OCAS-DRI-DBS-19-16
NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT CONFIRMATION TEST

2019 Mercedes-Benz S450

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8 May 2019

Final Report

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

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
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Washington, DC 20590

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16. Abstract These tests were conducted on the subject 2019 Mercedes-Benz S450 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 test for all four DBS test scenarios.		
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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 Mercedes-Benz S450. 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

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2019 Mercedes-Benz S450

SUMMARY RESULTS

VIN: *WDDUG6GB2KA4xxxx*

Test Date: *11/13/2018*

Test 1 - Subject Vehicle Encounters Stopped Principal Other Vehicle

SV 25 mph: *Pass*

Test 2 - Subject Vehicle Encounters Slower Principal Other Vehicle

SV 25 mph POV 10 mph: *Pass*

SV 45 mph POV 20 mph: *Pass*

Test 3 - Subject Vehicle Encounters Decelerating Principal Other Vehicle

SV 35 mph POV 35 mph: *Pass*

Test 4 - Subject Vehicle Encounters Steel Trench Plate

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: ***Pass***

Notes:

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

(Page 1 of 2)

2019 Mercedes-Benz S450

TEST VEHICLE INFORMATION

VIN: *WDDUG6GB2KA4xxxx*

Body Style: *Sedan* Color: *Diamond White Metallic*

Date Received: *11/2/2018* Odometer Reading: *42 mi*

Engine: *3 L V-6*

Transmission: *Automatic*

Final Drive: *RWD*

Is the vehicle equipped with:

ABS	X	Yes		No
Adaptive Cruise Control		Yes	X	No
Collision Mitigating Brake System	X	Yes		No

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Daimler AG Stuttgart*

Date of manufacture: *08/18*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *245/40R20*

Rear: *275/35R20*

Recommended cold tire pressure: Front: *260 kPa (37 psi)*

Rear: *290 kPa (42 psi)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

(Page 2 of 2)

2019 Mercedes-Benz S450

TIRES

Tire manufacturer and model: *Good Year Eagle F1*

Front tire size: *245/40/R20*

Rear tire size: *275/35R20*

VEHICLE ACCEPTANCE

Verify the following before accepting the vehicle:

__X__ All options listed on the "window sticker" are present on the test vehicle

__X__ Tires and wheel rims are the same as listed.

__X__ There are no dents or other interior or exterior flaws.

__X__ The vehicle has been properly prepared and is in running condition.

__X__ 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 Mercedes-Benz S450

GENERAL INFORMATION

Test date: *11/13/2018*

AMBIENT CONDITIONS

Air temperature: *22.8 C (73 F)*

Wind speed: *0.0 m/s (0.0 mph)*

X Windspeed ≤ 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: *260 kPa (37 psi)*

Rear: *290 kPa (42 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*579.7 kg (1278 lb)*	Right Front	*538.0 kg (1186 lb)*
Left Rear	*535.2 kg (1180 lb)*	Right Rear	*547.0 kg (1206 lb)*
		Total:	*2199.9 kg (4850 lb)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

2019 Mercedes-Benz S450

Name of the DBS option, option package, etc.: *Standard: Active Brake Assist*

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

Brake application mode used for test: *Hybrid control*

What is the speed range over which the DBS system Functions?

	Vehicles traveling in front	***Stationary vehicles***	***Crossing vehicles***	***Crossing pedestrians***	***Stationary pedestrians***
Vehicles without Driver Assistance package	*Up to approx. 155 mph (250 km/h)*	*Up to approx. 50 mph (80 km/h)*	*No reaction*	*Up to approx. 37 mph (60 km/h)*	*No reaction*
Vehicles with Driver Assistance package	*Up to approx. 155 mph (250 km/h)*	*Up to approx. 62 mph (100 km/h)*	*Up to approx. 43 mph (70 km/h)*	*Up to approx. 43 mph (70 km/h)*	*Up to approx. 43 mph (70 km/h)*

Does the vehicle system require an initialization sequence/procedure?

No, the system does not need an initialization sequence/procedure. The system is active after startup; the sensors are already calibrated in the End-Of-Line procedure before leaving the plant.

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

The driver receives a notification in the IC. The system should return back to normal function at the next ignition cycle after rectifying the issue.

How is the Forward Collision Warning presented to the driver?

(Check all that apply)

- X Warning light
- X Buzzer or audible alarm
- ___ Vibration
- ___ Other

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

2019 Mercedes-Benz S450

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

If Active Brake Assist has detected a risk of collision, a repeated beep warning tone sounds and the

distance warning lamp lights up in the instrument cluster. The warning tone will sound until the detected

risk of collision is no longer present.

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

______ No

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

The system can be turned off by navigating into the multimedia system and following the sequence:
Vehicle Assistance >
Active Brake Assist >
Off

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

______ No

If yes, please provide a full description.

Available Settings: Early, Medium, or Late.

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

2019 Mercedes-Benz S450

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

If yes, please provide a full description.

The system may be impaired or may not function in the following situations:

- *In snow, rain, fog, heavy spray, if there is glare, in direct sunlight or in greatly varying ambient light*
- *If the sensors are dirty, fogged up, damaged or covered*
- *If the sensors malfunction due to other radar source interference, for example strong radar reflections in parking garages*
- *If a loss of tire pressure or a defective tire has been detected and displayed*

The driver receives a notification in the IC. The system should return back to normal function at the next ignition cycle after rectifying the issue.

The system may not react correctly:

- *In complex traffic situations where objects cannot always be clearly identified.*
- *To pedestrians or vehicles if they move quickly into the sensor detection range.*
- *To pedestrians who are hidden by other objects.*
- *If the typical outline of a pedestrian cannot be distinguished from the background.*
- *If a pedestrian is not recognized as such, e.g. due to special clothing or other objects.*
- *On bends with a tight radius.*

Notes:

Section III
TEST PROCEDURES

A. TEST PROCEDURE OVERVIEW

Four test scenarios were used, as follows:

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

An overview of each of the test procedures follows.

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

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

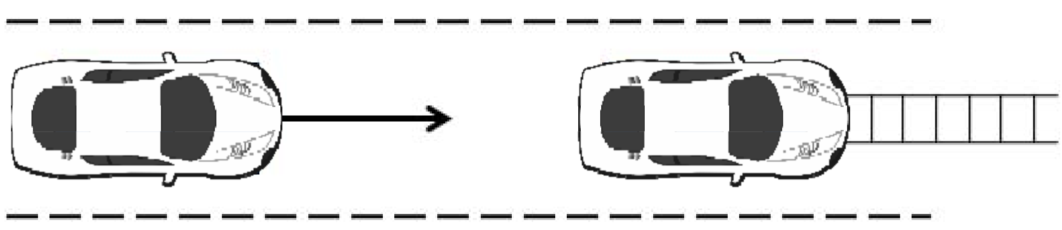


Figure 1. Depiction of Test 1

a. Procedure

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

The SV ignition was cycled prior to each test run. The SV was driven at a nominal speed of 25 mph (40.2 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.

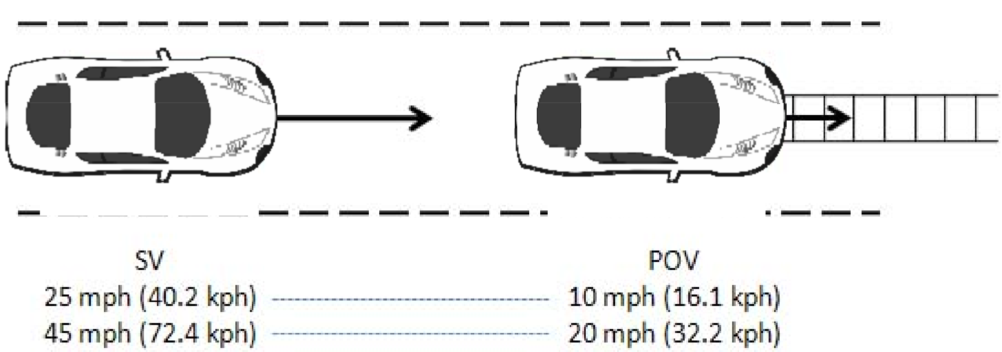


Figure 2. Depiction of Test 2

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.

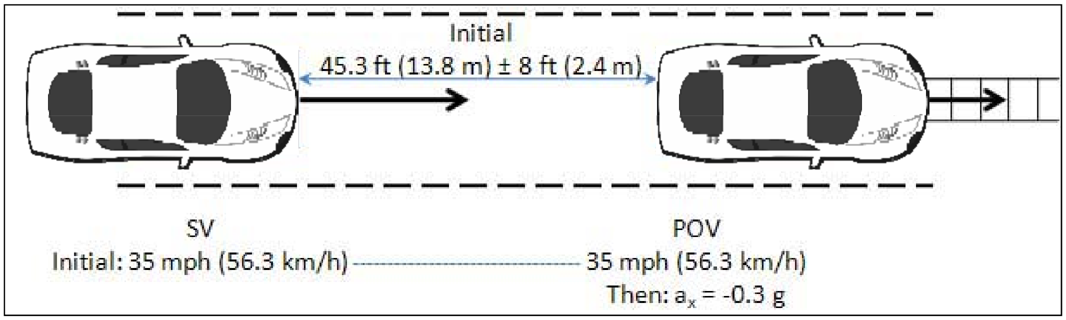


Figure 3. Depiction of Test 3 with POV Decelerating

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) ± 8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve 0.3 ± 0.03 g. The SV throttle pedal was released within 500 ms of $t_{FCW,}$ and the SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

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

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the POV and the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The headway between the SV and POV must have been constant from the onset of the applicable validity period to the onset of POV braking.
- The SV and POV speed could not deviate more than ±1.0 mph (1.6 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 ±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 → t_{FCW}	45 ft (14 m) → t_{FCW}	Within 500 ms of FCW1 onset	Varies	1.4	32 ft (10 m)

b. Criteria

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

4. 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 ± 5%
Tactile	5^{th}	3 dB	60 dB	Identified Center Frequency ± 20%

2. General Validity Criteria

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

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

3. Validity Period

The valid test interval began:

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

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

Test 3: 3 seconds before the onset of POV braking

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

The valid test interval ended:

Test 1: When either of the following occurred:

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

Tests 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 allows 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, in a two-stage manner, forward along the rail, 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	45050092	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; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2182	Date: 10/16/2017 Due: 10/16/2019
					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: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/4/2018 Due: 1/4/2019

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

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

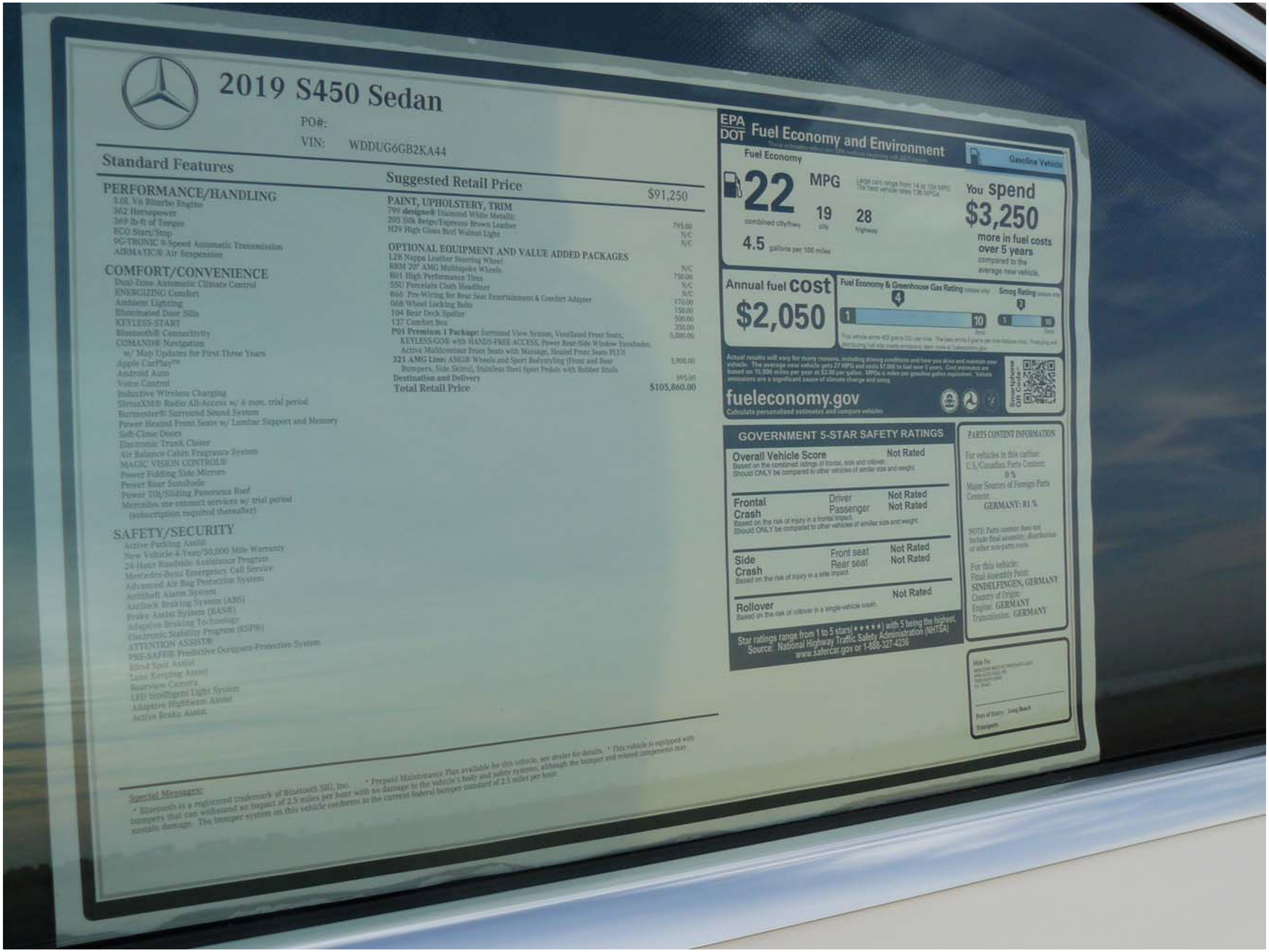


Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

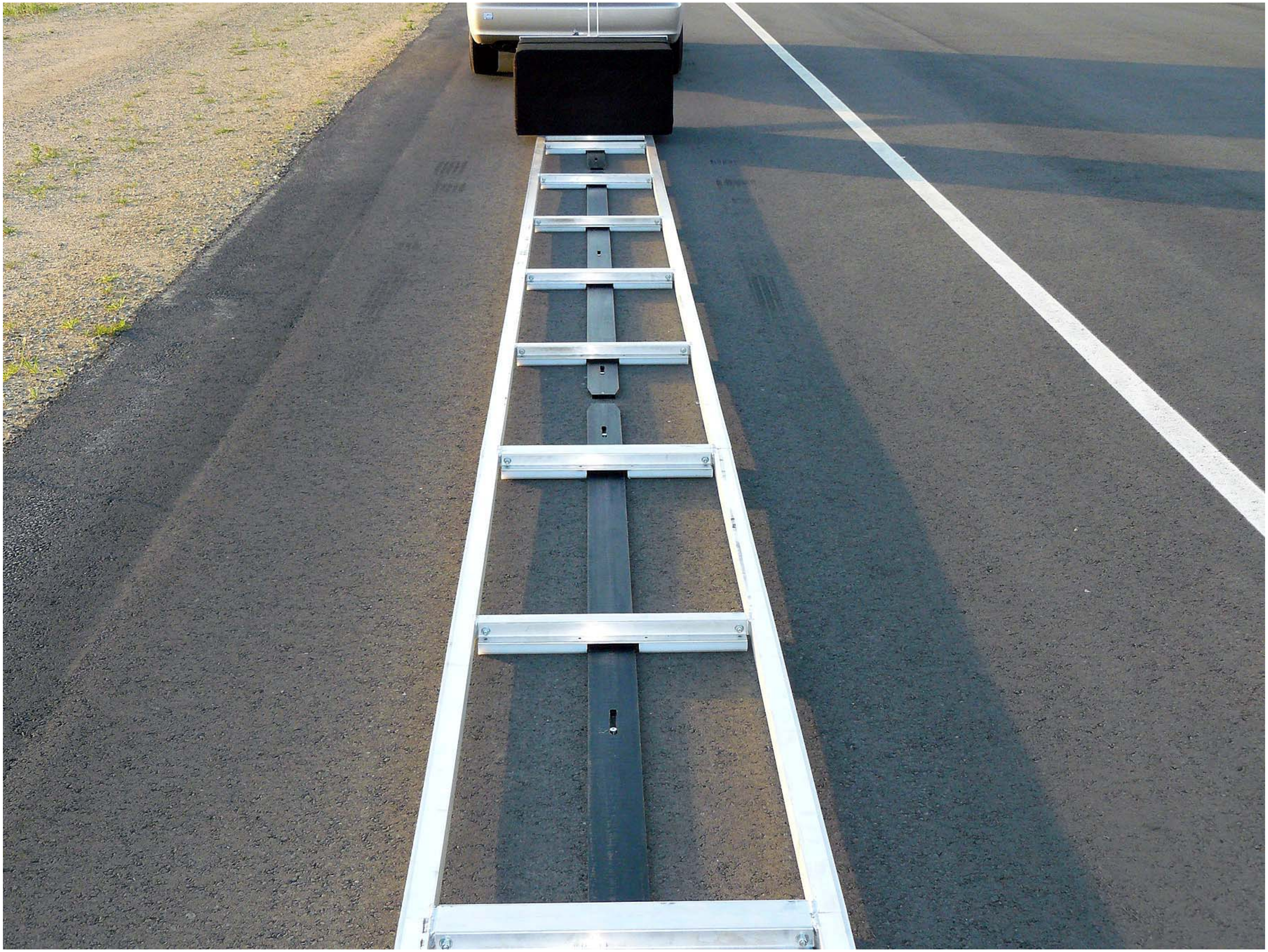


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. MicroAutoBox Installed in Subject Vehicle


Figure A12. Sensor for Detecting Auditory and Visual Alerts

Figure A13. Computer and Brake Actuator Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

Figure A15. AEB Visual Alert

Figure A16. AEB/FCW System Setting Controls

Figure A17. Menu Page for AEB Settings

APPENDIX B

Excerpts from Owner's Manual

Overview of driving systems and driving safety systems

In this section, you will find information about the following driving systems and driving safety systems:

- 360° Camera (→ page 228)
- ABS (**A**nti-lock **B**raking **S**ystem) (→ page 192)
- Active Distance Assist DISTRONIC (→ page 203)
- AIR BODY CONTROL (→ page 215)
- Active Brake Assist (→ page 196)
- Active Lane Keeping Assist (→ page 246)
- ATTENTION ASSIST (→ page 237)
- BAS (**B**rake **A**ssist **S**ystem) (→ page 192)
- Hill Start Assist (→ page 214)
- EBD (**E**lectronic **B**rakeforce **D**istribution) (→ page 196)
- ESP® (**E**lectronic **S**tability **P**rogram) (→ page 193)
- Active Speed Limit Assist (→ page 206)
- HOLD function (→ page 214)
- STEER CONTROL (→ page 196)
- Active Steering Assist (→ page 208)
- MAGIC BODY CONTROL (→ page 217)
- Night View Assist (→ page 240)
- Active Parking Assist (→ page 231)
- Parking Assist PARKTRONIC (→ page 222)
- Rear view camera (→ page 226)
- Cruise control (→ page 200)
- Blind Spot Assist and Active Blind Spot Assist (→ page 243)
- Traffic Sign Assist (→ page 239)

Function of ABS (Anti-lock Braking System)

ABS regulates the brake pressure in critical driving situations:

- During braking, e.g. at full brake application or insufficient tire traction, the wheels are prevented from locking.
- Vehicle steerability while braking is ensured.

If ABS intervenes when braking, you will feel a pulsing in the brake pedal. The pulsating brake pedal can be an indication of hazardous road conditions and can serve as a reminder to take extra care while driving.

System limitations

- ABS is active from speeds of approx. 5 mph (8 km/h).
- ABS may be impaired or may not function if a malfunction has occurred and the yellow ABS warning lamp lights up continuously in the instrument cluster after the engine is started.

Function of BAS (Brake Assist System)

⚠ **WARNING** Risk of an accident caused by a malfunction in BAS (Brake Assist System)

If BAS is malfunctioning, the braking distance in an emergency braking situation is increased.

▶ Depress the brake pedal with full force in emergency braking situations. ABS prevents the wheels from locking.

BAS supports your emergency braking situation with additional brake force.

If you depress the brake pedal quickly, BAS is activated:

- BAS automatically boosts the brake pressure.
- BAS can shorten the braking distance.
- ABS prevents the wheels from locking.

The brakes will function as usual once you release the brake pedal. BAS is deactivated.

Function of ESP® (Electronic Stability Program)

WARNING Risk of skidding if ESP® is malfunctioning

If ESP® is malfunctioning, ESP® cannot carry out vehicle stabilization. In addition, other driving safety systems are switched off.

▶ Drive on carefully.

▶ Have ESP® checked at a qualified specialist workshop.

WARNING Risk of skidding if ESP® is deactivated

If you deactivate ESP®, ESP® cannot carry out vehicle stabilization.

▶ ESP® should only be deactivated in the following situations.

Mercedes-AMG vehicles: observe the notes in the Supplement. Otherwise, you may not recognize dangers.

ESP® can monitor and improve driving stability and traction in the following situations, within physical limits:

- When pulling away on wet or slippery roadway.
- When braking.
- In strong side winds when you are driving faster than 50 mph (80 km/h).

If the vehicle deviates from the direction desired by the driver, ESP® can stabilize the vehicle by intervening in the following ways:

- One or more wheels are braked.
- The engine output is adapted according to the situation.

ESP® is deactivated if the ESP® OFF warning lamp lights up continuously in the instrument cluster:

- Driving stability will no longer be improved.
- Crosswind Assist is no longer active.
- The drive wheels could spin.
- ETS/4ETS traction control is still active.

125 mph (200 km/h) when driving straight ahead or cornering slightly.
- The vehicle is stabilized by means of individual brake application on one side.

Function of EBD (electronic brake force distribution)

EBD is characterized by the following:
- Monitoring and regulating the brake pressure on the rear wheels.
- Improved driving stability when braking, especially on bends.

Function of STEER CONTROL

STEER CONTROL helps you by transmitting a noticeable steering force to the steering wheel in the direction required for vehicle stabilization.

This steering recommendation is given particularly in the following situations:
- Both right wheels or both left wheels are on a wet or slippery road surface when you brake
- The vehicle starts to skid

System limitations

STEER CONTROL may be impaired or may not function in the following situations:
- ESP® is deactivated
- ESP® is malfunctioning
- The steering is malfunctioning

If ESP® is malfunctioning, you will be assisted further by the electric power steering.

Function of Active Brake Assist

Active Brake Assist consists of:
- Distance warning function
- Autonomous braking function
- Situation-dependent braking assistance
- **Vehicles with Driving Assistance Package:** Evasive Steering Assist

Active Brake Assist can help you to minimize the risk of a collision with vehicles or pedestrians or to reduce the effects of such a collision.

If Active Brake Assist has detected a risk of collision, a warning tone sounds and the distance warning lamp lights up in the instrument cluster.

If you do not react to the warning, autonomous braking can be initiated in critical situations.

In especially critical situations, Active Brake Assist can initiate autonomous braking directly. In this case, the warning lamp and warning tone occur simultaneously with the braking application.

If you apply the brake yourself in a critical situation or apply the brake during autonomous braking, situation-dependent braking assistance occurs. This increases the brake pressure up to maximum full-stop braking if necessary.

If the autonomous braking function or the situation-dependent braking assistance is triggered, additional preventive measures for occupant protection (PRE-SAFE®) may also be initiated, if the vehicle is equipped with these.

WARNING Risk of an accident caused by limited detection performance of Active Brake Assist

Active Brake Assist cannot always clearly identify objects and complex traffic situations.

In such cases, Active Brake Assist might:

- Give a warning or brake without reason
- Not give a warning or not brake

▶ Always pay careful attention to the traffic situation; do not rely on Active Brake Assist alone. Active Brake Assist is only an aid. The driver is responsible for maintaining a suitable distance to the vehicle in front, vehicle speed and for braking in good time.

▶ Be prepared to brake or swerve if necessary.

Also observe the system limitations of Active Brake Assist.

The individual subfunctions are available in the following speed ranges:
Distance warning function

The distance warning function issues a warning at speeds:

- From approximately 4 mph (7 km/h), if your vehicle is critically close to a vehicle or pedestrian. An intermittent warning tone sounds and the distance warning lamp lights up in the instrument cluster.

Brake immediately or take evasive action, provided it is safe to do so and the traffic situation allows this.

The distance warning function can aid you in the following situations with an intermittent warning tone and a warning lamp:

	Vehicles traveling in front	Stationary vehicles	Crossing vehicles	Moving pedestrians	Stationary pedestrians
Vehicles without Driving Assistance package	Up to approx. 155 mph (250 km/h)	Up to approx. 50 mph (80 km/h)	No reaction	Up to approx. 50 mph (80 km/h)	No reaction
Vehicles with Driving Assistance package	Up to approx. 155 mph (250 km/h)	Up to approx. 62 mph (100 km/h)	Up to approx. 43 mph (70 km/h)	Up to approx. 50 mph (80 km/h)	Up to approx. 43 mph (70 km/h)

Autonomous braking function
The autonomous braking function may intervene at speeds starting from approximately 4 mph (7 km/h) in the following situations:

	Vehicles traveling in front	Stationary vehicles	Crossing vehicles	Crossing pedestrians	Stationary pedestrians
Vehicles without Driving Assistance package	Up to approx. 124 mph (200 km/h)	Up to approx. 31 mph (50 km/h)	No reaction	Up to approx. 37 mph (60 km/h)	No reaction
Vehicles with Driving Assistance package	Up to approx. 155 mph (250 km/h)	Up to approx. 62 mph (100 km/h)	Up to approx. 43 mph (70 km/h)	Up to approx. 43 mph (70 km/h)	Up to approx. 43 mph (70 km/h)

Situation-dependent braking assistance
Situation-dependent braking assistance may intervene at speeds starting from approximately 4 mph (7 km/h) in the following situations:

	Vehicles traveling in front	Stationary vehicles	Crossing vehicles	Crossing pedestrians	Stationary pedestrians
Vehicles without Driving Assistance package	Up to approx. 155 mph (250 km/h)	Up to approx. 50 mph (80 km/h)	No reaction	Up to approx. 37 mph (60 km/h)	No reaction
Vehicles with Driving Assistance package	Up to approx. 155 mph (250 km/h)	Up to approx. 62 mph (100 km/h)	Up to approx. 43 mph (70 km/h)	Up to approx. 43 mph (70 km/h)	Up to approx. 43 mph (70 km/h)

Canceling a brake application of Active Brake Assist

You can cancel a brake application of Active Brake Assist at any time by:

- Depressing the accelerator pedal fully.
- Releasing the brake pedal.

Active Brake Assist may cancel the brake application when one of the following conditions is fulfilled:

- You maneuver to avoid the obstacle.
- There is no longer a risk of collision.
- An obstacle is no longer detected in front of your vehicle.

Evasive Steering Assist (only vehicles with Driving Assistance Package)

Evasive Steering Assist has the following characteristics:

- Can detect stationary or crossing pedestrians.
- Can assist the driver with additional steering assistance if it detects a swerving maneuver.
- Can be activated by an abrupt steering movement during a swerving maneuver.
- Can assist during swerving and straightening of the vehicle.
- Can react from a speed of approximately 12 mph (20 km/h) up to a speed of approximately 43 mph (70 km/h).
- You can prevent the assistance at any time by actively steering.

⚠ **WARNING** Risk of an accident despite Evasive Steering Assist

Evasive Steering Assist cannot always clearly identify objects and complex traffic situations.

In addition, the steering support of Evasive Steering Assist is generally not sufficient to avoid a collision.

In such cases Evasive Steering Assist can:

- give an unnecessary warning or provide assistance
- not give a warning or not provide assistance

▶ Always pay careful attention to the traffic situation; do not rely on Evasive Steering Assist alone.

▶ Be ready to brake and take evasive action if necessary.

▶ Prevent the assistance by actively steering in non-critical driving situations.

▶ Drive at an appropriate speed if pedestrians are close to the path of your vehicle.

Also observe the system limitations of Evasive Steering Assist.

System limitations

The system may be impaired or may not function in the following situations:

- In snow, rain, fog, heavy spray, if there is glare, in direct sunlight or in greatly varying ambient light.
- If the sensors are dirty, fogged up, damaged or covered.

- If the sensors malfunction due to other radar source interference, for example strong radar reflections in parking garages.
- If a loss of tire pressure or a defective tire has been detected and displayed.

The system may not react correctly:

- In complex traffic situations where objects cannot always be clearly identified.
- To pedestrians or vehicles if they move quickly into the sensor detection range.
- To pedestrians who are hidden by other objects.
- If the typical outline of a pedestrian cannot be distinguished from the background.
- If a pedestrian is not recognized as such, e.g. due to special clothing or other objects.
- On bends with a tight radius.

Setting Active Brake Assist

Multimedia system:

Vehicle ▸▸ Assistance ▸▸ Active Brake Assist

Vehicles without Driving Assistance Package: The settings can be made after starting the vehicle.

Vehicles with Driving Assistance Package: The settings can be made when the ignition is switched on.

The following settings are available:

- Early
- Medium
- Late

▶ Select a setting.

ⓘ Your selection is retained when the vehicle is next started.

Deactivating Active Brake Assist

ⓘ It is recommended that you always leave Active Brake Assist activated.

▶ Select Off.
The distance warning function and the autonomous braking function are deactivated.

Vehicles without Driving Assistance Package: When the vehicle is next started, the medium setting is automatically selected.

Vehicles with Driving Assistance Package: Evasive Steering Assist is not available. When the ignition is next started, the medium setting is selected automatically and Evasive Steering Assist is available.

ⓘ If Active Brake Assist is deactivated, the symbol appears in the status bar of the multifunction display.

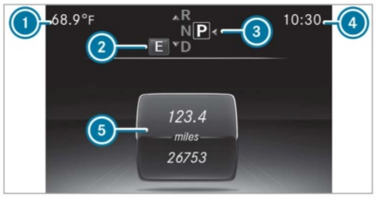
Speed control cruise control

Function of cruise control

Cruise control regulates the speed to the value selected by the driver.

If you accelerate to overtake, for example, the stored speed is not deleted. If you remove your foot from the accelerator pedal after overtaking,

Overview of displays on the multifunction display



1. Outside temperature
2. Drive program
3. Transmission position
4. Time
5. Display section

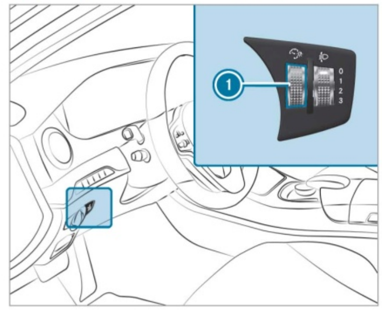
ⓘ **Vehicles with an Instrument Display in the Widescreen Cockpit:** the position of the displays will differ from those displayed here.

Further displays on the multifunction display:

- Gearshift recommendation (→ page 179)
- Active Parking Assist activated (→ page 233)
- Parking Assist PARKTRONIC deactivated (→ page 225)
- Cruise control (→ page 200)
- Active Distance Assist DISTRONIC (→ page 203)
- Active Brake Assist(→ page 200)
- Active Steering Assist(→ page 208)
- Active Lane Keeping Assist(→ page 246)
- Active Lane Change Assist(→ page 210)
- HOLD function (→ page 214)
- Adaptive Highbeam Assist (→ page 148)

Vehicles with Traffic Sign Assist: Detected instructions and traffic signs (→ page 239).

Adjusting the instrument lighting



▶ Turn brightness control 1 up or down. The lighting of the Instrument Display and in the control elements of the vehicle interior is adjusted.

Menus and submenus

Functions on the Service menu of the on-board computer

On-board computer:

→ Service

▶ **To select the function:** swipe upwards or downwards on the left-hand Touch Control.

▶ Press the left-hand Touch Control.

Functions in the Service menu:

- Message memory (→ page 478)
- Tires:
  - Checking the tire pressure with the tire pressure monitoring system (→ page 440)
  - Restarting the tire pressure monitoring system (→ page 441)
- ASSYST PLUS: calling up the service due date (→ page 395)

Calling up the assistant display

On-board computer:

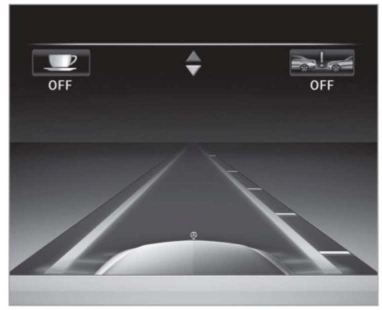
→ Assistance

ⓘ When you have set the style to Classic, you can view the assistant display menu contents in the left-hand portion of the Instrument Display.

The following displays are available on the assistant display menu:

- Assistant display
- Attention level (→ page 237)

▶ **To switch between the displays:** swipe upwards or downwards on the left-hand Touch Control.



Status displays on the assistant display:

- OFF: ATTENTION ASSIST deactivated
- OFF: Active Brake Assist deactivated
- Light lane markings: Active Lane Keeping Assist activated
- Green lane markings: Active Lane Keeping Assist active

Display messages	Possible causes/consequences and ▶ Solutions
Active Brake Assist Functions Limited See Operator's Manual	* **Vehicles with Driving Assistance Package:** Active Brake Assist with cross-traffic function, Evasive Steering Assist or PRE-SAFE® PLUS is malfunctioning. **Vehicles without Driving Assistance Package:** Active Brake Assist is malfunctioning. ▶ Visit a qualified specialist workshop.
Active Brake Assist Functions Currently Limited See Operator's Manual	* **Vehicles with the Driving Assistance Package:** Active Brake Assist with cross-traffic function, Evasive Steering Assist or PRE-SAFE® PLUS are temporarily unavailable or only partially available. **Vehicles without the Driving Assistance package:** Active Brake Assist is temporarily unavailable. The ambient conditions are outside the system limits . ▶ Drive on. As soon as the ambient conditions are within the system limits, the system will become available again. ▶ If the display message does not disappear, stop the vehicle while paying attention to road and traffic conditions and restart the engine.
PRE-SAFE Inoperative See Operator's Manual	* PRE-SAFE® functions are malfunctioning. ▶ Visit a qualified specialist workshop.
Mercedes me connect Services Limited See Operator's Manual	* Service limited. At least one of the main functions of the Mercedes me connect system is malfunctioning. ▶ Observe the notes on the diagnostics connection (→ page 23). ▶ Visit a qualified specialist workshop.

APPENDIX C

Run Log

Subject Vehicle: **2019 Mercedes-Benz S450** Test Date: 11/13/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-15	**Brake characterization and confirmation**						See Appendix D
16	Static Run						
17	**Stopped POV**	N					Brake Force ramp too slow
18		Y	2.41	8.68	0.92	Pass	
19		N					Never reaches desired force
20		N					Displacement = 1.45 after check run
21		N					Brake Force drop off rate changed to 90 lb/s
22		Y	2.43	8.78	0.94	Pass	
23		Y	2.49	6.51	0.98	Pass	
24		Y	2.52	7.36	0.96	Pass	
25		N					SV speed
26		Y	2.38	9.27	0.97	Pass	
27		Y	2.44	8.39	0.85	Pass	
28		Y	2.39	16.44	1.06	Pass	
29	Static Run						

Subject Vehicle: **2019 Mercedes-Benz S450** Test Date: 11/13/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
30	**Slower POV, 25 vs 10**	Y	2.69	11.80	1.07	Pass	CIB onset before DBS
31		Y	2.47	12.60	1.04	Pass	CIB onset before DBS
32		Y	2.40	12.15	1.05	Pass	CIB onset before DBS
33		Y	2.41	12.13	1.03	Pass	CIB onset before DBS
34		N					POV speed
35		Y	2.40	11.96	1.09	Pass	CIB onset before DBS
36		Y	2.42	12.09	1.07	Pass	CIB onset before DBS
37		Y	2.37	12.05	1.03	Pass	CIB onset before DBS
38	Static run						
							Brake Force = 16.0 lbs after check runs
39	**Slower POV, 45 vs 20**	Y	2.92	14.24	1.13	Pass	CIB onset before DBS
40		Y	2.96	13.93	1.10	Pass	CIB onset before DBS
41		Y	2.89	14.11	1.10	Pass	CIB onset before DBS
42		N					Throttle
43		Y	2.97	14.14	1.12	Pass	CIB onset before DBS
44		Y	2.88	13.73	1.09	Pass	CIB onset before DBS
45		Y	2.92	14.17	1.11	Pass	CIB onset before DBS
46		Y	2.96	8.28	0.95	Pass	

Subject Vehicle: **2019 Mercedes-Benz S450** Test Date: 11/13/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
47	Static run						
48	**Braking POV, 35**	Y	2.02	4.35	1.13	Pass	CIB onset before DBS
49		Y	1.94	5.30	1.09	Pass	CIB onset before DBS
50		Y	1.91	7.21	1.10	Pass	CIB onset before DBS
51		Y	1.96	18.46	0.95	Pass	No Brake Prime
52		Y	2.00	2.74	1.13	Pass	
53		Y	2.05	6.17	1.13	Pass	CIB onset before DBS
54		N					SV Speed
55		N					Yaw Rate
56		Y	1.90	14.97	0.75	Pass	
57	Static run						
58	STP - Static run						
59	**Baseline, 25**	Y			0.49		
60		Y			0.49		
61		Y			0.49		
62		Y			0.49		
63	Baseline, 25	Y			0.48		

Subject Vehicle: **2019 Mercedes-Benz S450** Test Date: 11/13/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
64		Y			0.51		
65		Y			0.47		
66	STP - Static run						
67	**Baseline, 45**	N					Throttle
68		Y			0.45		
69		Y			0.46		
70		Y			0.52		
71		Y			0.47		
72		N					SV Speed
73		Y			0.52		
74		Y			0.53		
75		Y			0.52		
76	STP - Static run						
77	**STP False Positive, 25**	Y			0.43	Pass	
78		Y			0.46	Pass	
79		Y			0.46	Pass	

Subject Vehicle: **2019 Mercedes-Benz S450** Test Date: 11/13/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
80	**STP False Positive, 25**	Y			0.46	Pass	
81		Y			0.46	Pass	
82		Y			0.46	Pass	
83		Y			0.45	Pass	
84	STP - Static run						
85	**STP False Positive, 45**	Y			0.44	Pass	
86		Y			0.48	Pass	
87		Y			0.42	Pass	
88		Y			0.46	Pass	
89		Y			0.46	Pass	
90		Y			0.46	Pass	
91		Y			0.45	Pass	
92	STP - Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2019 Mercedes-Benz S450** Test Date: 11/13/2018

DBS Initial Brake Characterization				
Run Number	**Stroke at 0.4 g (in)**	**Force at 0.4 g (lb)**	**Slope**	**Intercept**
1	1.606807	22.38266	0.94177	-0.16996
3	1.635118	22.02155	1.03337	-0.13829
4	1.612136	21.72424	1.003347	-0.31917

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	N					
6			Y	0.452	1.62		1.43	
7			Y	0.395	1.50		1.52	
8		25	Y	0.405	1.50		1.48	
9		45	Y	0.385	1.50		1.56	
10	**Hybrid**	35	Y	0.533	1.50	21.72	16.30	
11		35	Y	0.418	1.50	15.00	14.35	
12		25	Y	0.436	1.50	15.00	13.76	
13		25	Y	0.378	1.50	14.00	14.81	
14		45	Y	0.357	1.50	14.00	15.69	
15			Y	0.398	1.50	15.50	15.58	

Appendix E

TIME HISTORY PLOTS

LIST OF FIGURES

Description of Time History Plots

A set of time history plots is provided for each valid run in the test series. Each set of plots comprises time varying data from both the Subject Vehicle (SV) and the Principal Other Vehicle (POV), as well as pass/fail envelopes and thresholds. 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 (in) – position of the accelerator pedal and brake pedal.

- 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 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 plot indicating the Ax, 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). A green circle or red asterisk is displayed at the moment the POV brake level achieves 0.27g. A green circle indicates that the test was valid (the threshold was crossed during the appropriate interval) and a red asterisk indicates that the test was invalid (the threshold was crossed out of the appropriate interval).

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

For the brake force plot, a dashed black threshold line indicating a brake force of 2.5 lbs is given. 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.

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

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.

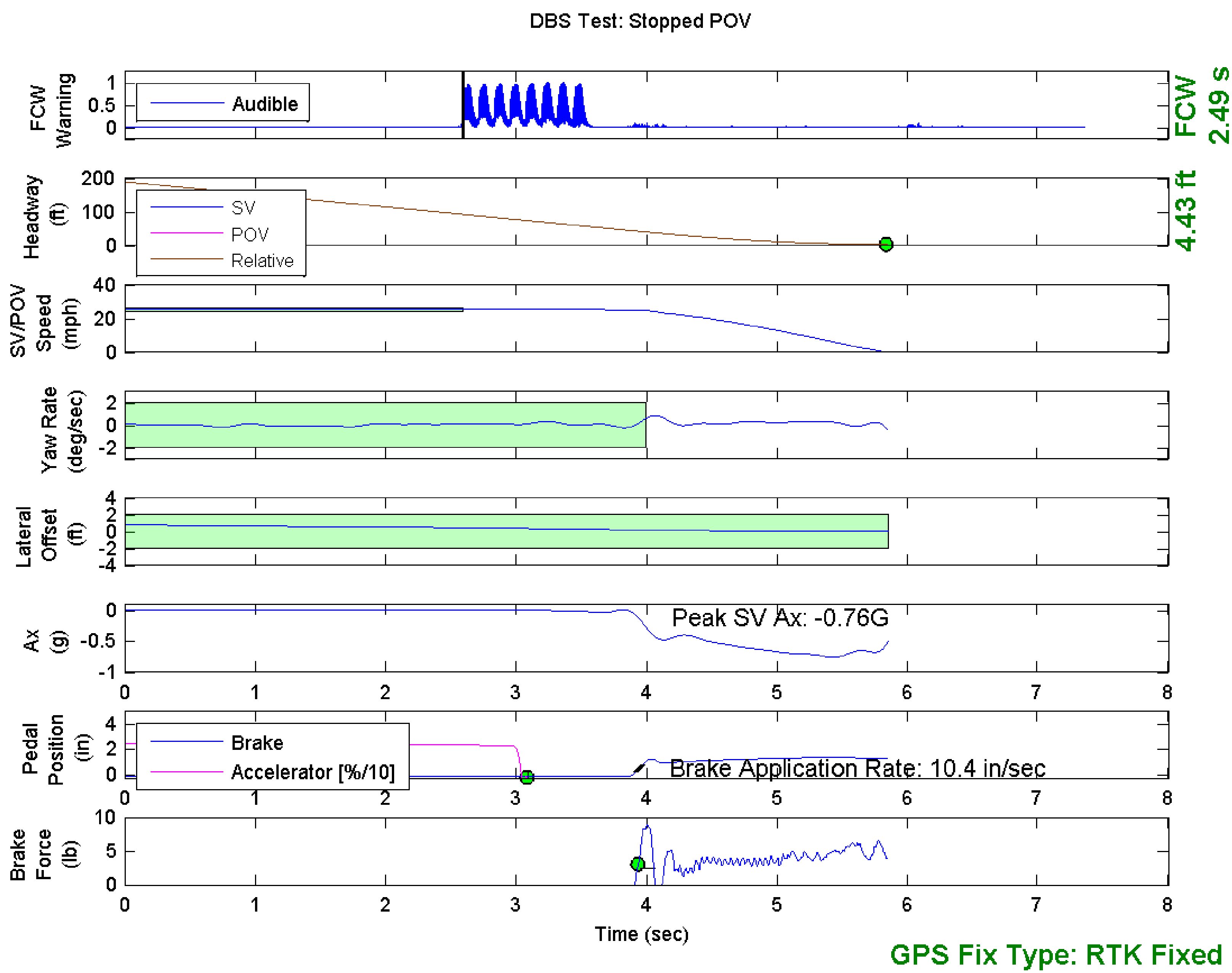


Figure E1. Example Time History for Stopped POV, Passing

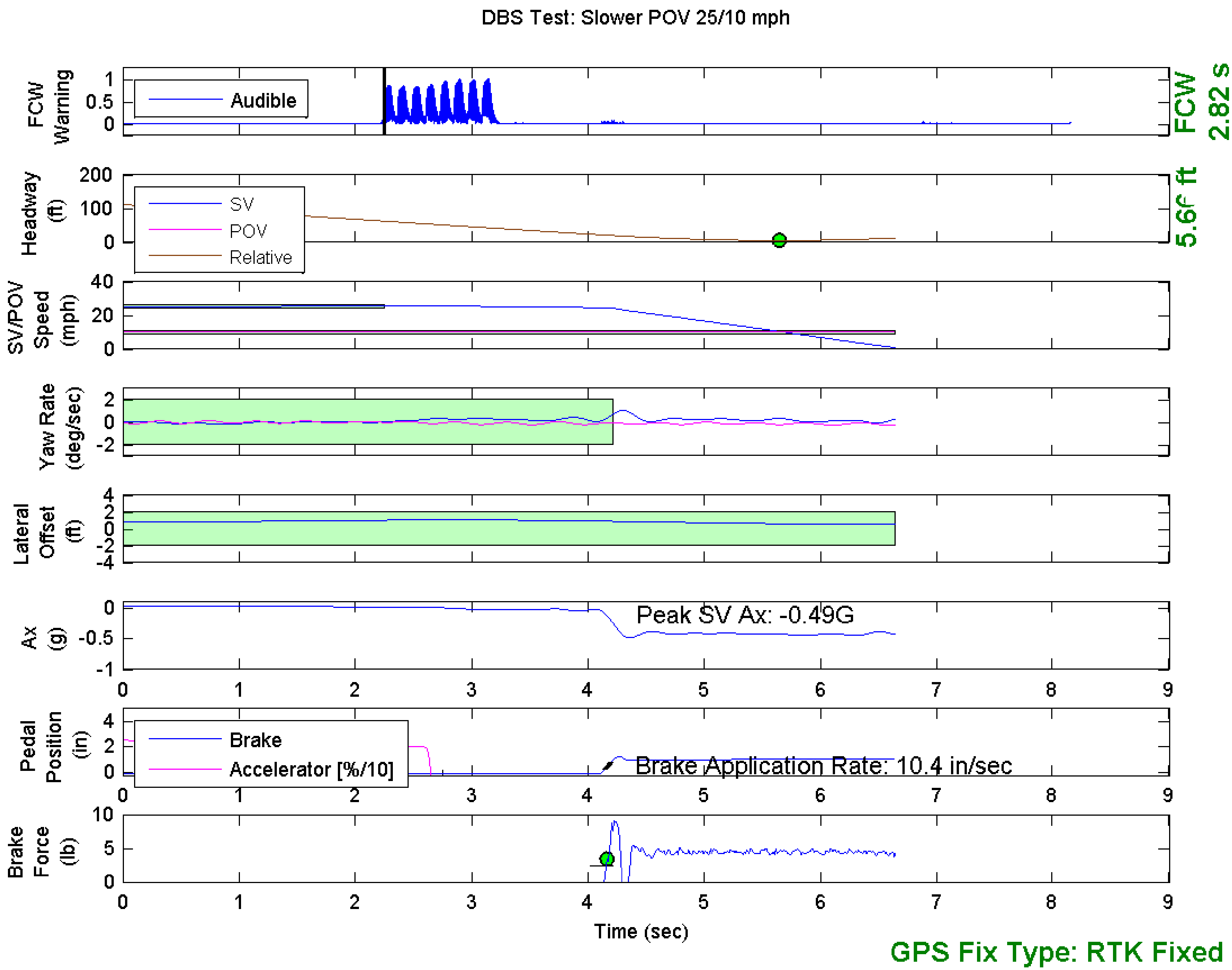


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

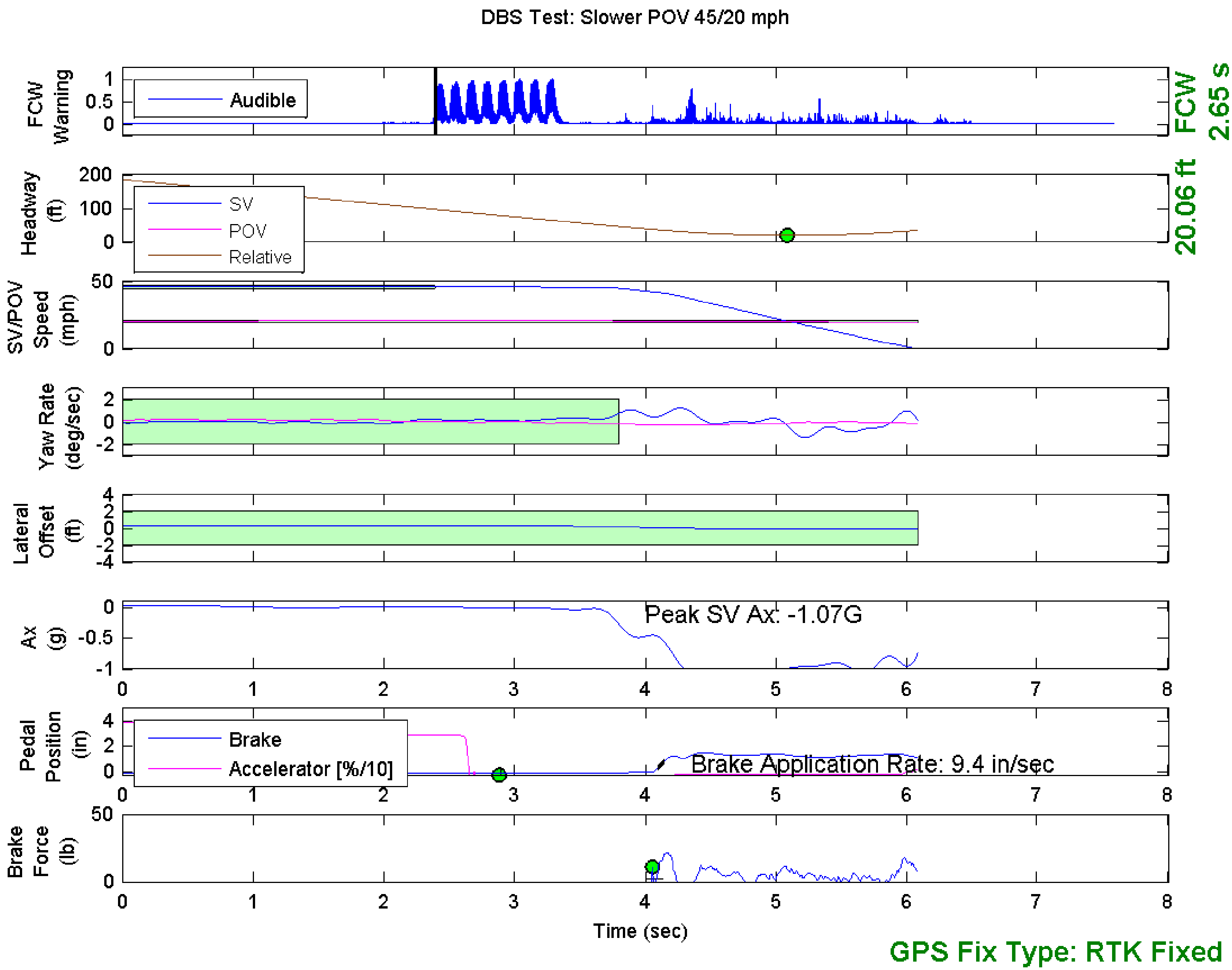


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

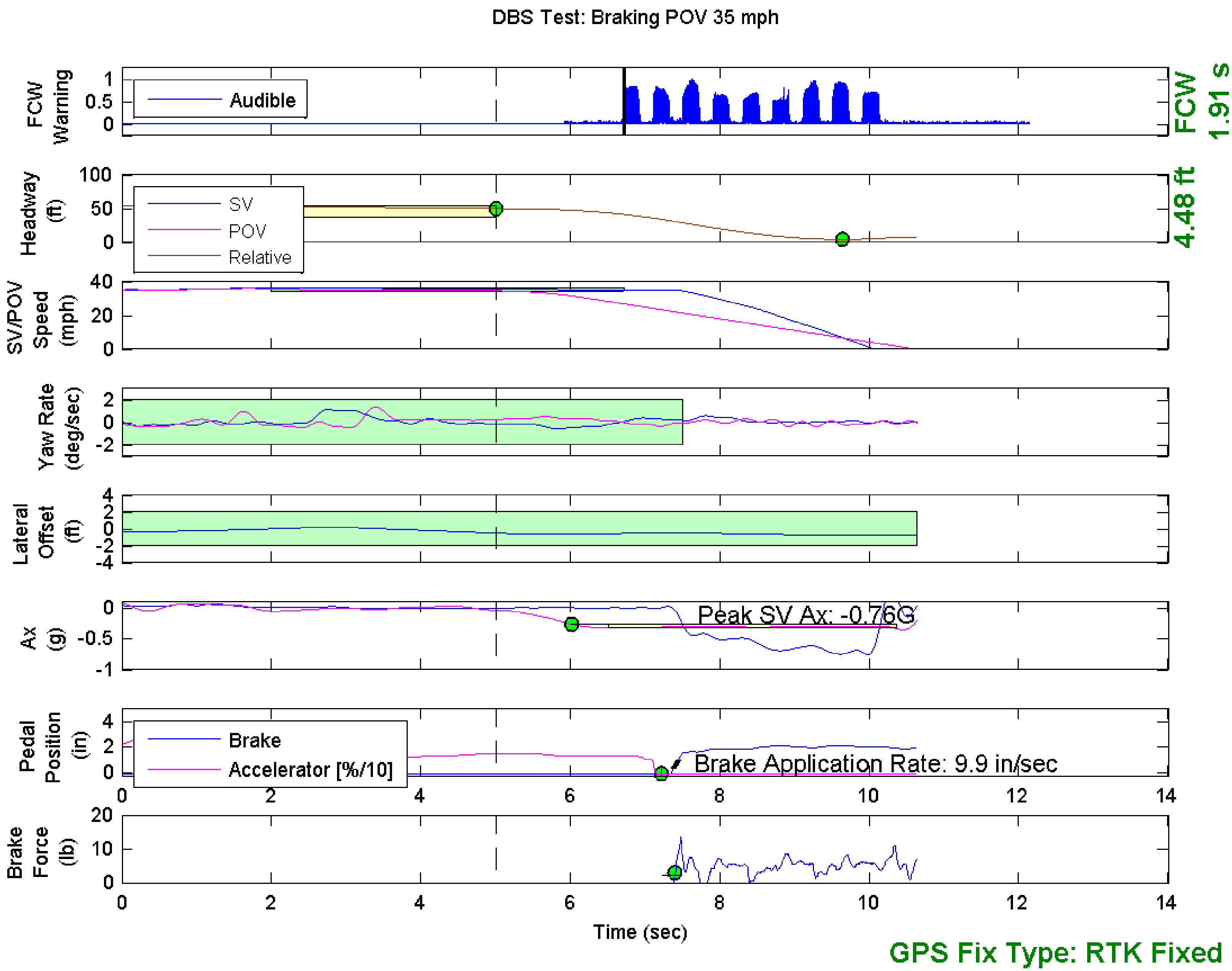


Figure E4. Example Time History for Braking POV 35, Passing

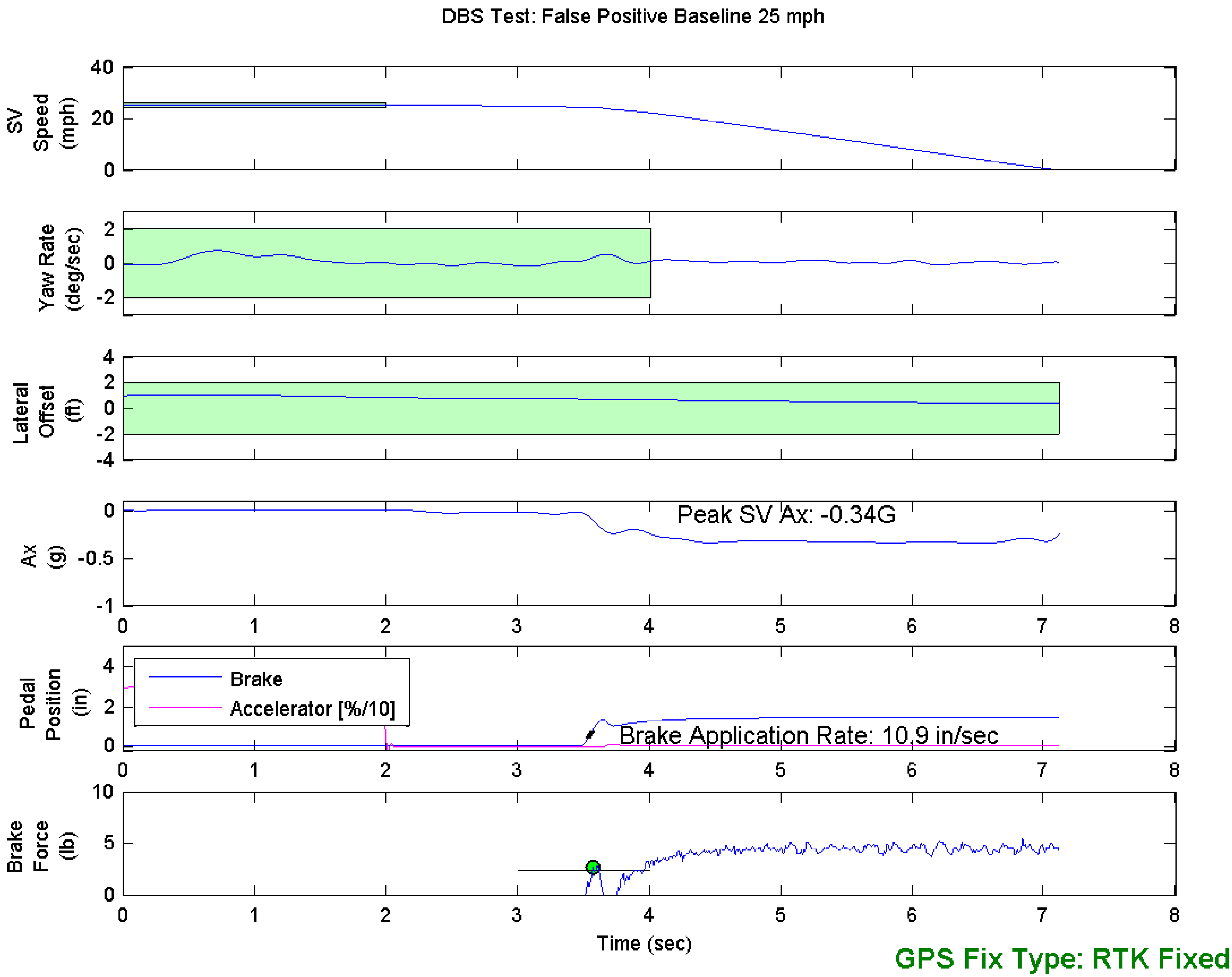


Figure E5. Example Time History for False Positive Baseline 25, Passing

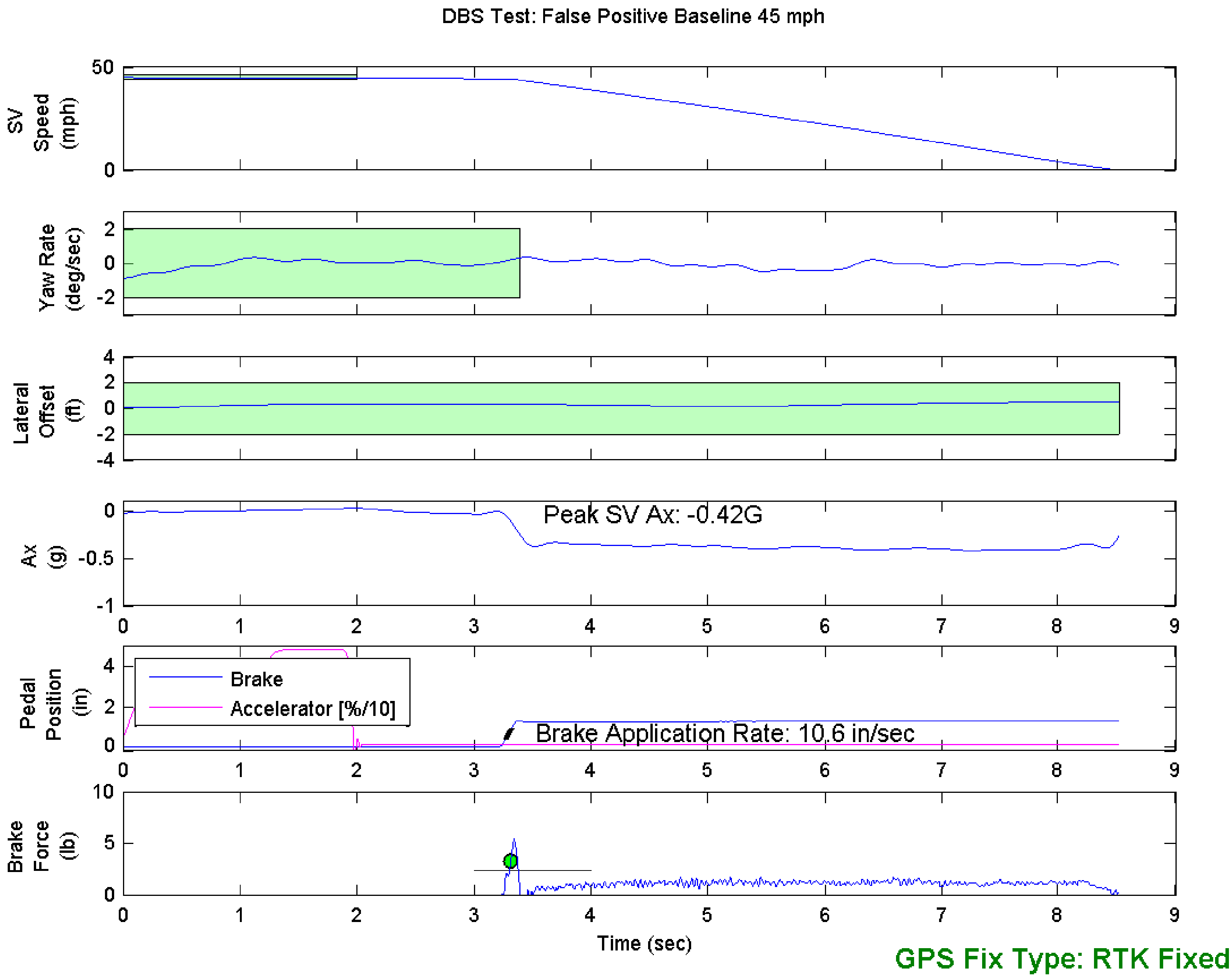


Figure E6. Example Time History for False Positive Baseline 45, Passing

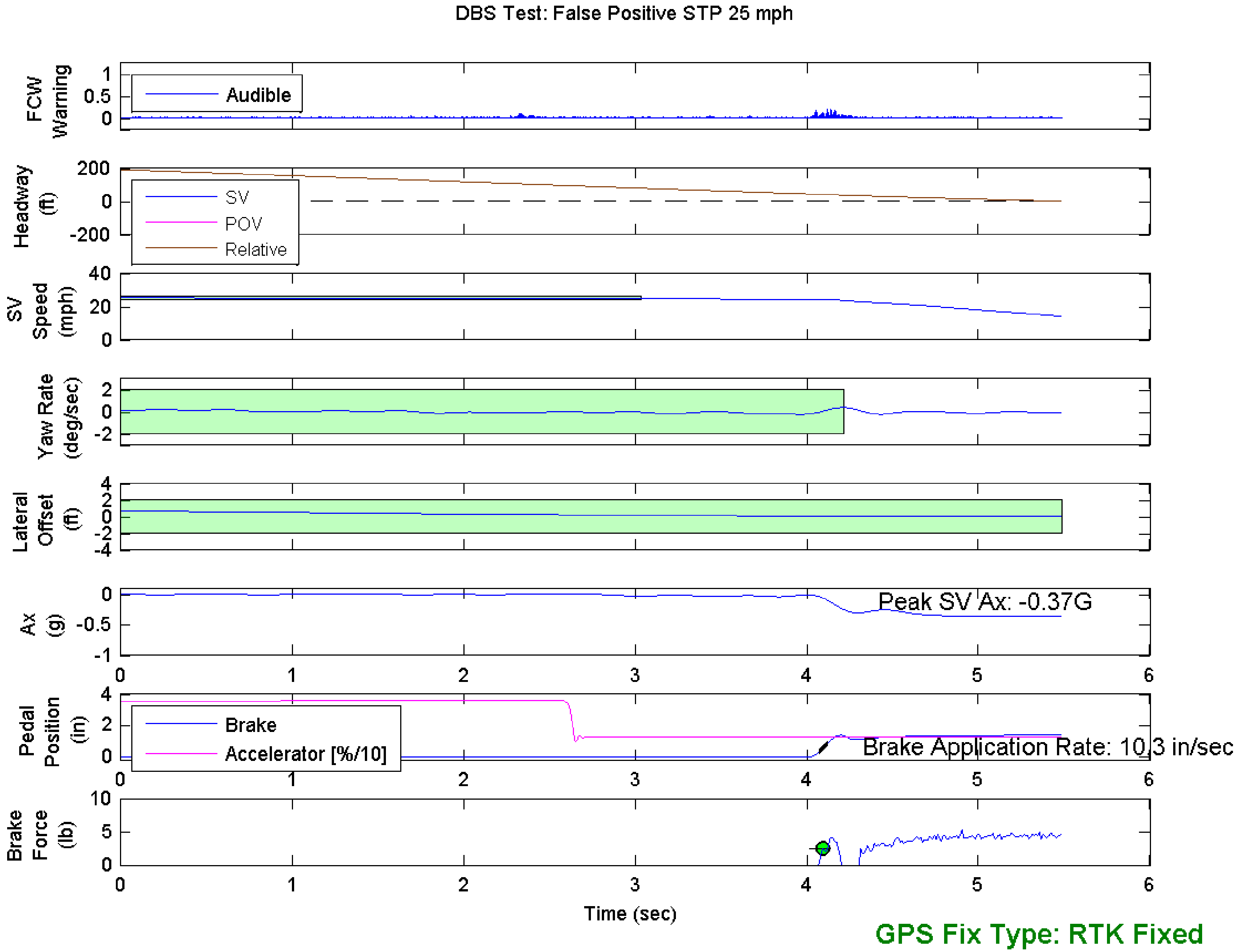


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

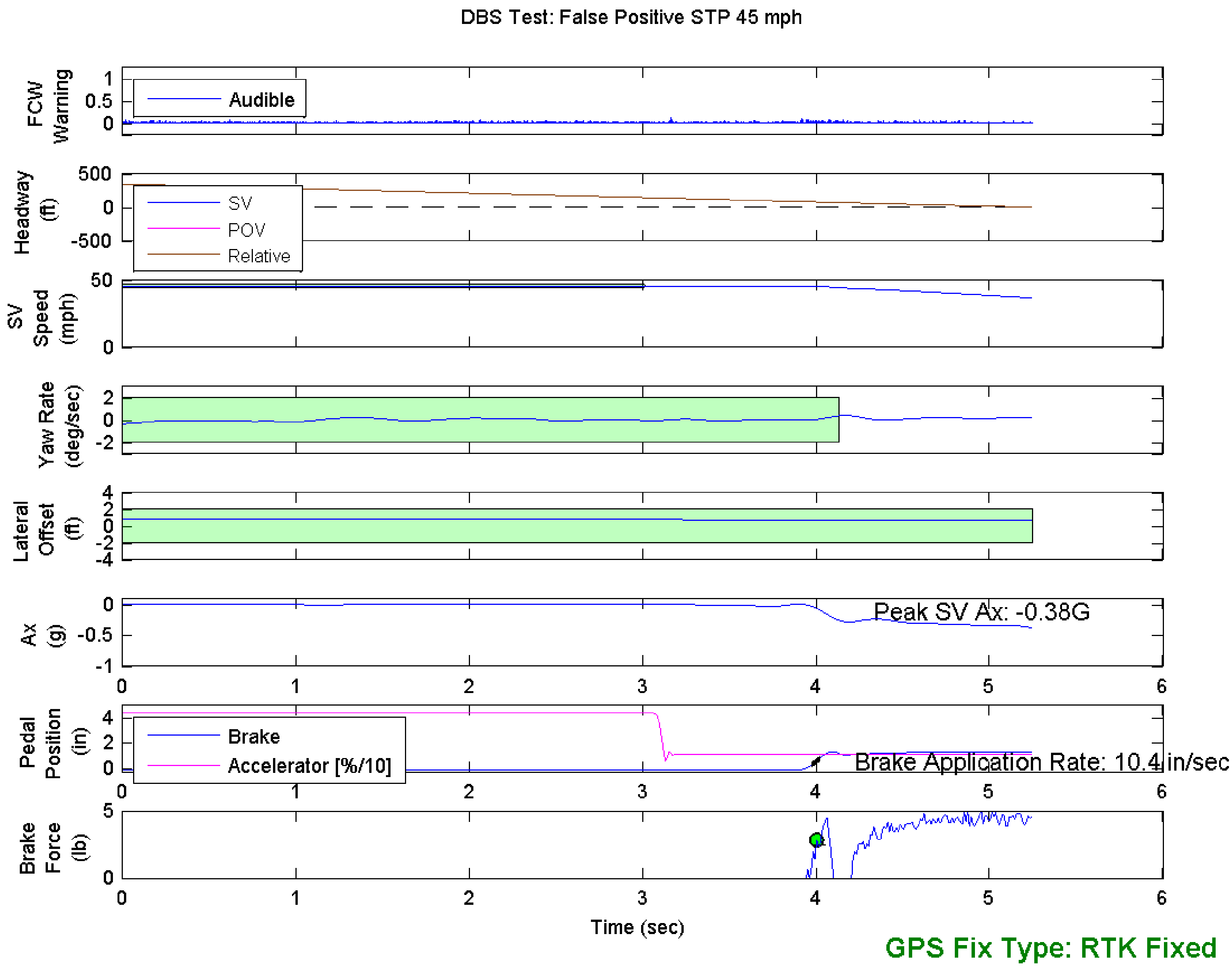


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

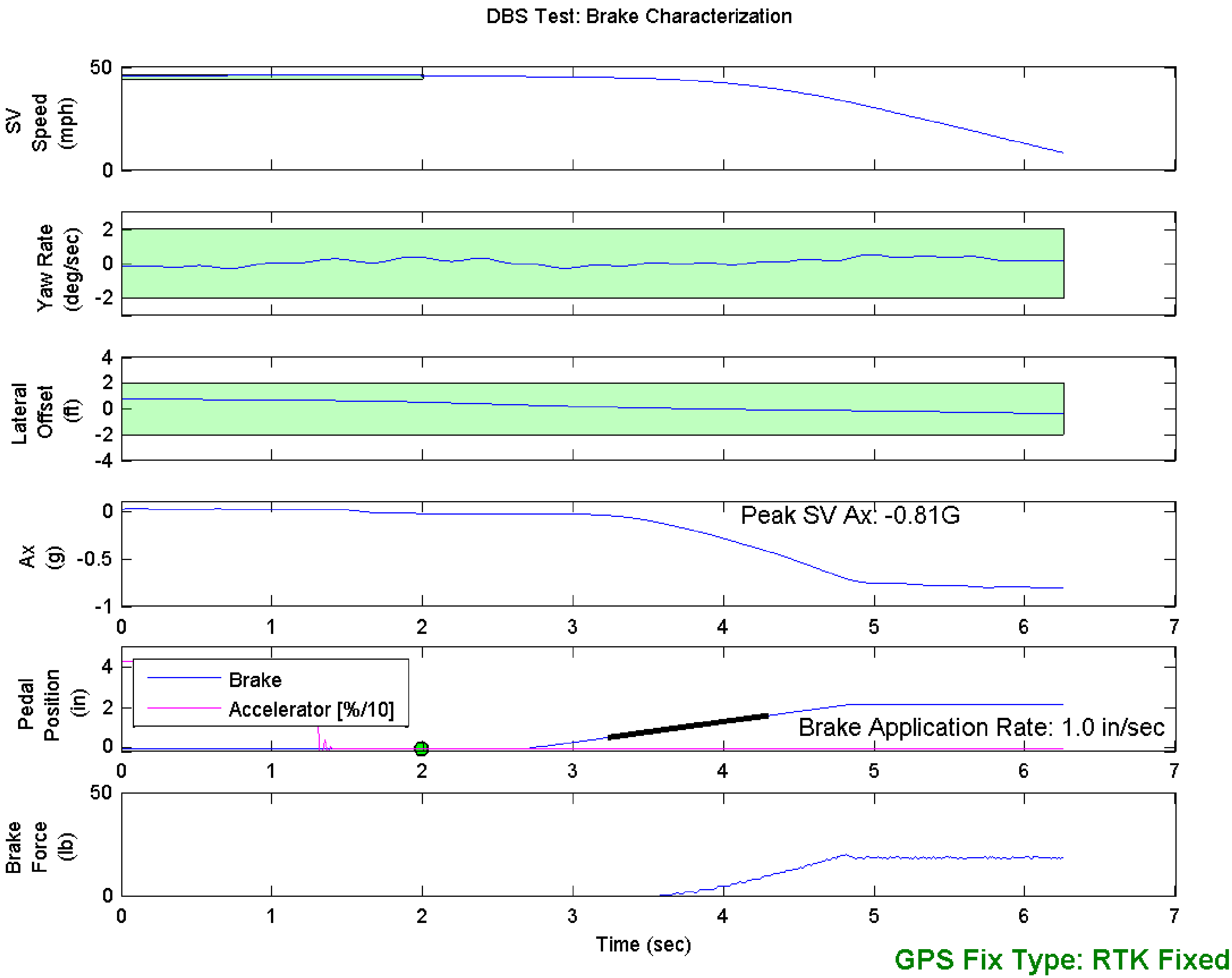


Figure E9. Example Time History for DBS Brake Characterization, Passing

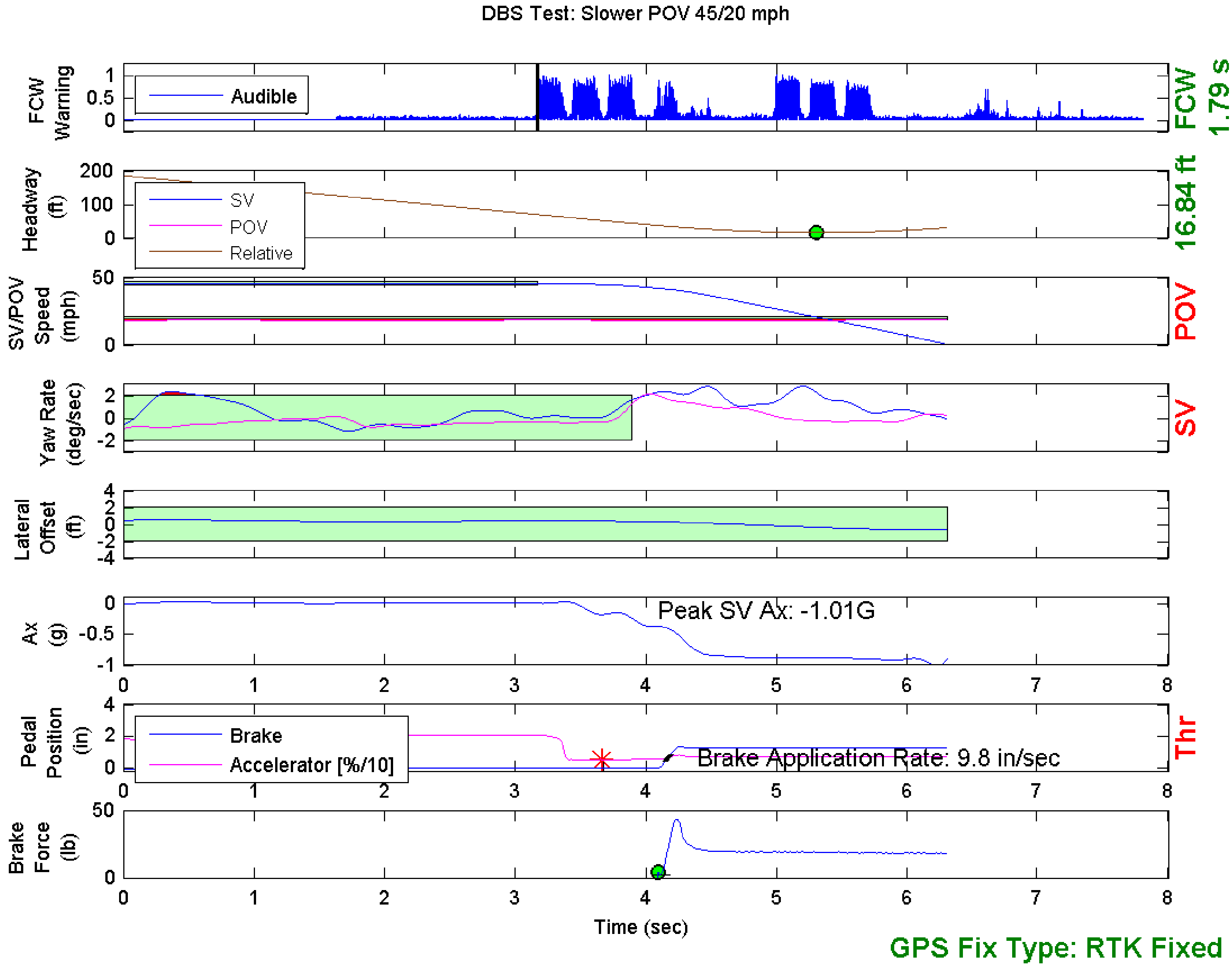


Figure E10. Example Time History Displaying Various Invalid Criteria

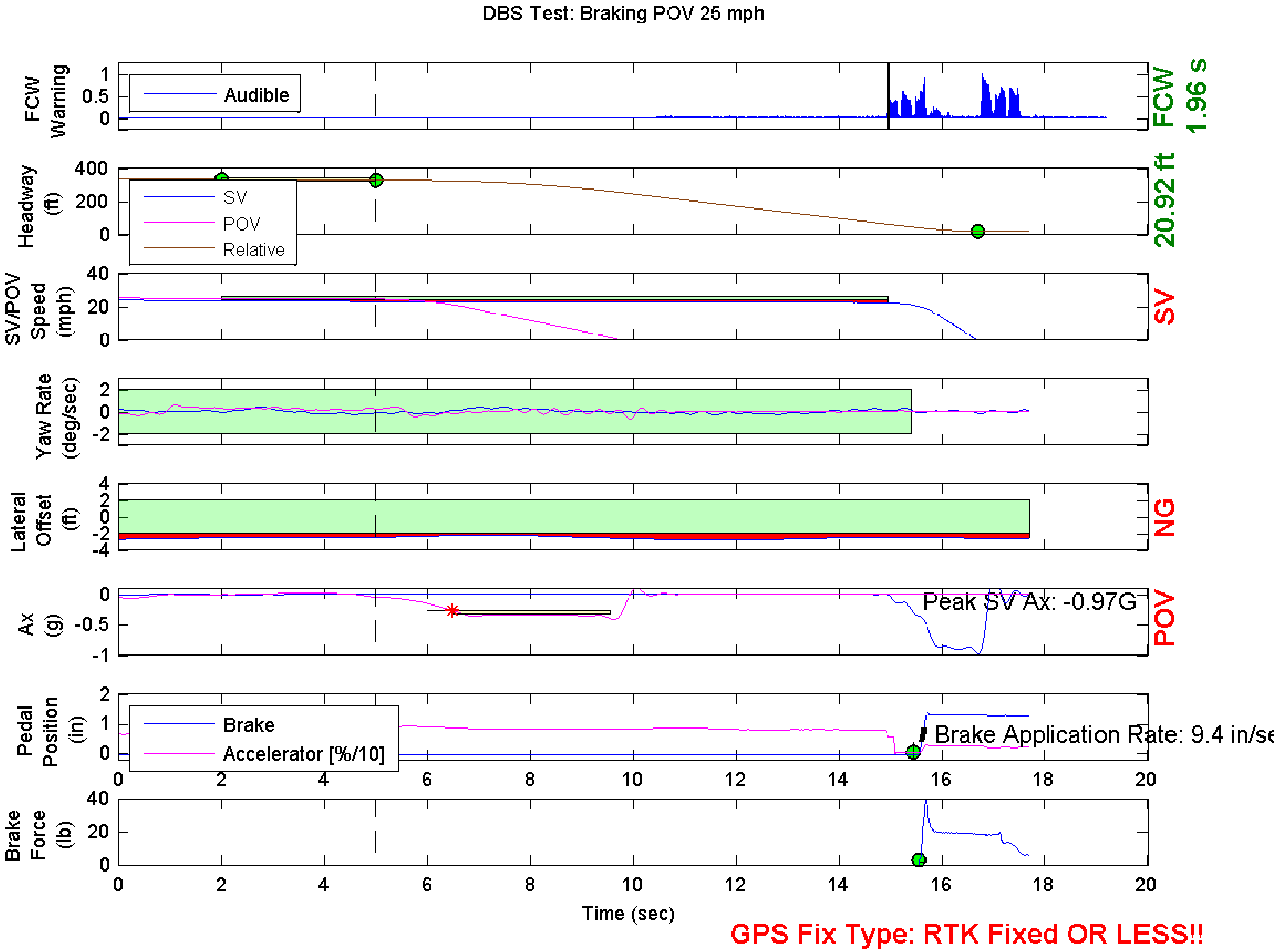


Figure E11. Example Time History Displaying Various Invalid Criteria

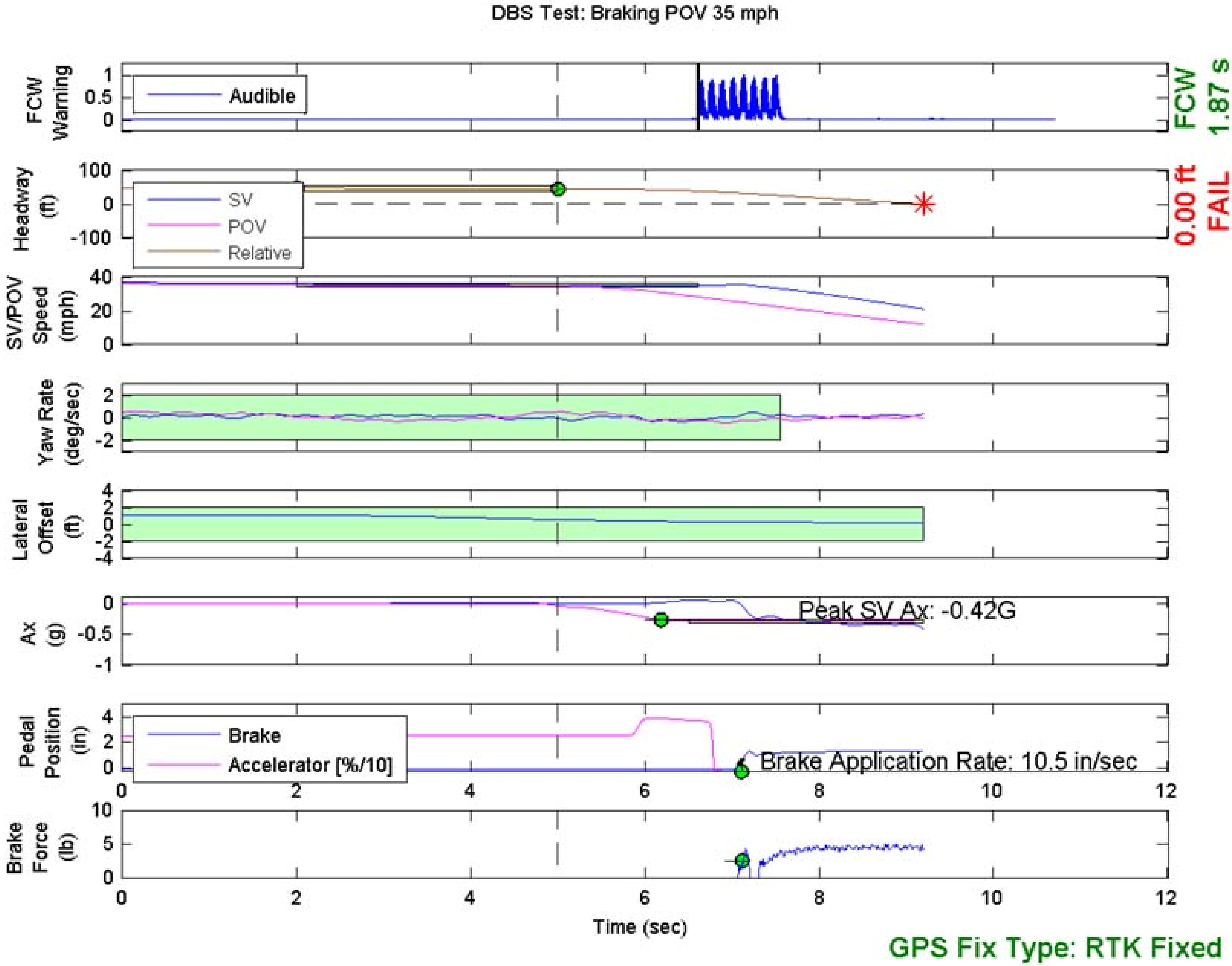


Figure E12. Example Time History for a Failed Run

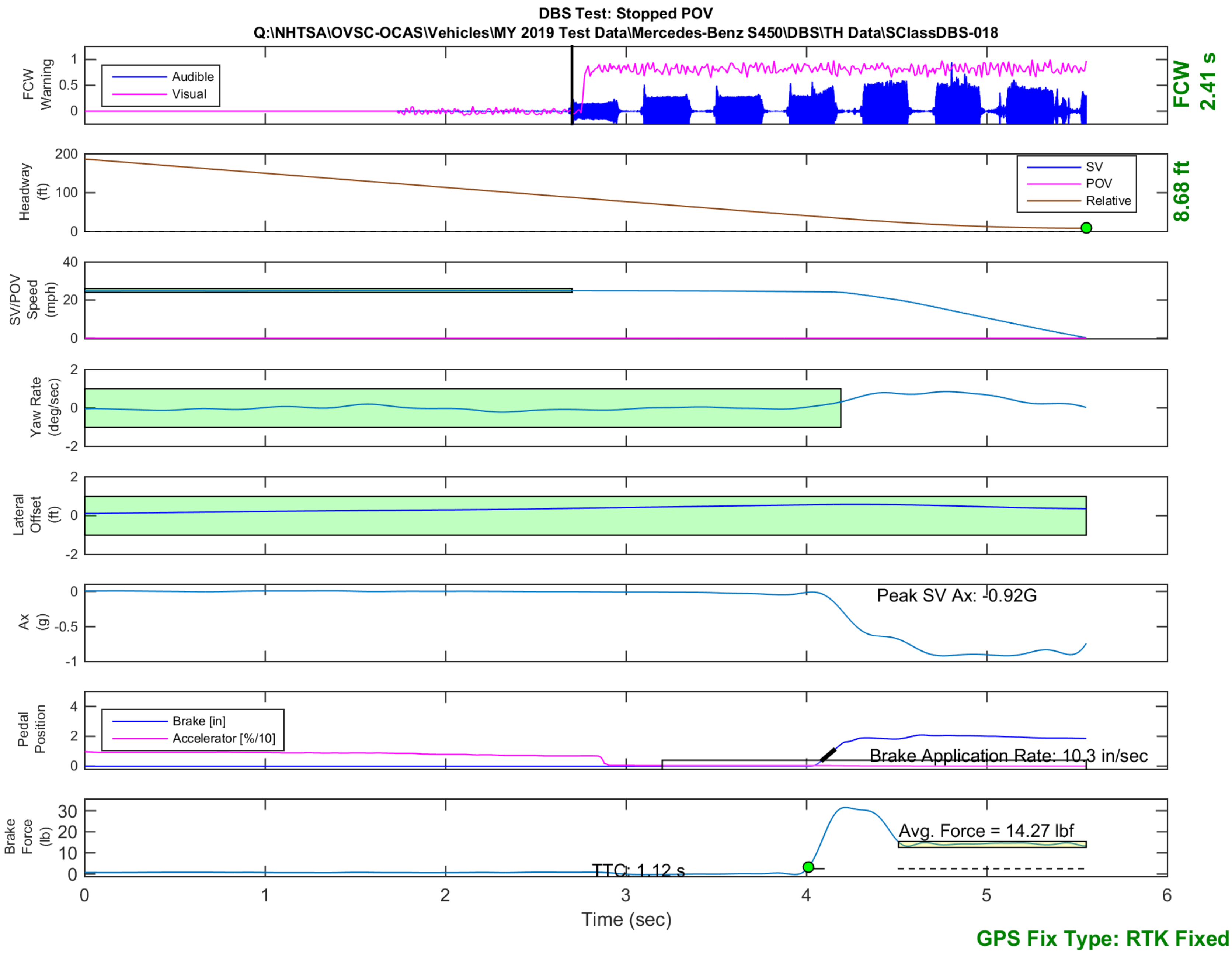


Figure E13. Time History for DBS Run 18, SV Encounters Stopped POV

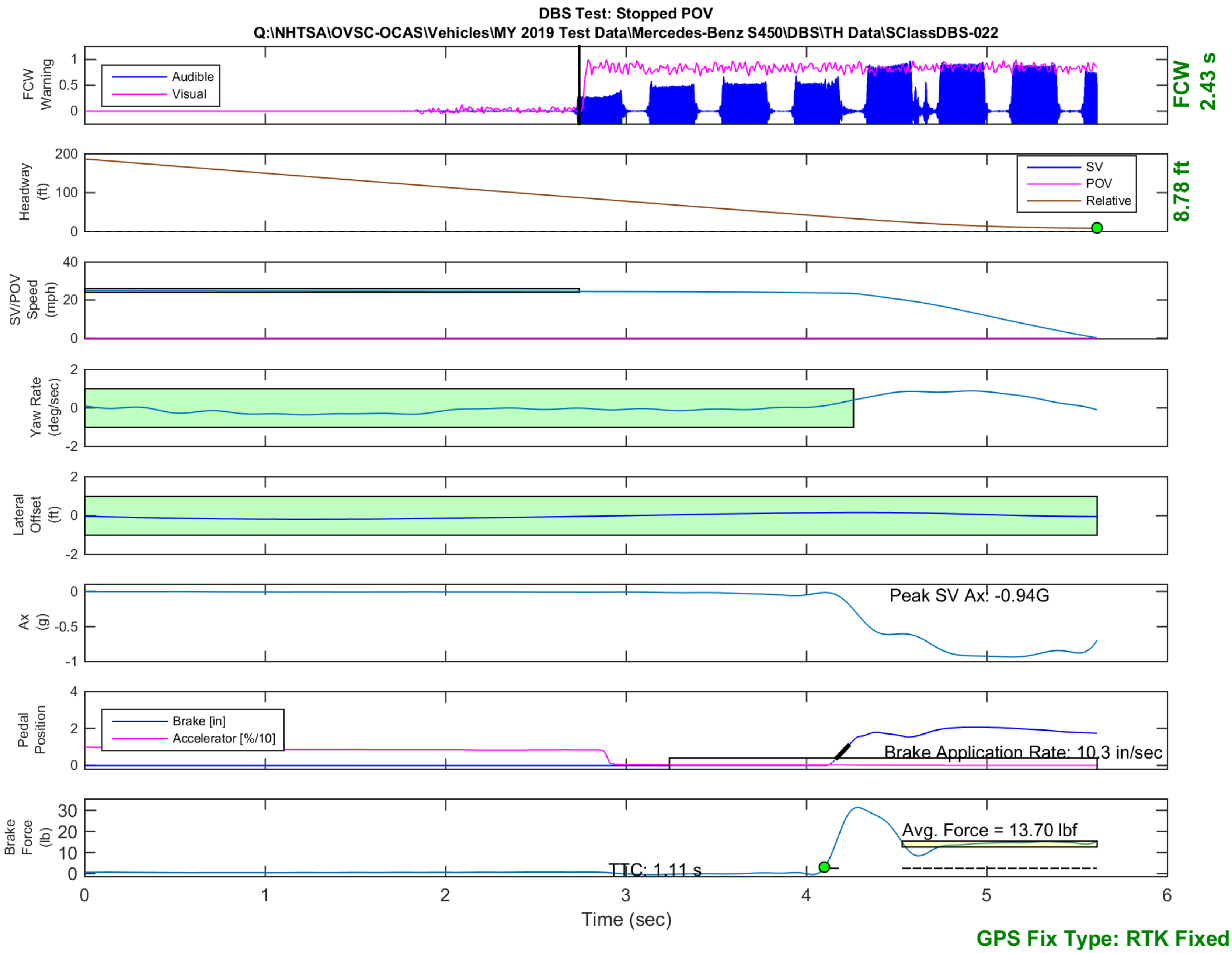


Figure E14. Time History for DBS Run 22, SV Encounters Stopped POV

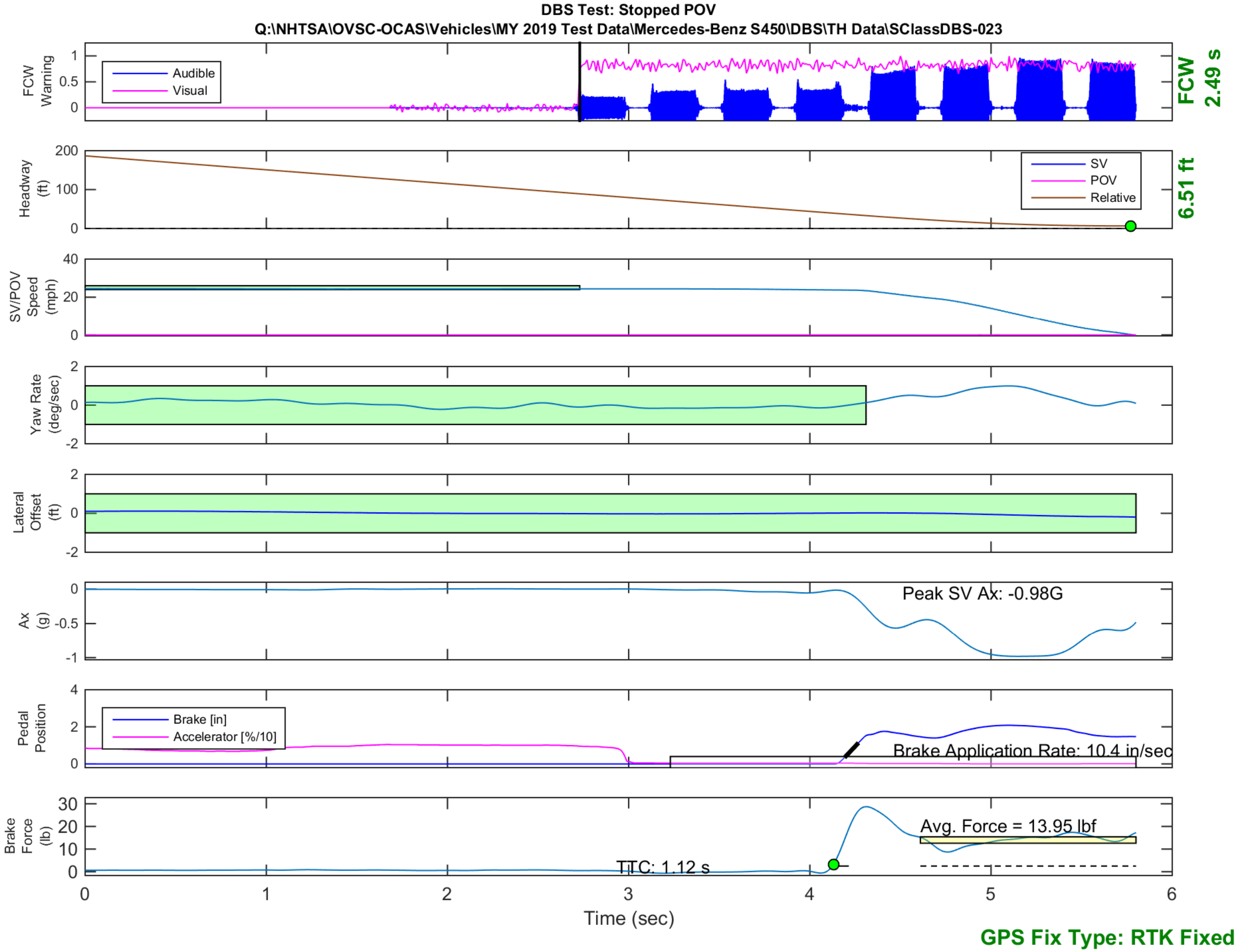


Figure E15. Time History for DBS Run 23, SV Encounters Stopped POV

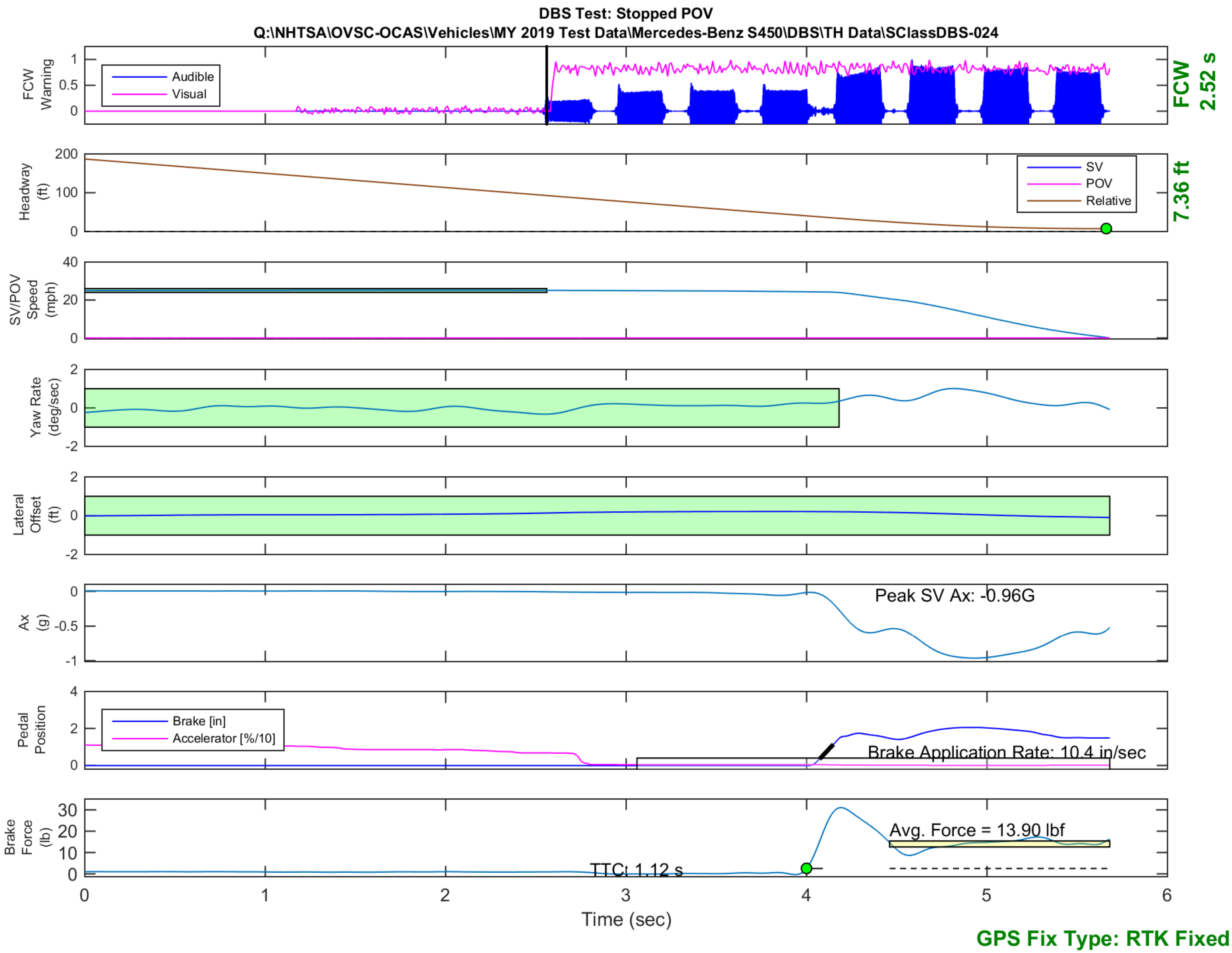


Figure E16. Time History for DBS Run 24, SV Encounters Stopped POV

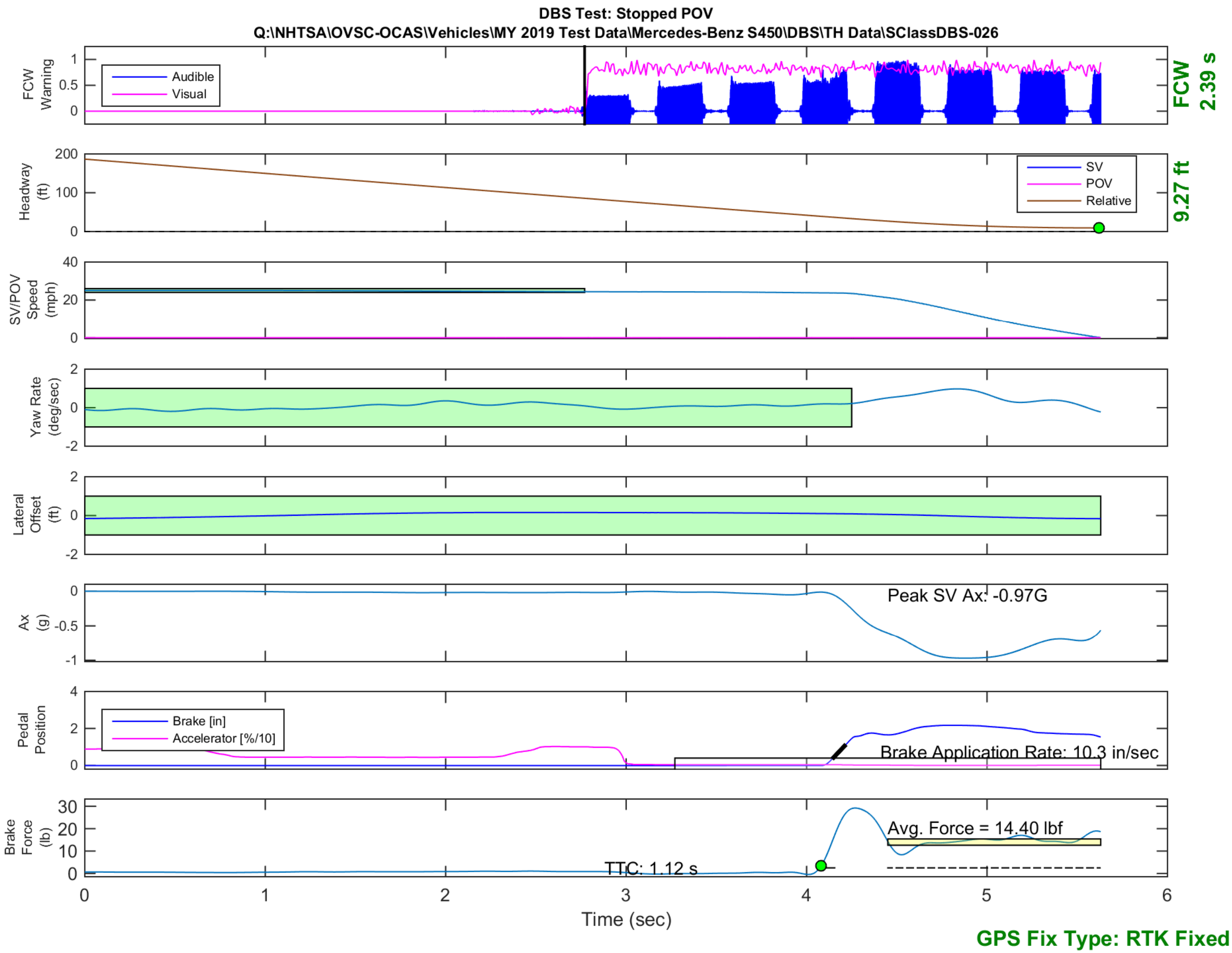


Figure E17. Time History for DBS Run 26, SV Encounters Stopped POV

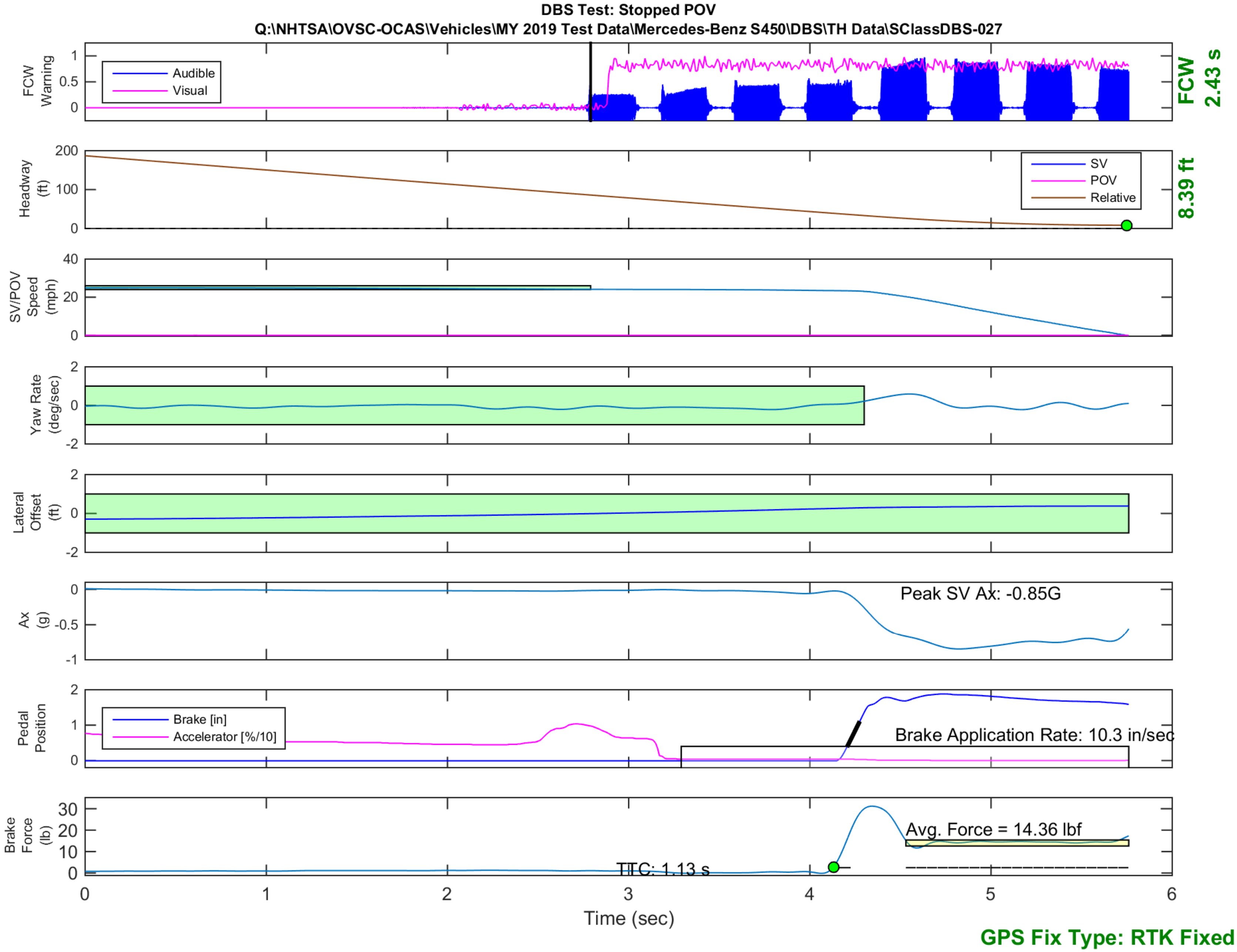


Figure E18. Time History for DBS Run 27, SV Encounters Stopped POV

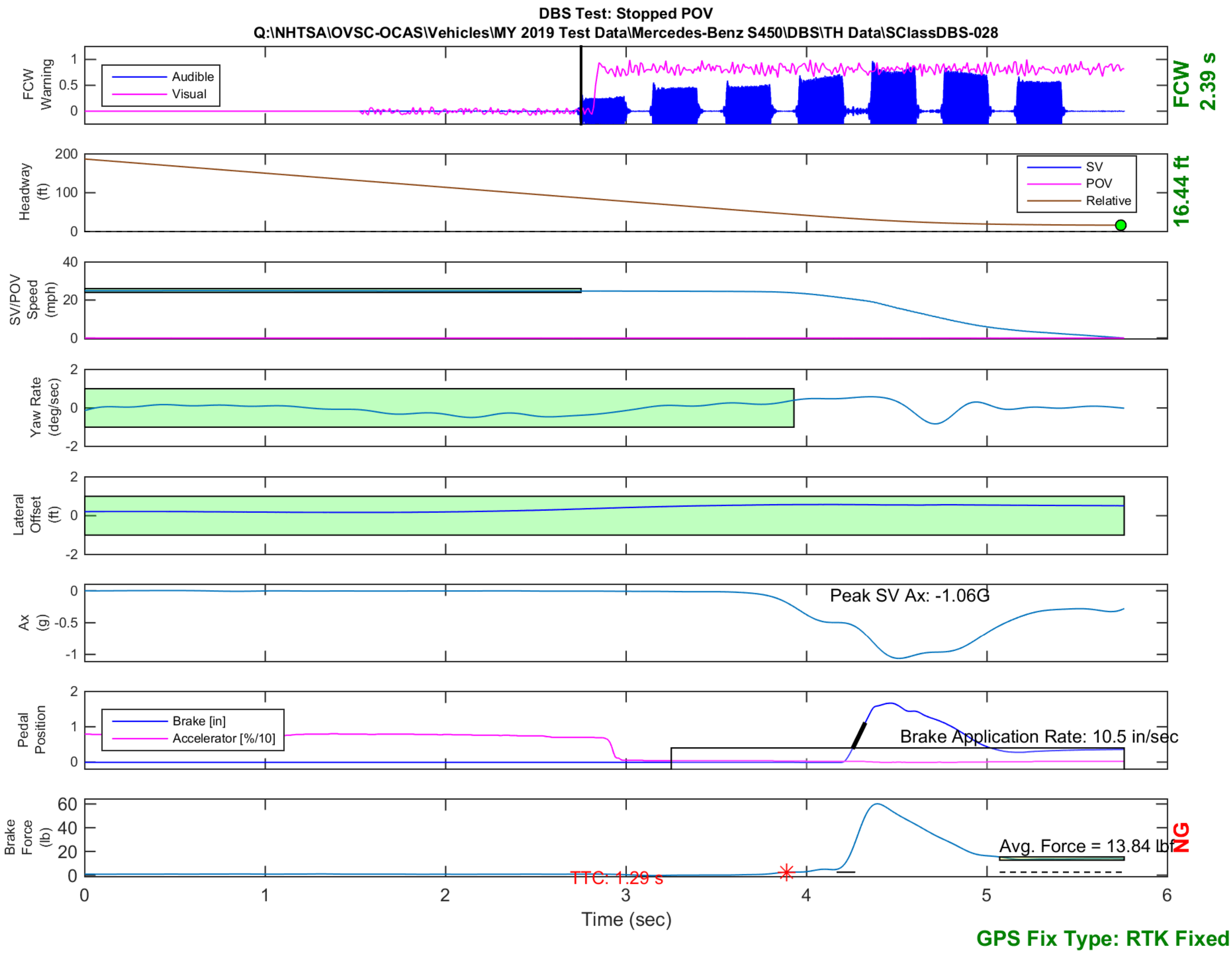


Figure E19. Time History for DBS Run 28, SV Encounters Stopped POV

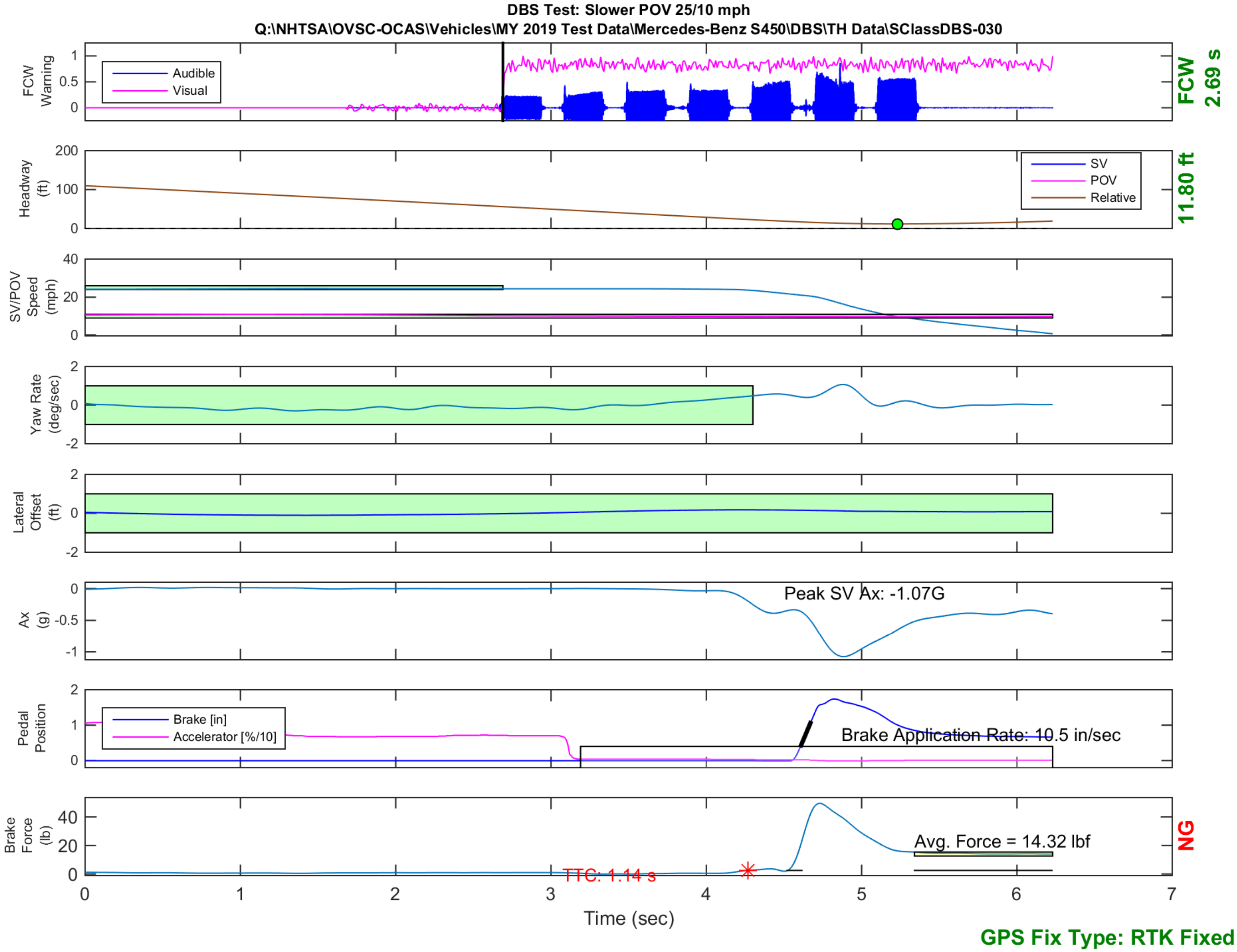


Figure E20. Time History for DBS Run 30, SV Encounters Slower POV, SV 25 mph, POV 10 mph

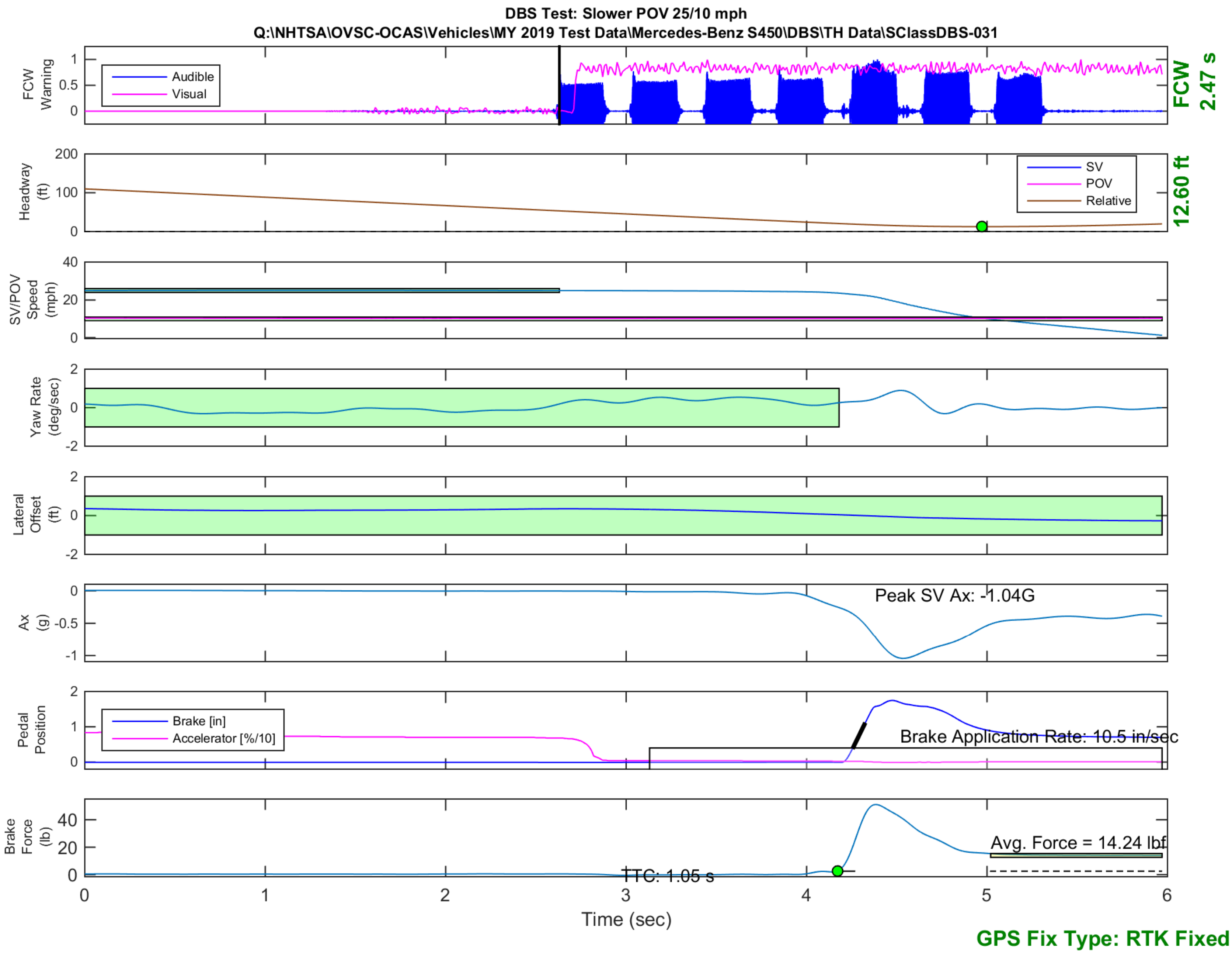


Figure E21. Time History for DBS Run 31, SV Encounters Slower POV, SV 25 mph, POV 10 mph

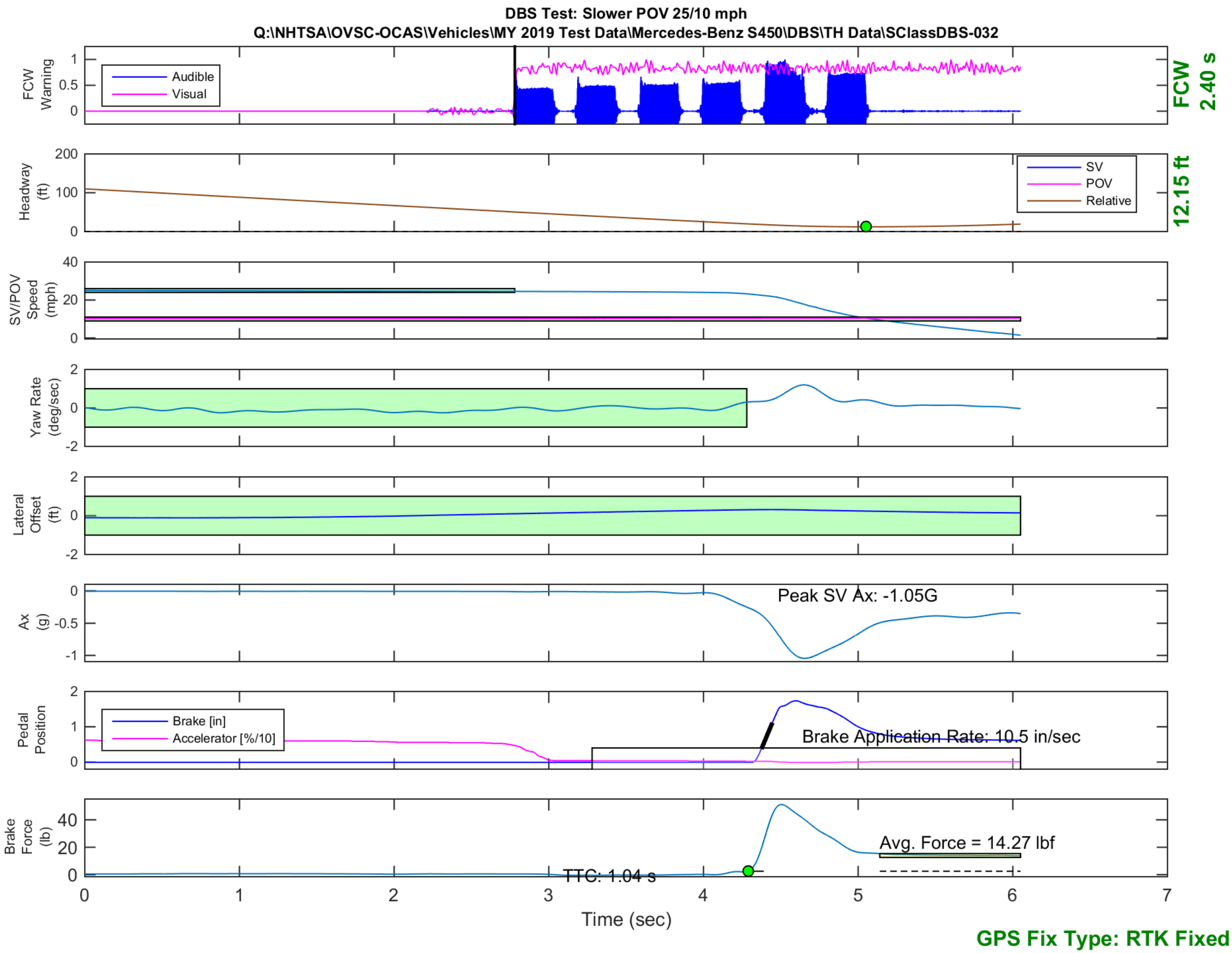


Figure E22. Time History for DBS Run 32, SV Encounters Slower POV, SV 25 mph, POV 10 mph

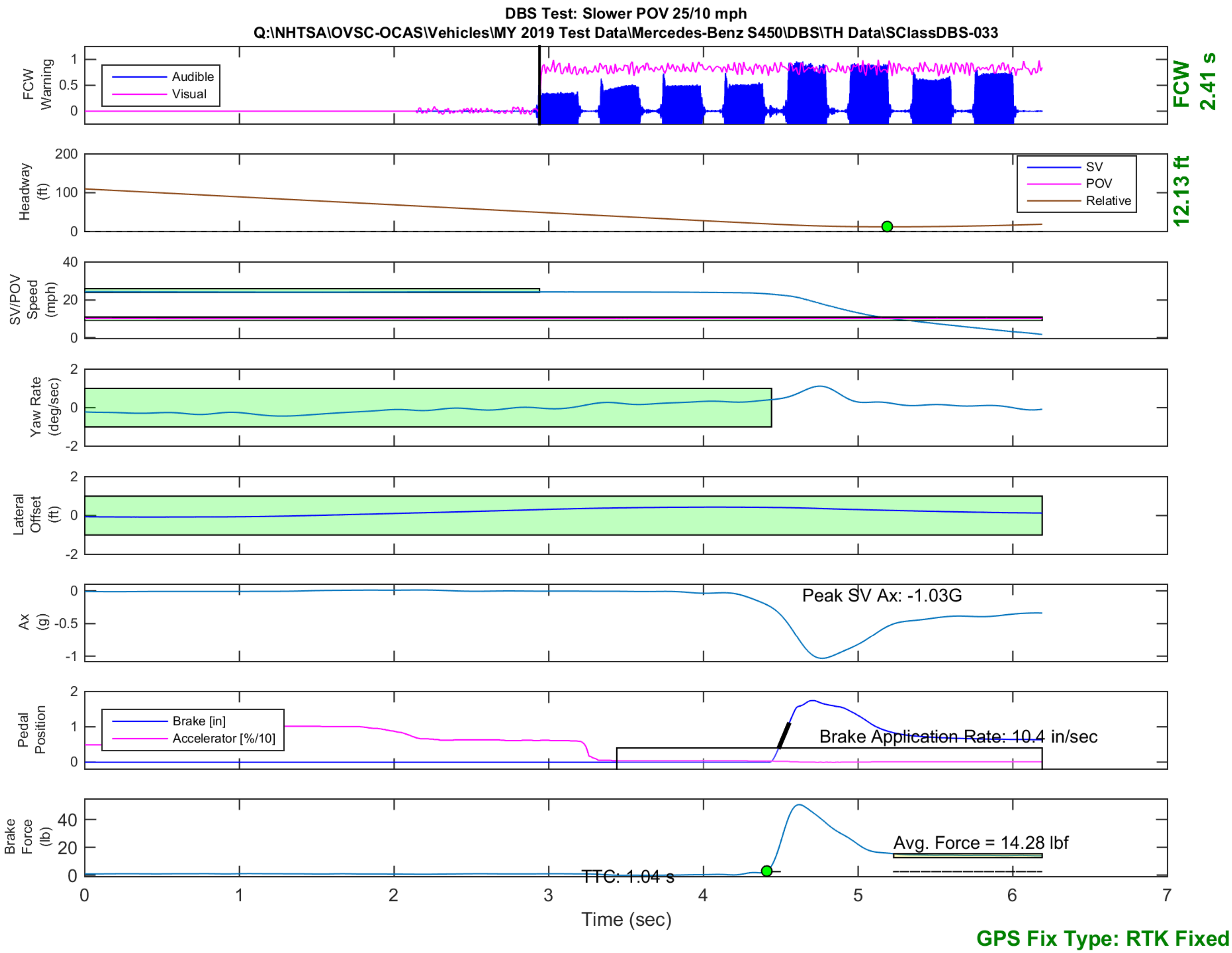


Figure E23. Time History for DBS Run 33, SV Encounters Slower POV, SV 25 mph, POV 10 mph

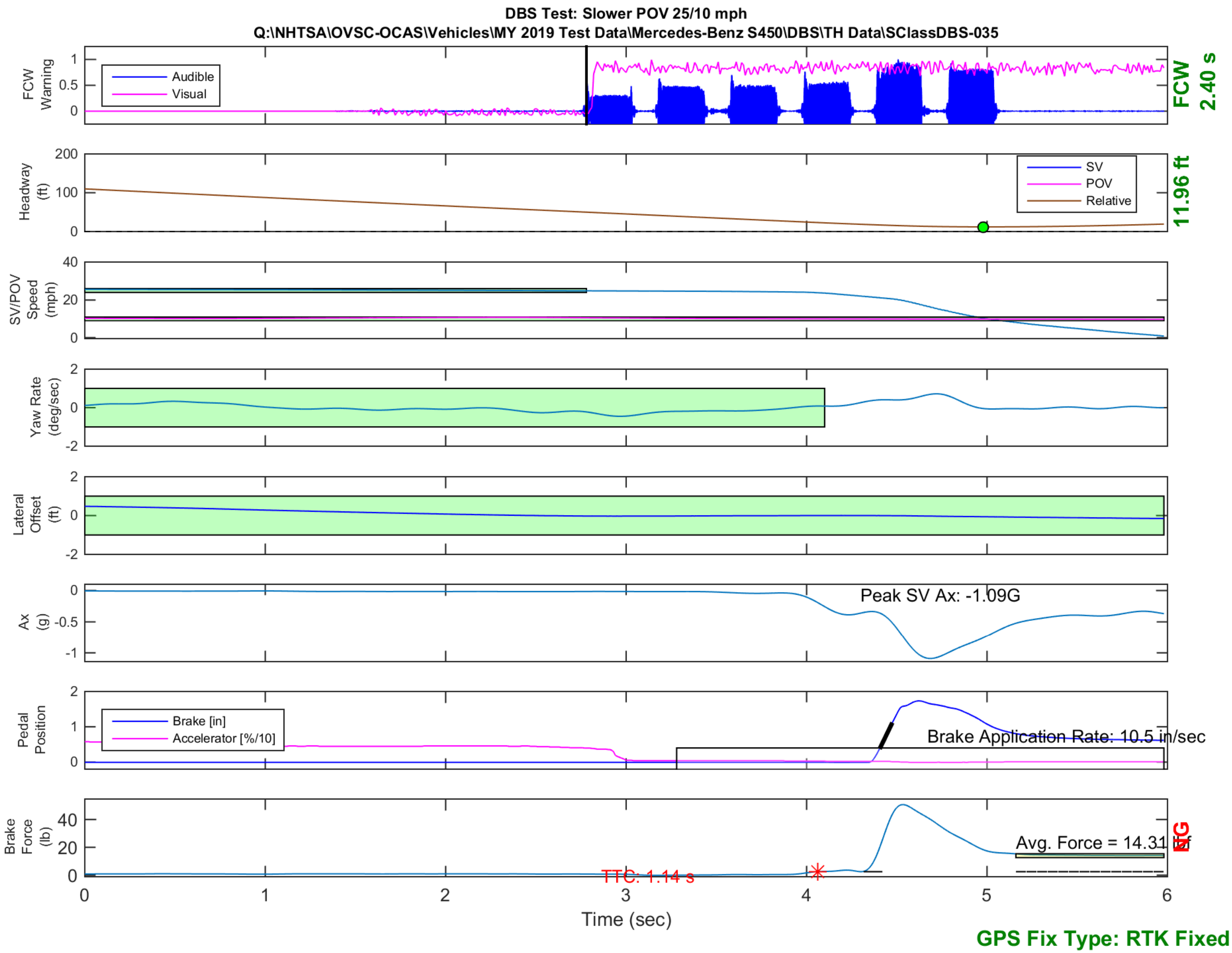


Figure E24. Time History for DBS Run 35, SV Encounters Slower POV, SV 25 mph, POV 10 mph

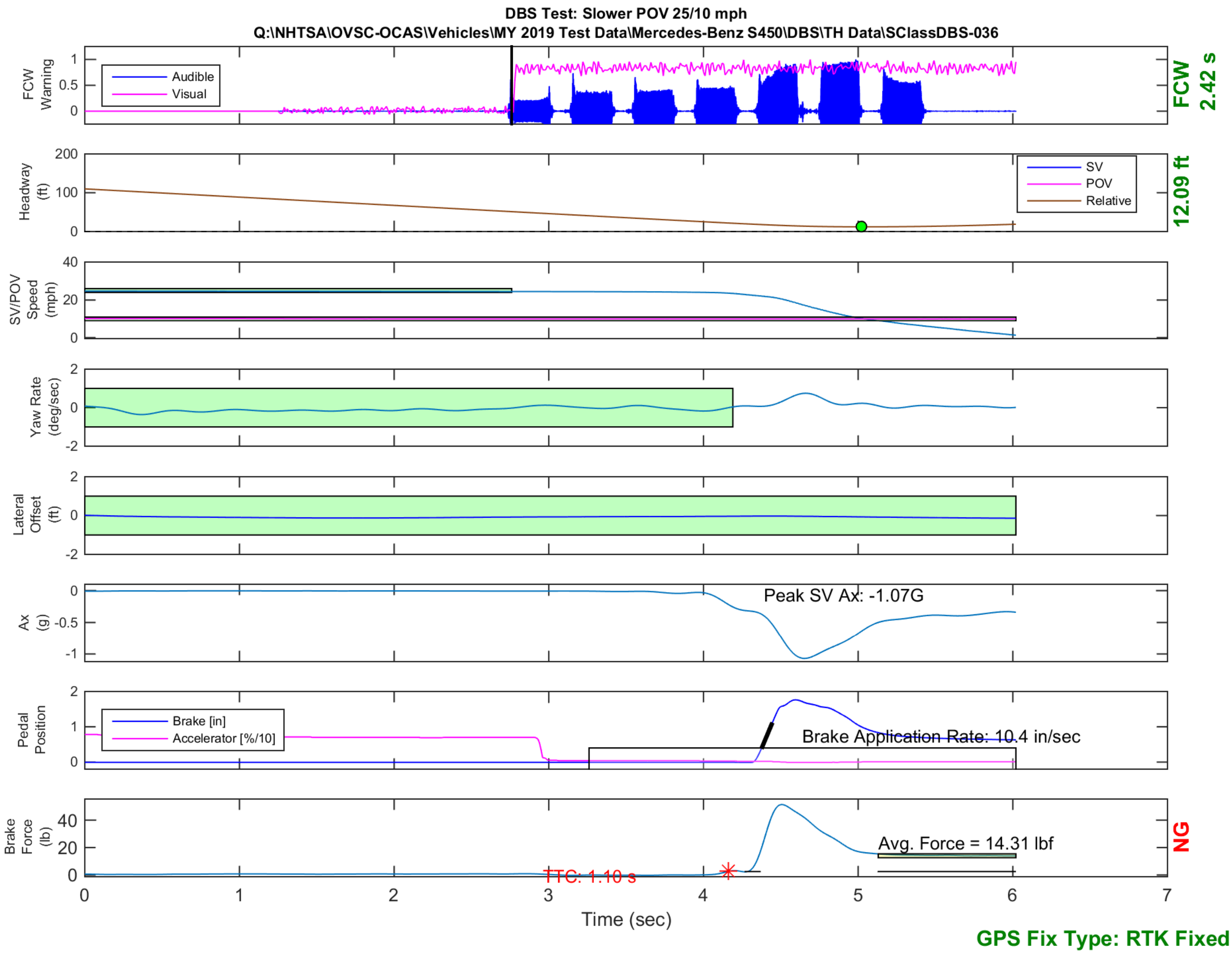


Figure E25. Time History for DBS Run 36, SV Encounters Slower POV, SV 25 mph, POV 10 mph

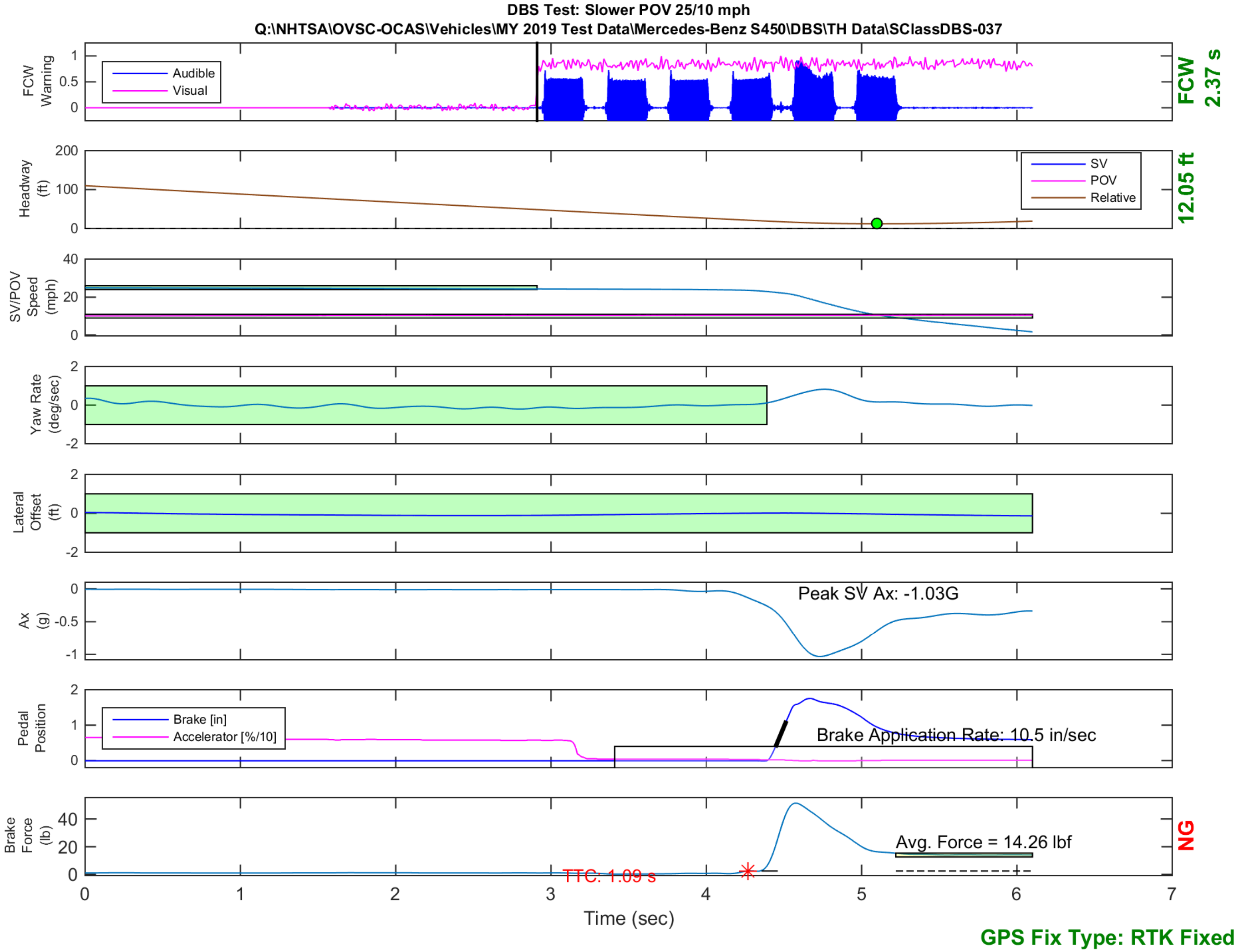


Figure E26. Time History for DBS Run 37, SV Encounters Slower POV, SV 25 mph, POV 10 mph

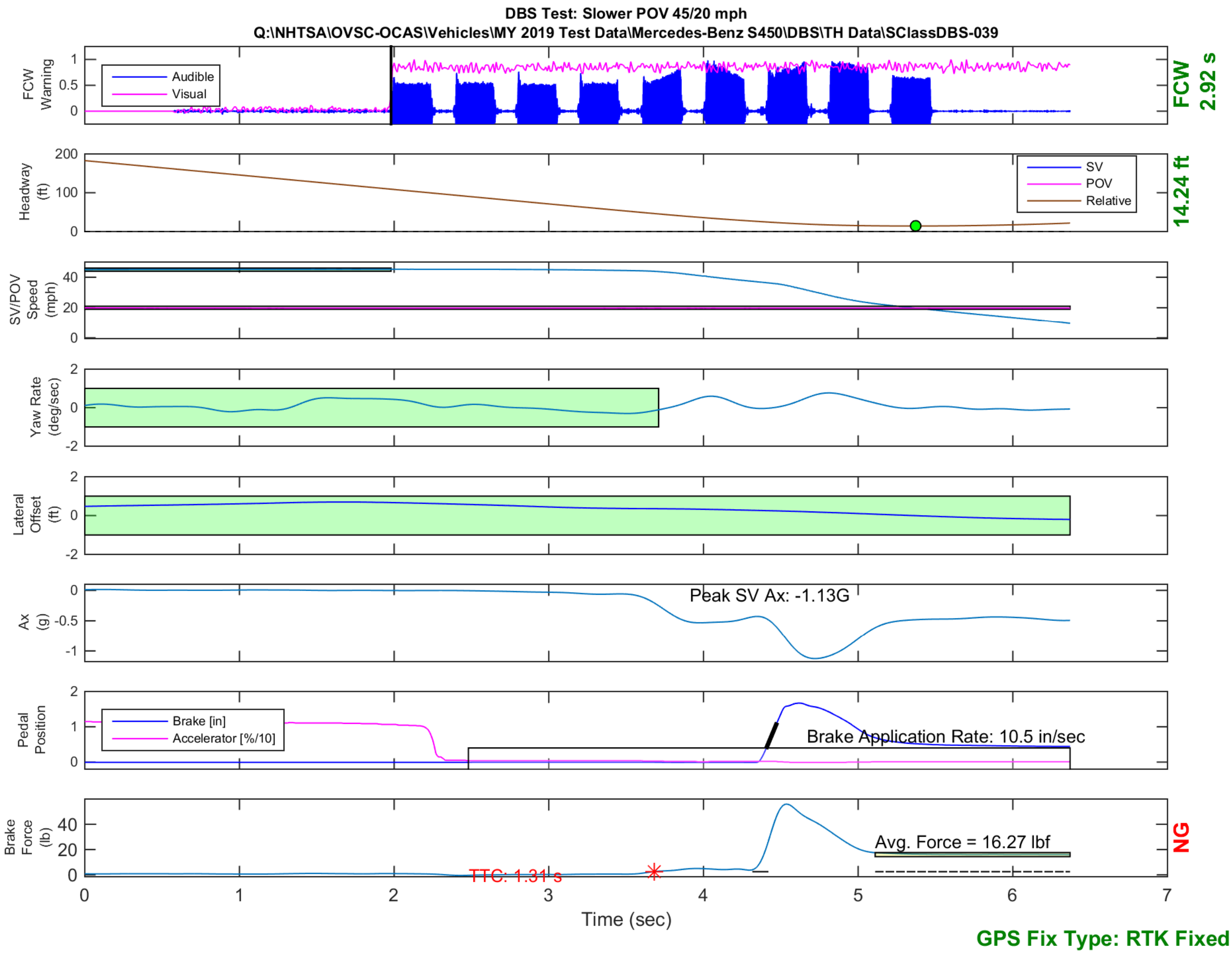


Figure E27. Time History for DBS Run 39, SV Encounters Slower POV, SV 45 mph, POV 20 mph

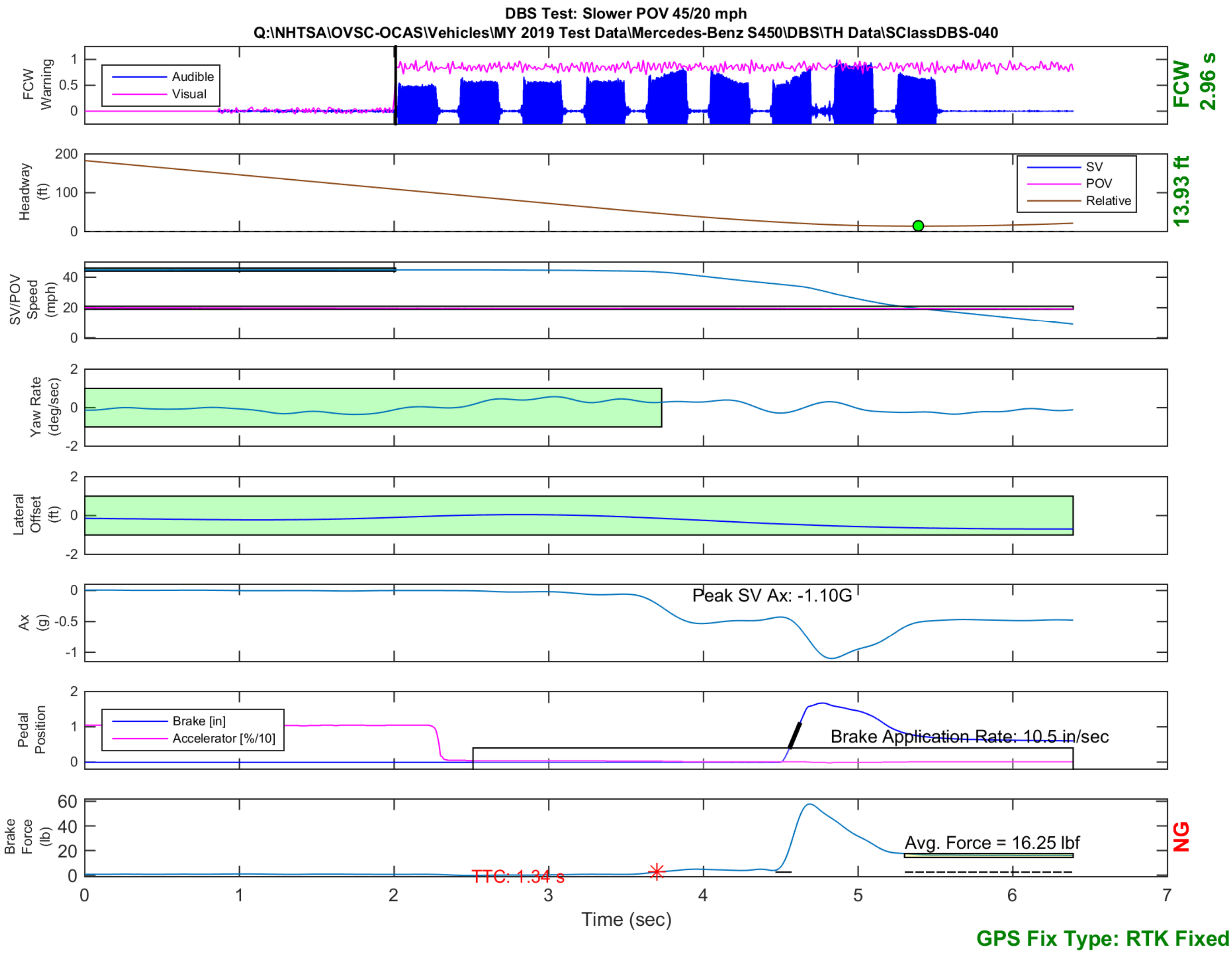


Figure E28. Time History for DBS Run 40, SV Encounters Slower POV, SV 45 mph, POV 20 mph

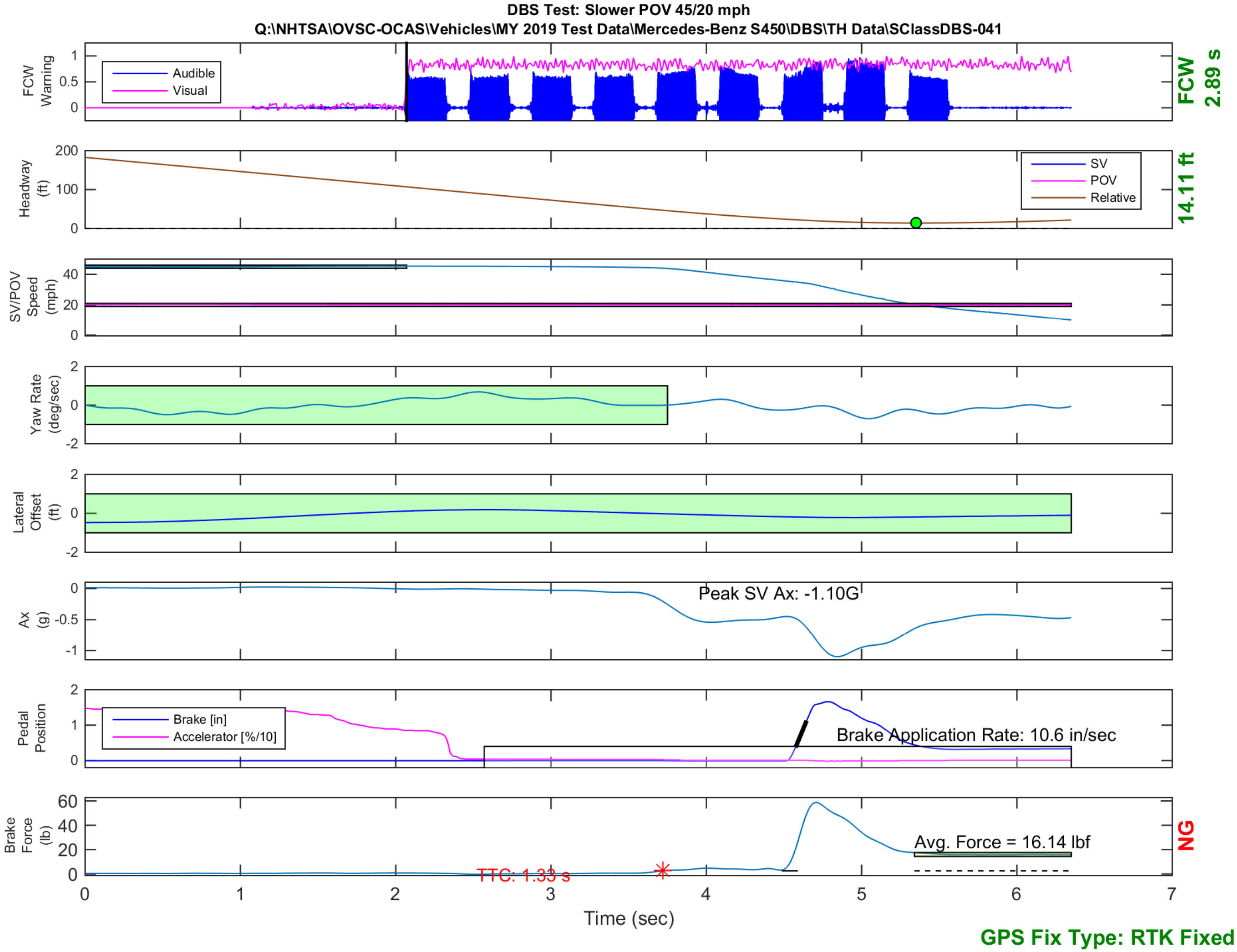


Figure E29. Time History for DBS Run 41, SV Encounters Slower POV, SV 45 mph, POV 20 mph

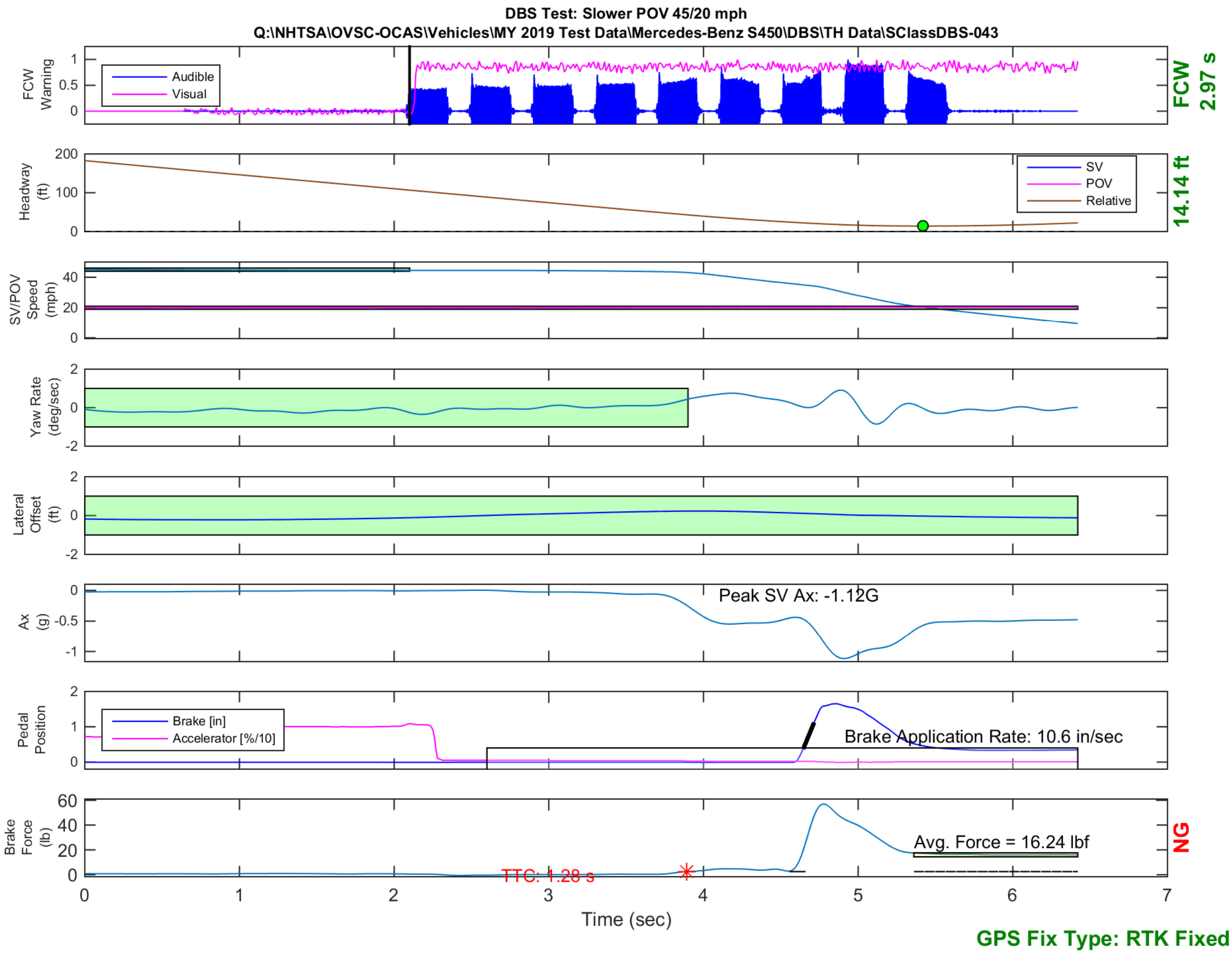


Figure E30. Time History for DBS Run 43, SV Encounters Slower POV, SV 45 mph, POV 20 mph

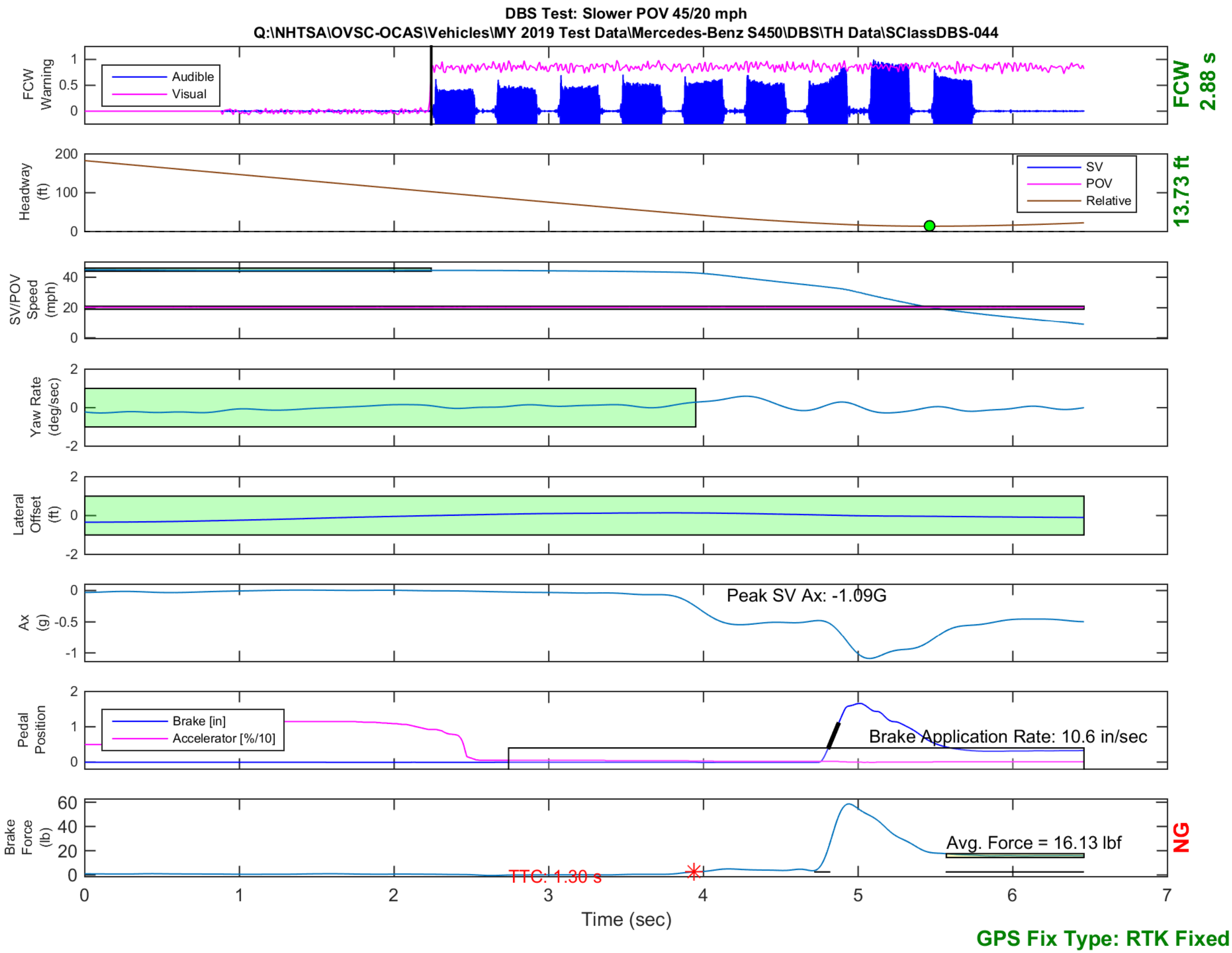


Figure E31. Time History for DBS Run 44, SV Encounters Slower POV, SV 45 mph, POV 20 mph

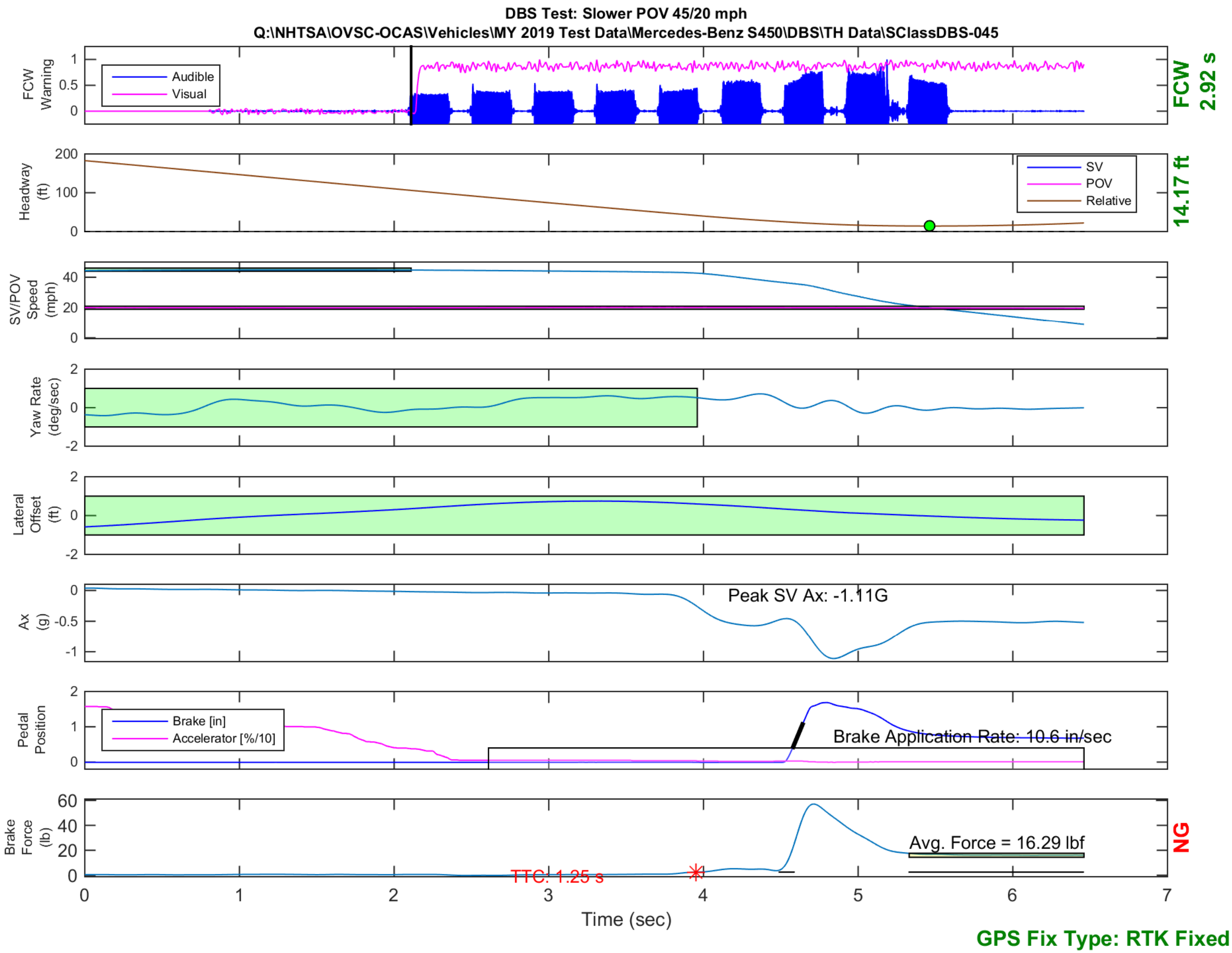


Figure E32. Time History for DBS Run 45, SV Encounters Slower POV, SV 45 mph, POV 20 mph

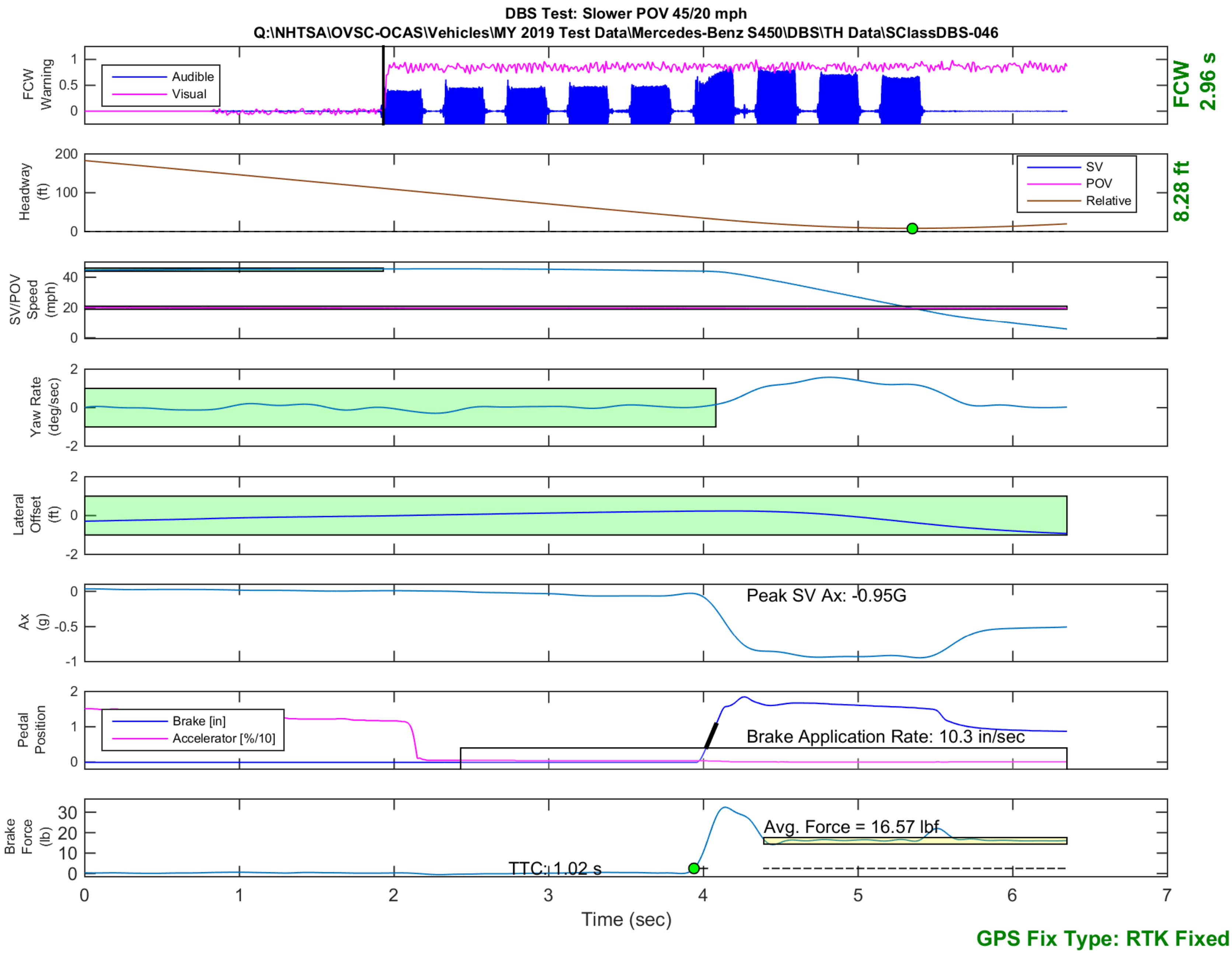


Figure E33. Time History for DBS Run 46, SV Encounters Slower POV, SV 45 mph, POV 20 mph

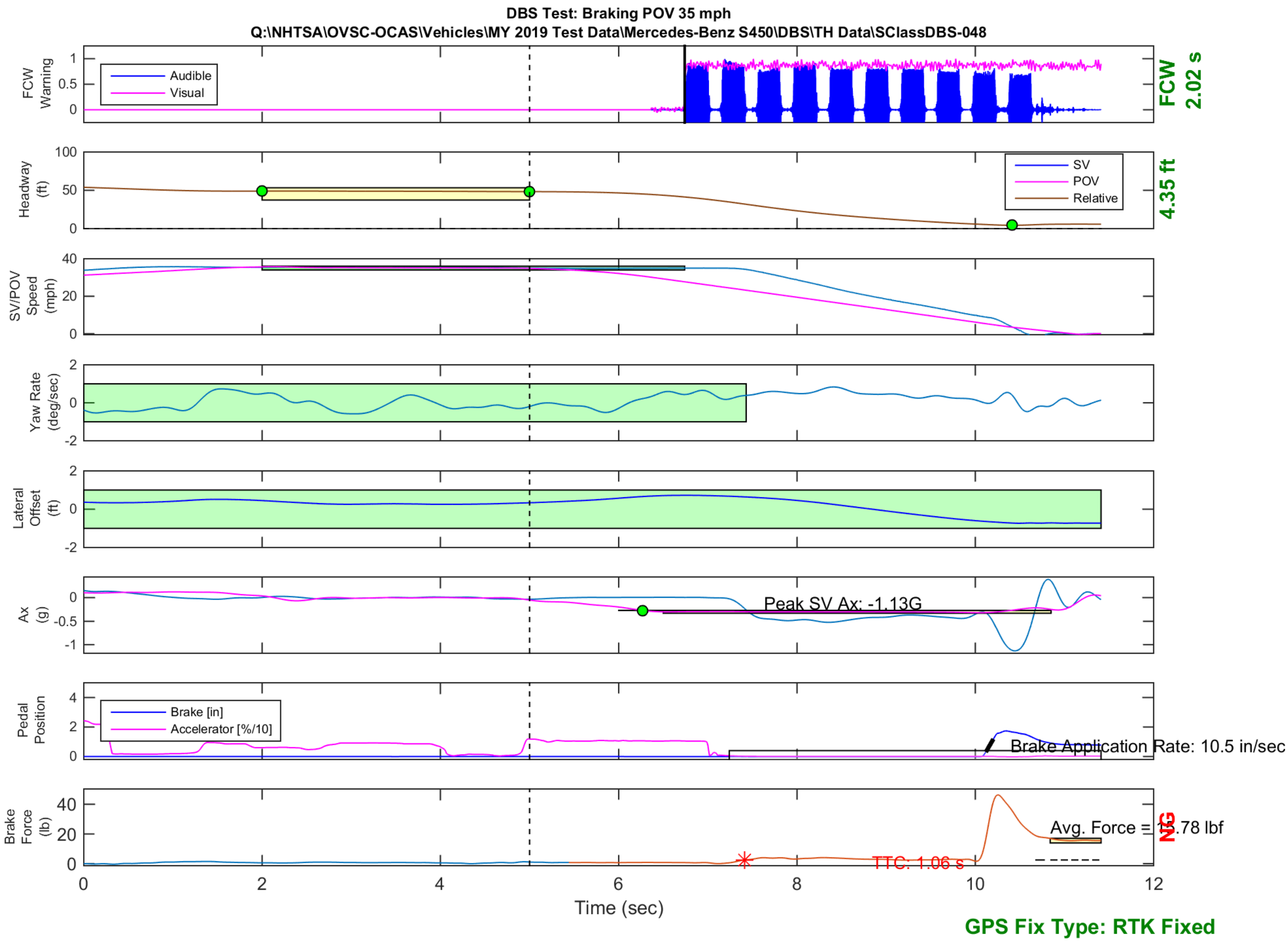


Figure E34. Time History for DBS Run 48, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

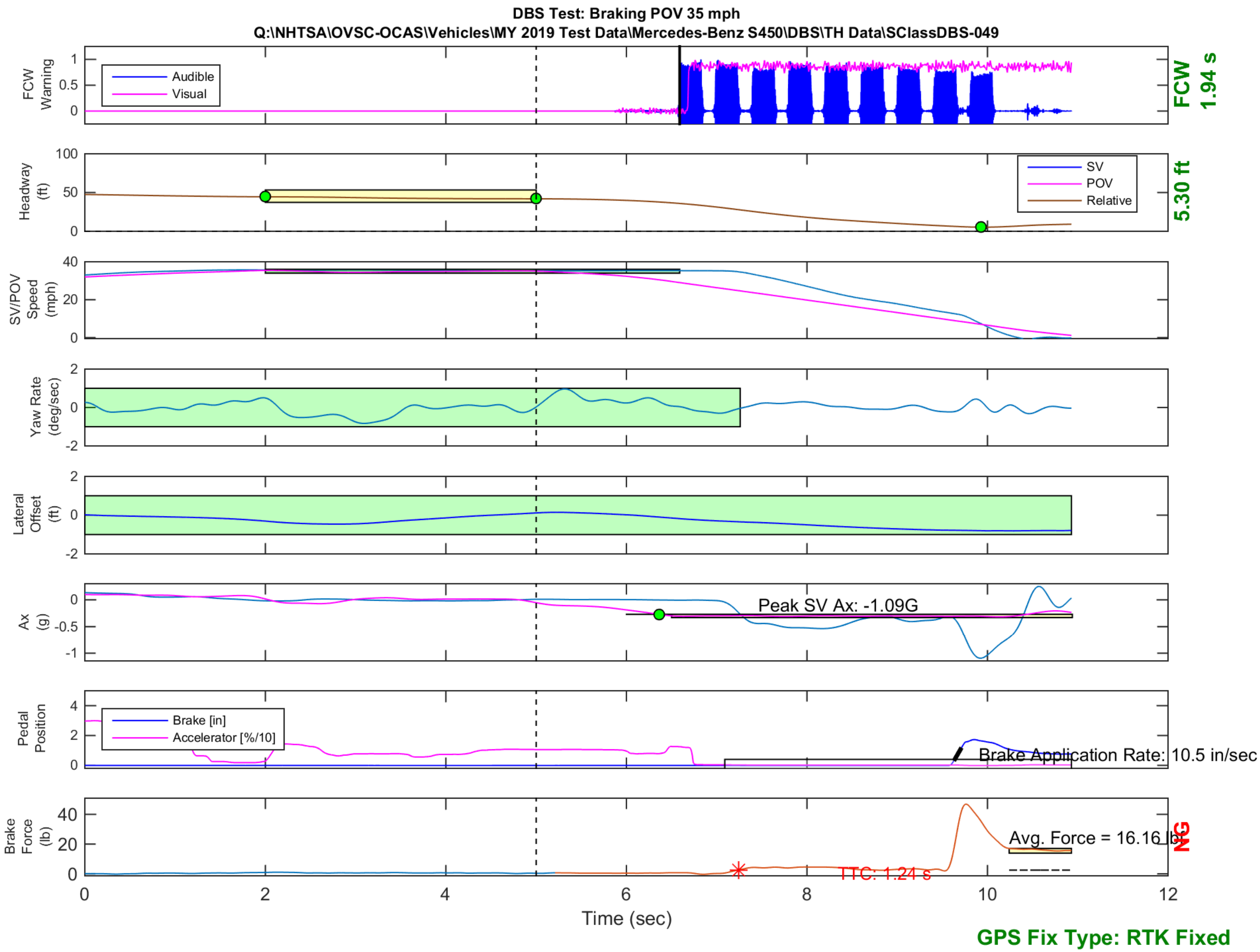


Figure E35. Time History for DBS Run 49, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

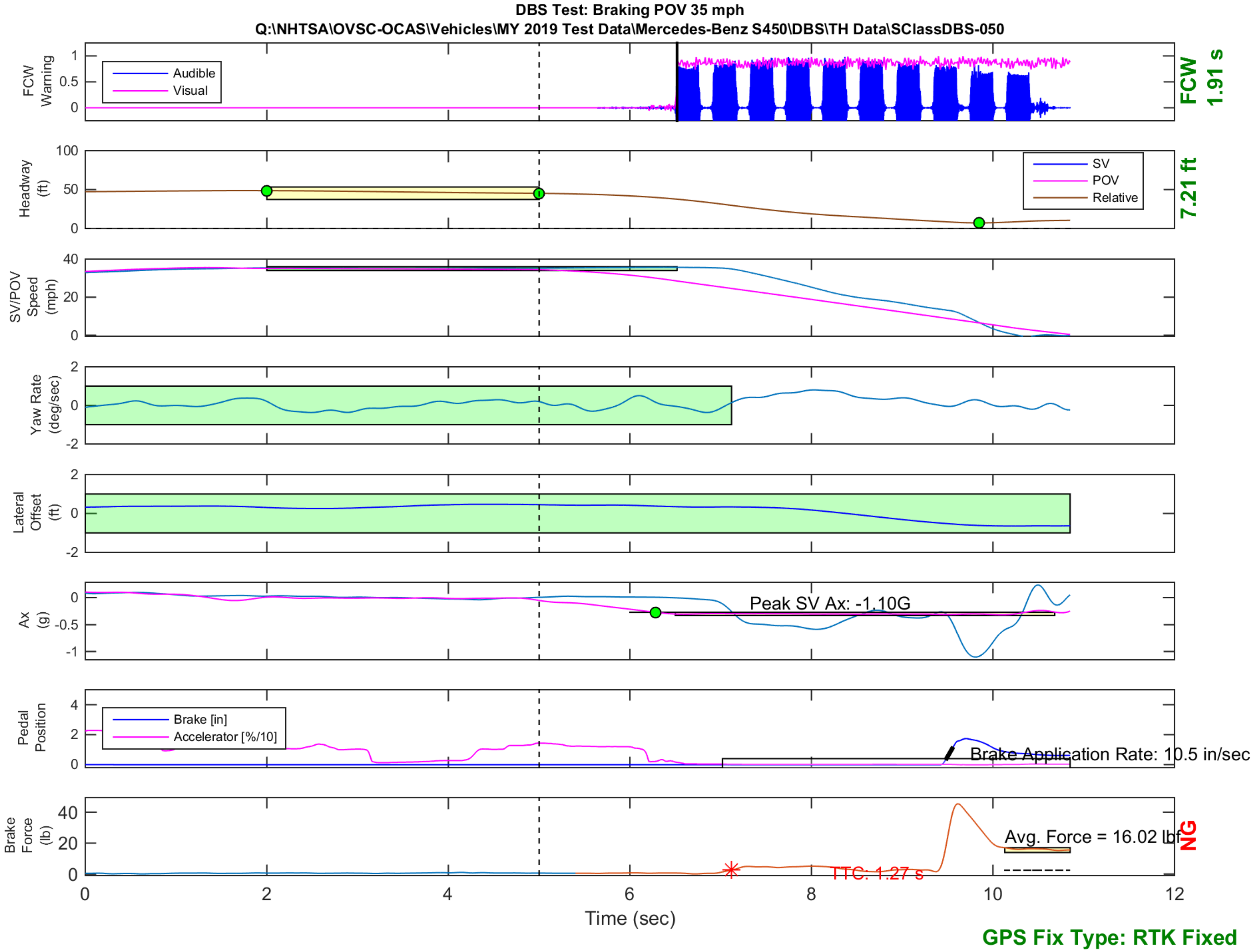


Figure E36. Time History for DBS Run 50, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

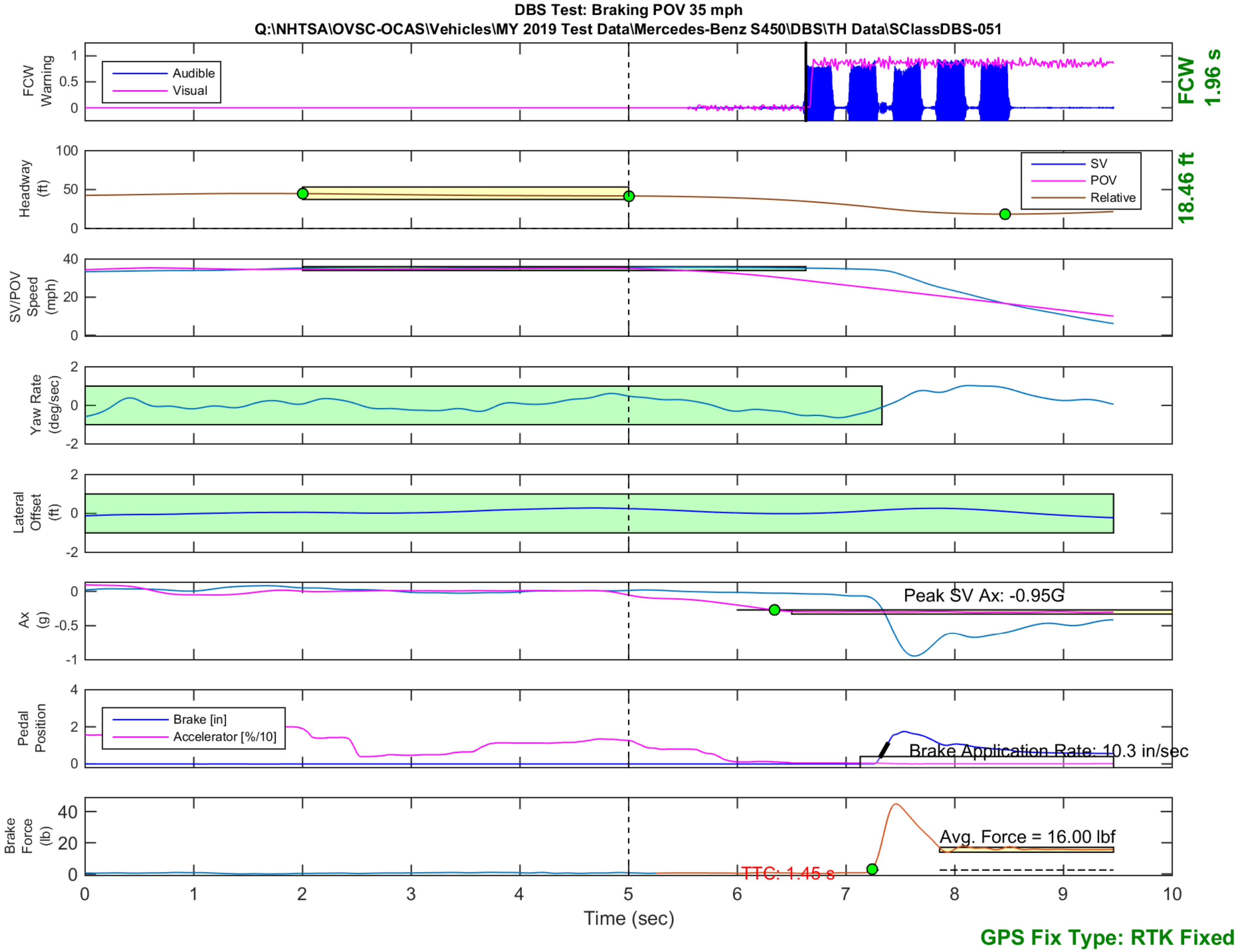


Figure E37. Time History for DBS Run 51, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

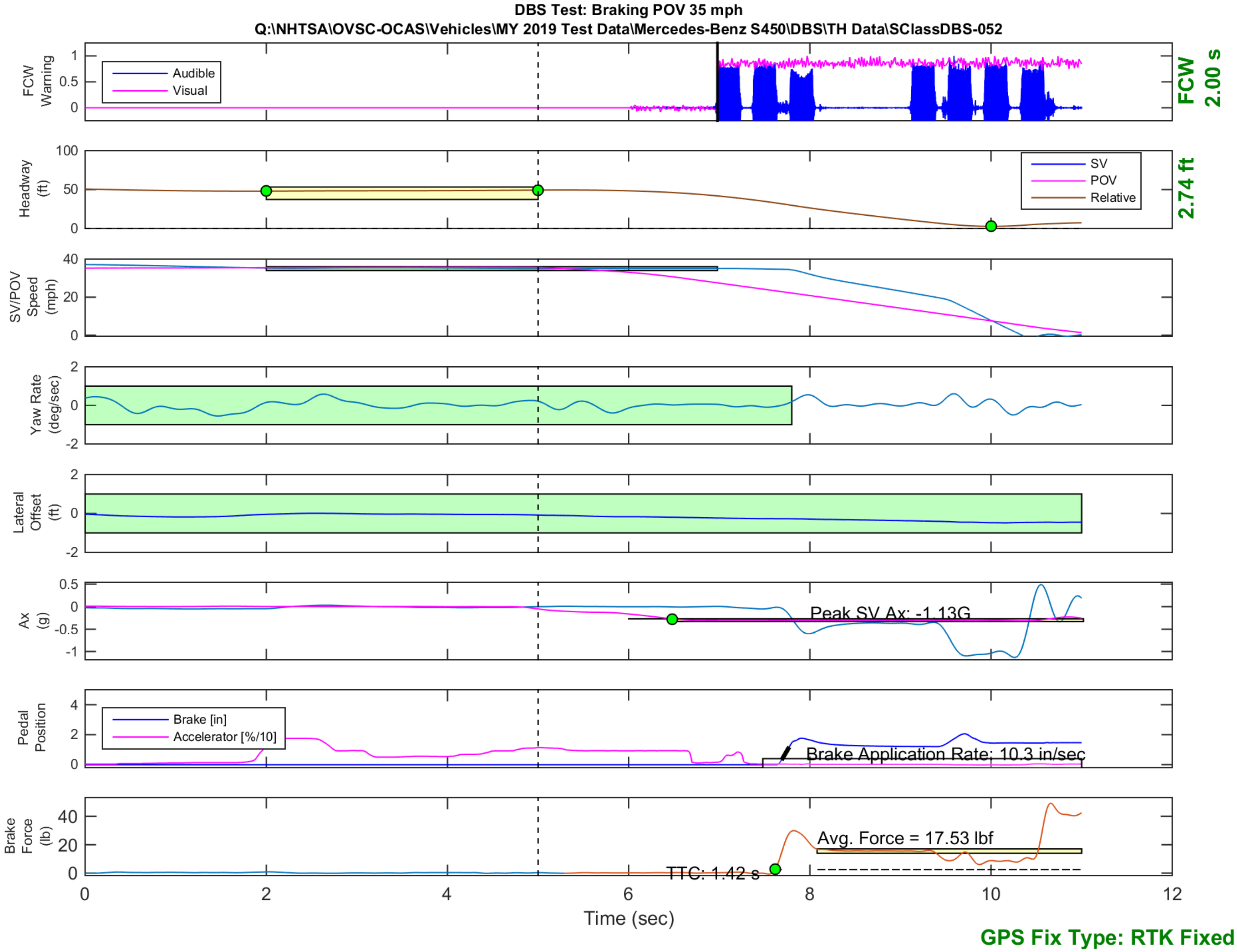


Figure E38. Time History for DBS Run 52, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

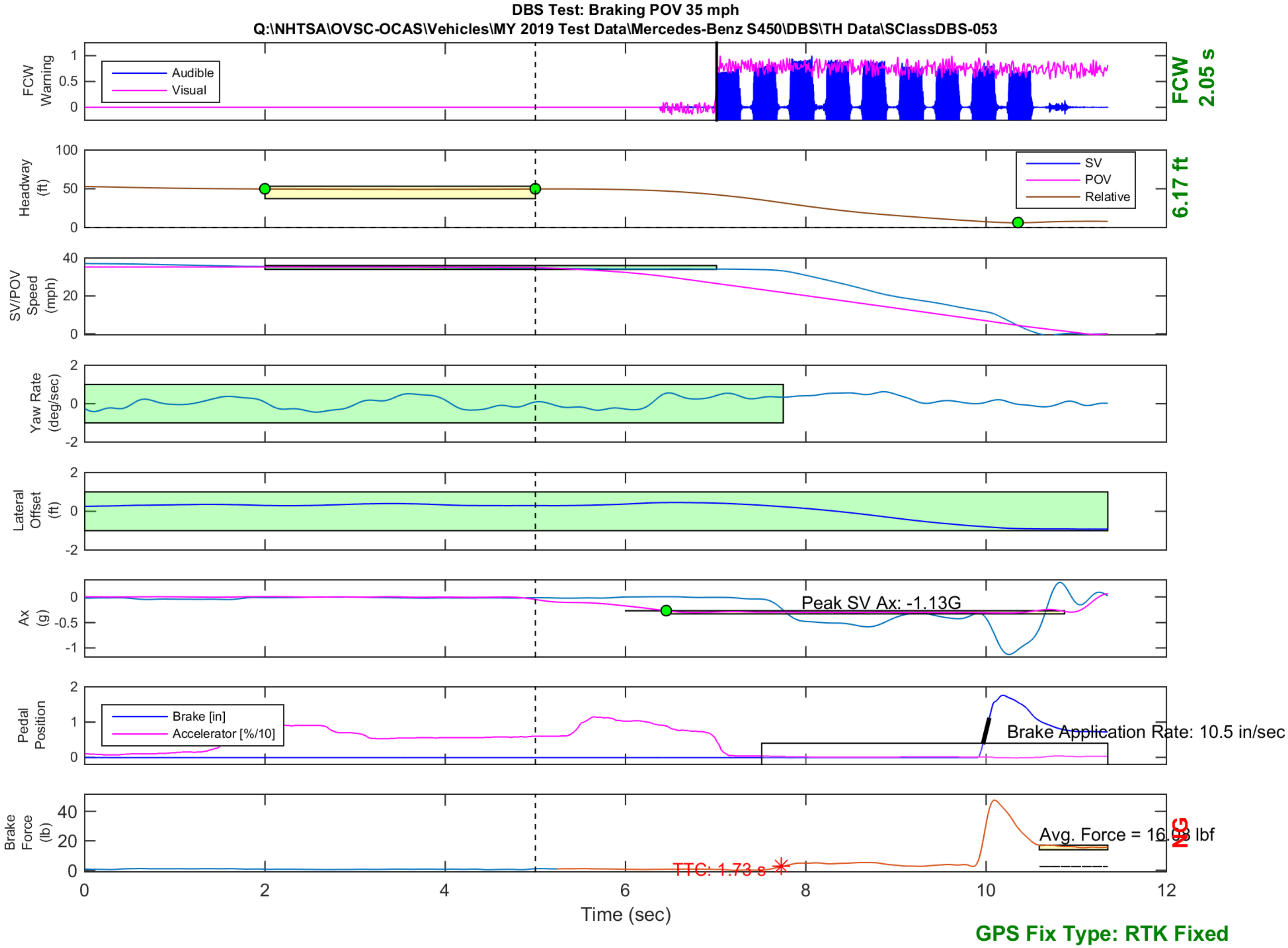


Figure E39. Time History for DBS Run 53, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

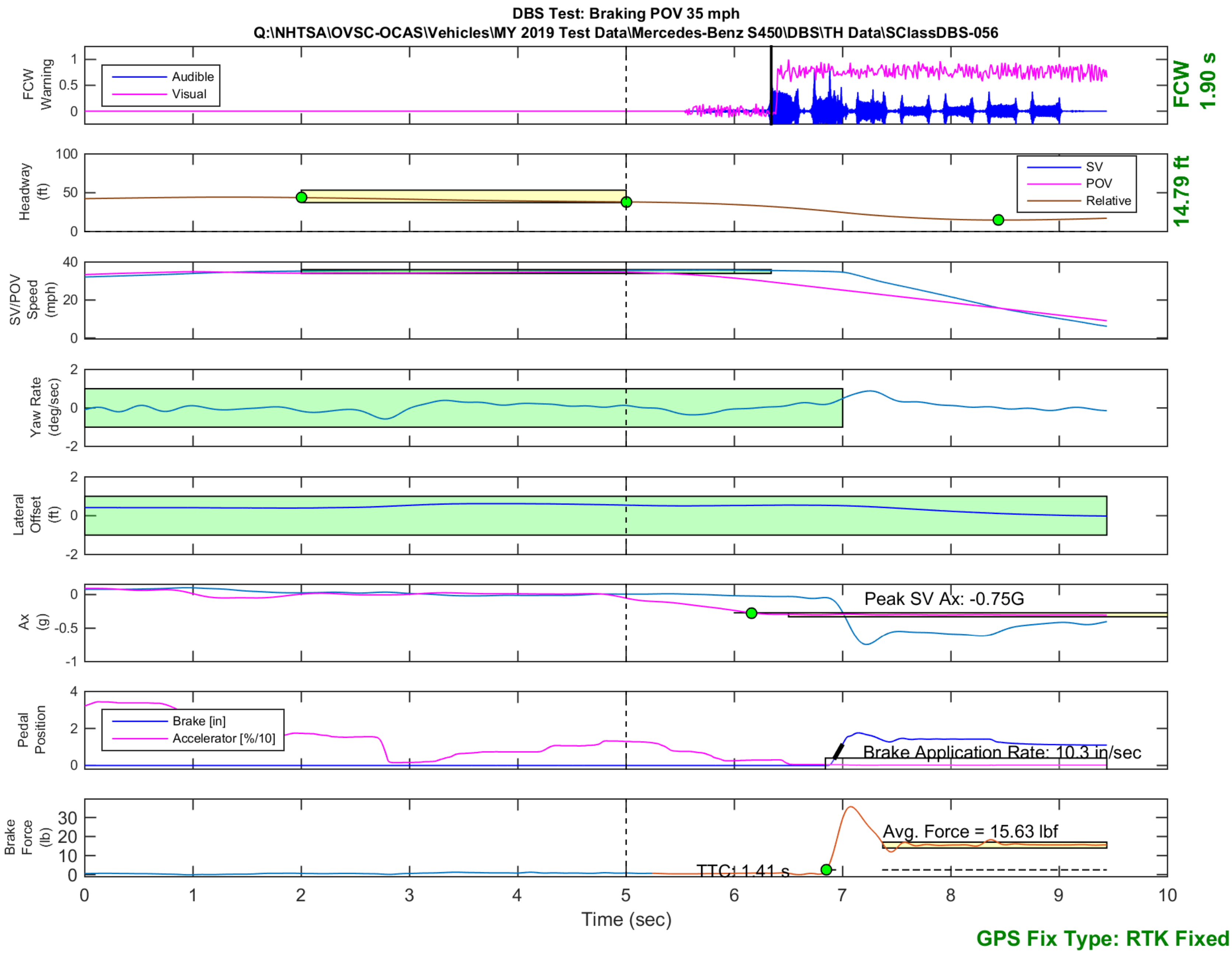


Figure E40. Time History for DBS Run 56, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

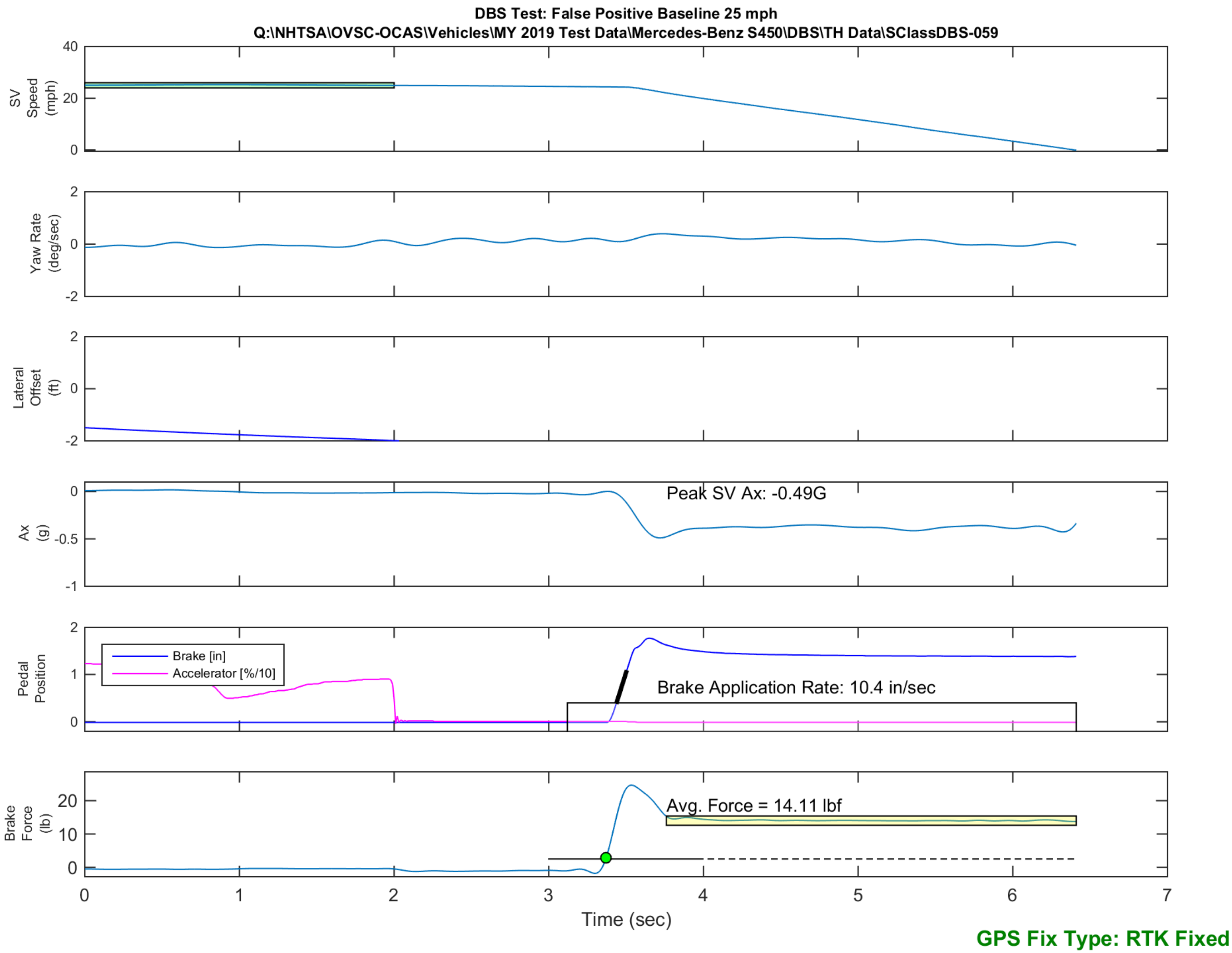


Figure E41. Time History for DBS Run 59, False Positive Baseline, SV 25 mph

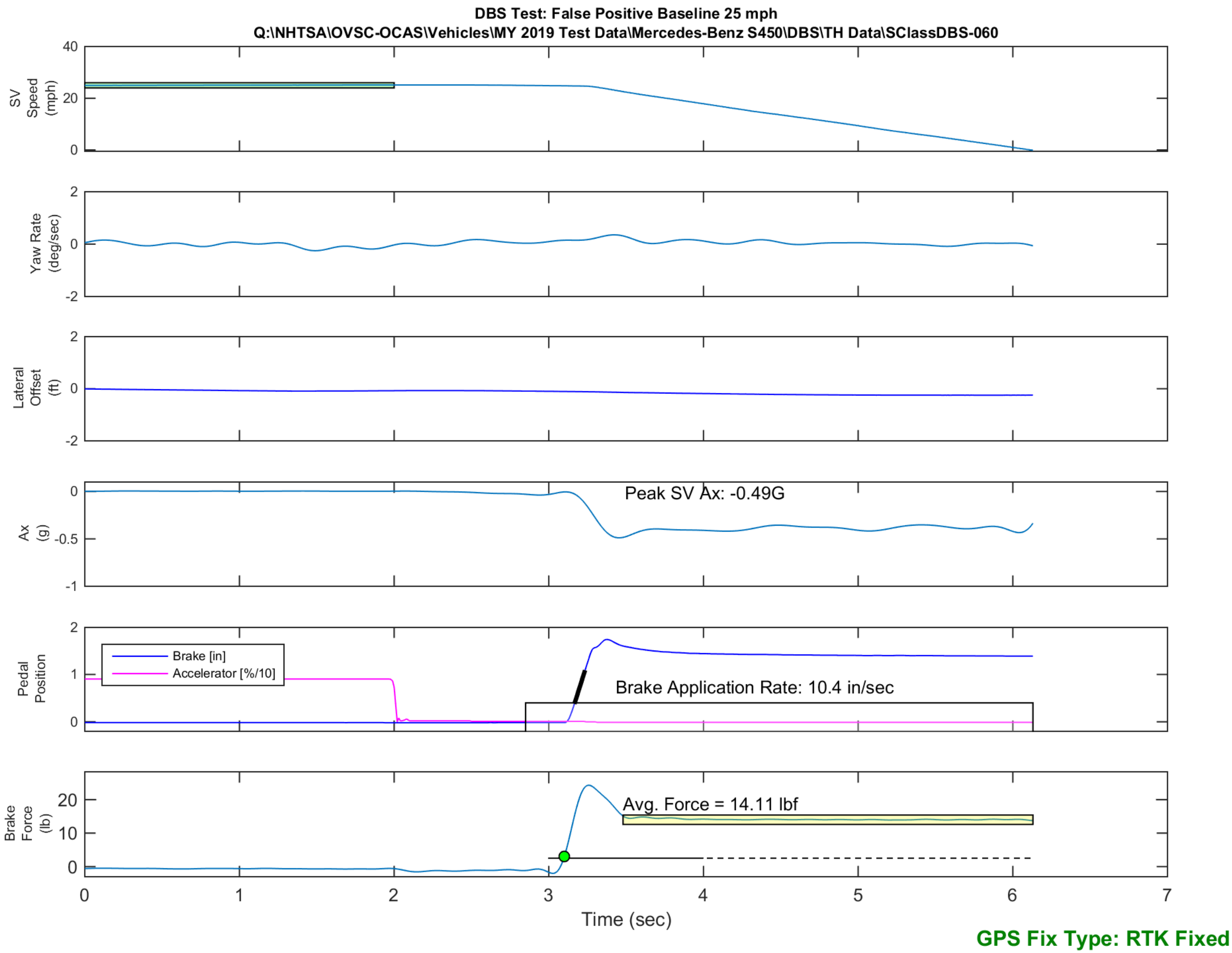


Figure E42. Time History for DBS Run 60, False Positive Baseline, SV 25 mph

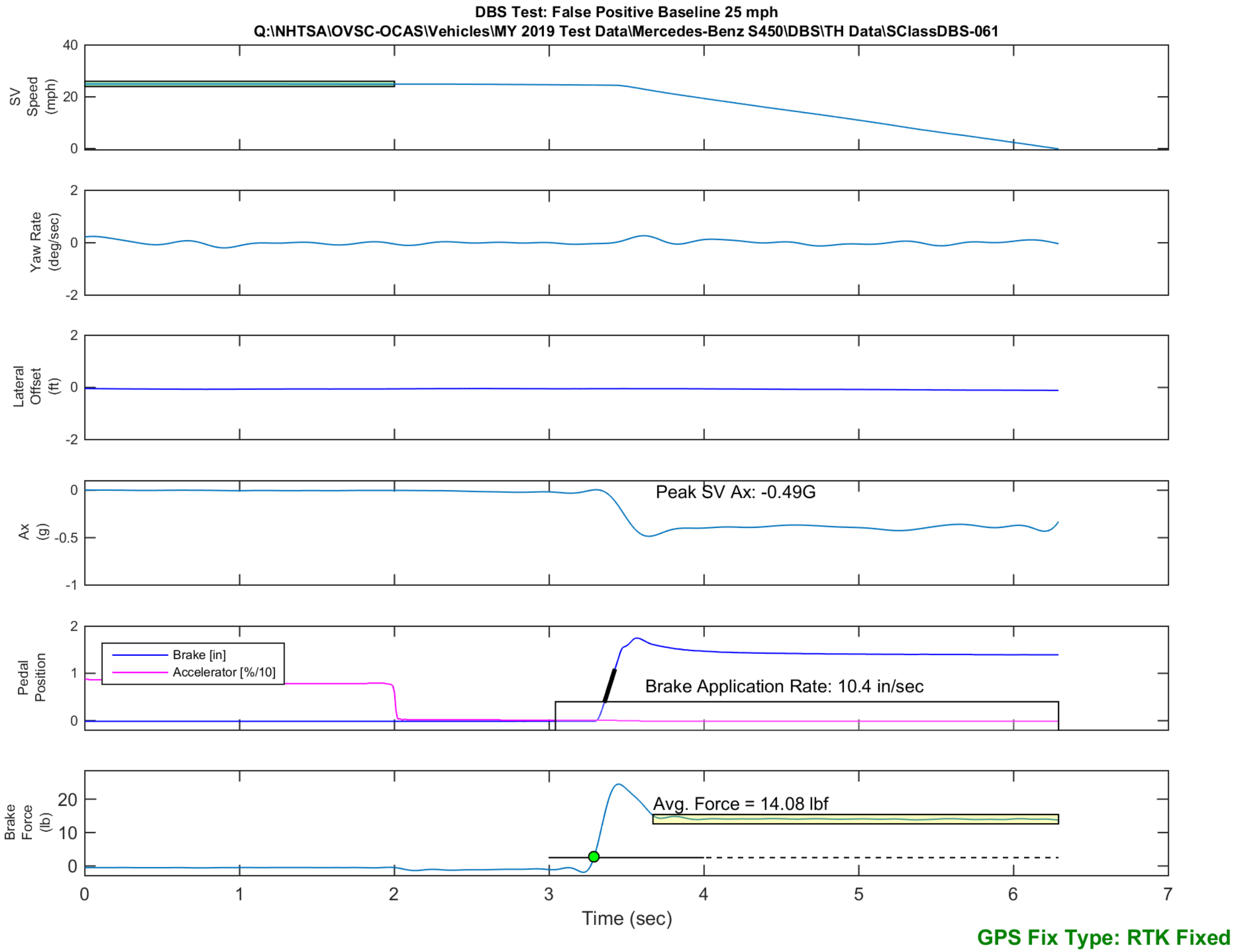


Figure E43. Time History for DBS Run 61, False Positive Baseline, SV 25 mph

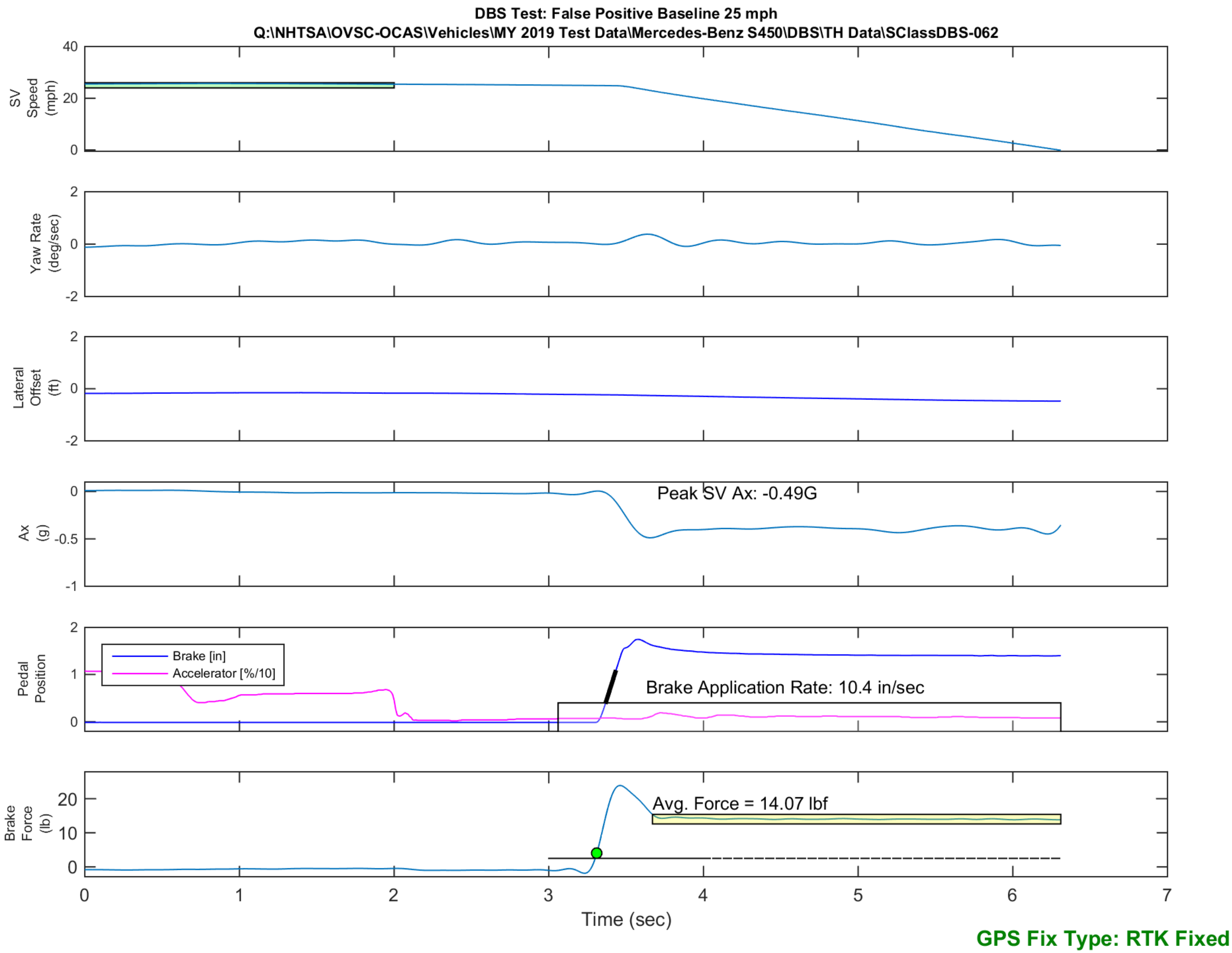


Figure E44. Time History for DBS Run 62, False Positive Baseline, SV 25 mph

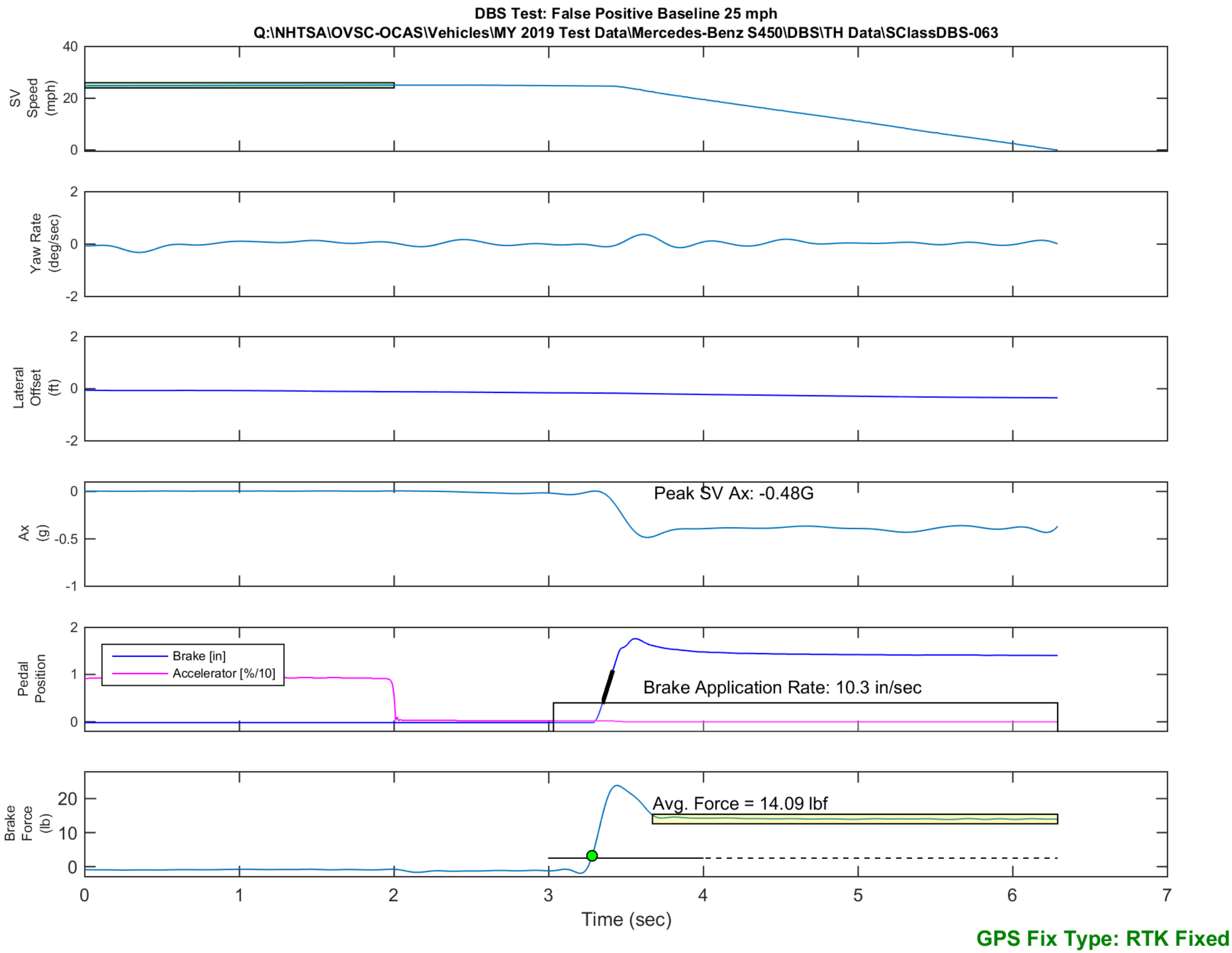


Figure E45. Time History for DBS Run 63, False Positive Baseline, SV 25 mph

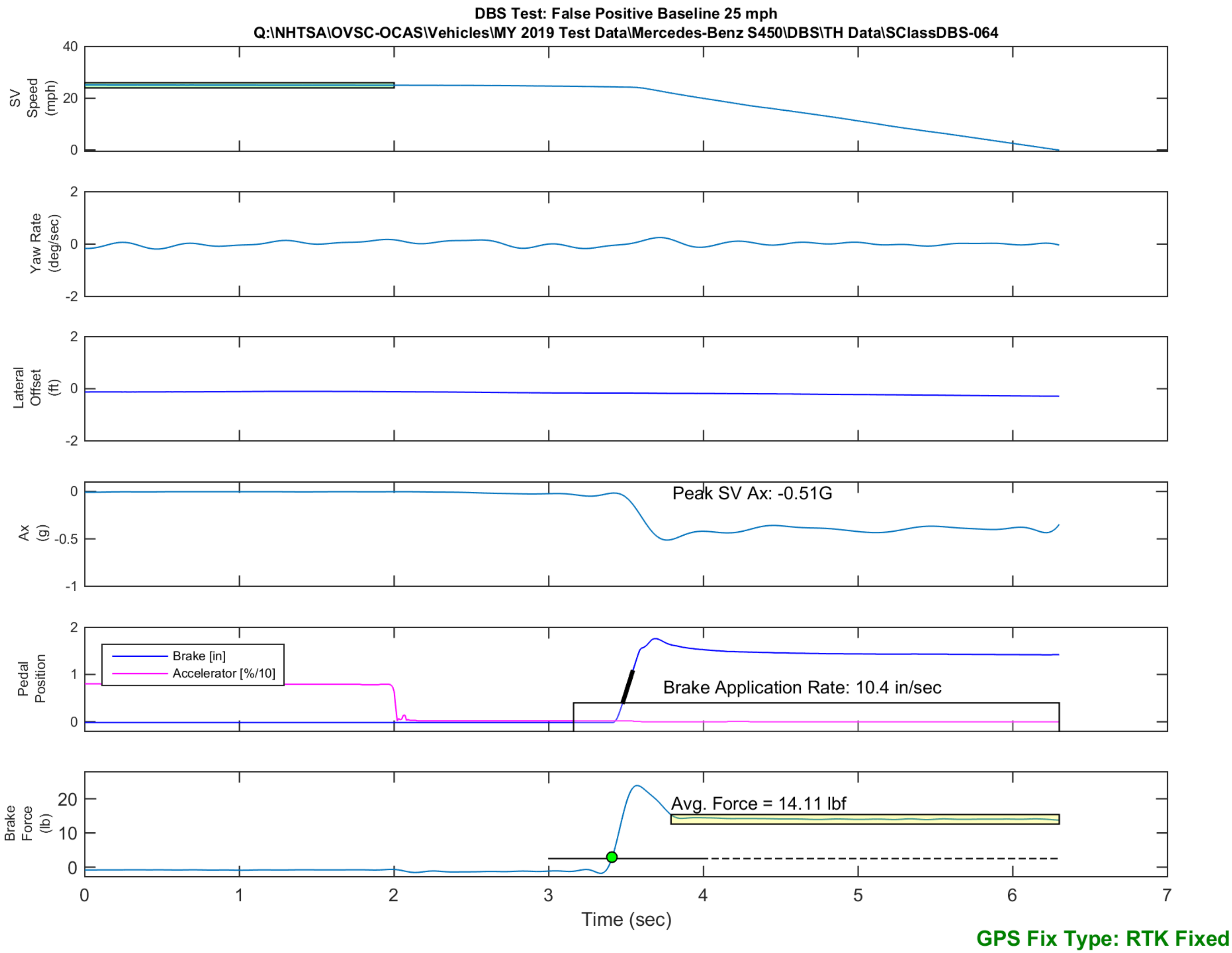


Figure E46. Time History for DBS Run 64, False Positive Baseline, SV 25 mph

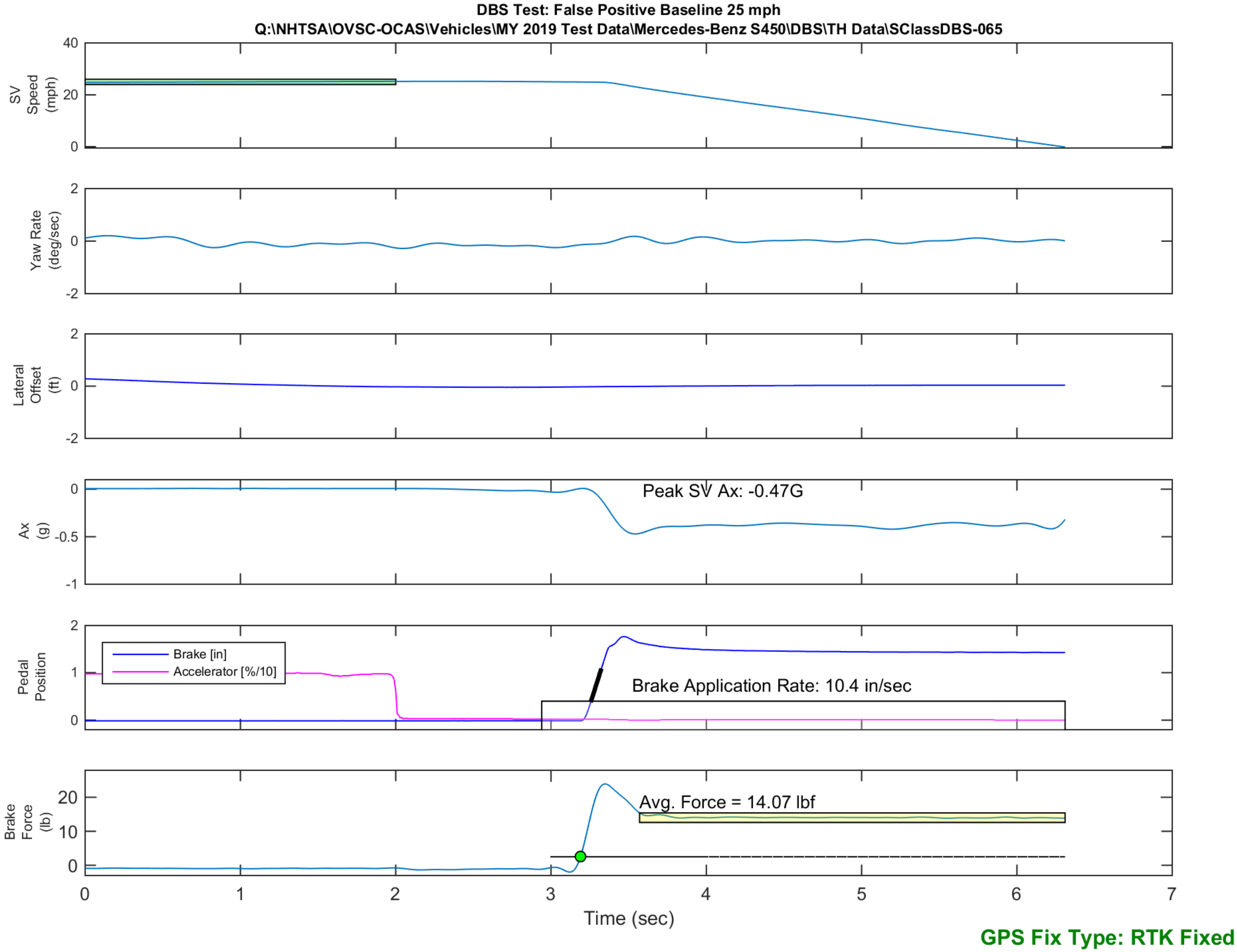


Figure E47. Time History for DBS Run 65, False Positive Baseline, SV 25 mph

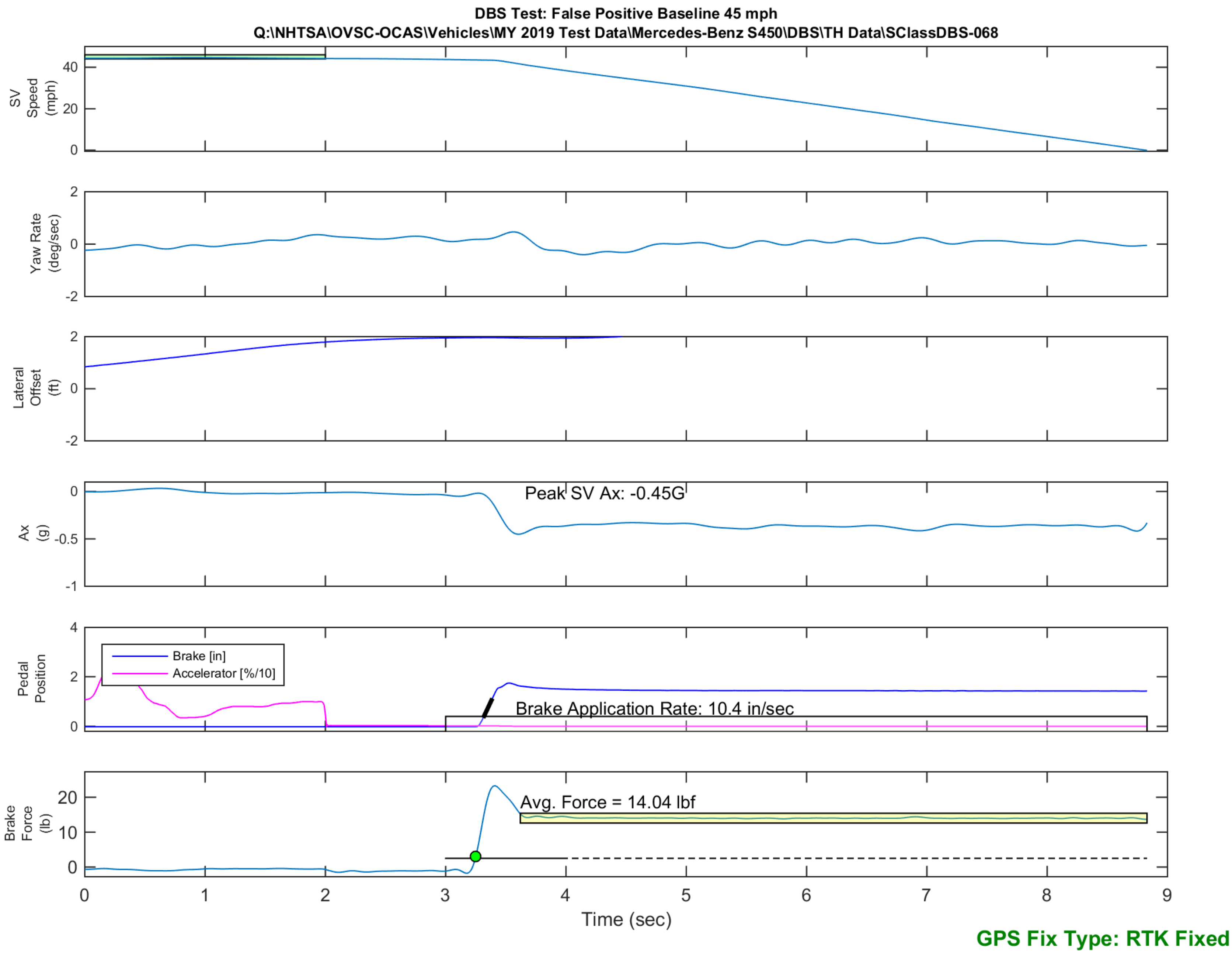


Figure E48. Time History for DBS Run 68, False Positive Baseline, SV 45 mph

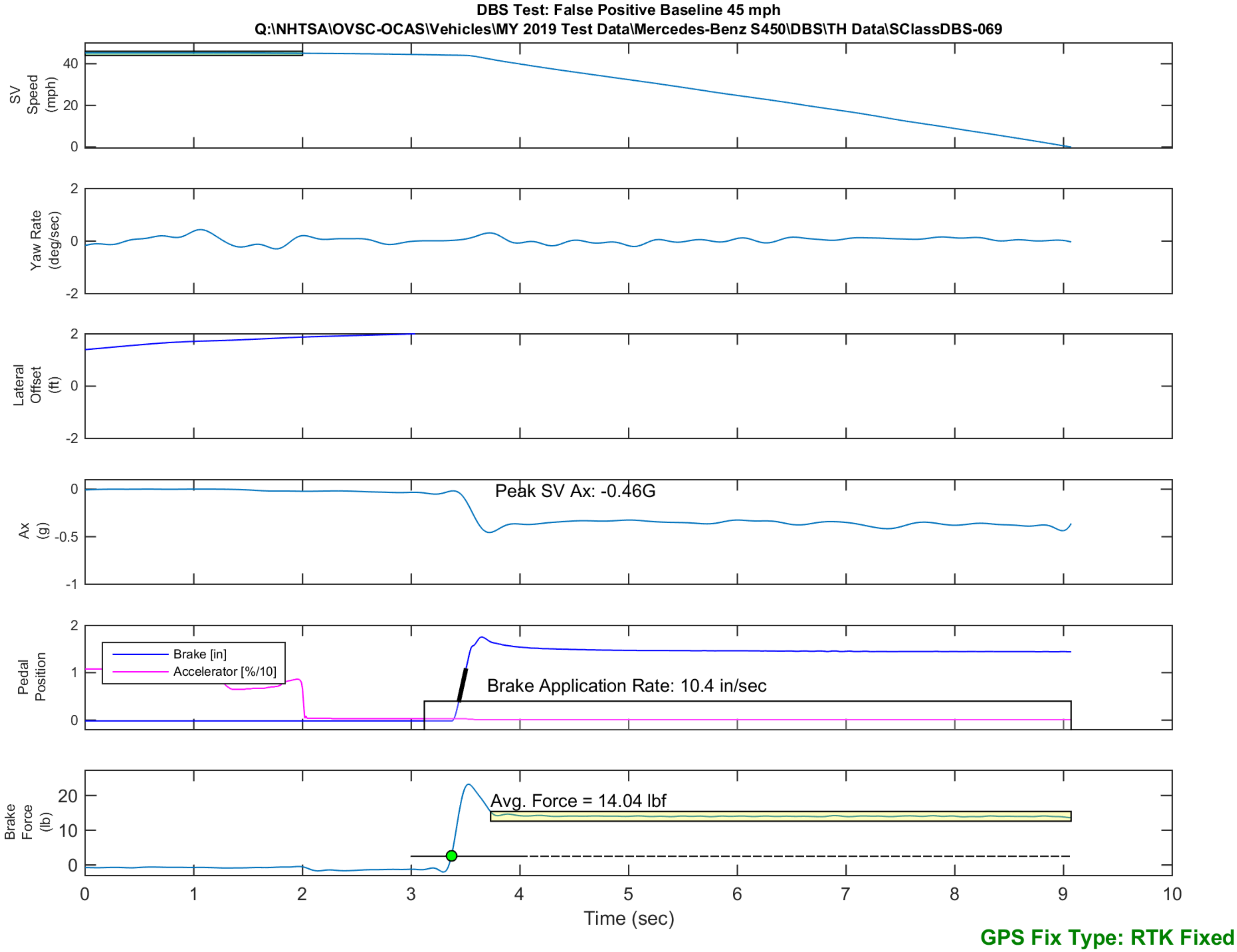


Figure E49. Time History for DBS Run 69, False Positive Baseline, SV 45 mph

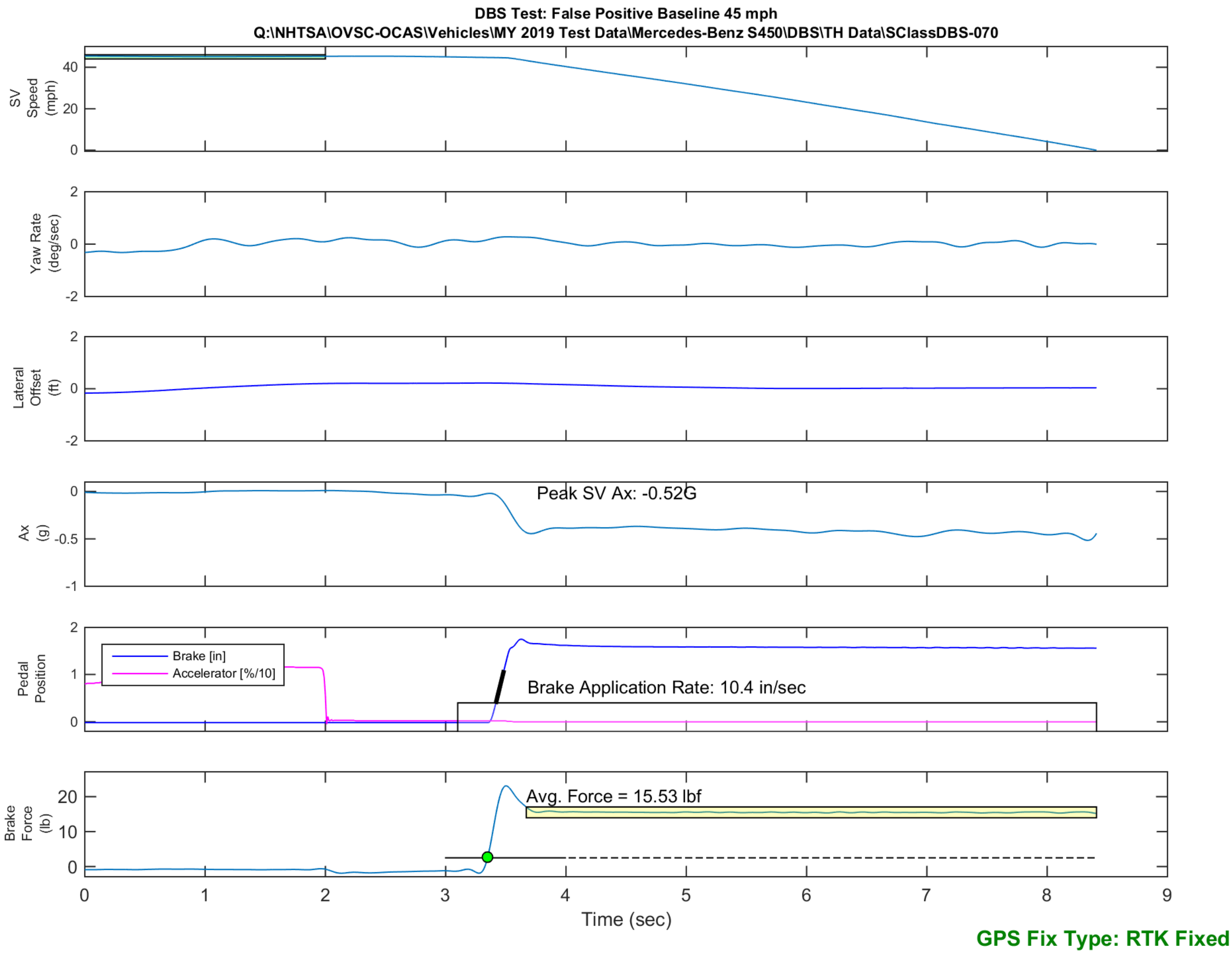


Figure E50. Time History for DBS Run 70, False Positive Baseline, SV 45 mph

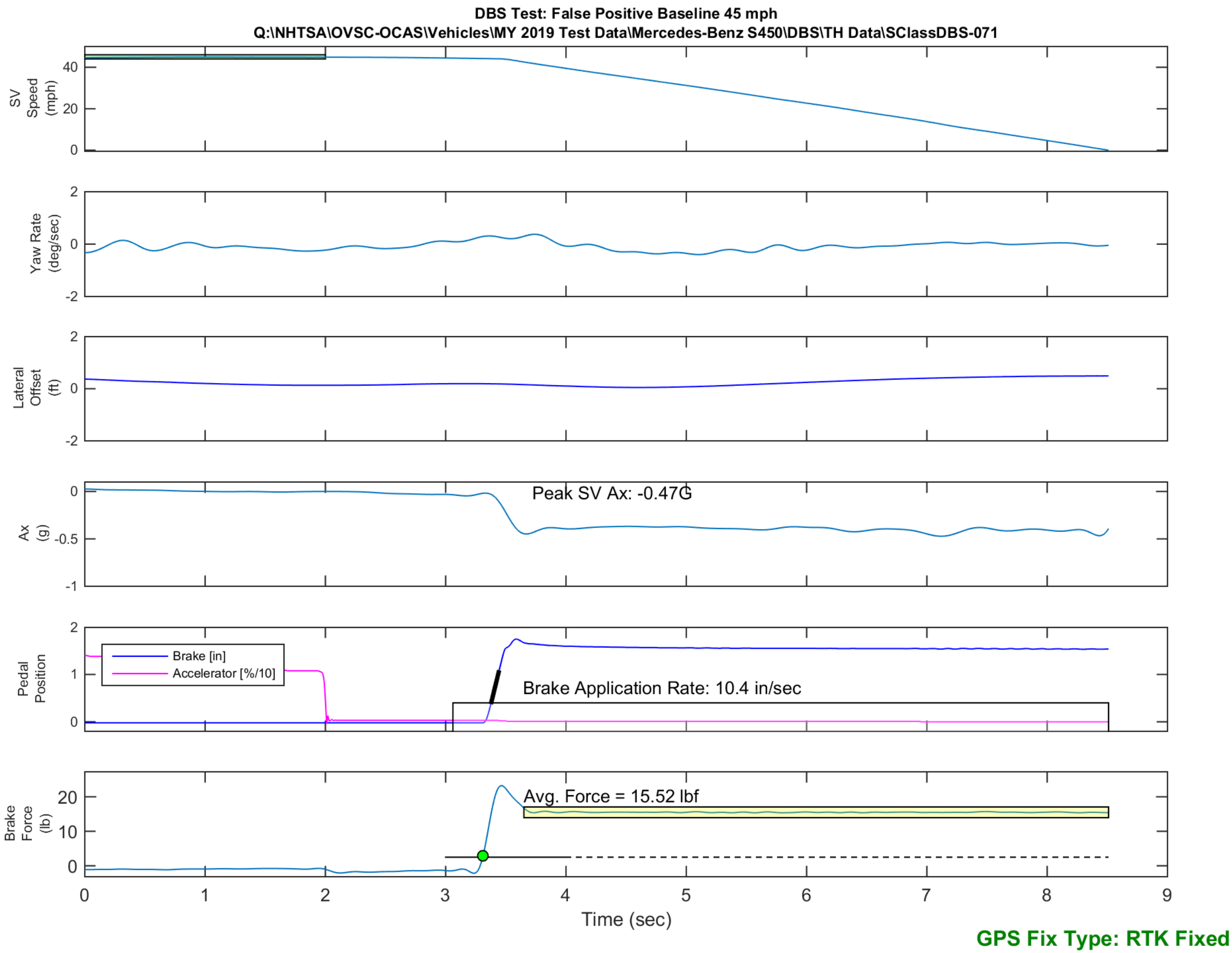


Figure E51. Time History for DBS Run 71, False Positive Baseline, SV 45 mph

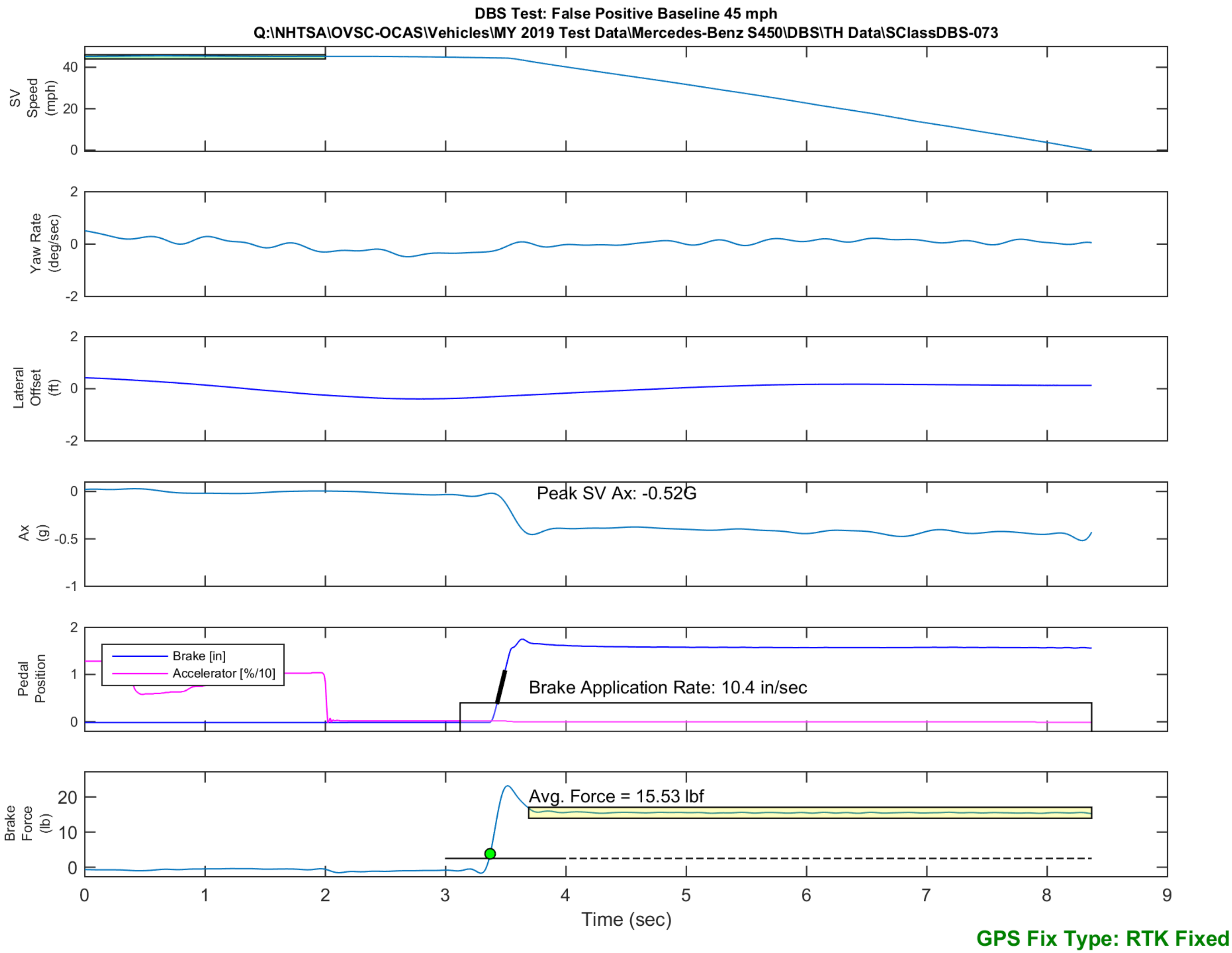


Figure E52. Time History for DBS Run 73, False Positive Baseline, SV 45 mph

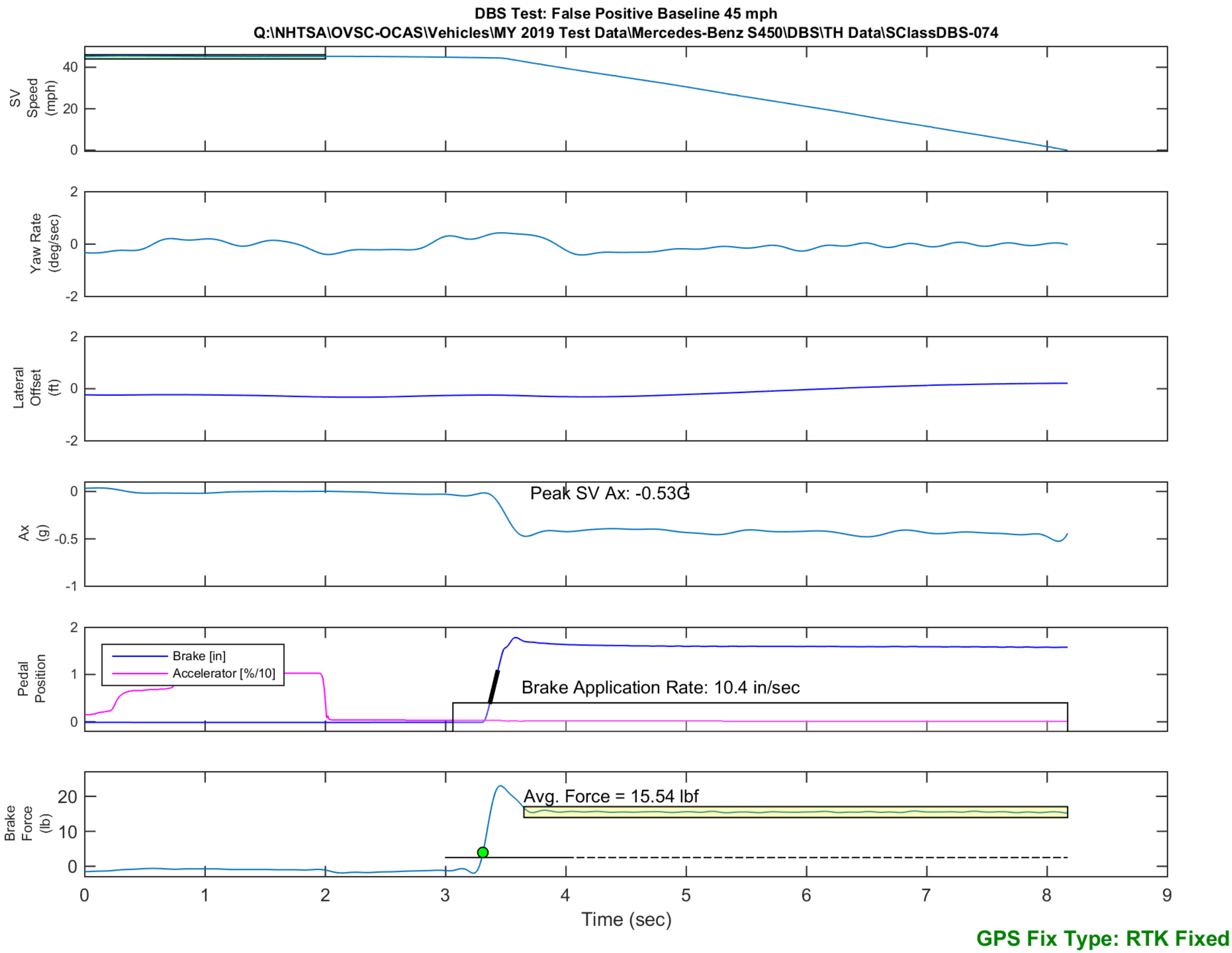


Figure E53. Time History for DBS Run 74, False Positive Baseline, SV 45 mph

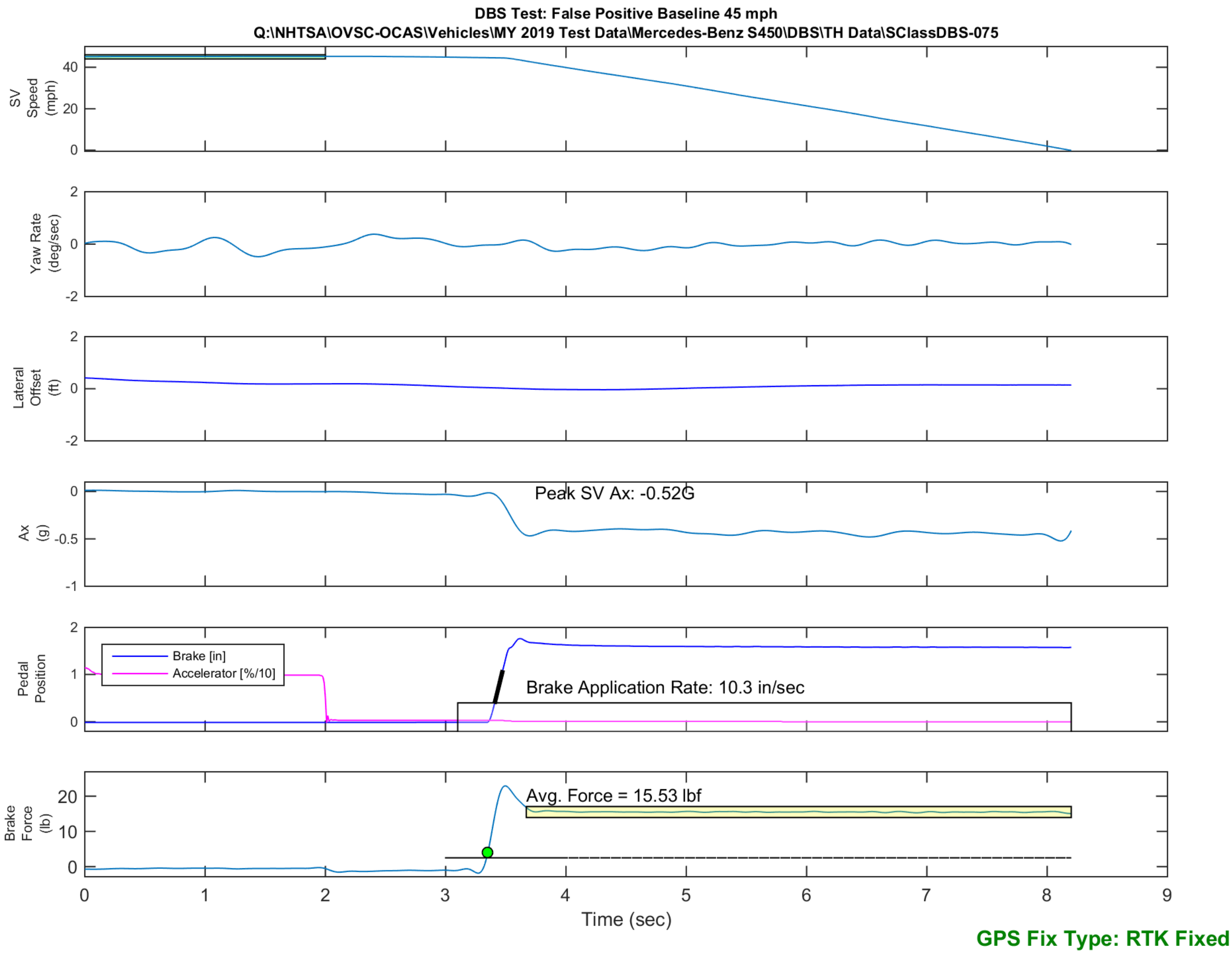


Figure E54. Time History for DBS Run 75, False Positive Baseline, SV 45 mph

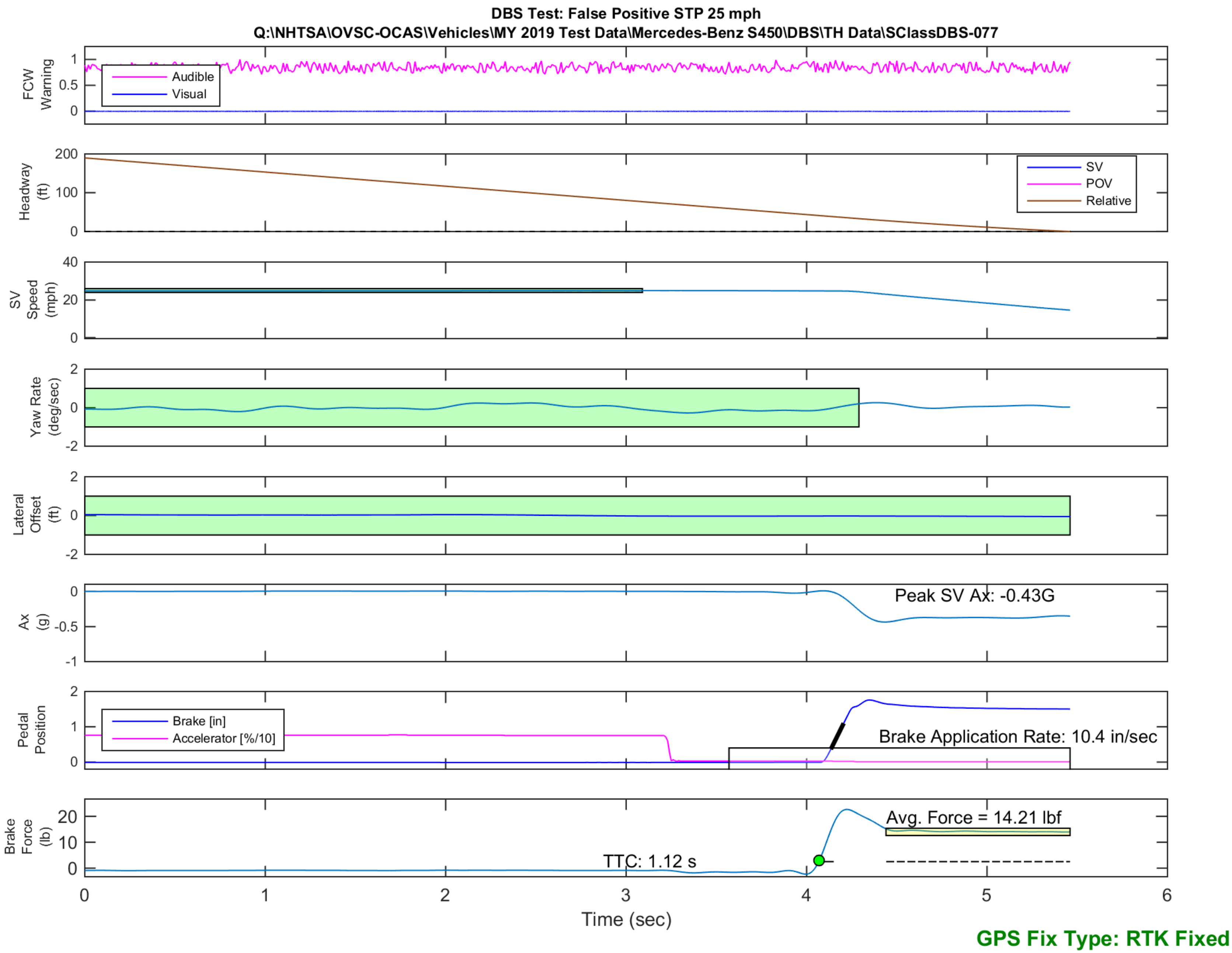


Figure E55. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 25 mph

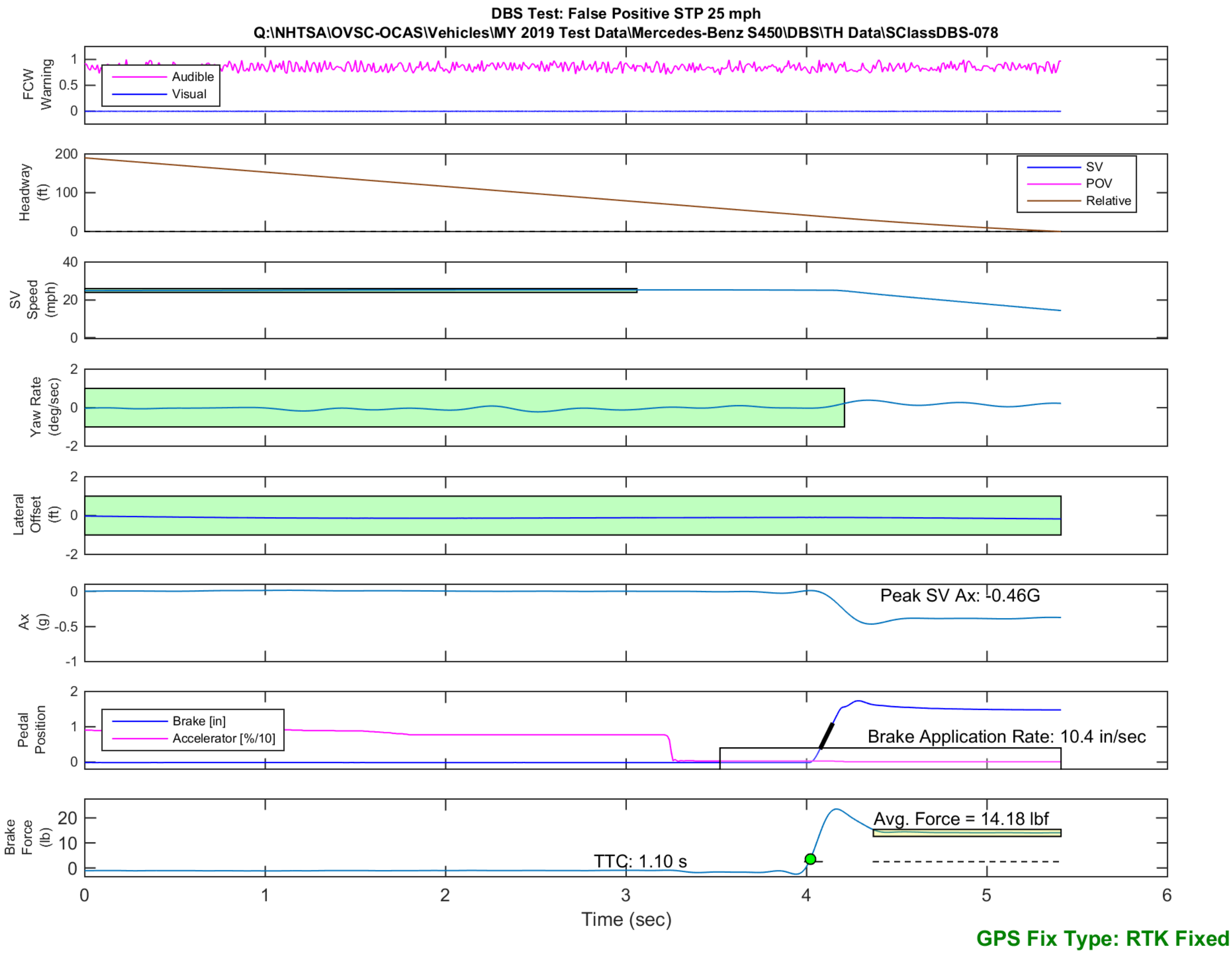


Figure E56. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 25 mph

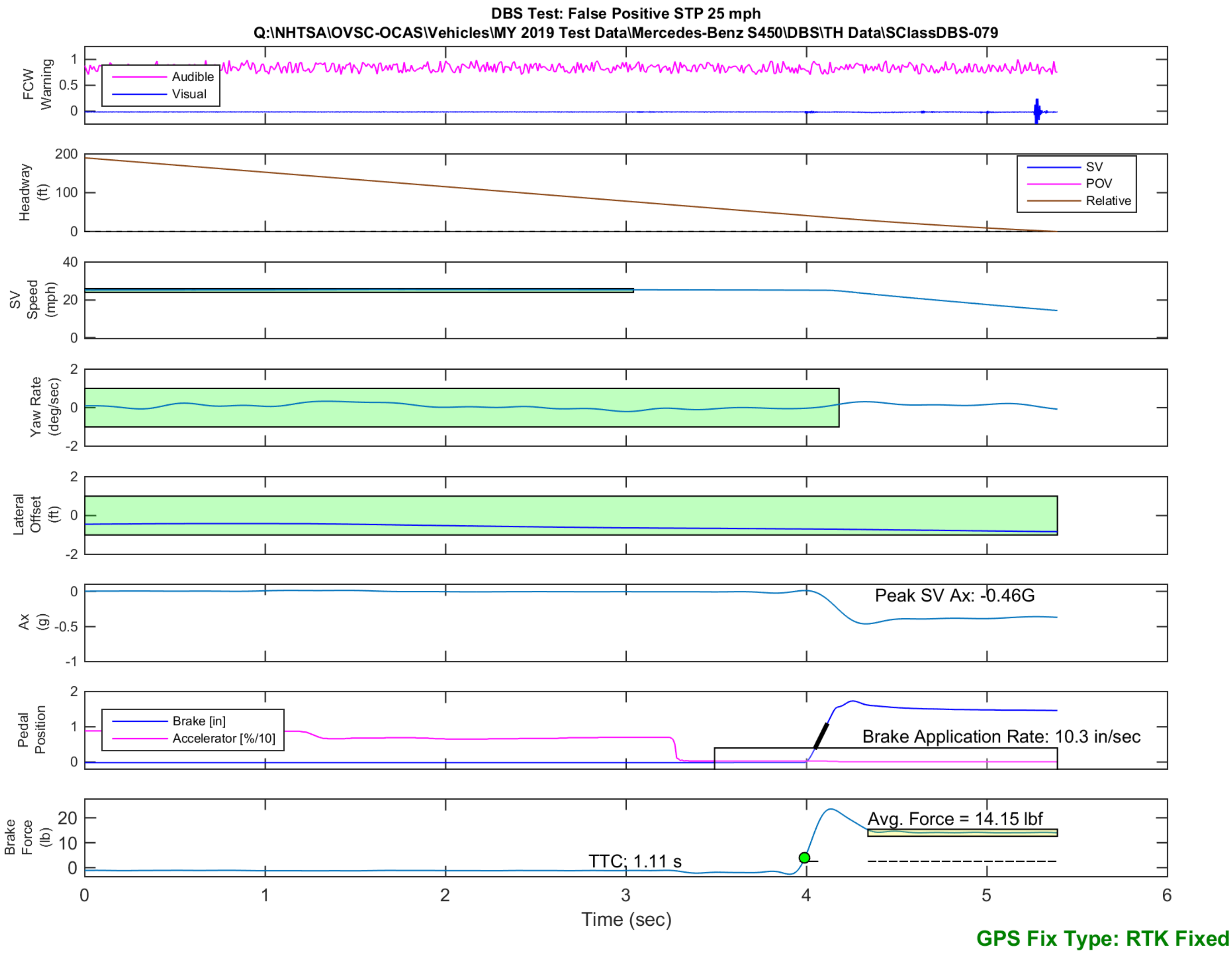


Figure E57. Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 25 mph

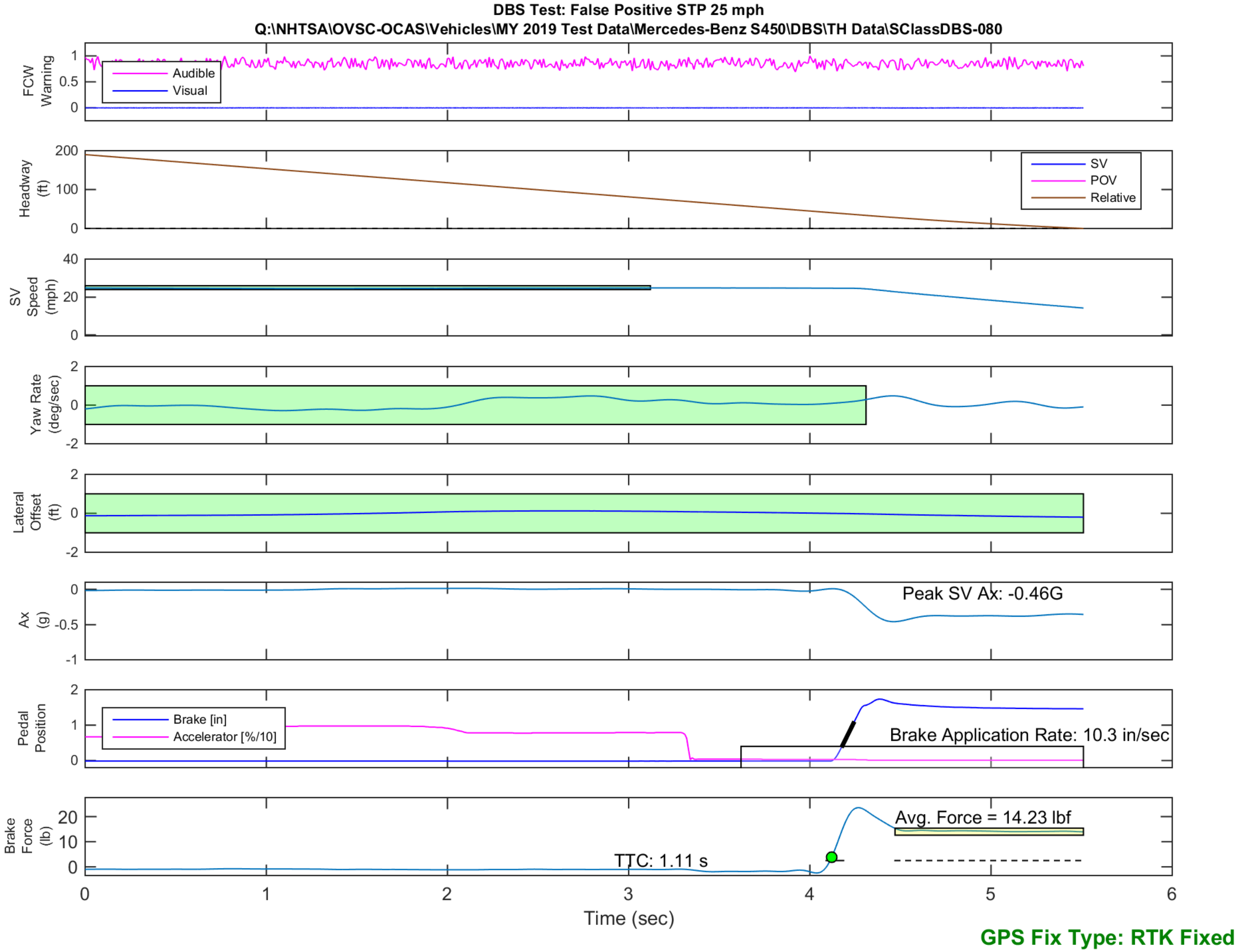


Figure E58. Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 25 mph

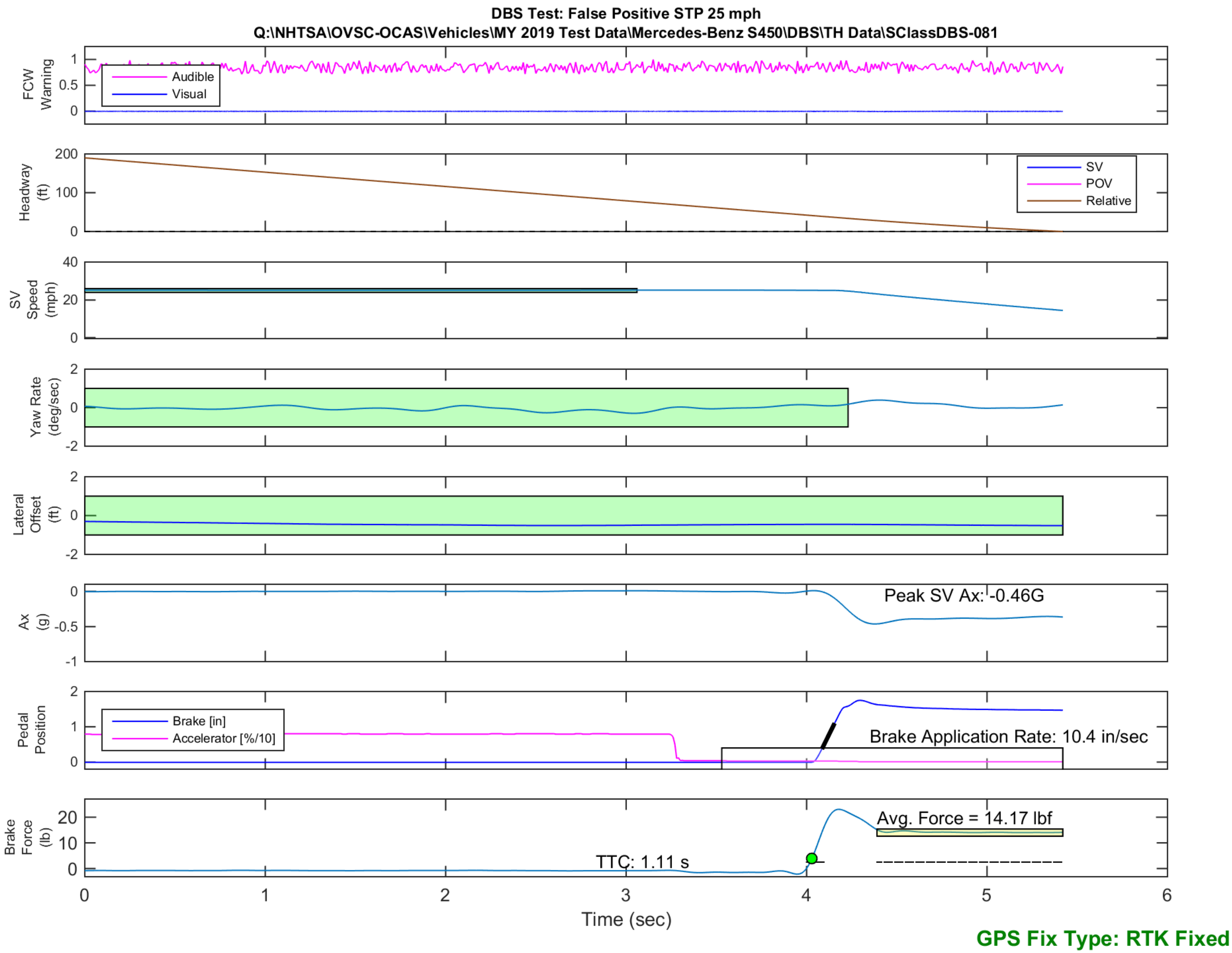


Figure E59. Time History for DBS Run 81, SV Encounters Steel Trench Plate, SV 25 mph

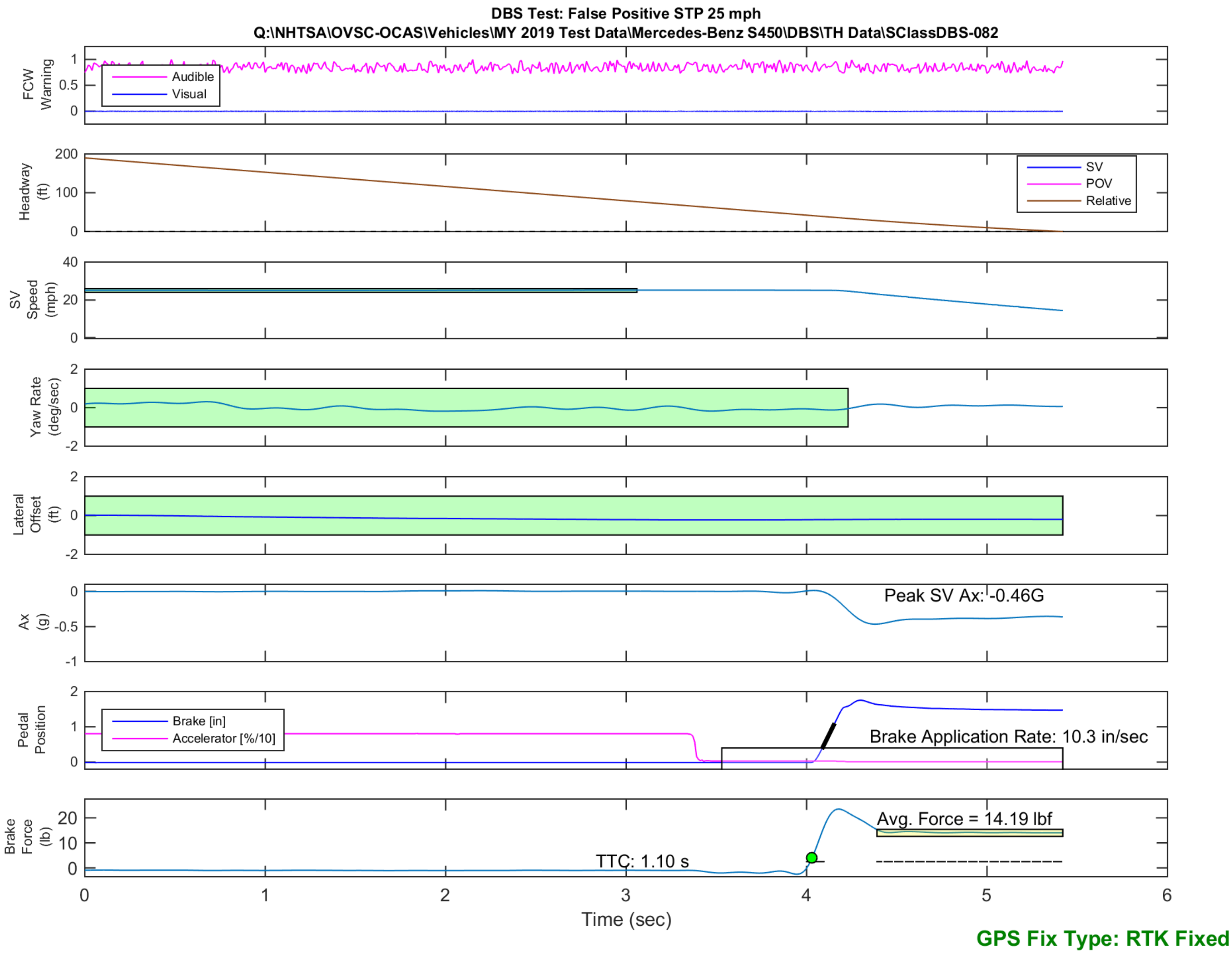


Figure E60. Time History for DBS Run 82, SV Encounters Steel Trench Plate, SV 25 mph

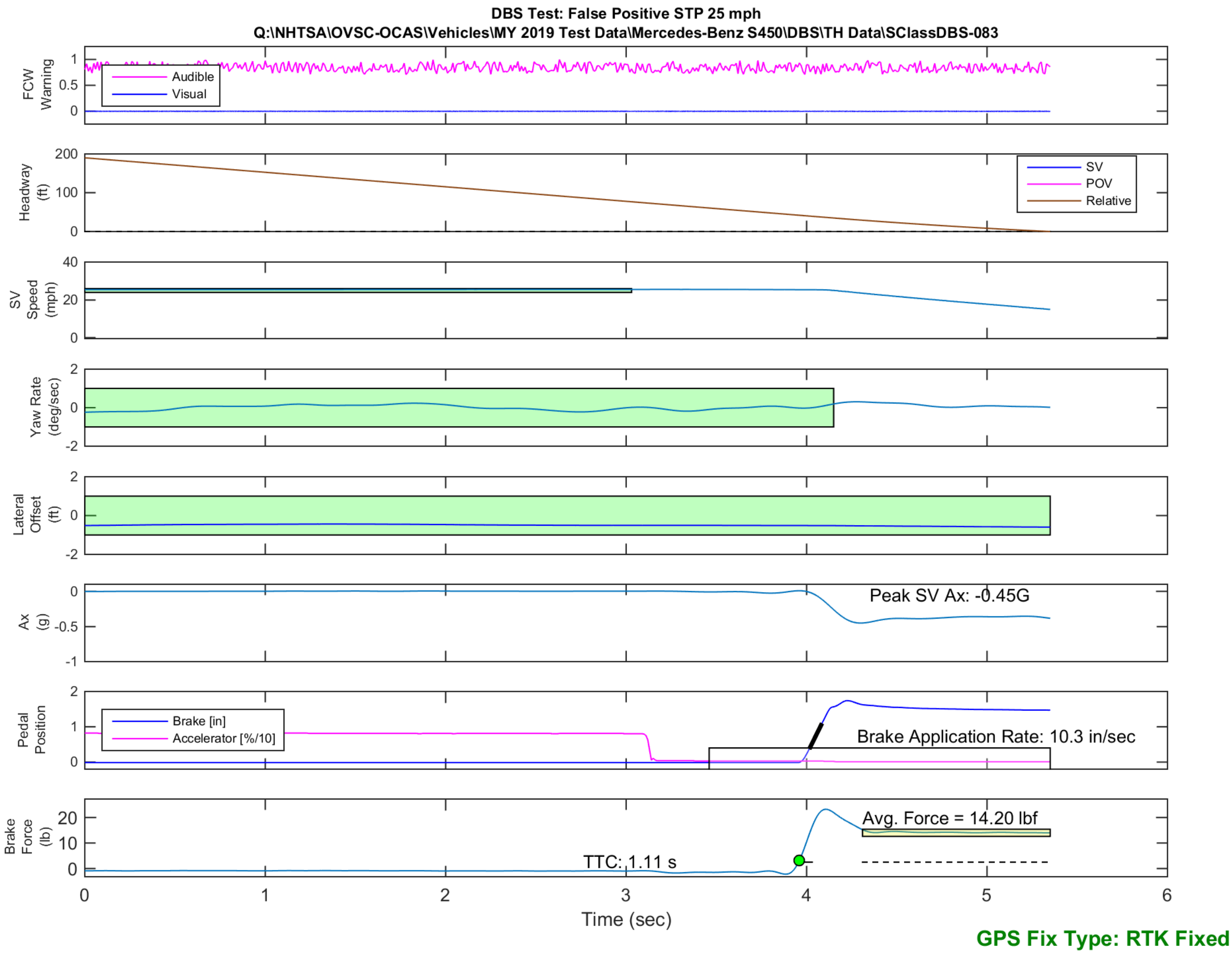


Figure E61. Time History for DBS Run 83, SV Encounters Steel Trench Plate, SV 25 mph

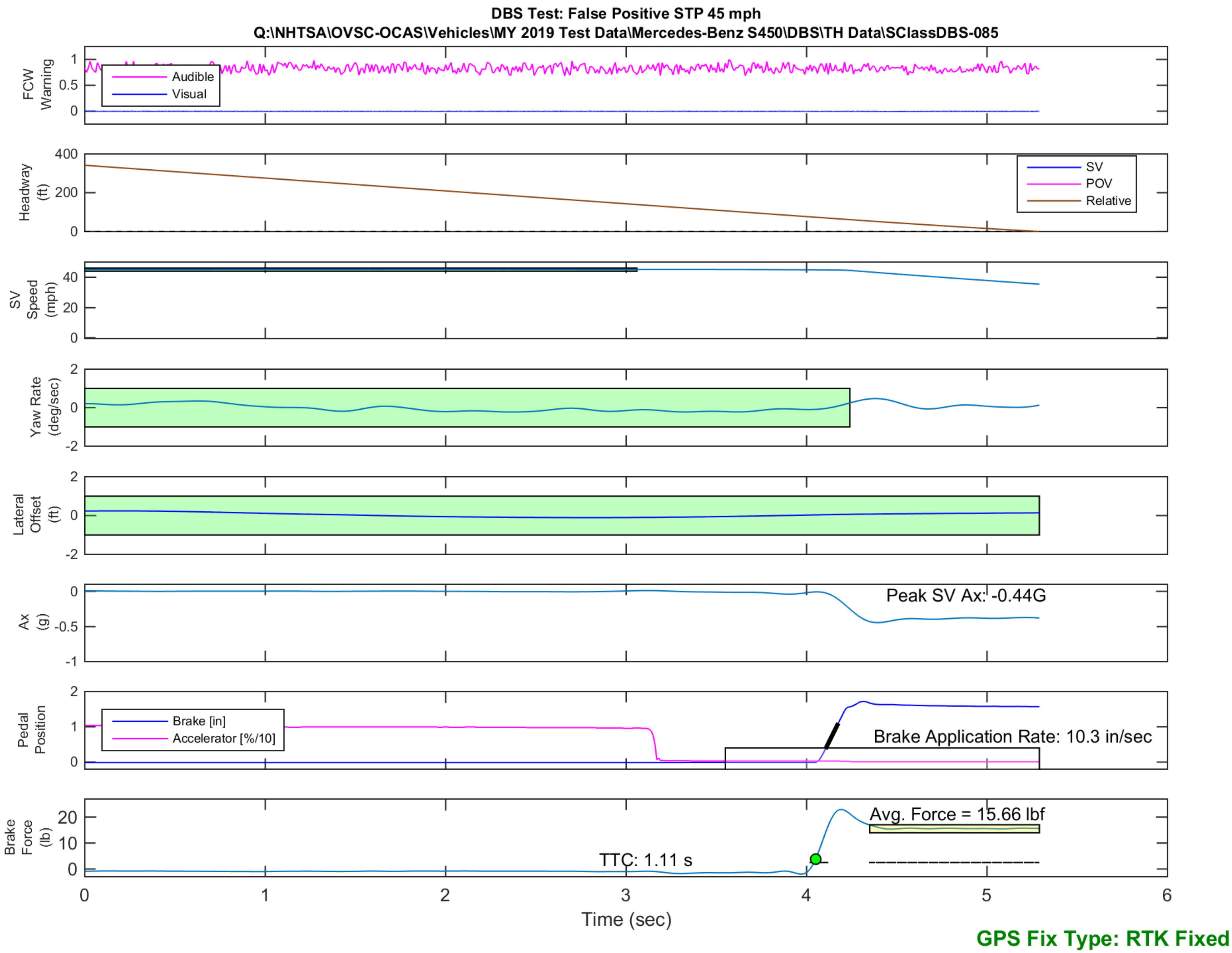


Figure E62. Time History for DBS Run 85, SV Encounters Steel Trench Plate, SV 45 mph

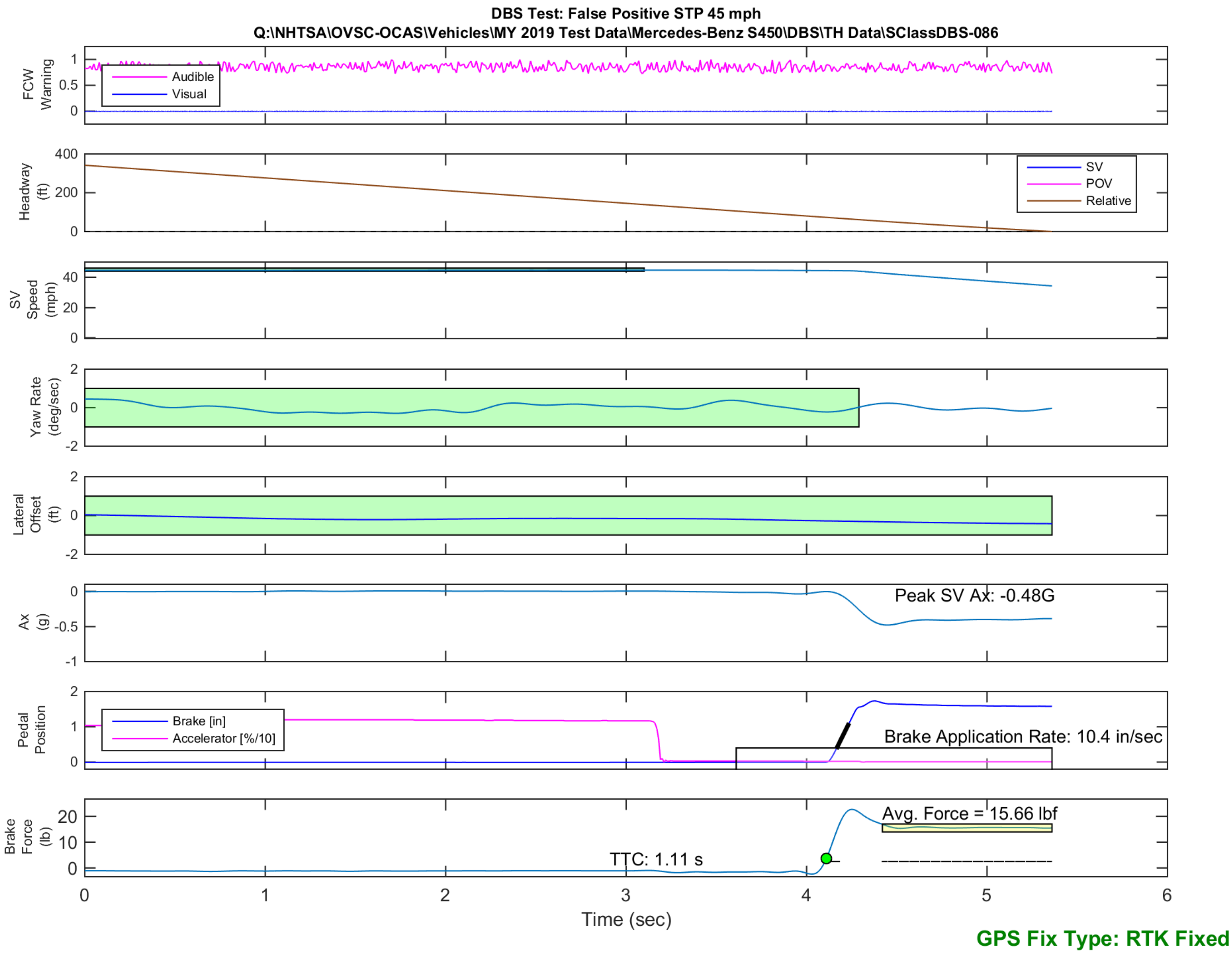


Figure E63. Time History for DBS Run 86, SV Encounters Steel Trench Plate, SV 45 mph

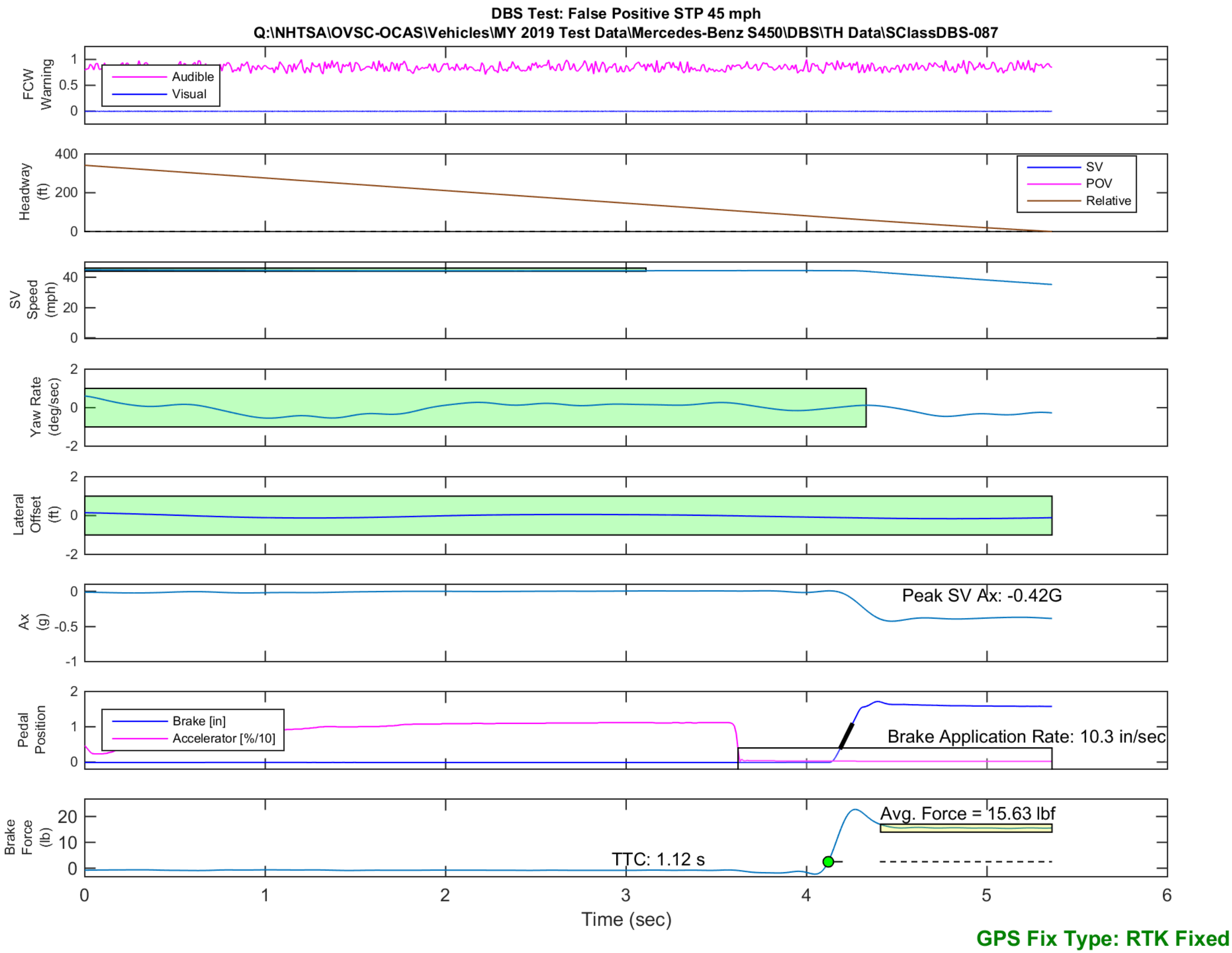


Figure E64. Time History for DBS Run 87, SV Encounters Steel Trench Plate, SV 45 mph

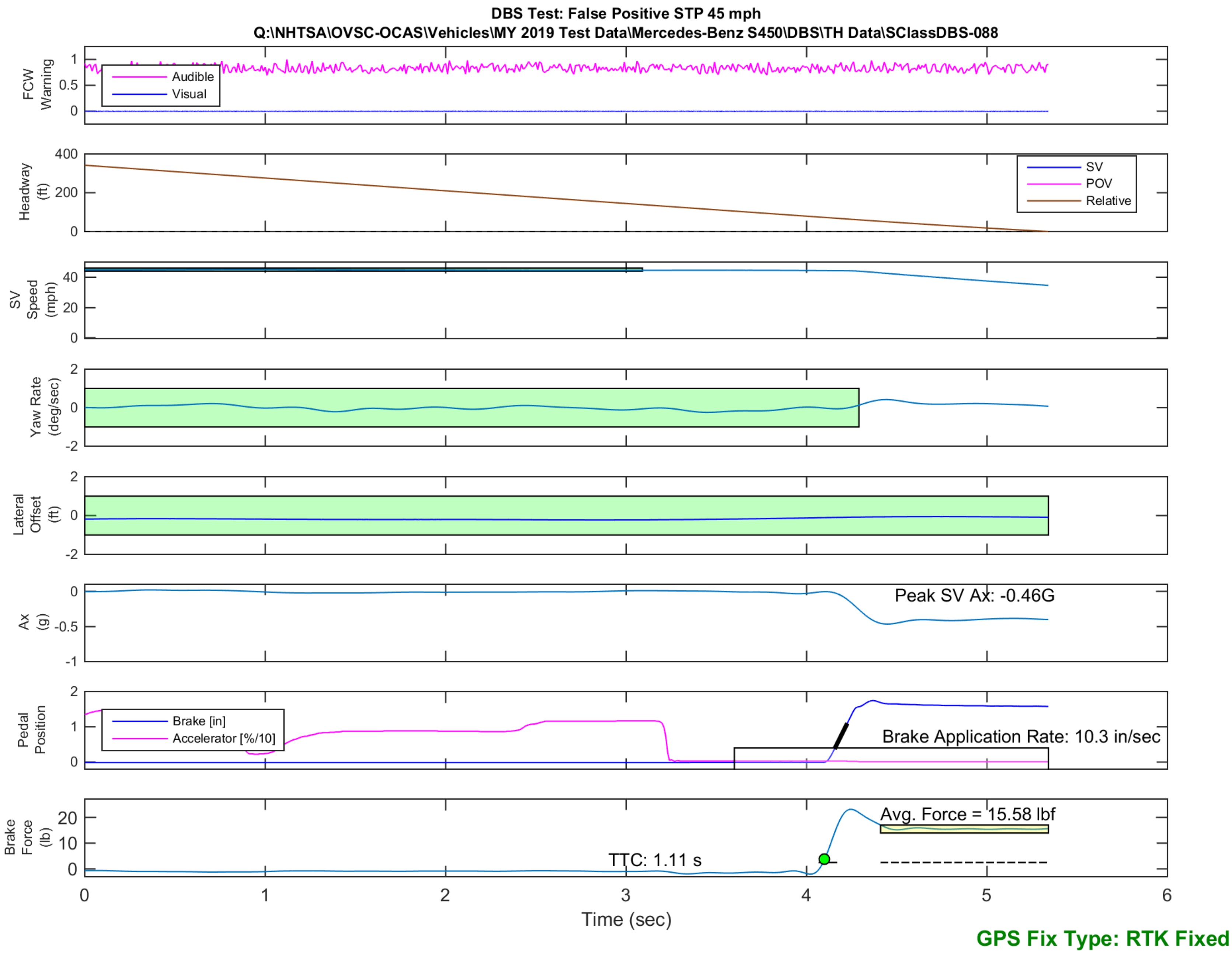


Figure E65. Time History for DBS Run 88, SV Encounters Steel Trench Plate, SV 45 mph

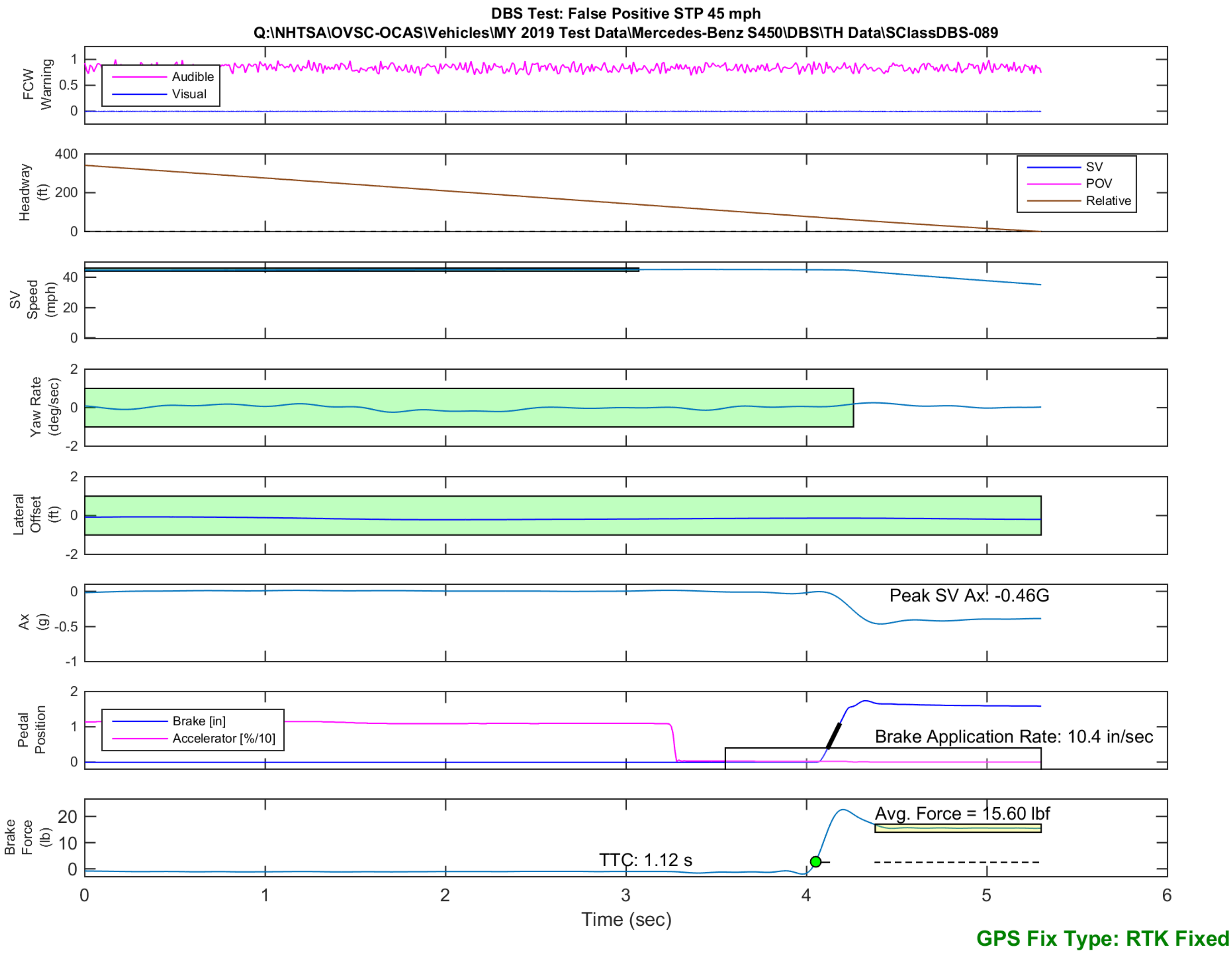


Figure E66. Time History for DBS Run 89, SV Encounters Steel Trench Plate, SV 45 mph

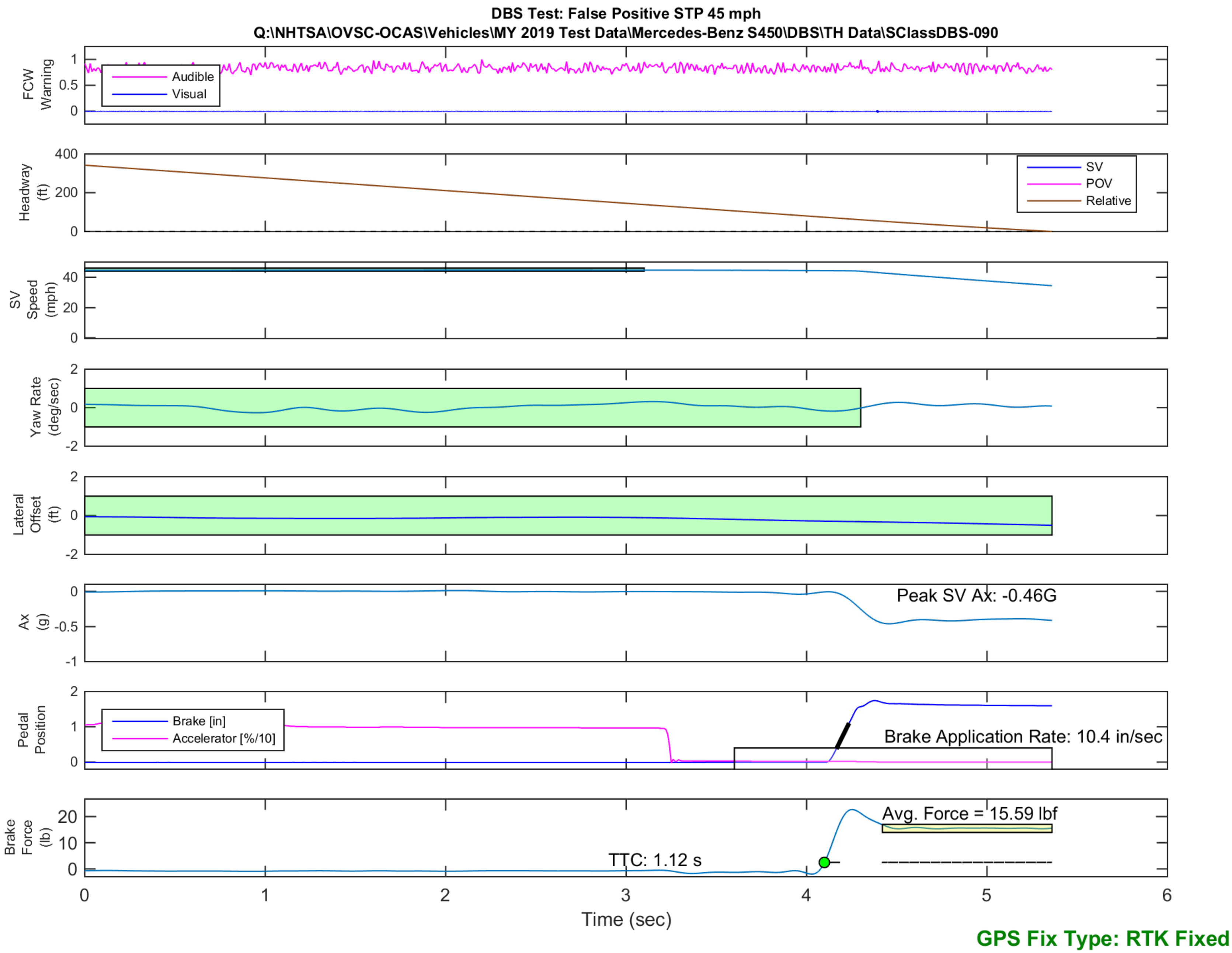


Figure E67. Time History for DBS Run 90, SV Encounters Steel Trench Plate, SV 45 mph

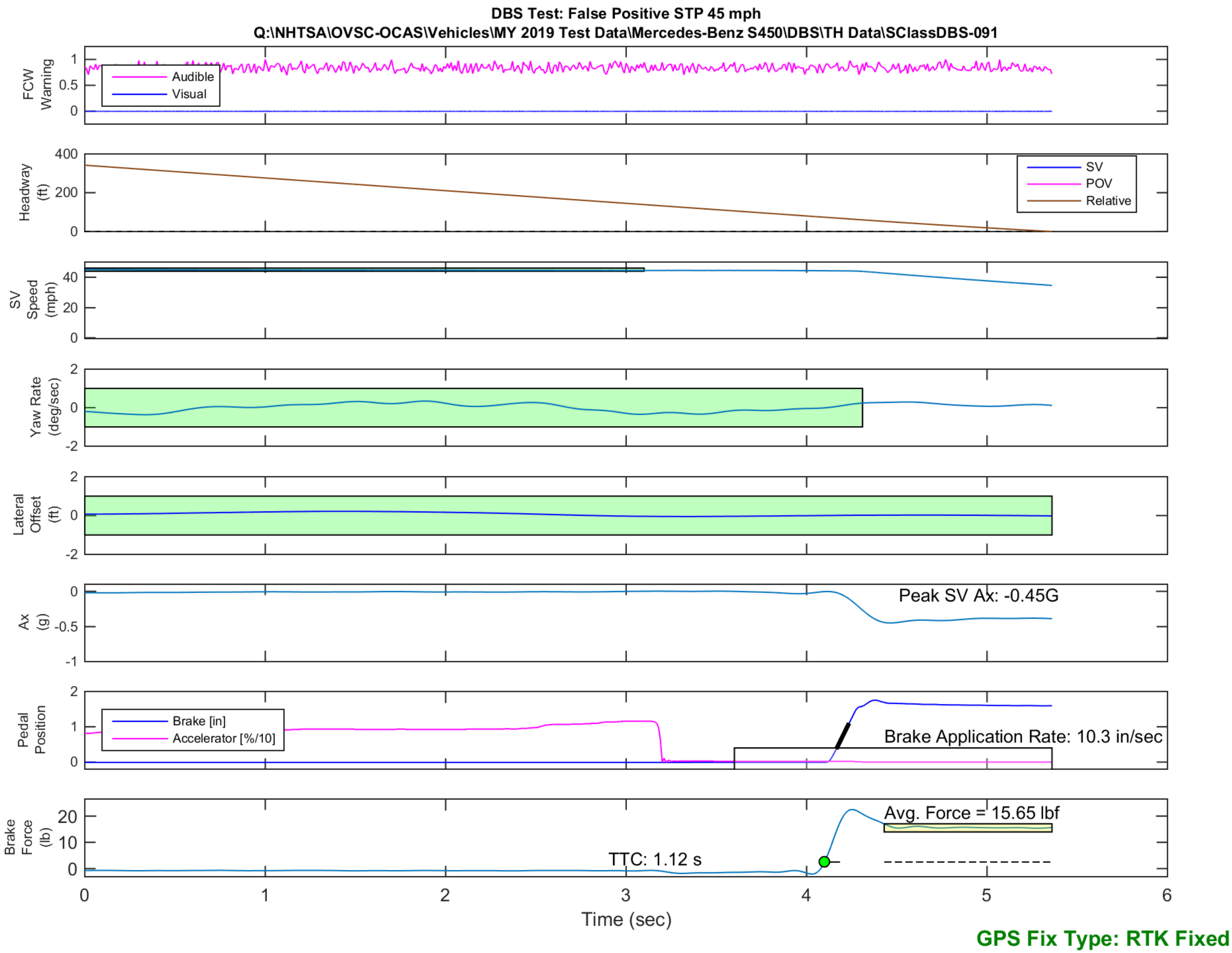


Figure E68. Time History for DBS Run 91, SV Encounters Steel Trench Plate, SV 45 mph

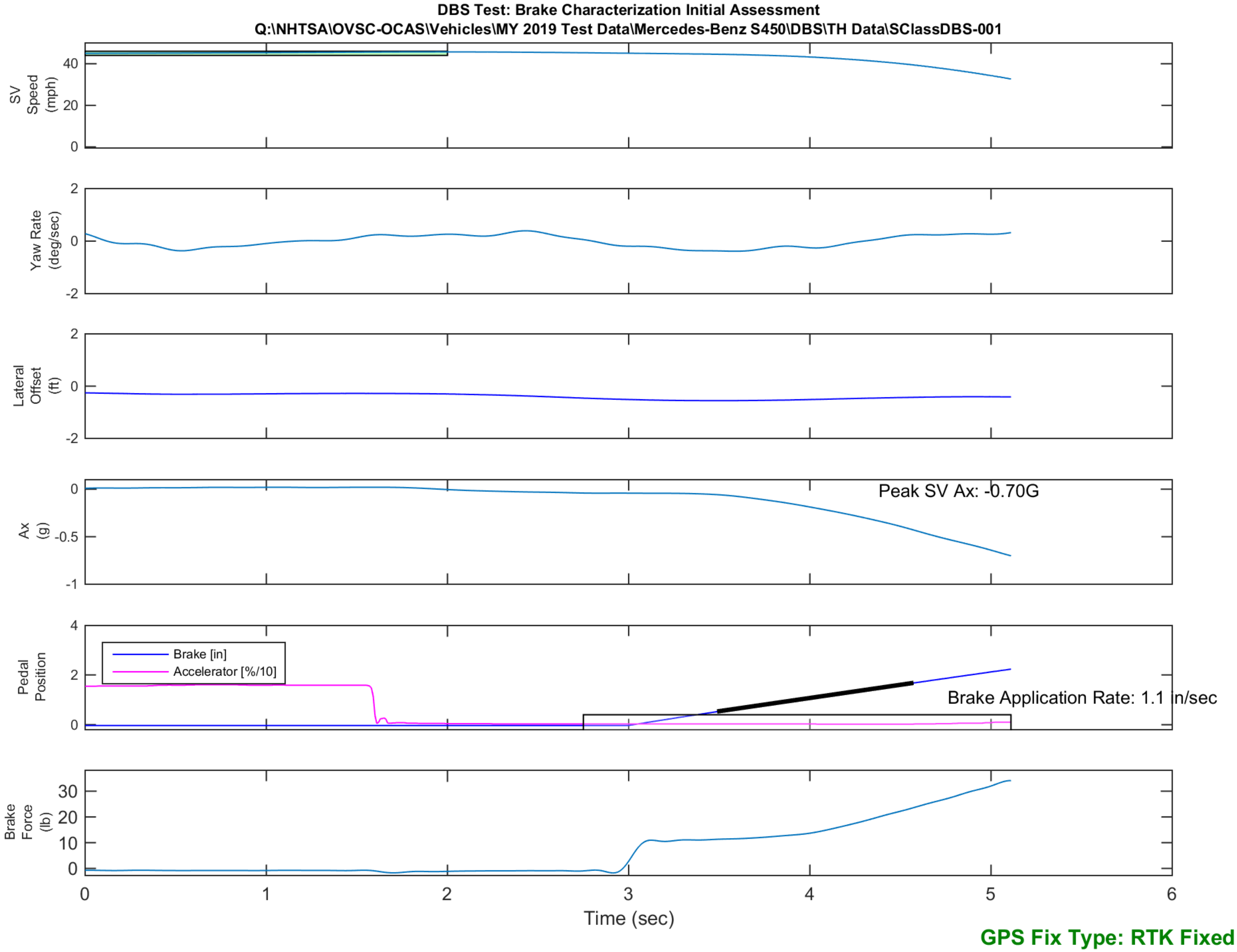


Figure E69. Time History for DBS Run 1, Brake Characterization Initial

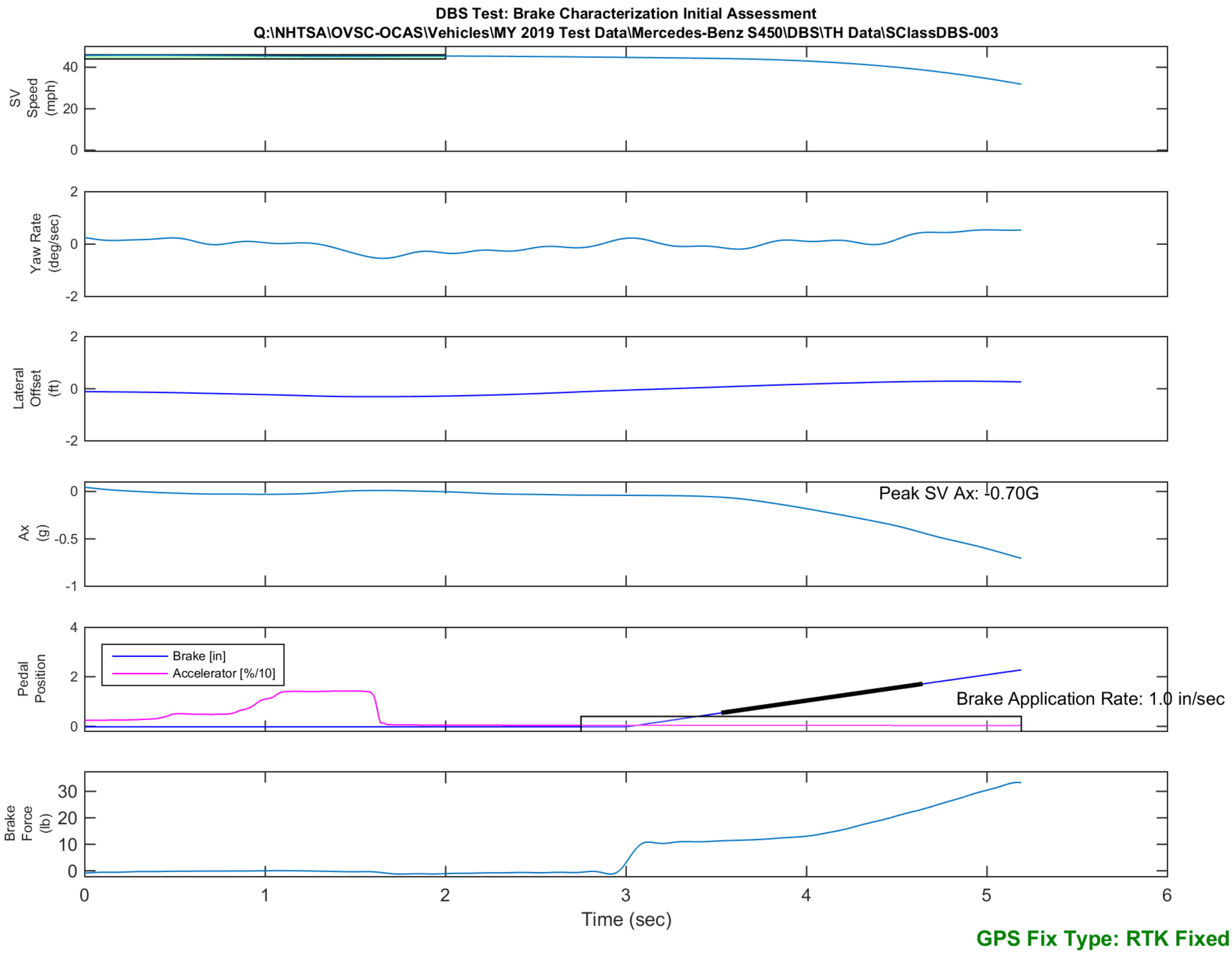


Figure E70. Time History for DBS Run 3, Brake Characterization Initial

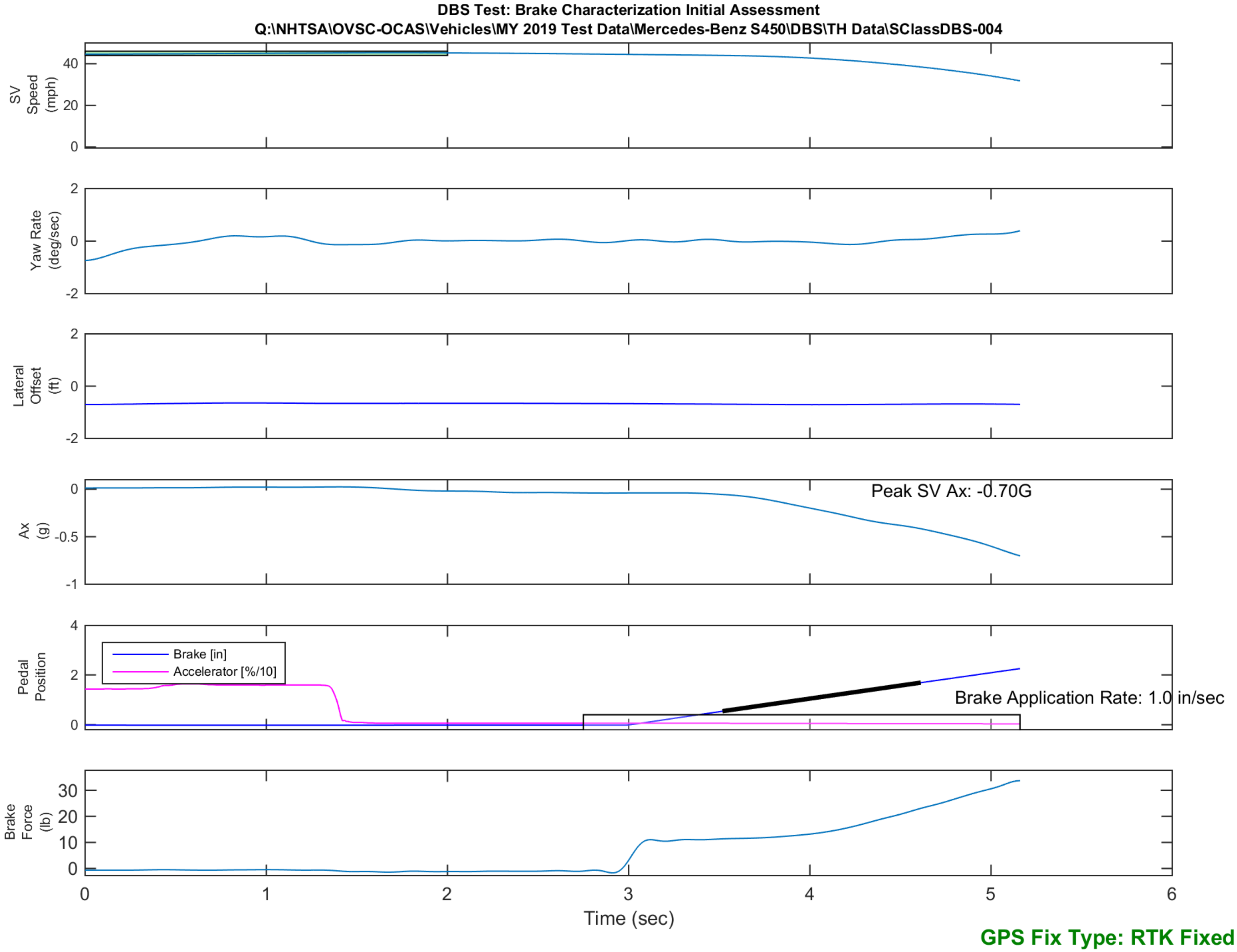


Figure E71. Time History for DBS Run 4, Brake Characterization Initial

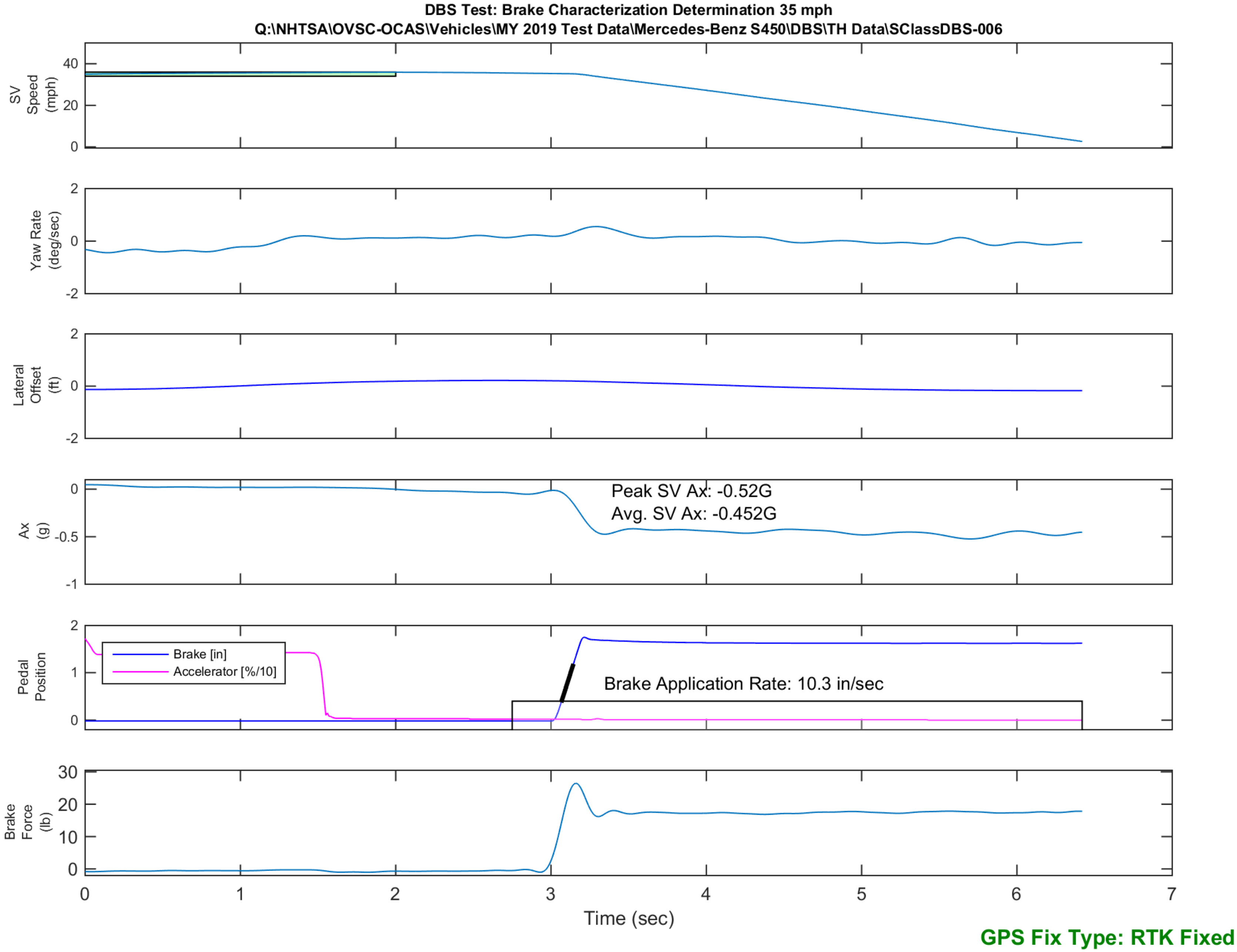


Figure E72. Time History for DBS Run 6, Brake Characterization Determination 35 mph

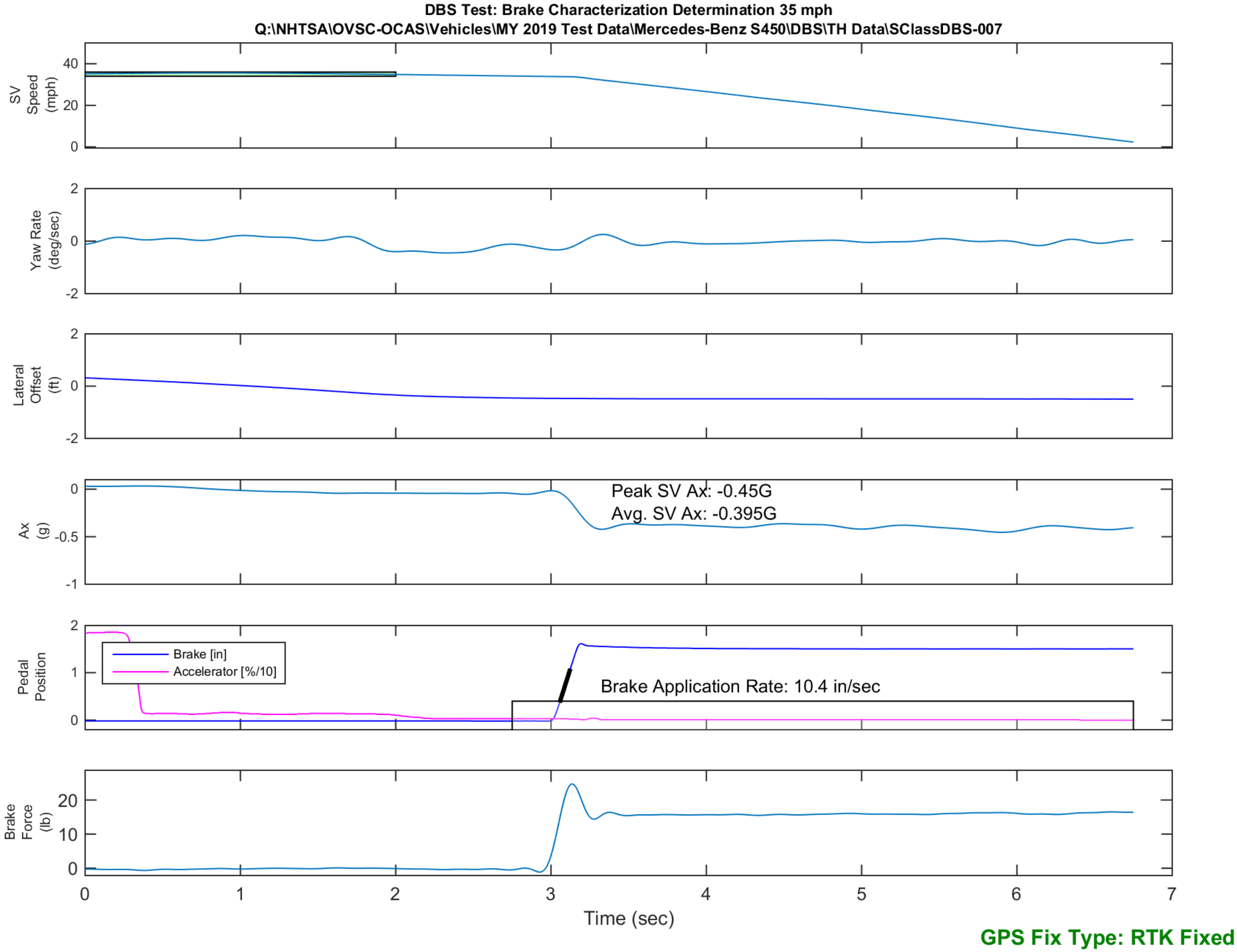


Figure E73. Time History for DBS Run 7, Brake Characterization Determination 35 mph

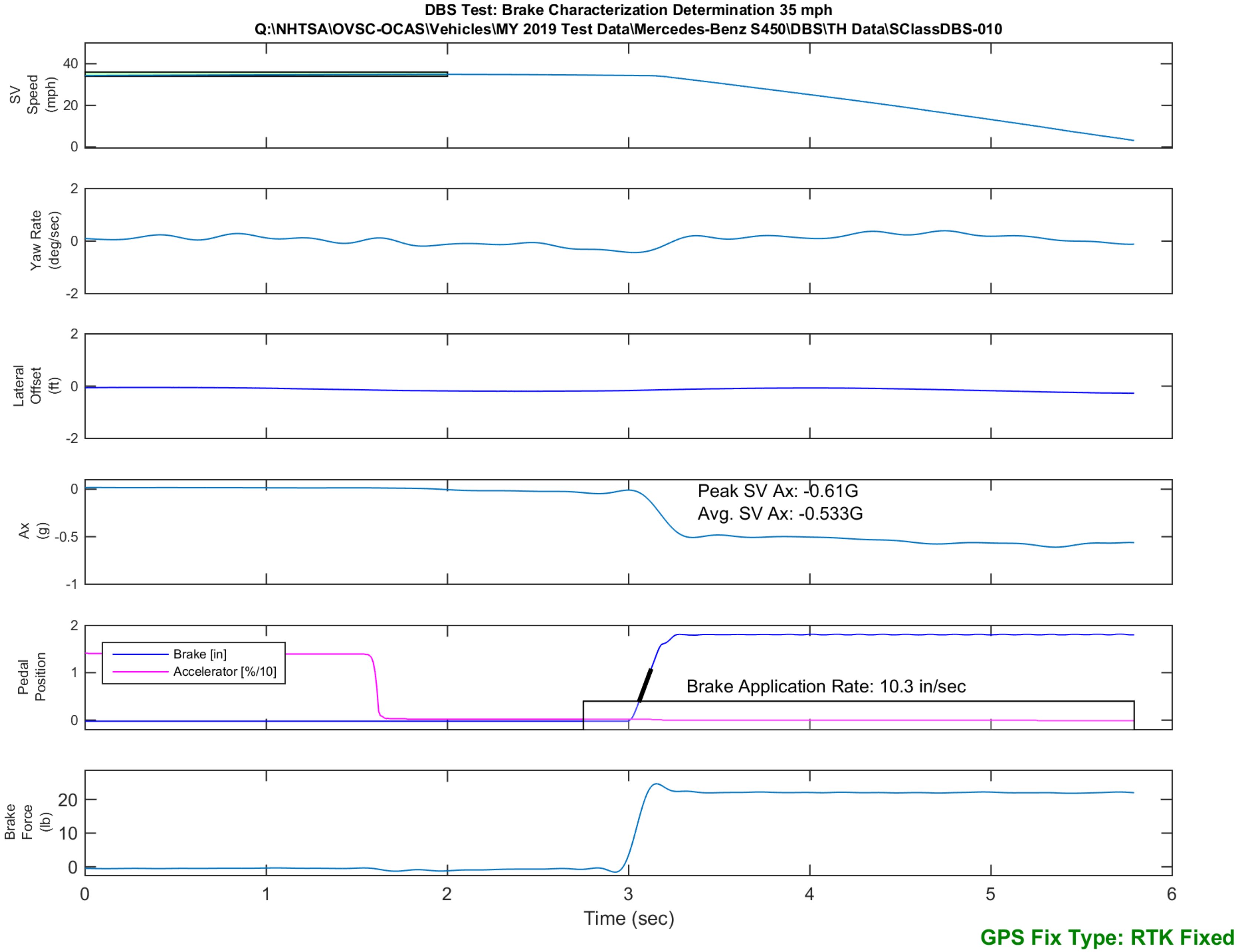


Figure E74. Time History for DBS Run 10, Brake Characterization Determination 35 mph

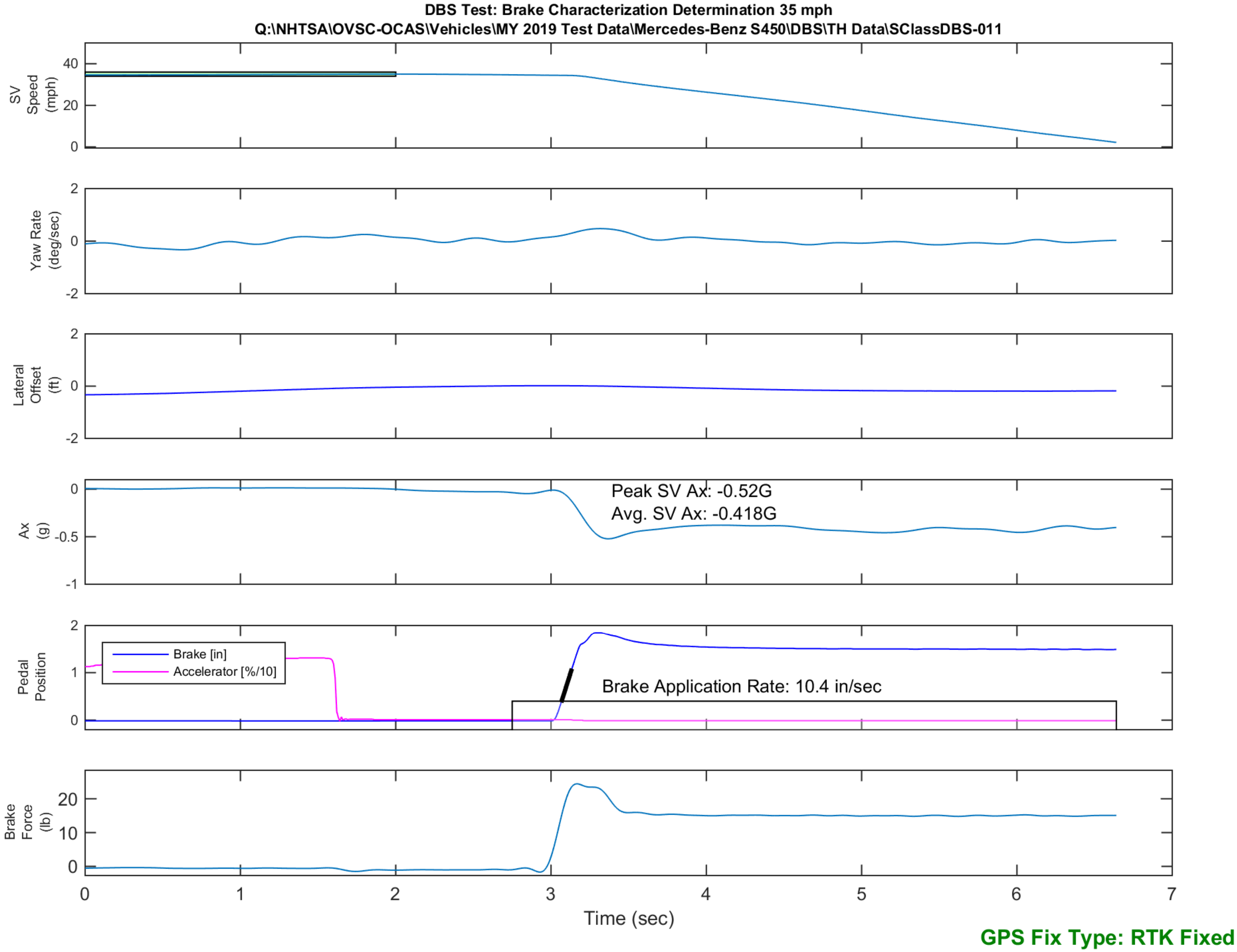


Figure E75. Time History for DBS Run 11, Brake Characterization Determination 35 mph

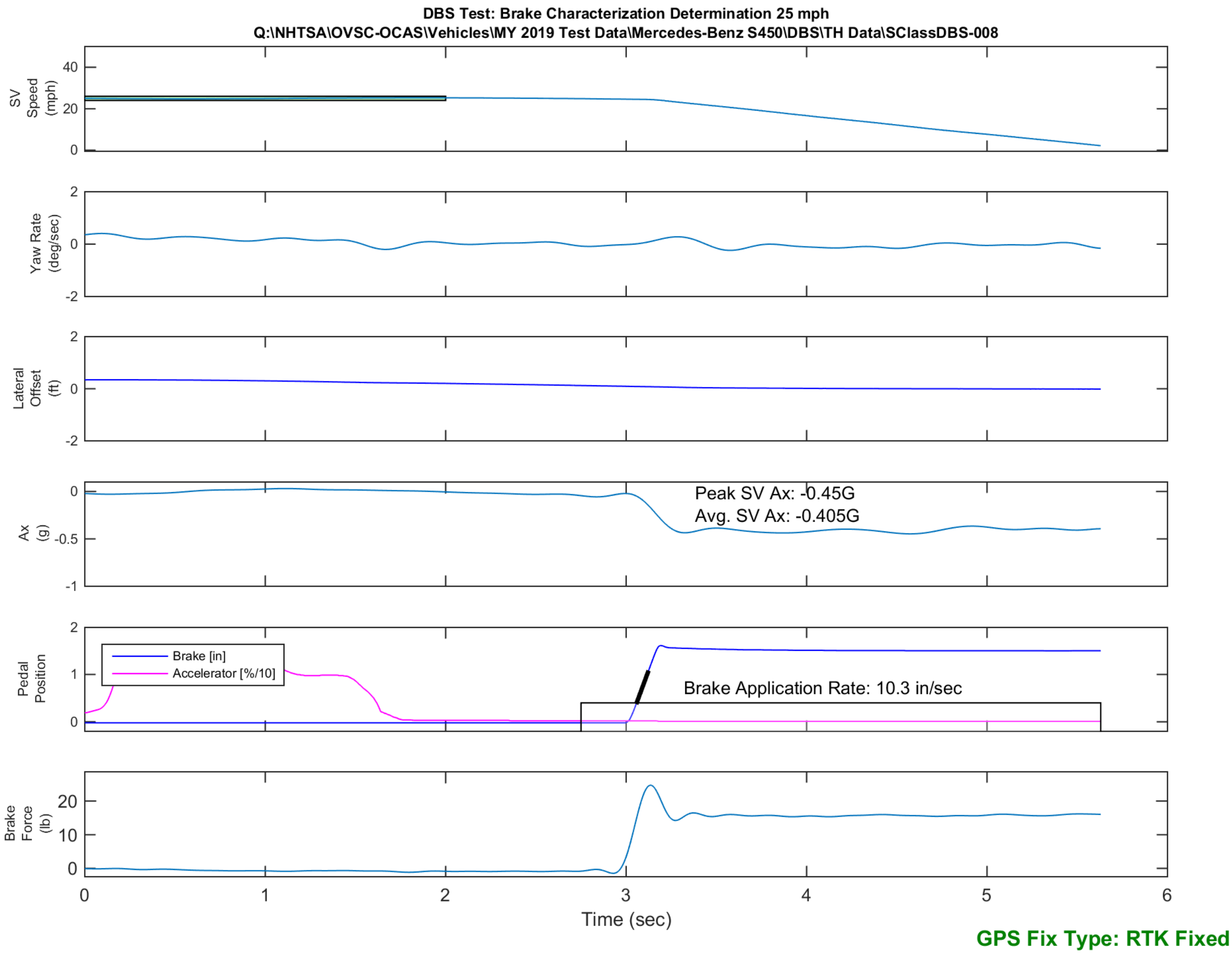


Figure E76. Time History for DBS Run 8, Brake Characterization Determination 25 mph

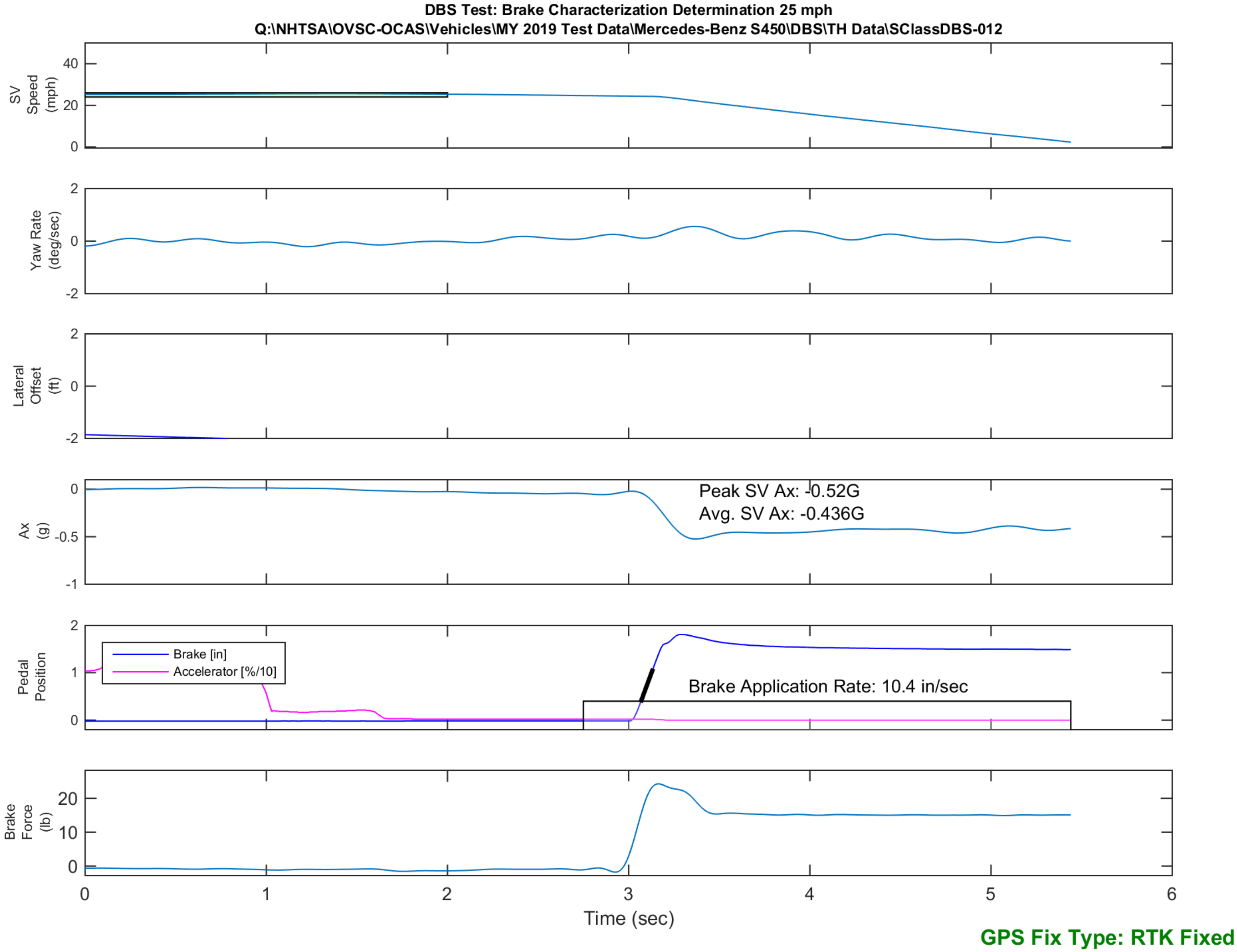


Figure E77. Time History for DBS Run 12, Brake Characterization Determination 25 mph

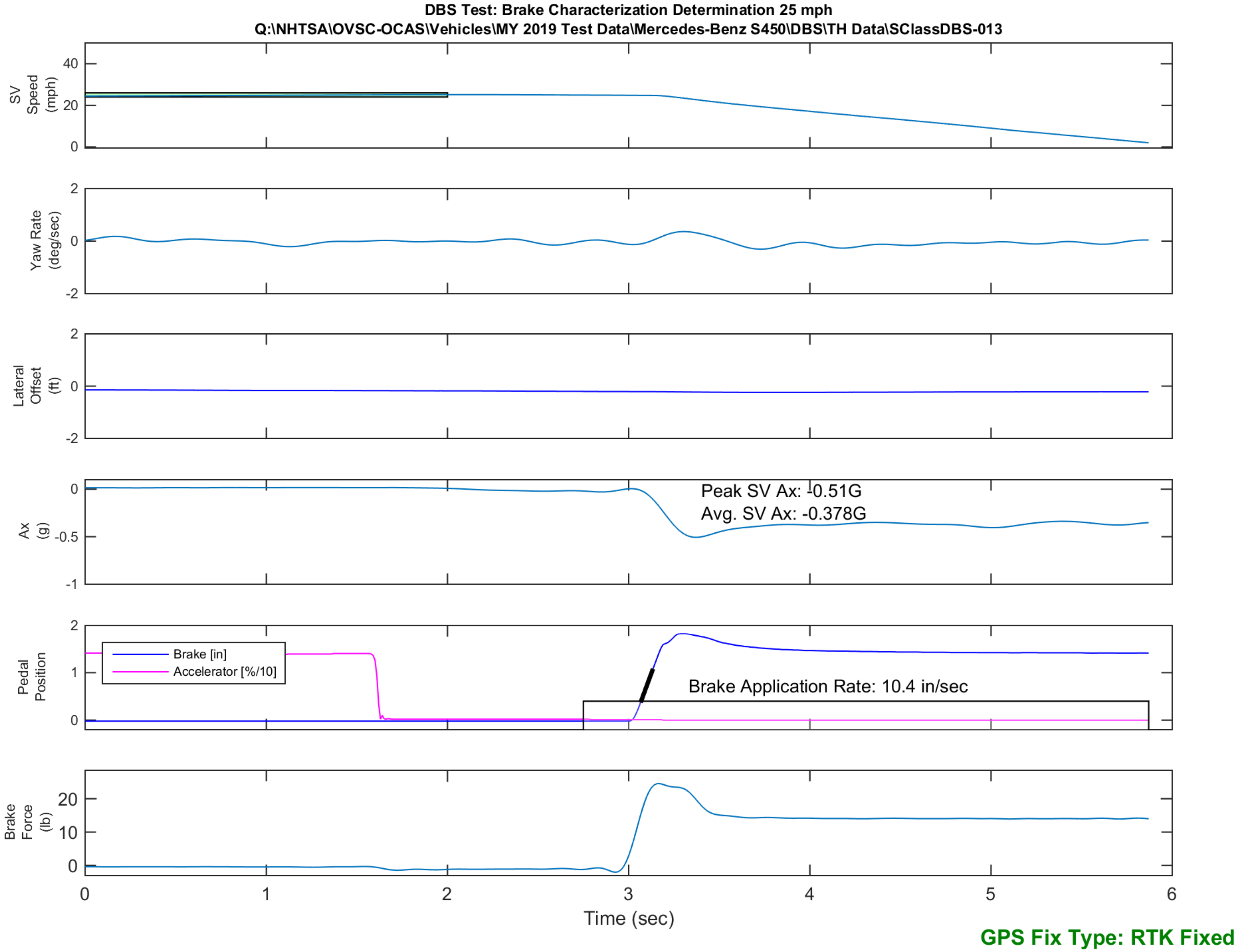


Figure E78. Time History for DBS Run 13, Brake Characterization Determination 25 mph

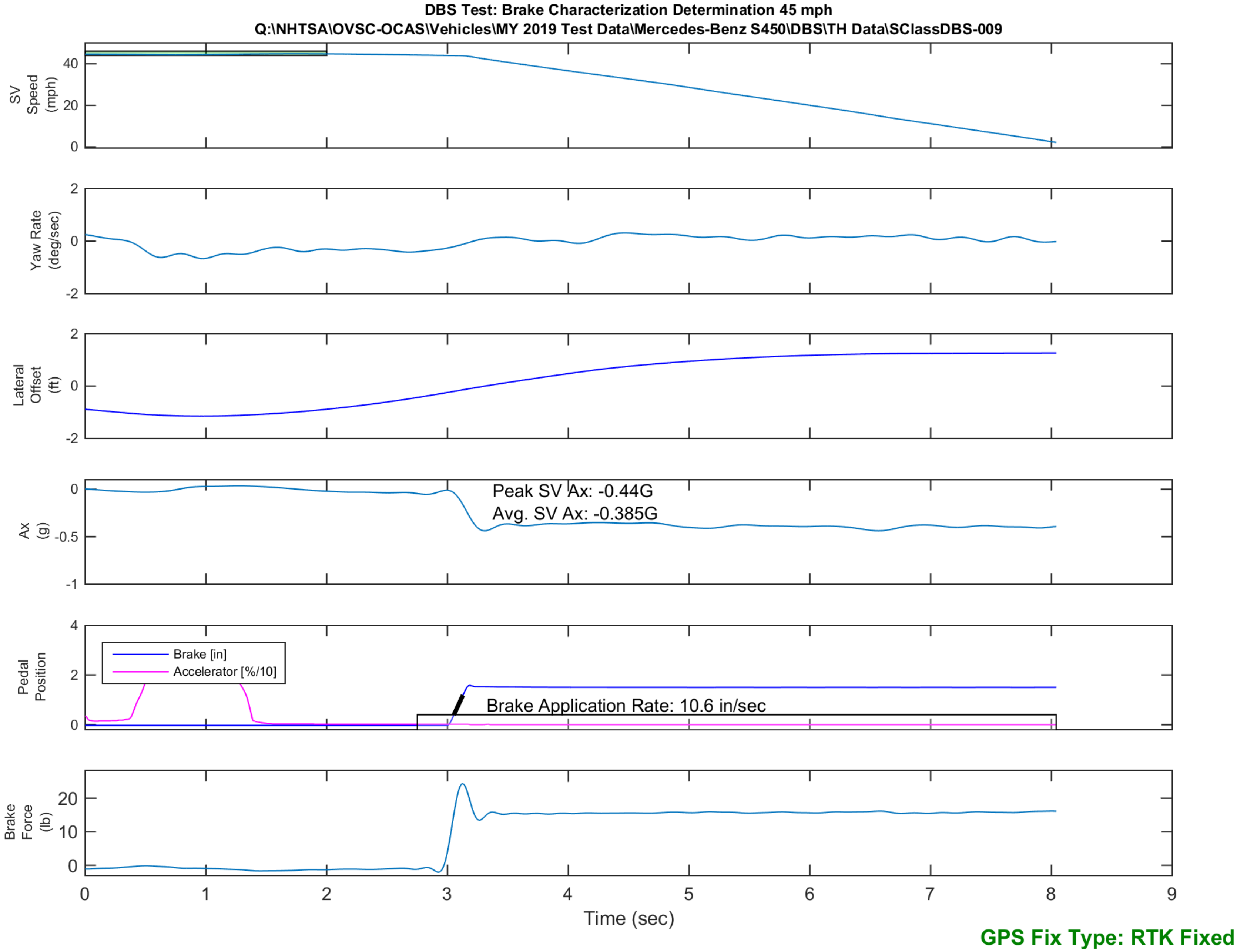


Figure E79. Time History for DBS Run 9, Brake Characterization Determination 45 mph

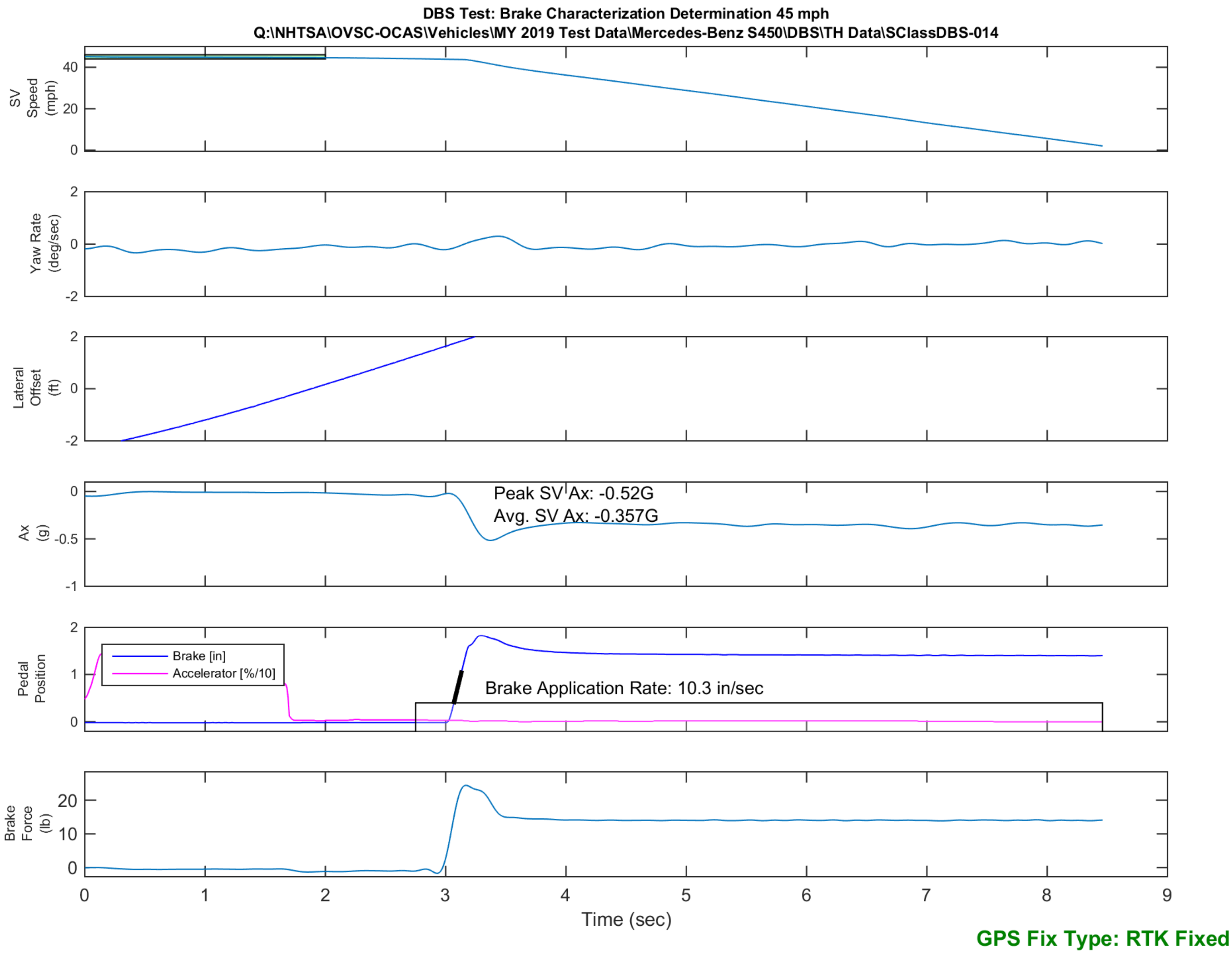


Figure E80. Time History for DBS Run 14, Brake Characterization Determination 45 mph

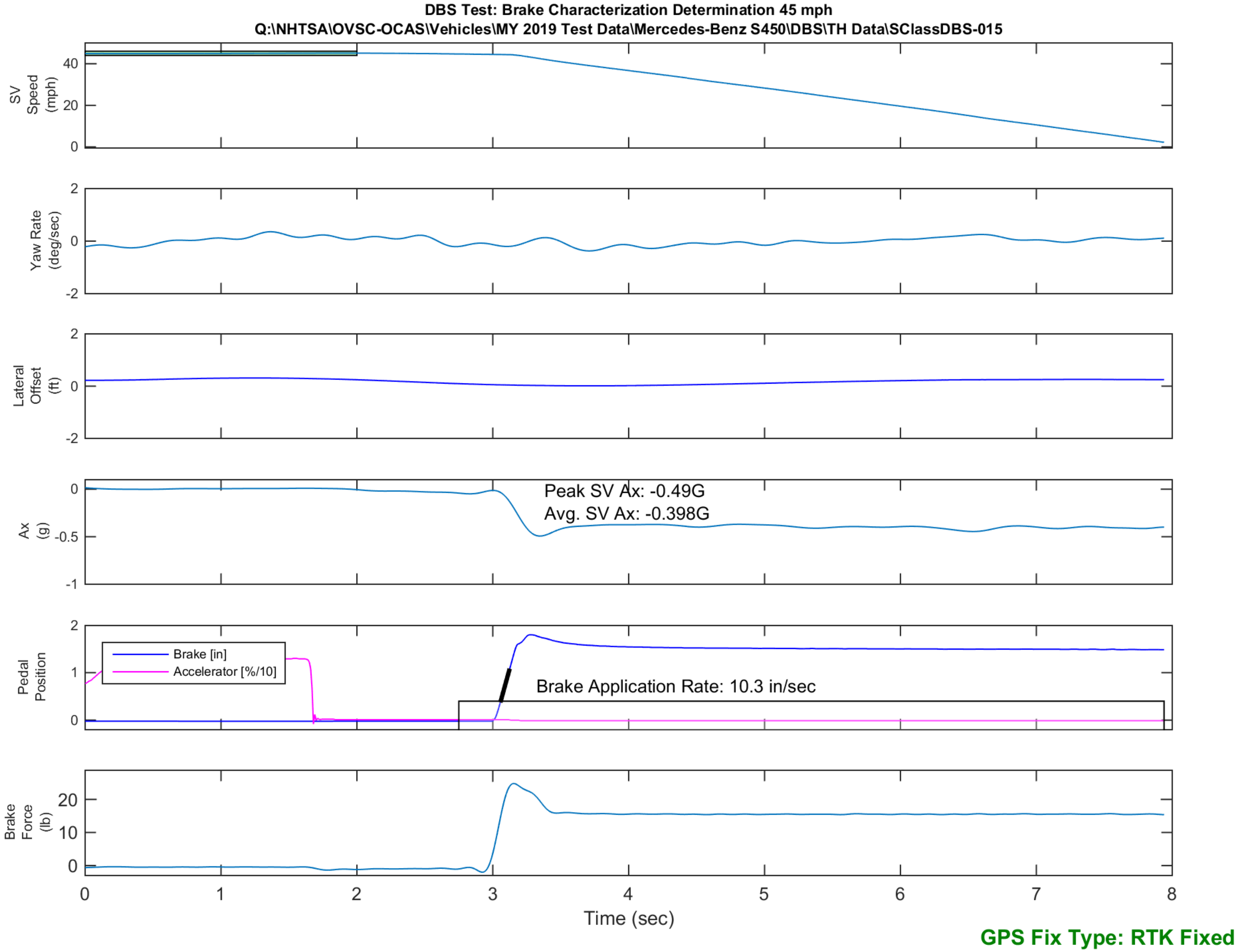


Figure E81. Time History for DBS Run 15, Brake Characterization Determination 45 mph