OCAS-DRI-FCW-18-04
NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST

2018 Mazda Mazda3

DYNAMIC RESEARCH, INC.
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25 July 2018

Final Report

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

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-200)
Washington, DC 20590

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Date: 25 July 2018

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16. Abstract These tests were conducted on the subject 2018 Mazda Mazda3 in accordance with the specifications of the Office of Crash Avoidance Standards most current Test Procedure in docket NHTSA-2006-26555 to confirm the performance of a forward collision warning system. The vehicle passed the requirements of the test for all three FCW test scenarios.			
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Section I
INTRODUCTION

This test evaluates the ability of a forward collision warning (FCW) system to detect and alert drivers to potential hazards in the path of the vehicle as specified in the New Car Assessment Program "Forward Collision Warning Confirmation", February 2013. Three driving scenarios are utilized to assess this technology. In the first test, a subject vehicle (SV) approaches a stopped principle other vehicle (POV) in the same lane of travel. The second test begins with the SV initially following the POV at the same constant speed. After a short while, the POV stops suddenly. The third test consists of the SV, traveling at a constant speed, approaching a slower moving POV, which is also being driven at a constant speed.

Section II
DATA SHEETS

FORWARD COLLISION WARNING

DATA SHEET 1: TEST SUMMARY

2018 Mazda Mazda3

VIN: *3MZBN1M39JM1xxxx*

Test Date: *12/11/2017*

Forward Collision Warning setting: *Distance: Far, Volume: High*

Test 1 -	Subject Vehicle Encounters Stopped Principal Other Vehicle:	***Pass***
Test 2 -	Subject Vehicle Encounters Decelerating Principal Other Vehicle:	***Pass***
Test 3 -	Subject Vehicle Encounters Slower Principal Other Vehicle:	***Pass***

Overall: ***Pass***

Notes:

FORWARD COLLISION WARNING

DATA SHEET 2: VEHICLE DATA

(Page 1 of 2)

2018 Mazda Mazda3

TEST VEHICLE INFORMATION

VIN: *3MZBN1M39JM1xxxx*

Body Style: *Hatchback* Color: *Red*

Date Received: *12/6/2017* Odometer Reading: *217 mi*

Engine: *2.5 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: *Mazda Motor Manufacturing De Mexico*

Date of manufacture: *09/17*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *215/45 R18*

Rear: *215/45 R18*

Recommended cold tire pressure: Front: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

FORWARD COLLISION WARNING

DATA SHEET 2: VEHICLE DATA

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2018 Mazda Mazda3

TIRES

Tire manufacturer and model: *Dunlop SP Sport 5000*

Front tire size: *215/45 R18*

Rear tire size: *215/45 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.

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS (Page 1 of 2)

2018 Mazda Mazda3

GENERAL INFORMATION

Test date: *12/11/2017*

AMBIENT CONDITIONS

Air temperature: *17.2 C (63 F)*

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

X Wind speed ≤ 10 m/s (22 mph)

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS (Page 2 of 2)

2018 Mazda Mazda3

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*473.6 kg (1044 lb)*	Right Front	*440.4 kg (971 lb)*
Left Rear	*321.1 kg (708 lb)*	Right Rear	*303.5 kg (669 lb)*
		Total:	*1538.6 kg (3392 lb)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 4)

2018 Mazda Mazda3

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.

The FCW system for this vehicle provides both visual and audible alerts. The audible alert was a series of beeps centered around 2000 Hz. The visual alert was displayed on the HUD with the word "Brake!" flashing the color red.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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Is the vehicle equipped with a switch whose purpose is to render FCW inoperable?

X Yes

____ No

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

Using the menu buttons in the center console area or the touch screen of the display, the driver can go to "Settings" then select "Safety" then select "Distance Recognition Support System" then uncheck "System."

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

X Yes

____ No

If yes please provide a full description

Using the menu buttons in the center console area or the touch screen of the display, the driver can go to "Settings" then select "Safety" then select "Distance Recognition Support System." The operator then has the options to turn the system off, set the warning distance, and set the warning volume.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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2018 Mazda Mazda3

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

If yes please provide a full description.

In the following cases, the Forward Sensing Camera (FSC) cannot detect target objects correctly, and each system may be unable to operate normally.

- *The height of the vehicle ahead is low.*
- *You drive your vehicle at the same speed as the vehicle ahead.*
- *Headlights are not turned on during the night or when going through a tunnel.*

In the following cases, the Forward Sensing Camera (FSC) may not be able to detect target objects correctly.

- *Under bad weather condition, such as rain, fog and snow.*
- *The window washer is being used or the windshield wipers are not used when it's raining.*
- *Ice, fog, snow, frost, rainfall, dirt, or foreign matter such as a plastic bag is stuck on the windshield.*
- *Trucks with low loading platforms and vehicles with an extremely low or high profile.*
- *When driving next to walls with no patterning (including fences and longitudinally striped walls).*
- *The taillights of the vehicle ahead are turned off.*
- *A vehicle is outside the illumination range of the headlights.*
- *The vehicle is making a sharp turn, or ascending or descending a steep slope.*
- *Entering or exiting a tunnel.*
- *Heavy luggage is loaded causing the vehicle to tilt.*
- *Strong light is shone at the front of the vehicle (back light or high-beam light from on-coming vehicles).*
- *There are many light emitters on the vehicle ahead.*
- *When the vehicle ahead is not equipped with taillights or the taillights are turned off at nighttime.*
- *Elongated luggage or cargo is loaded onto installed roof rails and covers the Forward Sensing Camera (FSC).*
- *Exhaust gas from the vehicle in front, sand, snow, and water vapor rising from manholes and grating, and water splashed into the air.*

- *When towing a malfunctioning vehicle.*
- *The vehicle is driven with tires having significantly different wear.*
- *The vehicle is driven on down slopes or bumpy roads.*
- *There are water puddles on the road.*
- *The surroundings are dark such as during the night, early evening, or early morning, or in a tunnel or indoor parking lot.*
- *The illumination brightness of the headlights is reduced or the headlight illumination is weakened due to dirt or a deviated optical axis.*
- *The target object enters the blind spot of the Forward Sensing Camera (FSC).*
- *A person or object bursts onto the road from the shoulder or cuts right in front of you.*
- *You change lanes and approach a vehicle ahead.*
- *When driving extremely close to the target object.*
- *Tire chains or a temporary spare tire is installed.*
- *The vehicle ahead has a special shape. For example, a vehicle towing a trailer house or a boat, or a vehicle carrier carrying a vehicle with its front pointed rearward.*

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Three test procedures were used, as follows:

Test 1. Subject Vehicle (SV) Encounters Stopped Principal Other Vehicle (POV) on a Straight Road
Test 2. Subject Vehicle Encounters Decelerating Principal Other Vehicle
Test 3. Subject Vehicle Encounters Slower Principal Other Vehicle

With the exception of trials associated with Test 1, all trials were performed with SV and POV 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. Except for Test 2, the brake lights of the POV were not illuminated.

In order to pass the test, if the FCW system provides a warning timing adjustment for the driver, at least one setting must meet the criterion of the test procedure. Therefore, if the vehicle was equipped with a warning timing adjustment, only the most "conservative" (earliest warning) setting was tested.

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 FCW function to detect a stopped lead vehicle, as depicted in Figure 1.

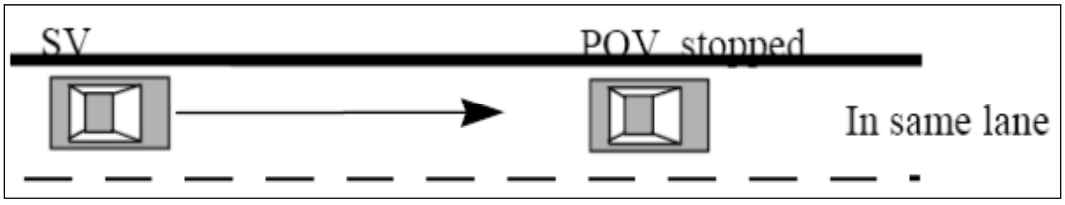

Figure 1. Depiction of Test 1

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when the time-to-collision (TTC) is at least 2.1 seconds. (Note: TTC values were computed in accordance with Ref 1). The TTC for this test was calculated by considering the speeds of the subject vehicle (SV) and the lead vehicle (POV) at the time of the FCW alert (i.e., when the SV and POV speeds are nominally equal to 45 and 0 mph (72.4 and 0 kph), respectively).

b. 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 the SV approaches the rear of the POV.

The SV was driven at a nominal speed of 45 mph (72.4 kph) in the center of the lane of travel, toward the parked POV. The test began when the SV was 492 ft (150 m) from the POV and ended when either of the following occurred:

- The required FCW alert occurred.
- The TTC to the POV fell to less than 90 percent of the minimum allowable range (i.e., TTC = 1.9 sec) for the onset of the required FCW alert.

The SV driver then steered and/or braked to keep the SV from striking the POV.

For an individual test trial to be valid, the following was required throughout the test:

- The SV vehicle speed could not deviate from the nominal speed by more than 1.0 mph (1.6 kph) for a period of three seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90 percent of the minimum allowable range for onset of the required FCW alert.
- The SV driver could not apply any force to the brake pedal before the required FCW alert occurred, or before the range fell to less than 90 percent of the minimum allowable range for onset of the required FCW alert.

- The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, could not exceed 2.0 ft (0.6 m).

- The yaw rate of the SV could not exceed ±1 deg/sec during the test.

Nominally, the Test 1 series was comprised of seven individual trials. The FCW system must satisfy the TTC alert criteria for at least five of the seven test trials.

2. TEST 2 – SUBJECT VEHICLE ENCOUNTERS DECELERATING PRINCIPAL OTHER VEHICLE

The SV in this test initially followed the POV at a constant time gap, and then the POV suddenly decelerated, as depicted in Figure 2. The test evaluates the ability of the FCW to recognize a decelerating lead vehicle and to issue an alert to SV driver in a timely manner.

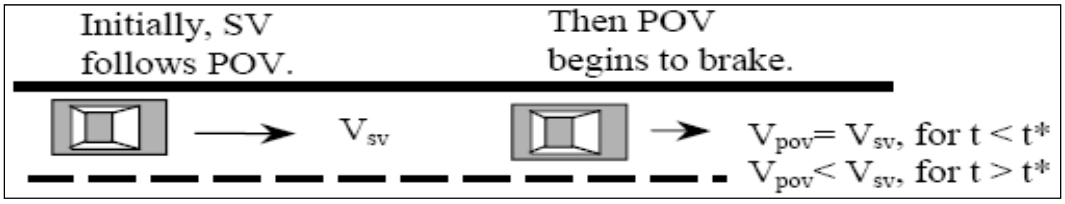

Figure 2. Depiction of Test 2

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when TTC is at least 2.4 seconds. The TTC for this test, a prediction of the time it would take for the SV to collide with the POV, was calculated by considering three factors at the time of the FCW alert: (1) the speed of the SV, (2) the speed of the POV, and (3) the deceleration of the POV[1].

[1]To simplify calculation of the TTC for Test 2, the deceleration of the POV is assumed to remain constant from the time of the FCW alert until the POV comes to a stop (i.e., a "constant" rate of slowing is assumed).

b. Procedure

Test 2 began with the SV and the POV traveling on a straight, flat road at a constant speed of 45.0 mph (72.4 kph), in the center of the lane of travel. The headway from the SV to the POV was nominally maintained at 98.4 ft (30 m) until the POV braking was initiated.

The test began approximately 7 seconds before the driver of the POV started a braking maneuver in which the POV brakes were rapidly applied and modulated such that a constant deceleration of 0.3 g was achieved within 1.5 seconds after braking is initiated. The test ended when either of the following conditions was satisfied:

- The required FCW alert occurred.
- The TTC to the POV fell to less than 90% of the minimum allowable range (i.e., TTC = 2.2 sec) for the onset of the required FCW alert.

The SV driver then steered and/or braked to keep the SV from striking the POV.

For an individual test trial to be valid, the following was required throughout the test:

- The initial POV vehicle speed could not deviate from the nominal speed by more than 1.0 mph (1.6 kph) for a period of 3 seconds prior to the initiation of POV braking.
- The speed of the SV could not deviate from the nominal speed by more than 1.0 mph (1.6 kph) for a period of 3 seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90 percent of the minimum allowable range for onset of the required FCW alert.
- The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, could not exceed 2.0 ft (0.6 m).
- The yaw rates of the SV and POV could not exceed ±1 deg/sec during the test.

- The POV deceleration level was nominally required to be 0.3 g within 1.5 seconds after initiation of POV braking. The acceptable error magnitude of the POV deceleration was ±0.03g, measured at the time the FCW alert first occurred. An initial overshoot beyond the deceleration target was acceptable, however the first local deceleration peak observed during an individual trial could not exceed 0.375 g for more than 50 ms. Additionally, the deceleration could not exceed 0.33 g over a period defined from (1) 500 ms after the first local deceleration peak occurs, to (2) the time when the FCW alert first occurred.

- The tolerance for the headway from the SV to the POV was ±8.2 ft (±2.5 m), measured at two instants in time: (1) three seconds prior to the time the POV brake application was initiated, and (2) at the time the POV brake application was initiated.

- SV driver could not apply any force to the brake pedal before the required FCW alert occurred, or before the range fell to less than 90 percent of the minimum allowable range for onset of the required FCW alert.

Nominally, the Test 2 series was comprised of seven individual trials. The FCW system must satisfy the TTC alert criteria for at least five of the seven test trials.

3. TEST 3 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE

This test examines the ability of the FCW system to recognize a slower lead vehicle being driven with a constant speed and issue a timely alert. As depicted in Figure 3, the scenario was conducted with a closing speed equal to 25.0 mph (40.2 kph).

Figure 3. Depiction of Test 3

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when TTC is at least 2.0 seconds. The TTC for this test, a prediction of the time it would take for the SV to collide with the POV, was calculated by considering the speeds of the SV and POV at the time of the FCW alert.

b. Procedure

Throughout the test, the POV was driven at a constant 20.0 mph (32.2 kph) in the center of the lane of travel.

The SV was driven at 45.0 mph (72.4 kph), in the center lane of travel, toward the slow-moving POV.

The test began when the headway from the SV to the POV was 329 ft (100 m) and ended when either of the following occurred:

- The required FCW alert occurred.
- The TTC to the POV fell to less than 90% of the minimum allowable range (i.e., TTC = 1.8 sec) for the onset of the required FCW alert.

The SV driver then steered and/or braked to keep the SV from striking the POV.

For an individual test trial to be valid, the following was required throughout the test:

- The SV vehicle speed could not deviate from the nominal speed by more than 1.0 mph (1.6 kph) for a period of 3 seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90 percent of the minimum allowable range for onset of the required FCW alert.
- Speed of the POV could not deviate from the nominal speed by more than 1.0 mph (1.6 kph) during the test.
- The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, could not exceed 2.0 ft (0.6 m).

- The yaw rates of the SV and POV could not exceed ±1 deg/sec during the test.

- SV driver could not apply any force to the brake pedal before the required FCW alert occurred, or before the range fell to less than 90 percent of the minimum allowable range for onset of the required FCW alert.

Nominally, the Test 3 series was comprised of seven individual trials. The FCW system must satisfy the TTC alert criteria for at least five of the seven test trials.

B. Principal Other Vehicle

The vehicle used as the Principal Other Vehicle (POV) was a 2000 Honda Accord. This satisfied the test requirement of Ref 1 that the POV be a mid-size sedan. The vehicle had a rear license plate in order to provide a suitable representative radar profile. Vehicle loading consisted of the driver plus equipment and instrumentation.

C. Automatic Braking System

The POV was equipped with an automatic braking system, which was used in Test 2. The braking system consisted of the following components:

- High pressure nitrogen bottle, strapped to the front passenger seat, with regulator and pressure gauges.
- Pneumatic piston-type actuator, with solenoid valve
- "Pickle" switch to activate brakes

D. Instrumentation

Table 1 lists the sensors, signal conditioning and data acquisition equipment used for these tests.

TABLE 1. 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	0.5 psi 3.45 kPa	Ashcroft, D1005PS	1039350	By: DRI Date: 12/13/2016 Due: 12/13/2017
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	±1.0% of applied load	Intercomp, SWII	1110M206352	By: DRI Date: 12/13/2016 Due: 12/13/2017
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±100 m/s^2 Angular Rate: ±100 deg/s Angular Disp: ±180 deg	Position: ±2 cm Velocity: 0.05 km/h Accel: ≤ 0.01% of full range Angular Rate: ≤ 0.01% of full range Roll/Pitch Angle: ±0.03 deg Heading Angle: ±0.1 deg	Oxford Technical Solutions (OXTS), Inertial+		By: Oxford Technical Solutions
					2182	Date: 1/14/2016 Due: 1/14/2018
					2176	Date: 3/9/2016 Due: 3/9/2018
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

TABLE 1. TEST INSTRUMENTATION AND EQUIPMENT (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
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
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: 1/17/2017 Due: 1/17/2018

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

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 signals types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 2.

Table 2. Audible and Tactile Warning Filter Parameters

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

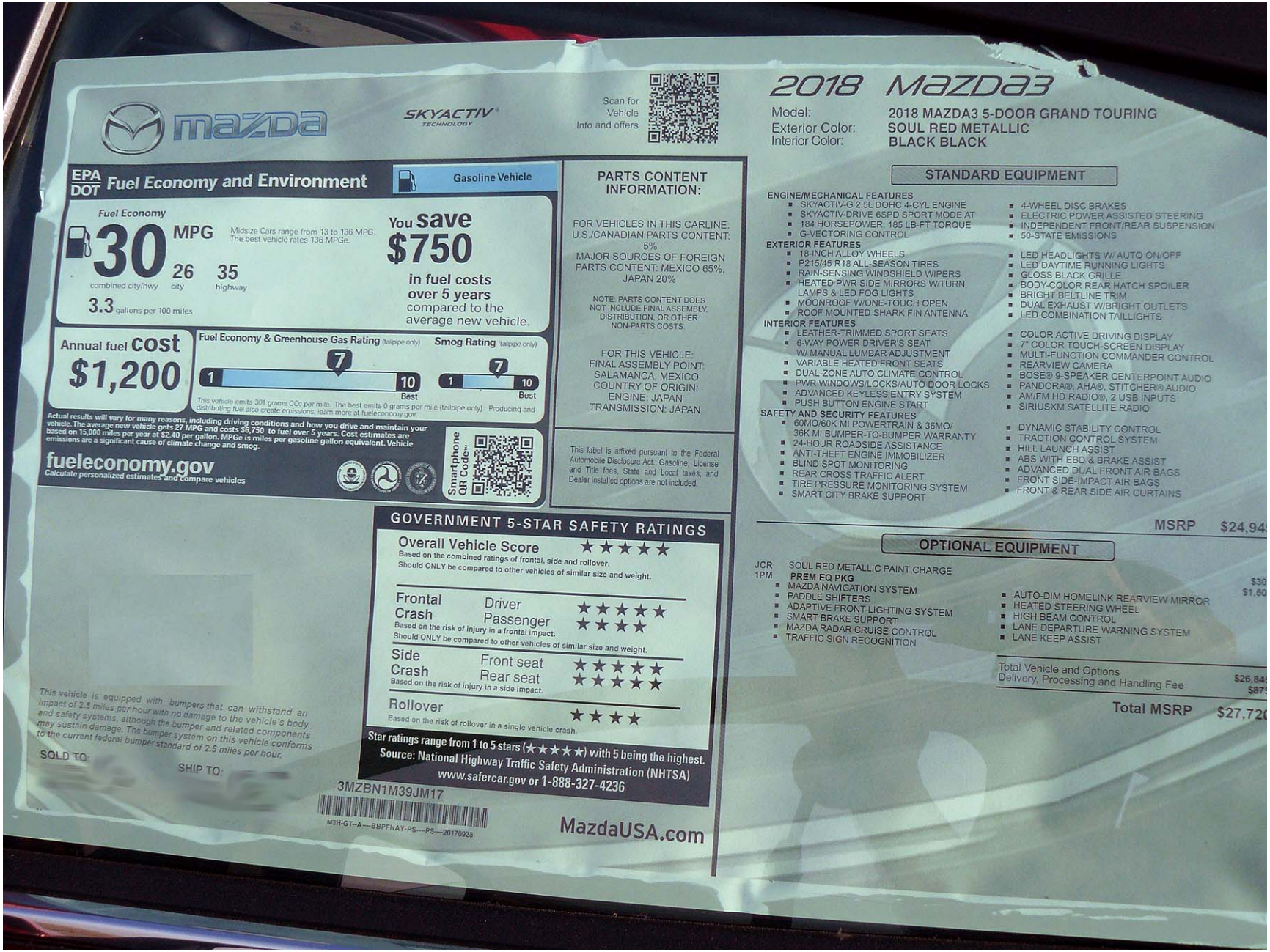

Figure A3. Window Sticker (Monroney Label)

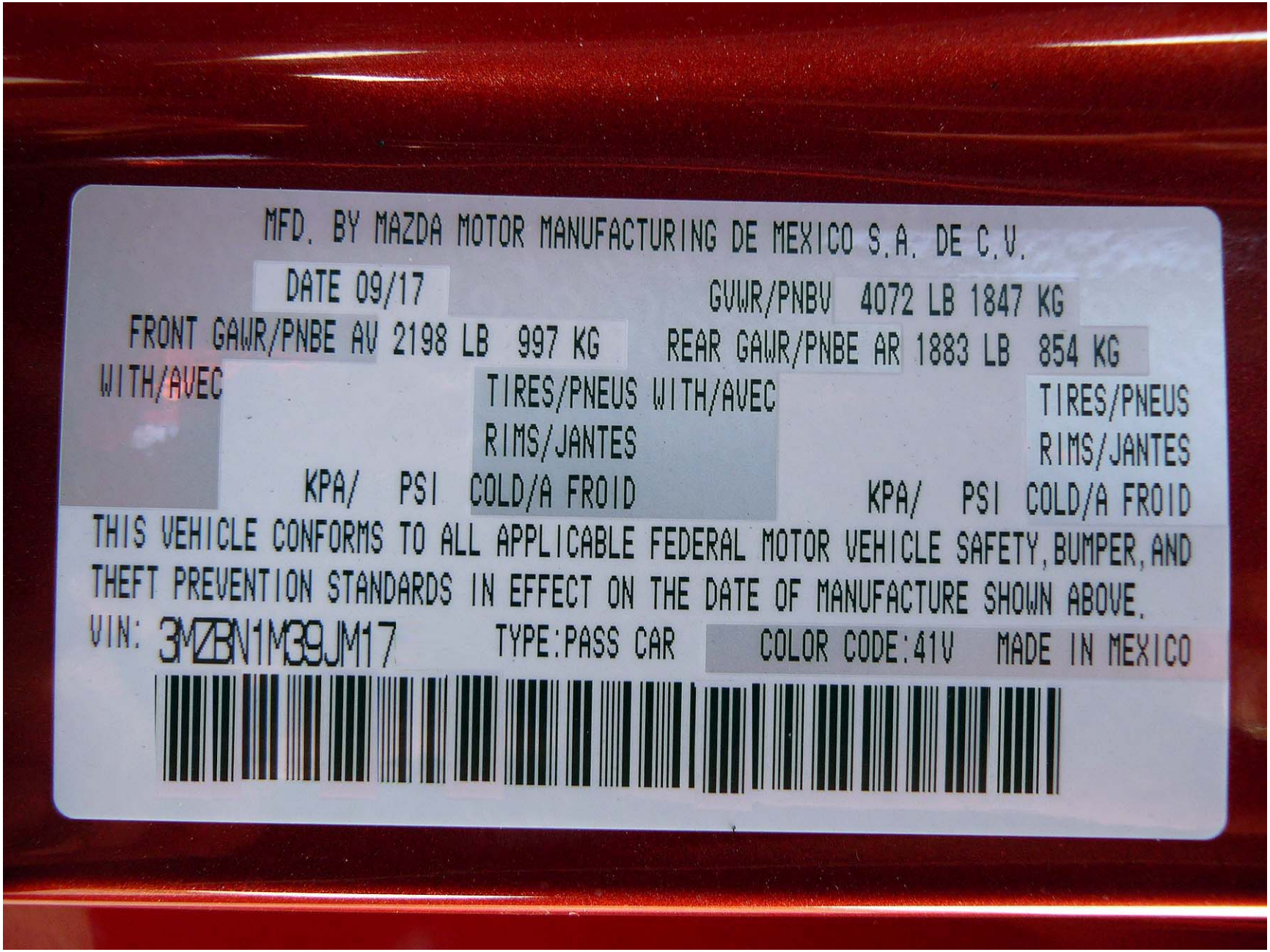

Figure A4. Vehicle Certification Label

Figure A5. Front View of Principal Other Vehicle

Figure A6. Rear View of Principal Other Vehicle

Figure A7. DGPS, Inertial Measurement Unit and MicroAutoBox Installed in Subject Vehicle

Figure A8. Computer Installed in Subject Vehicle

Figure A9. Sensor for Detecting Auditory and Visual Alerts

Figure A10. Brake Actuation System Installed in Principal Other Vehicle

Figure A11. FCW Visual Alert

Figure A12. FCW System Setting Menus

APPENDIX B

Excerpts from Owner's Manual

Seat Belt Precautions

Seat belts help to decrease the possibility of severe injury during accidents and sudden stops. Mazda recommends that the driver and all passengers always wear seat belts.

(Except Mexico)
All of the seat belt retractors are designed to keep the lap/shoulder belts out of the way when not in use.
The driver's seat belt has no provisions for child-restraint systems and has only an emergency locking mode. The driver may wear it comfortably, and it will lock during a collision.
However, the front passenger's seat and all rear lap/shoulder belt retractors operate in two modes: emergency locking mode, and for child-restraint systems, automatic locking mode. While we recommend you put all children in the rear seats, if you must use the front passenger seat for a child, slide the front passenger seat as far back as possible and make sure any child-restraint system is secured properly.

(Mexico)
All the seats have lap/shoulder belts. These belts have retractors with inertia locks that keep them out of the way when not in use. The locks allow the belts to remain comfortable on users, but they will lock in position during a collision.

⚠ WARNING

Always wear your seat belt and make sure all occupants are properly restrained:
Not wearing a seat belt is extremely dangerous. During a collision, occupants not wearing seat belts could hit someone or things inside the vehicle or even be thrown out of the vehicle. They could be seriously injured or even killed. In the same collision, occupants wearing seat belts would be much safer.

Do not wear twisted seat belts:
Twisted seat belts are dangerous. In a collision, the full width of the belt is not available to absorb the impact. This puts more force on the bones beneath the belt, which could cause serious injury or death. So, if your seat belt is twisted, you must straighten the seat belt to remove any twists and to allow the full width of the belt to be used.

Never use one seat belt on more than one person at a time:
Using one seat belt for more than one person at a time is dangerous. A seat belt used in this way cannot spread the impact forces properly and the two passengers could be crushed together and seriously injured or even killed. Never use one belt for more than one person at a time and always operate the vehicle with each occupant properly restrained.

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Child-Restraint System Installation

▼ Categories of Child-Restraint Systems

NOTE
When purchasing, ask the manufacturer of the child-restraint system which type of child-restraint system is appropriate for your child and vehicle.

(Mexico)
Child-restraint systems are classified into the following 5 groups according to the UNECE 44 regulation.

Group	Age	Weight
0	Up to about 9 months old	Up to 10 kg (up to 22 lb)
0+	Up to about 2 years old	Up to 13 kg (up to 29 lb)
1	About 8 months to 4 years old	9 kg — 18 kg (20 lb — 40 lb)
2	About 3 to 7 years old	15 kg — 25 kg (33 lb — 55 lb)
3	About 6 to 12 years old	22 kg — 36 kg (48 lb — 79 lb)

(Except Mexico)
Please comply with the legal regulations concerning the use of child-restraint systems in your country.

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Child-Restraint System Suitability for Various Seat Positions Table

(Mexico)

Provided information in the table shows your child-restraint system suitability for various seating position. For installation suitability of other manufacturer child-restraint system, carefully consult the manufacturer's instructions which accompany the child-restraint system.

When installing a child-restraint system, the following points must be observed:

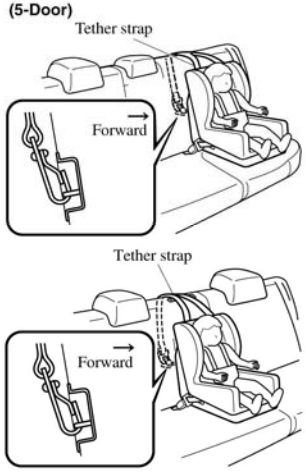
- If the child-restraint system does not fit into the seatback because of the head restraint, adjust the head restraint or remove the head restraint so that the child-restraint system fits into the seatback. However, when installing a backless booster seat, always install the vehicle head restraint to the seat where the backless booster seat is installed.
  Refer to Head Restraints on page 2-10.
- When installing a child-restraint system to the rear seat, adjust the front seat position so that the front seat does not contact the child-restraint system.
  Refer to Seat Operation on page 2-5.
- When installing a child-restraint system came equipped with a tether, remove the head restraint.
  Refer to Head Restraints on page 2-10.

LATCH lower anchor-secured child-restraint systems

When installing a child-restraint system to the rear seat, refer to the child-restraint system manufacturer's instructions and the Using LATCH Lower Anchor on page 2-40.

Mass group	Size Class	Fixture	Seat Positions		
			Vehicle LATCH positions	Rear seat (center)	Front passenger seat (outboard)
			Rear seat (outboard)		
Carrycot	F	ISO/L1	X	X	X
	G	ISO/L2	X	X	X
		(1)	X	X	X
GROUP 0 Up to 10 kg (up to 22 lb)	E	ISO/R1	IL	X	X
		(1)	X	X	X
GROUP 0+ Up to 13 kg (up to 29 lb)	E	ISO/R1	IL	X	X
	D	ISO/R2	IL	X	X
	C	ISO/R3	IL	X	X
		(1)	X	X	X

(5-Door)



Always install the head restraint and adjust it to the appropriate position after removing the child-restraint system:
Driving with the head restraint removed is dangerous as impact to the occupant's head cannot be prevented during emergency braking or in a collision, which could result in a serious accident, injury or death.
Refer to Head Restraints on page 2-10.

▼ Using Automatic Locking Mode*

Follow these instructions when using a child-restraint system, unless you are attaching a LATCH-equipped child-restraint system to the rear LATCH lower anchors. Refer to "Using LATCH Lower Anchor" (page 2-40).

NOTE
Follow the child-restraint system manufacturer's instructions carefully. If you are not sure whether you have a LATCH system or tether, check in the child-restraint system manufacturer's instructions and follow them accordingly. Depending on the type of child-restraint system, it may use LATCH system instead of seat belts or if the belt goes across the child's chest, may recommend against using automatic locking mode.

1. Make sure the seatback is securely latched by pushing it back until it is fully locked.
2. Remove the head restraint. However, when installing a backless booster seat, always install the vehicle head restraint to the seat where the backless booster seat is installed.
   Refer to Head Restraints on page 2-10.
3. Secure the child-restraint system with the lap portion of the lap/shoulder belt. See the manufacturer's instructions on the child-restraint system for belt routing instructions.

*Some models.

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▼ Pre-Crash Safety Technology

Pre-crash safety technology is designed to assist the driver in averting collisions or reduce their severity in situations where they cannot be avoided.

Collision damage reduction in low vehicle speed range

Forward driving

Smart City Brake Support (SCBS)..... page 4-124

Collision damage reduction in medium/high speed range

Smart Brake Support (SBS).....page 4-128

▼ Camera and Sensors

Forward Sensing Camera (FSC)

The Forward Sensing Camera (FSC) detects lane indications and recognizes headlights, taillights and city lights during nighttime driving. In addition, it also detects the vehicle ahead, pedestrians, or obstructions. The following systems also use the Forward Sensing Camera (FSC).

- High Beam Control system (HBC)
- Lane-keep Assist System (LAS) & Lane Departure Warning System (LDWS)
- Traffic Sign Recognition System (TSR)
- Smart City Brake Support (SCBS)
- Smart Brake Support (SBS)

The Forward Sensing Camera (FSC) is installed at the top of the windshield near the rearview mirror.
Refer to Forward Sensing Camera (FSC) on page 4-131.

Radar sensor (front)

The radar sensor (front) functions by detecting the radio waves reflected off a vehicle ahead sent from the radar sensor. The following systems also use the radar sensor (front).

- Mazda Radar Cruise Control (MRCC)
- Distance Recognition Support System (DRSS)
- Smart Brake Support (SBS)

The radar sensor (front) is mounted behind the radiator grille.
Refer to Radar Sensor (Front) on page 4-136.

Smart Brake Support (SBS)*

The SBS system alerts the driver of a possible collision using a display and warning sound if the radar sensor (front) and the Forward Sensing Camera (FSC) determine that there is the possibility of a collision with a vehicle ahead while the vehicle is being driven at about 15 km/h or faster (10 mph or faster). Furthermore, if the radar sensor (front) and the Forward Sensing Camera (FSC) determines that a collision is unavoidable, the automatic brake control is performed to reduce damage in the event of a collision.
In addition, when the driver depresses the brake pedal, the brakes are applied firmly and quickly to assist. (Brake Assist (SBS brake assist))

⚠ WARNING

Do not rely completely on the SBS system and always drive carefully:
The SBS is designed to reduce damage in the event of a collision, not avoid an accident. The ability to detect an obstruction is limited depending on the obstruction, weather conditions, or traffic conditions. Therefore, if the accelerator pedal or brake pedal is mistakenly operated it could result in an accident. Always verify the safety of the surrounding area and depress the brake pedal or accelerator pedal while keeping a safer distance from vehicles ahead or on-coming vehicles.

⚠ CAUTION

In the following cases, turn the system off to prevent a mis-operation:

- *The vehicle is being towed or when towing another vehicle.*
- *The vehicle is on a chassis roller.*
- *When driving on rough roads such as in areas of dense grass or off-road.*

NOTE

- *The SBS system operates when all of the following conditions are met:*
  - *The ignition is switched ON.*
  - *The SBS system is on.*
  - *The vehicle speed is about 15 km/h or faster (10 mph or faster).*
  - *The relative speed between your vehicle and the vehicle ahead is about 15 km/h or faster (10 mph or faster).*
  - *The Dynamic Stability Control (DSC) is not operating.*

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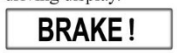
- *The SBS system may not operate under the following conditions:*
  - *If the vehicle is accelerated rapidly and it comes close to a vehicle ahead.*
  - *The vehicle is driven at the same speed as the vehicle ahead.*
  - *The accelerator pedal is depressed.*
  - *The brake pedal is depressed.*
  - *The steering wheel is being operated.*
  - *The selector lever is being operated.*
  - *The turn signal is being used.*
  - *When the vehicle ahead is not equipped with taillights or the taillights are turned off.*
  - *When warnings and messages, such as a dirty windshield, related to the Forward Sensing Camera (FSC) are being displayed in the center display.*
- *Although the objects which activate the system are four-wheeled vehicles, the radar sensor (front) could detect the following objects, determine them to be an obstruction, and operate the SBS system.*
  - *Objects on the road at the entrance to a curve (including guardrails and snow banks).*
  - *A vehicle appears in the opposite lane while cornering or rounding a curve.*
  - *When crossing a narrow bridge.*
  - *When passing under a low gate or through a tunnel or narrow gate.*
  - *When entering an underground parking area.*
  - *Metal objects, bumps, or protruding objects on the road.*
  - *If you suddenly come close to a vehicle ahead.*
  - *When driving in areas where there is high grass or forage.*
  - *Two-wheeled vehicles such as motorbikes or bicycles.*
  - *Pedestrians or non-metallic objects such as standing trees.*
- *When the system operates, the user is notified by the active driving display.*
- *The SBS warning indication (amber) turns on when the system has a malfunction. Refer to Warning Lights on page 4-24.*

▼ Smart Brake Support (SBS) Indicator Light (Red)

If the SBS is operating, the indicator light (red) flashes.

▼ Collision Warning

If there is the possibility of a collision with a vehicle ahead, the beep sounds continuously and a warning is indicated in the active driving display.



▼ Stopping The Smart Brake Support (SBS) System Operation

The SBS system can be temporarily deactivated.
Refer to Personalization Features on page 9-12.
When the SBS system is turned off, the SBS OFF indicator light turns on.

When the engine is restarted, the system becomes operational.

NOTE
If the SBS system operation is turned off, the Smart City Brake Support (SCBS) system operation is turned off simultaneously.

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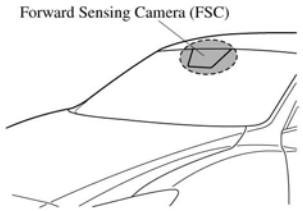
Forward Sensing Camera (FSC)

Your vehicle is equipped with a Forward Sensing Camera (FSC). The Forward Sensing Camera (FSC) is positioned near the rearview mirror and used by the following systems.

- High Beam Control System (HBC)
- Lane-keep Assist System (LAS) & Lane Departure Warning System (LDWS)
- Traffic Sign Recognition System (TSR)
- Smart City Brake Support (SCBS)
- Smart Brake Support (SBS)



The Forward Sensing Camera (FSC) determines the conditions ahead of the vehicle while traveling at night and detects traffic lanes. The distance in which the Forward Sensing Camera (FSC) can detect objects varies depending on the surrounding conditions.

⚠ WARNING

Do not modify the suspension:
If the vehicle height or inclination is changed, the system will not be able to correctly detect vehicles ahead. This will result in the system not operating normally or mistakenly operating, which could cause a serious accident.

⚠ CAUTION

➢ *Do not apply accessories, stickers or film to the windshield near the Forward Sensing Camera (FSC).*
If the area in front of the Forward Sensing Camera (FSC) lens is obstructed, it will cause the system to not operate correctly. Consequently, each system may not operate normally which could lead to an unexpected accident.

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- *Do not disassemble or modify the Forward Sensing Camera (FSC).*
  Disassembly or modification of the Forward Sensing Camera (FSC) will cause a malfunction or mistaken operation. Consequently, each system may not operate normally which could lead to an unexpected accident.
- *Heed the following cautions to assure the correct operation of the Forward Sensing Camera (FSC).*
  - *Be careful not to scratch the Forward Sensing Camera (FSC) lens or allow it to get dirty.*
  - *Do not remove the Forward Sensing Camera (FSC) cover.*
  - *Do not place objects on the dashboard which reflect light.*
  - *Always keep the windshield glass around the camera clean by removing dirt or fogging. Use the windshield defroster to remove fogging on the windshield.*
  - *Consult an Authorized Mazda Dealer regarding cleaning the interior side of the windshield around the Forward Sensing Camera (FSC).*
  - *Consult an Authorized Mazda Dealer before performing repairs around the Forward Sensing Camera (FSC).*
  - *The Forward Sensing Camera (FSC) is installed to the windshield. Consult an Authorized Mazda Dealer for windshield repair and replacement.*
  - *When cleaning the windshield, do not allow glass cleaners or similar cleaning fluids to get on the Forward Sensing Camera (FSC) lens. In addition, do not touch the Forward Sensing Camera (FSC) lens.*
  - *When performing repairs around the rearview mirror, consult an Authorized Mazda Dealer.*
  - *Consult an Authorized Mazda Dealer regarding cleaning of the camera lens.*
  - *Do not hit or apply strong force to the Forward Sensing Camera (FSC) or the area around it. If the Forward Sensing Camera (FSC) is severely hit or if there are cracks or damage caused by flying gravel or debris in the area around it, stop using the following systems and consult an Authorized Mazda Dealer.*
    - *High Beam Control System (HBC)*
    - *Lane-keep Assist System (LAS) & Lane Departure Warning System (LDWS)*
    - *Traffic Sign Recognition System (TSR)*
    - *Smart City Brake Support (SCBS)*
    - *Smart Brake Support (SBS)*
  - *The direction in which the Forward Sensing Camera (FSC) is pointed has been finely adjusted. Do not change the installation position of the Forward Sensing Camera (FSC) or remove it. Otherwise, it could result in damage or malfunction.*
- *Always use tires for all wheels that are of the specified size, and the same manufacturer, brand, and tread pattern. In addition, do not use tires with significantly different wear patterns on the same vehicle as the system may not operate normally.*

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➢ *The Forward Sensing Camera (FSC) includes a function for detecting a soiled windshield and informing the driver, however, depending on the conditions, it may not detect plastic shopping bags, ice or snow on the windshield. In such cases, the system cannot accurately determine a vehicle ahead and may not be able to operate normally. Always drive carefully and pay attention to the road ahead.*

NOTE

- *In the following cases, the Forward Sensing Camera (FSC) cannot detect target objects correctly, and each system may be unable to operate normally.*
  - *The height of the vehicle ahead is low.*
  - *You drive your vehicle at the same speed as the vehicle ahead.*
  - *Headlights are not turned on during the night or when going through a tunnel.*
- *In the following cases, the Forward Sensing Camera (FSC) may not be able to detect target objects correctly.*
  - *Under bad weather condition, such as rain, fog and snow.*
  - *The window washer is being used or the windshield wipers are not used when it's raining.*
  - *Ice, fog, snow, frost, rainfall, dirt, or foreign matter such as a plastic bag is stuck on the windshield.*
  - *Trucks with low loading platforms and vehicles with an extremely low or high profile.*
  - *When driving next to walls with no patterning (including fences and longitudinally striped walls).*
  - *The taillights of the vehicle ahead are turned off.*
  - *A vehicle is outside the illumination range of the headlights.*
  - *The vehicle is making a sharp turn, or ascending or descending a steep slope.*
  - *Entering or exiting a tunnel.*
  - *Heavy luggage is loaded causing the vehicle to tilt.*
  - *Strong light is shone at the front of the vehicle (back light or high-beam light from on-coming vehicles).*
  - *There are many light emitters on the vehicle ahead.*
  - *When the vehicle ahead is not equipped with taillights or the taillights are turned off at nighttime.*
  - *Elongated luggage or cargo is loaded onto installed roof rails and covers the Forward Sensing Camera (FSC).*
  - *Exhaust gas from the vehicle in front, sand, snow, and water vapor rising from manholes and grating, and water splashed into the air.*
  - *When towing a malfunctioning vehicle.*
  - *The vehicle is driven with tires having significantly different wear.*
  - *The vehicle is driven on down slopes or bumpy roads.*
  - *There are water puddles on the road.*

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- *The surroundings are dark such as during the night, early evening, or early morning, or in a tunnel or indoor parking lot.*
- *The illumination brightness of the headlights is reduced or the headlight illumination is weakened due to dirt or a deviated optical axis.*
- *The target object enters the blind spot of the Forward Sensing Camera (FSC).*
- *A person or object bursts onto the road from the shoulder or cuts right in front of you.*
- *You change lanes and approach a vehicle ahead.*
- *When driving extremely close to the target object.*
- *Tire chains or a temporary spare tire is installed.*
- *The vehicle ahead has a special shape. For example, a vehicle towing a trailer house or a boat, or a vehicle carrier carrying a vehicle with its front pointed rearward.*

- *If the Forward Sensing Camera (FSC) cannot operate normally due to backlight or fog, the system functions related to the Forward Sensing Camera (FSC) are temporarily stopped and the following warning lights turn on. However, this does not indicate a malfunction.*
  - *High Beam Control System (HBC) warning light (amber)*
  - *Lane-keep Assist System (LAS) & Lane Departure Warning System (LDWS) warning light*
  - *Smart Brake Support/Smart City Brake Support (SBS/SCBS) warning light (amber)*
- *If the Forward Sensing Camera (FSC) cannot operate normally due to high temperatures, the system functions related to the Forward Sensing Camera (FSC) are temporarily stopped and the following warning lights turn on. However, this does not indicate a malfunction. Cool down the area around the Forward Sensing Camera (FSC) such as by turning on the air conditioner.*
  - *High Beam Control System (HBC) warning light (amber)*
  - *Lane-keep Assist System (LAS) & Lane Departure Warning System (LDWS) warning light*
  - *Smart Brake Support/Smart City Brake Support (SBS/SCBS) warning light (amber)*
- *If the Forward Sensing Camera (FSC) detects that the windshield is dirty or foggy, the system functions related to the Forward Sensing Camera (FSC) are temporarily stopped and the following warning lights turn on. However, this does not indicate a problem. Remove the dirt from the windshield or press the defroster switch and defog the windshield.*
  - *High Beam Control System (HBC) warning light (amber)*
  - *Lane-keep Assist System (LAS) & Lane Departure Warning System (LDWS) warning light*
  - *Smart Brake Support/Smart City Brake Support (SBS/SCBS) warning light (amber)*

- *If there are recognizable cracks or damage caused by flying gravel or debris on the windshield, always have the windshield replaced. Consult an Authorized Mazda Dealer for replacement.*

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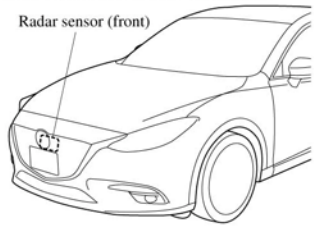
Radar Sensor (Front)

Your vehicle is equipped with a radar sensor (front).
The following systems also use the radar sensor (front).

- Distance Recognition Support System (DRSS)
- Mazda Radar Cruise Control (MRCC)
- Smart Brake Support (SBS)

The radar sensor (front) functions by detecting the radio waves reflected off a vehicle ahead or an obstruction sent from the radar sensor.
The radar sensor (front) is mounted behind the front emblem.



If the Smart Brake Support/Smart City Brake Support (SBS/SCBS) Warning Light (amber) is illuminated, the area around the radar sensor may be dirty. Refer to "Warning Guidance" in the center display (Type B audio).
Refer to If a Warning Light Turns On or Flashes on page 7-25.

⚠ CAUTION

Heed the following precautions to assure correct operation of each system.

- *Do not adhere stickers (including transparent stickers) to the surface of the radiator grille and front emblem in and around the radar sensor (front), and do not replace the radiator grille and front emblem with any product that is not a genuine product designed for use with the radar sensor (front).*
- *The radar sensor (front) includes a function for detecting soiling of the radar sensor's front surface and informing the driver, however, depending on the conditions, it may require time to detect or it may not detect plastic shopping bags, ice or snow. If this occurs, the system may not operate correctly, therefore always keep the radar sensor (front) clean.*
- *Do not install a grille guard.*
- *If the front part of the vehicle has been damaged in a vehicle accident, the position of the radar sensor (front) may have moved. Stop the system immediately and always have the vehicle inspected at an Authorized Mazda Dealer.*

- *Do not use the front bumper to push other vehicles or obstructions such as when pulling out of a parking space. Otherwise, the radar sensor (front) could be hit and its position deviated.*
- *Do not remove, disassemble, or modify the radar sensor (front).*
- *For repairs, replacement or paint work around the radar sensor (front), consult an Authorized Mazda Dealer.*
- *Do not modify the suspension. If the suspension are modified, the vehicle's posture could change and the radar sensor (front) may not be able to correctly detect a vehicle ahead or an obstruction.*

NOTE

- *Under the following conditions, the radar sensor (front) may not be able to detect vehicles ahead or obstructions correctly and each system may not operate normally.*
  - *The rear surface of a vehicle ahead does not reflect radio waves effectively, such as an unloaded trailer or an automobile with a loading platform covered by a soft top, vehicles with a hard plastic tailgate, and round-shaped vehicles.*
  - *Vehicles ahead with low vehicle height and thus less area for reflecting radio waves.*
  - *Visibility is reduced due to a vehicle ahead casting off water, snow, or sand from its tires and onto your windshield.*
  - *The trunk/luggage compartment is loaded with heavy objects or the rear passenger seats are occupied.*
  - *Ice, snow, or soiling is on the front surface of the front emblem.*
  - *During inclement weather such as rain, snow, or sand storms.*
  - *When driving near facilities or objects emitting strong radio waves.*
- *Under the following conditions, the radar sensor (front) may not be able to detect vehicles ahead or obstructions.*
  - *The beginning and end of a curve.*
  - *Roads with continuous curves.*
  - *Narrow lane roads due to road construction or lane closures.*
  - *The vehicle ahead enters the radar sensor's blind spot.*
  - *The vehicle ahead is running abnormally due to accident or vehicle damage.*
  - *Roads with repeated up and down slopes*
  - *Driving on poor roads or unpaved roads.*
  - *The distance between your vehicle and the vehicle ahead is extremely short.*
  - *A vehicle suddenly comes close such as by cutting into the lane.*
- *To prevent incorrect operation of the system, use tires of the same specified size, manufacturer, brand, and tread pattern on all four wheels. In addition, do not use tires with significantly different wear patterns or tire pressures on the same vehicle (Including the temporary spare tire).*
- *If the battery power is weak, the system may not operate correctly.*

- *If the vehicle is driven on a road with little traffic and few vehicles ahead or obstructions for the radar sensor (front) to detect, the sensor detects that the radar sensor (front) is dirty and the Smart Brake Support/Smart City Brake Support (SBS/SCBS) Warning Light (amber) may be temporarily turned on. However, it does not indicate a malfunction.*

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APPENDIX C

Run Log

Subject Vehicle: **2018 Mazda Mazda3** Date: 12/11/2017

Principal Other Vehicle: 2000 Honda Accord

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
1	Stopped POV	Y	3.02	See Notes	0.92	Pass	In comparison to the surrounding light from the speed display, the intensity of the visual alert was insufficiently distinct to be detected by the sensor.
2		Y	2.94		0.84	Pass	
3		Y	2.93		0.83	Pass	
4		Y	2.94		0.84	Pass	
5		Y	2.96		0.86	Pass	
6		Y	2.96		0.86	Pass	
7		Y	2.96		0.86	Pass	
8	Slower POV, 45 vs 20	Y	2.89		0.89	Pass	
9		N					SV Yaw Rate
10		Y	2.87		0.87	Pass	
11		Y	2.89		0.89	Pass	
12		Y	2.97		0.97	Pass	
13		Y	2.90		0.9	Pass	
14		Y	2.97		0.97	Pass	
15		Y	2.90		0.9	Pass	

Subject Vehicle: **2018 Mazda Mazda3** Date: 12/11/2017

Principal Other Vehicle: 2000 Honda Accord

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
16	Braking POV, 45	N					POV Brake
17		N					POV Speed
18		Y	2.90		0.50	Pass	
19		Y	3.03		0.63	Pass	
20		Y	2.91		0.51	Pass	
21		Y	2.93		0.53	Pass	
22		N					SV Acceleration
23		Y	3.00		0.60	Pass	
24		Y	2.88		0.48	Pass	
25		Y	2.96		0.56	Pass	

APPENDIX D

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 and the Principal Other Vehicle, 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 pertinent 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:

- FCW Test 1 – Stopped POV (SV at 45 mph)
- FCW Test 2 – Braking POV (Both vehicles at 45 mph with a 30 m gap, POV brakes at 0.3 g)
- FCW Test 3 – Slower Moving POV (SV at 45 mph, POV at 20 mph)

Time history figures include the following sub-plots:

- 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 of the following:
    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (e.g., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Light sensor signal
- TTC (sec) – indicates the Time to Collision as calculated up to the point of FCW alert issuance. The value of TTCW (Time to Collision at Warning) is given numerically on the right side of the figure. A passing value is indicated in green, while a failing value is indicated in red.
- SV Speed (mph) – speed of the Subject Vehicle

- POV Speed (mph) – speed of the Principal Other Vehicle
- Yaw Rate (deg/sec) – yaw rate of both the Subject Vehicle and Principal Other Vehicle
- Lateral Offset (ft) – lateral offset within the lane from the Subject Vehicle to the Principal Other Vehicle
- Ax (g) – Longitudinal acceleration of both the Subject Vehicle and Principal Other Vehicle
- Headway (ft) – Longitudinal separation between front of Subject Vehicle to rear of Principal Other Vehicle (Exclusive to test type 2)

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

Each of the time history plot figures can 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.

Green envelopes indicate that the time-varying data should 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.

Yellow envelopes indicate that the time-varying data should not exceed the envelope only at the left and/or right ends. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

For the warning plot, a dashed black threshold line indicates the threshold used to determine the onset of the FCW alert. The alert is considered on the first time the alert signal crosses this threshold line.

For the TTC plot, a dashed black threshold line indicates the minimum allowable TTC for the given test scenario. If the FCW alert occurs before this minimum allowable TTC, a green dot appears. However, if there is no alert or the alert occurs after the minimum allowable TTC, a red asterisk is shown on the plot.

For the Ax plot, a dashed black threshold line is given for at a value of -0.05 g. For a test run to be valid, the longitudinal acceleration of the Subject Vehicle must not fall below this threshold (i.e. the driver cannot apply any brakes). Additionally, for test type 2, the plot indicating the longitudinal acceleration of the Principal Other Vehicle includes a yellow envelope indicating the deceleration (0.3 g ± 0.03 g) allowed while braking. Exceedance of this threshold is indicated with red asterisks at the beginning and/or end of the threshold boundary.

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. Instantaneous samplings
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 not exceed this threshold in order to be valid
   - Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds

3. Instantaneous sampling 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 time history plots for each test type (including passing, failing and invalid runs) are shown in Figure D1 through Figure D6. Actual time history data plots for the vehicle under consideration are provided subsequently.

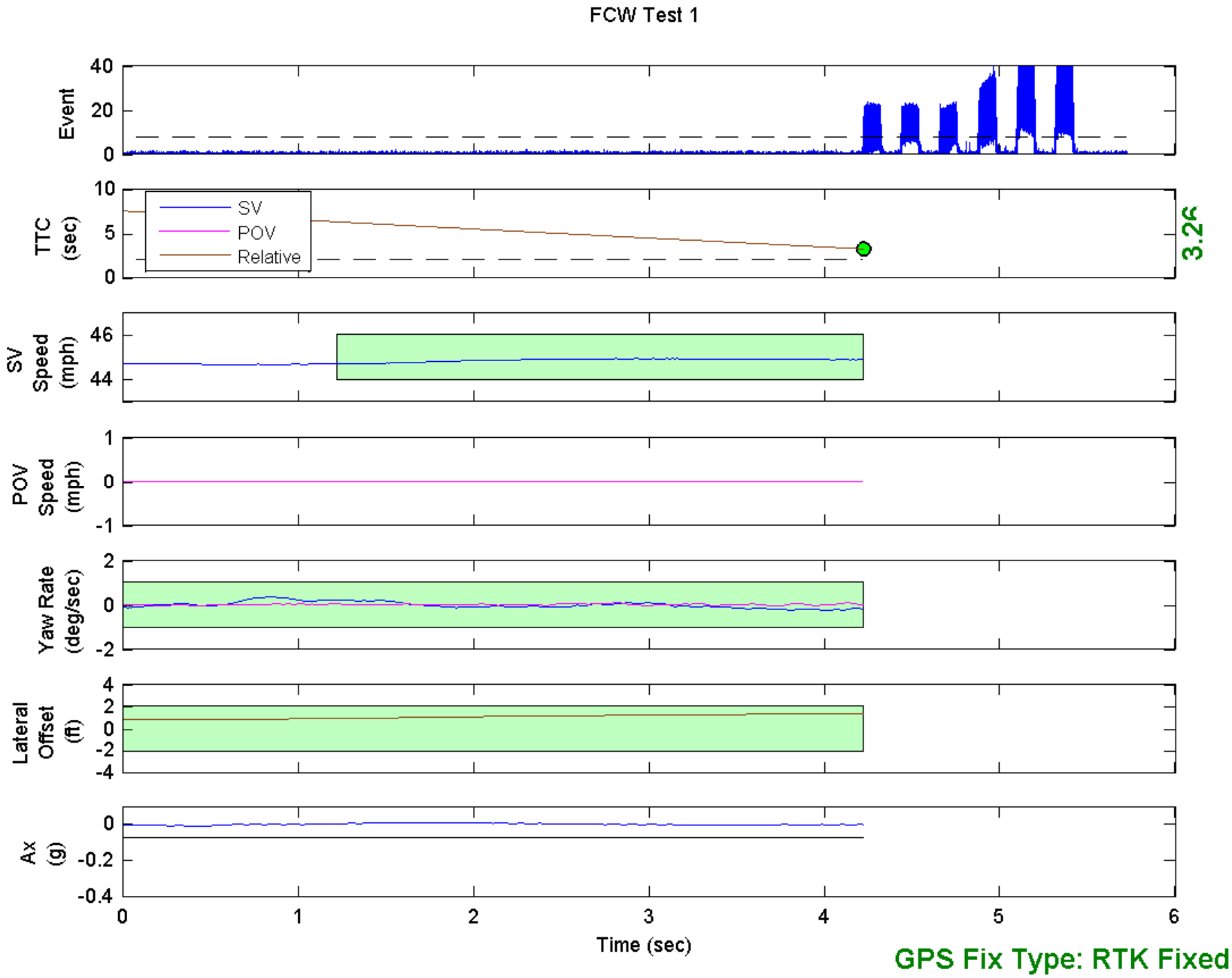

Figure D1. Example Time History for Test Type 1, Passing

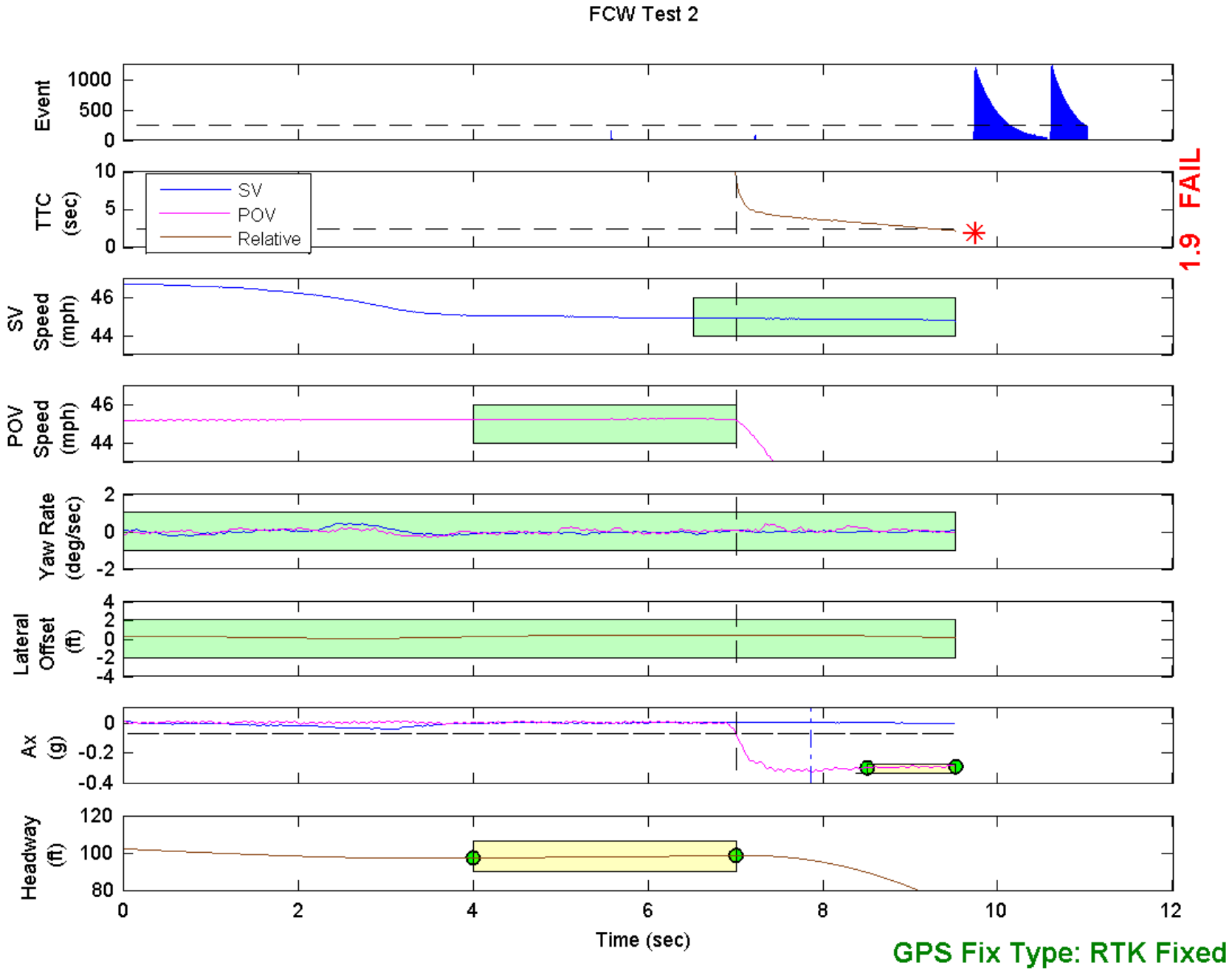

Figure D2. Example Time History for Test Type 2, Failing

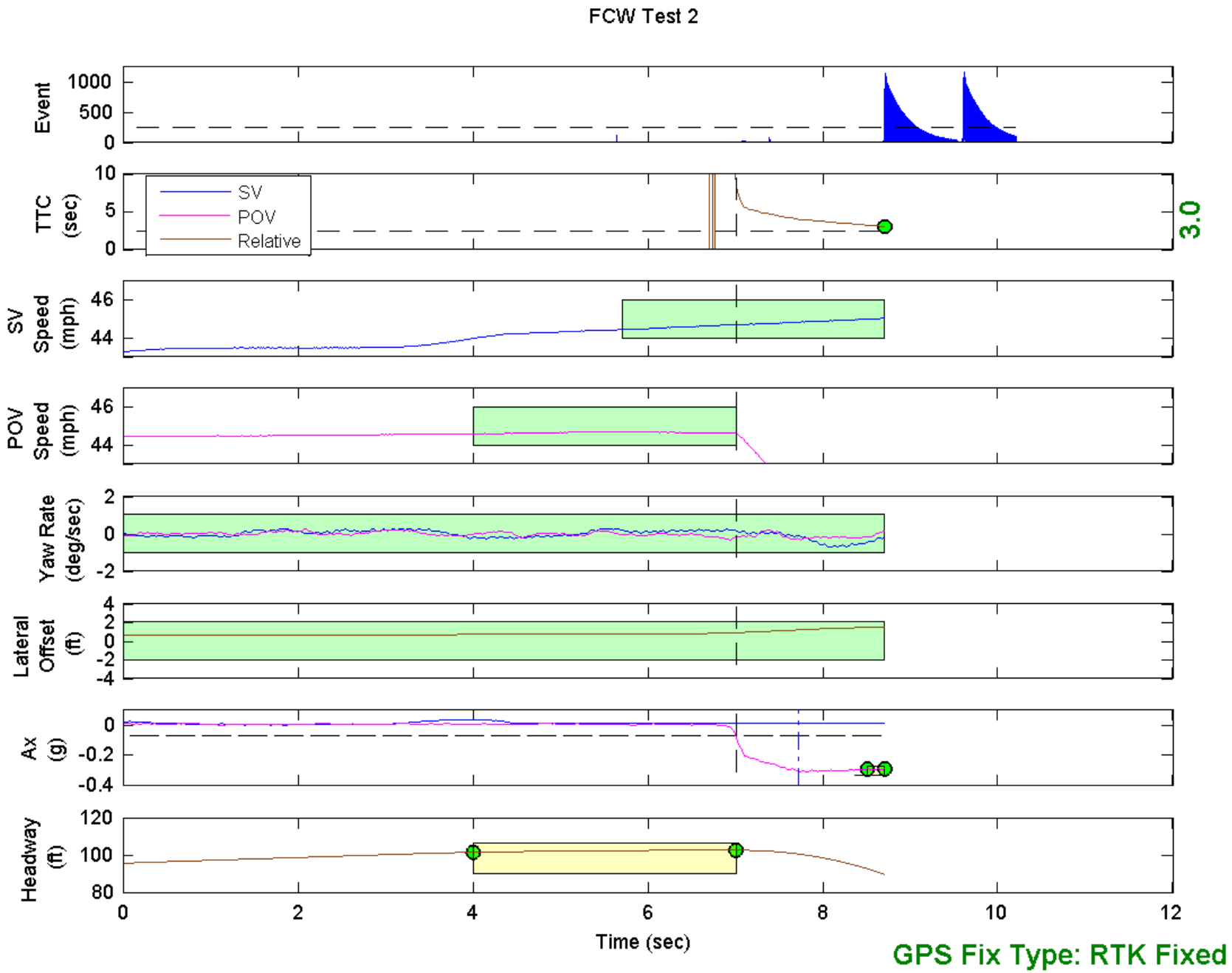

Figure D3. Example Time History for Test Type 2, Passing

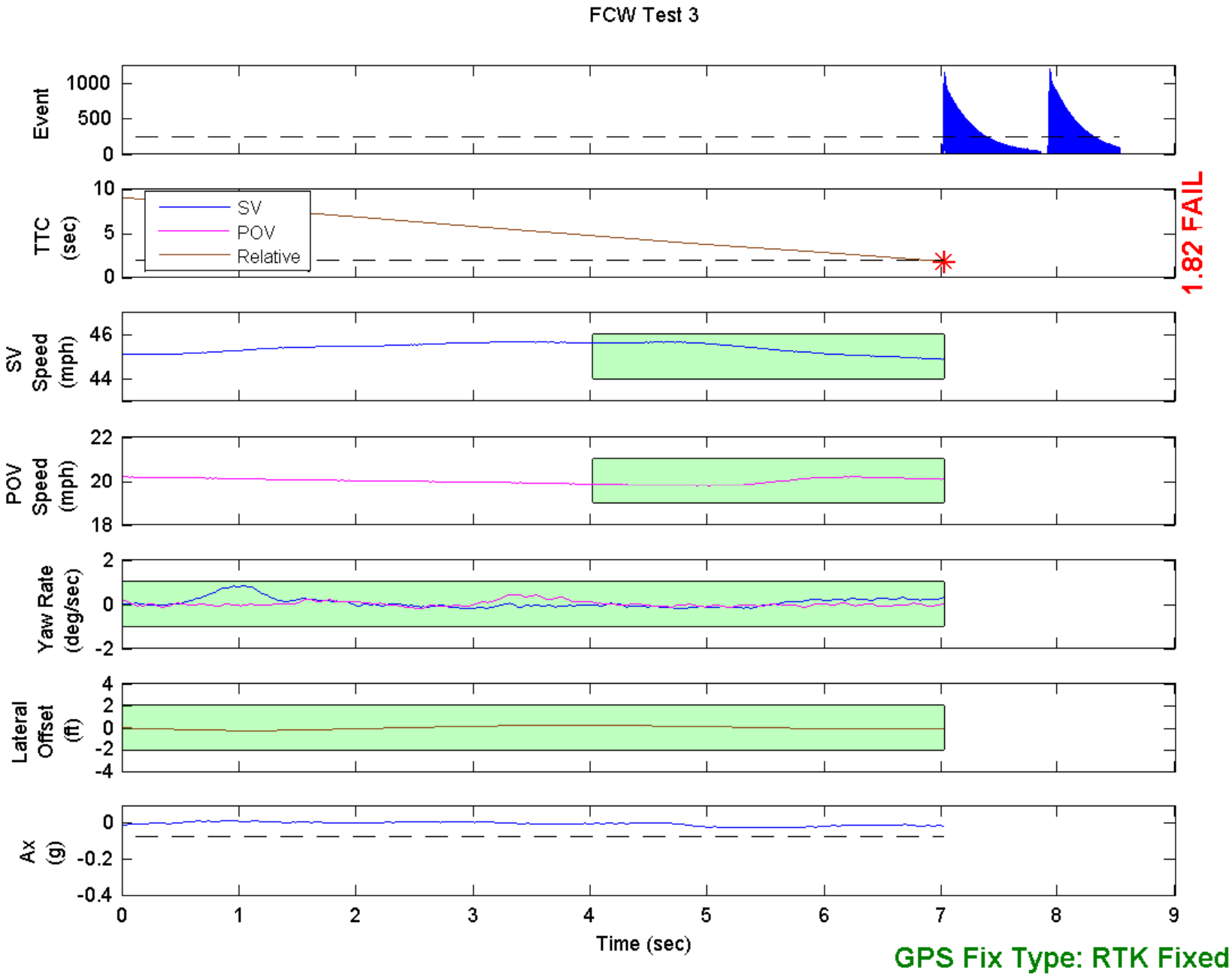

Figure D4. Example Time History for Test Type 3, Failing

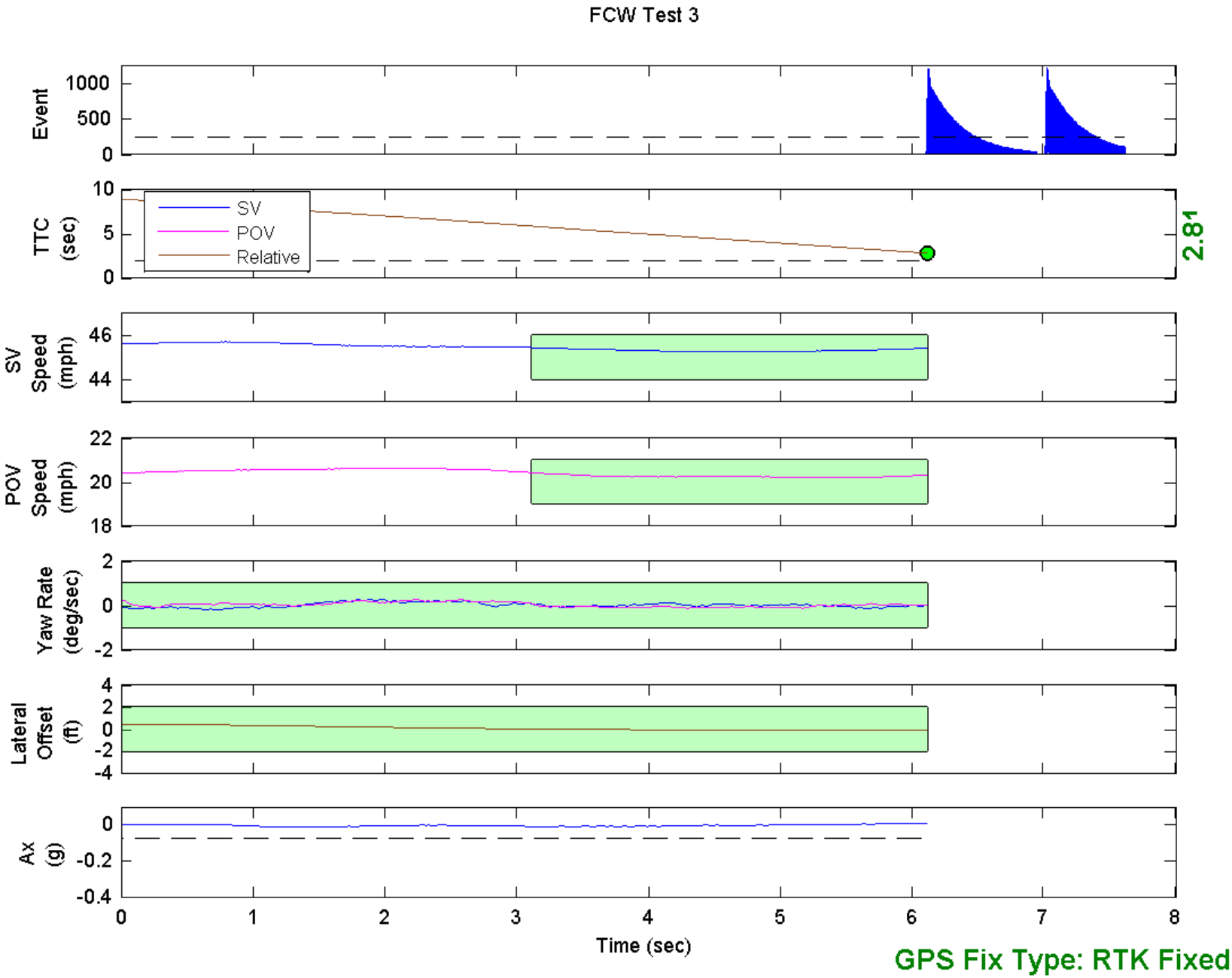

Figure D5. Example Time History for Test Type 3, Passing

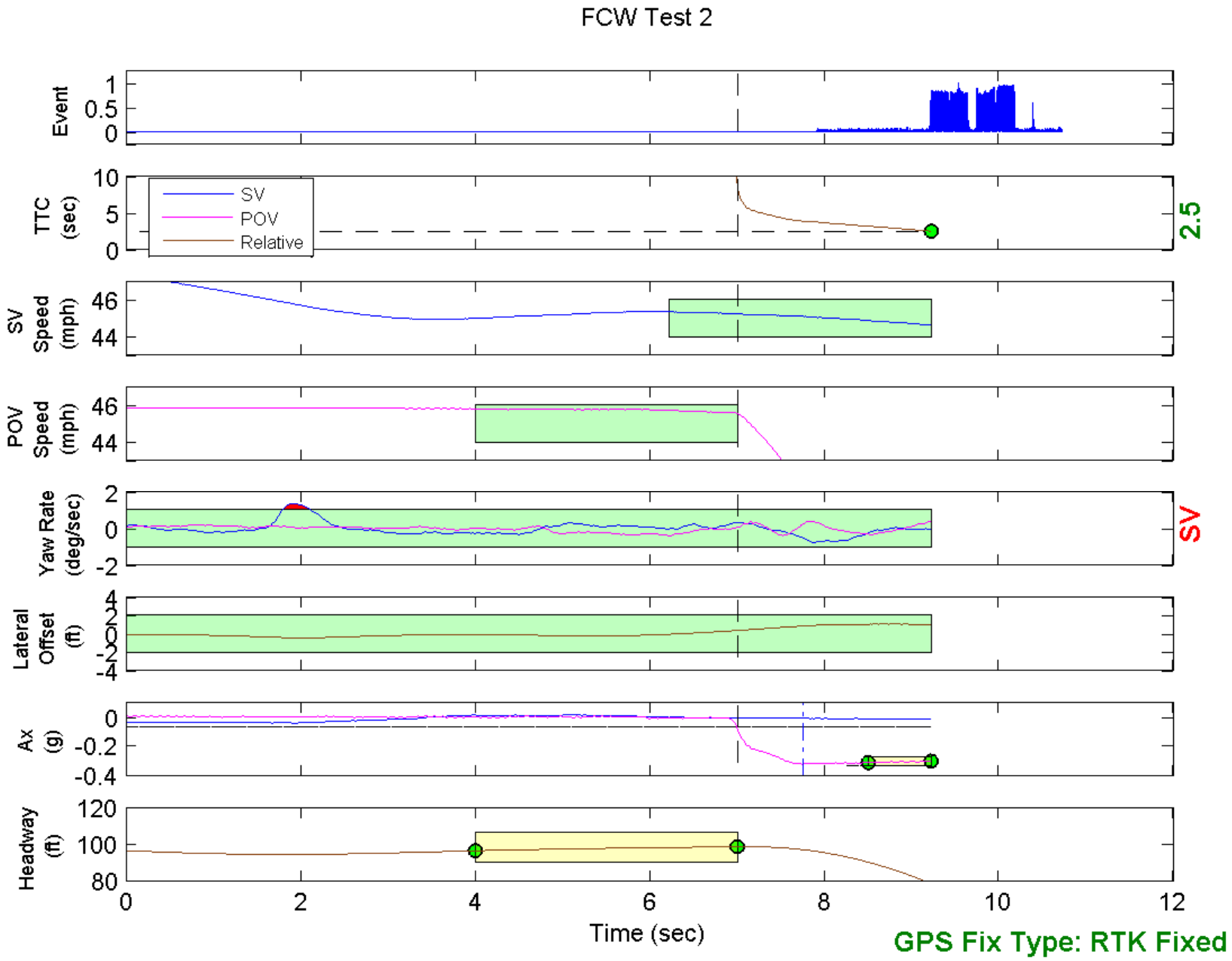

Figure D6. Example Time History for Test Type 2, Invalid Run Due to Subject Vehicle Yaw Rate

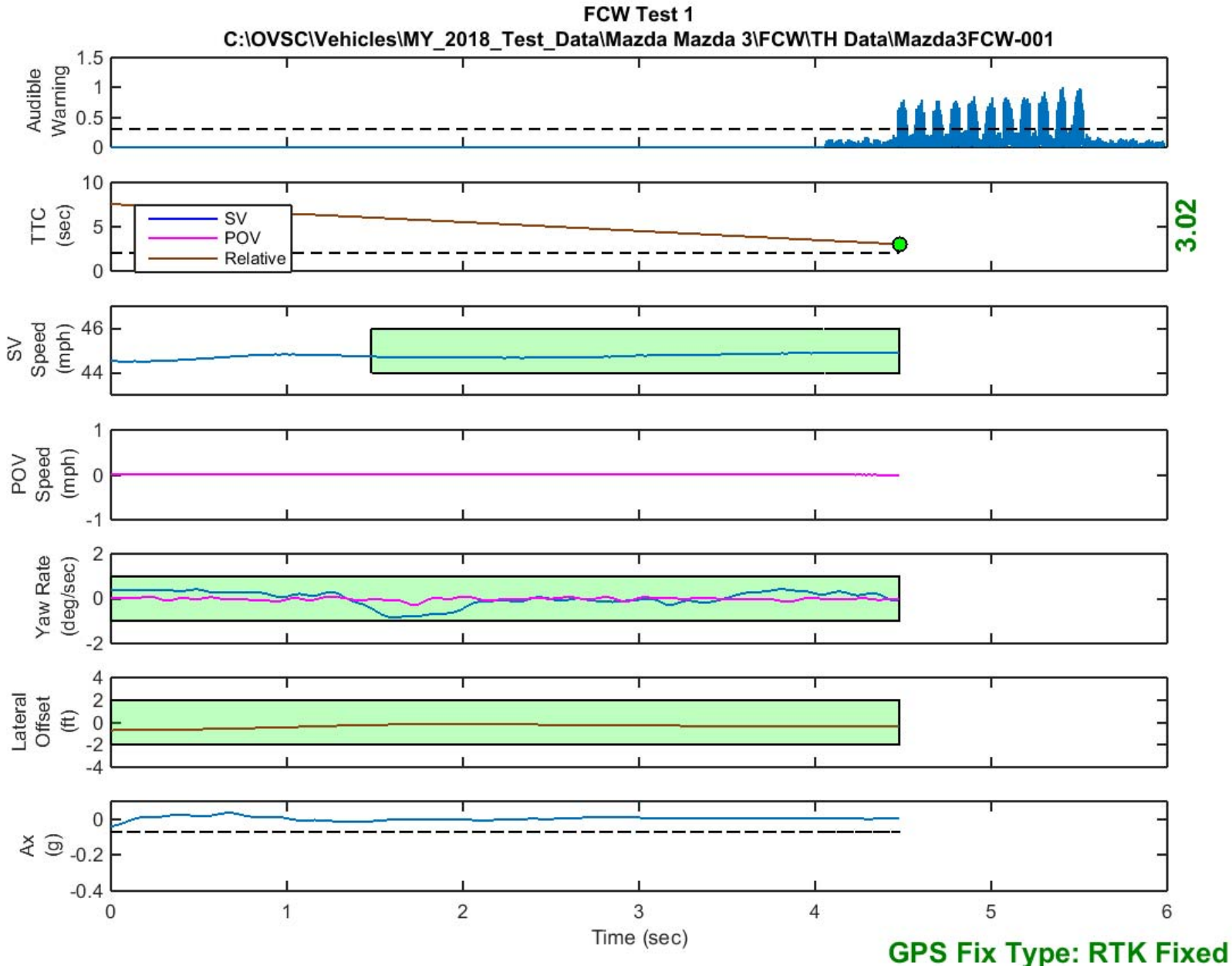

Figure D7. Time History for Run 01, FCW Test 1, Audible Warning

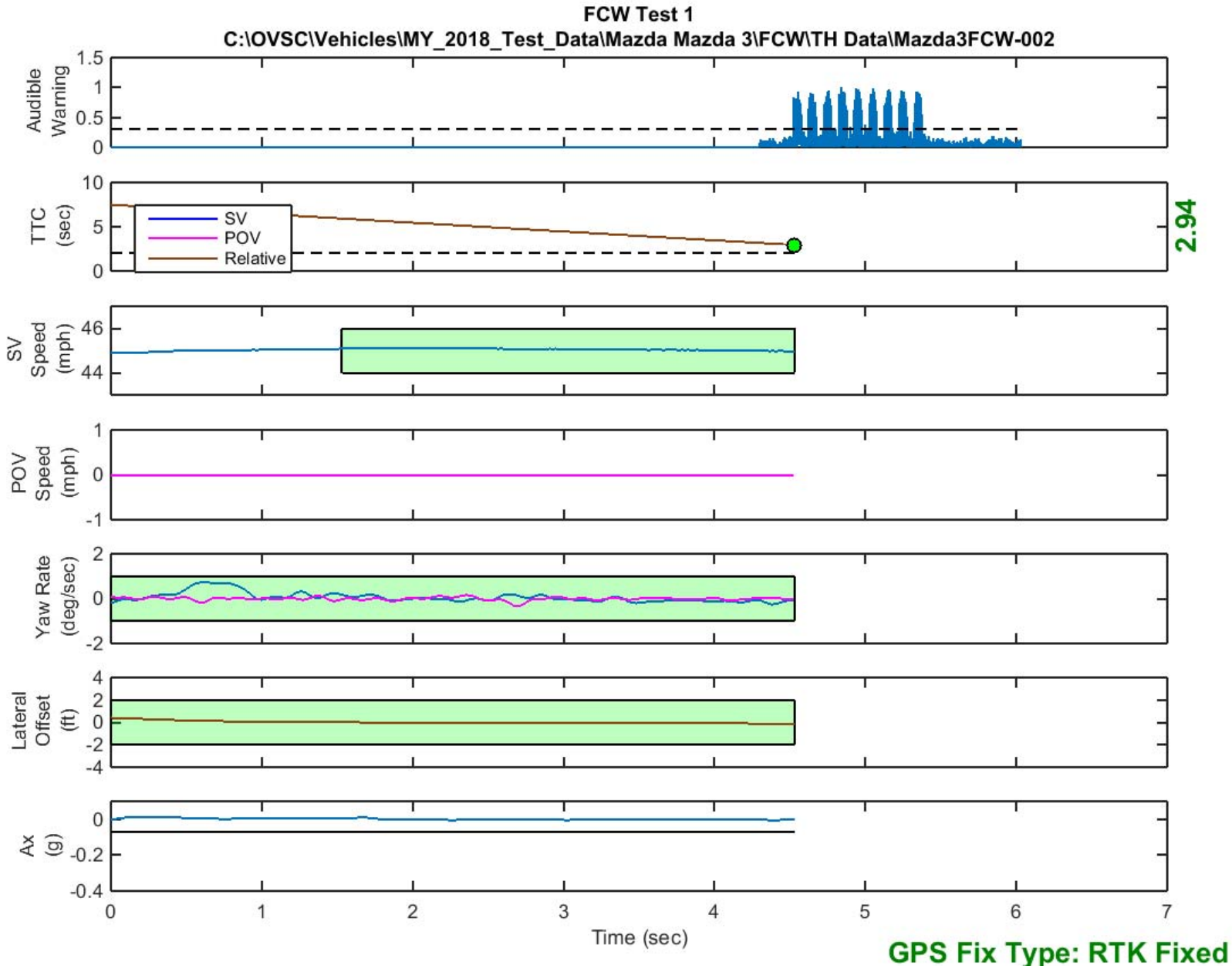

Figure D8. Time History for Run 02, FCW Test 1, Audible Warning

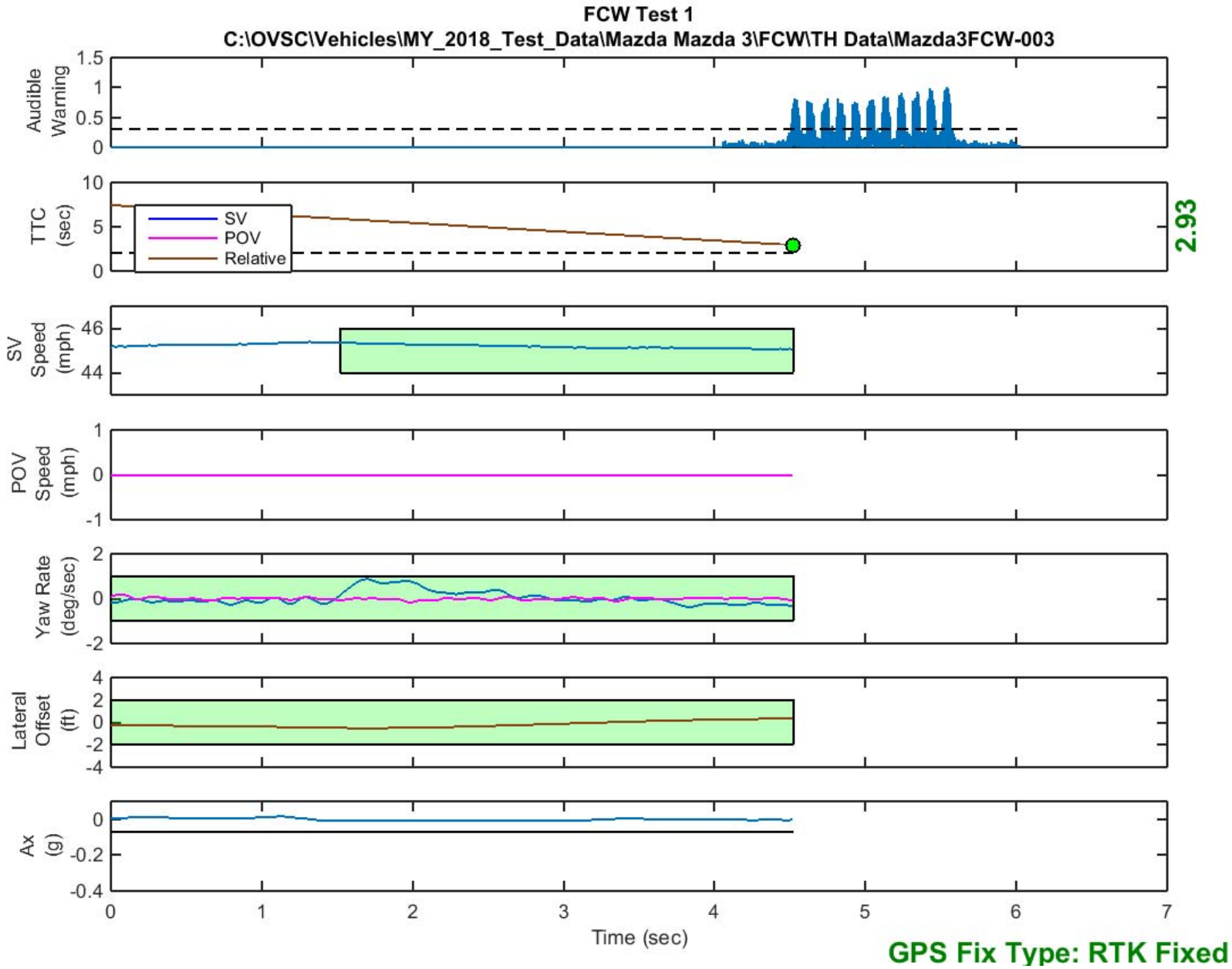

Figure D9. Time History for Run 03, FCW Test 1, Audible Warning

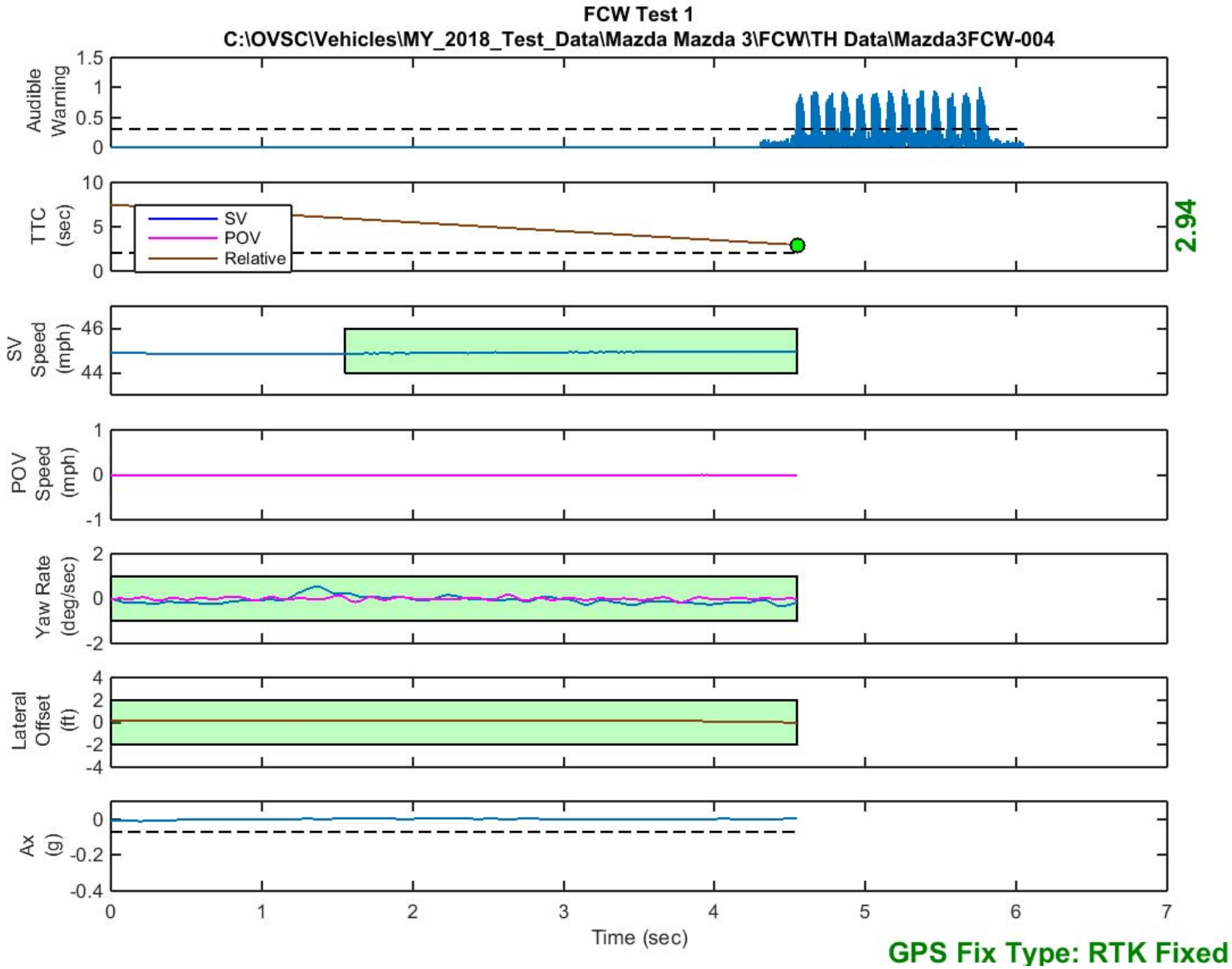

Figure D10. Time History for Run 04, FCW Test 1, Audible Warning

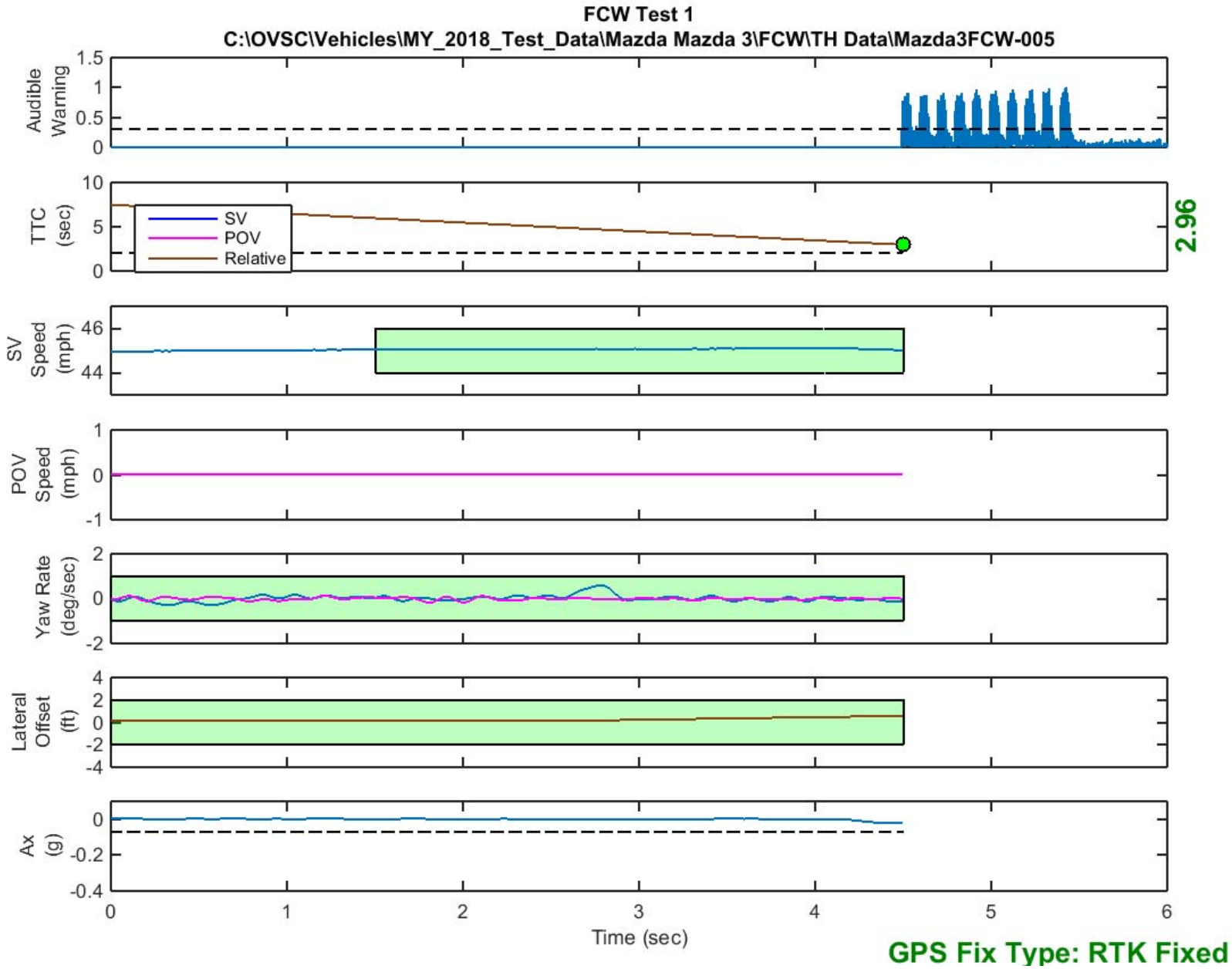

Figure D11. Time History for Run 05, FCW Test 1, Audible Warning

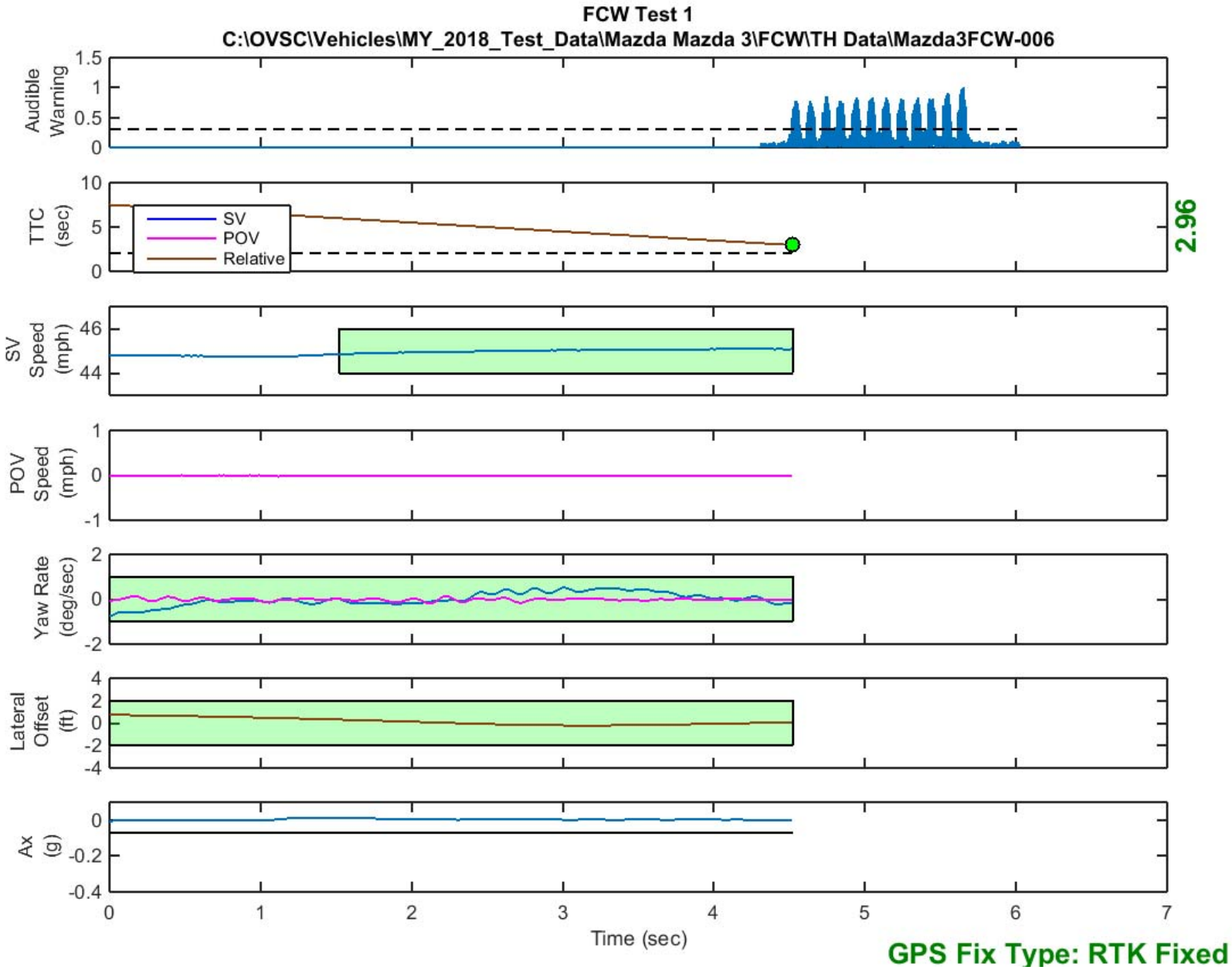

Figure D12. Time History for Run 06, FCW Test 1, Audible Warning

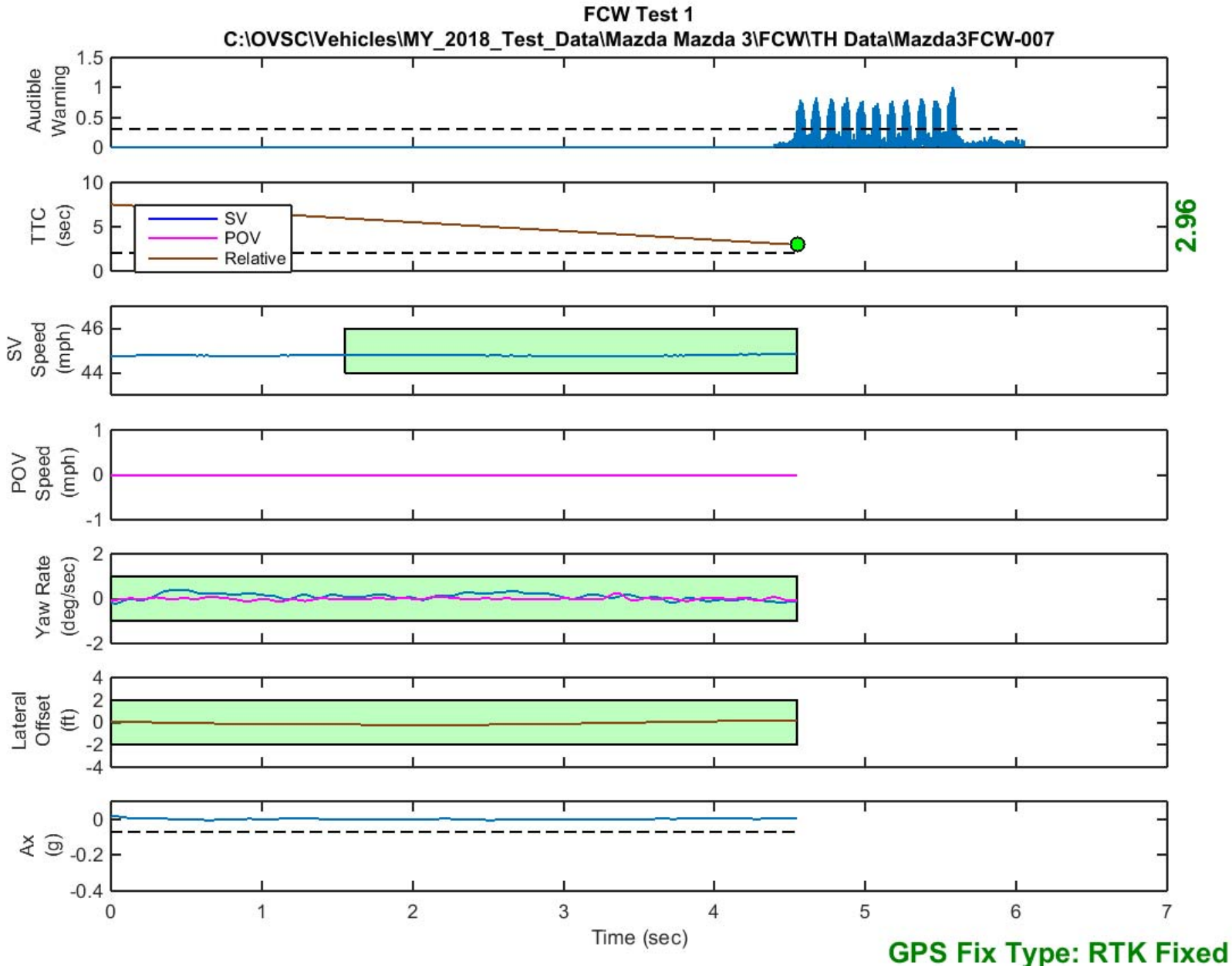

Figure D13. Time History for Run 07, FCW Test 1, Audible Warning

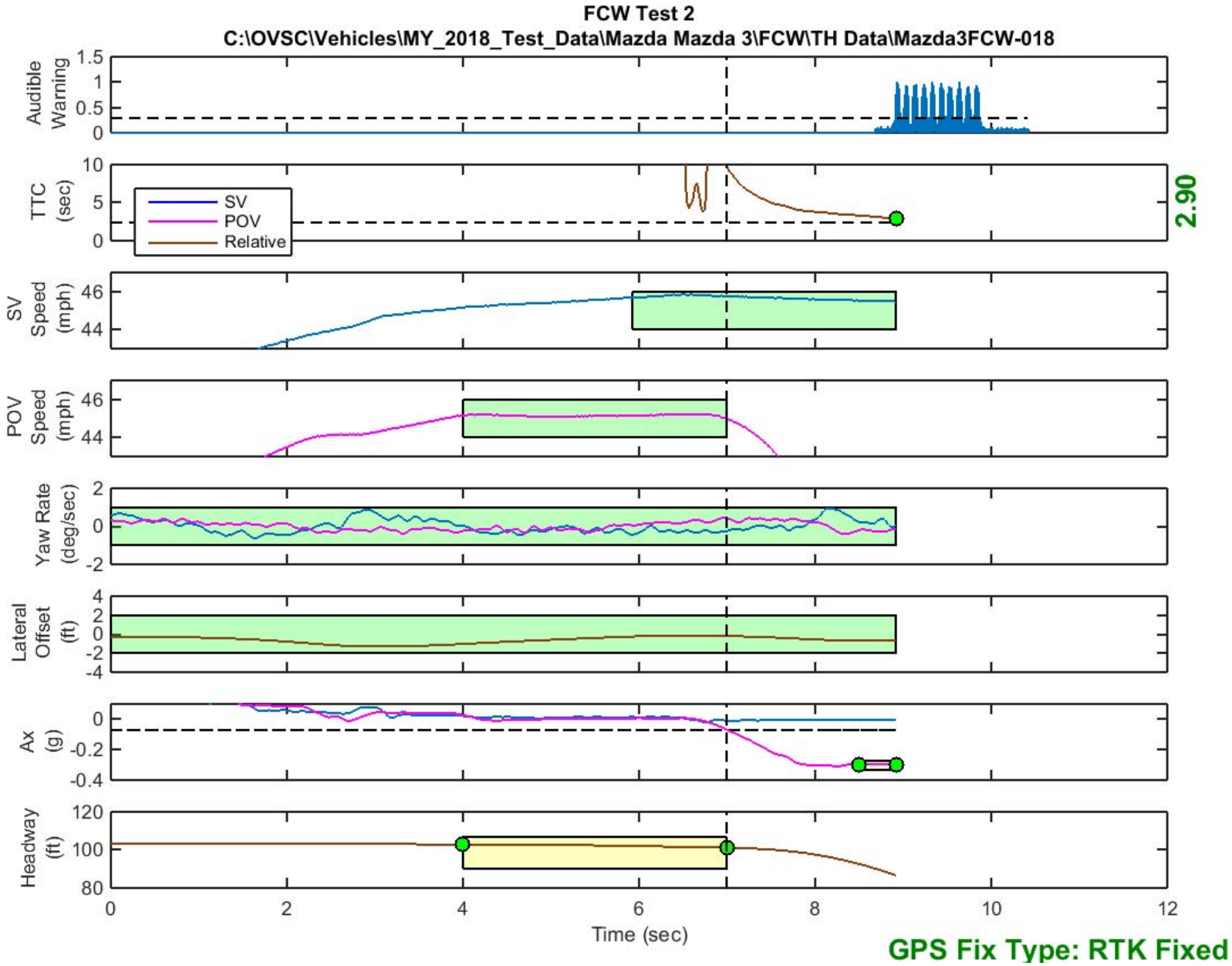

Figure D14. Time History for Run 18, FCW Test 2, Audible Warning

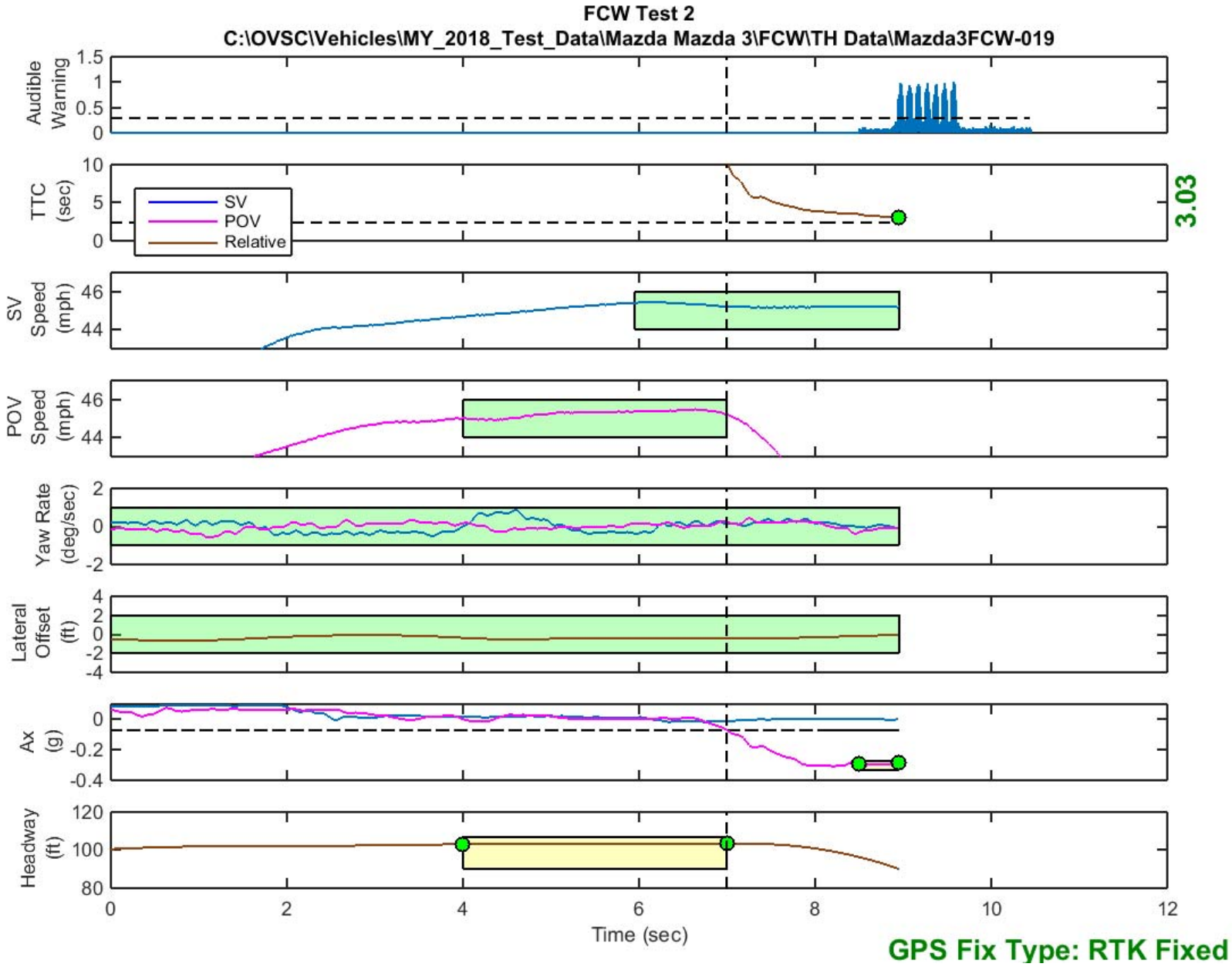

Figure D15. Time History for Run 19, FCW Test 2, Audible Warning

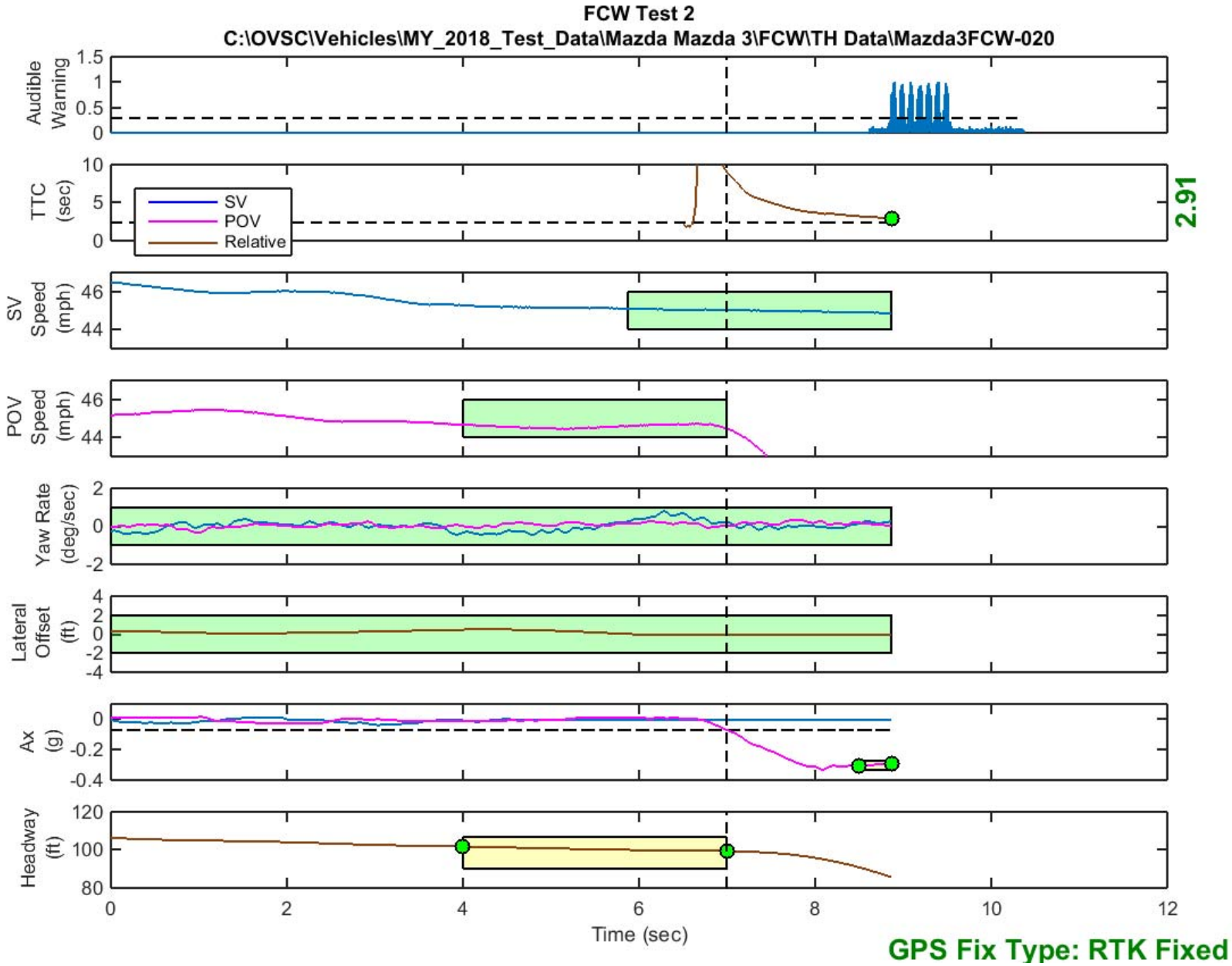

Figure D16. Time History for Run 20, FCW Test 2, Audible Warning

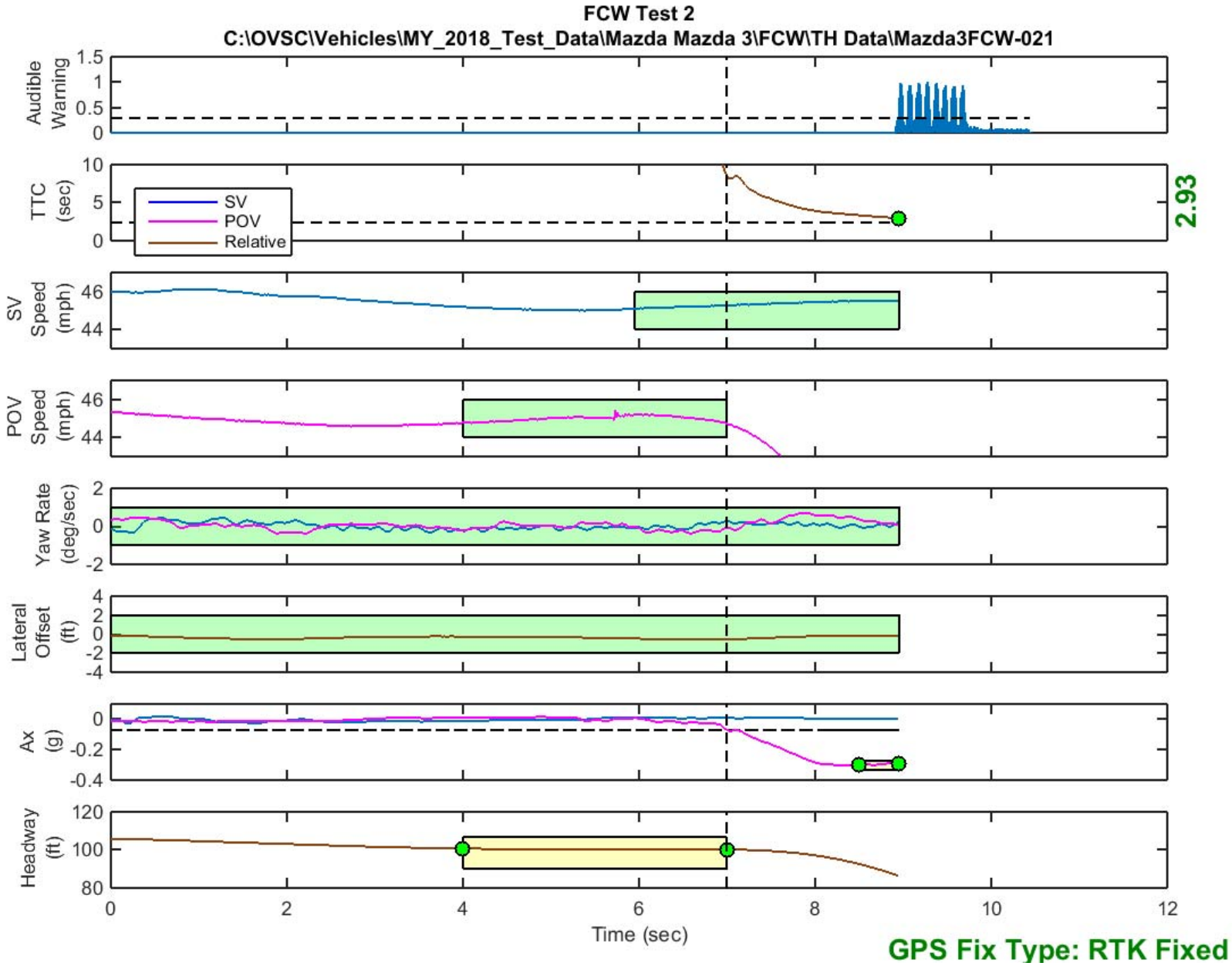

Figure D17. Time History for Run 21, FCW Test 2, Audible Warning

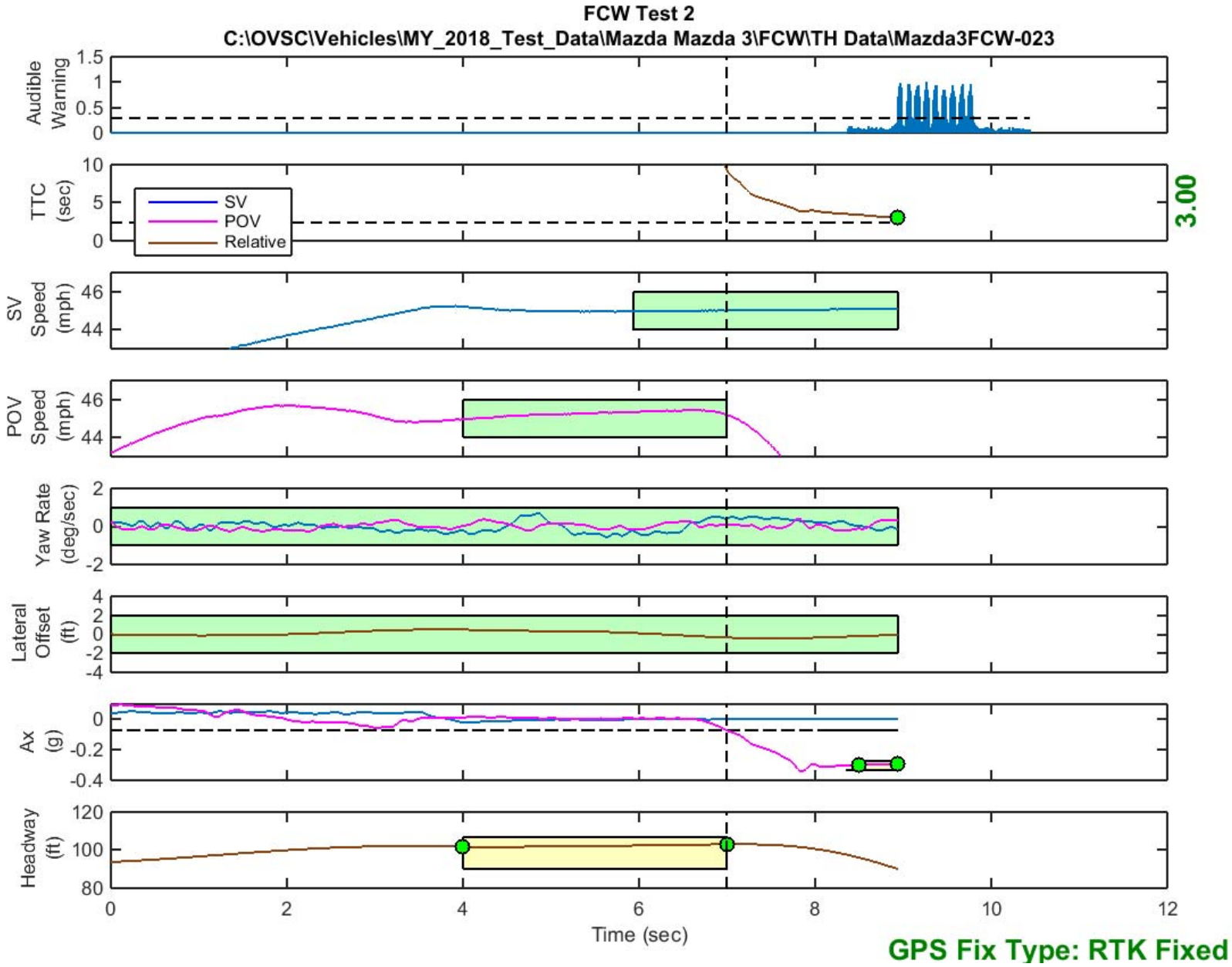

Figure D18. Time History for Run 23, FCW Test 2, Audible Warning

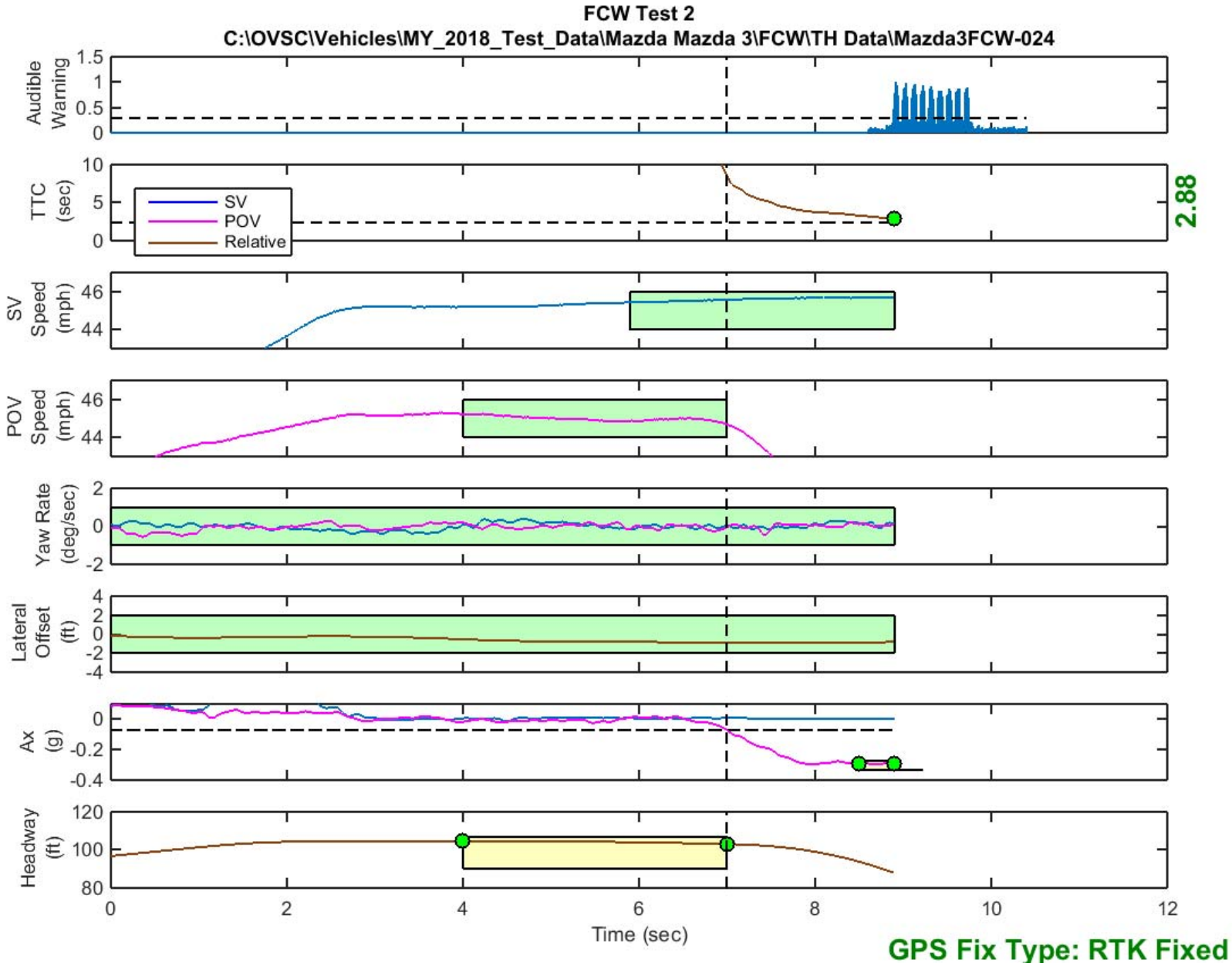

Figure D19. Time History for Run 24, FCW Test 2, Audible Warning

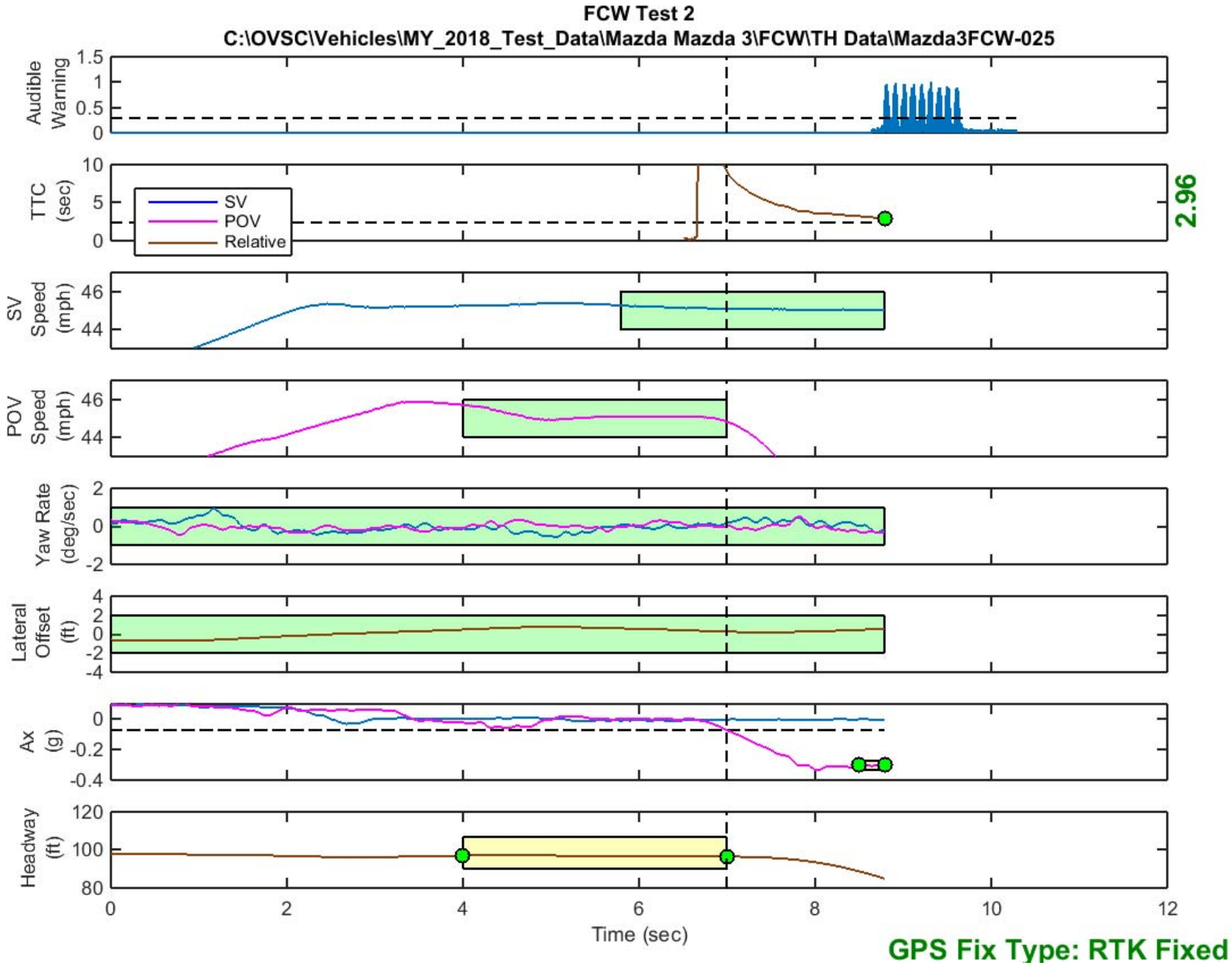

Figure D20. Time History for Run 25, FCW Test 2, Audible Warning

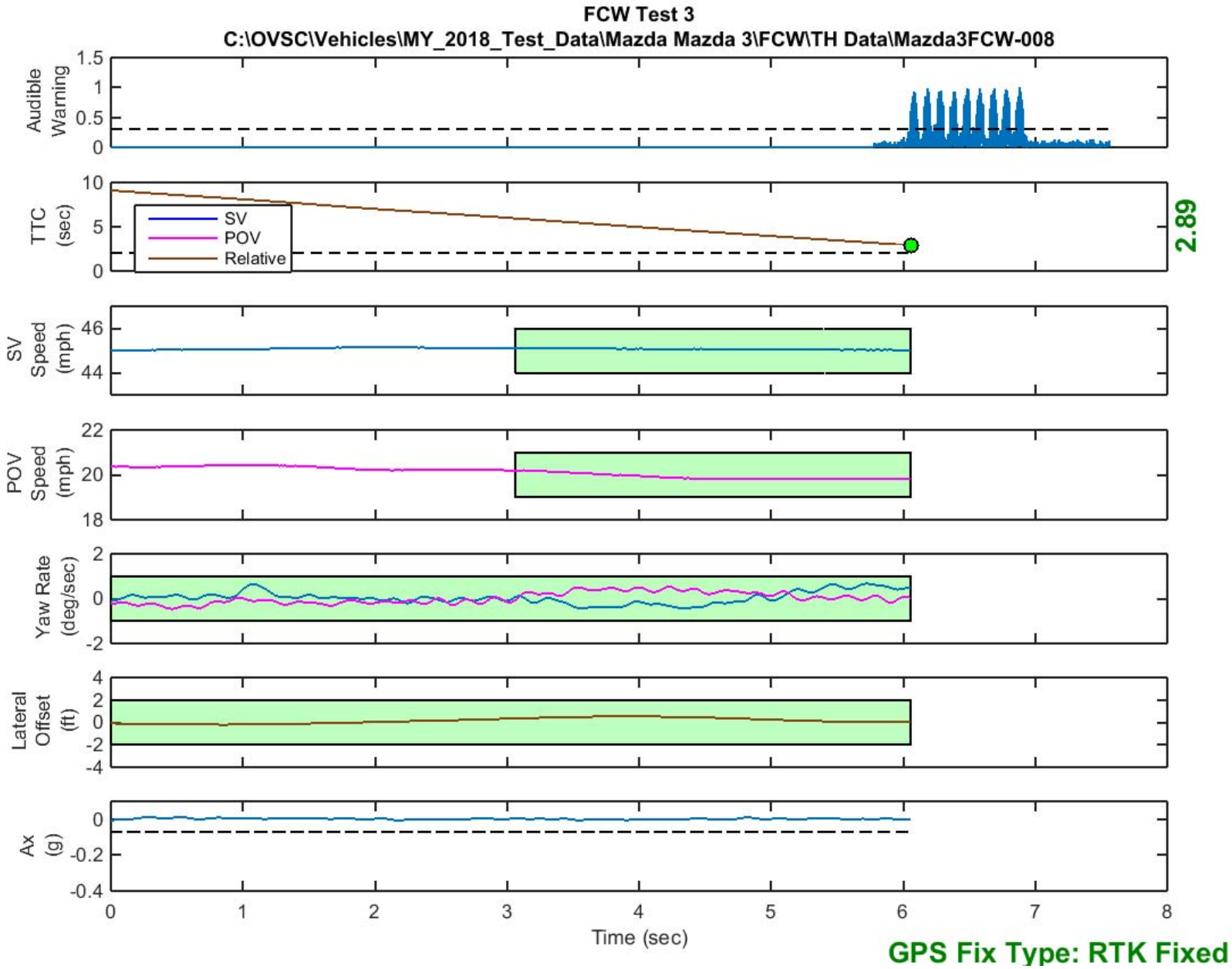

Figure D21. Time History for Run 08, FCW Test 3, Audible Warning

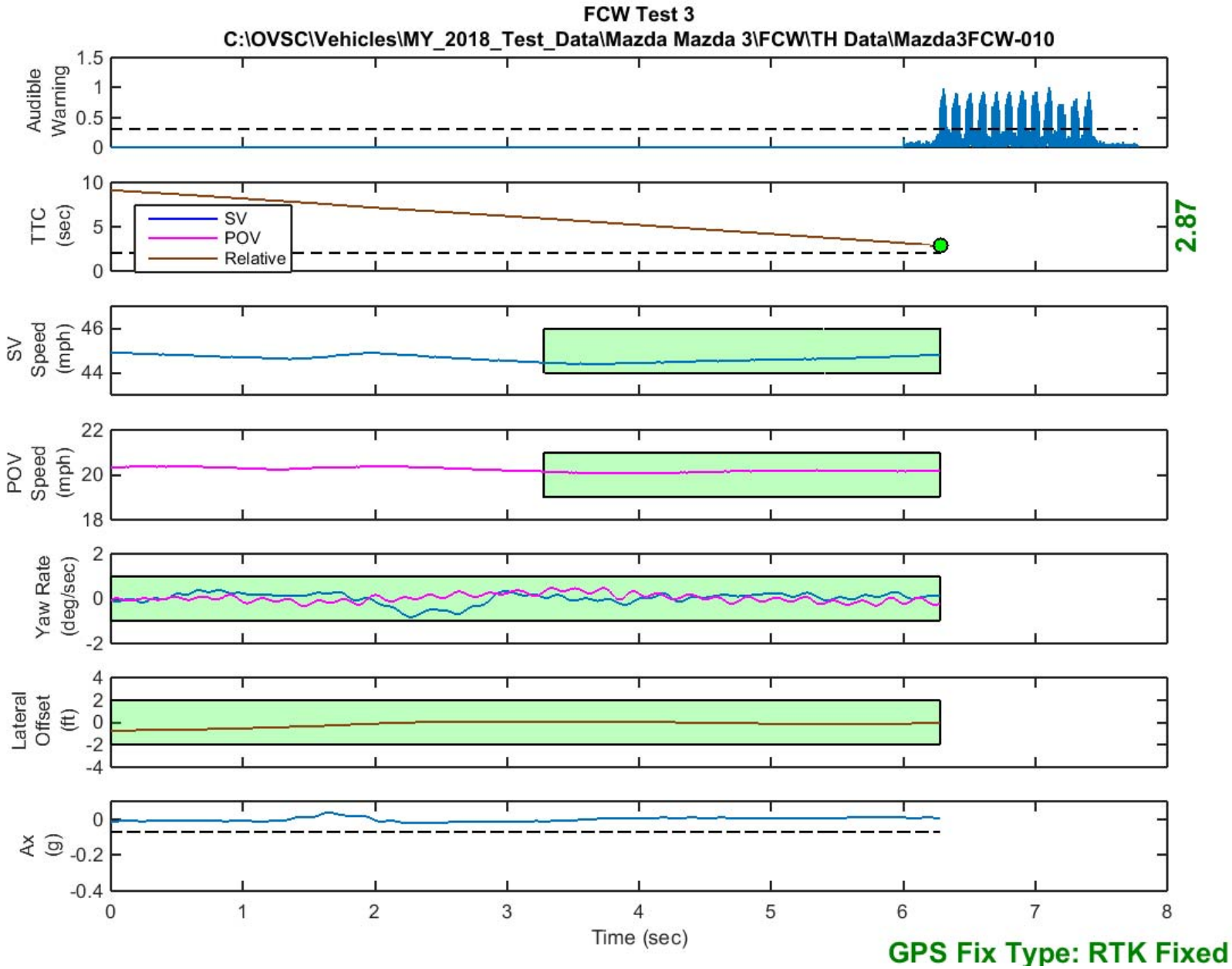

Figure D22. Time History for Run 10, FCW Test 3, Audible Warning

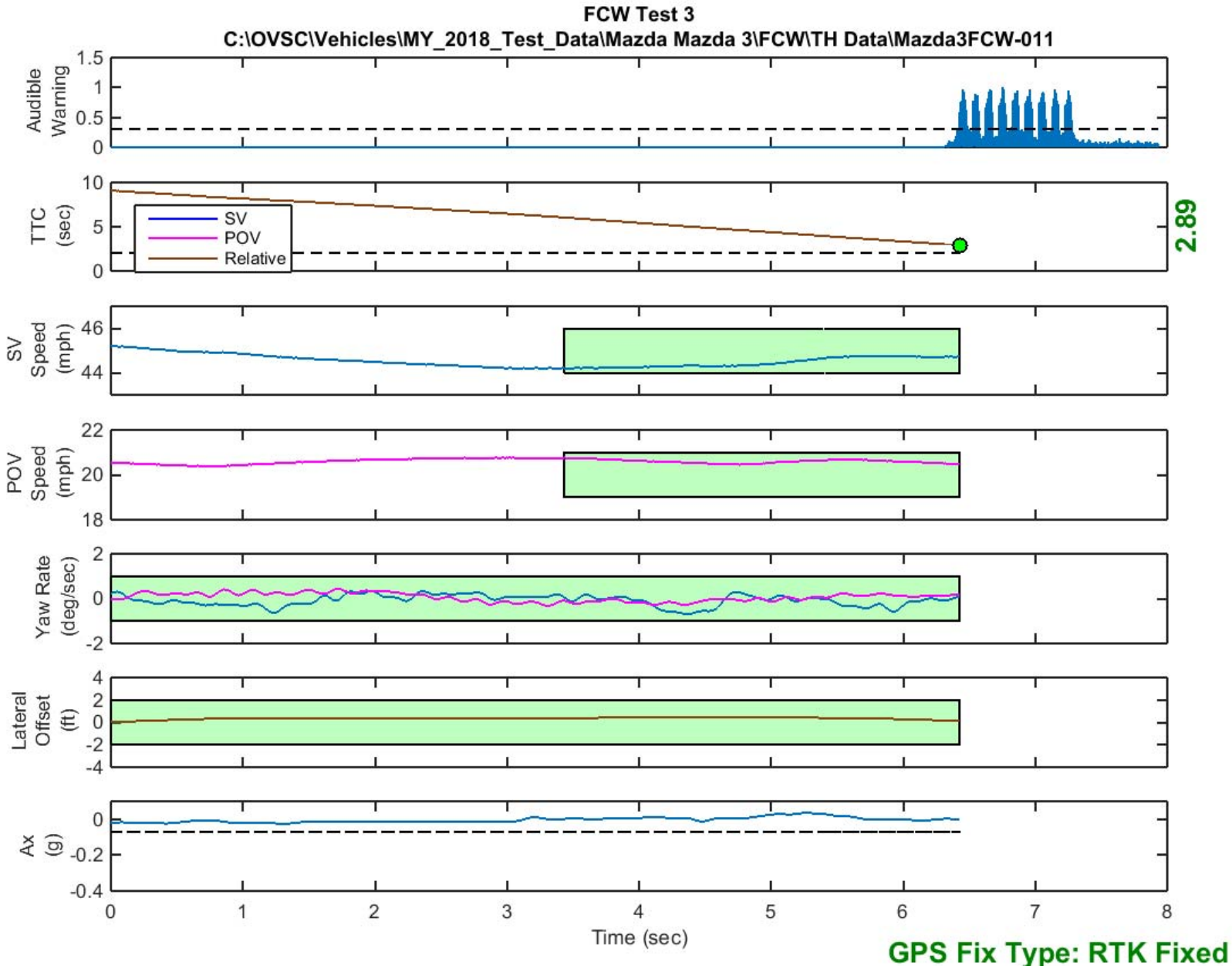

Figure D23. Time History for Run 11, FCW Test 3, Audible Warning

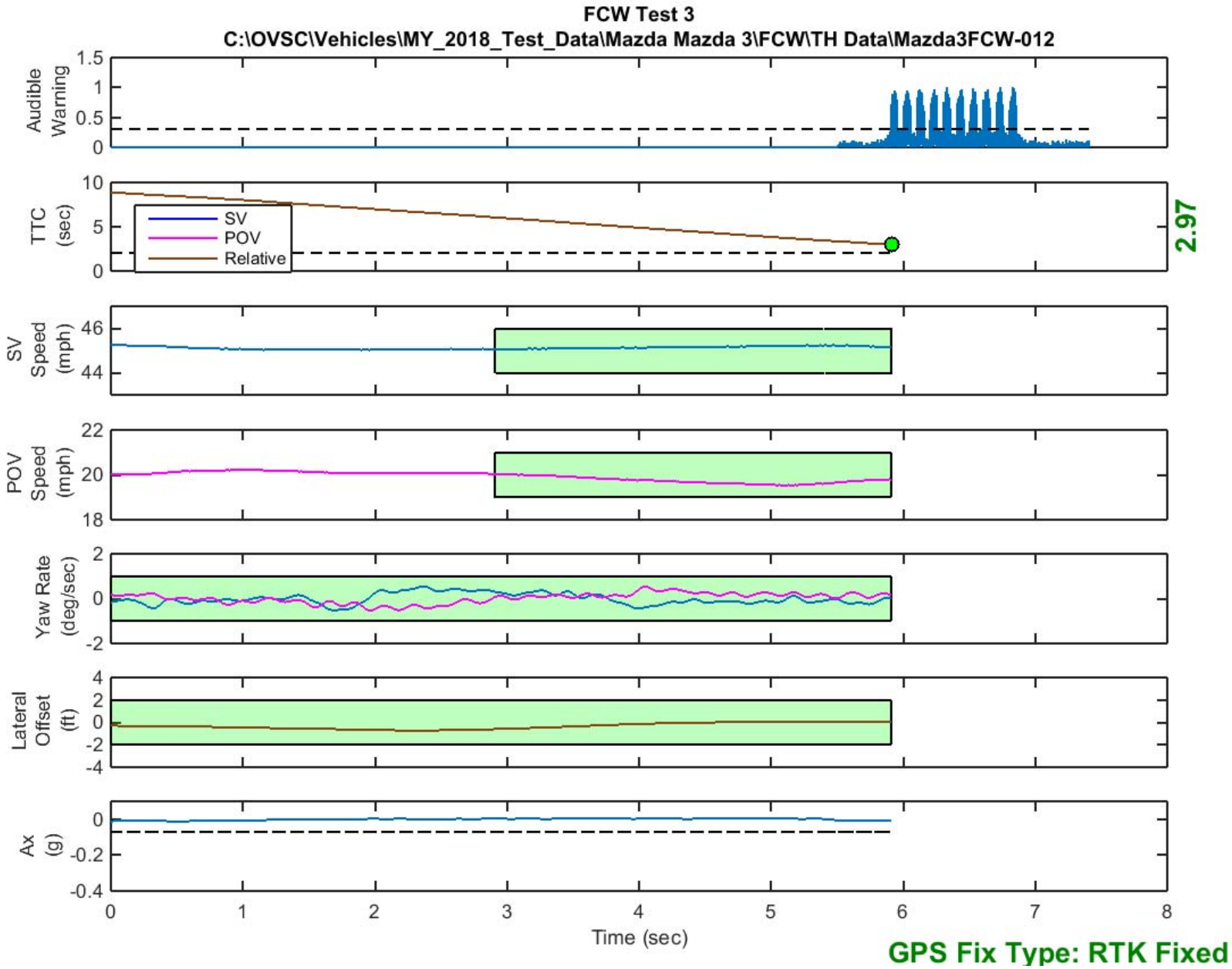

Figure D24. Time History for Run 12, FCW Test 3, Audible Warning

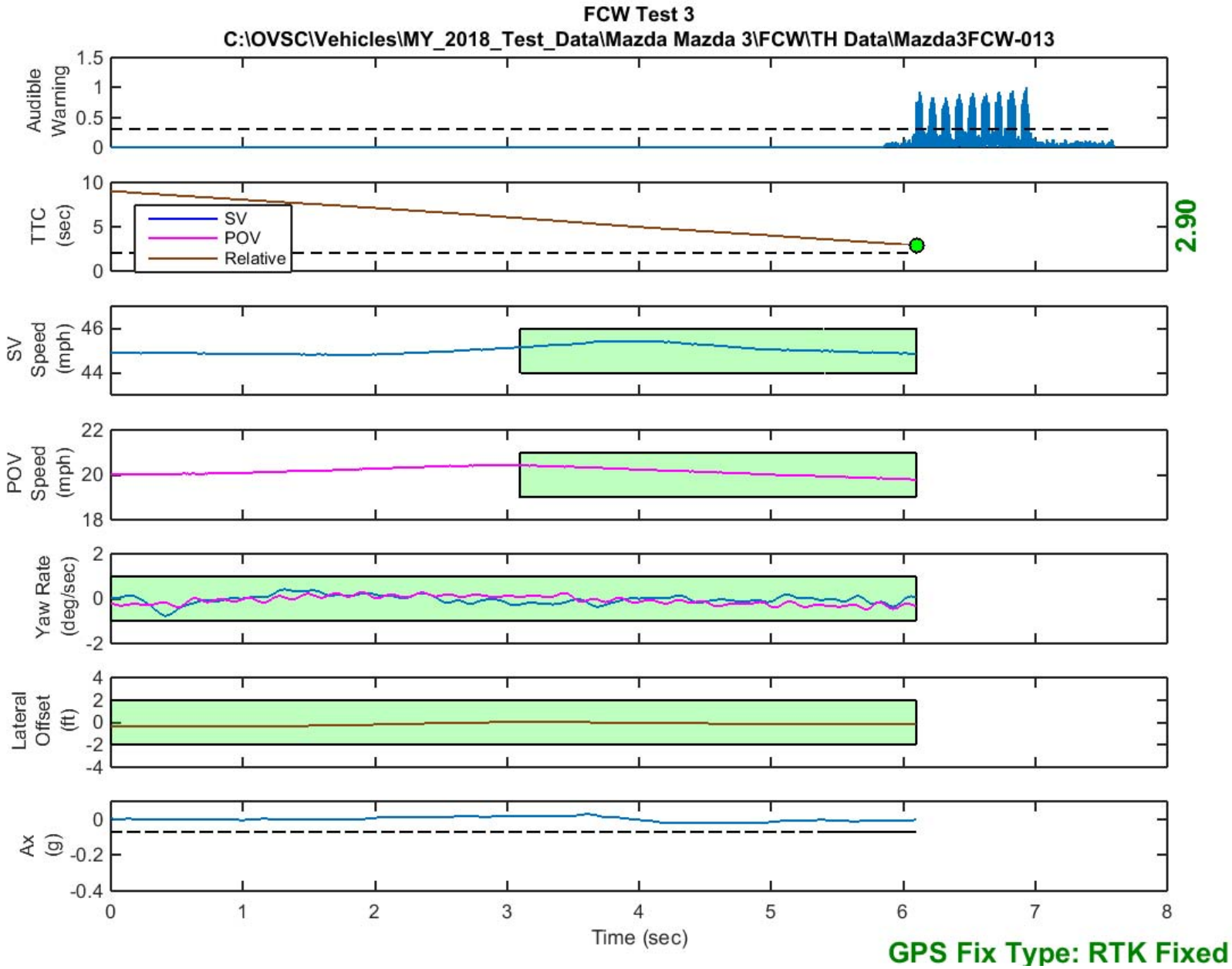

Figure D25. Time History for Run 13, FCW Test 3, Audible Warning

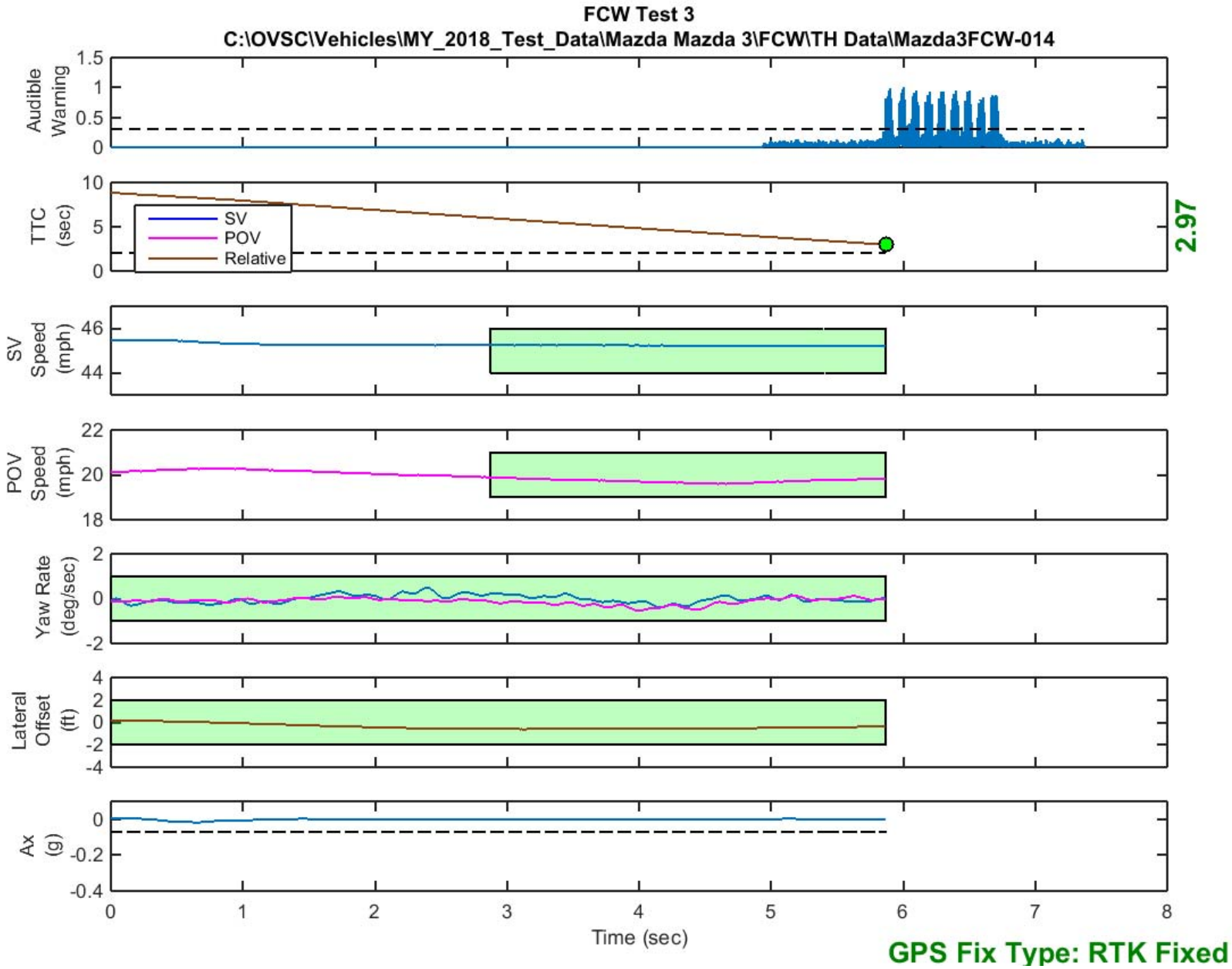

Figure D26. Time History for Run 14, FCW Test 3, Audible Warning

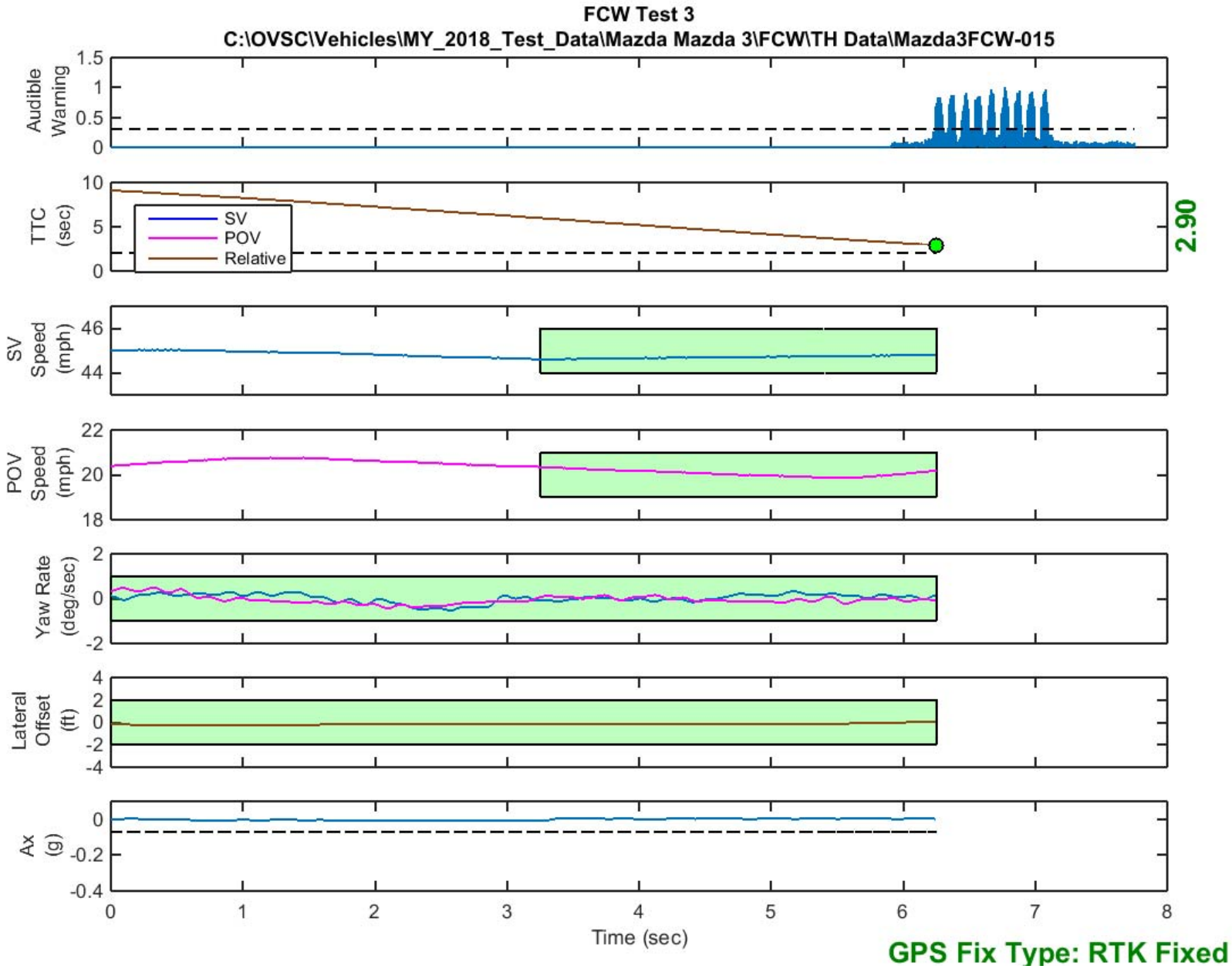

Figure D27. Time History for Run 15, FCW Test 3, Audible Warning