

OCAS-DRI-FCW-13-006

NCAP FORWARD COLLISION WARNING CONFIRMATION TEST

2013 Chevrolet Volt

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17 December, 2012

Final Report

Prepared Under Contract No.: DTNH22-08-D-00095

**U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
1200 New Jersey Avenue, SE
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Washington, DC 20590**

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16. Abstract These tests were conducted on the subject 2013 Chevrolet Volt 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", March 2010. 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

2013 Chevrolet Volt

VIN: 1G1RH6E48DU1xxxx

Test Date: 12/4/2012

Forward Collision Warning setting: Far

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)

2013 Chevrolet Volt

TEST VEHICLE INFORMATION

VIN: 1G1RH6E48DU1xxxx

Body Style: Sedan

Color: Silver

Date Received: 11/12/2012

Odometer Reading: 23 mi

Engine: 1.4 L Inline 4

Transmission: None (Electric
Motor)

Final Drive: FWD

Is the vehicle equipped with:

ABS X Yes No

Adaptive Cruise Control X Yes No

Collision Mitigating Brake System Yes X No

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: General Motors LLC

Date of manufacture: 10/12

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: 215/55R17

Rear: 215/55R17

Recommended cold tire pressure: Front: 260 kPa (38 psi)

Rear: 260 kPa (38 psi)

FORWARD COLLISION WARNING

DATA SHEET 2: VEHICLE DATA

(Page 2 of 2)

2013 Chevrolet Volt

TIRES

Tire manufacturer and model: Goodyear Assurance

Front tire size: 215/55R17

Rear tire size: 215/55R17

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)
2013 Chevrolet Volt

GENERAL INFORMATION

Test date: 12/4/2012

AMBIENT CONDITIONS

Air temperature: 15.6 C (60 F)

Wind speed: 1.5 m/s (3.5 mph)

- X Wind speed $\leq$ 10 m/s (22 mph)
- X Tests were not performed during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, or ash.
- X Tests were conducted during daylight hours with good atmospheric visibility (defined as an absence of fog and the ability to see clearly for more than 5000 meters). The tests were not conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and camera "washout" or system inoperability results.

VEHICLE PREPARATION

Verify the following:

All non consumable fluids at 100 % capacity : X

Fuel tank is full: X

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

Front: 260 kPa (38 psi)

Rear: 260 kPa (38 psi)

FORWARD COLLISION WARNING
DATA SHEET 3: TEST CONDITIONS (Page 2 of 2)
2013 Chevrolet Volt

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front: 579.2 kg (1277 lb)

Right Front 534.3 kg (1178 lb)

Left Rear 382.8 kg (844 lb)

Right Rear 359.2 kg (792 lb)

Total: 1855.6 kg (4091 lb)

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 3)

2013 Chevrolet Volt

How is the Forward Collision Warning X Warning light
presented to the driver?
(Check all that apply) 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 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 audible warning consists of repeated beeps, whose primary frequency is approximately 2000 Hz.

The visual alert consists of a small telltale that flashes (red), and (later) the message "Forward Collision Alert". The telltale is located in the left side of the instrument cluster, and the message appears in the center common display area. The telltale appears to be an image of two vehicles colliding.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 2 of 3)

2013 Chevrolet Volt

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.

A switch, located on the left side of the steering wheel, toggles the FCW system between "Off", "Far", "Medium", and "Near". When pressed, an image showing this appears in the center common display area.

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

If yes please provide a full description

FCW does not warn of pedestrians, animals, signs, guardrails, bridges, construction barrels, or other objects. FCW does not provide a warning to help avoid a crash, unless it detects a vehicle. FCW may not detect a vehicle ahead if the FCW sensor is blocked by dirt, snow, or ice, or if the windshield is damaged. It may also not detect a vehicle on winding or hilly roads, or in conditions that can limit visibility, such as fog, rain, or snow, or if the headlamps or windshield are not cleaned or in proper condition.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 3 of 3)

2013 Chevrolet Volt

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.

A switch, located on the left side of the steering wheel, toggles the FCW system between "Off", "Far", "Medium", and "Near". When pressed, an image showing this appears in the center common display area.

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.

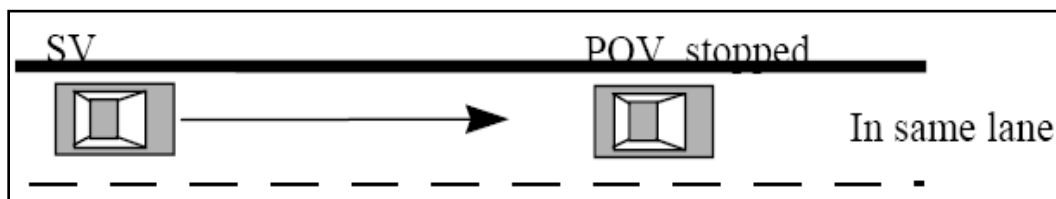


Figure 1. Depiction of Test 1

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.

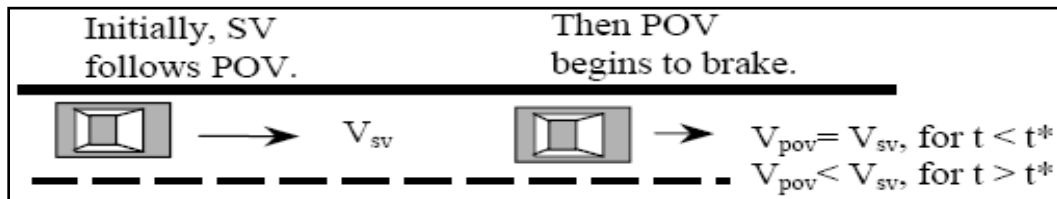


Figure 2. Depiction of Test 2

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 POV¹.

b. Procedure

¹To 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).

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 $\pm 0.03g$, 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.

As part of the pre-test instrumentation verification process, the tonal frequency of the audible warning was determined through use of the PSD (Power Spectral Density) function in Matlab. This was accomplished in order to identify the center frequency around which a band-pass filter was applied to subsequent audible warning data such that the beginning of the audible warning could be programmatically determined. The band-pass filter used for the audible warning signal was a phase-less, forward-reverse pass, 5th order elliptical (Cauer) digital filter, with 3 dB peak-to-peak ripple, minimum stop-band attenuation of 60 dB, and a pass-band of center frequency $\pm 5\%$ of the identified center frequency.

TABLE 1. TEST INSTRUMENTATION AND EQUIPMENT

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	0.5 psi 3.45 kPa	Ashcroft, D1005PS
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	± 1.0% of applied load	Intercomp, SWII
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)
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 +
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

TABLE 1. TEST INSTRUMENTATION AND EQUIPMENT (CONTD)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model
Data Acquisition System [Includes amplification, anti-aliasing, and analog to digital conversion.]	Record Time; Position; Velocity; Distance to lane markings; Headway distance; Closing Velocity; Lateral, Longitudinal, and Vertical Accels; Roll, Yaw, and Pitch Rates; Roll, Yaw and Pitch Angles.	Sufficient to meet or exceed individual sensors	Sound digitized at 10 kHz, all other channels digitized at 100 Hz. Accuracy is sufficient to meet or exceed individual sensors	SoMat, eDaq ECPU processor
				SoMat, High level Board EHLS
Microphone	Sound (to measure time at alert)	Max SPL: 139 dB/SPL Frequency Response: 40 Hz – 20 kHz	≤ 3 dB over Freq. Resp. Range	Sennheiser, e614
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor
Accelerometer	Acceleration (to measure time at alert)	± 5g	≤ 3% of full range	Silicon Designs, 2210-005
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

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle



CHEVROLET

2013 CHEVROLET VOLT

EXTERIOR: SILVER ICE METALLIC
INTERIOR: JET BLACK AND WHITE

ENGINE, RANGE
ELECTRIC DRIVE

STANDARD EQUIPMENT

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

- 8 YEAR / 100,000 MILE BATTERY AND VOLTEC COMPONENT LIMITED WARRANTY SEE DEALER FOR DETAILS
- 5 YEAR / 100,000 MILE POWERTRAIN LIMITED WARRANTY SEE DEALER FOR DETAILS

MECHANICAL

- BATTERY, PROPULSION, LITHIUM ION,
- ELECTRIC DRIVE UNIT, VOLTEC
- ENGINE, RANGE EXTENDER, 1.4L INTERNAL COMBUSTION ENGINE
- TIRE SEALANT + INFLATOR KIT IN PLACE OF SPARE TIRE

SAFETY & SECURITY

- 2012 TOP SAFETY PICK FROM THE INSURANCE INSTITUTE FOR HIGHWAY SAFETY

- AIRBAGS, DUAL-STAGE FRONTAL, SIDE-IMPACT, & KNEE FOR DRIVER AND FRONT PASSENGER
- AIRBAGS, ROOF RAIL
- SIDE-IMPACT FOR FRONT AND REAR OUTBOARD SEATING POSITIONS
- ANTILOCK BRAKE SYSTEM, 4 WHEEL DISC
- REAR CHILD SEAT LATCH ANCHORS
- THEFT DETERRENT SYSTEM, CONTENT THEFT ALARM
- DAYTIME RUNNING LAMPS
- STABILITRAK-STABILITY CONTROL INCLUDES TRACTION CONTROL
- REMOTE KEYLESS ENTRY WITH REMOTE START
- PEDESTRIAN FRIENDLY ALERT
- POWER DOOR LOCKS WITH LOCKOUT PROTECTION
- HEADLAMPS, AUTO ON/OFF
- TIRE PRESSURE MONITOR
- KEYLESS ACCESS

- 3 YRS ONSTAR DIRECTIONS & CONNECTIONS W/ AUTOMATIC CRASH RESPONSE, TURN-BY-TURN NAVIGATION, MYVOLT.COM, AND ONSTAR REMOTELINK (ASK DEALER ABOUT GEOGRAPHIC COVERAGE)

EXTERIOR

- MIRRORS, OUTSIDE HEATED, POWER ADJUSTABLE, BODY COLOR
- REAR WINDOW DEFROSTER
- WINDSHIELD WIPERS VARIABLE & INTERMITTENT
- WINDSHIELD, SOLAR ABSORBING
- WHEELS, 17" PAINTED ALUMINUM

INTERIOR

- CHEVROLET MYLINK RADIO WITH 7" SCREEN, 6 SPEAKERS
- AIR CONDITIONING, AUTOMATIC
- AUXILIARY AUDIO INPUT JACK
- FLOOR MATS, CARPET FRONT/REAR
- STEERING COLUMN, TILT &

TELESCOPING

- VISORS, ILLUMINATED VANITY MIRRORS
- EFFICIENCY DISPLAY SCREENS W/ PROGRAMMABLE CHARGE TIMES
- STEERING WHEEL RADIO CONTROLS
- CRUISE CONTROL
- FRONT BUCKET SEATS,
- REAR SEAT, 40/40 SPLIT FOLDING SEATBACK
- POWER WINDOWS EXPRESS DOWN, DRIVER EXPRESS UP
- USB PORT
- XM RADIO + SERVICE SUBSCRIPTION SOLD SEPARATELY BY SIRIUSXM AFTER 3 MTHS
- UNIVERSAL HOME REMOTE
- BLUETOOTH FOR PHONE

OTHER

- CHARGE CORD, 120 V PORTABLE

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MANUFACTURER'S SUGGESTED RETAIL PRICE

STANDARD VEHICLE PRICE \$39,100

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

LOW EMISSIONS PACKAGE (ENHANCED AT-PZEV EMISSIONS)

PREMIUM TRIM PKG INCLUDES:

- LEATHER APPOINTED SEATING
- HEATED FRONT SEAT, DRIVER AND PASSENGER
- LEATHER WRAP STEERING WHEEL
- REAR SEAT REMOVEABLE ARMREST

ENHANCED SAFETY PKG 1 INCLUDES:

- AUTO-DIMMING INSIDE REARVIEW MIRROR
- REAR PARK ASSIST
- REAR VISION CAMERA

EPA DOT Fuel Economy and Environment

Fuel Economy

Electricity
Charge Time: 4 hours (240V)
98 MPGe
35 kW-hrs per 100 miles
combined city/highway

Driving Range

All electric range
0 15 30 38 miles

Gasoline Only

37 MPG
2.7 gallons per 100 miles
combined city/highway

Gasoline only
0 15 30 38 miles

You save
\$6,850
in fuel costs
over 5 years
compared to the
average new vehicle.

Plug-In Hybrid Vehicle Electricity-Gasoline

Annual fuel cost
\$950

Fuel Economy & Greenhouse Gas Rating (tailpipe only)

1 10 Best

This vehicle emits 81 grams CO₂ per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel & electricity also create emissions; learn more at fuelconomy.gov.

Smog Rating (tailpipe only)

1 9 10 Best

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score

★★★★★
Based on the combined ratings of frontal, side and rollover.
Should ONLY be compared to other vehicles of similar size and weight.

Frontal Crash

★★★★★
Based on the risk of injury in a frontal impact.
Should ONLY be compared to other vehicles of similar size and weight.

Side Crash

★★★★★
Based on the risk of injury in a side impact.

Rollover

★★★★★
Based on the risk of rollover in a single-vehicle crash.

Star ratings range from 1 to 5 stars (★★★★★) with 5 being the highest.
Source: National Highway Traffic Safety Administration (NHTSA)
www.safercar.gov or 1-888-327-4236

PARTS CONTENT

FOR VEHICLES IN THIS U.S./CANADIAN PARTS

MAJOR SOURCES OF F
CONTENT: JAPAN 18%
KOREA 17%

NOTE: PARTS CONTENT DOES NOT INCLUDE ASSEMBLY, DISTRIBUTION, OR

FOR THIS VEHICLE:

FINAL ASSEMBLY POINT
DETROIT, MI U.S.A.

COUNTRY OF ORIGIN:

ENGINE: UNITED STATES
TRANSMISSION (ELECTRIC DRIVE UNIT): JAPAN

ORDER NO. GWTWC6 SALES CODE E
SALES MODEL CODE 1RC68
DEALER NO.
FINAL ASSEMBLY:
DETROIT, MI U.S.A.

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

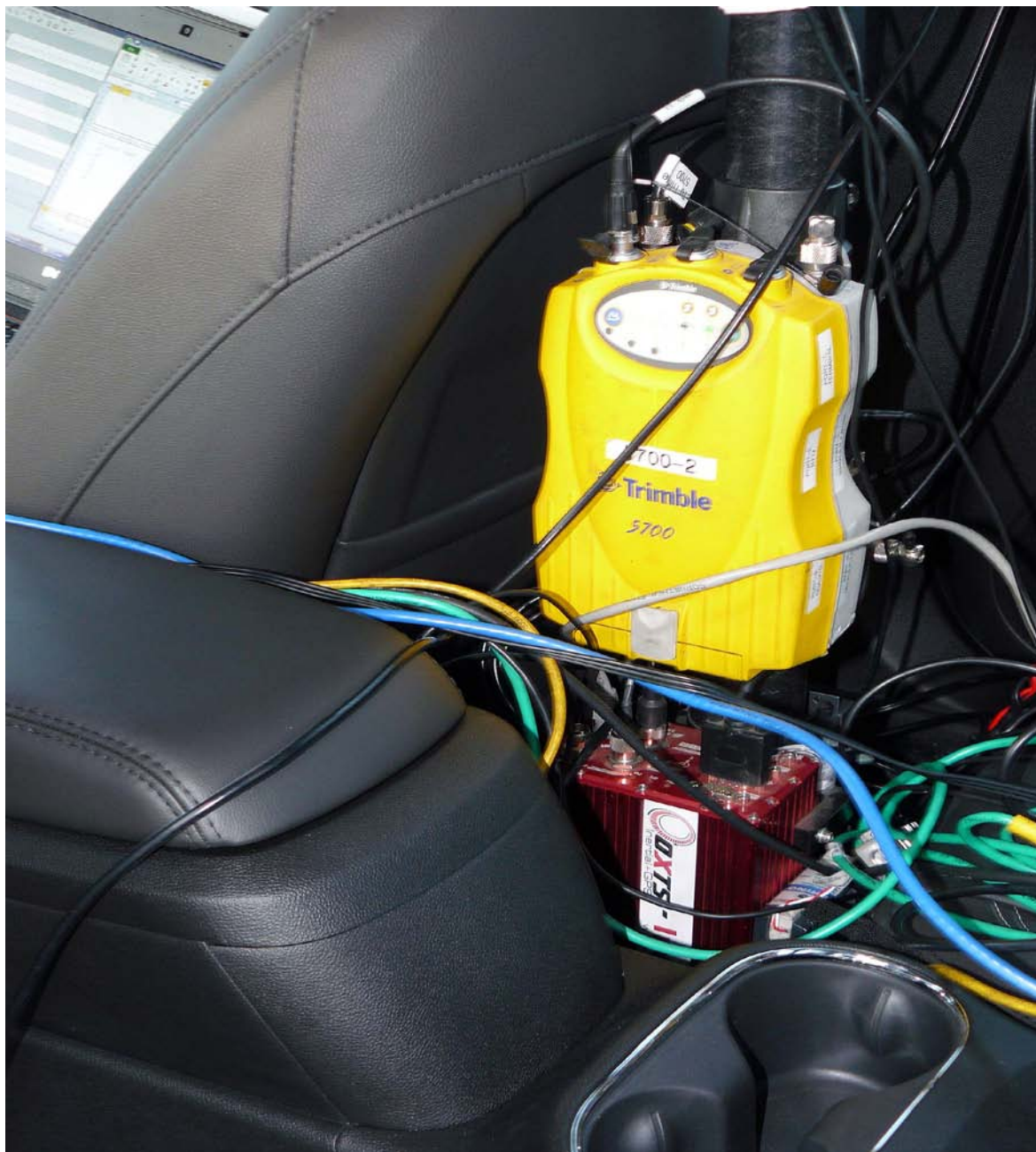


Figure A7. DGPS and Inertial Measurement Unit Installed in Subject Vehicle



Figure A8. Data Acquisition System Installed in Subject Vehicle



Figure A9. Computer Installed in Subject Vehicle



Figure A10. Brake Actuation System Installed in Principal Other Vehicle



Figure A11. Sensors for Detecting Acoustic and Visual Alerts



Figure A12. Warning System On-Off and Settings Adjustment Switch

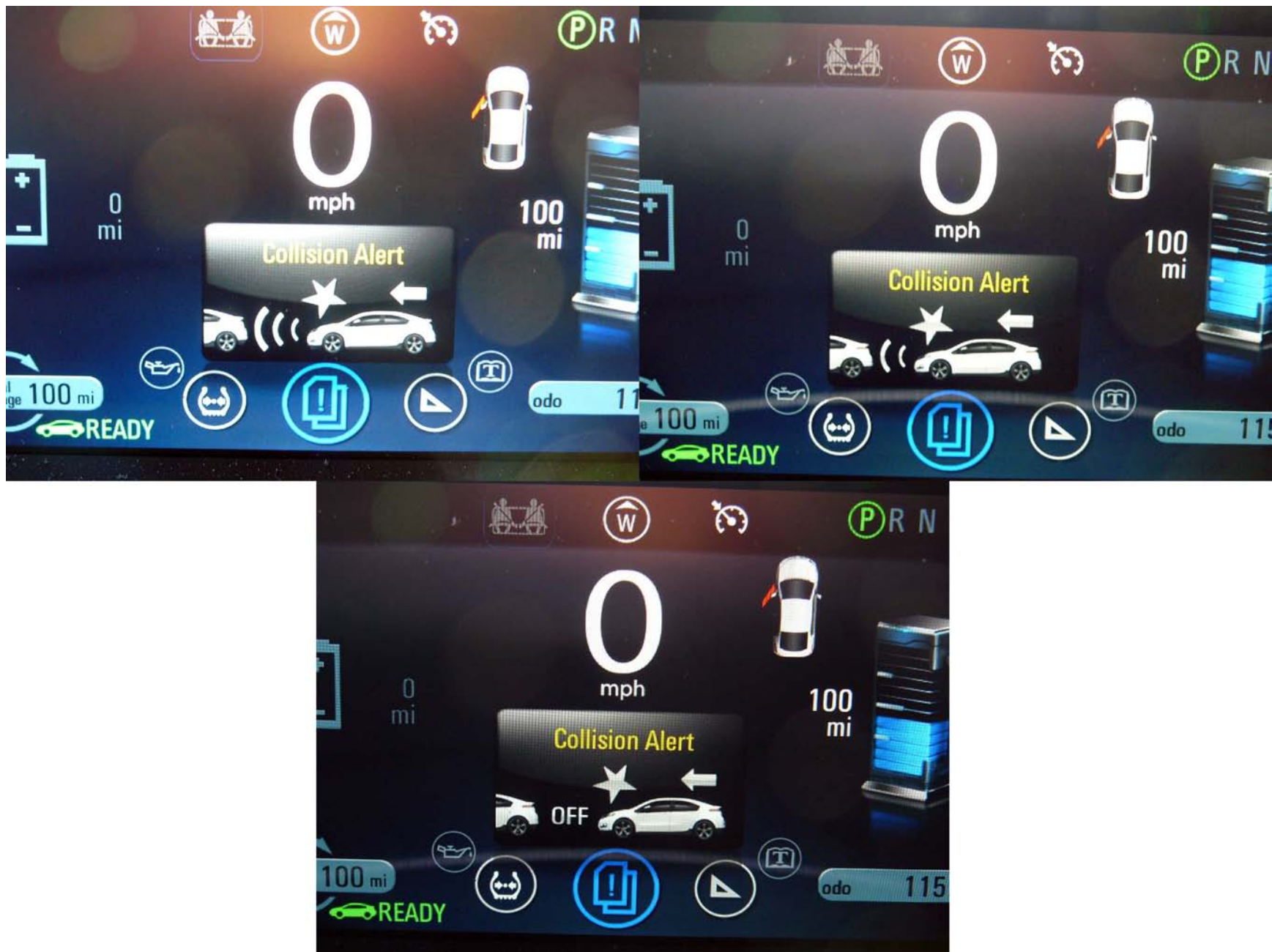


Figure A13. Display for FCW Settings



Figure A14. Visual Warning Display

APPENDIX B

Excerpts from Owner's Manual

9-38 Driving and Operating

- To slow down in very small amounts, move the thumbwheel toward SET/- briefly. Each time this is done, the vehicle goes about 1 km/h (1 mph) slower.

Passing Another Vehicle While Using Cruise Control

Use the accelerator pedal to increase vehicle speed. When you take your foot off the pedal, the vehicle will slow down to the previously set cruise control speed.

Using Cruise Control on Hills

How well the cruise control works on hills depends upon the vehicle speed, load, and the steepness of the hills. When going up steep hills, you might have to step on the accelerator pedal to maintain the vehicle speed. When going downhill, you might have to brake or shift to a lower gear to maintain the vehicle speed. When the brakes are applied the cruise control is disengaged.

Ending Cruise Control

There are three ways to end cruise control:

- Step lightly on the brake pedal; when cruise control disengages, the indicator light will not be lit.
- Press .
- Press  to turn the cruise control system off completely. The cruise control cannot be resumed.

Erasing Speed Memory

The cruise control set speed is erased from memory if  is pressed or if the vehicle is turned off.

Object Detection Systems

Forward Collision Alert (FCA) System

The Forward Collision Alert (FCA) system may help to avoid or reduce the harm caused by front-end crashes. FCA provides a flashing visual alert and beeps when approaching a vehicle directly ahead too quickly. FCA also provides a visual alert if following another vehicle much too closely. The FCA symbol is on top of the instrument panel to the right of the steering wheel.

The forward-looking FCA camera sensor is on the windshield ahead of the rearview mirror. FCA detects vehicles within a distance of approximately 60 m (197 ft) and operates at speeds above 40 km/h (25 mph).

⚠ WARNING

FCA is a warning system and does not apply the brakes. When approaching a slower-moving or stopped vehicle ahead too rapidly, or when following a vehicle too closely, FCA may not provide a warning with enough time to help avoid a crash. FCA does not warn of pedestrians, animals, signs, guardrails, bridges, construction barrels, or other objects. Be ready to take action and apply the brakes. For more information, see *Defensive Driving* on page 9-5.

Detecting the Vehicle Ahead

The green vehicle ahead indicator will appear when a vehicle is detected ahead. Whenever this indicator does not appear, FCA will not respond. The indicator may disappear on curves, highway exit ramps, or hills, or due to poor visibility. The FCA system will not detect another vehicle ahead until it is completely in the driving lane.

⚠ WARNING

FCA does not provide a warning to help avoid a crash, unless it detects a vehicle. FCA may not detect a vehicle ahead if the FCA sensor is blocked by dirt, snow, or ice, or if the windshield is damaged. It may also not detect a vehicle on winding or hilly roads, or in conditions that can limit visibility such as fog, rain, or snow, or if the headlamps or windshield are not cleaned or in proper condition. Keep the windshield, headlamps, and FCA sensors clean and in good repair.

9-40 Driving and Operating

Collision Alert



When your vehicle approaches another vehicle too rapidly, the red FCA display will flash and sound several beeps. When this occurs, the brake system prepares for driver braking to occur more rapidly. Continue to apply the brake pedal as the driving situation dictates.

Tailgating Alert

The red FCA display will stay continuously illuminated if the vehicle ahead remains much too close.

Selecting the Alert Timing



The Collision Alert control is on the steering wheel. Press COLLISION ALERT to set the alert timing to far, medium, near or off. The first button press shows the current control setting on the DIC. Additional button presses will change this setting. The chosen setting will remain until it is changed and will affect both the Collision Alert and the Tailgating Alert features. The timing of both alerts will vary based on vehicle speed. The faster the vehicle speed, the further away the alert will occur.

Consider traffic and weather conditions when selecting the alert timing. The range of selectable alert timing may not be appropriate for all drivers and driving conditions.

Following Distance Indication

The following distance indication displays the distance to a moving vehicle in front. When a vehicle is detected ahead at speeds over 40 km/h (25 mph), the distance is indicated in seconds on the Driver Information Center (DIC). See *Driver Information Center (DIC)* on page 5-41. The minimum distance is 0.5 seconds away. If there is no vehicle ahead, or the vehicle ahead is out of range, dashes will be displayed.

Unnecessary Alerts

FCA may sometimes set unnecessary alerts to turning vehicles, vehicles in other lanes, objects that are not vehicles,

or shadows. These alerts are normal operation and the vehicle does not need service.

Other Messages

There are messages that may appear on the Driver Information Center (DIC) in the instrument cluster to provide information about FCA. See *Object Detection System Messages* on page 5-48.

Cleaning the System

If the FCA system does not seem to operate properly, clean the outside of the windshield area in front of the camera sensor before considering taking the vehicle in for service.

Ultrasonic Parking Assist

If available, the Ultrasonic Front and Rear Parking Assist (UFRPA) or Ultrasonic Rear Parking Assist (URPA) system assists the driver with parking and avoiding objects. At speeds less than 8 km/h (5 mph), the system detects objects up to 2.5 m (8 ft) behind the vehicle, and

at least 25 cm (10 in) off the ground. If the vehicle has the UFRPA system, it also detected objects 1.2 m (4 ft) in front of the vehicle.

WARNING

The parking assist system does not detect children, pedestrians, bicyclists, animals, or objects located below the bumper or that are too close or too far from the vehicle. It is not available at speeds greater than 8 km/h (5 mph). To prevent injury, death, or vehicle damage, even with parking assist, always check the area around the vehicle and check all mirrors before moving forward or backing.

How the System Works

When the vehicle is shifted into R (Reverse) the sensors are automatically turned on. After the vehicle is shifted out of R (Reverse), the rear sensors are turned off and

the front sensors (if equipped) stay on until the vehicle is above a speed of 8 km/h (5 mph). For the front park assist system to be active again without shifting into R (Reverse), the park assist button in the overhead console must be pressed. See "Turning the System On and Off" later in this section.

When the vehicle is in N (Neutral), the system may be active. If the vehicle is in a car wash, the sensors may detect objects in the car wash. See "Turning the System On and Off" later in this section to turn the system off.

For vehicles with UFRPA, high-toned beeps from the front speakers are for objects detected near the front bumper. Low-toned beeps from the rear speakers are for objects detected near the rear bumper. The interval between the beeps becomes shorter as the vehicle gets closer to the obstacle. When the distance is less than 30 cm (12 in) the beeping is a continuous tone for five seconds.

APPENDIX C

Run Log

Subject Vehicle: **2013 Chevrolet Volt**

Date: 4 December 2012

Principal Other Vehicle: 2000 Honda Accord

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
1	FCW1 (Stopped)	N	2.44				Speed high
2		Y	2.54	2.61	0.51	Pass	
3		Y	2.54	2.56	0.46	Pass	
4		Y	2.43	2.44	0.34	Pass	
5		N					Speed high
6		N					Yaw rate high
7		Y	2.33	2.38	0.28	Pass	
8		Y	2.59	2.63	0.53	Pass	
9		N					Speed high
10		Y	2.33	2.37	0.27	Pass	
11		N					Yaw rate high
12		Y	2.43	2.45	0.35	Pass	
13	FCW3 (Slower)	N					Yaw rate high
14		Y	2.56	2.59	0.59	Pass	
15		N					Lateral offset high
16		Y	2.39	2.43	0.43	Pass	
17		Y	2.43	2.49	0.49	Pass	
18		Y	2.78	2.82	0.82	Pass	
19		Y	2.49	2.54	0.54	Pass	
20		Y	2.21	2.25	0.25	Pass	
21		Y	2.88	2.93	0.93	Pass	

Principal Other Vehicle: 2000 Honda Accord

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
23	FCW2 (Braking)	N					
24		N					Yaw Rate High
25		N					
26		N					
27		N					
28		N					
29		N					
30		N					
31		N					
32		N					
33		N					
34		N					
35		N					
36		N					
37		N					
38		Y	2.54	2.58	0.18	Pass	
39		Y	2.60	2.64	0.24	Pass	
40		N					
41		Y	2.99	3.03	0.63	Pass	
42		Y	2.67	2.69	0.29	Pass	
43		Y	2.96	3.04	0.64	Pass	
44		N					
45		N					
46		Y	2.57	2.59	0.19	Pass	

Subject Vehicle: **2013 Chevrolet Volt**

Date: 4 December 2012

Principal Other Vehicle: 2000 Honda Accord

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
47	FCW2 (Braking)	N					
48		Y	2.59	2.61	0.21	Pass	

APPENDIX D

Time History Plots

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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. The data shown in time history plots for test type 2 differs slightly from the data shown in test types 1 and 3, owing to the headway distance criterion which is used exclusively for test type 2.

Time history figures include the following sub-plots:

- Event – indicates timing of warning issued by FCW system. Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any of the following,:
 - o Filtered and rectified sound signal
 - o Filtered and rectified acceleration (e.g., steering wheel vibration)
 - o Light sensor signal
 - o Discrete on/off value
- 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)

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 test type 2, the plot indicating the longitudinal acceleration of the Principal Other Vehicle includes a solid black threshold line indicating the maximum deceleration (-0.33 g) allowed while braking. Exceedance of this threshold is indicated with red shading in the area between the measured time-varying data and 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.

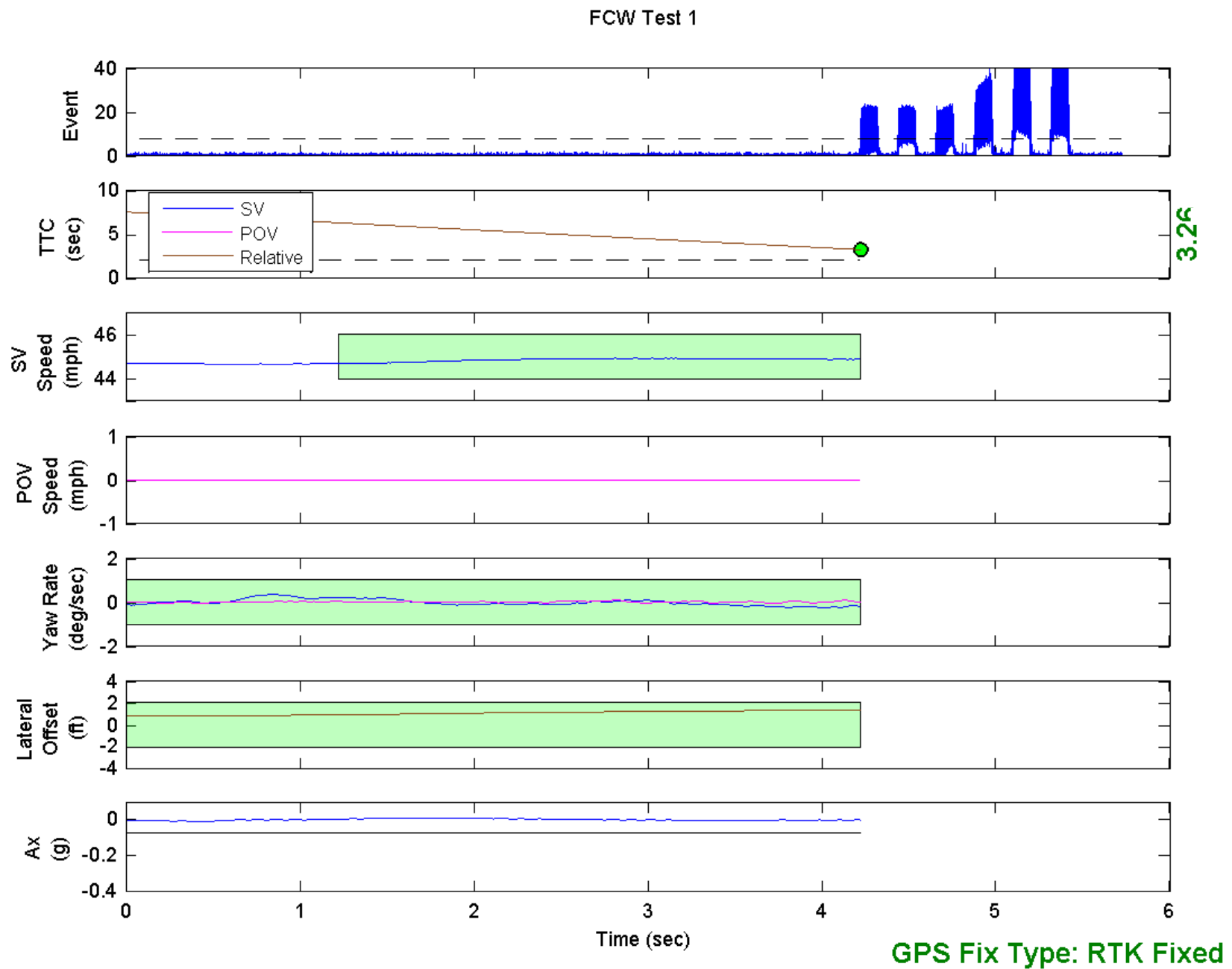


Figure D1. Example Time History for Test Type 1, Passing

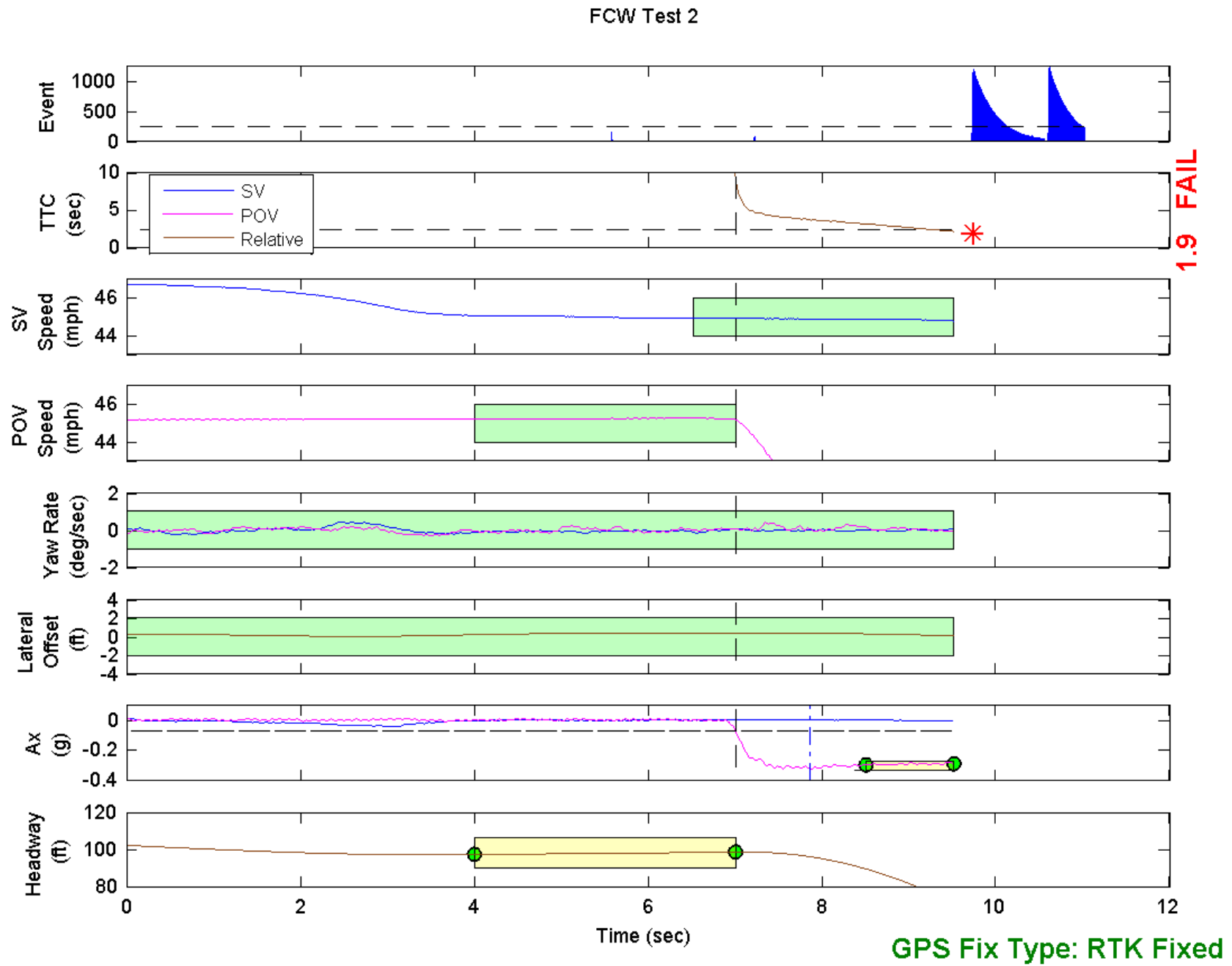


Figure D2. Example Time History for Test Type 2, Failing

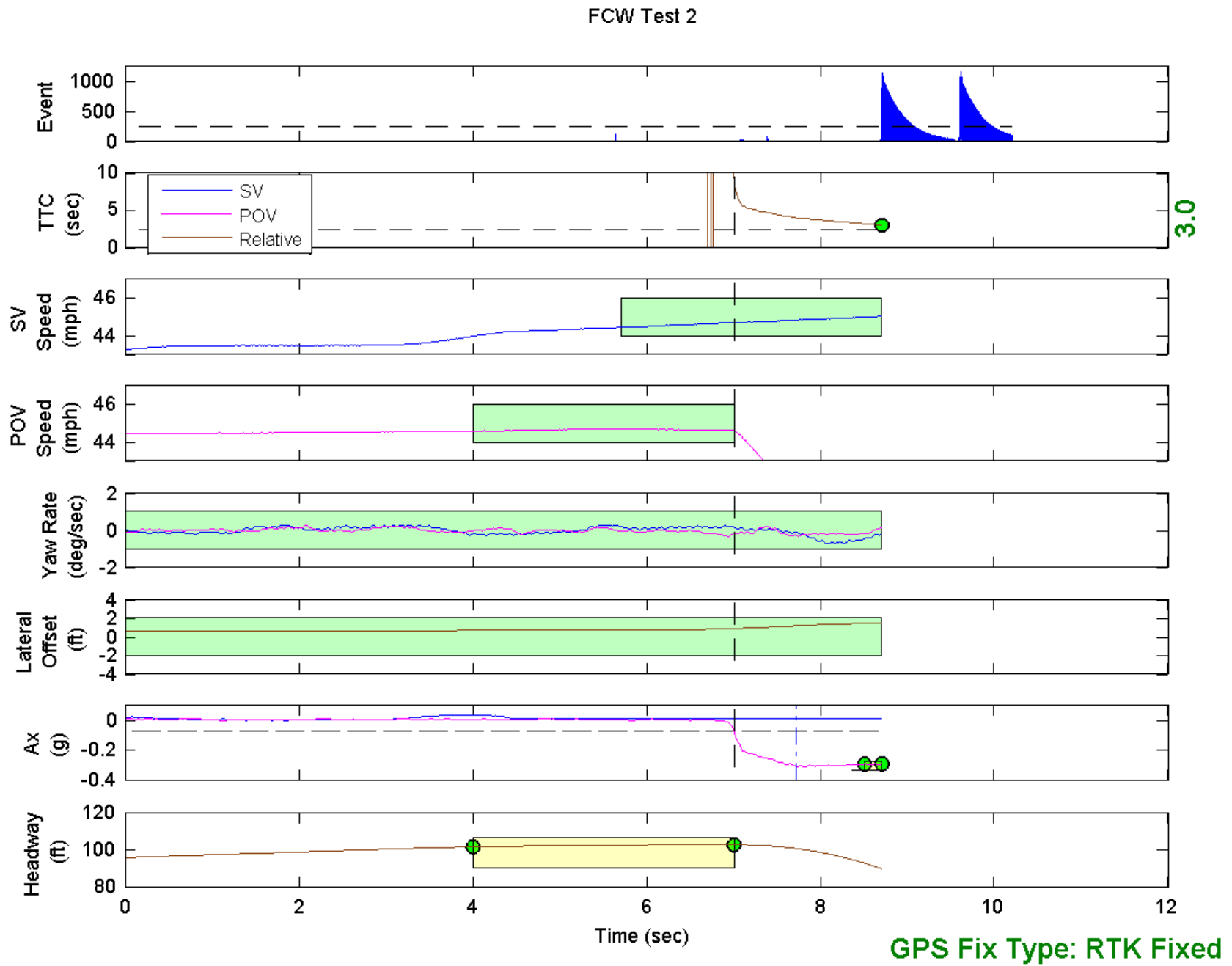


Figure D3. Example Time History for Test Type 2, Passing

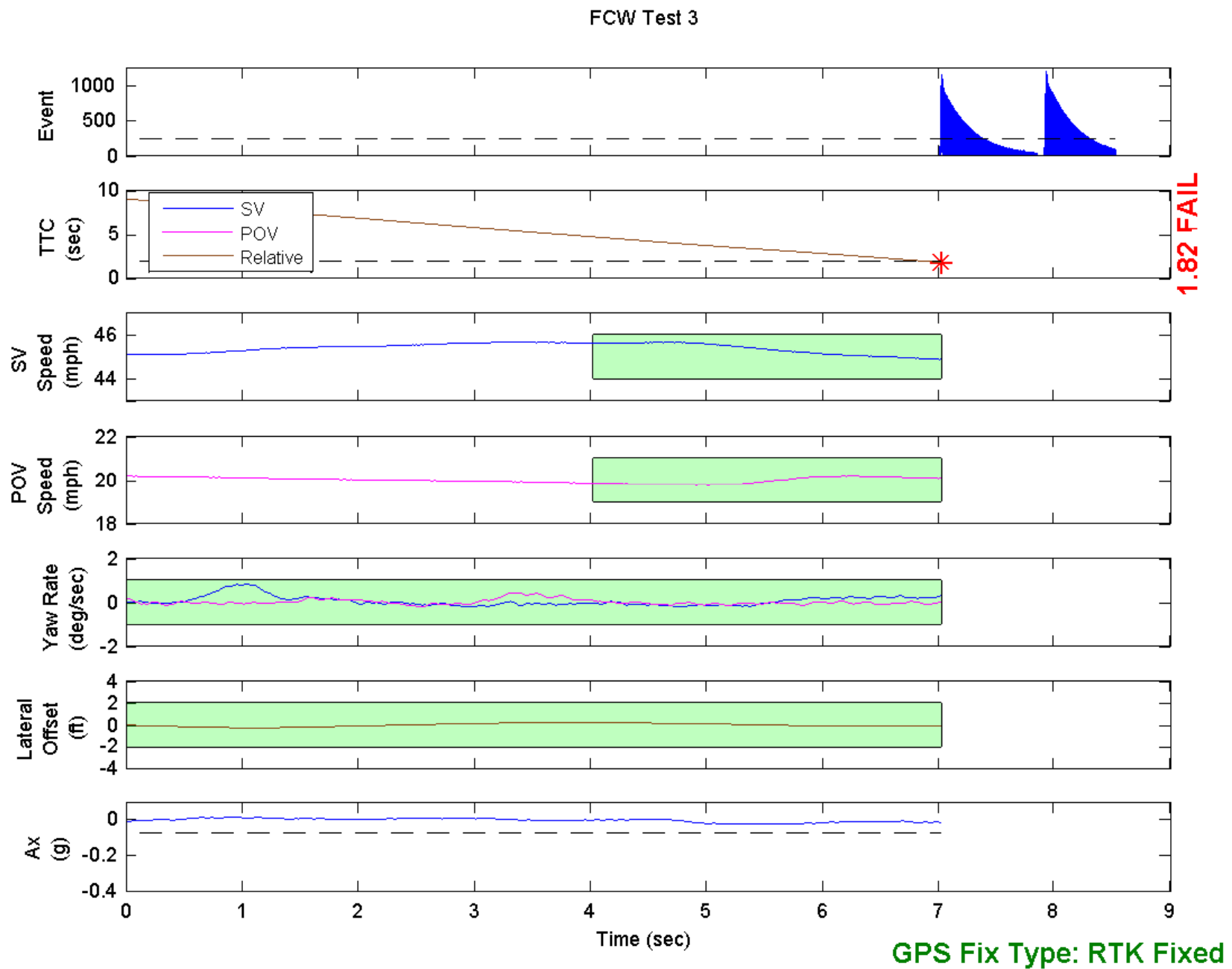


Figure D4. Example Time History for Test Type 3, Failing

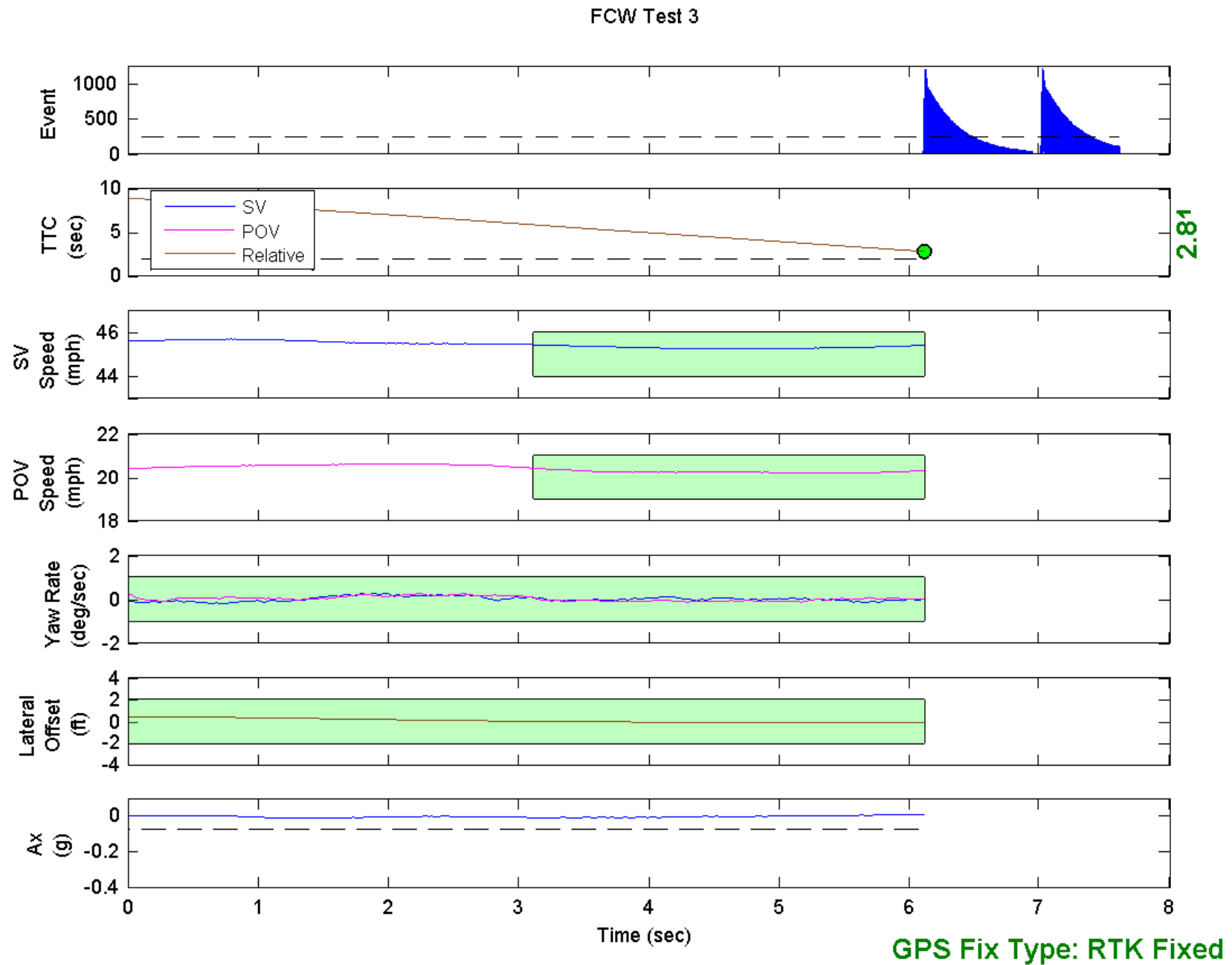


Figure D5. Example Time History for Test Type 3, Passing

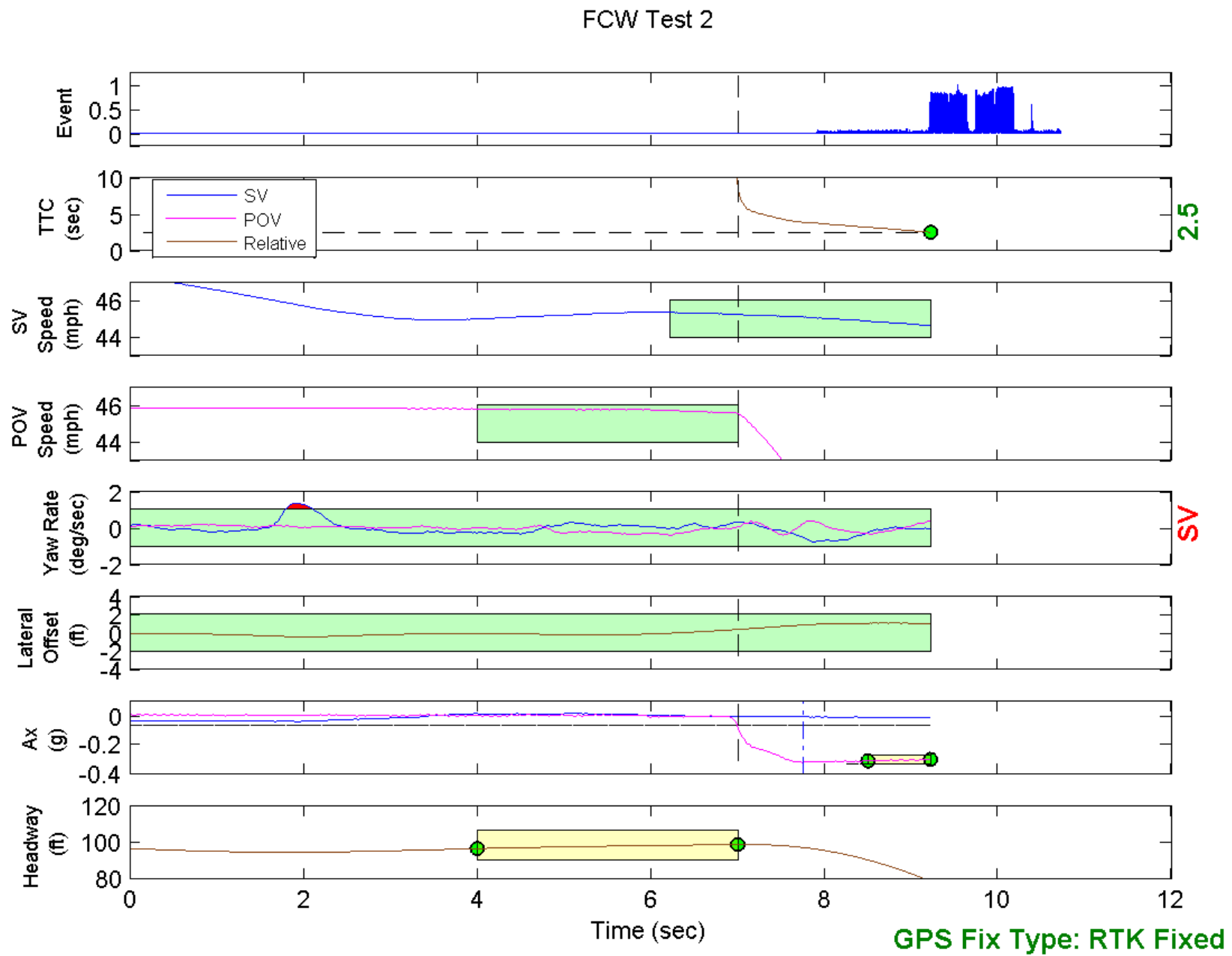


Figure D6. Example Time History for Test Type 2, Invalid Run Due to Subject Vehicle Yaw Rate

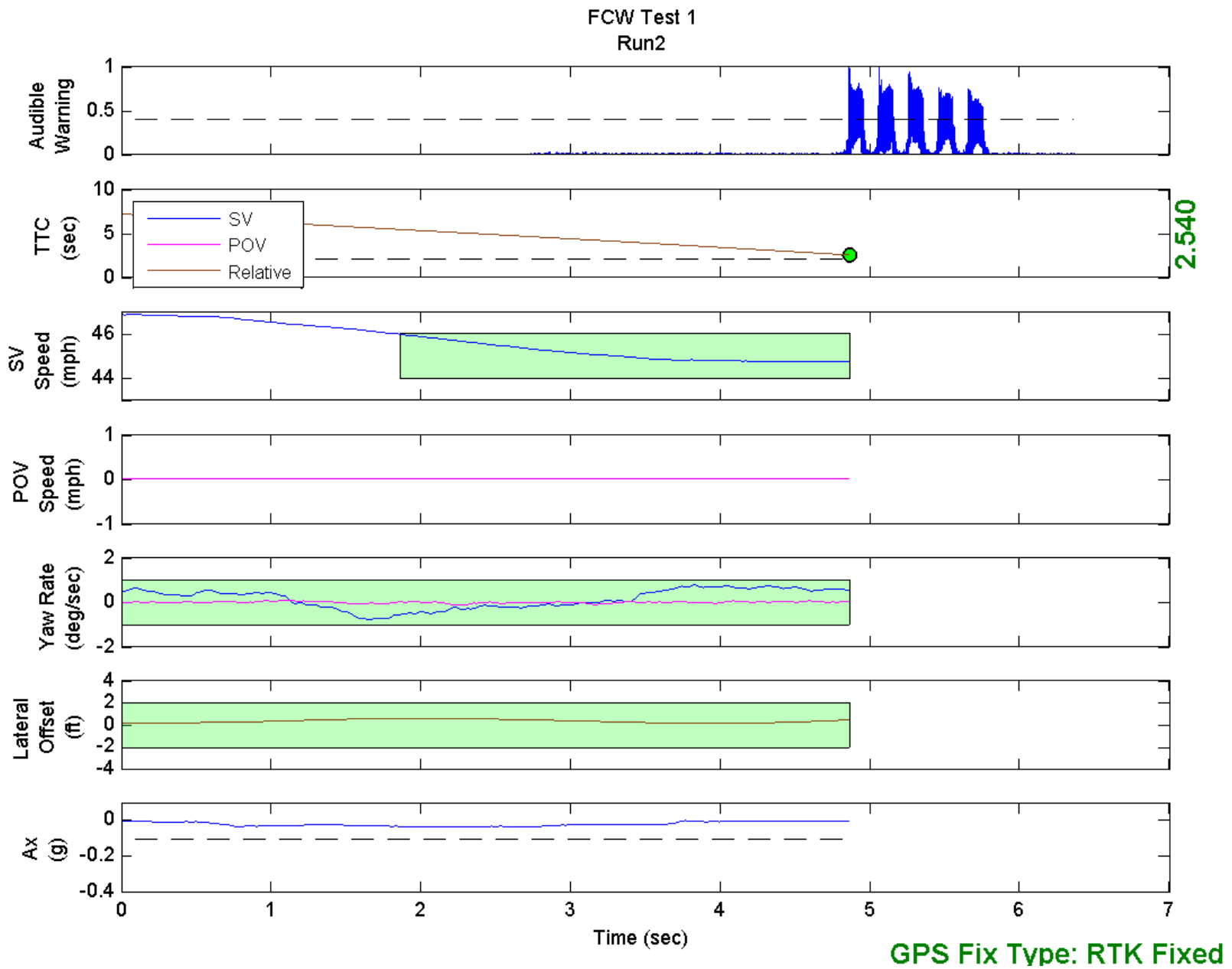


Figure D7. Time History for Run 2, FCW Test 1, Audible Warning

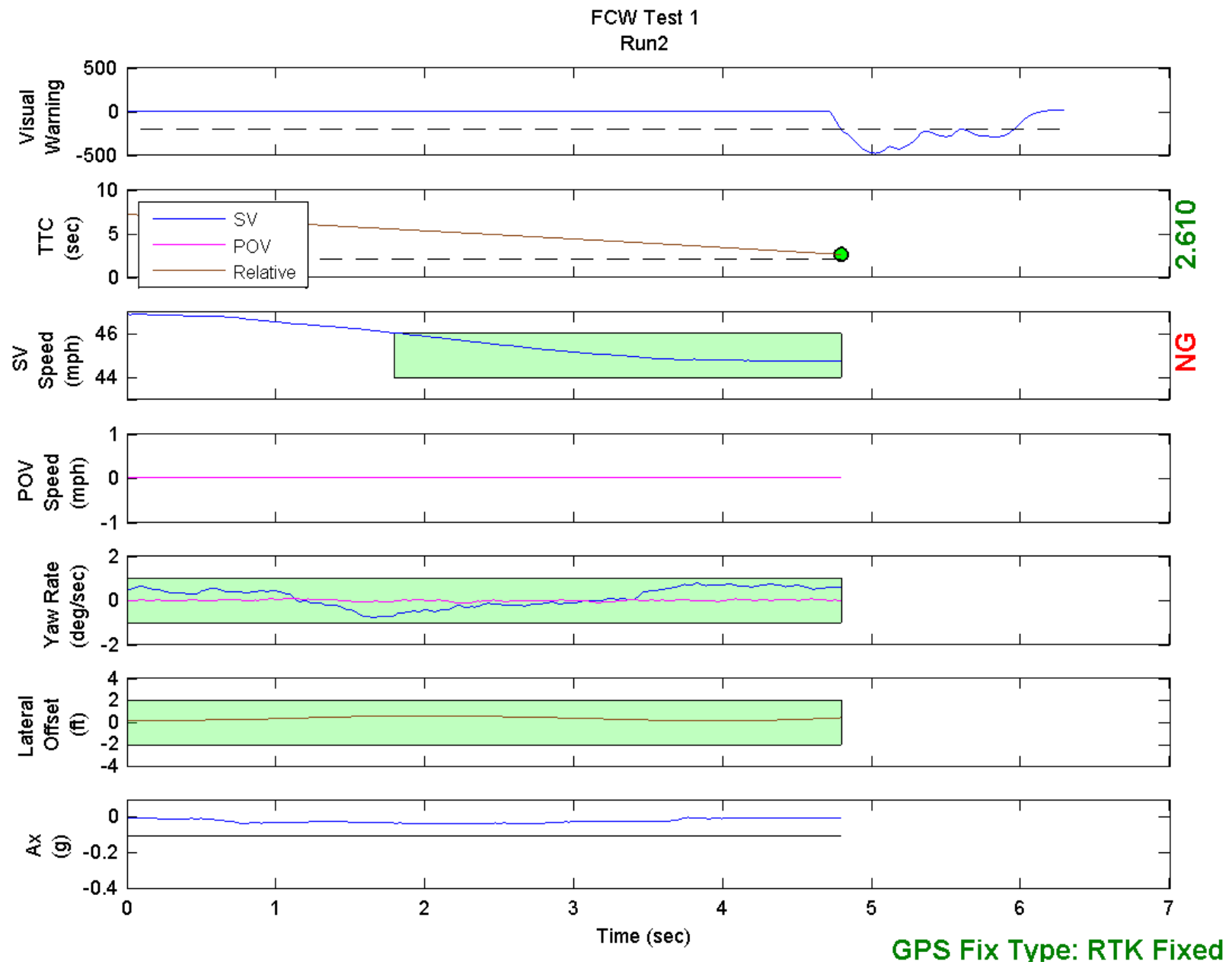


Figure D8. Time History for Run 2, FCW Test 1, Visual Warning

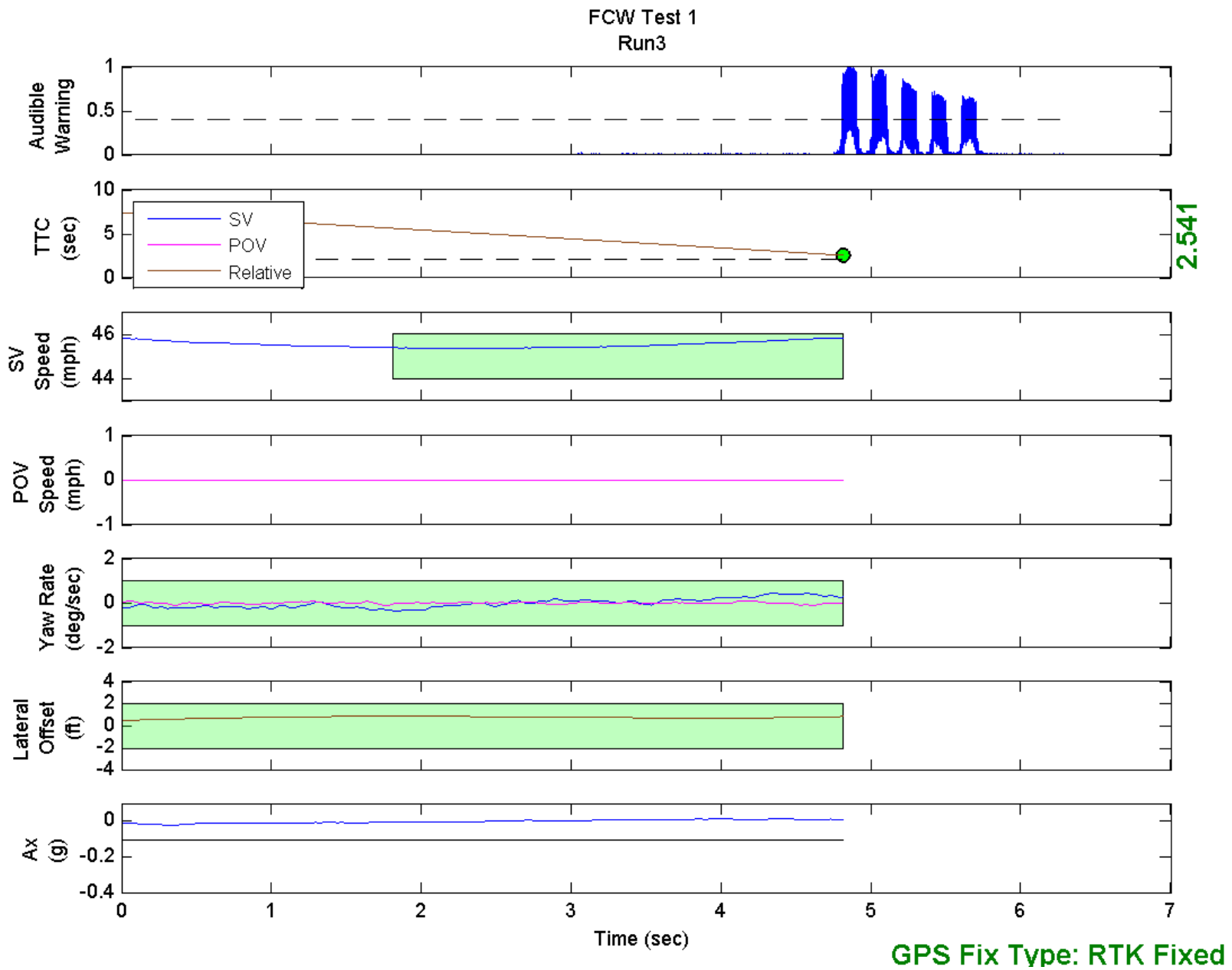


Figure D9. Time History for Run 3, FCW Test 1, Audible Warning

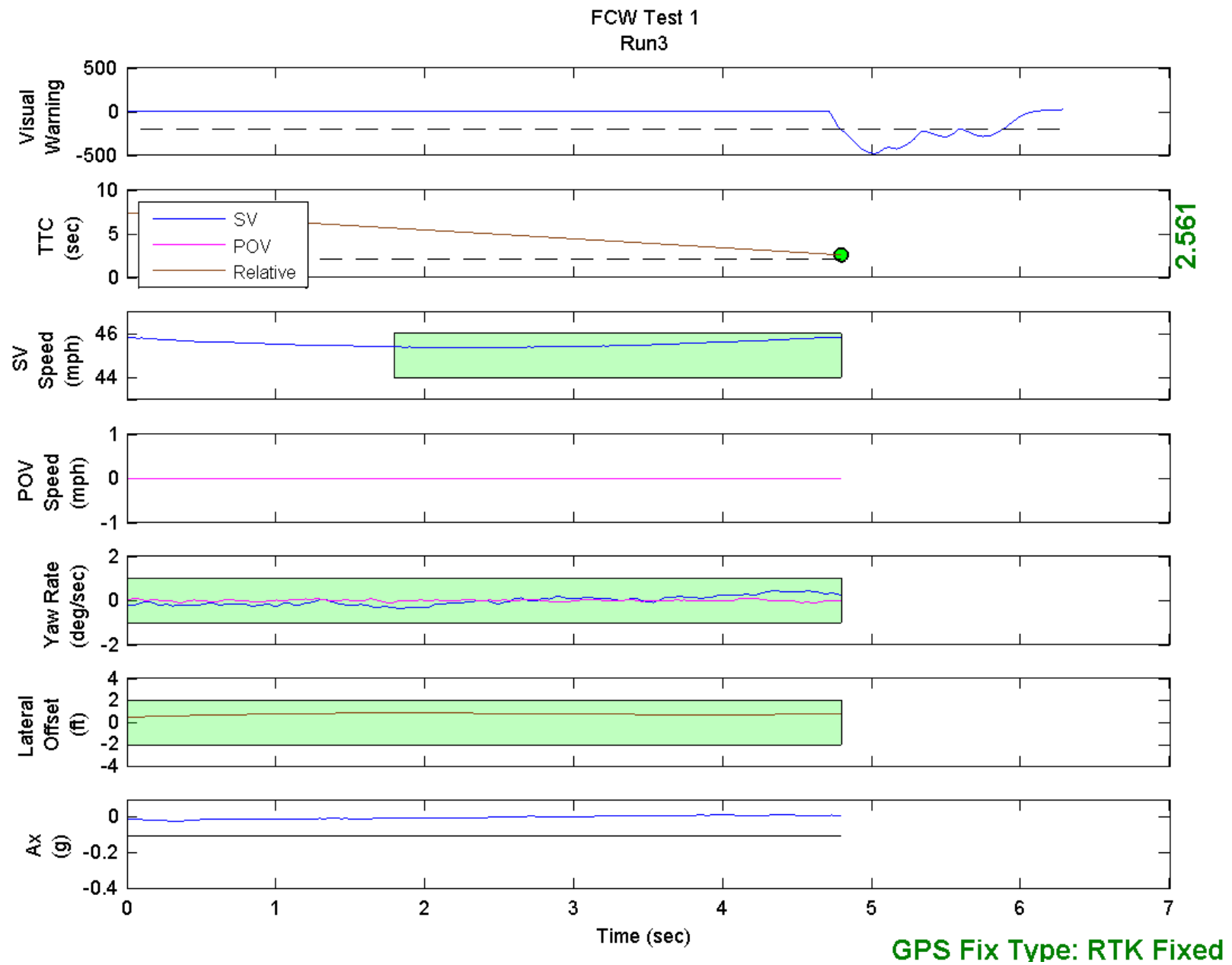


Figure D10. Time History for Run 3, FCW Test 1, Visual Warning

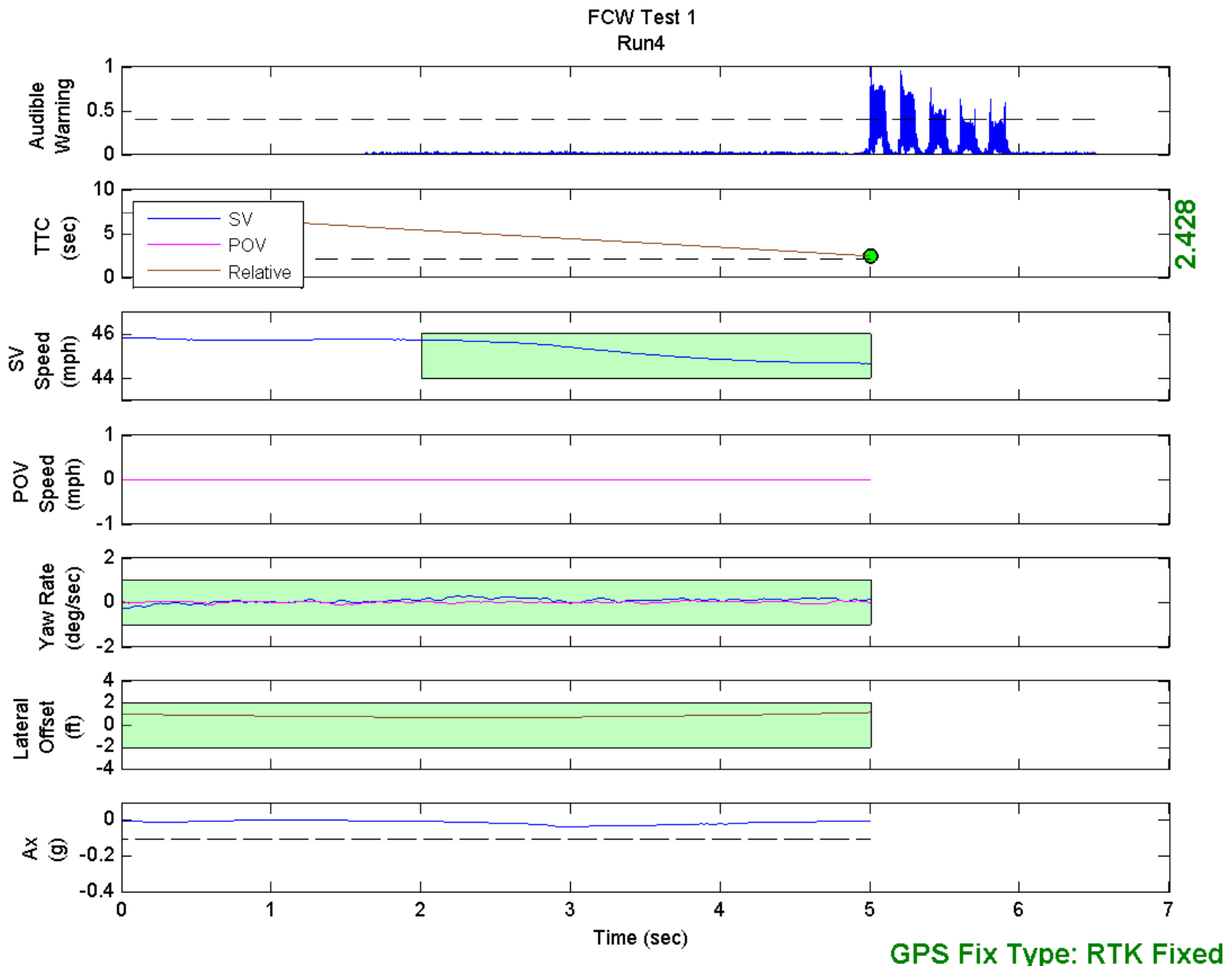


Figure D11. Time History for Run 4, FCW Test 1, Audible Warning

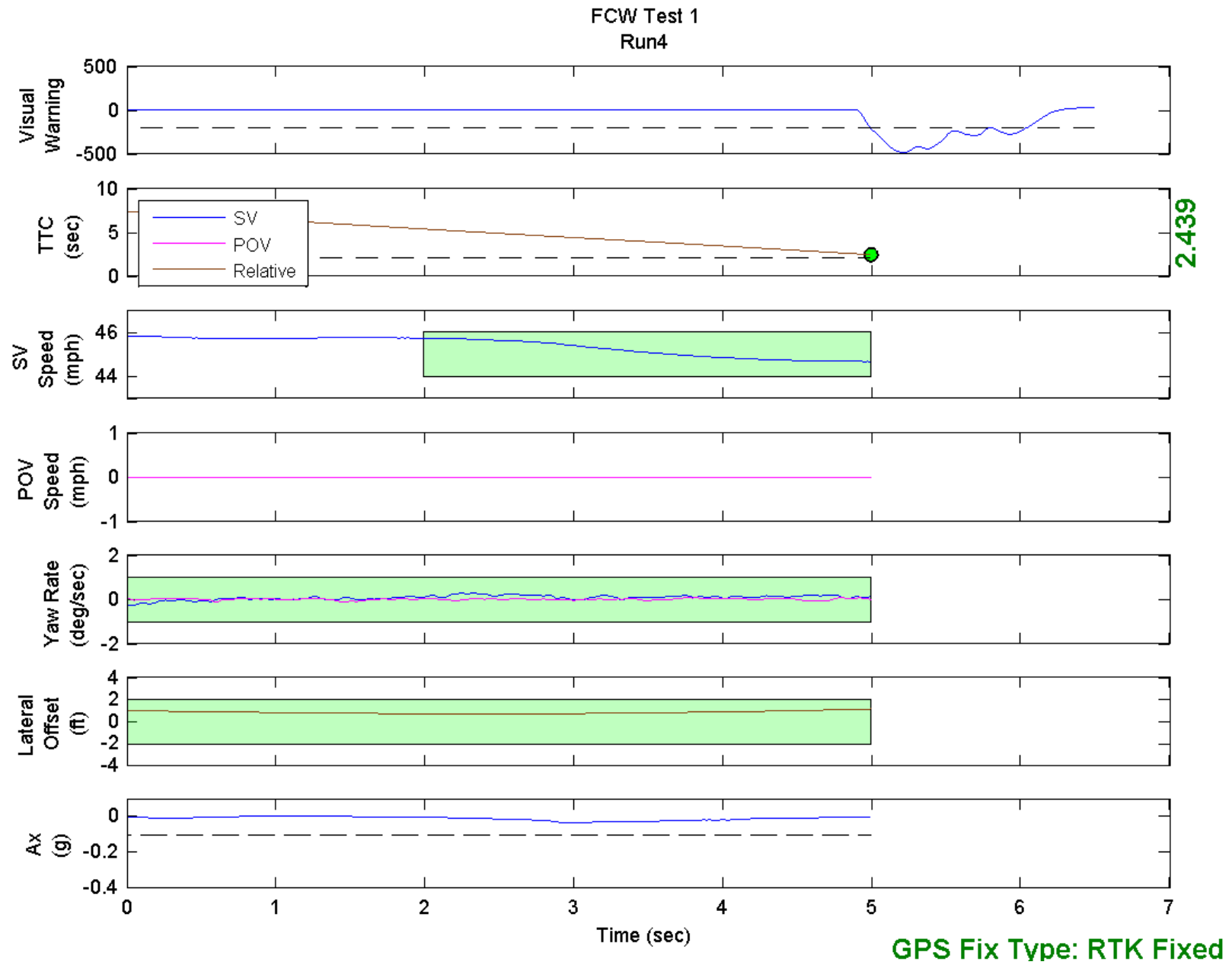


Figure D12. Time History for Run 4, FCW Test 1, Visual Warning

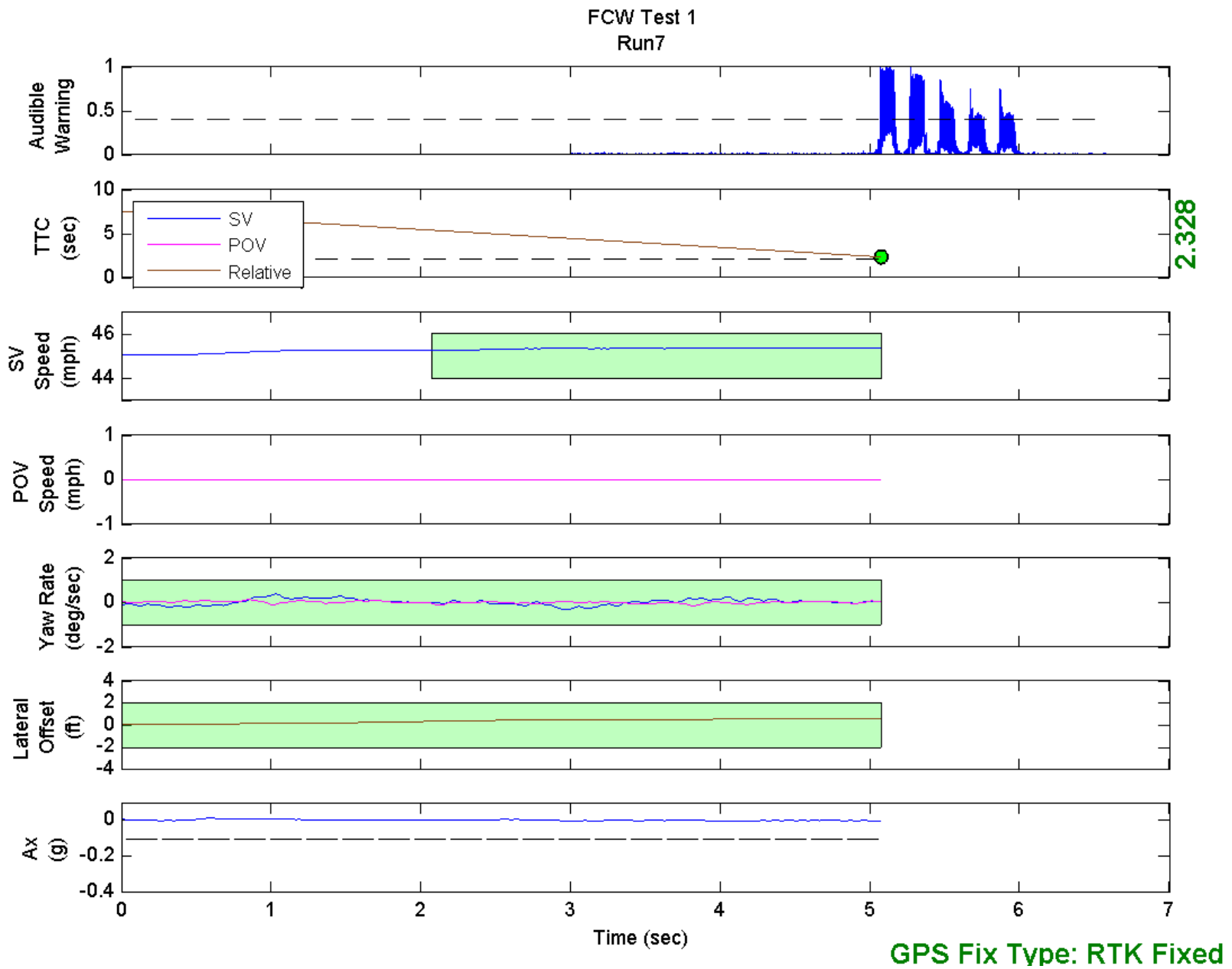


Figure D13. Time History for Run 7, FCW Test 1, Audible Warning

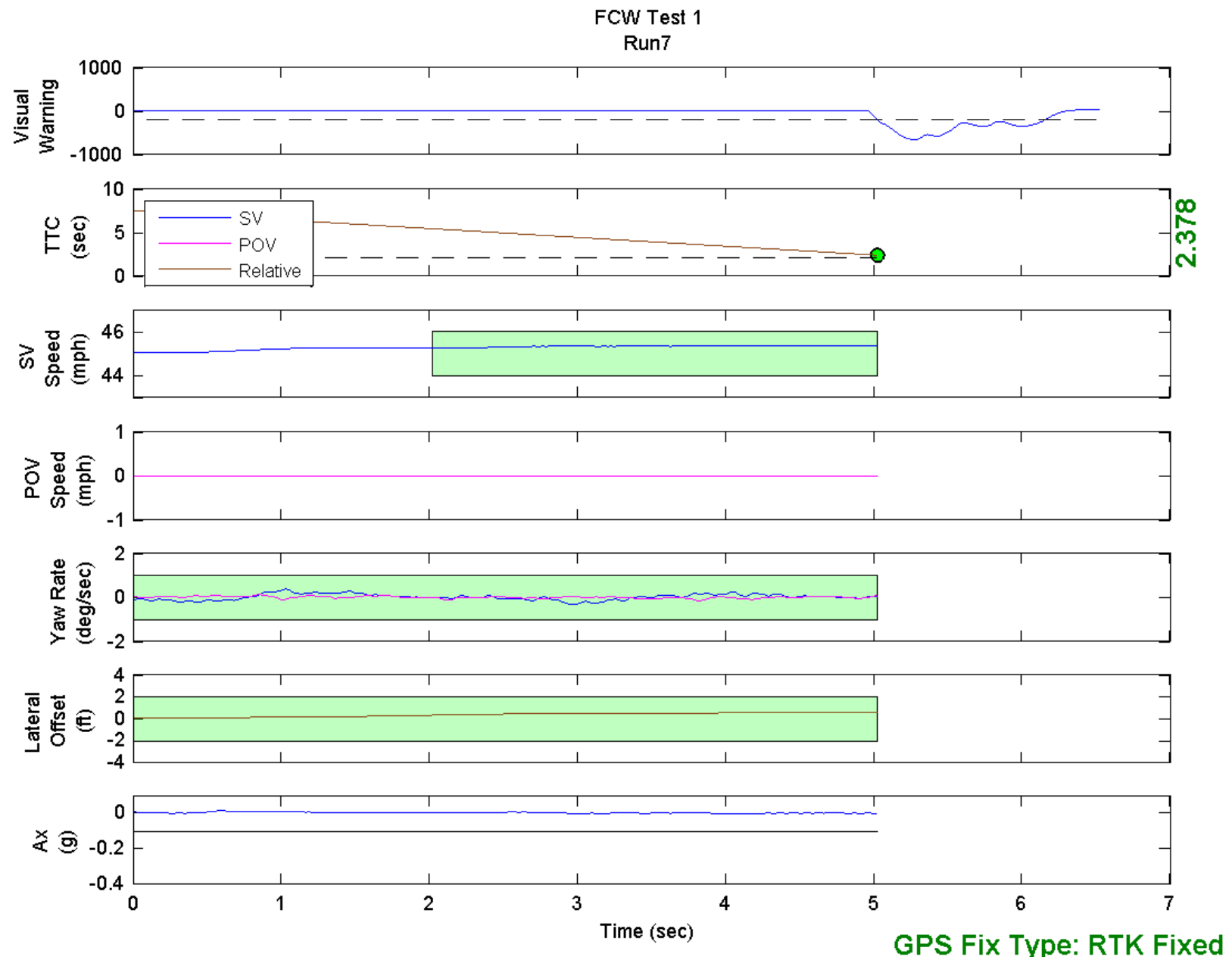


Figure D14. Time History for Run 7, FCW Test 1, Visual Warning

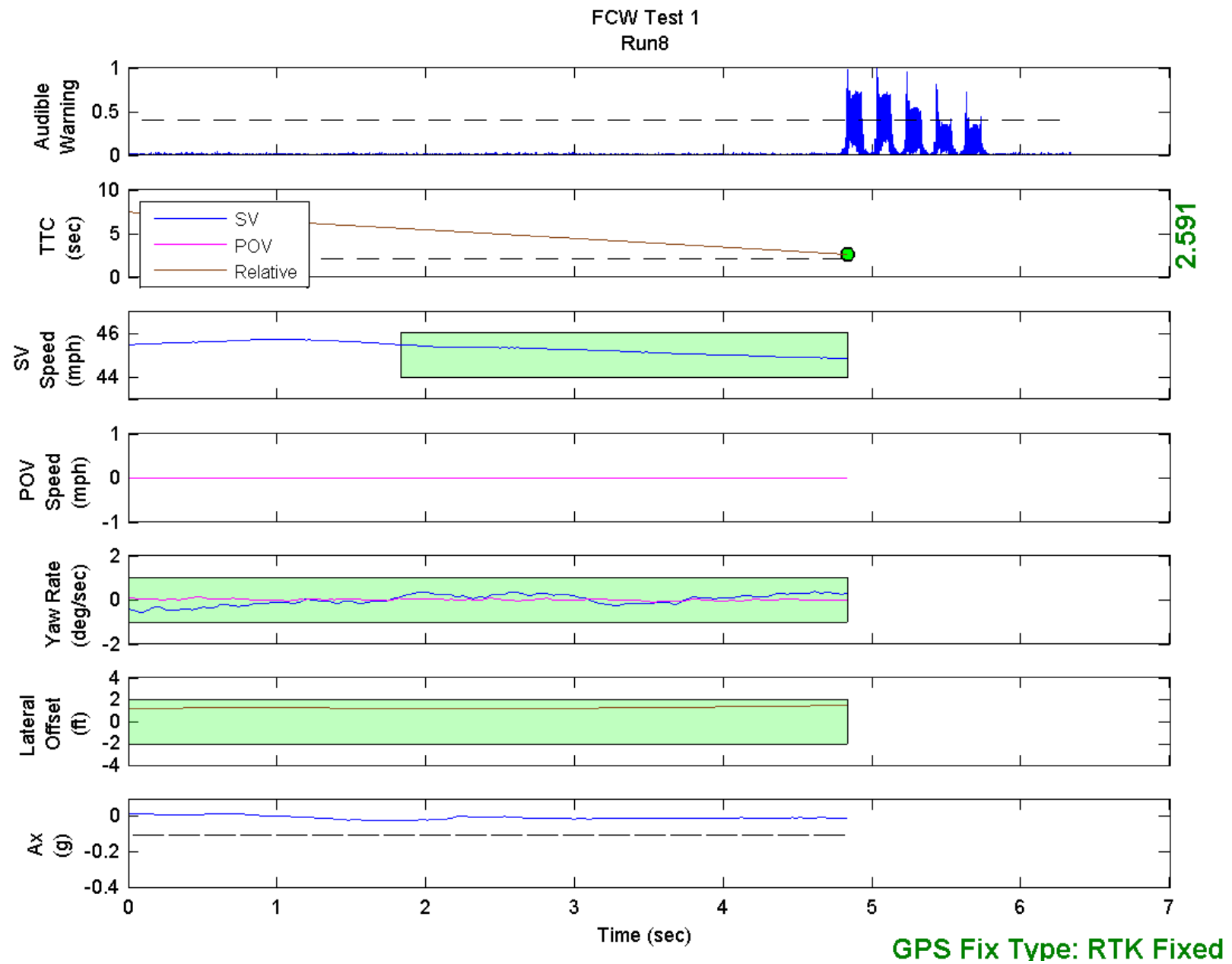


Figure D15. Time History for Run 8, FCW Test 1, Audible Warning

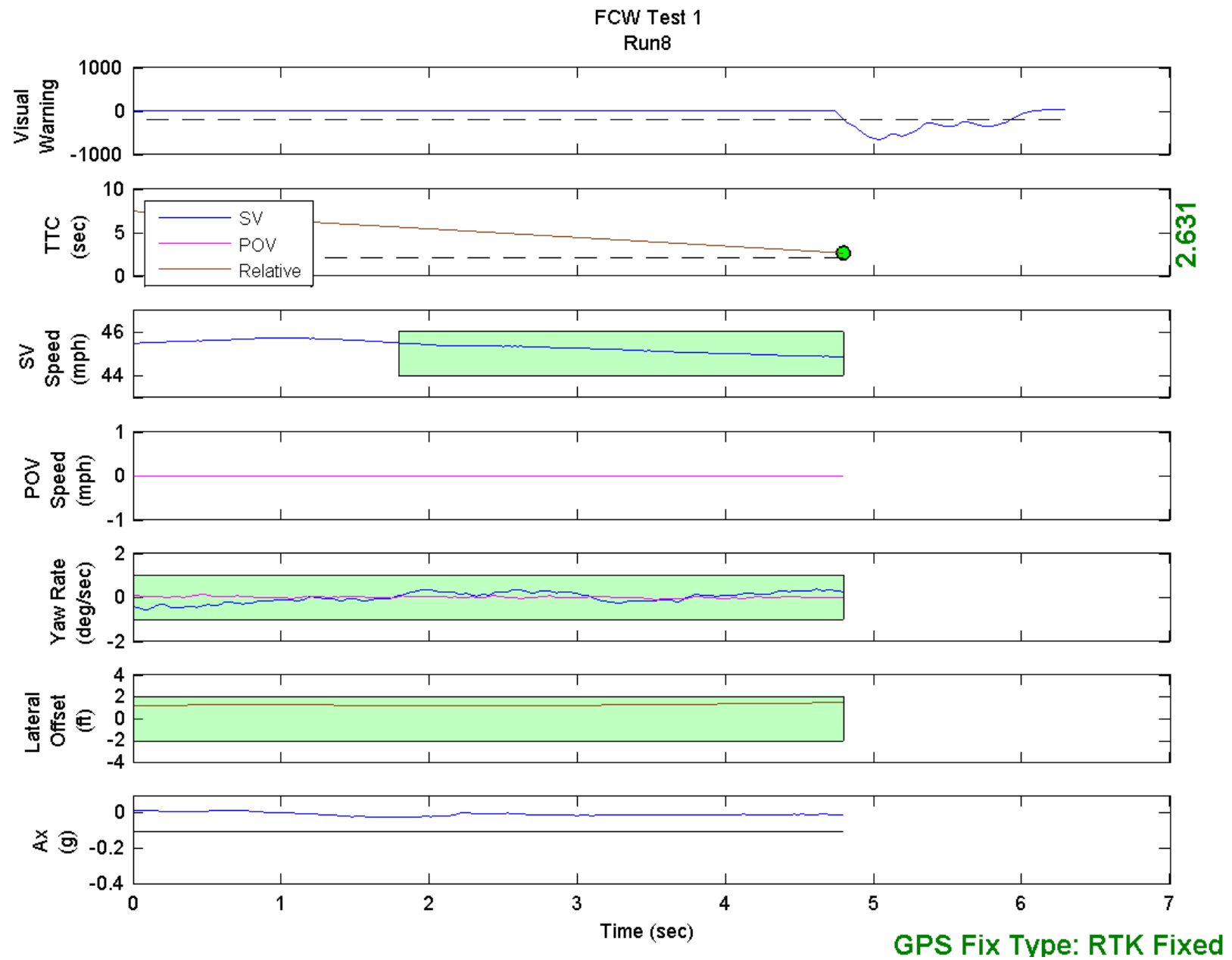


Figure D16. Time History for Run 8, FCW Test 1, Visual Warning

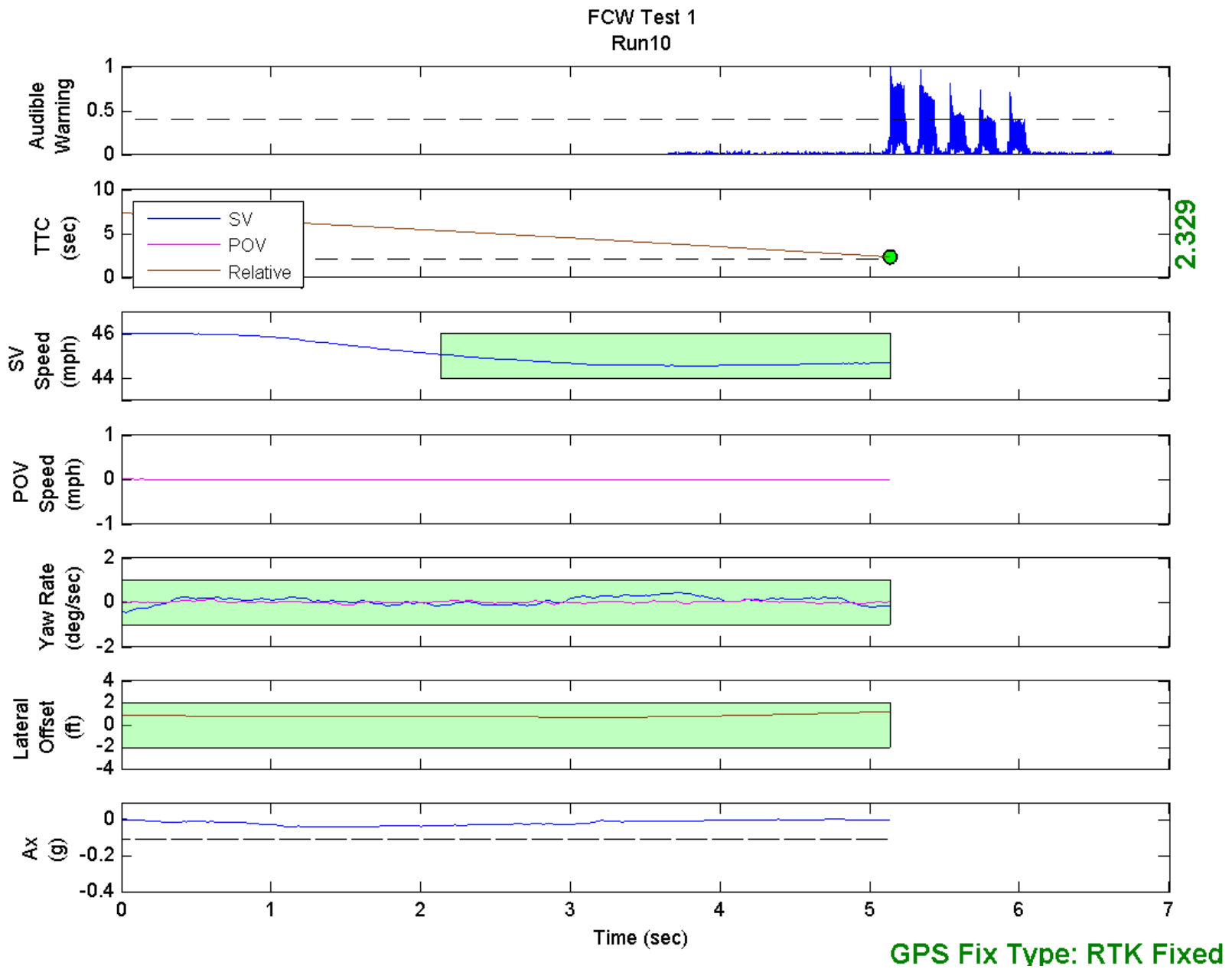


Figure D17. Time History for Run 10, FCW Test 1, Audible Warning

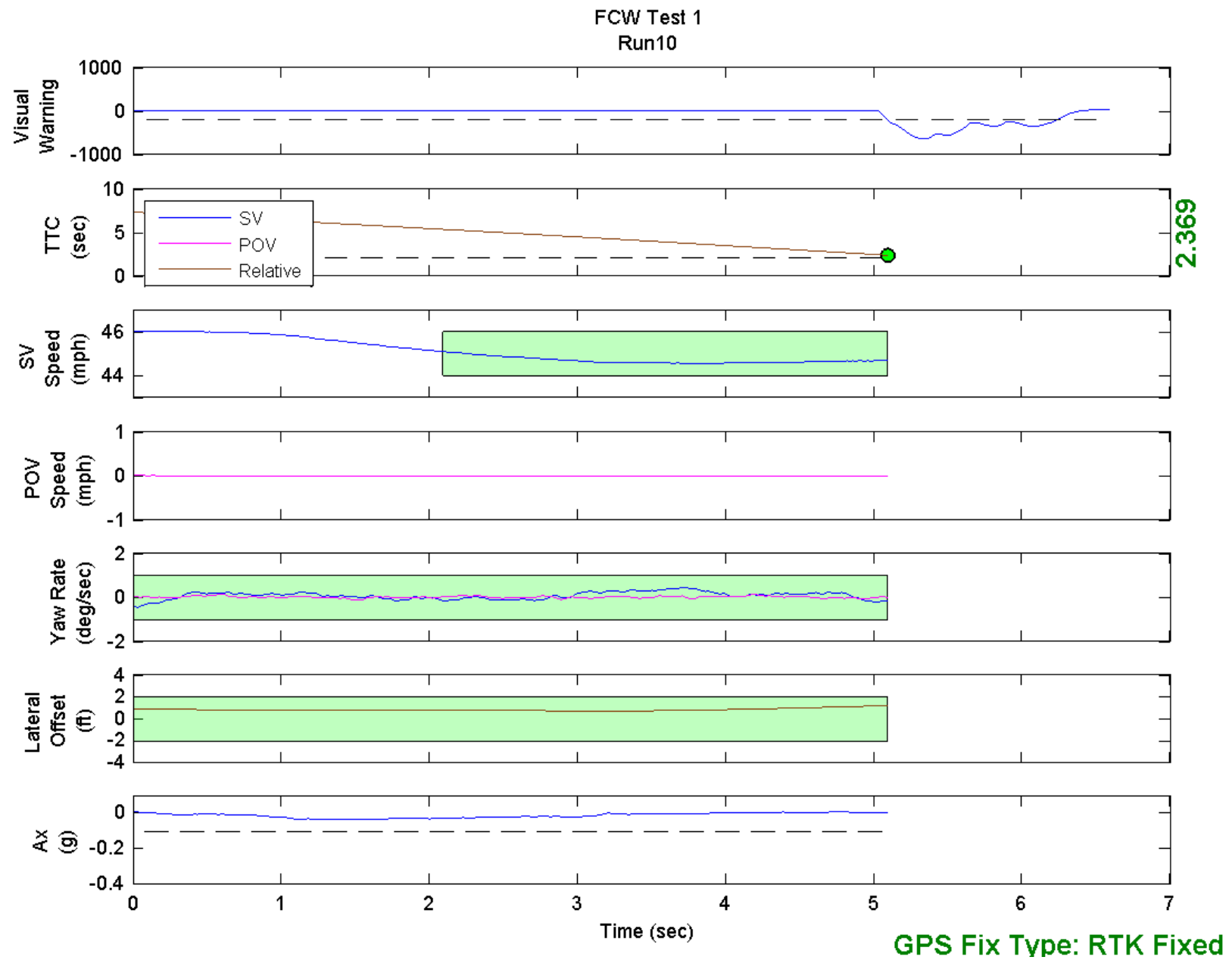


Figure D18. Time History for Run 10, FCW Test 1, Visual Warning

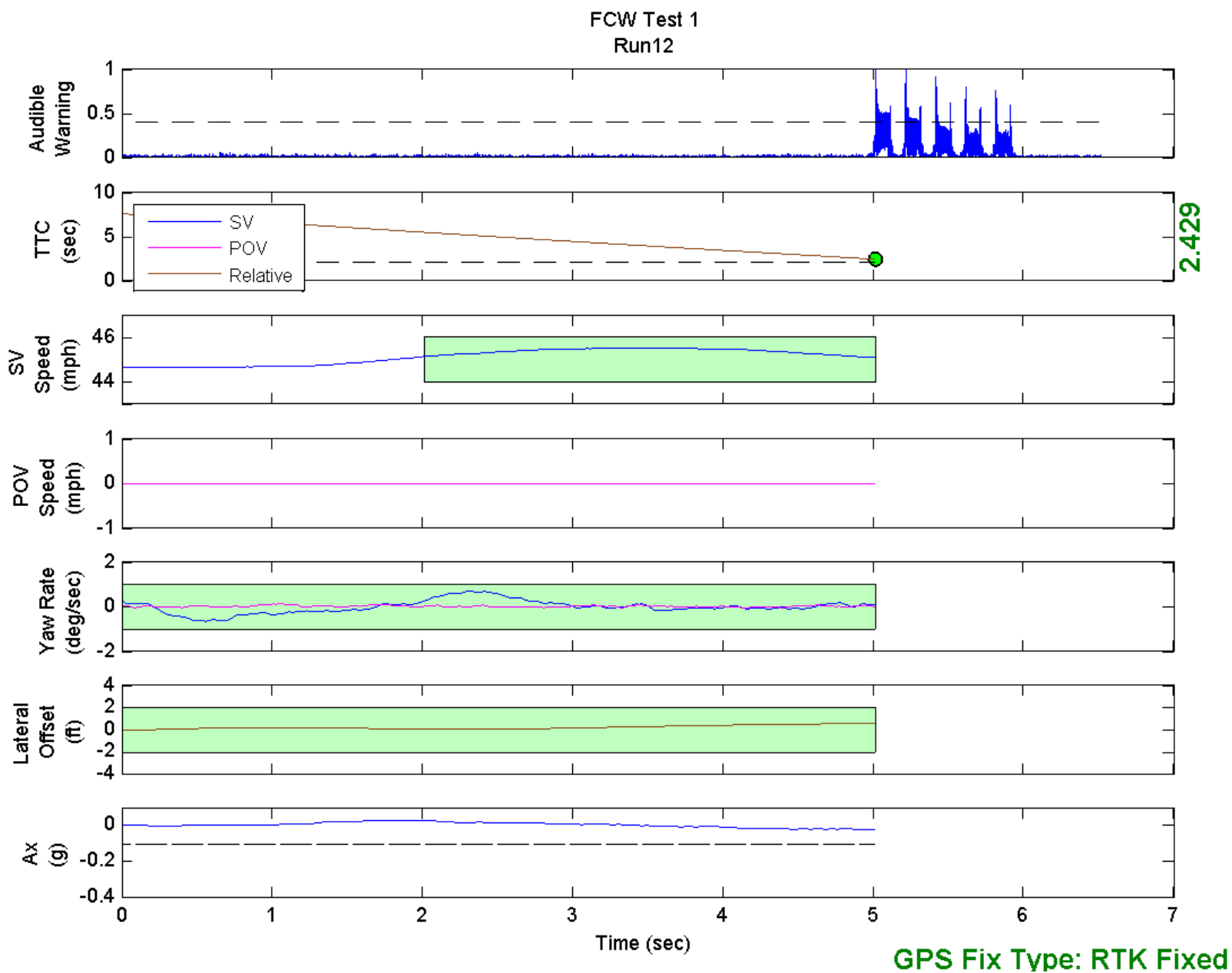


Figure D19. Time History for Run 12, FCW Test 1, Audible Warning

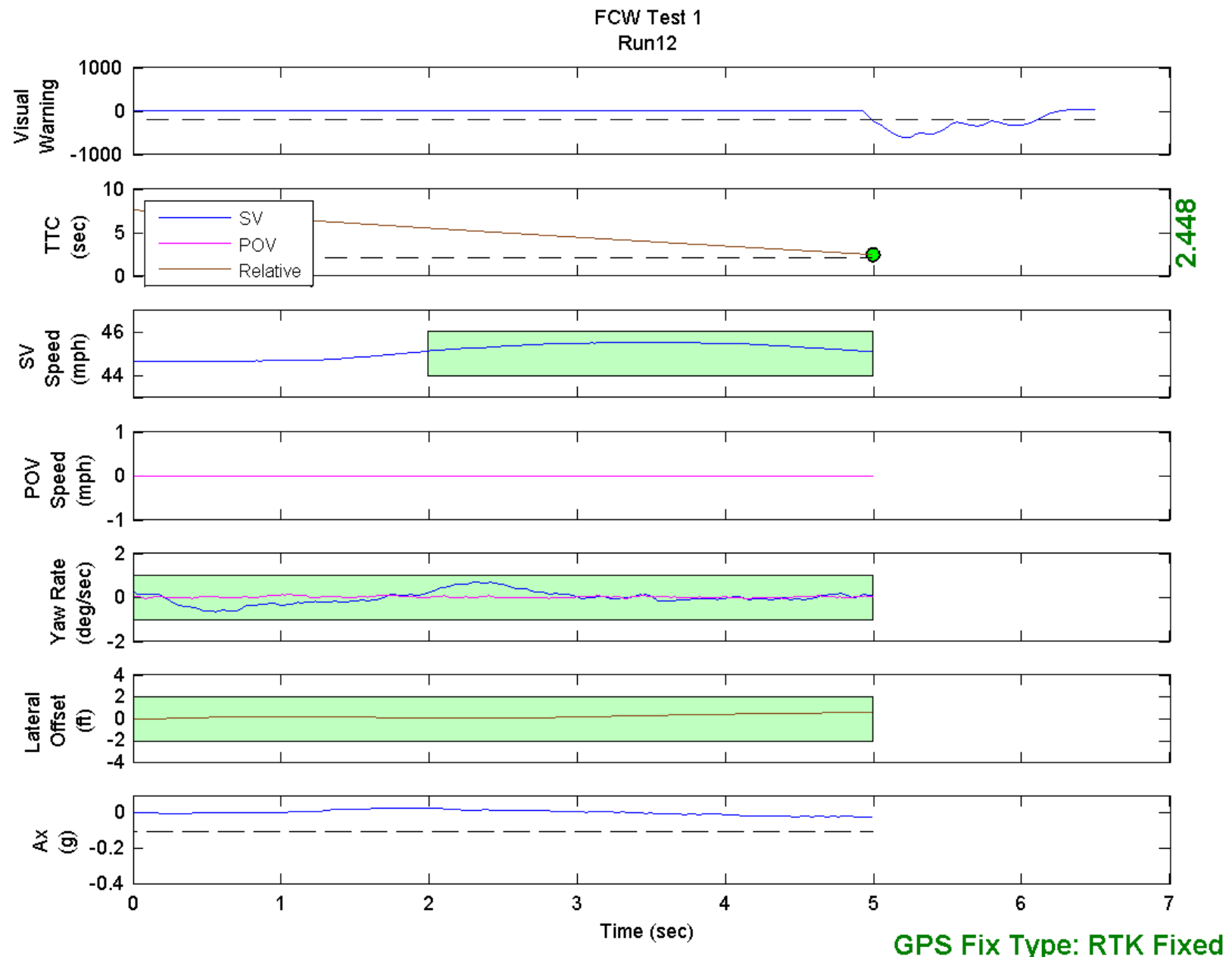


Figure D20. Time History for Run 12, FCW Test 1, Visual Warning

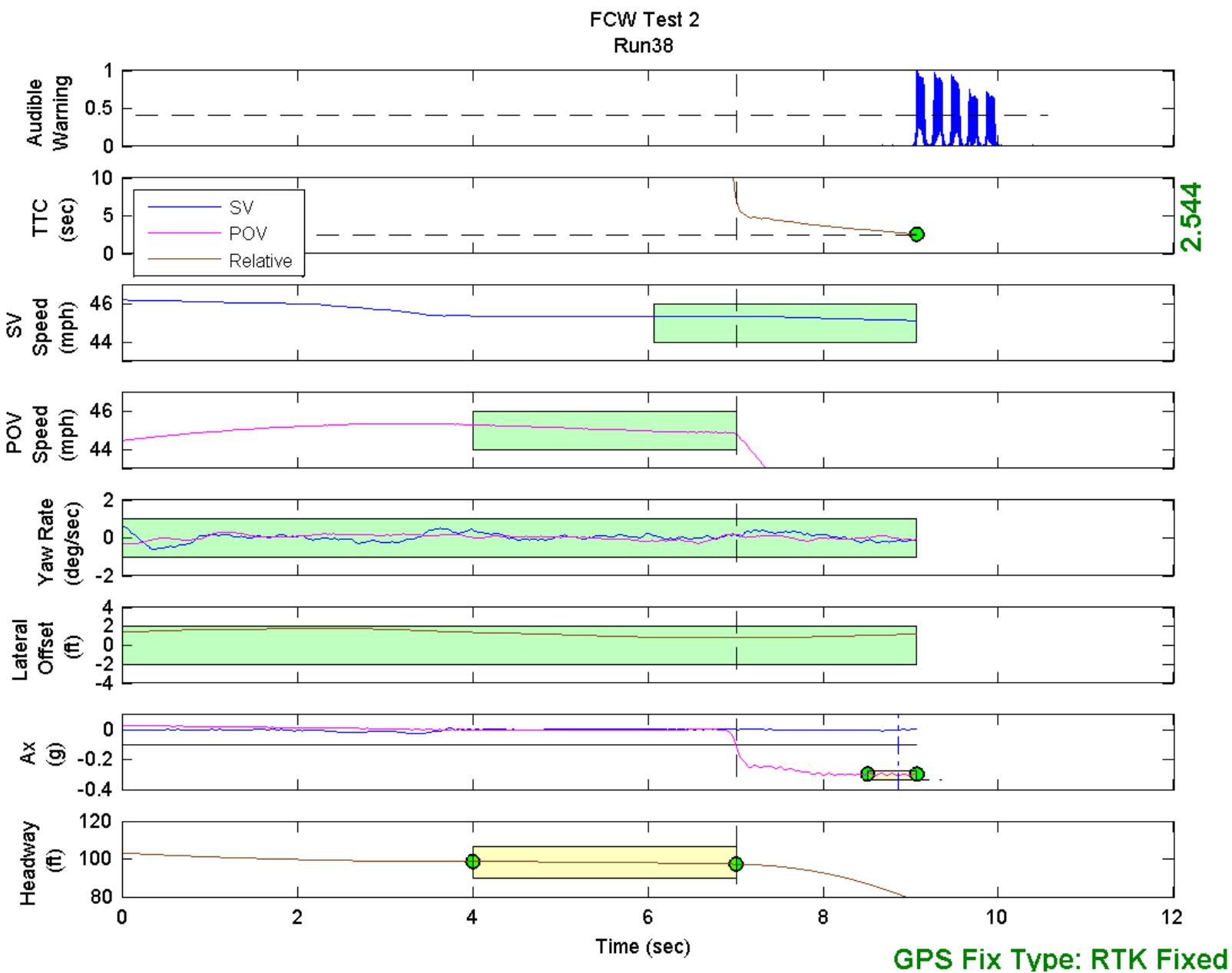


Figure D21. Time History for Run 38, FCW Test 2, Audible Warning

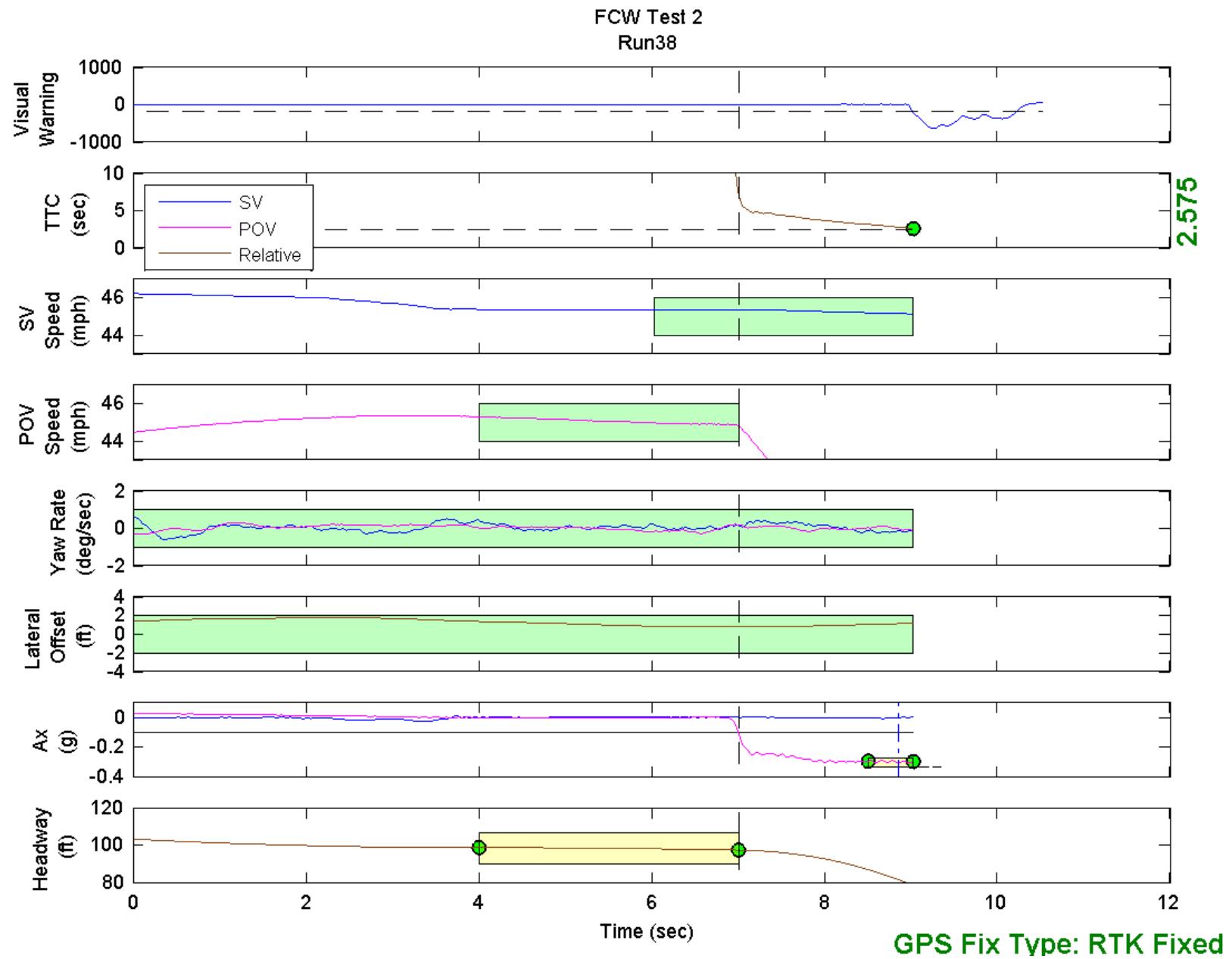


Figure D22. Time History for Run 38, FCW Test 2, Visual Warning

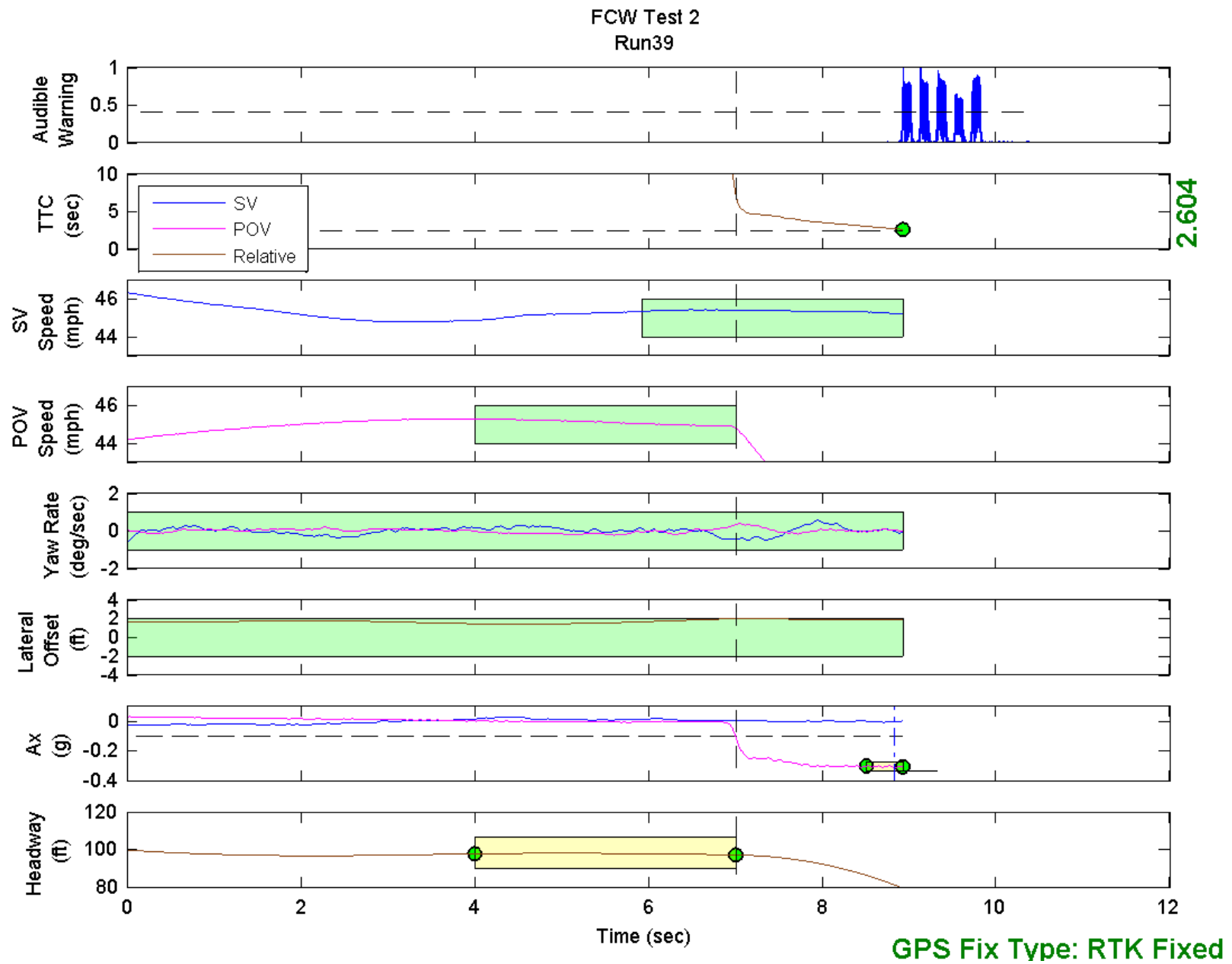


Figure D23. Time History for Run 39, FCW Test 2, Audible Warning

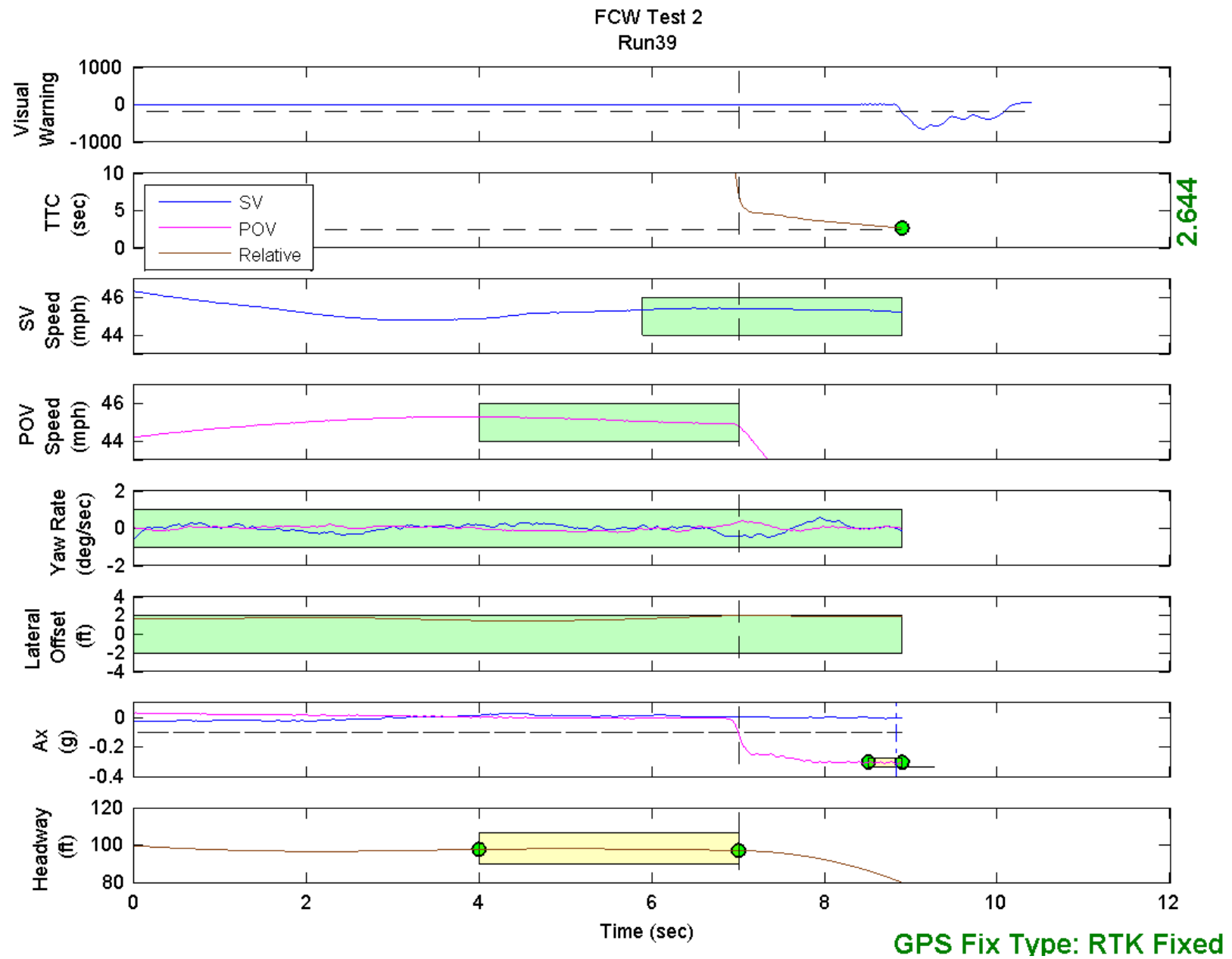


Figure D24. Time History for Run 39, FCW Test 2, Visual Warning

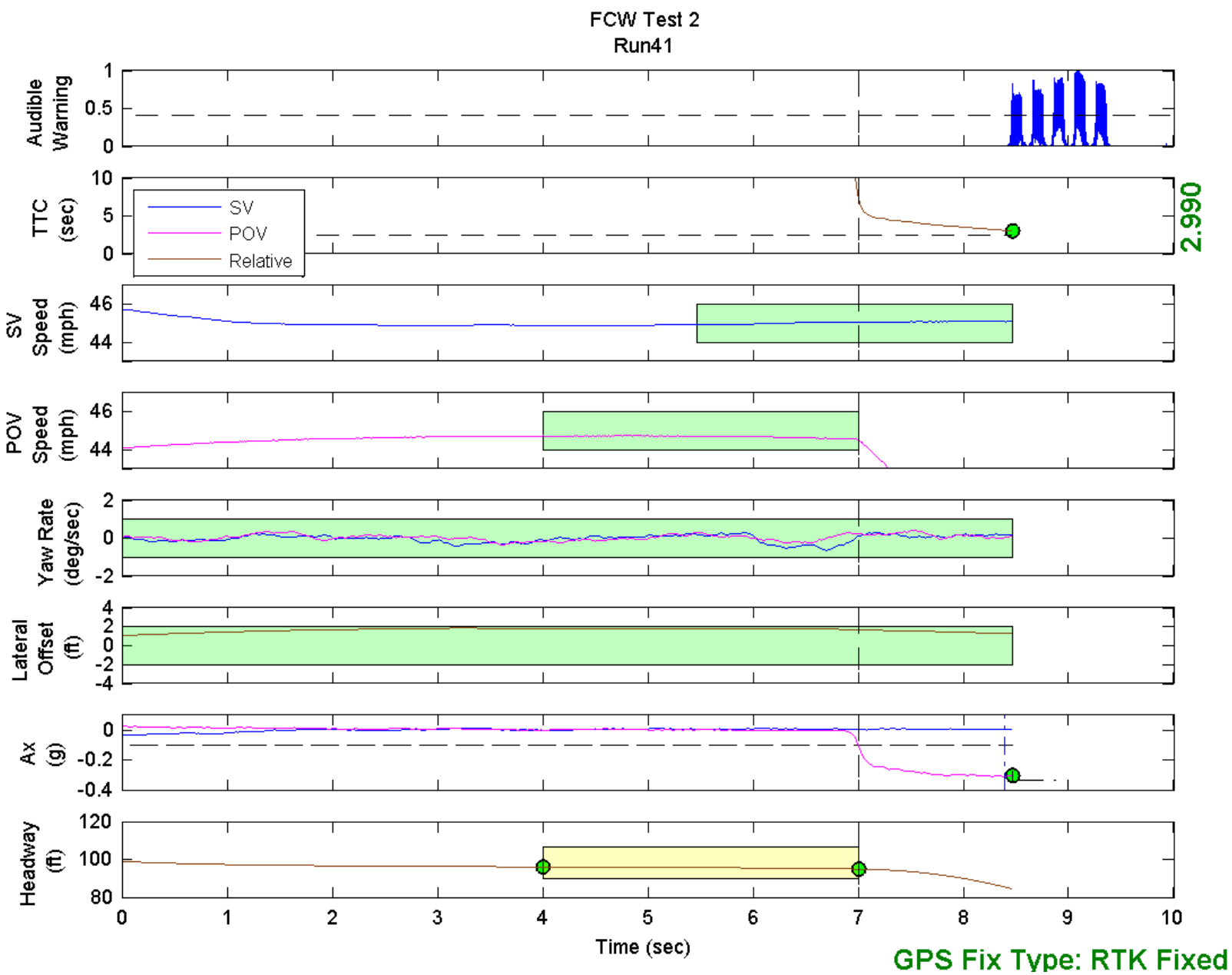


Figure D25. Time History for Run 41, FCW Test 2, Audible Warning

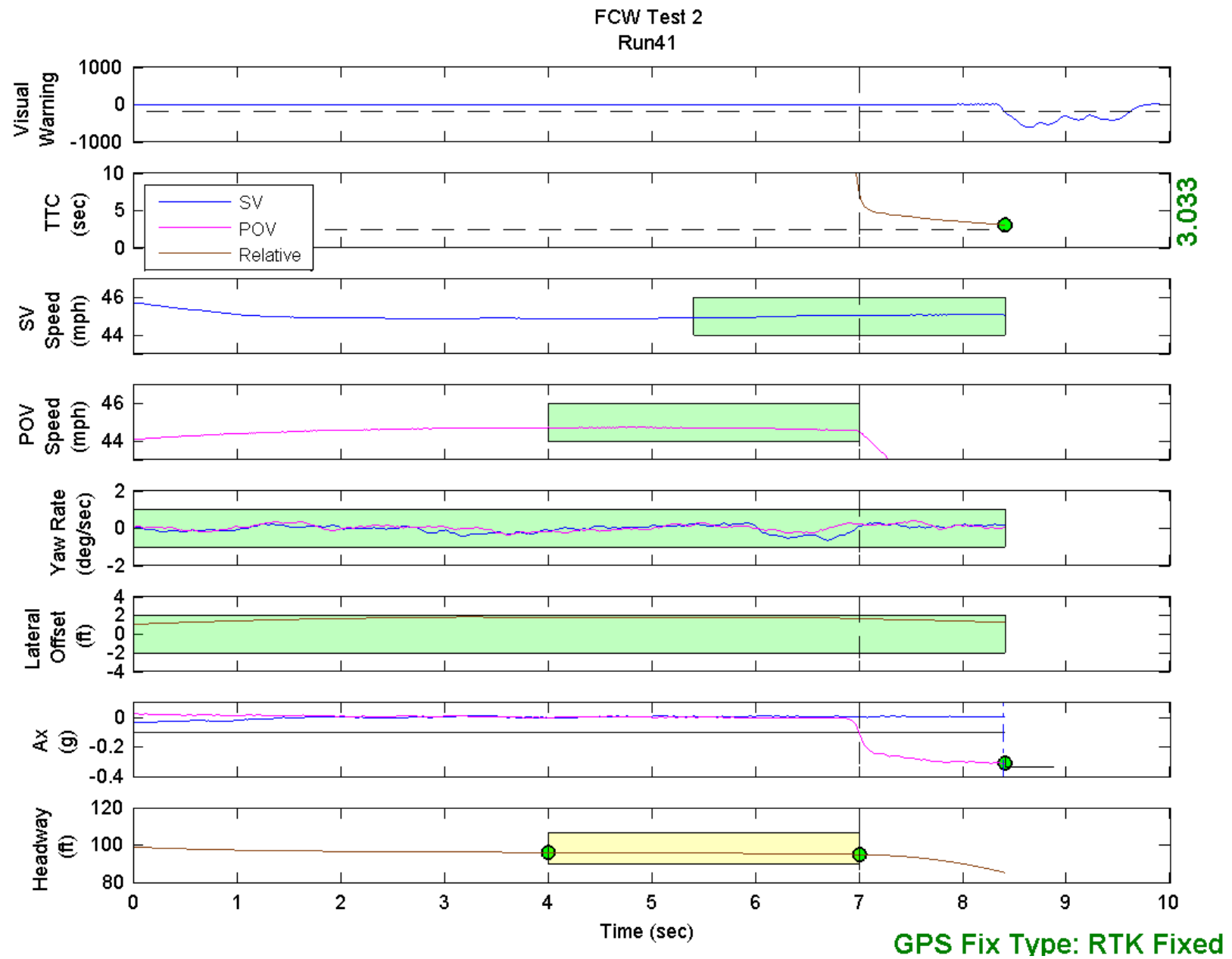


Figure D26. Time History for Run 41, FCW Test 2, Visual Warning

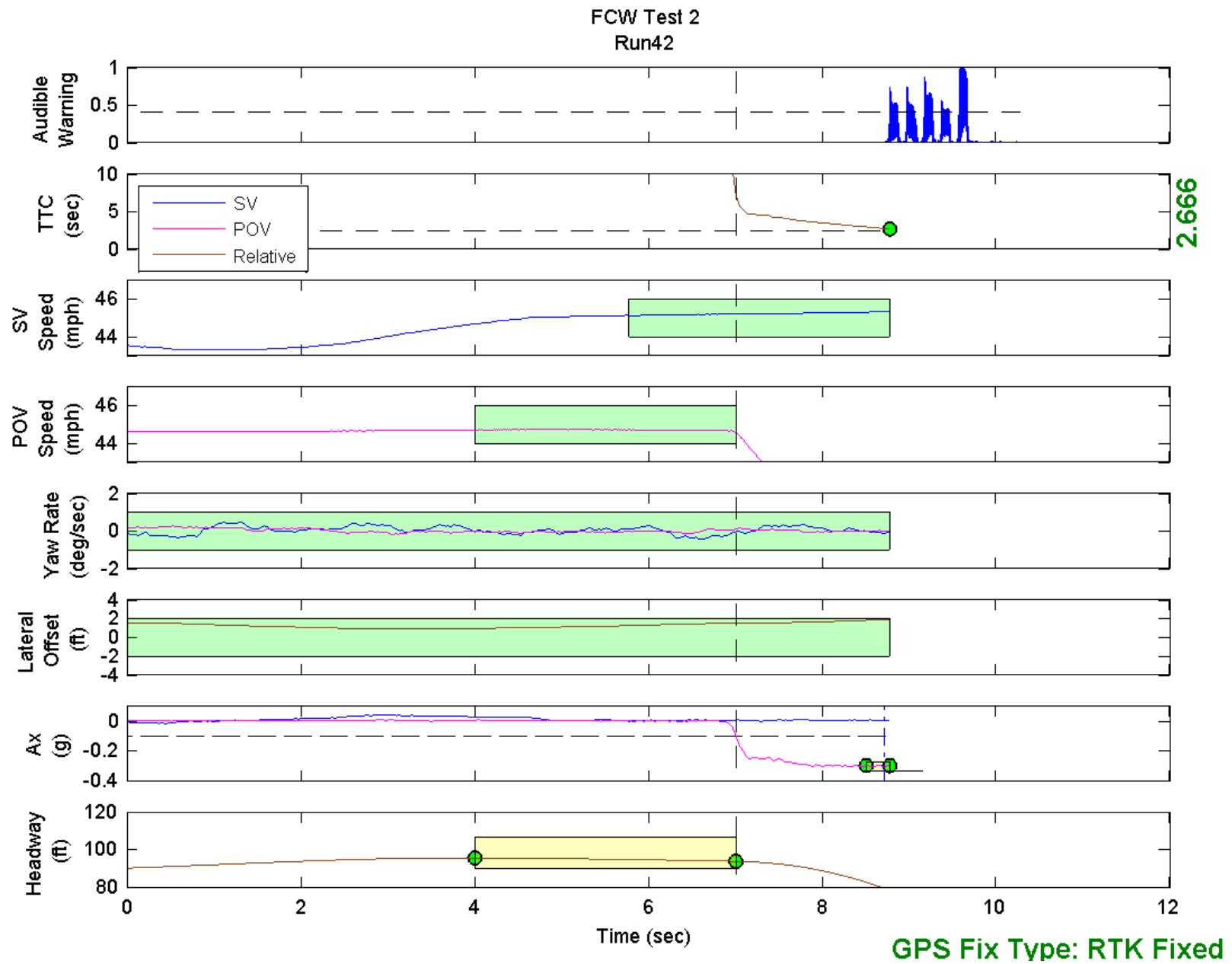


Figure D27. Time History for Run 42, FCW Test 2, Audible Warning

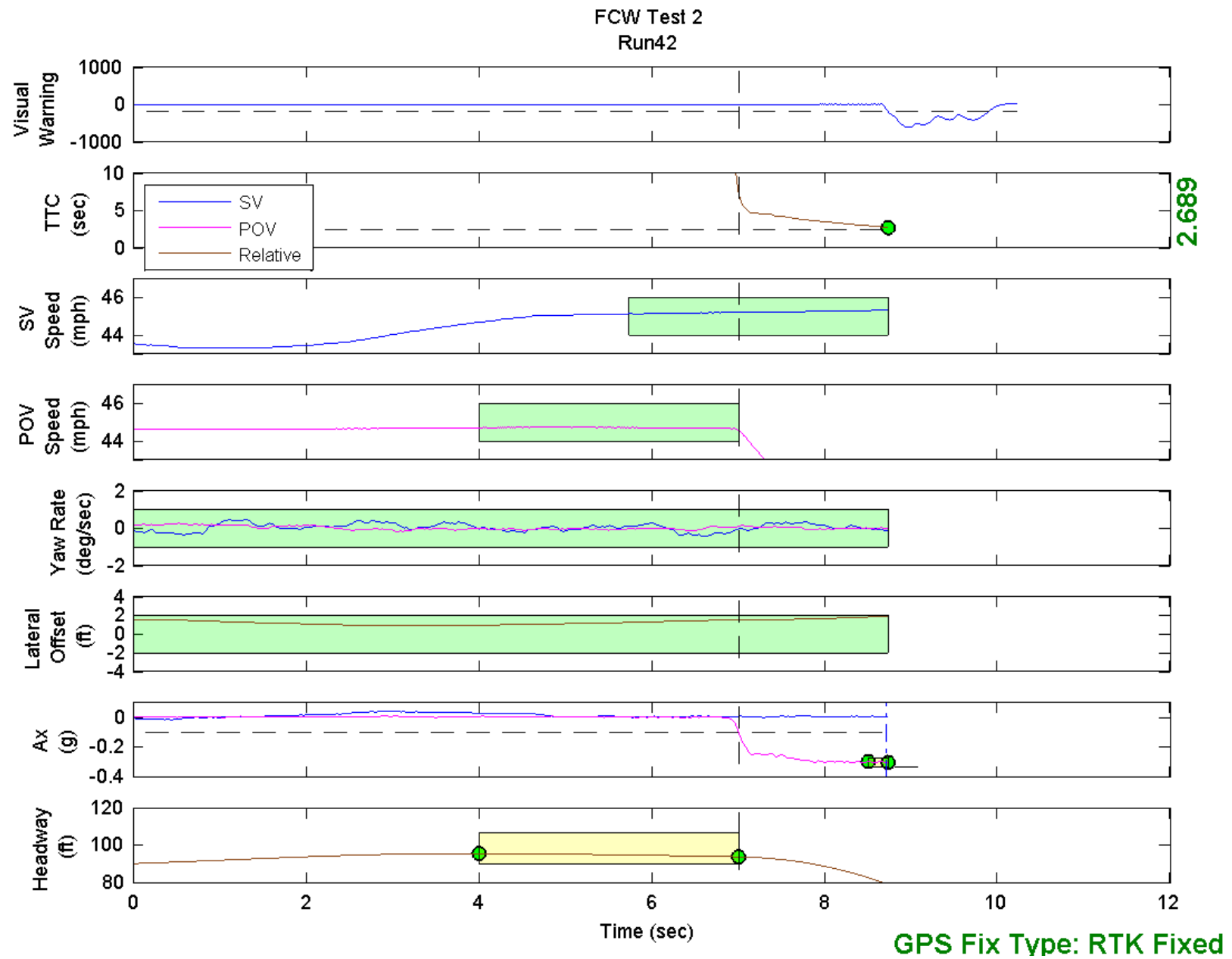


Figure D28. Time History for Run 42, FCW Test 2, Visual Warning

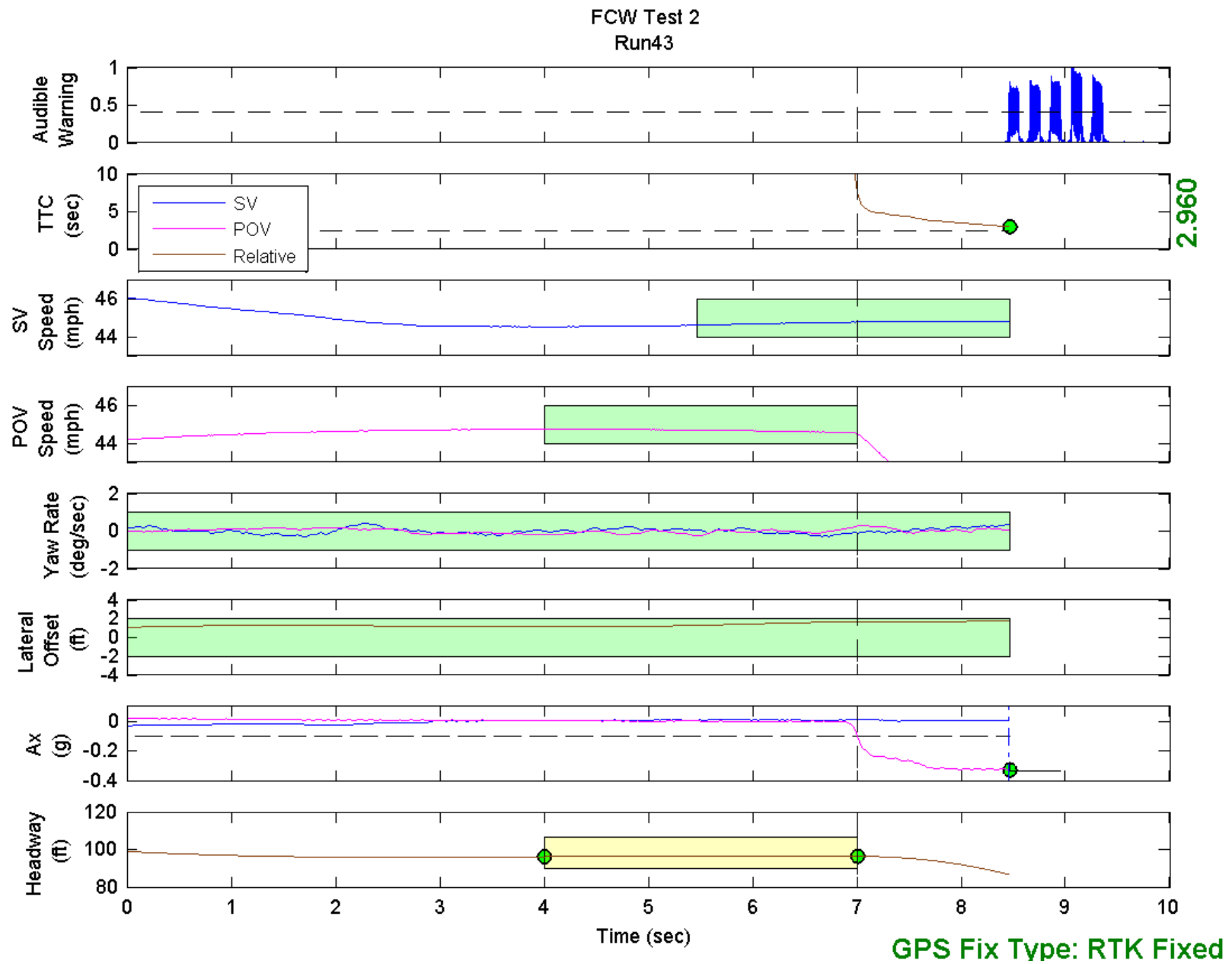


Figure D29. Time History for Run 43, FCW Test 2, Audible Warning

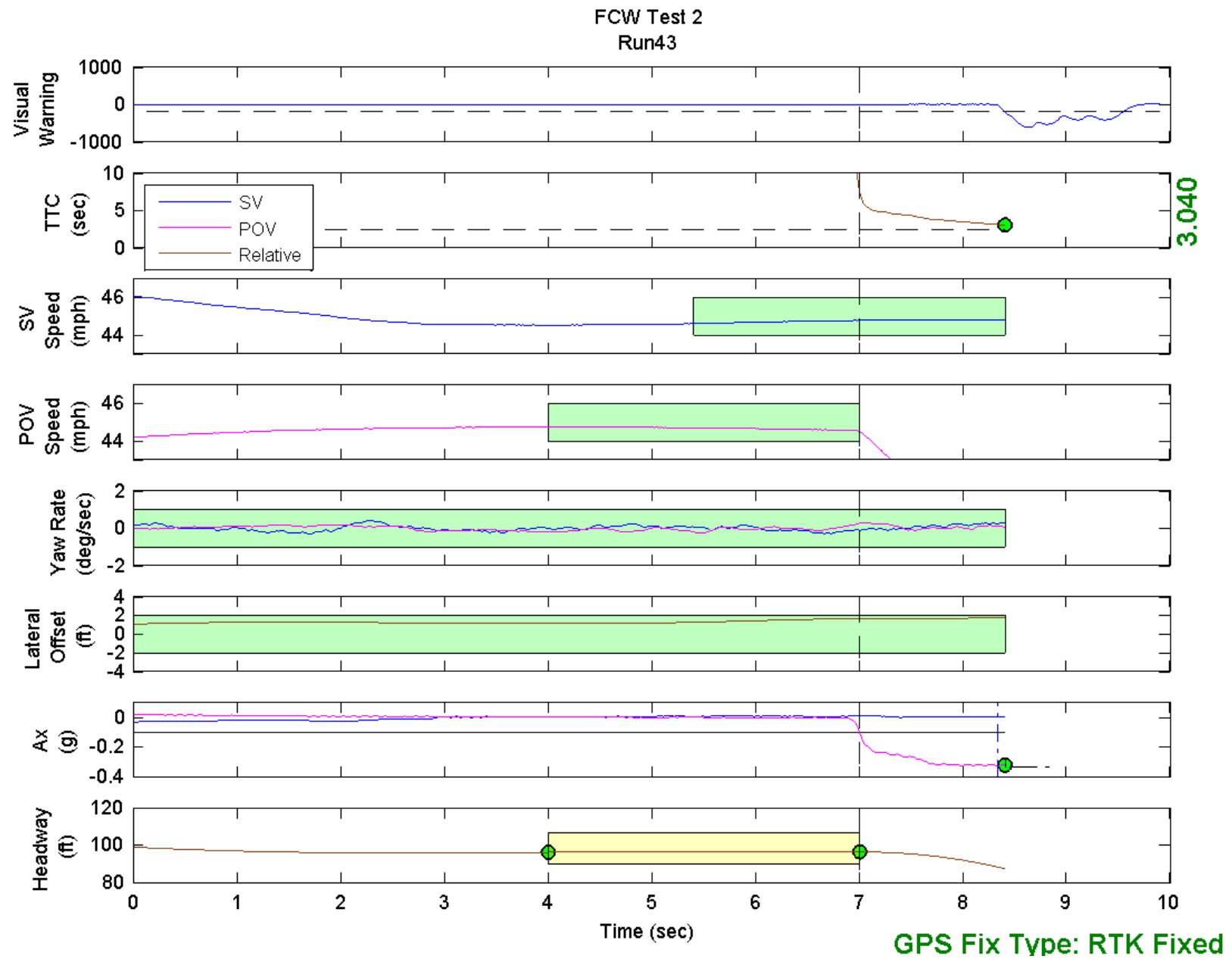


Figure D30. Time History for Run 43, FCW Test 2, Visual Warning

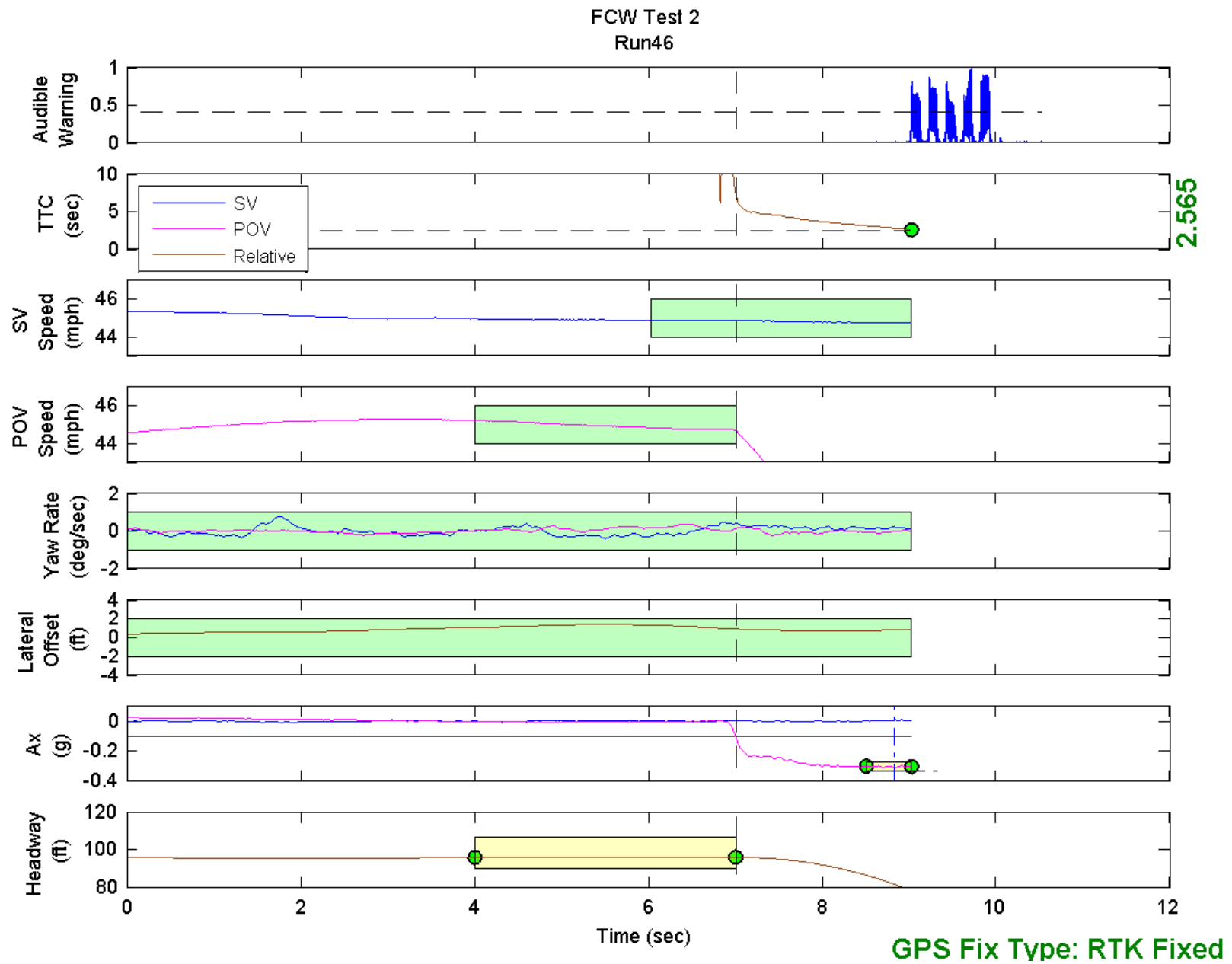


Figure D31. Time History for Run 46, FCW Test 2, Audible Warning

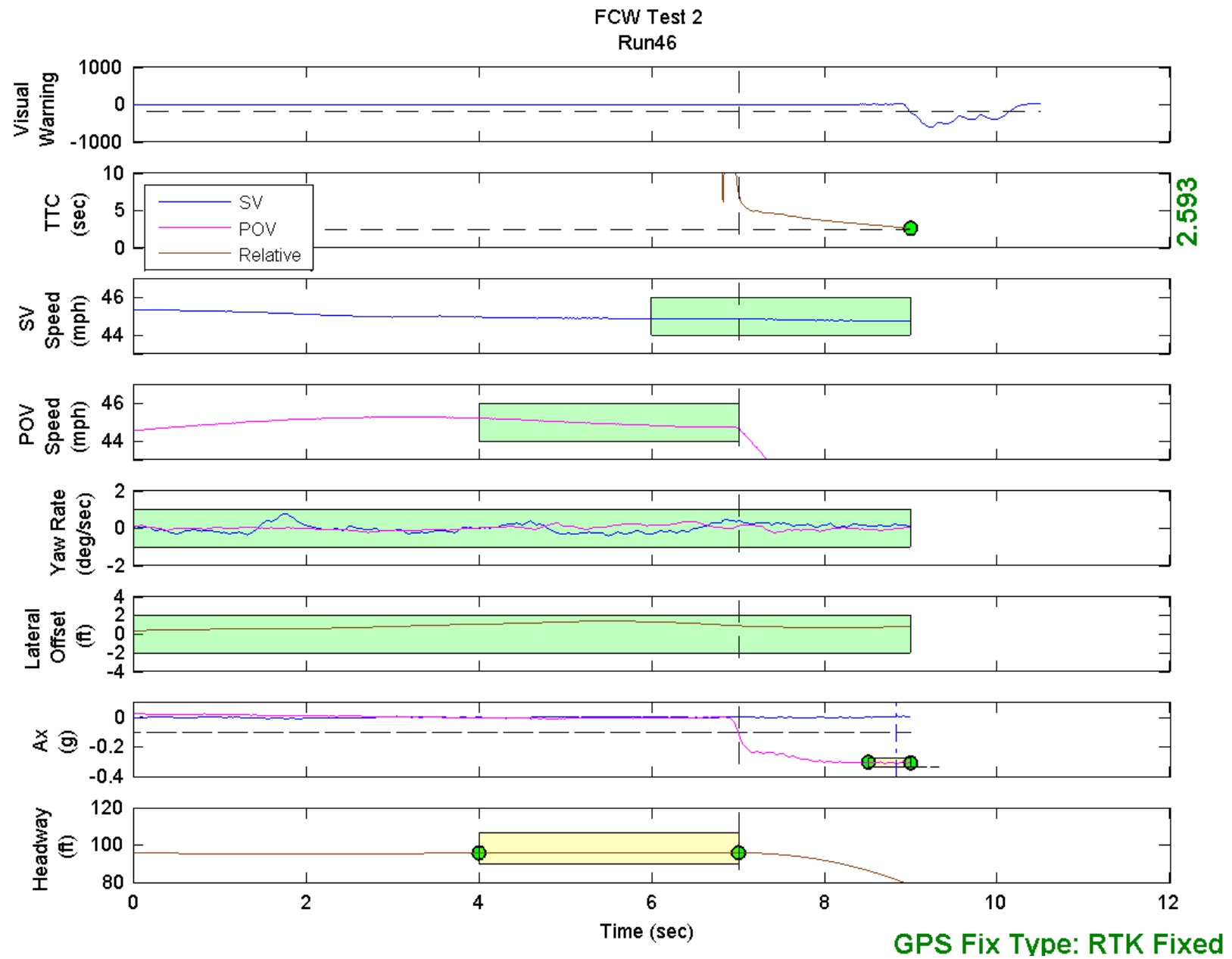


Figure D32. Time History for Run 46, FCW Test 2, Visual Warning

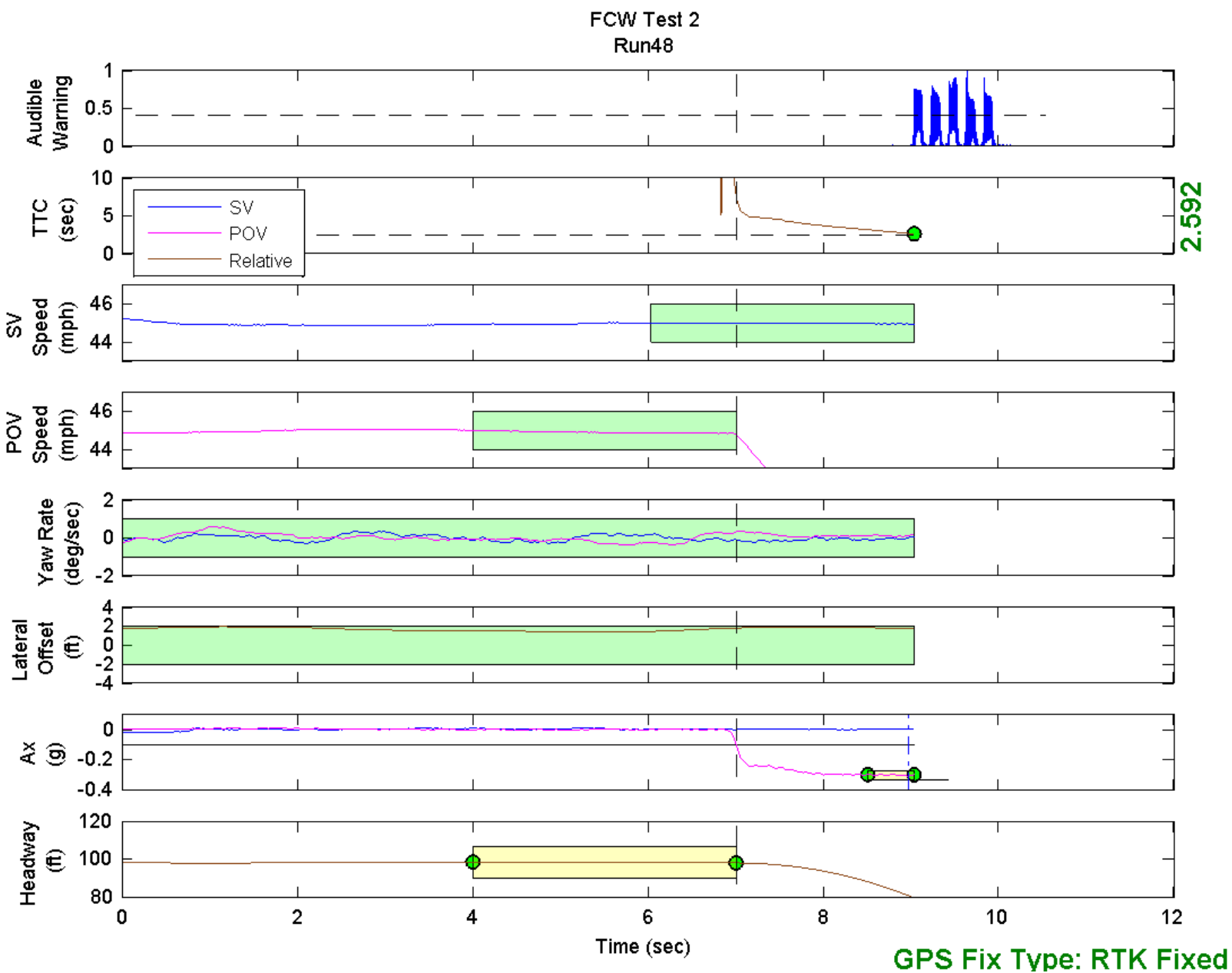


Figure D33. Time History for Run 48, FCW Test 2, Audible Warning

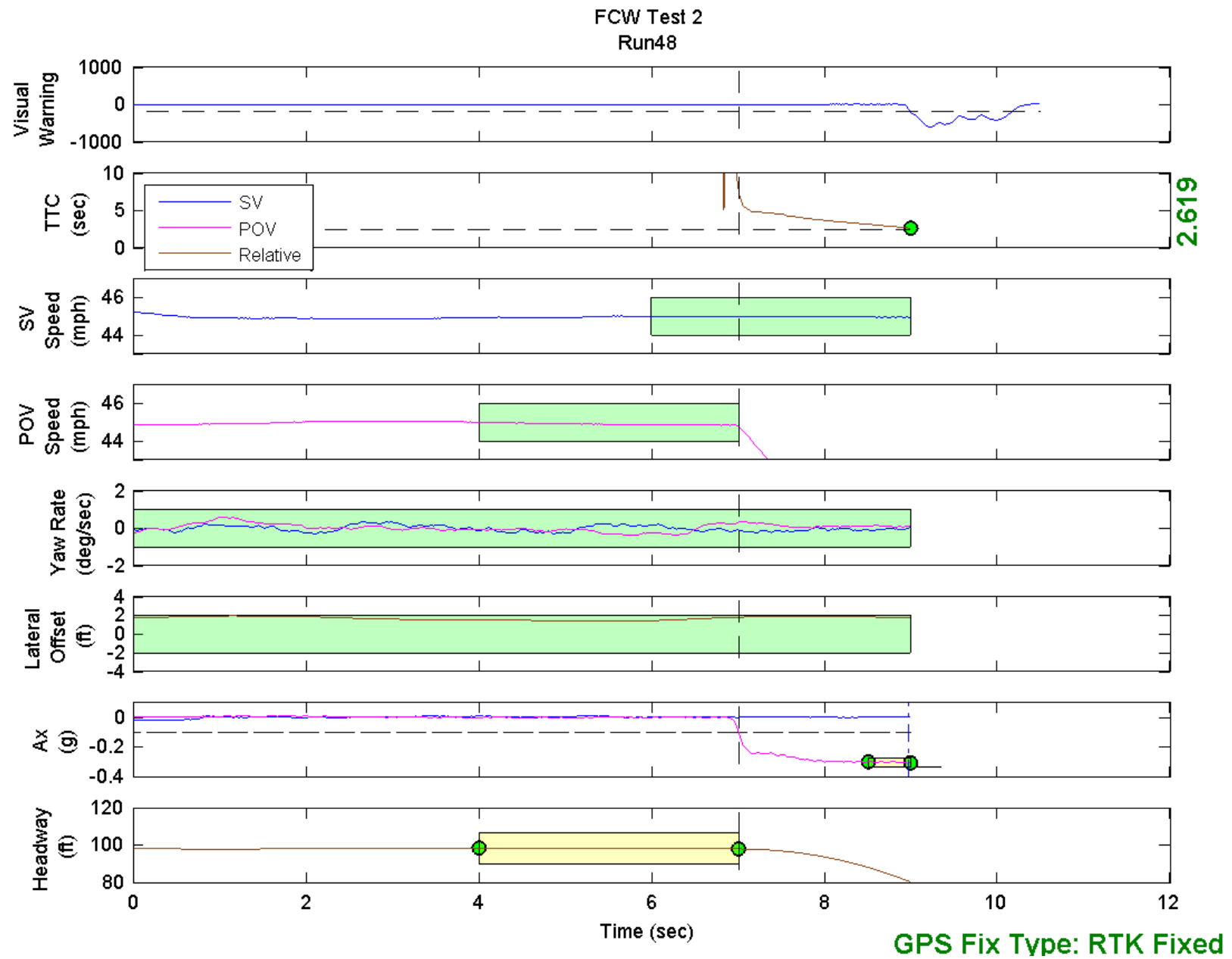


Figure D34. Time History for Run 48, FCW Test 2, Visual Warning

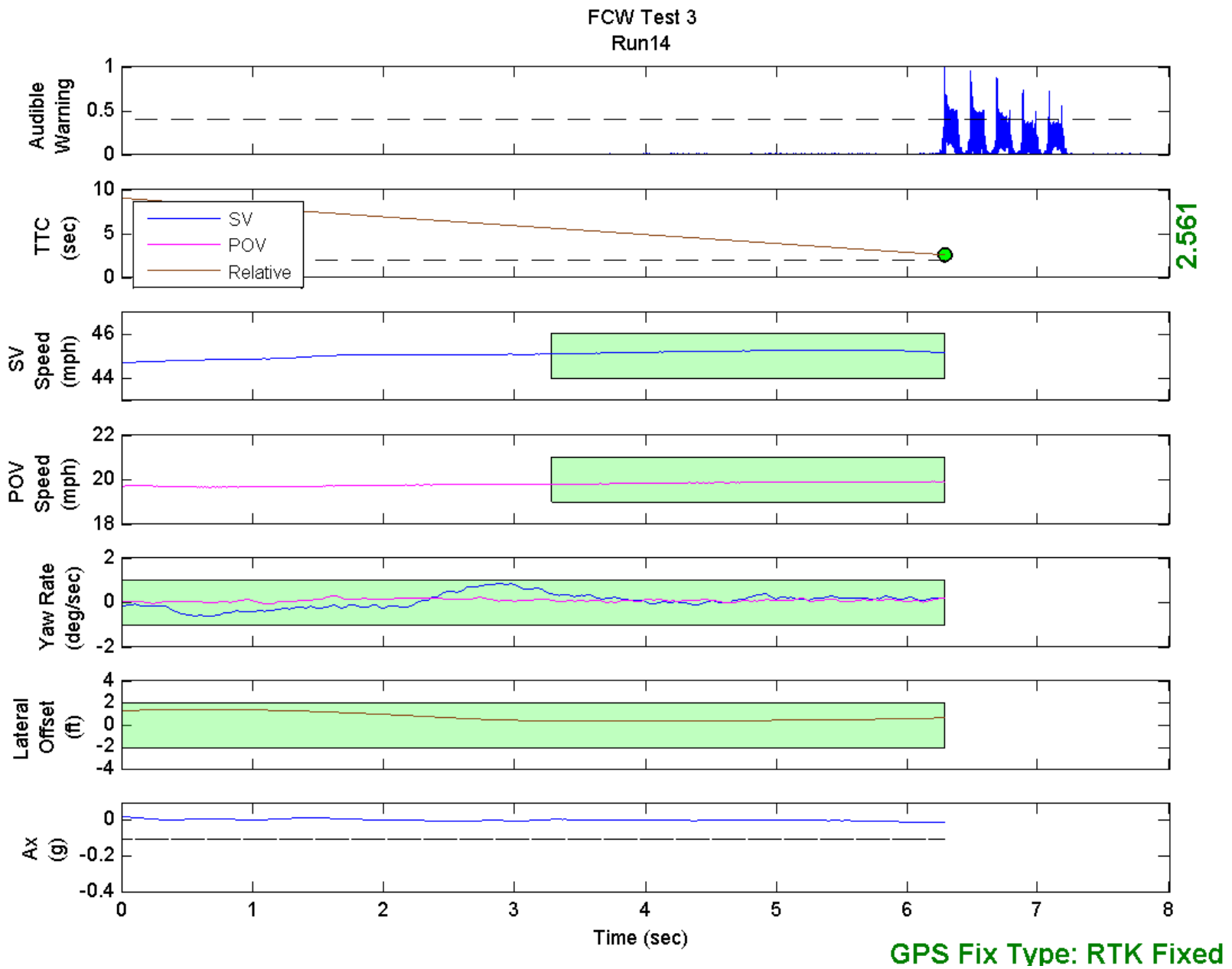


Figure D35. Time History for Run 14, FCW Test 3, Audible Warning

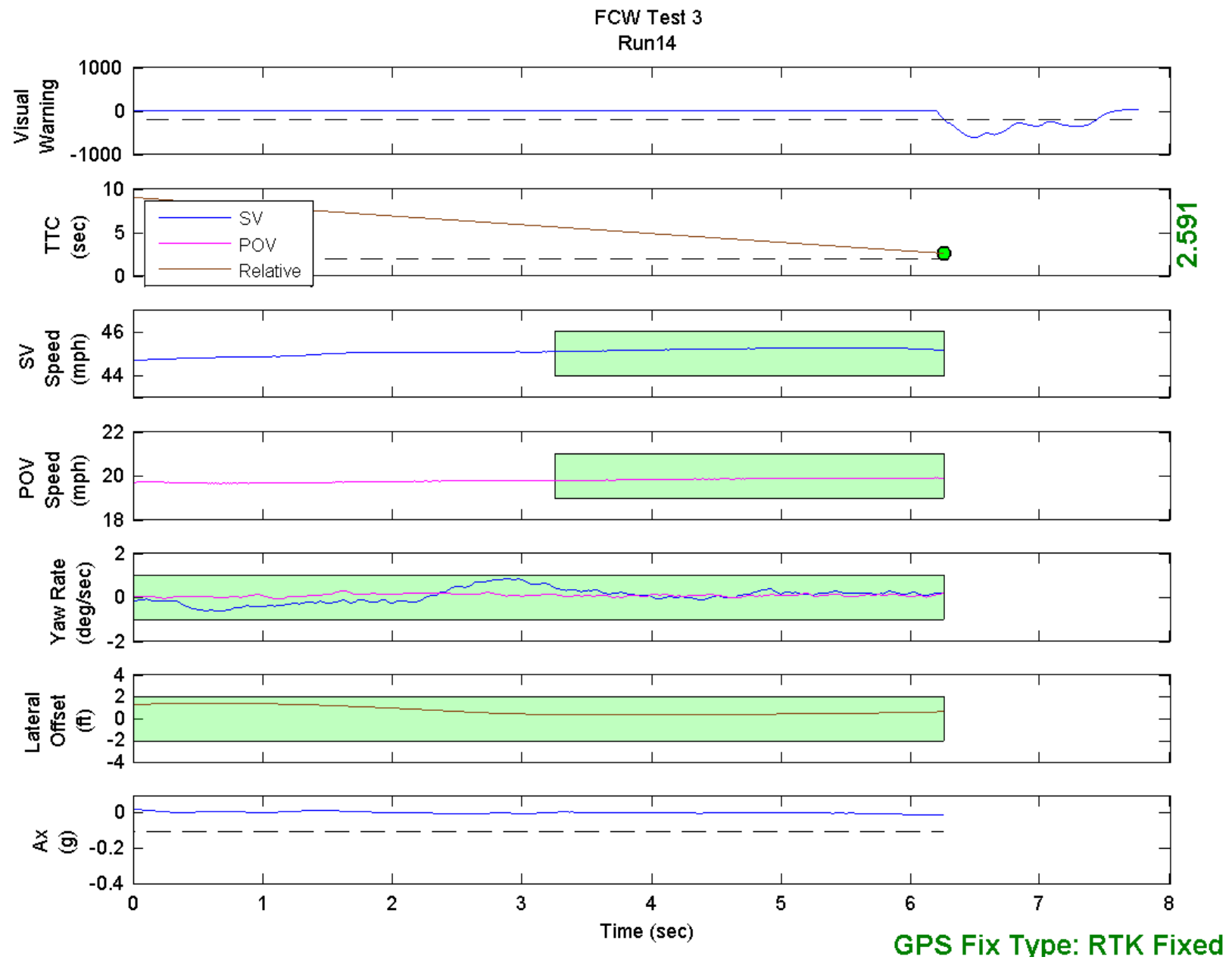


Figure D36. Time History for Run 14, FCW Test 3, Visual Warning

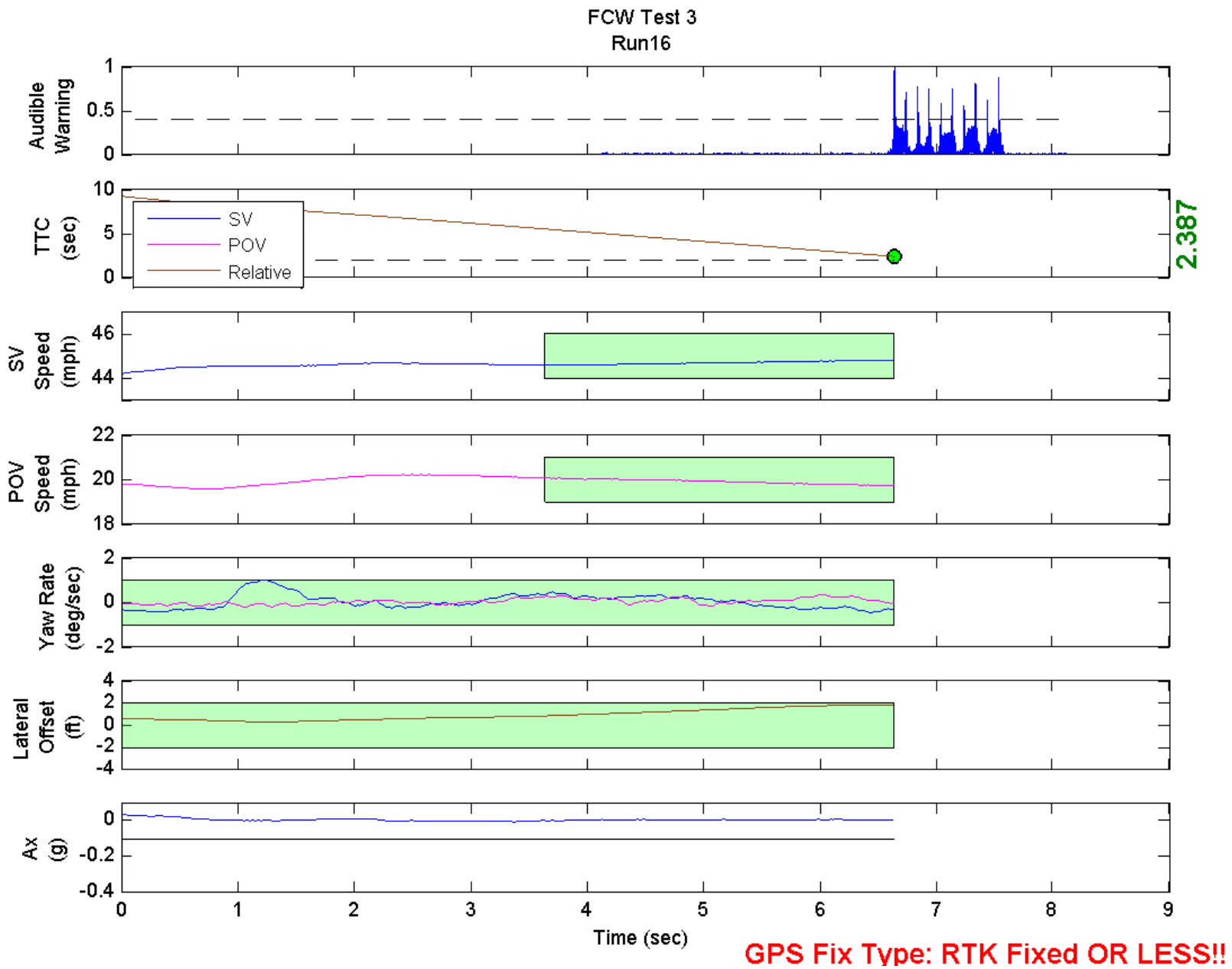


Figure D37. Time History for Run 16, FCW Test 3, Audible Warning

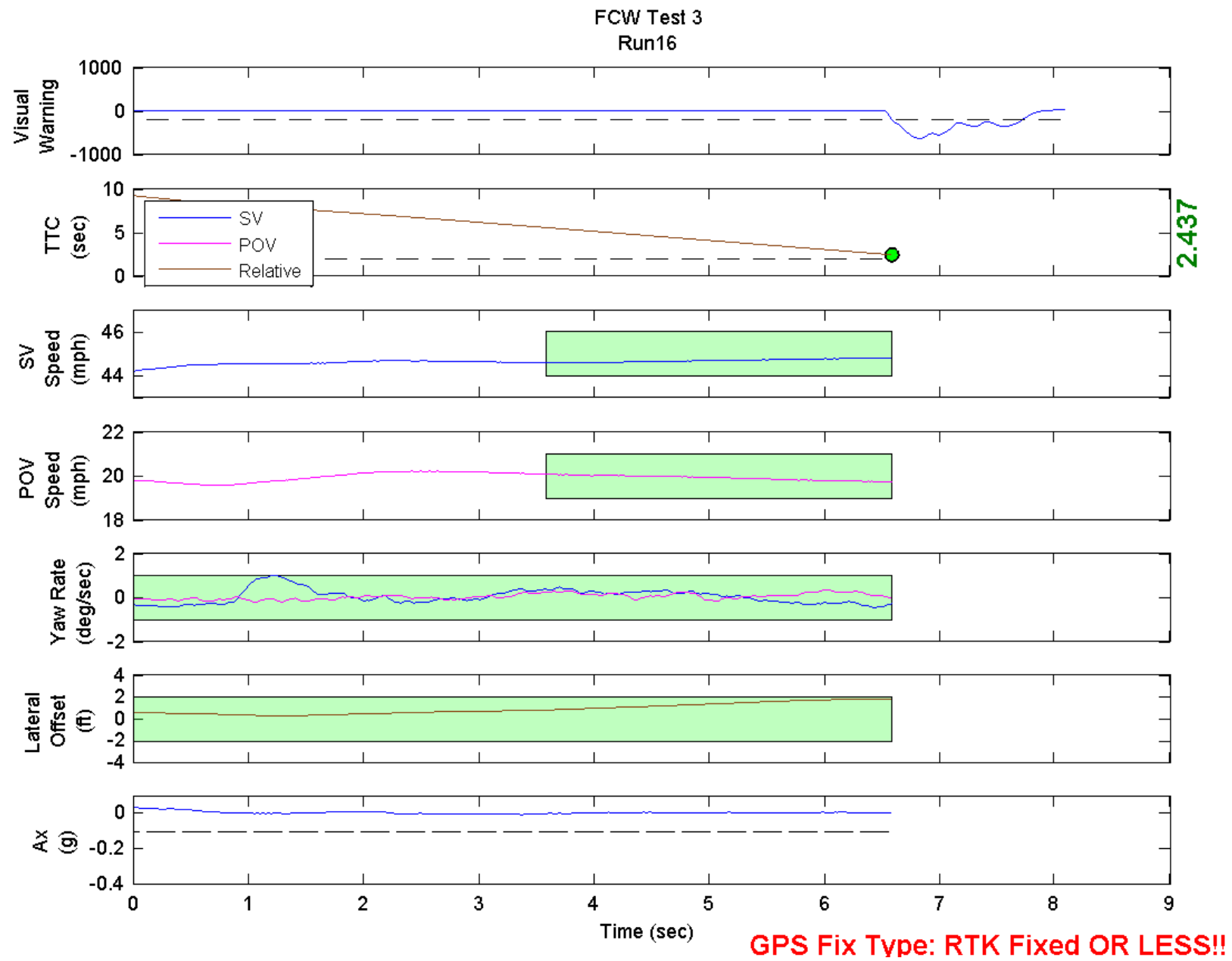


Figure D38. Time History for Run 16, FCW Test 3, Visual Warning

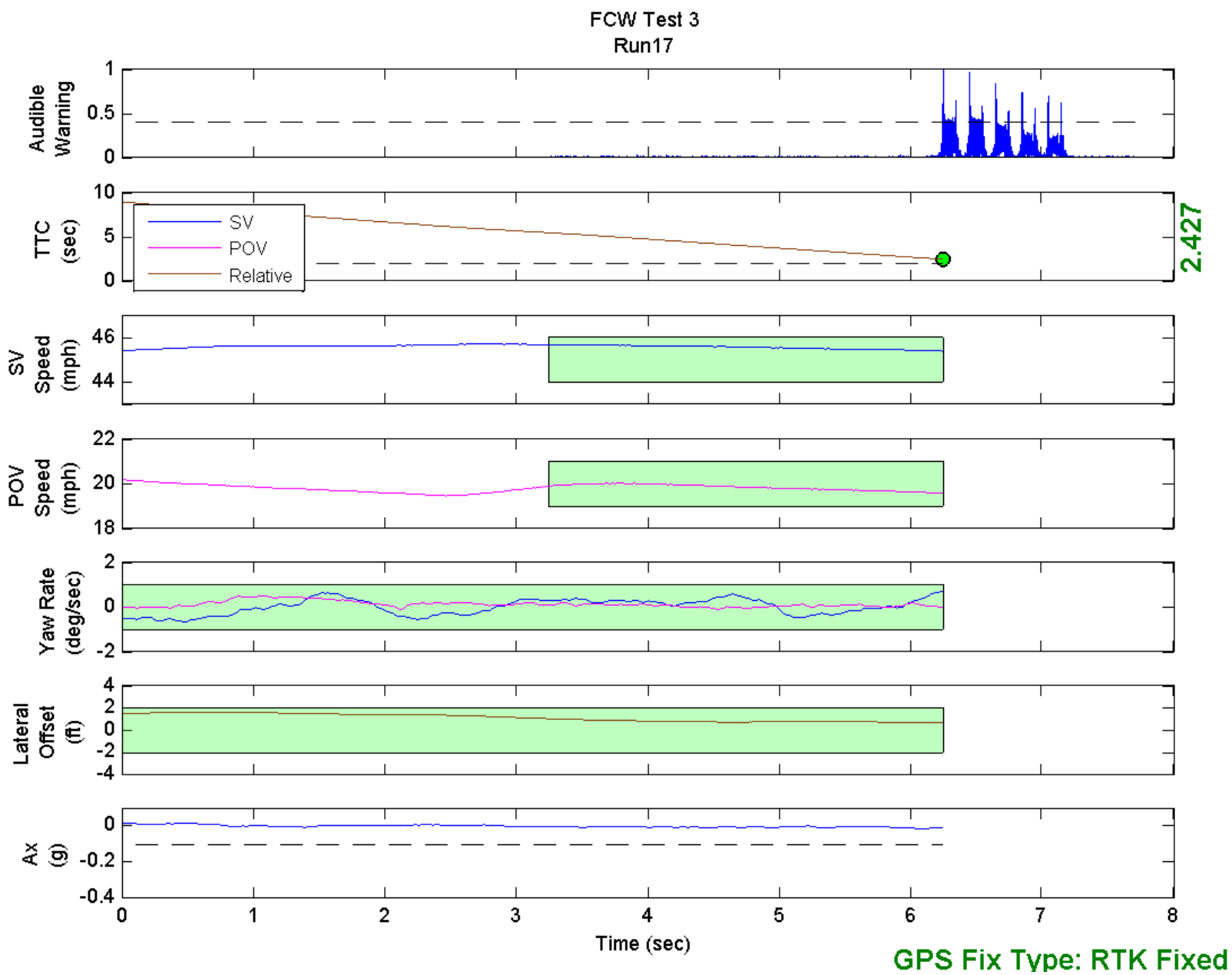


Figure D39. Time History for Run 17, FCW Test 3, Audible Warning

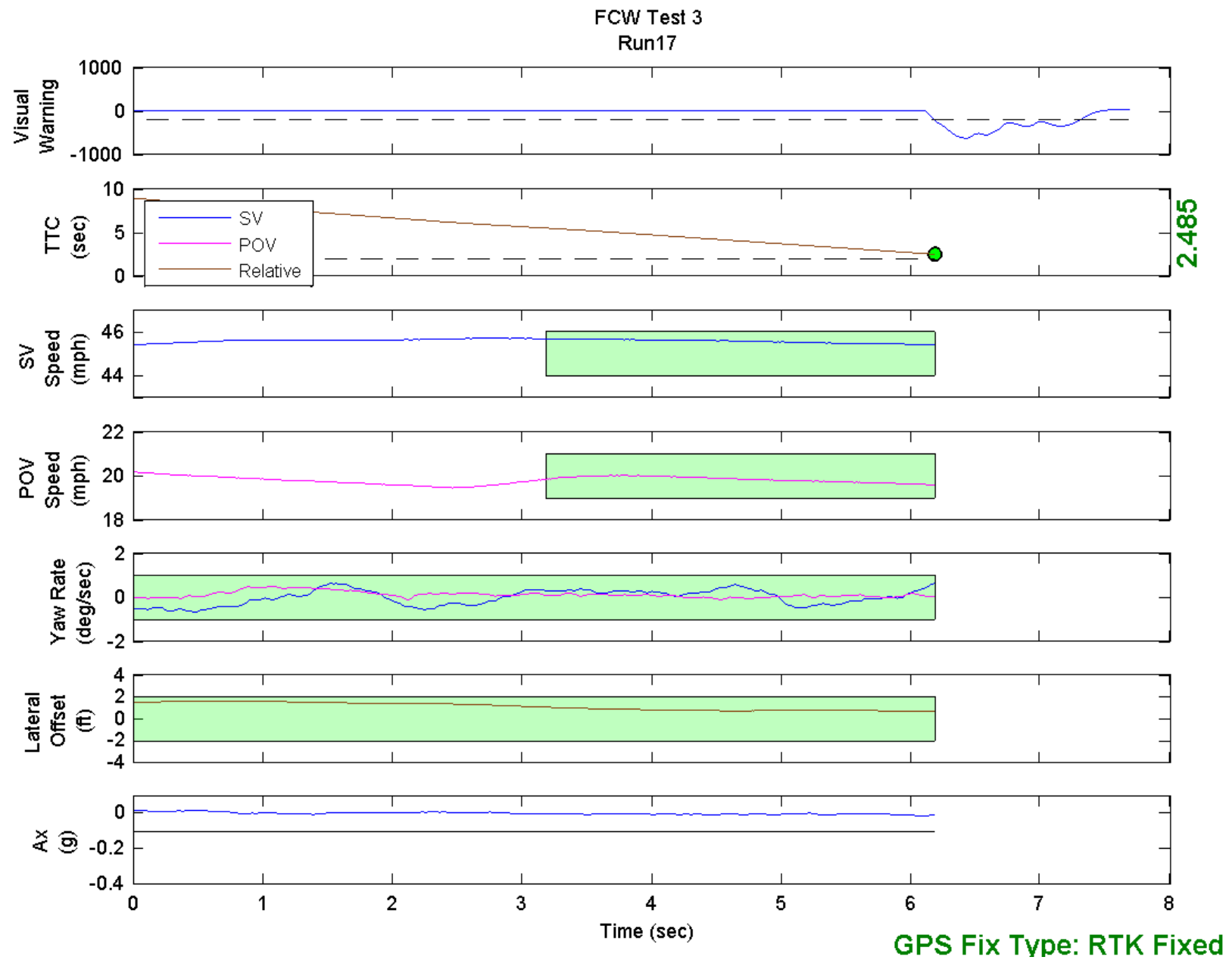


Figure D40. Time History for Run 17, FCW Test 3, Visual Warning

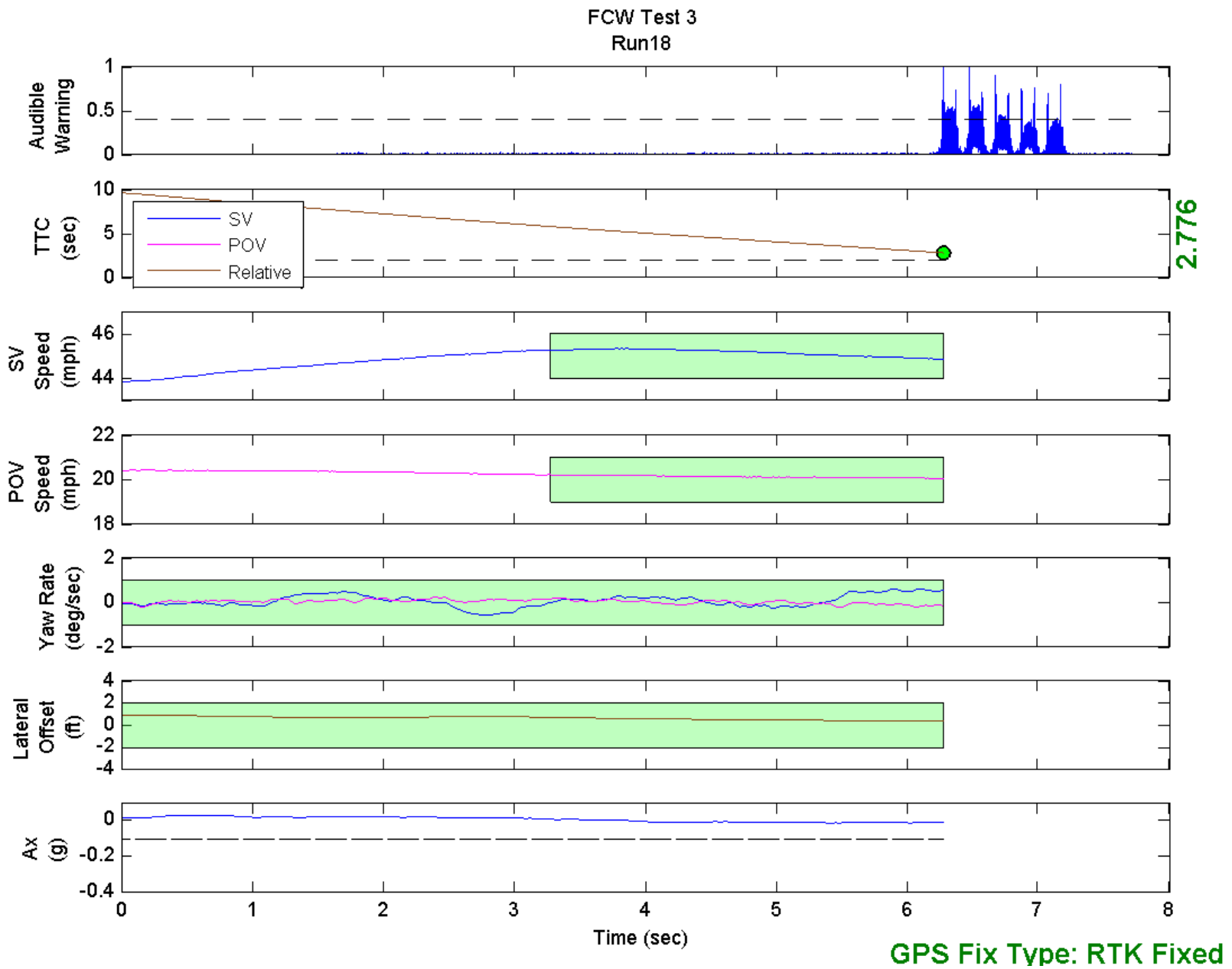


Figure D41. Time History for Run 18, FCW Test 3, Audible Warning

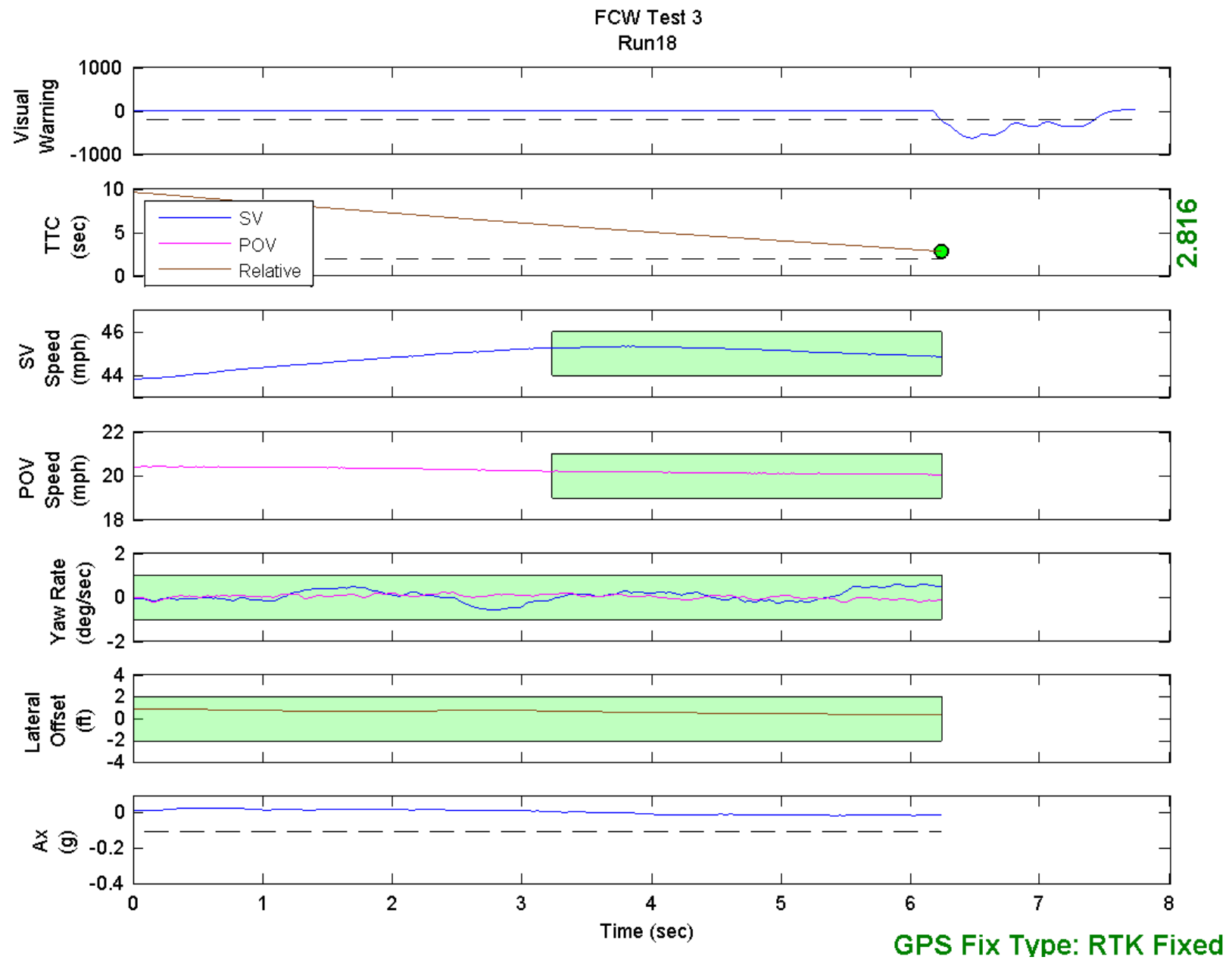


Figure D42. Time History for Run 18, FCW Test 3, Visual Warning

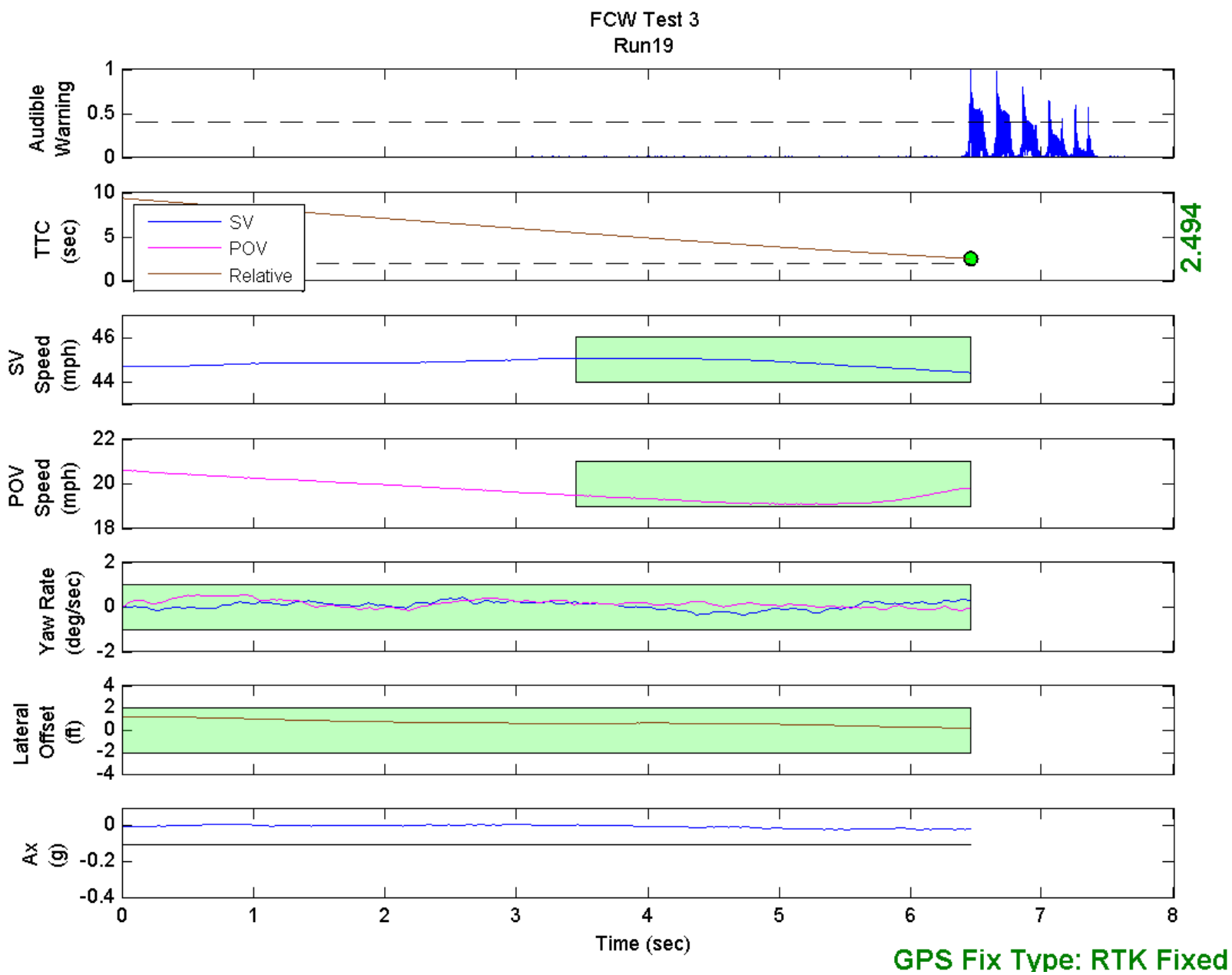


Figure D43. Time History for Run 19, FCW Test 3, Audible Warning

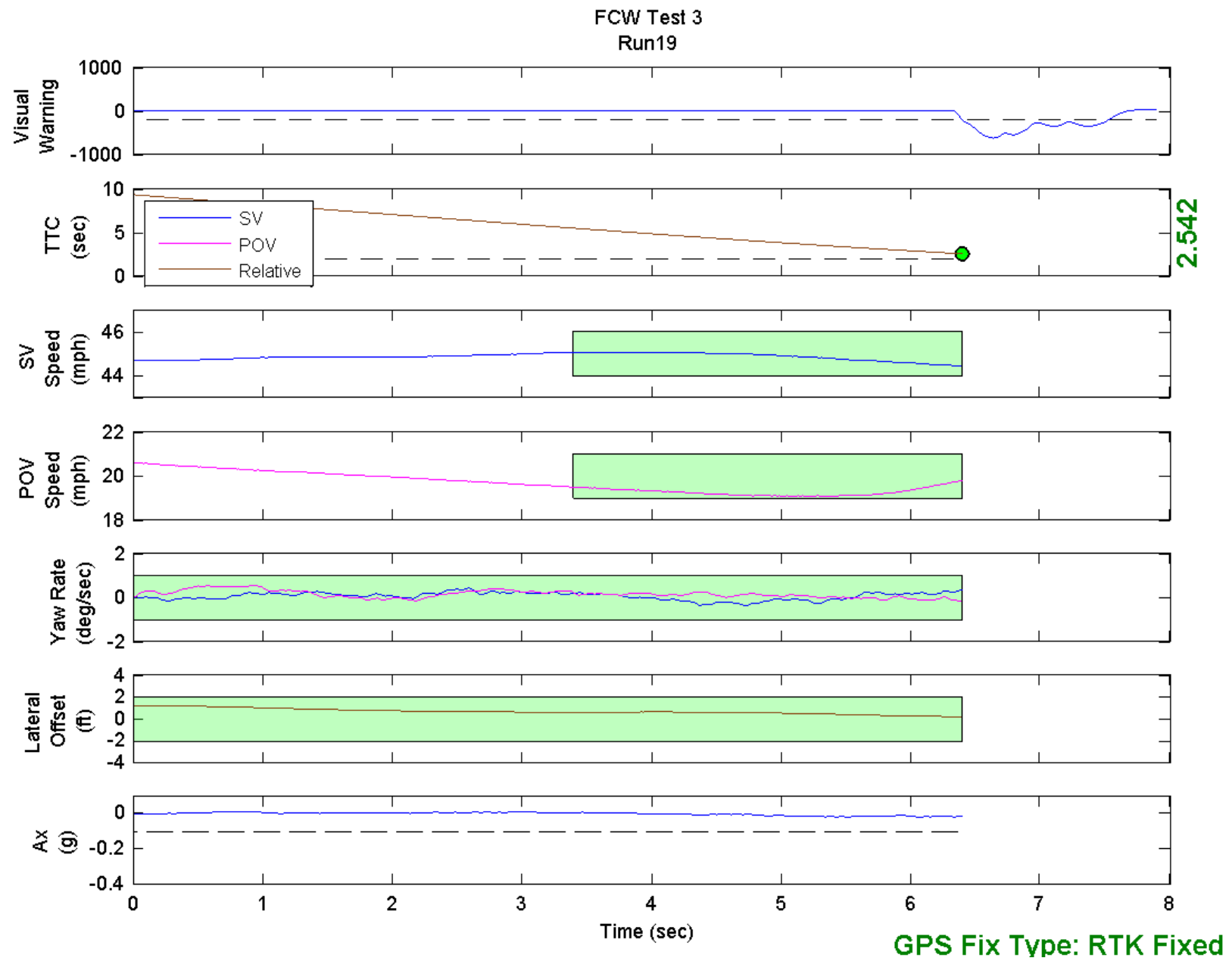


Figure D44. Time History for Run 19, FCW Test 3, Visual Warning

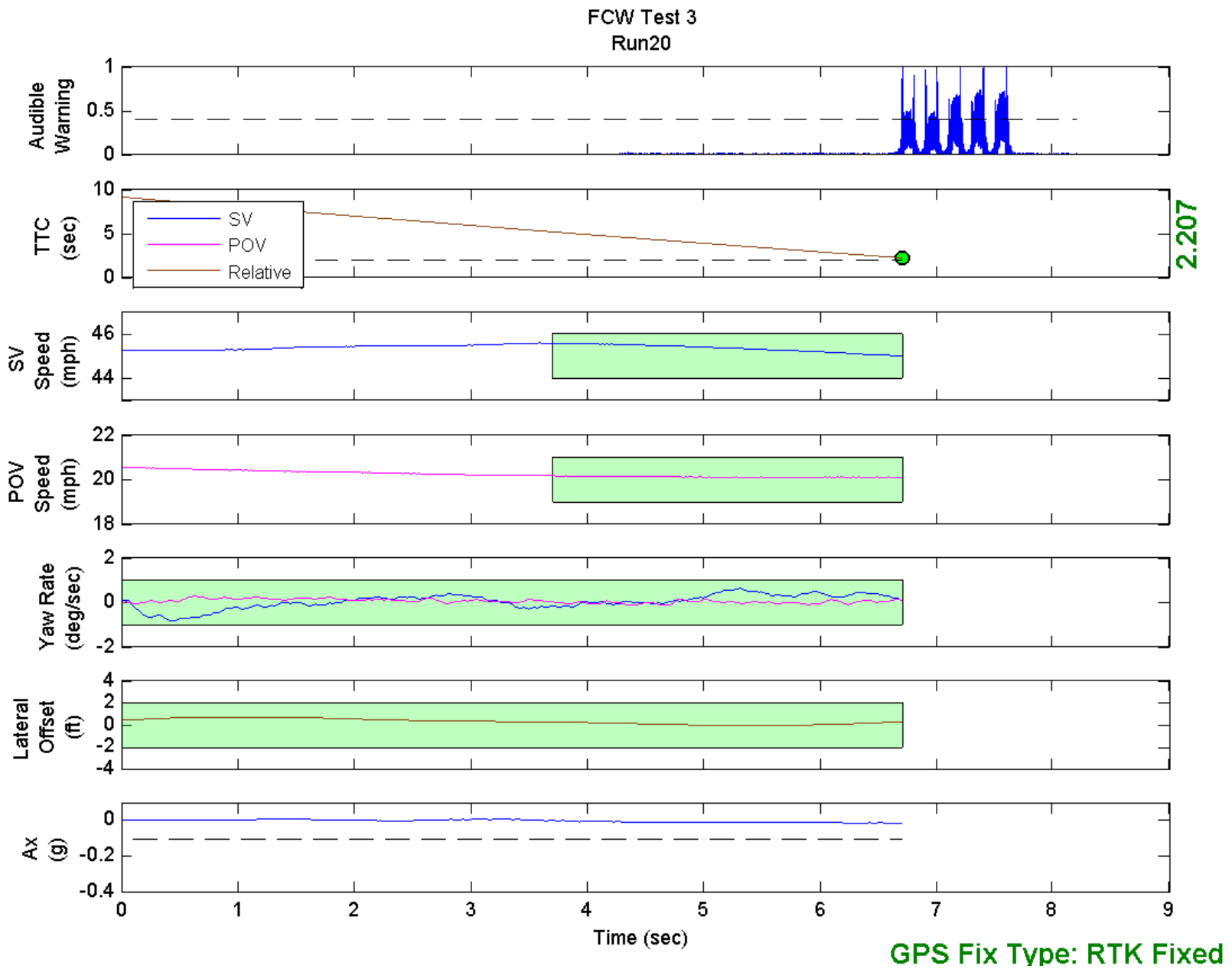


Figure D45. Time History for Run 20, FCW Test 3, Audible Warning

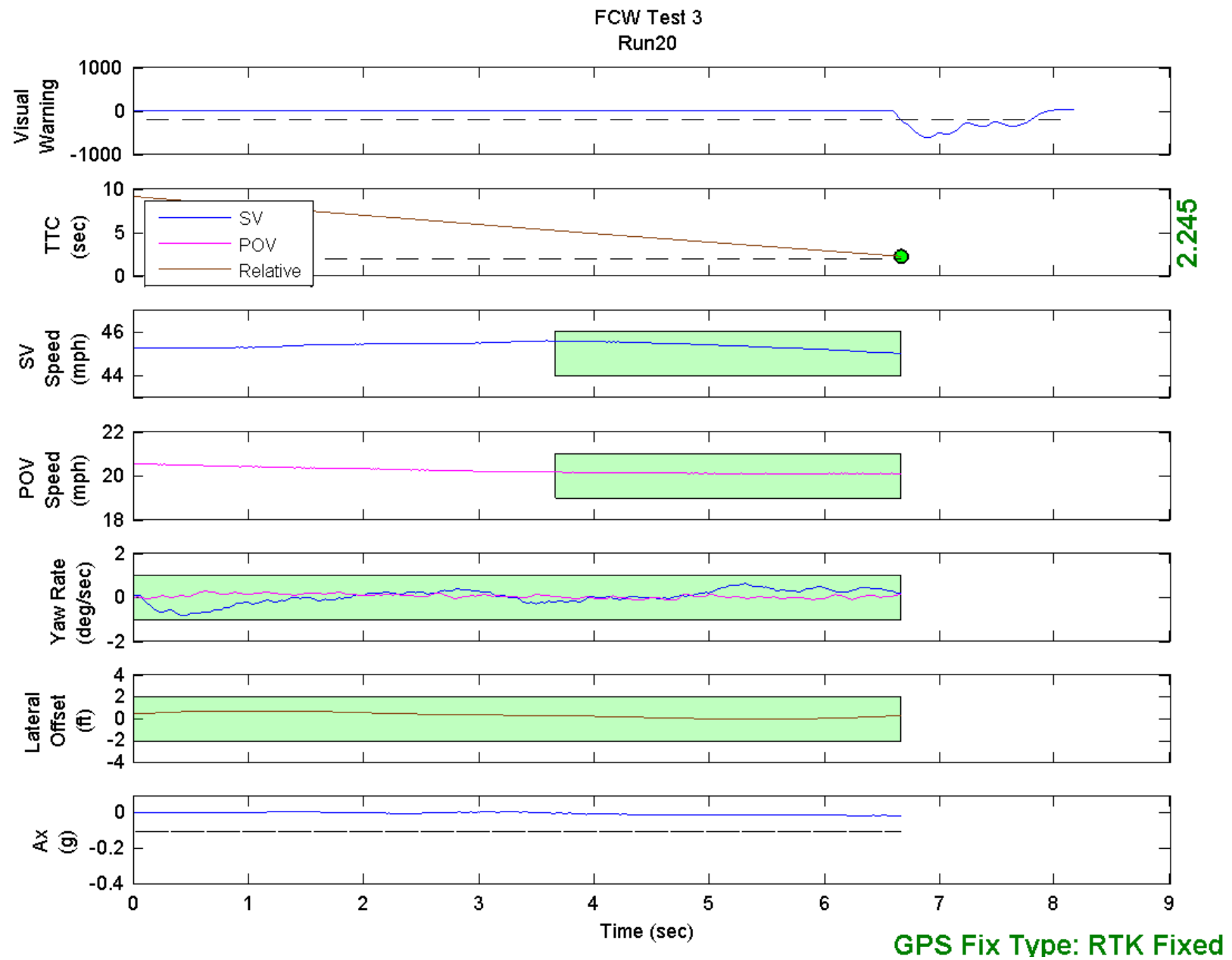


Figure D46. Time History for Run 20, FCW Test 3, Visual Warning

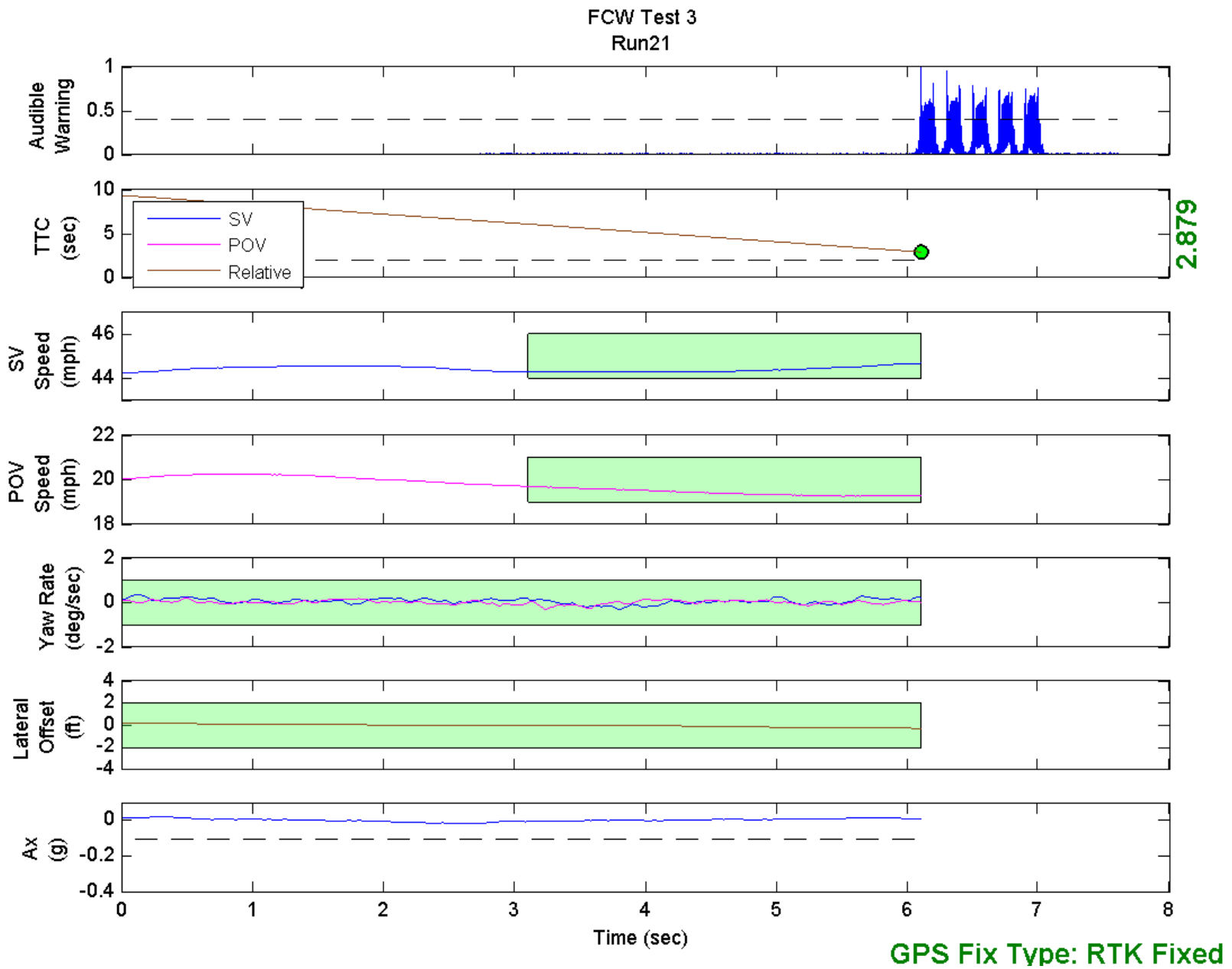


Figure D47. Time History for Run 21, FCW Test 3, Audible Warning

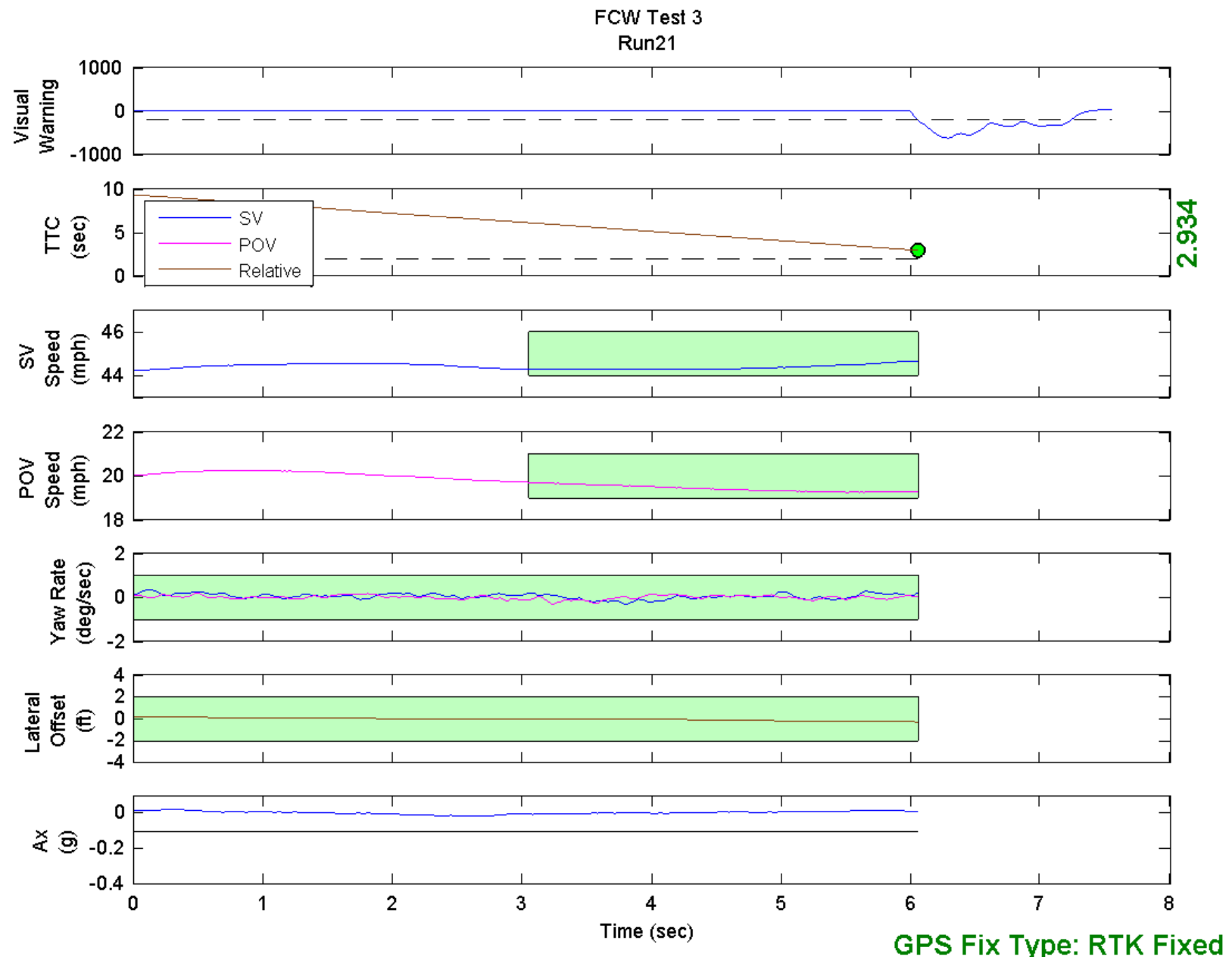


Figure D48. Time History for Run 21, FCW Test 3, Visual Warning