NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
NCAP-DRI-FCW-20-11

2020 Kia Niro Hybrid EX Premium

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13 July 2020

Final Report

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

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

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16. Abstract These tests were conducted on the subject 2020 Kia Niro Hybrid EX Premium in accordance with the specifications of the New Car Assessment Program's (NCAP) most current Test Procedure in docket NHTSA-2006-26555-0134 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's "Forward Collision Warning Confirmation" test procedure, dated 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 RESULTS SUMMARY

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2020 Kia Niro Hybrid EX Premium

VIN: *KNDCE3LC3L537xxxx*

Test Date: *6/4/2020*

Forward Collision Warning setting: *Forward Safety: Active Assist on*
Warning Timing: Normal

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 1)

2020 Kia Niro Hybrid EX Premium

TEST VEHICLE INFORMATION

VIN: *KNDCE3LC3L537xxxx*

Body Style: *SUV* Color: *Silky Silver*

Date Received: *5/26/2020* Odometer Reading: *25 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *KIA MOTORS CORPORATION*

Date of manufacture: *12/19*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *205/60R16*

Rear: *205/60R16*

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

Rear: *250 kPa (36 psi)*

TIRES

Tire manufacturer and model: *Michelin Energy Saver A/S*

Front tire specification: *205/60R16 92H*

Rear tire specification: *205/60R16 92H*

Front tire DOT prefix: *B3 7R 04MX*

Rear tire DOT prefix: *B3 7R 04MX*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Kia Niro Hybrid EX Premium

GENERAL INFORMATION

Test date: *6/4/2020*

AMBIENT CONDITIONS

Air temperature: *27.8 C (82 F)*

Wind speed: *2.6 m/s (5.8 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)

2020 Kia Niro Hybrid EX Premium

WEIGHT

Weight of vehicle as tested including driver and instrumentation:

Left Front:	*482.6 kg (1064 lb)*	Right Front:	*453.6 kg (1000 lb)*
Left Rear:	*330.7 kg (729 lb)*	Right Rear:	*311.6 kg (687 lb)*
		Total:	*1578.5 kg (3480 lb)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 3)

2020 Kia Niro Hybrid EX Premium

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

Forward Collision-Avoidance Assist-Ped (FCA-Ped)

Forward Collision Warning Setting used in test: *Forward Safety: Active Assist on*

Warning Timing: Normal

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

The system uses a fusion type which includes radar and mono camera. The camera is located behind the windshield near the rearview mirror and the radar is located behind the front grille.

How is the Forward Collision Warning presented to the driver? (Check all that apply)

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

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

The driver is alerted by images in the instrument cluster, an auditory alert, and steering wheel vibration.

The image initially shown in the instrument cluster is shown in Appendix A, Figure A16. When the system determines that braking is needed, the words "Emergency Braking" replace "Collision Warning". See the Owner's Manual pages 5-72 and 5-73 shown in Appendix B, Pages B-9 and B-10.

The auditory alert is a 1500 Hz tone that is initially pulsed approximately 8 times per second and then becomes continuous.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 2 of 3)

2020 Kia Niro Hybrid EX Premium

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.

The driver can deactivate the FCA using controls located on the right side of the steering wheel to interact with menus on the LCD. The sequence is:

User Settings

Driver Assistance

Forward Safety

Select "Off" to disable

See Appendix A, Figure A13.

The FCA is reactivated on each ignition cycle.

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.

The driver can adjust the warning timing using controls located on the right side of the steering wheel to interact with menus on the LCD. The sequence is:

User Settings

Driver Assistance

Warning Timing

Select: Normal or Later

See Appendix A, Figure A14.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 3 of 3)

2020 Kia Niro Hybrid EX Premium

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.

System limitations are described in the Owner's Manual, Pages 5-78 through 5-85 shown in Appendix B, Pages B-15 through B-22.

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)

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.

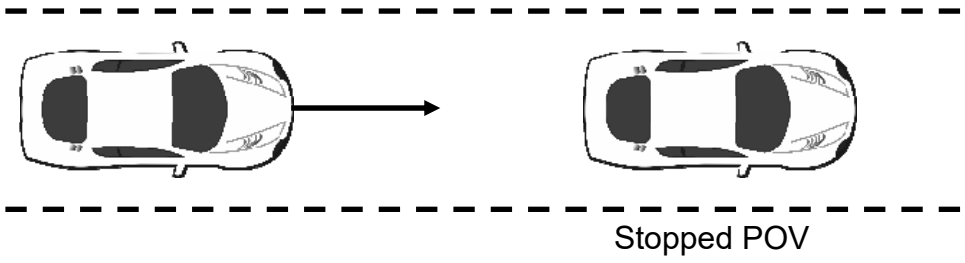

Figure 1. Depiction of Test 1

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. The TTC for this test was calculated by considering the speeds of the SV and the 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 km/h), 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 that the SV approaches the rear of the POV.

The SV was driven at a nominal speed of 45 mph (72.4 km/h) 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% 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 km/h) for a period of three seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90% 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 (1) the required FCW alert occurred or (2) the range fell to less than 90% 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.

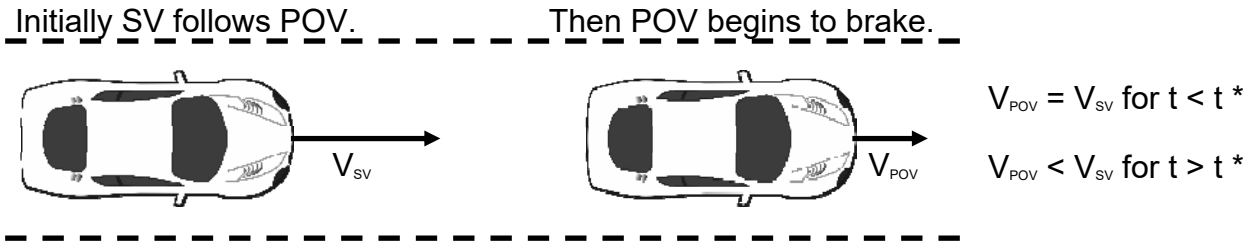

Figure 2. Depiction of Test 2

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].

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 km/h), 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.

[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).

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 km/h) 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 km/h) for a period of 3 seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90% 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 ±0.03 g, 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 500 ms after the first local deceleration peak occurs, to 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 (1) the required FCW alert occurred or (2) the range fell to less than 90% 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 to issue a timely alert. As depicted in Figure 3, the scenario was conducted with a closing speed equal to 25.0 mph (40.2 km/h).

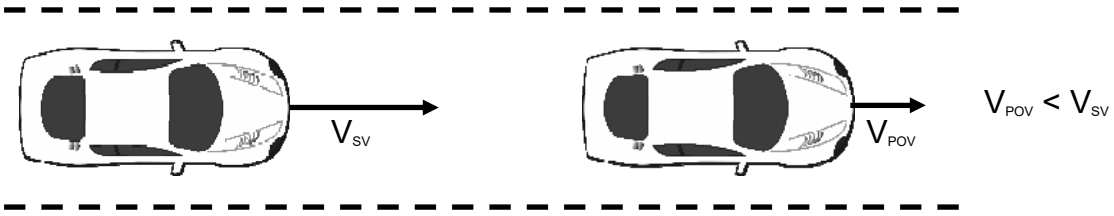

Figure 3. Depiction of Test 3

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 km/h) in the center of the lane of travel.

The SV was driven at 45.0 mph (72.4 km/h), 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., TT = 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 km/h) for a period of 3 seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90% 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 km/h) 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 (1) the required

FCW alert occurred or (2) before the range fell to less than 90% 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 2006 Acura RL. This satisfied the test requirement 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	< 1% error between 20 and	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	1500 lb/platform 6672 N	0.5% of applied load	Intercomp SW II	NT2888	By: DRI Date: 1/16/2020 Due: 1/16/2021
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	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2182	Date: 9/16/2019 Due: 9/16/2021
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 auditory 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 visual alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at haptic 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: 1/6/2020 Due: 1/6/2021

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

For systems that implement audible or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the audible warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent audible or tactile warning data so that the beginning of such warnings can be programmatically determined. The band-pass filter used for these warning signal types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 2.

Table 2. Audible and Tactile Warning Filter Parameters

Warning Type	Filter Order	Peak-to-Peak Ripple	Minimum Stop Band Attenuation	Passband 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

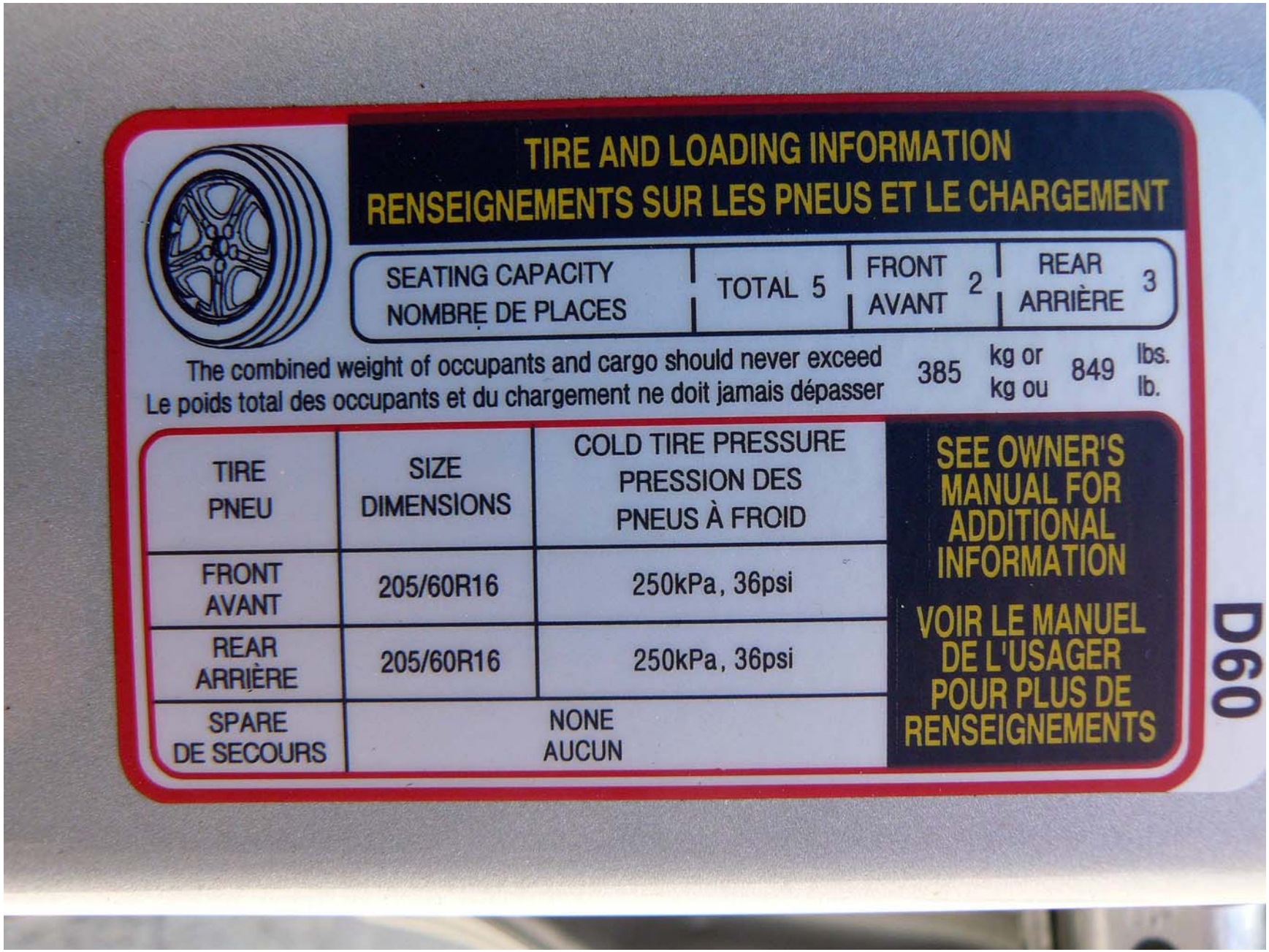

Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle

Figure A7. Rear View of Principal Other Vehicle

Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A9. Sensor for Detecting Auditory Alerts

Figure A10. Sensor for Detecting Visual Alerts

Figure A11. Computer Installed in Subject Vehicle

Figure A12. Brake Actuation System Installed in Principal Other Vehicle

Figure A13. System Setup Menus (page 1 of 2)

Figure A14. System Setup Menus (page 2 of 2)

Figure A15. Control for Changing System Parameters

Figure A16. FCW Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

User settings mode (if equipped)

ODEP049586L

In this mode, you can change the settings of the instrument cluster, doors, lamps, etc.

1. Driver Assistance
2. Door
3. Lights
4. Sound
5. Convenience
6. Service Interval
7. Other
8. Language
9. Reset

The information provided may differ depending on which functions are applicable to your vehicle.

ODEP049584L

Shift to P to edit settings

This warning message appears if you try to adjust the User Settings while driving.

For your safety, change the User Settings after parking the vehicle, applying the parking brake and moving the shift lever to P (Park).

1. Driver Assistance (if equipped)

Items	Explanation
SCC Reaction	• Fast/Normal/Slow To adjust the sensitivity of Smart Cruise Control system. ❉ For more details, refer to “Smart Cruise Control (SCC)” in chapter 5.
Driving Assist	• Lane Following Assist To select the function. ❉ For more details, refer to “Lane Following Assist (LFA)” in chapter 5. • Highway Driving Assist To select the function. ❉ For more details, refer to “Highway Driving Assist (HDA)” in chapter 5.
Driver Attention Warning	• Leading Vehicle Departure Alert To select the function. ❉ For more details, refer to “Leading vehicle departure alert” in chapter 5. • Low Activity Warning To select the function. ❉ For more details, refer to “Driver Attention Warning (DAW)” in chapter 5.
Warning Timing	• Normal/Later To select when to provide a warning for all driver assistance system.

❉ The information provided may differ depending on which functions are applicable to your vehicle.

Items	Explanation
Forward Safety	• Active Assist/Warning Only/Off To select the function. ❉ For more details, refer to “Forward Collision-Avoidance Assist (FCA)” in chapter 5.
Lane Safety	• Lane Keeping Assist / Lane Departure Warning / Off To select the function. ❉ For more details, refer to “Lane Keeping Assist (LKA)” in chapter 5.
Blind-Spot Safety	• Warning Only/Off To select the function. ❉ For more details, refer to “Blind-spot Collision Warning (BCW)” in chapter 5.
Parking Safety	• Rear Cross-Traffic Safety To select the function. ❉ For more details, refer to “Rear Cross-traffic Collision Warning (RCCW)” in chapter 5.

❉ The information provided may differ depending on which functions are applicable to your vehicle.

Electronic Parking Brake (EPB) Warning Light (if equipped)

EPB

This warning light illuminates:

- Once you set the ignition switch or ENGINE START/STOP button to the ON position.
  - It illuminates for approximately 3 seconds and then goes off.
- When there is a malfunction with the EPB.

  In this case, have your vehicle inspected by an authorized Kia dealer.

✻ NOTICE - Electronic Parking Brake (EPB) Warning Light

The Electronic Parking Brake (EPB) Warning Light may illuminate when the Electronic Stability control (ESC) Indicator Light comes on to indicate that the ESC is not working properly (This does not indicate malfunction of the EPB).

LED Headlamp Warning Light (if equipped)

This warning light illuminates:

- Once you set the ignition switch or ENGINE START/STOP button to the ON position.
  - It illuminates for approximately 3 seconds and then goes off.
- When there is a malfunction with the LED headlamp.

In this case, have your vehicle inspected by an authorized Kia dealer.

⚠ CAUTION - LED Headlamp Warning Light

Continuous driving with the LED Headlamp Warning Light on can reduce LED headlamp (low beam) life.

Forward Collision-Avoidance Assist System Warning Light (if equipped)

This warning light illuminates:

- Once you set the ignition switch or ENGINE START/STOP button to the ON position.
  - The FCA warning light illuminates for approximately 3 seconds and then turns off.
- When there is a malfunction with FCA.

  If this occurs, have your vehicle inspected by an authorized Kia dealer.

❇ For more details, refer to “Forward Collision-Avoidance Assist (FCA)” in chapter 5.

FORWARD COLLISION-AVOIDANCE ASSIST (FCA) (SENSOR FUSION) (IF EQUIPPED)

FCA system is to reduce or to avoid accident risk. It recognizes the distance from the vehicle ahead, the pedestrian or the cyclist through the sensors (i.e. front view camera and front radar), and, if necessary, warns the driver of accident risk with the warning message or the warning alarms and apply emergency braking.

❊ FCA stands for Forward Collision-Avoidance Assist.

❊ Sensor fusion (front view camera + front radar) FCA system operates for the vehicle ahead, the pedestrian or the cyclist in front.

⚠ WARNING

Take the following precautions when using Forward Collision-Avoidance Assist system:

- **This system is only a supplemental system and it is not intended to, nor does it replace the need for the extreme care and attention of the driver. The sensing range and objects detectable by the sensors are limited. Pay attention to the road conditions at all times.**
- **NEVER drive too fast in accordance with the road conditions or while cornering.**
- **Always drive cautiously to prevent unexpected and sudden situations from occurring. FCA system does not stop the vehicle completely and is only intended to help mitigate an imminent collision.**

System setting and activation

Forward safety

The driver can activate FCA system by placing the ignition switch or ENGINE START/STOP button to the ON position and by selecting:

"User Settings → Driver Assistance → Forward Safety"

- If you select "Active Assist", FCA system activates. FCA produces warning messages and warning alarms in accordance with the collision risk levels. Also, it controls the brakes in accordance with the collision risk levels.
- If you select "Warning Only", FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.
- If you select "Off", FCA system deactivates,

The warning light illuminates on the LCD display, when you cancel FCA system. The driver can monitor the FCA ON/OFF status on the LCD display. Also, the warning light illuminates when the ESC (Electronic Stability Control) is turned off. When the warning light remains ON with FCA activated, have your vehicle inspected by an authorized Kia dealer.

Warning Timing

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The driver can select the initial warning activation time on the LCD display.

Go to the “User Settings → Driver Assistance → Warning Timing → Normal/Later”

The options for the initial Forward Collision Warning includes the following:

- Normal:

When this condition is selected, the initial Forward Collision Warning system is activated normally. This setting allows for a nominal amount of distance between the vehicle ahead before the initial warning occurs.

- Later:

When this condition is selected, the initial Forward Collision Warning system is activated later than normal. This setting reduces the amount of distance between the vehicle ahead, the pedestrian or the cyclist before the initial warning occurs.

Select 'Later' when traffic is light and when driving speed is slow.

If the vehicle in front puts on a burst of speed, the driver can notice the warning alarm is early even though the later option is selected.

✻ NOTICE

If you change the warning timing, the warning timing of other systems may change. Always be aware of warning timing before changing the warning timing.

Prerequisite for activation

FCA system gets ready to be activated, when the “Active assist” or “Warning only” under the Forward Safety is selected on the LCD display, and when the following prerequisites are satisfied.

- The ESC is activated.
- The driving speed is over 5 mph (8 km/h). (However, FCA is activated within certain driving speed.)
- When recognizing the vehicle or the pedestrian or the cyclist in front. (However, FCA does not activate according to conditions in front and vehicle systems, but it notices only certain warnings.)
- FCA does not operate properly or it only produces a warning alarms in accordance with the driving or vehicle condition.
- If the warning only under the Forward Safety is selected, FCA produces only warning alarms in accordance with the collision risk levels.

✻ NOTICE

FCA may not operate properly according to the frontal situation, the direction of pedestrian or cyclist and speed.

⚠ WARNING

- **Completely stop the vehicle in a safe location before operating the switch on the steering wheel to activate/deactivate FCA system.**
- **FCA system automatically activates upon placing the ignition switch to the ON position. The driver can deactivate FCA system by canceling the system setting on the LCD display or Infotainment System screen.**
- **FCA system automatically deactivates upon canceling the ESC. When the ESC is canceled, FCA system cannot be activated on the LCD display or Infotainment System screen.**

  FCA system warning light will illuminate, which is normal.

FCA warning message and system control

FCA system produces warning messages and warning alarms in accordance with the collision risk levels of followings like vehicle's sudden braking in front or lack of vehicle to vehicle distance or collision to pedestrians or cyclist. Also, it controls the brakes in accordance with the collision risk levels.

The driver can select the initial warning activation time in the User settings in the LCD display. The options for the initial Forward Collision Warning include Normal or Late initial warning time.

Collision Warning (1st warning)

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- The warning message appears on the LCD display with the warning alarms.
- The Vehicle may slow down slightly
  - It will operate if the vehicle speed is greater than 5 mph (8 km/h) and less than or equal to 110 mph (180 km/h) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)

- For pedestrians and cyclists, the vehicle speed is greater than or equal to 5 mph (8 km/h) and less than 45 mph (70 km/h). (Depending on the condition of pedestrians and bike riders and the surrounding environment the possible maximum operating speed may be reduced.)

• FCA system controls the brakes within certain limit to release shock from the collision.

- If you select “Warning Only”, FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.

Emergency braking (2nd warning)

OJF058390L

• The warning message appears on the LCD display with the warning alarms.

• The brake control is maximized just before a collision, reducing impact when it strikes a forward vehicle.

- It will operate if the vehicle speed is greater than 5 mph (8 km/h) and less than or equal to 50 mph (80 km/h) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)

- For pedestrians and cyclists, the vehicle speed is greater than or equal to 5 mph (8 km/h) and less than 45 mph (70 km/h). (Depending on the condition of pedestrians and bike riders and the surrounding environment the possible maximum operating speed may be reduced.)

• FCA system controls the brakes within certain limit to release shock from the collision.

FCA system controls the maximum brakes just before the collision.

- If you select “Warning Only”, FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.

Brake operation

- In an urgent situation, the braking system enters into the ready status for prompt reaction to assist the driver in depressing the brake pedal.
- FCA system provides additional braking power for optimum braking performance, when the driver depresses the brake pedal.
- The braking control is automatically deactivated, when the driver sharply depresses the accelerator pedal, or when the driver abruptly operates the steering wheel.
- The braking control is automatically canceled, when risk factors disappear.

⚠ CAUTION

The driver should always pay great caution to vehicle operation, even though there is no warning message or warning alarm.

⚠ WARNING

FCA system cannot avoid all collisions. FCA system might not completely stop the vehicle before a collision, due to ambient, weather and road conditions. The driver has the responsibility to drive safely and control the vehicle.

⚠ WARNING

FCA system operates in accordance with certain risk factors, such as the distance from the vehicle/passer-by in front, the speed of the vehicle/passer-by in front, and the driver's vehicle operation.

Detecting sensors (front view camera/front radar)

The sensors are that detecting the distance to vehicles ahead, pedestrian or cyclist.

In bad weather conditions such as heavy rain, heavy snow, and fog, or when sensor is covered by foreign material, dust, tec., the sensors will be degraded and the system will be temporarily disabled.

Always keep the sensor clean.

✻ NOTICE

- **Do not install any accessories, such as license plate molding or sticker, on the sensor area. Nor arbitrarily replace the bumper. Those may adversely affect the sensing performance.**
- **Always keep the sensor/bumper area clean.**
- **Use only soft cloths to wash the vehicle. Also, do not spray highly-pressurized water on the sensor installed on the bumper.**
- **Be careful not to apply unnecessary force on the frontal sensor area. When the sensor moves out of the correct position due to external force, the system may not normally operate even without the warning light or message. In this case, have your vehicle inspected by an authorized Kia dealer.**
- **Use only the genuine Kia sensor cover. Do not arbitrarily apply paint on the sensor cover.**

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- **Do not tint the window or install stickers, accessories around the inside mirror where the camera is installed.**
- **Make sure the frontal camera installation point does not get wet.**
- **Do not impact or arbitrarily remove any radar/camera components.**
- **Do not place reflective objects(white paper or mirror etc.) on the crash pad.**
  The system may activate unnecessarily due to reflect of the sunlight.
- **Excessive audio volume may disturb the sound of the system warning alarm.**
- **For more cautions for the camera sensor, refer to the "Lane Keeping Assist (LKA)" in this chapter.**

Warning message and warning light

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If the sensor or sensor cover is covered by bad weather or foreign objects, dust, etc., FCA system operation may temporarily stop. In this case, the warning message appears to warn the driver.

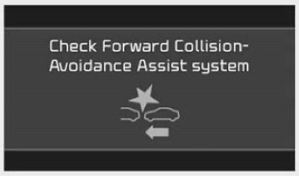
This is not a malfunction with FCA system. To operate FCA system again, remove the foreign substances.

FCA system may not properly operate when the front radar is contaminated or an object such as an open area is not existed after engine start.

⚠ WARNING

FCA system may not activate without any warning messages according to driving condition, traffic on the road, weather, road condition, etc.

System malfunction



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- When FCA system is not working properly, the FCA warning light ( ) will illuminate and the warning message will appear for a few seconds. After the message disappears, the master warning light (⚠) will illuminate. In this case, have your vehicle inspected by an authorized Kia dealer.
- The FCA warning message may appear along with the illumination of the ESC warning light.

⚠ WARNING

- **FCA system is only a supplemental system for the driver's convenience. The driver has the ultimate responsibility to control and operate the vehicle safely. Do not solely depend on FCA system. Rather, maintain a safe braking distance, and, if necessary, depress the brake pedal to lower the driving speed.**
- **In certain instances and under certain driving conditions, FCA system may activate unintentionally. This initial warning message appears on the LCD display with a warning chime.**

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Also, in certain instances the front radar sensor or camera recognition system may not detect the vehicle, pedestrian or cyclist (if equipped) ahead. FCA system may not activate and the warning message will not be displayed.

- **FCA system may unnecessarily produce the warning message and the warning alarms. Also, due to the sensing limitation, FCA system may not produce the warning message and the warning alarm at all.**
- **When there is a malfunction with FCA system, the braking control does not operate upon detecting a collision risk even with other braking systems normally operating.**

(Continued)

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- **FCA system operates only for the vehicle/pedestrian in front, while driving forward. It does not operate for any animals or vehicles in the opposite direction.**
- **FCA system does not recognize the vehicle, which transversally drives across the crossroad, or the vehicle, which is parked in the transversal direction.**
- **If the vehicle in front stops suddenly, you may have less control of the brake system. Therefore, always keep safe distance between your vehicle and the vehicle in front of you.**
- **FCA system may activate during braking and the vehicle may stop suddenly. And the load in the vehicle may endanger passengers. Therefore, always be mindful of the load volume in the vehicle.**

(Continued)

(Continued)

- **FCA system may not activate if the driver applies the brake pedal to avoid risk of collision.**
- **FCA system does not operate when the vehicle is in reverse. In these circumstances, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce the driving speed in order to maintain a safe dis tance.**
- **The regular braking function will operate normally even if There is a problem with the FCA brake control system or other functions. In this case, the braking control will not operate in an imminent collision.**

(Continued)

(Continued)

- **FCA system may not activate according to driving condition, traffic on the road, weather, road condition, etc.**
- **FCA system may not activate in response to all types of vehicles.**

Limitation of the system

FCA system is an assistant system for a driver in a certain risky driving condition and it does not take every responsibility for all risks from driving condition.

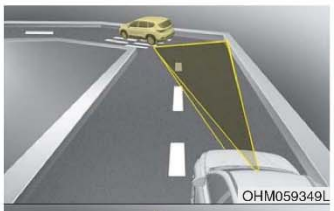
FCA system monitors the driving situations through the radar and the camera sensor. Thus, for a situation out of the sensing range, FCA system may not normally operate. The driver should pay great caution in the following situations. FCA system operation may be limited.

Recognizing vehicles

The sensor may be limited when:

- The front view camera or front radar sensor is blocked with a foreign object or debris
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign matter (sticker, bug, etc.) on the glass
- Inclement weather such as heavy rain or snow obscures the field of view of the radar sensor or camera
- There is interference by electromagnetic waves
- There is severe irregular reflection from the radar sensor
- The front view camera/front radar sensor recognition is limited
- The vehicle in front is too small to be detected (for example a motorcycle etc.)
- The vehicle in front is an oversize vehicle or trailer that is too big to be detected by the camera recognition system (for example a tractor trailer, etc.)
- The camera's field of view is not well illuminated (either too dark or too much reflection or too much backlight that obscures the field of view)
- The vehicle in front does not have their rear lights or their rear lights does not turned ON or their rear lights are located unusually.
- The outside brightness changes suddenly, for example when entering or exiting a tunnel
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- The field of view in front is obstructed by sun glare
- The vehicle in front is driving erratically
- The vehicle is on unpaved or uneven rough surfaces, or road with sudden gradient changes.
- The vehicle is driven near areas containing metal substances as a construction zone, railroad, etc.
- The vehicle drives inside a building, such as a basement parking lot
- The front view camera does not recognize the entire vehicle in front.
- The front view camera is damaged.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- The shadow is on the road by a median strip, trees, etc.
- The vehicle drives through a tollgate.
- The windshield glass is fogged up; a clear view of the road is obstructed.
- The rear part of the vehicle in front is not normally visible. (the vehicle turns in other direction or the vehicle is overturned.)
- The adverse road conditions cause excessive vehicle vibrations while driving
- The sensor recognition changes suddenly when passing over a speed bump

- The vehicle in front is moving longitudinally to the driving direction
- The vehicle in front is stopped longitudinally
- The vehicle in front is driving towards your vehicle or reversing
- You are on a roundabout and the vehicle in front circles
- It is difficult to secure the field of view of the front view camera such as backlight, reflected light, and darkness.
- When the front camera is blocked by continuous washer spray and wiper operation.
- The vehicle in front is a special purpose vehicle, a trailer, or a truck loading with unusual shape of luggage.
- The ambient light is too high or low.
- The front view camera is contaminated by front glass tinting, attaching film, water proof coating, damaged, foreign material such as a sticker, worm, etc.
- When the front view camera (including lens) or front radar is damaged.
- If not using headlamp or using weak light in the night or in a tunnel.
- Backlight is shining in the driving direction of the vehicle. (Including oncoming vehicle headlights.)
- When the rear part of the front vehicle is small or low.
- When a trailer or other vehicle is towing the front vehicle.
- When the ground clearance of the front vehicle is high.
- When a front vehicle makes sudden lane changes unexpectedly.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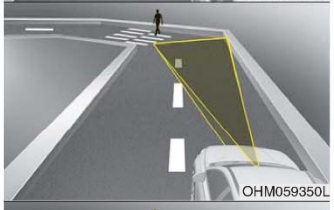
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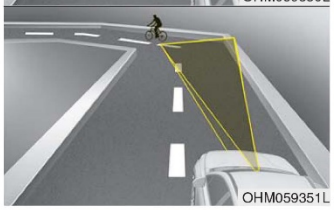
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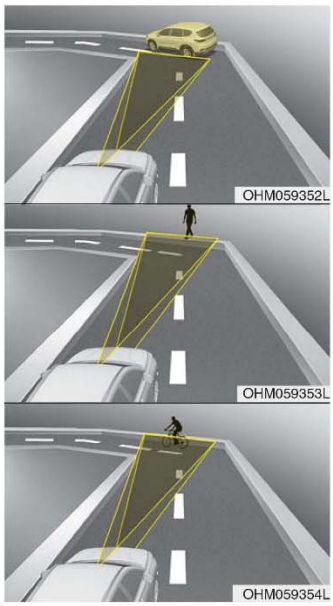
- Driving on a curve

The performance of Forward Collision-Avoidance Assist system may be limited when driving on a curved road.

The front view camera or front radar sensor recognition system may not detect the vehicle, pedestrian or cyclist traveling in front on a curved road.

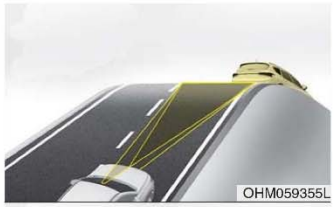
This may result in no alarm and braking when necessary.

Always pay attention to road and driving conditions, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.



Forward Collision-Avoidance Assist system may recognize a vehicle or pedestrian or cyclist in the next lane or outside the lane when driving on a curved road.

If this occurs, the system may unnecessarily alarm the driver and apply the brake. Always pay attention to road and driving conditions, while driving.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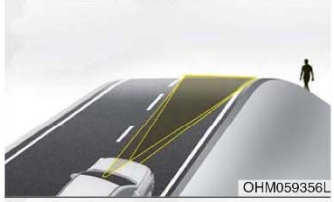
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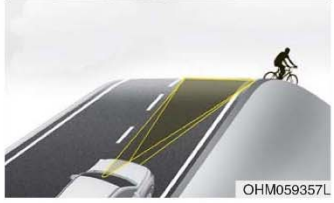
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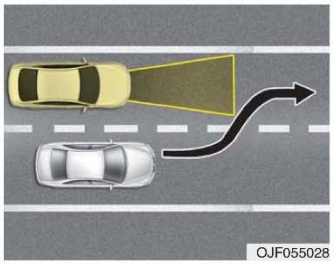
- Driving on a slope

The performance of Forward Collision-Avoidance Assist system may be decreased while driving upward or downward on a slope. The front view camera or front radar sensor recognition may not detect the vehicle, pedestrian or cyclist in front.

This may result in unnecessary alarm and braking or no alarm and braking when necessary.

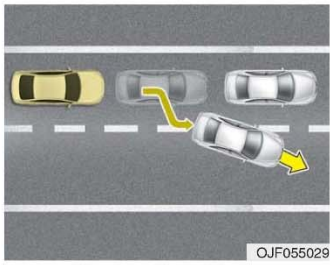
When the system suddenly recognizes the vehicle, pedestrian or cyclist in front while passing over a slope, you may experience sharp deceleration.

Always keep your eyes forward while driving upward or downward on a slope, and, if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

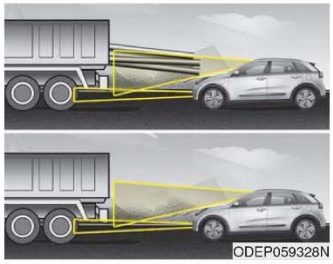

OJF055028

- Changing lanes

When a vehicle changes lanes in front of you, Forward Collision-Avoidance Assist system may not immediately detect the vehicle, especially if the vehicle changes lanes abruptly. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.


OJF055029

When driving in stop-and-go traffic, and a stopped vehicle in front of you merges out of the lane, Forward Collision-Avoidance Assist system may not immediately detect the new vehicle that is now in front of you. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.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- Recognizing the vehicle

When the vehicle in front has heavy loading extended rearward, or when the vehicle in front has higher ground clearance, it may induce a hazardous situation. Always pay attention to road and driving conditions, while driving and, if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

Detecting pedestrian or cyclist

The sensor may be limited when:

- The pedestrian or cyclist is not fully detected by the camera recognition system, for example, if the pedestrian is leaning over or is not fully walking upright
- The pedestrian or cyclist is moving very quickly or appears abruptly in the front view camera detection area
- The pedestrian or cyclist is wearing clothing that easily blends into the background, making it difficult to be detected by the front view camera recognition system
- The outside lighting is too bright (e.g. when driving in bright sunlight or in sun glare) or too dark (e.g. when driving on a dark rural road at night)

- It is difficult to detect and distinguish the pedestrian or cyclist from other objects in the surroundings, for example, when there is a group of pedestrians, cyclists or a large crowd
- There is an item similar in shape or appearance to a person
- The pedestrian or cyclist is below the sensor's viewing range
- The sensor can not identify the pedestrian's outline because of other items changing their profile, such as mobility assistance devices
- The front view camera or front radar is obstructed by a foreign object or debris
- Inclement weather such as heavy rain or snow obscures the field of view of the radar sensor or camera
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- The field of view in front is obstructed by sun glare
- The windshield glass is fogged up; a clear view of the road is obstructed
- The adverse road conditions cause excessive vehicle vibrations while driving
- When the pedestrian or cyclist suddenly enters the path of travel of the vehicle
- When the cyclist in front is riding perpendicular to the direction of travel
- When there is any electromagnetic interference
- When the cyclist is near areas containing metal objects such as a construction zone, railroad, etc.
- If the bicycle material is not reflected well on the radar
- When a pedestrian or cyclist's height is small.
- When a pedestrian or cyclist's behavior is unstable.
- When a pedestrian or cyclist suddenly interrupts in front of the vehicle.
- When there are many pedestrians or cyclists.
- When there is an object that reflects radar well. (such as a guardrail or a nearby vehicle)

⚠ WARNING

- **Do not use Forward Collision avoidance Assist system when towing a vehicle. Application of FCA system while towing may adversely affect the safety of your vehicle or the towing vehicle.**
- **Use extreme caution when the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance.**
- **FCA system is designed to detect and monitor the vehicle ahead or detect a pedestrian or cyclist in the roadway through front view camera recognition and front radar signals. It may not always detect bicycles, motorcycles, or smaller wheeled objects such as luggage bags, shopping carts, or strollers.**

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- **Never try to test the operation of FCA system. Doing so may cause severe injury or death.**
- **If the front bumper, front glass, front view camera or front radar have been replaced or repaired, have your vehicle inspected by an authorized Kia dealer.**
- **If the system detects an object that has a similar shape or characteristics of a vehicle or a pedestrian, FCA system may operate.**

✻ NOTICE

In some instances, FCA system may be cancelled when subjected to electromagnetic interference.

This device complies with Part 15 of the FCC rules.

Operation is subject to the following three conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.
3. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the device.

APPENDIX C

Run Log

Subject Vehicle: **2020 Kia Niro Hybrid EX Premium** Test Date: **6/4/2020**

Principal Other Vehicle: **2006 Acura RL**

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
1	**Stopped POV**	Y	2.51	2.46	0.41	Pass	
2		Y	2.70	2.65	0.60	Pass	
3		Y	2.69	2.65	0.59	Pass	
4		Y	2.71	2.66	0.61	Pass	
5		Y	2.71	2.66	0.61	Pass	
6		Y	2.69	2.65	0.59	Pass	
7		Y	2.70	2.66	0.60	Pass	
16	**Decelerating POV, 45**	N					SV Speed, SV Yaw Rate
17		Y	2.50	2.46	0.10	Pass	
18		Y	2.53	2.46	0.13	Pass	
19		Y	2.45	2.41	0.05	Pass	
20		Y	2.53	2.48	0.13	Pass	
21		Y	2.50	2.47	0.10	Pass	
22		Y	2.60	2.58	0.20	Pass	
23		Y	2.56	2.52	0.16	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
8	**Slower POV, 45 vs 20**	Y	2.29	2.25	0.29	Pass	
9		N					POV Speed
10		Y	2.28	2.22	0.28	Pass	
11		Y	2.32	2.26	0.32	Pass	
12		Y	2.31	2.26	0.31	Pass	
13		Y	2.30	2.25	0.30	Pass	
14		Y	2.32	2.28	0.32	Pass	
15		Y	2.31	2.26	0.31	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 (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.

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 – Decelerating 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

Other Notations

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

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

Examples of 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.

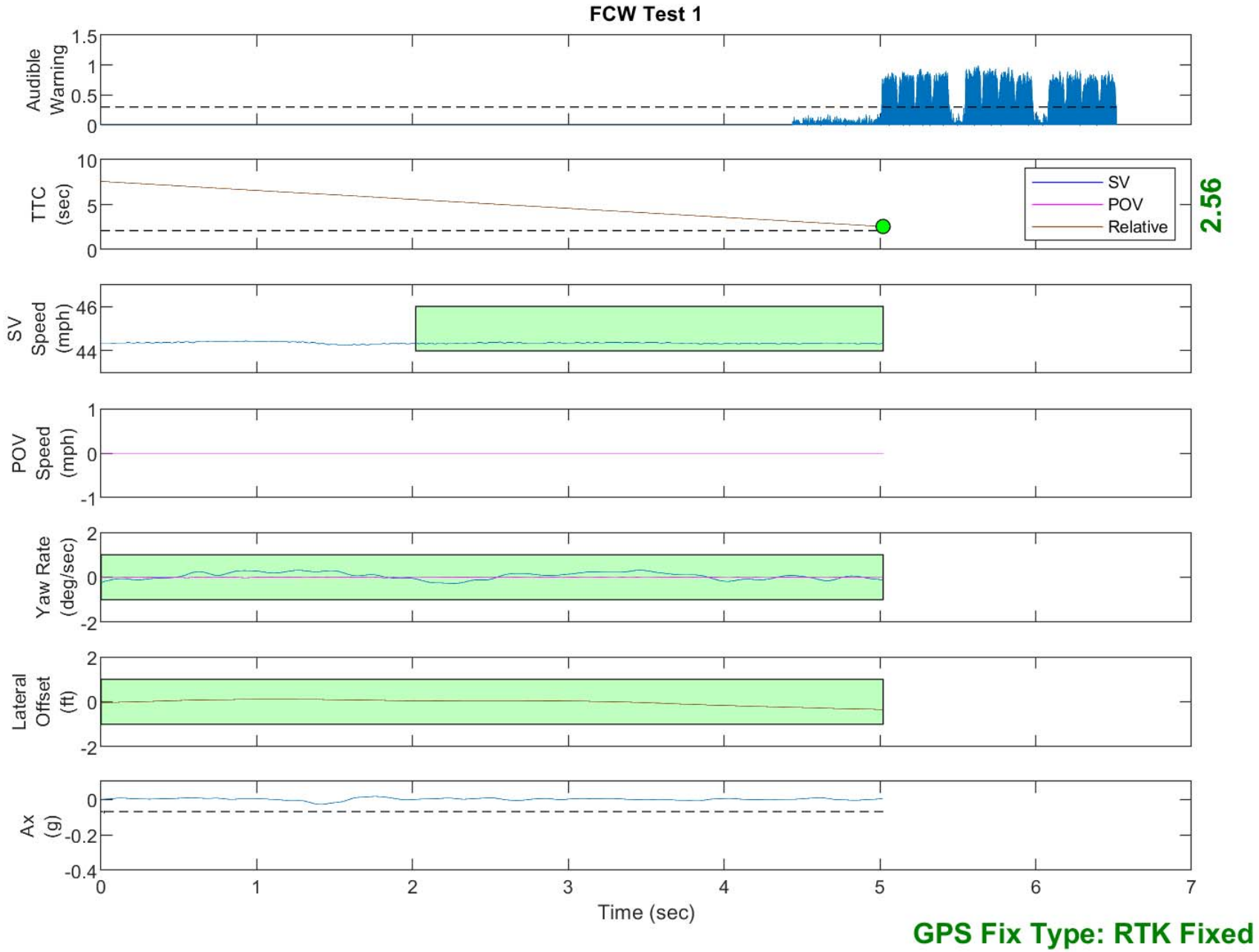

Figure D1. Example Time History for Test Type 1, Passing

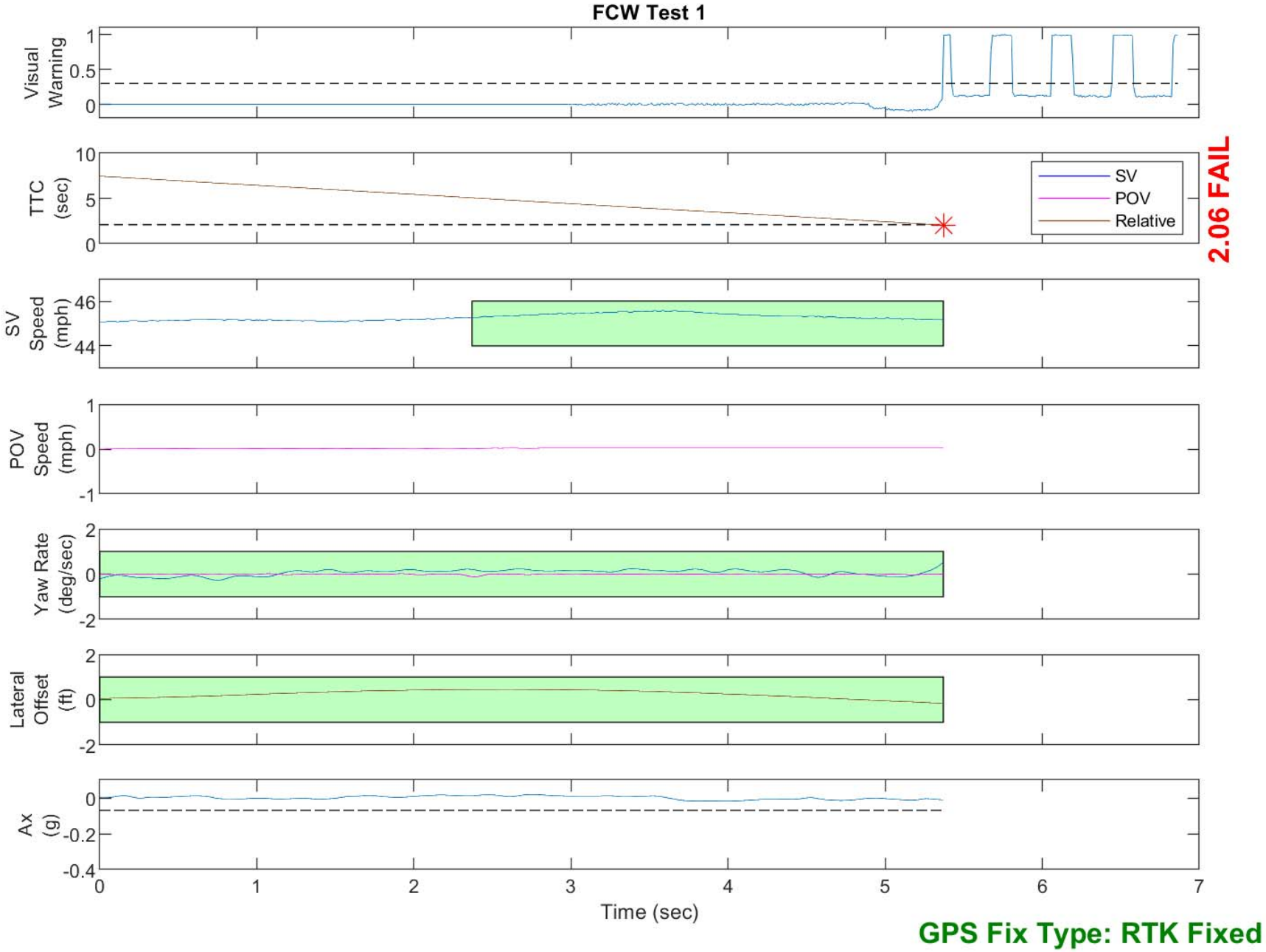

Figure D2. Example Time History for Test Type 1, Failing

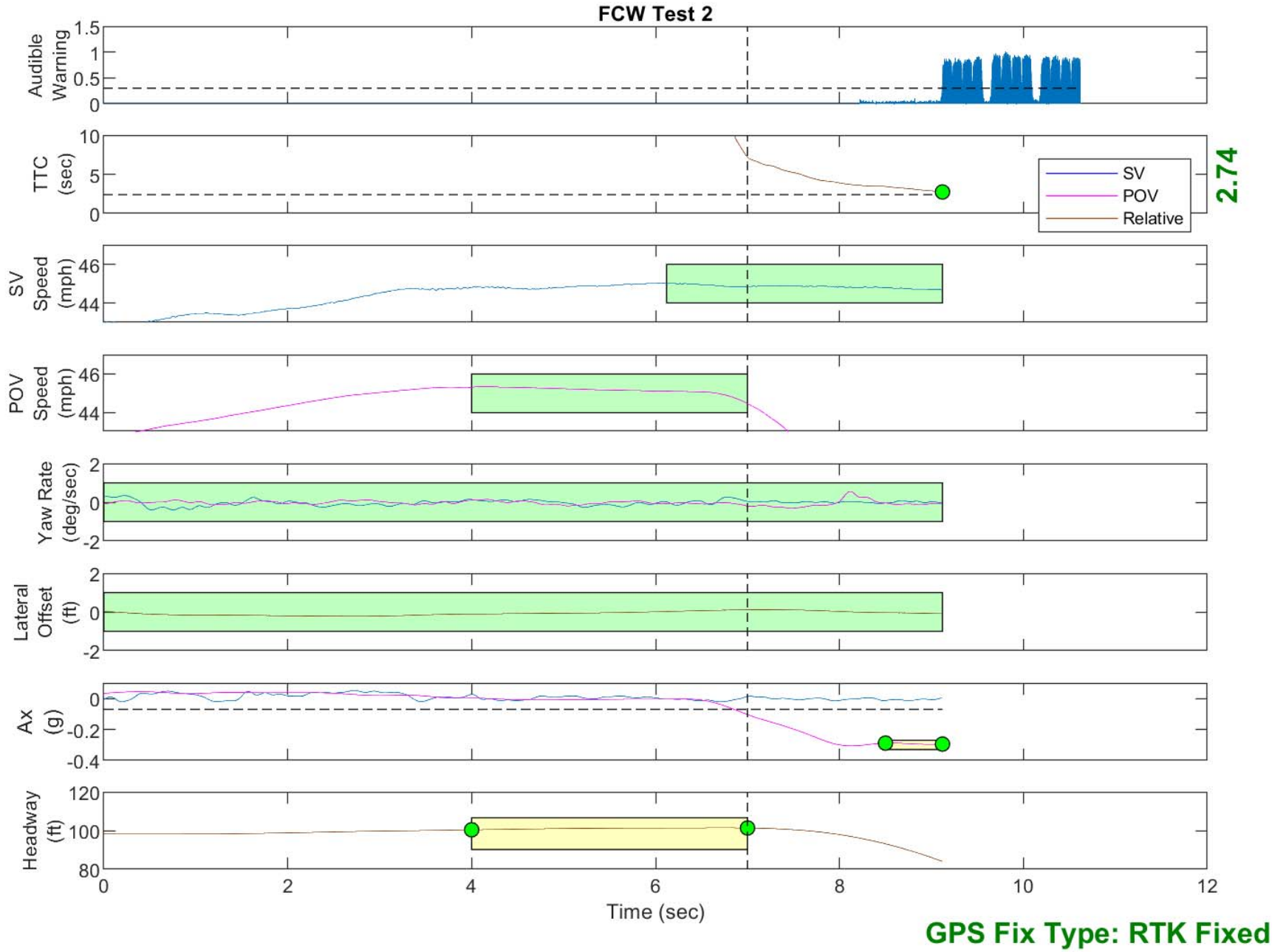

Figure D3. Example Time History for Test Type 2, Passing

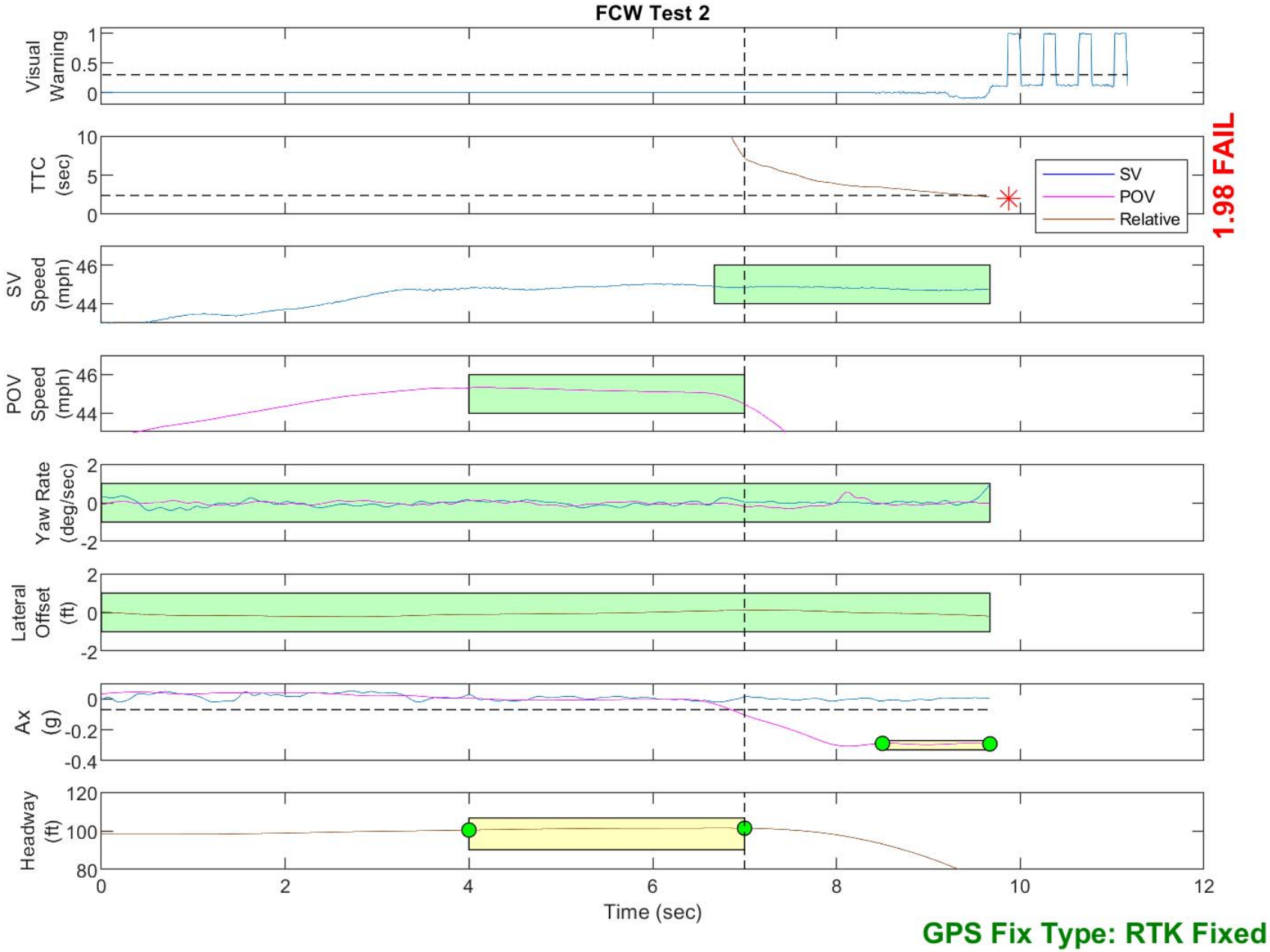

Figure D4. Example Time History for Test Type 2, Failing

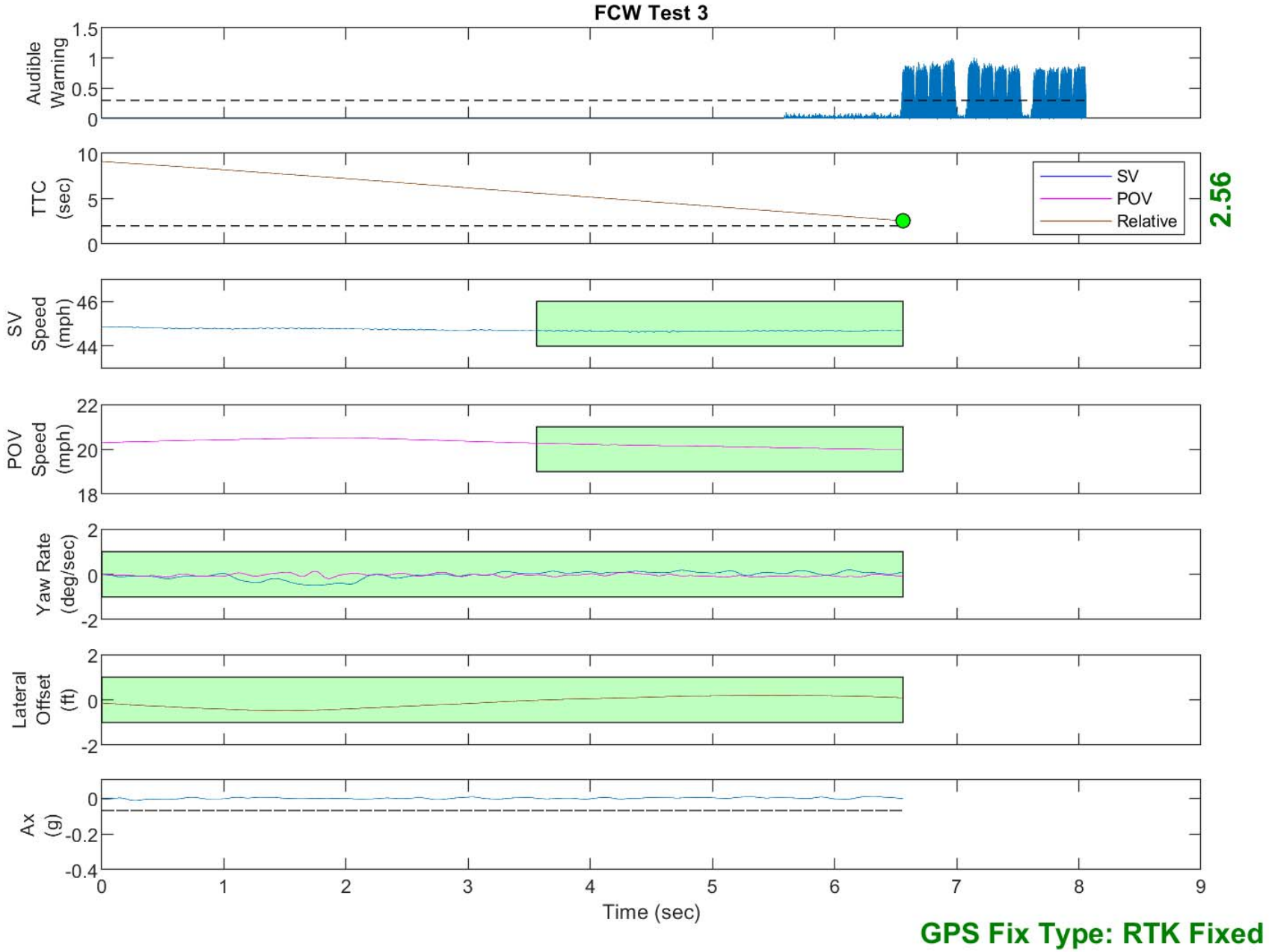

Figure D5. Example Time History for Test Type 3, Passing

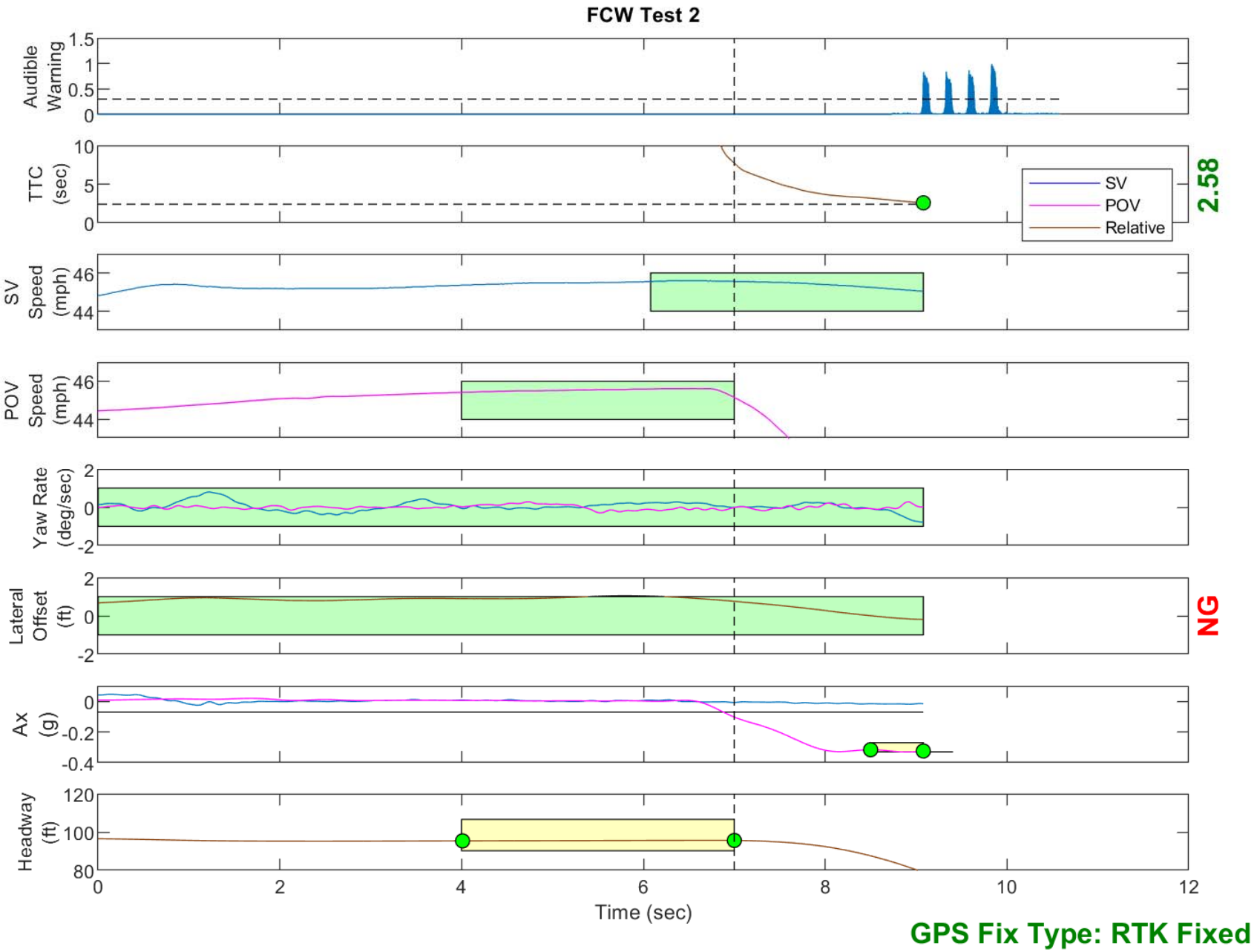

Figure D6. Example Time History Showing Invalid Lateral Offset Criteria

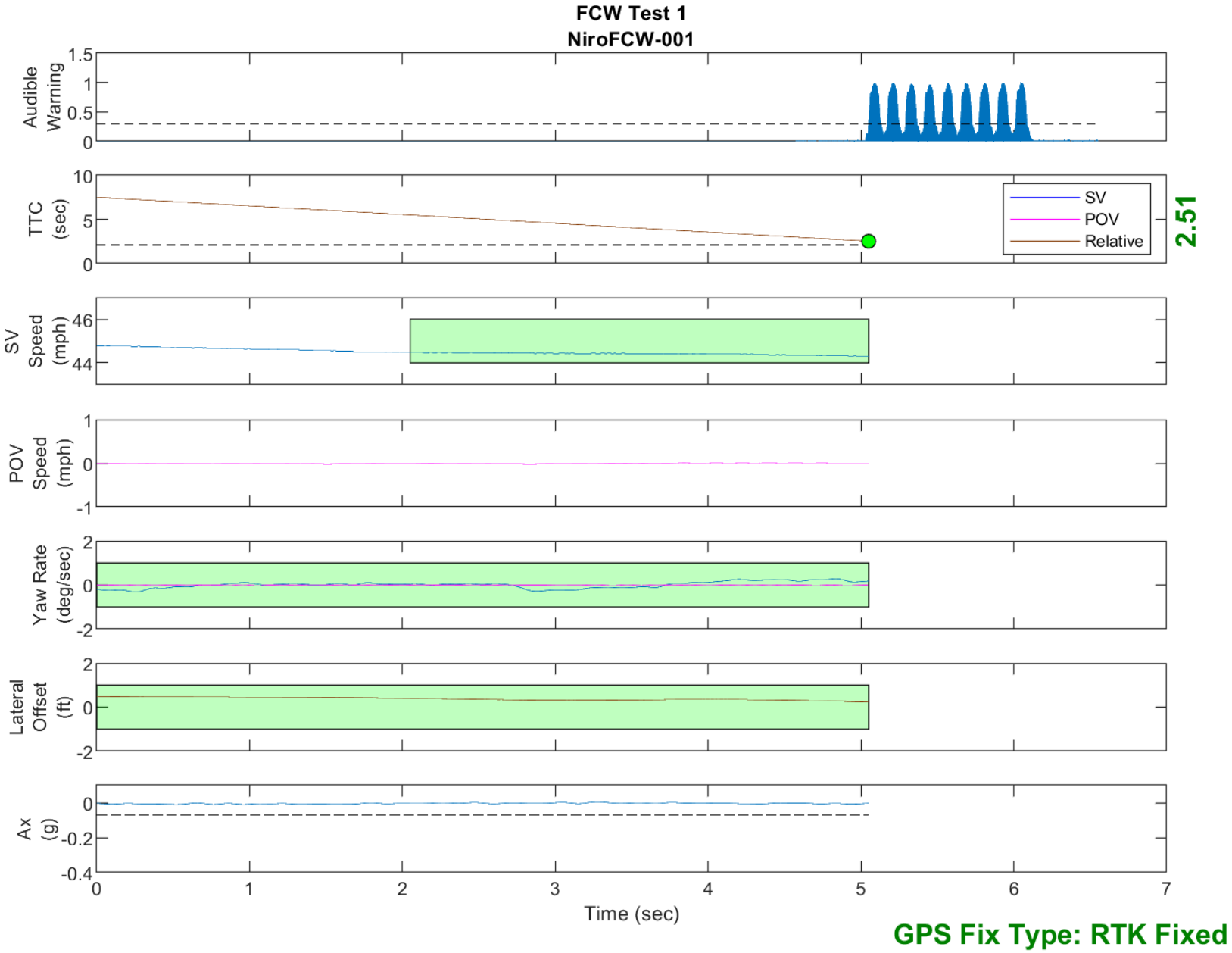

Figure D7. Time History for Run 1, FCW Test 1, Audible Warning

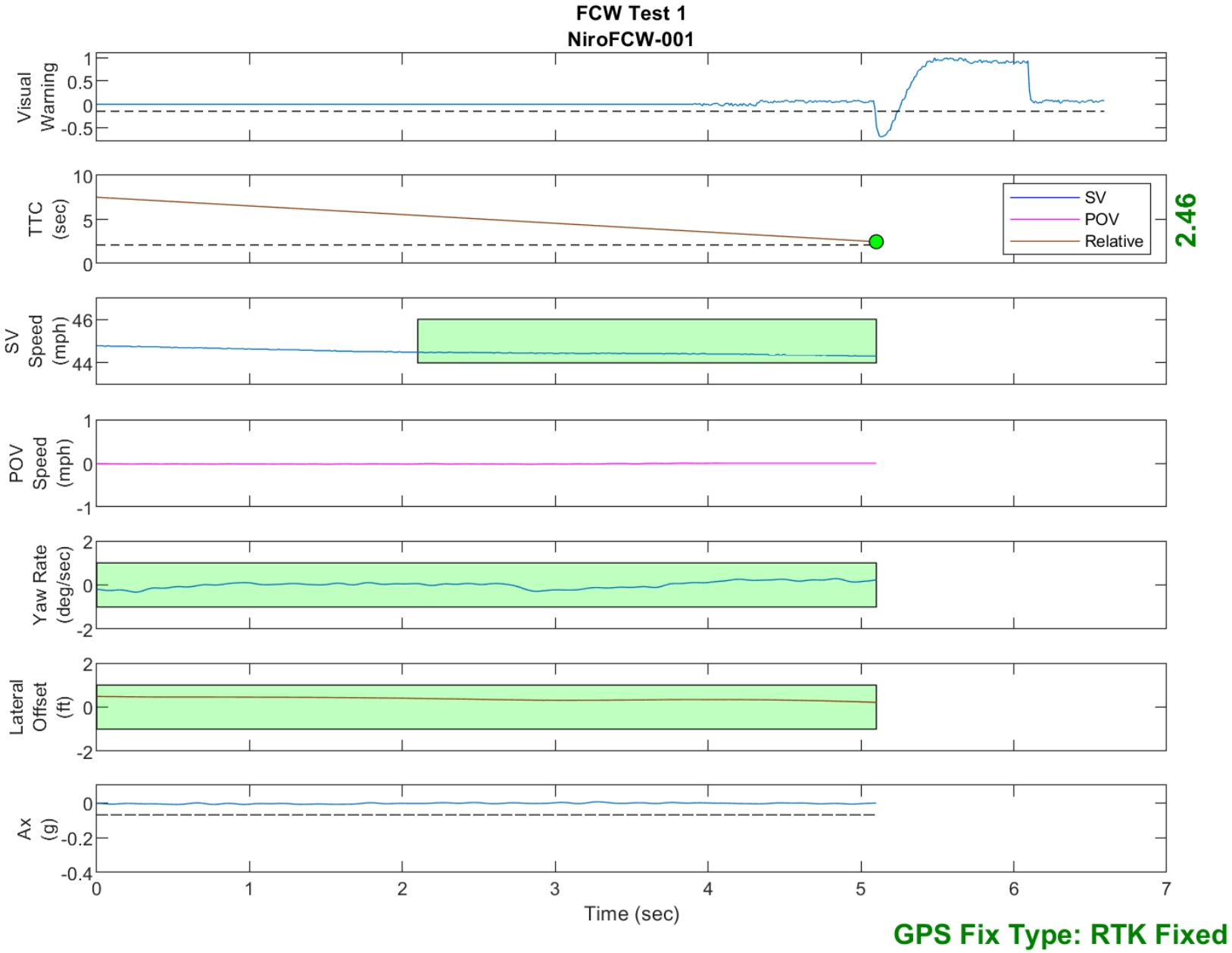

Figure D8. Time History for Run 1, FCW Test 1, Visual Warning

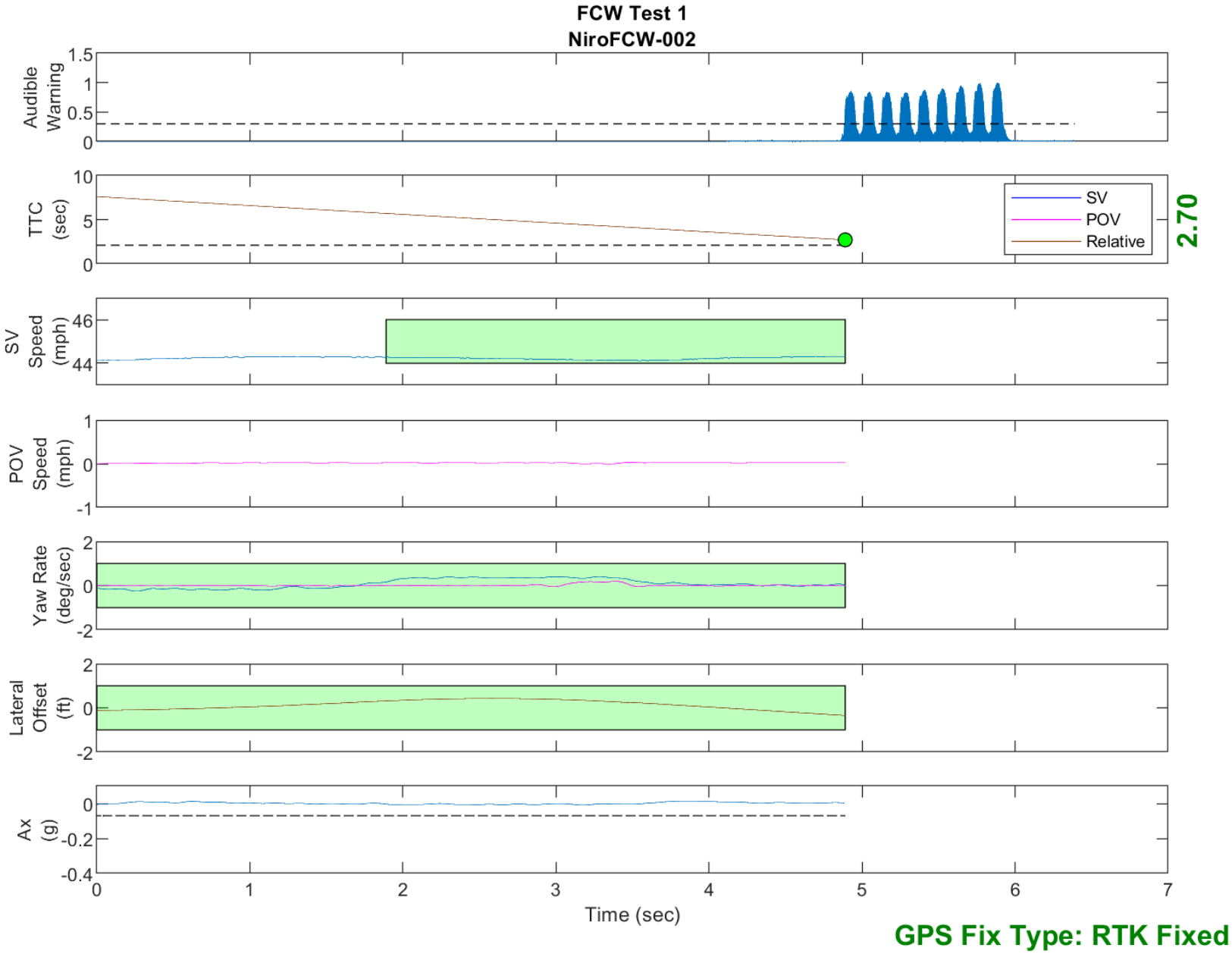

Figure D9. Time History for Run 2, FCW Test 1, Audible Warning

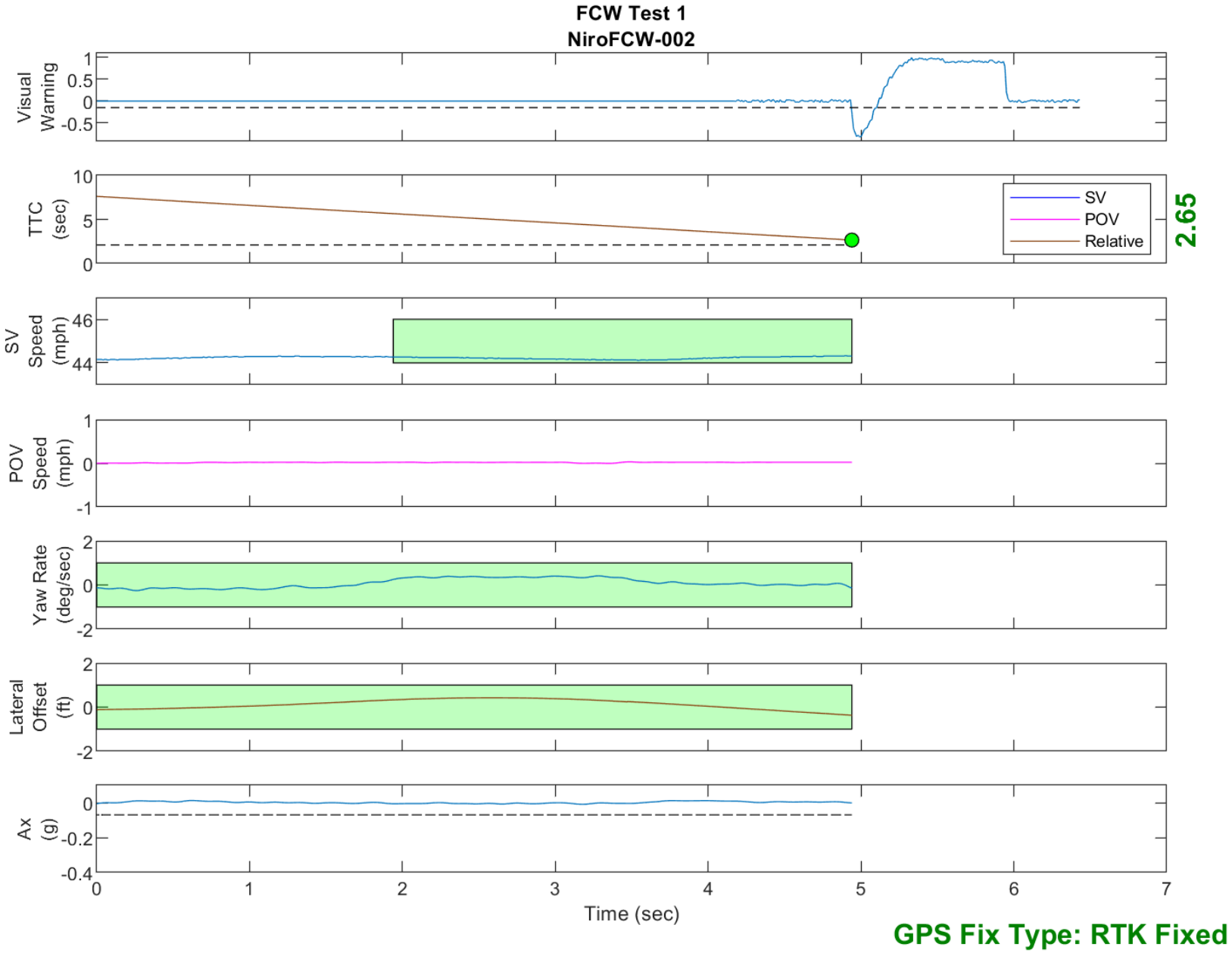

Figure D10. Time History for Run 2, FCW Test 1, Visual Warning

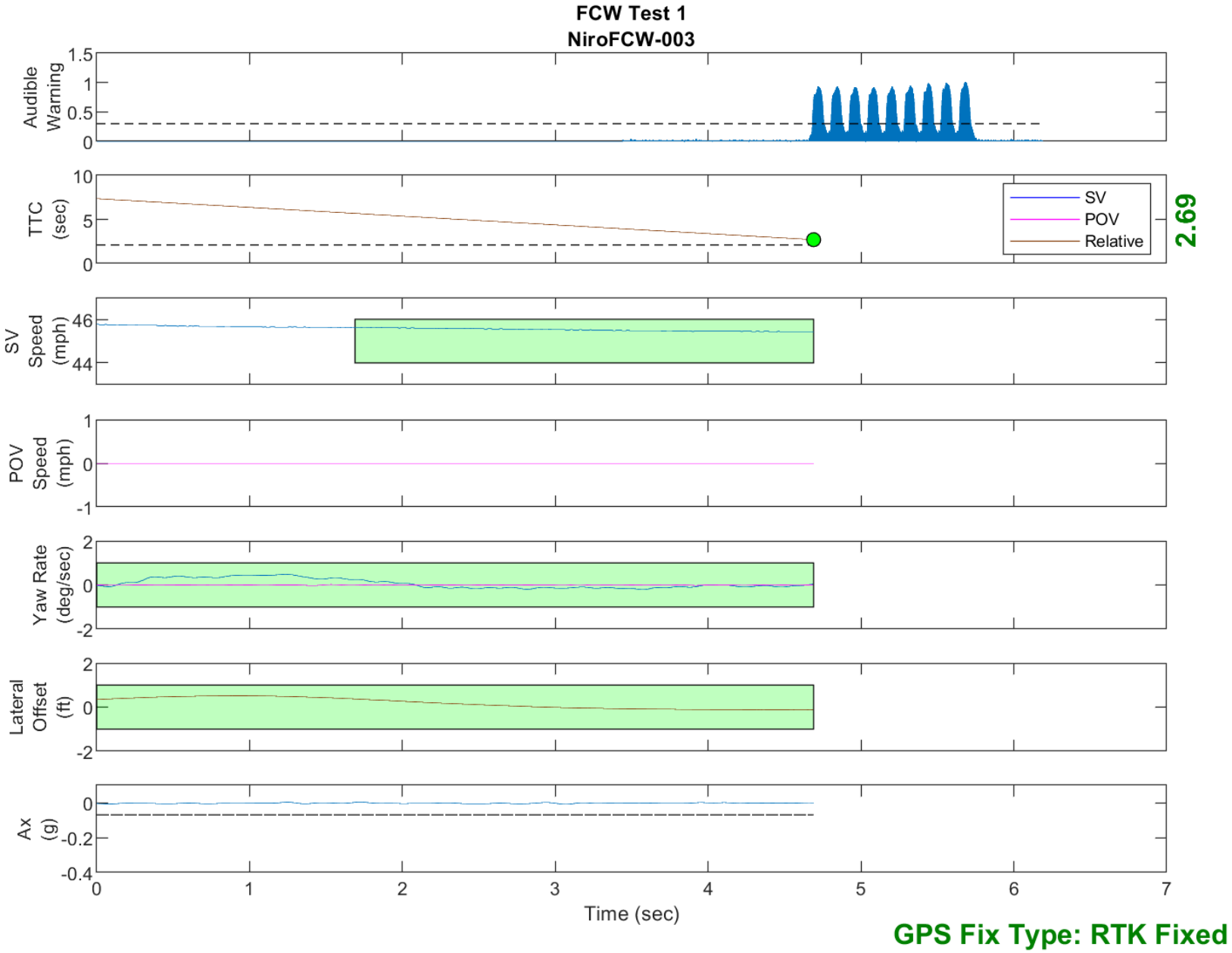

Figure D11. Time History for Run 3, FCW Test 1, Audible Warning

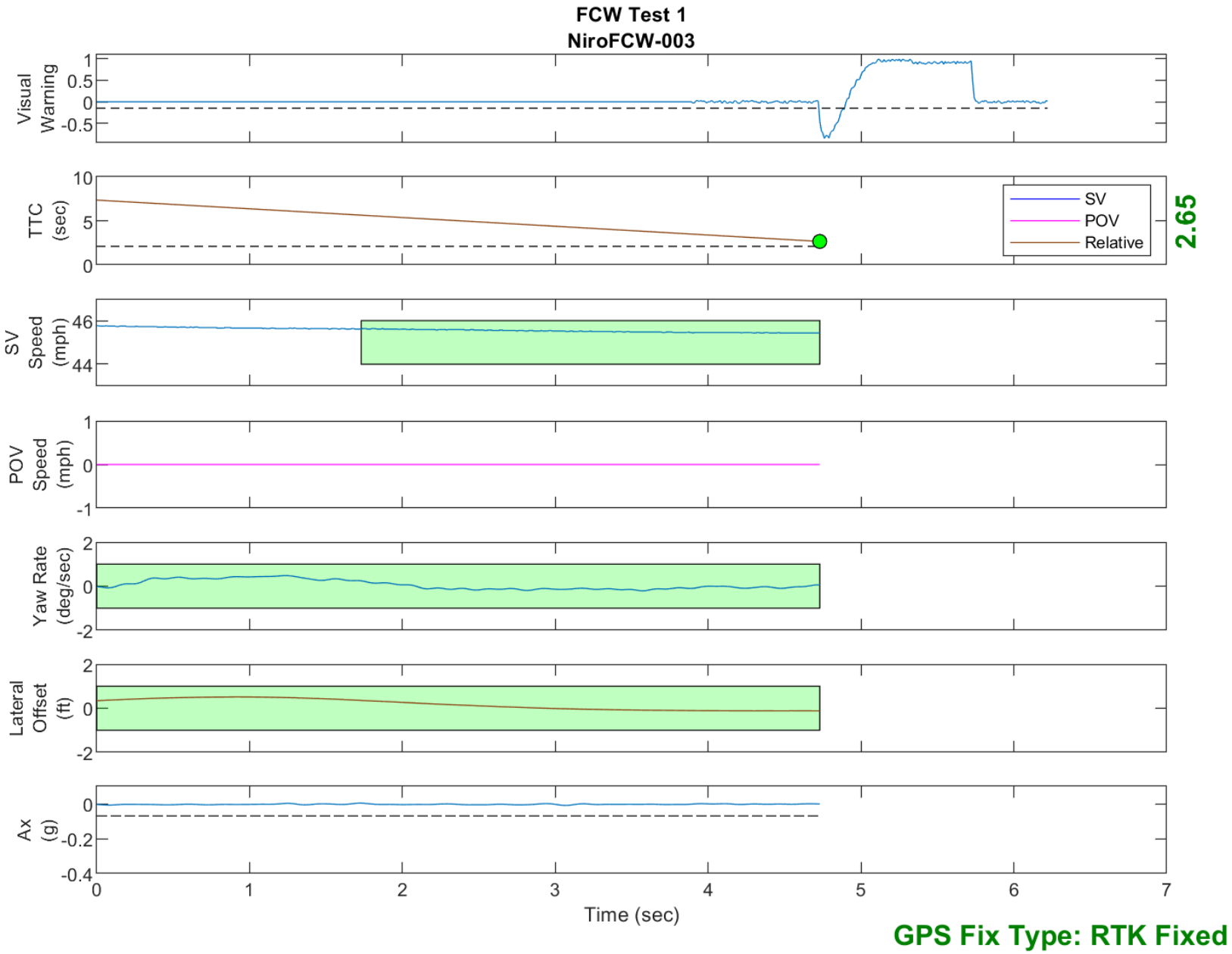

Figure D12. Time History for Run 3, FCW Test 1, Visual Warning

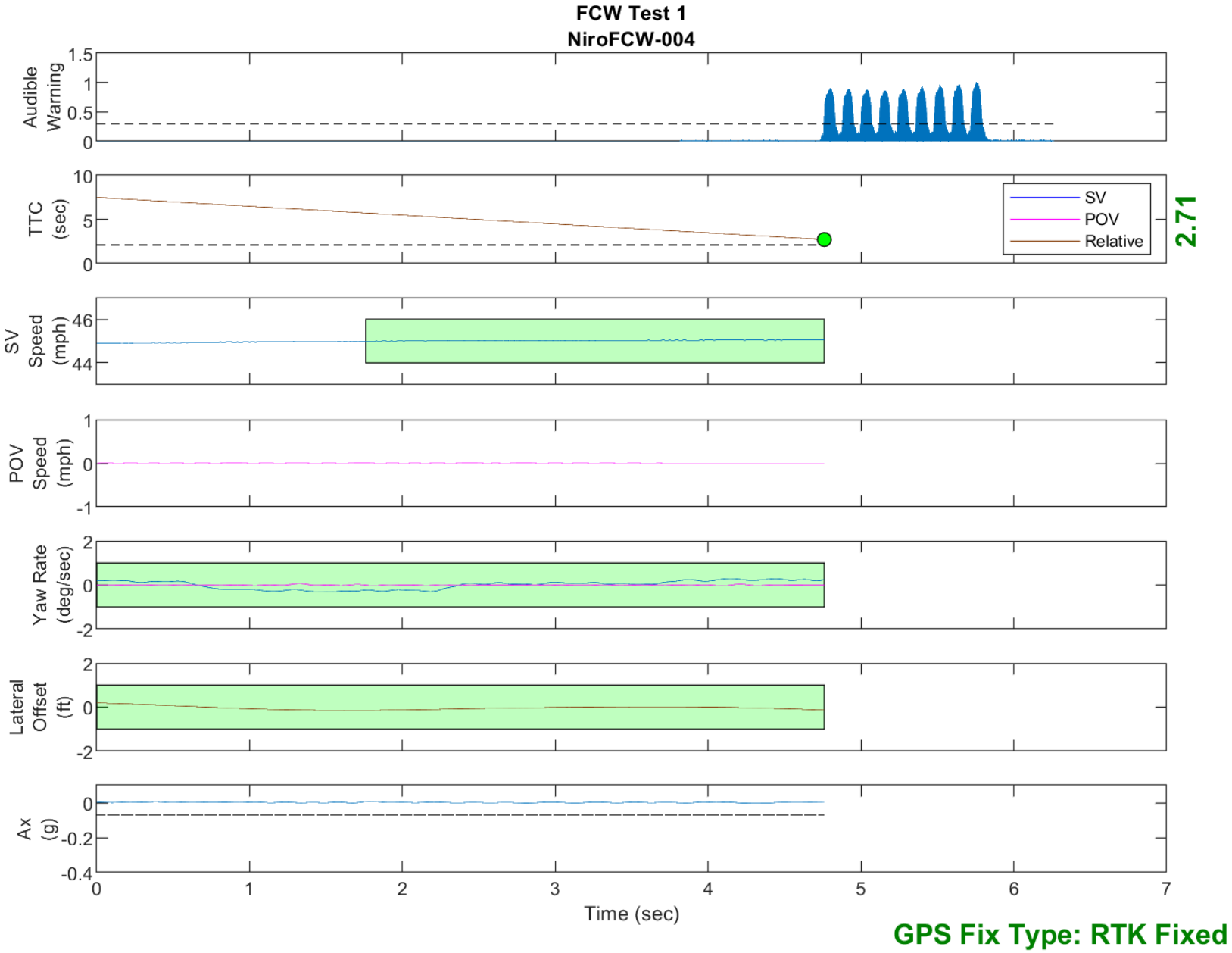

Figure D13. Time History for Run 4, FCW Test 1, Audible Warning

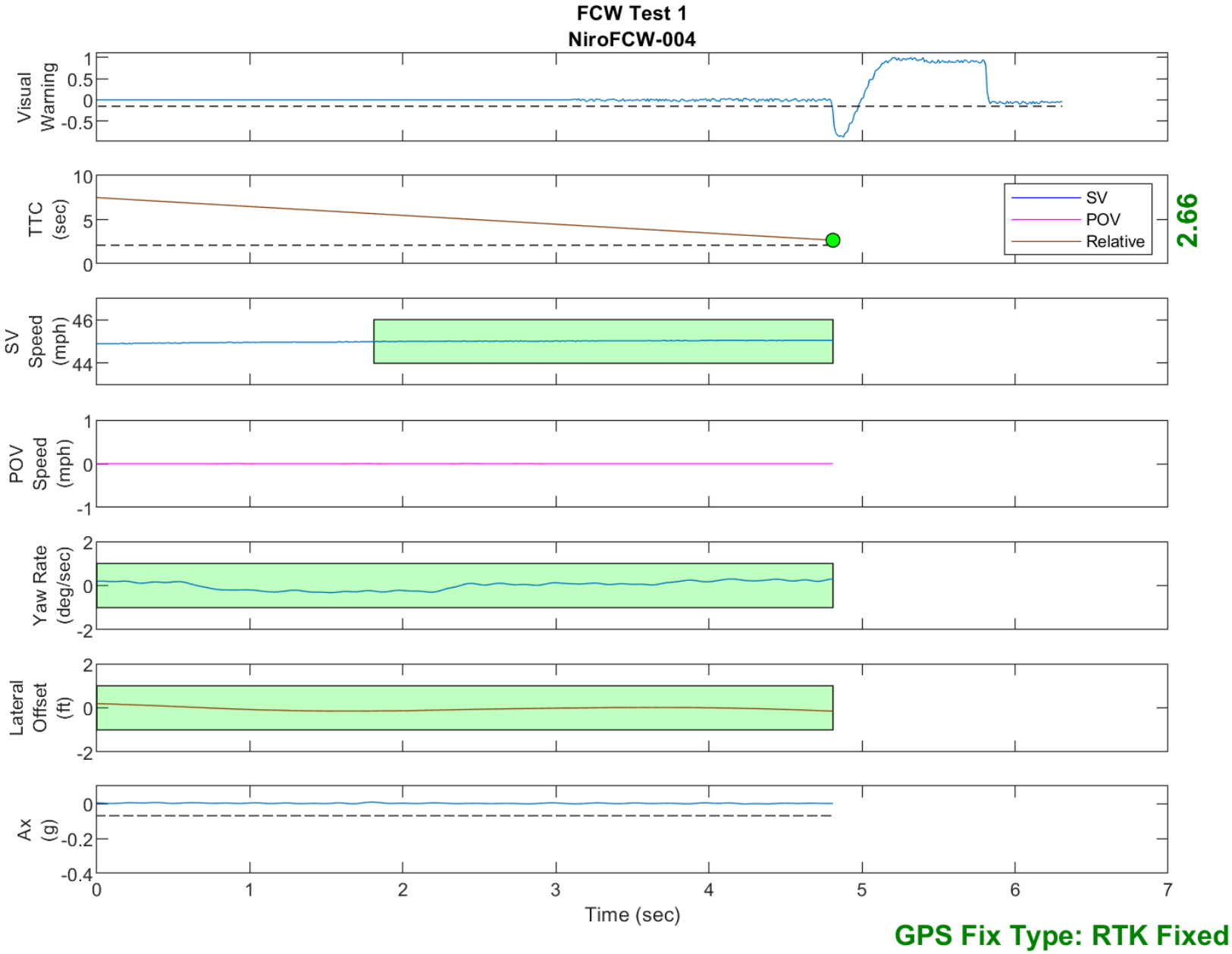

Figure D14. Time History for Run 4, FCW Test 1, Visual Warning

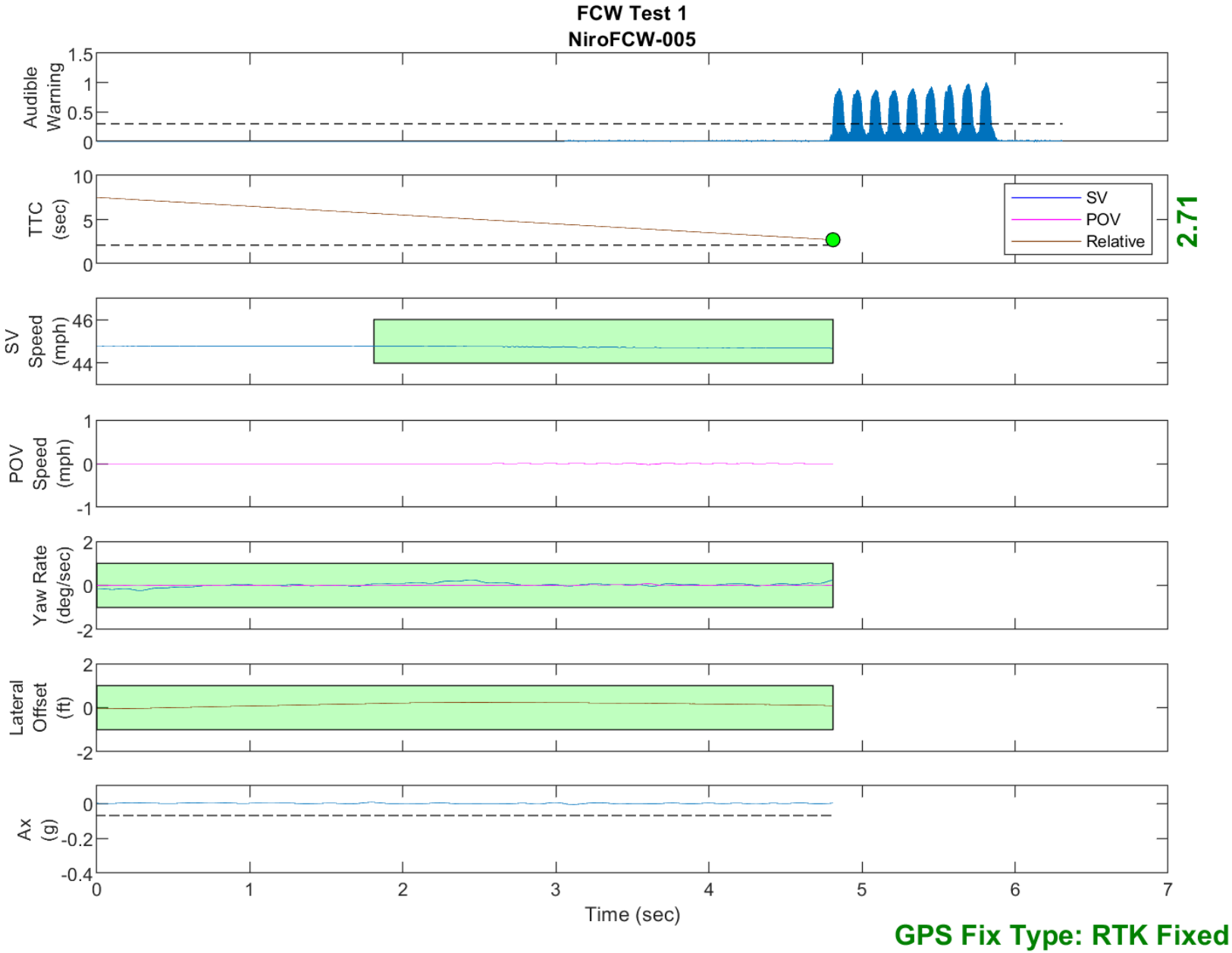

Figure D15. Time History for Run 5, FCW Test 1, Audible Warning

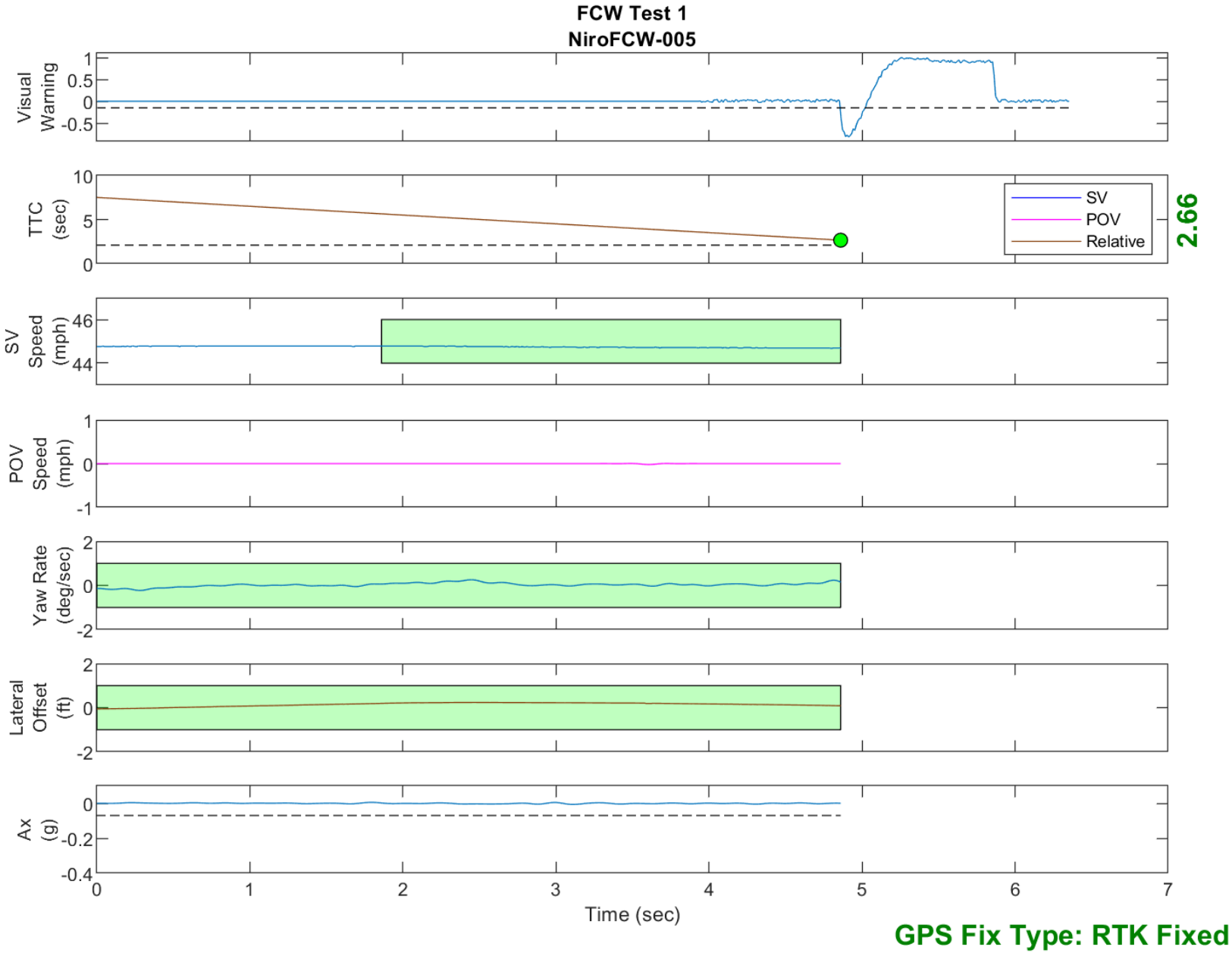

Figure D16. Time History for Run 5, FCW Test 1, Visual Warning

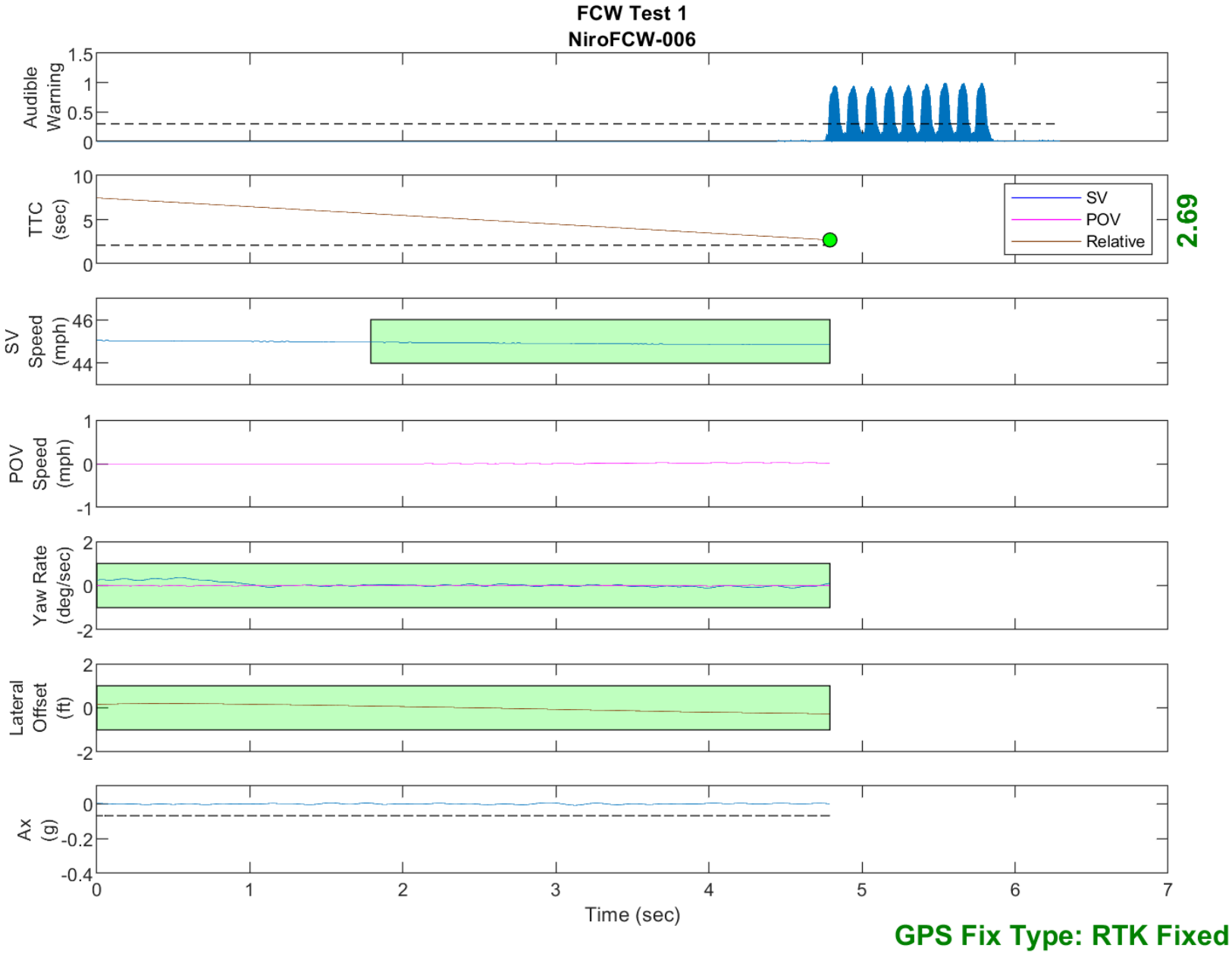

Figure D17. Time History for Run 6, FCW Test 1, Audible Warning

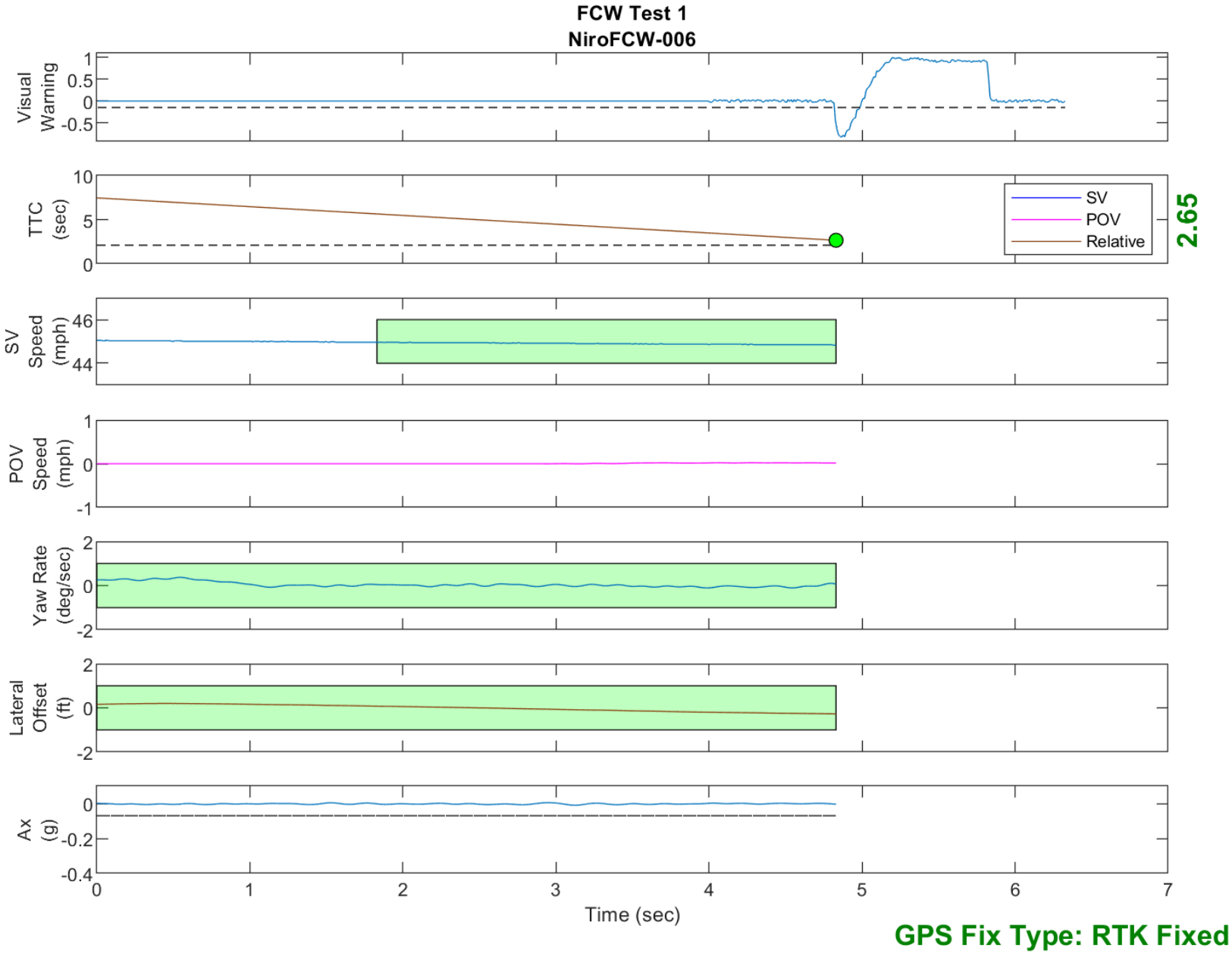

Figure D18. Time History for Run 6, FCW Test 1, Visual Warning

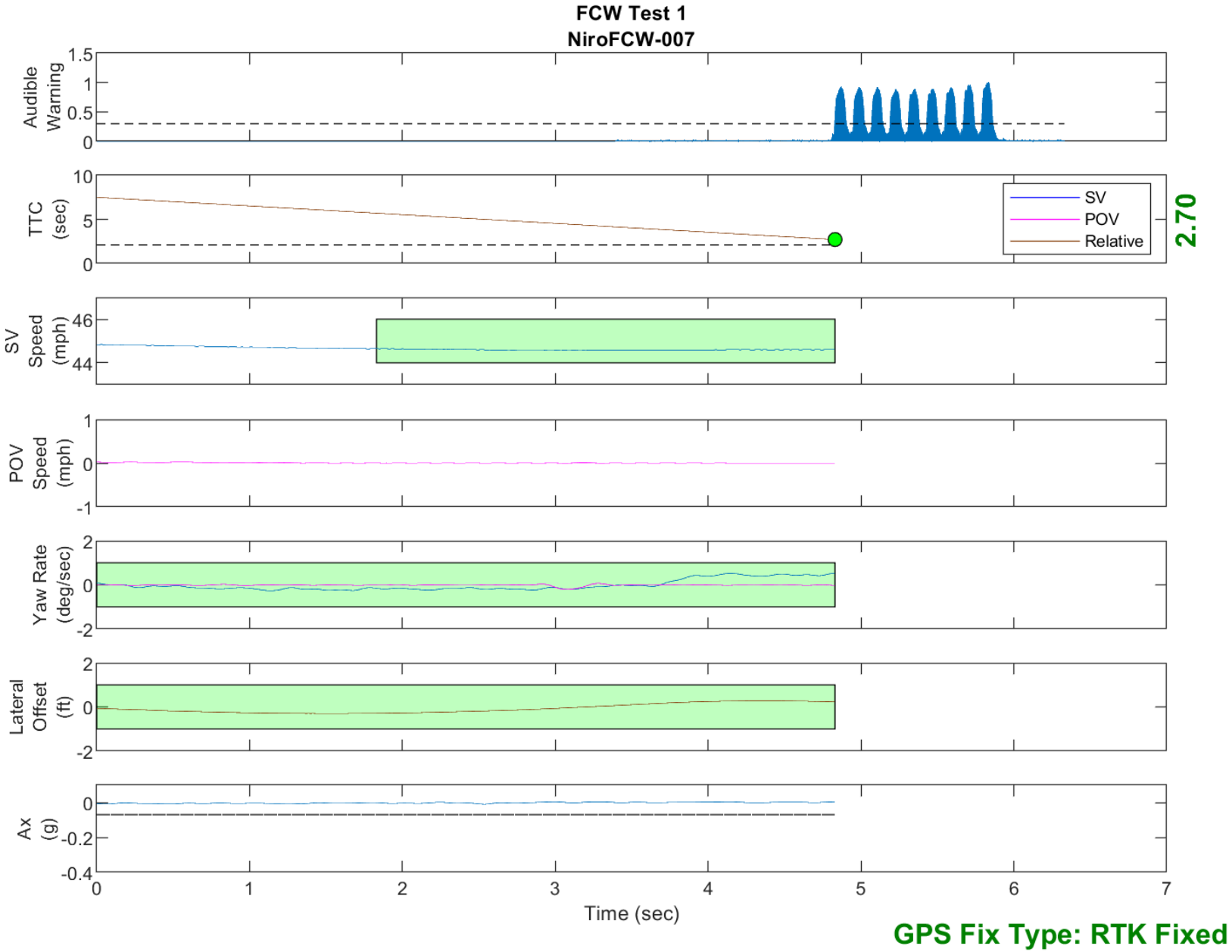

Figure D19. Time History for Run 7, FCW Test 1, Audible Warning

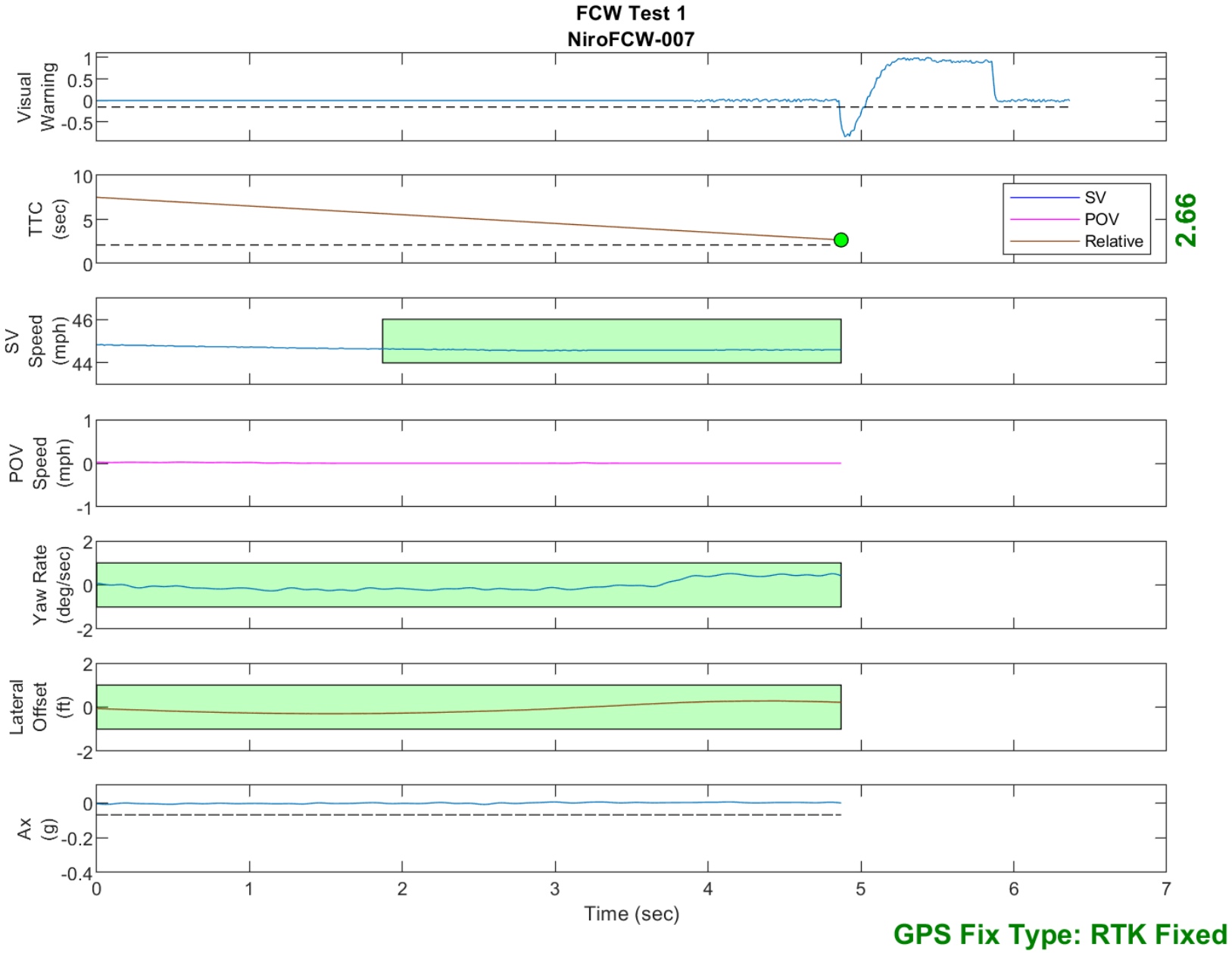

Figure D20. Time History for Run 7, FCW Test 1, Visual Warning

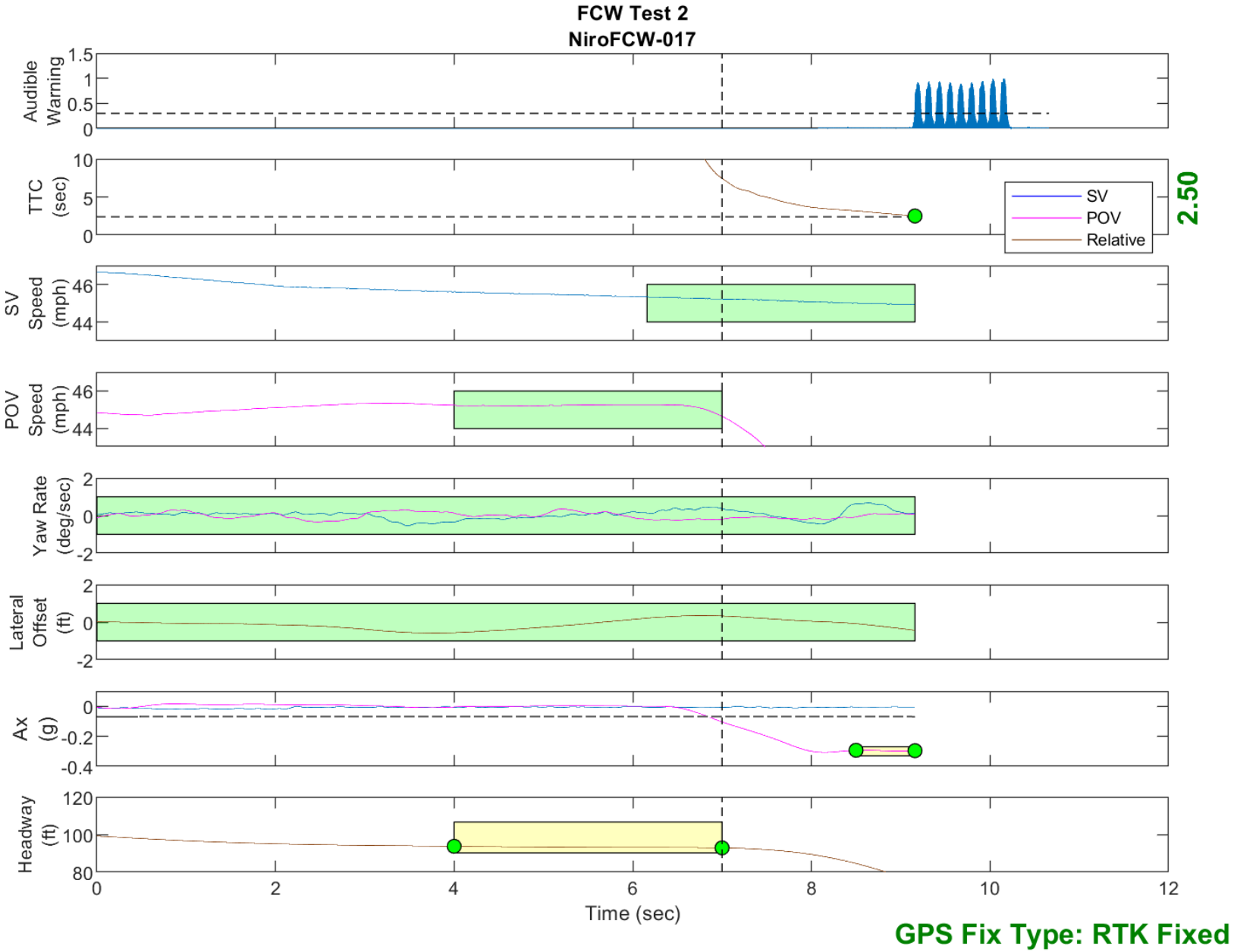

Figure D21. Time History for Run 17, FCW Test 2, Audible Warning

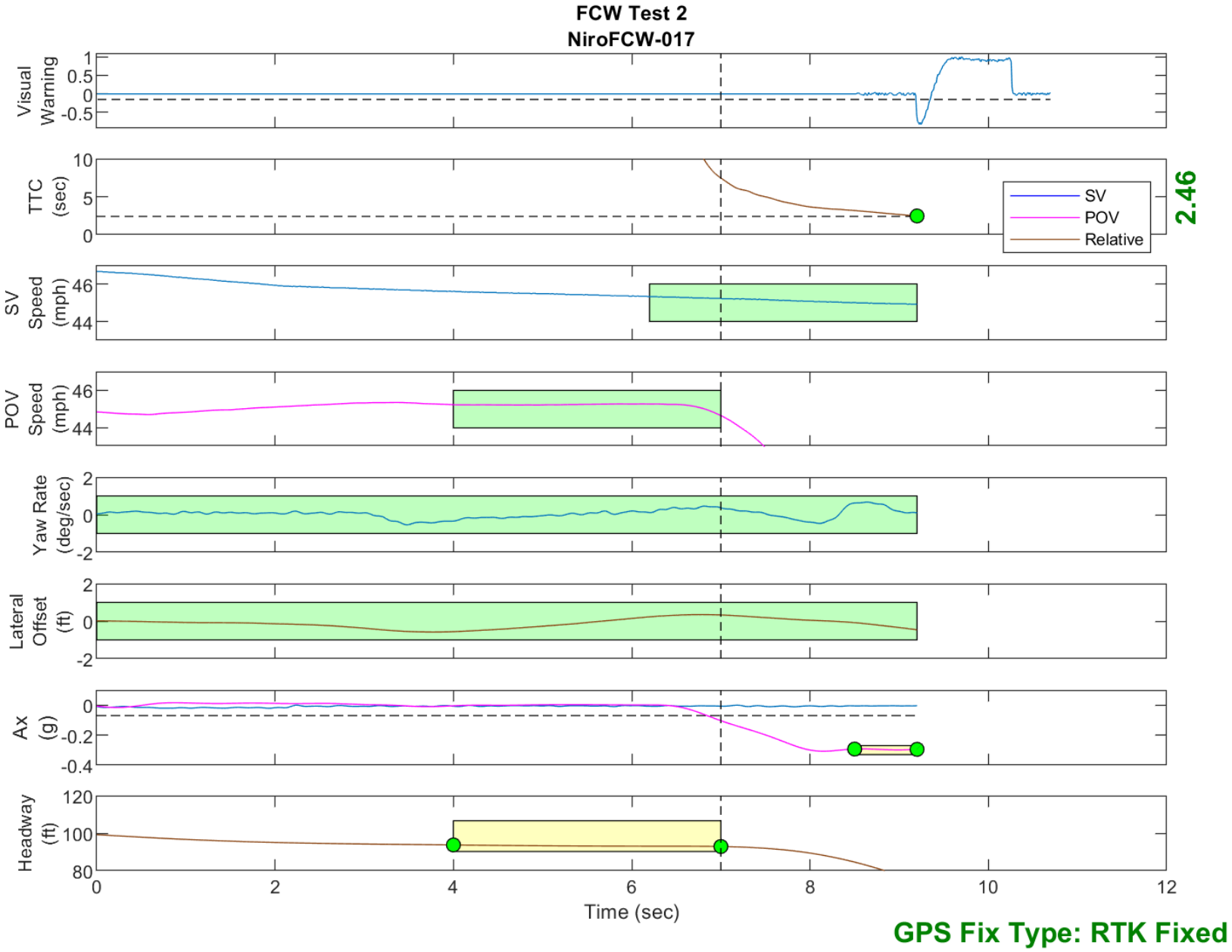

Figure D22. Time History for Run 17, FCW Test 2, Visual Warning

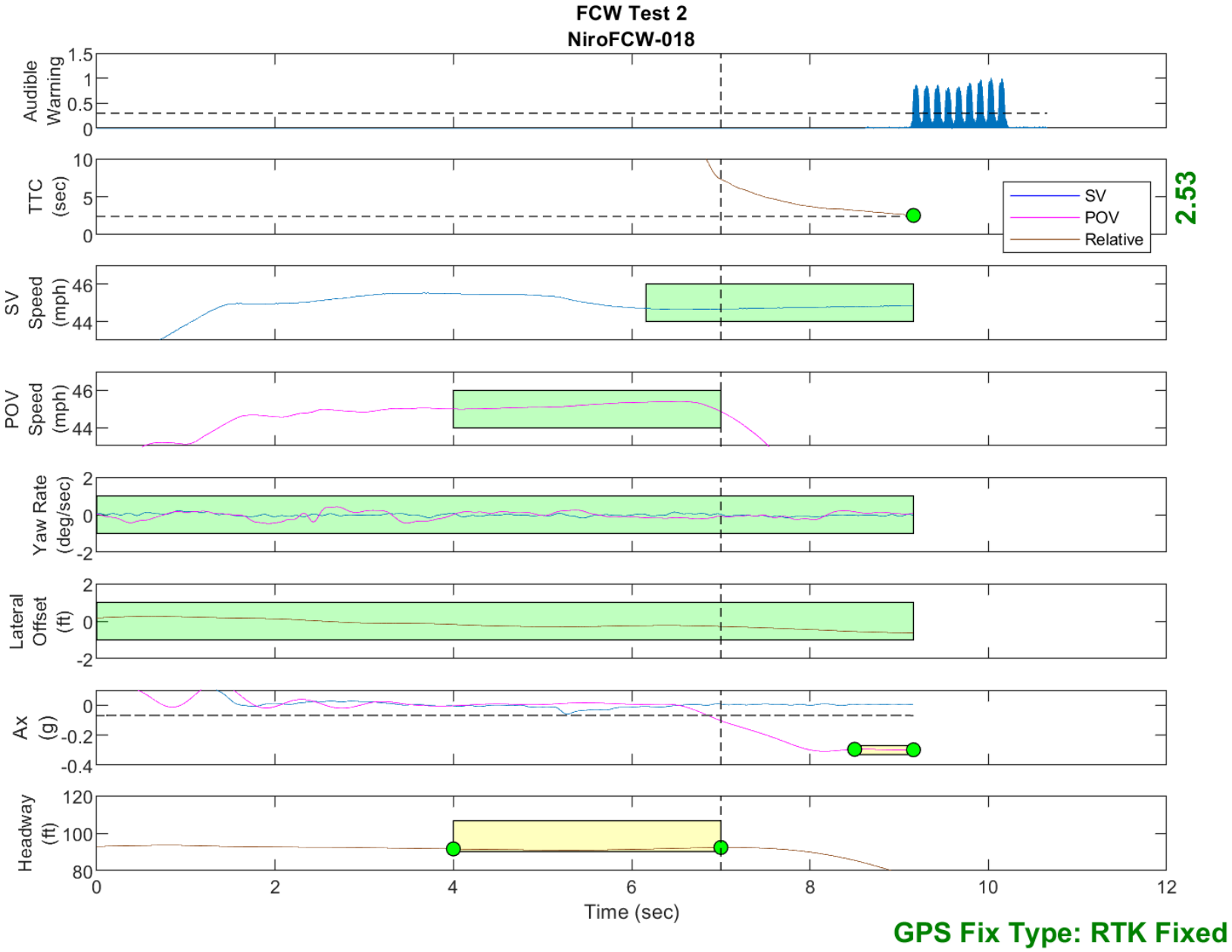

Figure D23. Time History for Run 18, FCW Test 2, Audible Warning

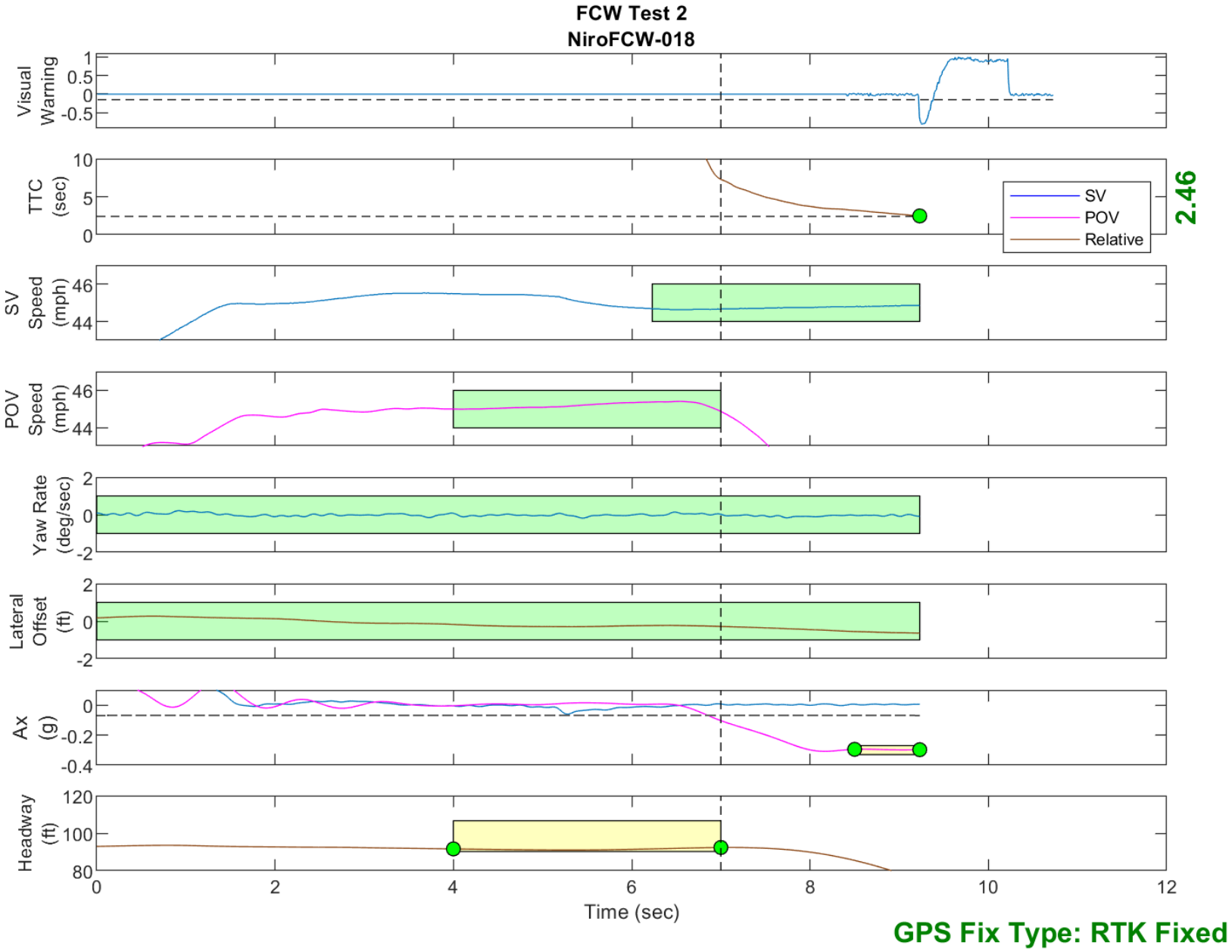

Figure D24. Time History for Run 18, FCW Test 2, Visual Warning

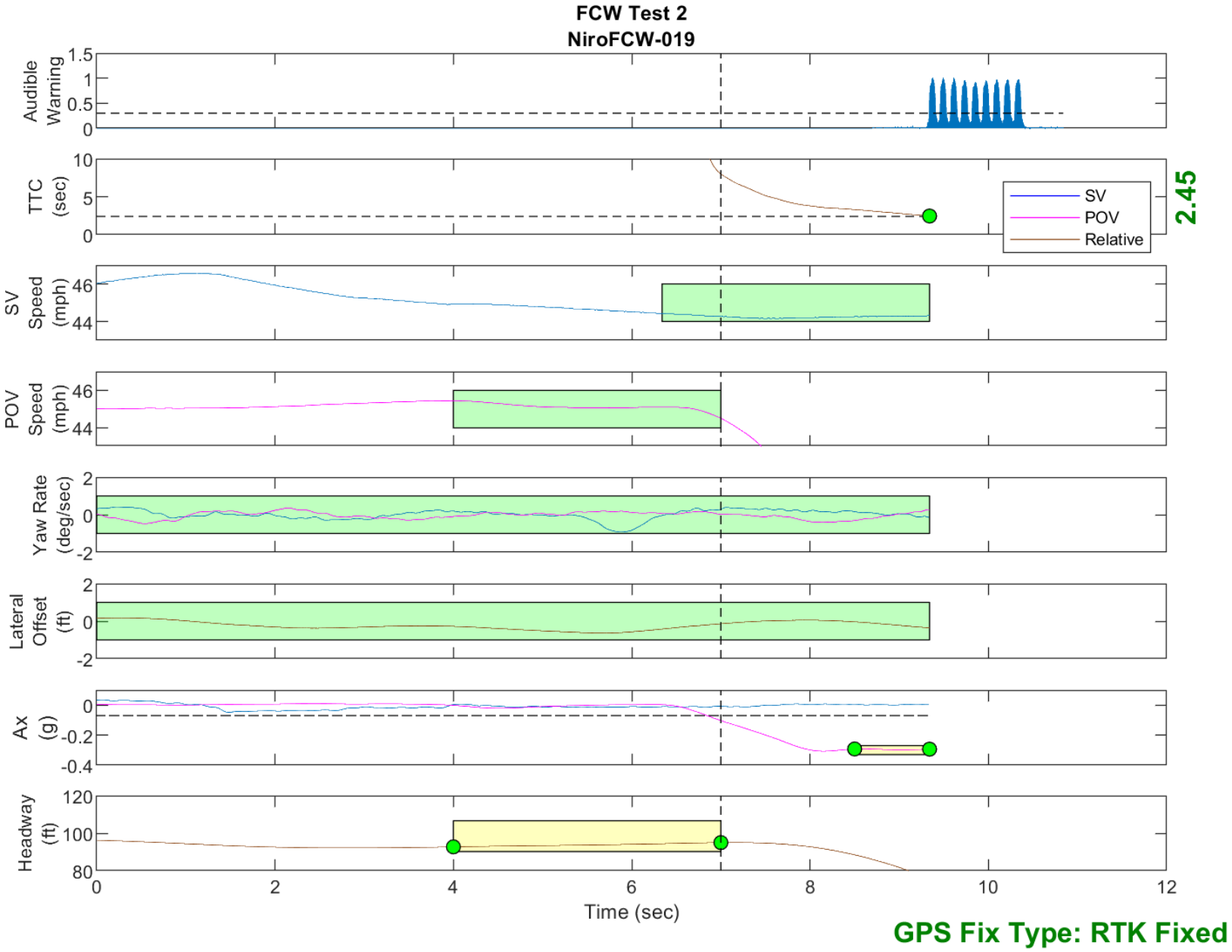

Figure D25. Time History for Run 19, FCW Test 2, Audible Warning

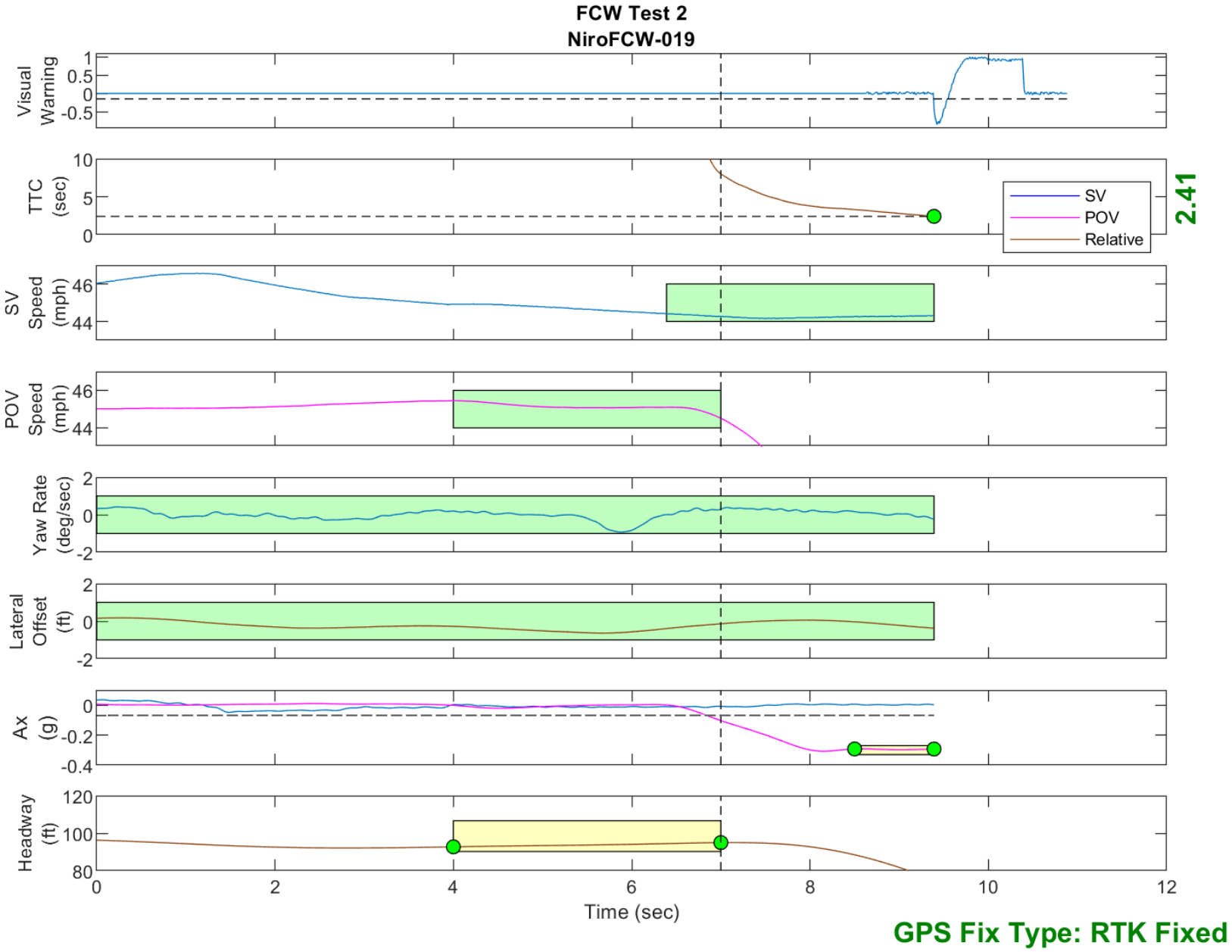

Figure D26. Time History for Run 19, FCW Test 2, Visual Warning

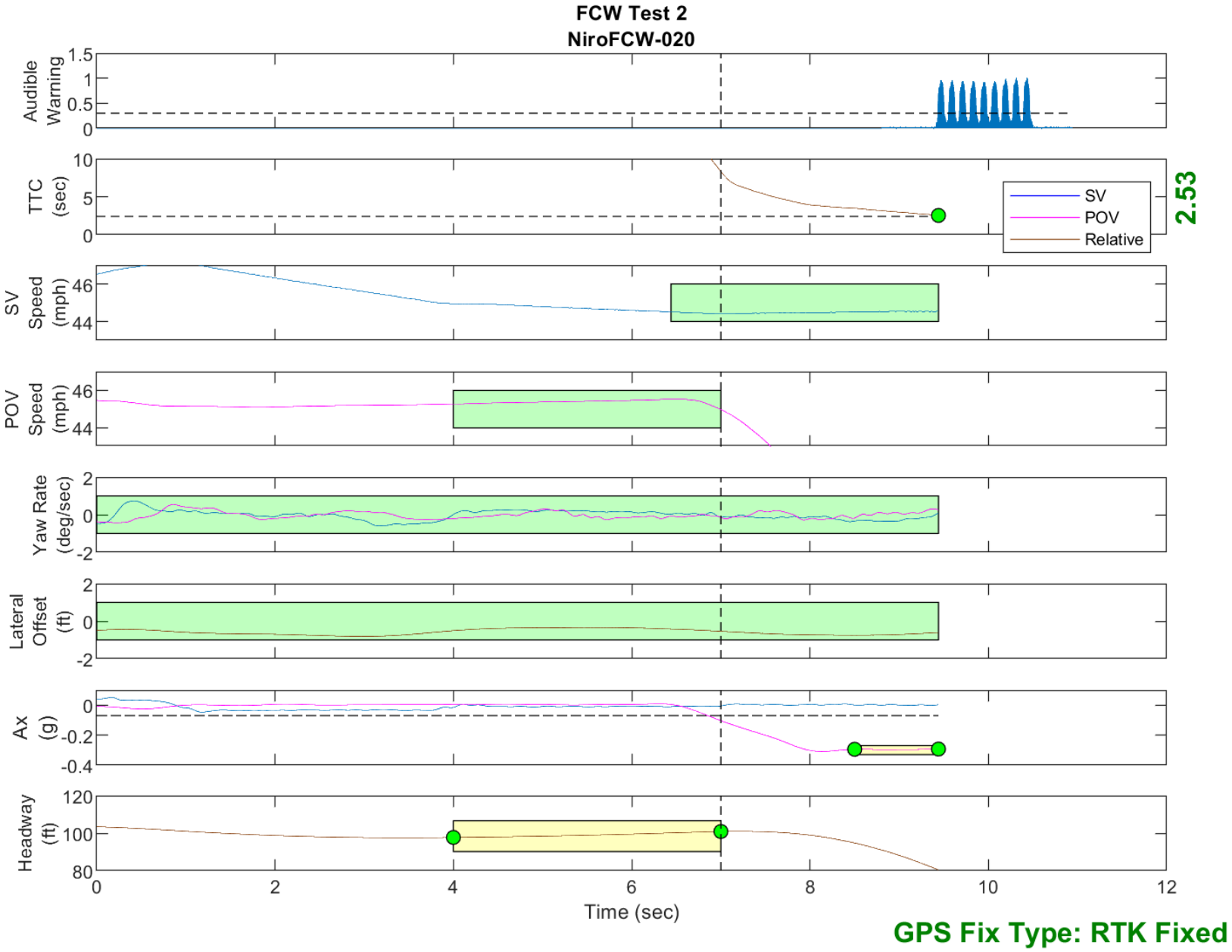

Figure D27. Time History for Run 20, FCW Test 2, Audible Warning

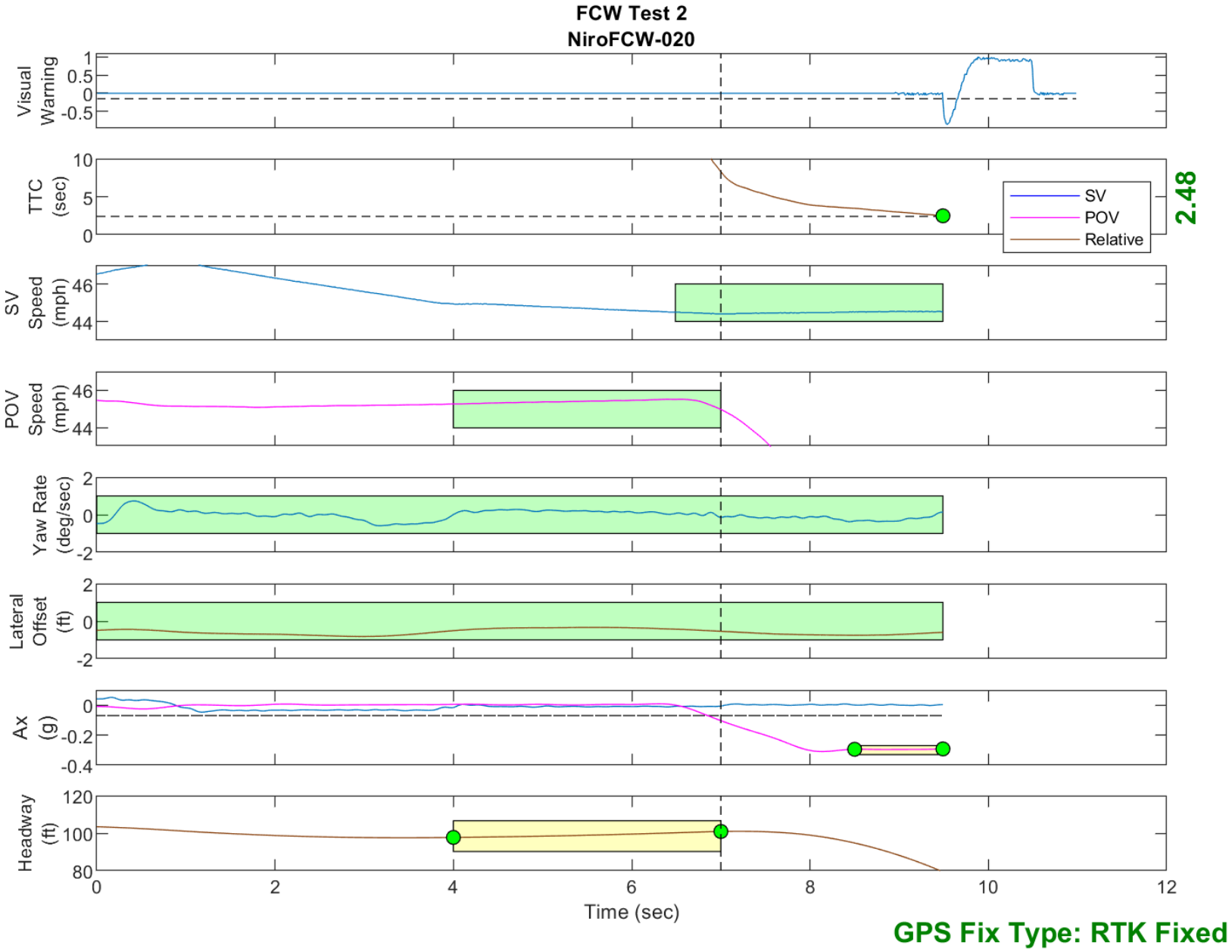

Figure D28. Time History for Run 20, FCW Test 2, Visual Warning

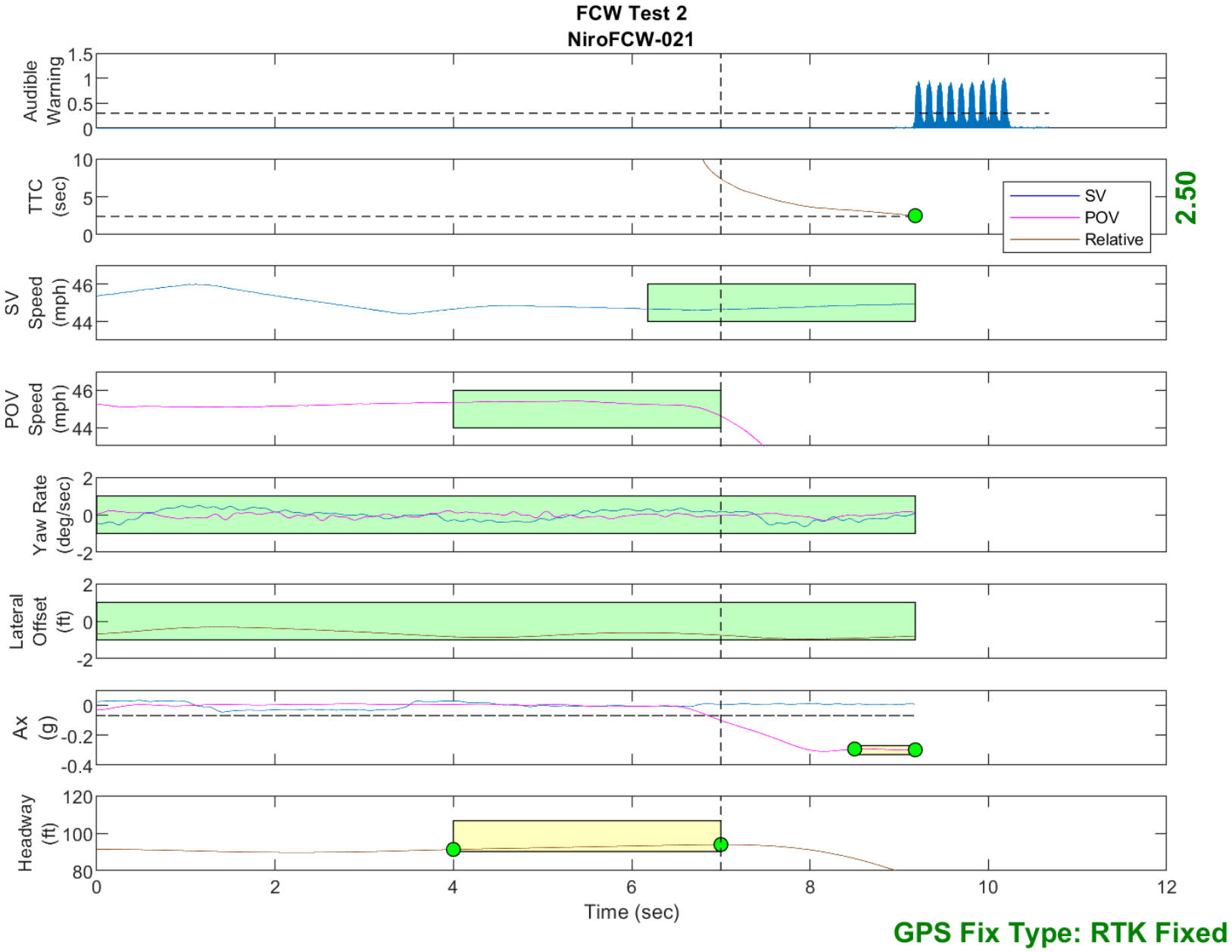

Figure D29. Time History for Run 21, FCW Test 2, Audible Warning

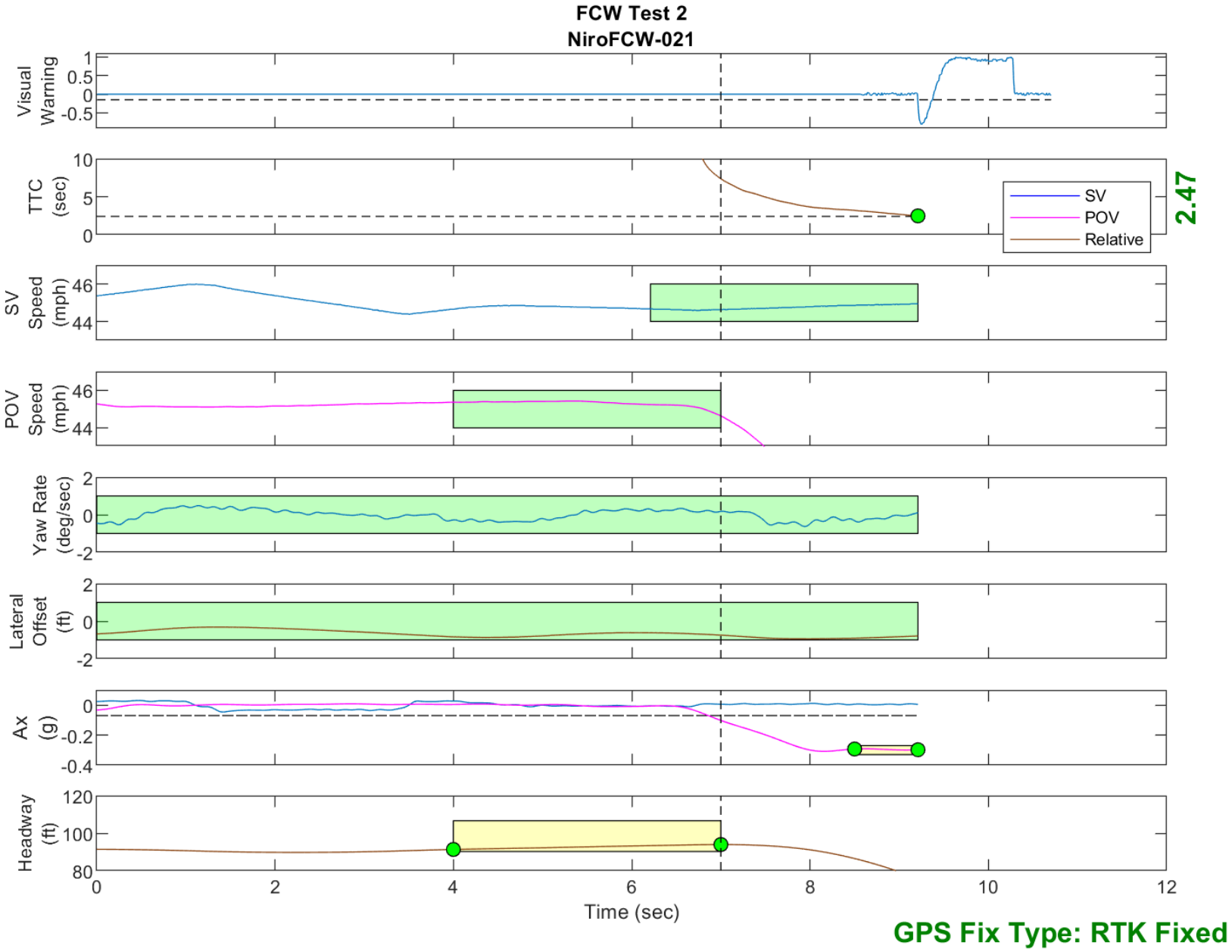

Figure D30. Time History for Run 21, FCW Test 2, Visual Warning

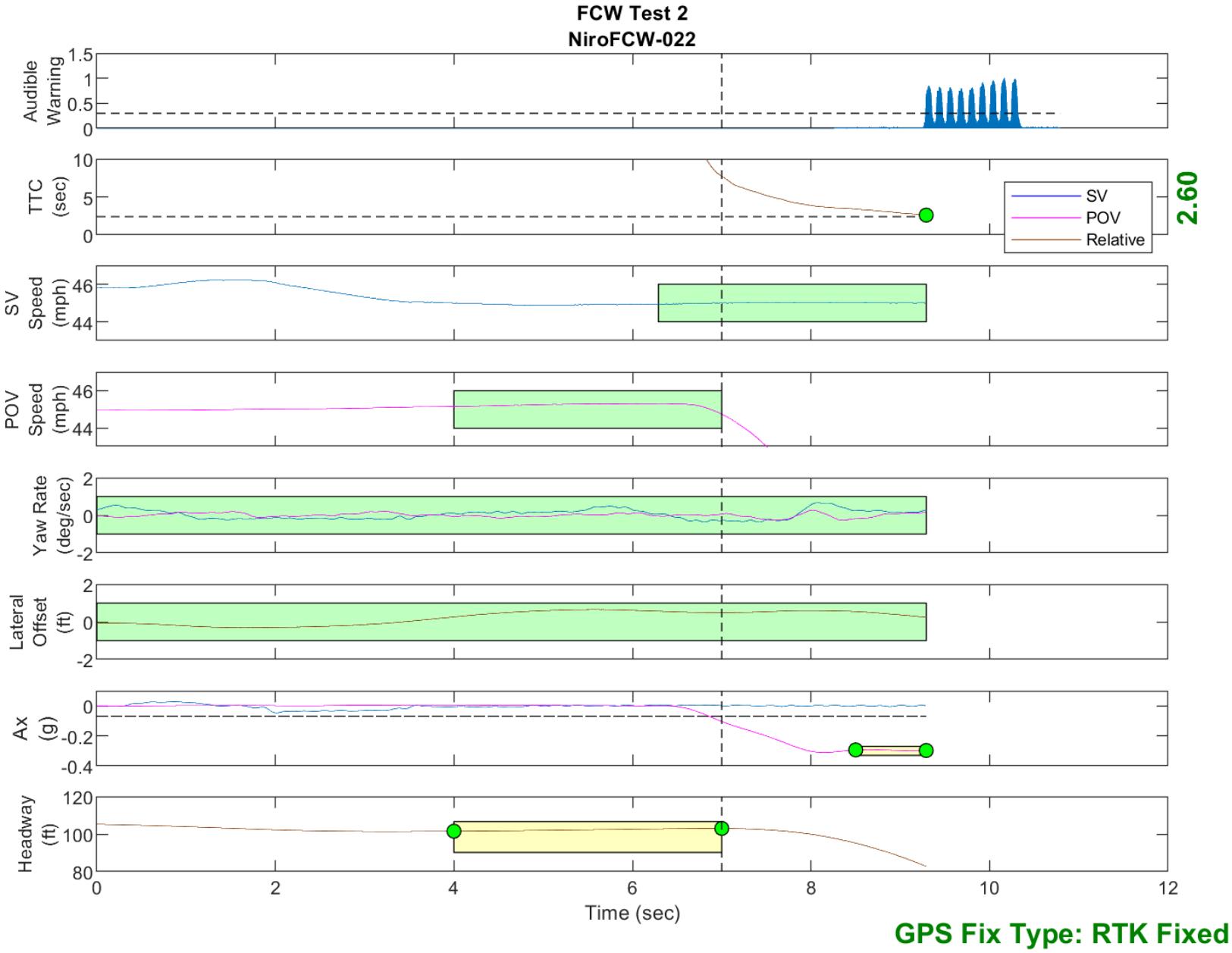

Figure D31. Time History for Run 22, FCW Test 2, Audible Warning

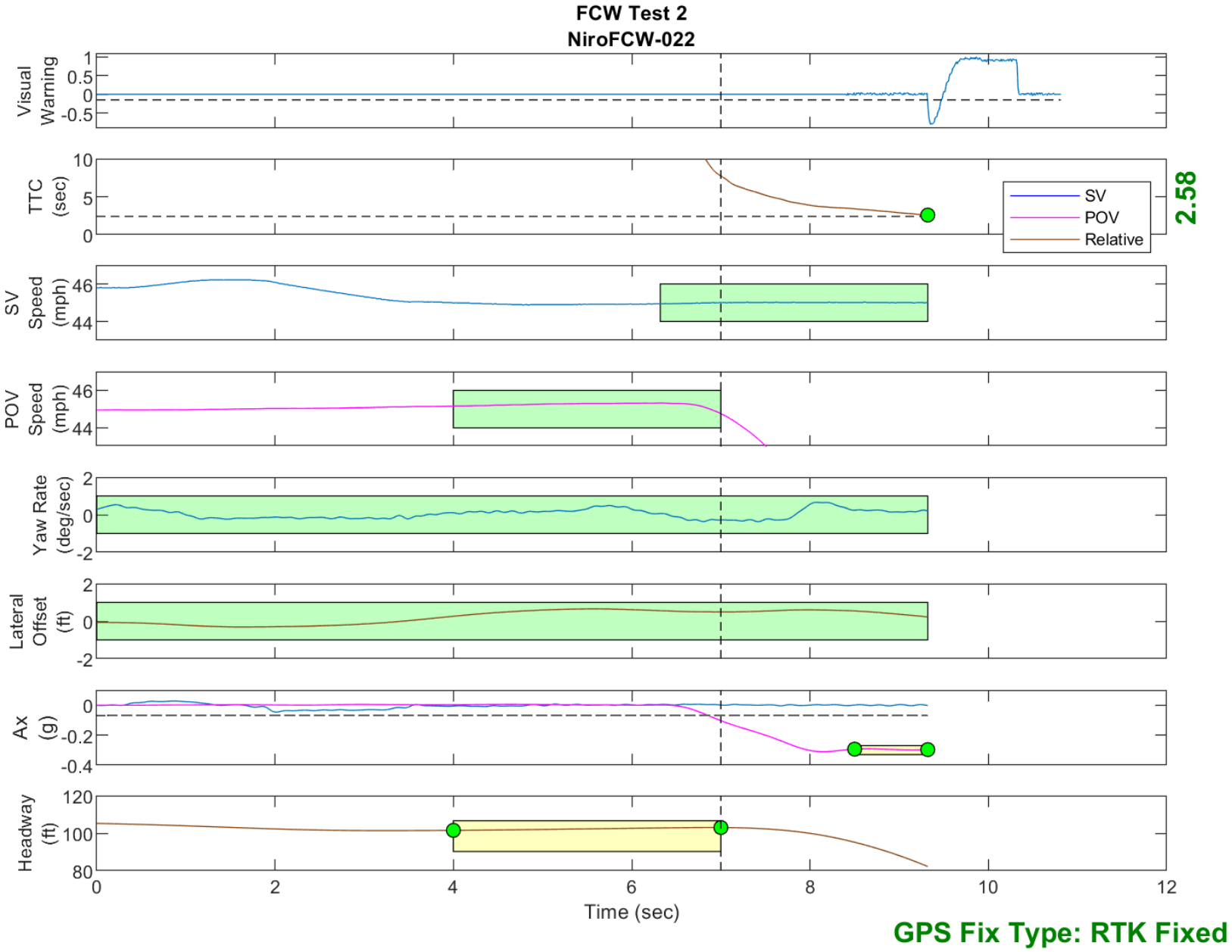

Figure D32. Time History for Run 22, FCW Test 2, Visual Warning

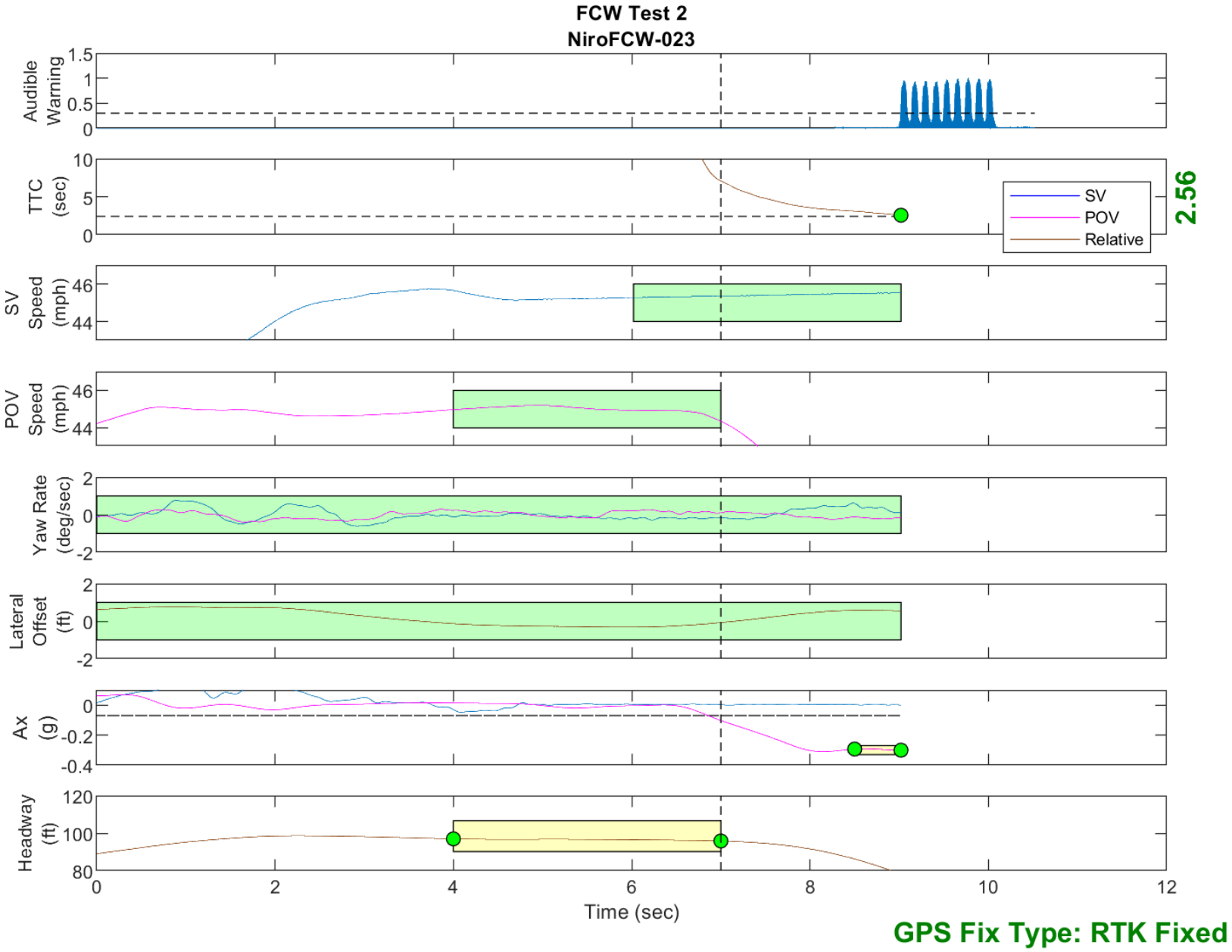

Figure D33. Time History for Run 23, FCW Test 2, Audible Warning

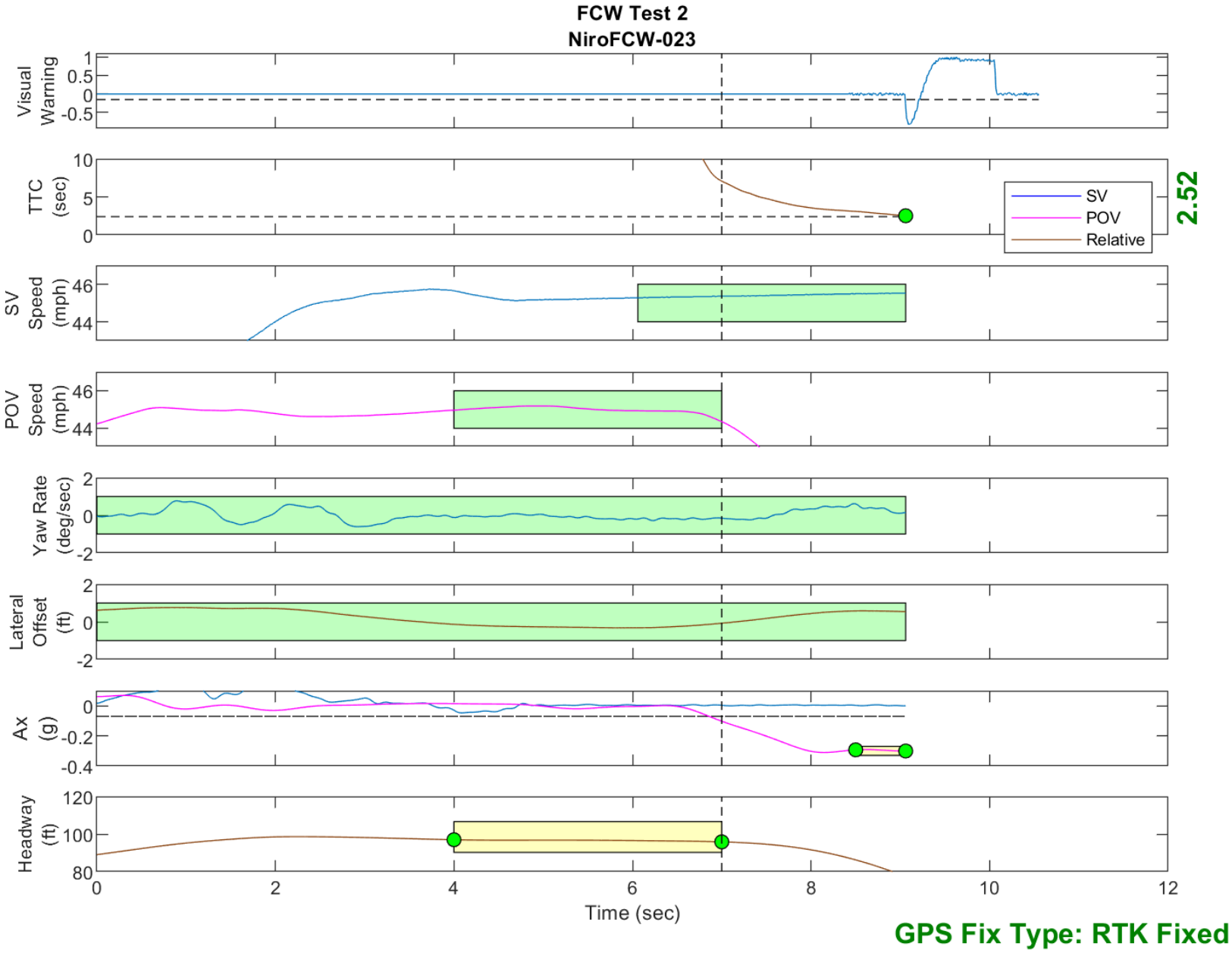

Figure D34. Time History for Run 23, FCW Test 2, Visual Warning

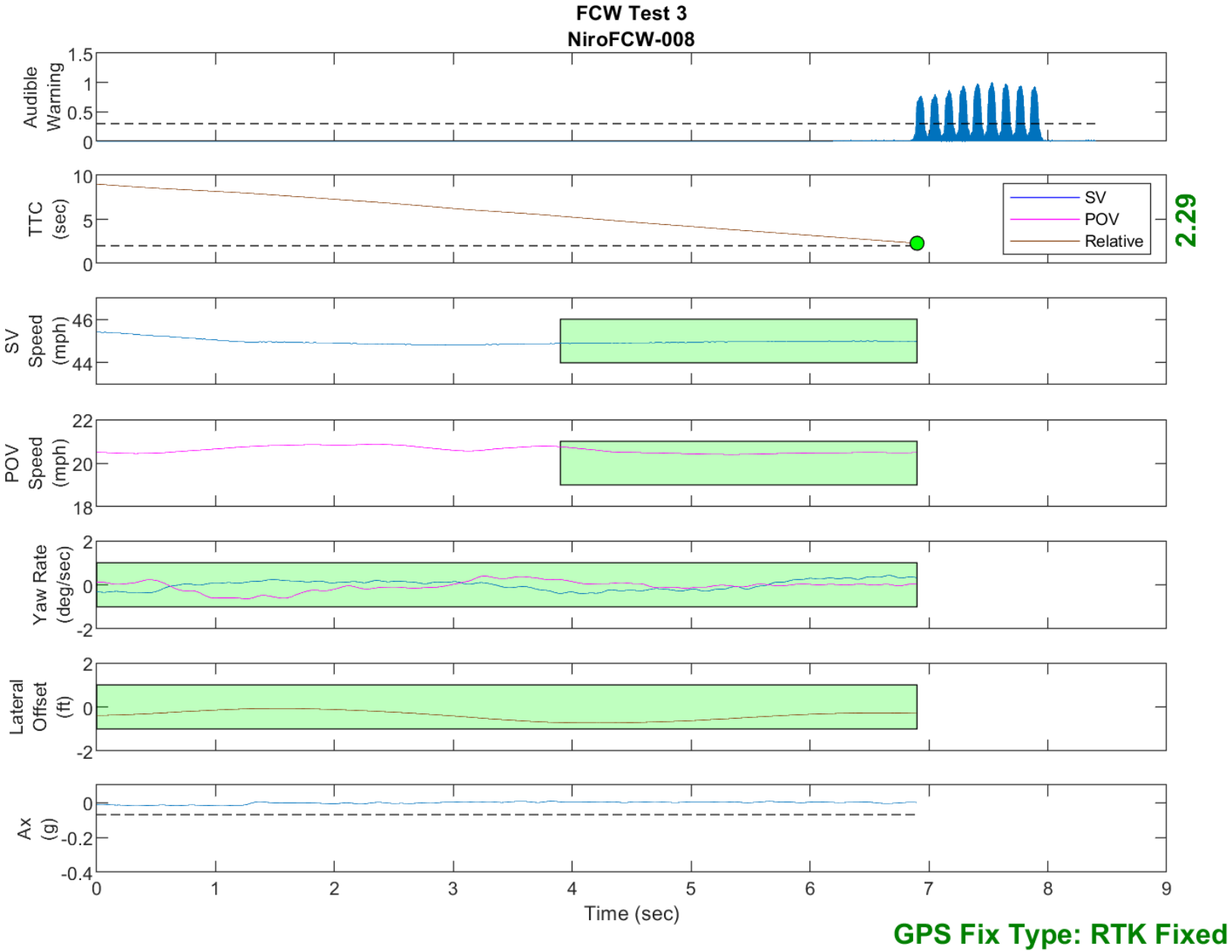

Figure D35. Time History for Run 8, FCW Test 3, Audible Warning

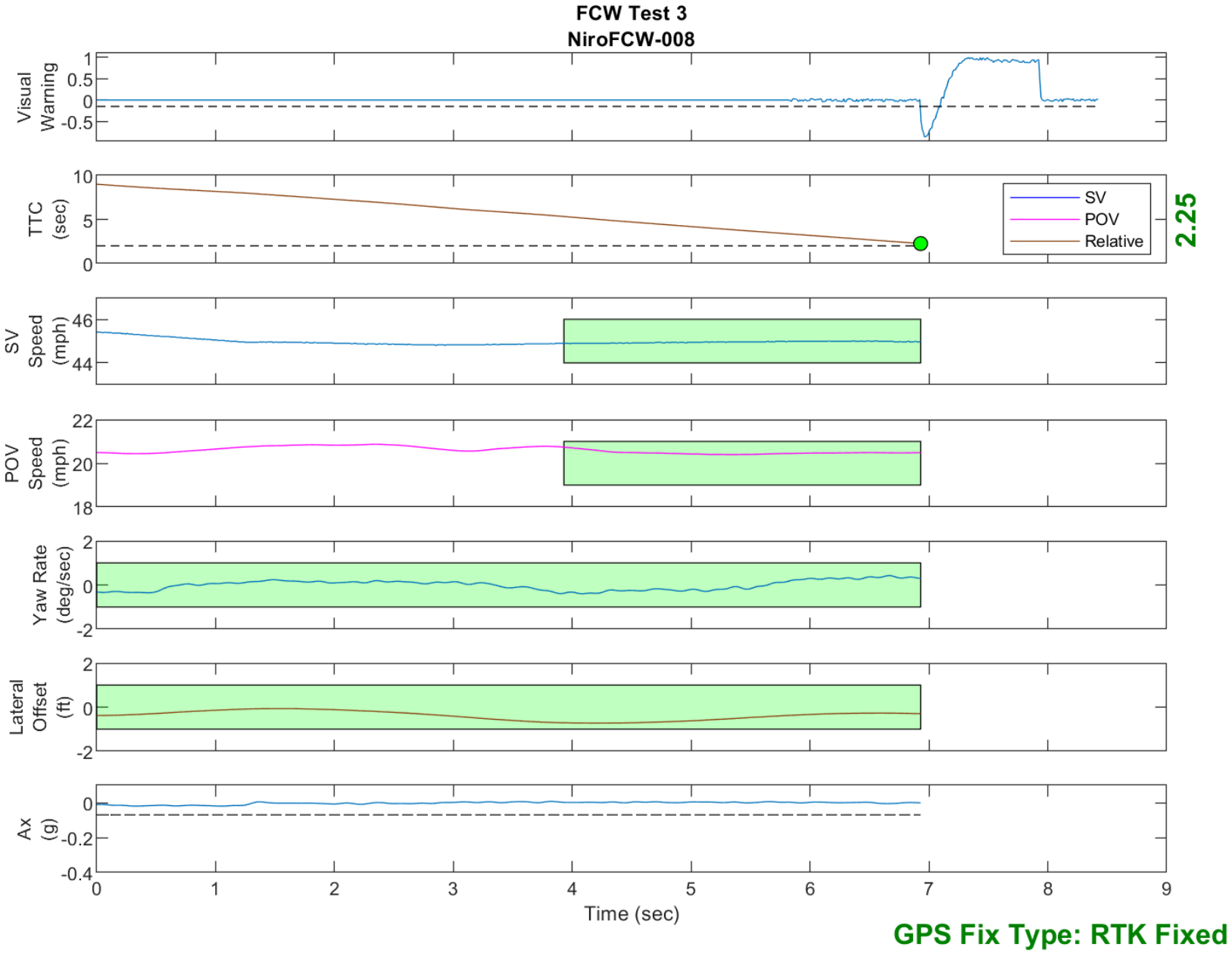

Figure D36. Time History for Run 8, FCW Test 3, Visual Warning

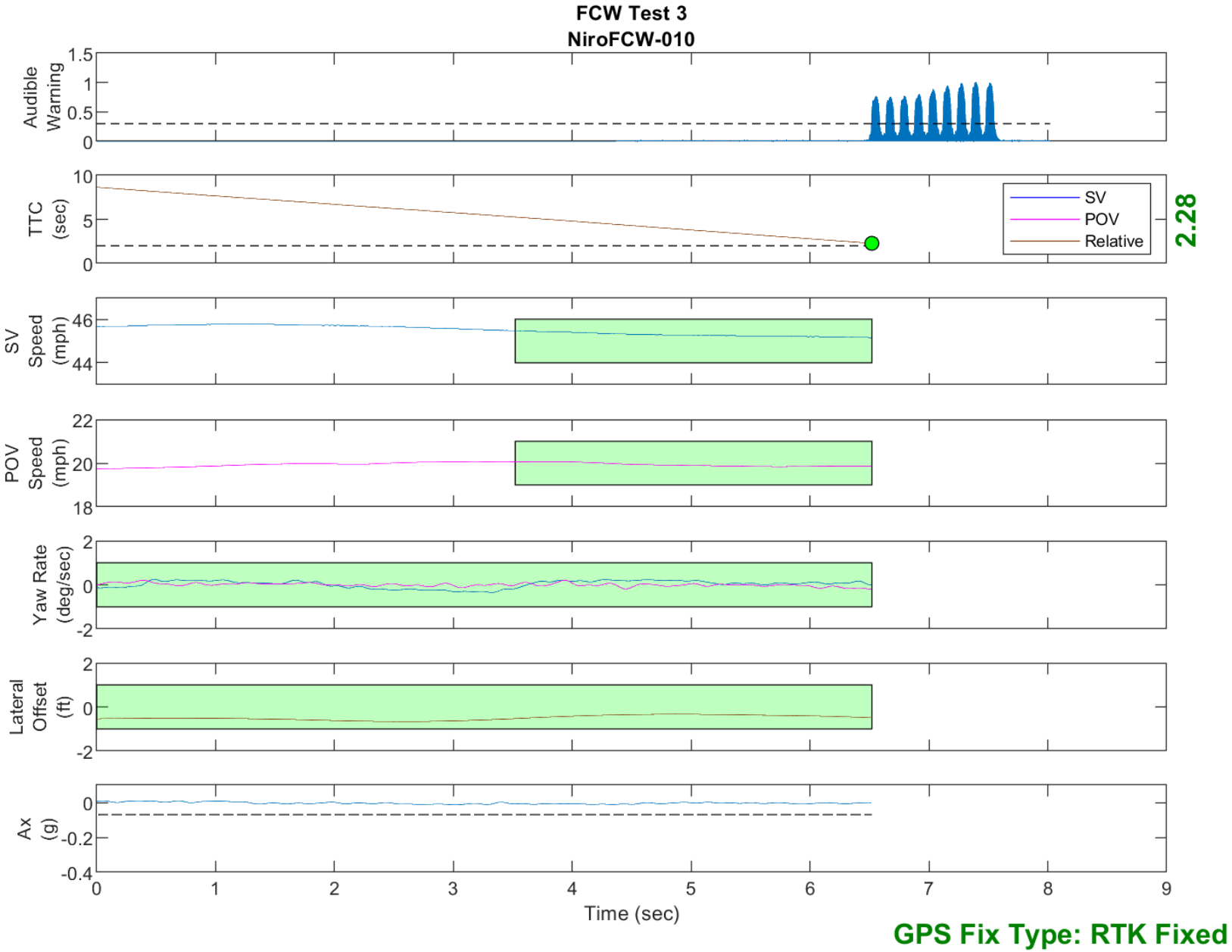

Figure D37. Time History for Run 10, FCW Test 3, Audible Warning

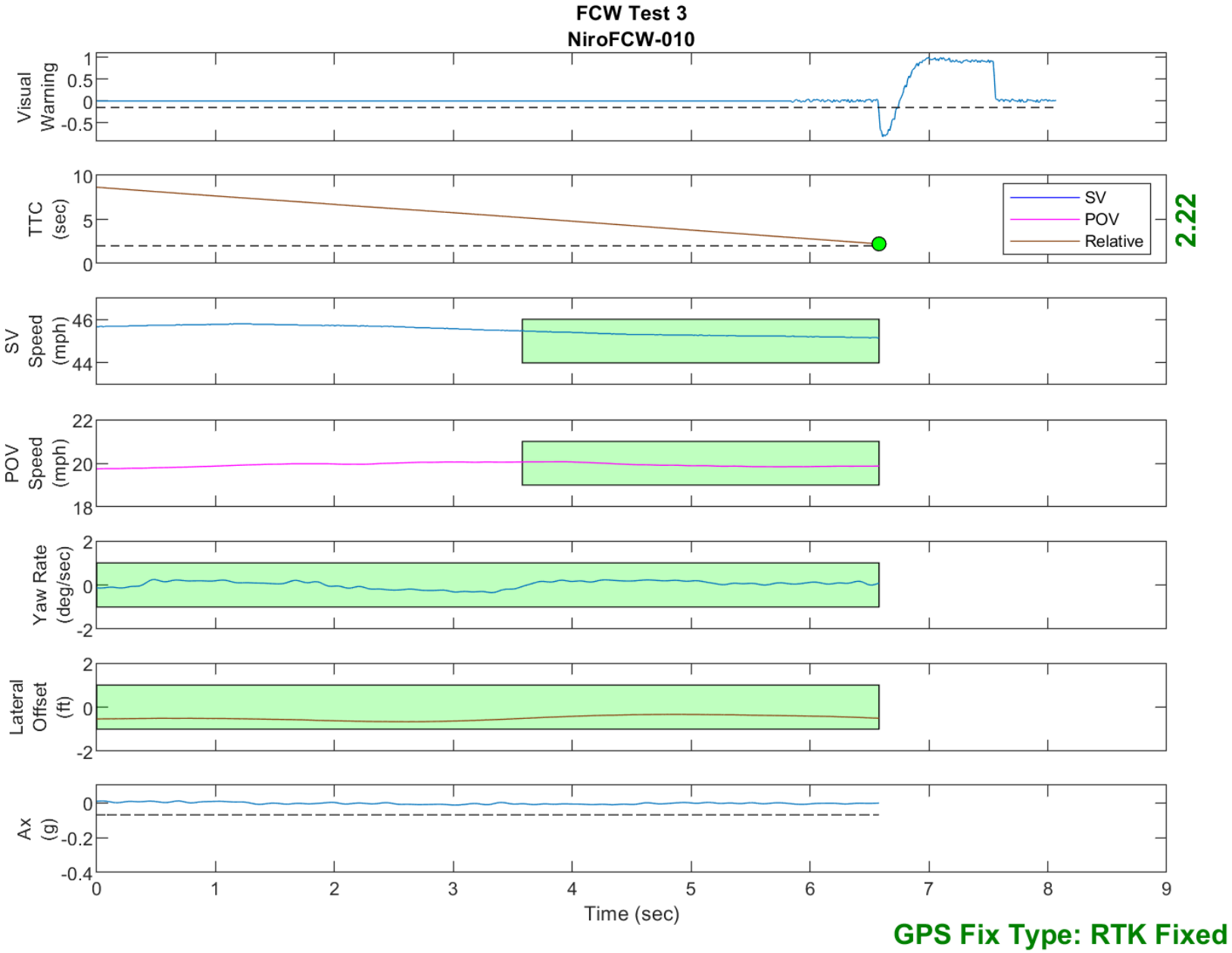

Figure D38. Time History for Run 10, FCW Test 3, Visual Warning

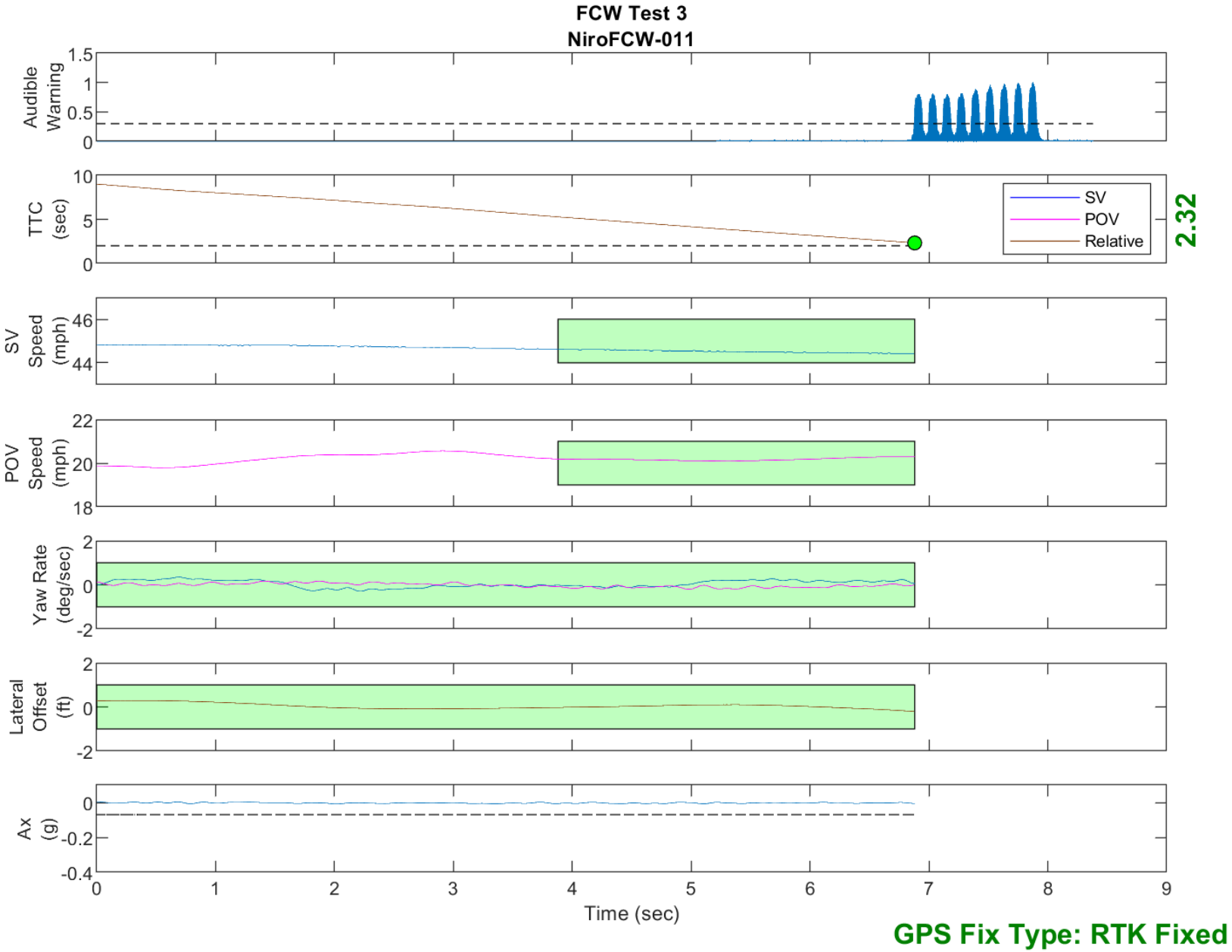

Figure D39. Time History for Run 11, FCW Test 3, Audible Warning

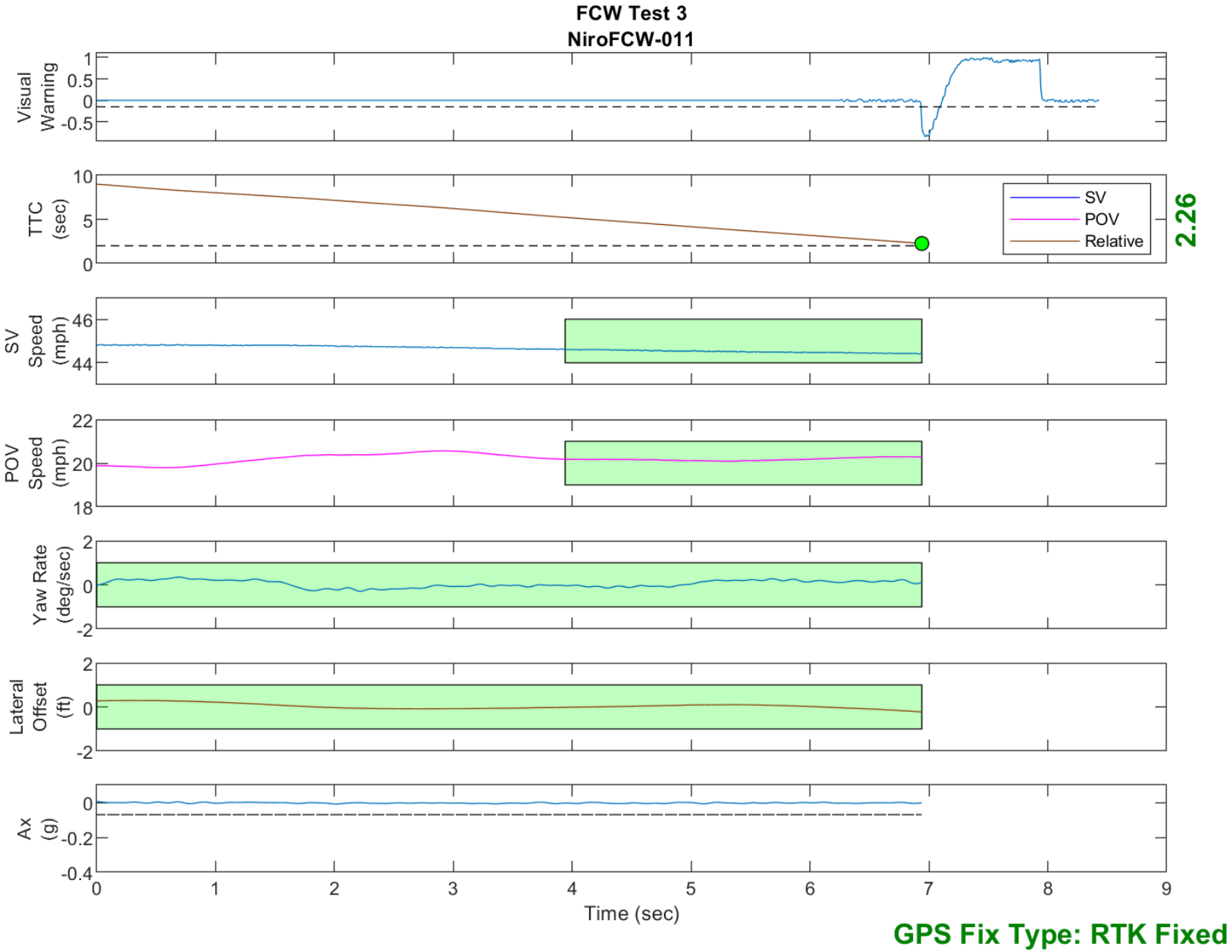

Figure D40. Time History for Run 11, FCW Test 3, Visual Warning

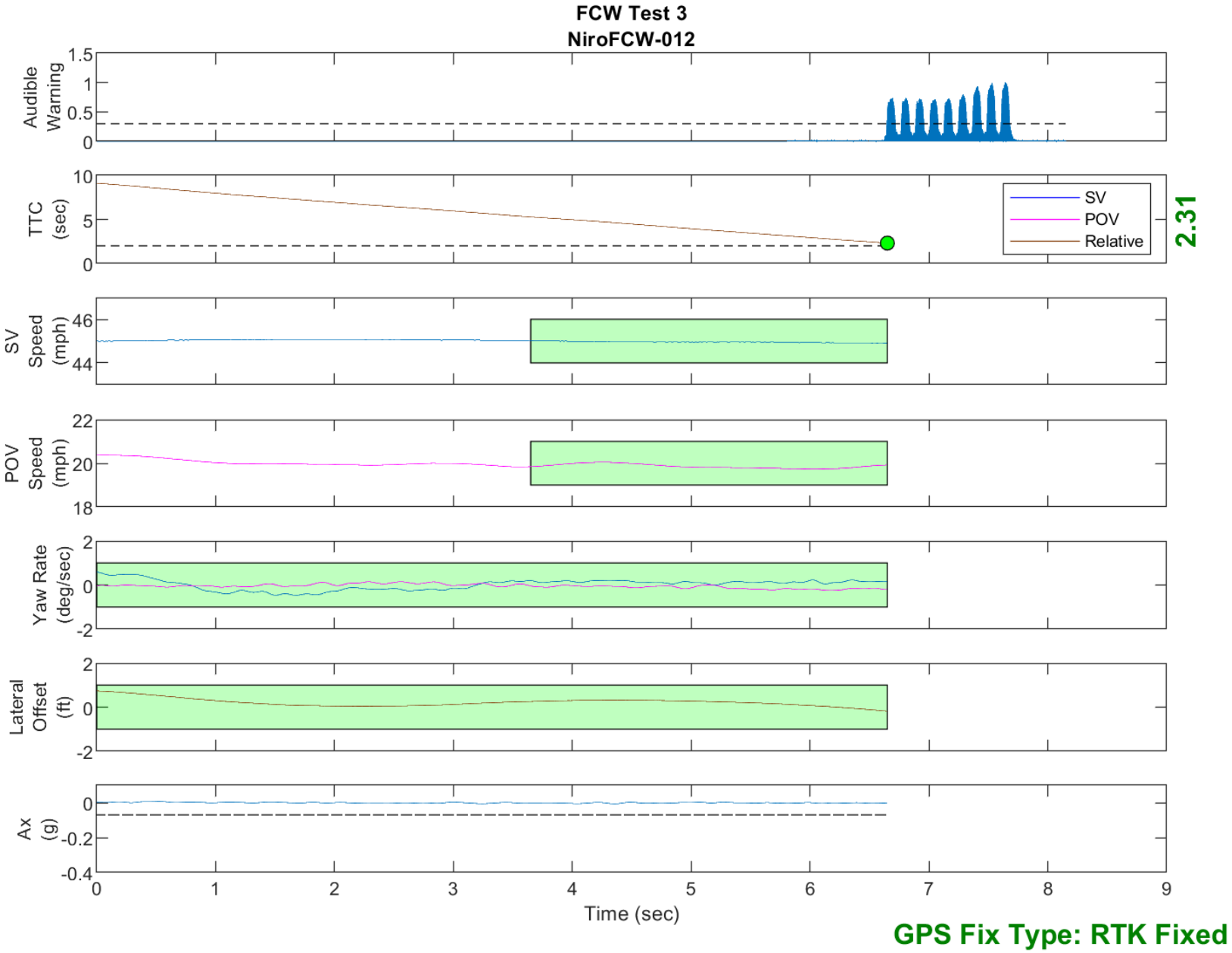

Figure D41. Time History for Run 12, FCW Test 3, Audible Warning

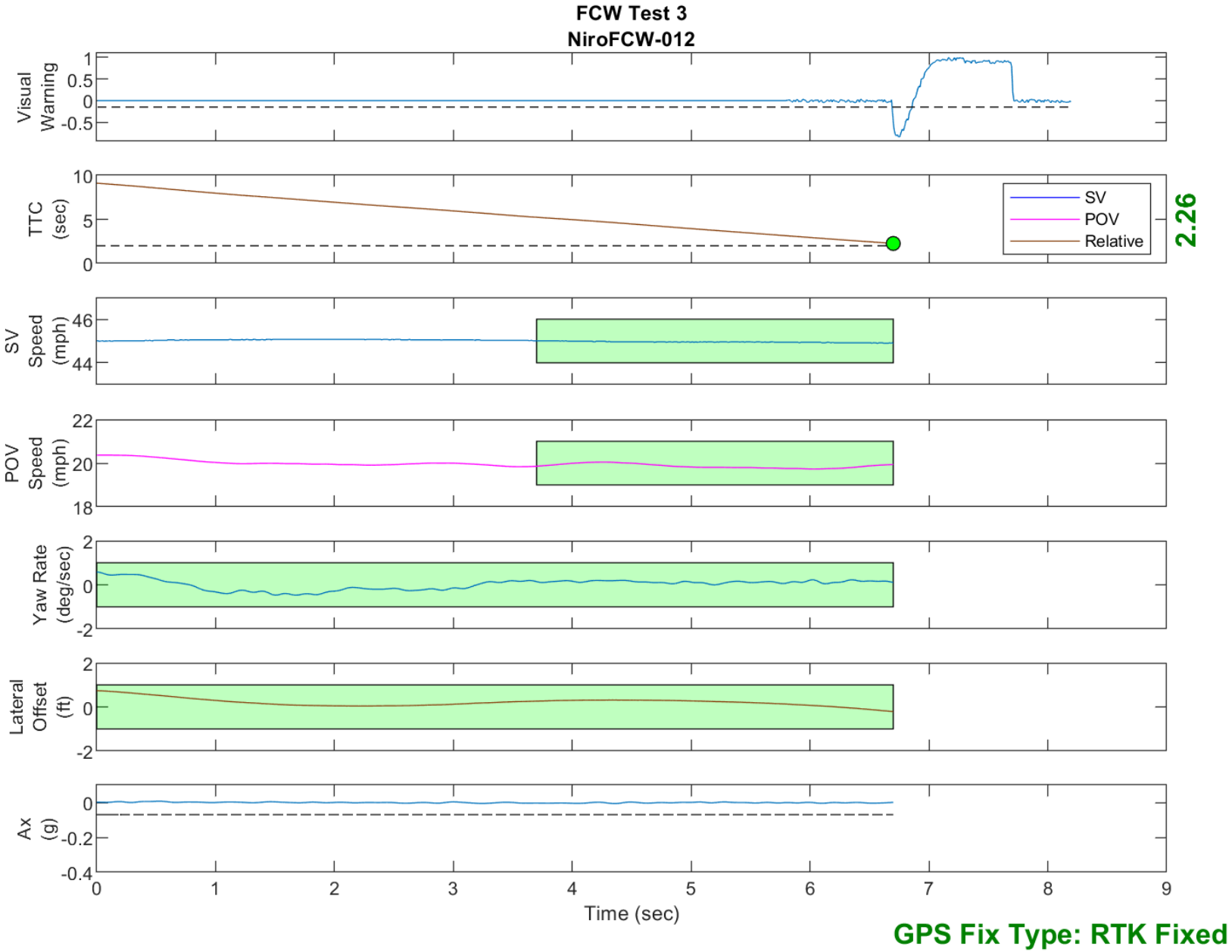

Figure D42. Time History for Run 12, FCW Test 3, Visual Warning

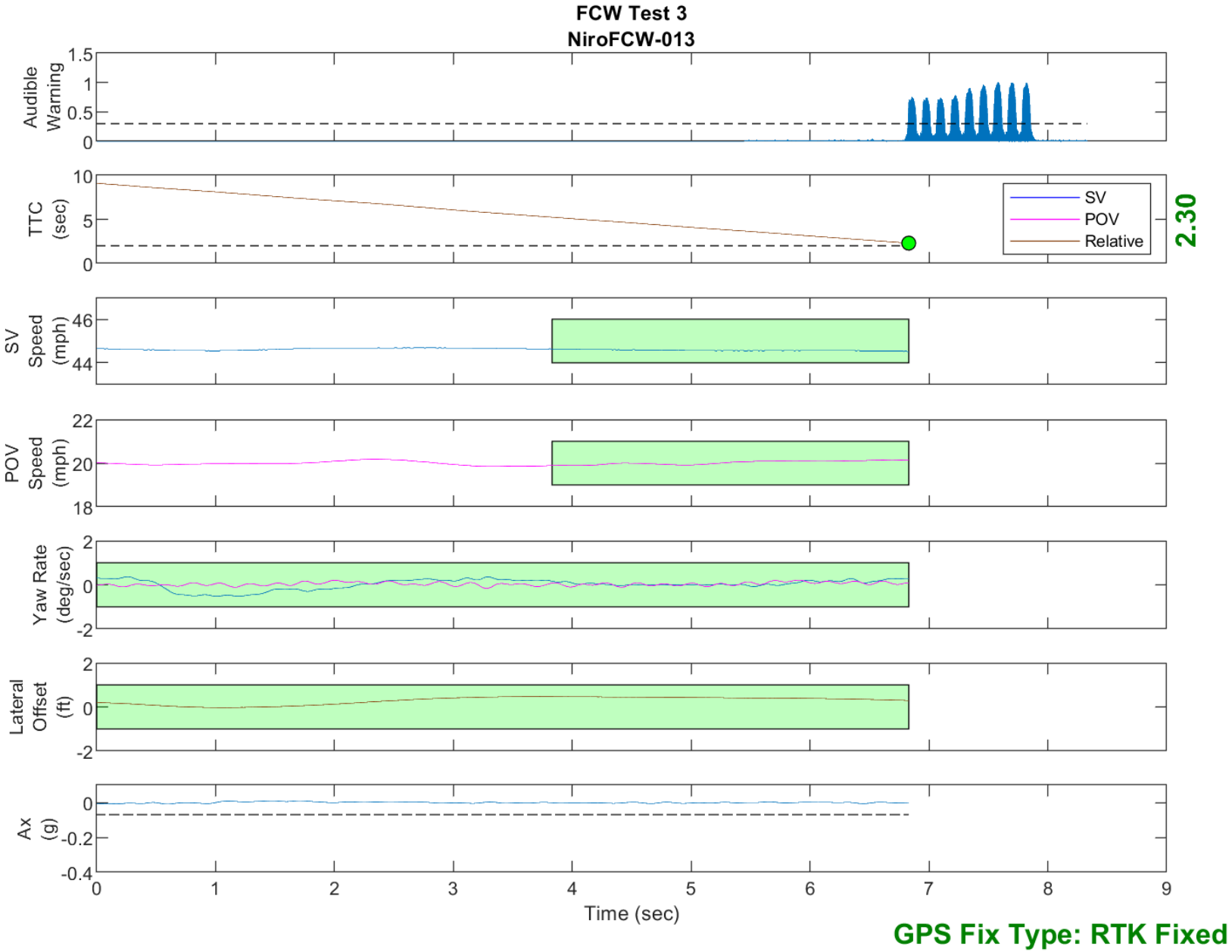

Figure D43. Time History for Run 13, FCW Test 3, Audible Warning

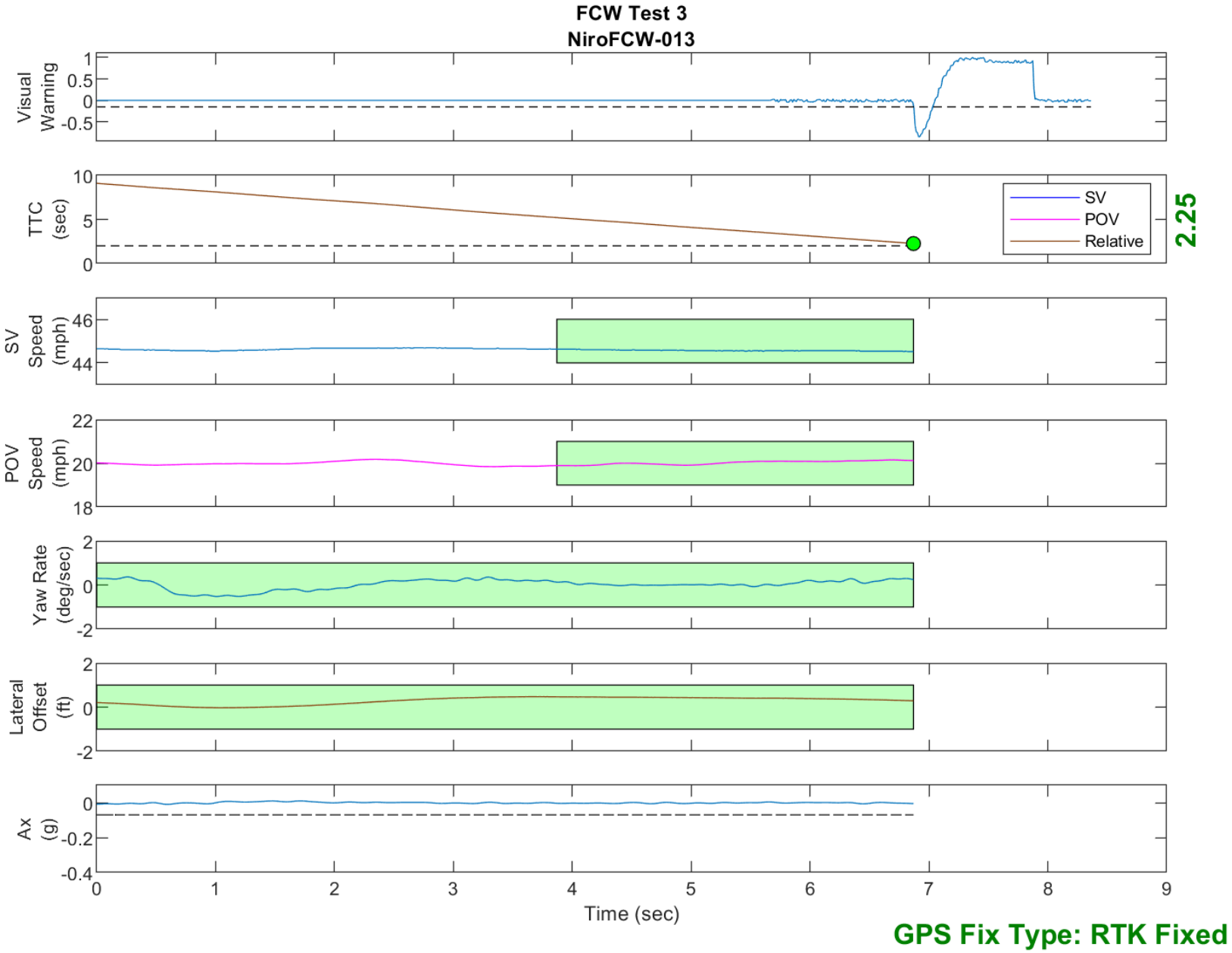

Figure D44. Time History for Run 13, FCW Test 3, Visual Warning

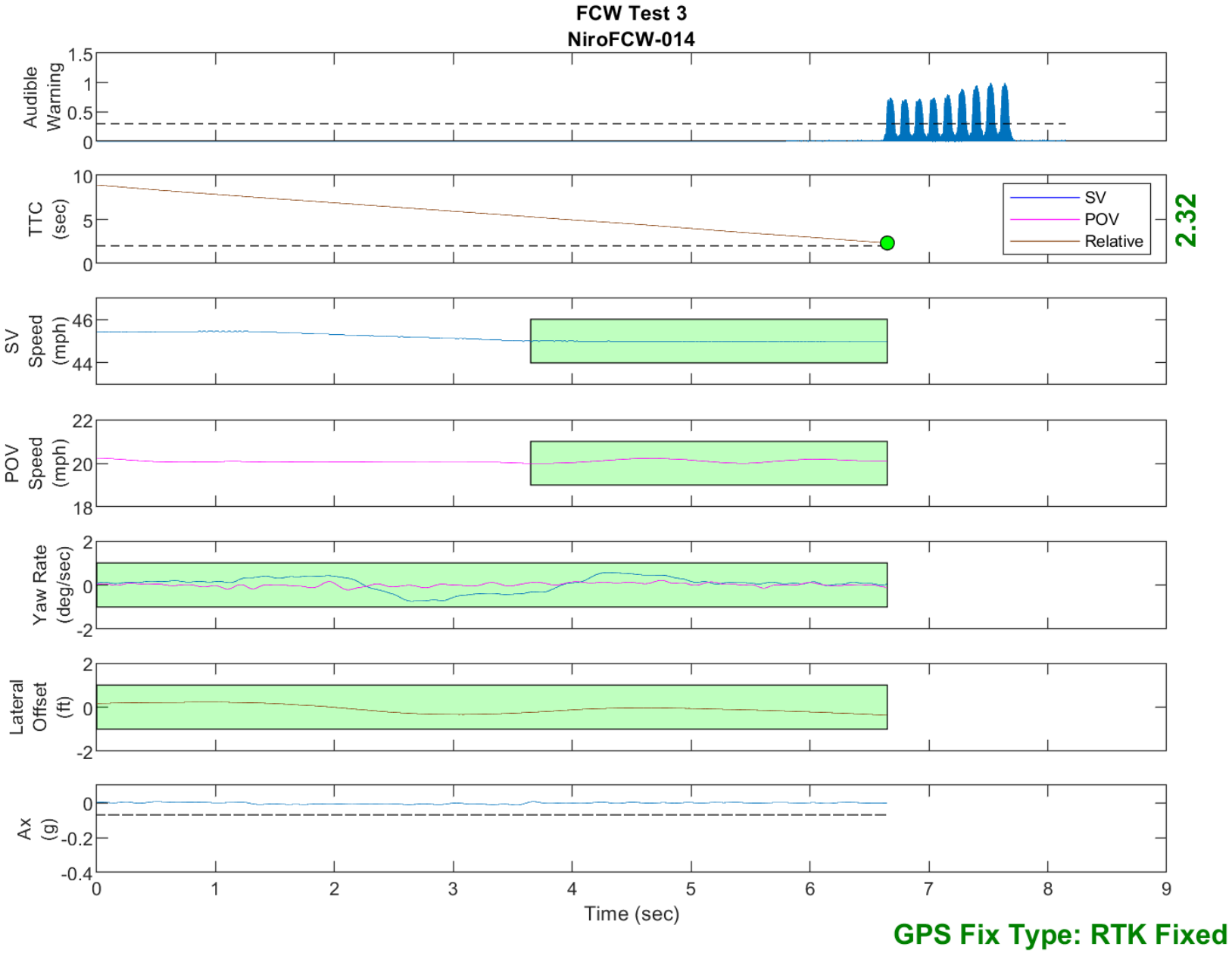

Figure D45. Time History for Run 14, FCW Test 3, Audible Warning

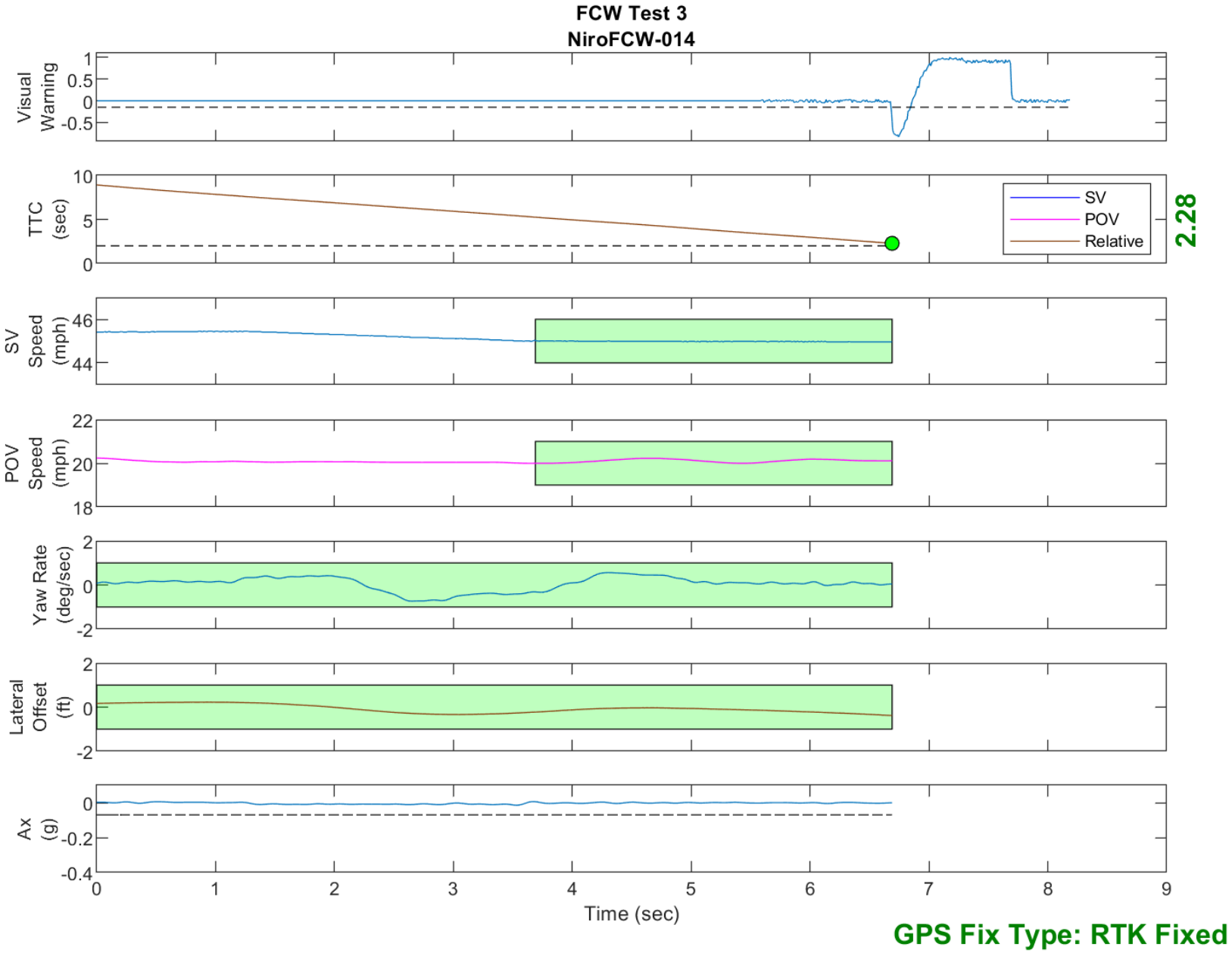

Figure D46. Time History for Run 14, FCW Test 3, Visual Warning

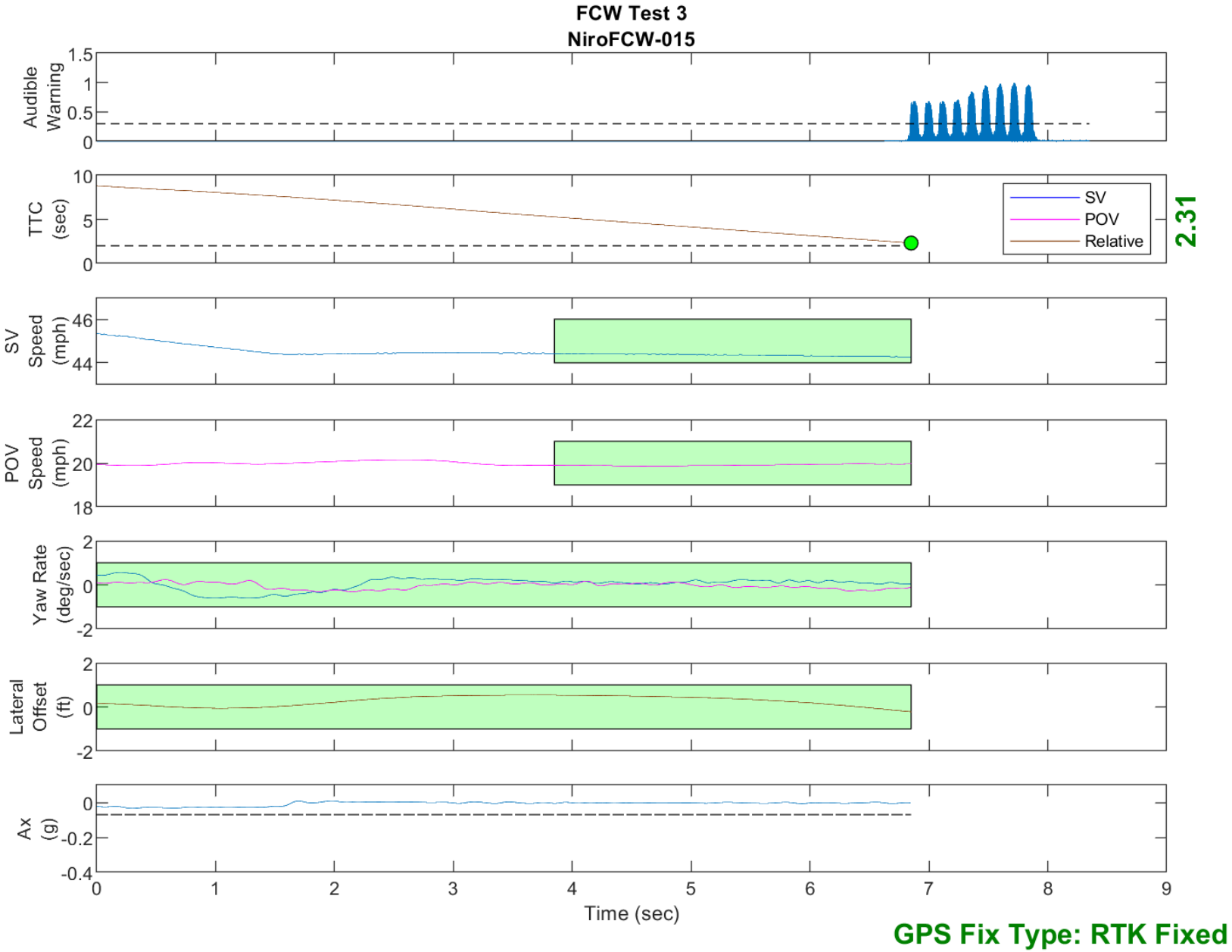

Figure D47. Time History for Run 15, FCW Test 3, Audible Warning

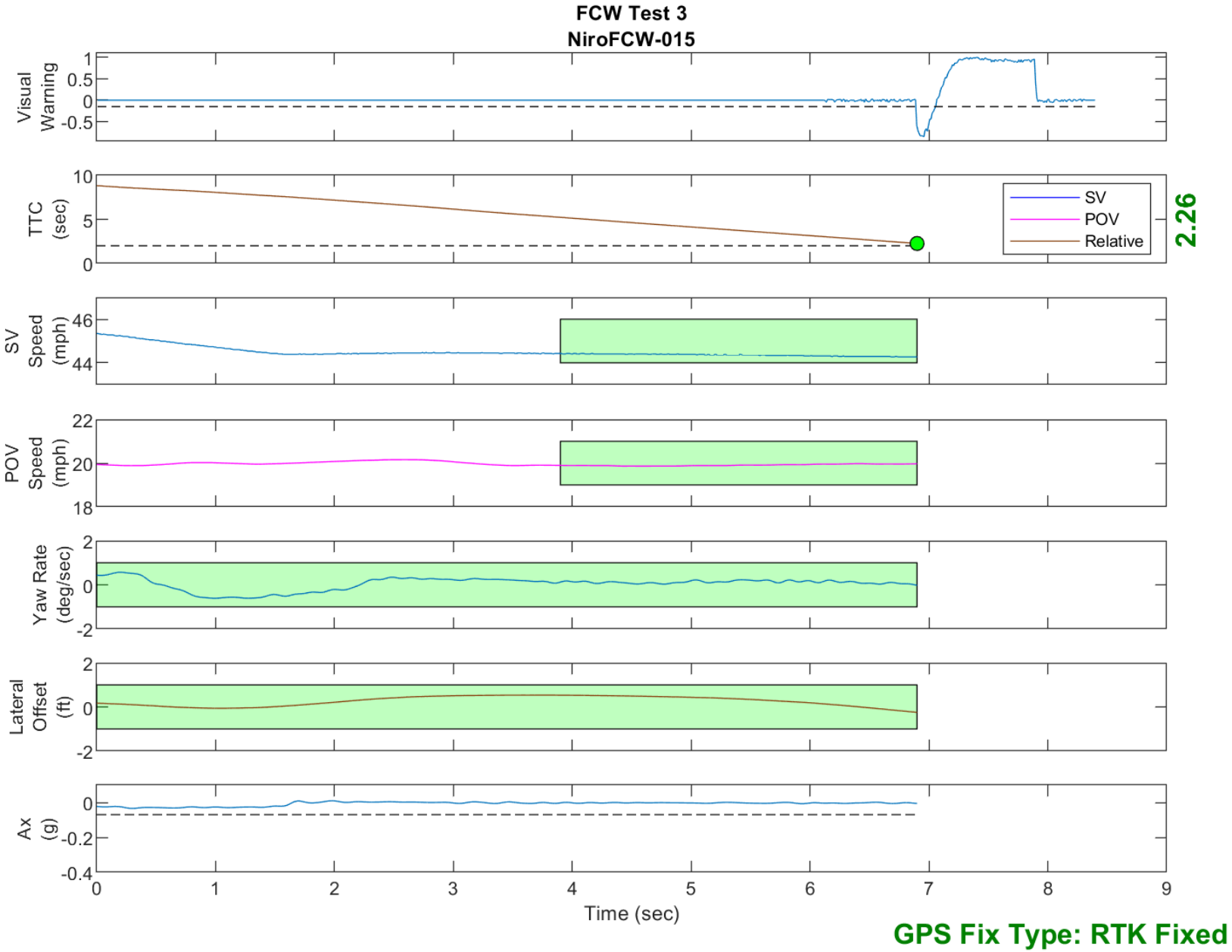

Figure D48. Time History for Run 15, FCW Test 3, Visual Warning