OCAS-DRI-DBS-19-21
NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST

2019 Lexus NX 300

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30 April 2019

Final Report

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U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
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16. Abstract These tests were conducted on the subject 2019 Lexus NX 300 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 Lexus NX 300. 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 SYSTEM

DATA SHEET 1: TEST RESULTS

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2019 Lexus NX 300

SUMMARY RESULTS

VIN: *JTJYARBZ6K21xxxx*

Test Date: *12/10/2018*

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 SYSTEM

DATA SHEET 2: VEHICLE DATA

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2019 Lexus NX 300

TEST VEHICLE INFORMATION

VIN: *JTJYARBZ6K21xxxx*

Body Style: *SUV* Color: *Caviar*

Date Received: *11/30/2018* Odometer Reading: *55 mi*

Engine: *2 L Inline 4*

Transmission: *Automatic*

Final Drive: *FWD*

Is the vehicle equipped with:

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

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Toyota Motor Corporation*

Date of manufacture: *06/18*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *225/60 R18*

Rear: *225/60 R18*

Recommended cold tire pressure: Front: *220 kPa (32 psi)*

Rear: *220 kPa (32 psi)*

DYNAMIC BRAKE SUPPORT SYSTEM

DATA SHEET 2: VEHICLE DATA

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2019 Lexus NX 300

TIRES

Tire manufacturer and model: *Michelin Primacy MXM4*

Front tire size: *225/60 R18*

Rear tire size: *225/60 R18*

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 SYSTEM

DATA SHEET 3: TEST CONDITIONS

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2019 Lexus NX 300

GENERAL INFORMATION

Test date: *12/10/2018*

AMBIENT CONDITIONS

Air temperature: *10.0 C (50 F)*

Wind speed: *2.1 m/s (4.6 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: *220 kPa (32 psi)*

Rear: *220 kPa (32 psi)*

DYNAMIC BRAKE SUPPORT SYSTEM

DATA SHEET 3: TEST CONDITIONS

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WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*590.6 kg (1302 lb)*	Right Front	*523.4 kg (1154 lb)*
Left Rear	*397.3 kg (876 lb)*	Right Rear	*387.8 kg (855 lb)*
		Total:	*1899.1 kg (4187 lb)*

DYNAMIC BRAKE SUPPORT SYSTEM

DATA SHEET 4:

DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

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2019 Lexus NX 300

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

Lexus Safety System+ (LSS+)

System setting used for test (if applicable):

High Sensitivity

Brake application mode used for test:

Hybrid control

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

10 kph (7 mph) (Per manufacturer supplied information)

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

180 kph (110 mph, 50 mph (80 kph) for pedestrians,

Does the vehicle system require an initialization sequence/procedure?

Yes.

Sensor calibration is necessary which can be done by the following procedure:

• Driving along the lane marker for more than 1 km with greater than 35 mph driving speed.

• 1km distance driving is not necessarily continuous driving, but split driving with a total of 1 km distance is OK.

• Lane marker should exist both on sides (left and right) and it does not matter whether it is solid line or dotted line.

• It is ideal to put several vehicles (2-3 vehicles) beside the driving lane to be detected by camera.

• No sensor calibration completed indication will be displayed to driver.

• Please make sure no "IG OFF" after sensor calibration is completed. If an ignition cycle occurs, sensor calibration needs to be done again (Per manufacturer supplied information)

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

No deactivation or reduction of DBS will happen after repeated DBS activation.

DYNAMIC BRAKE SUPPORT SYSTEM

DATA SHEET 4:

DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

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How is the Forward Collision Warning presented to the driver?

(Check all that apply)

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

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

Light warning:

Location: In the IP driver control meter (TFT display)
Color: Red and white
Word: "BRAKE"

Sound: Repeated beeping sound

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.

Yes, you can find ON/OFF setting in the driver IP control display meter (TFT display) which you can change by switches on the steering wheel. Even if system is deactivated once, it will turn "ON" at each ignition cycle.

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

- **X** Yes
- No

If yes, please provide a full description.

Yes, using the switches located on the right hand side of the steering wheel and the display in the center of the instrument panel in front of the driver, select Vehicle Settings --> PCS --> Sensitivity (Far/Middle/Near).

DYNAMIC BRAKE SUPPORT SYSTEM

DATA SHEET 4:

DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

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2019 Lexus NX 300

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.

Conditions under which the system may operate even if there is no possibility of a collision

- *In some situations such as the following, the system may determine that there is a possibility of a frontal collision and operate.*
  - *When passing a vehicle or pedestrian*
  - *When changing lanes while overtaking a preceding vehicle*
  - *When overtaking a preceding vehicle that is changing lanes*
  - *When overtaking a preceding vehicle that is making a left/right turn*
  - *When passing a vehicle in an oncoming lane that is stopped to make a right/left turn*
  - *When driving on a road where relative location to vehicle ahead in an adjacent lane may change, such as on a winding road*
  - *When rapidly closing on a vehicle ahead*
  - *If the front of the vehicle is raised or lowered, such as when the road surface is uneven or undulating*
  - *When approaching objects on the roadside, such as guardrails, utility poles, trees, or walls*
  - *When there is a vehicle, pedestrian, or object by the roadside at the entrance of a curve*
  - *When driving on a narrow path surrounded by a structure, such as in a tunnel or on an iron bridge*
  - *When there is a metal object (manhole cover, steel plate, etc.), steps, or a protrusion on the road surface or roadside*
  - *When a crossing pedestrian approaches very close to the vehicle*
  - *When passing through a place with a low structure above the road (low ceiling, traffic sign, etc.)*
  - *When passing under an object (billboard, etc.) at the top of an uphill road*

(continued next page)

- *When rapidly closing on an electric toll gate barrier, parking area barrier, or other barrier that opens and closes*
- *When using an automatic car wash*
- *When driving through or under objects that may contact the vehicle, such as thick grass, tree branches, or a banner*
- *When the vehicle is hit by water, snow, dust, etc. from a vehicle ahead*
- *When driving through steam or smoke*
- *When there are patterns or paint on the road or a wall that may be mistaken for a vehicle or pedestrian*
- *When driving near an object that reflects radio waves, such as a large truck or guardrail*
- *When driving near a TV tower, broad-casting station, electric power plant, or other location where strong radio waves or electrical noise may be present*

Situations in which the system may not operate properly

- *In some situations such as the following, a vehicle may not be detected by the radar sensor and camera sensor, preventing the system from operating properly:*
  - *If an oncoming vehicle is approaching your vehicle*
  - *If a vehicle ahead is a motorcycle or bicycle*
  - *When approaching the side or front of a vehicle*
  - *If a preceding vehicle has a small rear end, such as an unloaded truck*
  - *If a preceding vehicle has a low rear end, such as a low bed trailer*
  - *If a vehicle ahead is carrying a load which protrudes past its rear bumper*
  - *If a vehicle ahead has extremely high ground clearance*
  - *If a vehicle ahead is irregularly shaped, such as a tractor or side car*
  - *If the sun or other light is shining directly on a vehicle ahead*
  - *If a vehicle cuts in front of your vehicle or emerges from beside a vehicle*
  - *If a vehicle ahead makes an abrupt maneuver (such as sudden swerving, acceleration or deceleration)*
  - *When suddenly cutting behind a preceding vehicle*

(continued next page)

- *When a vehicle ahead is not directly in front of your vehicle*
- *When driving in inclement weather such as heavy rain, fog, snow or a sandstorm*
- *When the vehicle is hit by water, snow, dust, etc. from a vehicle ahead*
- *When driving through steam or smoke*
- *When driving in a place where the surrounding brightness changes suddenly, such as at the entrance or exit of a tunnel*
- *When a very bright light, such as the sun or the headlights of oncoming traffic, shines directly in to the camera sensor*
- *When the surrounding area is dim, such as at dawn or dusk, or while at night or in a tunnel*
- *After the engine has started the vehicle has not been driven for a certain amount of time*
- *While making a left/right turn and for a few seconds after making a left/right turn*
- *While driving on a curve and for a few seconds after driving on a curve*
- *If your vehicle is skidding*
- *If the front of the vehicle is raised or lowered*
- *If the wheels are misaligned*
- *If a wiper blade is blocking the camera sensor*
- *The vehicle is wobbling.*
- *The vehicle is being driven at extremely high speeds.*
- *When driving on a hill*
- *If the radar sensor or camera sensor is misaligned*

- *In some situations such as the following, sufficient braking force may not be obtained, preventing the system from performing properly:*
  - *If the braking functions cannot operate to their full extent, such as when the brake parts are extremely cold, extremely hot, or wet*
  - *If the vehicle is not properly maintained (brakes or tires are excessively worn, improper tire inflation pressure, etc.)*
  - *When the vehicle is being driven on a gravel road or other slippery surface*

(continued next page)

- *Some pedestrians such as the following may not be detected by the radar sensor and camera sensor, preventing the system from operating properly:*
  - *Pedestrians shorter than approximately 3.2 ft. (1 m) or taller than approximately 6.5 ft. (2 m)*
  - *Pedestrians wearing oversized clothing (a rain coat, long skirt, etc.), making their silhouette obscure*
  - *Pedestrians who are carrying large baggage, holding an umbrella, etc., hiding part of their body*
  - *Pedestrians who are bending forward or squatting*
  - *Pedestrians who are pushing a stroller, wheelchair, bicycle or other vehicle*
  - *Groups of pedestrians which are close together*
  - *Pedestrians who are wearing white and look extremely bright*
  - *Pedestrians in the dark, such as at night or while in a tunnel*
  - *Pedestrians whose clothing appears to be nearly the same color or brightness as their surroundings*
  - *Pedestrians near walls, fences, guardrails, or large objects*
  - *Pedestrians who are on a metal object (manhole cover, steel plate, etc.) on the road*
  - *Pedestrians who are walking fast*
  - *Pedestrians who are changing speed abruptly*
  - *Pedestrians running out from behind a vehicle or a large object*
  - *Pedestrians who are extremely close to the side of the vehicle (outside rear view mirror, etc.)*
- *If the PCS warning light flashes or illuminates and a warning message is displayed on the multi-information display The pre-collision system may be temporarily unavailable or there may be a malfunction in the system.*
- *In the following situations, the warning light will turn off, the message will disappear and the system will become operational when normal operating conditions return:*
  - *When the radar sensor or camera sensor or the area around either sensor is hot, such as in the sun*
  - *When the radar sensor or camera sensor or the area around either sensor is cold, such as in an extremely cold environment*

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- *When a front sensor is dirty or covered with snow, etc.*
- *When the part of the windshield in front of the camera sensor is fogged up or covered with condensation or ice*
- *If the camera sensor is obstructed, such as when the hood is open or a sticker is attached to the windshield near the camera sensor*

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.

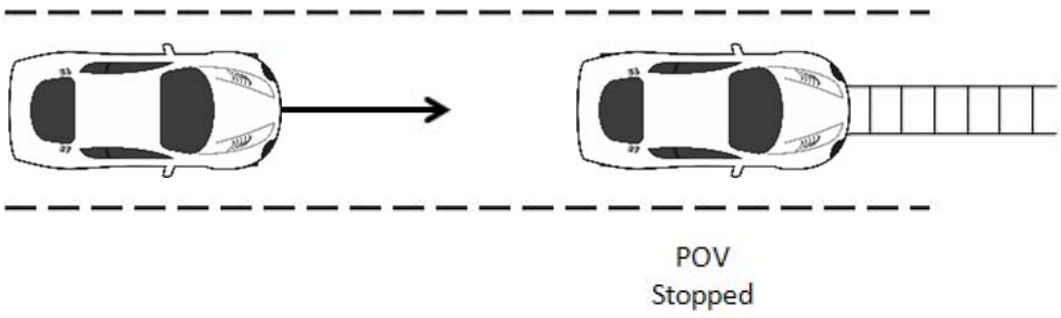


Figure 1. Depiction of Test 1

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 brake 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.

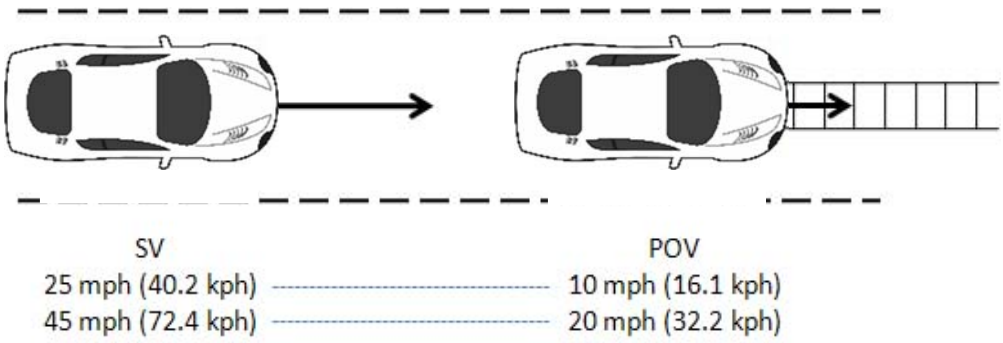


Figure 2. Depiction of Test 2

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.

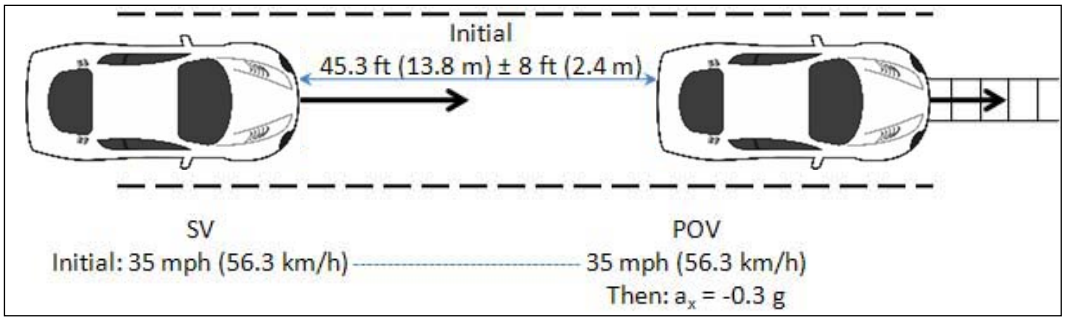


Figure 3. Depiction of Test 3 with POV Decelerating

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	5th	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5th	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 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 8/28/2018 Due: 8/28/2019
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	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

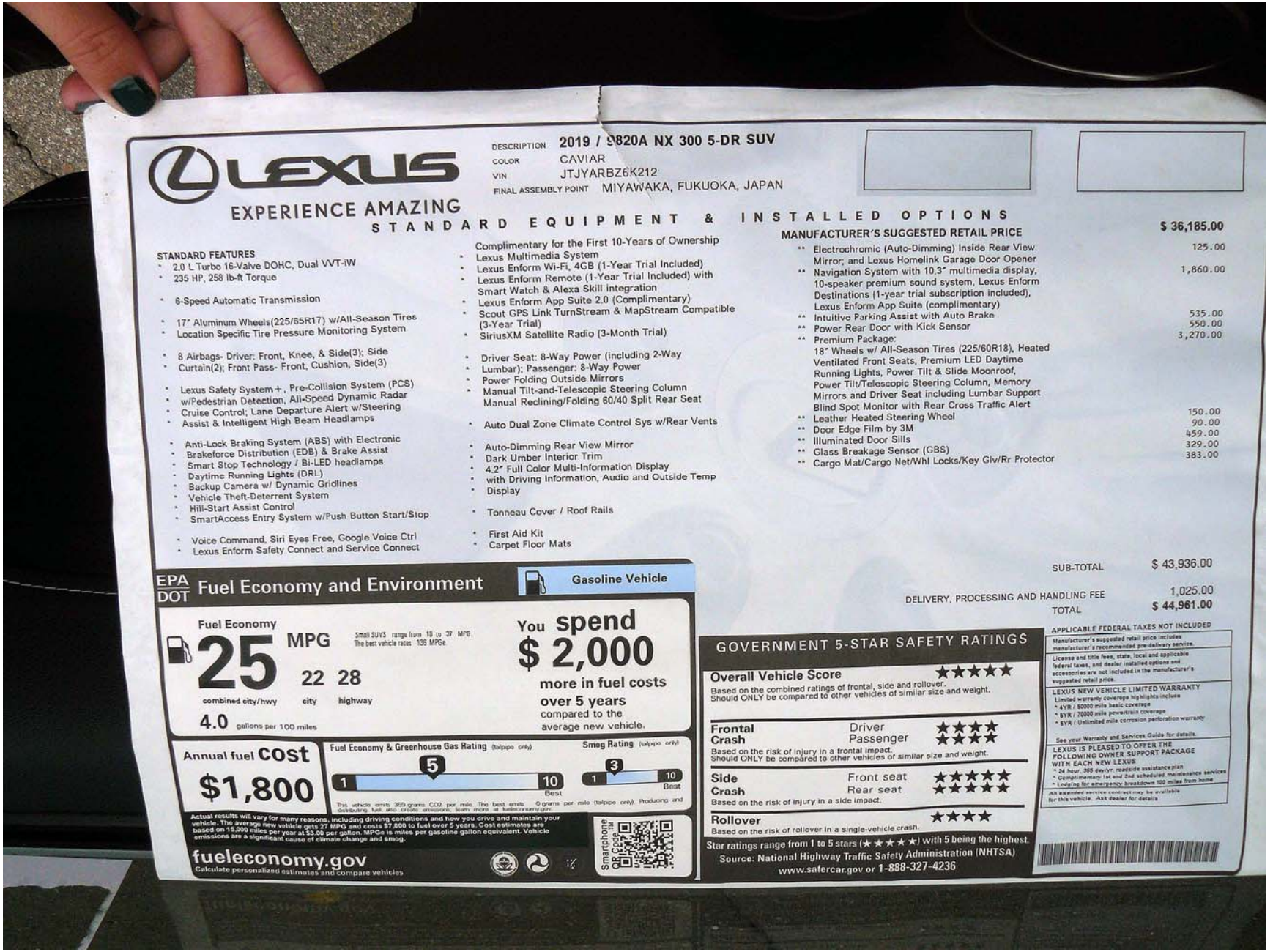


Figure A3. Window Sticker (Monroney Label)

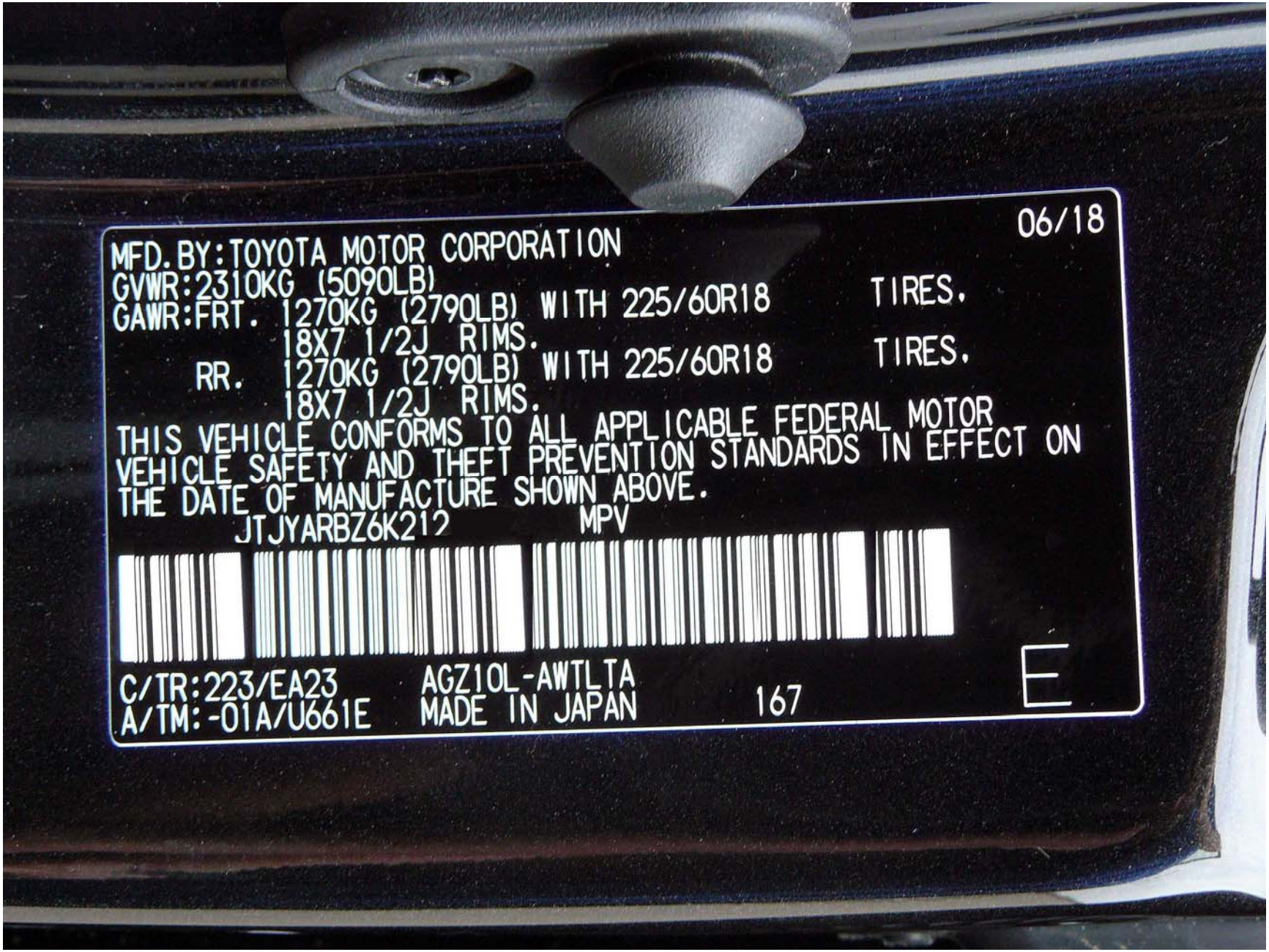


Figure A4. Vehicle Certification Label

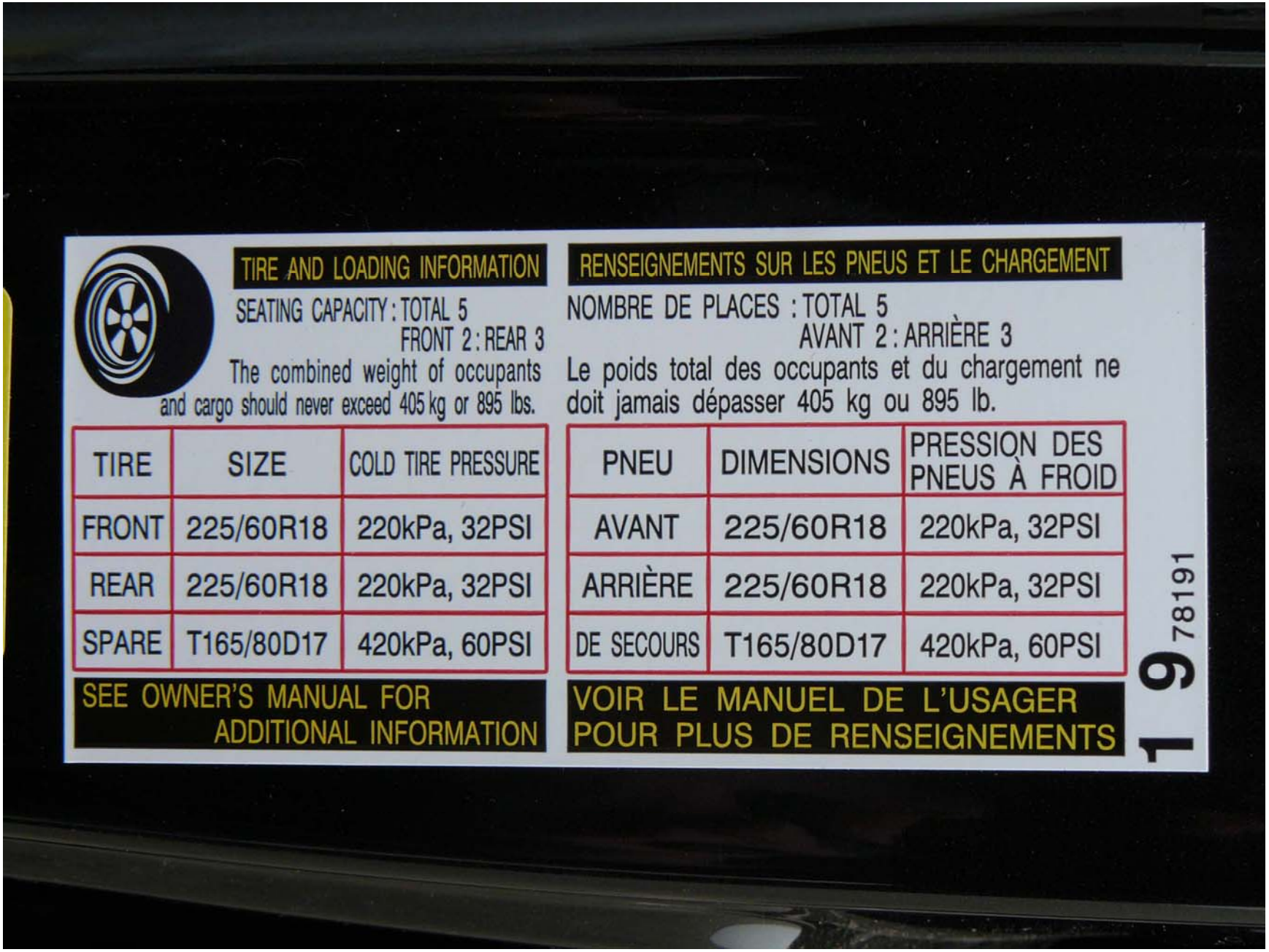


Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV.

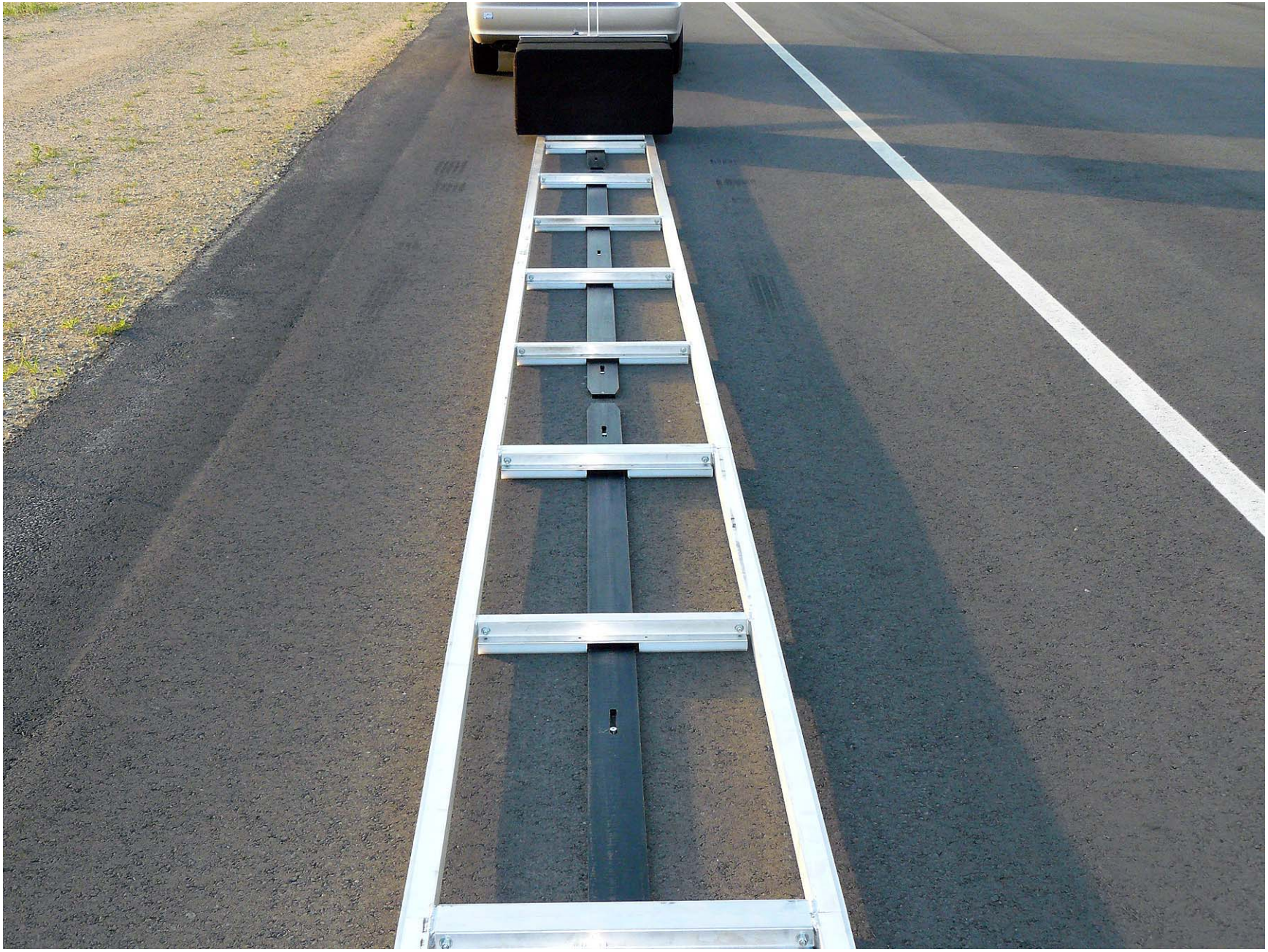


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensors for Detecting Visual and Auditory Alerts

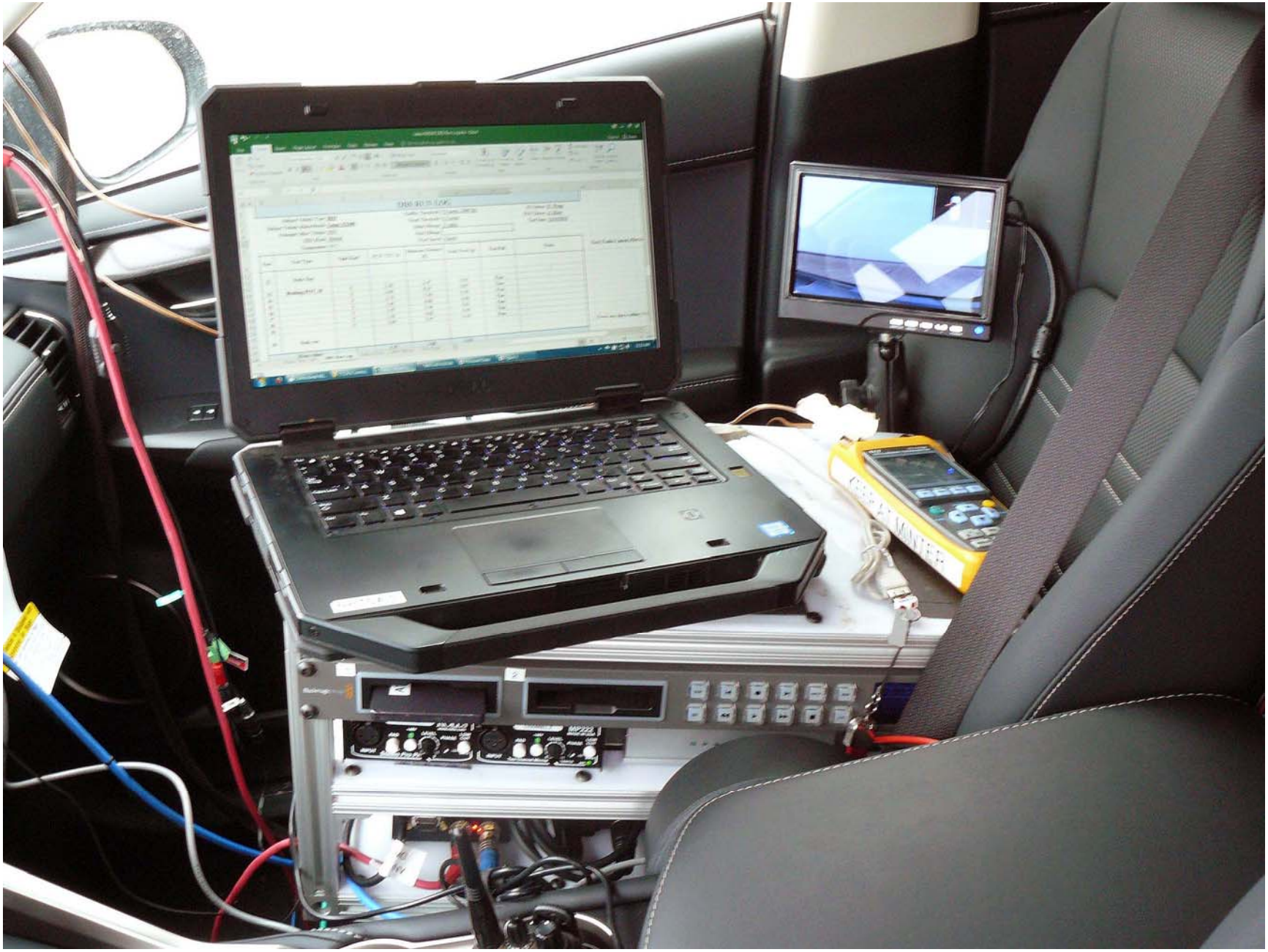


Figure A12. Computer and Brake Actuator Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in POV System

Figure A14. AEB Visual Alert

Figure A15. AEB Setup Menus

APPENDIX B

Excerpts from Owner’s Manual

Warning lights and indicators

The warning lights and indicators inform the driver of the status of the vehicle's various systems.

Instrument cluster

For the purpose of explanation, the following illustration displays all warning lights and indicators illuminated.

The units used on the meters and some indicators may differ depending on the target region.

Warning lights

Warning lights inform the driver of malfunctions in any of the vehicle's systems.

(U.S.A.) Brake system warning light*1 (→P.358)


(Red) (Canada) Brake system warning light*1 (→P.358)


Charging system warning light*2 (→P.358)


Low engine oil pressure warning light*2 (→P.358)


High coolant temperature warning light*2 (→P.359)


(Yellow) Brake system warning light*1 (→P.359)

(U.S.A.) Malfunction indicator lamp*1 (→P.359)


(Canada) Malfunction indicator lamp*1 (→P.359)


SRS warning light*1 (→P.359)

(U.S.A.) ABS warning light*1 (→P.360)


(Canada) ABS warning light*1 (→P.360)


(Yellow) Electric power steering system warning light*1 (→P.360)


(Red) Electric power steering system warning light*1 (→P.360)

PCS warning light*1 (→P.360)


(Orange) LDA indicator*2 (→P.361)

(if equipped) PKSB OFF indicator*1, 3 (→P.361)


Slip indicator light*1 (→P.361)

Brake hold operated indicator*1, 3 (→P.361)

(U.S.A.) Parking brake indicator*3 (→P.362)


(Canada) Parking brake indicator*3 (→P.362)


Low fuel level warning light (→P.362)


Driver's and front passenger's seat belt reminder light (→P.362)


Rear passengers' seat belt reminder light*4 (→P.363)


Master warning light*1 (→P.363)


Tire pressure warning light*1 (→P.363)


Brake Override System/Drive-Start Control warning light*2 (→P.364)

*1: These lights turn on when the engine switch is turned to IGNITION ON mode to indicate that a system check is being performed. They will turn off after

Driving assist system information

Select to display the operational status of the following systems:

- LDA (Lane Departure Alert with steering control) (→P.197)
- Dynamic radar cruise control with full-speed range (→P.205)

The displayed icon changes depending on the system used.

Warning message display

Select to display warning messages and measures to be taken if a malfunction is detected. (→P.367)

Settings display

The settings of the following items can be changed using the meter control switches.

For functions that can be enabled or disabled, the function switches between on and off each time ● is pressed.

■ **LDA (Lane Departure Alert with steering control) (→P.197)**

Select to set up the following items.

- Steering Assist

Select to enable/disable steering wheel assistance.

- Alert

Select to set a vibrator or buzzer as the notification method used to warn the driver.

- Alert sensitivity

Select to set the warning sensitivity.

- Sway warning

Select to enable/disable the vehicle sway warning.

- Sway sensitivity

Select to set the vehicle sway warning sensitivity.

■ **PCS (Pre-Collision System) (→P.190)**

Select to set up the following items.

- PCS on/off

Select to enable/disable the pre-collision system.

- PCS sensitivity

Select to change the warning timing.

■ **PKSA (Parking Support Alert) (if equipped) (→P.214)**

Select to set up the following items.

- Intuitive parking assist sensor

Select to enable/disable the intuitive parking assist sensor.

- Volume

Select to set the volume of the buzzer which sounds when the parking support alert is operated.

■ **PKSB (Parking Support Brake System) (if equipped) (→P.220)**

- PKSB on/off

Select to enable/disable the parking support brake function (for static objects).

■ **Clock**

Select to switch between 12-hour dis-

PCS (Pre-Collision System)

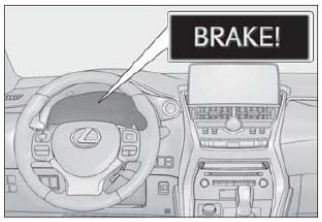
The pre-collision system uses a radar sensor and camera sensor to detect vehicles and pedestrians in front of your vehicle. When the system determines that the possibility of a frontal collision with a vehicle or pedestrian is high, a warning operates to urge the driver to take evasive action and the potential brake pressure is increased to help the driver avoid the collision. If the system determines that the possibility of a frontal collision with a vehicle or pedestrian is extremely high, the brakes are automatically applied to help avoid the collision or help reduce the impact of the collision.

The pre-collision system can be disabled/enabled and the warning timing can be changed. (→P.192)

System functions

■ Pre-collision warning

When the system determines that the possibility of a frontal collision is high, a buzzer will sound and a warning message will be displayed on the multi-information display to urge the driver to take evasive action.



■ Pre-collision brake assist

When the system determines that the possibility of a frontal collision is high, the system applies greater braking force in relation to how strongly the brake pedal is depressed.

■ Pre-collision braking

When the system determines that the possibility of a frontal collision is high, the system warns the driver. If the system determines that the possibility of a frontal collision is extremely high, the brakes are automatically applied to help avoid the collision or reduce the collision speed.

■ Suspension control

When the system determines that the possibility of a frontal collision is high, the Adaptive Variable Suspension System (→P.239) will control the damping force of the shock absorbers to help maintain an appropriate vehicle posture.

WARNING

■ Limitations of the pre-collision system

- The driver is solely responsible for safe driving. Always drive safely, taking care to observe your surroundings. Do not use the pre-collision system instead of normal braking operations under any circumstances. This system will not prevent collisions or lessen collision damage or injury in every situation. Do not overly rely on this system. Failure to do so may lead to an accident, resulting in death or serious injury.
- Although this system is designed to help avoid a collision or help reduce the impact of the collision, its effectiveness may change according to various conditions, therefore the system may not always be able to achieve the same level of performance.
  Read the following conditions carefully. Do not overly rely on this system and always drive carefully.
  - Conditions under which the system may operate even if there is no possibility of a collision: →P.194
  - Conditions under which the system may not operate properly: →P.195
- Do not attempt to test the operation of the pre-collision system yourself, as the system may not operate properly, possibly leading to an accident.

■ Pre-collision braking

- When the pre-collision braking function is operating, a large amount of braking force will be applied.
- If the vehicle is stopped by the operation of the pre-collision braking function, the pre-collision braking function operation will be canceled after approximately 2 seconds. Depress the brake pedal as necessary.
- The pre-collision braking function may not operate if certain operations are performed by the driver. If the accelerator pedal is being depressed strongly or the steering wheel is being turned, the system may determine that the driver is taking evasive action and possibly prevent the pre-collision braking function from operating.
- In some situations, while the pre-collision braking function is operating, operation of the function may be canceled if the accelerator pedal is depressed strongly or the steering wheel is turned and the system determines that the driver is taking evasive action.
- If the brake pedal is being depressed, the system may determine that the driver is taking evasive action and possibly delay the operation timing of the pre-collision braking function.

■ When to disable the pre-collision system

In the following situations, disable the system, as it may not operate properly, possibly leading to an accident resulting in death or serious injury:

- When the vehicle is being towed
- When your vehicle is towing another vehicle
- When transporting the vehicle via truck, boat, train or similar means of transportation
- When the vehicle is raised on a lift with the engine running and the tires are allowed to rotate freely
- When inspecting the vehicle using a drum tester such as a chassis dynamometer or speedometer tester, or when using an on vehicle wheel balancer
- When a strong impact is applied to the front bumper or front grille, due to an accident or other reasons

WARNING

- If the vehicle cannot be driven in a stable manner, such as when the vehicle has been in an accident or is malfunctioning
- When the vehicle is driven in a sporty manner or off-road
- When the tires are not properly inflated
- When the tires are very worn
- When tires of a size other than specified are installed
- When tire chains are installed
- When a compact spare tire or an emergency tire puncture repair kit is used
- If equipment (snow plow, etc.) that may obstruct the radar sensor or camera sensor is temporarily installed to the vehicle

Changing settings of the pre-collision system

■ Enabling/disabling the pre-collision system

The pre-collision system can be enabled/disabled on the multi-information display as following:

The system is automatically enabled each time the engine switch is turned to IGNITION ON mode.

1 Press "〈" or "〉" of meter control switches and select ⚙.

2 Press "∧" or "∨" of meter control switches and select 🚗, and press ●.

3 Press "∧" or "∨" of meter control switches and select "PCS", and press ● to select the desired setting (on/off).

If the system is disabled, the PCS warning light will turn on and a message will be displayed on the multi-information display.

■ Changing the pre-collision warning timing

The pre-collision warning timing can be changed on the multi-information display as following:

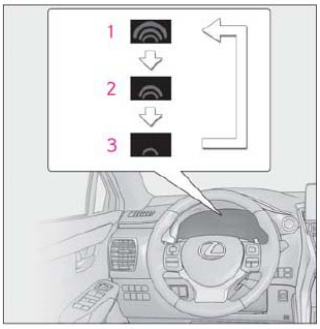
The operation timing setting is retained when the engine switch is turned off.

1 Press "〈" or "〉" of meter control switches and select ⚙.

2 Press "∧" or "∨" of meter control switches and select 🚗, and press ●.

3 Press "∧" or "∨" of meter control switches and select "Sensitiv-

ity", and press ● to select the desired setting.



1 Far

The warning will begin to operate earlier than with the default timing.

2 Middle

This is the default setting.

3 Near

The warning will begin to operate later than with the default timing.

■ **Operational conditions**

The pre-collision system is enabled and the system determines that the possibility of a frontal collision with a vehicle or pedestrian is high.
Each function is operational at the following speeds:

● Pre-collision warning:
- Vehicle speed is between approximately 7 and 110 mph (10 and 180 km/h). (For detecting a pedestrian, vehicle speed is between approximately 7 and 50 mph [10 and 80 km/h].)
- The relative speed between your vehicle and the vehicle or pedestrian ahead is approximately 7 mph (10 km/h) or more.

● Pre-collision brake assist:
- Vehicle speed is between approximately 20 and 110 mph (30 and 180 km/h). (For detecting a pedestrian, vehicle speed is between approximately 20 and 50 mph [30 and 80 km/h].)
- The relative speed between your vehicle and the vehicle or pedestrian ahead is approximately 20 mph (30 km/h) or more.

● Pre-collision braking:
- Vehicle speed is between approximately 7 and 110 mph (10 and 180 km/h). (For detecting a pedestrian, vehicle speed is between approximately 7 and 50 mph [10 and 80 km/h].)
- The relative speed between your vehicle and the vehicle or pedestrian ahead is approximately 7 mph (10 km/h) or more.

The system may not operate in the following situations:

● If a battery terminal has been disconnected and reconnected and then the vehicle has not been driven for a certain amount of time

● If the shift lever is in R

● If VSC is disabled (only the pre-collision warning function will be operational)

■ **Pedestrian detection function**

The pre-collision system detects pedestrians based on the size, profile, and motion of a detected object. However, a pedestrian may not be detected depending on the surrounding brightness and the motion, posture, and angle of the detected object, preventing the system from operating properly. (→P.195)

■ **Cancelation of the pre-collision braking**

If either of the following occur while the pre-collision braking function is operating, it will be canceled:

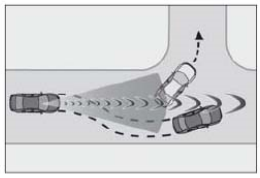
● The accelerator pedal is depressed strongly.

● The steering wheel is turned sharply or abruptly.

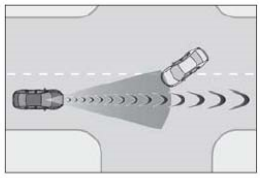
■ **Conditions under which the system may operate even if there is no possibility of a collision**

● In some situations such as the following, the system may determine that there is a possibility of a frontal collision and operate.

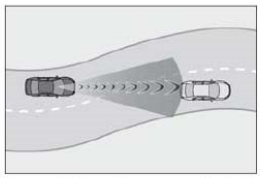
- When passing a vehicle or pedestrian
- When changing lanes while overtaking a preceding vehicle
- When overtaking a preceding vehicle that is changing lanes
- When overtaking a preceding vehicle that is making a left/right turn



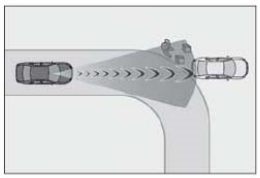
- When passing a vehicle in an oncoming lane that is stopped to make a right/left turn



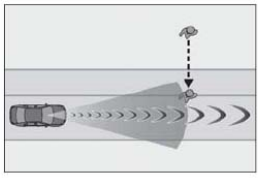
- When driving on a road where relative location to vehicle ahead in an adjacent lane may change, such as on a winding road



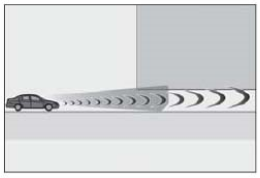
- When rapidly closing on a vehicle ahead
- If the front of the vehicle is raised or lowered, such as when the road surface is uneven or undulating
- When approaching objects on the roadside, such as guardrails, utility poles, trees, or walls
- When there is a vehicle, pedestrian, or object by the roadside at the entrance of a curve



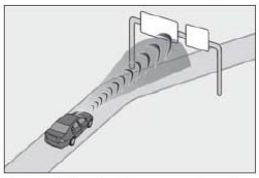
- When driving on a narrow path surrounded by a structure, such as in a tunnel or on an iron bridge
- When there is a metal object (manhole cover, steel plate, etc.), steps, or a protrusion on the road surface or roadside
- When a crossing pedestrian approaches very close to the vehicle



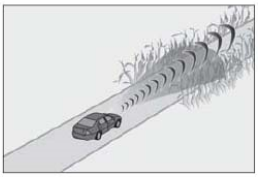
- When passing through a place with a low structure above the road (low ceiling, traffic sign, etc.)



- When passing under an object (billboard, etc.) at the top of an uphill road



- When rapidly closing on an electric toll gate barrier, parking area barrier, or other barrier that opens and closes
- When using an automatic car wash
- When driving through or under objects that may contact the vehicle, such as thick grass, tree branches, or a banner

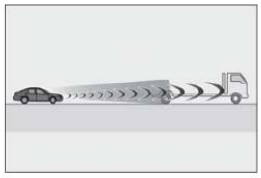


- When the vehicle is hit by water, snow, dust, etc. from a vehicle ahead
- When driving through steam or smoke
- When there are patterns or paint on the road or a wall that may be mistaken for a vehicle or pedestrian
- When driving near an object that reflects radio waves, such as a large truck or guardrail
- When driving near a TV tower, broadcasting station, electric power plant, or other location where strong radio waves or electrical noise may be present

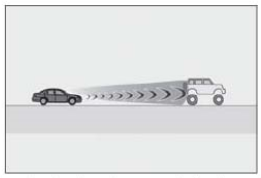
■ Situations in which the system may not operate properly

● In some situations such as the following, a vehicle may not be detected by the radar sensor and camera sensor, preventing the system from operating properly:

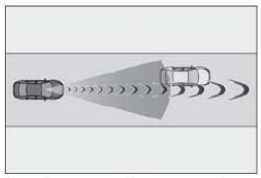
- If an oncoming vehicle is approaching your vehicle
- If a vehicle ahead is a motorcycle or bicycle
- When approaching the side or front of a vehicle
- If a preceding vehicle has a small rear end, such as an unloaded truck
- If a preceding vehicle has a low rear end, such as a low bed trailer



- If a vehicle ahead is carrying a load which protrudes past its rear bumper
- If a vehicle ahead has extremely high ground clearance

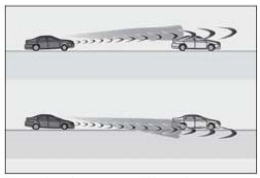


- If a vehicle ahead is irregularly shaped, such as a tractor or side car
- If the sun or other light is shining directly on a vehicle ahead
- If a vehicle cuts in front of your vehicle or emerges from beside a vehicle
- If a vehicle ahead makes an abrupt maneuver (such as sudden swerving, acceleration or deceleration)
- When suddenly cutting behind a preceding vehicle
- When a vehicle ahead is not directly in front of your vehicle



- When driving in inclement weather such as heavy rain, fog, snow or a sandstorm
- When the vehicle is hit by water, snow, dust, etc. from a vehicle ahead
- When driving through steam or smoke
- When driving in a place where the sur-

rounding brightness changes suddenly, such as at the entrance or exit of a tunnel
- When a very bright light, such as the sun or the headlights of oncoming traffic, shines directly into the camera sensor
- When the surrounding area is dim, such as at dawn or dusk, or while at night or in a tunnel
- After the engine has started the vehicle has not been driven for a certain amount of time
- While making a left/right turn and for a few seconds after making a left/right turn
- While driving on a curve and for a few seconds after driving on a curve
- If your vehicle is skidding
- If the front of the vehicle is raised or lowered



- If the wheels are misaligned
- If a wiper blade is blocking the camera sensor
- The vehicle is wobbling.
- The vehicle is being driven at extremely high speeds.
- When driving on a hill
- If the radar sensor or camera sensor is misaligned

● In some situations such as the following, sufficient braking force may not be obtained, preventing the system from performing properly:
- If the braking functions cannot operate to their full extent, such as when the brake parts are extremely cold, extremely hot, or wet
- If the vehicle is not properly maintained (brakes or tires are excessively worn, improper tire inflation pressure, etc.)
- When the vehicle is being driven on a gravel road or other slippery surface

● Some pedestrians such as the following may not be detected by the radar sensor and camera sensor, preventing the system from operating properly:
- Pedestrians shorter than approximately 3.2 ft. (1 m) or taller than approximately 6.5 ft. (2 m)
- Pedestrians wearing oversized clothing (a rain coat, long skirt, etc.), making their silhouette obscure
- Pedestrians who are carrying large baggage, holding an umbrella, etc., hiding part of their body
- Pedestrians who are bending forward or squatting
- Pedestrians who are pushing a stroller, wheelchair, bicycle or other vehicle
- Groups of pedestrians which are close together
- Pedestrians who are wearing white and look extremely bright
- Pedestrians in the dark, such as at night or while in a tunnel
- Pedestrians whose clothing appears to be nearly the same color or brightness as their surroundings
- Pedestrians near walls, fences, guardrails, or large objects
- Pedestrians who are on a metal object (manhole cover, steel plate, etc.) on the road
- Pedestrians who are walking fast
- Pedestrians who are changing speed abruptly
- Pedestrians running out from behind a vehicle or a large object
- Pedestrians who are extremely close to the side of the vehicle (outside rear view mirror, etc.)

■ **If the PCS warning light flashes or illuminates and a warning message is displayed on the multi-information display**

The pre-collision system may be temporarily unavailable or there may be a malfunction in the system.

● In the following situations, the warning light will turn off, the message will disappear and the system will become operational when normal operating conditions return:
- When the radar sensor or camera sensor or the area around either sensor is hot, such as in the sun
- When the radar sensor or camera sensor or the area around either sensor is cold, such as in an extremely cold environment
- When a front sensor is dirty or covered

with snow, etc.
- When the part of the windshield in front of the camera sensor is fogged up or covered with condensation or ice (Defogging the windshield: →P.258)
- If the camera sensor is obstructed, such as when the hood is open or a sticker is attached to the windshield near the camera sensor

● If the PCS warning light continues to flash or remains illuminated or the warning message does not disappear even though the vehicle has returned to normal, the system may be malfunctioning. Have the vehicle inspected by your Lexus dealer immediately.

■ **If VSC is disabled**

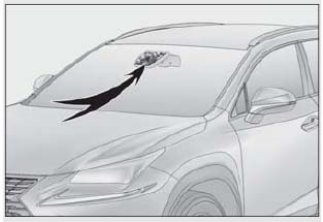
● If VSC is disabled (→P.240), the pre-collision brake assist and pre-collision braking functions are also disabled.

● The PCS warning light will turn on and "VSC Turned Off Pre-Collision Brake System Unavailable" will be displayed on the multi-information display.

LDA (Lane Departure Alert with steering control)

When driving on highways and freeways with white (yellow) lines, this function alerts the driver when the vehicle might depart from its lane and provides assistance by operating the steering wheel to keep the vehicle in its lane.

The LDA system recognizes visible white (yellow) lines with the camera sensor on the upper portion of the windshield.



Functions included in LDA system

■ **Lane departure alert function**

When the system determines that the vehicle might depart from its lane, a warning is displayed on the multi-information display, and either the warning buzzer sounds or the steering wheel vibrates to alert the driver.

When the warning buzzer sounds or the steering wheel vibrates, check the surrounding road situation and carefully operate the steering wheel to move the vehicle back to the center of the lane.

■ ABS warning light

Warning light	Details/Actions
 (U.S.A.)  (Canada)	Indicates a malfunction in: ● The ABS, or ● The brake assist system → **Have the vehicle inspected by your Lexus dealer immediately.**

■ Electric power steering system warning light (warning buzzer)

Warning light	Details/Actions
 (Yellow)  (Red)	Indicates a malfunction in the EPS (Electric Power Steering) system → **Have the vehicle inspected by your Lexus dealer immediately.**

■ PCS warning light

Warning light	Details/Actions
 (Flashes or illuminates)	Indicates a malfunction in the PCS (Pre-Collision System) or that the system is temporarily unavailable due to the vehicle being extremely hot/cold, or dirt around a front sensor, etc. (→P.196, 368) → **Follow the instructions displayed on the multi-information display. (→P.196, 368)** If the PCS (Pre-Collision System) or VSC (Vehicle Stability Control) system is disabled, the PCS warning light will illuminate. → **P.197**

Messages and warnings

The warning lights and warning buzzers operate as follows depending on the content of the message. If a message indicates the need for inspection by a dealer, have the vehicle inspected by your Lexus dealer immediately.

	System warning light	Warning buzzer*	Warning
Comes on	—	Sounds	Indicates an important situation, such as when a system related to driving is malfunctioning or that danger may result if the correction procedure is not performed
—	Comes on or flashes	Sounds	Indicates an important situation, such as when the systems shown on the multi-information display may be malfunctioning
Flashes	—	Sounds	Indicates a situation, such as when damage to the vehicle or danger may result
Comes on	—	Does not sound	Indicates a condition, such as malfunction of electrical components, their condition, or indicates the need for maintenance
Flashes	—	Does not sound	Indicates a situation, such as when an operation has been performed incorrectly, or indicates how to perform an operation correctly

*: A buzzer sounds the first time a message is shown on the multi-information display.

■ **System warning lights**

The master warning light does not come on or flash in the following cases. Instead, a separate system warning light will come on along with a message shown on the multi-information display.

- Malfunction of the ABS
  The ABS warning light comes on. (→P.360)
- Malfunction of the charging system
  The charging system warning light comes on. (→P.358)

■ **If "Shift to P Before Exiting Vehicle" is shown**

Message is displayed when the driver's door is opened without turning the engine switch to OFF with the shift lever in any position other than P.
Shift the shift lever to P.

■ **If "Front Camera Unavailable" or "Front Camera Unavailable Remove Debris On Windshield" is shown**

The following systems may be suspended until the problem shown in the message is resolved. (→P.196, 360)

- PCS (Pre-Collision System)
- LDA (Lane Departure Alert with steering control)
- Dynamic radar cruise control with full-speed range
- Adaptive High-beam System
- Automatic High Beam

WARNING

When the compact spare tire is attached

The vehicle speed may not be correctly detected, and the following systems may not operate correctly:

- ABS & Brake assist
- VSC
- TRAC
- Dynamic radar cruise control with full-speed range
- PCS (Pre-Collision System)
- EPS
- AVS (Adaptive Variable Suspension system) (if equipped)
- LDA (Lane Departure Alert with steering control)
- Panoramic view monitor (if equipped)
- Lexus parking assist monitor (if equipped)
- Intuitive parking assist (if equipped)
- Navigation system (if equipped)
- BSM (Blind spot monitor) (if equipped)
- Automatic high Beam (if equipped)

Also, not only can the following system not be utilized fully, but it may even negatively affect the drive-train components:

- AWD system (if equipped)

Speed limit when using the compact spare tire

Do not drive at speeds in excess of 50 mph (80 km/h) when a compact spare tire is installed on the vehicle.
The compact spare tire is not designed for driving at high speeds. Failure to observe this precaution may lead to an accident causing death or serious injury.

After using the tools and jack

Before driving, make sure all the tools and jack are securely in place in their storage location to reduce the possibility of personal injury during a collision or sudden braking.

NOTICE

Be careful when driving over bumps with the compact spare tire installed on the vehicle

The vehicle becomes lower when driving with the compact spare tire compared to when driving with standard tires. Be careful when driving over uneven road surfaces.

Driving with tire chains and the compact spare tire

Do not fit tire chains to the compact spare tire.
Tire chains may damage the vehicle body and adversely affect driving performance.

When replacing the tires

When removing or fitting the wheels, tires or the tire pressure warning valve and transmitter, contact your Lexus dealer as the tire pressure warning valve and transmitter may be damaged if not handled correctly.

■ PCS (Pre-Collision System) (→P.190)

Function	Default setting	Customized setting	A	B	C	D
PCS (Pre-Collision System)	On	Off	–	O	–	–
Adjust alert timing	Middle	Far	–	O	–	–
		Near				

■ Power back door*1 (→P.96)

Function	Default setting	Customized setting	A	B	C	D
Back door automatic open and stop position	5	Stop at the desired position (height)*2	O	–	–	O
		1 to 5				
Back door opener switch operations	When the back door is locked*3	When the back door is unlocked	–	–	O	–
Power back door operations	On	Off	–	O	–	–
Operation buzzer volume	3	1	–	O	–	–
		2				
Kick Sensor*1, 4	On	Off	–	O	–	–

*1: If equipped

*2: Configured by operating the switch of the lower back door. (→P.107)

*3: While carrying the electronic key on your person, press the back door opener switch.

*4: When the towing hitch is installed, the kick sensor does not work

■ Driving mode select switch (→P.236)

Function	Default setting	Customized setting	A	B	C	D
Powertrain control in custom mode	Normal	Power	O	–	–	–
		Eco				

APPENDIX C

Run Log

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-16	Brake characterization and confirmation						See Appendix D
17	Static Run						
18	**Stopped POV**	Y	2.56	12.15	1.03	Pass	
19		Y	2.56	12.48	0.98	Pass	
20		Y	2.49	12.45	0.97	Pass	
21		Y	2.57	12.44	0.97	Pass	
22		Y	2.52	12.58	0.99	Pass	
23		Y	2.46	12.40	0.97	Pass	
24		Y	2.52	12.37	0.96	Pass	
25	Static Run						
26	**Slower POV, 25 vs 10**	Y	2.17	9.53	0.93	Pass	
27		Y	2.14	9.37	0.79	Pass	
28		Y	2.20	9.19	0.78	Pass	

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
29		Y	2.32	8.80	0.77	Pass	
30		Y	2.39	9.17	0.78	Pass	
31		N					throttle
32		Y	2.18	9.57	0.92	Pass	
33		Y	2.49	9.58	0.91	Pass	
34	Static run						
35	**Slower POV, 45 vs 20**	Y	2.83	11.08	1.01	Pass	
36		Y	2.79	12.51	1.09	Pass	
37		Y	2.77	9.22	0.95	Pass	
38		Y	2.69	14.46	1.16	Pass	
39		Y	2.97	14.84	1.14	Pass	
40		Y	3.02	10.93	1.05	Pass	
41		Y	2.82	13.26	1.16	Pass	

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
42	Static run						
43	STP - Static run						
44	**Baseline, 25**	N					throttle
45		Y			0.49		
46		Y			0.49		
47		Y			0.49		
48		Y			0.50		
49		Y			0.50		
50		Y			0.50		
51		Y			0.49		
52	STP - Static run						
53	**Baseline, 45**	Y			0.48		
54		Y			0.47		

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
55		Y			0.48		
56		N					SV speed
57		Y			0.47		
58		Y			0.48		
59		Y			0.46		
60		Y			0.47		
61	STP - Static run						
62	**STP False Positive, 25**	N					throttle
63		Y			0.44	Pass	
64		Y			0.45	Pass	
65		Y			0.44	Pass	
66		Y			0.42	Pass	
67		Y			0.43	Pass	
68		Y			0.42	Pass	

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
69		N					throttle
70		Y			0.42	Pass	
71	STP - Static run						
72	**STP False Positive, 45**	Y			0.42	Pass	
73		Y			0.46	Pass	
74		Y			0.48	Pass	
75		N					SV speed
76		Y			0.47	Pass	
77		Y			0.47	Pass	
78		Y			0.46	Pass	
79		N					SV speed
80		Y			0.46	Pass	
81	STP - Static run						

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
82	Static Run						
83	**Braking POV, 35**	Y	2.10	2.47	0.58	Pass	
84		Y	2.06	0.25	0.87	Pass	
85		Y	1.74	5.34	0.58	Pass	
86		Y	1.95	4.80	0.60	Pass	
87		Y	1.97	5.44	0.61	Pass	
88		Y	1.91	4.02	0.59	Pass	
89		Y	1.94	3.47	0.59	Pass	
90	Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2019 Lexus NX 300** Test Date: 12/10/2018

DBS Initial Brake Characterization				
Run Number	**Stroke at 0.4 g (in)**	**Force at 0.4 g (lb)**	**Slope**	**Intercept**
1	1.728105	25.05897	0.794769	0.165866
2	1.723893	24.87904	0.668651	0.303678
3	1.720138	24.85424	0.726852	0.284569

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**
4	Displacement	35	Y	0.484	1.72		1.42	
5			Y	0.410	1.55		1.51	
6		25	Y	0.442	1.55		1.40	
7			Y	0.388	1.45		1.49	
8		45	Y	0.357	1.45		1.62	
9			Y	0.383	1.55		1.62	
10	Hybrid	35	Y	0.513		24.93	19.44	

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**
11			Y	0.461		20.00	17.35	
12			Y	0.430		17.50	16.28	
13			Y	0.413		16.50	15.98	
14		45	Y	0.395		16.50	16.71	
15		25	Y	0.433		16.50	15.24	
16			Y	0.405		15.50	15.31	

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.

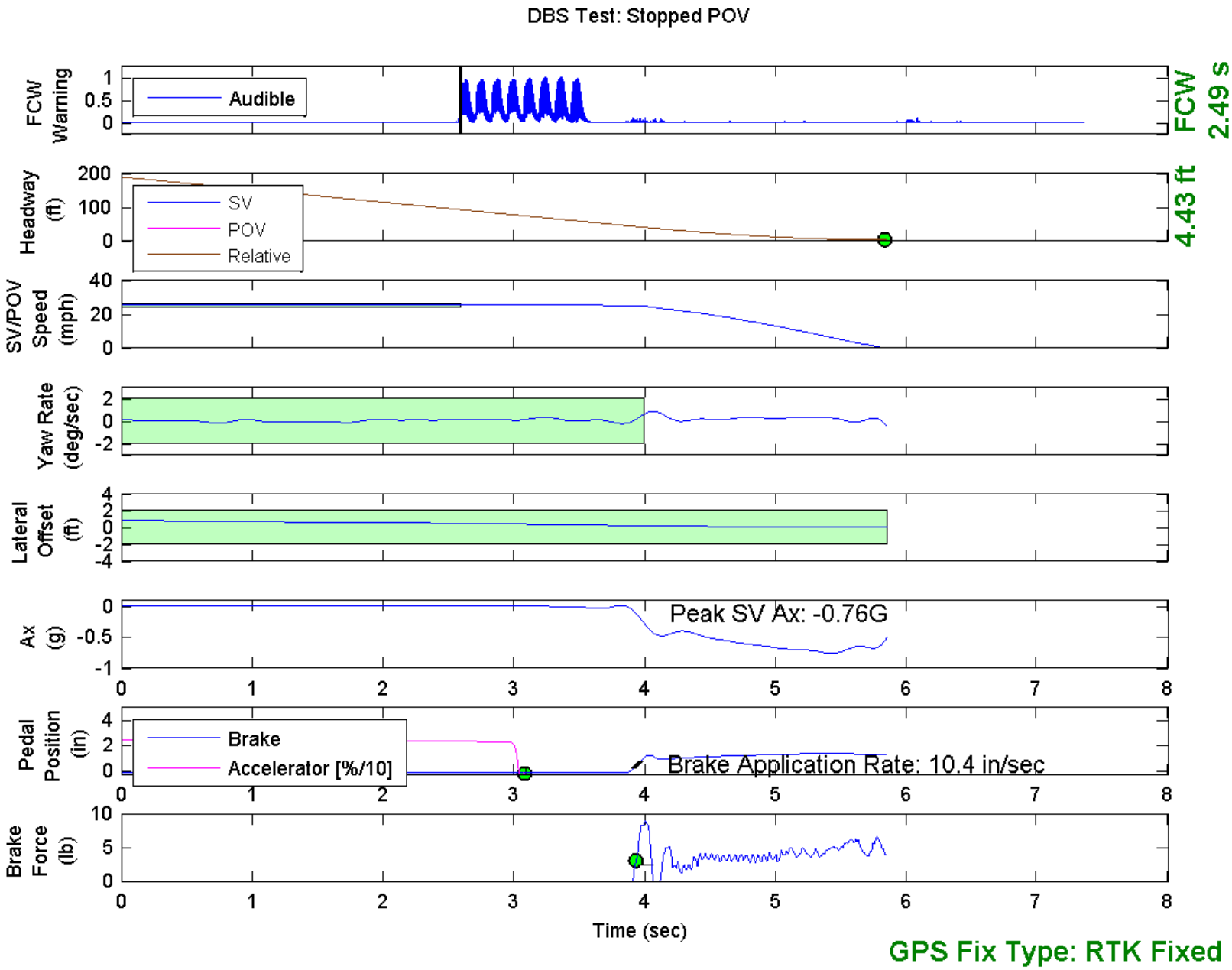


Figure E1. Example Time History for Stopped POV, Passing

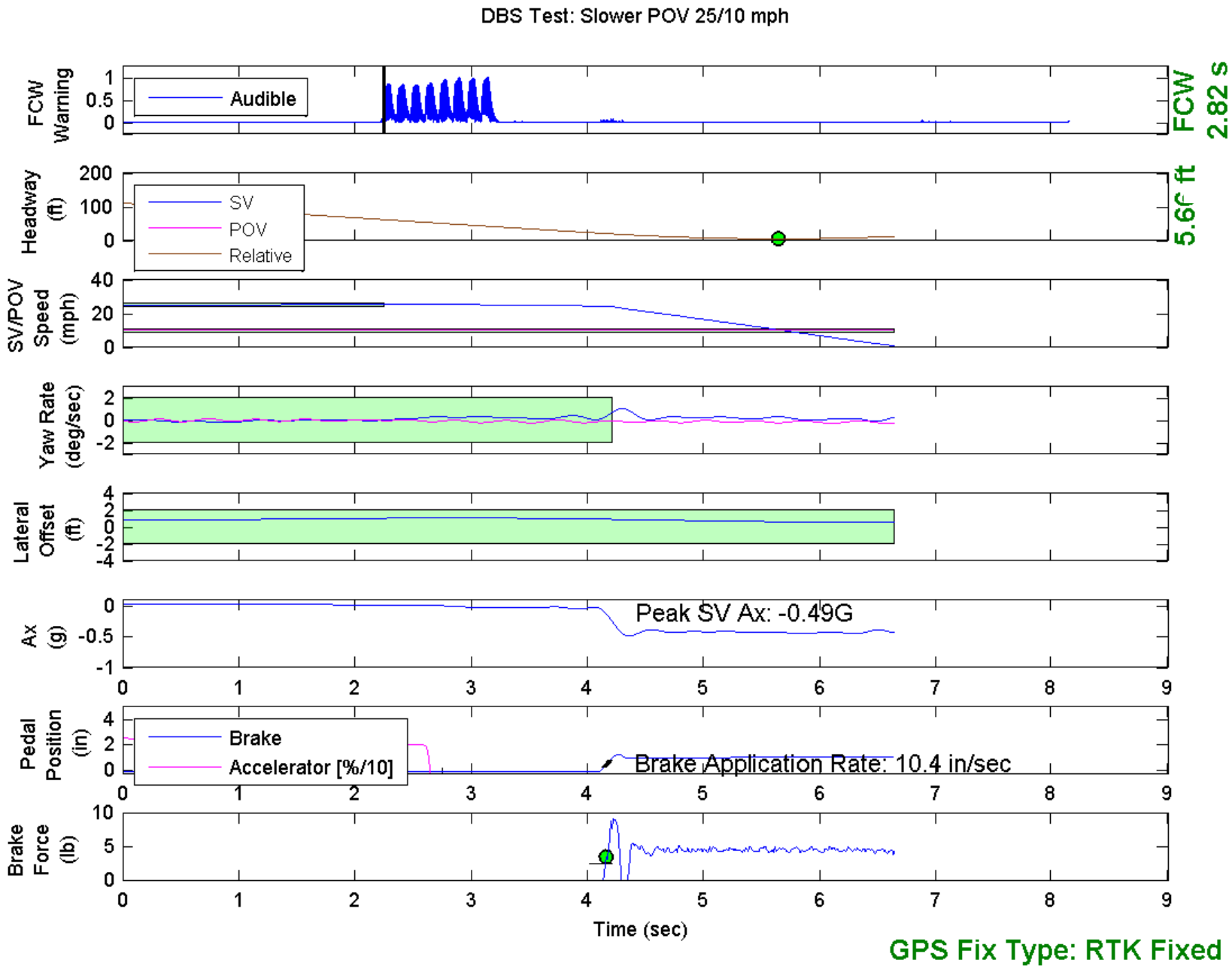


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

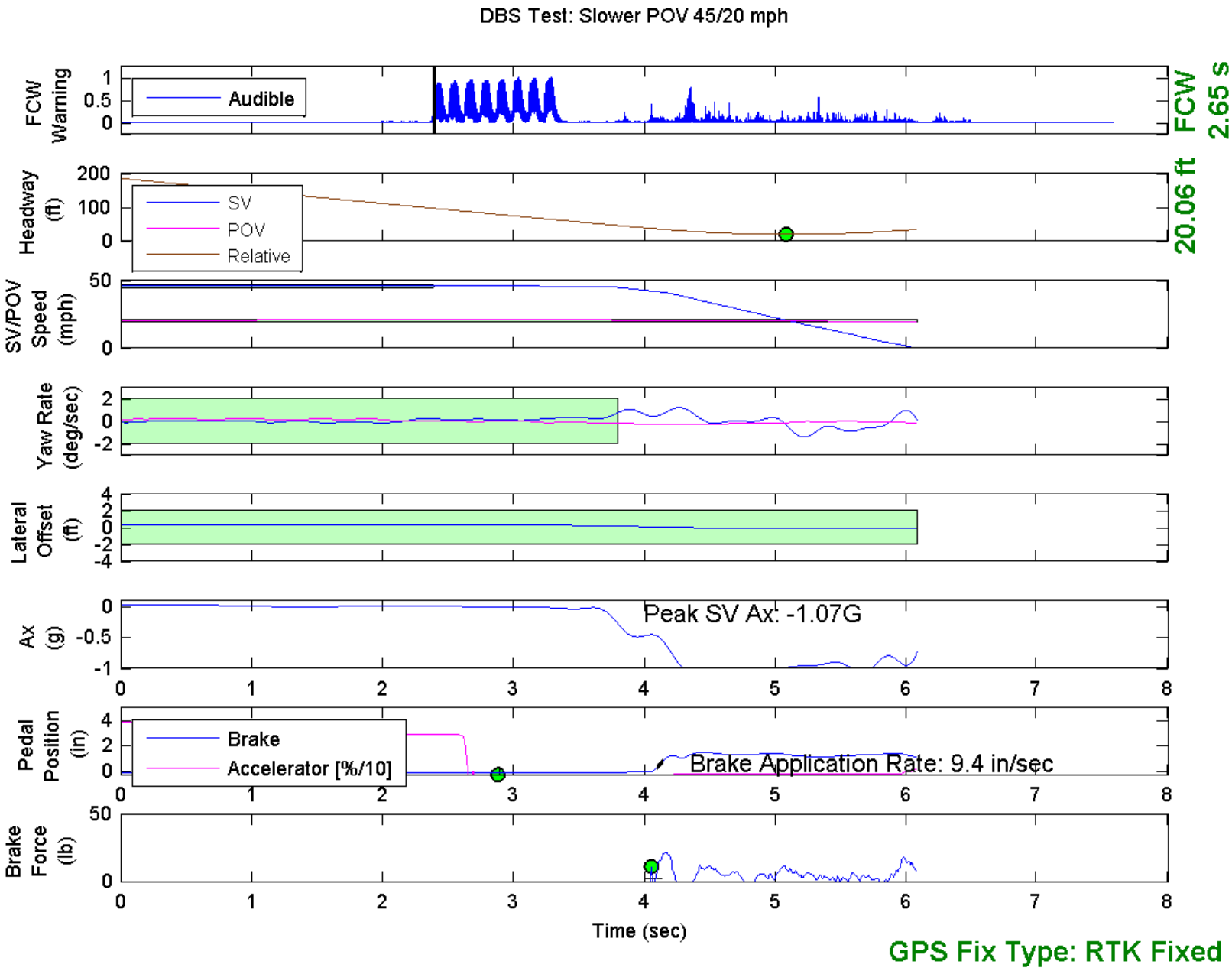


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

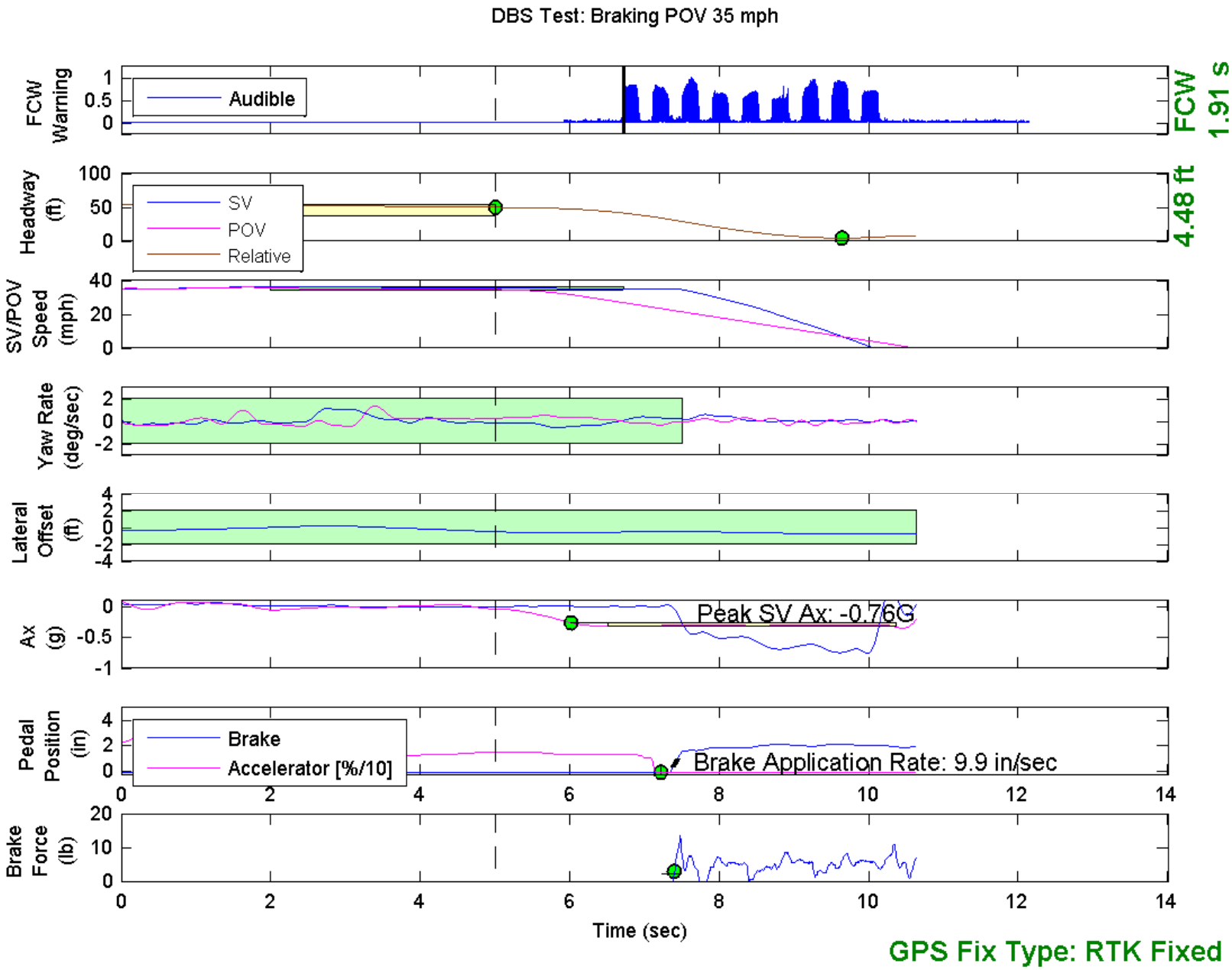


Figure E4. Example Time History for Braking POV 35, Passing

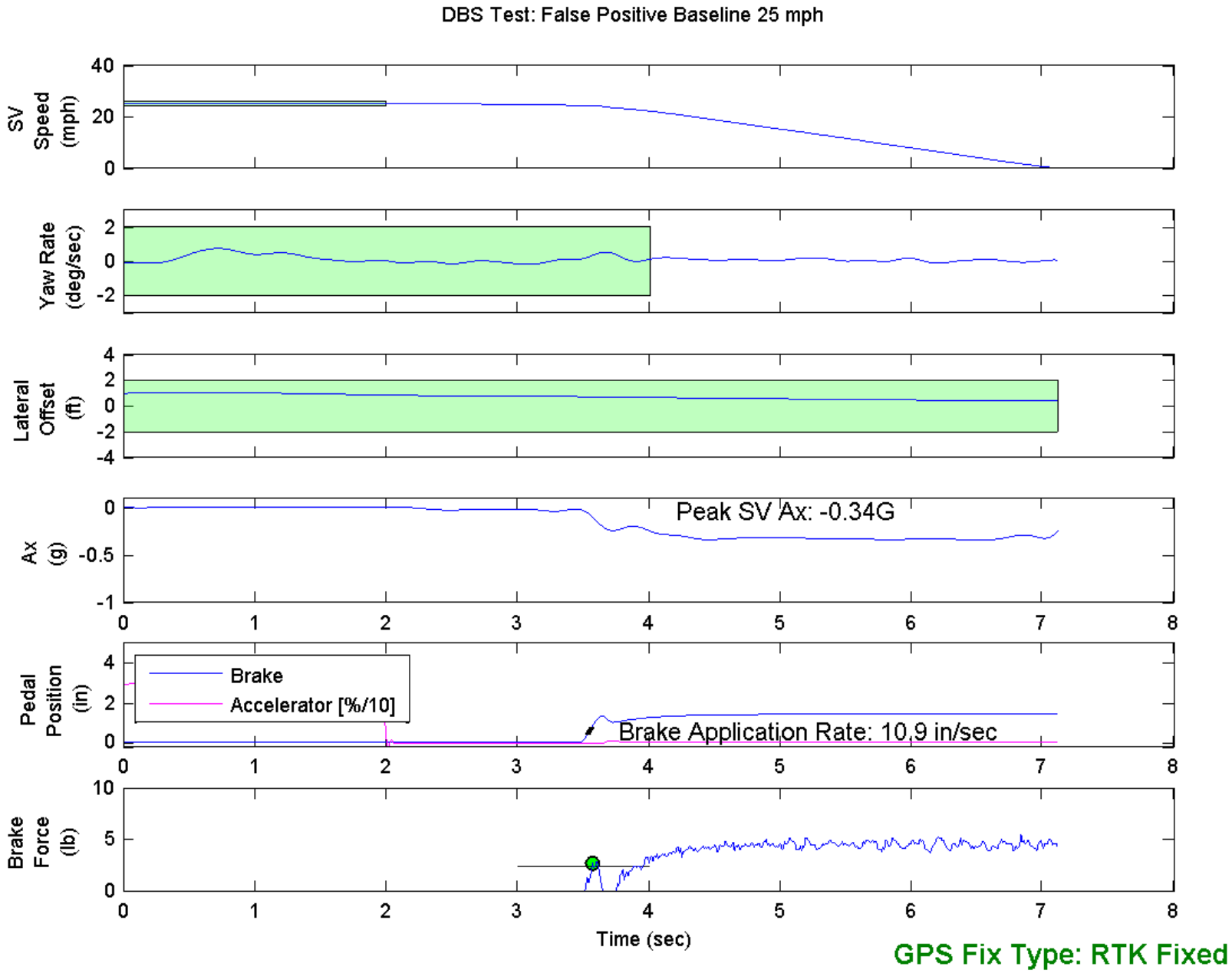


Figure E5. Example Time History for False Positive Baseline 25, Passing

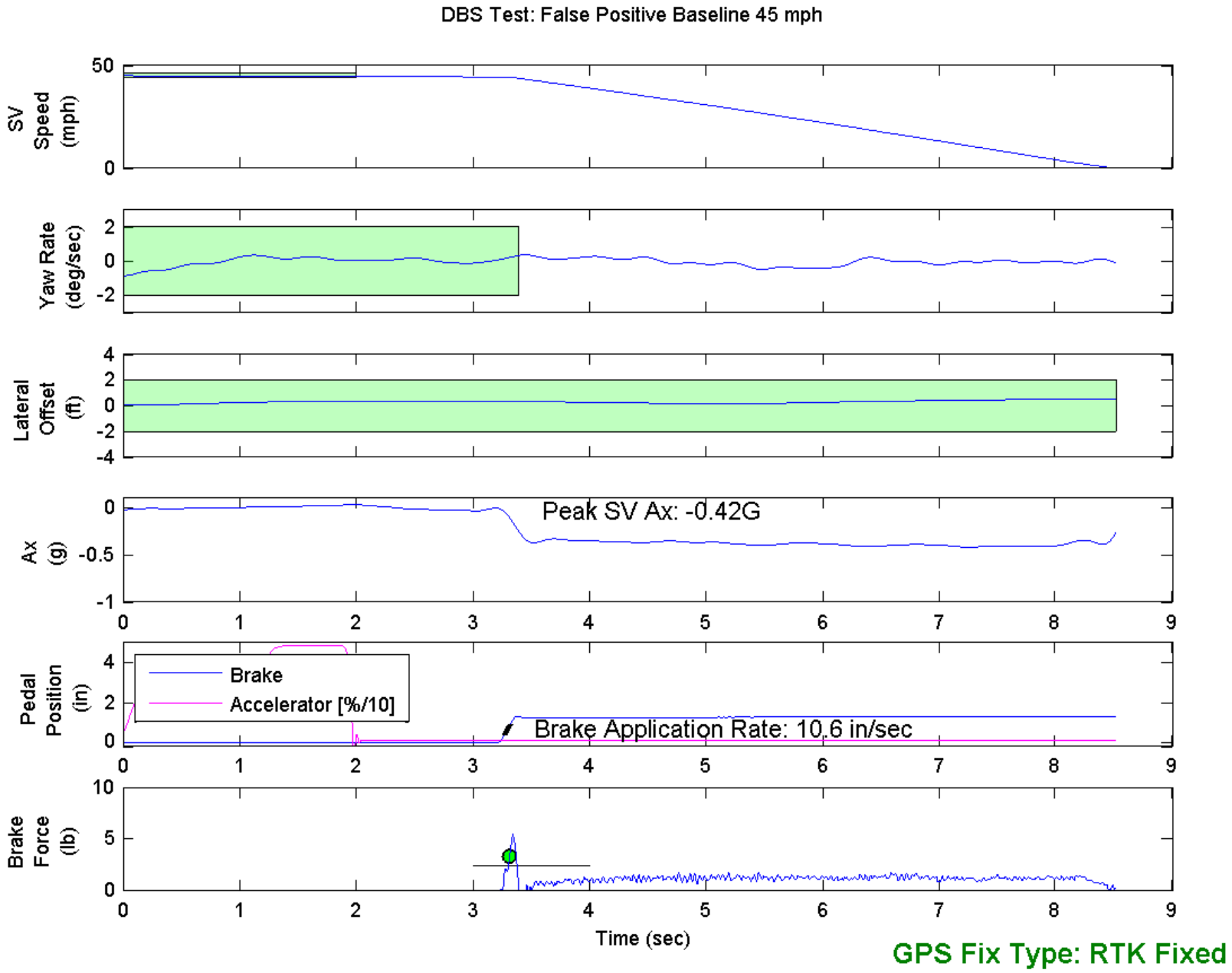


Figure E6. Example Time History for False Positive Baseline 45, Passing

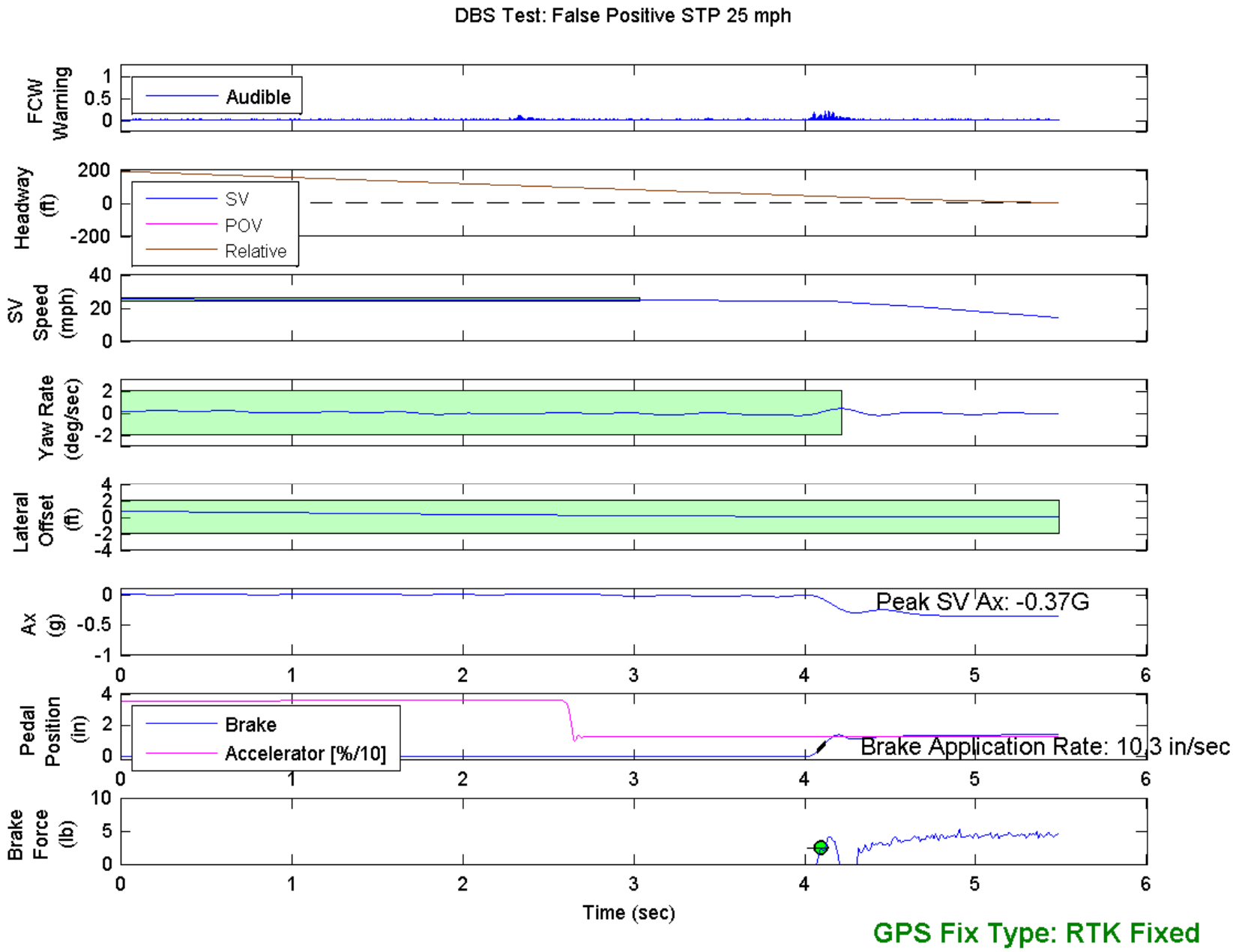


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

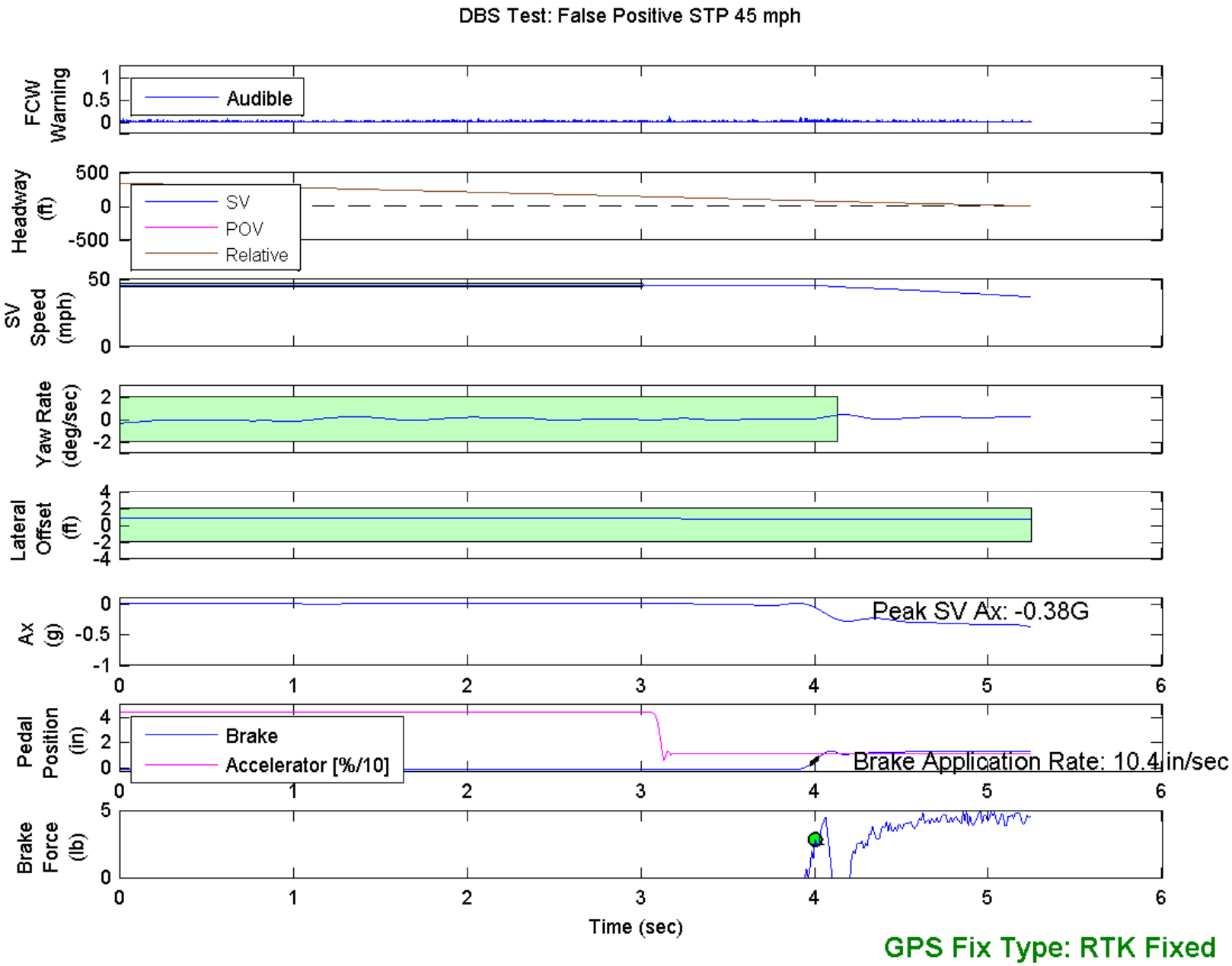


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

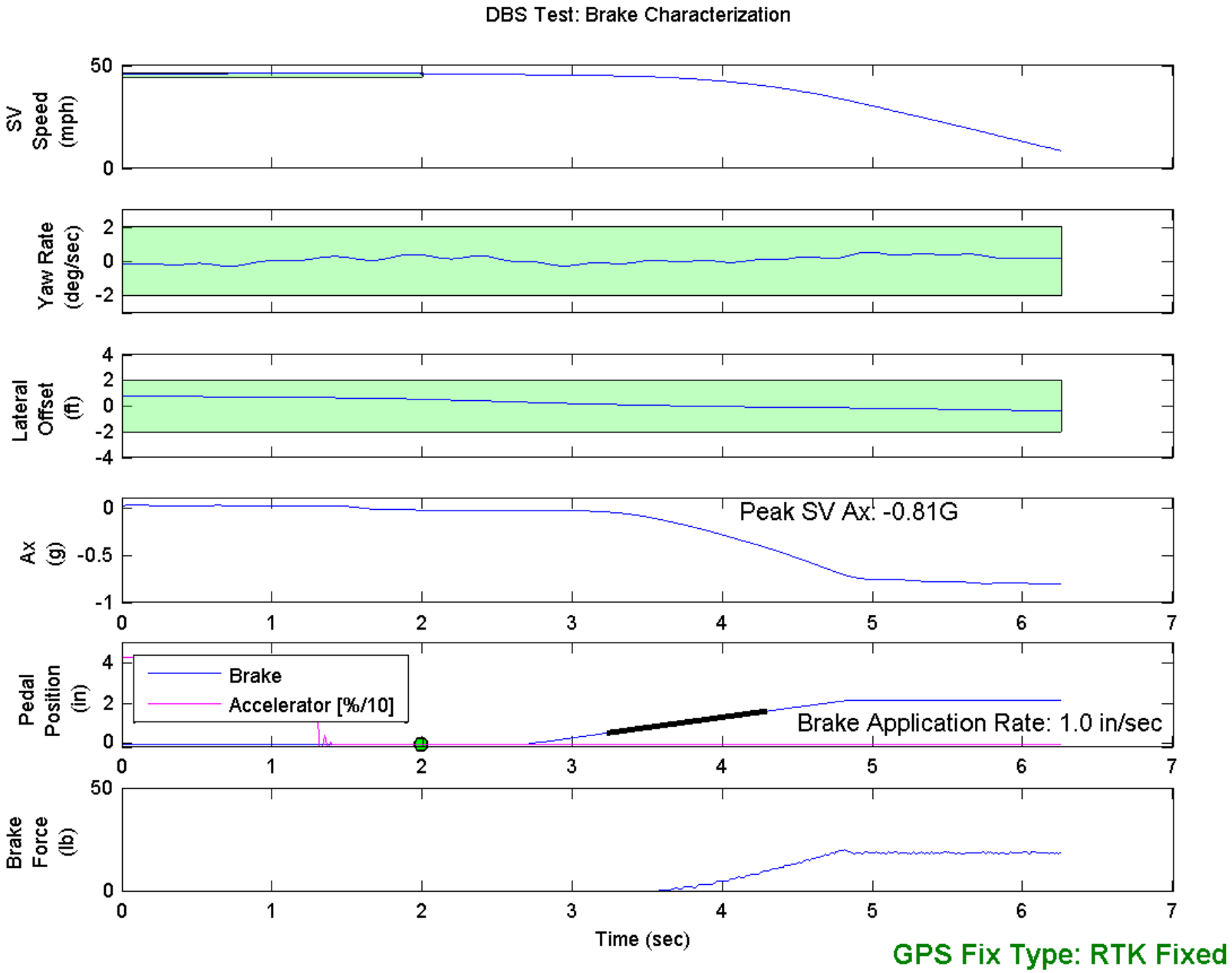


Figure E9. Example Time History for DBS Brake Characterization, Passing

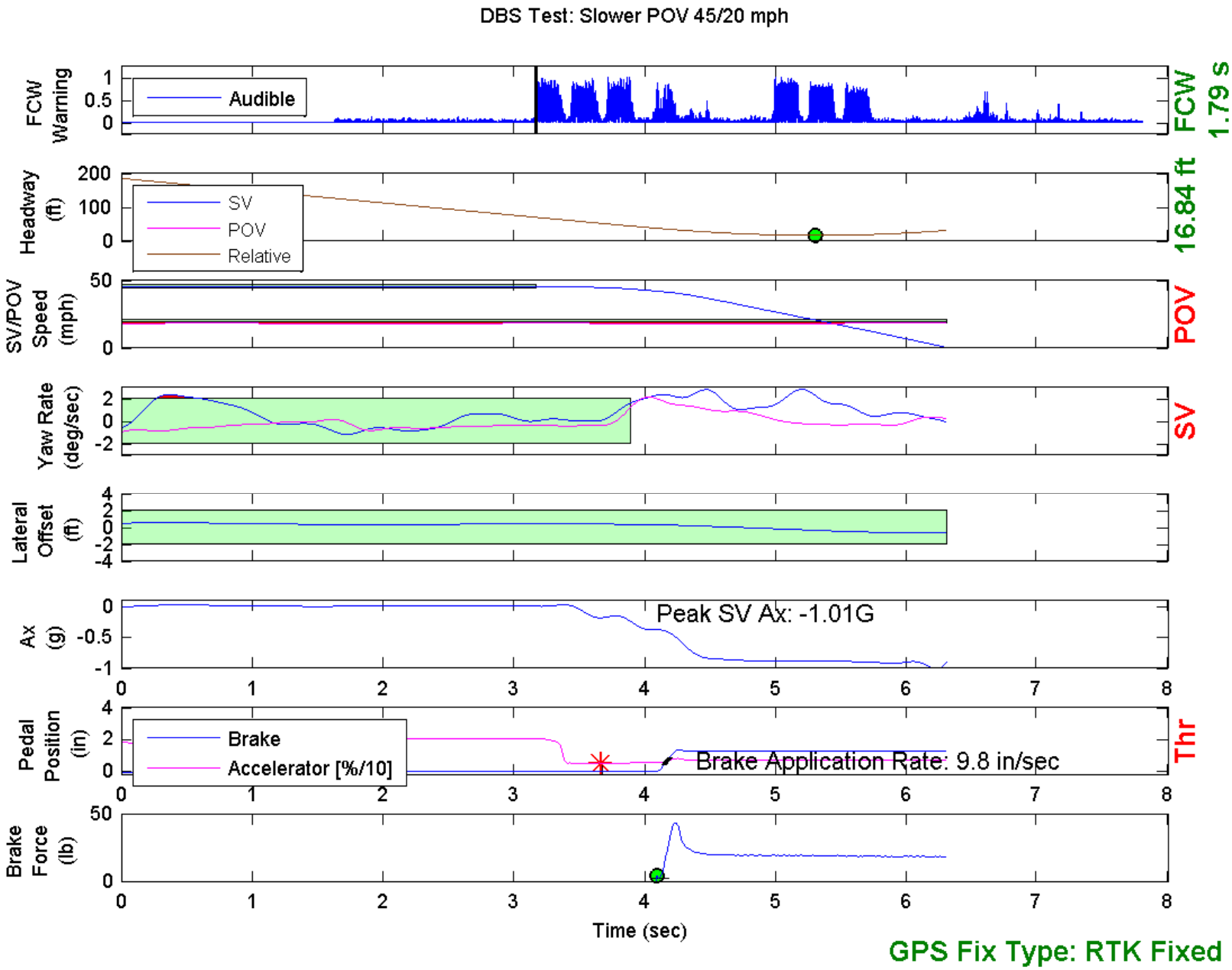


Figure E10. Example Time History Displaying Various Invalid Criteria

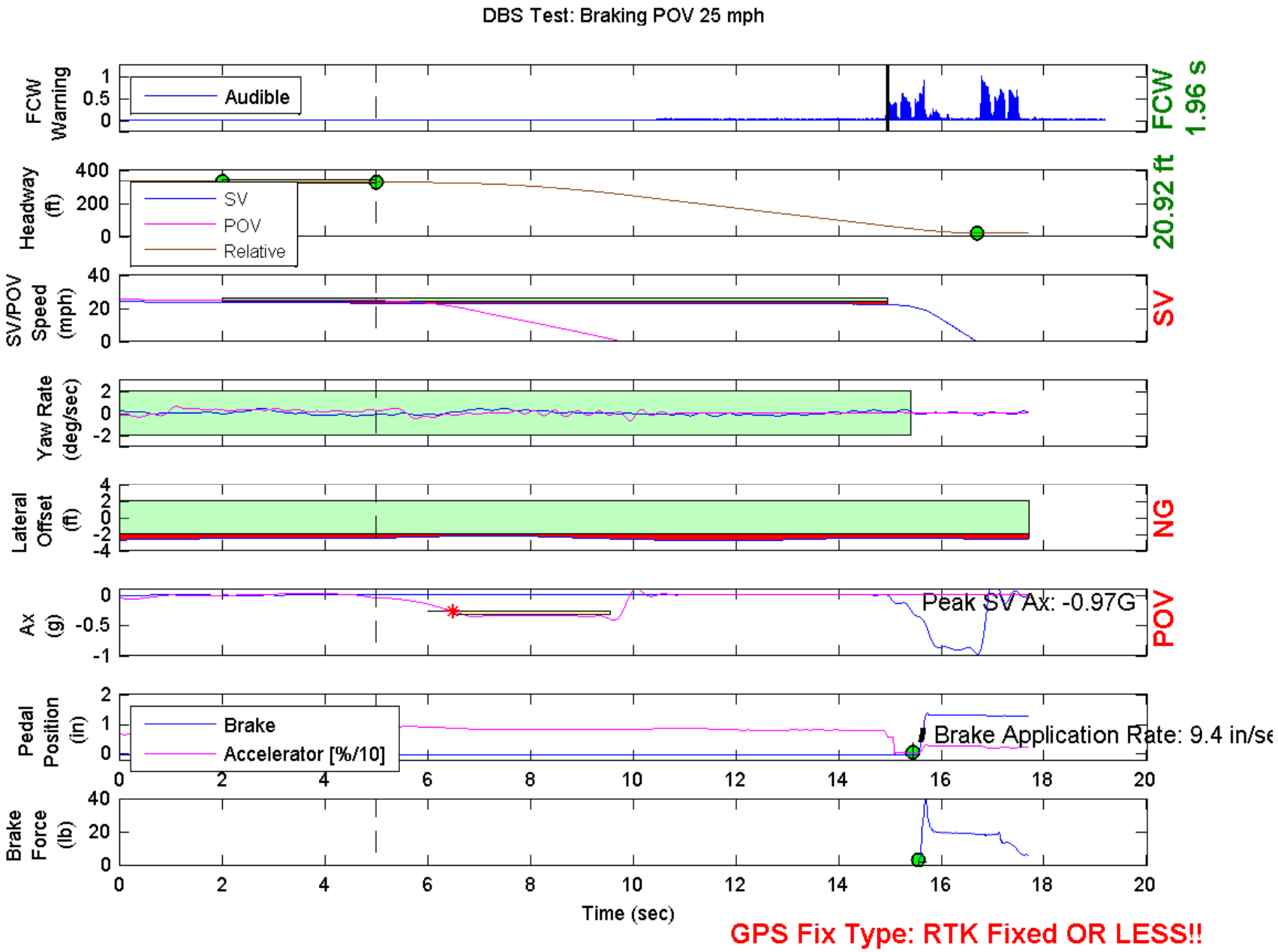


Figure E11. Example Time History Displaying Various Invalid Criteria

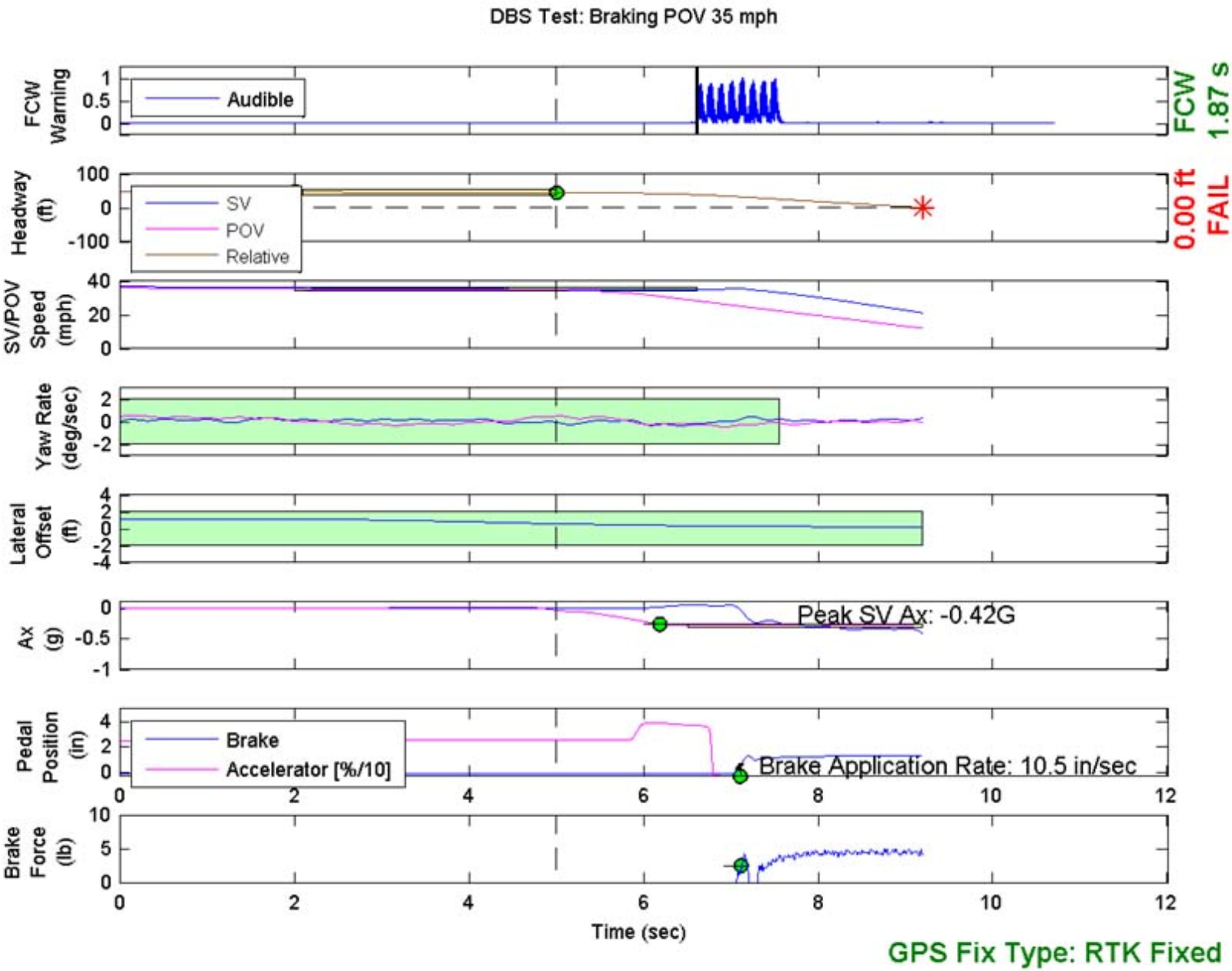


Figure E12. Example Time History for a Failed Run

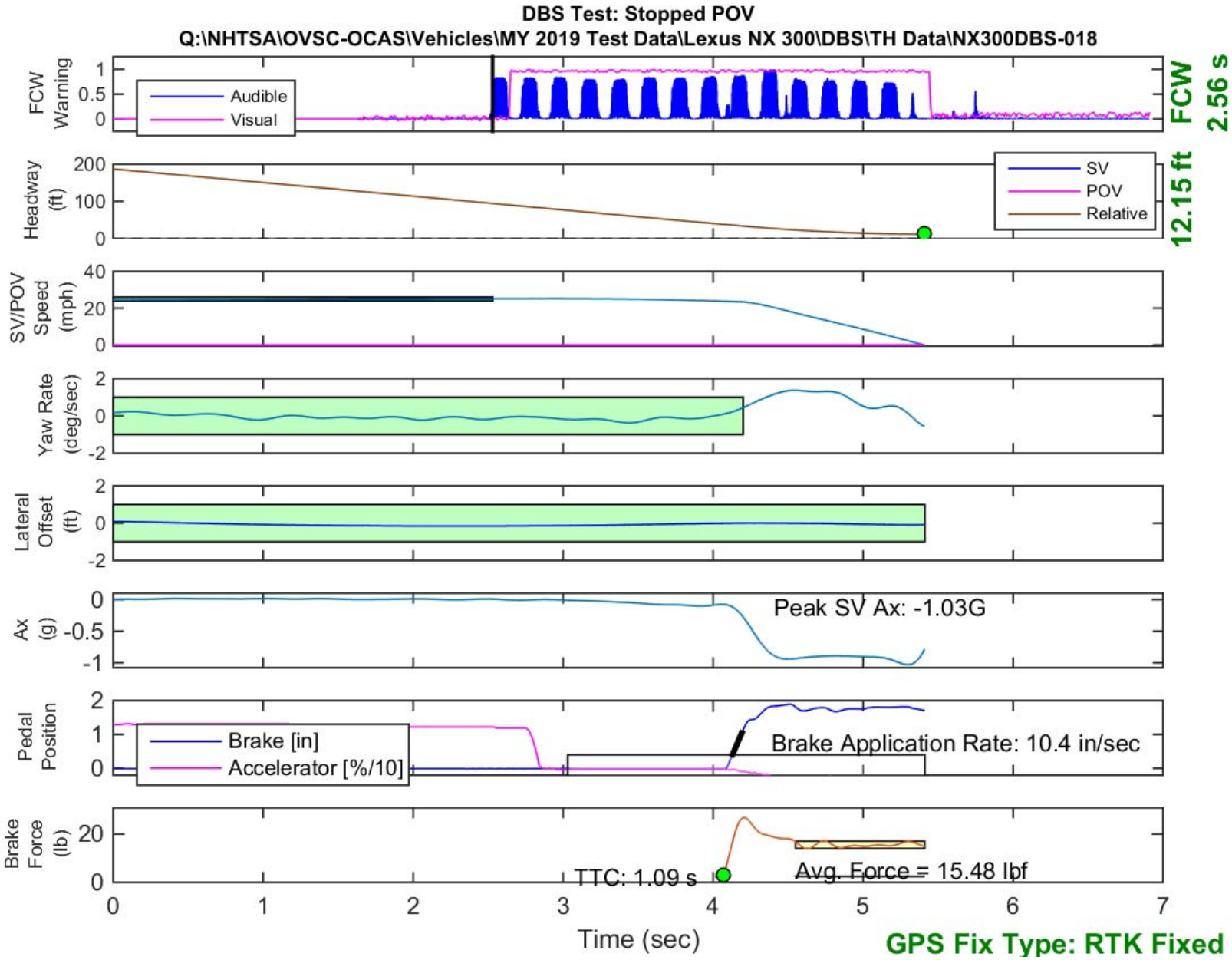


Figure E13. Time History for DBS Run 18, SV Encounters Stopped POV

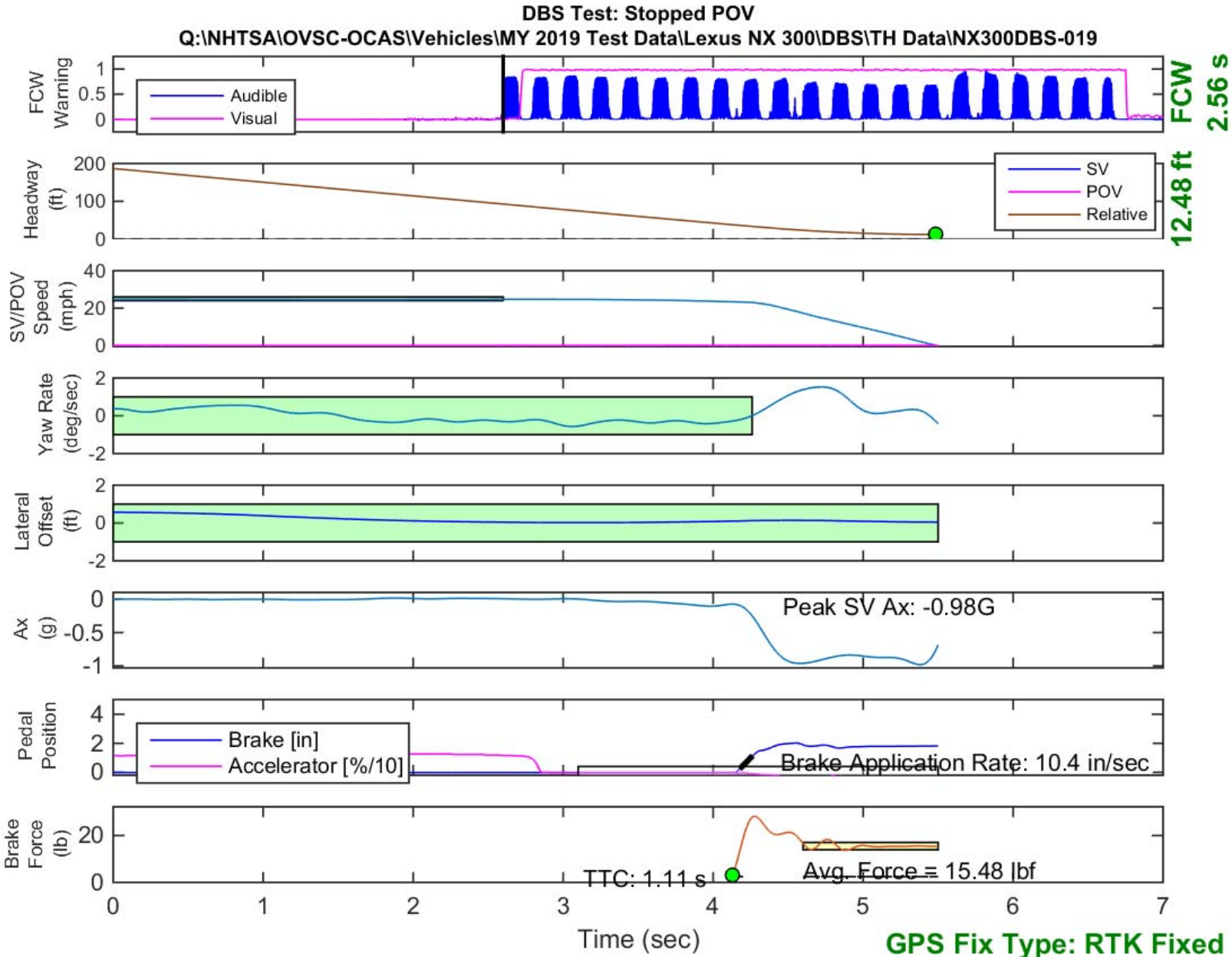


Figure E14. Time History for DBS Run 19, SV Encounters Stopped POV

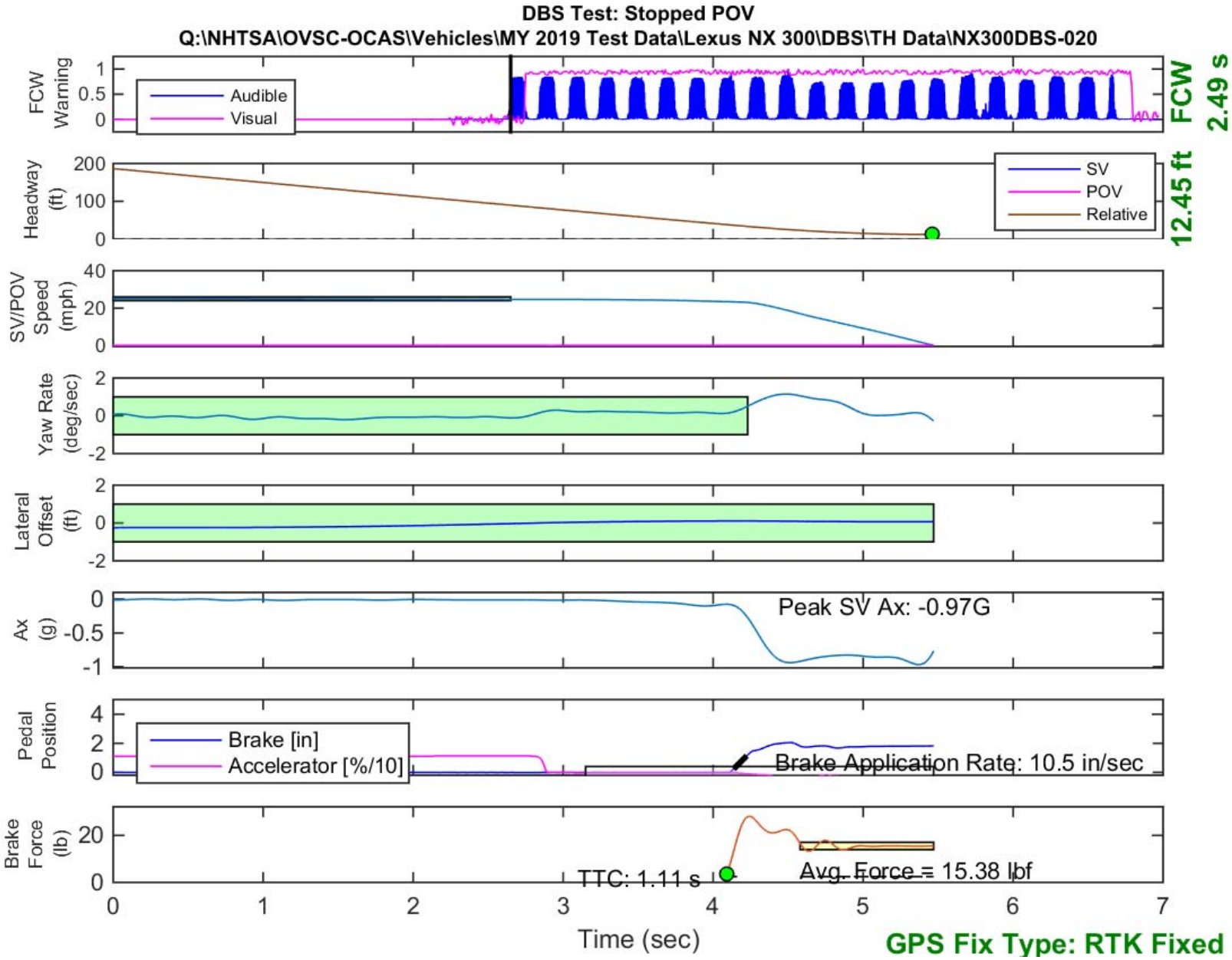


Figure E15. Time History for DBS Run 20, SV Encounters Stopped POV

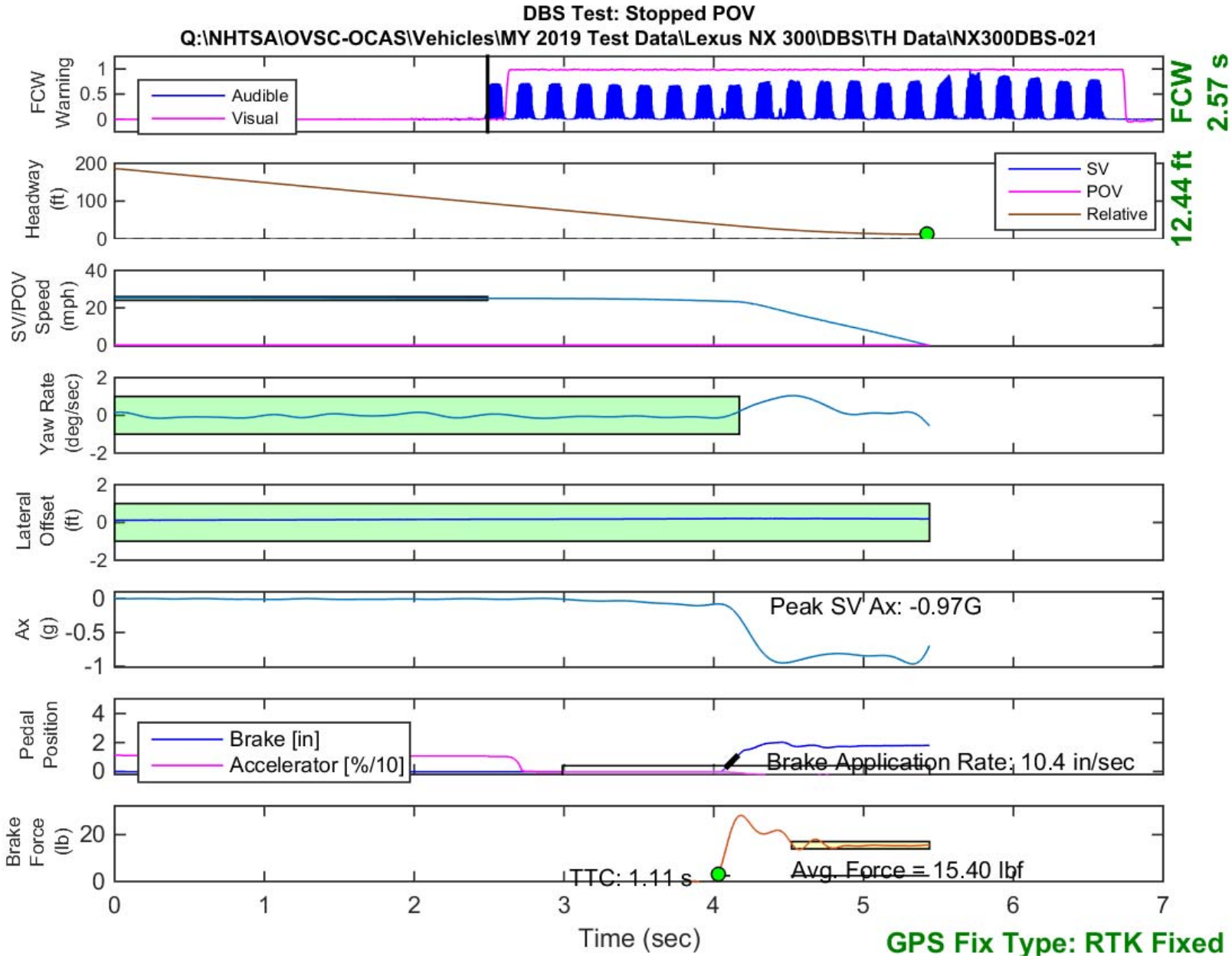


Figure E16. Time History for DBS Run 21, SV Encounters Stopped POV

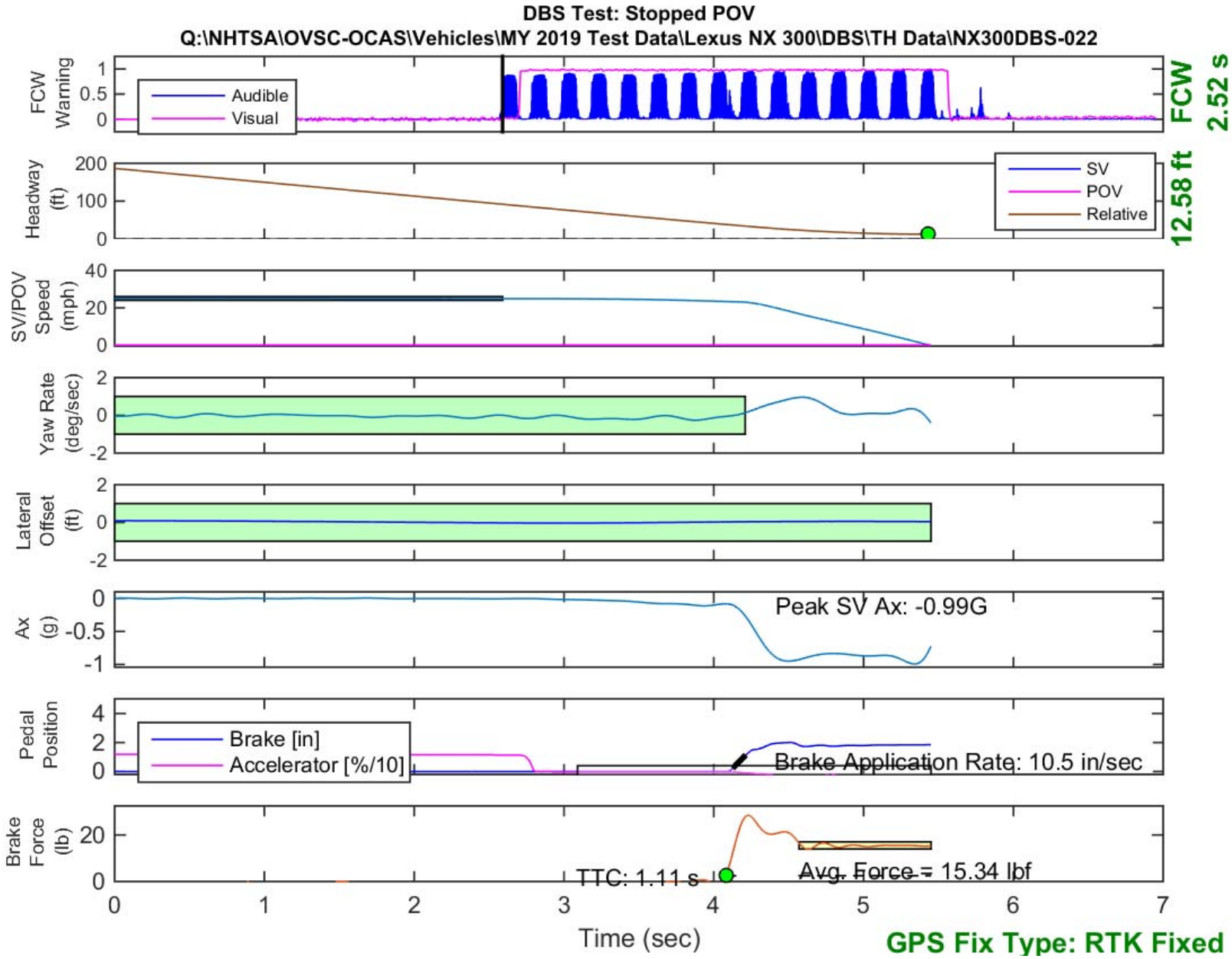


Figure E17. Time History for DBS Run 22, SV Encounters Stopped POV

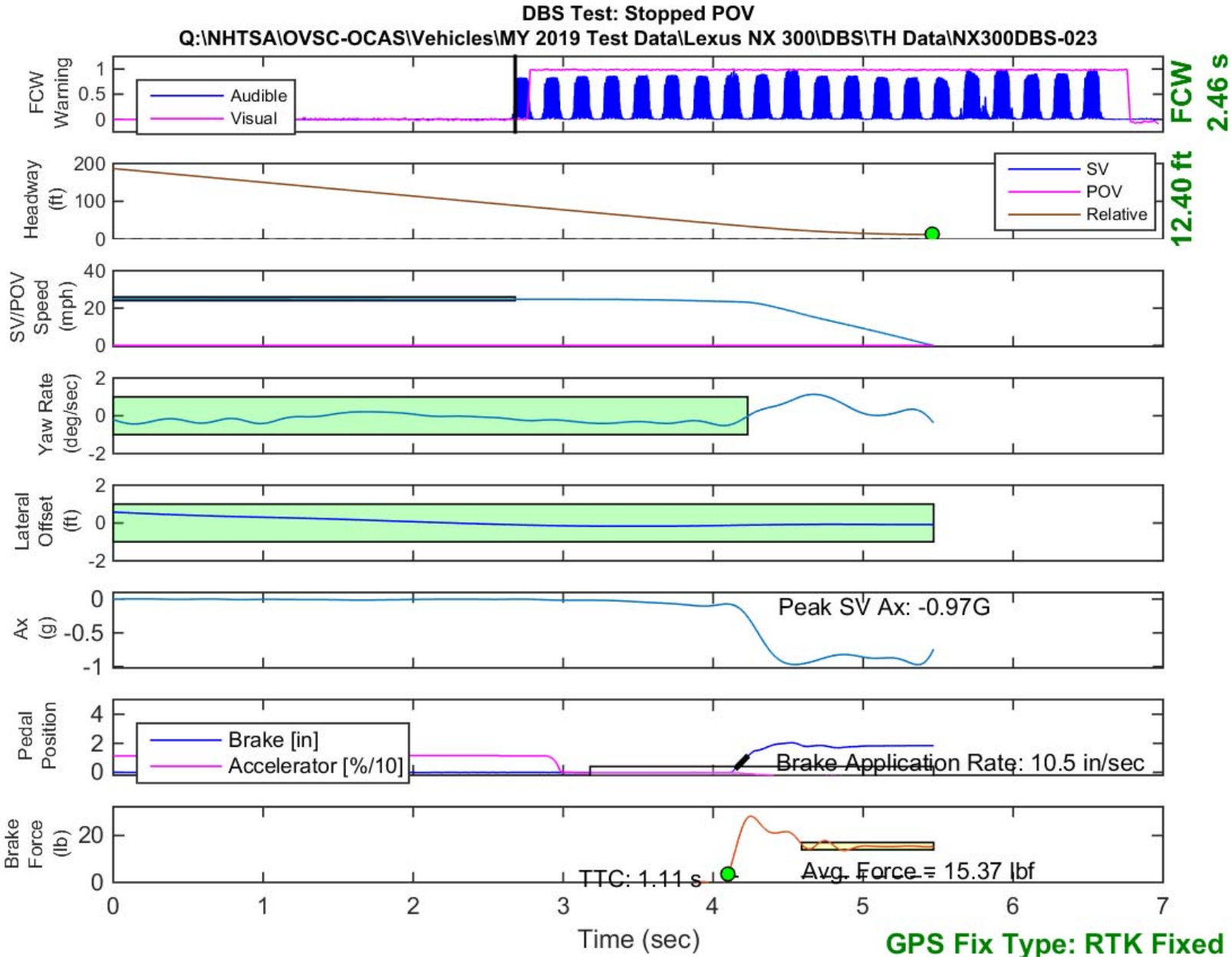


Figure E18. Time History for DBS Run 23, SV Encounters Stopped POV

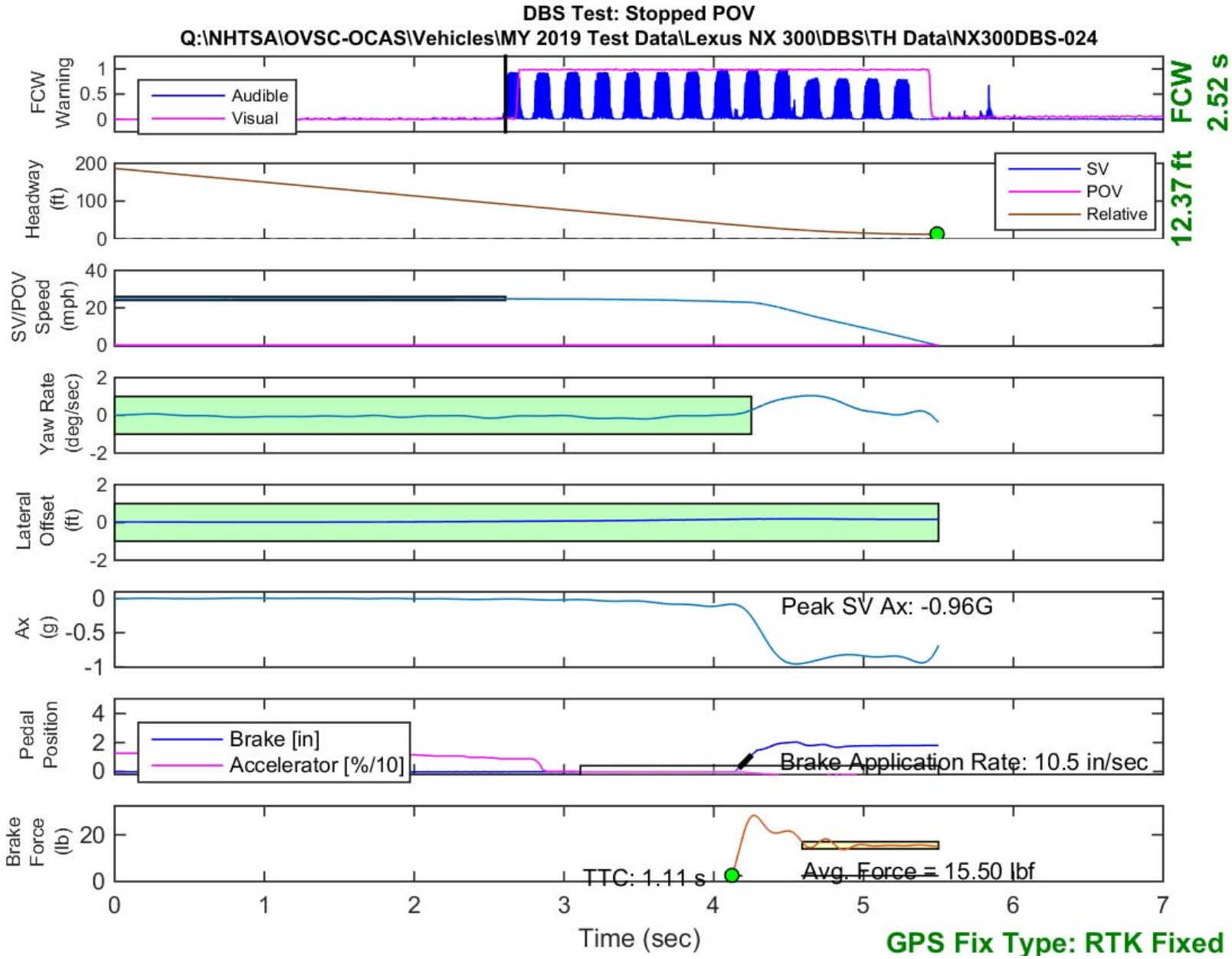


Figure E19. Time History for DBS Run 24, SV Encounters Stopped POV

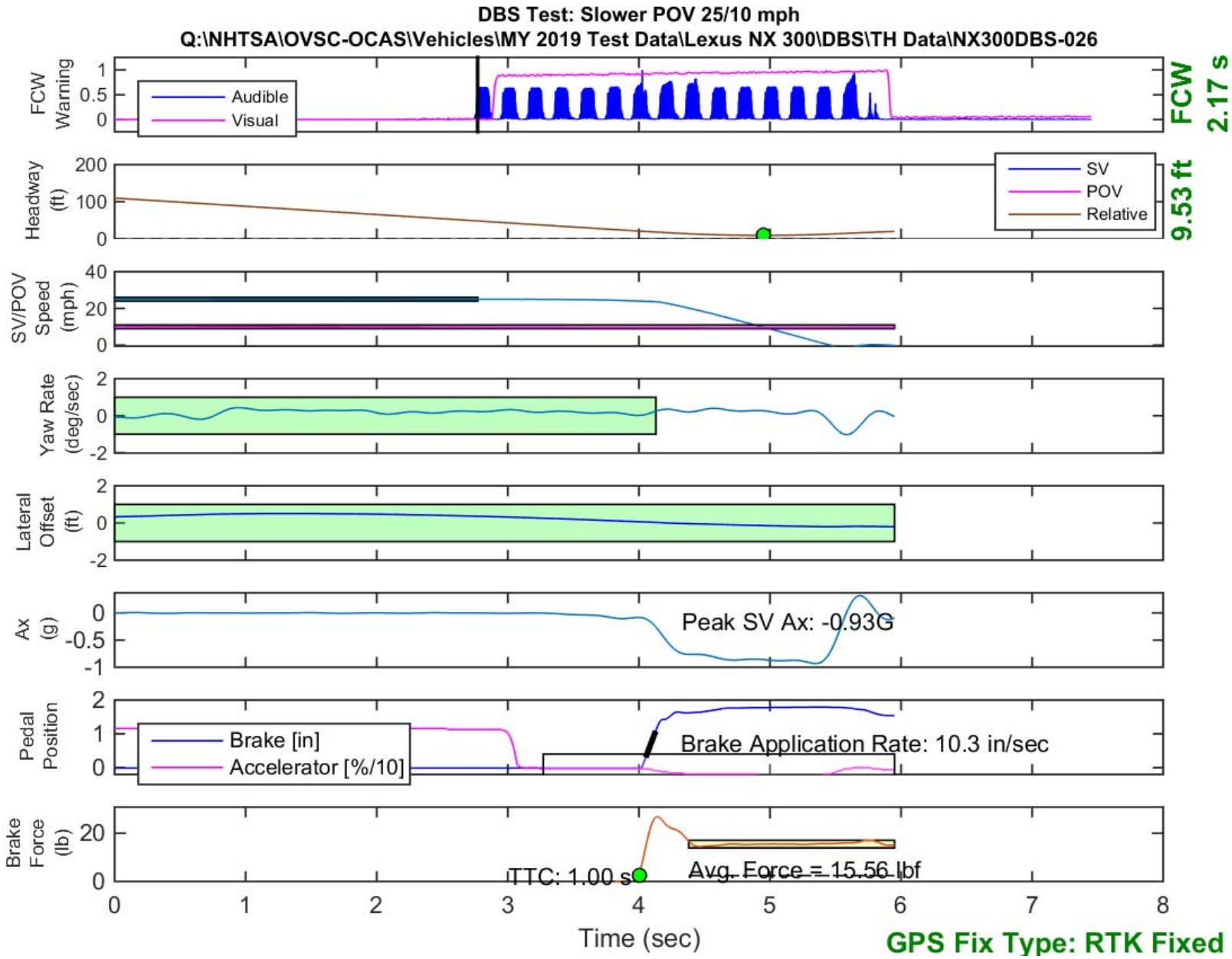


Figure E20. Time History for DBS Run 26, SV Encounters Slower POV, SV 25 mph, POV 10 mph

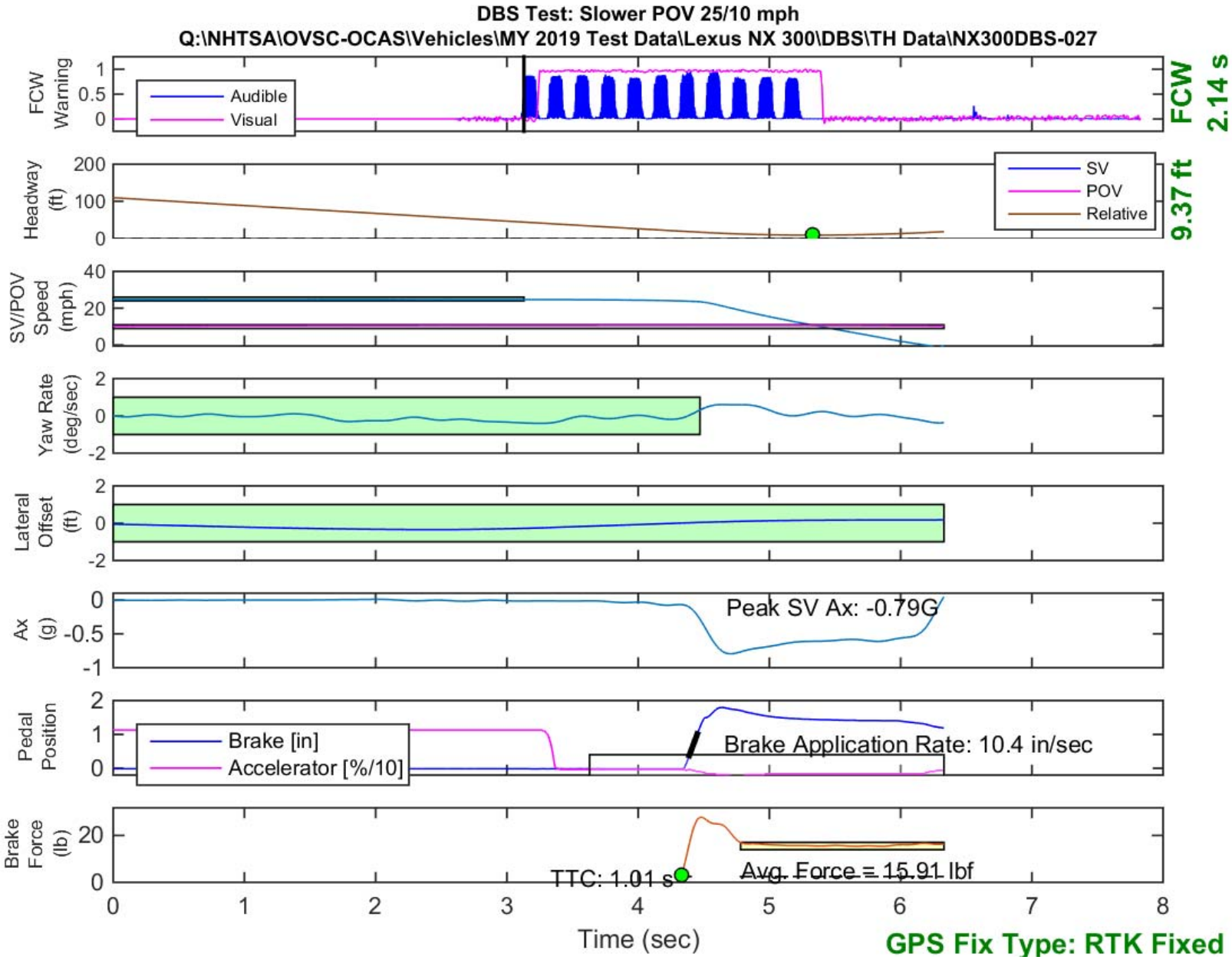


Figure E21. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph

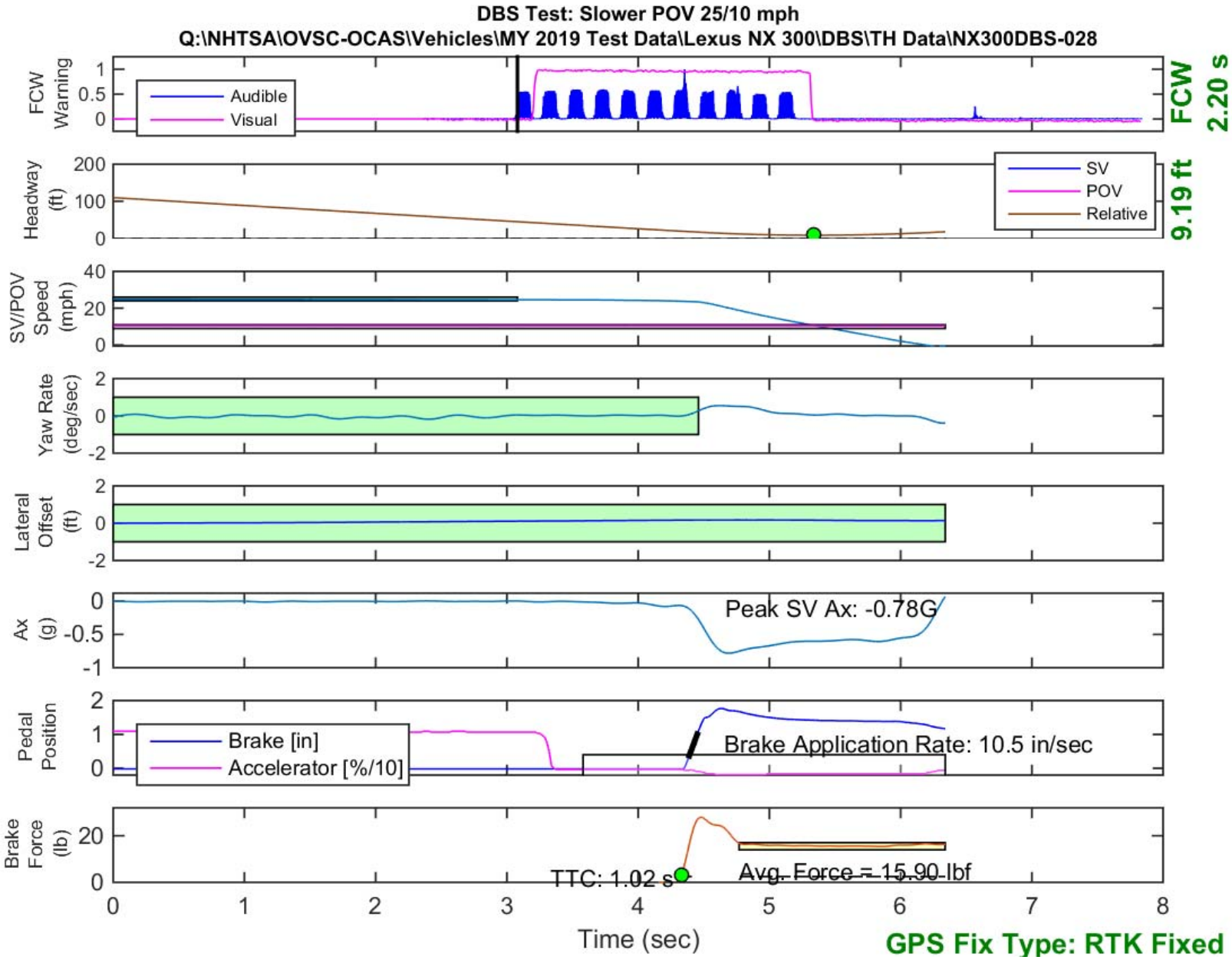


Figure E22. Time History for DBS Run 28, SV Encounters Slower POV, SV 25 mph, POV 10 mph

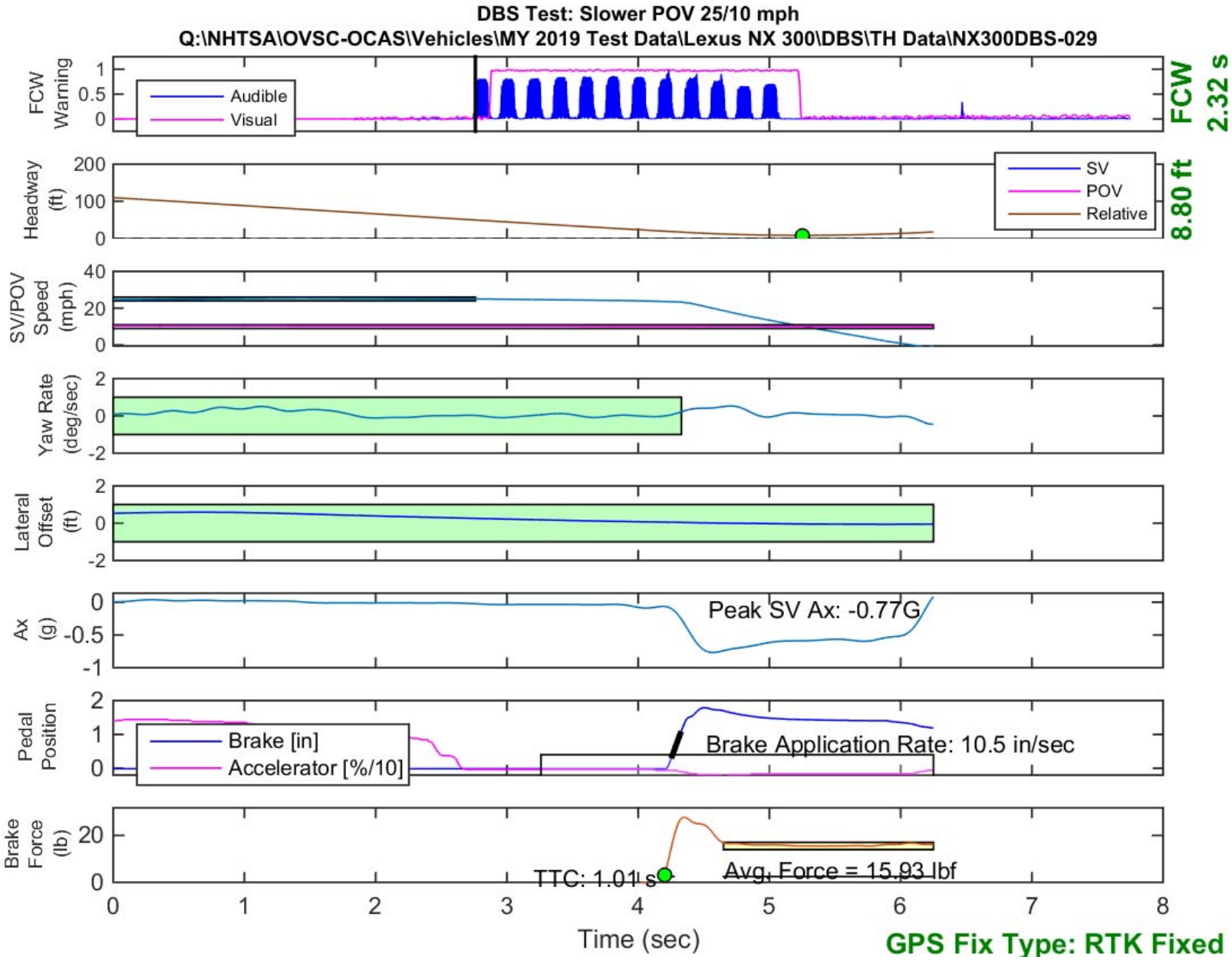


Figure E23. Time History for DBS Run 29, SV Encounters Slower POV, SV 25 mph, POV 10 mph

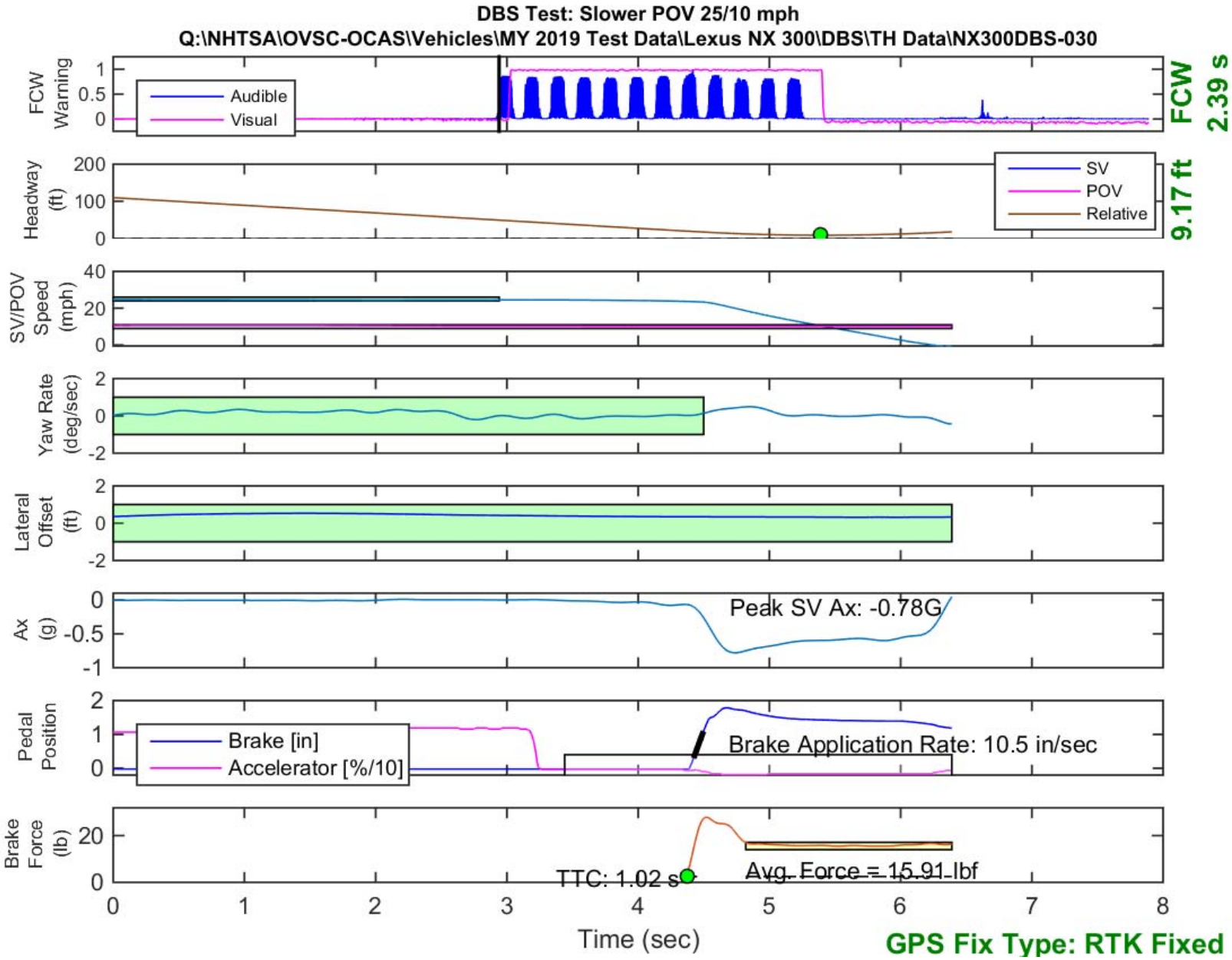


Figure E24. Time History for DBS Run 30, SV Encounters Slower POV, SV 25 mph, POV 10 mph

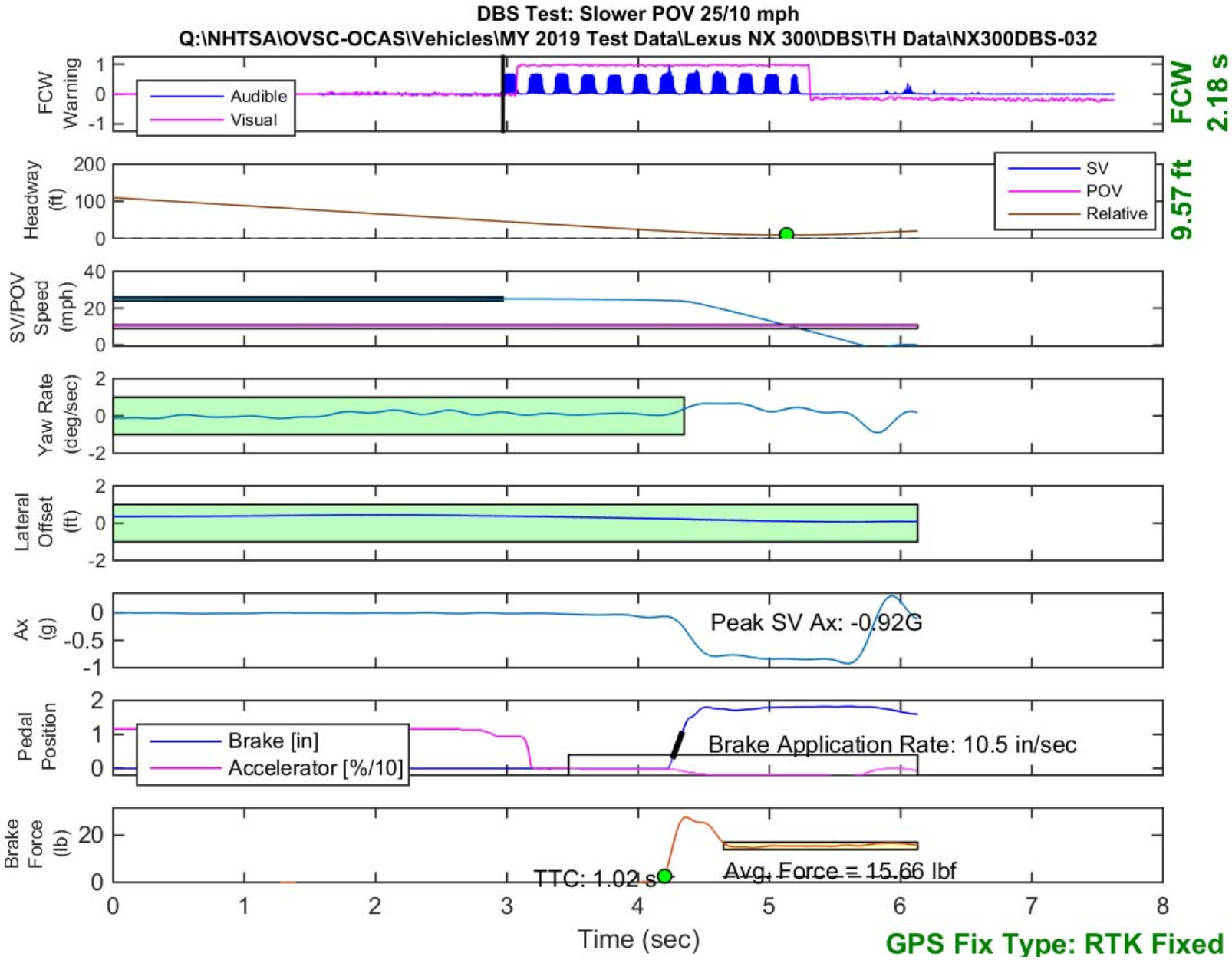


Figure E25. Time History for DBS Run 32, SV Encounters Slower POV, SV 25 mph, POV 10 mph

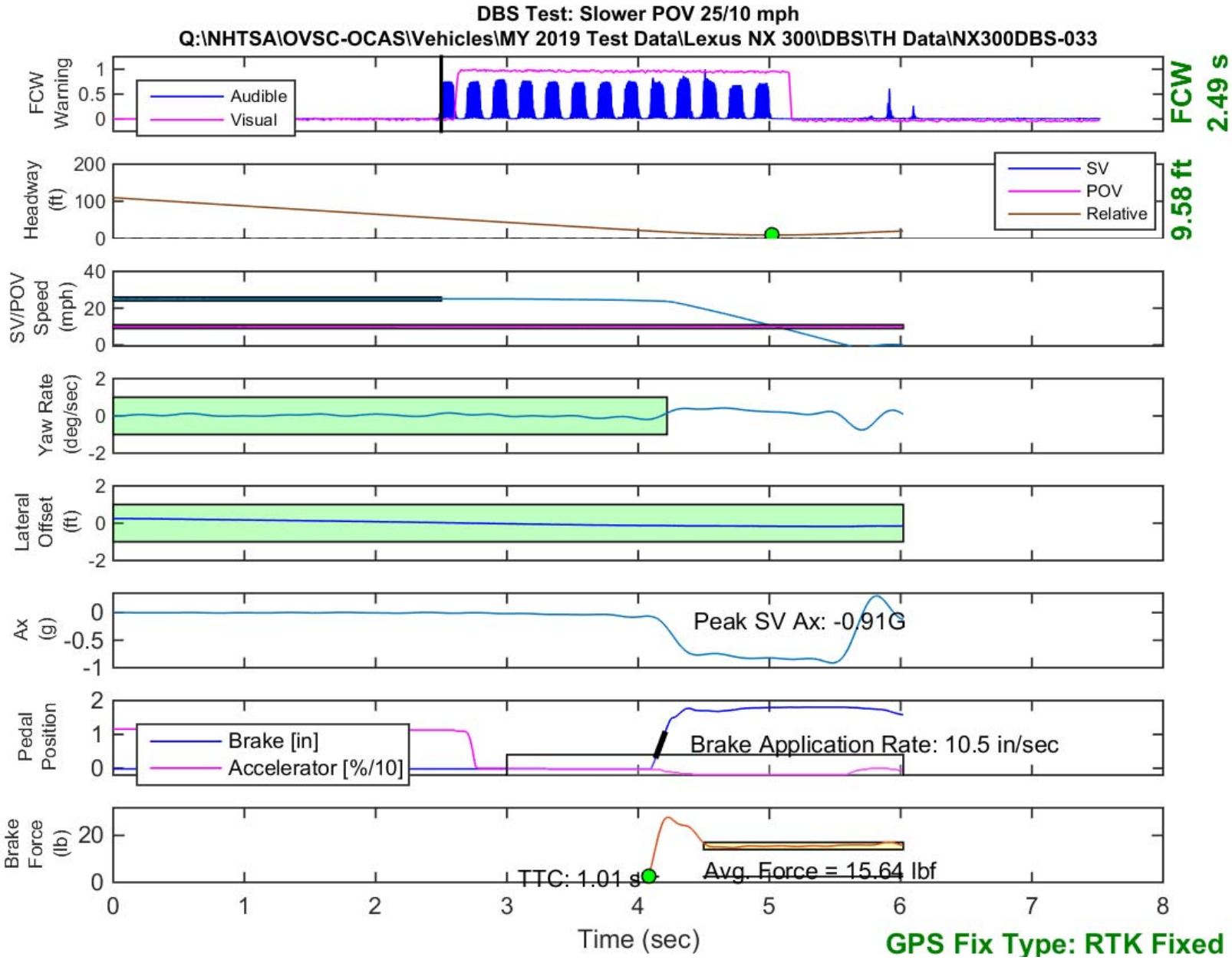


Figure E26. Time History for DBS Run 33, SV Encounters Slower POV, SV 25 mph, POV 10 mph

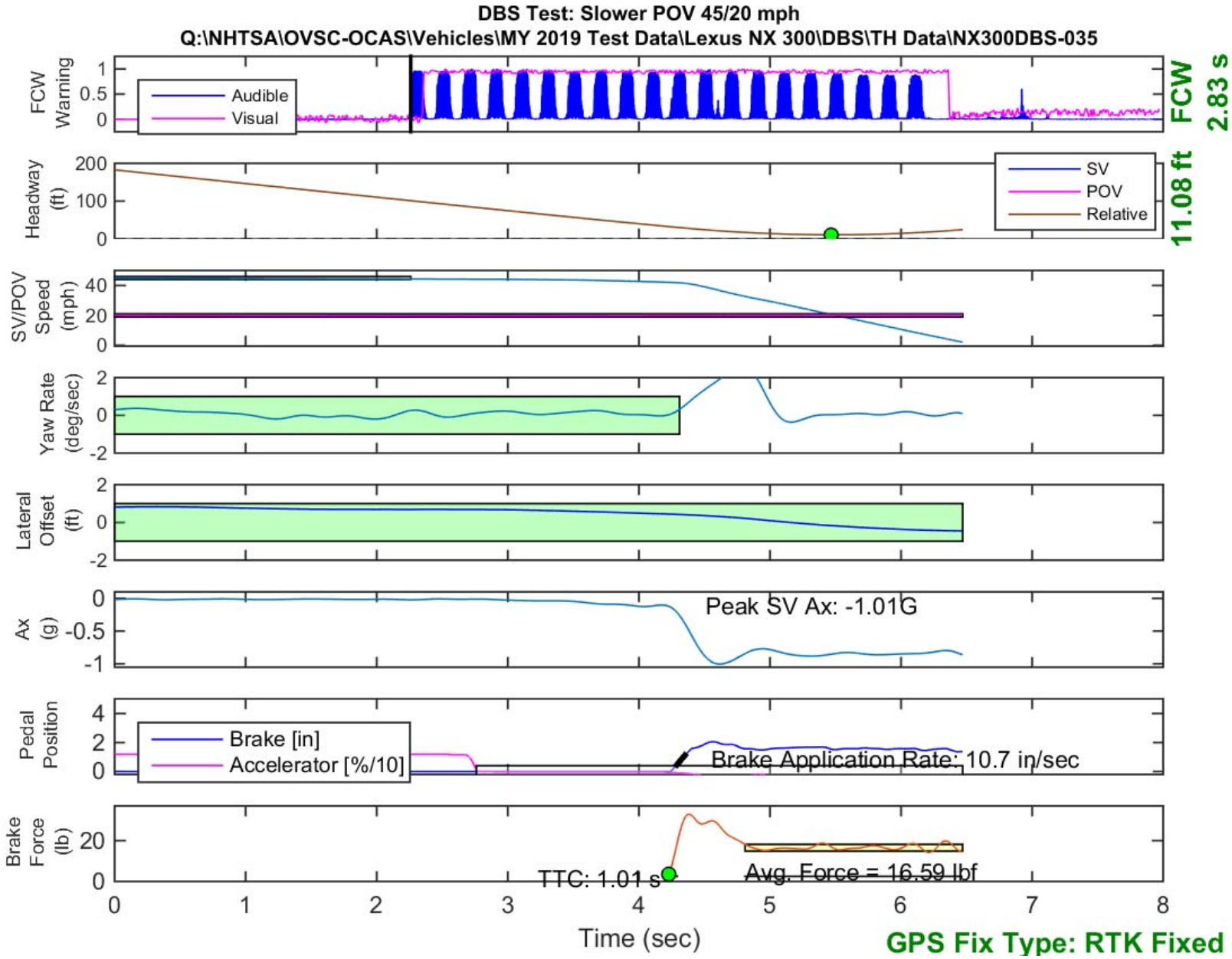


Figure E27. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph

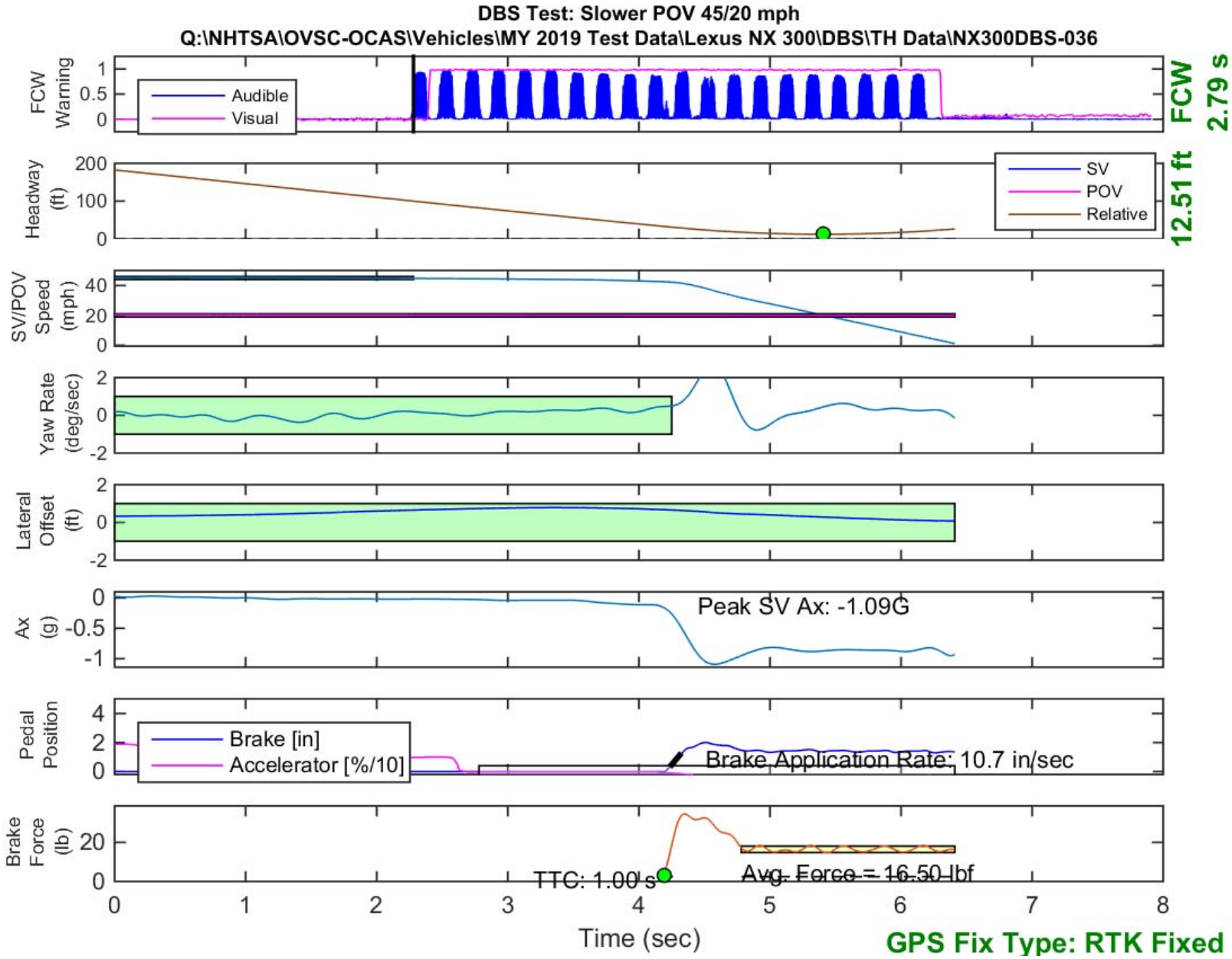


Figure E28. Time History for DBS Run 36, SV Encounters Slower POV, SV 45 mph, POV 20 mph

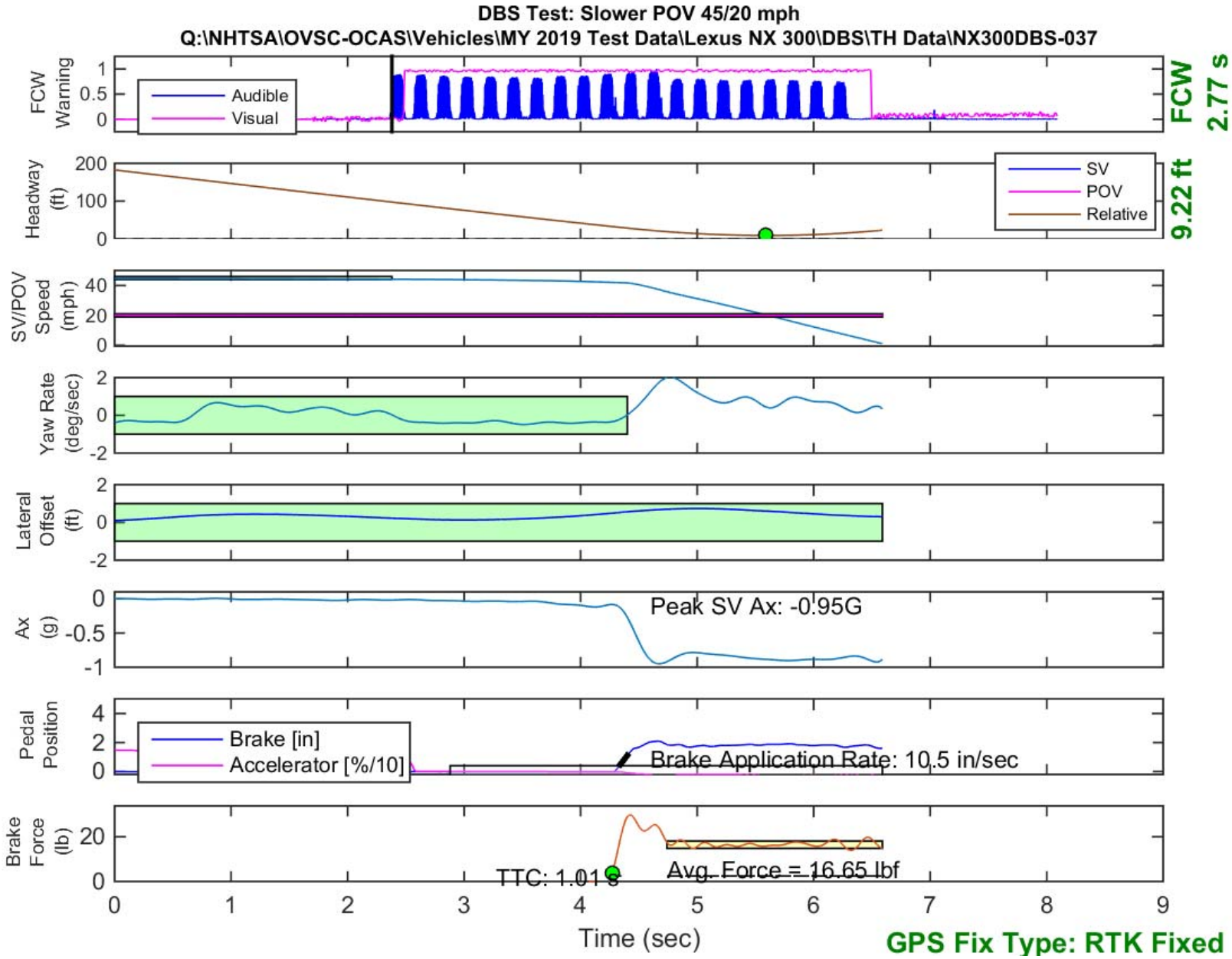


Figure E29. Time History for DBS Run 37, SV Encounters Slower POV, SV 45 mph, POV 20 mph

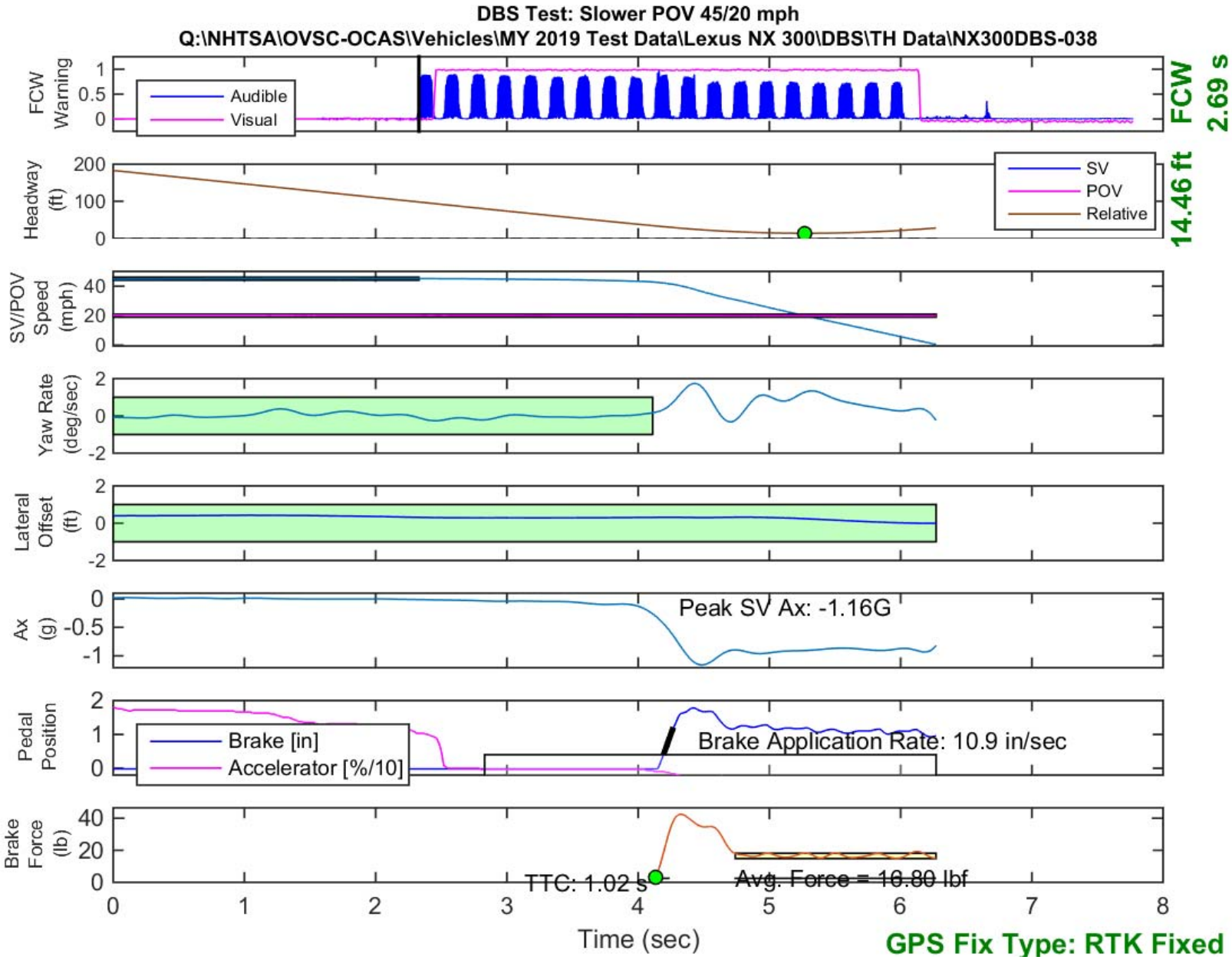


Figure E30. Time History for DBS Run 38, SV Encounters Slower POV, SV 45 mph, POV 20 mph

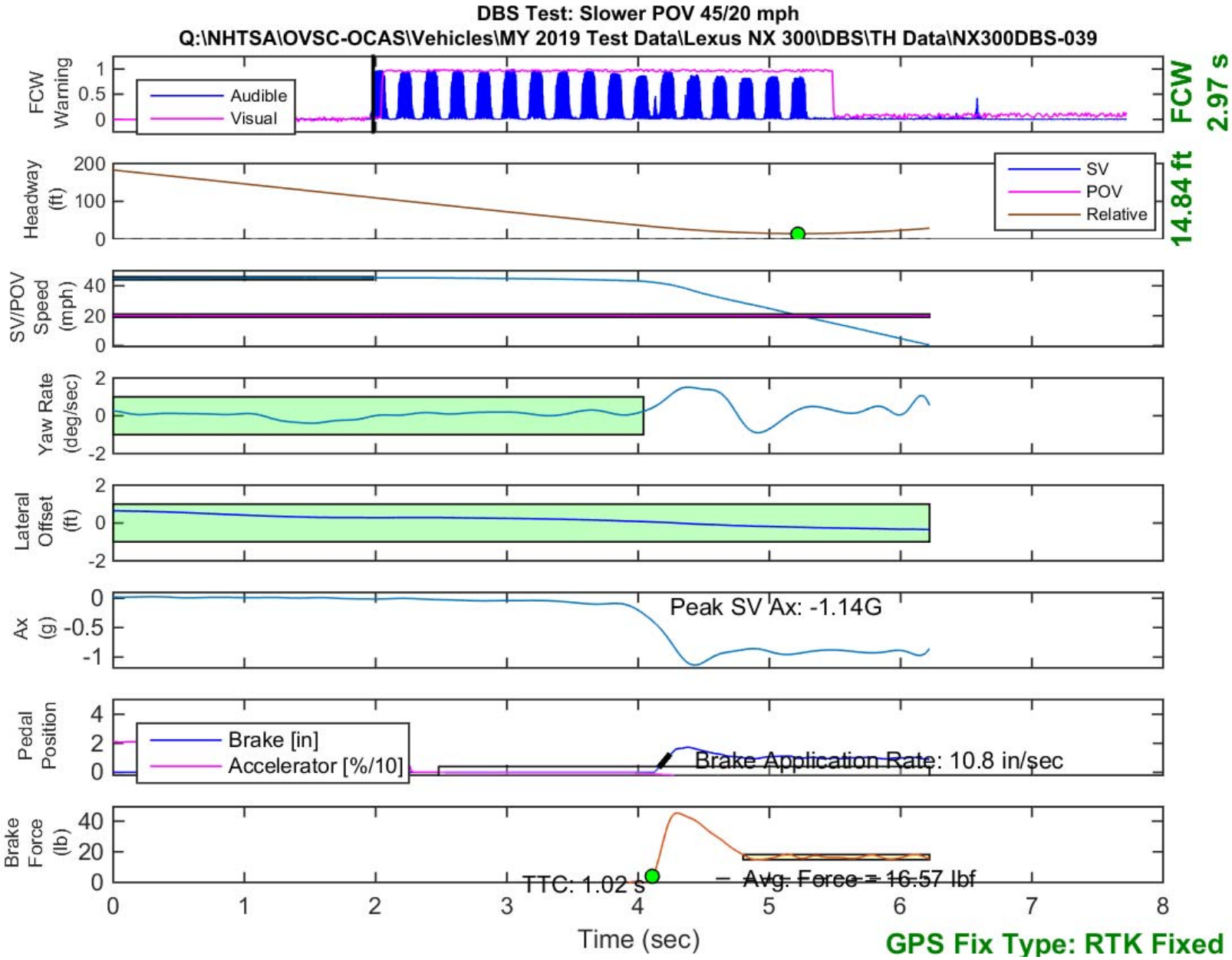


Figure E31. Time History for DBS Run 39, SV Encounters Slower POV, SV 45 mph, POV 20 mph

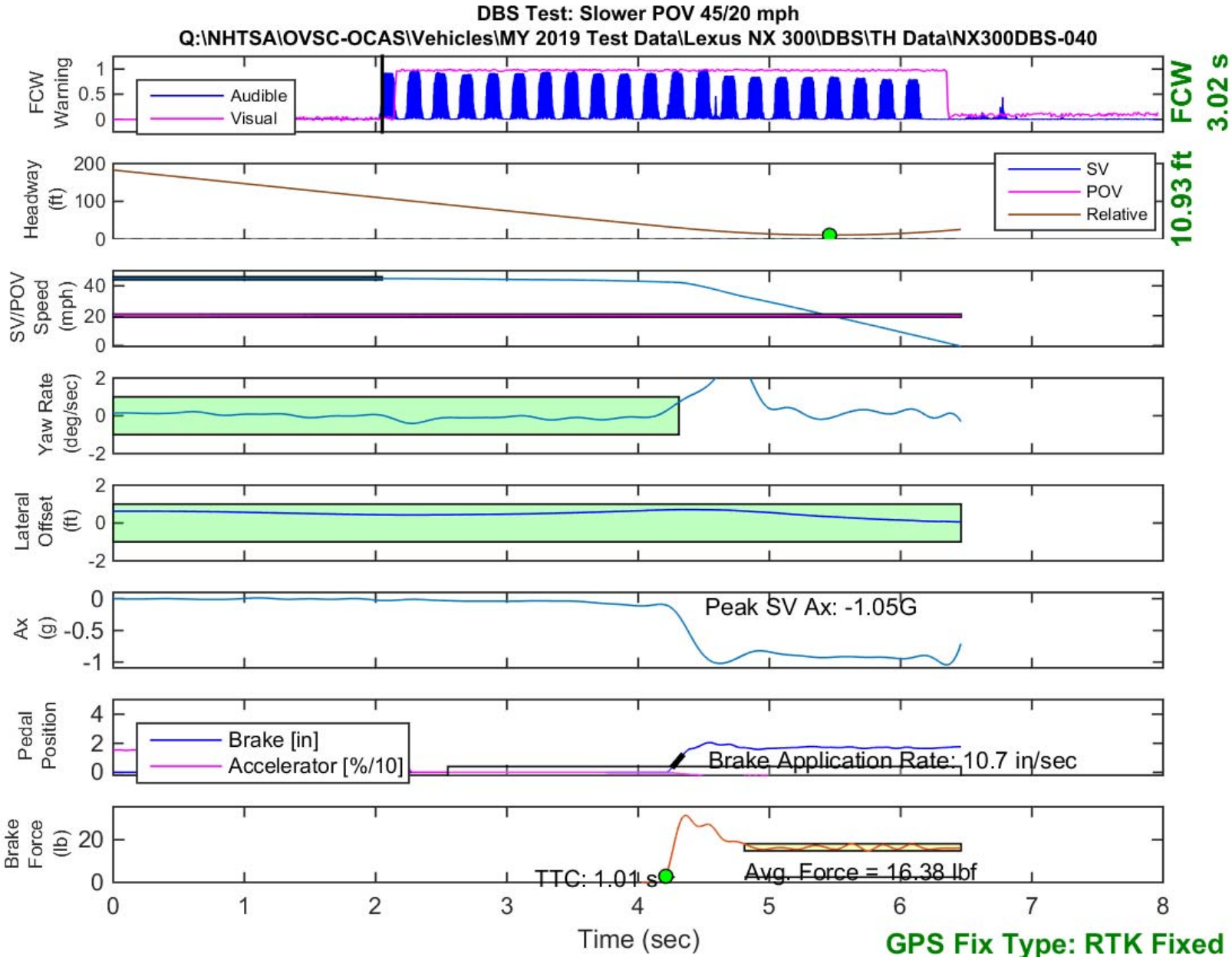


Figure E32. Time History for DBS Run 40, SV Encounters Slower POV, SV 45 mph, POV 20 mph

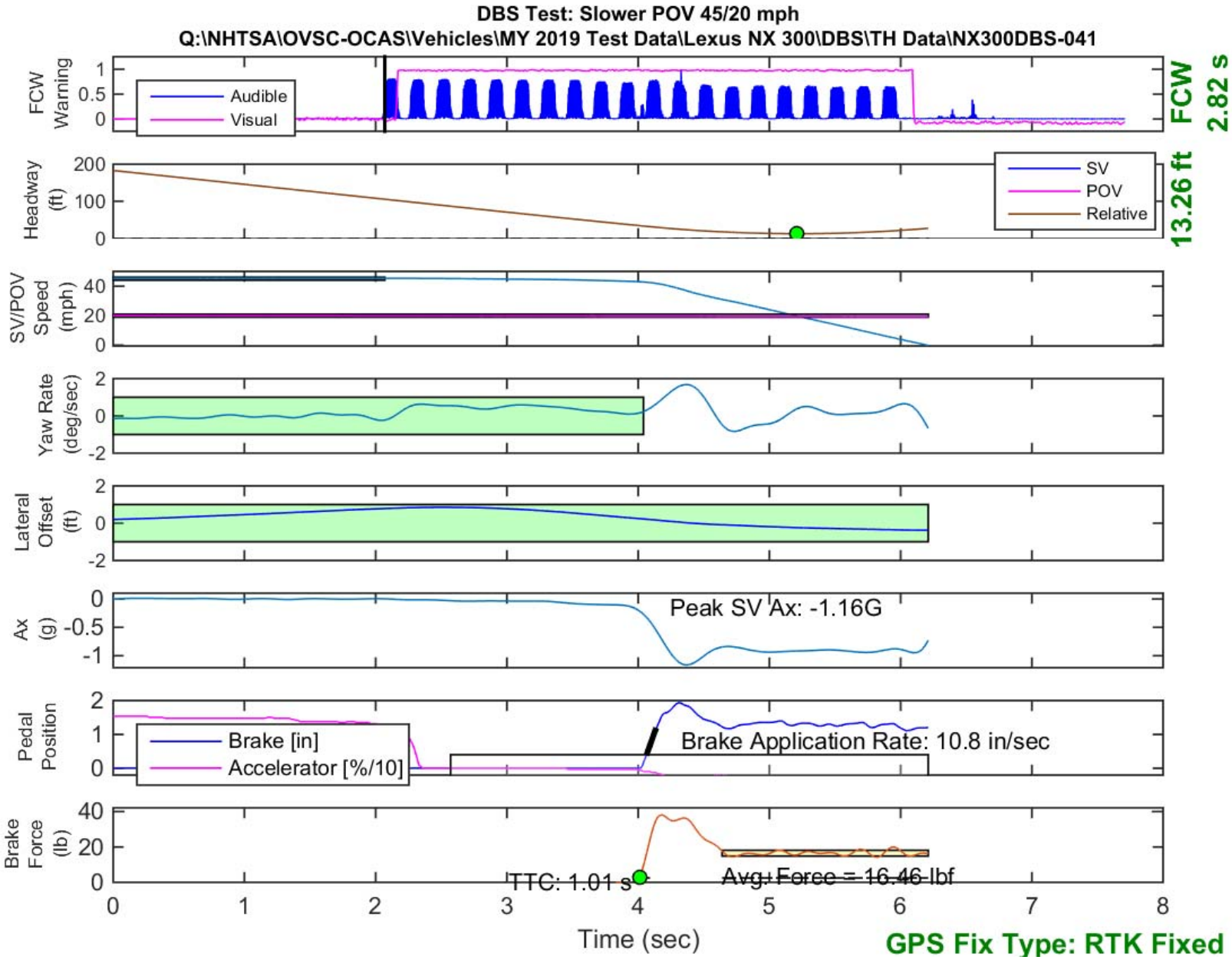


Figure E33. Time History for DBS Run 41, SV Encounters Slower POV, SV 45 mph, POV 20 mph

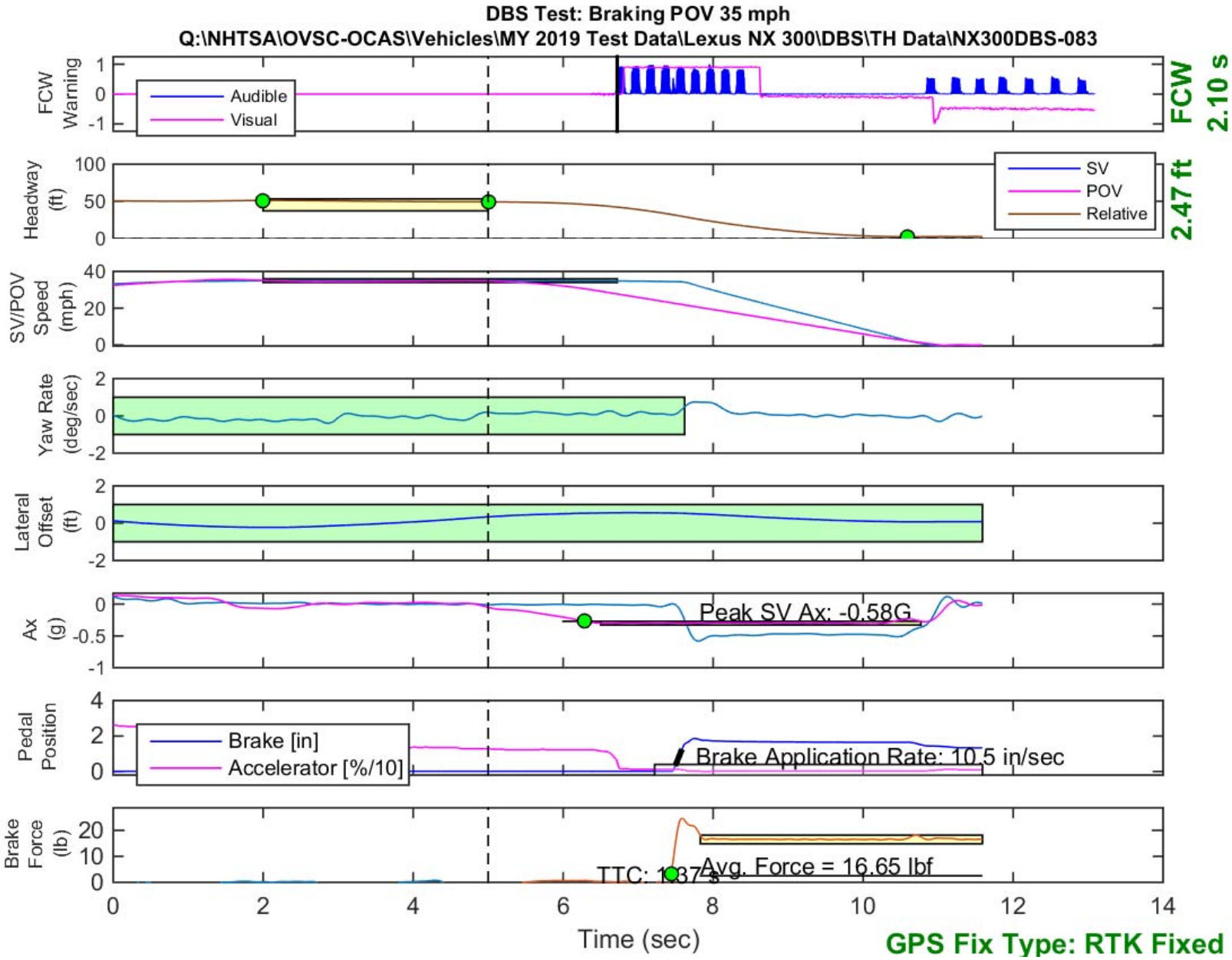


Figure E34. Time History for DBS Run 83, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

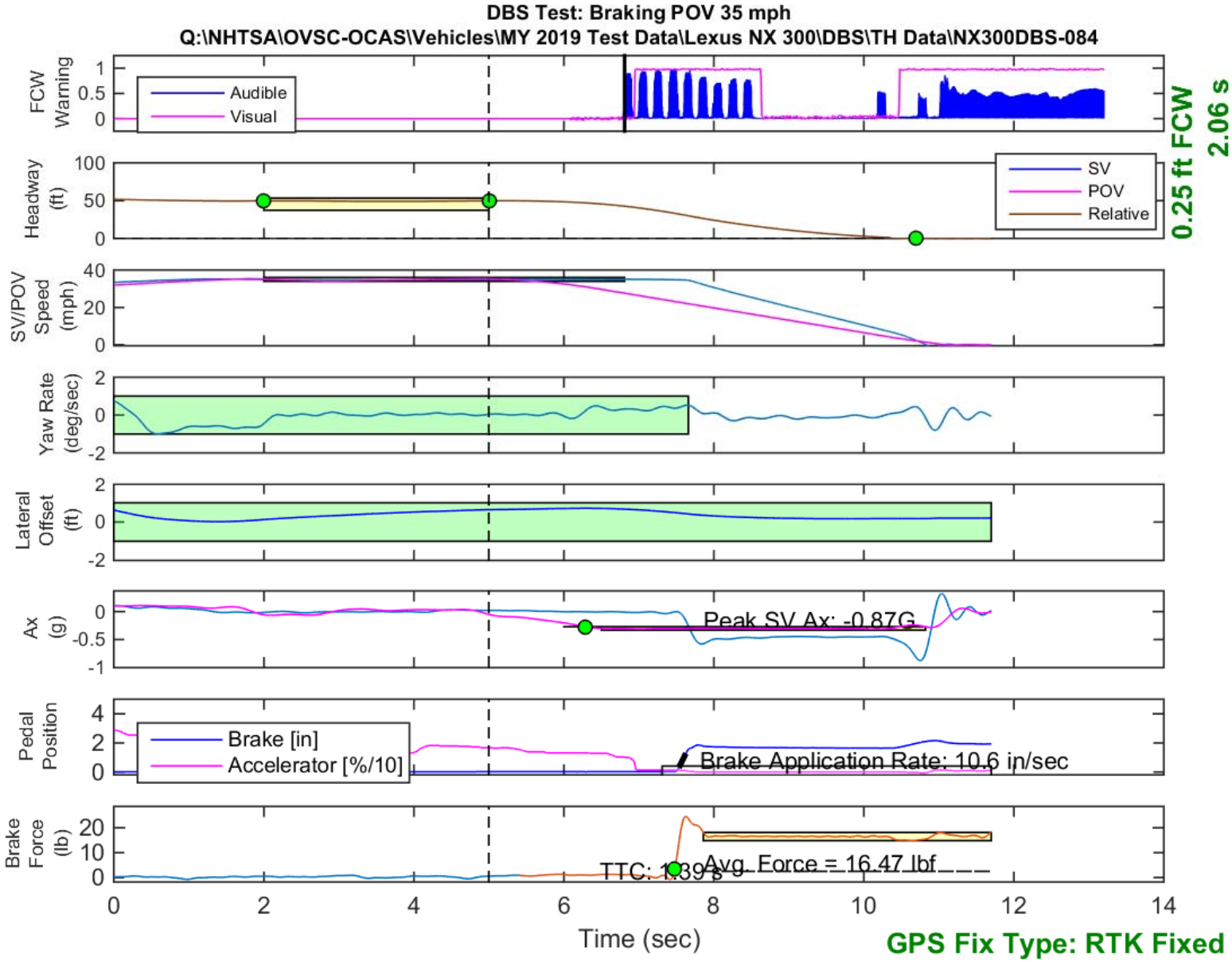


Figure E35. Time History for DBS Run 84, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

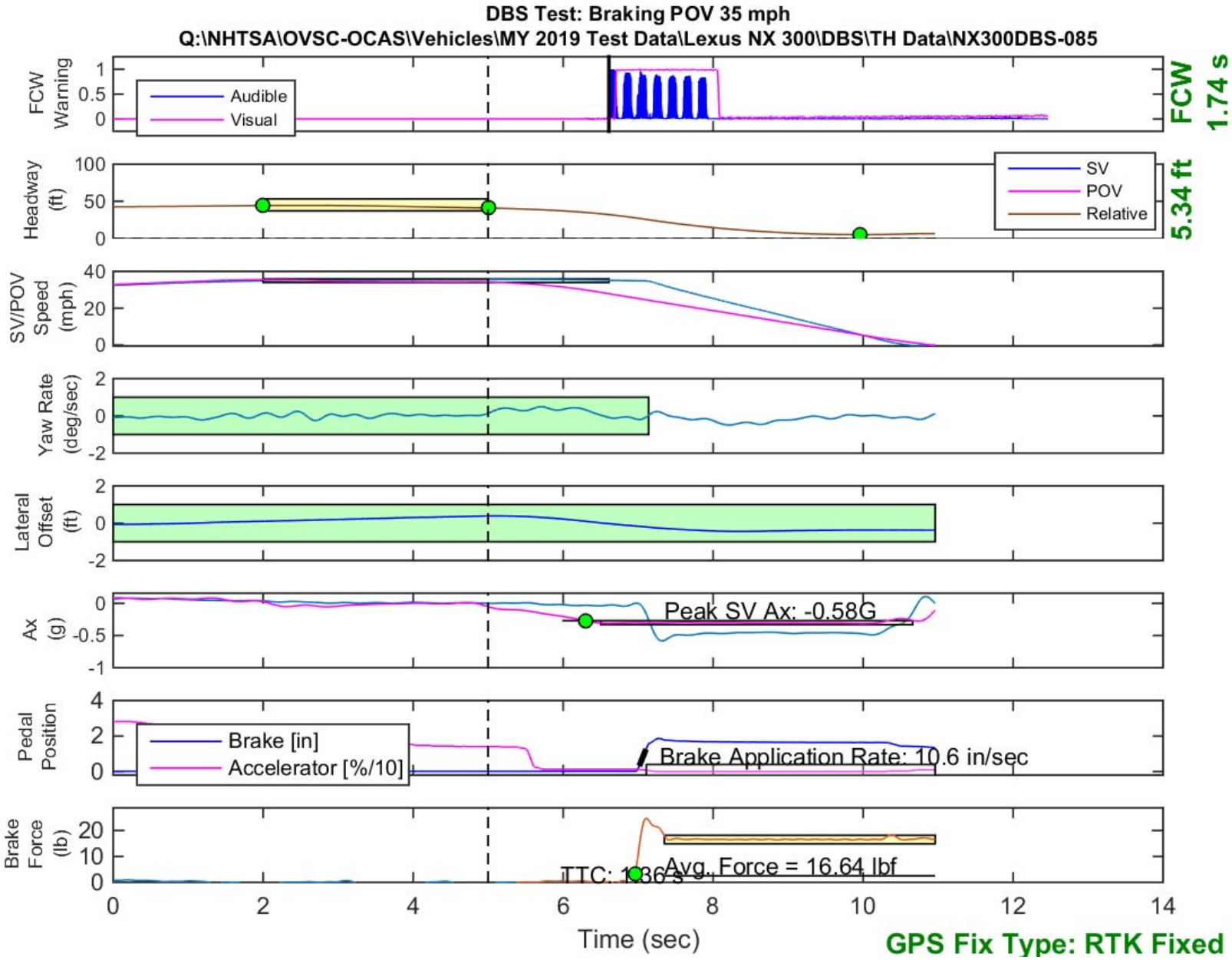


Figure E36. Time History for DBS Run 85, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

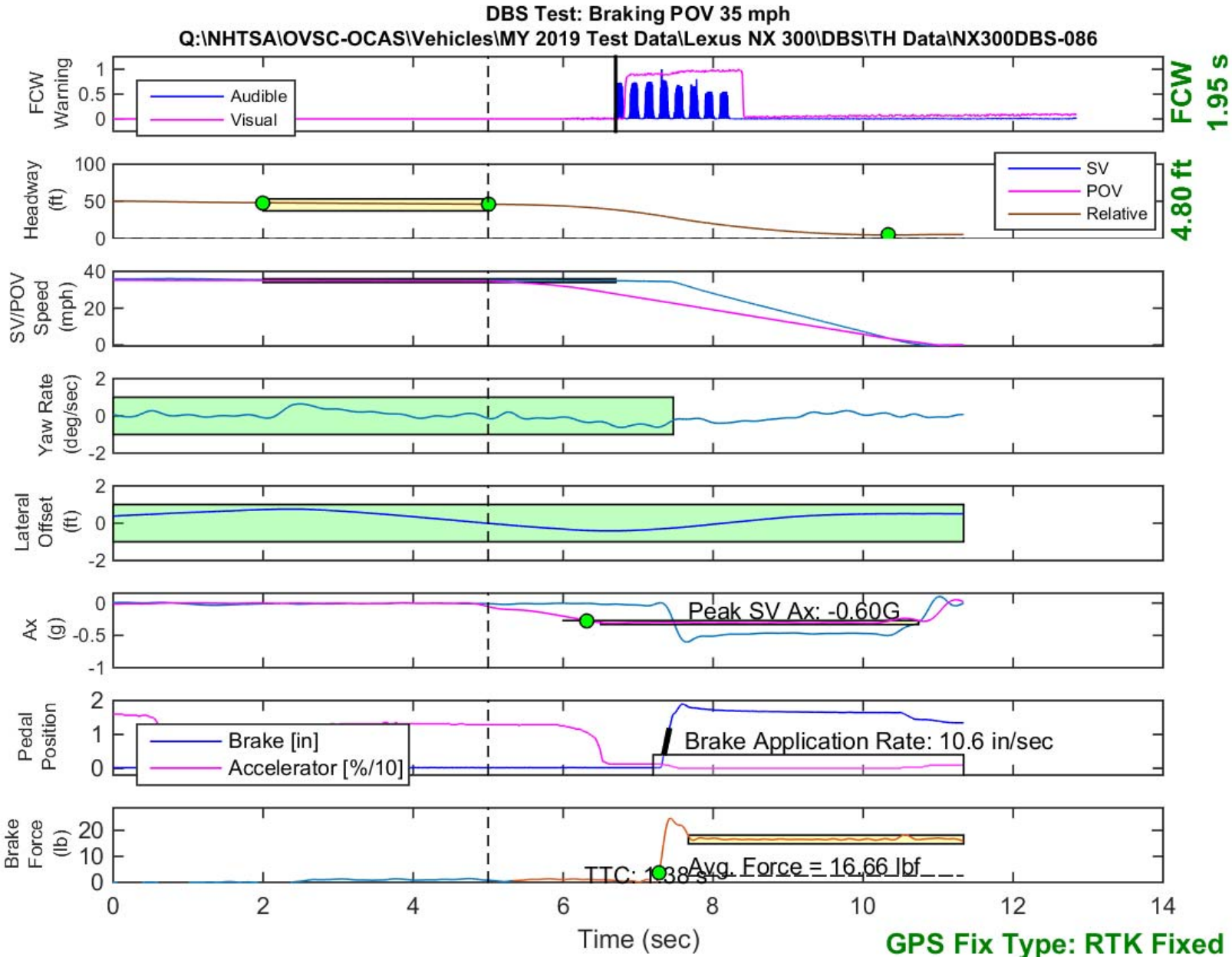


Figure E37. Time History for DBS Run 86, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

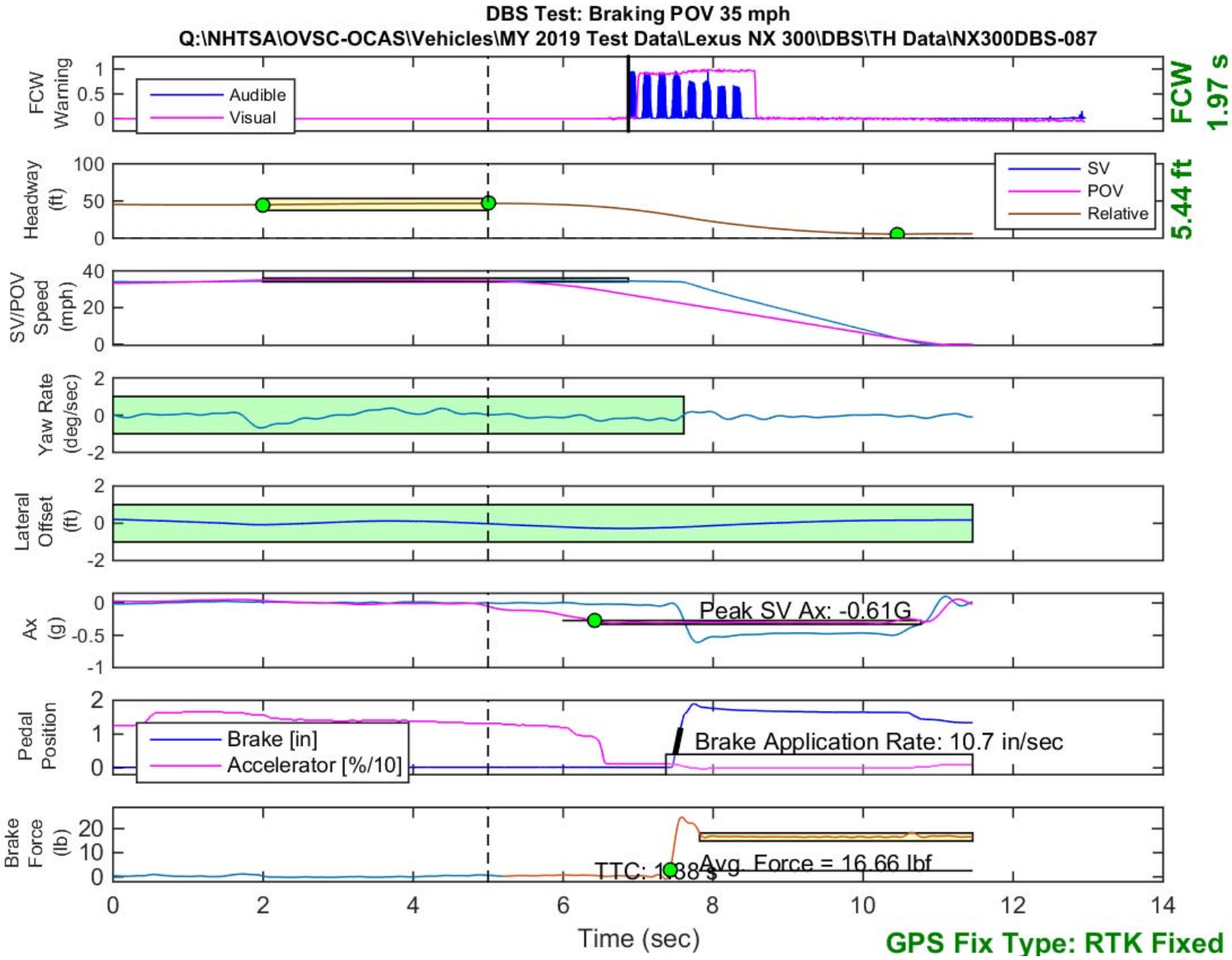


Figure E38. Time History for DBS Run 87, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

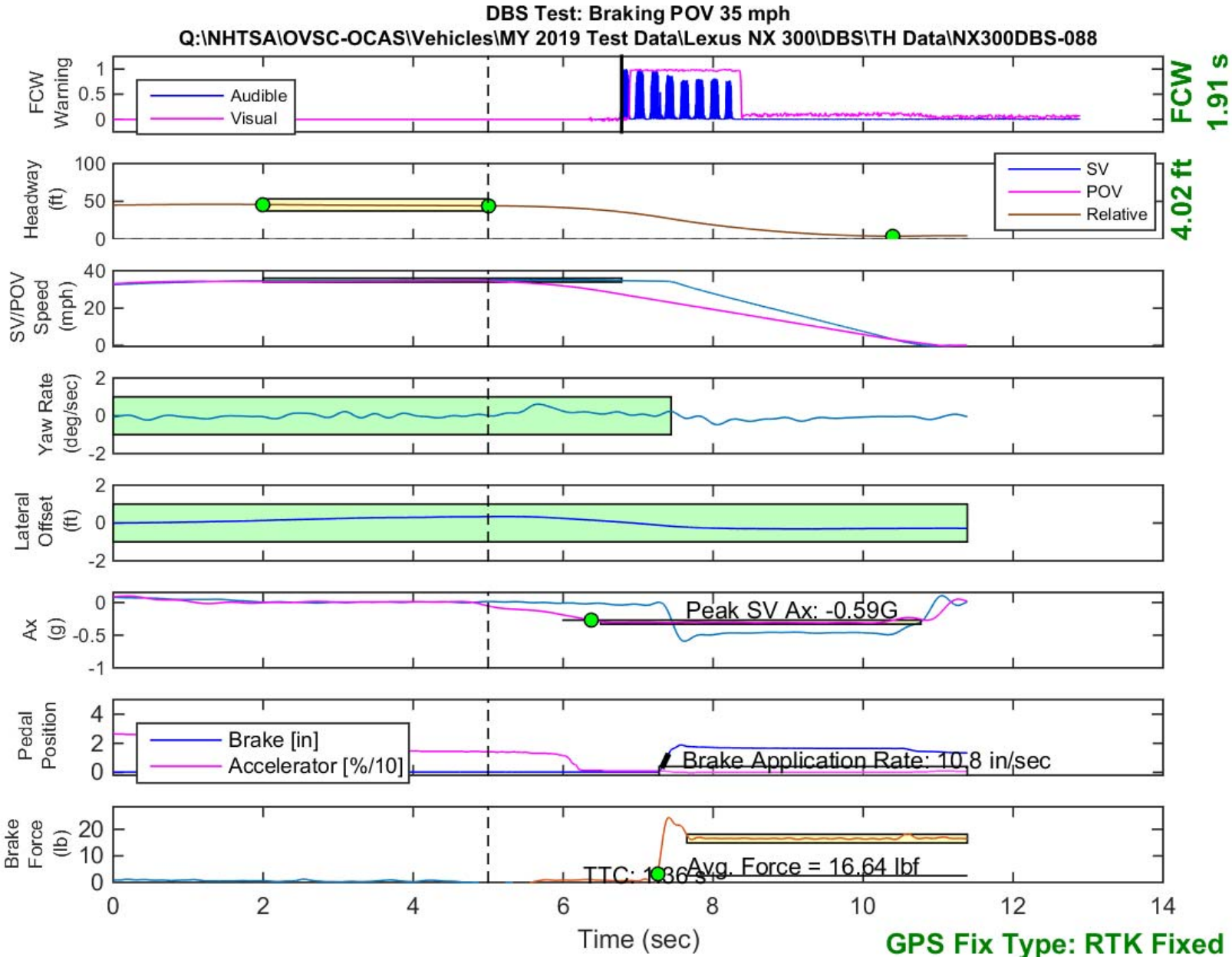


Figure E39. Time History for DBS Run 88, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

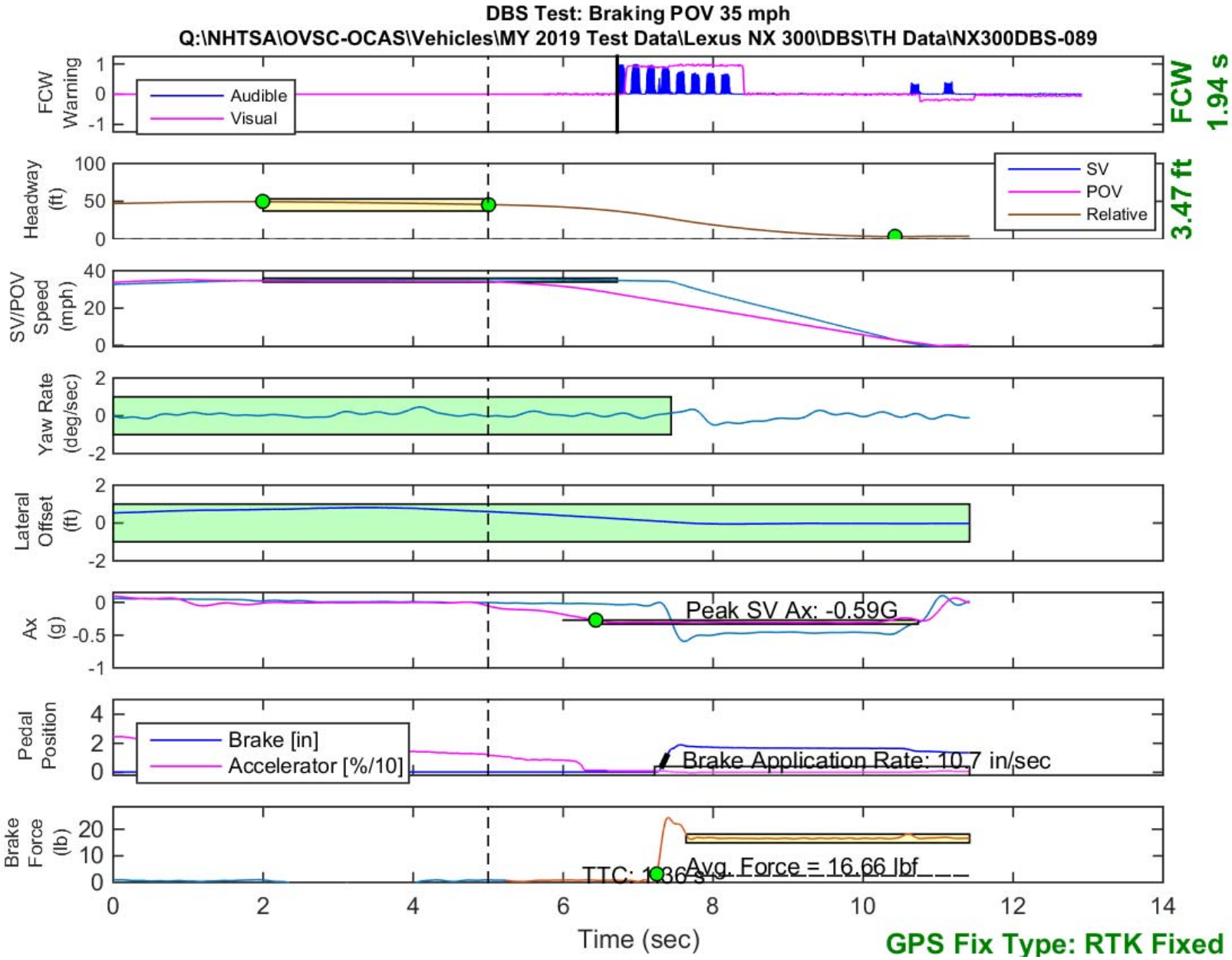


Figure E40. Time History for DBS Run 89, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

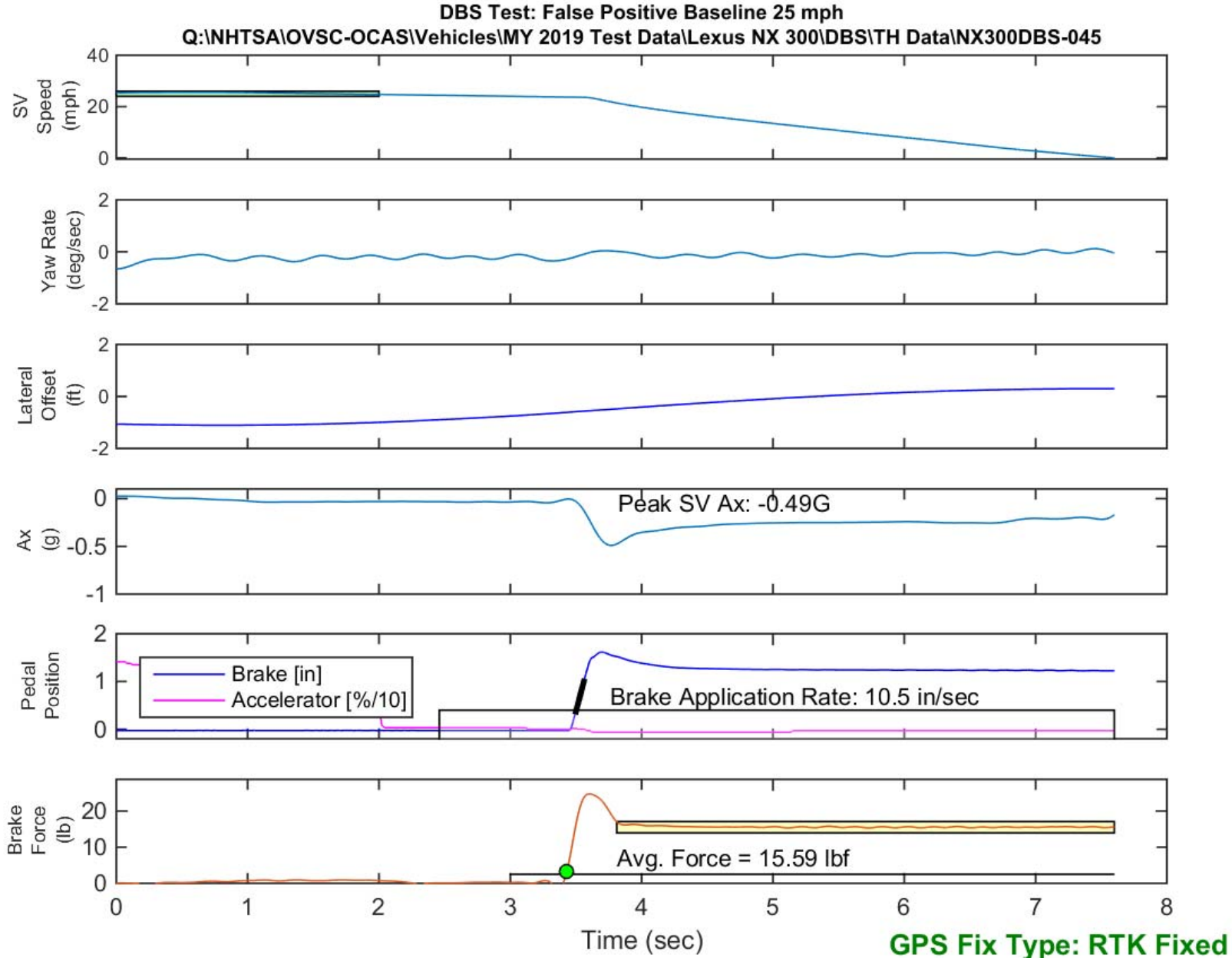


Figure E41. Time History for DBS Run 45, False Positive Baseline, SV 25 mph

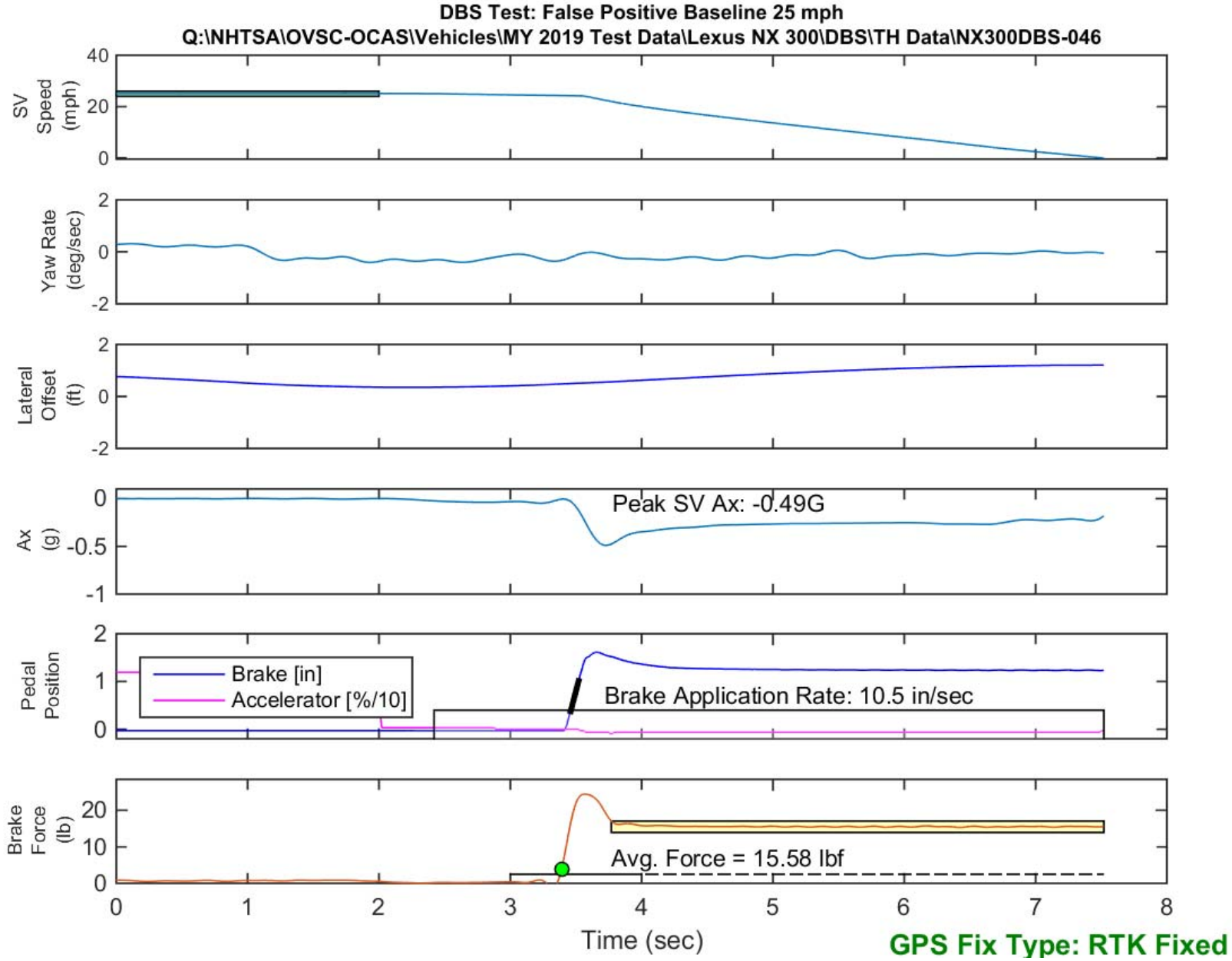


Figure E42. Time History for DBS Run 46, False Positive Baseline, SV 25 mph

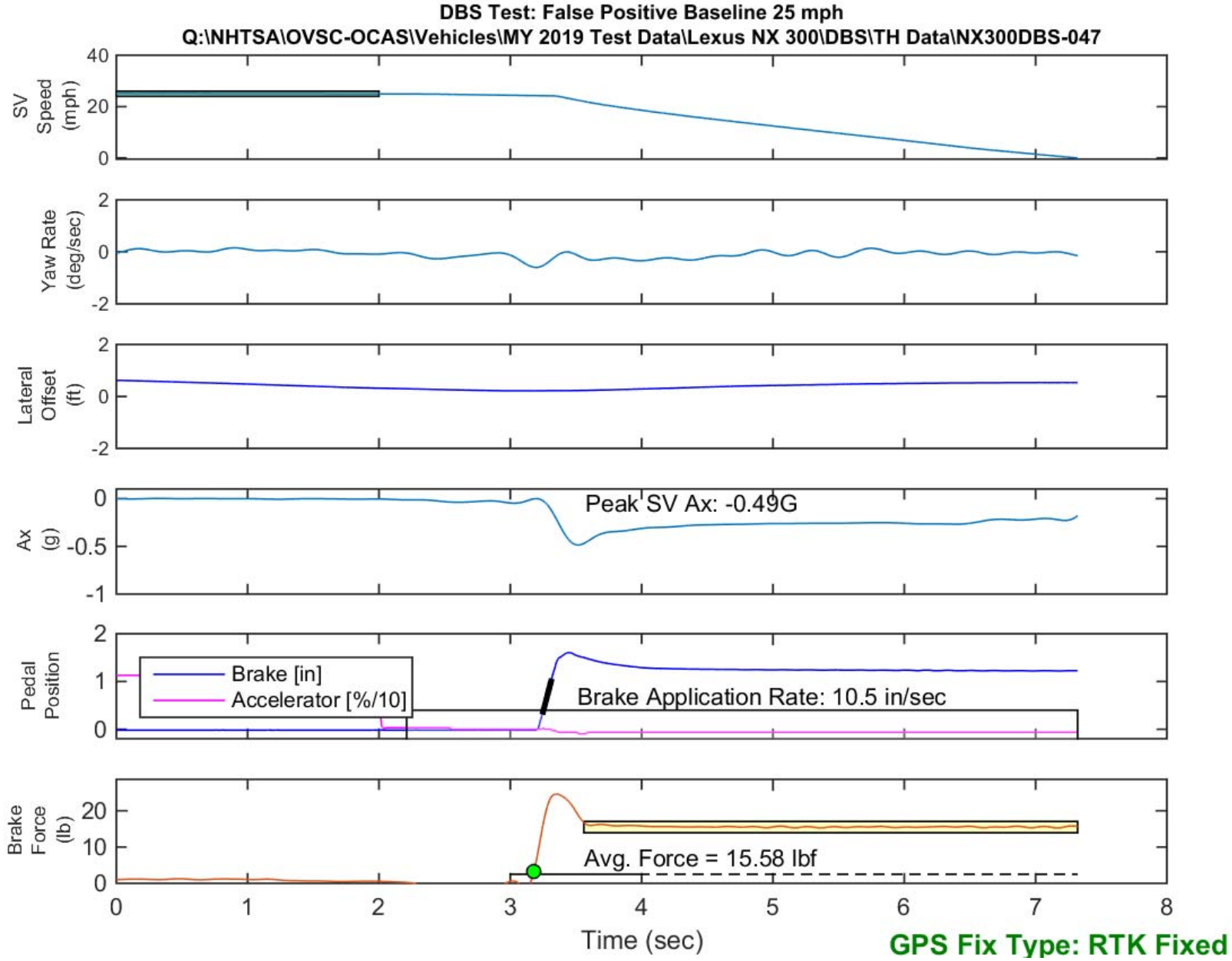


Figure E43. Time History for DBS Run 47, False Positive Baseline, SV 25 mph

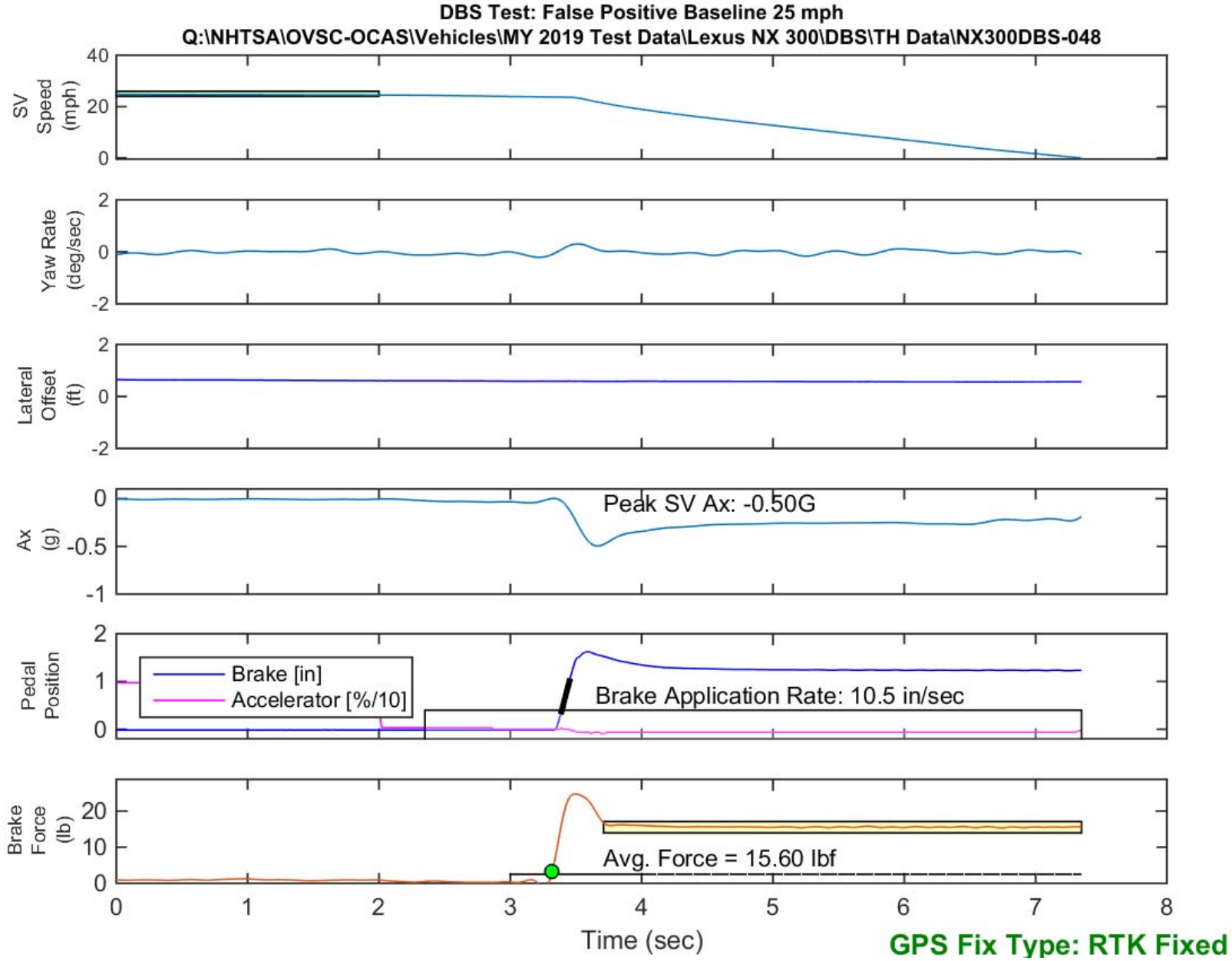


Figure E44. Time History for DBS Run 48, False Positive Baseline, SV 25 mph

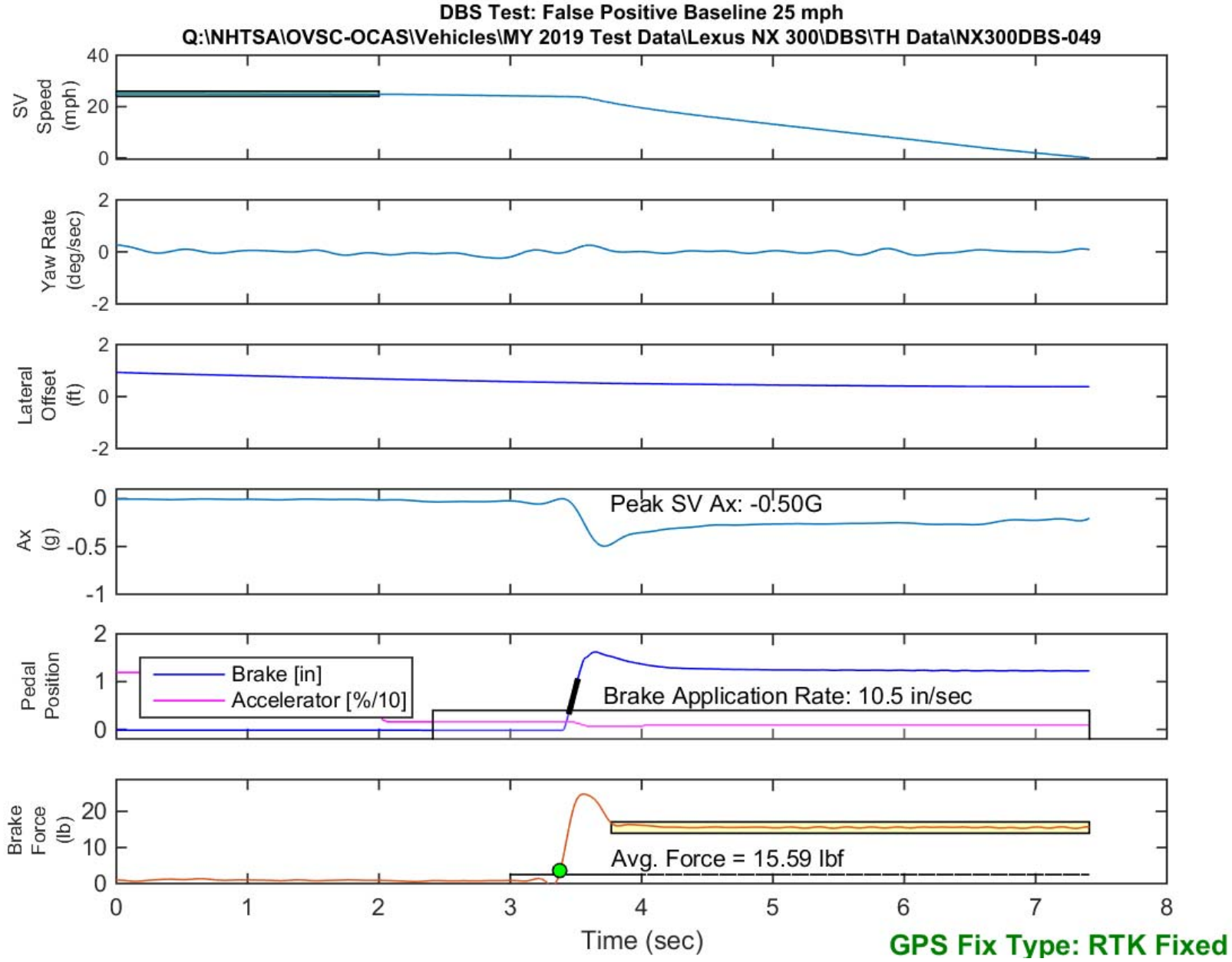


Figure E45. Time History for DBS Run 49, False Positive Baseline, SV 25 mph

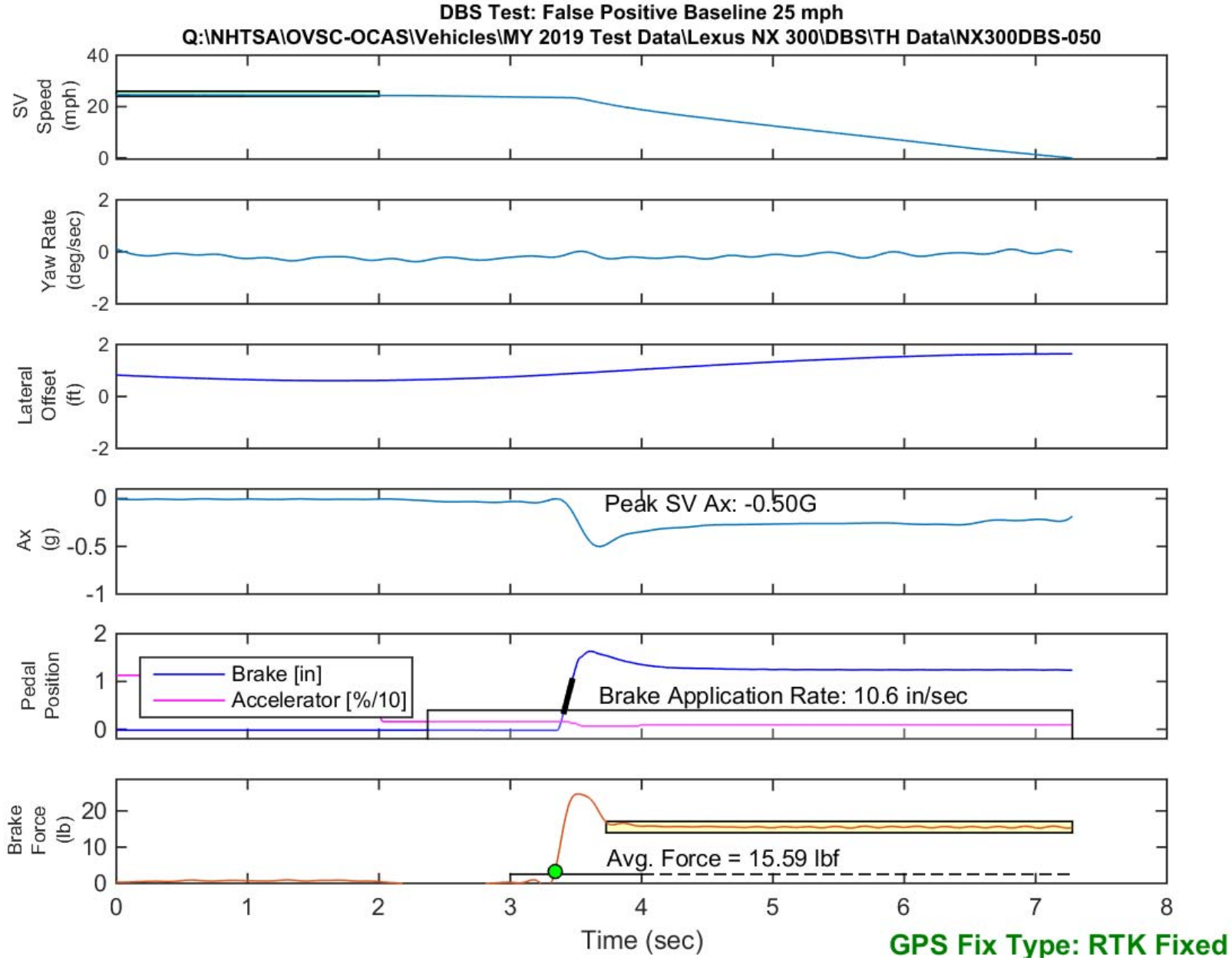


Figure E46. Time History for DBS Run 50, False Positive Baseline, SV 25 mph

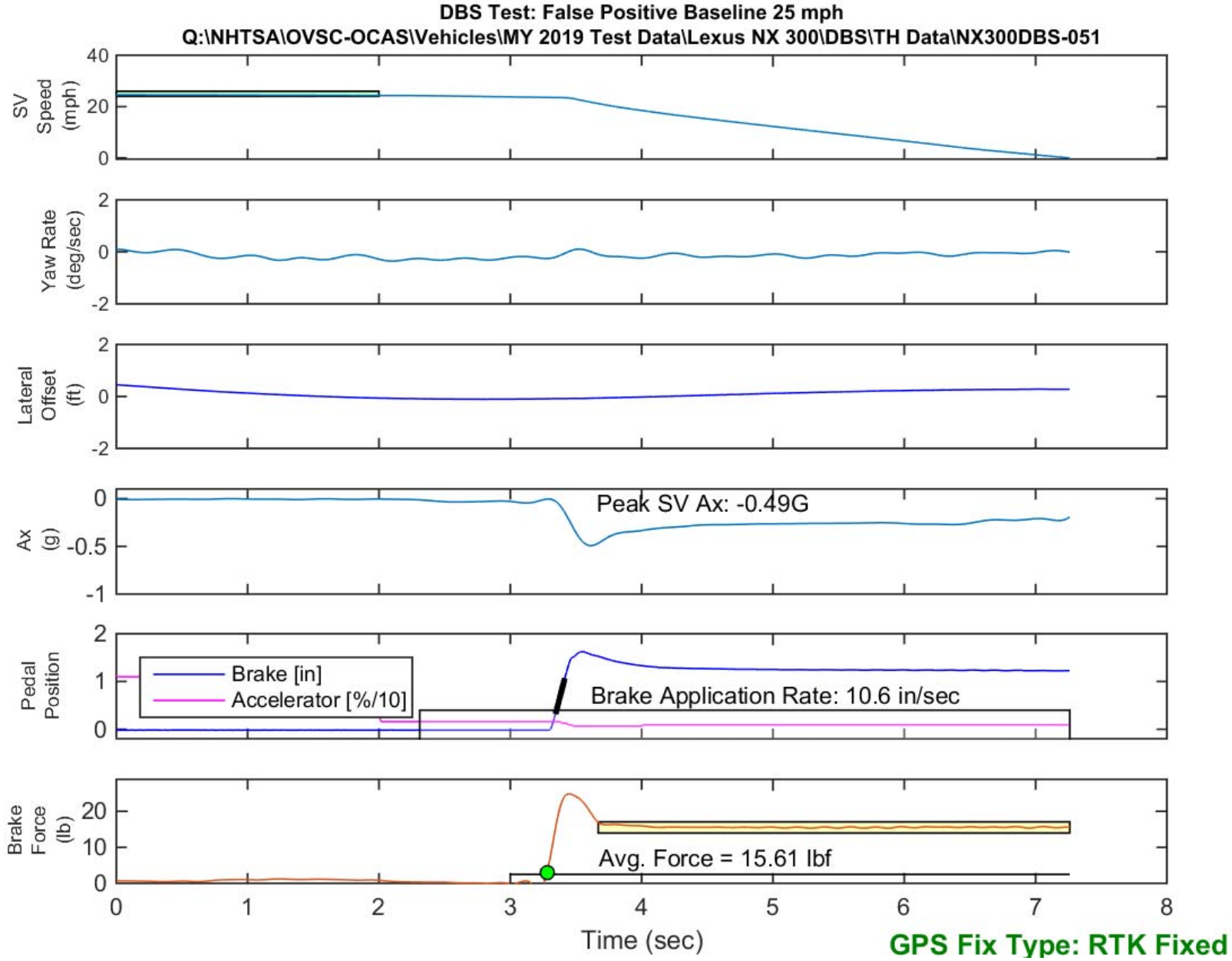


Figure E47. Time History for DBS Run 51, False Positive Baseline, SV 25 mph

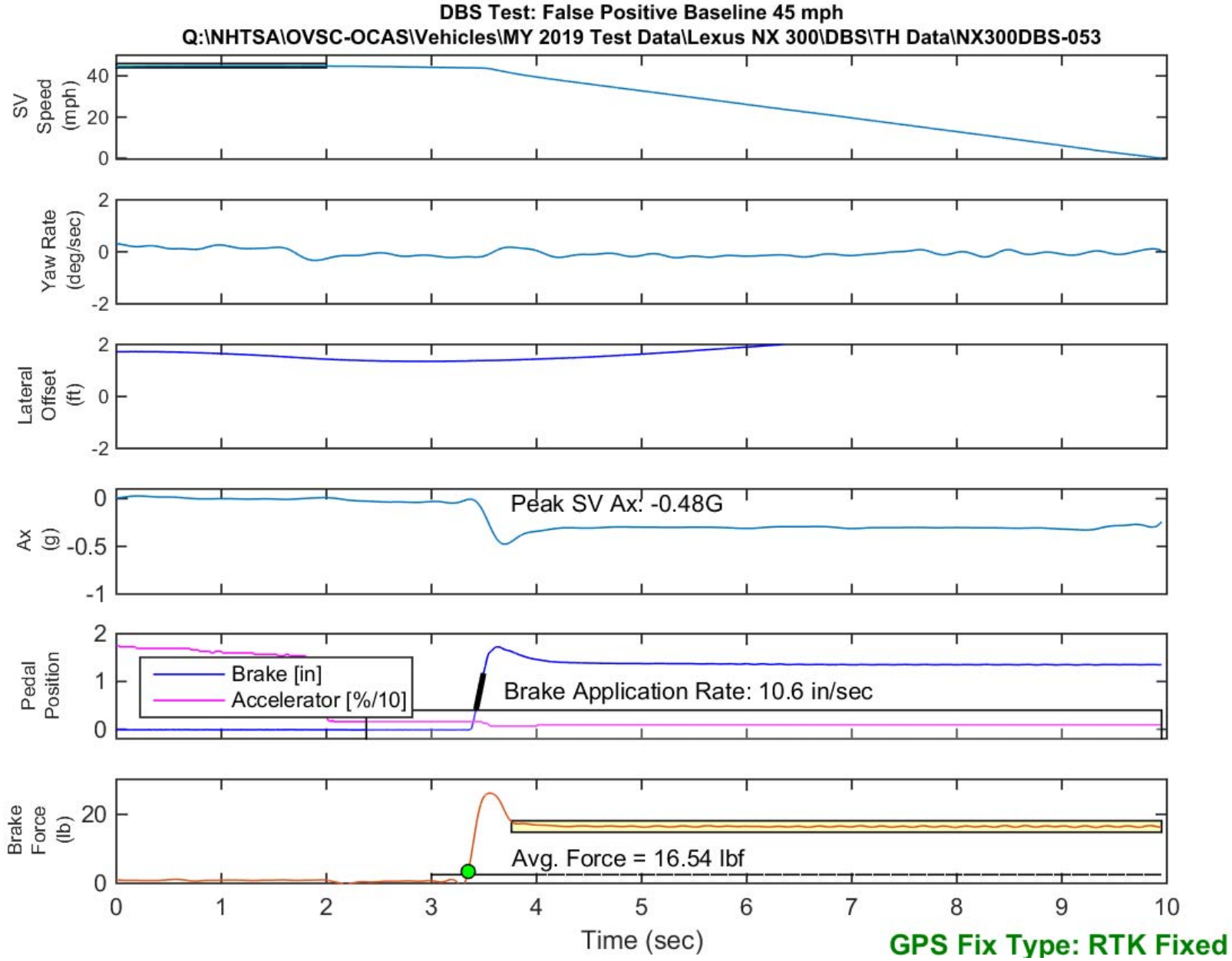


Figure E48. Time History for DBS Run 53, False Positive Baseline, SV 45 mph

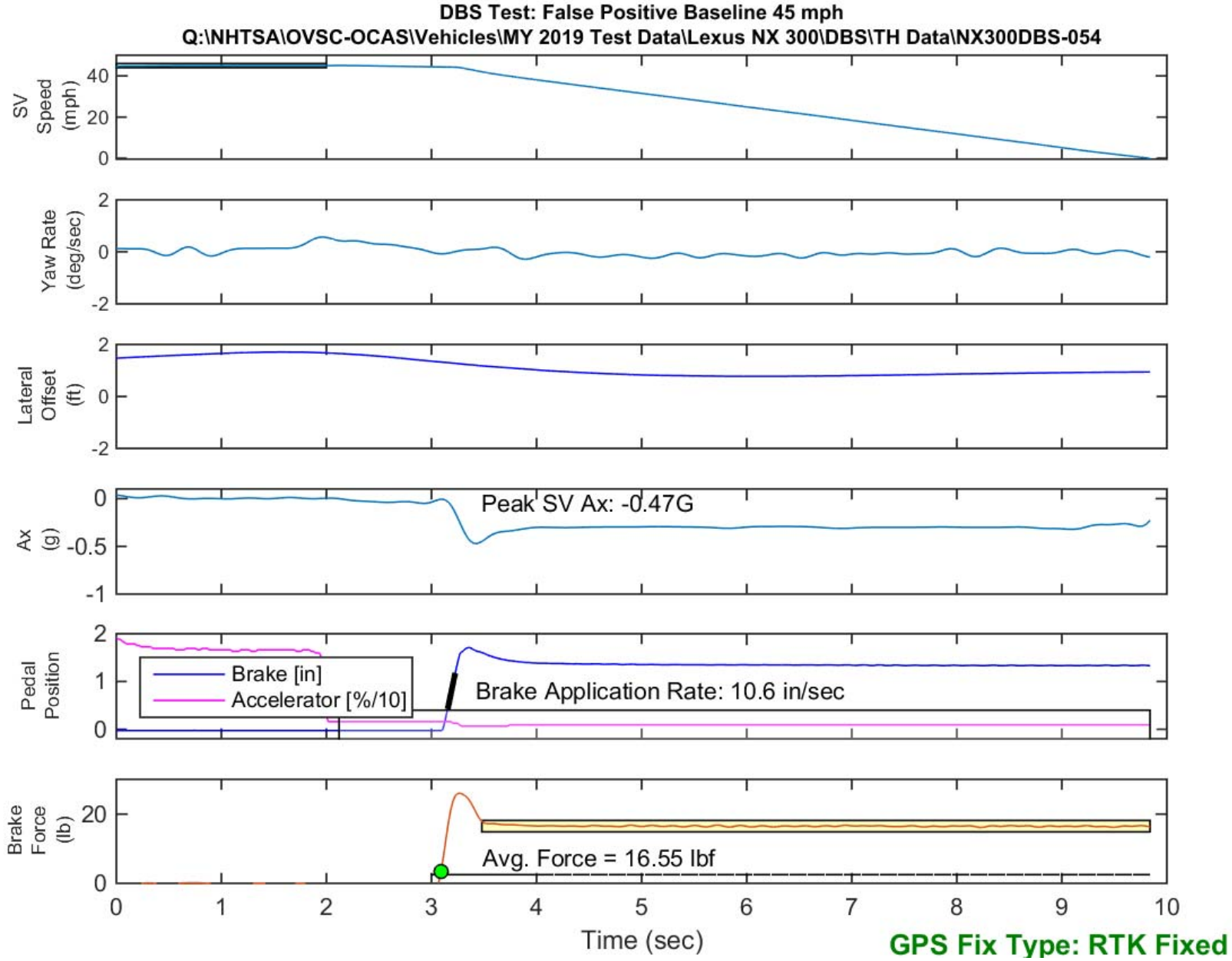


Figure E49. Time History for DBS Run 54, False Positive Baseline, SV 45 mph

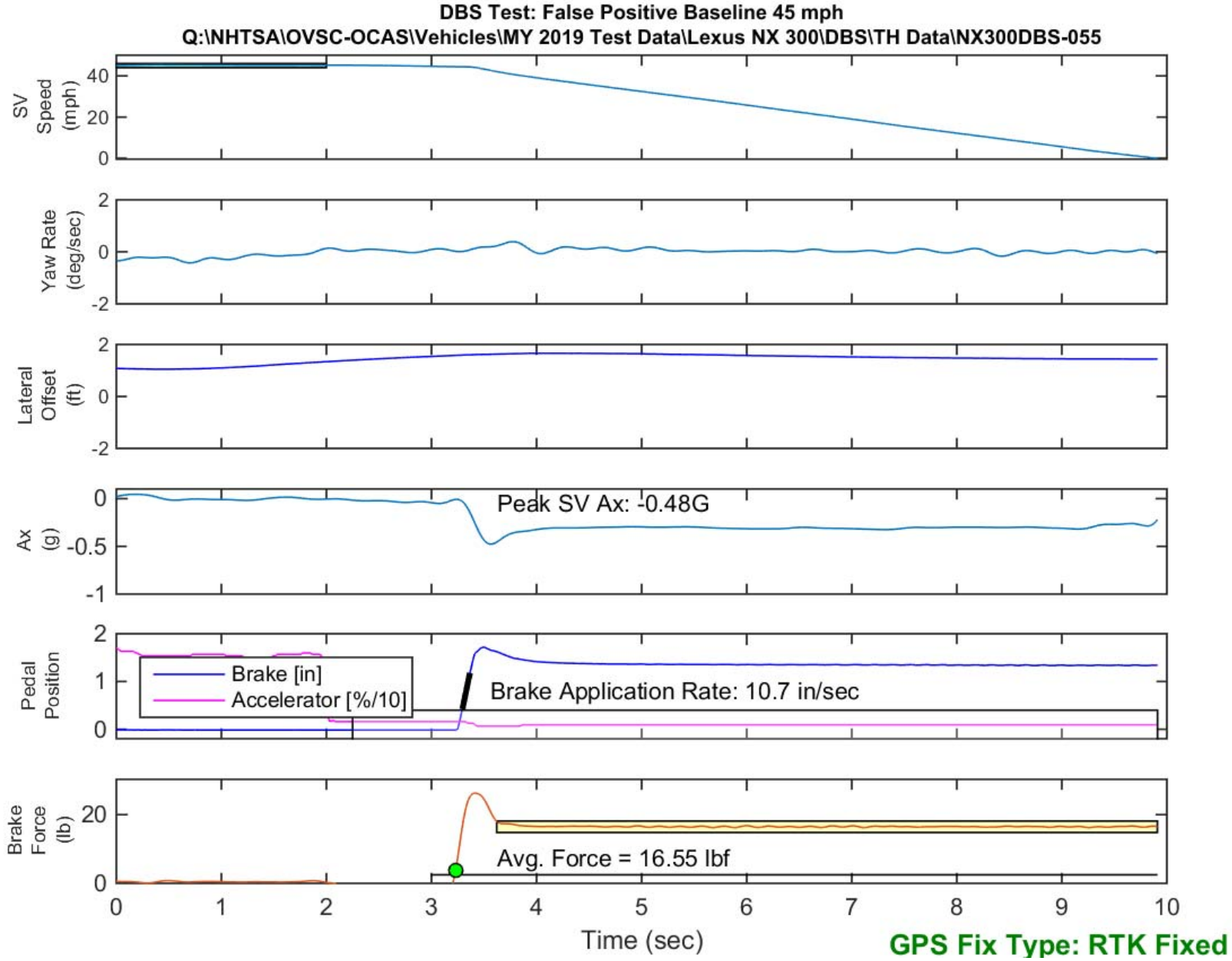


Figure E50. Time History for DBS Run 55, False Positive Baseline, SV 45 mph

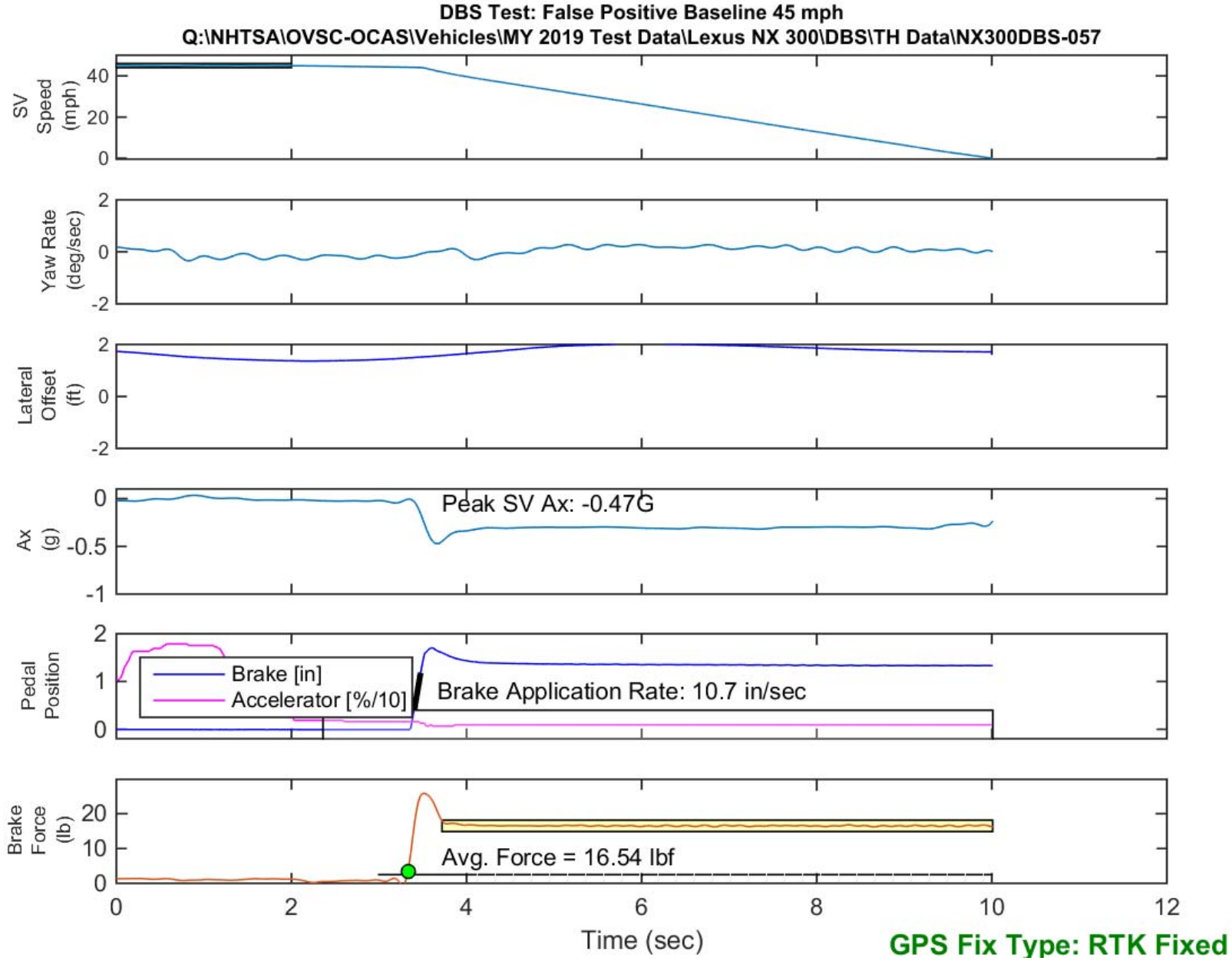


Figure E51. Time History for DBS Run 57, False Positive Baseline, SV 45 mph

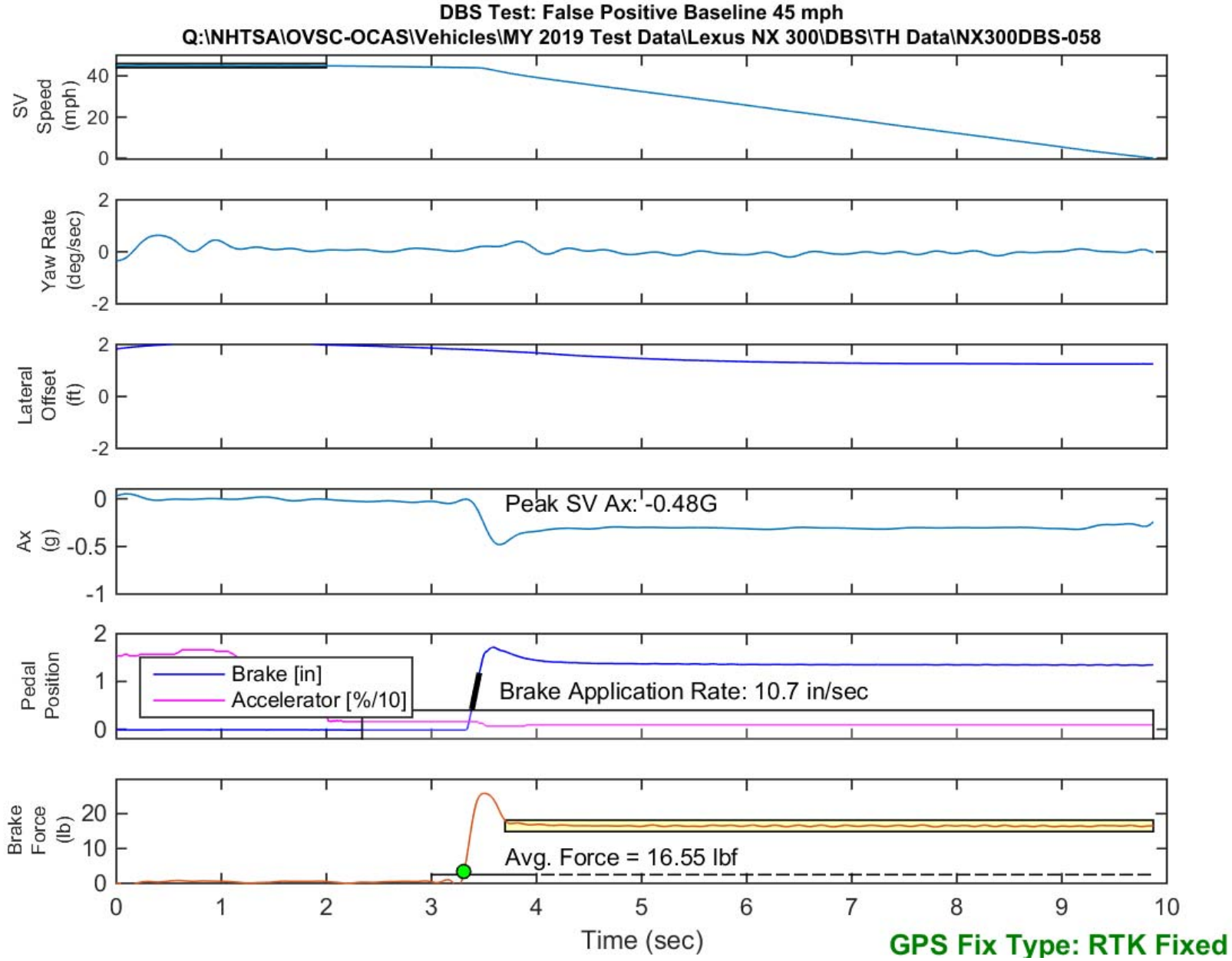


Figure E52. Time History for DBS Run 58, False Positive Baseline, SV 45 mph

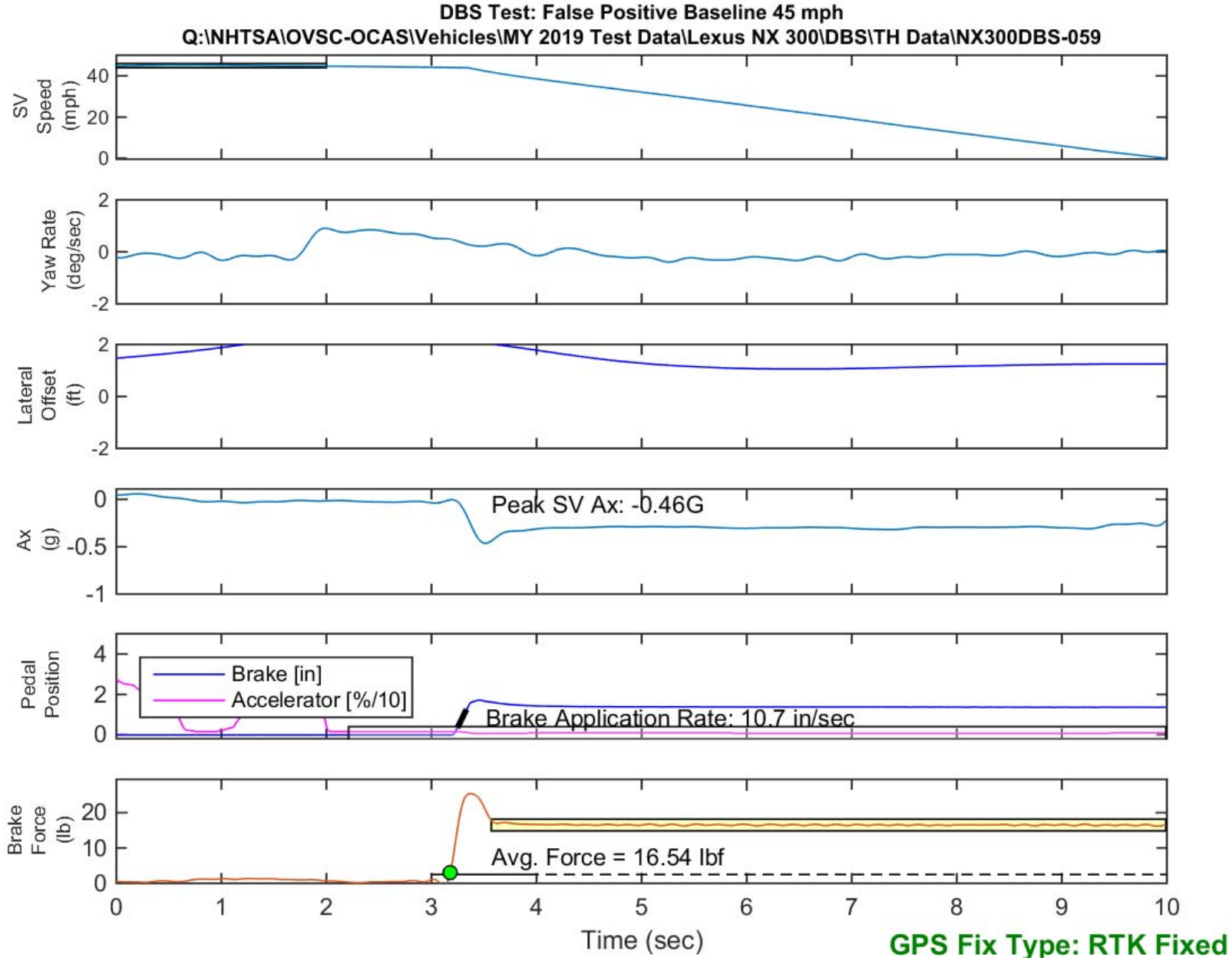


Figure E53. Time History for DBS Run 59, False Positive Baseline, SV 45 mph

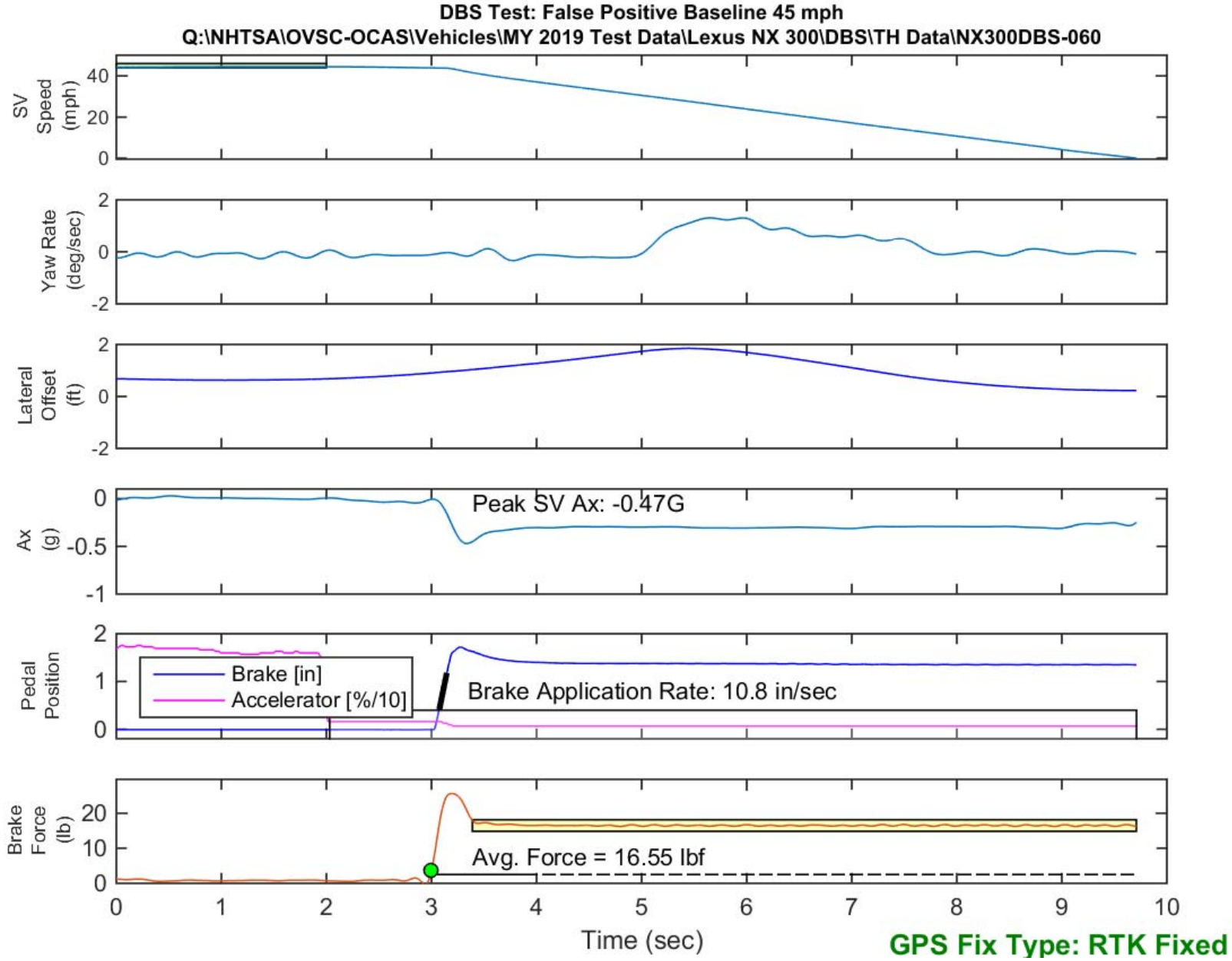


Figure E54. Time History for DBS Run 60, False Positive Baseline, SV 45 mph

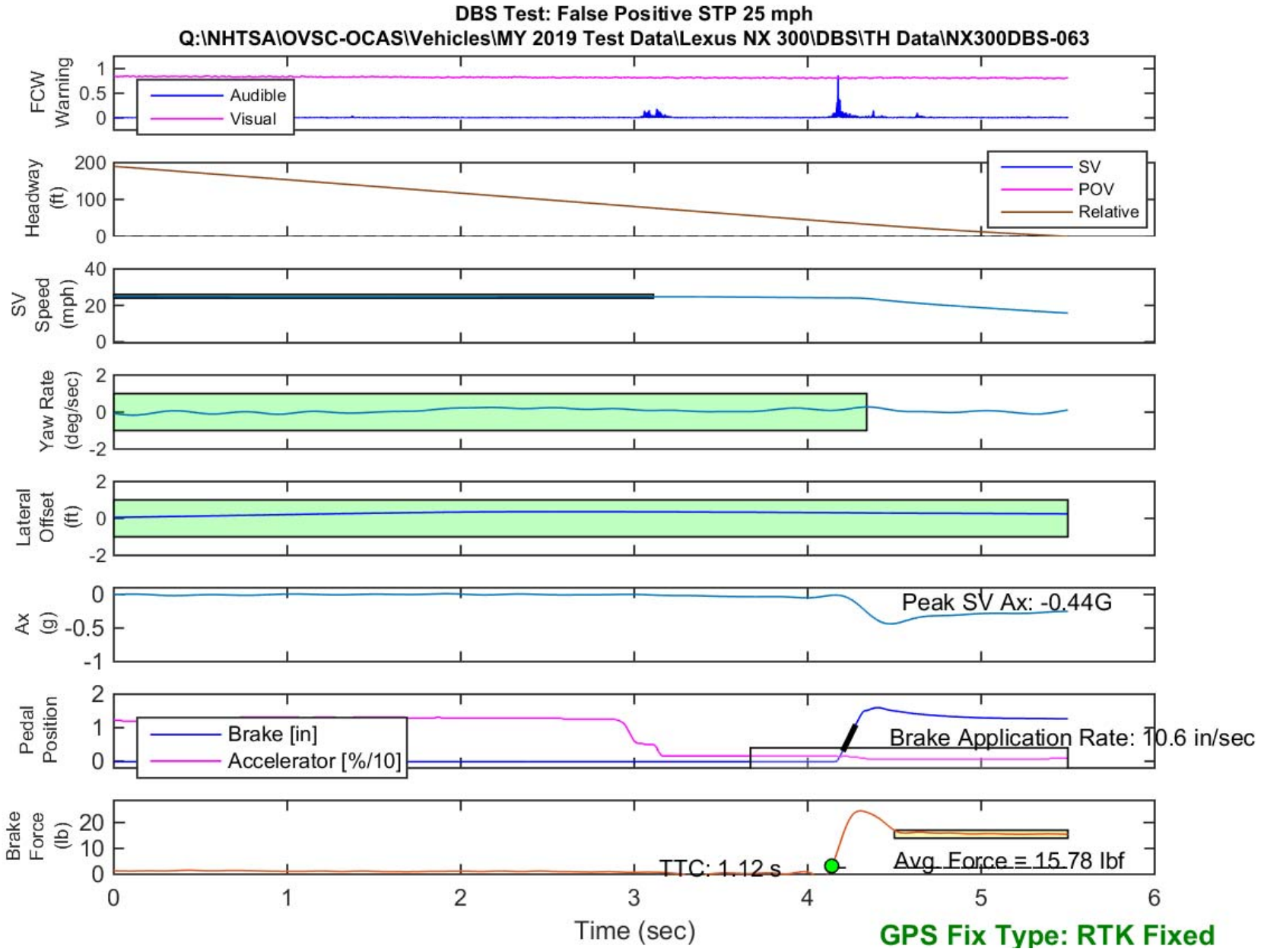


Figure E55. Time History for DBS Run 63, SV Encounters Steel Trench Plate, SV 25 mph

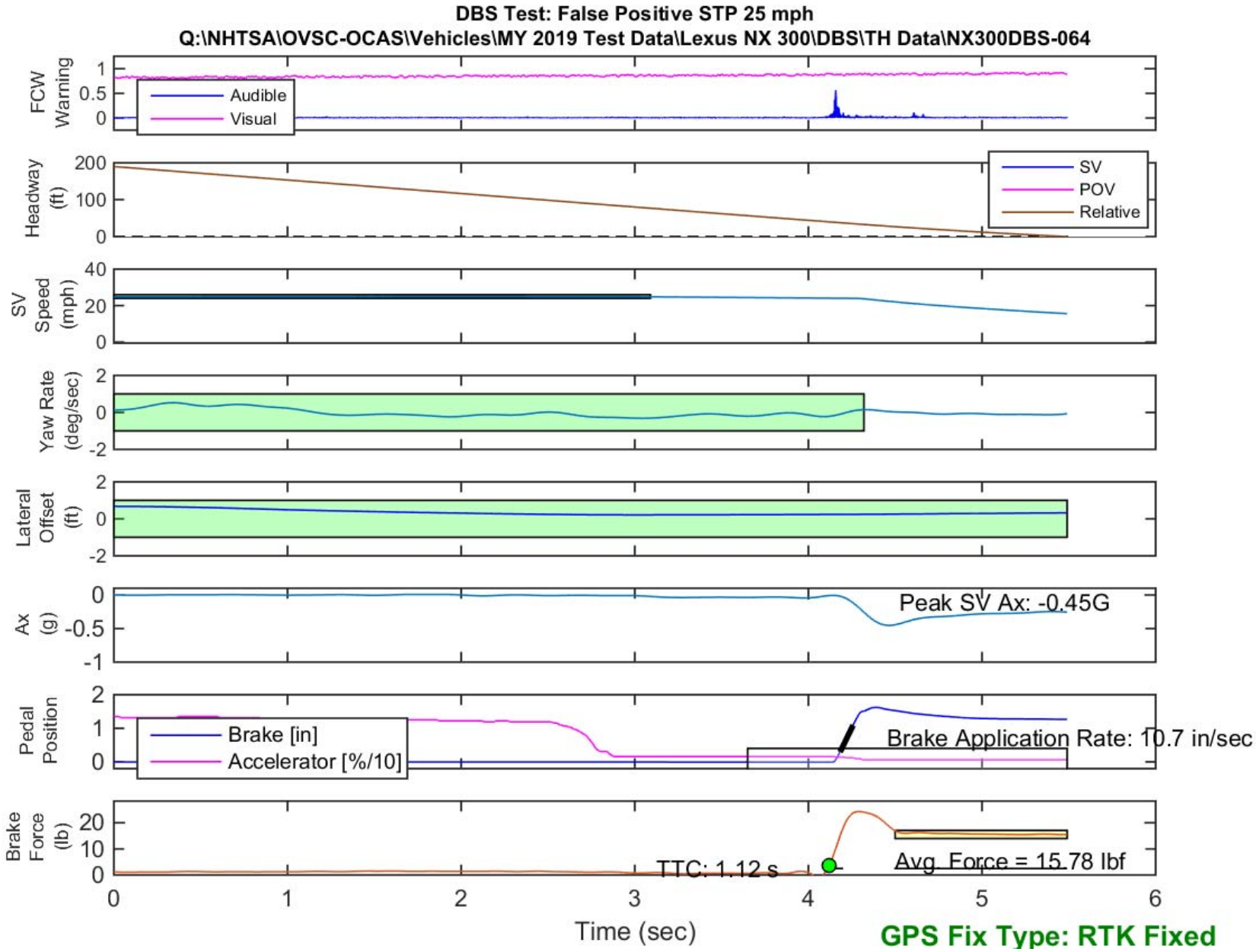


Figure E56. Time History for DBS Run 64, SV Encounters Steel Trench Plate, SV 25 mph

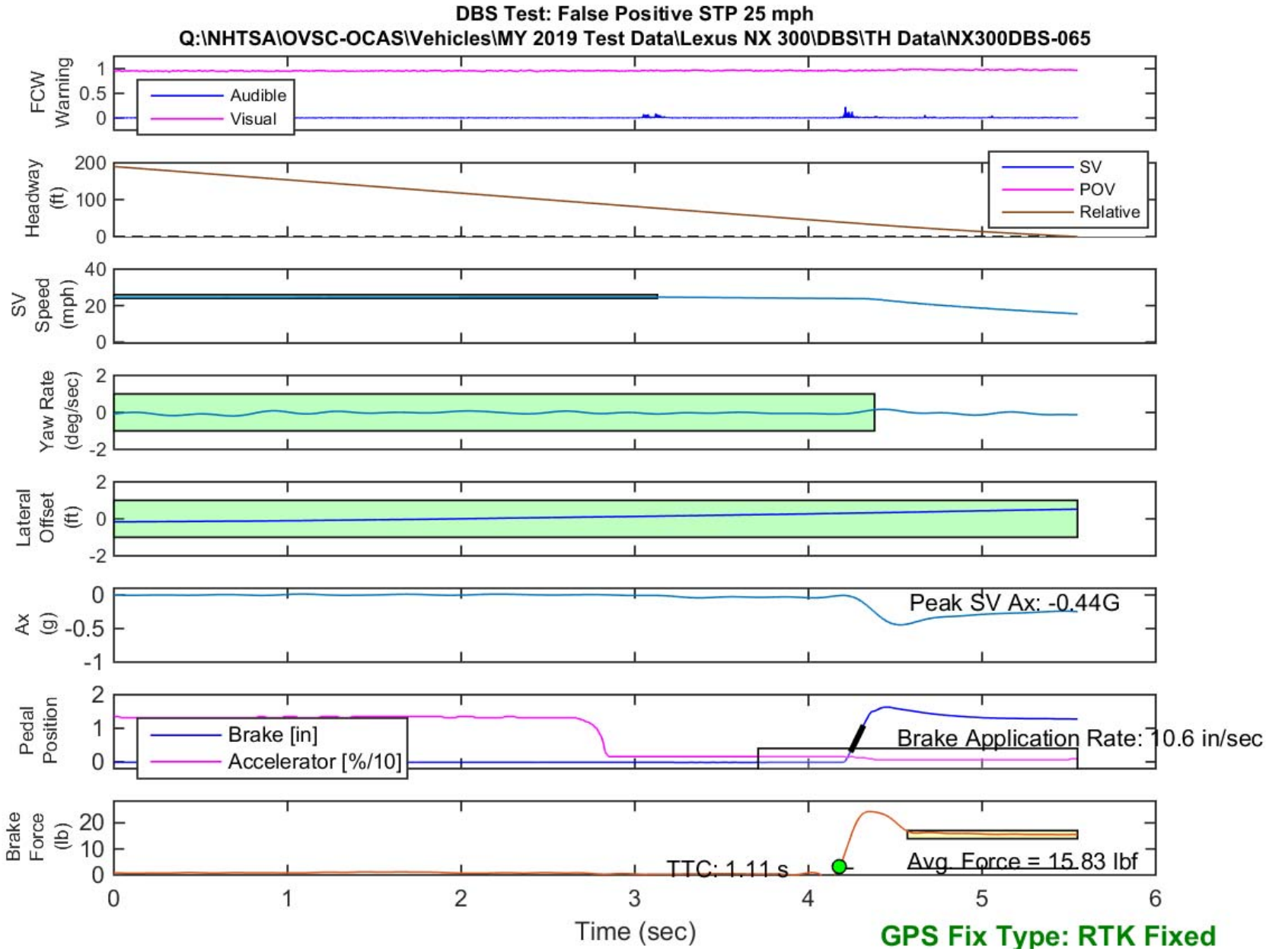


Figure E57. Time History for DBS Run 65, SV Encounters Steel Trench Plate, SV 25 mph

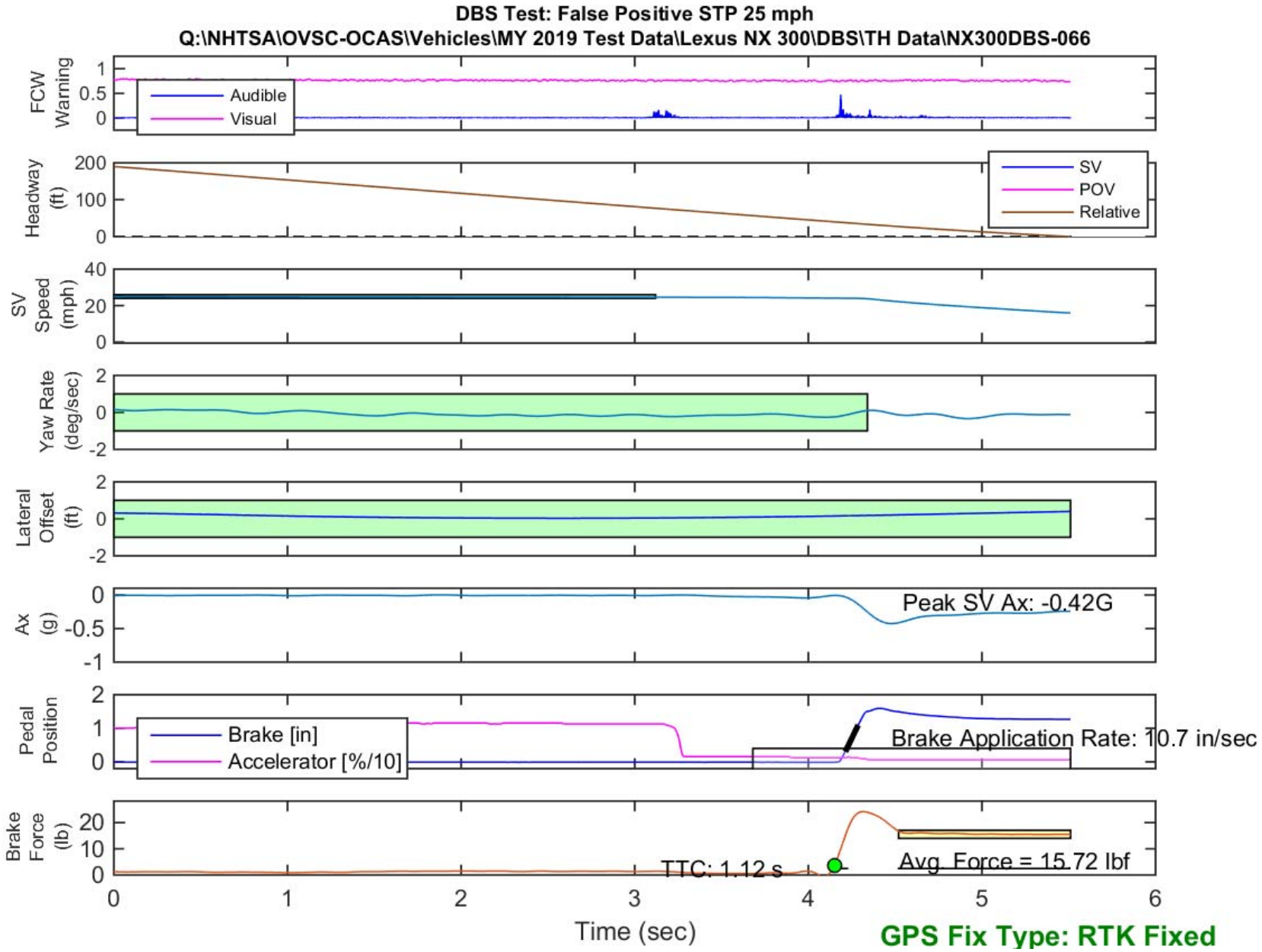


Figure E58. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph

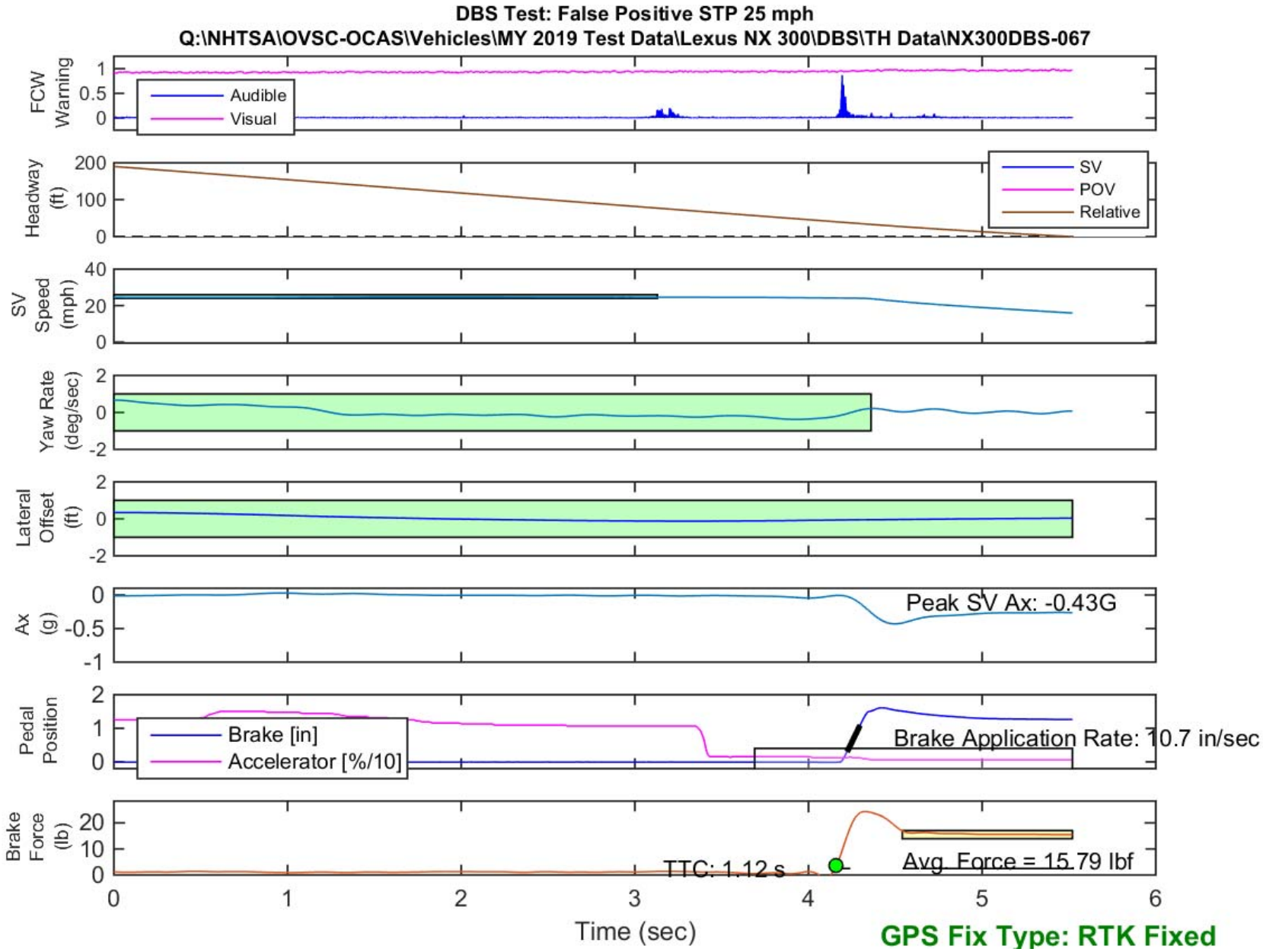


Figure E59. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph

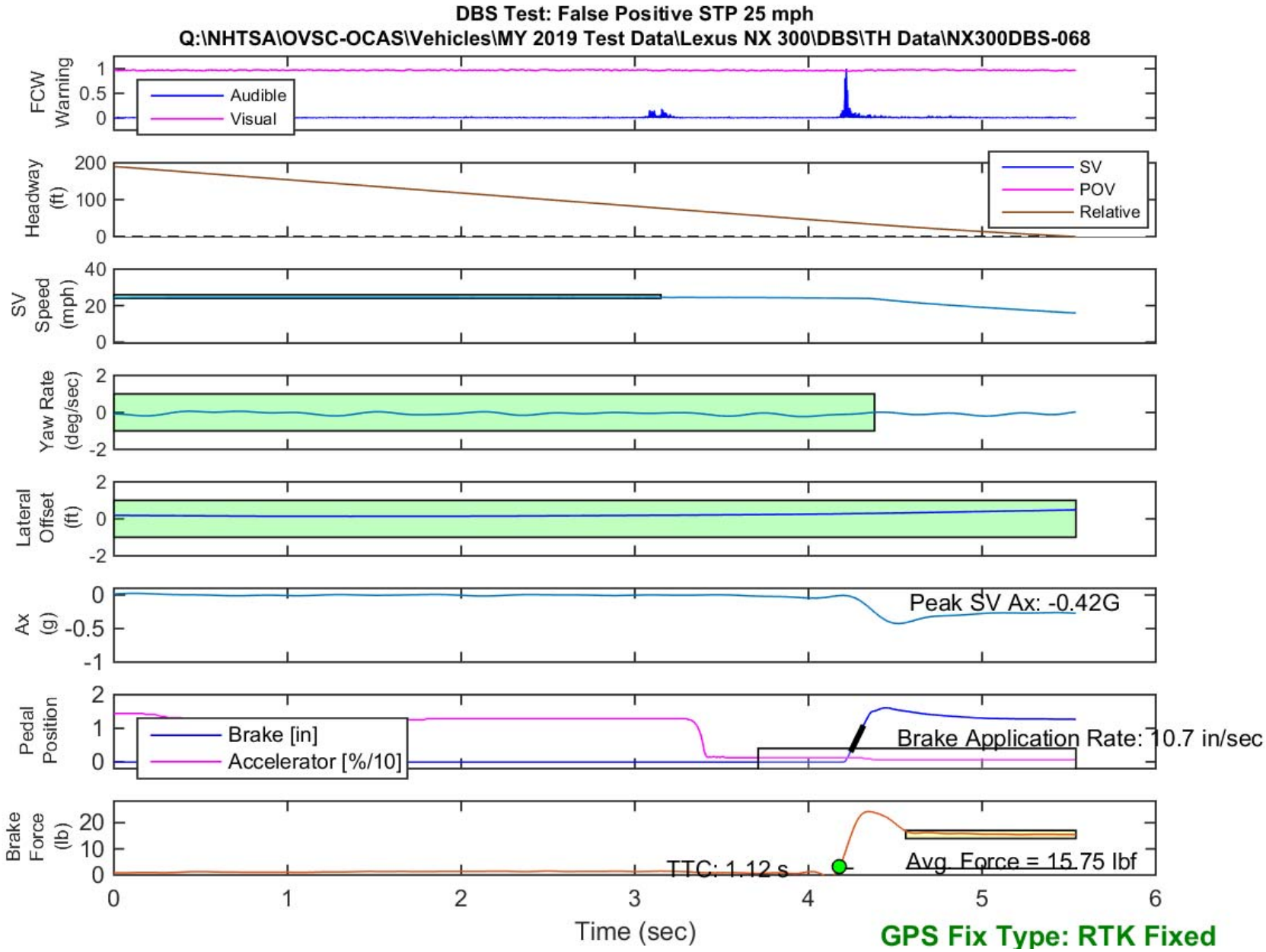


Figure E60. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph

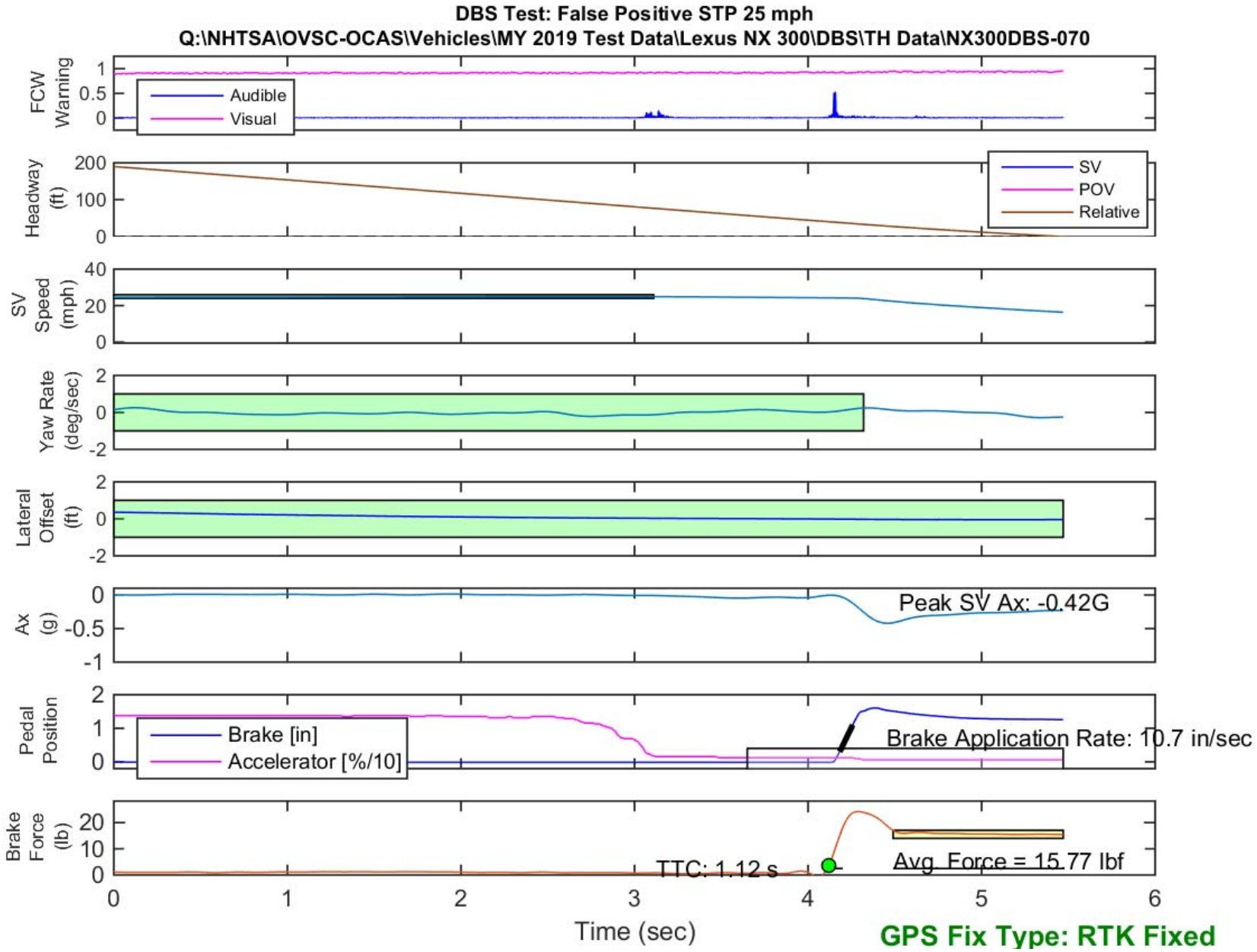


Figure E61. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph

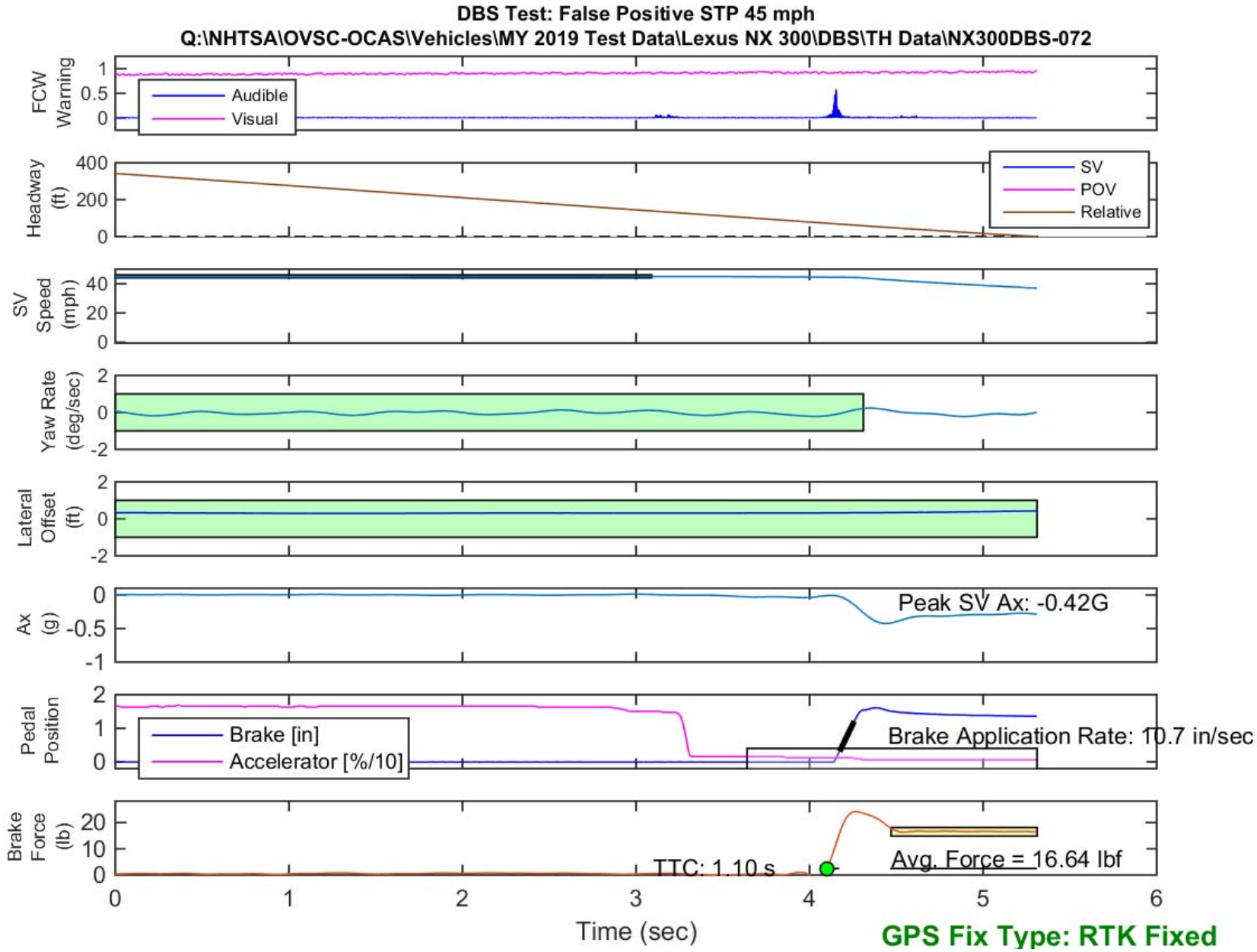


Figure E62. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 45 mph

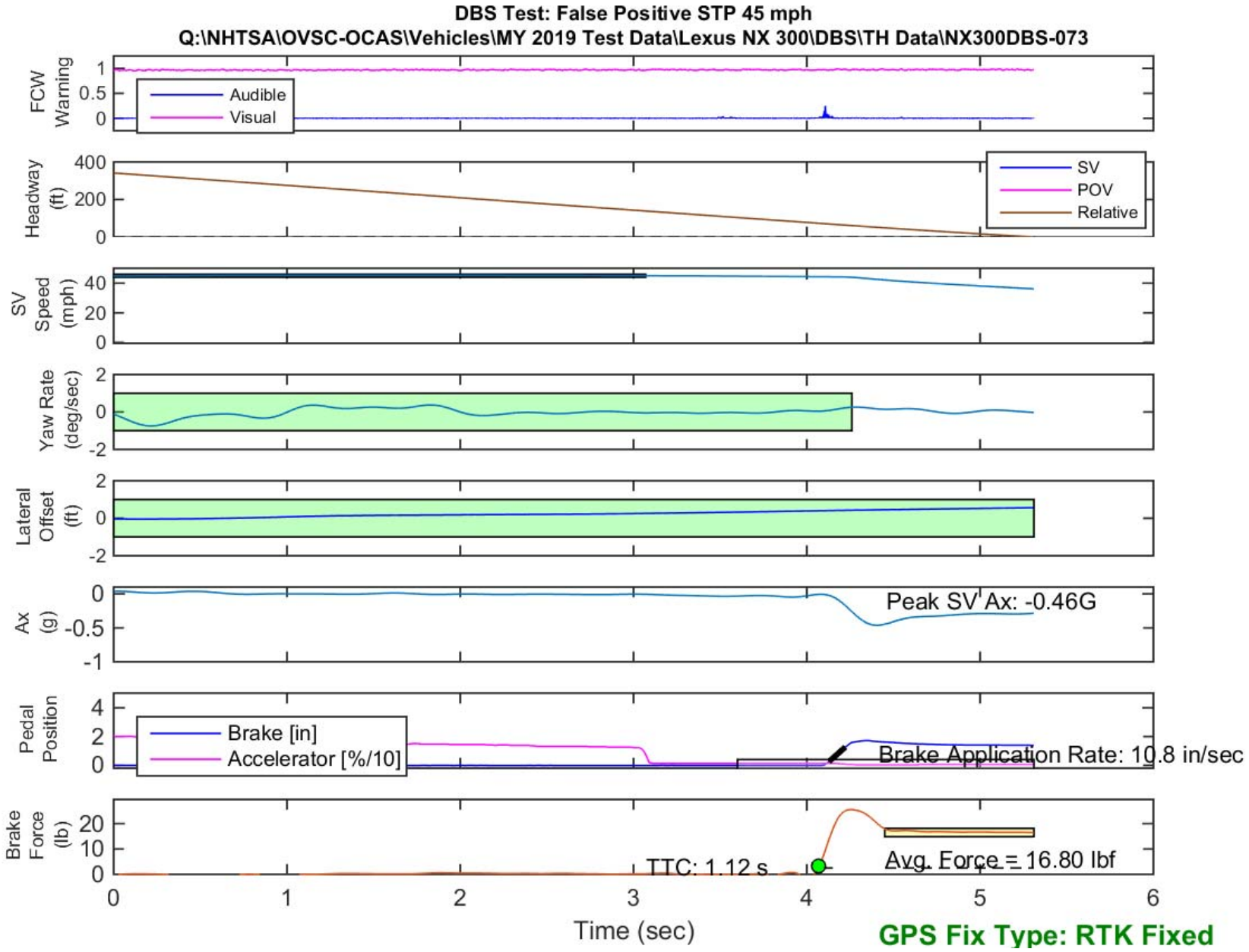


Figure E63. Time History for DBS Run 73, SV Encounters Steel Trench Plate, SV 45 mph

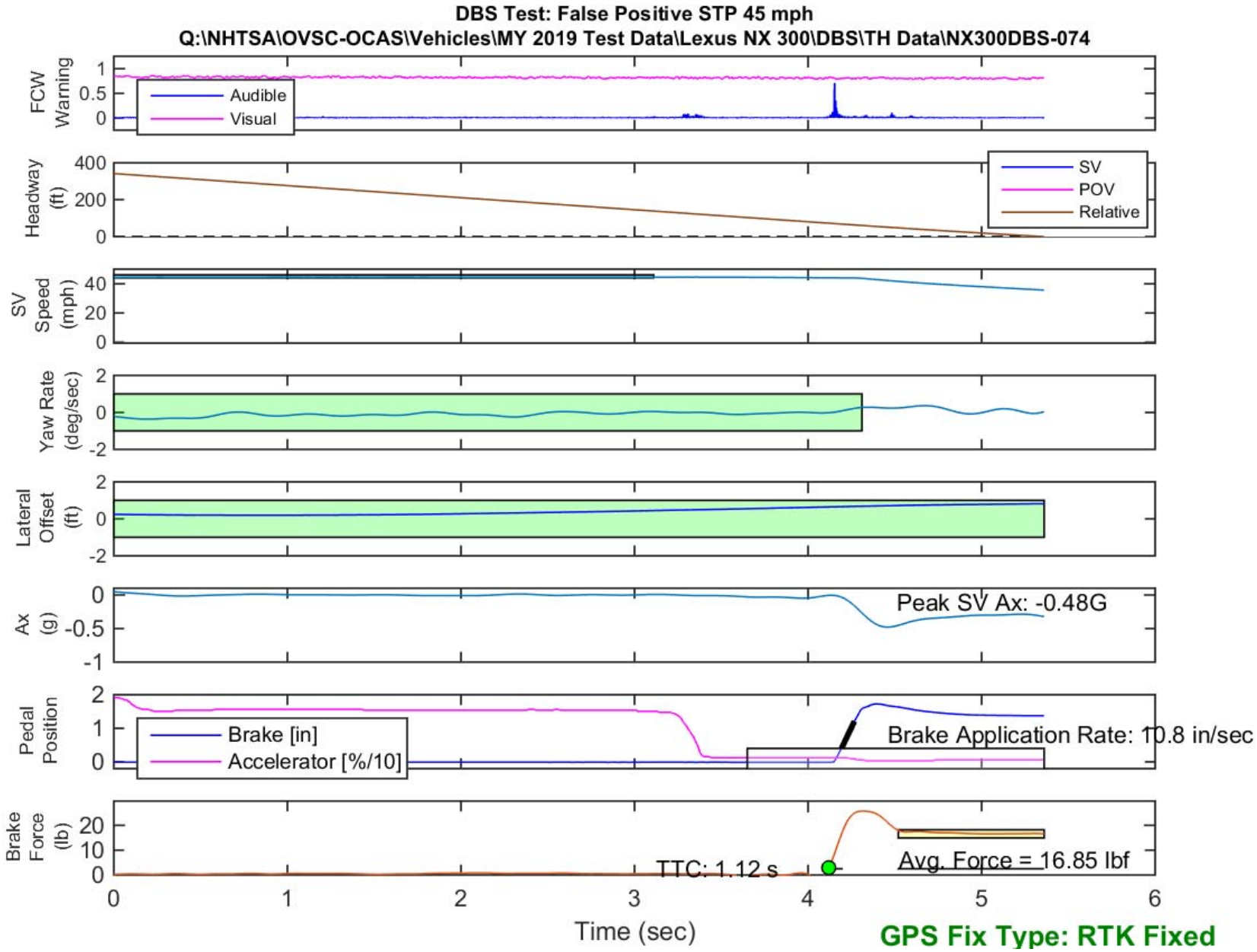


Figure E64. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph

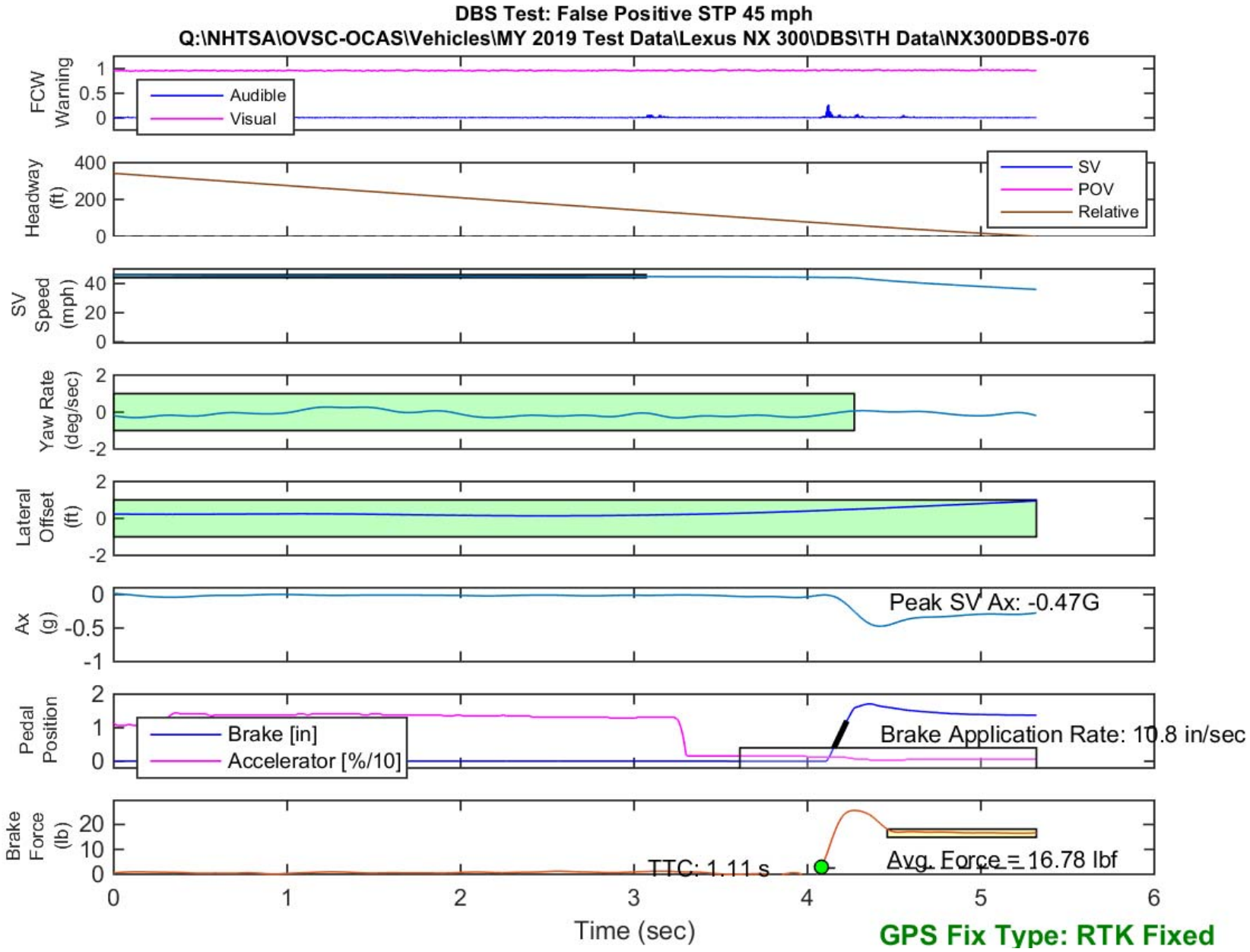


Figure E65. Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph

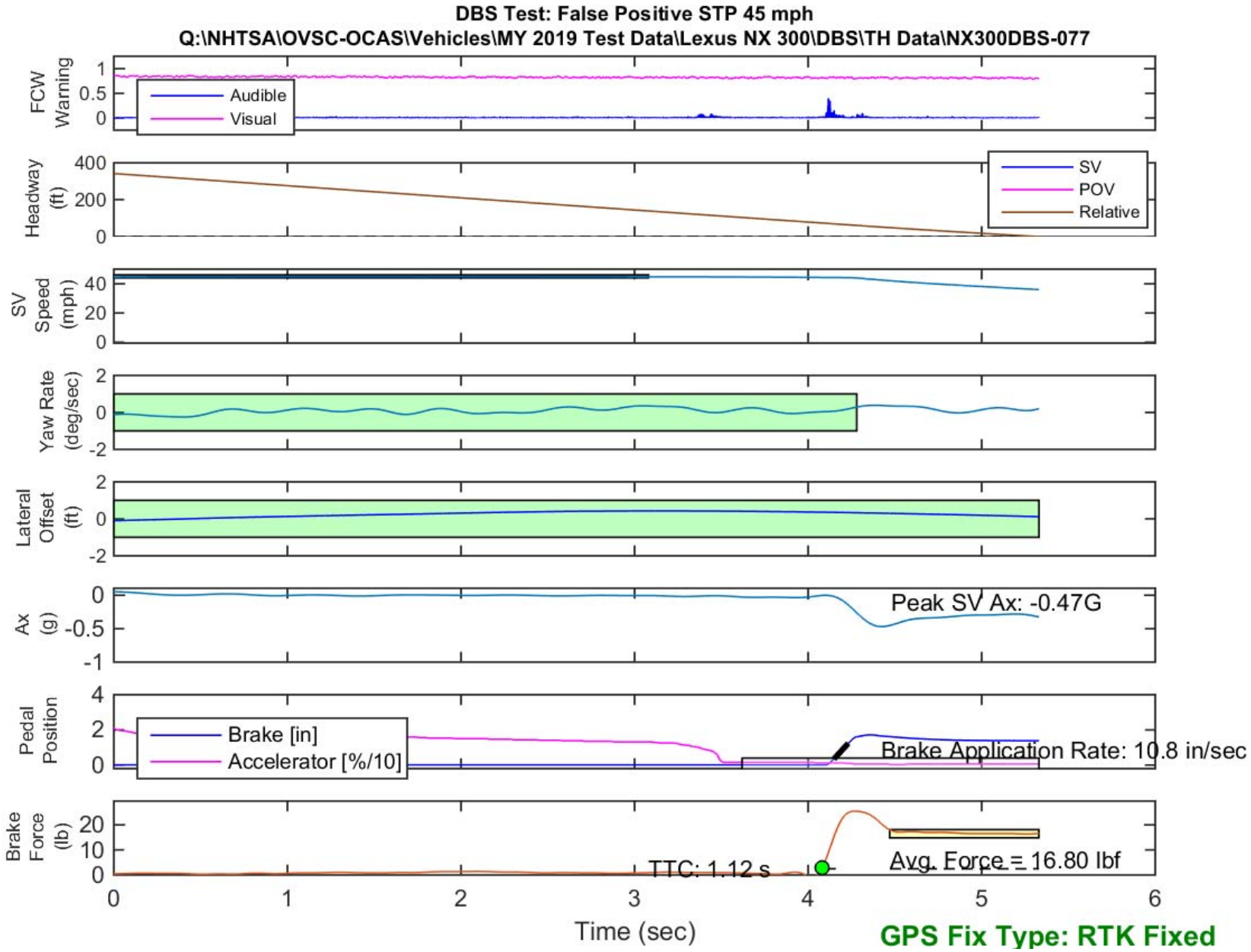


Figure E66. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph

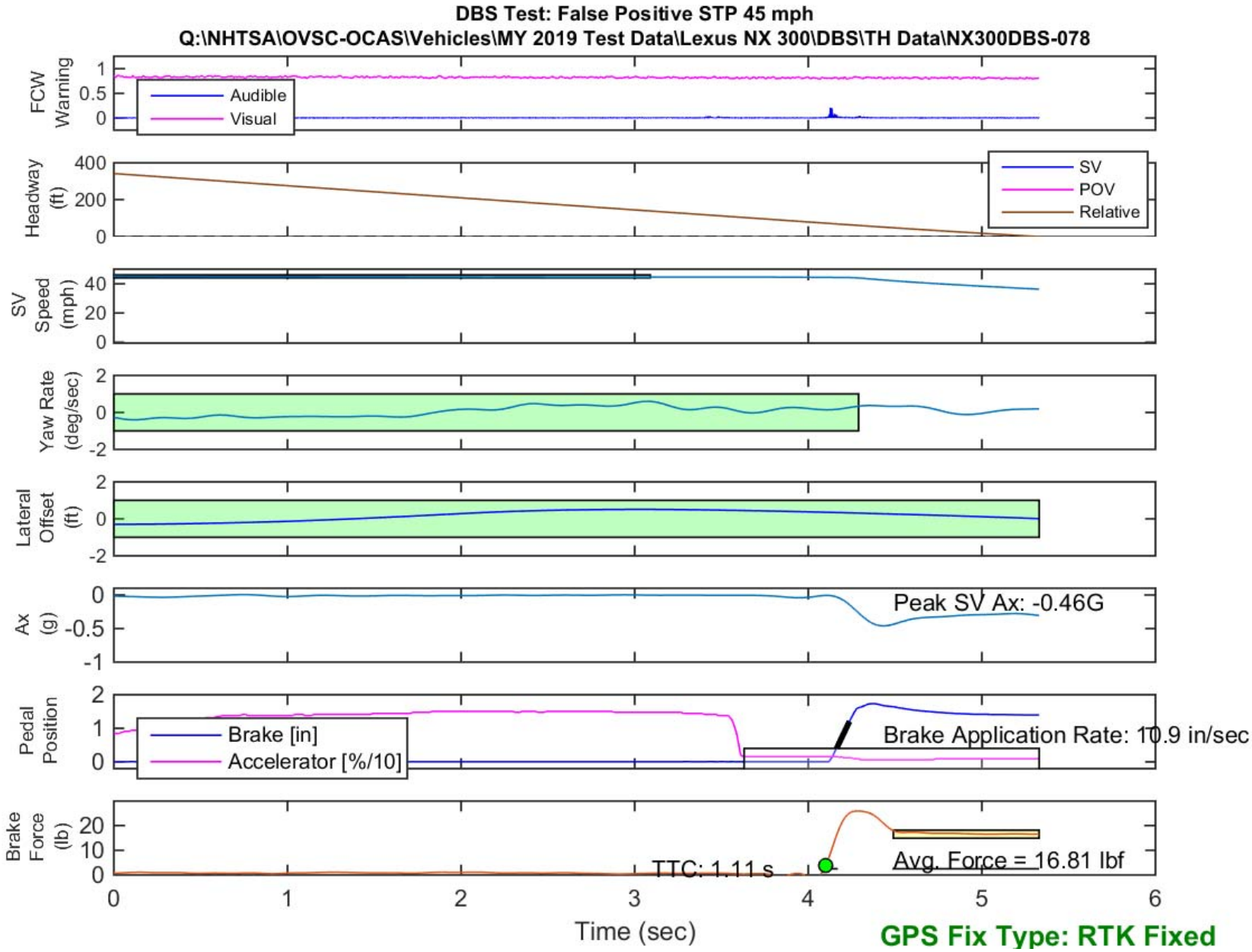


Figure E67. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph

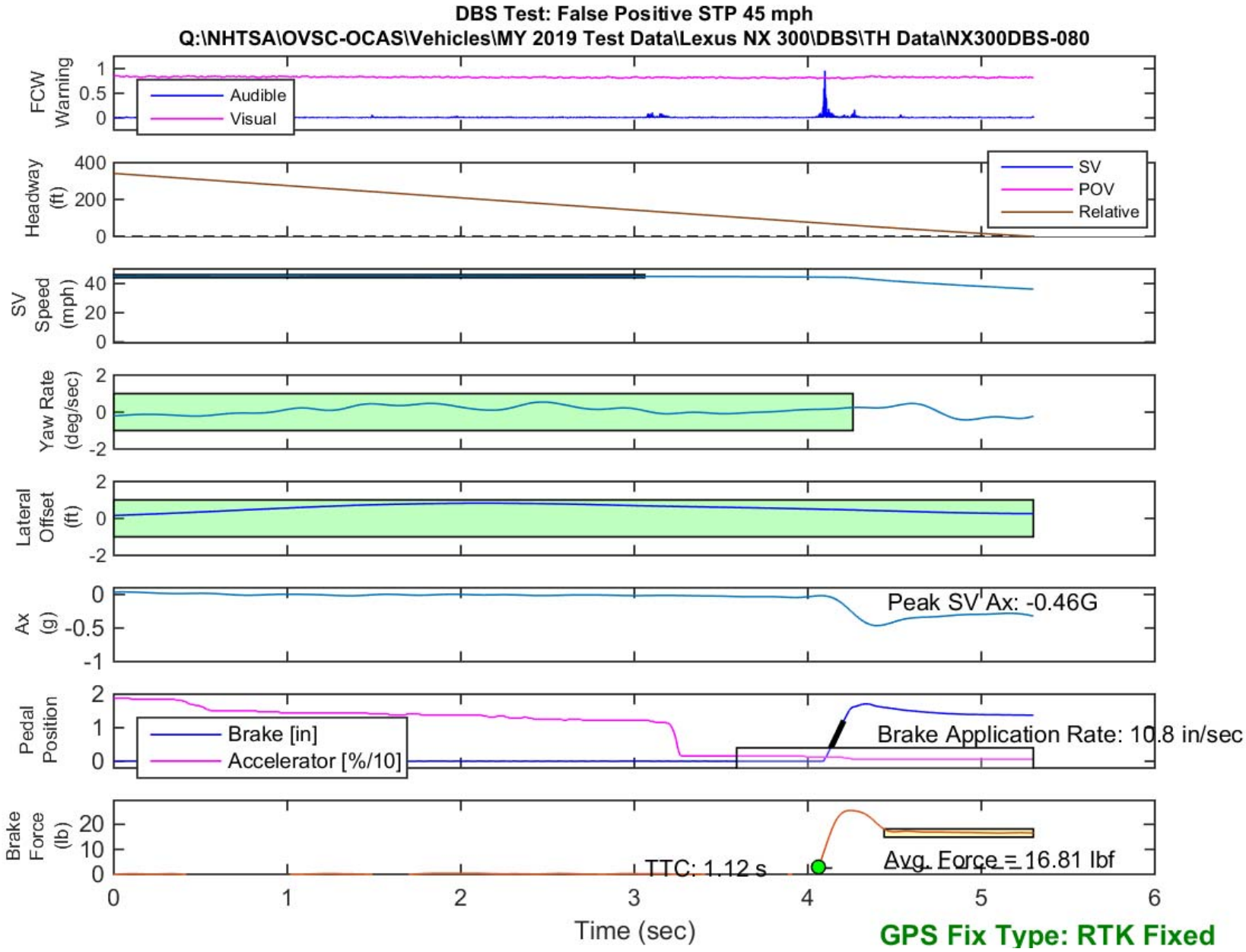


Figure E68. Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph

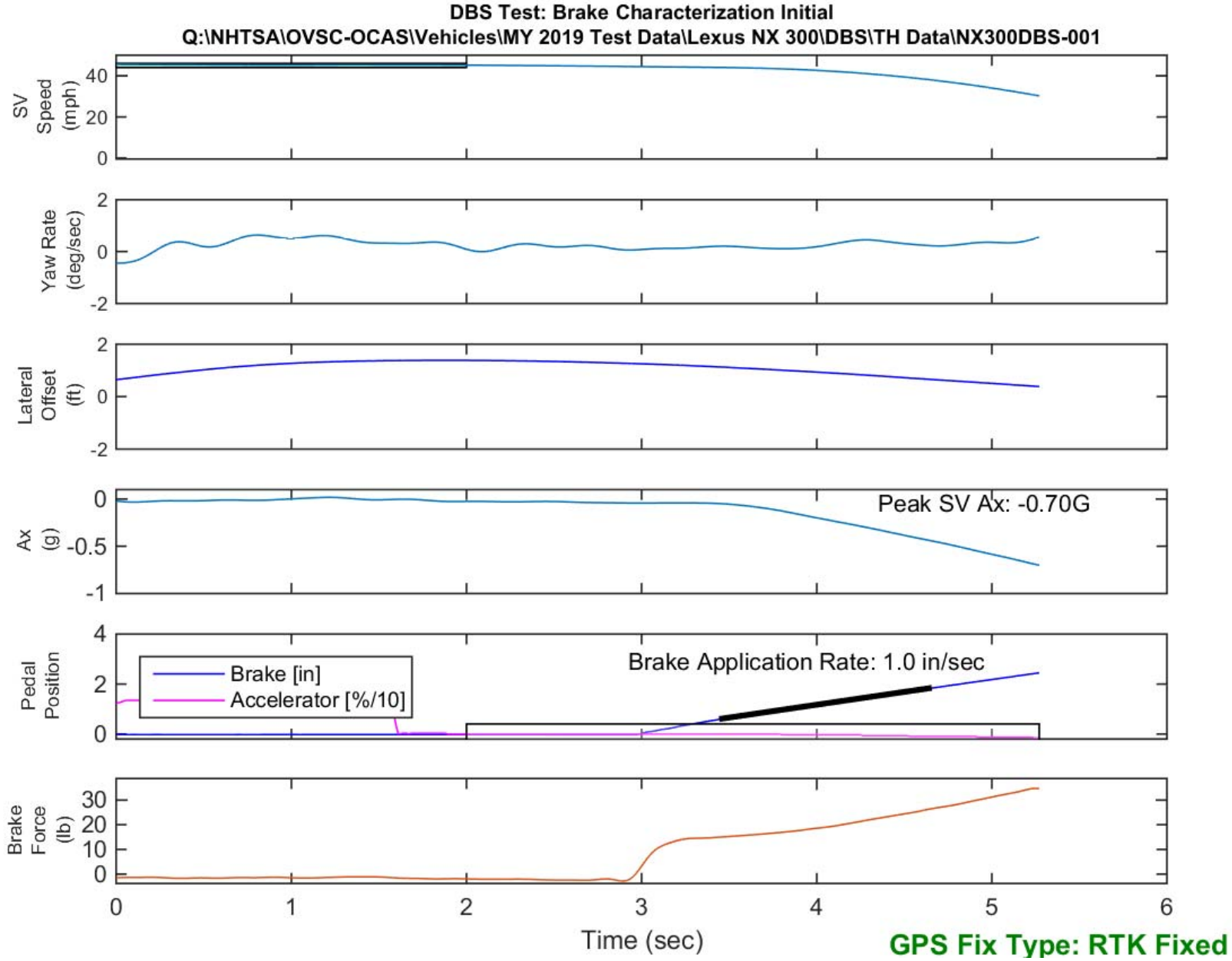


Figure E69. Time History for DBS Run 1, Brake Characterization Initial

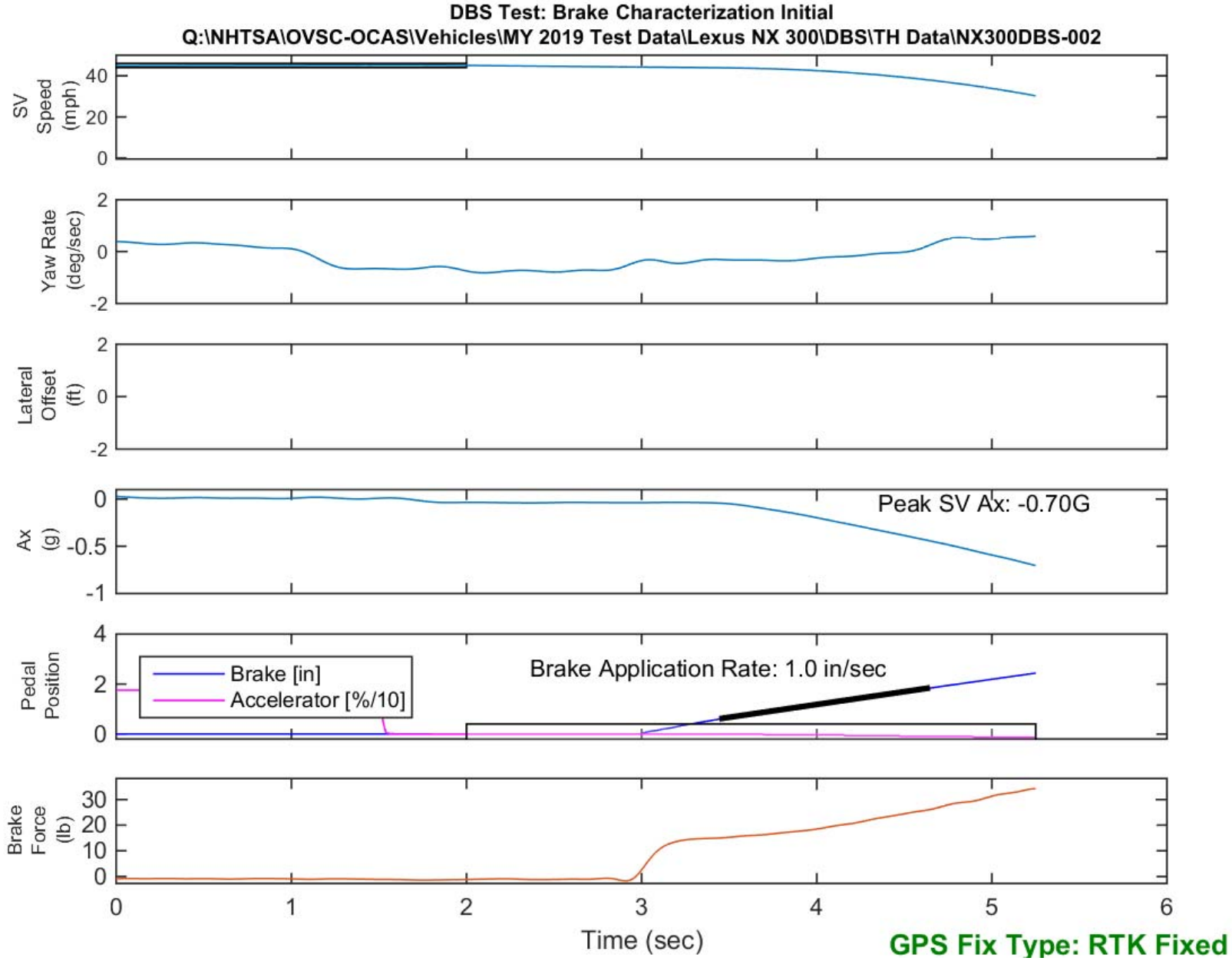


Figure E70. Time History for DBS Run 2, Brake Characterization Initial

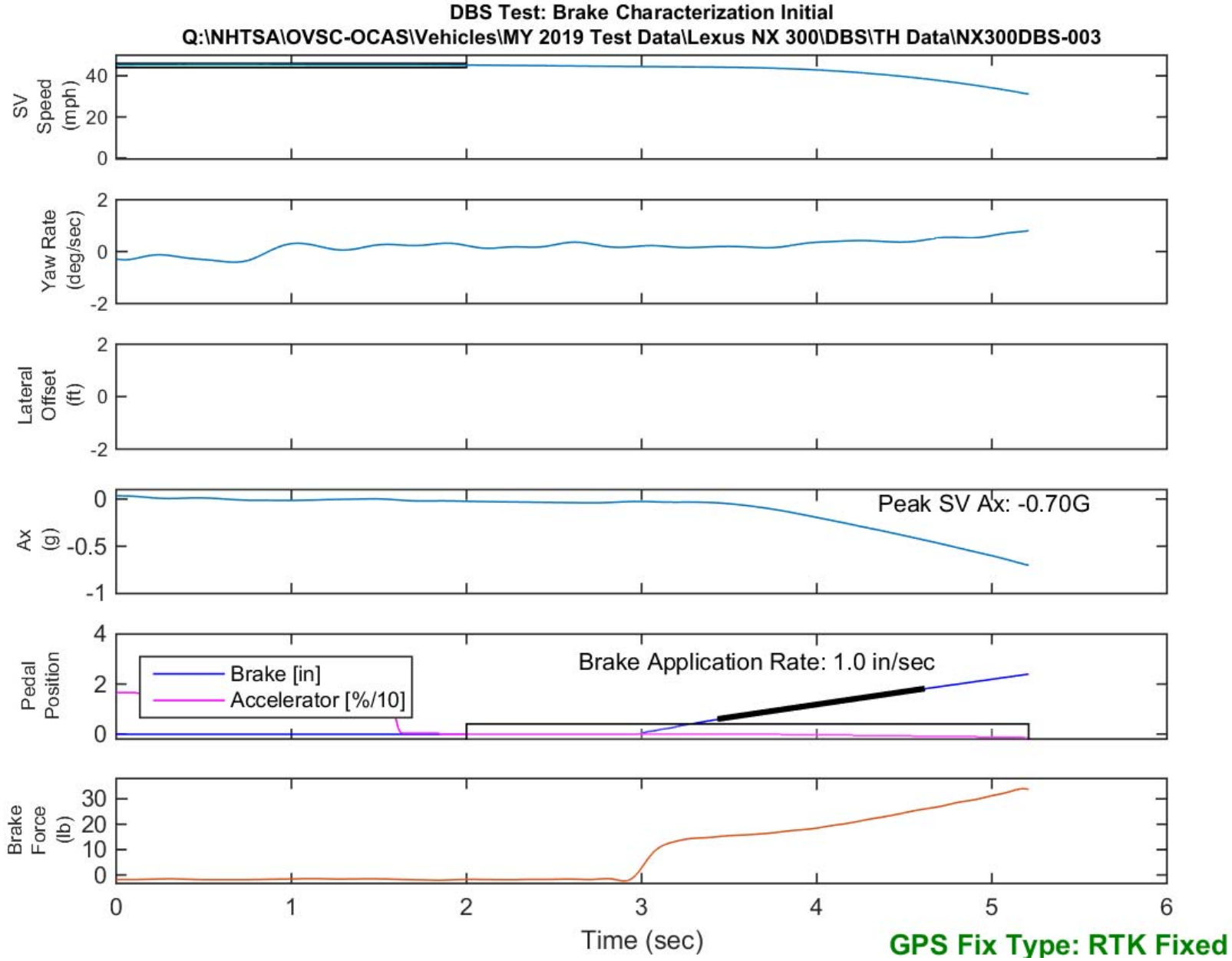


Figure E71. Time History for DBS Run 3, Brake Characterization Initial

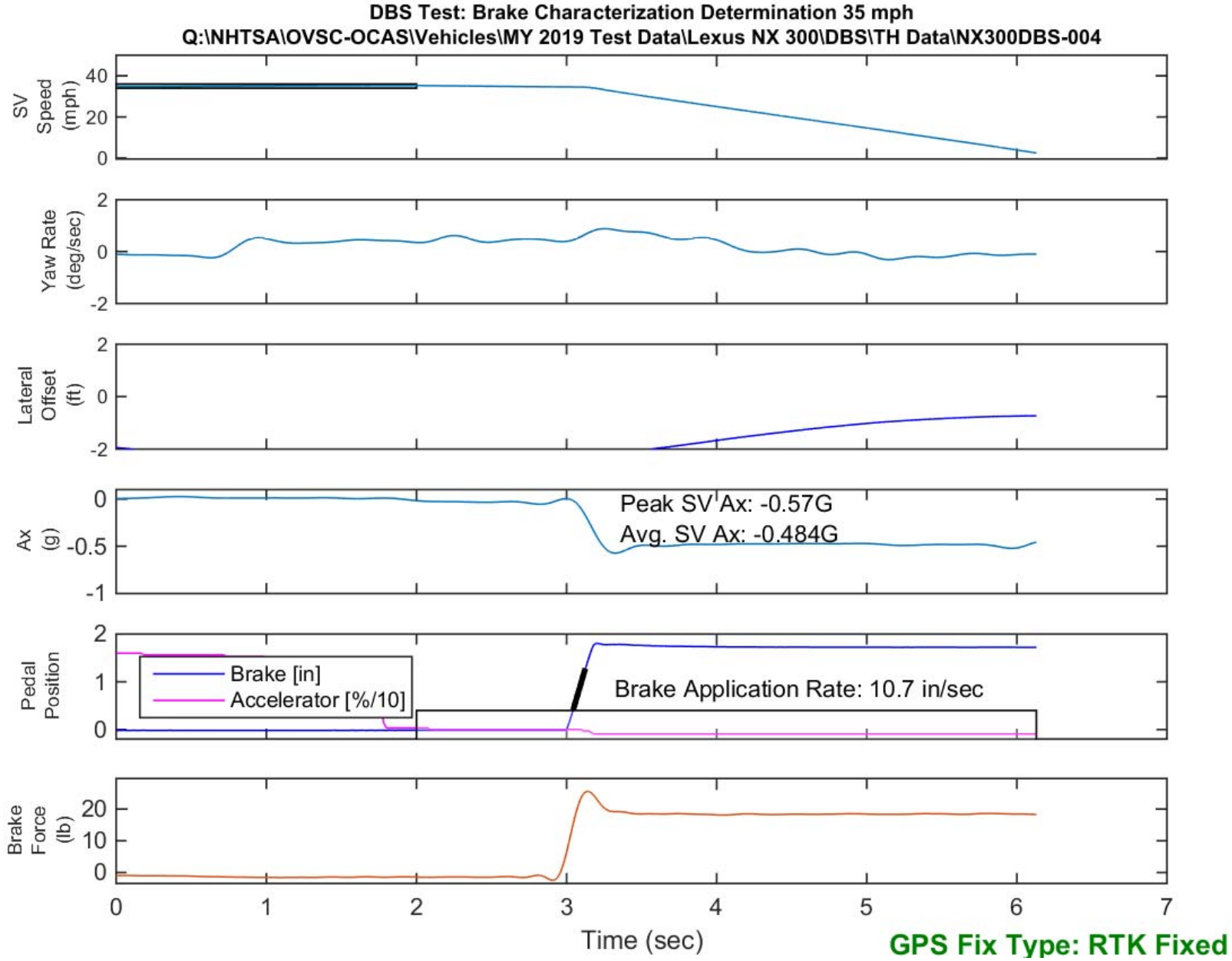


Figure E72. Time History for DBS Run 4, Brake Characterization Determination 35 mph

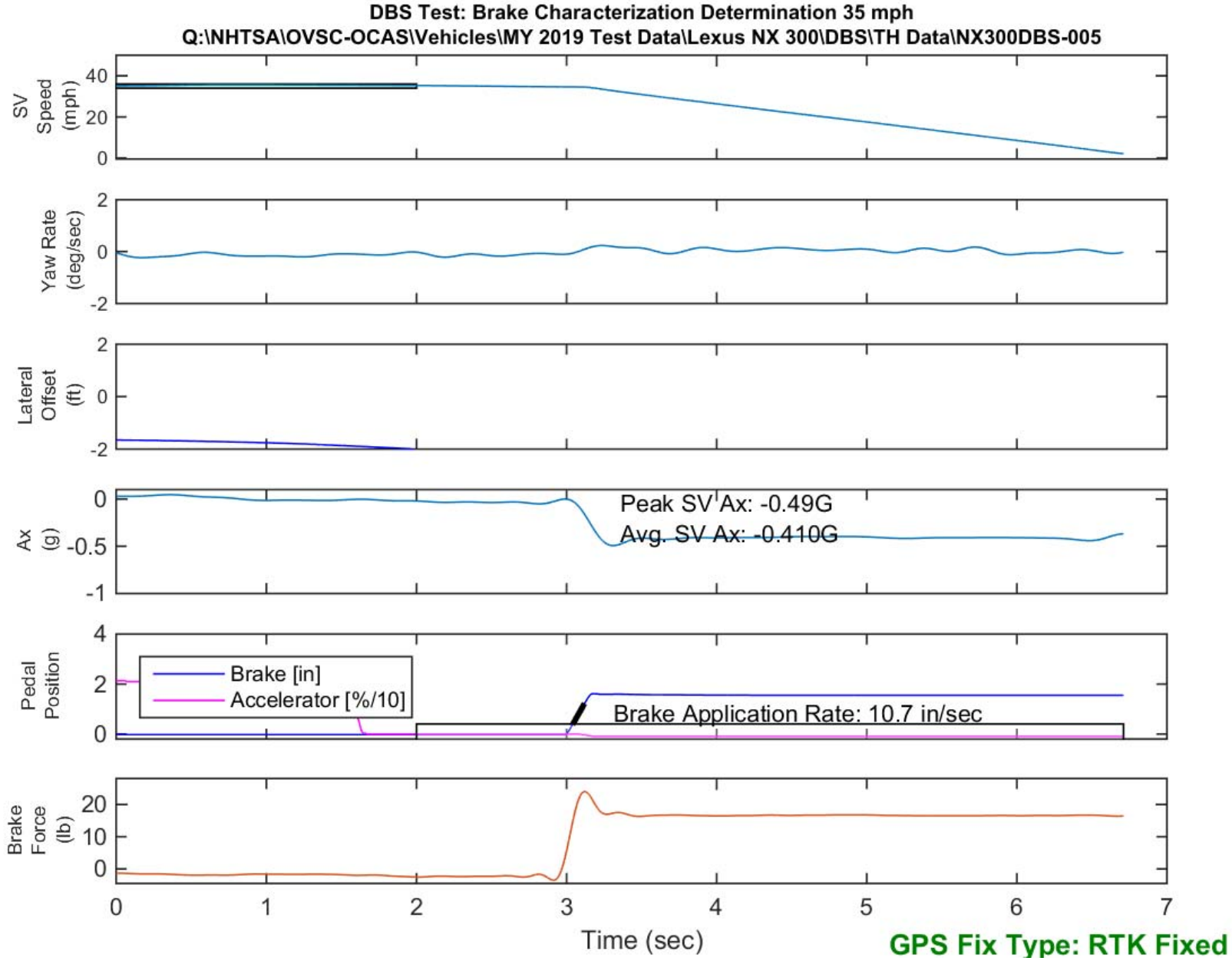


Figure E73. Time History for DBS Run 5, Brake Characterization Determination 35 mph

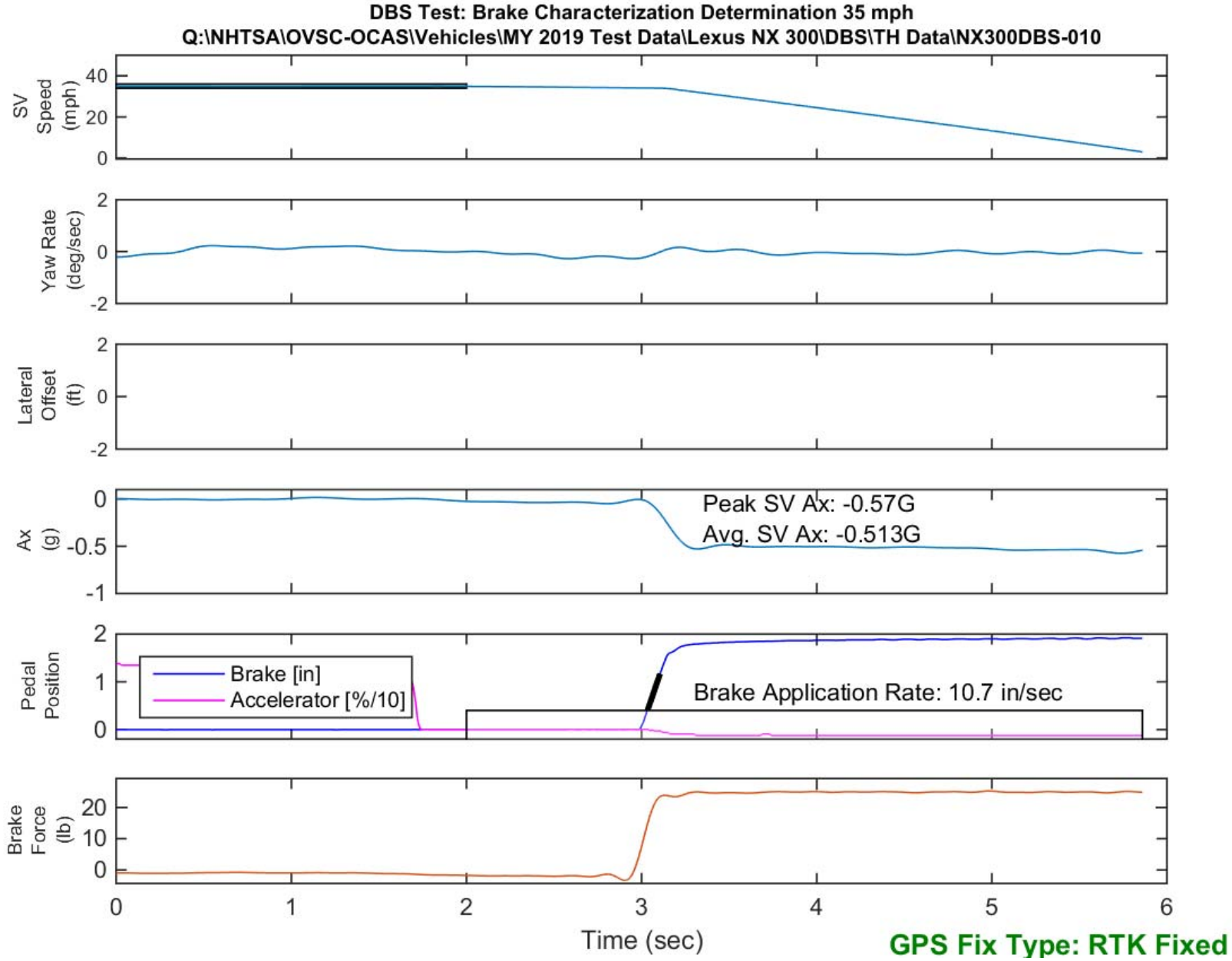


Figure E74. Time History for DBS Run 10, Brake Characterization Determination 35 mph

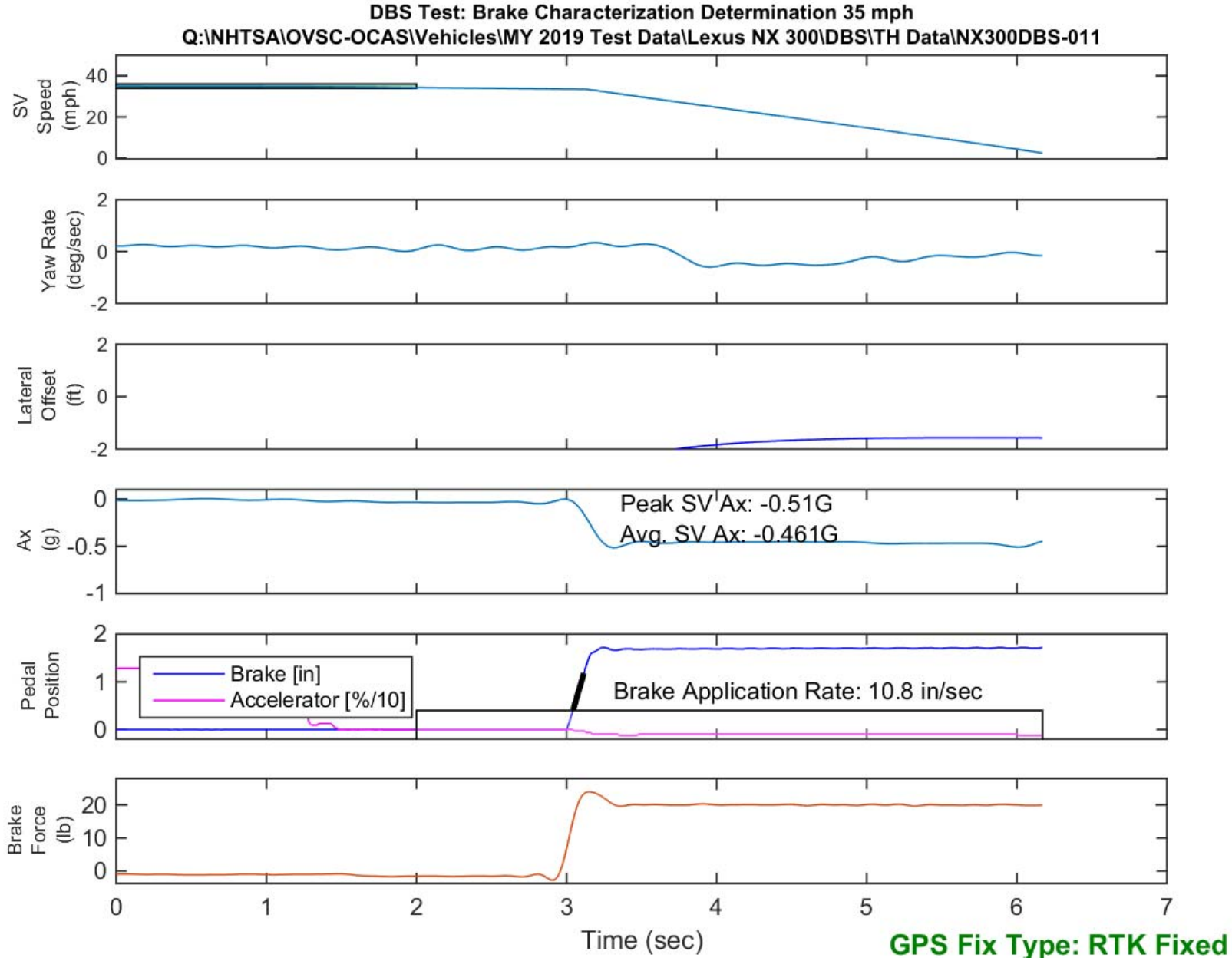


Figure E75. Time History for DBS Run 11, Brake Characterization Determination 35 mph

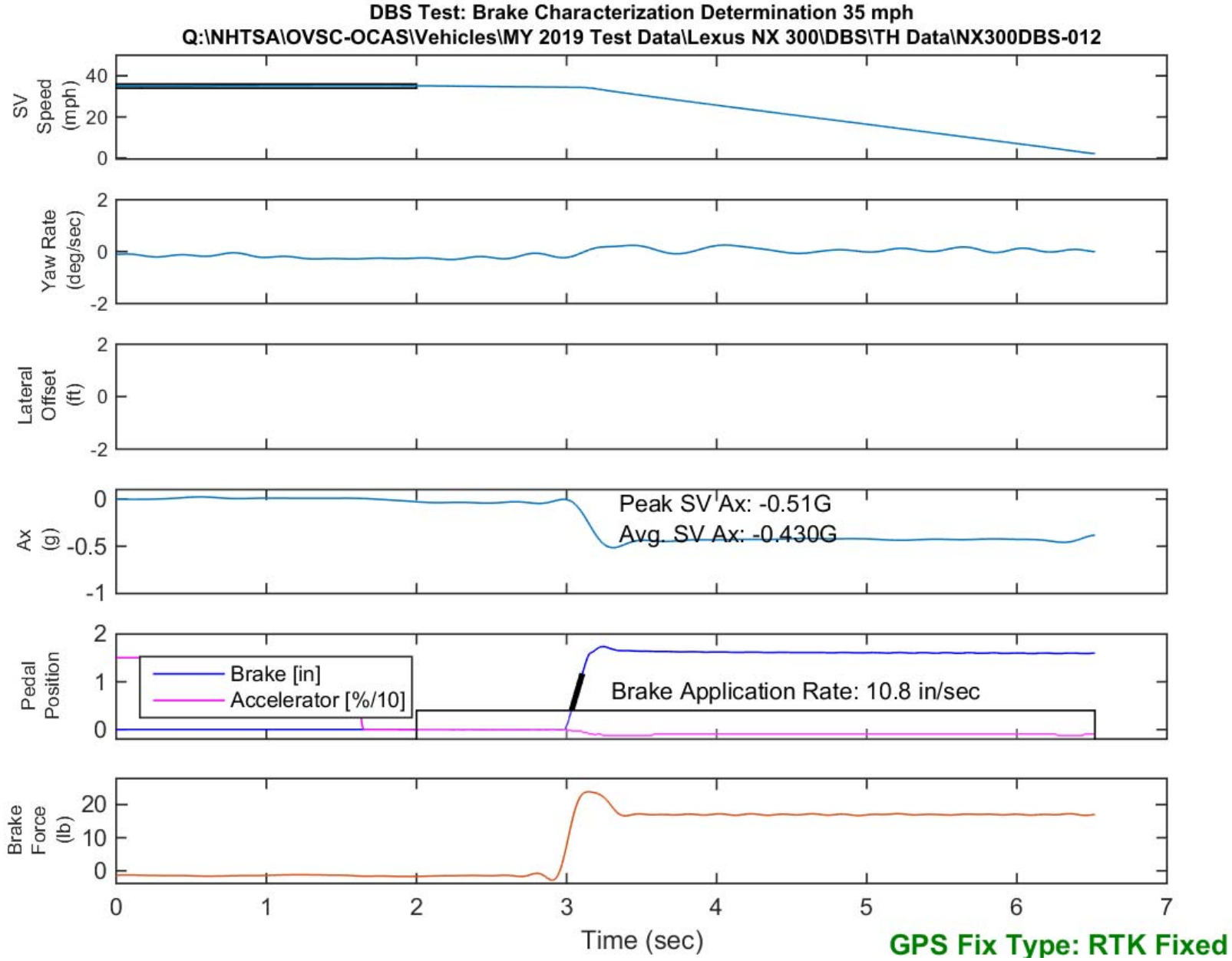


Figure E76. Time History for DBS Run 12, Brake Characterization Determination 35 mph

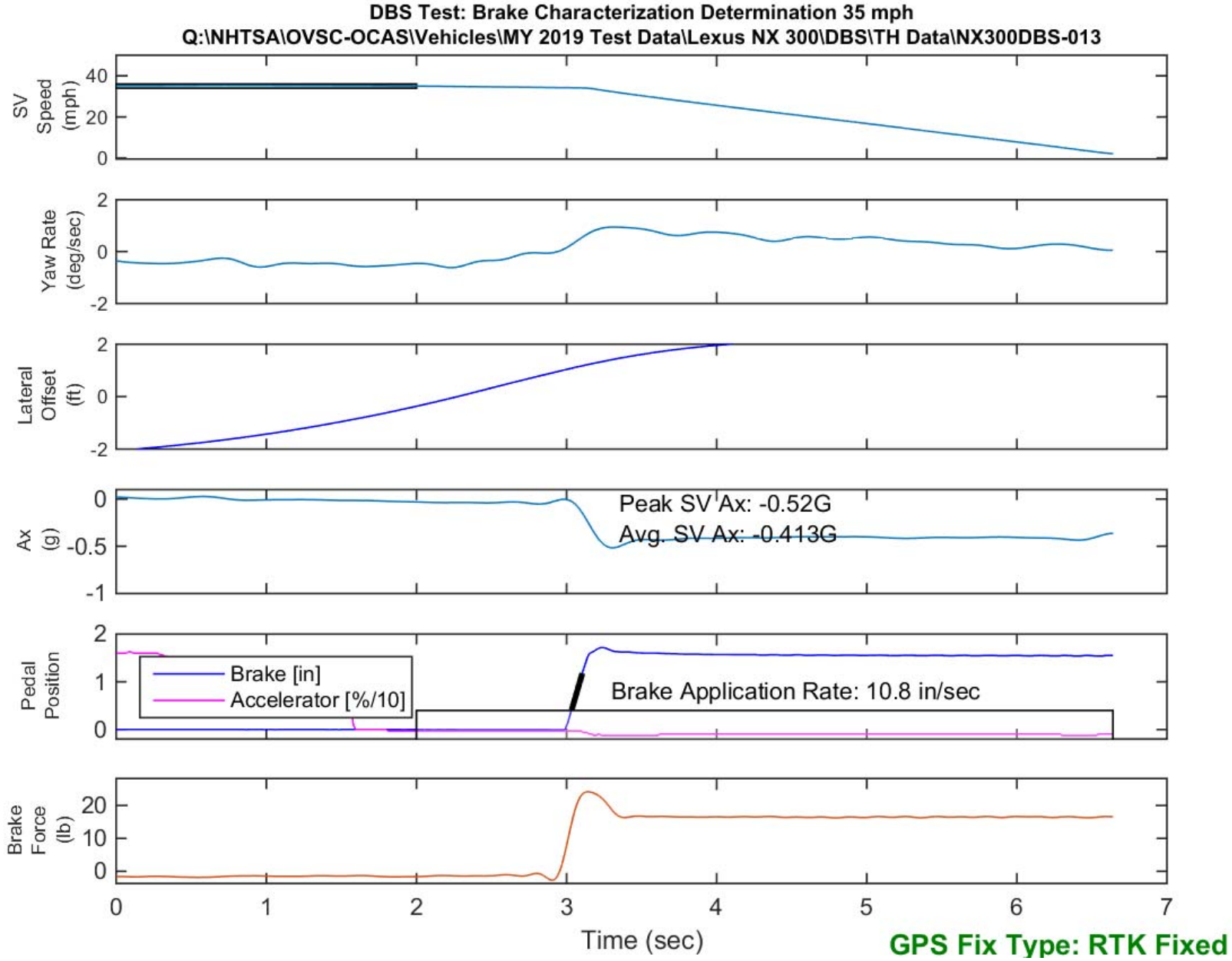


Figure E77. Time History for DBS Run 13, Brake Characterization Determination 35 mph

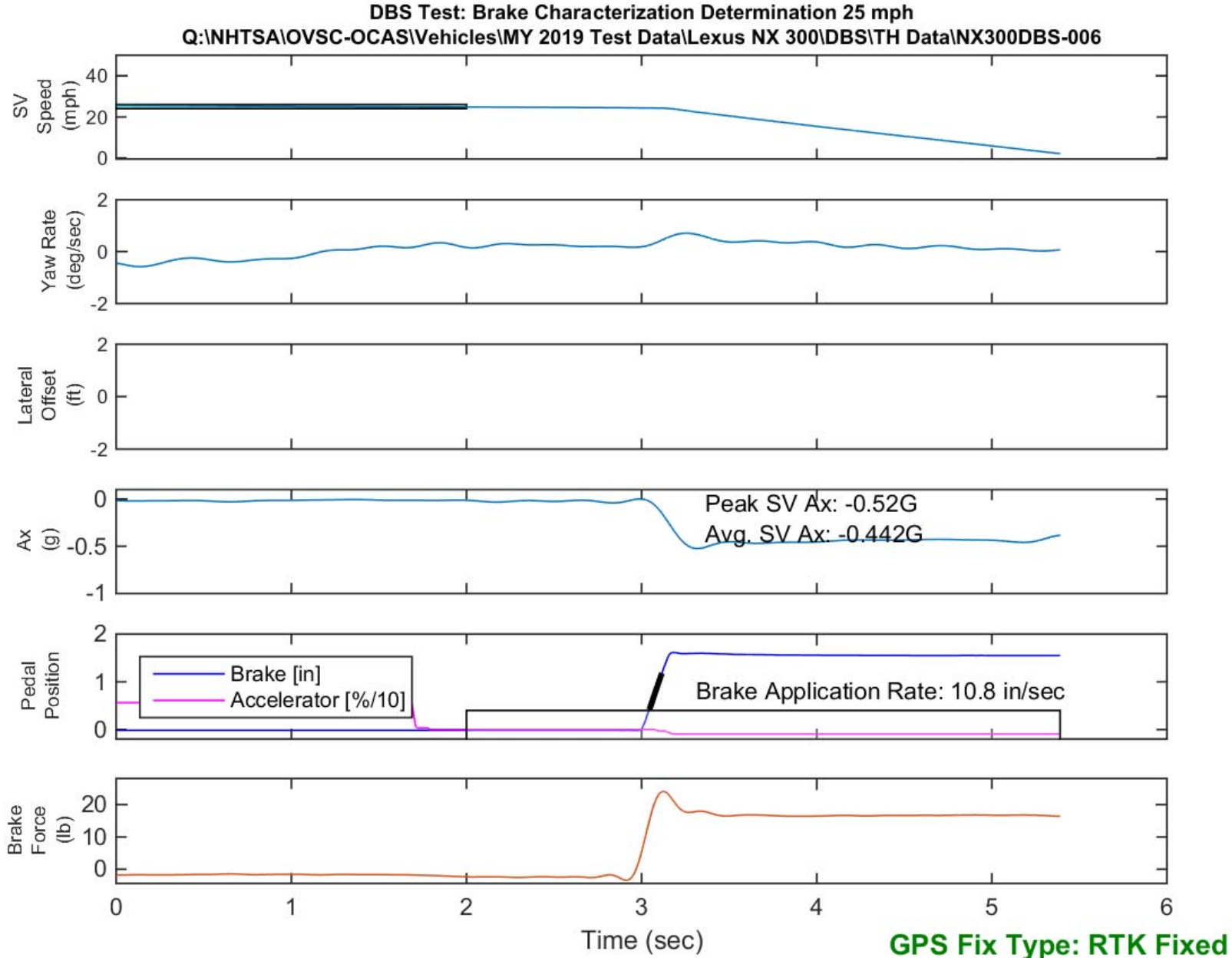


Figure E78. Time History for DBS Run 6, Brake Characterization Determination 25 mph

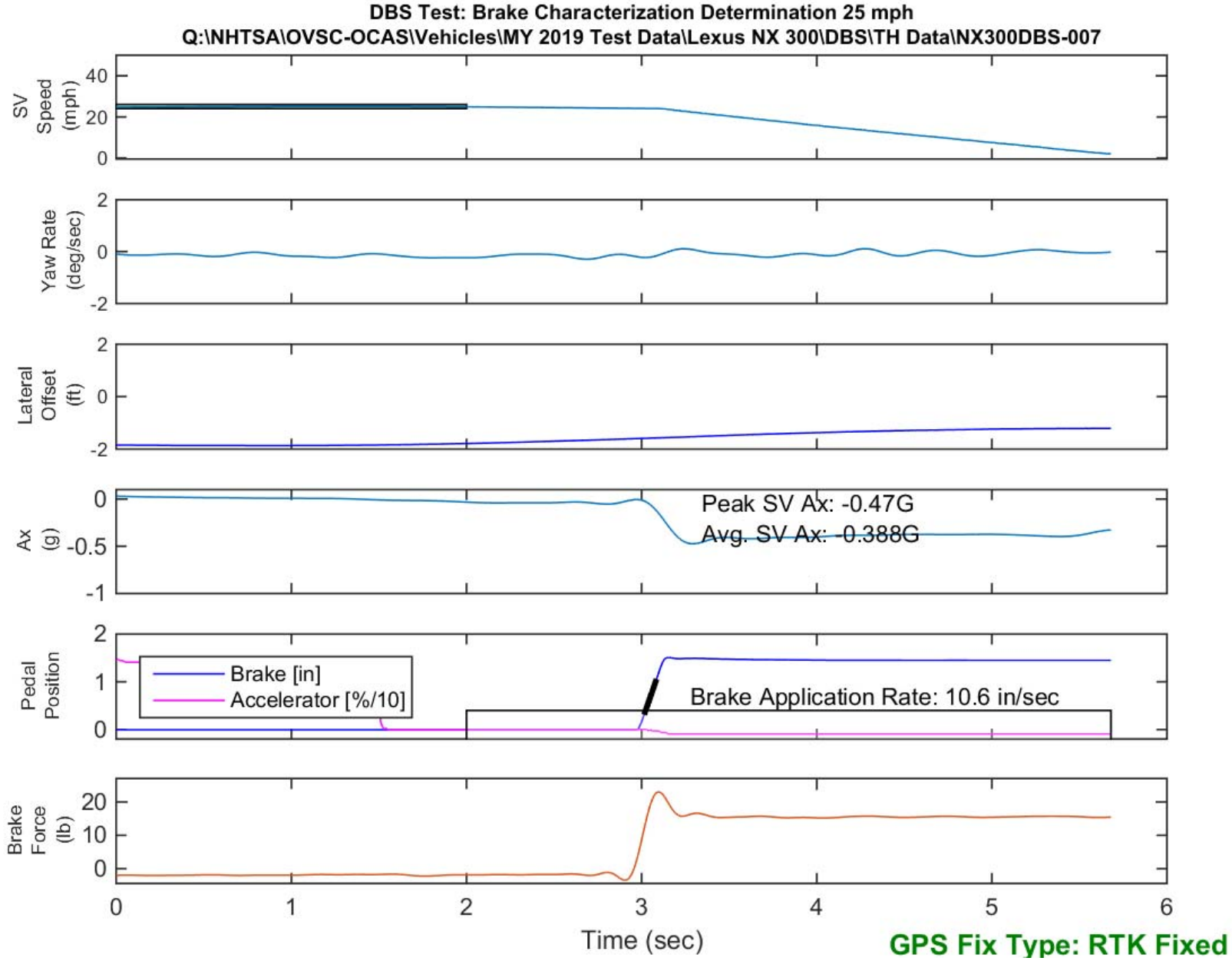


Figure E79. Time History for DBS Run 7, Brake Characterization Determination 25 mph

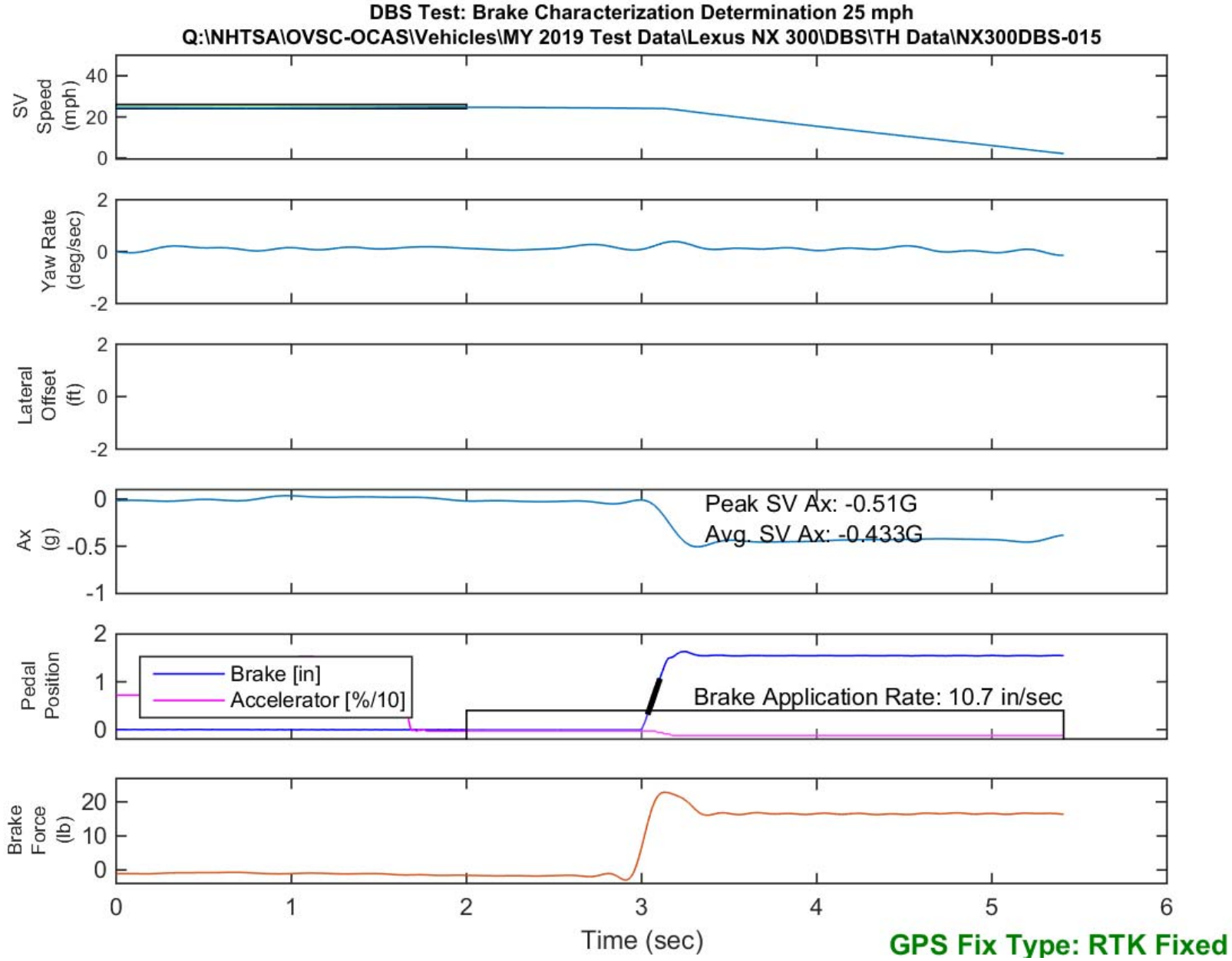


Figure E80. Time History for DBS Run 15, Brake Characterization Determination 25 mph

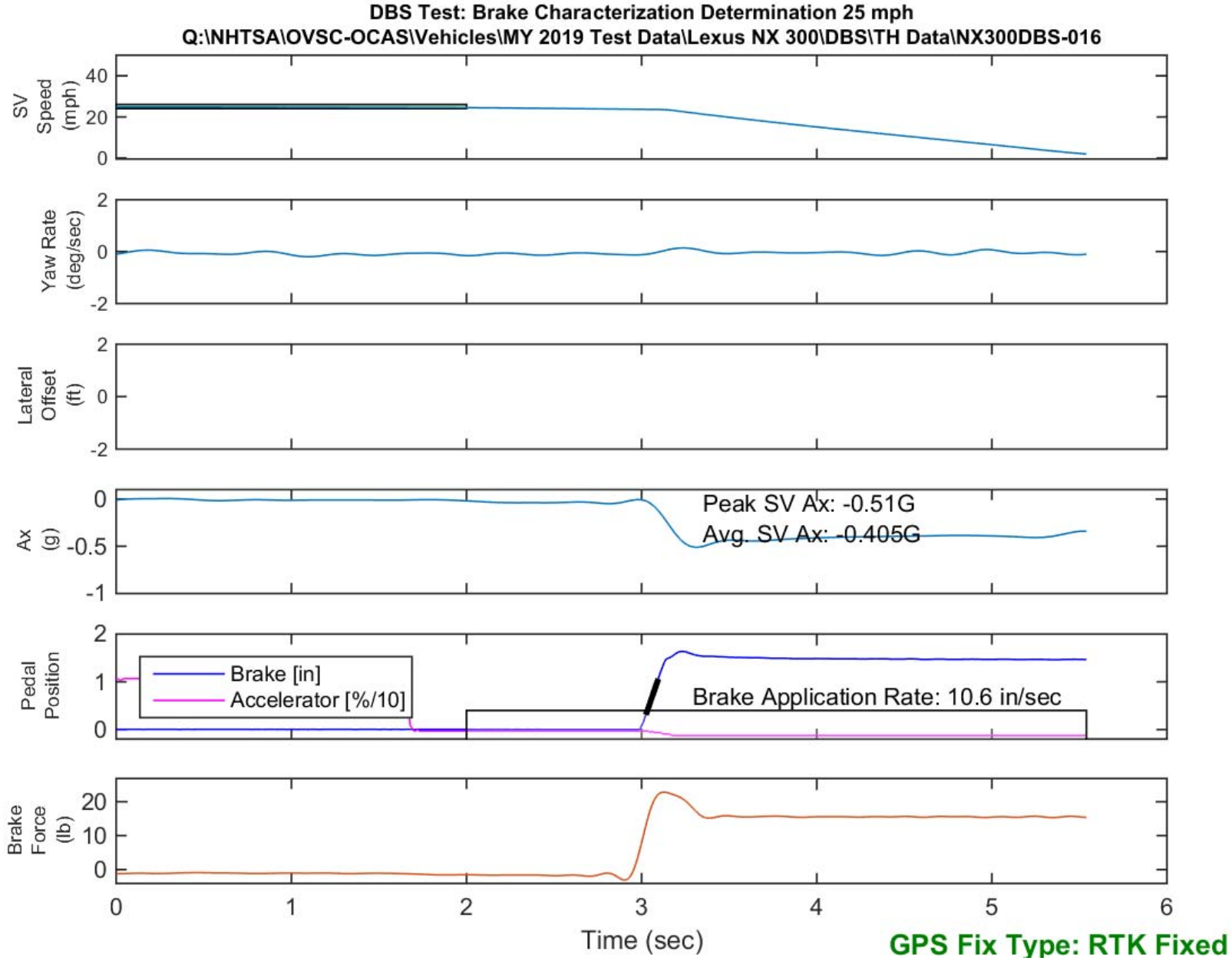


Figure E81. Time History for DBS Run 16, Brake Characterization Determination 25 mph

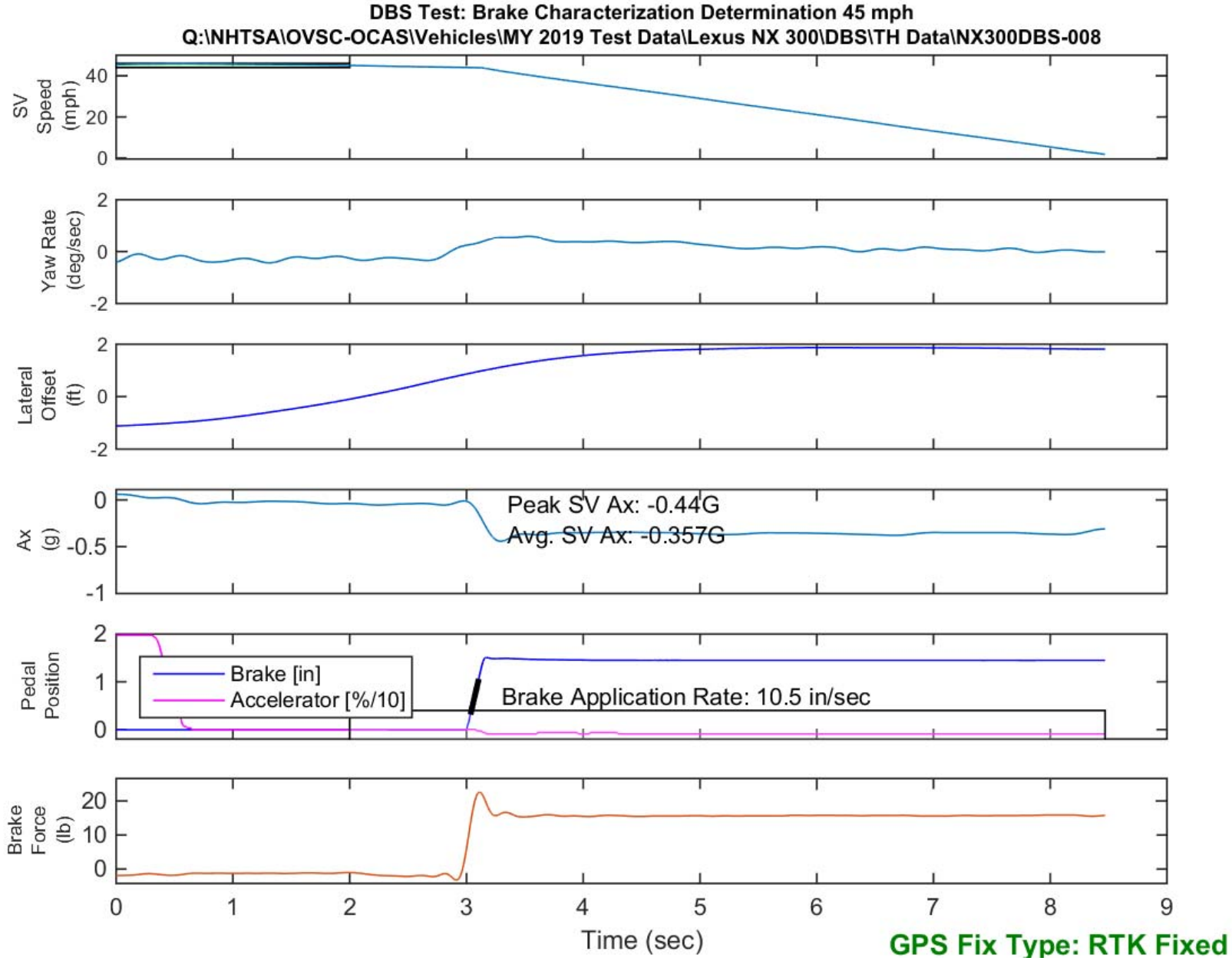


Figure E82. Time History for DBS Run 8, Brake Characterization Determination 45 mph

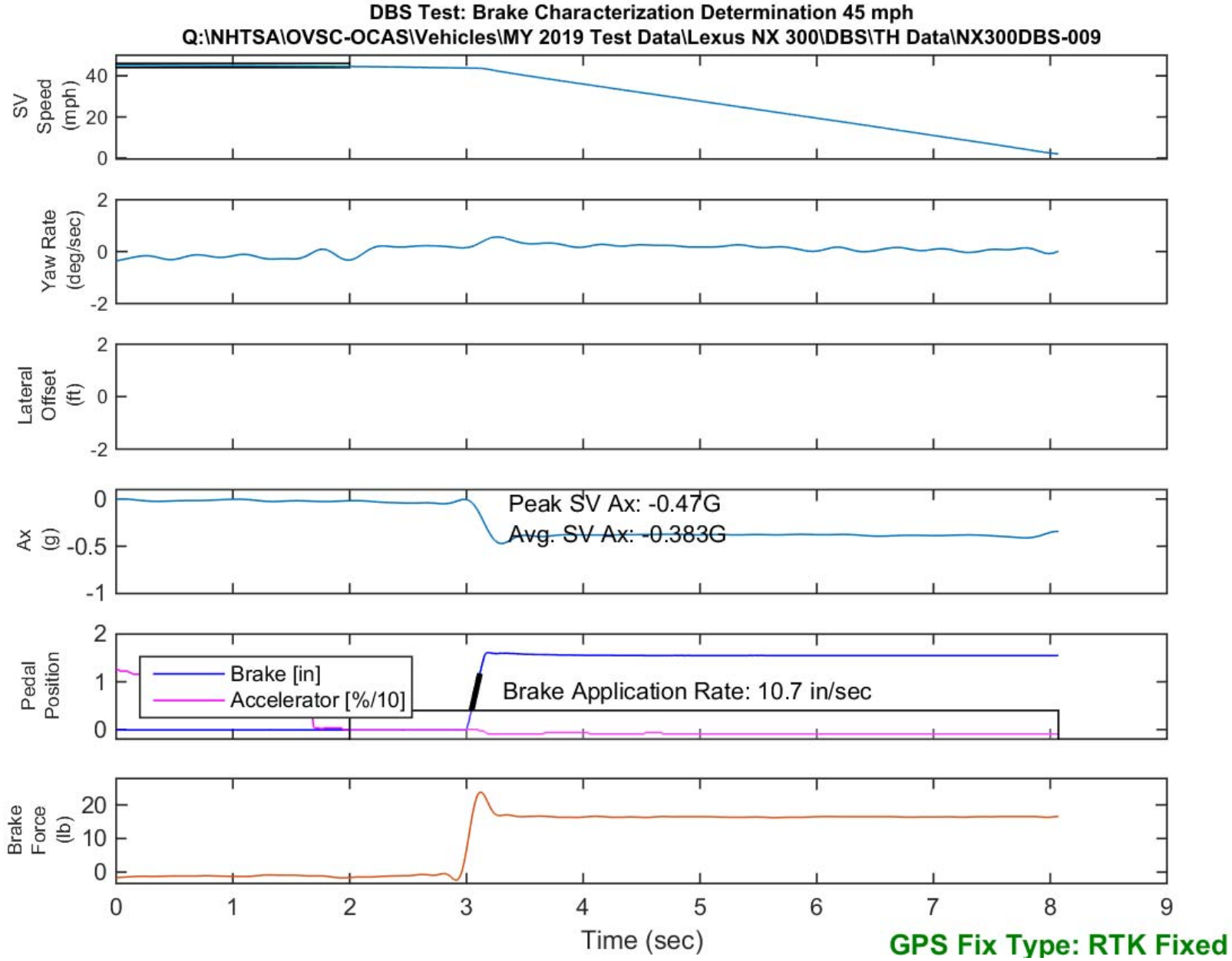


Figure E83. Time History for DBS Run 9, Brake Characterization Determination 45 mph

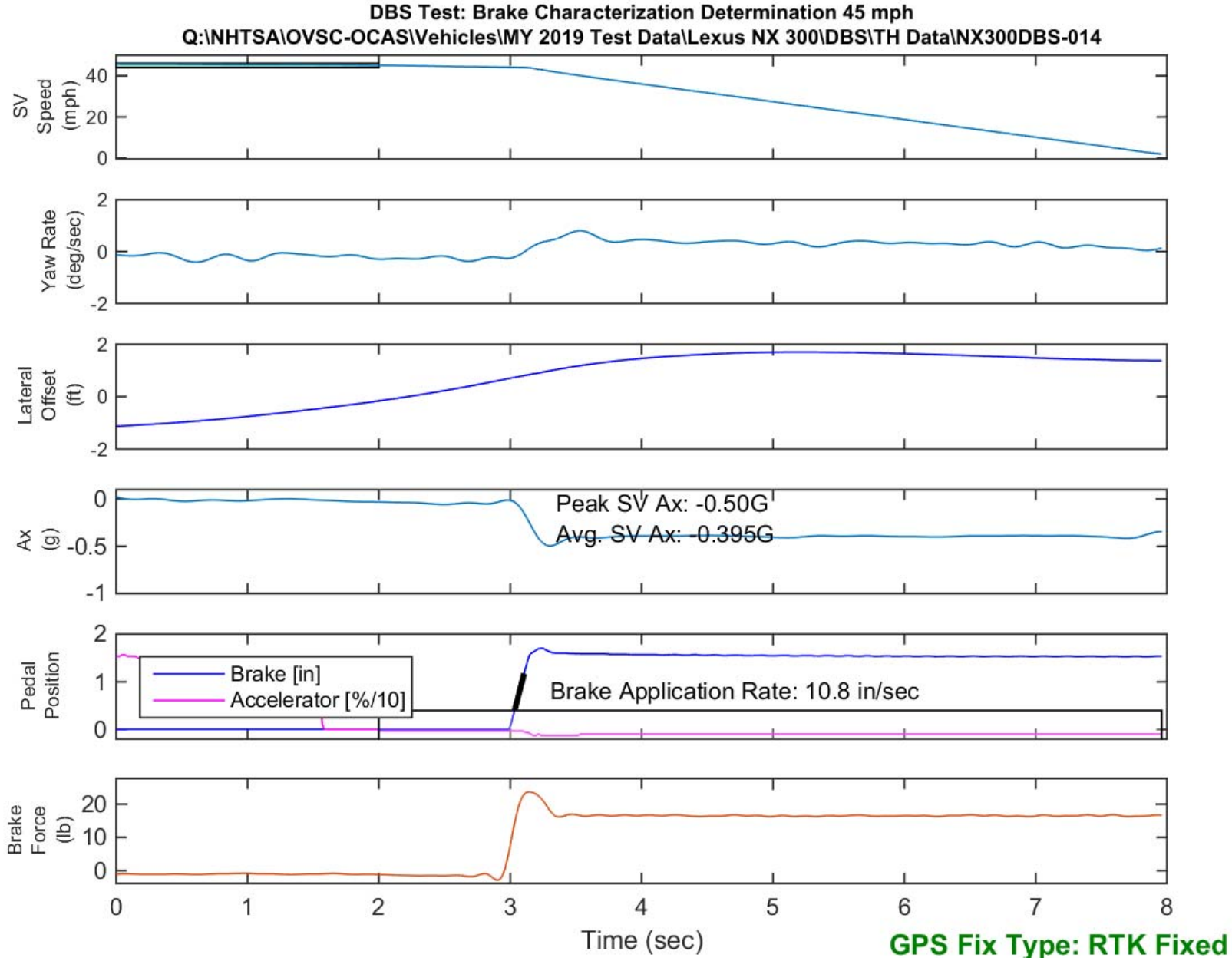


Figure E84. Time History for DBS Run 14, Brake Characterization Determination 45 mph