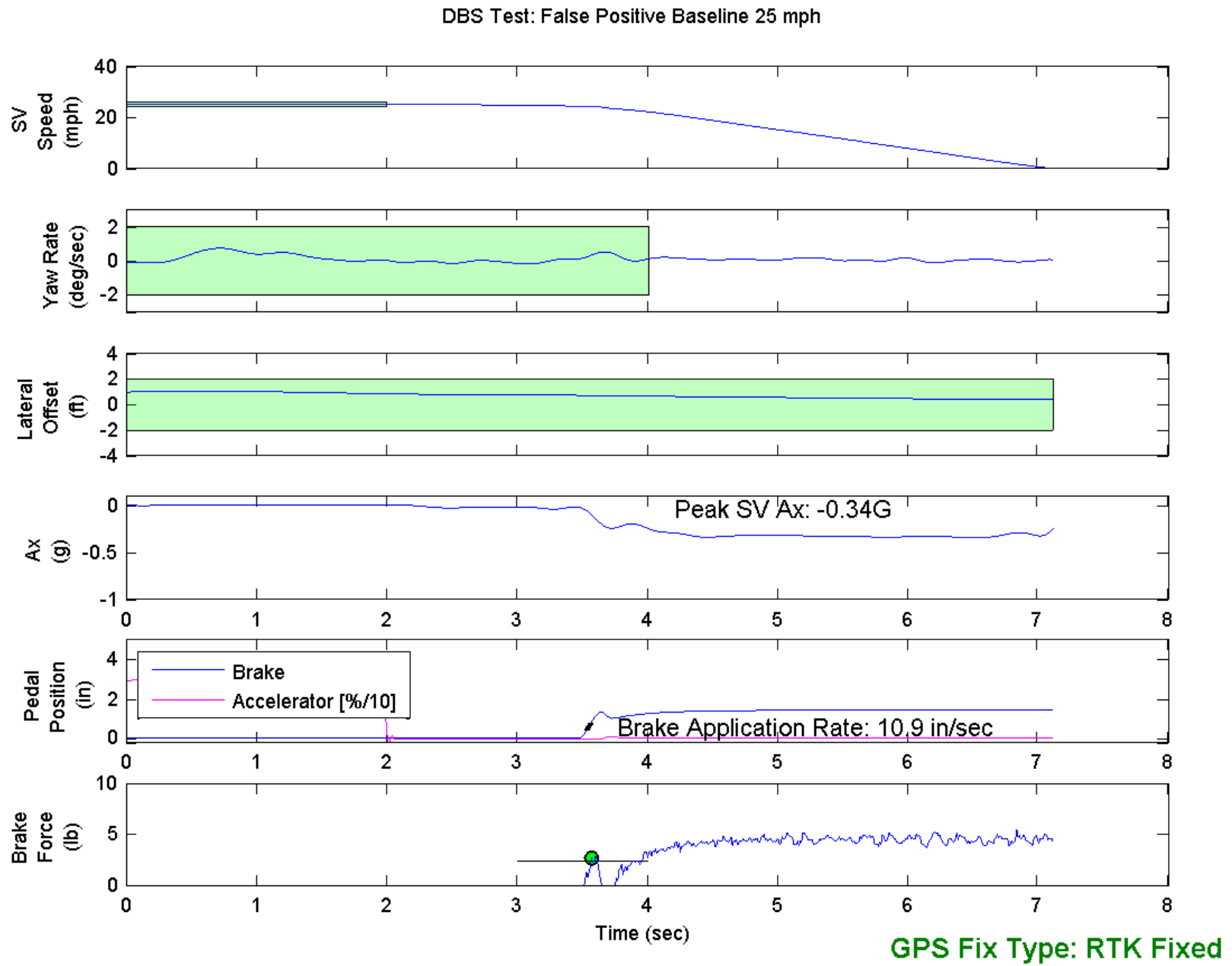


Figure E5. Example Time History for False Positive Baseline 25, Passing

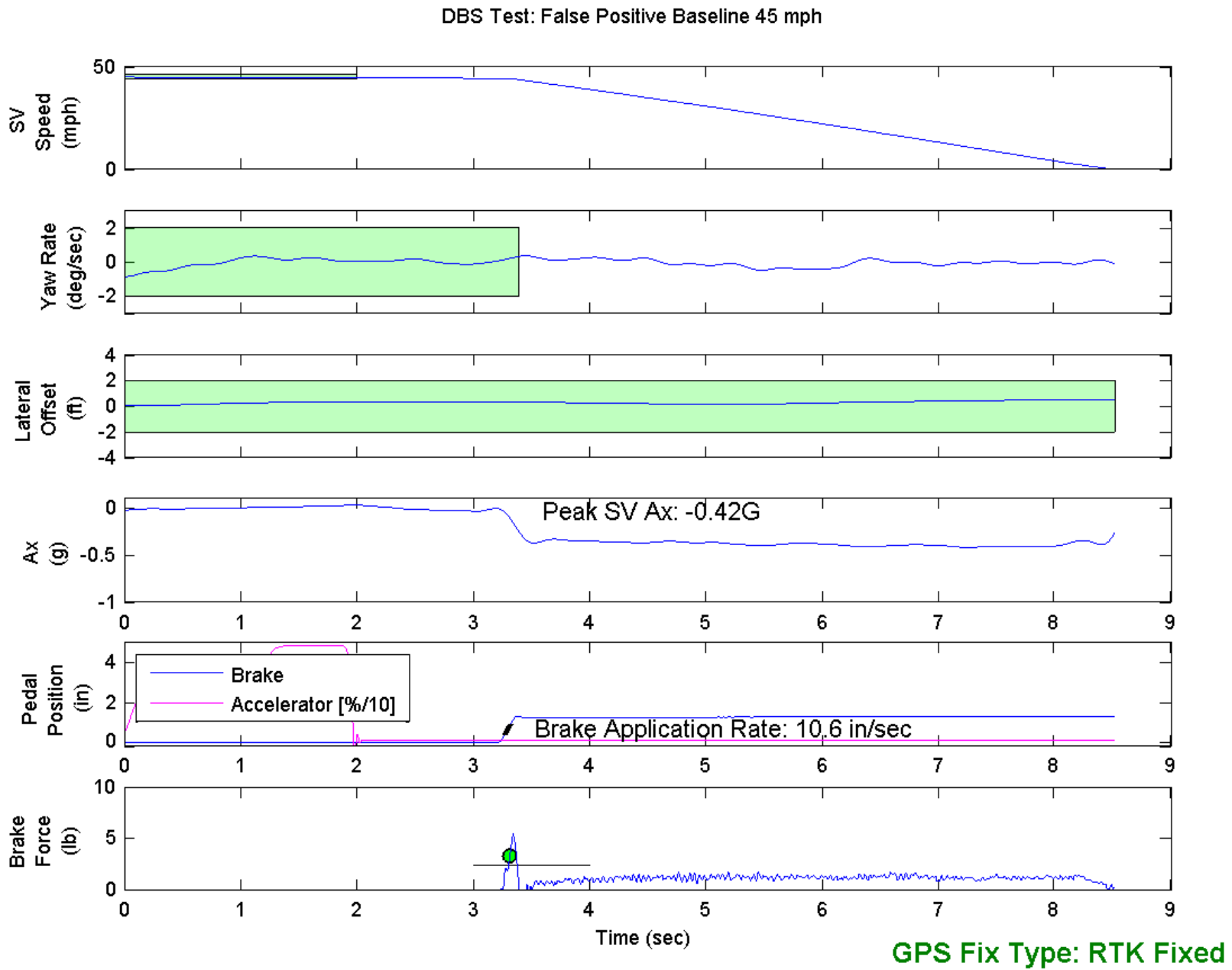


Figure E6. Example Time History for False Positive Baseline 45, Passing

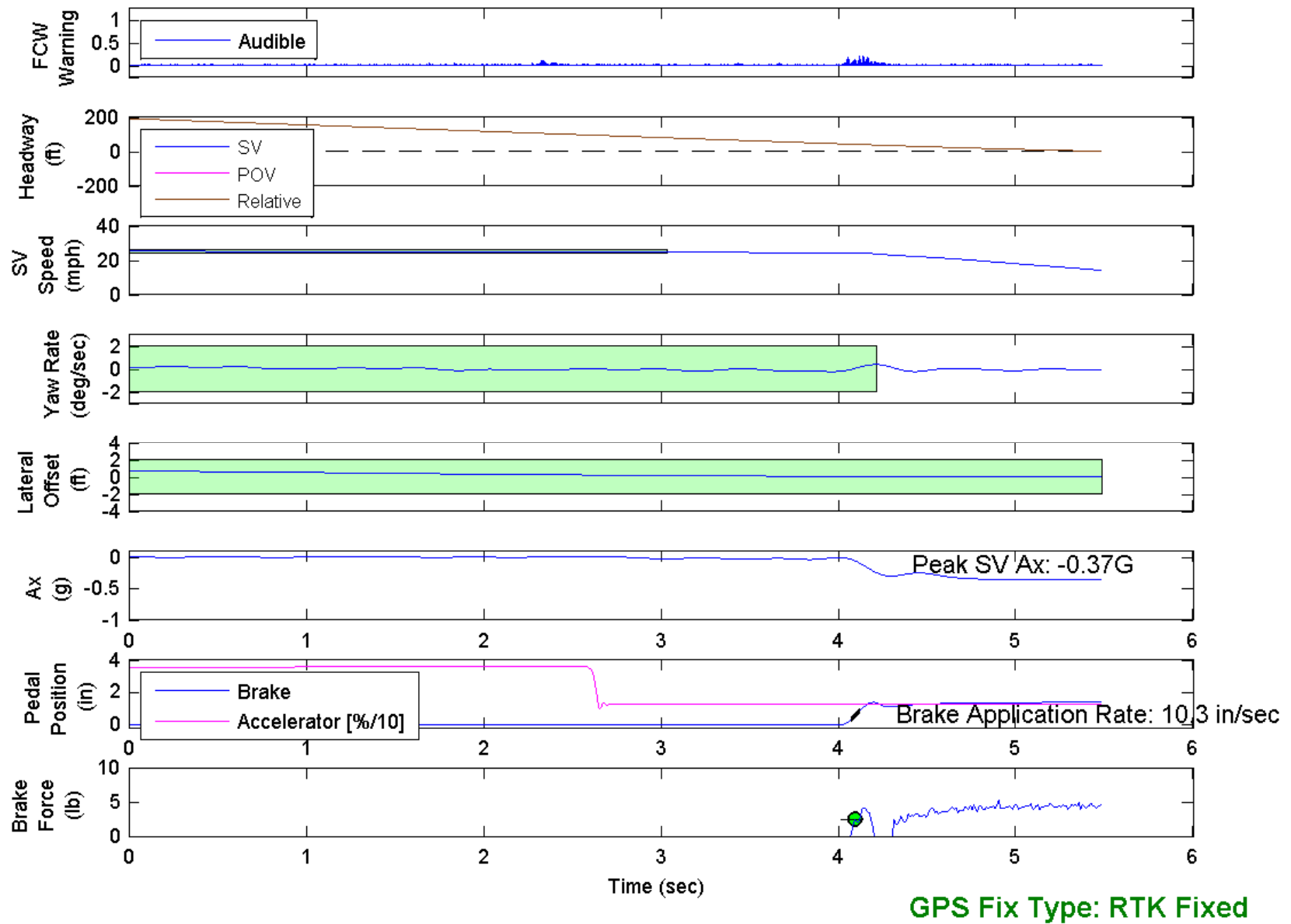


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

DBS Test: False Positive STP 45 mph

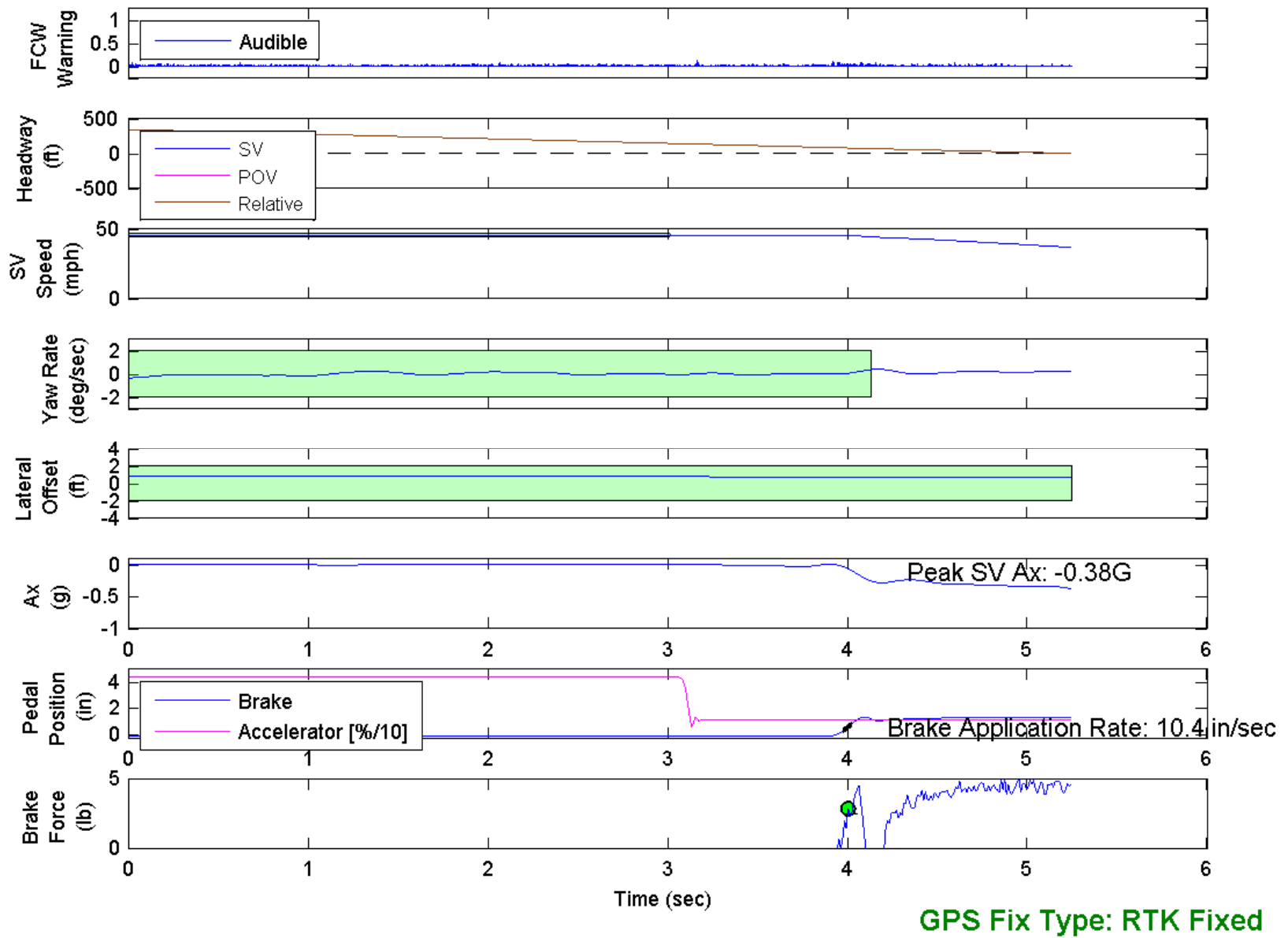


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

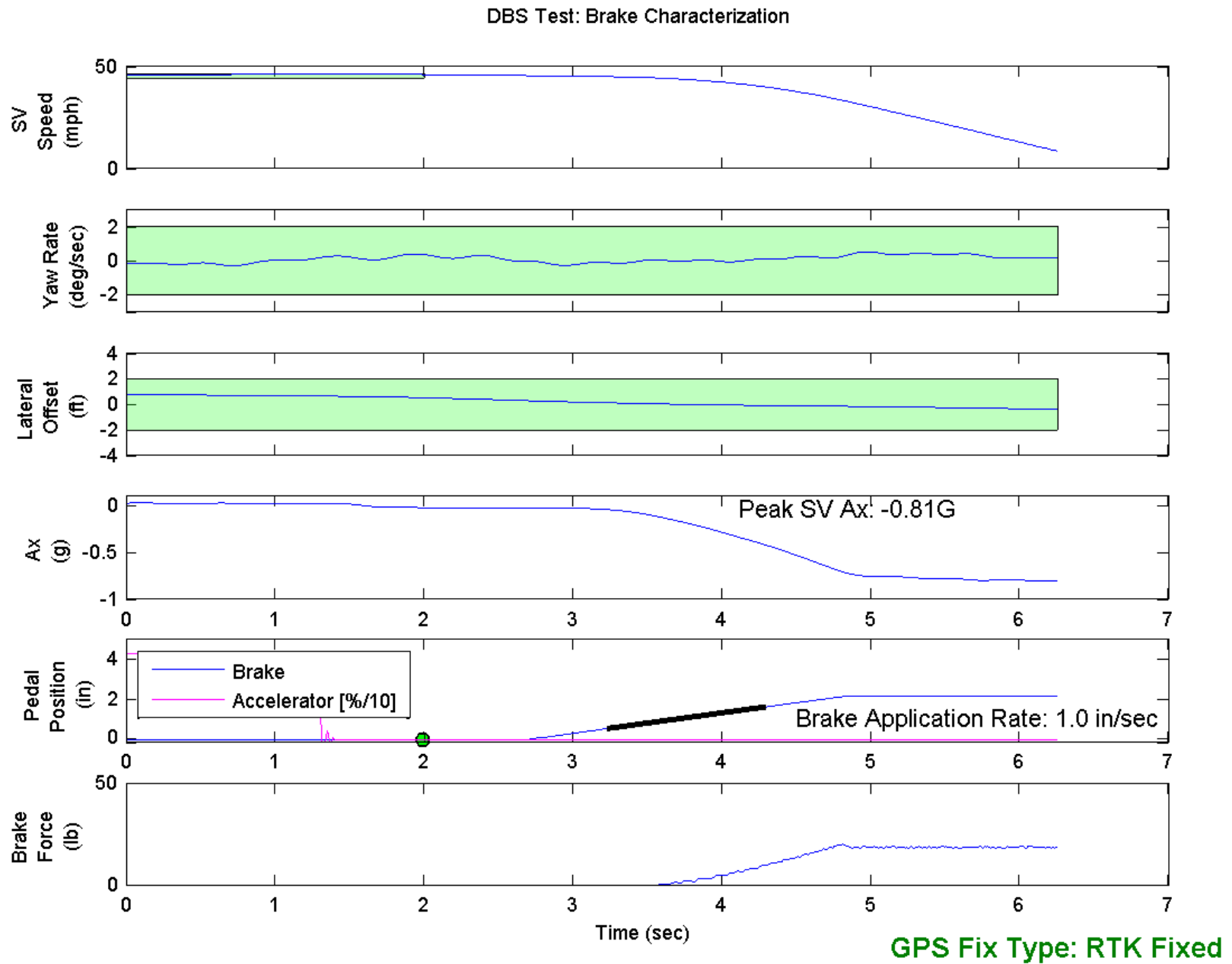


Figure E9. Example Time History for DBS Brake Characterization, Passing

DBS Test: Slower POV 45/20 mph

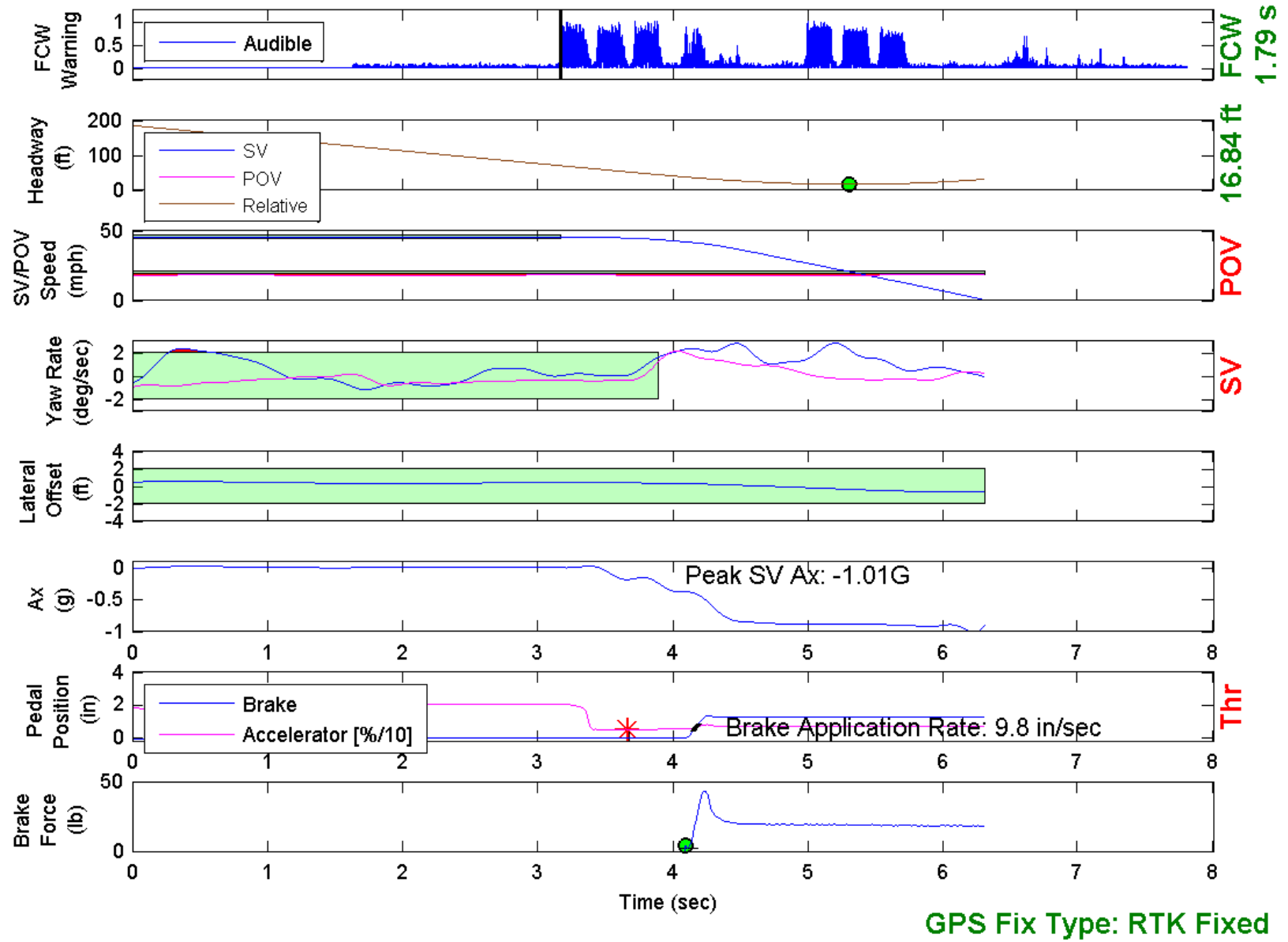


Figure E10. Example Time History Displaying Various Invalid Criteria

DBS Test: Braking POV 25 mph

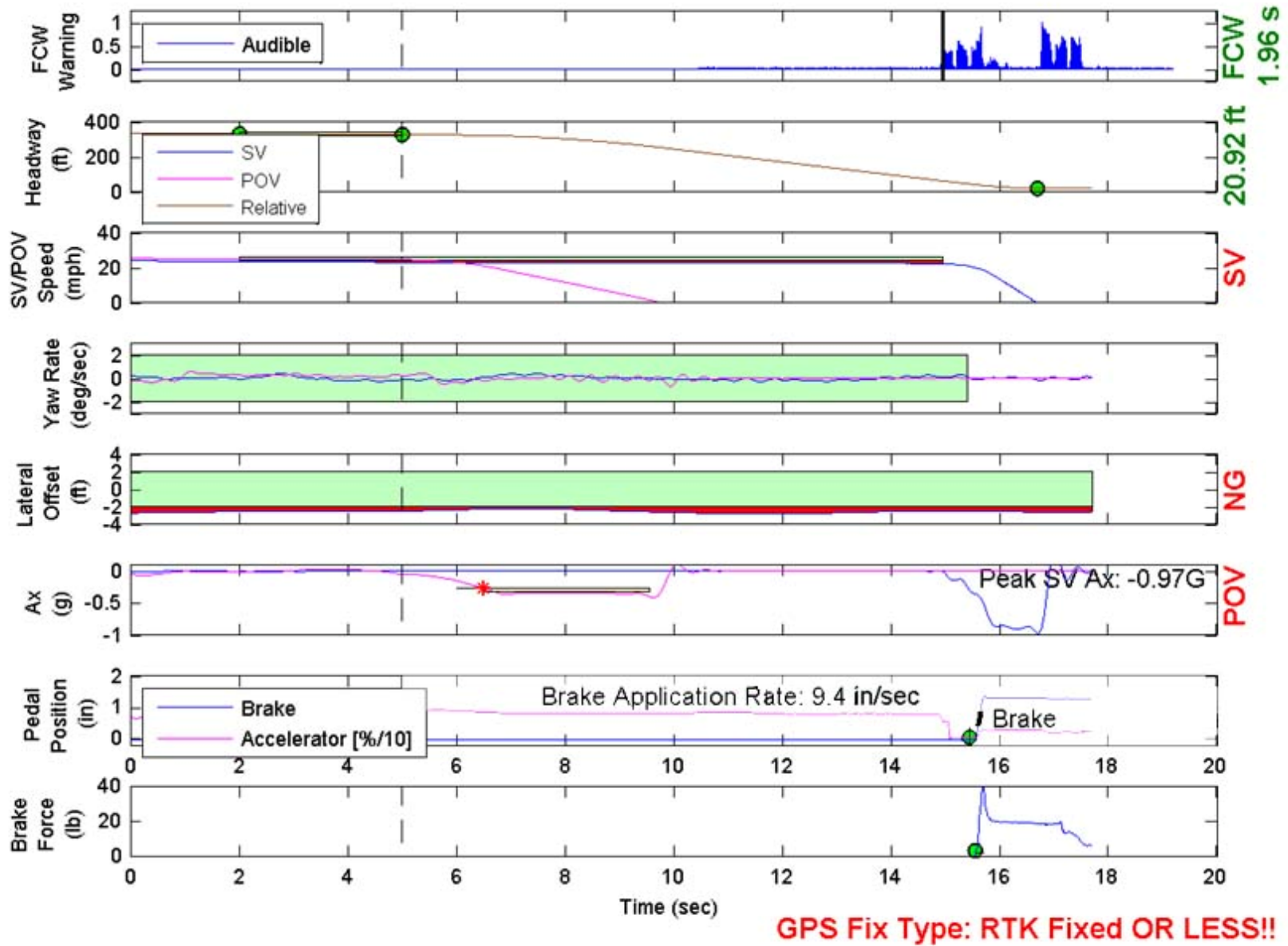


Figure E11. Example Time History Displaying Various Invalid Criteria

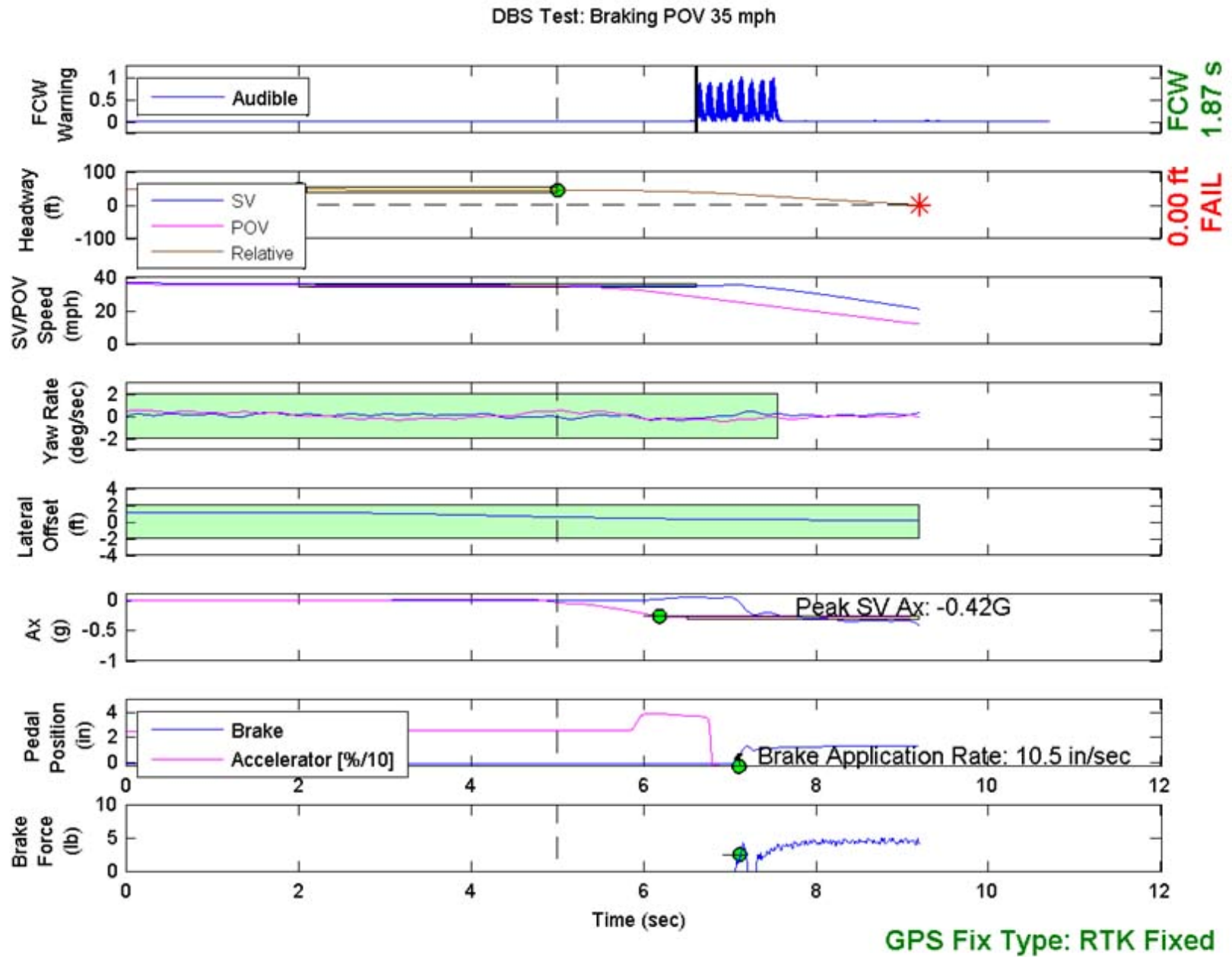


Figure E12. Example Time History for a Failed Run

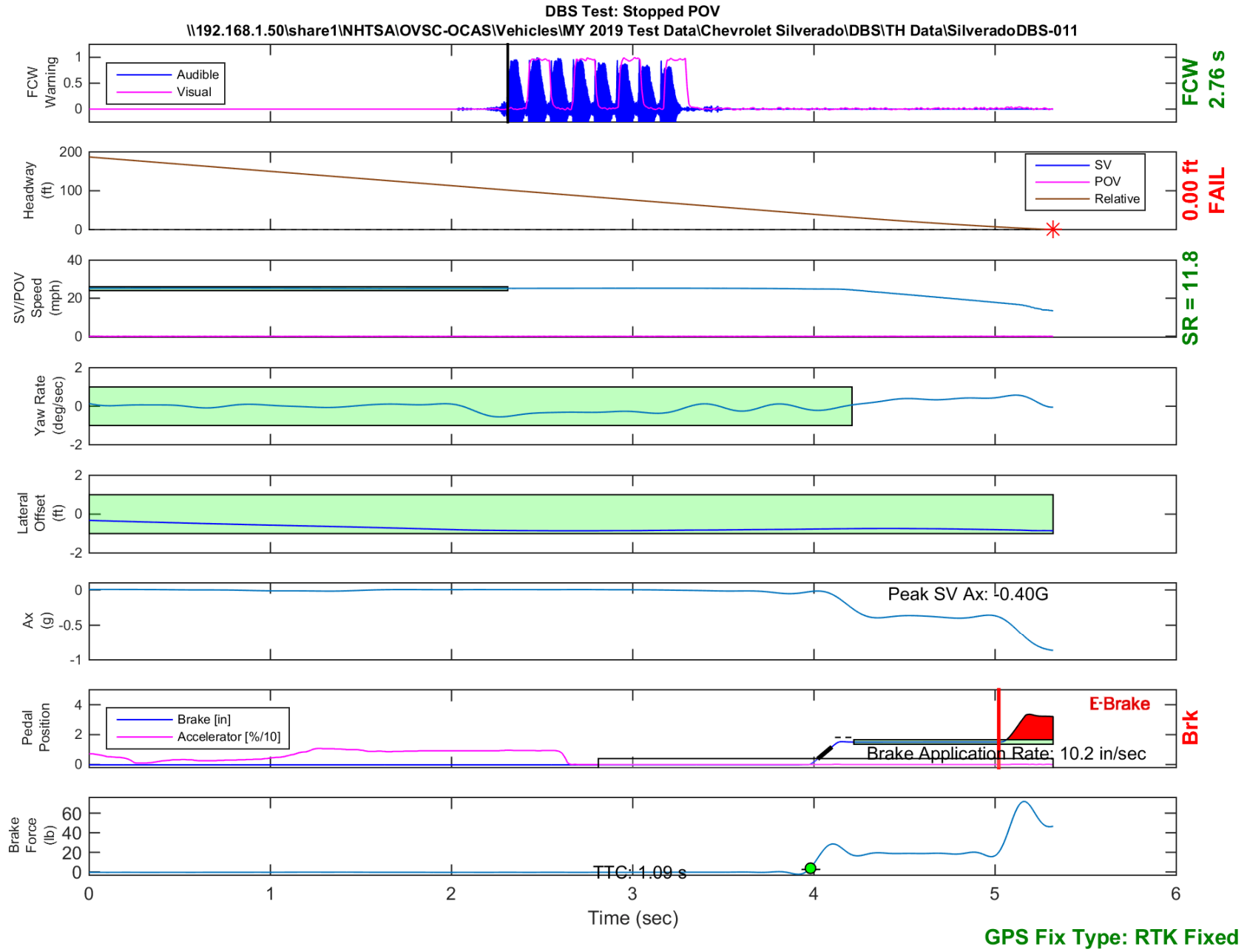


Figure E13. Time History for DBS Run 11, SV Encounters Stopped POV

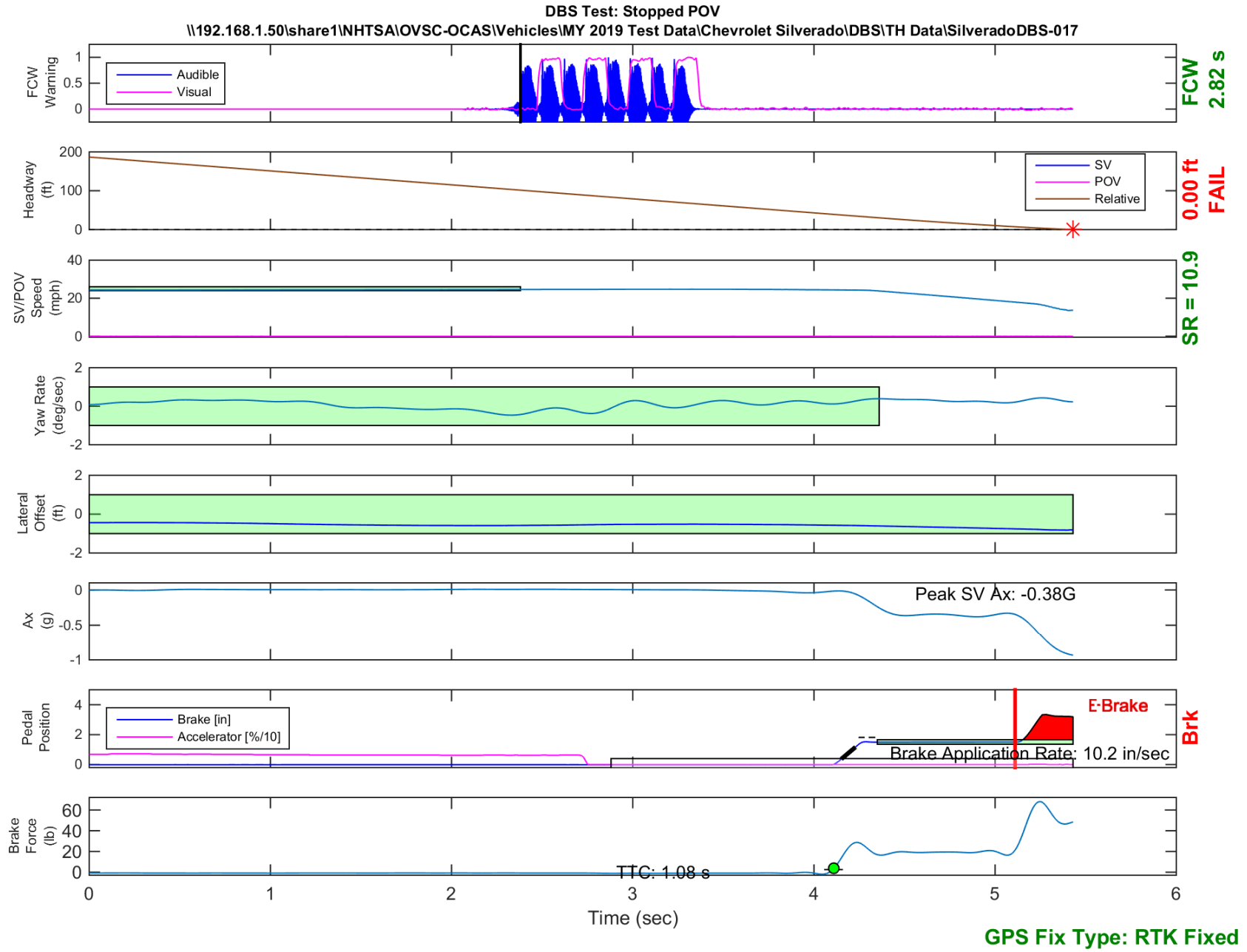


Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV

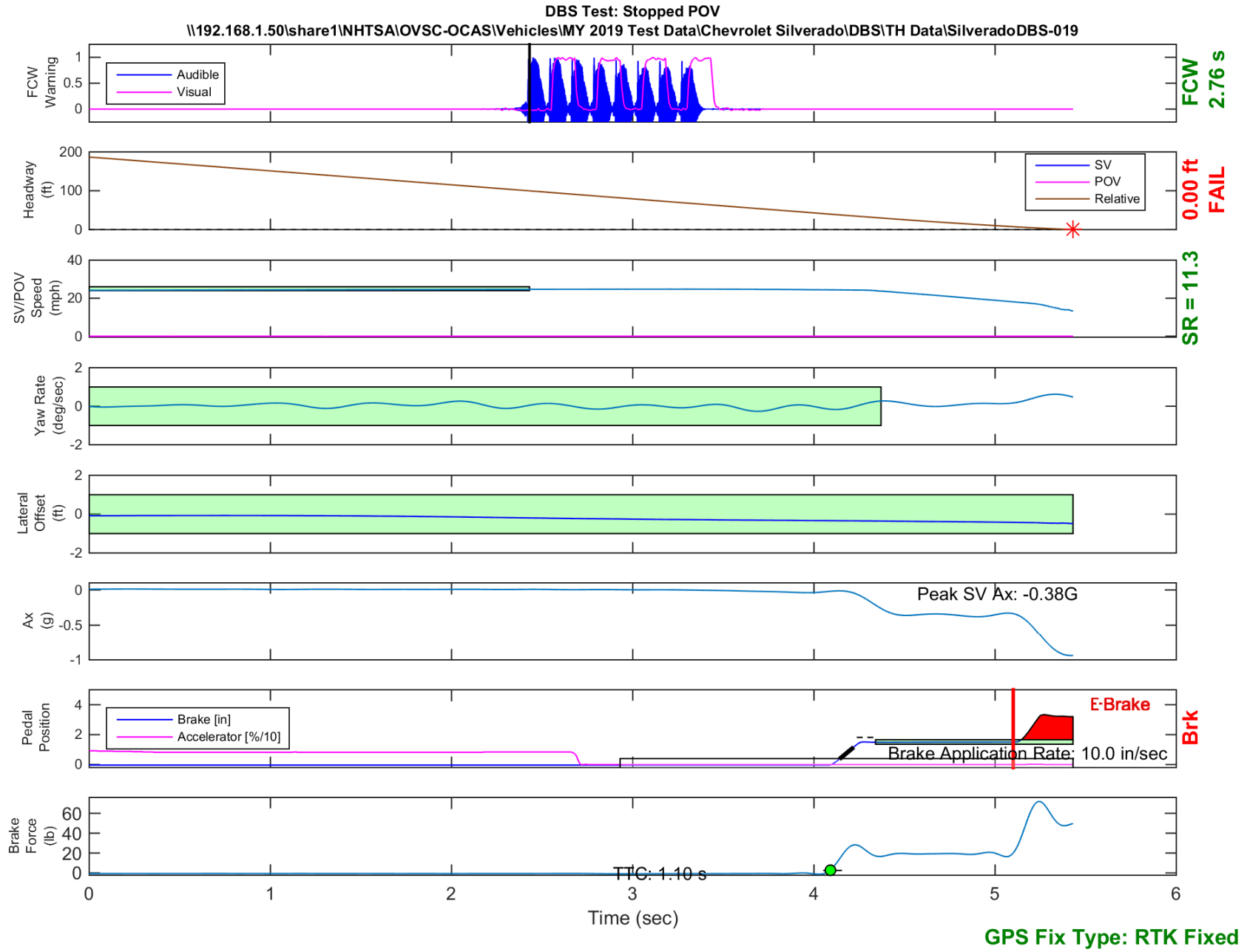


Figure E15. Time History for DBS Run 19, SV Encounters Stopped POV

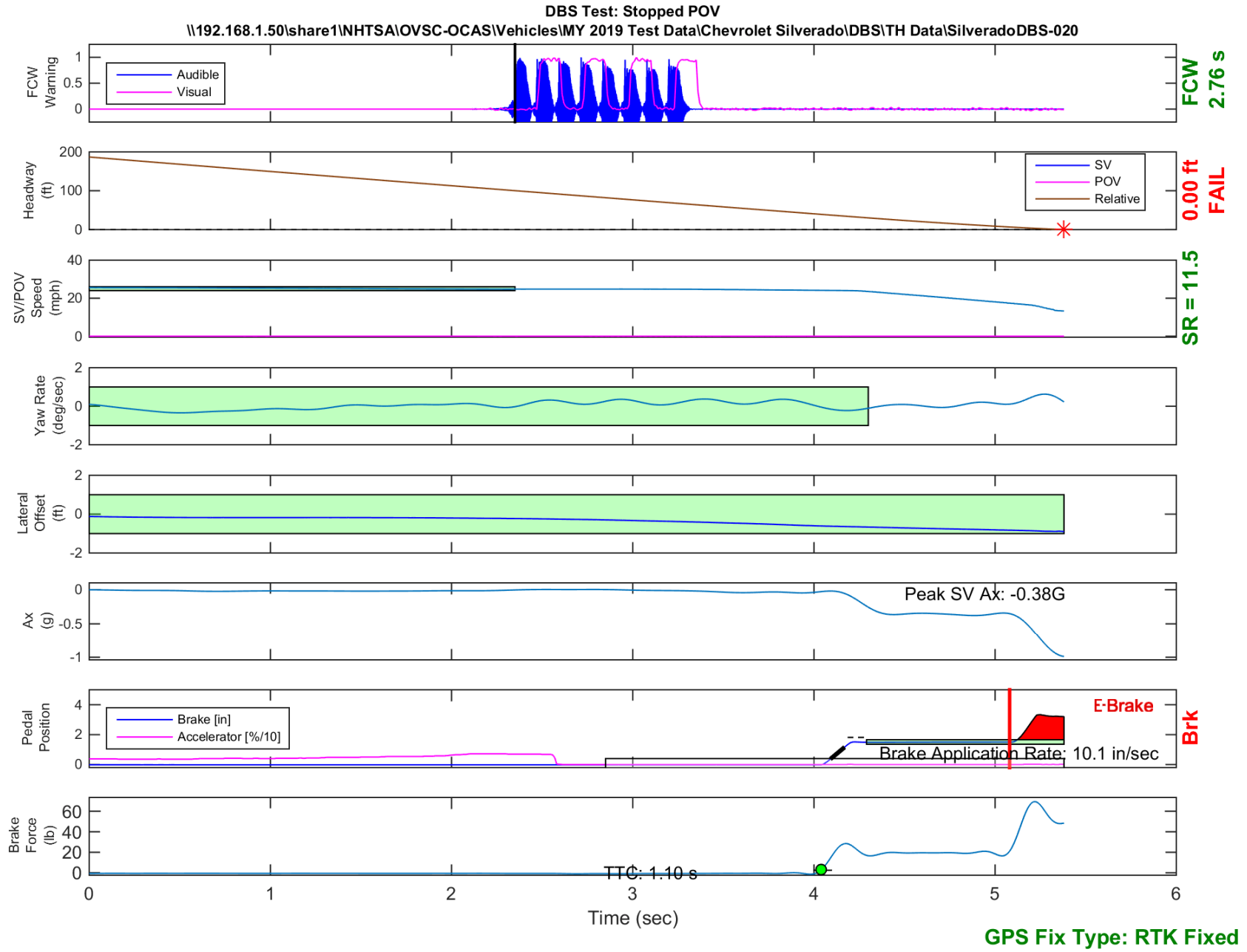


Figure E16. Time History for DBS Run 20, SV Encounters Stopped POV

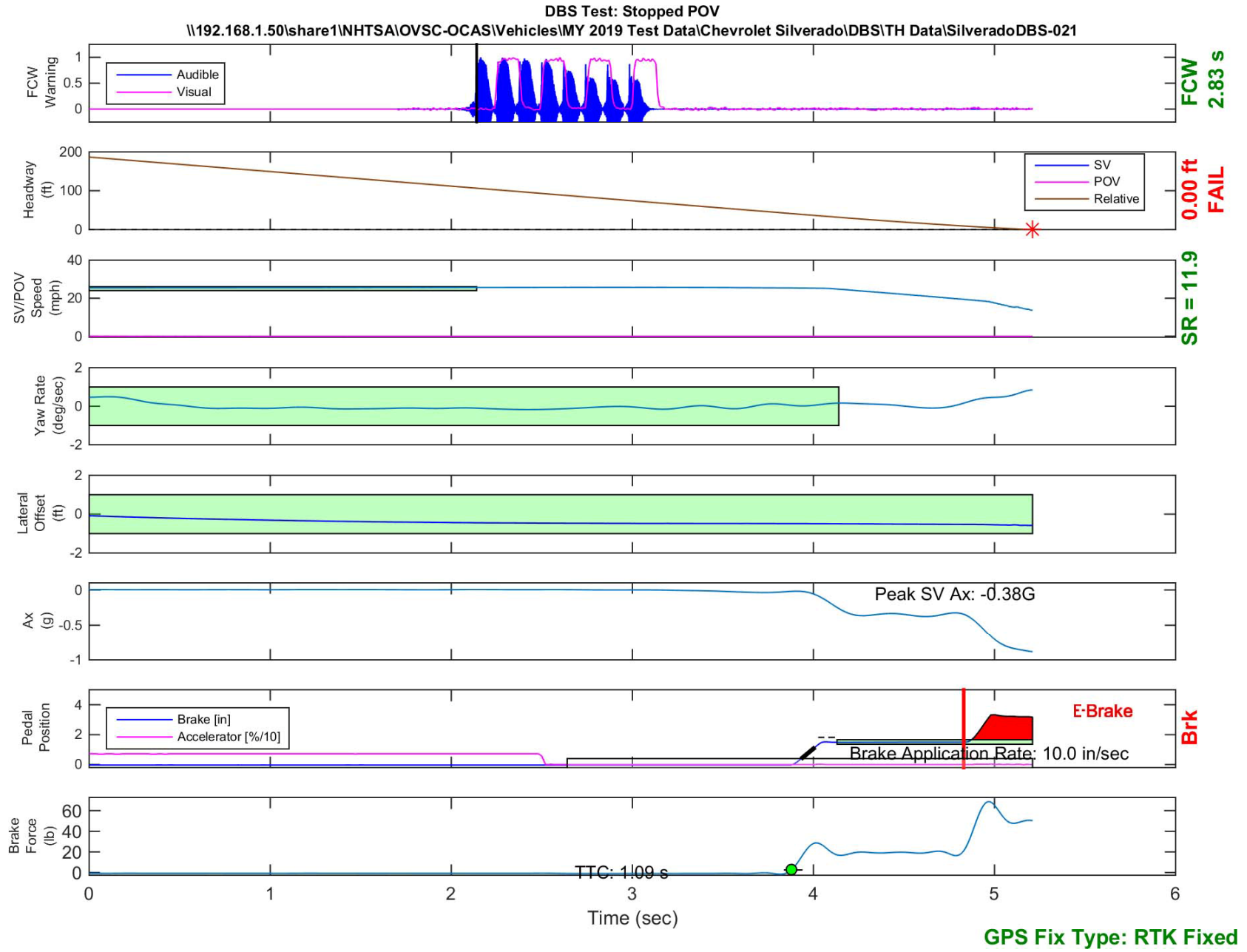


Figure E17. Time History for DBS Run 21, SV Encounters Stopped POV

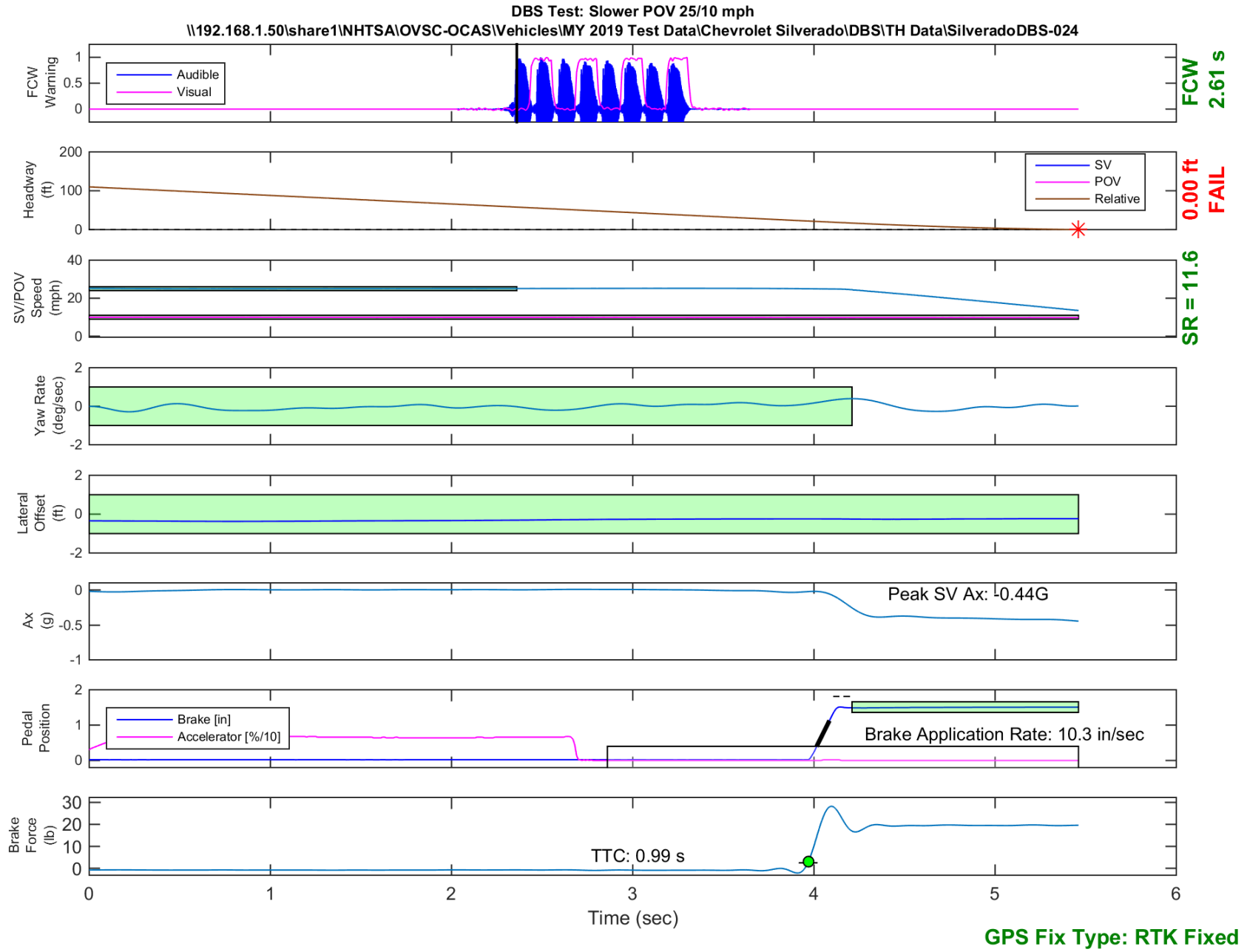


Figure E18. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph

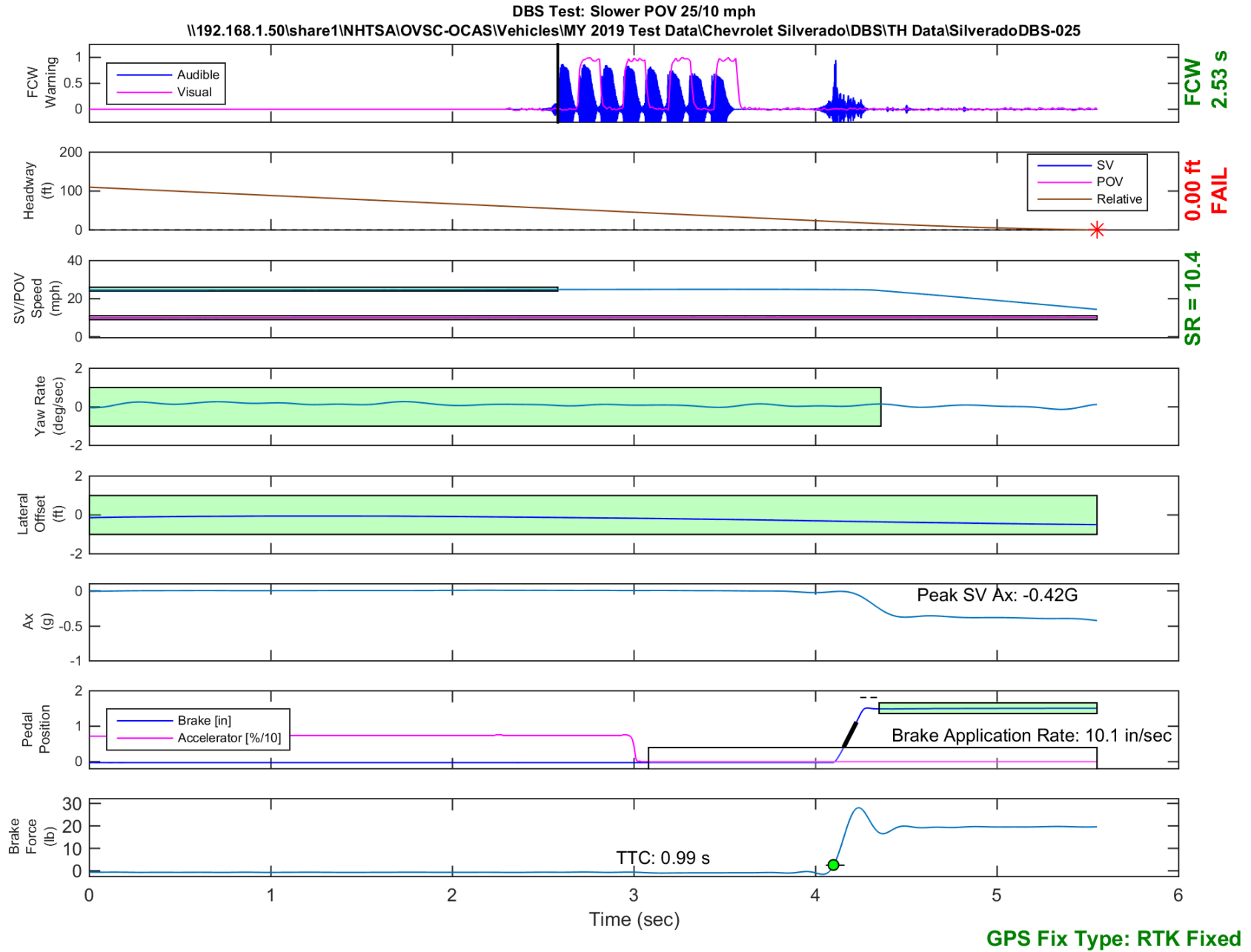


Figure E19. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph

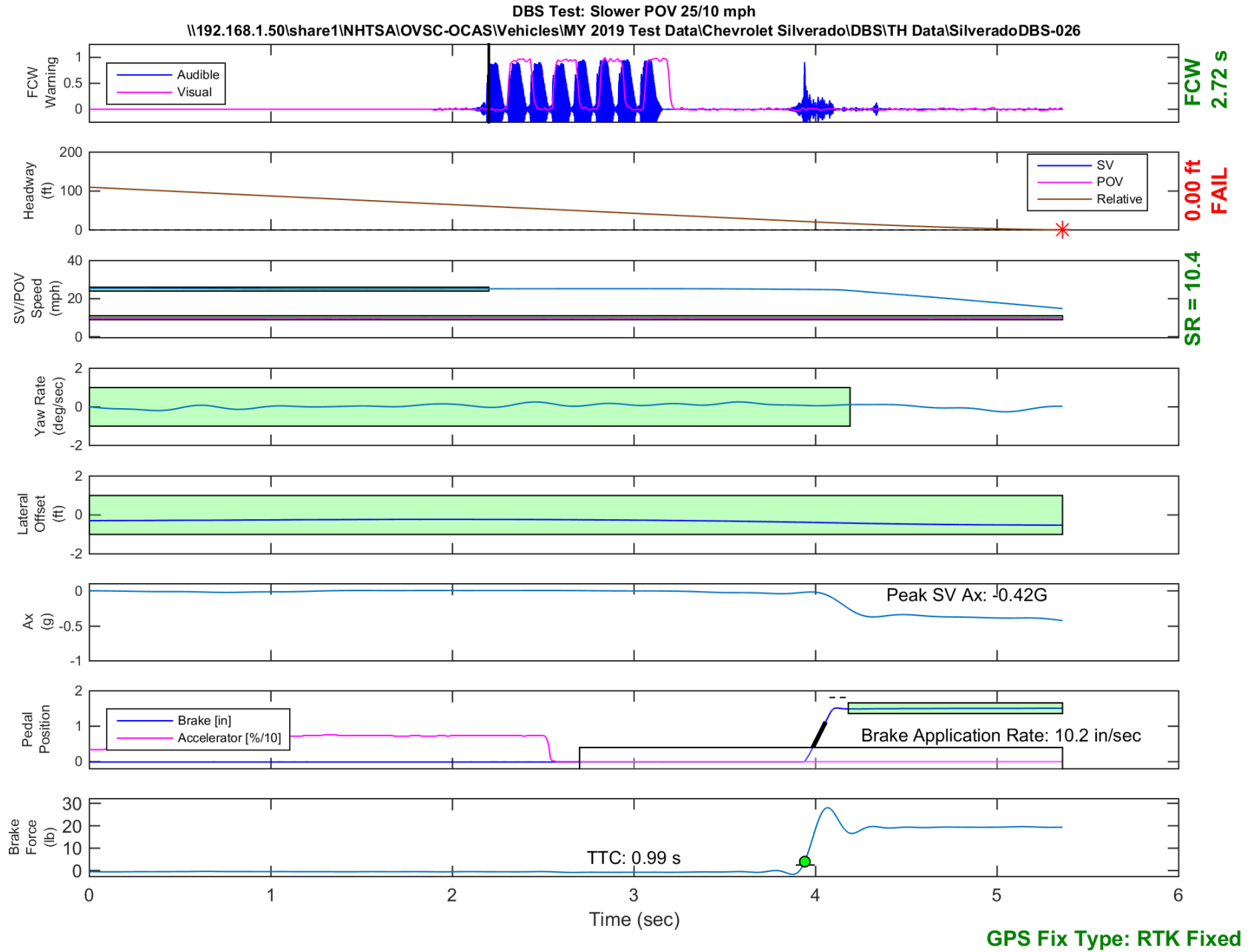


Figure E20. Time History for DBS Run 26, SV Encounters Slower POV, SV 25 mph, POV 10 mph

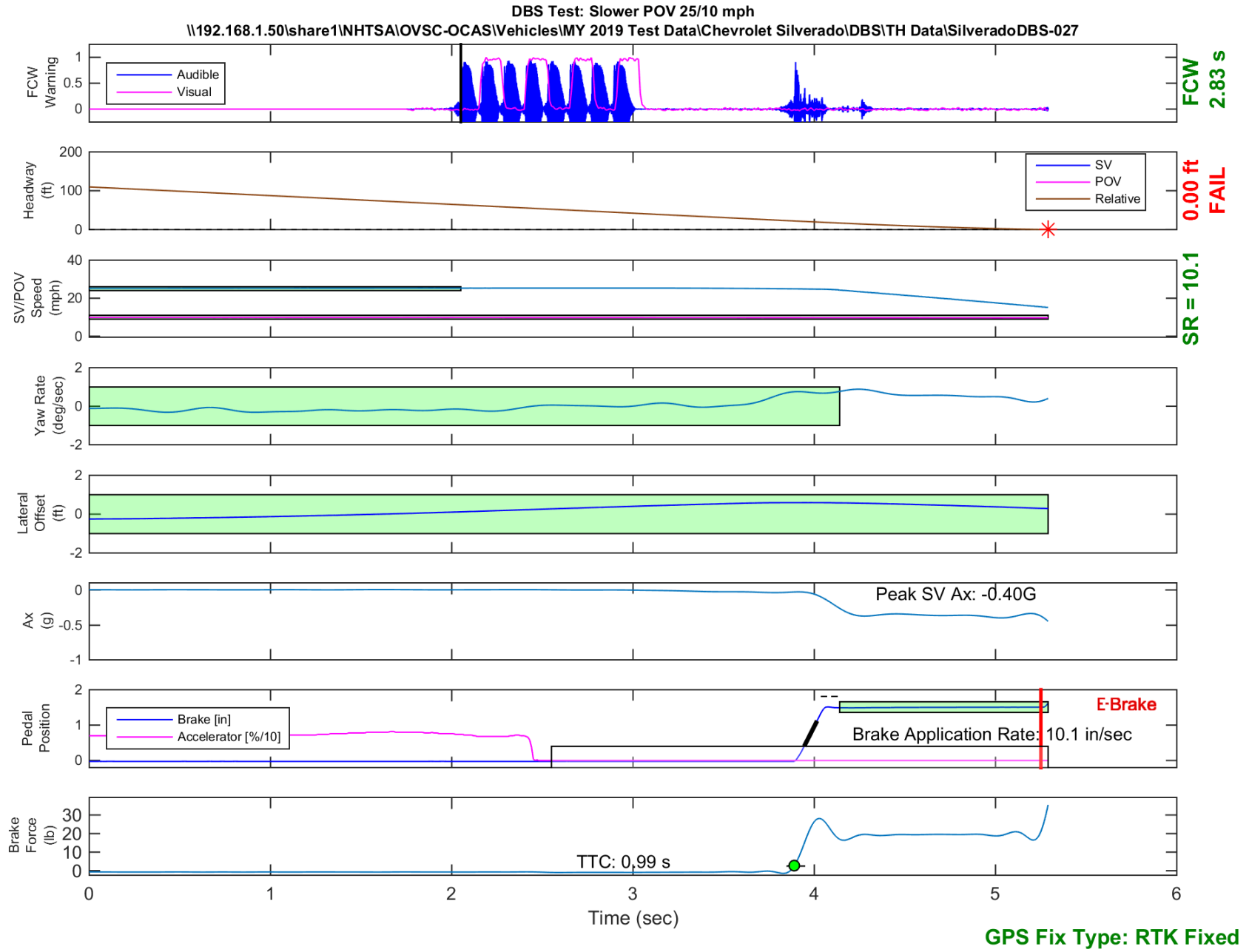


Figure E21. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph

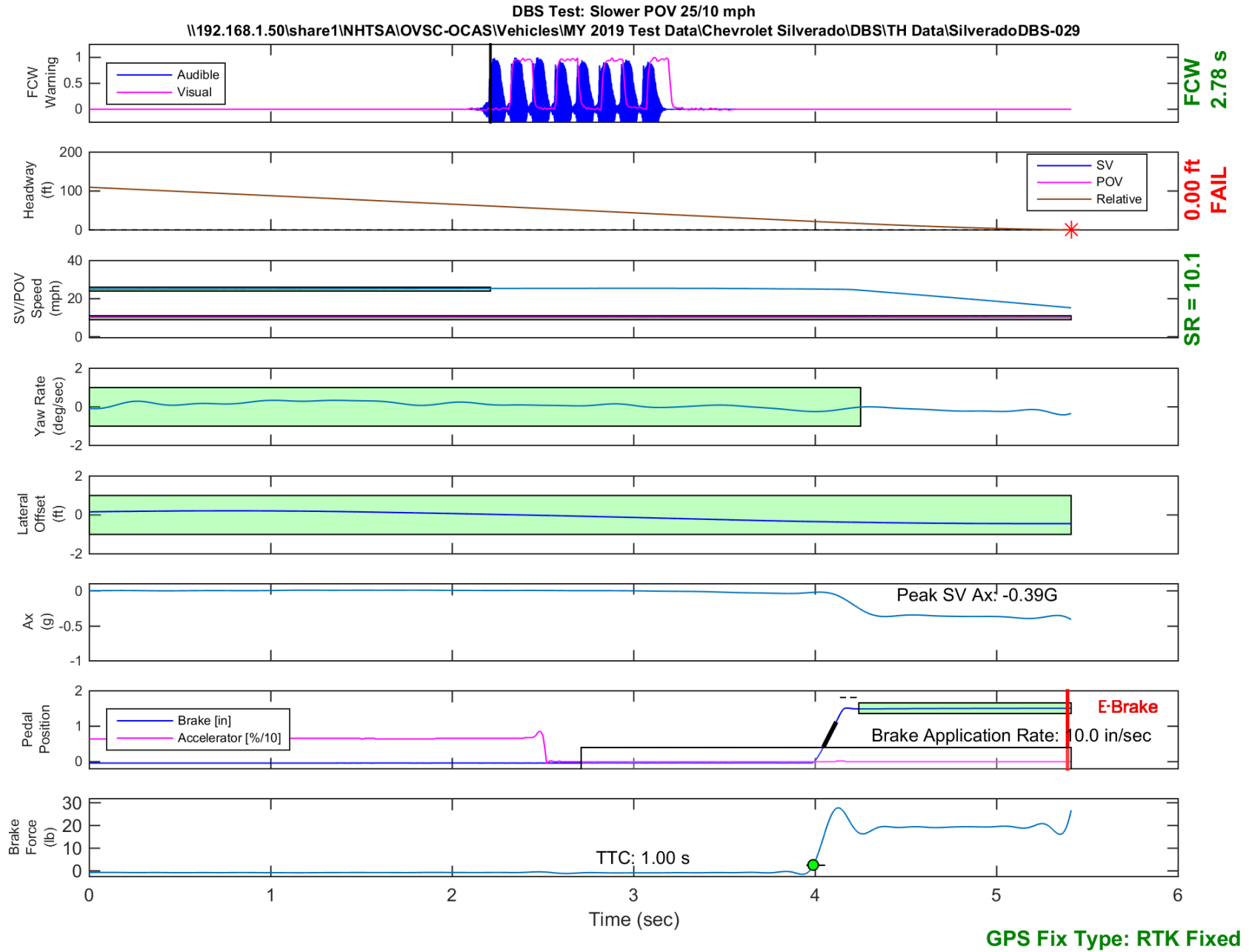


Figure E22. Time History for DBS Run 29, SV Encounters Slower POV, SV 25 mph, POV 10 mph

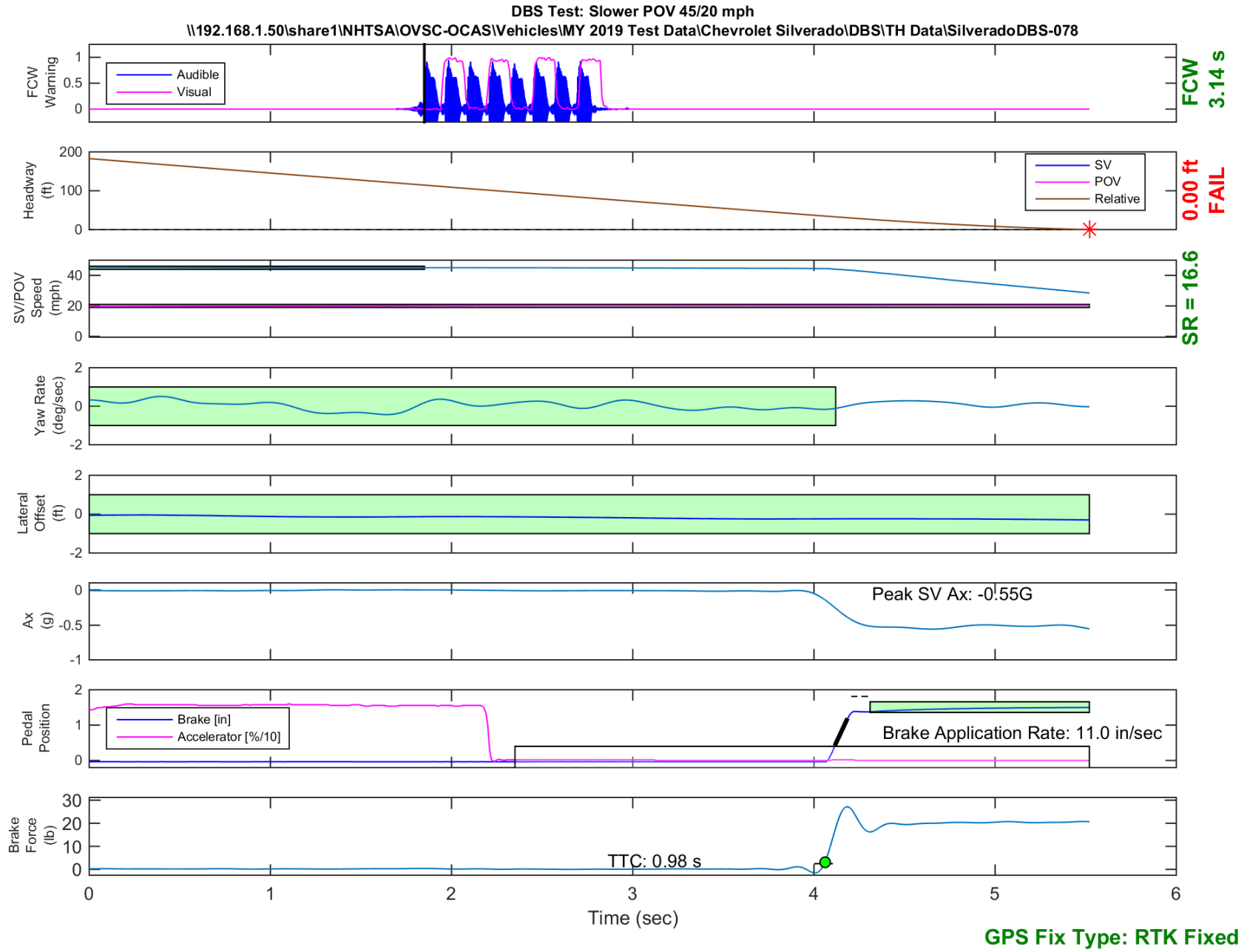


Figure E23. Time History for DBS Run 78, SV Encounters Slower POV, SV 45 mph, POV 20 mph

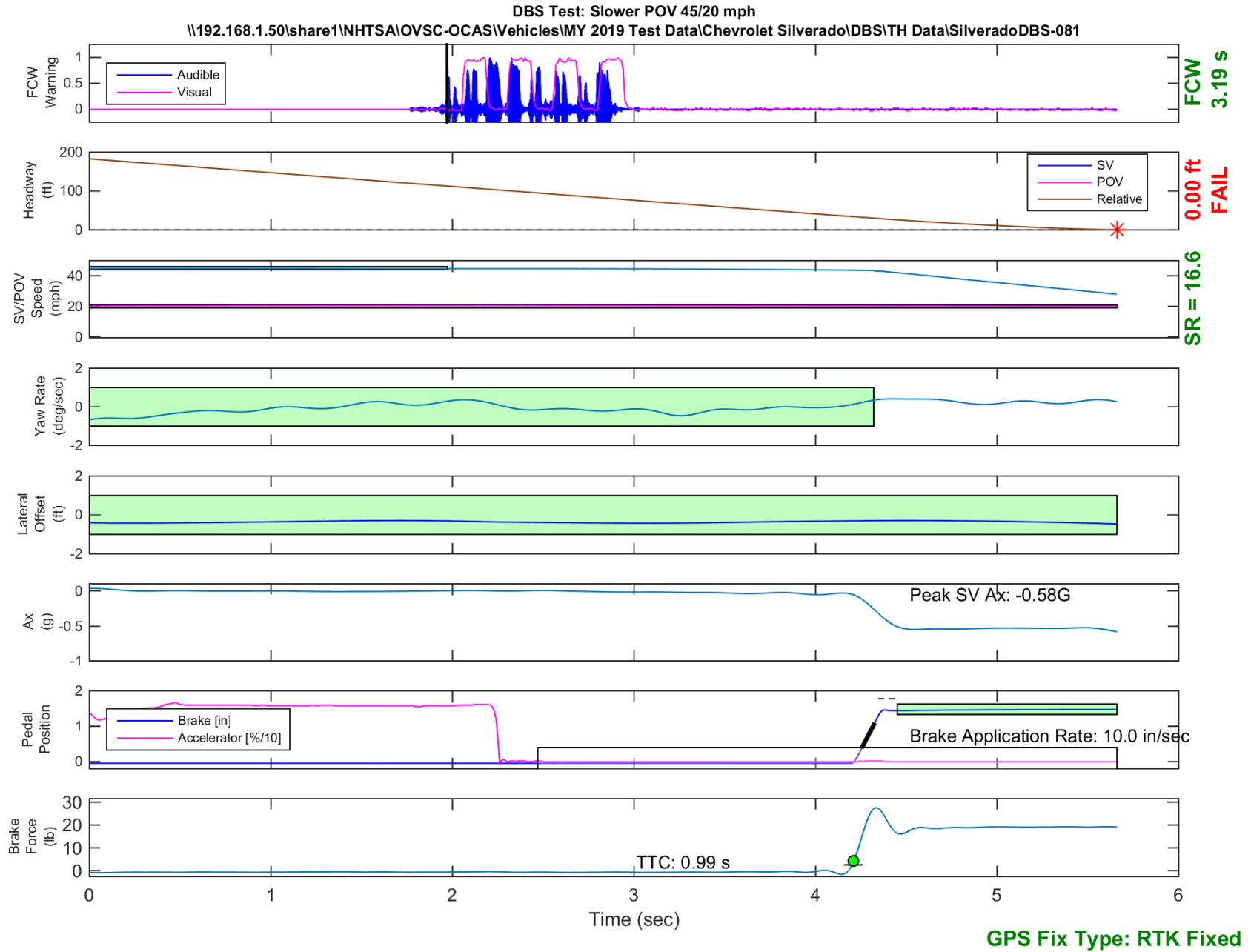


Figure E24. Time History for DBS Run 81, SV Encounters Slower POV, SV 45 mph, POV 20 mph

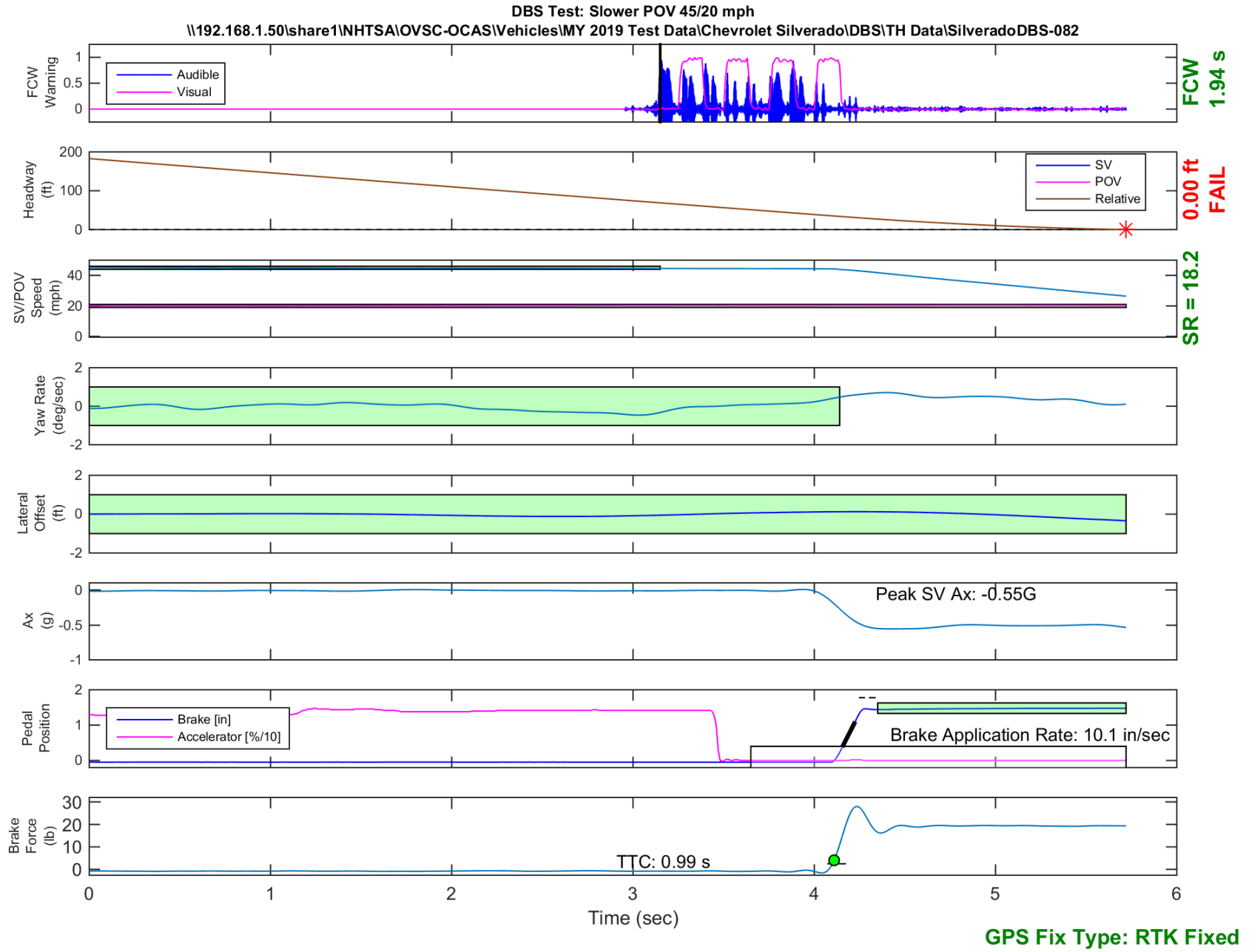


Figure E25. Time History for DBS Run 82, SV Encounters Slower POV, SV 45 mph, POV 20 mph

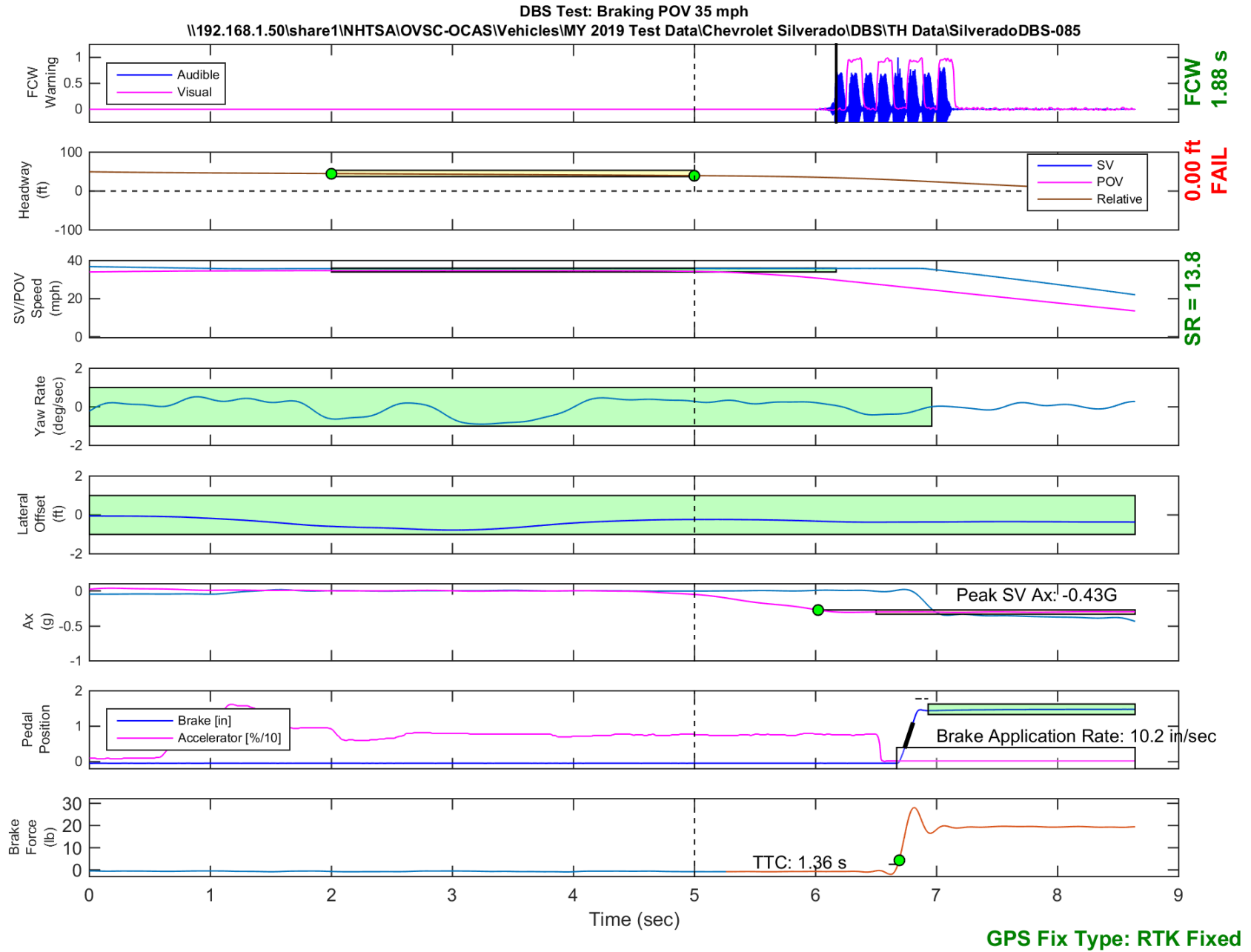


Figure E26. Time History for DBS Run 85, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

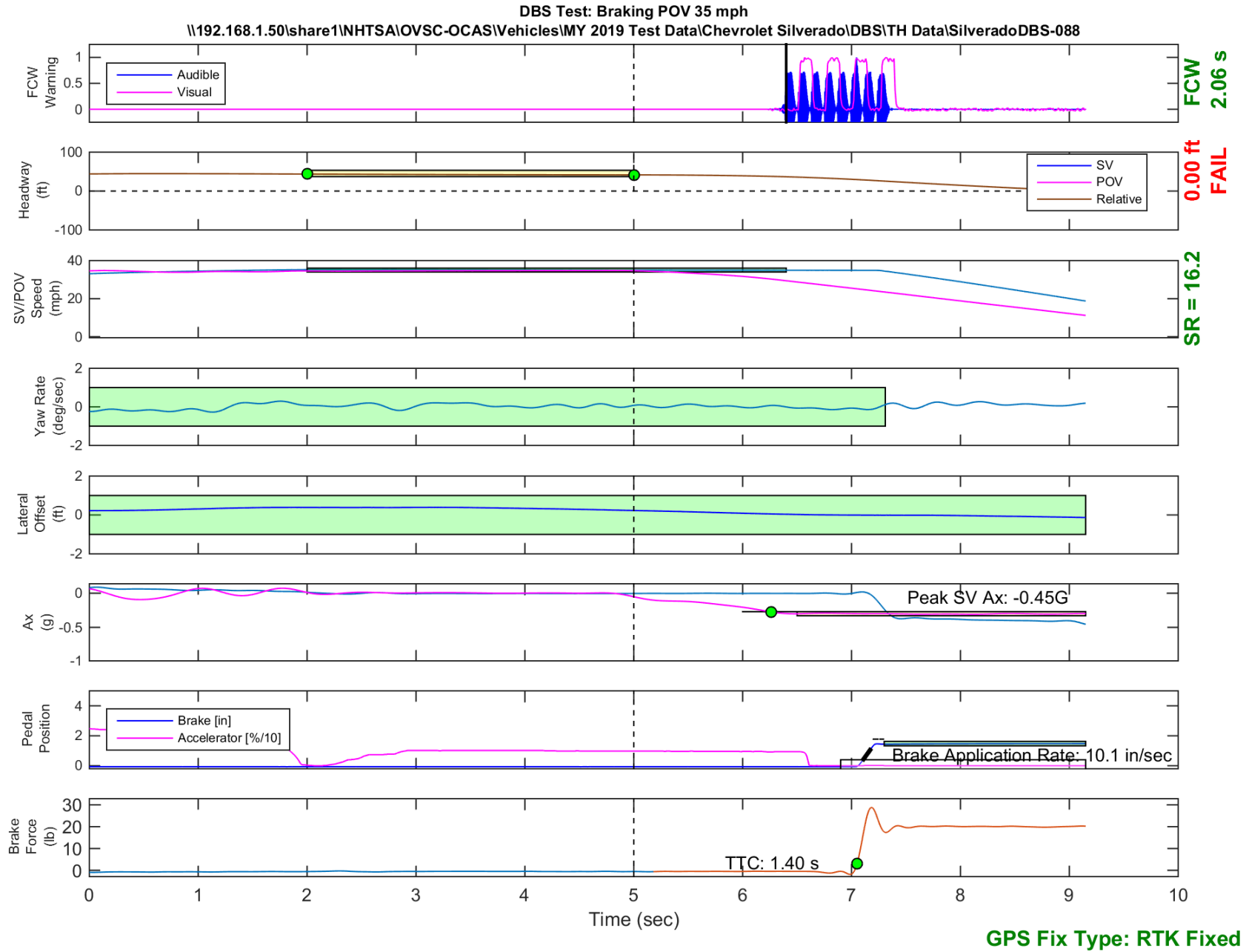


Figure E27. Time History for DBS Run 88, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

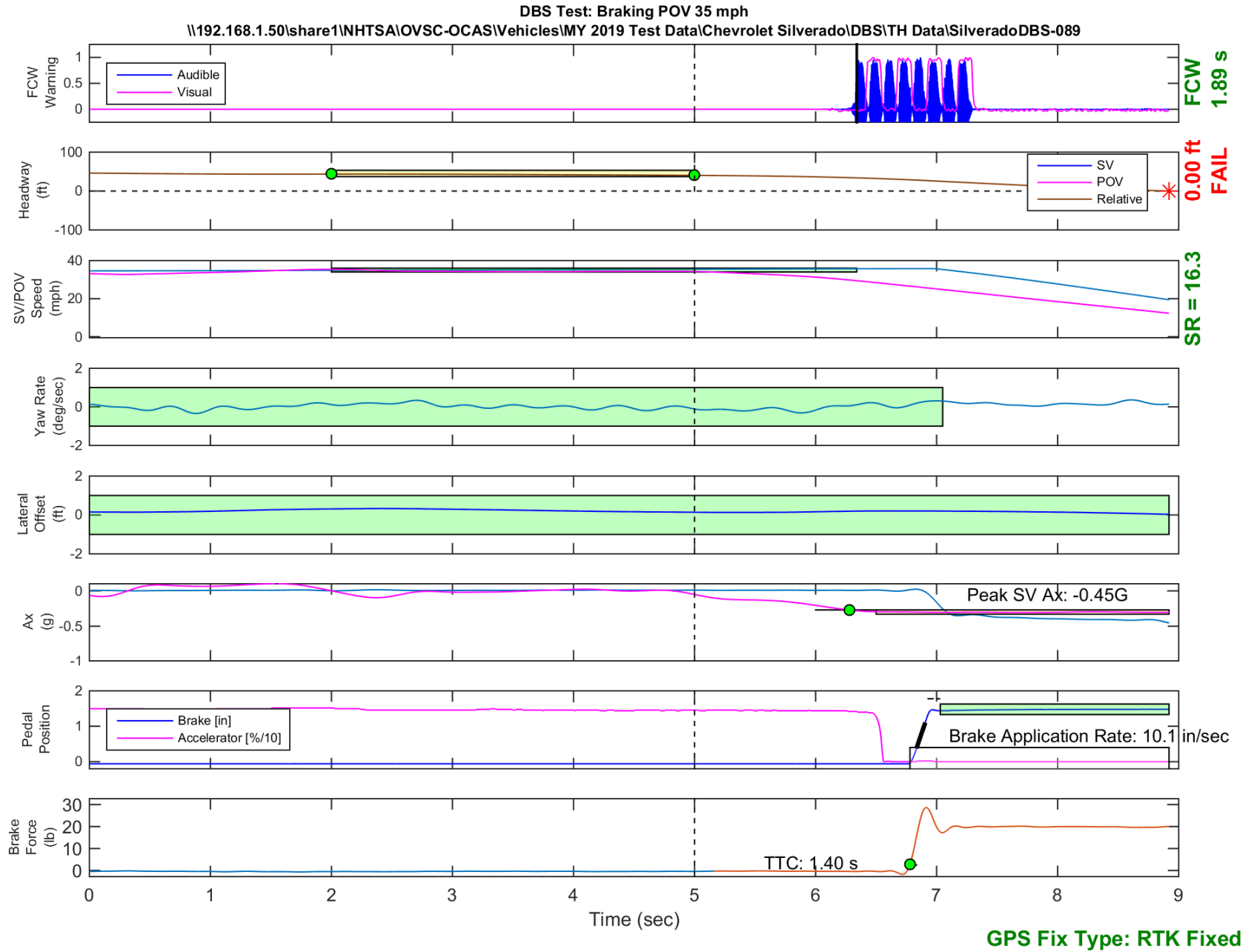
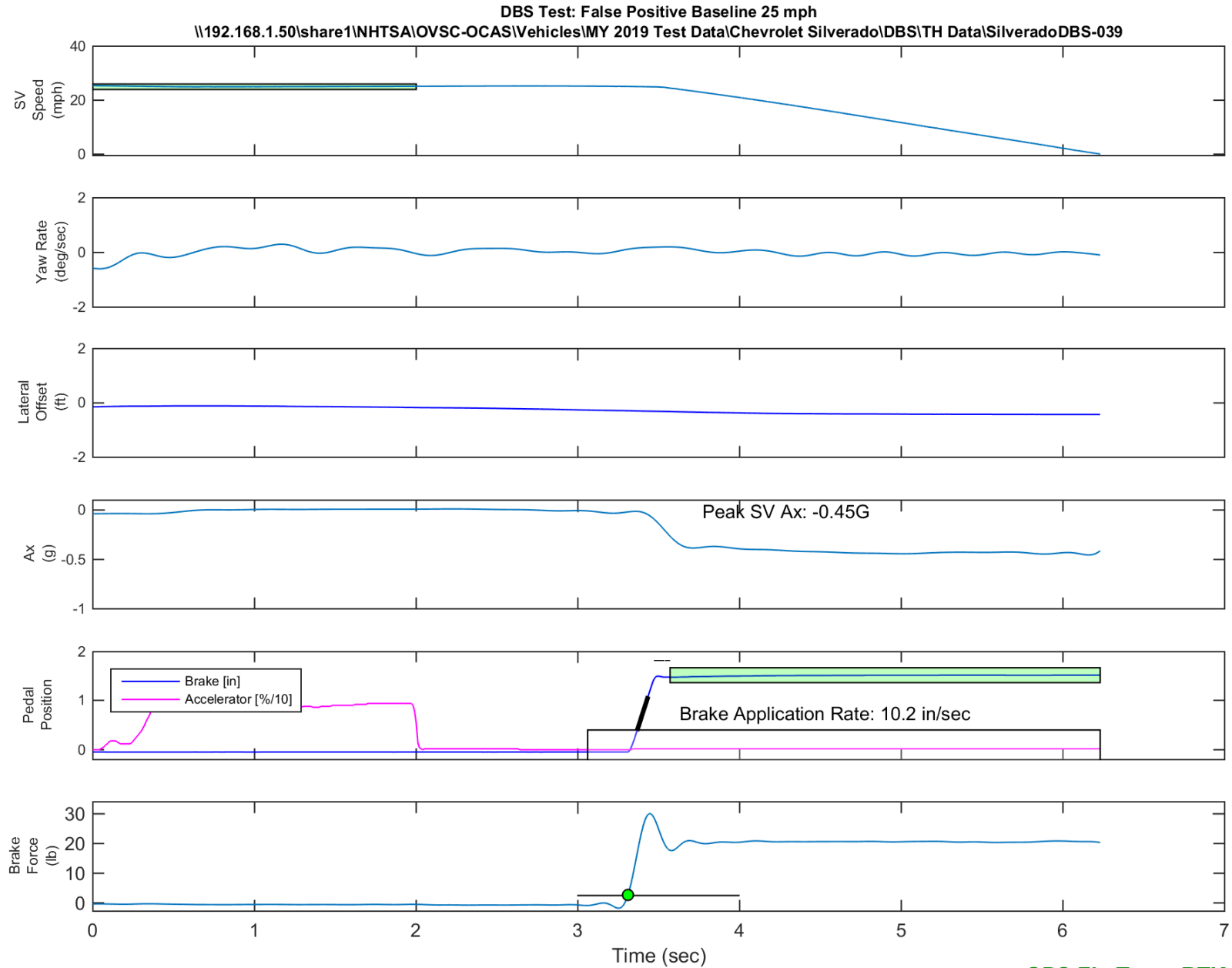
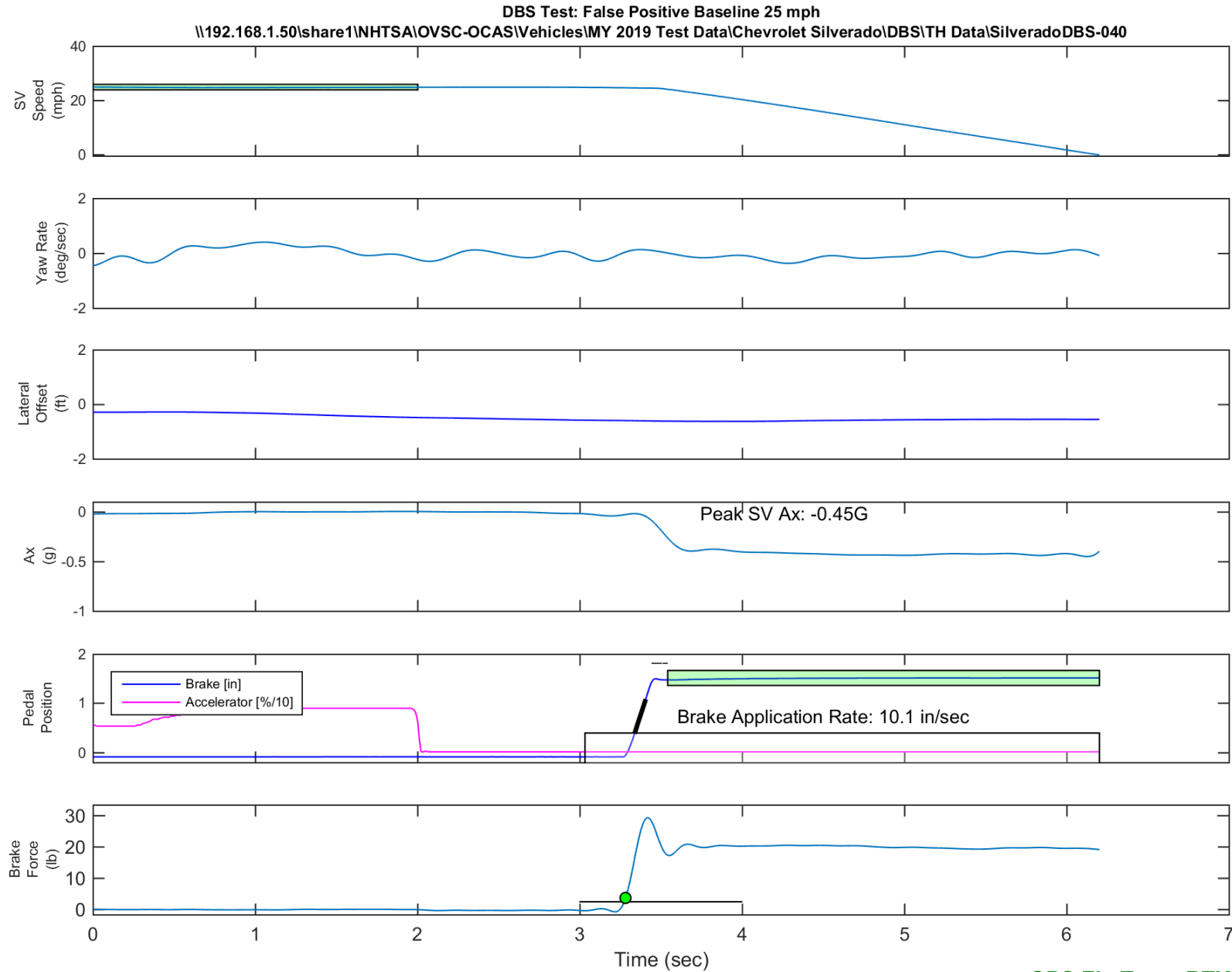


Figure E28. Time History for DBS Run 89, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph



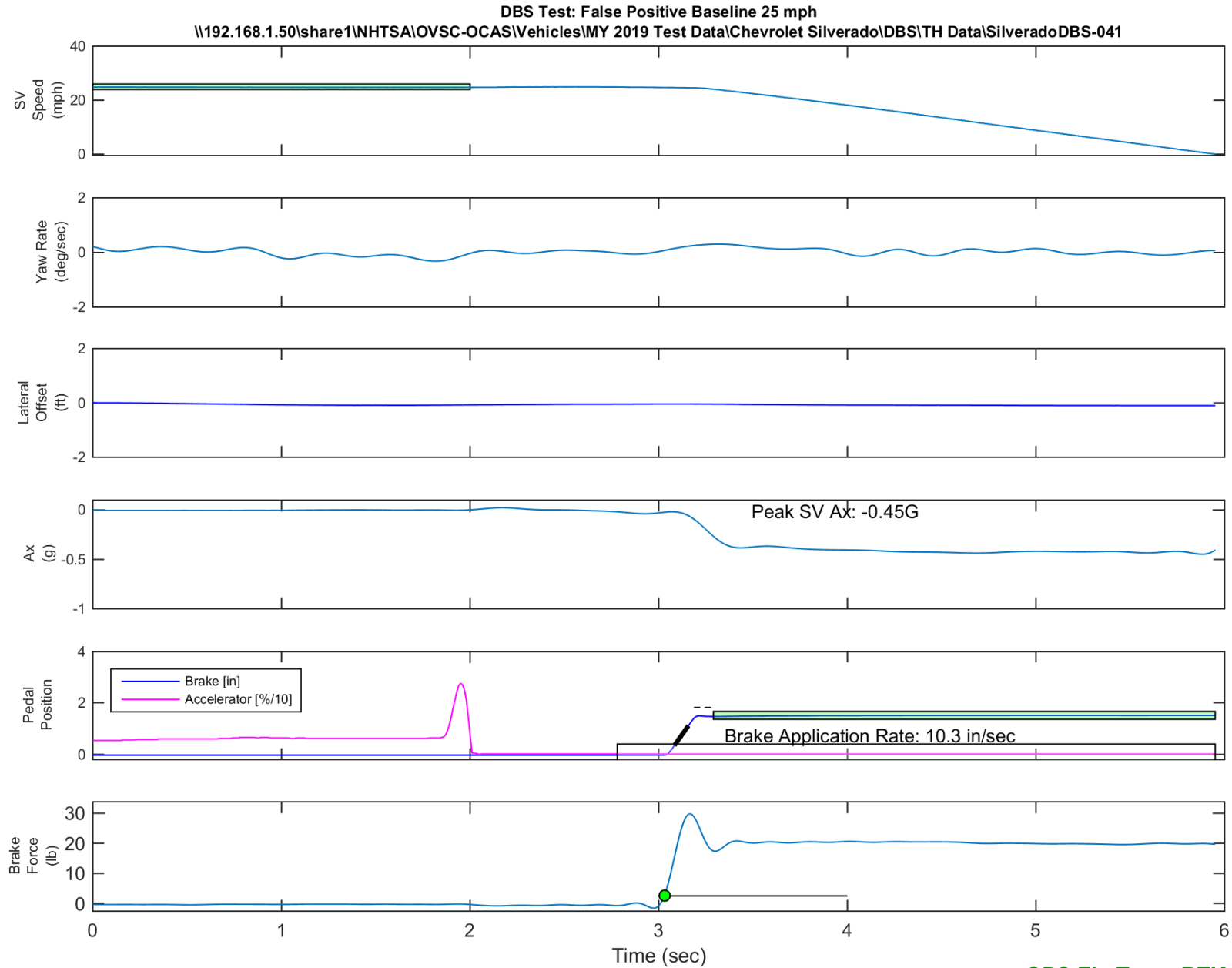
GPS Fix Type: RTK Fixed

Figure E29. Time History for DBS Run 39, False Positive Baseline, SV 25 mph



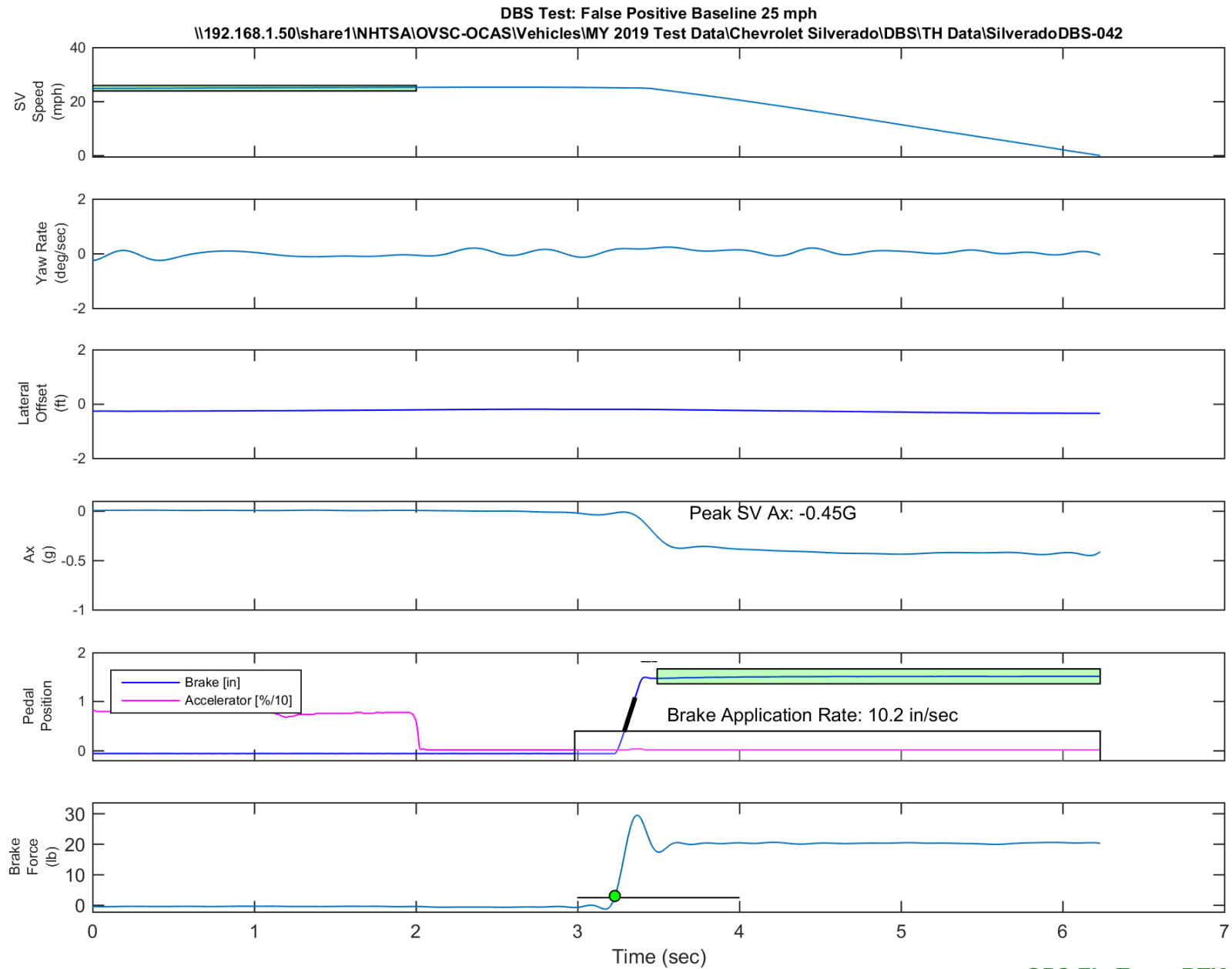
GPS Fix Type: RTK Fixed

Figure E30. Time History for DBS Run 40, False Positive Baseline, SV 25 mph



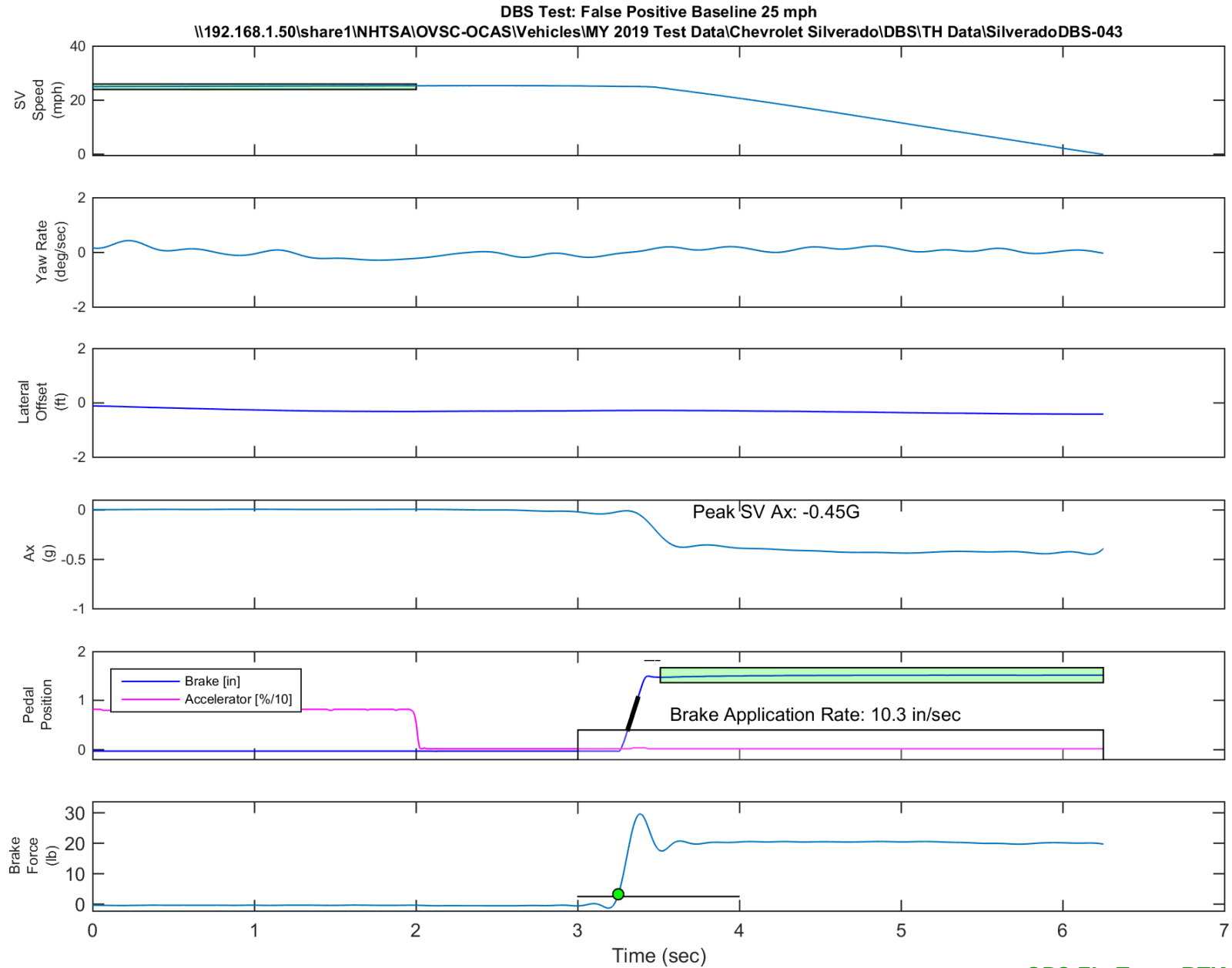
GPS Fix Type: RTK Fixed

Figure E31. Time History for DBS Run 41, False Positive Baseline, SV 25 mph



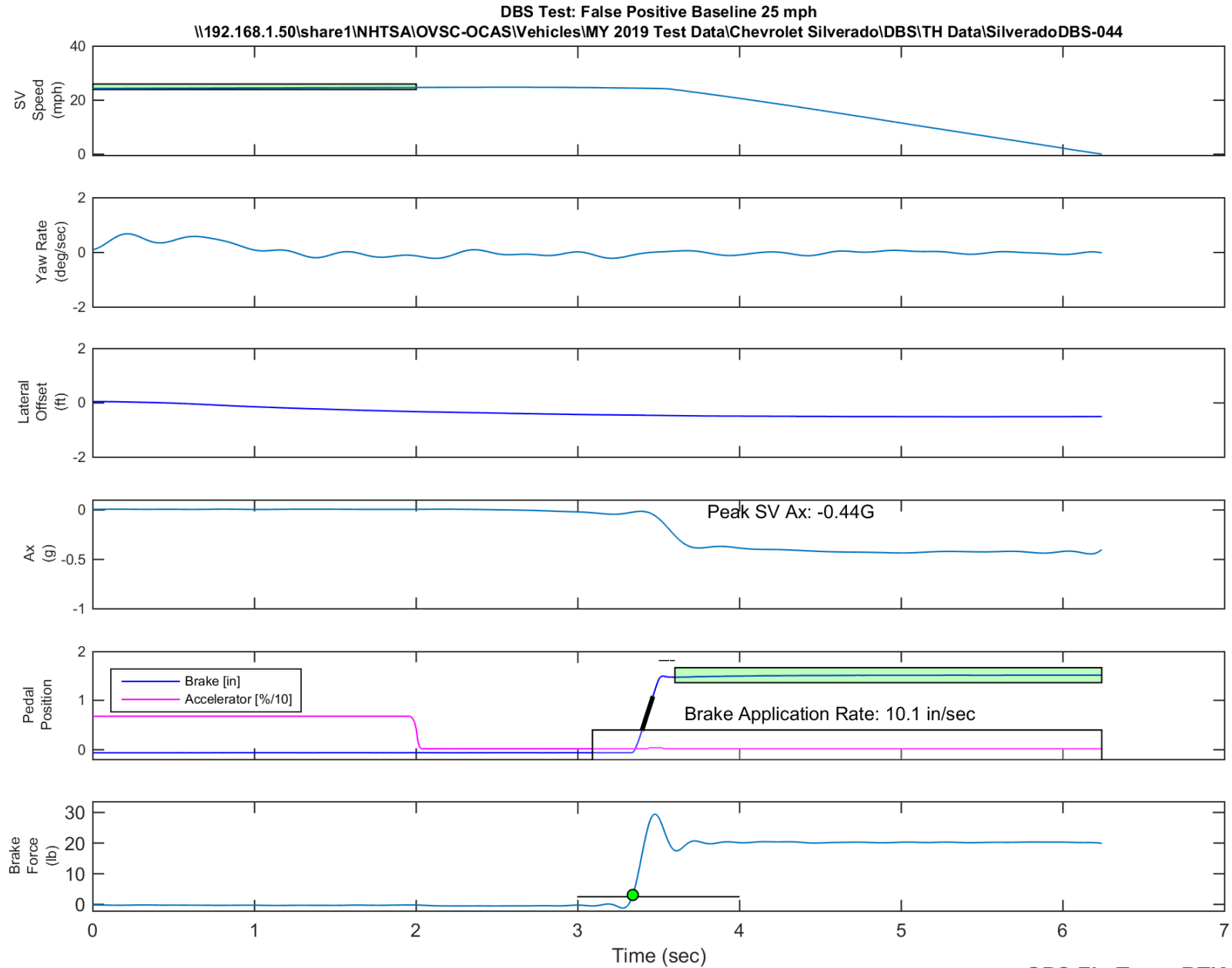
GPS Fix Type: RTK Fixed

Figure E32. Time History for DBS Run 42, False Positive Baseline, SV 25 mph



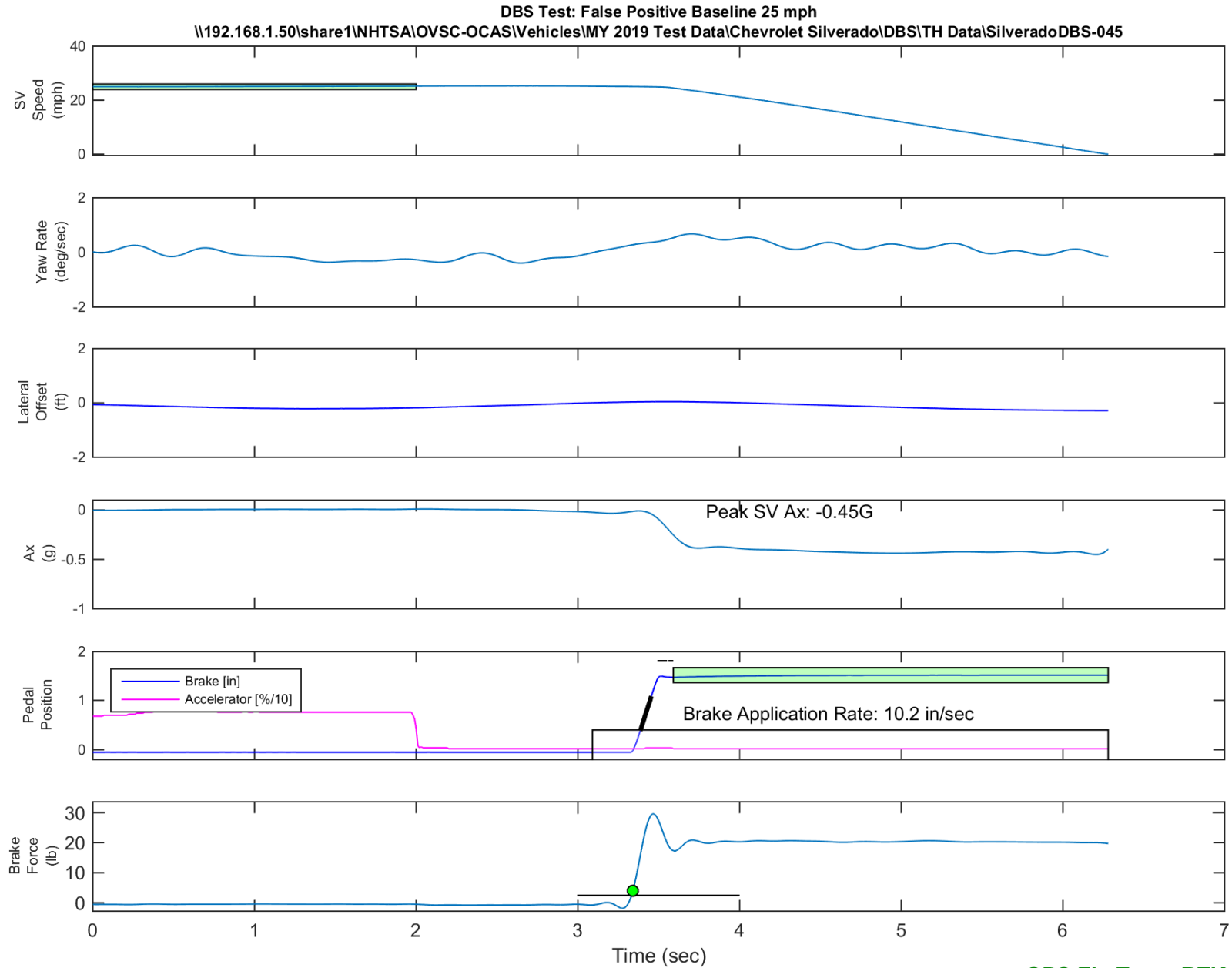
GPS Fix Type: RTK Fixed

Figure E33. Time History for DBS Run 43, False Positive Baseline, SV 25 mph



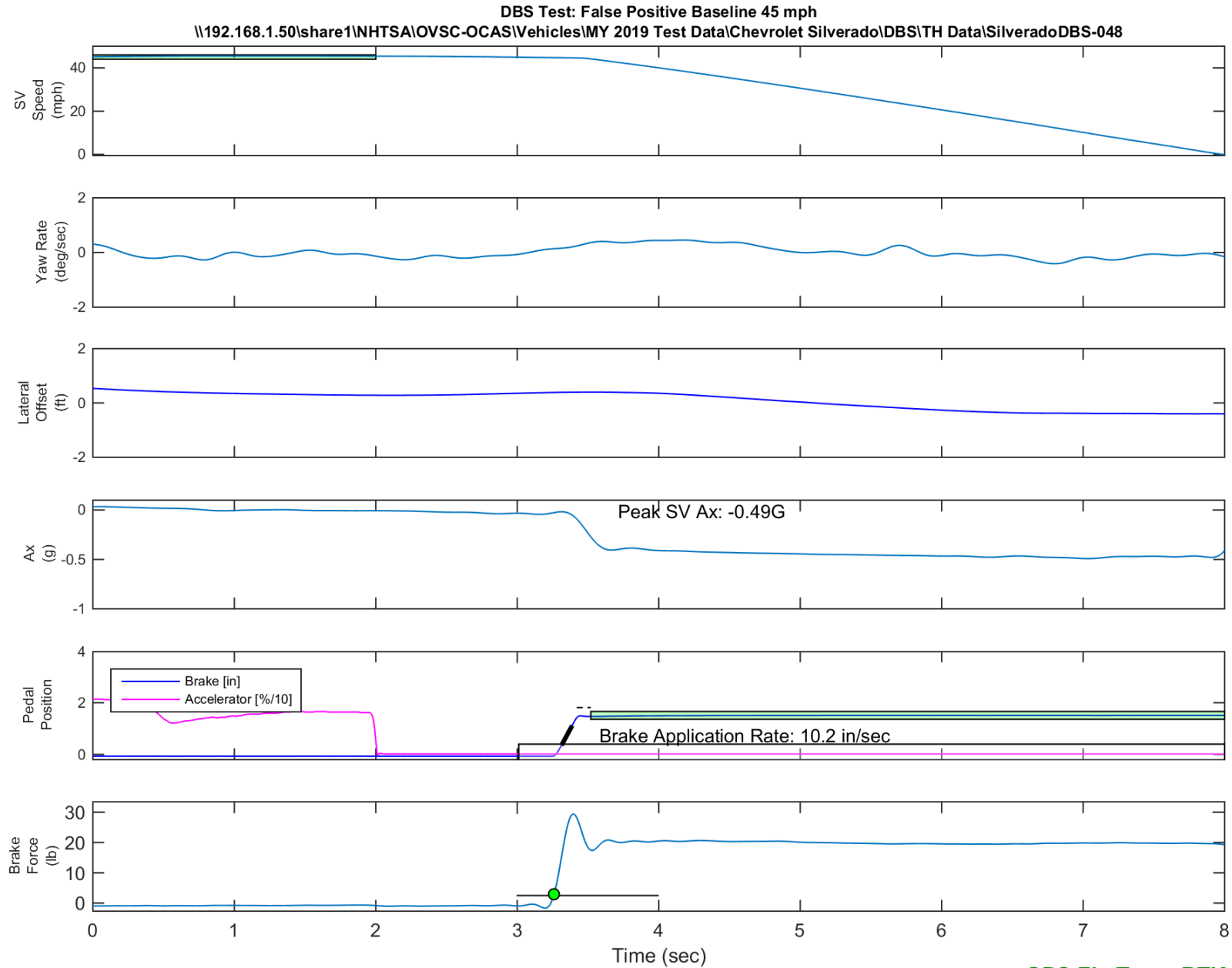
GPS Fix Type: RTK Fixed

Figure E34. Time History for DBS Run 44, False Positive Baseline, SV 25 mph



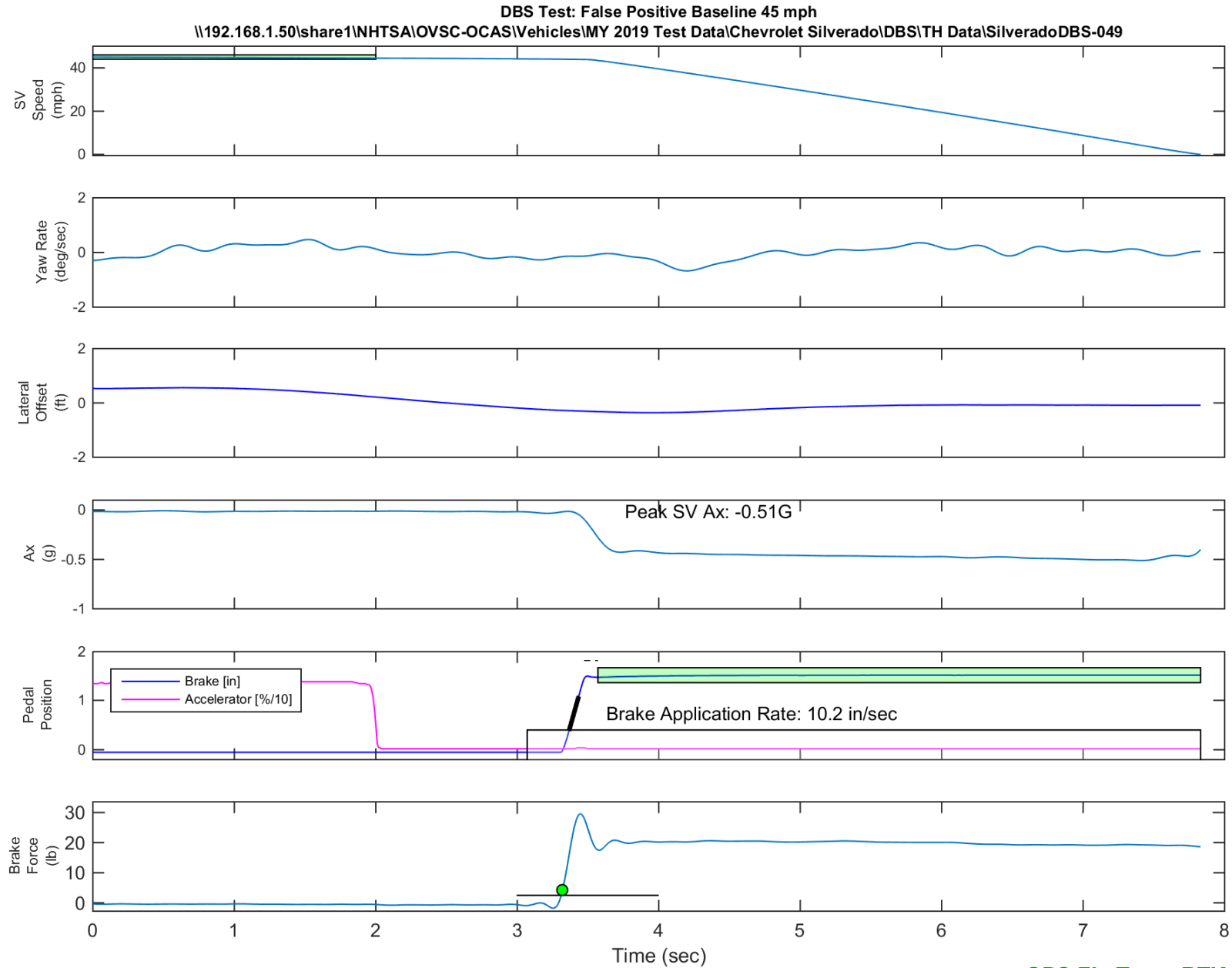
GPS Fix Type: RTK Fixed

Figure E35. Time History for DBS Run 45, False Positive Baseline, SV 25 mph



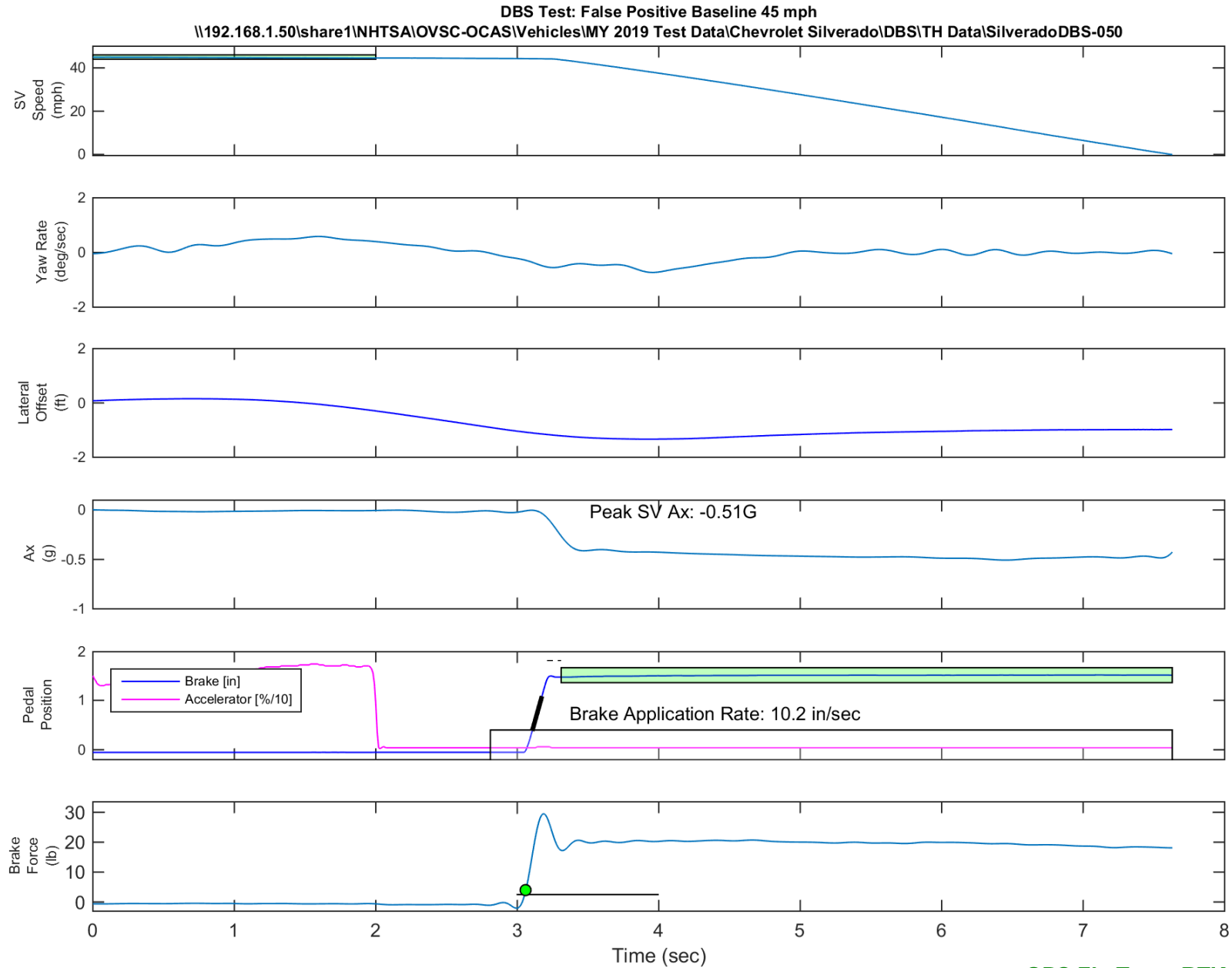
GPS Fix Type: RTK Fixed

Figure E36. Time History for DBS Run 48, False Positive Baseline, SV 45 mph



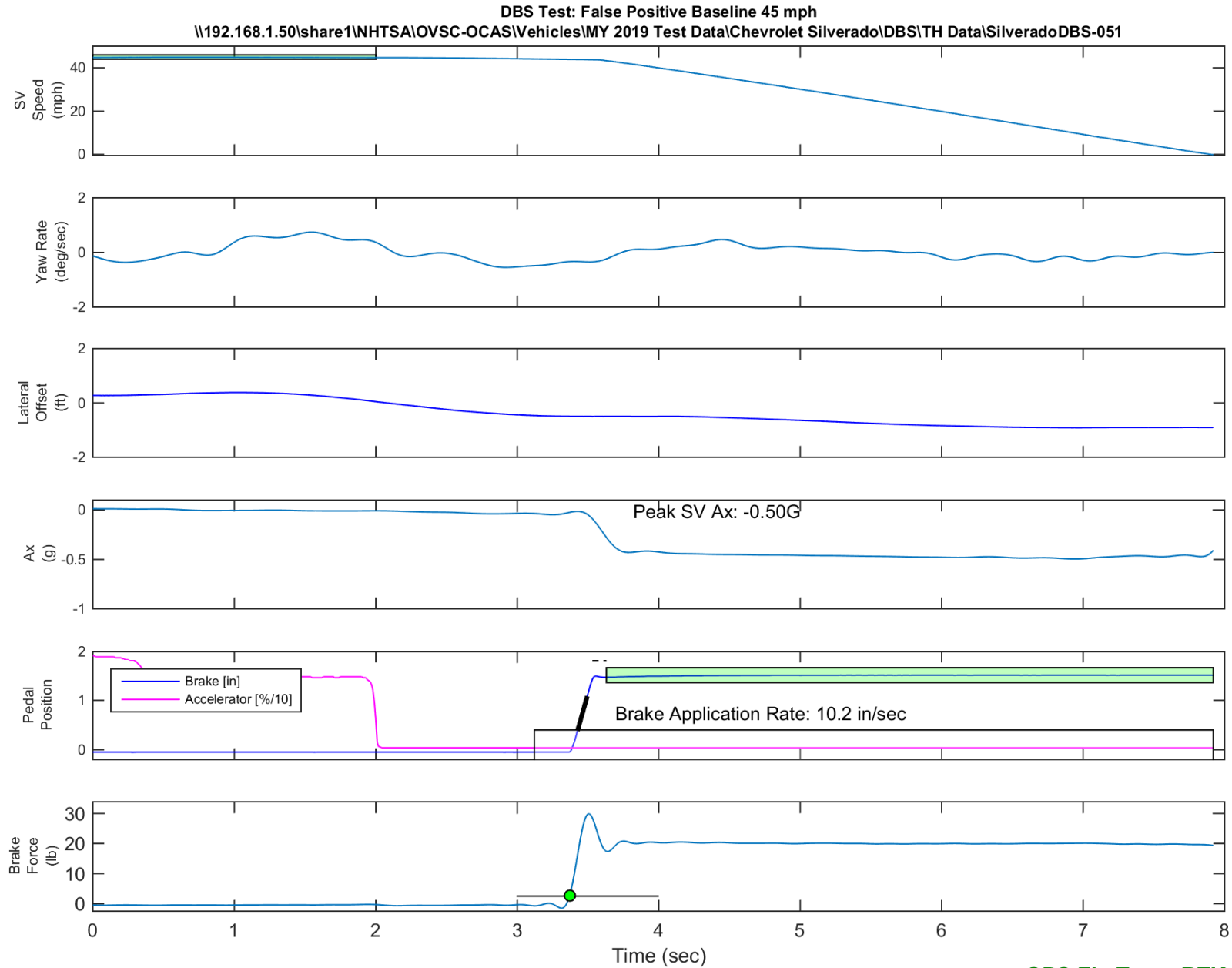
GPS Fix Type: RTK Fixed

Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 45 mph



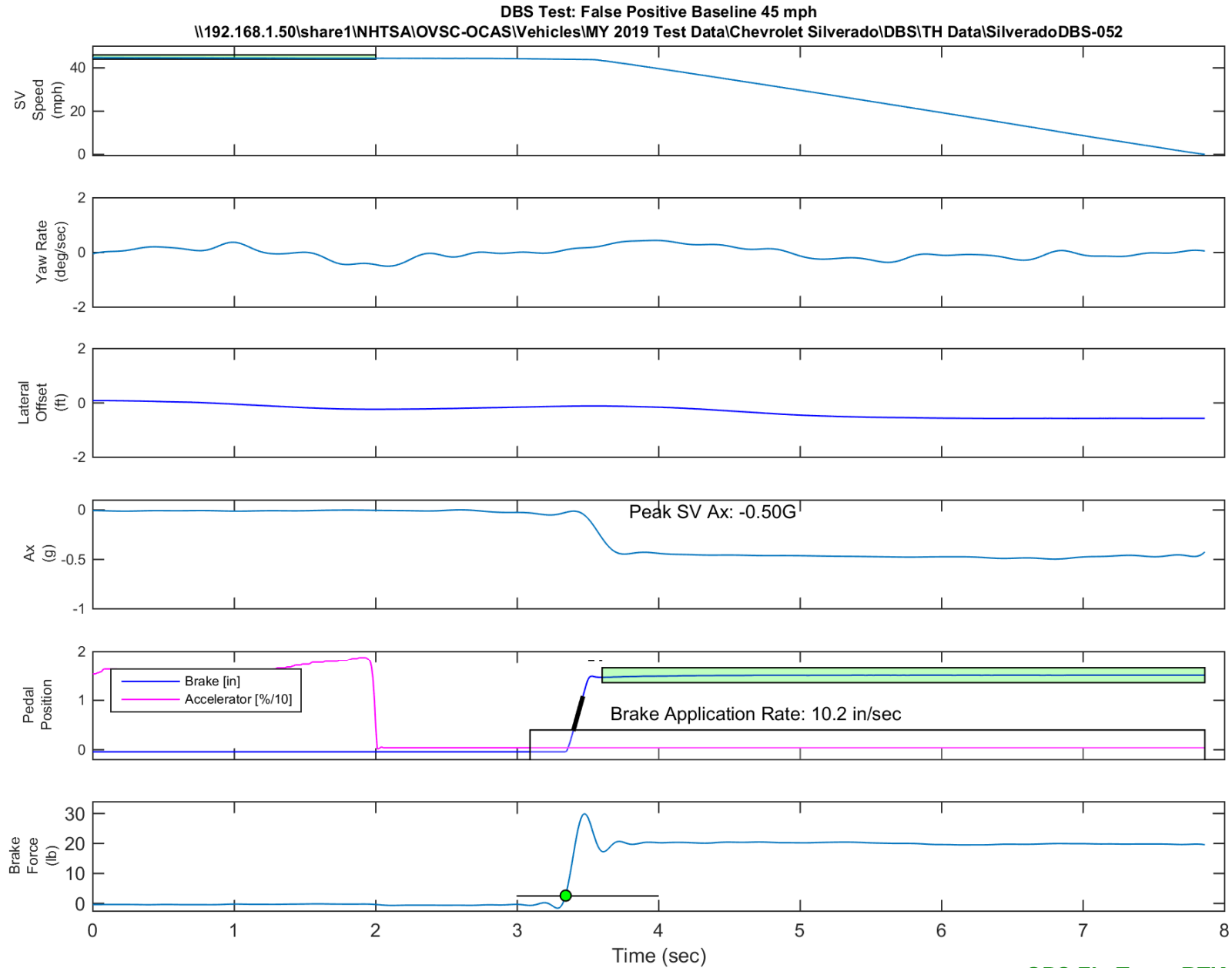
GPS Fix Type: RTK Fixed

Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 45 mph



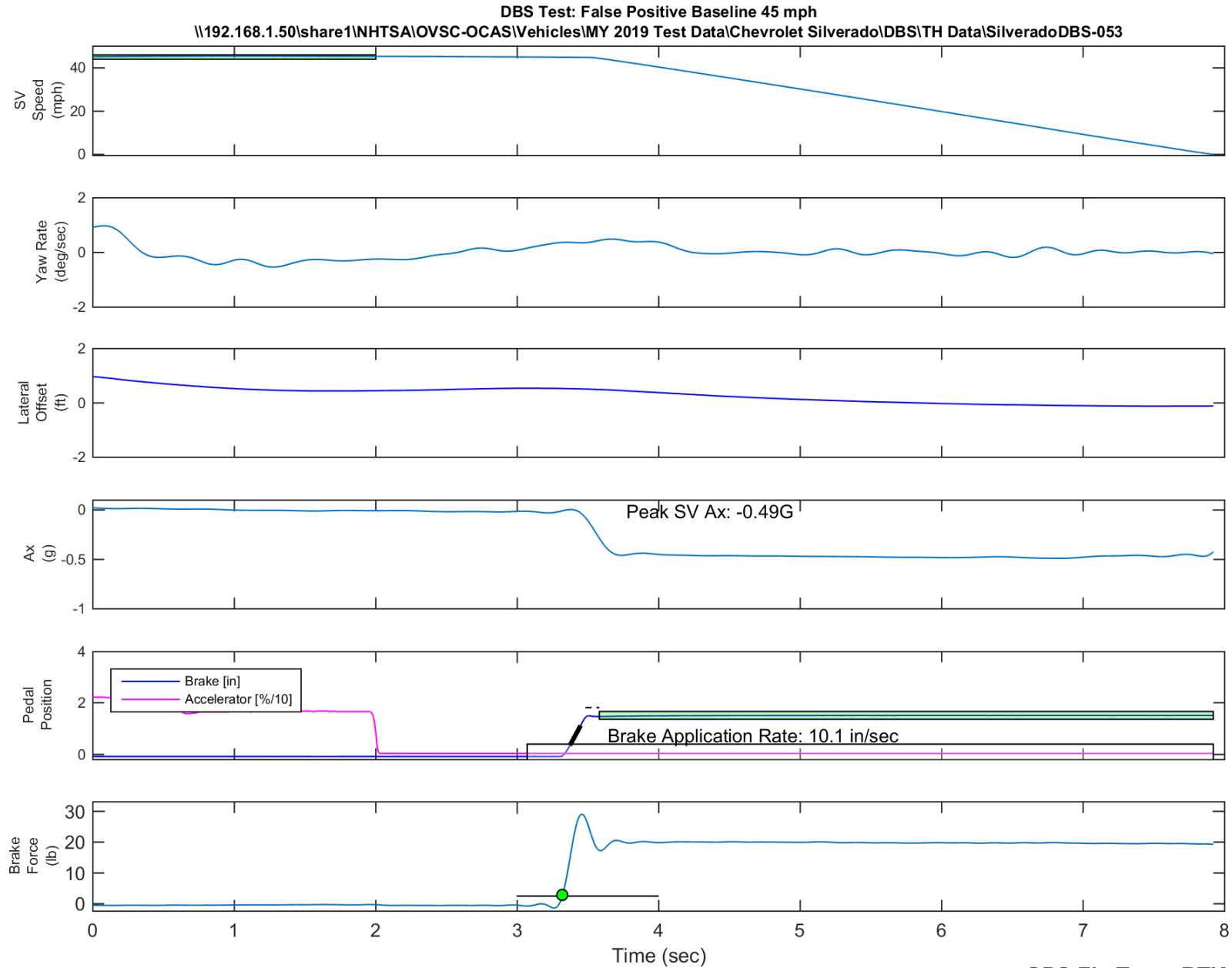
GPS Fix Type: RTK Fixed

Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 45 mph



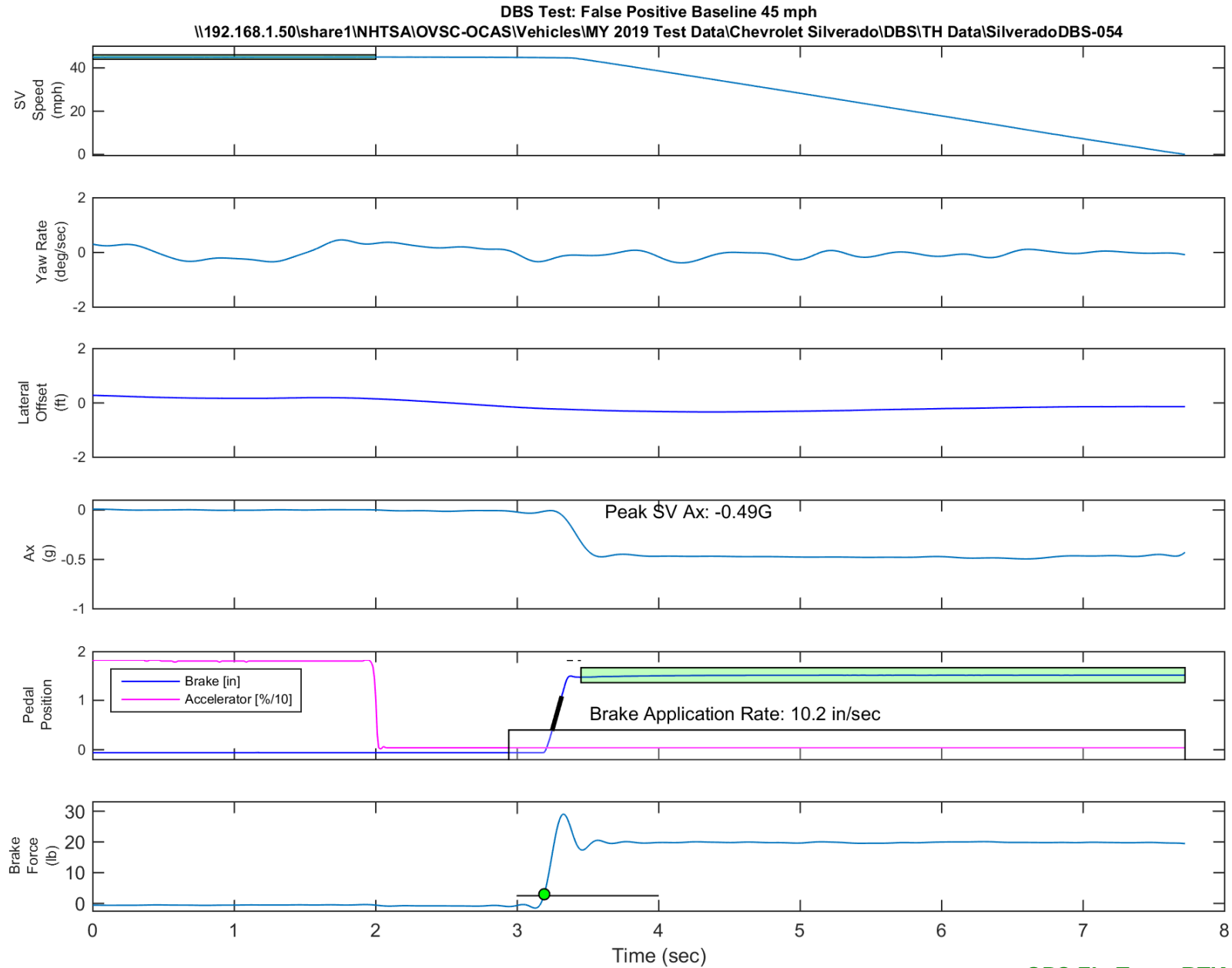
GPS Fix Type: RTK Fixed

Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 45 mph



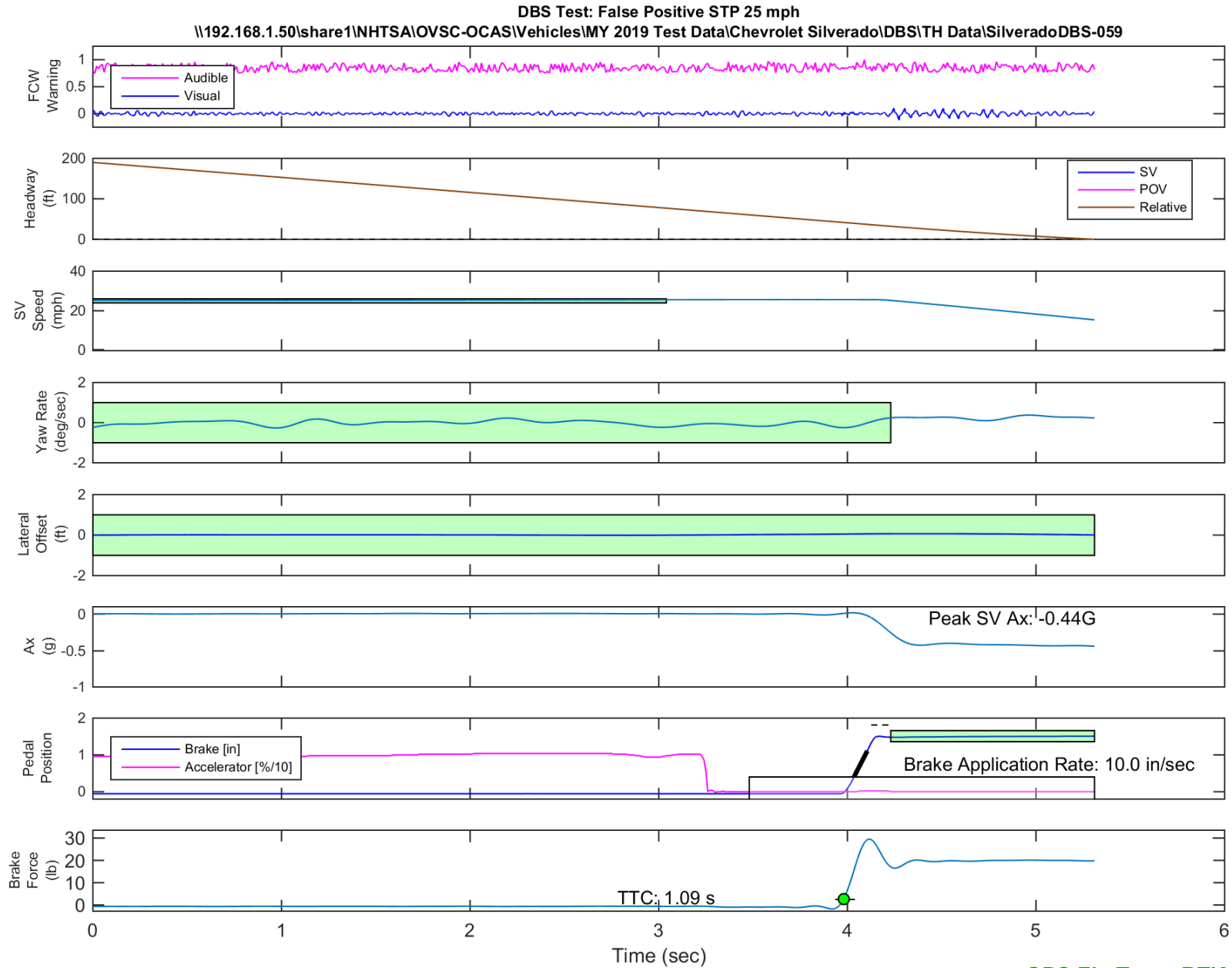
GPS Fix Type: RTK Fixed

Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 45 mph



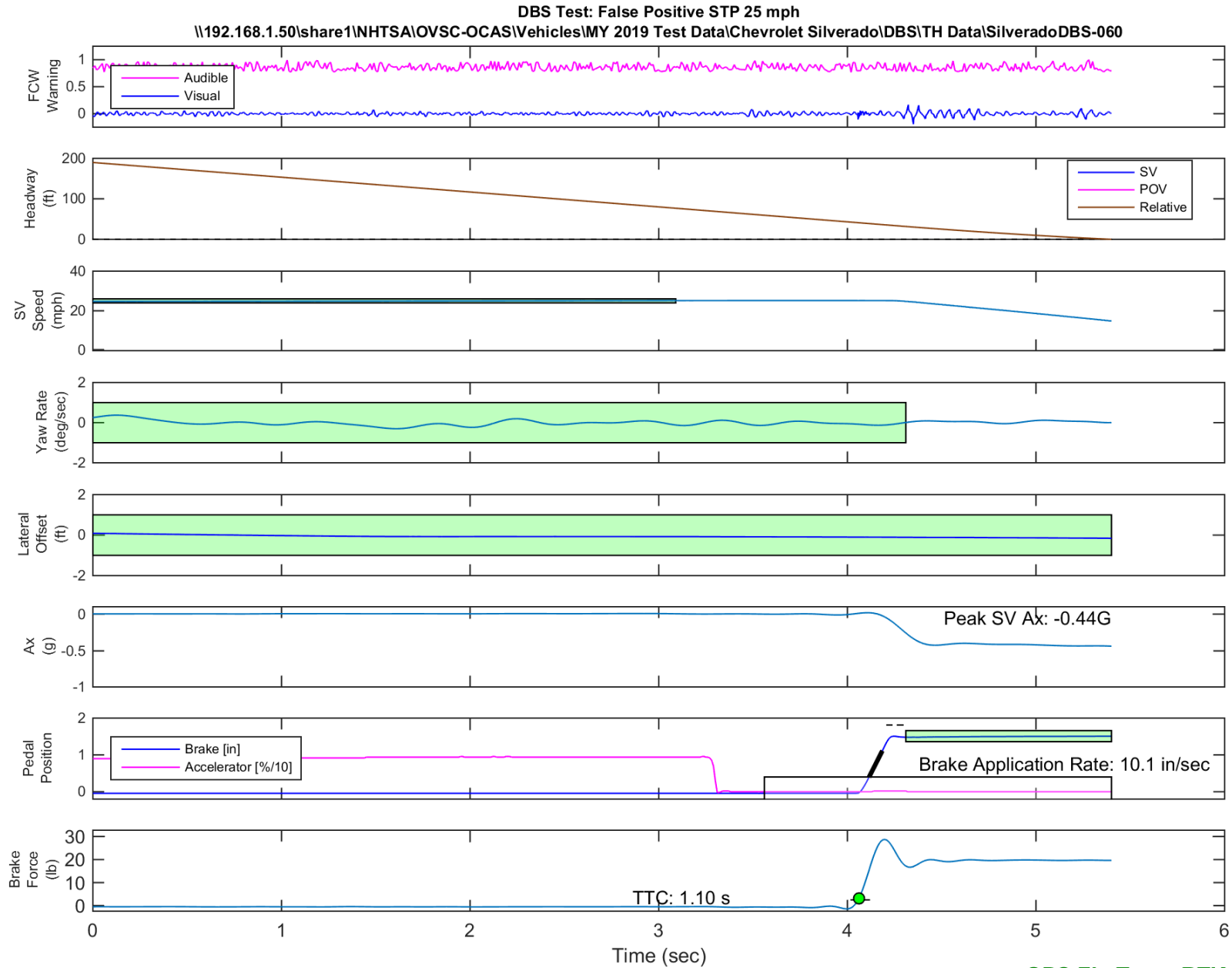
GPS Fix Type: RTK Fixed

Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 45 mph



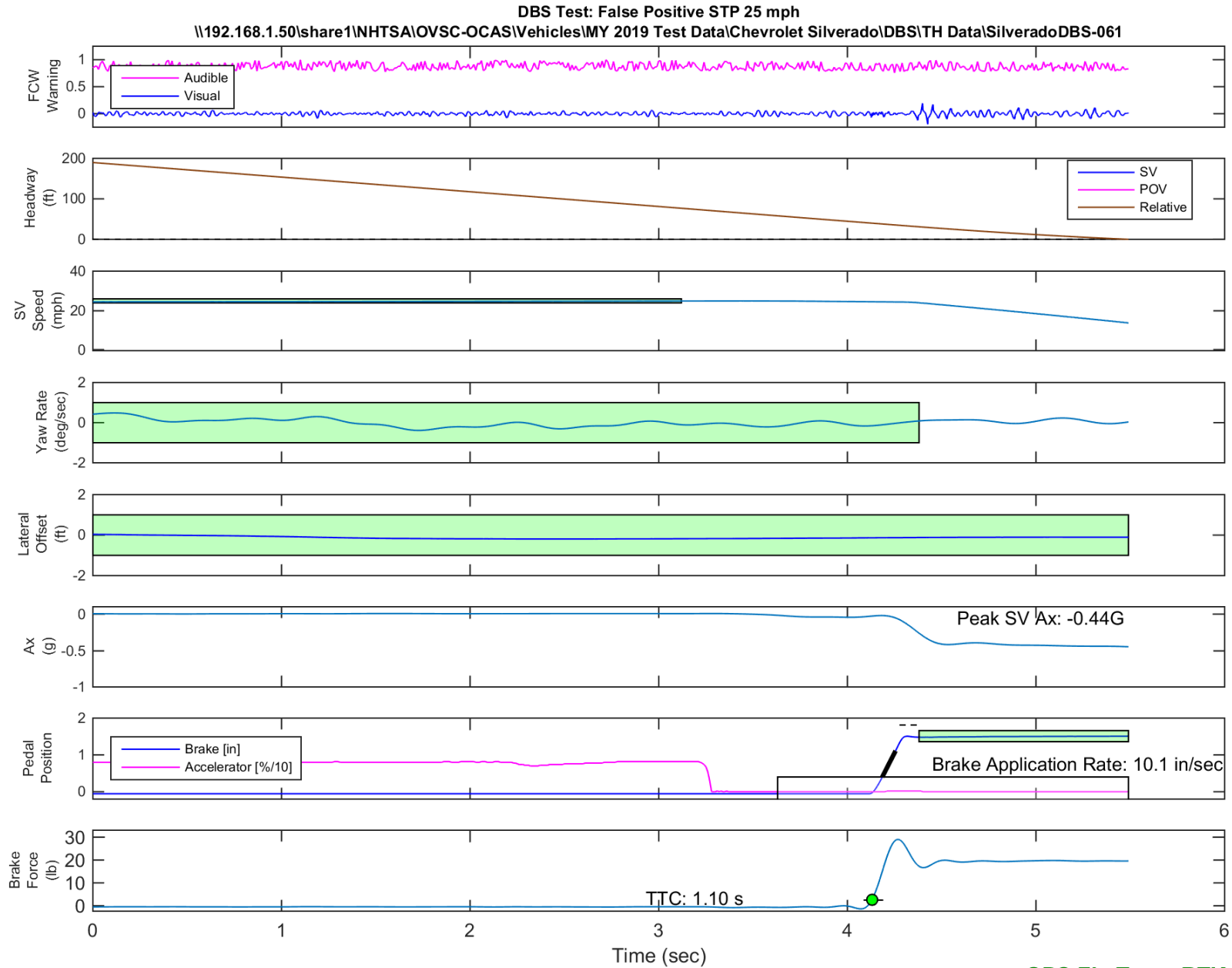
GPS Fix Type: RTK Fixed

Figure E43. Time History for DBS Run 59, SV Encounters Steel Trench Plate, SV 25 mph



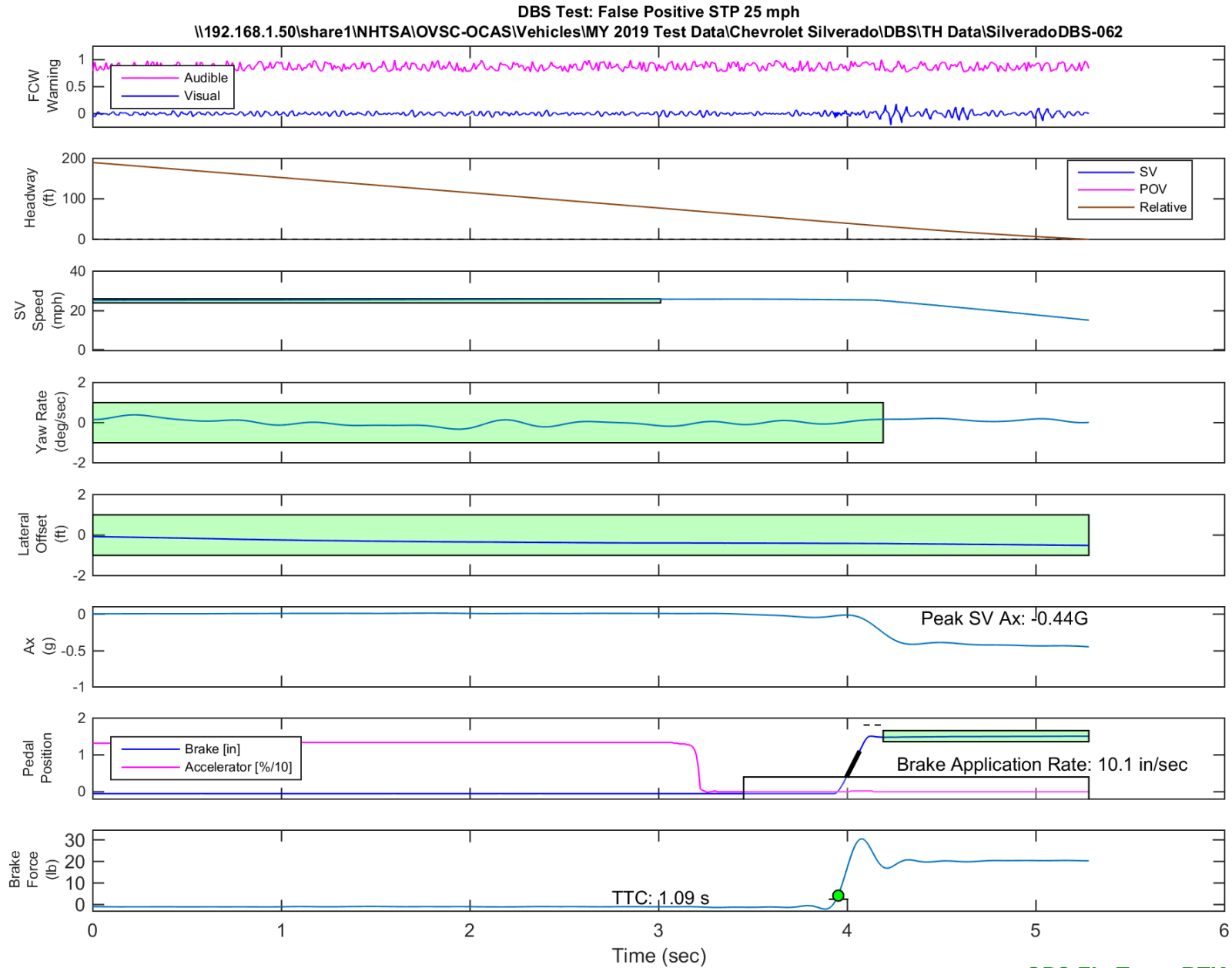
GPS Fix Type: RTK Fixed

Figure E44. Time History for DBS Run 60, SV Encounters Steel Trench Plate, SV 25 mph



GPS Fix Type: RTK Fixed

Figure E45. Time History for DBS Run 61, SV Encounters Steel Trench Plate, SV 25 mph



GPS Fix Type: RTK Fixed

Figure E46. Time History for DBS Run 62, SV Encounters Steel Trench Plate, SV 25 mph

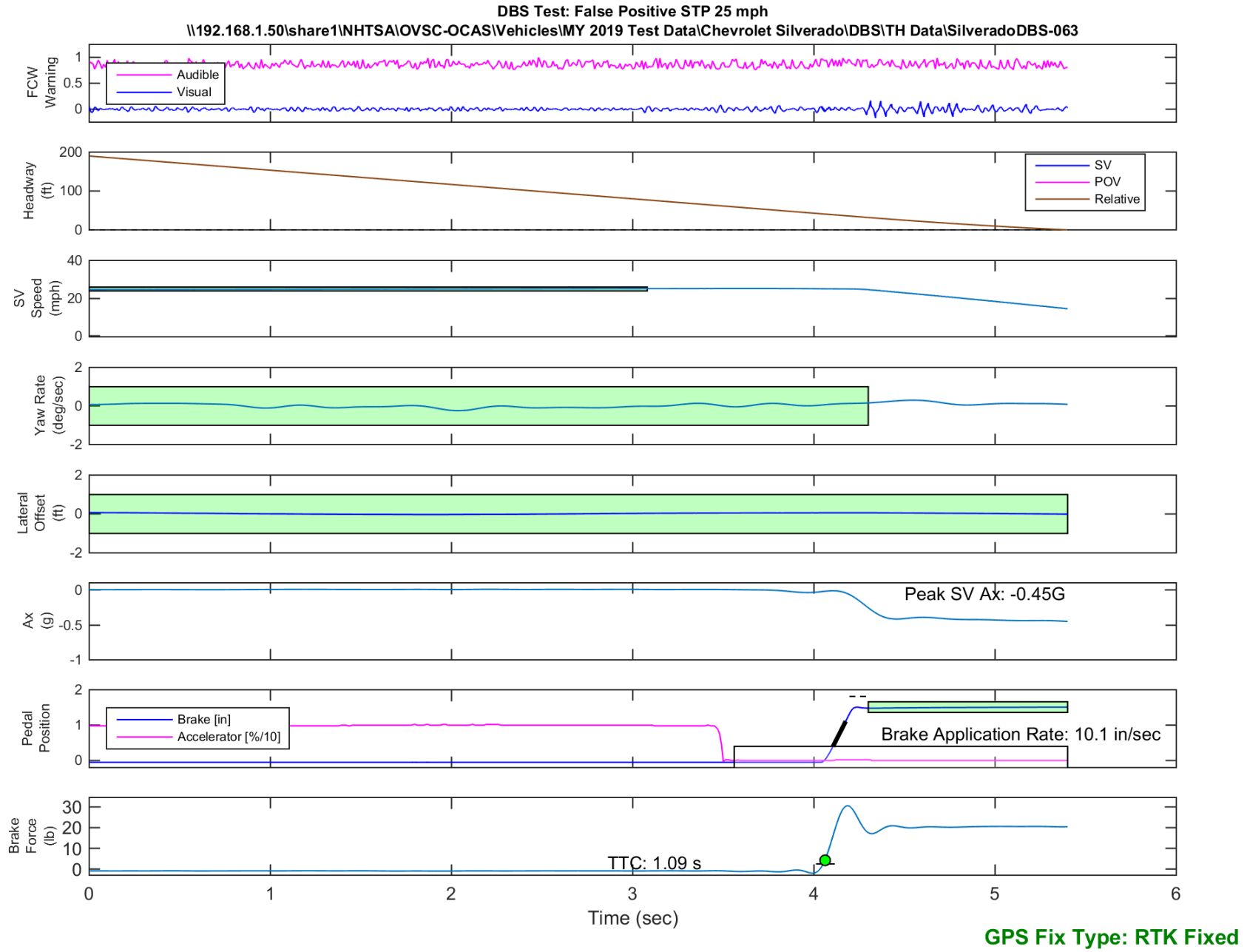
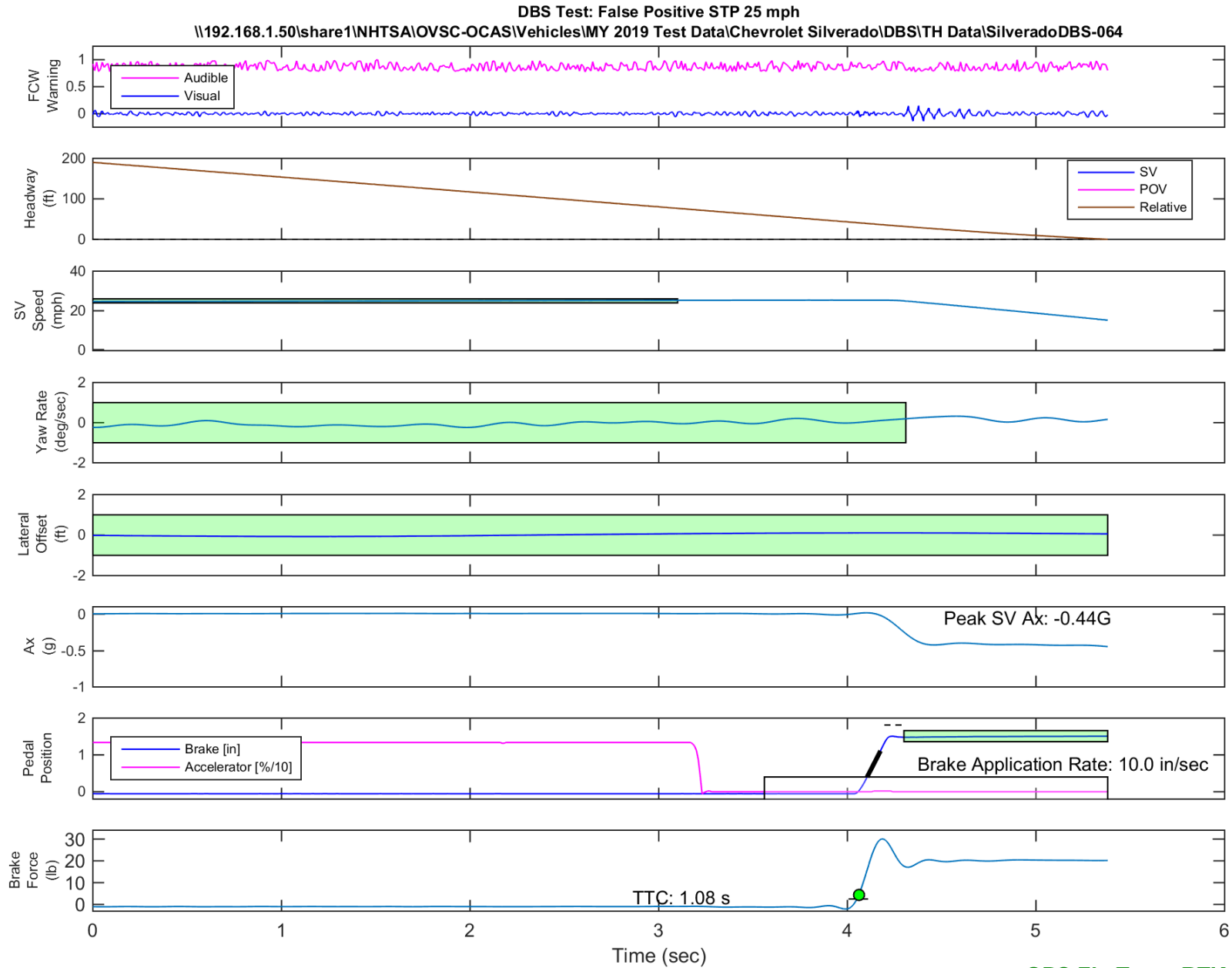
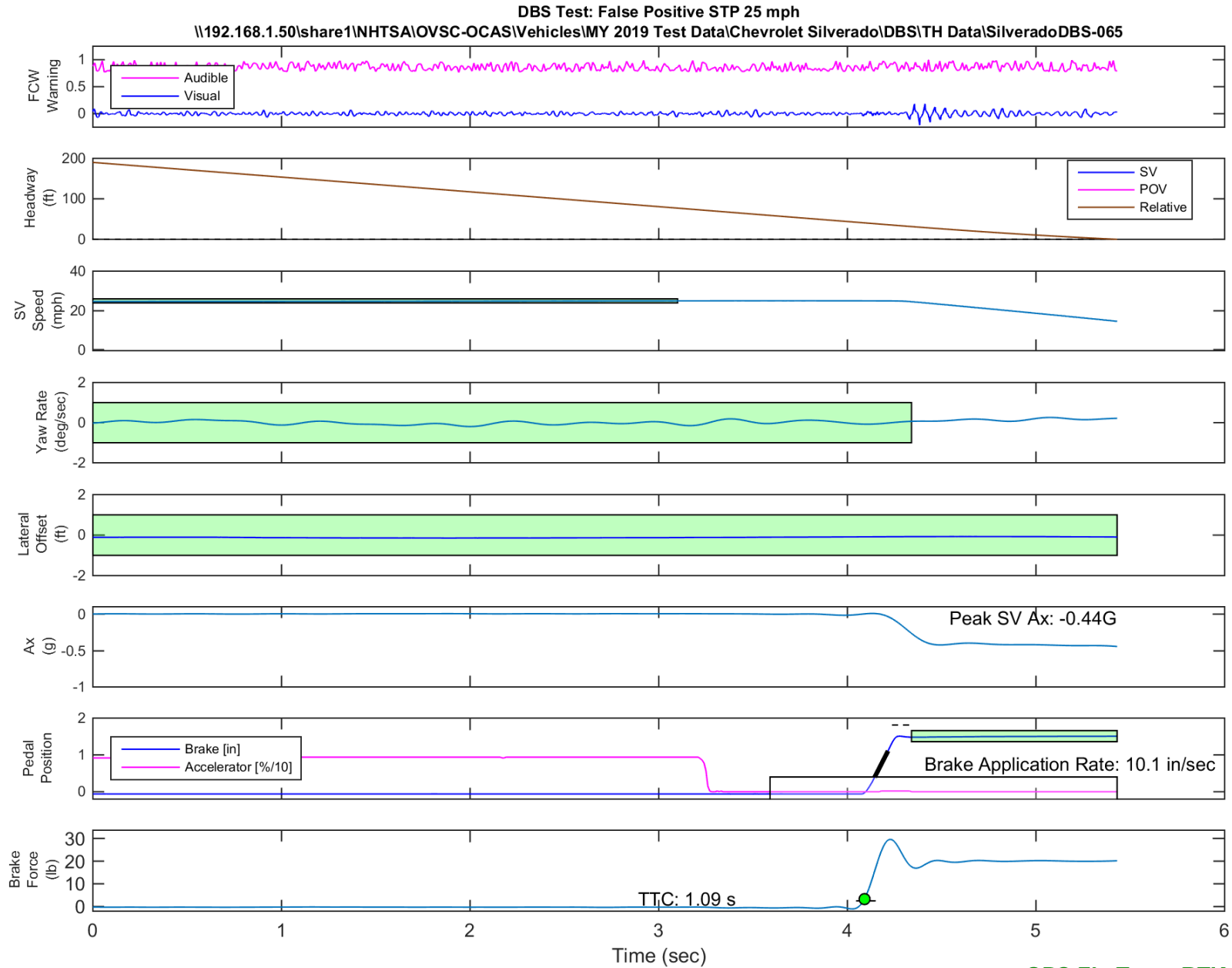


Figure E47. Time History for DBS Run 63, SV Encounters Steel Trench Plate, SV 25 mph



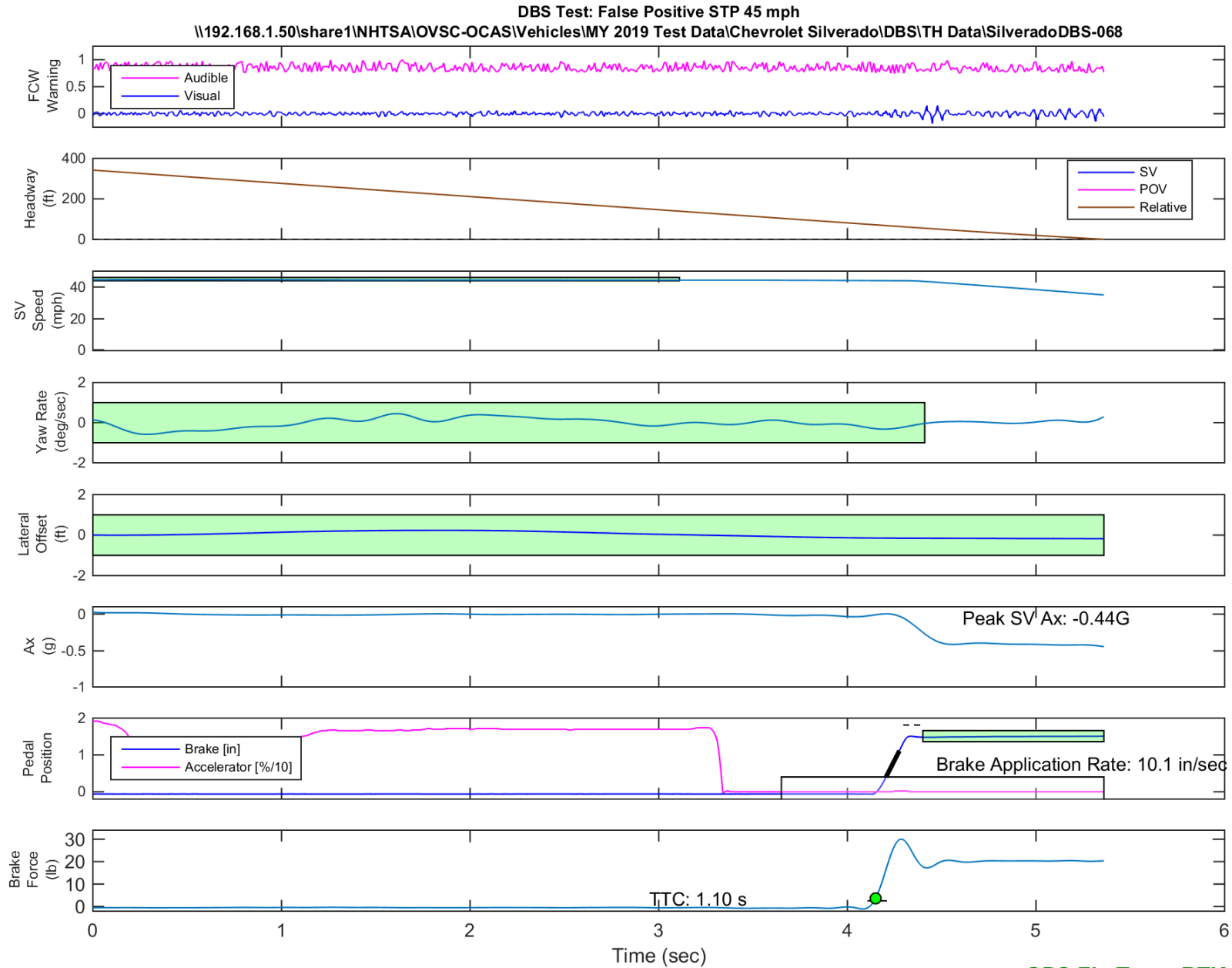
GPS Fix Type: RTK Fixed

Figure E48. Time History for DBS Run 64, SV Encounters Steel Trench Plate, SV 25 mph



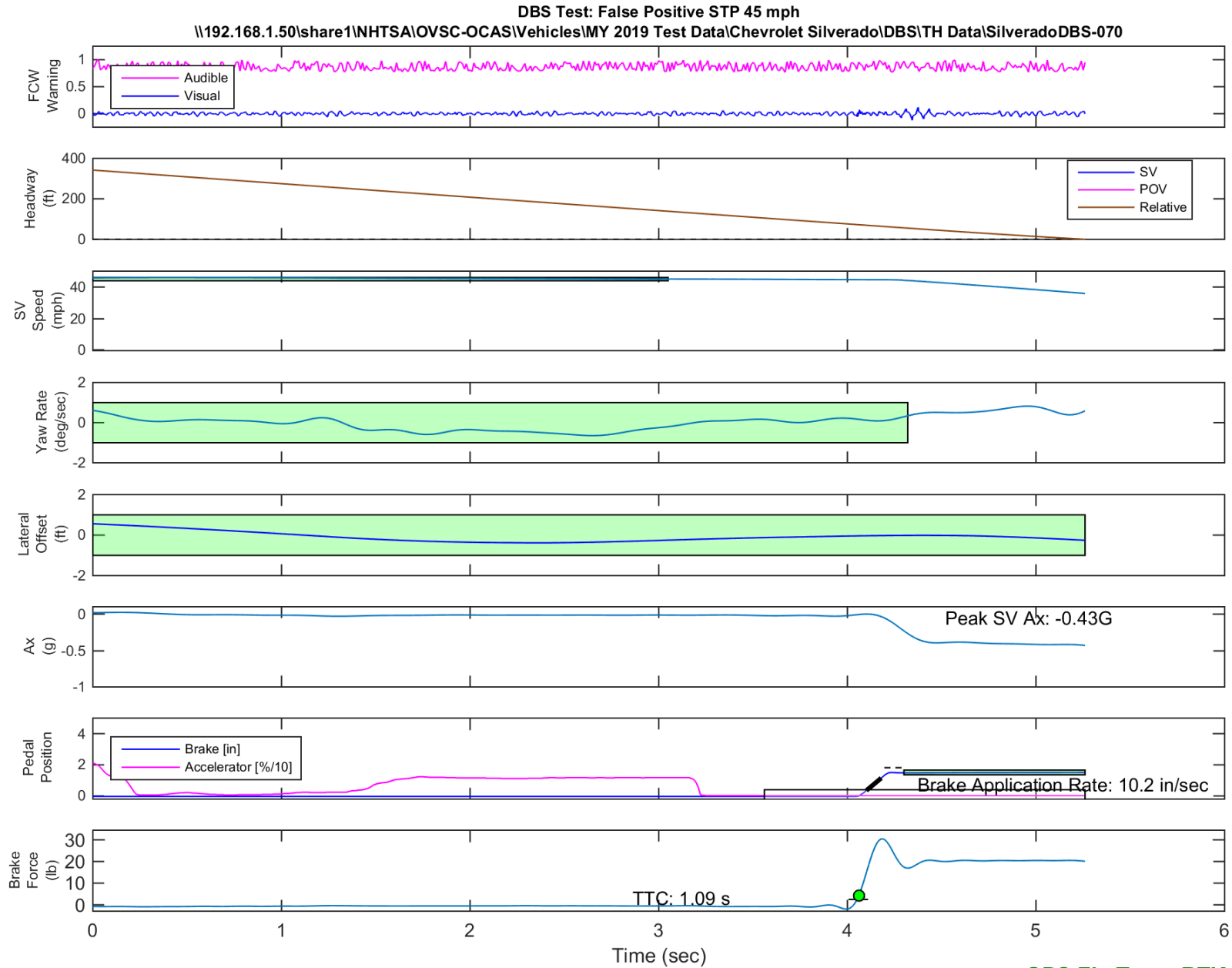
GPS Fix Type: RTK Fixed

Figure E49. Time History for DBS Run 65, SV Encounters Steel Trench Plate, SV 25 mph



GPS Fix Type: RTK Fixed

Figure E50. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 45 mph



GPS Fix Type: RTK Fixed

Figure E51. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 45 mph

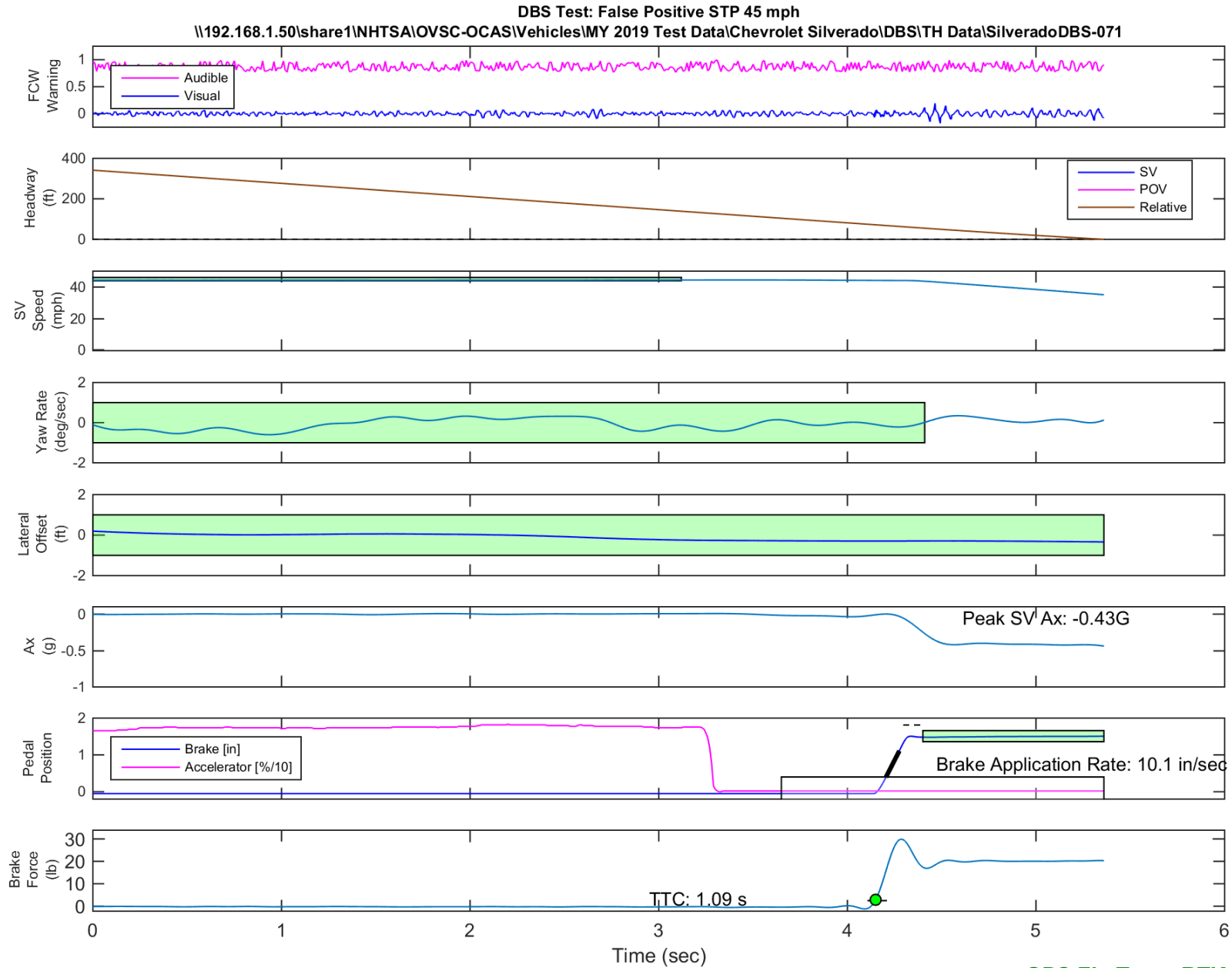
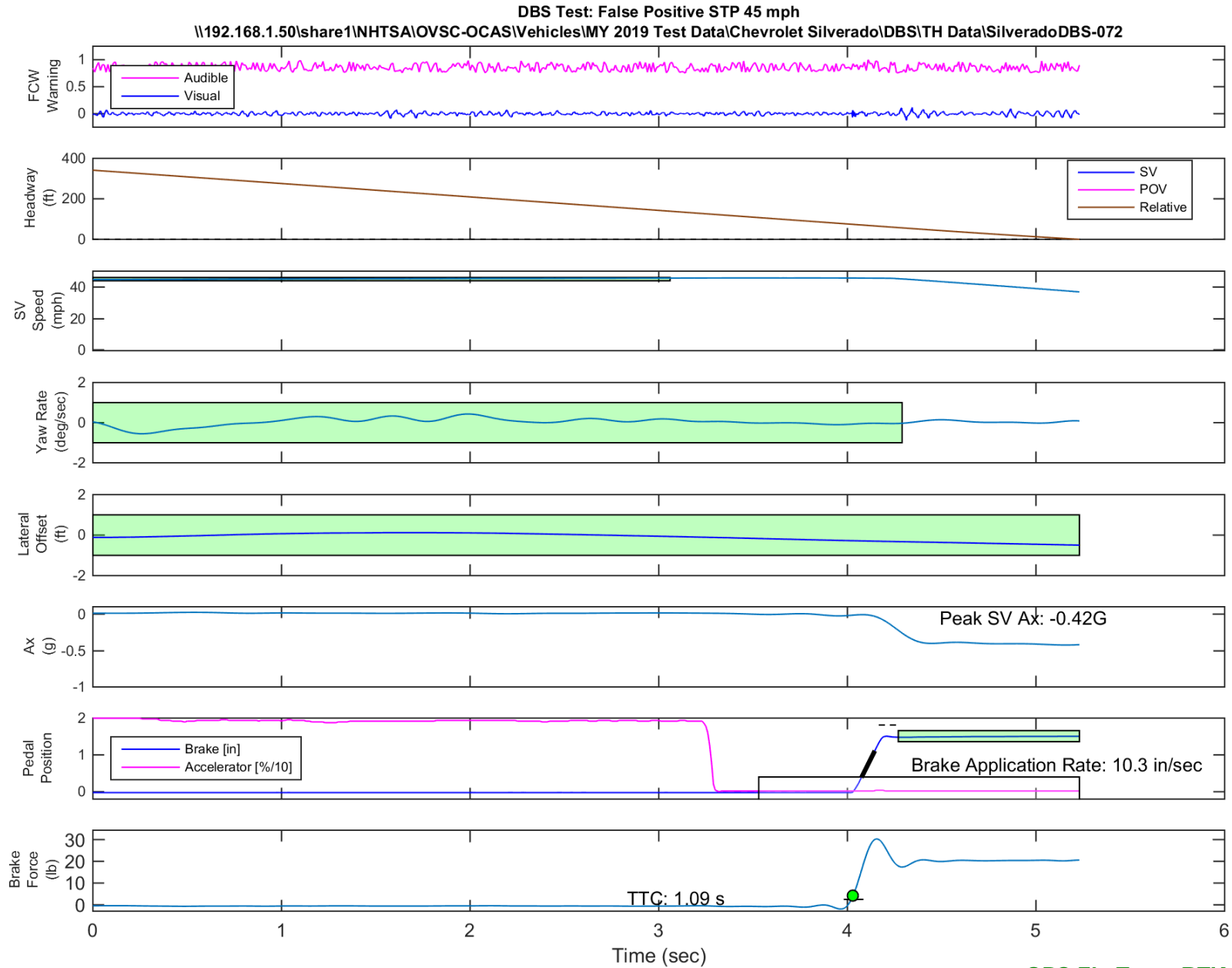
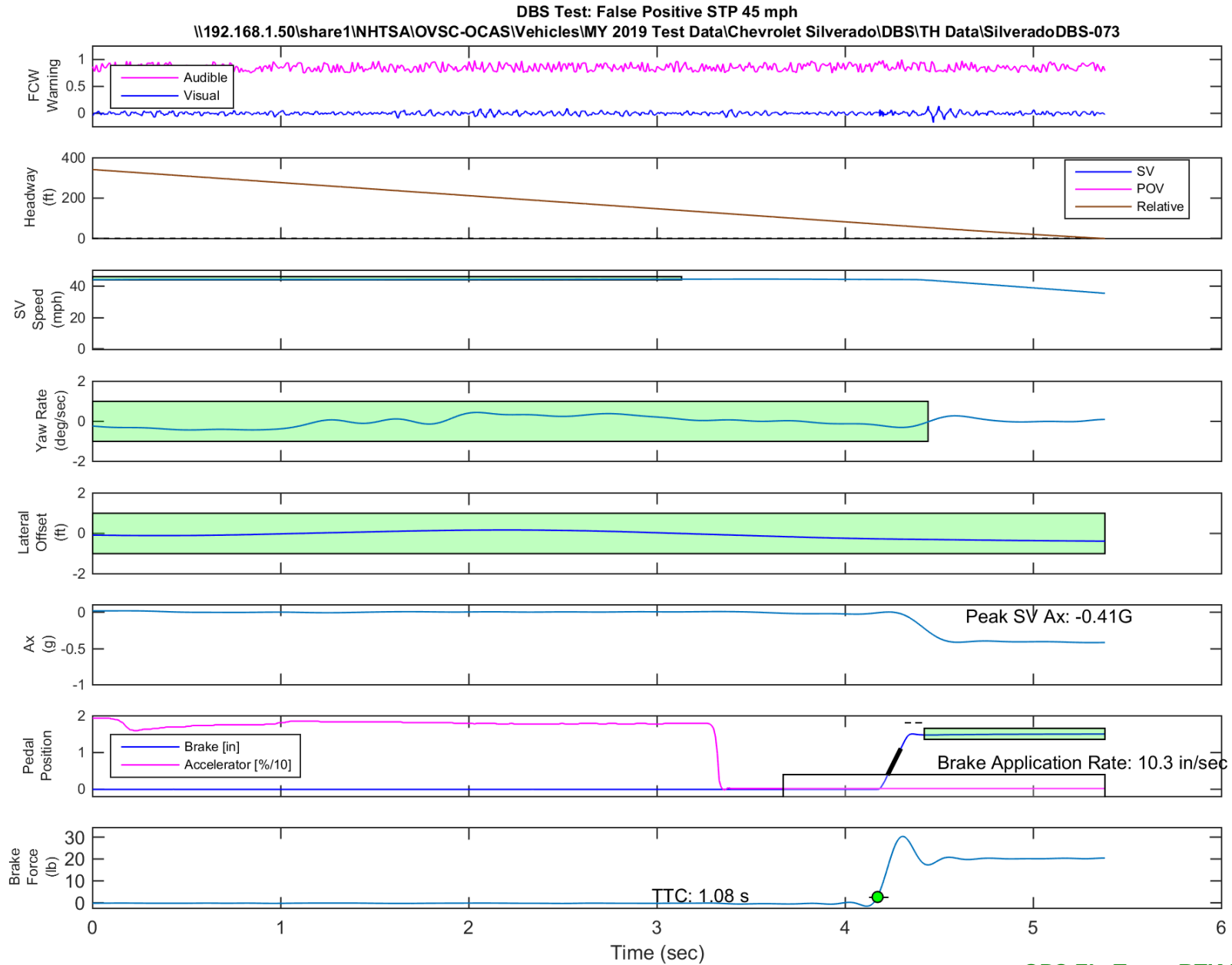


Figure E52. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 45 mph



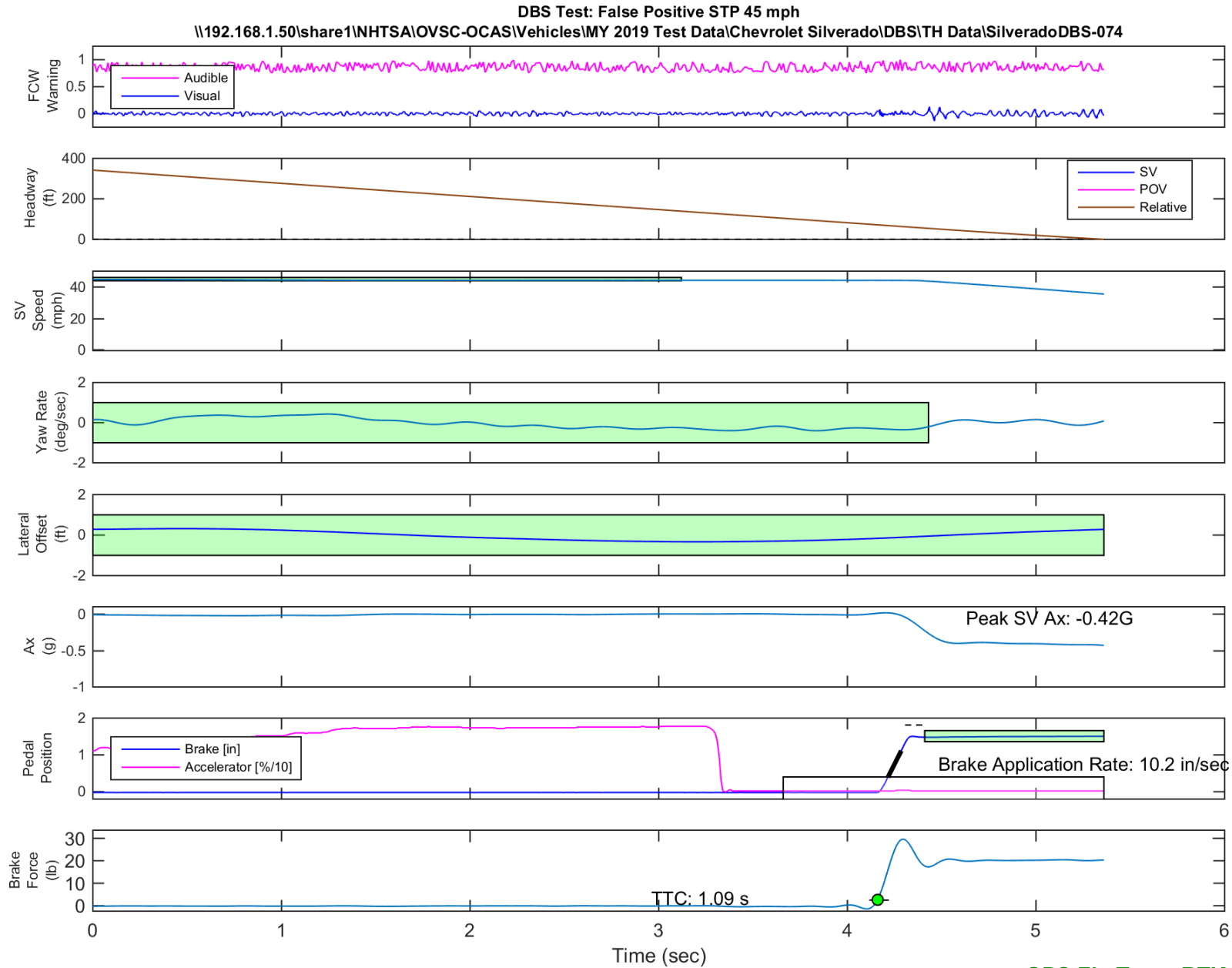
GPS Fix Type: RTK Fixed

Figure E53. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 45 mph



GPS Fix Type: RTK Fixed

Figure E54. Time History for DBS Run 73, SV Encounters Steel Trench Plate, SV 45 mph



GPS Fix Type: RTK Fixed

Figure E55. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph

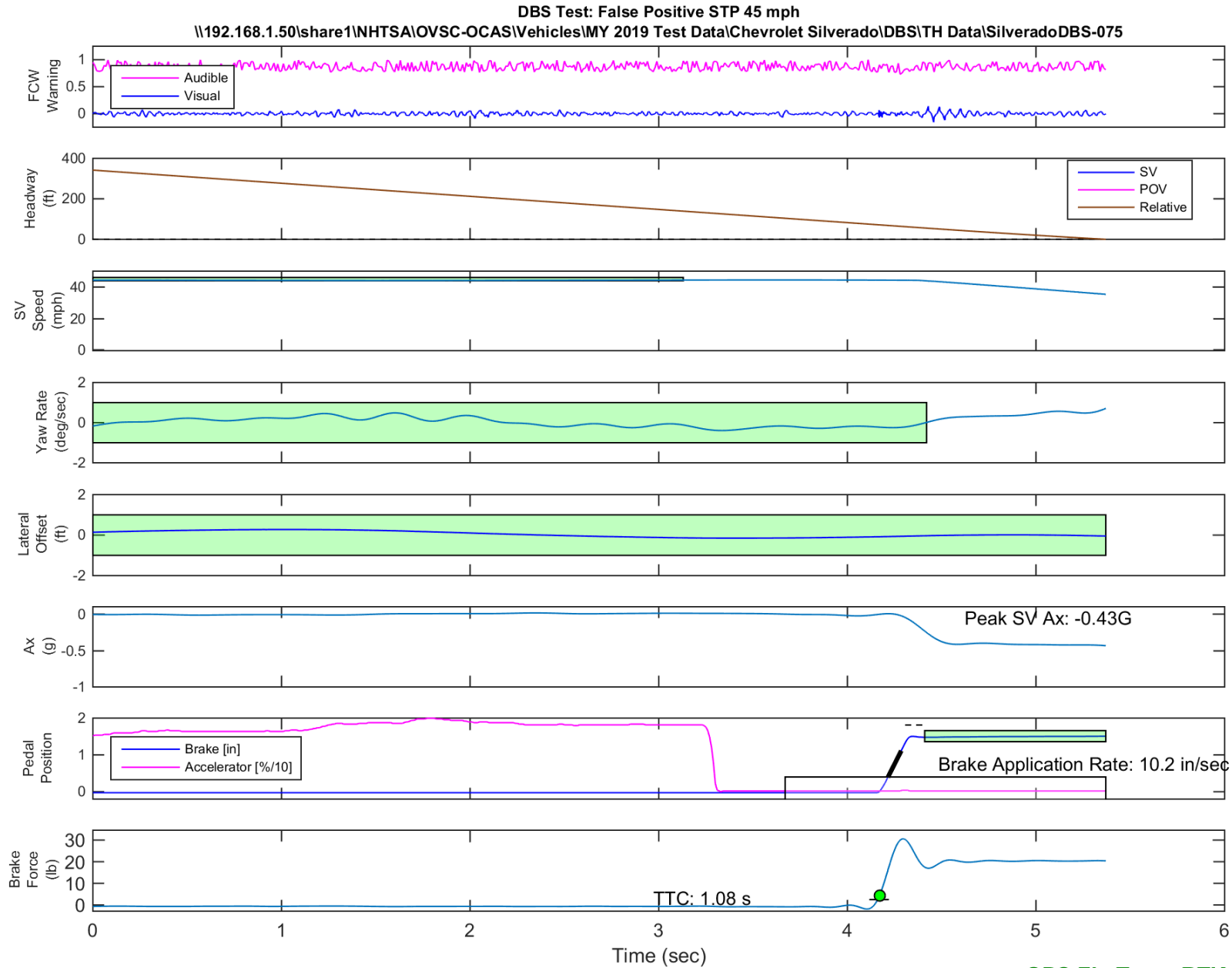


Figure E56. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph

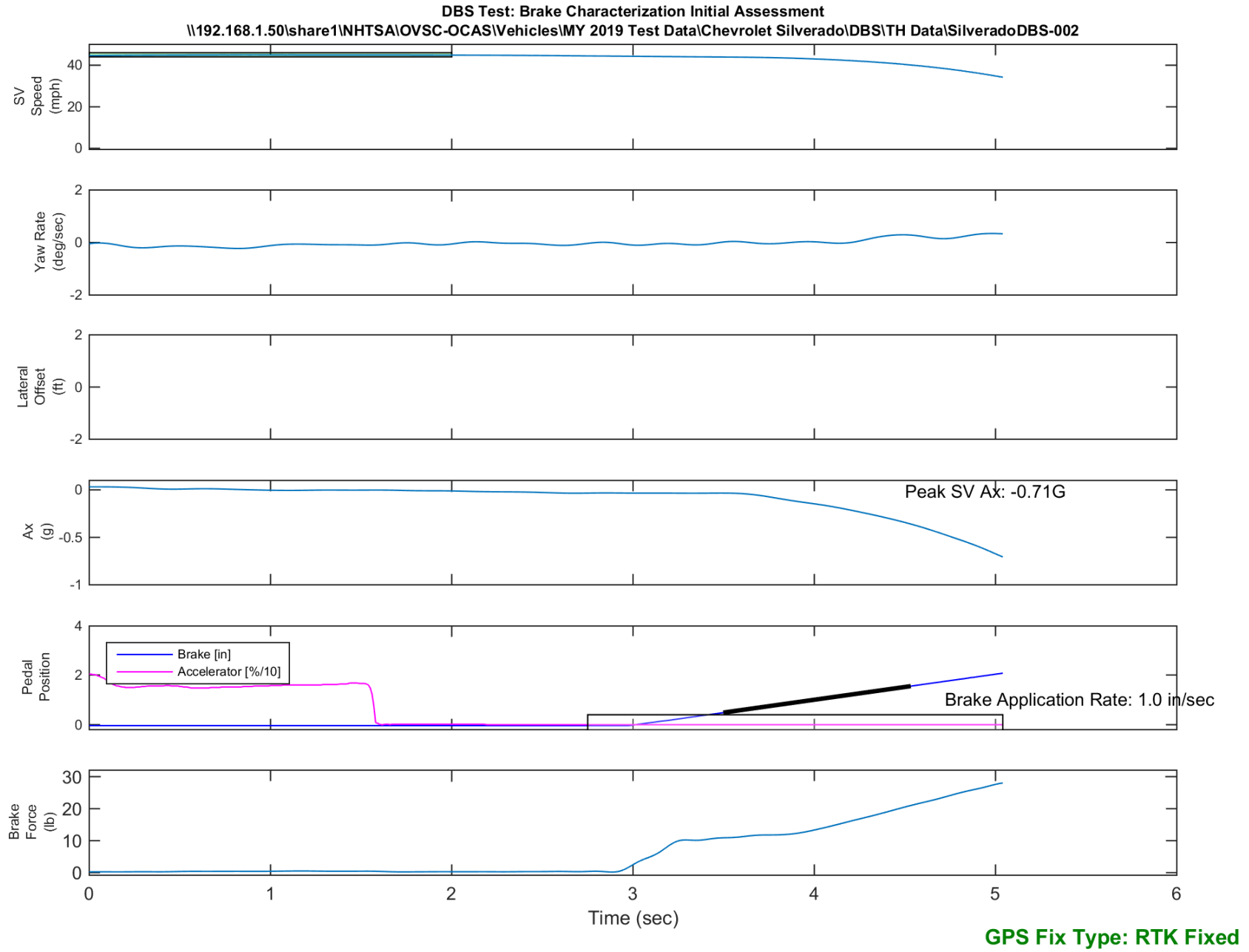


Figure E57. Time History for DBS Run 2, Brake Characterization Initial

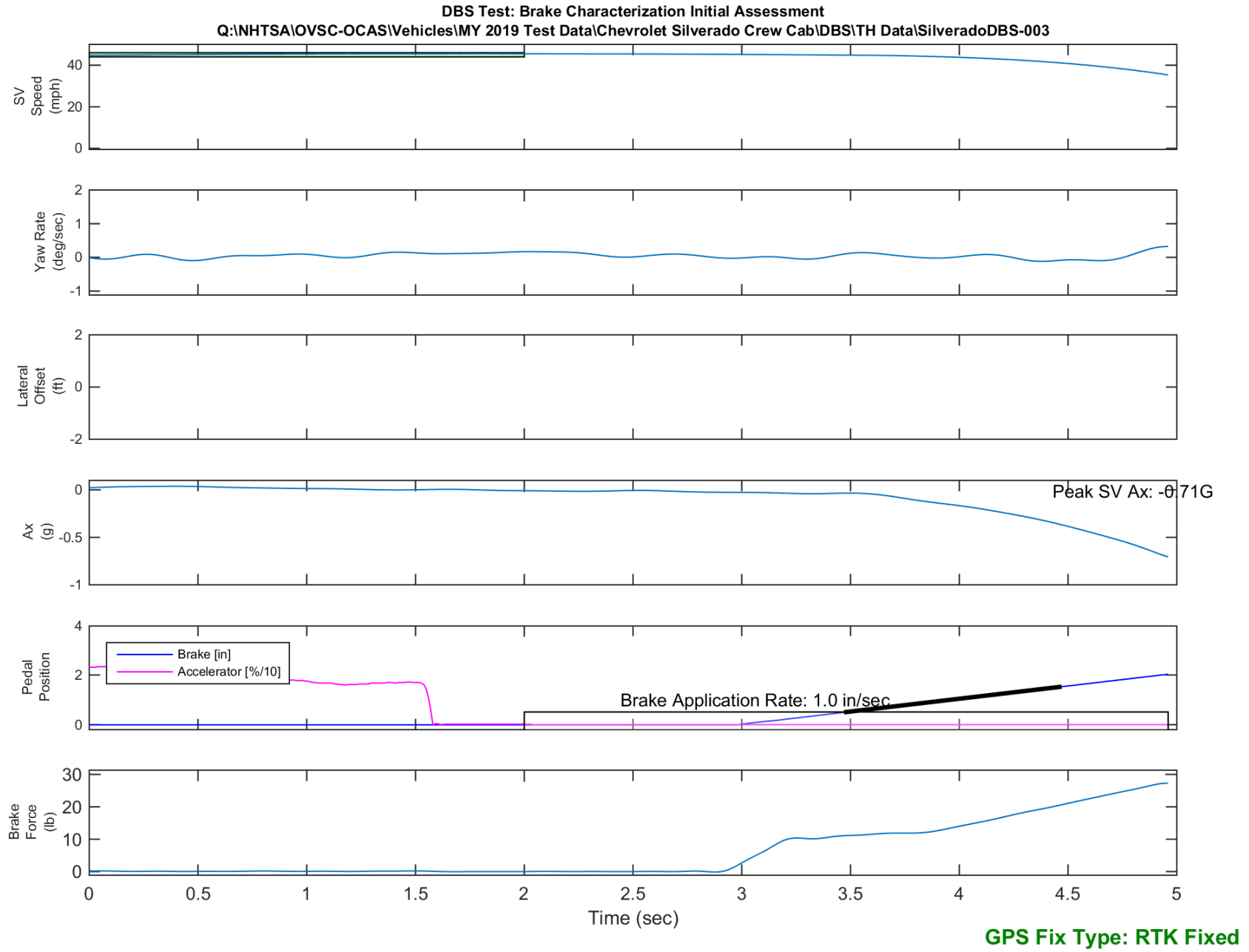


Figure E58. Time History for DBS Run 3, Brake Characterization Initial

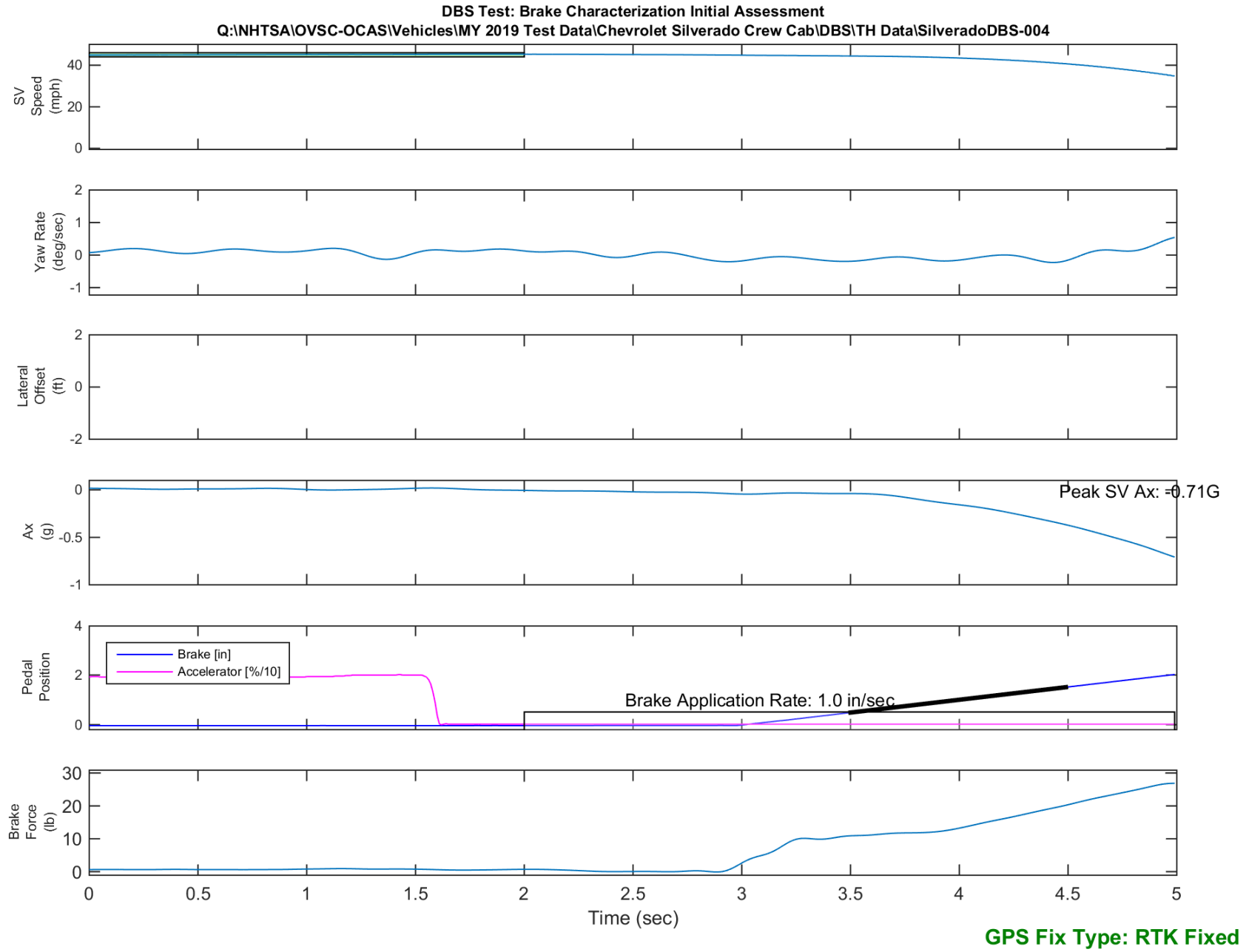
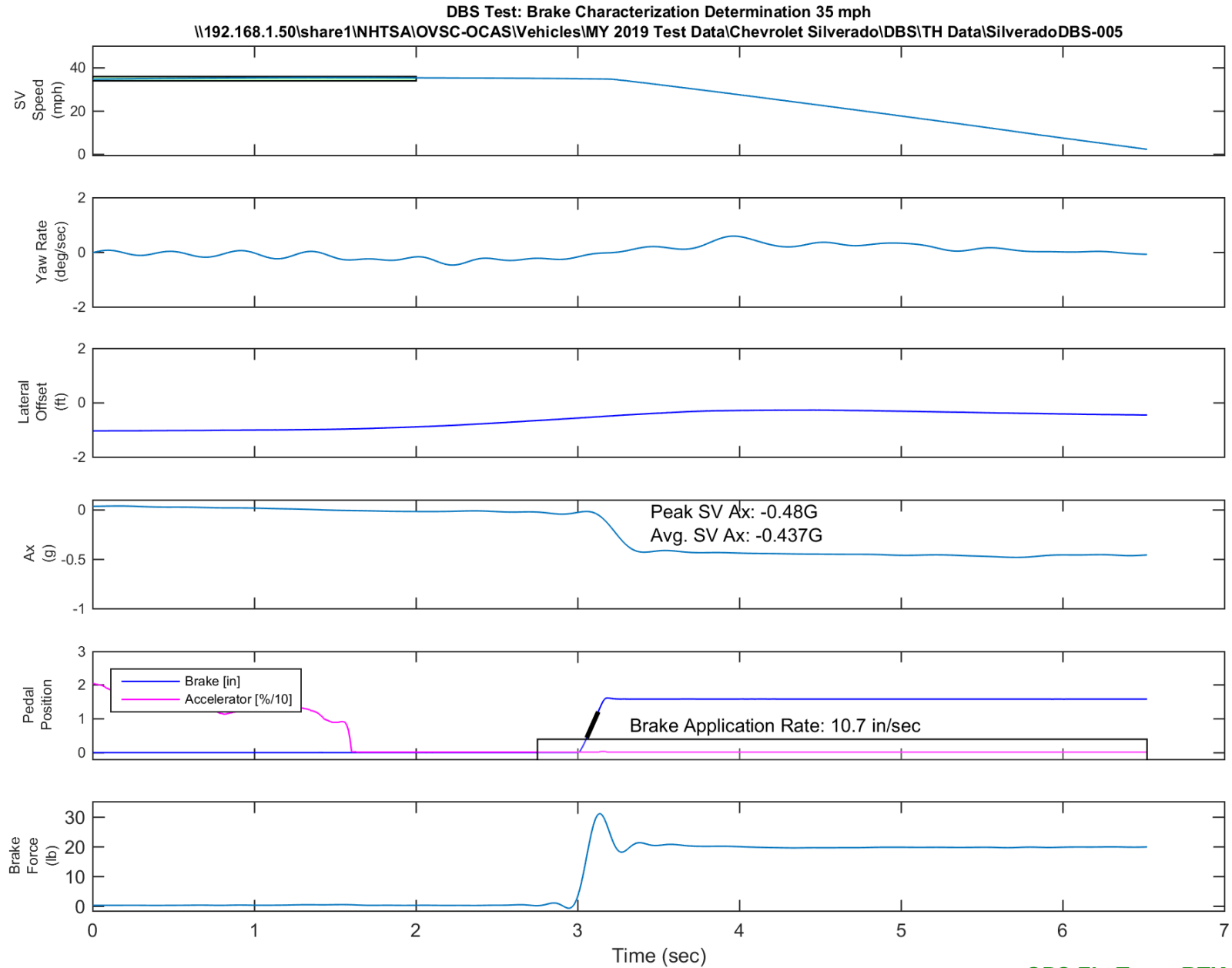
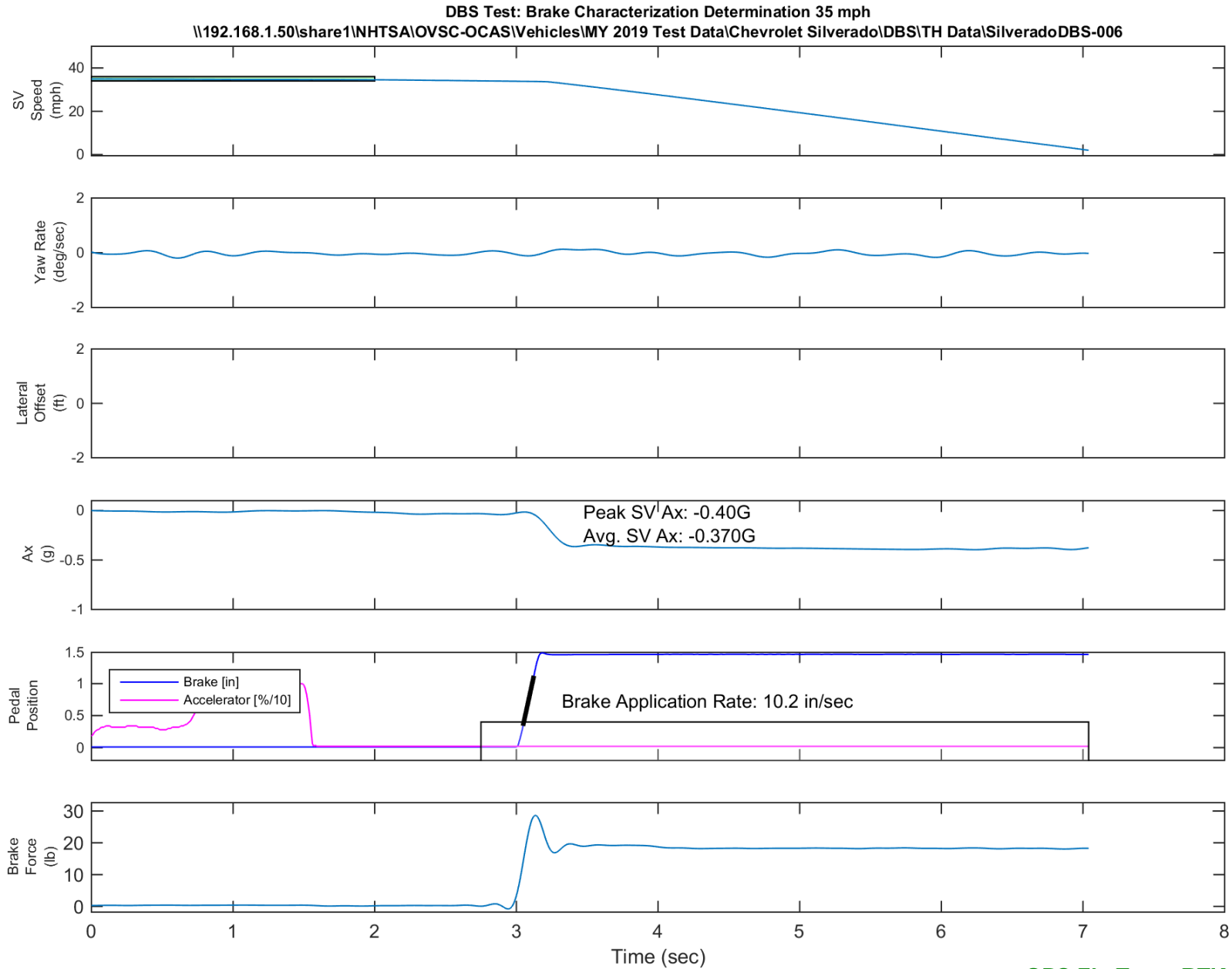


Figure E59. Time History for DBS Run 4, Brake Characterization Initial



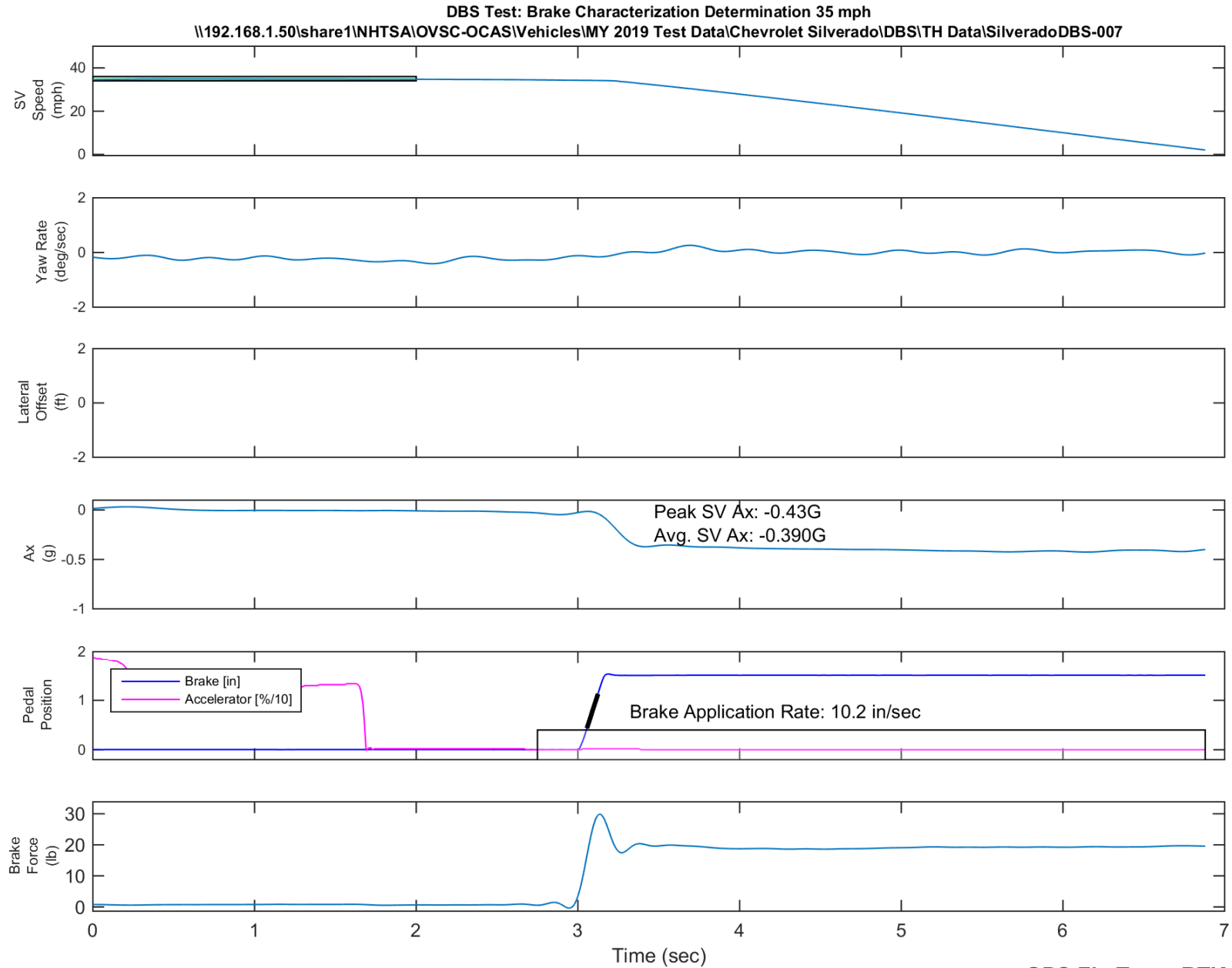
GPS Fix Type: RTK Fixed

Figure E60. Time History for DBS Run 5, Brake Characterization Determination 35 mph



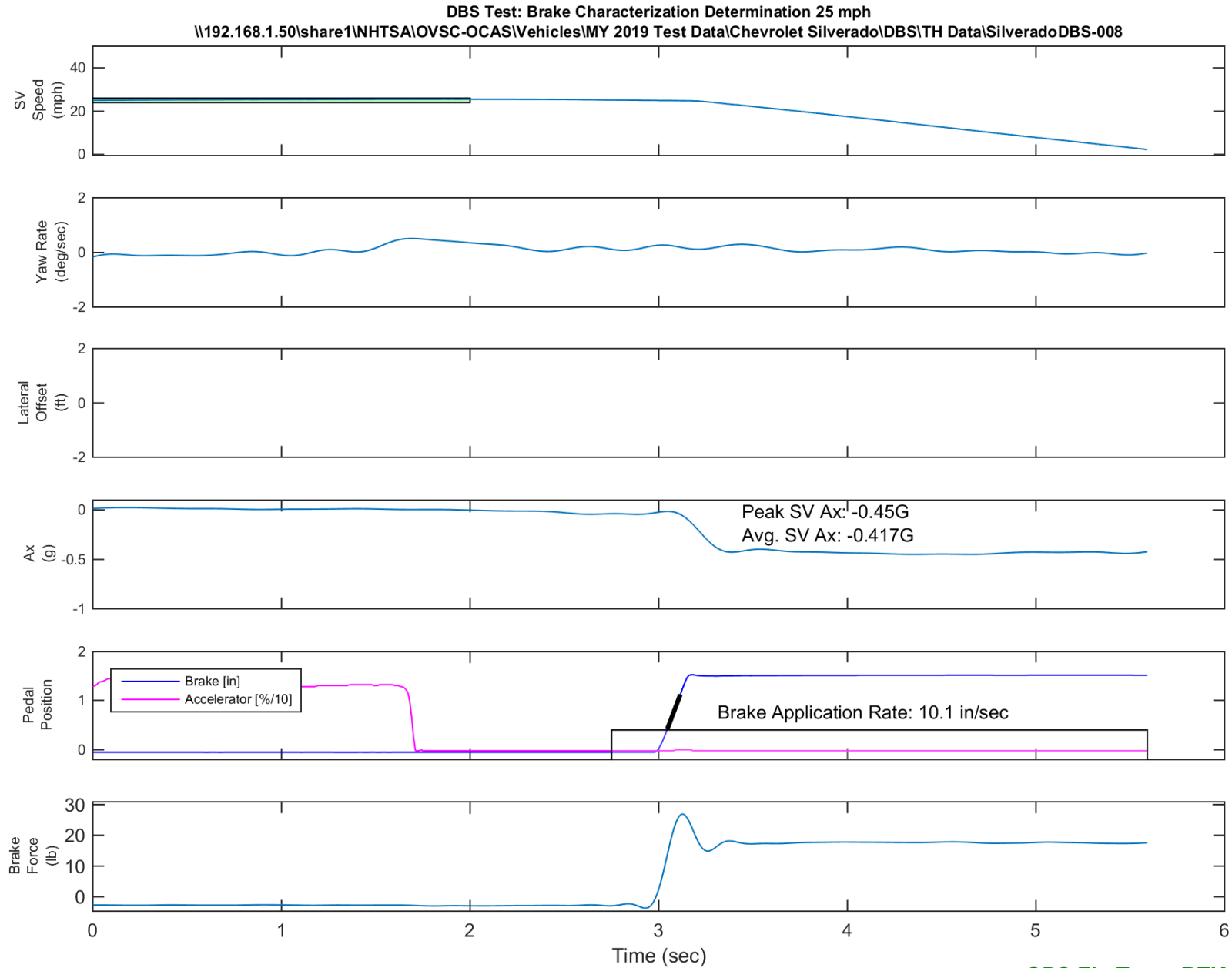
GPS Fix Type: RTK Fixed

Figure E61. Time History for DBS Run 6, Brake Characterization Determination 35 mph



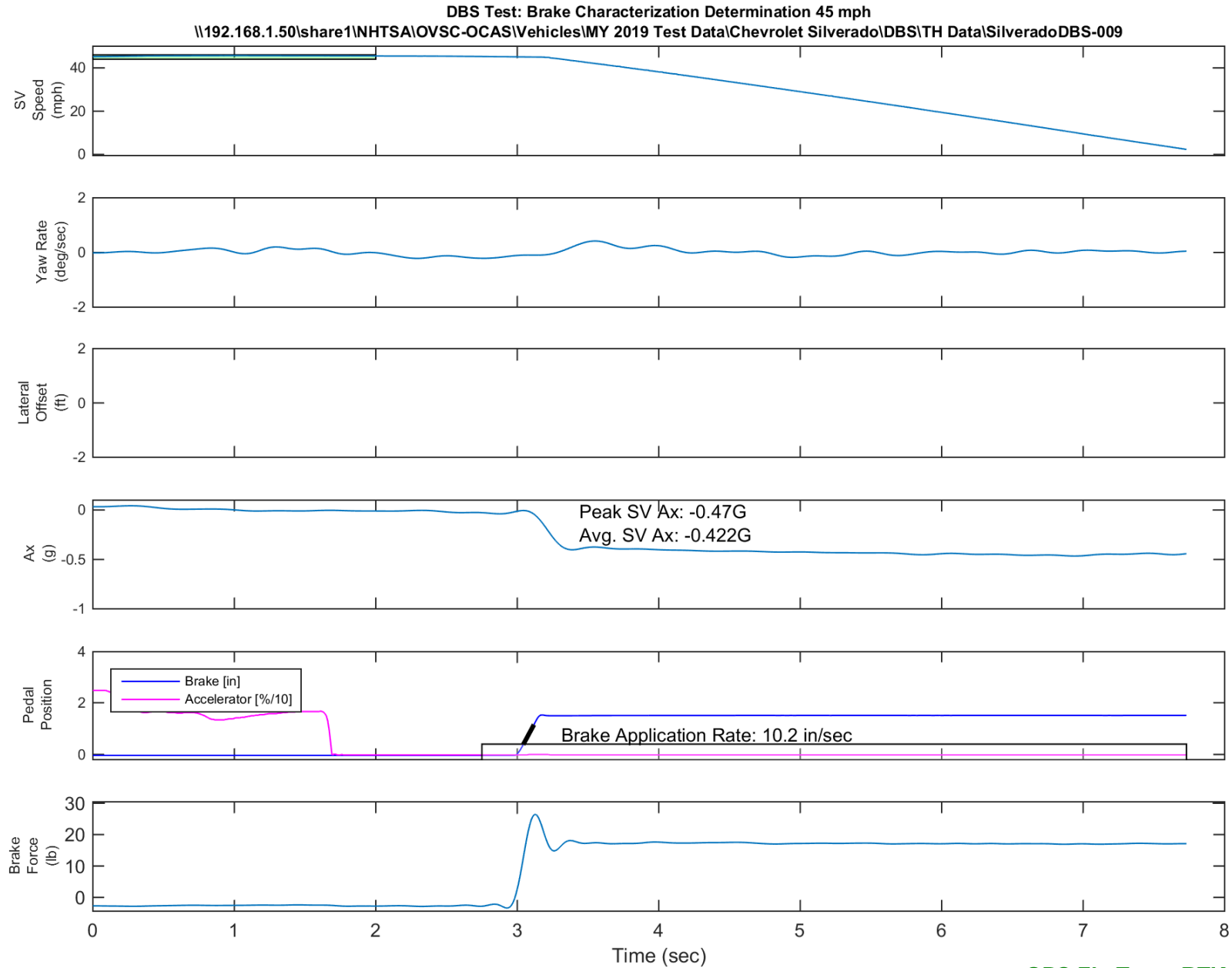
GPS Fix Type: RTK Fixed

Figure E62. Time History for DBS Run 7, Brake Characterization Determination 35 mph



GPS Fix Type: RTK Fixed

Figure E63. Time History for DBS Run 8, Brake Characterization Determination 25 mph



GPS Fix Type: RTK Fixed

Figure E64. Time History for DBS Run 9, Brake Characterization Determination 45 mph