PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM RESEARCH TEST
NCAP-DRI-PAEB-20-01

2020 Audi Q5 45 TFSI quattro

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Final Report

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U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
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16. Abstract These research tests were conducted on the subject 2020 Audi Q5 45 TFSI quattro in accordance with the specifications of the National Highway Traffic Safety Administration's draft test procedure in docket NHTSA-2019-0102-0005 to confirm the performance of a Pedestrian Automatic Emergency Braking system, with modifications to include use of an articulated pedestrian test mannequin and additional tests speeds and lighting conditions.		
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Section I

INTRODUCTION

Pedestrian Automatic Emergency Braking (PAEB) systems are a subset of Automatic Emergency Braking (AEB) systems. PAEB systems are designed to avoid or mitigate vehicle crashes with pedestrians by automatically applying the Subject Vehicle's (SV's) brakes when the system determines that, without intervention, collision with a pedestrian will occur. PAEB systems typically work as an extension of Forward Collision Warning (FCW) systems, which alert the driver to the possibility of a collision unless driver action is taken. PAEB systems employ sensors capable of detecting pedestrians in the forward path. Current PAEB technology typically involves RADAR, LIDAR, or vision-based (camera) sensors, and measurement of vehicle operating conditions such as speed, driver steering, and brake application, etc. Algorithms in the system's Central Processing Unit (CPU) use this information to continuously monitor the likelihood of a collision with a pedestrian and command a brake actuator to apply the brakes when necessary.

The test procedure contained herein provides methods and specifications for collecting performance data on PAEB systems for light vehicles with gross vehicle weight ratings of up to 4,536 kg (10,000 lbs).

The test method used to evaluate PAEB performance on the test track was prescribed by NHTSA in a test procedure titled, "Pedestrian Automatic Emergency Brake System Confirmation Test (Working Draft)", dated September 2019 (Docket NHTSA-2019-0102-0005). For the testing reported herein, an articulating Pedestrian Test Mannequin (PTM) was used for testing, as opposed to the poseable one prescribed. Furthermore, additional test conditions were used, involving additional SV test speeds and nighttime tests using the SV's high beam headlights and low beam headlights.

The PAEB tests include ten pedestrian pre-crash test scenarios. There are seven (S1) crossing test scenarios in which a pedestrian is traveling across the SV's lane of travel. In the first three S1 test scenarios, an SV approaches an adult PTM starting on the right-hand side of the lane of travel (i.e., nearside) and moving towards the left-hand side (i.e., offside) with a point of impact at (a) 25% overlap from the passenger side of the SV, (b) 50% overlap, and (c) 75% overlap. In the S1d scenario, the SV approaches a crossing child PTM running from behind parked vehicles from the right-hand side of the lane towards the left-hand side with the point of impact at 50% overlap. In the S1e scenario, the SV approaches an adult PTM running from the left side of the lane towards the right with a 50% overlap point of impact. The S1f and S1g scenarios are false positive tests. In the S1f scenario, the SV approaches an adult PTM, which begins moving from the right-hand side of the lane but safely stops short of entering the SV's lane of travel. In the S1g scenario, the adult PTM also crosses from the right-hand side of the lane towards the left-hand side, but safely crosses the lane of travel completely.

There are also three (S4) in-path scenarios in which an adult pedestrian is either standing or walking away from the vehicle within the SV's lane of travel. In the first two test scenarios, the SV approaches a stationary adult PTM in its lane of travel at a 25% overlap point of impact. In the S4a scenario, the PTM is facing away from the approaching SV. In the S4b scenario, the PTM is facing towards the SV. In the third test scenario (S4c), the SV approaches an adult PTM while the PTM is traveling within and in the same direction as the SV's lane of travel at a 25% overlap point of impact.

For all of these tests, the adult and child PTM's are strikeable mannequins with visual and radar reflectivity characteristics representing a pedestrian. In test scenario S1d, the child PTM has the characteristics of the 7-year-old child. All of the other test scenarios use an adult PTM with the characteristics of a 50^{th} percentile adult male.

The false positive scenarios (S1f and S1g) are used to evaluate the propensity of a PAEB system to inappropriately activate in a non-critical driving scenario that does not present a safety risk to the SV occupant(s) or pedestrian.

The purpose of the testing reported herein was to objectively quantify the performance of a PAEB system installed on a 2020 Audi Q5 45 TFSI quattro. This test is part of the Crash Avoidance program to assess Pedestrian Automatic Braking Systems sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No. DTNH22-14-D-00333.

The test reported herein is one of a series of research and development tests accomplished for the purpose of refining test procedures, protocols, and specifications, as well as data analysis parameters and presentation methods that are preliminarily described in NHTSA 's test procedure titled, "Pedestrian Automatic Emergency Brake System Confirmation Test (Working Draft)", dated September 2019 (Docket NHTSA-2019-0102-0005). Some of these procedural details changed over the course of the test series in order to address unanticipated concerns or ambiguities, and also in recognition of the different characteristics of AEB implementation by the various manufacturers. In particular, the threshold for determining the onset of PAEB braking was originally set at -0.15 g, and subsequently changed to -0.03 g later in the series. As a result, some of the results indicate the earlier threshold and some the later. The results presented herein are for the -0.03 g threshold.

Section II

DATA SHEETS

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

2020 Audi Q5 45 TFSI quattro

VIN: *WA1BNAFY0L200xxxx*

Day Test Date: *6/30/2020*

Night Test Date: *7/6/2020*

System Setting: *Early*

Upper Capabilities

	Maximum Test Speed Without Consistent SV-to-PTM Contact[1]		
Scenario	**Daytime (km/h)**	**Night-High Beam (km/h)**	**Night-Low Beam (km/h)**
S1a	40		
S1b	50	*	*
S1c	40		
S1d	35	*	*
S1e	60	45	*
S1f			
S1g			
S4a	35	*	*
S4b	16		
S4c	50	*	16

* All test series resulted in consistent SV-to-PTM contact

[1] Consistent SV-to-PTM Contact is defined as the SV contacting the PTM in more than 3 trials at a given test speed.

S1a: SV Encounters an Adult PTM Crossing at 5 km/h from the Nearside at 25% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
16	6	6	16.3						
40	5	3	35.1						

S1b: SV Encounters an Adult PTM Crossing at 5 km/h from the Nearside at 50% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11				3	0	1.0	3	0	0.6
16	5	5	15.8	3	0	3.1	3	0	0.0
20	5	5	20.2						
30	5	5	29.8						
40	5	5	39.9	3	0	11.7	3	0	1.1
50	6	4	41.7						
55	3	0	34.1						
60	1	0	23.4						

S1c: SV Encounters an Adult PTM Crossing at 5 km/h from the Nearside at 75% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
16	4	4	9.0						
40	5	5	40.4						

S1d: SV Encounters a Crossing Child PTM Running at 5 km/h From Behind Parked Cars from the Nearside at 50% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11				3	0	0.5	3	0	0.0
16	5	4	15.4	3	0	0.1	4	0	0.3
20	5	5	20.0						
30	5	5	30.0						
35	5	5	35.2						
40	5	2	31.9	3	0	6.4	3	0	0.4

S1e: SV Encounters an Adult PTM Running at 8 km/h from the Offside at 50% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
35							4	1	19.9
40	5	5	37.1	6	6	37.5	3	0	1.0
45				5	4	39.1			
50	5	5	43.2	3	0	35.7			
55	7	5	39.2						
60	6	4	44.5						

S1f, S1g: Peak Deceleration Summary

(Day tests only)

S1f: SV Encounters an Adult PTM Crossing at 5 km/h from the Nearside that Stops Short of the Entering the SV Path of Travel

S1g: SV Encounters an Adult PTM Crossing at 5 km/h from the Nearside that Clears the SV Path of Travel

Trial Number	S1f SV: 40 km/h PTM: 5 km/h	S1g SV: 40 km/h PTM: 5 km/h
	Peak Deceleration (g)	
1	0.72	1.11
2	0.79	0.81
3	0.91	0.42
4	0.49	0.22
5	0.45	1.04

S4a: SV Encounters a Stationary Adult PTM Facing Away from the SV in the SV Lane of Travel at 25% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11				3	0	0.0	3	0	0.1
16	5	5	16.0	3	0	0.0	3	0	0.0
35	5	3	29.1						
40	3	0	25.5	3	0	9.7	3	0	16.3

S4b: SV Encounters a Stationary Adult PTM Facing Toward the SV in the SV Lane of Travel at 25% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
16	5	5	15.8						
35	4	1	23.8						
40	3	0	29.9						

S4c: SV Encounters an Adult PTM Traveling at 5 km/h in the SV Lane of Travel at 25% Overlap

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11				3	0	0.3			
16	3	0	8.1	4	1	4.2	7	5	11.7
35							3	0	5.4
40	5	5	40.0	3	0	9.5	3	0	17.2
50	5	5	49.9						
55	5	2	46.5						
60	3	0	28.7						

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 2: VEHICLE DATA

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2020 Audi Q5 45 TFSI quattro

TEST VEHICLE INFORMATION

VIN: *WA1BNAFY0L200xxxx*

Body Style: *SUV* Color: *Monsoon Gray Metallic*

Date Received: *5/18/2020* Odometer Reading: *55 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Audi AG*

Date of manufacture: *0819*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *255/45R20 101H*

Rear: *255/45R20 101H*

Recommended cold tire pressure: Front: *230 kPa (33 psi)*

Rear: *250 kPa (36 psi)*

TIRES

Tire manufacturer and model: *Continental Cross Contact LX Sport*

Front tire size: *255/45R20 101H*

Rear tire size: *255/45R20 101H*

Front tire DOT prefix: *P512WC1L*

Rear tire DOT prefix: *P512WC1L*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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2020 Audi Q5 45 TFSI quattro

DAYTIME TEST GENERAL INFORMATION

Test date: *6/30/2020*

AMBIENT CONDITIONS

Air temperature: *35.0 C (95 F)*

Wind speed: *3.6 m/s (8.1 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.

The tests were conducted in an area void of overhead signs, bridges, or other significant structures over or near the testing site. Each trial was conducted with no vehicles, obstructions, or stationary objects within one lane width of either side of the SV path, unless otherwise specified. Shadows cast by objects other than the SV, test equipment, or the obstructing vehicles were not present in the SV lane of travel, or within one lane width of either side of the SV path.

OBSTRUCTION VEHICLES

Forward obstructing vehicle: *1999 Honda Accord*

Rear obstructing vehicle: *2012 Toyota Highlander*

VEHICLE PREPARATION (DAY)

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: *230 kPa (33 psi)*

Rear: *250 kPa (36 psi)*

NIGHTTIME TEST GENERAL INFORMATION

Test date: *7/6/2020*

AMBIENT CONDITIONS

Air temperature: *19.4 C (67 F)*

Wind speed: *2.3 m/s (5.1 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 The tests were conducted between 1 hour after sunset and 1 hour before sunrise with good atmospheric visibility. There was no streetlighting.

The tests were conducted in an area void of overhead signs, bridges, or other significant structures over or near the testing site. Each trial was conducted with no vehicles, obstructions, or stationary objects within one lane width of either side of the SV path, unless otherwise specified. Shadows cast by objects other than the SV, test equipment, or the obstructing vehicles were not present in the SV lane of travel, or within one lane width of either side of the SV path.

OBSTRUCTION VEHICLES

Forward obstructing vehicle: *1999 Honda Accord*

Rear obstructing vehicle: *2012 Toyota Highlander*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

2020 Audi Q5 45 TFSI quattro

VEHICLE PREPARATION (NIGHT)

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: *230 kPa (33 psi)*

Rear: *250 kPa (36 psi)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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2020 Audi Q5 45 TFSI quattro

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*533.0 kg (1175 lb)*	Right Front:	*527.1 kg (1162 lb)*
Left Rear:	*477.2 kg (1052 lb)*	Right Rear:	*477.2 kg (1052 lb)*
		Total:	*2014.5 kg (4441 lb)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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2020 Audi Q5 45 TFSI quattro

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

Pre Sense City

Type and location of sensors the system uses:

Single camera located behind the windshield near the rearview mirror.

Are there any available settings for the PAEB system (i.e. Range adjustment, etc.)?

X Yes

___ No

If yes, please provide a full description.

Select in the Infotainment system (left control button):

Vehicle

Audi drive select

Driver assistance

Audi pre sense

Prewarning select Off, Early, Medium or Late

See Appendix A, Figures A13 and A14.

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

How is the PAEB alert presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

___ Vibration

X Other: *Brake Jerk*

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

2020 Audi Q5 45 TFSI quattro

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 visual warning is presented in the center of the instrument cluster. See Appendix A, Figure A16.

The auditory warning is a constant tone centered at 1800 Hz.

In addition to these, there is a brake jerk as part of the warning cascade.

Does the vehicle system require an initialization sequence/procedure? ____ Yes

X No

If yes, please provide a full description.

What are the minimum and maximum vehicle speeds over which the PAEB system is active?

Minimum: *10 km/h (6 mph) (Per manufacturer supplied information)*

Maximum: *80 km/h (50 mph) (Per manufacturer supplied information)*

Will the system deactivate due to repeated PAEB activations, impacts or near-misses? ____ Yes

X No

If yes, please provide a full description.

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

2020 Audi Q5 45 TFSI quattro

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

____ No

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

Select in the Infotainment system: button left control button >

Vehicle

Audi drive select

Driver assistance

Audi pre sense

Turn on/off Audi pre sense - select or deselect

If the system is switched off, it switches on again automatically once the ignition is switched on again.

See Appendix A, Figures A13 and A14.

Are there other driving modes or conditions that render PAEB inoperable or reduce its effectiveness? **X** Yes

____ No

If yes, please provide a full description.

The system has a self-test algorithm, which will reduce the system performance or deactivate completely if the following conditions are observed:

- *Mud/dirt/snow accumulation on the sensor*
- *If the ESC is turned off or in sport mode*

If the system detects sensor blockage, FCW, DBS, CIB will not be available and the system will show a notification in the vehicle cluster.

Additional system limitations are described in the Owner's Manual, pages 134 and 135, shown in Appendix B, pages B-7 and B-8.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Ten test scenarios were used, as follows:

- S1a. Subject Vehicle (SV) Encounters a Crossing Adult Pedestrian Test Mannequin (PTM) from the Nearside at 25% Overlap
- S1b. SV Encounters a Crossing Adult PTM from the Nearside at 50% Overlap
- S1c. SV Encounters a Crossing Adult PTM from the Nearside at 75% Overlap
- S1d. SV Encounters a Crossing Child PTM Running from Behind Parked Cars from the Nearside at 50% Overlap
- S1e. SV Encounters a Crossing Adult PTM Running from the Offside at 50% Overlap
- S1f. SV Encounters a Crossing Adult PTM From the Nearside and Stops Short of Entering the SV Path of Travel
- S1g. SV Encounters a Crossing Adult PTM From the Nearside and Clears the SV Path of Travel
- S4a. SV Encounters a Stationary Adult PTM on the Nearside of the Road Facing Away from the SV at 25% Overlap
- S4b. SV Encounters a Stationary Adult PTM on the Nearside of the Road Facing Toward the SV at 25% Overlap
- S4c. SV Encounters an Adult PTM on the Nearside of the Road Walking in the Same Direction as the SV at 25% Overlap

The 89 different combinations of scenario, nominal SV speeds, and lighting conditions are listed in Table 1. This includes 35 daytime, 27 low beam nighttime, and 27 high beam nighttime combinations. Testing generally started at the lowest test speed in Table 1 and progressed through higher test speeds.

For all scenarios except S4c, the 16 and 40 km/h speeds were considered to be the “non-conditional" speeds. Testing at these speeds was conducted without regard to whether the results showed that "consistent contact" occurred between the SV and PTM. Consistent contact was defined as the SV contacting the PTM in three or more test trials at a given speed. If this occurred, then testing at any higher speeds was not conducted. Rather, the speed would be stepped down by 5 km/h and testing of that scenario and lighting treatment would be conducted at that lower speed. This was done to more precisely identify the highest speed at which the vehicle's PAEB system was able to avoid colliding with the PTM.

So, for example, for Scenario S1d, if the vehicle did not contact the PTM at 16, 20, or 30 km/h, but did contact the PTM in three trials at 40 km/h, then testing would be done at 35 km/h. However, testing would not be done at 50 or 60 km/h. Note that there were 20 possible scenario and ambient lighting condition combinations that could involve testing at the "step down" speed, for a total of 109 possible test combinations.

Table 1. Test Scenario, Speed, and Lighting Condition Matrix

	Nominal SV Speeds (km/h)								Lighting Condition		
										Night	
Scenario	16	20	30	40	50	60	70	80	Day	Low Beams	High Beams
S1a	X	-	-	X	-	-	-	-	X	-	-
S1b	X	X*	X*	X	X*	X*	-	-	X	X*	X*
S1c	X	-	-	X	-	-	-	-	X	-	-
S1d	X	X*	X*	X	X*	X*	-	-	X	X*	X*
S1e	-	-	-	X	X*	X*	-	-	X	X*	X*
S1f	-	-	-	X	-	-	-	-	X	-	-
S1g	-	-	-	X	-	-	-	-	X	-	-
S4a	X	-	-	X	X*	X*	X*	X*	X	X*	X*
S4b	X	-	-	X	-	-	-	-	X	-	-
S4c	-	-	-	X	-	-	-	-	X	X*	X*

* Additional test condition (i.e., not part of the test procedure titled, "Pedestrian Automatic Emergency Brake System Confirmation Test (Working Draft)", dated September 2019.

All of the test trials were performed with SV automatic transmissions in ‘‘Drive’’ or with manual transmissions in the highest gear capable of sustaining the desired test speed. Manual transmission clutches remained engaged during all maneuvers.

An overview of each of the test procedures follows.

B. SV Approach to a Crossing Pedestrian (S1)

1. S1 TEST SCENARIOS

The following S1 test scenarios were used to evaluate PAEB system performance.

a. S1a-b-c Scenarios – SV Encounters a Crossing Adult PTM from the Nearside at 25/50/75% Overlap

These tests evaluate the ability of the SV PAEB system to detect and respond to a crossing adult pedestrian walking into the SV path from the nearside.

Figure 1 below illustrates the S1a, S1b, and S1c test scenarios. See Table 3 for details on the test setup.

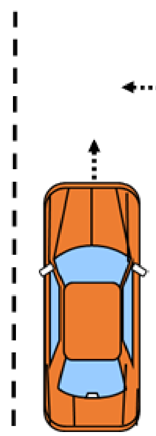


Figure 1. Scenarios S1a, b, c; Nearside Crossing Adult Pedestrian Walking 25/50/75% Overlap

- S1a test conditions:
    - SV Speeds (km/h): 16, 40
    - PTM Speed (km/h): 5
    - PTM Type: Adult
    - Overlap: 25%
    - Direction of PTM Approach: Nearside

- S1b test conditions:
  - SV Speeds (km/h): 16, 20, 30, 40, 50, 60
  - PTM Speed (km/h): 5
  - PTM Type: Adult
  - Overlap: 50%
  - Direction of PTM Approach: Nearside

- S1c test conditions:
  - SV Speeds (km/h): 16, 40
  - PTM Speed (km/h): 5
  - PTM Type: Adult
  - Overlap: 75%
  - Direction of PTM Approach: Nearside

b. S1d Scenario – SV Encounters a Crossing Child PTM Running from Behind Parked Cars from the Nearside at 50% Overlap

This test evaluates the ability of the SV PAEB system to detect and respond to a crossing child pedestrian running into the SV path from behind parked vehicles from the nearside.

Figure 2 below illustrates the S1d test scenario. See Table 3 for details on the test setup.

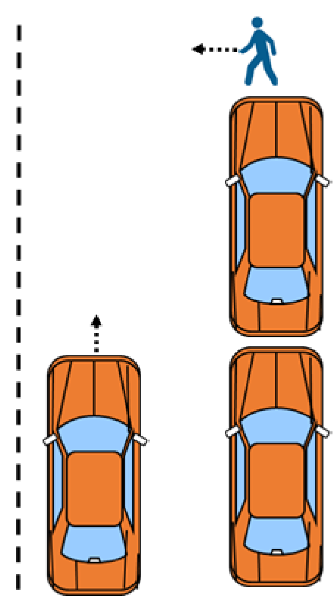


Figure 2. Scenario S1d; Nearside Obstructed Crossing Child Running, 50% Overlap

- S1d test conditions:
    - SV Speeds (km/h): 16, 20, 30, 40, 50, 60
    - PTM Speed (km/h): 5
    - PTM Type: Child
    - Overlap: 50%
    - Direction of PTM Approach: Nearside

c. S1e Scenario – SV Encounters a Crossing Adult PTM from the Offside at 50% Overlap

This test evaluates the ability of the SV PAEB system to detect and respond to a crossing adult pedestrian running into the SV path from the offside.

Figure 3 below illustrates the S1e test condition. See Table 4 for details on the test setup.

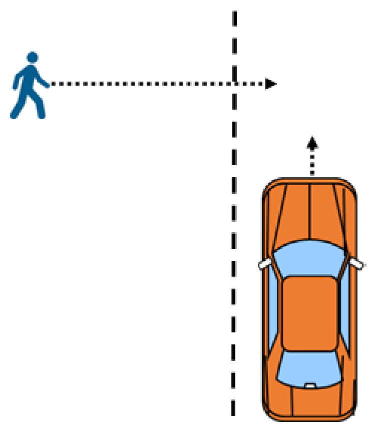


Figure 3. Scenario S1e; Offside Crossing Adult Running 50% Overlap

- S1e test conditions:
    - SV Speeds (km/h): 40, 50, 60
    - PTM Speed (km/h): 8
    - PTM Type: Adult
    - Overlap: 50%
    - Direction of PTM Approach: Offside

d. S1f Scenario – SV Encounters a Crossing Adult PTM from the Nearside that Stops Short of Entering the SV Travel Path

This test evaluates how the SV PAEB system will respond to a crossing adult pedestrian walking from the nearside that stops short of entering the vehicles path.

Figure 4 below illustrates the S1f test condition. See Table 3 for details on the test setup.

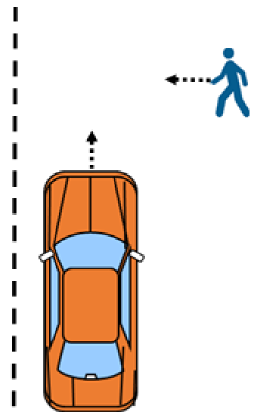


Figure 4. Scenario S1f; Nearside Crossing Adult Walking Stops Short

- S1f test conditions:
    - SV Speeds (km/h): 40
    - PTM Speed (km/h): 5
    - PTM Type: Adult
    - Overlap: 0% (stops short of vehicle path)
    - Direction of PTM Approach: Nearside

e. S1g Scenario – SV Encounters a Crossing Adult PTM from the Nearside that Clears the SV Travel Path

This test evaluates how the SV PAEB system will respond to a crossing adult pedestrian walking from the nearside that clears the vehicle's path. Figure 5 below illustrates the setup for the S1g test condition. See Table 3 for details on the test setup.

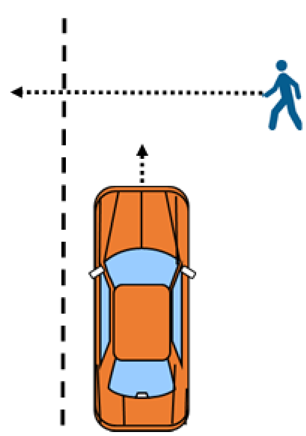


Figure 5. Scenario S1g; Nearside Crossing Adult Walking Clears Path

- S1g test conditions:
  - SV Speeds (km/h): 40
  - PTM Speed (km/h): 5
  - PTM Type: Adult
  - Overlap: 100% (crosses beyond vehicle path)
  - Direction of PTM Approach: Nearside

2. <u>PEDESTRIAN TEST MANNEQUIN PLACEMENT AND MOVEMENT</u>

For tests S1a-b-c-d-f-g, the PTM was positioned 3.5 m (11.5 ft) from the SV centerline on the nearside with its orientation perpendicular to the SV centerline. For test S1e, the PTM was positioned 5.5 m (18.0 ft) from the SV centerline on the offside with its orientation also perpendicular to the SV centerline.

Trigger timing for the S1 tests assumed that the SV will approach the crossing PTM at a constant speed with no PAEB system intervention. Trigger timing for the

- S1a test was set up so that the PTM would contact the front of the SV at 25% of the SV width (i.e., on the passenger side of the vehicle).
- S1b-d-e tests were set up so that the PTM would contact the front of the SV at 50% of the SV width (i.e., the center of the SV).
- S1c test was set up so that the PTM would contact on the front of the SV at 75% of the SV width (i.e., on the driver side of the vehicle).
- S1f test was set up so that the PTM would contact the front of the SV at 50% of the SV width, but the PTM forward motion was stopped at -25% of the SV width. This means that the PMT did not enter the direct path of the SV.
- S1g test was set up so that the PTM would clear the direct path of the SV. For calculating trigger timing for PTM motion 125% of the SV width was used.

a. PTM Position as a Function of SV Position

i. PTM Position Validity Criterion

In the course of testing PAEB systems, it is necessary to confirm that the required conflict scenario was presented to each vehicle in a repeatable and verifiable fashion, trial after trial. This is particularly important in the pedestrian crossing scenarios (S1a-g). For the purposes of these tests, the ideal PTM lateral lane position (Y_{PTM}) is expressed as a function of SV position longitudinally within the lane (X_{SV} - i.e., headway between the front of the SV to the contact-side of the PTM.). That is:

$$Y_{PTM} = f(X_{SV})$$

Note that the terms “longitudinal” and “lateral” herein are defined relative to the SV lane of travel. Therefore, PTM lateral lane position refers to the PTM position across the lane.

On this basis, the validity of a given trial is determined by computing the sample-by-sample difference of the measured Y_{PTM} position and the ideal position, and then applying a tolerance. The tolerance chosen as the validity criterion for the S1 scenarios was 10% of the width of a typical 1.8-meter-wide vehicle, or 0.18 m (18 cm).

ii. Methodology

In order to compute a positional error of the PTM (laterally within the lane), it is necessary to pre-compute the ideal positional relationship between the SV longitudinal lane position and the lateral position of the PTM based on the parameters specified per scenario, assuming the SV had not begun its avoidance maneuver. These parameters include:

- SV speed (v_{SV})
- PTM speed (v_{PTM})
- Percent Overlap at Impact (%OL)
- PTM start distance (Y_{PTM0})
- PTM acceleration distance (D_{acc})
- PTM Move distance (D_{move})
- SV width (W_{SV})

From these parameters, the spatial relationship of the PTM relative to the SV position along the travel lane is determined.

Figure 6 illustrates the coordinate system used for the validation of Scenario 1 (S1a, b, c, d, e, f, g).

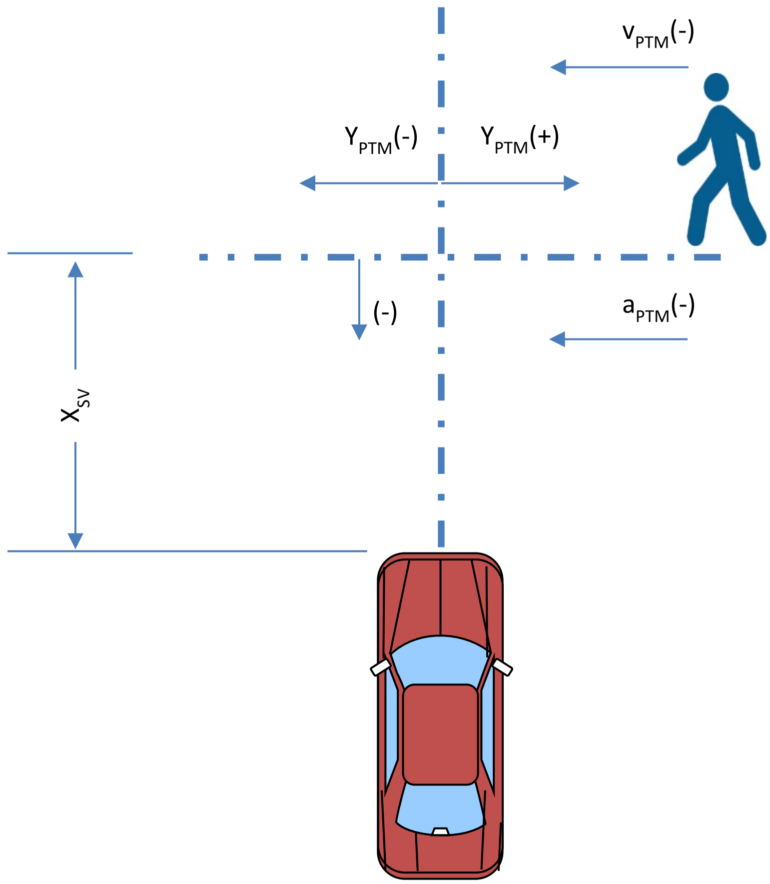


Figure 6. Coordinate System for Validation of Scenario 1

Note that Y_{PTM} is measured relative to the center of the lane (in this case, shown coincident with the center of the SV) with positive values to the right (as viewed from the SV). Note also that X_{SV} is measured parallel to the travel lane between the near edge of the PTM and the front-most point of the SV, such that X_{SV} is negative during the approach phase.

Figure 7 illustrates the ideal lateral lane position of the PTM as a function of SV longitudinal lane position, taking each scenario parameter into consideration.

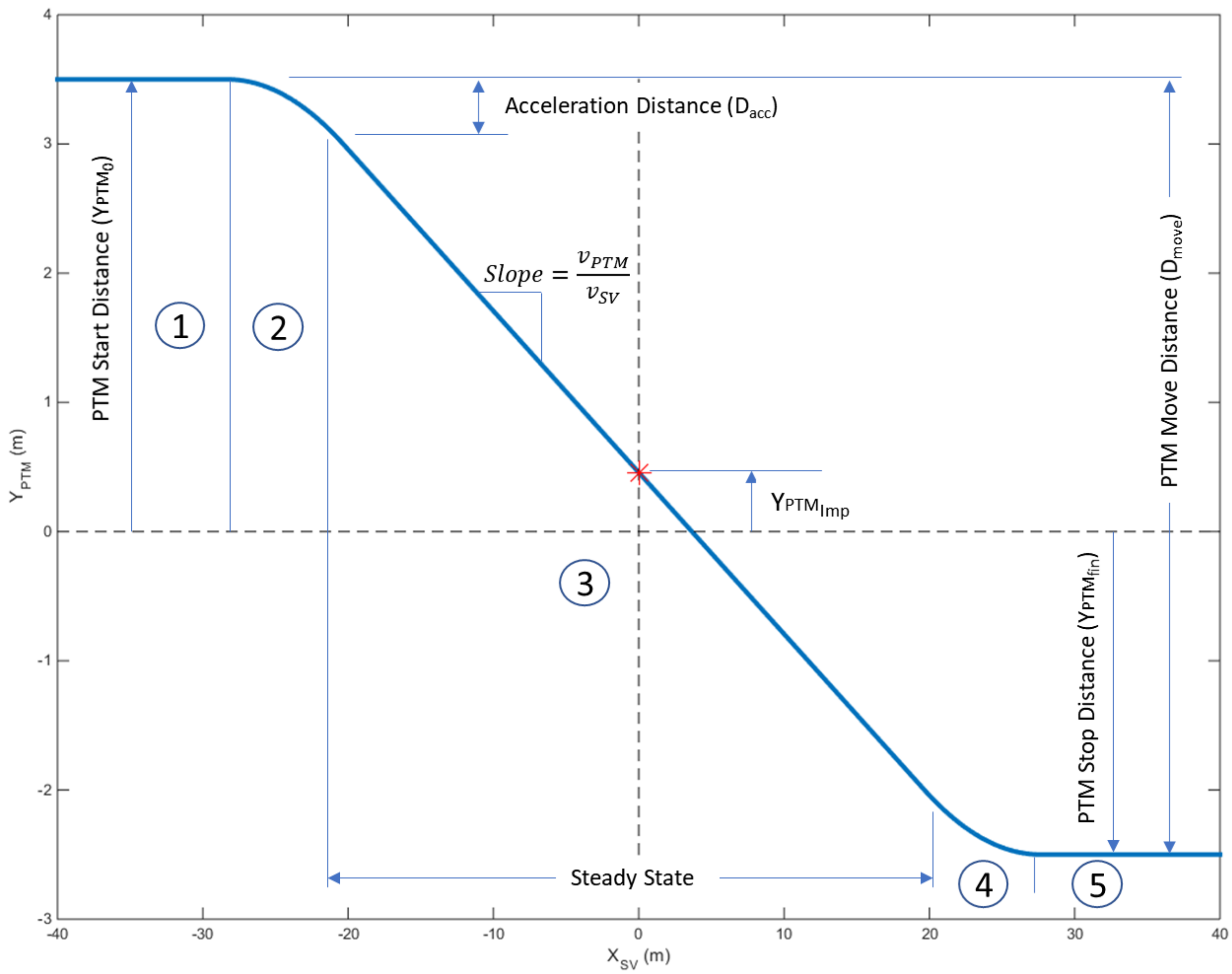


Figure 7. PTM Lateral Lane Position as a Function of SV Longitudinal Lane Position

The ideal trajectory of the PTM lateral lane position as a function of headway is computed in 5 separate domains. These domains are:

- Stationary domain, initial: The PTM is stationary at the side of the roadway as the SV approaches
- Acceleration domain: The PTM accelerates to its prescribed speed over a prescribed distance
- Steady State domain: The PTM speed, v_{PTM}, and SV speed, v_{SV}, are both steady-state. Note that $Y_{PTM_{imp}}$ is defined as the offset distance at impact (if there is no intervention by the PAEB system or driver braking)
- Deceleration domain: The PTM decelerates from its prescribed speed to rest over a prescribed distance (relevant only for scenario S1f)
- Stationary domain, final: The PTM is stationary at its final position as the SV

proceeds in the lane (relevant only for scenario S1f)

The boundaries of these domains are:

- X_{SV} at PTM motion start ($X_{SV_{PTM\ Start}}$)
- X_{SV} at PTM steady state start ($X_{SV_{SS\ Start}}$)
- X_{SV} at PTM steady state end ($X_{SV_{SS\ end}}$)
- X_{SV} at PTM motion stop ($X_{SV_{PTM\ Stop}}$)

Table 2 provides the domain boundaries for each PAEB scenario for the standard scenario SV speeds. Note that the details of the calculations follow.

Table 2. Domain Boundaries Per Scenario

Scenario		Domain (X_{SV},Y_{PTM})			
Type	SV Speed (km/h)	PTM Start (m)	Steady State Start (m)	Steady State End (m)	PTM Stop (m)
S1a	16	(-11.34, 3.50)	(-8.14, 3.00)	(7.86, -2.00)	(11.06, -2.50)
	40	(-28.34, 3.50)	(-20.34, 3.00)	(19.66, -2.00)	(27.66, -2.50)
S1b	16	(-12.80, 3.50)	(-9.60, 3.00)	(6.40, -2.00)	(9.60, -2.50)
	40	(-32.00, 3.50)	(-24.00, 3.00)	(16.00, -2.00)	(24.00, -2.50)
S1c	16	(-14.26, 3.50)	(-11.06, 3.00)	(4.94, -2.00)	(8.14, -2.50)
	40	(-35.66, 3.50)	(-27.66, 3.00)	(12.34, -2.00)	(20.34, -2.50)
S1d	16	(-12.80, 3.50)	(-9.60, 3.00)	(6.40, -2.00)	(9.60, -2.50)
	40	(-32.00, 3.50)	(-24.00, 3.00)	(16.00, -2.00)	(24.00, -2.50)
S1e	40	(-32.50, -5.50)	(-22.50, -4.50)	(12.50, 2.50)	(22.50, 3.50)
S1f	40	(-32.00, 3.50)	(-24.00, 3.00)	W_{SV} Dependent	W_{SV} Dependent
S1g	40	(-42.97, 3.50)	(-34.97, 3.00)	(5.03, -2.00)	(13.03, -2.50)

In order to compute the values for these domain boundaries, it is necessary to compute several intermediate values:

Y_{PTM} at the point of impact, as defined by the Percent Overlap specified by the scenario:

$$Y_{PTM_{imp}} = (50\% - \%OL)W_{SV}$$

where,

W_{SV} = SV width (assumed here to be 1.8 meters)

In scenario S1f, in which the PTM comes to rest without entering the SV lane of travel such that no collision can occur, it is also necessary to compute the deceleration and stop distances:

$$Y_{PTM_{fin}} = Y_{PTM_0} - D_{move}$$

where,

$Y_{PTM_{fin}}$	= final position of PTM with respect to the lane
Y_{PTM_0}	= initial position of PTM with respect to the lane
D_{move}	= distance moved by the PTM, defined by scenario

In the acceleration domain, it is assumed that the PTM undergoes constant acceleration from rest to the specified PTM speed, such that the acceleration can be computed as:

$$a = \frac{{v_{PTM}}^2}{2D_{acc}}$$

where,

v_{PTM}	= velocity of PTM, defined by scenario
D_{acc}	= acceleration distance of PTM, defined by scenario

The longitudinal distance covered by the SV during the acceleration phase of the PTM is computed as:

$$\Delta X_{SV_{acc}} = \frac{2D_{acc}v_{SV}}{v_{PTM}}$$

where,

$\Delta X_{SV_{acc}}$	= Change in SV longitudinal lane position during the acceleration of the PTM
v_{SV}	= SV velocity, defined by scenario

Computing the domain boundaries:

$$X_{SV_{SS\ start}} = \left[Y_{PTM_0} - D_{acc} - Y_{PTM_{Imp}}\right]\frac{v_{SV}}{v_{PTM}}$$

$$X_{SV_{SS\ end}} = \left[Y_{PTM_{fin}} + D_{acc} - Y_{PTM_{Imp}}\right]\frac{v_{SV}}{v_{PTM}}$$

$$X_{SV_{PTM\ start}} = \Delta X_{SV_{acc}} + X_{SV_{SS\ Start}}$$

$$X_{SV_{PTM\ stop}} = X_{SV_{SS\ end}} - \Delta X_{SV_{acc}}$$

where,

$X_{SV_{SS\ start}}$ = SV longitudinal lane position at the beginning of steady state domain

$X_{SV_{SS\ end}}$ = SV longitudinal lane position at the end of steady state domain

$X_{SV_{PTM\ start}}$ = SV longitudinal lane position at the start of PTM motion

$X_{SV_{PTM\ stop}}$ = SV longitudinal lane position at the end of PTM motion

Finally, lateral lane position values are computed for each domain.

Domain 1 (Stationary):

$$Y_{PTM} = Y_{PTM_0} \qquad \text{for} \quad X_{SV} \leq X_{SV_{PTM\ start}}$$

Domain 2 (Acceleration):

$$Y_{PTM} = Y_{PTM_0} - \frac{1}{2}a_{PTM}\left[\frac{X_{SV} - X_{SV_{PTM\ Start}}}{v_{SV}}\right]^2 \qquad \text{for} \quad X_{SV_{PTM\ start}} < X_{SV} \leq X_{SV_{SS\ start}}$$

where,

a_{PTM} = PTM acceleration, defined by scenario

X_{SV} = measured SV longitudinal lane position

Domain 3 (Steady State):

$$Y_{PTM} = \frac{v_{PTM}}{v_{SV}} X_{SV} + Y_{PTM_{imp}} \qquad \text{for} \quad X_{SV_{SS\ start}} < X_{SV} \leq X_{SV_{SS\ end}}$$

Domain 4 (Deceleration):

$$Y_{PTM} = Y_{PTM_{fin}} + D_{acc} + v_{PTM} \frac{\left(X_{SV} - X_{SV_{SS\ end}}\right)}{v_{SV}} + \frac{1}{2} a_{PTM} \left[\frac{X_{SV} - X_{SV_{SS\ end}}}{v_{SV}}\right]^2$$

$$\text{for} \quad X_{SV_{SS\ end}} < X_{SV} \leq X_{SV_{PTM\ stop}}$$

Domain 5 (Stationary):

$$Y_{PTM} = Y_{PTM_{fin}} \qquad \text{for} \quad X_{SV} > X_{SV_{PTM\ stop}}$$

After each trial is completed, the measured X_{SV} values are used to compute ideal Y_{PTM} values, sample-by-sample. Measured Y_{PTM} values are then compared to the ideal Y_{PTM} values in order to compute a lateral lane position error for the PTM:

$$Y_{PTM_{err}} = Y_{PTM_{ideal}} - Y_{PTM_{meas}}$$

Y_{PTM} error is then plotted in the time domain for the entire validity window and checked to determine exceedances beyond the acceptable threshold of ±18 cm (or 10% of a typical 1.8 m wide vehicle). The validity window started at 4.0 sec Time-To-Collision (TTC) and ends at the earliest of any of the following:

- SV braking is initiated
- SV-to-PTM contact occurs
- The front of the SV crosses the X_{SV} zero point

3. <u>OBSTRUCTION VEHICLES</u>

Two parked vehicles positioned along the nearside of the test lane were used as obstructions. The obstructions blocked the view of the pedestrian from the vehicle sensors limiting the reveal time (the time that the vehicle's sensors have to process that a pedestrian is approaching the SV lane of travel). Parked Obstruction Vehicle 1 (PV1) was a mid-sized sedan (1999 Honda Accord) positioned closest to the pedestrian path. Parked Obstruction Vehicle 2 (PV2) was a mid-sized Sport Utility Vehicle (2012 Toyota

Highlander) positioned behind PV1.

4. SV ZERO POSITION

- The SV and PTM were centered on the SV centerline with the PTM facing the direction specified for each test scenario.

- The front-most location of the SV was positioned such that it just contacted the PTM. This was the “zero position.” The zero position did not change based on different overlap test conditions. Note that the determination of whether there was a collision between the SV and PTM is based on whether the zero position has been crossed. This means that for this purpose, the front of the SV is considered to have a rectangular shape (even if it actually has some curvature). Note also that the arms of the PTM were not considered contact points.

- The zero position was documented both prior to and immediately after conduct of a test series.

5. LAST MOMENT BRAKING

In order to reduce the likelihood of damage to both the PTM and test vehicle, it was determined that Last Moment Braking (LMB) would be implemented for scenarios in which the nominal speed was 40 km/h or higher. LMB is defined as braking applied by the driver to reduce the speed and energy of the collision with the PTM in the event that a collision becomes impossible to avoid.

LMB was implemented as follows: the computer onboard the SV continuously computed and monitored TTC. If TTC dropped below a preset value (i.e. 1.0 sec) and no alert or braking had been provided by the PAEB system at that time, then the computer would provide an audible beep, and the driver would apply the brakes forcefully and as quickly as possible. When LMB was used, the preset TTC value was selected such that a collision would be inevitable (i.e., even immediate maximum braking would not reduce SV speed enough to avoid colliding with the PTM). Thus, the overall outcome of the trial (collision/no collision) would not be affected by the use of LMB.

6. TEST TRIAL CONDUCT AND VALIDITY (S1)

An overview of each test trial is as follows: For each trial for the S1 scenarios, the SV and PTM were first positioned at their respective start positions. The SV was accelerated to its nominal test speed, and the driver maintained its position in the center of the lane. When the SV was at a designated longitudinal distance from the PTM, the PTM accelerated to its nominal test speed. If a PAEB alert was issued by the vehicle, the driver then fully released the throttle (within 500 ms of the alert). After the vehicle either came to a stop or passed through the plane defined by the PTM’s movement, which was perpendicular to the SV's line of travel, the trial was concluded.

a. PTM Validity

For each test trial to be valid, the following criteria were required to be met.

- The PTM was secured to the apparatus used for motion such that its position relative to the apparatus remained constant.
- The PTM was at the start position distance on the PTM path from the SV path and did not move until the triggering criteria for motion were met.
- PTM start position nearside: 3.5 m ± 2.54 cm (11.4 ft ± 1 in)
- PTM start position offside: 5.5 m ± 2.54 cm (18.04 ft ± 1 in)
- When triggered, the PTM was accelerated to the test speed over the required distance and held at that test speed until the PTM was clear of the SV path, stopped short of entering the SV path, or was contacted by the SV.
- PTM speed:
    - 5 km/h (3.1 mph) within an acceleration distance of 0.5 m (1.64 ft)
    - 8 km/h (4.9 mph) within acceleration distance 1.0 m (3.28 ft)
- PTM position: ±0.18m from ideal lateral position within the lane, as a function of SV longitudinal position within the lane[2].
- While the PTM was in motion, the PTM path remained perpendicular to the SV centerline. Lateral deviations induced by wind, equipment, or surface conditions were monitored.

b. SV Validity

For an individual test trial to be valid, the following criteria were required to be met:

- The SV driver seatbelt was latched.
- The SV driver cycled the ignition prior to each run.
- The front initial brake temperature (IBT) was between 149°F (65°C) and 212°F (100°C) at the onset of each test.
    - If the IBT was less than 149°F (65°C), the brakes were heated to the IBT by making one or more brake applications from a speed of 31.1 mph (50 km/h), at a deceleration rate not greater than 0.31g (3 m/s²).
    - If the IBT was greater than 212°F (100°C), the SV was driven at speeds up to 62.1 mph (100 km/h) until the IBT specified in this section was reached.
- The SV was driven at the nominal speed specified for each test. The speed tolerance was ±1.0 km/h.

[2] The ideal lateral position of the PTM within the lane was calculated as a function of SV longitudinal lane position as described in Section III B 2 a ii and shown in Figure 7.

- The following requirements were held true throughout each trial.
  - The driver used the least amount of steering input necessary to maintain the SV position in the center of the test lane. The lateral distance between the centerline of the SV and the center of the travel lane did not deviate more than ± 20 cm (8 in). A measurement and display of SV lateral lane position was presented to the driver in order to regulate the lateral lane position during the execution of a trial. These data were also recorded and used as validation of lane position in post-process.
  - The yaw rate of the SV did not exceed ±1.0 deg/s.
  - The SV driver modulated the throttle, using smooth inputs, to maintain a constant SV speed ±1.0 km/h.
  - With the exception of LMB (described above), the SV driver did not apply any force to the brake pedal until the end of the test unless the PTM was contacted or the front of the SV had crossed the path of the PTM.
- The SV throttle was fully released within 500 ms after the SV PAEB warning event was presented (visual, haptic, or audible). If no SV warning event was presented by the SV PAEB system, the SV driver modulated the throttle to maintain a constant speed until either the onset of PAEB or, if the SV's PAEB system did not activate, the end of the test occurred (i.e., contact with the PTM occurred).

c. Validity Period

- The valid test interval began when the longitudinal TTC of the SV = 4.0 seconds.
- For scenarios S1a-b-c-d-e, the test ended when any of the following occurred:
  - The SV contacted the PTM; or
  - The SV stopped (via PAEB) before contacting the PTM; or
  - The PTM cleared the direct path of the SV.
- For scenarios S1f-g, the test ended when either of the following occurred:
  - The front of the SV crossed the path of the PTM (i.e., the front most location of the SV front bumper crosses the zero position.
  - The SV stopped (via PAEB).

d. End-of-Test Instructions

After the test was complete, the SV driver manually applied force to the brake pedal, bringing the vehicle to a stop (if necessary), and placed the transmission in park (automatic transmission) or neutral (manual transmission).

The test trial was then complete.

e. Number of Test Trial Repeats

Combinations of test speeds and lighting conditions were tested as shown in Table 1. Five repeat trials were conducted for each test condition. As noted above, for all scenarios except S4c, the 16 and 40 km/h speeds were considered to be the "non-conditional" speeds. Testing at these speeds was conducted without regard to whether the results showed that "consistent contact" occurred between the SV and PTM. Consistent contact was defined as the SV contacting the PTM in three or more test trials at a given speed. If this occurred, then testing at any higher speeds was not conducted. Rather, the speed would be reduced by 5 km/h and testing of that scenario and lighting treatment would be conducted at that lower speed. This was done to more precisely identify the highest speed at which the vehicle's PAEB system was able to avoid colliding with the PTM.

f. Speed Reduction (S1a-b-c-d-e)

The magnitude of the SV speed reduction attributable to PAEB intervention (as shown in Datasheet 1) was calculated in one of two ways, depending on whether or not a test trial concluded with the SV colliding with the PTM.

- If the SV contacted the PTM during a test trial, the PAEB speed reduction was calculated by subtracting the SV speed at the time of contact (i.e., when longitudinal range becomes zero) from the average SV speed calculated at TTC = 4.0 seconds.
- If the SV did not contact the PTM during a test trial (i.e., PAEB intervention prevented the crash), the SV speed at the time of SV and PTM contact was taken to be zero. The speed reduction was therefore equal to the SV speed at TTC = 4.0 seconds.

g. Deceleration (S1f-g)

The peak SV deceleration within the validity period was documented for each test trial performed for the S1f-g scenarios.

h. Pass/Fail Criteria

There were no pass/fail criteria for these research tests.

C. SV Approach to a Pedestrian Walking Along/Against Traffic (S4)

1. <u>S4 TEST SCENARIOS</u>

a. S4a Scenario – SV Encounters a Stationary Adult PTM on the Nearside of the Road Facing Away from the SV at 25% Overlap

This test evaluates the ability of the SV PAEB system to detect and respond to an adult pedestrian standing in front of the vehicle on the nearside of the road facing away from the approaching SV.

Figure 8 below illustrates the test setup for the S4a test. See Table 5 for details on the test setup.

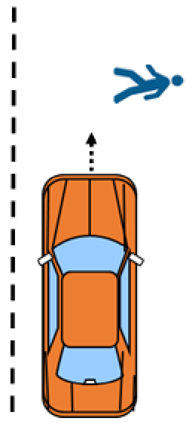


Figure 8. Scenario S4a; Nearside Standing Adult Facing Away From SV, 25% Overlap

- S4a test conditions:
    - SV Speeds (km/h): 16, 40
    - PTM Speed (km/h): 0
    - PTM Type: Adult
    - Overlap: 25%
    - Direction of PTM Approach: Facing away from the SV

b. S4b Scenario – SV Encounters a Stationary Adult PTM on the Nearside of the Road Facing Towards the SV at 25% Overlap

This test evaluates the ability of the SV PAEB system to detect and respond to an adult pedestrian standing in front of the vehicle on the nearside of the road facing towards the approaching SV.

Figure 9 below illustrates the test setup for the S4b test scenario. See Table 5 for details on the test setup.

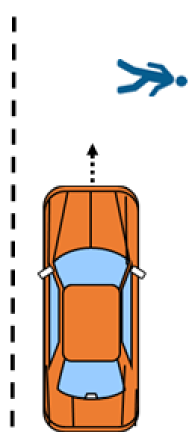


Figure 9. Scenario S4b; Nearside Standing Adult Facing Towards SV, 25% Overlap

- S4b test conditions:
  - SV Speeds (km/h): 16, 40
  - PTM Speed (km/h): 0
  - PTM Type: Adult
  - Overlap: 25%
  - Direction of PTM Approach: Facing towards the SV

c. S4c Scenario – SV Encounters an Adult PTM on the Nearside of the Road Walking Away from the SV, but in the Same Direction as the SV, at 25% Overlap

This test evaluates the ability of the SV PAEB system to detect and respond to an adult pedestrian walking in front of the vehicle on the nearside of the road facing away from the approaching SV.

Figure 10 below illustrates the test setup for the S4c test scenario. See Table 5 for details on the test setup.

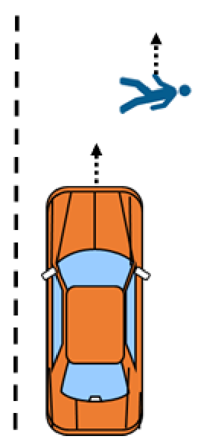


Figure 10. Scenario S4c; Nearside Walking Adult Away From SV, 25% Overlap

- S4c test conditions:
  - SV Speeds (km/h): 40
  - PTM Speed (km/h): 5
  - PTM Type: Adult
  - Overlap: 25%
  - Direction of PTM Approach: Facing and moving away from SV

2. PEDESTRIAN TEST MANNEQUIN PLACEMENT AND MOVEMENT

For the S4a-b-c scenarios, the PTM was positioned in the direct path of the SV at a 25% overlap on the nearside. The orientation of the PTM was either facing towards or away from the SV and was either stationary or moving for the duration of the tests.

The PTM was stationary in scenarios S4a and S4b, and therefore, no trigger timing was required.

Trigger timing for the S4c scenario was set up so that the PTM was moving and had reached steady state speed before TTC has been reduced to 7 seconds (i.e., 7 seconds before SV-to-PTM contact would occur if there was no PAEB system intervention).

3. SV ZERO POSITION

- The SV was centered on the SV path at the start of the test lane. The PTM was located on the PTM path which was parallel to the SV path inside the test lane located on the nearside. The SV overlap was 25% of the SV width, which was the distance between the SV centerline path and the PTM centerline path. The PTM faced the direction specified for each test scenario.
- The SV was positioned such that it just contacted the PTM. This was the "zero position." Note that the determination of whether there was a collision between the SV and PTM was based on whether the zero position had been crossed. Note also that the arms of the PTM were not considered contact points.
- The zero position was documented prior to, and immediately after, conduct of a test series.

4. LAST MOMENT BRAKING

In order to reduce the likelihood of damage to both the PTM and test vehicle, it was determined that Last Moment Braking (LMB) would be implemented for scenarios in which the nominal speed was 40 km/h or higher. LMB is defined as braking applied by the driver to reduce the speed and energy of the collision with the PTM in the event that a collision becomes impossible to avoid.

LMB was implemented as follows: the computer onboard the SV continuously computed and monitored TTC. If TTC dropped below a preset value (i.e., 1.0 sec) and no alert or braking had been provided by the PAEB system at that time, then the computer would provide an audible beep, and the driver would apply the brakes forcefully and as quickly as possible. When LMB was used, the preset TTC value was selected such that a collision would be inevitable (i.e., even immediate maximum braking would not reduce SV speed enough to avoid colliding with the PTM). Thus, the overall outcome of the trial (collision/no collision) would not be affected by the use of LMB.

5. TEST TRIAL CONDUCT AND VALIDITY

An overview of each test trial is as follows: For each trial for the S4 scenarios, the SV and PTM were first positioned at their respective start positions. The SV was accelerated to its nominal test speed, and the driver maintained its position in the center of the lane. When the SV was at a designated longitudinal distance from the PTM, the PTM accelerated to its nominal test speed (S4c only). If a PAEB alert was issued by the vehicle, the driver then fully released the throttle (within 500 ms of the alert). After the vehicle either came to a stop or passed through the plane defined by the PTM's movement (S4c only), which is parallel to the SV's line of travel, the trial was concluded.

a. PTM Validity

For all S4 scenarios, a required condition for validity of every trial was that the PTM was secured to the motion apparatus such that its position relative to the apparatus remained constant throughout the test.

For the S4c scenario, the following additional criteria were required for test validity:

- The PTM was at the start position distance on the PTM path and did not move until the triggering criteria for motion were met.
- When triggered, the PTM was accelerated to the test speed over the required distance and held at that test speed until a contact event or the SV speed was reduced to zero and no contact had occurred.
    - PTM speed: 5 km/h (3.1 mph) within an acceleration distance of 1.0 m (3.28 ft)
    - PTM position: ±0.18 m from the ideal lateral position within the lane, as a function of SV longitudinal position within the lane[3].
- While the PTM was in motion, the PTM path remained parallel to the SV path. Lateral deviations induced by wind, equipment, or surface conditions were monitored.

b. SV Validity

For an individual test trial to be valid, the following criteria were required to be met:

- The SV driver seatbelt was latched.
- The SV driver cycled the ignition prior to each run.
- The front IBT was between 149°F (65°C) and 212°F (100°C) at the onset of each test.
    - If the IBT was less than 149°F (65°C), the brakes were heated to the IBT by making one or more brake applications from a speed of 31.1 mph (50 km/h), at a deceleration rate not greater than 0.31g (3 m/s²).

[3] The ideal lateral position of the PTM within the lane was calculated as a function of SV longitudinal lane position as described in Section III B 2 a ii and shown in Figure 7.

  - If the IBT was greater than 212°F (100°C), the SV was driven at speeds up to 62.1 mph (100 km/h) until the IBT specified in this section is reached.
- The SV was driven at the nominal speed specified for each test. The speed tolerance was ±1.0 km/h
- For scenario S4c only, PTM motion began when the longitudinal TTC of the SV = 7.0 seconds.
- The following requirements were held true throughout each trial:
  - The driver used the least amount of steering input necessary to maintain the SV position in the center of the test lane. The lateral distance between the centerline of the SV and the center of the travel lane did not deviate more than ± 20 cm (8 in). A measurement and display of SV lateral lane position was presented to the driver in order to regulate the lateral lane position during the execution of a trial. These data were also recorded and used as validation of lane position in post-process.
  - The yaw rate of the SV did not exceed ± 1.0 deg/s.
  - The SV driver modulated the throttle using smooth inputs to maintain a constant SV speed ±1.0 km/h.
  - With the exception of LMB (described above), the SV driver did not apply any force to the brake pedal until the end of the test unless the PTM was contacted by the SV.
- The SV throttle was fully released within 500 ms after the SV PAEB warning event was presented (visual, haptic, or audible). If no SV warning event was presented by the SV PAEB system, the SV driver modulated the throttle to maintain constant speed until either the onset of PAEB or, if the SV's PAEB system did not activate, the end of the test occurred (i.e., contact with the PTM occurred).

c. Validity Period

- The valid test interval began when the longitudinal TTC of the SV was 4.0 seconds.
- For scenarios S4a-b, the test ended when either of the following occurred:
  - The SV came into contact with the PTM; or
  - The SV came to a stop before making contact with the PTM.
- For scenario S4c, the test ended when either of the following occurred:
  - The SV came into contact with the PTM; or
  - 1 second after the velocity of the SV became less than or equal to that of the PTM.

d. End-of-Test Instructions

After the test was complete, the SV driver manually applied force to the brake pedal, bringing the vehicle to a stop (if necessary), and placed the transmission in park (automatic transmission) or neutral (manual transmission).

The test trial was then complete.

e. Number of Test Trial Repeats

Combinations of test speeds, and lighting conditions were tested as shown in Table 1. Five repeat trials were conducted for each test condition. As noted above, for all scenarios except S4c, the 16 and 40 km/h speeds were considered to be the "non-conditional" speeds. Testing at these speeds was conducted without regard to whether the results showed that "consistent contact" occurred between the SV and PTM. Consistent contact was defined as the SV contacting the PTM in three or more test trials at a given speed. If this occurred, then testing at any higher speeds was not conducted. Rather, the speed would be reduced by 5 km/h and testing of that scenario and lighting treatment would be conducted at that lower speed. This was done to more precisely identify the highest speed at which the vehicle's PAEB system was able to avoid colliding with the PTM.

f. Speed Reduction

The magnitude of the SV speed reduction attributable to PAEB intervention (as shown in Datasheet 1) was calculated in one of two ways, depending on whether a test trial concluded with the SV colliding with the PTM.

- If the SV contacted the PTM during a test trial, the PAEB speed reduction was calculated by subtracting the SV speed at the time of contact (i.e., when the longitudinal range becomes zero) from the average SV speed calculated at TTC = 4.0 seconds.
- If the SV did not contact the PTM during a test trial (i.e., PAEB intervention prevented the crash):
    - Scenarios S4a-b: The SV speed at the time of SV and PTM contact was taken to be zero. The speed reduction was therefore equal to the SV speed at TTC = 4.0 seconds.
    - Scenario S4c: The PAEB speed reduction was calculated by subtracting the SV speed at the minimum longitudinal SV-to-PTM range during the validity period from the SV speed at TTC = 4.0 seconds.

g. Pass/Fail Criteria

There were no pass/fail criteria for these research tests.

D. Summary of Scenarios

Figure 11 illustrates the offset conditions used for the different scenarios and Tables 3 through 6 provide summaries of the scenario setups.

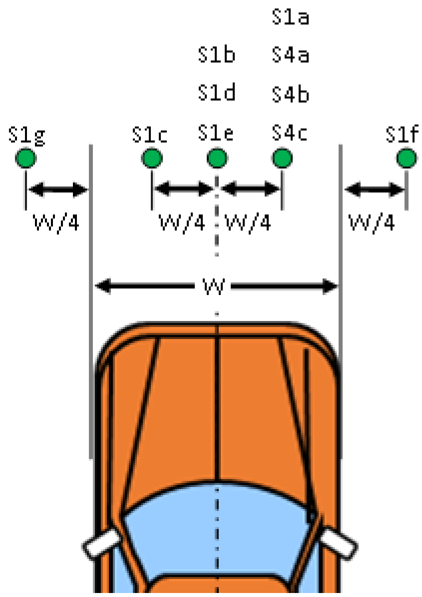


Figure 11. Offset Conditions

Table 3. Summary of S1a-b-c-d-f-g Scenarios Setup

PTM Type	Adult (S1a-b-c-f-g) Child (S1d)	
PTM Location	Nearside	
PTM Action	Crossing SV Path (S1a-b-c-d-g)	
	Not crossing SV Path (S1f)	
PTM Move Distance	6 m (19 ft)	
PTM Start Distance	3.5 m (11.48 ft)	
PTM Acceleration Distance	0.5 m (1.64 ft)	
Overlap *(Determined from the SV width. Measurement transferred to the location on the PTM path. Minus 25% and 125% do not result in SV-to-PTM contact.)*	S1a	25%
	S1 b-d	50%
	S1c	75%
	S1f	-25%
	S1g	125%
SV Start Distance	182 m (600 ft)	
Lane Width *(Not standard lane width. Adapted to SV width. Lane width should be centered on SV path.)*	SV Width + 40 cm (16 in)	
Lane Length *(Based on 4.0 sec TTC and SV speed = 40 km/h (25 mph).)*	44 m (145 ft)	
Obstruction *(S1d only)*	PV1D1	1 m (3.2 ft)
	PV2D1	1 m (3.2 ft)
	PVD1	1 m (3.2 ft)

Drawing illustrates setup but is not to scale

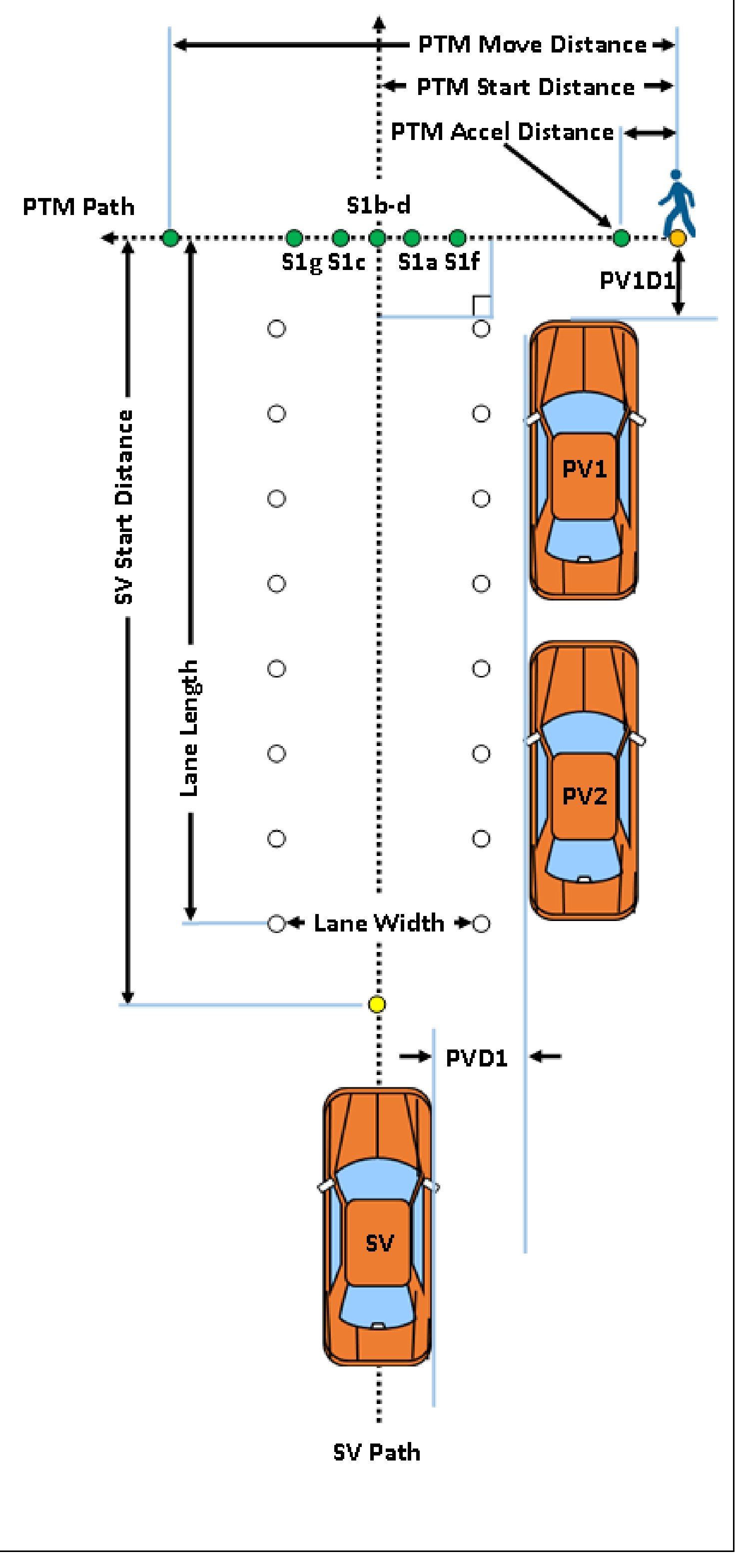


Table 4. Summary of S1e Scenario Setup

PTM Type	Adult	**Drawing illustrates setup but is not to scale**
PTM Location	Offside	
PTM Action	Crossing SV Path	
PTM Move Distance	9 m (29.5 ft)	
PTM Start Distance	5.5 m (18 ft)	
PTM Acceleration Distance	1.0 m (3.2 ft)	
Overlap *(Determined from the SV width. Measurement transferred to the location on the PTM path.)*	50%	
SV Start Distance	182 m (600 ft)	
Lane Width *(Not standard lane width. Adapted to SV width. Lane width should be centered on SV path.)*	SV Width + 40 cm (16 in)	
Lane Length *(Based on 4.0 sec TTC and SV speed = 40 km/h (25 mph).)*	44 m (145 ft)	

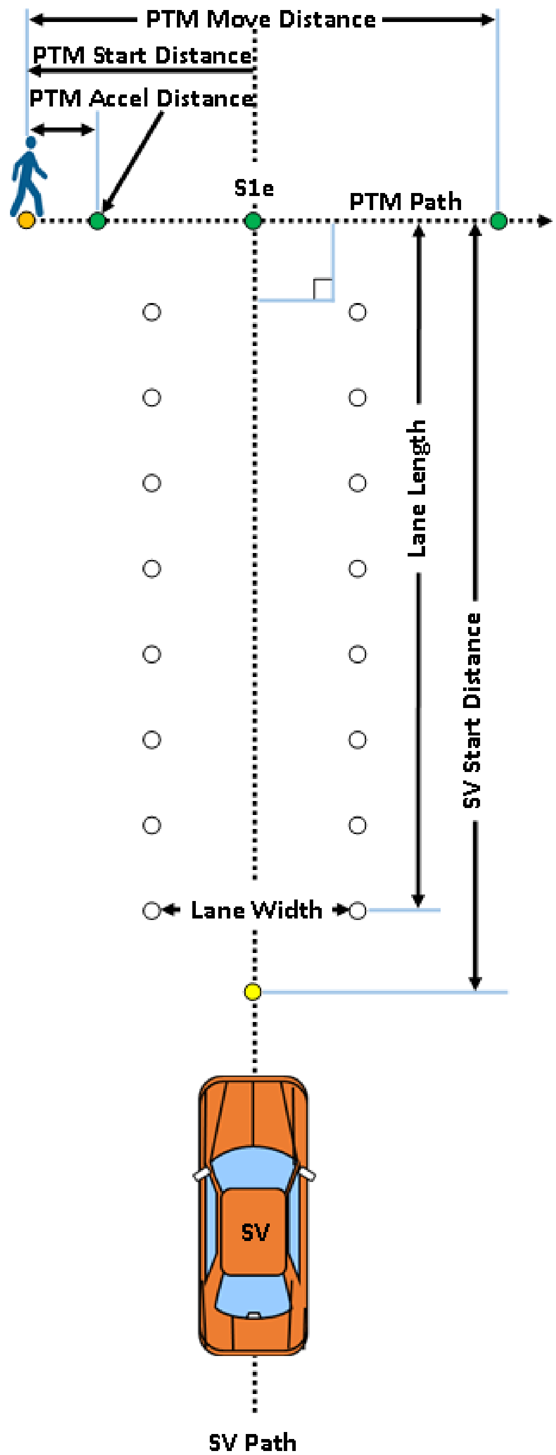


Table 5. Summary of S4a-b Scenarios Setup

S4a-b Scenario		
PTM Type	Adult	
PTM Location	Nearside In-Path	
PTM Action	S4a	Stationary Facing Away
	S4b	Stationary Facing Towards
PTM Move Distance	N/A	
PTM Start Distance	N/A	
PTM Acceleration Distance	N/A	
Overlap *(Determined from the SV width. Measurement transferred to the location on the PTM path.)*	25%	
SV Start Distance	182 m (600 ft)	
Lane Width *(Not standard lane width. Adapted to SV width. Lane width should be centered on SV path.)*	SV Width + 40 cm (16 in)	
Lane Length *(Based on 4.0 sec TTC and SV speed = 40 km/h (25 mph).)*	44 m (145 ft)	

Drawing illustrates setup but is not to scale

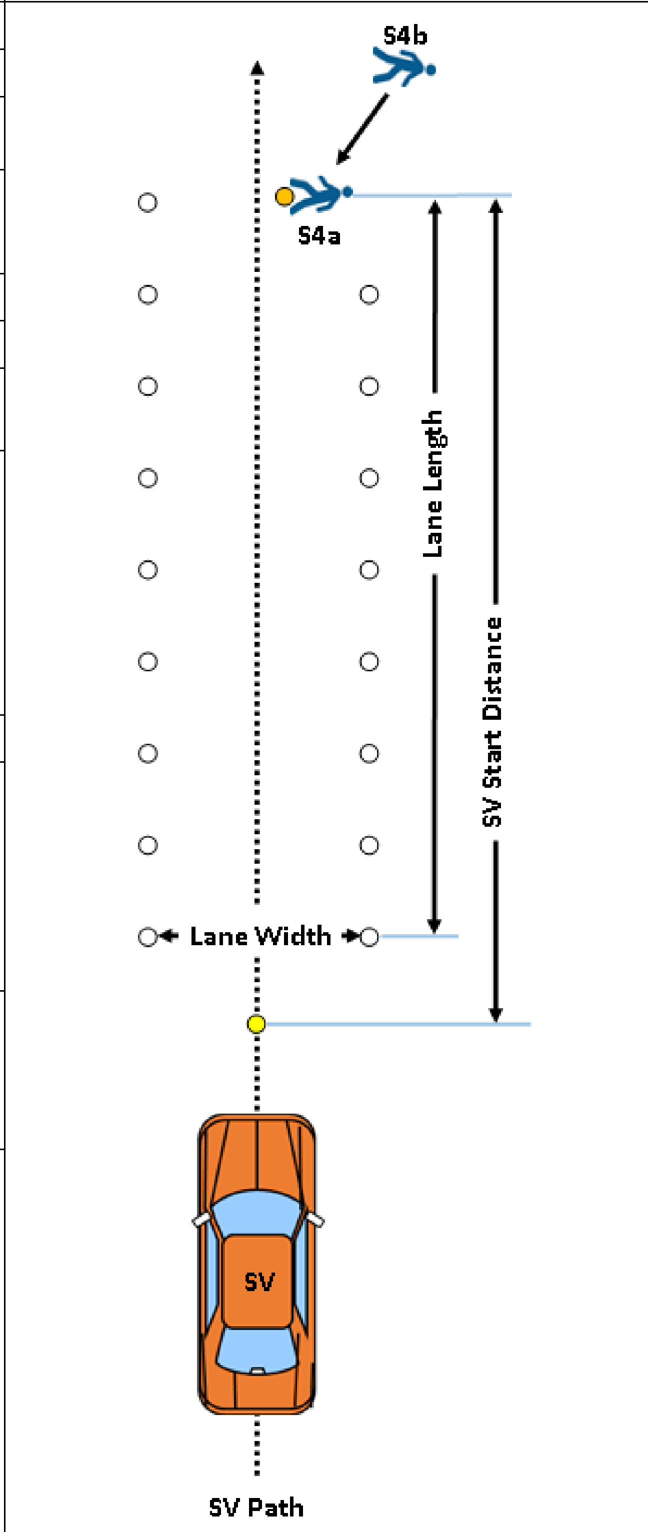
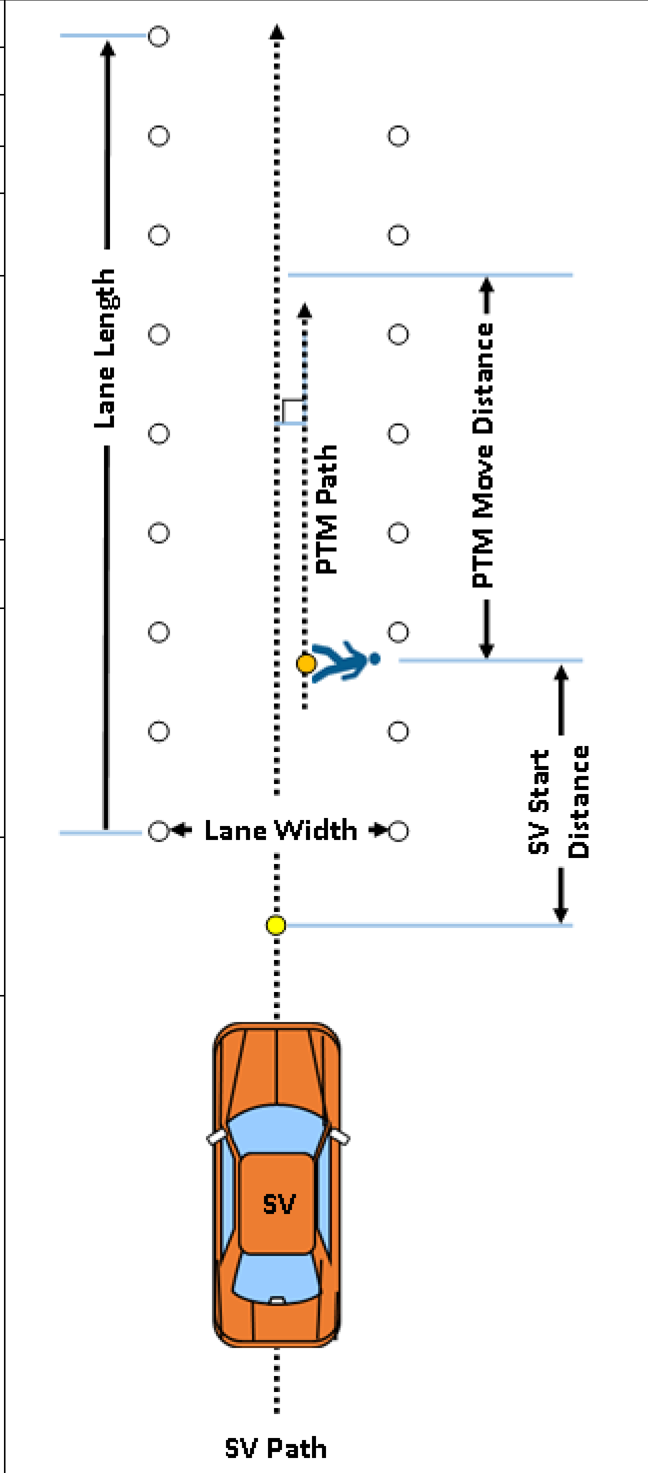


Table 6. Summary of S4c Scenario Setup

PTM Type	Adult	**Drawing illustrates setup but is not to scale**
PTM Location	Nearside In-Path	
PTM Action	Moving Away	
PTM Move Distance	17 m (55 ft)	
PTM Start Distance	N/A	
PTM Acceleration Distance	1 m (3.28 ft)	
Overlap *(Determined from the SV width. Measurement transferred to the location on the PTM path.)*	25%	
SV Start Distance	182 m (600 ft)	
Lane Width *(Not standard lane width. Adapted to SV width. Lane width should be centered on SV path.)*	SV Width + 40 cm (16 in)	
Lane Length *(Based on 4.0 sec TTC and SV speed = 40 km/h (25 mph).)*	44 m (145 ft)	



E. Pre-Test Brake Burnishing

To achieve full brake system capability, and to ensure consistent performance, the procedure defined in section 14.1.2 and section 14.1.3 of NHTSA Laboratory Test Procedure for FMVSS No. 135 Light Vehicle Brake Systems (TP-135-01) was used to burnish new SV brake components.

- The SV was loaded to its GVWR.
- From a speed of 49.7 mph (80 km/h), 200 stops were performed with an average deceleration of 0.31g (3.0 m/s²) during each stop.
    - Each stop was performed with the transmission in gear.
    - The Initial Brake Temperature (IBT), defined as the average brake pad or lining friction material temperature on the highest-temperature axle of the SV at the onset of a test trial, was ≤ 100°C (212°F) at the onset of each stop.
    - The interval from the onset of one stop to the onset of the next was either the time necessary to reduce the IBT to ≤ 100°C (212°F), or the distance of 2 km (1.24 miles), whichever occurred first.
    - The vehicle was accelerated to 49.7 mph (80 km/h) after each stop and that speed was maintained until initiating the next.

1. <u>SV BRAKE WARM-UP AND TEMPERATURE MAINTENANCE DURING TESTING</u>

The IBT was between 149°F (65°C) and 212°F (100°C) at the onset of each test.

- If the IBT was less than 149°F (65°C), the brakes were heated to the IBT by making one or more brake applications from a speed of 31.1 mph (50 km/h), at a deceleration rate not greater than 0.31g (3 m/s²).
- If the IBT was greater than 212°F (100°C), the SV was driven at speeds up to 62.1 mph (100 km/h) until the IBT specified was reached

F. Pedestrian Test Mannequin and Motion System

Adult and child Pedestrian Test Mannequins (PTMs) from 4activeSystems were used for these tests. These are articulated mannequins with movable legs and poseable arms. Note that these mannequins are used in Euro NCAP PAEB testing.

The mannequins are strikeable objects with certain characteristics representative of humans. The adult mannequin represents a 50^{th} percentile adult male, and the child mannequin represents a 7-year-old child. They were designed to be recognized by mono and stereo cameras, as well as by radar and infrared systems.

The motion system used for these tests was the Micro Low Profile Robotic Vehicle (µLPRV) developed by Dynamic Research, Inc. The µLPRV is a small robotic platform that is self-contained, self-propelled, self-guided, and programmable, such that it can follow 2-dimensional trajectories in coordination with the SV. The µLPRV comprises an over-runnable chassis, drive system, steering system, DGPS/IMU sensor, wireless communication system, and control software in order to measure and control the movements of the µLPRV during a test sequence. The pedestrian mannequins are affixed by means of a central clear plastic post. At the base of the clear plastic post, a plastic-covered steel flange is captured by a horseshoe-shaped clamp that attaches to a ferrous plate secured to the upper surface of the µLPRV by magnetic attraction between the ferrous plate on the surface of the µLPRV and the high-power magnets in the horseshoe shaped clamp.

In operation, position and velocity information from the SV are transmitted continuously over a WiFi network to a control computer. The control computer coordinates the motions of the µLPRV and the SV, so that the scenarios can be controlled in a precise and repeatable way.

G. Instrumentation

Table 7 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

Table 7. Test Instrumentation and Equipment

<table>
<tr><th>Type</th><th>Output</th><th>Range</th><th>Accuracy, Other Primary Specs</th><th>Mfr, Model</th><th>Serial Number</th><th>Calibration Dates
Last
Due</th></tr>
<tr><td>Tire Pressure Gauge</td><td>Vehicle Tire Pressure</td><td>0-100 psi
0-690 kPa</td><td>< 1% error between 20 and</td><td>Omega DPG8001</td><td>17042707002</td><td>By: DRI
Date: 8/18/2020
Due: 8/18/2021</td></tr>
<tr><td>Platform Scales</td><td>Vehicle Total, Wheel, and Axle Load</td><td>1500 lb/platform</td><td>0.5% of applied load</td><td>Intercomp SW500</td><td>0410MN20001</td><td>By: DRI
Date: 4/20/2020
Due: 4/20/2021</td></tr>
<tr><td>Linear (string) encoder</td><td>Throttle pedal travel</td><td></td><td></td><td></td><td>49041190</td><td>By: DRI
Date: 7/2/2020
Due: 7/2/2021</td></tr>
<tr><td>SV Multi-Axis Inertial Sensing System</td><td rowspan="2">Position;
Longitudinal, Lateral, and Vertical Accels;
Lateral, Longitudinal and Vertical Velocities;
Roll, Pitch, Yaw Rates;
Roll, Pitch, Yaw Angles</td><td rowspan="2">Latitude: ±90º
Longitude: ±180º
Altitude: 0-18 km
Velocity: 0-1000 knots Accel: ±5g
Angular Rate: ±300 º/s
Angular Disp: ±180º</td><td rowspan="2">Position: ±2 cm
Velocity: 0.1 km/h
Accel: ≤ 0.05%
Angular Rate: ≤ 0.05%
Roll/Pitch Angle: ±0.05º
Heading Angle: ±0.1º</td><td rowspan="2">Oxford xNAV 550</td><td>015386</td><td>By: Oxford Technical Solutions
Date: 8/8/2019
Due: 8/8/2021</td></tr>
<tr><td>PTT Multi-Axis Inertial Sensing System</td><td>015102</td><td>By: Oxford Technical Solutions
Date: 3/6/2020
Due: 3/6/2022</td></tr>
</table>

Table 7. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2020 Due: 1/6/2021
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 ms	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A

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

H. Pre-Test Brake Burnishing

To achieve full brake system capability, and to ensure consistent performance, the procedure defined in section 14.1.2 and section 14.1.3 of NHTSA Laboratory Test Procedure for FMVSS No. 135 Light Vehicle Brake Systems (TP-135-01) was used to burnish new SV brake components.

- The SV was loaded to its GVWR.
- From a speed of 49.7 mph (80 km/h), 200 stops were performed with an average deceleration of 0.31g (3.0 m/s²) during each stop.
    - Each stop was performed with the transmission in gear.
    - The Initial Brake Temperature (IBT), defined as the average brake pad or lining friction material temperature on the highest-temperature axle of the SV at the onset of a test trial, was ≤ 100°C (212°F) at the onset of each stop.
    - The interval from the onset of one stop to the onset of the next was either the time necessary to reduce the IBT to ≤ 100°C (212°F), or the distance of 2 km (1.24 miles), whichever occurred first.
    - The vehicle was accelerated to 49.7 mph (80 km/h) after each stop and that speed was maintained until initiating the next.

2. <u>SV BRAKE WARM-UP AND TEMPERATURE MAINTENANCE DURING TESTING</u>

The IBT was between 149°F (65°C) and 212°F (100°C) at the onset of each test.

- If the IBT was less than 149°F (65°C), the brakes were heated to the IBT by making one or more brake applications from a speed of 31.1 mph (50 km/h), at a deceleration rate not greater than 0.31g (3 m/s²).
- If the IBT was greater than 212°F (100°C), the SV was driven at speeds up to 62.1 mph (100 km/h) until the IBT specified was reached.

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle As-Delivered

Figure A2. Rear View of Subject Vehicle As-Delivered

Figure A3. Front View of Subject Vehicle As-Tested

Figure A4. Rear View of Subject Vehicle As-Tested

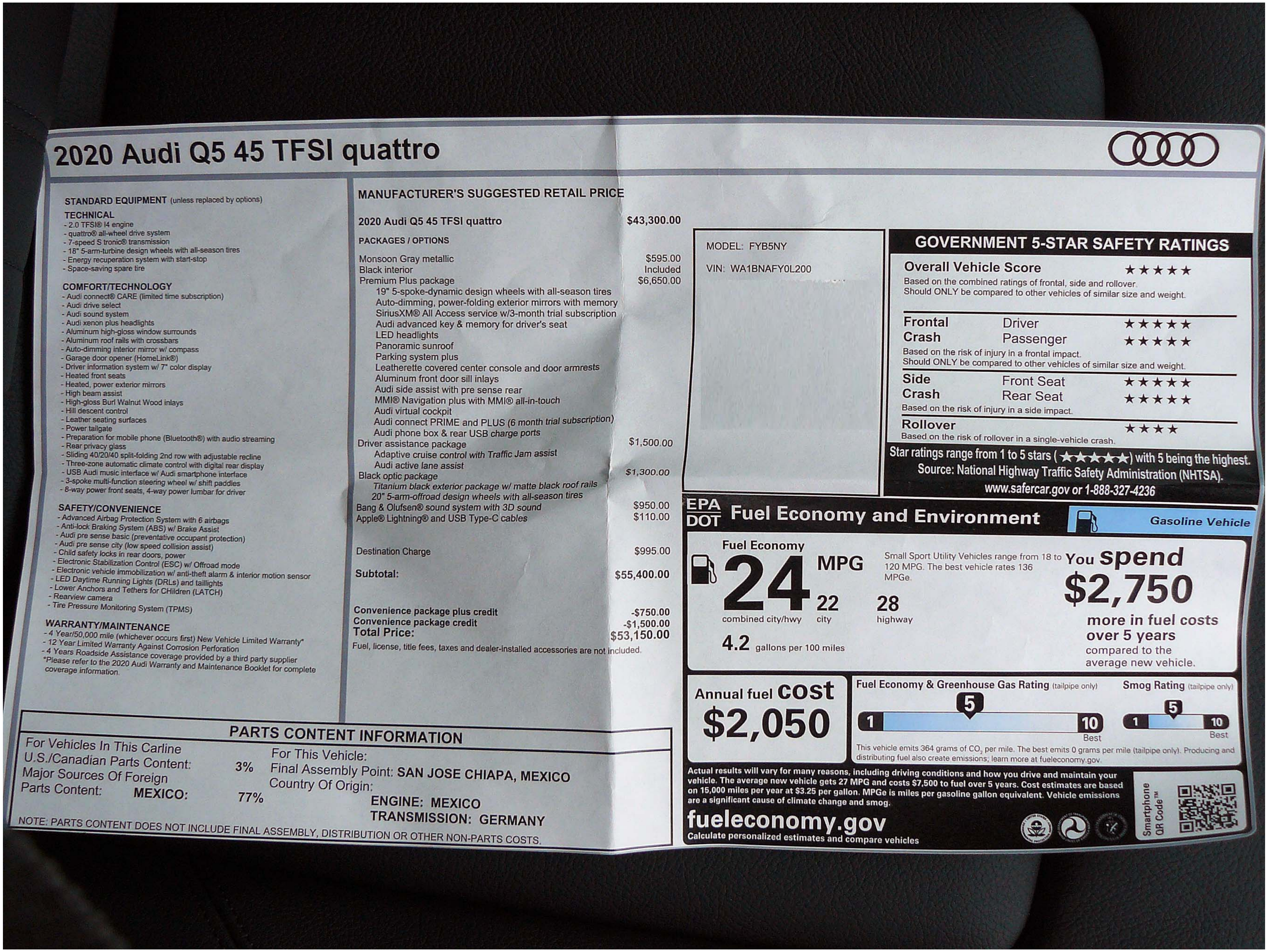


Figure A5. Window Sticker (Monroney Label)

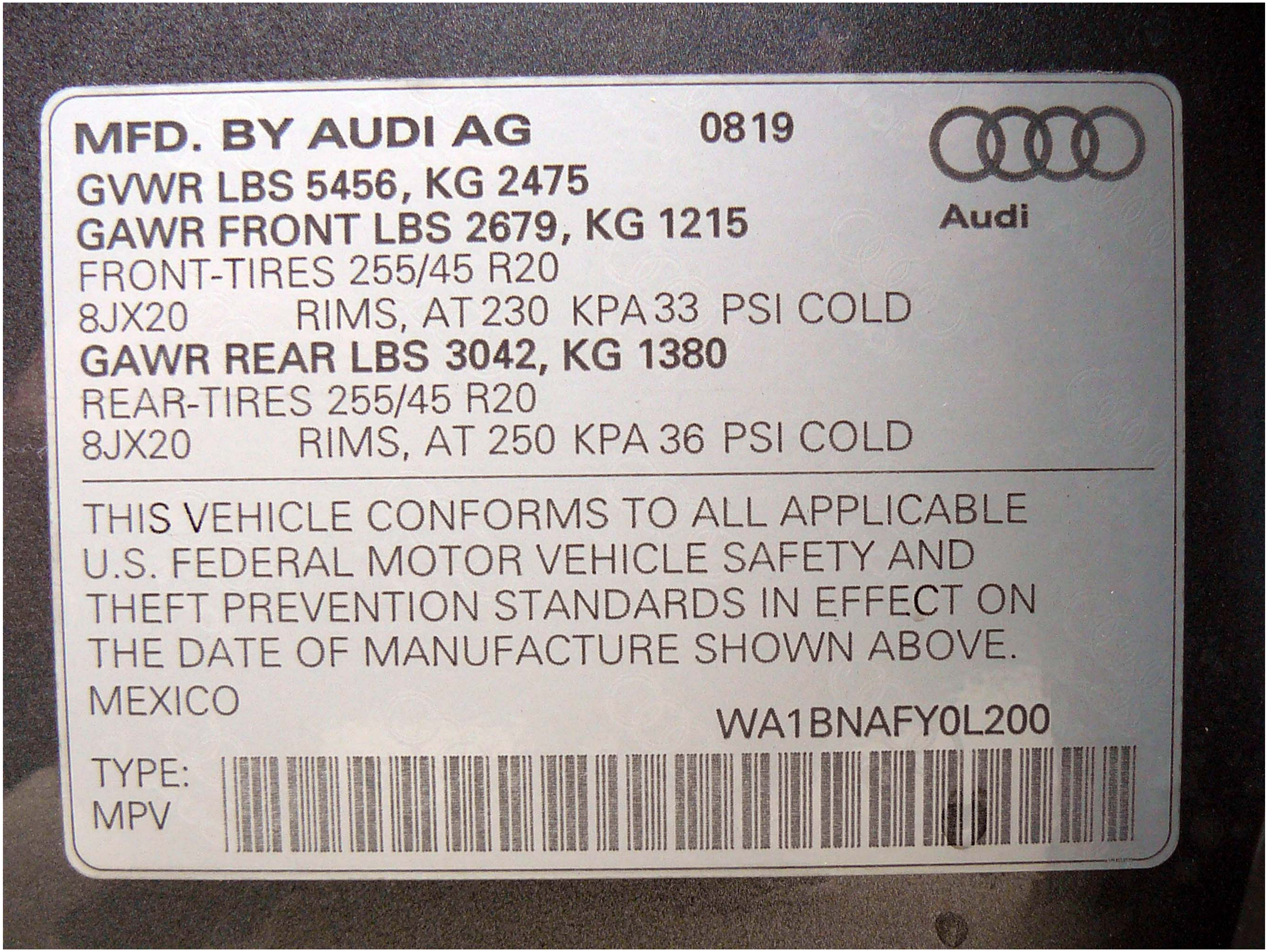


Figure A6. Vehicle Certification Label

Figure A7. Tire Placard

Figure A8. Adult and Child Pedestrian Surrogates and Motion Platform

Figure A9. Obstruction Vehicles

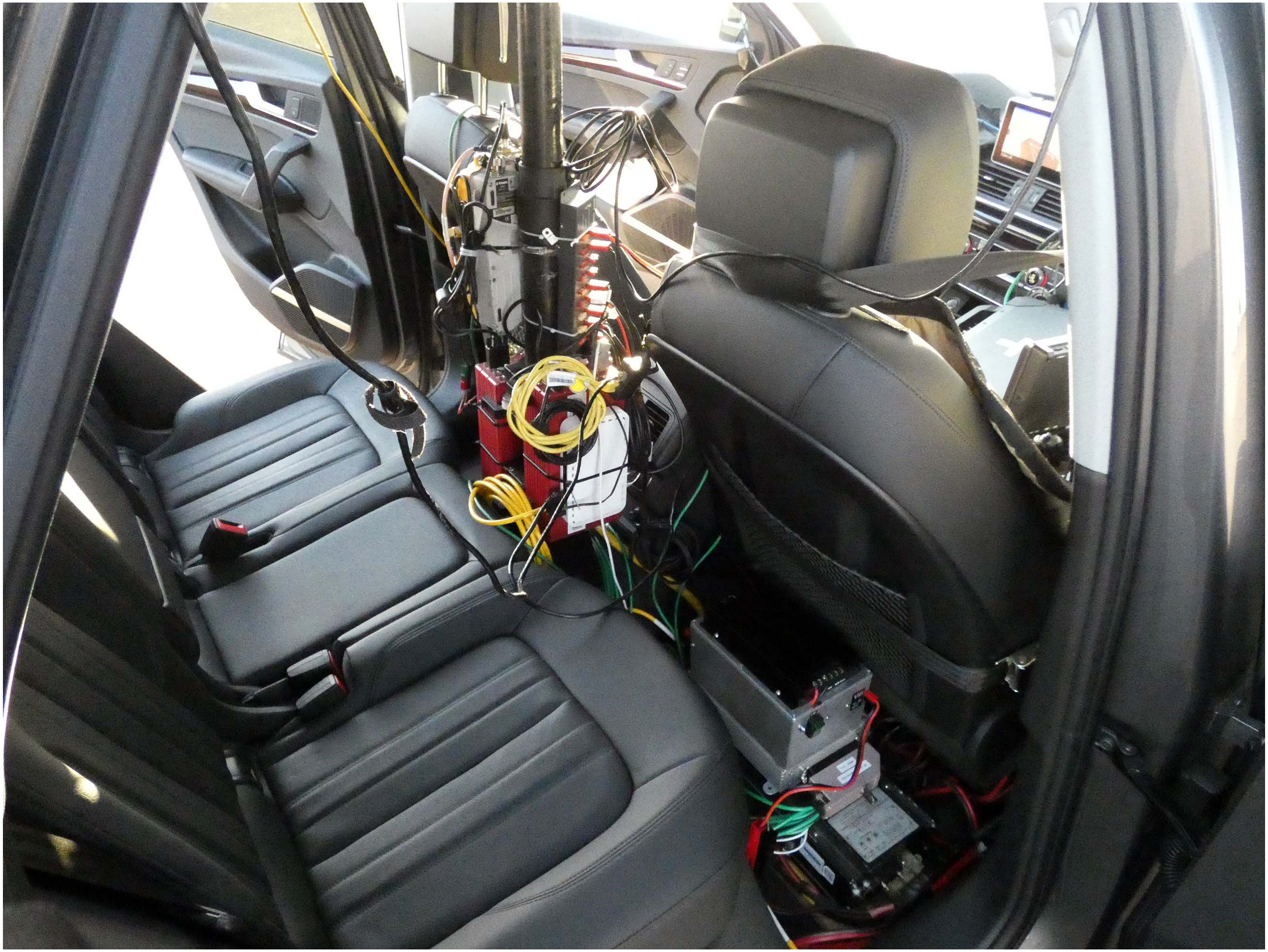


Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

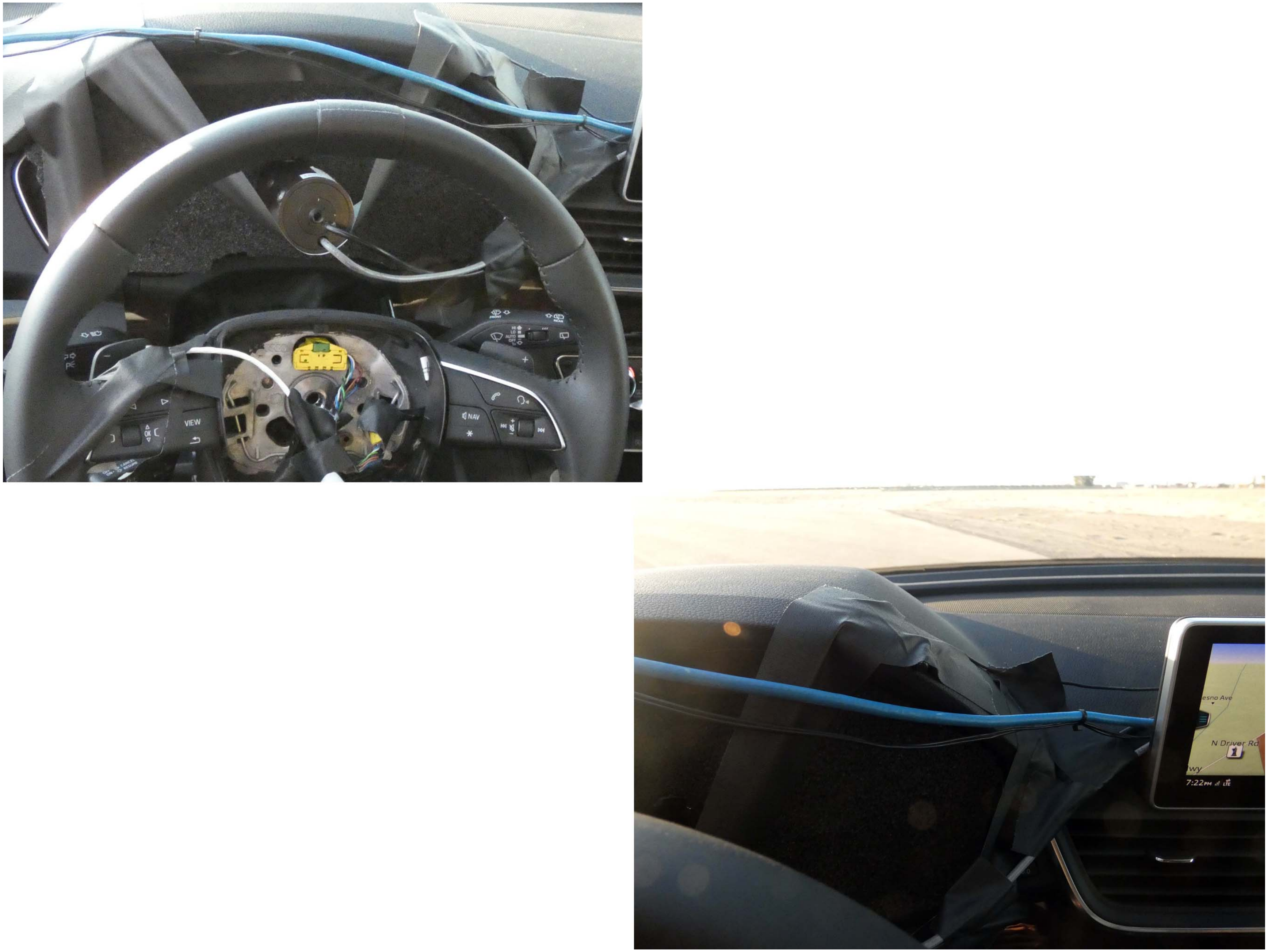


Figure A11. Sensors for Detecting Auditory and Visual Alerts

Figure A12. Computer Installed in Subject Vehicle

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

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

Figure A15. Controls for System Setup

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

Indicator lights overview

Description

The indicator lights in the instrument cluster blink or turn on. They indicate functions or malfunctions.

Messages may appear with some indicator lights. A warning signal will sound at the same time. The indicator lights and messages may be covered by other displays. To show them again, select the second tab for messages with the multifunction steering wheel ⇨ *page 17* or ⇨ *page 20*.

Some indicator lights in the display can display in several colors.

⚠ Central indicator light

If the ⚠ or ⚠ indicator light turns on, check the message in the instrument cluster.

Overview

Some indicator lights turn on briefly as a function check when you switch the ignition on. These systems are marked with a ✓ in the following tables. If one of these indicator lights does not turn on, there is a malfunction in that system.

Your vehicle has either a monochrome display or a multicolored display, depending on vehicle equipment. Some indicator lights appear white on a monochrome display. The ⚠ or ⚠ central indicator light turns on at the same time to indicate the priority of these indicator lights.

The following indicator lights may be available, depending on the vehicle equipment:

Red indicator lights

⚠	Central indicator light ⇨ *page 10*, Audi pre sense ⇨ *page 131*, instrument cluster ⇨ *page 14*
	Safety belt ⇨ *page 273*
	Engine start system ⇨ *page 76*
	Transmission ⇨ *page 82*
	Drive system ⇨ *page 86*
PARK	Electromechanical parking brake ⇨ *page 89*
(P)	Electromechanical parking brake ⇨ *page 89*
(!)	Brake system ✓ ⇨ *page 90*, ⇨ *page 89*, ⇨ *page 335*
BRAKE	Brake system ✓ ⇨ *page 90*, ⇨ *page 89*, ⇨ *page 335*
	Steering ✓ ⇨ *page 166*
	Air suspension ⇨ *page 23*
	Electrical system ⇨ *page 336*
	Engine oil pressure ⇨ *page 330*
MIN	Engine oil level (MIN) ⇨ *page 330*
	Cooling system ⇨ *page 333*
	Hood ⇨ *page 328*
	Adaptive cruise control ✓ ⇨ *page 123*
	Traffic jam assist ⇨ *page 128*

Yellow indicator lights

⚠	Central indicator light ⇨ *page 10*
	Safety systems ✓ ⇨ *page 269*
	Transmission ⇨ *page 82*

▶

	Drive system ⇨ page 86, ⇨ page 333
	Vehicle sound ⇨ page 86
	Engine start system ⇨ page 76
	Keys ⇨ page 76
	Electromechanical parking brake ⇨ page 90
	Brake system ⇨ page 89
	Electronic Stabilization Control (ESC) ⇨ page 22
OFF	Electronic Stabilization Control (ESC) ✓ ⇨ page 22
ESC OFF	Electronic Stabilization Control (ESC) ⇨ page 165
ABS	Anti-lock braking system (ABS) ✓ ⇨ page 22
(ABS)	Anti-lock braking system (ABS) ✓ ⇨ page 22
	Steering ⇨ page 166

	All wheel drive/sport differential ⇨ page 23
	Suspension control ⇨ page 23
	Air suspension ⇨ page 23
	Engine speed limitation ⇨ page 16
	Tank system ⇨ page 324
	Electrical system ⇨ page 336
MIN	Engine oil level (MIN) ⇨ page 330
MAX	Engine oil level (MAX) ⇨ page 330
SENSOR	Engine oil sensor ⇨ page 330
	Malfunction Indicator Lamp (MIL) ✓ ⇨ page 326
	Engine warm-up request ⇨ page 330
	Washer fluid level ⇨ page 339
	Windshield wipers ⇨ page 50
AC	Charging system ⇨ page 100
P	Parking aid ⇨ page 163
	Tire pressure ⇨ page 359
TPMS	Tire pressure ⇨ page 359
	Bulb failure indicator ⇨ page 44
	Headlight range control system ⇨ page 44
	Adaptive light ⇨ page 44
	Light/rain sensor ⇨ page 44, ⇨ page 50
	Driver's door ⇨ page 30
	Battery in vehicle key ⇨ page 27
	Audi side assist ⇨ page 145
	Active lane assist ⇨ page 137
	Audi pre sense ⇨ page 135
SOS	Emergency call function ⇨ page 217

►

80A012721BJ

General information

Applies to: vehicles with Audi adaptive cruise control

Fig. 110 Front of the vehicle: sensors and video camera

The areas with the radar and ultrasonic sensors and the video camera ⇨ *fig. 110* must not be covered by stickers, deposits or any other objects, because this can interfere with the adaptive cruise control function. For information on cleaning, see ⇨ *page 361*. The same applies for any modifications made in the front area.

In some driving situations, the adaptive cruise control function is restricted:

– Vehicles can only be detected when they are within the sensor detection zones ⇨ *page 121, fig. 109*.
– The system has a limited ability to detect vehicles that are a short distance ahead, off to the side of your vehicle or moving into your lane.
– Objects that are difficult to detect such as motorcycles, vehicles with high ground clearance or an overhanging load are detected late or not detected at all.
– When driving through curves ⇨ *page 123*.
– When the vehicle is stationary ⇨ *page 123*.

⚠ WARNING

Always pay attention to the traffic around you when adaptive cruise control is switched on. As the driver, you are still responsible for your own speed and the distance to other vehicles. The adaptive cruise control is used to assist you. The driver must always take action to avoid a collision. The driver is always responsible for braking at the correct time.

– For safety reasons, do not use adaptive cruise control when the road surface is in poor condition and/or in bad weather conditions (such as ice, fog, gravel, heavy rain and hydroplaning). Using the system under these conditions increases the risk of an accident.
– Switch adaptive cruise control off temporarily when driving in turning lanes, on expressway exits (except if predictive control is switched on) or in construction zones. This prevents the vehicle from accelerating to the stored speed when in these situations.
– The adaptive cruise control system will not brake by itself if you put your foot on the accelerator pedal. Doing so can override the speed and distance regulation.
– When approaching stationary obstacles such as stopped traffic, adaptive cruise control will respond with limited function.
– Adaptive cruise control does not respond to people, animals, or crossing or oncoming objects.
– The function of the radar sensors can be affected by reflective objects such as guard rails, the entrance to a tunnel, heavy rain or ice.

(!) Note

The sensors can be displaced by impacts or damage to the bumper, wheel housing and underbody. This can impair the adaptive cruise control. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

(i) Tips

For an explanation on conformity with the FCC regulations in the United States and the Industry Canada regulations, see ⇨ *page 390*.

Distance warning: currently unavailable. See owner's manual

This message appears if the system has a temporary failure. If this occurs multiple times, drive to an authorized Audi dealer or authorized Audi Service Facility immediately to have the malfunction corrected.

ACC: Please fasten seat belt

The system is not completely available if the driver's seat belt is unfastened.

Stationary object ahead

This message appears if you would like to switch the system on and there is a stationary object directly in front of your vehicle.

Door open

The system is not available when the door is open.

Audi pre sense

Introduction

Applies to: vehicles with Audi pre sense

Within the limits of the system, the pre sense functions can initiate measures in particularly dangerous situations to protect the vehicle passengers and other road users.

– Due to the interlinking of various vehicle systems, critical driving situations can be detected by **pre sense basic** and measures for preventative occupant protection are can be initiated.
– The **pre sense front** system uses the data from the adaptive cruise control* radar sensors and the camera to calculate the probability of a collision. Within the limits of the system, an impending collision with vehicles can be detected in both urban and rural speed ranges. In this case, the system warns the driver visually, acoustically and with a jerk on the brakes if necessary. If needed, it can initiate a partial or full deceleration to reduce the collision speed or to avoid the collision under certain circumstances. In conjunction with pre sense basic/rear, the front safety belts are also reversibly tensioned when needed. The pre sense front is also active when adaptive cruise control* is switched off.
– **Pre sense rear** contains pre sense basic functions. It uses the data from the side assist* radar sensors and calculates within the limits of the system the probability of a rear end collision with the vehicle behind you. Pre sense rear is also active when side assist* is switched off.
– Within the limits of the system, **pre sense city** uses the camera data and can detect an impending collision with vehicles and pedestrians. In this case, the system warns the driver visually, acoustically and with a jerk on the brakes if necessary. If needed, it can initiate a full deceleration to reduce the collision speed or to avoid the collision under certain circumstances. In conjunction with pre sense basic/rear, the front safety belts are also reversibly tensioned when needed.

⚠ WARNING

Read the general information in ⇨ ⚠ *in General information on page 122*, ⇨ ⚠ *in General information on page 141*.

ⓘ Tips

– Certain pre sense functions switch off when driving in reverse.
– The pre sense functions may not be available if there is a malfunction in the ESC system or the airbag control module.
– Note that the reversible belt tensioner on the front passenger's side deactivates when the front passenger's airbag is deactivated.
– Switch the pre sense off when you are not using public streets or when loading the vehicle onto a vehicle carrier, train, ship, or other type of transportation. This can prevent an undesired intervention from the pre sense system.

Audi pre sense basic

Applies to: vehicles with Audi pre sense basic

The pre sense basic functions are activated at a speed of approximately 20 mph (30 km/h) or higher. ▶

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The following functions can be triggered under certain conditions within the limits of the system:

– Tensioning of the safety belts (for example, during heavy braking): the front safety belts have reversible belt tensioners. If a collision does not occur, the safety belts loosen slightly and are ready to trigger again.
– Closing the windows and sunroof*
– Activation of the emergency flashers[1]

The message **Audi pre sense** ⚠ ⇨ *page 132, fig. 123* will warn you about the danger.

Audi drive select*: the trigger times are adjusted depending on the mode selected.

Audi pre sense front

Applies to: vehicles with Audi pre sense front

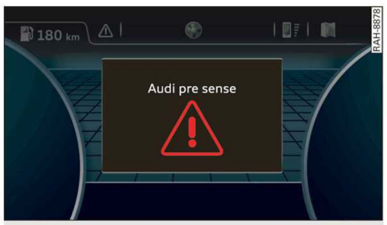

Fig. 123 Instrument cluster: approach warning

Description

Within the limits of the system, pre sense front can warn you of impending collisions and initiate the corresponding braking maneuvers or the supporting measures when avoiding a collision.

If detected in time, the system can rank the dangerous situation as critical if a vehicle driving ahead brakes suddenly, if your own vehicle is approaching a significantly slower vehicle at high speed or when there is an oncoming vehicle during a turning maneuver.

If detection is not possible, then pre sense front does not react.

Warnings

The system recognizes various dangerous situations. The **early warning** occurs if:

– A vehicle driving ahead brakes suddenly
– Your own vehicle approaches a significantly slower vehicle or stationary vehicle in the direction of travel

When this warning occurs, it may only be possible to avoid a collision by swerving or braking strongly. The message **Audi pre sense** ⚠ ⇨ *fig. 123* and a warning tone will warn you about the danger.

If you do not react enough or not at all to a dangerous situation that was detected by the system, pre sense front provides assistance by applying the brakes.

If a collision is imminent, the system will first provide an **acute warning** by braking sharply. You will also warned by an indicator in the instrument cluster display ⇨ *fig. 123*. If you do not react to the acute warning, pre sense front can brake with increasing force within the limits of the system [1]. This reduces the vehicle speed in the event of a collision. At low vehicle speeds, pre sense front can initiate a complete deceleration shortly before a collision with a vehicle driving ahead [1]. If pre sense front determines that you are not braking strongly enough when a collision is imminent, it can increase the braking force.

The following functions trigger in conjunction with pre sense basic/rear at corresponding vehicle speeds:

– Reversible tensioning of the front safety belts
– Closing the windows and sunroof*

Audi drive select*: depending on the selected mode, the reversible belt tensioner and the closing of the windows and sunroof* are not active.

Swerve assist

Swerve assist helps you to steer the vehicle around an obstacle in a critical situation. If you avoid an obstacle after the acute warning, then the swerve assist assists you by applying slight ▶

[1] This is not available in some countries.

underbody. Pre sense rear can be impaired by this. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

Tips

- The pre sense rear functions switch off when towing a trailer.
- The pre sense rear functions may also switch off if there is a malfunction in the side assist* system.

Audi pre sense city

Applies to: vehicles with Audi pre sense city

Description

Within the limits of the system, pre sense city can warn you of impending collisions with vehicles and pedestrians and initiate the applicable braking maneuver if needed. Pre sense city is active at speeds of approximately 6 mph (10 km/h) and higher.

A pedestrian warning can occur at speeds up to 50 mph (85 km/h), and vehicle warnings can occur at speeds up to 155 mph (250 km/h). A pre sense city braking maneuver is possible at speeds up to 50 mph (85 km/h).

Warnings

The system recognizes various dangerous situations. The **early warning** occurs if:

- A vehicle driving ahead brakes suddenly
- Your own vehicle approaches a vehicle in front of you that is traveling at a significantly slower speed or that is stationary
- A pedestrian is standing in the lane or is moving into the lane

When this warning occurs, it may only be possible to avoid a collision by swerving or braking strongly. The message **Audi pre sense** ⚠ ⇨ *page 132, fig. 123* and a warning tone will warn you about the danger.

The brakes may also be applied as an **acute warning** when there is an impending collision. If you do not react to the acute warning, pre sense city can brake to the point of complete deceleration within the limits of the system. This reduces the vehicle speed in the event of a collision. The message **Audi pre sense** ⚠ also appears.

The following functions are triggered in conjunction with pre sense basic/rear:

- Reversible tensioning of the front safety belts
- Closing the windows and sunroof*

Audi drive select*: the function is not active depending on the mode selected.

⚠ WARNING

- Pre sense city cannot overcome the laws of physics. It is a system designed to assist and it cannot prevent a collision in every circumstance. The driver must always intervene. The driver is always responsible for braking at the correct time. Do not let the increased safety provided tempt you into taking risks. This could increase your risk of a collision.
- The system can deploy incorrectly due to system-specific limits.
- To reduce the risk of an accident, please note that the camera does not always detect every object.
- Pre sense city does not react to animals, crossing or oncoming vehicles, objects such as bars, railings or railcars, and objects that are difficult to detect ⇨ ⚠ *in General information on page 122*.
- In trailer mode, the braking behavior of the trailer can be different than usual during automatic braking.

⚠ WARNING

Pre sense city may be restricted or unavailable in the following types of situations:

- In heavy fog, rain, spray, or snow
- When there are visual obstructions, such as glare, reflections or variations in light
- When it is dark
- If the camera window or the windshield is dirty, iced over, damaged or covered
- When driving on snow, ice or loose ground
- In curves
- If the ESC was restricted or switched off
- When towing a trailer

– When the driver's seat belt is unfastened
– For several seconds after the ignition is switched on

Note

Impacts or damage to the camera mount on the windshield can displace the sensor. Pre sense city can be impaired by this. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

Tips

– You can cancel the system braking intervention if you accelerate considerably or swerve away.
– Keep in mind that pre sense city can brake unexpectedly. Always secure any cargo or objects that you are transporting to reduce the risk of damage or injury.
– Specific pre sense city functions switch off when the ESC is limited or switched off ⇨ *page 165* or the hill descent assist is switched on ⇨ *page 92*.
– When there is a malfunction in the camera, the pre sense city functions also switch off.

Settings in the Infotainment system

Applies to: vehicles with Audi pre sense

▸ Select in the Infotainment system: MENU button > **Vehicle** > left control button > **Driver assistance** > **Audi pre sense**.

Turn on/off Audi pre sense - The pre sense functions can be turned on and off.

If the system is switched off, it switches on again automatically once the ignition is switched on again.

Prewarning - The early warning can be switched **off** or the pre sense city/front warning point can be set (**Early**/**Medium**/**Late**).

Set the warning time for the early warning to **Early** at first. If this causes undesired early warnings to appear, then set the warning time to **Medium**. The **Late** warning time should only be set in special circumstances.

Tips

Your settings are automatically stored and assigned to the vehicle key being used.

Messages

Applies to: vehicles with Audi pre sense

Audi pre sense: malfunction! Please contact Service

This message appears when the pre sense function is affected. For example, this could be caused by a faulty sensor. Drive immediately to an authorized Audi dealer or authorized Audi Service Facility to have the malfunction repaired.

Audi pre sense: currently limited. Sensor view limited due to surroundings. See owner's manual

This message appears if the radar sensor and camera view is obstructed, for example by leaves, snow, heavy spray or dirt. If necessary, clean the sensors and the area around the camera ⇨ *page 122, fig. 110* or ⇨ *page 141, fig. 131*.

Audi pre sense: currently limited. Trailer towing mode

For vehicles with a trailer hitch installed at the factory, the pre sense rear functions switch off when the electrical connector at the socket is plugged in. There is no guarantee the functions will switch off when using a retrofitted trailer hitch.

Audi pre sense: currently limited

This message appears if the ESC is restricted or switched off, for example.

Audi pre sense: currently limited. See owner's manual

This message appears when there is a temporary failure in a subsystem, such as the ESC. If this message appears repeatedly, drive to an authorized Audi dealer or authorized Audi Service Facility to have the malfunction corrected.

Audi pre sense: emergency braking system off ▸

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This message appears if the pre sense functions are switched off through the Infotainment system or if the system is not ready.

Audi active lane assist

Description

Applies to: vehicles with Audi active lane assist

Active lane assist (lane departure warning) detects lane marker lines within the limits of the system using a camera in the windshield. If you are approaching a detected lane marker line and it appears likely that you will leave the lane, the system will warn you with corrective steering. You can override this steering at any time. If you pass over a line, the steering wheel will vibrate lightly. In order for this warning vibration to occur, it must first be switched on in the Infotainment system. Active lane assist is ready for operation when the lane marker line is detected on at least one side of the vehicle.

The system is designed for driving on expressways and highways and therefore only activates at speeds above approximately 40 mph (65 km/h).

Applies to: vehicles with side assist: If you activate a turn signal when active lane assist is ready and it classifies a lane change as critical because of vehicles traveling alongside you or approaching you, there will be noticeable corrective steering shortly before you leave the lane. This will attempt to keep your vehicle in the lane.

Applies to: vehicles without side assist: When the system is ready, it will not warn you if you activate a turn signal before crossing the lane marker line. In this case, it assumes that you are changing lanes intentionally.

Applies to: vehicles with adaptive cruise control: There is no corrective steering or warnings if the system recognizes a distinct passing maneuver. If the conditions are met, traffic jam assist switches on at speeds under approximately 40 mph (65 km/h) ⇨ *page 128*.

⚠ WARNING

- The system warns the driver that the vehicle is leaving the lane using corrective steering. The driver is always responsible for keeping the vehicle within the lane.
- The system can help you keep the vehicle in the lane, but it does not drive by itself. Always keep your hands on the steering wheel.
- Corrective steering may not occur in certain situations, such as during heavy braking.
- There may be cases where the camera does not recognize all lane marker lines. Corrective steering can only take place on the side of the vehicle where lane marker lines are detected.
- Other road structures or objects could possibly be identified unintentionally as lane marker lines. As a result, corrective steering may be unexpected or may not occur.
- The camera view can be restricted, for example by vehicles driving ahead or by rain, snow, heavy spray or light shining into the camera. This can result in active lane assist not detecting the lane marker lines or detecting them incorrectly.
- In certain situations where visibility is low, the vehicle may switch from an “early” to “late” steering correction.
- Under certain conditions such as ruts in the road, an inclined roadway or crosswinds, the corrective steering alone may not be enough to keep the vehicle in the middle of the lane.
- For safety reasons, active lane assist must not be used when there are poor road and/or weather conditions such as slippery roads, fog, gravel, heavy rain, snow and the potential for hydroplaning. Using active lane assist under these conditions may increase the risk of a crash.

APPENDIX C

Run Log

Run Log for Daytime Tests

Subject Vehicle: *2020 Audi Q5 45 TFSI quattro*
Test Date: *6/30/2020*

Adult Pedestrian Test Mannequin: *Articulated 4A Adult*
Test Driver: *SFJ*

Child Pedestrian Test Mannequin: *Articulated 4A Child*

Forward Obstructing Vehicle: *1999 Honda Accord*

Rear Obstructing Vehicle: *2012 Toyota Highlander*

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
38	Static Run										
39	S1a	16	Day	Y	0.90	1.05	16.7	1.09	0.94	NC	
40				Y	1.48	0.78	16.1	1.01	1.31	NC	
41				Y	1.36	0.65	16.5	0.99	1.13	NC	
42				Y	1.30	1.18	15.8	1.04	1.17	NC	
43				Y	1.28	1.71	15.9	1.06	1.11	NC	
44				Y	1.10	1.38	16.5	1.08	1.07	NC	
45	S1a	40	Day	Y	1.42	0.96	39.9	1.09	1.07	NC	
46				Y	1.39	0.00	21.5	1.05	1.44	Contact	
47				Y	1.25	2.31	40.4	1.11	1.31	NC	
48				Y	0.92	0.00	34.1	1.10	0.96	Contact	
49				Y	0.89	0.84	39.6	1.13	0.90	NC	
50	Static Run										

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
1	Static Run										
2	S1b	16	Day	Y	1.69	0.04	15.5	0.96	1.23	NC	
3				Y	1.46	1.02	16.0	1.02	1.20	NC	
4				Y	1.63	1.23	15.8	1.01	1.17	NC	
5				Y	1.56	1.61	15.7	1.03	1.35	NC	
6				Y	1.42	0.47	16.1	1.04	1.31	NC	
14	S1b	20	Day	Y	1.70	0.97	20.0	1.10	1.21	NC	
15				Y	1.65	0.98	20.0	1.09	1.22	NC	
16				Y	1.63	0.80	20.3	1.08	1.21	NC	
17				Y	1.64	1.40	20.0	1.11	1.31	NC	
18				N							Legs did not move
19				Y	1.62	0.98	20.5	1.10	1.31	NC	
20	S1b	30	Day	Y	1.53	0.89	29.6	1.08	1.50	NC	
21				Y	1.69	0.92	29.9	1.07	1.49	NC	
22				Y	1.53	1.18	29.4	1.06	1.46	NC	
23				Y	1.76	1.16	30.0	1.10	1.50	NC	
24				Y	1.60	1.57	30.1	1.05	1.46	NC	
7	S1b	40	Day	Y	1.69	0.94	39.7	1.10	1.55	NC	
8				Y	1.53	0.48	39.9	1.08	1.48	NC	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
9	S1b	40	Day	Y	1.24	2.04	39.5	1.09	1.29	NC	
10				N							Lateral offset
11				N							Lateral offset
12				Y	1.30	1.66	40.2	1.11	1.36	NC	
13				Y	1.95	1.94	40.0	1.09	1.33	NC	
25	S1b	50	Day	Y	1.18	0.00	43.5	1.12	1.23	Contact	
26				Y	0.57	0.00	15.9	1.02	0.61	Contact	
27				Y	0.92	-0.07	46.6	1.05	0.95	NC	
28				Y	1.41	0.69	49.5	1.11	1.46	NC	
29				Y	1.08	0.00	48.2	1.11	1.09	NC	
30				Y	0.97	0.62	46.4	1.06	1.01	NC	
32	S1b	55	Day	Y	0.58	0.00	16.6	1.03	0.62	Contact	Broken windshield
33				Static Run							
34				N							PTM lateral error
35				Y	1.49	0.00	38.8	1.09	1.52	Contact	
36				Y	1.15	0.00	47.0	1.10	1.18	Contact	
37	Static Run										
31	S1b	60	Day	Y	0.75	0.00	23.4	1.03	0.80	Contact	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
51	S1c	16	Day	N							Throttle
52				Y	1.99	0.50	6.4	0.47	1.42	NC	
53				Y	2.00	0.65	6.6	0.50	1.30	NC	
54				Y	1.87	1.10	16.1	0.97	1.25	NC	
55				Y	2.01	0.49	6.7	0.48	1.41	NC	
56	S1c	40	Day	Y	1.39	2.45	41.2	1.14	1.45	NC	
57				Y	0.92	1.49	39.7	1.08	0.96	NC	
58				Y	1.02	1.80	40.1	1.09	1.05	NC	
59				Y	1.80	3.22	40.2	1.10	1.16	NC	
60				Y	0.96	2.06	40.9	1.04	1.00	NC	
61	Static Run										
167	S1d	16	Day	Y	1.41	0.00	12.4	1.01	1.19	Contact	
168				N							PTM lateral offset
169				Y	1.01	0.99	16.6	1.08	1.06	NC	
170				Y	1.58	1.04	15.2	1.02	1.16	NC	
171				N							PTM lateral offset
172				Y	1.38	1.05	16.1	1.03	1.11	NC	
173				Y	1.11	1.32	16.5	1.07	1.05	NC	
174	S1d	20	Day	Y	1.29	1.60	20.0	1.15	1.08	NC	
175				Y	0.95	1.84	19.8	1.19	1.00	NC	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
176	S1d	20	Day	Y	1.16	0.92	20.0	1.15	1.04	NC	
177				Y	1.27	1.03	20.1	1.11	1.15	NC	
178				N							PTM lateral error
179				Y	1.31	0.72	20.1	1.06	1.07	NC	
180	S1d	30	Day	Y	1.04	0.63	30.0	1.10	1.11	NC	
181				Y	1.21	0.95	30.1	1.11	1.24	NC	
182				Y	0.99	0.59	29.9	1.12	1.03	NC	
183				Y	1.10	0.80	30.4	1.10	1.18	NC	
184				N							PTM lateral error
185				Y	1.06	1.30	29.8	1.12	1.11	NC	
191	S1d	35	Day	N							PTM lateral error
192				Y	1.00	1.00	35.0	1.13	1.04	NC	
193				Y	0.93	1.29	35.3	1.15	1.01	NC	
194				Y	1.12	2.11	35.2	1.14	1.16	NC	
195				Y	0.71	0.20	35.4	1.07	0.75	NC	
196				Y	1.04	1.78	35.2	1.18	1.08	NC	
186	S1d	40	Day	Y	1.01	0.87	40.4	1.19	1.04	NC	
187				Y	0.87	0.00	27.6	1.16	0.90	Contact	
188				Y	0.77	0.00	36.8	1.11	0.83	NC	
189				Y	0.71	0.00	27.6	1.11	0.77	Contact	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
190	S1d	40	Day	Y	0.82	0.00	26.9	1.15	0.88	Contact	
75	S1e	40	Day	Y	1.22	1.34	38.1	1.11	1.25	NC	
76				Y	1.20	1.07	37.8	1.12	1.26	NC	
77				Y	1.10	2.63	40.0	1.09	1.14	NC	
78				N							PTM lateral error
79				Y	0.89	0.57	37.5	1.06	0.95	NC	
80				Y	1.31	0.00	32.0	1.09	1.36	NC	
81	S1e	50	Day	Y	1.04	1.32	46.0	1.09	1.10	NC	
82				Y	0.92	0.59	44.5	1.04	1.00	NC	
83				Y	1.31	1.76	43.1	1.15	1.35	NC	
84				Y	1.38	-0.31	39.4	1.11	1.04	NC	
85				Y	0.92	0.12	42.9	1.19	0.96	NC	
86	S1e	55	Day	N							SV lateral error
87				Y	1.17	0.00	3.4	0.23	1.20	Contact	
88				Static Run							
89				Y	1.01	0.00	35.8	1.14	1.06	Contact	
90				Y	1.33	1.42	46.4	1.16	1.37	NC	
91				Y	1.37	1.12	43.6	1.14	1.42	NC	
92				Y	1.31	1.95	50.0	1.15	1.39	NC	
93				Y	1.32	1.36	48.4	1.16	1.38	NC	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
94	S1e	55	Day	N							PTM lateral error
95				Y	1.26	1.18	47.1	1.15	1.33	NC	
96	S1e	60	Day	Y	1.24	1.54	46.3	1.14	1.29	NC	
97				N							PTM lateral error, SV Speed
98				Y	1.23	1.51	48.3	1.14	1.28	NC	
99				N							PTM lateral error
100	S1e	60	Day	Y	1.20	0.00	41.9	1.13	1.27	Contact	
101				Y	1.34	-0.34	46.5	1.12	1.37	NC	
102				Y	1.33	0.37	45.6	1.12	1.39	NC	
103				Y	1.20	0.00	38.5	1.12	1.21	Contact	
104	Static Run										
62	S1f	40	Day	Y	1.02	0.00	7.9	0.72	1.02	NC	
63				Y	1.26	0.00	10.4	0.79	1.29	NC	
64				Y	0.97	0.00	10.9	0.91	1.01	NC	
65				Y	1.30	0.00	6.8	0.49	1.35	NC	
66				Y	0.96	0.00	6.3	0.45	1.02	NC	
67	Static Run										

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
68	S1g	40	Day	N							SV lateral error
69				Y	1.15	0.00	24.4	1.11	1.15	NC	
70				Y	1.32	0.00	10.4	0.81	1.36	NC	
71				Y	1.85	0.00	8.0	0.42	1.62	NC	
72				Y	1.08	0.00	3.1	0.22	1.12	NC	
73				Y	1.37	0.00	27.9	1.04	1.40	NC	
74	Static Run										
132	S4a	16	Day	Y	2.02	0.52	16.3	1.03	1.34	NC	
133				N							SV lateral
134				Y	1.94	1.69	16.1	1.00	1.35	NC	
135				Y	2.07	1.45	15.9	0.97	1.36	NC	
136				Y	2.08	1.71	16.0	0.99	1.36	NC	
137				Y	2.13	1.09	15.8	0.98	1.40	NC	
142	S4a	35	Day	Y	1.82	1.45	34.9	1.13	1.64	NC	
143				Y	2.05	1.40	34.7	1.06	1.60	NC	
144				Y	2.02	2.27	35.1	1.08	1.59	NC	
145				Y	1.96	0.00	13.0	0.82	1.72	Contact	
146				Y	2.07	0.00	27.6	0.93	1.75	Contact	
147	Static Run										
138	S4a	40	Day	N							SV lateral
139				Y	1.98	0.00	27.7	0.97	1.74	Contact	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
140	S4a	40	Day	Y	2.07	0.00	29.6	1.00	1.75	Contact	
141				Y	2.06	0.00	19.1	1.01	1.72	Contact	
148	S4b	16	Day	Y	2.11	2.09	15.8	1.03	1.43	NC	
149				Y	2.15	2.04	15.3	0.99	1.44	NC	
150				Y	2.17	1.66	15.2	0.94	1.41	NC	
151				Y	2.05	1.63	16.2	0.94	1.41	NC	
152				Y	2.02	1.65	16.3	1.01	1.42	NC	
156	S4b	35	Day	Y	1.99	0.00	21.3	1.00	1.67	Contact	
157				Y	2.14	0.00	13.4	0.71	1.57	Contact	
158				Y	1.82	1.67	35.3	1.13	1.60	NC	
159				Y	2.03	0.00	25.3	0.97	1.59	Contact	
160	Static Run										
153	S4b	40	Day	Y	2.01	0.00	25.3	1.03	1.79	Contact	
154				Y	2.10	0.00	32.5	0.95	1.58	Contact	
155				Y	1.73	0.00	31.8	0.99	1.64	Contact	
105	Static Run										
106	S4c	16	Day	Y	1.84	0.00	9.1	0.52	1.24	Contact	
107				Y	2.31	0.00	8.4	0.50	1.29	Contact	
108				N							SV brake application

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
109	S4c	16	Day	Y	1.71	0.00	6.7	0.47	1.27	Contact	
110	S4c	40	Day	N							SV Yaw
111				Y	1.90	2.54	40.0	1.13	1.82	NC	
112				Y	1.91	3.16	40.0	1.07	1.33	NC	
113				Y	2.19	3.02	40.3	1.13	1.58	NC	
114				Y	2.21	3.03	39.7	1.14	1.67	NC	No video
115				Y	2.33	2.23	40.0	1.15	1.49	NC	
116	S4c	50	Day	Y	2.18	1.54	50.0	1.12	1.59	NC	
117				N							SV lateral
118				Y	2.46	1.59	49.6	1.08	1.61	NC	
119				N							SV lateral
120				Y	2.23	2.26	50.2	1.15	1.59	NC	
121				Y	1.97	0.87	50.0	1.10	1.54	NC	
122				Y	2.08	1.82	49.8	1.08	1.62	NC	
130	S4c	55	Day	Y	2.08	2.25	54.7	1.14	1.62	NC	
131				N							Lateral error
161				Y	1.99	0.00	33.5	1.07	1.57	Contact	
162				Y	1.96	0.00	54.8	1.11	1.71	Contact	
163				Y	1.90	1.17	54.7	1.13	1.74	NC	
164				Y	2.07	0.00	42.9	1.10	1.47	Contact	
166	Static Run										

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
123	S4c	60	Day	N							SV lateral
124				Y	1.84	0.00	54.2	1.12	1.53	Contact	
125				Y	1.89	0.00	7.0	0.54	1.59	Contact	
126				N							Lateral error
127				N							Lateral error
128				N							Brake application
129				Y	1.61	0.00	25.0	1.11	0.79	Contact	

Run Log for Nighttime Tests

Subject Vehicle: *2020 Audi Q5 45 TFSI quattro* Test Date: *7/6/2020*

Adult Pedestrian Test Mannequin: *Articulated 4A Adult* Test Driver: *JHR*

Child Pedestrian Test Mannequin: *Articulated 4A Child*

Forward Obstructing Vehicle: *1999 Honda Accord*

Rear Obstructing Vehicle: *2012 Toyota Highlander*

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
21	S1b	11	NHB	Y	0.74	0.00	0.9	0.06		Contact	No AEB
22				Y	0.66	0.00	1.0	0.05		Contact	No AEB
23				Y	0.67	0.00	1.2	0.29	0.16	Contact	
5	S1b	16	NHB	Y	0.86	0.00	2.6	0.22	0.84	Contact	
6				N							PTM lateral error
7				Y	1.06	0.00	2.8	0.23	1.00	Contact	
8				Y	1.14	0.00	4.0	0.34	1.03	Contact	
13	S1b	40	NHB	Y	1.57	0.00	14.2	1.03	1.05	Contact	
14				Y	1.50	0.00	10.8	0.89	1.07	Contact	
15				Y	1.68	0.00	10.2	0.59	1.12	Contact	
42	S1d	11	NHB	Y		0.00	0.2	0.02		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
43	S1d	11	NHB	Y		0.00	0.1	0.01		Contact	No warning, no AEB
44				Y	1.03	0.00	1.1	0.04		Contact	No AEB
30	S1d	16	NHB	Y		0.00	0.1	0.00		Contact	No warning, no AEB
31				Y		0.00	0.0	0.00		Contact	No warning, no AEB
32				Y		0.00	0.3	0.02		Contact	No warning, no AEB
36	S1d	40	NHB	Y	0.46	0.00	2.2	0.24	0.54	Contact	
37				Y	0.57	0.00	17.1	1.20	0.60	Contact	
38				Y		0.00	0.0	0.04		Contact	No warning, no AEB
51	S1e	40	NHB	Y	1.10	0.78	38.9	1.14	1.19	NC	
52				Y	1.10	0.76	38.5	1.16	1.14	NC	
53				Y	1.15	0.88	39.0	1.14	1.18	NC	
54				Y	1.03	0.00	31.4	1.10	1.07	Contact	
55				Y	1.09	1.50	40.6	1.12	1.11	NC	
56				Y	1.06	0.18	36.4	1.16	1.11	NC	
57	S1e	45	NHB	Y	1.10	0.19	41.3	1.13	1.15	NC	
61				Y	1.02	0.00	31.4	1.16	1.06	Contact	
62				N							Dummy legs did not move

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
63	S1e	45	NHB	Y	1.14	0.72	41.1	1.12	1.20	NC	
64				Y	1.02	0.56	40.2	1.14	1.06	NC	
65				Y	1.23	0.94	41.7	1.14	1.28	NC	
58	S1e	50	NHB	Y	1.12	0.00	34.8	1.12	1.14	Contact	
59				Y	0.94	0.00	34.7	1.16	1.00	Contact	
60				Y	1.13	0.00	37.5	1.11	1.16	Contact	
114	S4a	11	NHB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
115				Y		0.00	0.0	0.00		Contact	No warning, no AEB
116				Y		0.00	0.1	0.01		Contact	No warning, no AEB
102	S4a	16	NHB	Y		0.00	0.0	0.00		Contact	No warning, no AEB
103				Y		0.00	0.0	0.00		Contact	No warning, no AEB
104				Y		0.00	0.0	0.01		Contact	No warning, no AEB
108	S4a	40	NHB	Y	0.80	0.00	8.0	0.74	0.89	Contact	
109				Y	0.79	0.00	20.1	1.13	0.87	Contact	
110				Y	0.77	0.00	0.9	0.06		Contact	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
94	S4c	11	NHB	N							SV speed
95				Y		0.00	0.8	0.05		Contact	No warning, no AEB
96				Y		0.00	0.0	0.00		Contact	No warning, no AEB
97				Y		0.00	0.0	0.02		Contact	No warning, no AEB
80	S4c	16	NHB	Y		0.00	0.4	0.05		Contact	No warning, no AEB
81				Y		0.00	0.0	0.03		Contact	No warning, no AEB
82				Y	0.32	0.26	16.4	0.98	0.47	NC	
83				Y		0.00	0.0	0.02		Contact	No warning, no AEB
87	S4c	40	NHB	Y	-0.88	0.00	0.0	0.01		Contact	No warning, no AEB
88				Y	0.92	0.00	5.0	0.53	1.02	Contact	
89				N							SV brakes
90				Y	0.94	0.00	23.6	0.93	1.03	Contact	
16	S1b	11	NLB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
17				N							PTM lateral error
18				N							PTM lateral error

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
19	S1b	11	NLB	Y	0.69	0.00	1.7	0.09		Contact	No AEB
20				Y		0.00	0.0	0.03		Contact	No warning, no AEB
1	Static Run (1m)										
2	S1b	16	NLB	Y		0.00	0.0	0.02		Contact	No warning, no AEB
3				Y		0.00	0.1	0.04		Contact	No warning, no AEB
4				Y		0.00	0.0	0.02		Contact	No warning, no AEB
9	S1b	40	NLB	N							SV speed
10				Y	0.43	0.00	1.0	0.16	0.46	Contact	
11				Y	0.78	0.00	2.1	0.18	0.88	Contact	
12				Y		0.00	0.1	0.06		Contact	No warning, no AEB
39	S1d	11	NLB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
40				Y		0.00	0.0	0.00		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
41	S1d	11	NLB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
24	Static Run										
25	S1d	16	NLB	N							PTM lateral error, FCW after contact
26				Y		0.00	0.0	0.01		Contact	No warning, no AEB
27				Y		0.00	0.2	0.03		Contact	No warning, no AEB
28				Y		0.00	0.0	0.00		Contact	No warning, no AEB
29				Y	0.07	0.00	0.8	0.25	0.14	Contact	
33	S1d	40	NLB	Y		0.00	0.2	0.03		Contact	No warning, no AEB
34				Y		0.00	0.2	0.06		Contact	No warning, no AEB
35				Y		0.00	0.8	0.06		Contact	No warning, no AEB
66	S1e	35	NLB	Y	1.02	0.00	30.6	1.10	1.06	NC	
67				Y	1.10	0.00	23.5	1.13	1.11	Contact	Could not get light signal
68				Y	1.11	0.00	17.6	1.11	1.17	Contact	
69				N							PTM lateral error

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
70	S1e	35	NLB	Y	0.36	0.00	7.7	0.95	0.51	Contact	2 tone audio warning, 892 Hz
45	Static Run										
46	S1e	40	NLB	Y		0.00	0.2	0.03		Contact	No warning, no AEB
47				Y	0.30	0.00	2.4	0.28	0.31	Contact	
48				N							PTM fell before impact, no warning
49				N							PTM lateral error
50				Y		0.00	0.3	0.04		Contact	No warning, no AEB
111	S4a	11	NLB	Y		0.00	0.3	0.02		Contact	No warning, no AEB
112				Y		0.00	0.1	0.01		Contact	No warning, no AEB
113				Y		0.00	0.0	0.00		Contact	No warning, no AEB
98	Static Run										
99	S4a	16	NLB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
100				Y		0.00	0.1	0.01		Contact	No warning, no AEB
101				Y		0.00	0.0	0.00		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
105	S4a	40	NLB	Y	0.80	0.00	29.3	1.11	0.90	Contact	
106				Y	0.75	0.00	19.7	1.13	0.85	Contact	
107				Y		0.00	0.0	0.02		Contact	No warning, no AEB
71	Static Run										
72	S4c	16	NLB	N							SV speed
73				Y	0.22	0.01	16.1	1.07	0.86	NC	
74				Y	0.29	0.19	15.7	1.03	0.45	NC	
75				Y	0.29	0.21	16.3	1.01	0.44	NC	
76				Y		0.00	0.0	0.00		Contact	No warning, no AEB
77				Y	0.48	0.62	16.0	0.90	0.55	NC	
78				Y	0.15	0.00	1.0	0.19	0.29	Contact	
79				Y	0.26	0.10	16.6	0.88	0.37	NC	
91	S4c	35	NLB	Y	0.71	0.00	16.1	1.03	0.66	Contact	
92				Y		0.00	0.2	0.01		Contact	No warning, no AEB
93				Y		0.00	0.0	0.01		Contact	No warning, no AEB
84	S4c	40	NLB	Y	0.39	0.00	1.2	0.19	0.55	Contact	
85				Y	0.87	0.00	22.4	0.99	0.96	Contact	
86				Y	0.93	0.00	28.0	1.00	1.01	Contact	

APPENDIX D

Time History Plots

LIST OF FIGURES

Time History Plot Description

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 Pedestrian Test Mannequin (PTM), 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 codes indicating to which vehicle the data pertain.

Time history figures include the following sub-plots:

- FCW Warning – Displays the audible Forward Collision Warning alert. The alert data are filtered, rectified, and normalized. The vertical scale is 0 to 1. When no warning is detected the plot will display “No Wng” in red except that for scenarios S1f and S1g, for which no contact is the appropriate result, “No Warning” will be displayed in black.

  A vertical black bar on the plot indicates the TTC (sec) at the first moment of the warning issued by the FCW system. The FCW TTC is displayed to the right of the subplot in green.

- Headway (m) – Longitudinal separation (gap) between the front-most point of the SV and the PTM as defined by a rectangle. The minimum headway during the run is displayed to the right of the subplot. Note that there are cases where minimum headway can be zero without collision. This is because the plan view of the front of a vehicle is generally not rectangular, and headway is calculated from the front-most point of the vehicle. It is possible to have zero headway without. Also, for scenarios S1f and S1g, zero headway is appropriate since these are false positive tests.

  If no impact occurs, a green circle is displayed at the moment of minimum headway distance. If impact occurs, a red asterisk is displayed at the moment of impact and the word “Contact” is displayed in red. Additionally, along the time history data for the headway, the line is marked in bold if the PTM is within the forward path of the SV, and it is thin if the PTM is outside of the forward path of the SV.

- SV/PTM Speed (km/h) – Speed of the SV and PTM (if any). The speed reduction experienced by the SV is displayed to the right of the subplot. The speed tolerance applies until the until the FCW alert is given. If the PAEB intervenes before the FCW alert, the speed tolerance applies until the onset of PAEB braking. Note that there is no tolerance for PTM speed because PTM motion validity is a function of SV longitudinal position. Speed reduction (SR) values are shown in red when contact occurred.

- Yaw Rate (deg/sec) – Yaw rate of the SV. Its tolerance is ±1.0 deg/sec (required until there is PAEB system braking).

- Lateral Error (m) – For both the SV and PTM, Lateral Error is measured in the reference frame of the lane of travel. Note that for crossing (S1) test scenarios, Lateral Error for the PTM is the same as Longitudinal Error in its reference frame.

  For the SV, lateral error is defined to be the lateral distance between the centerline of the SV and the center of the lane of travel. Its tolerance is ±0.20 m.

  For the PTM in longitudinal (S4) test scenarios, the lateral error is defined to be the distance between the centerline of the PTM and its associated defined lateral position in the lane of travel. Its tolerance is ±0.18 m

  For the PTM in crossing (S1) test scenarios, the lateral error is defined to be the distance between the centerline of the PTM and its prescribed lateral position across the lane of travel as calculated by the defined SV longitudinal position and impact profiles provided by the test procedure. Its tolerance is ±0.18 m

- Ax (g) – Longitudinal acceleration of the SV. A dashed line is displayed at -0.03 g, which is used as the threshold to indicate PAEB braking. The onset of PAEB system braking is found by finding the moment when the SV's Ax crosses the threshold of -0.15 g. Once this point is found, the first moment when the SV Ax is below the indicated -0.03 g threshold but before the Ax crosses the -0.15 g point, is determined and said to be the moment of first PAEB braking. The TTC (sec) at first PAEB system braking is calculated and displayed to the right of the subplot, in green. Also, the peak value of Ax for the SV is shown on the subplot.

- Pedal Positions – Normalized positions of the accelerator pedal and brake pedal. As the brake pedal is only a contact switch; the position reading will either be 0 (off) or a 1 (on). A red "Brk" (indicating test invalidity) will appear to the right of the plot if the brake pedal was applied at any time during the run. The accelerator pedal is normalized, such that throttle off equals zero and wide-open throttle equals one. The throttle is required to be off starting 0.5 sec after either an audible FCW alert is provided or the onset of PAEB braking, whichever occurs first.

Envelopes and Thresholds

Some of the time history plot figures contain either green envelopes and/or black threshold lines. These envelopes and thresholds are used to programmatically and visually determine the validity of a given test run. Envelope and threshold exceedances are indicated with either red shading or red asterisks, and red text is placed to the right side of the plot indicating the type of exceedance. Such exceedances indicate either that the test was invalid or that there was contact between the SV and PTM.

For plots with green envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope boundaries at any time. Exceedances of a green envelope are indicated by red shading in the area between the measured time-varying data and the envelope boundaries.

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 color codes:

    - Blue = SV data
    - Magenta = PTM data
    - Brown = Relative data between SV and PTM (i.e., 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
    - Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds

3. Individual data point color codes:

    - Green circle = passing or valid value at a given moment in time
    - Red asterisk = failing or invalid value at a given moment in time

4. Text color codes:

    - Green = passing or valid value
    - Red = failing or invalid value

Other Notations

- Contact – Indicates that contact was made between the SV and PTM.
- ENV – Indicates that the value for that variable was outside of its specified validity envelope.
- NG – Indicates that the value for that variable was outside of bounds and therefore “No Good”.
- No Wng – No warning was detected.
- PTM – Indicates that the value for the Pedestrian Test Mannequin 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 Figures D1 through Figure D5. Figures D1 and D2 show typical passing and failing runs. Figures D3 through D5 show examples of invalid runs. Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure D6.

The test reported herein is one of a series of research and development tests accomplished for the purpose of refining test procedures, protocols, and specifications, as well as data analysis parameters and presentation methods that are preliminarily described in NHTSA ‘s test procedure titled, “Pedestrian Automatic Emergency Brake System Confirmation Test (Working Draft)”, dated September 2019 (Docket NHTSA-2019-0102-0005). Some of these procedural details changed over the course of the test series in order to address unanticipated concerns or ambiguities, and also in recognition of the different characteristics of AEB implementation by the various manufacturers. In particular, the threshold for determining the onset of PAEB braking was originally set at -0.15 g, and subsequently changed to -0.03 g later in the series. As a result, some of the results indicate the earlier threshold and some the later. The results presented herein are for the -0.03 g threshold.

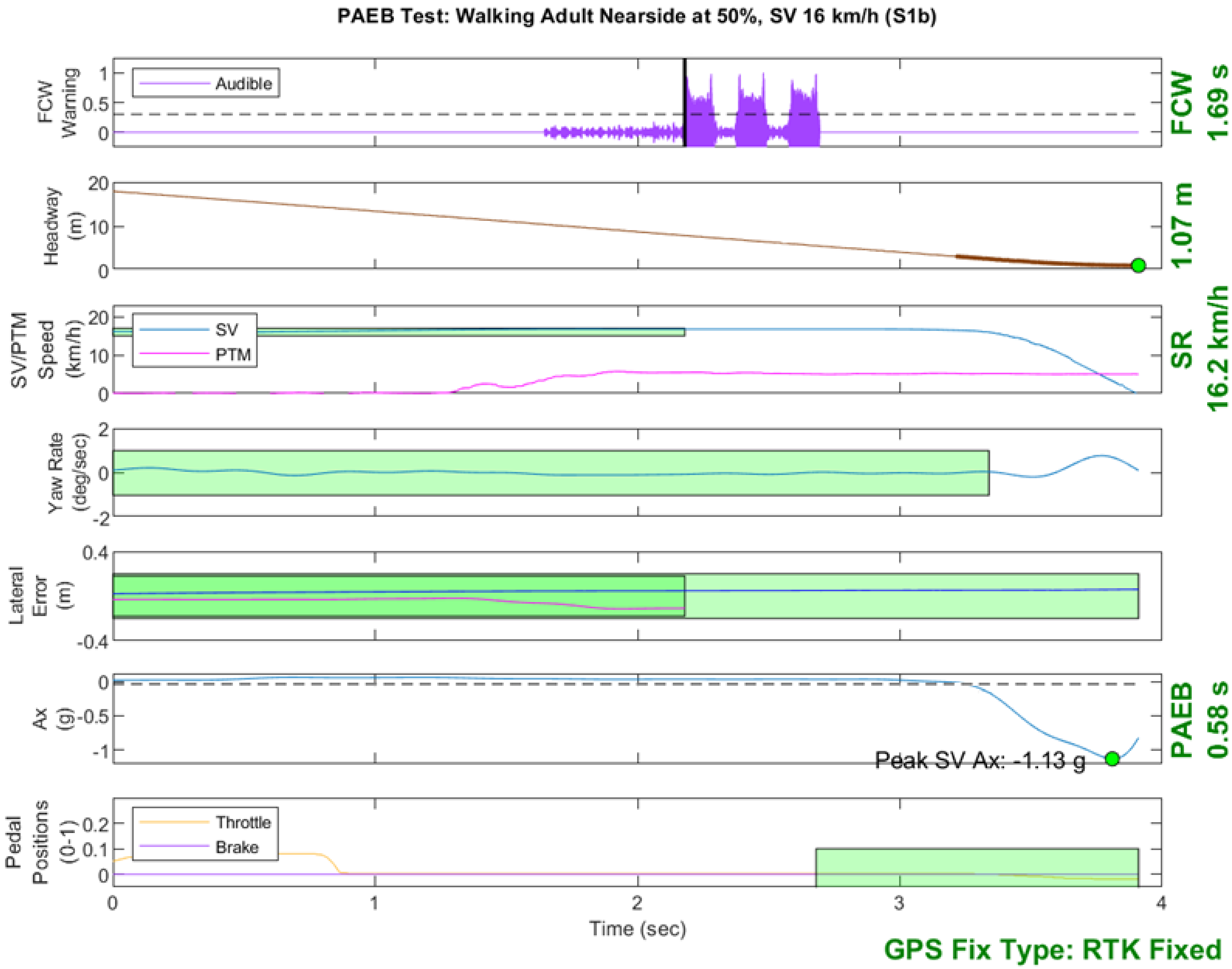

Figure D1. Example Time History for a Passing Run

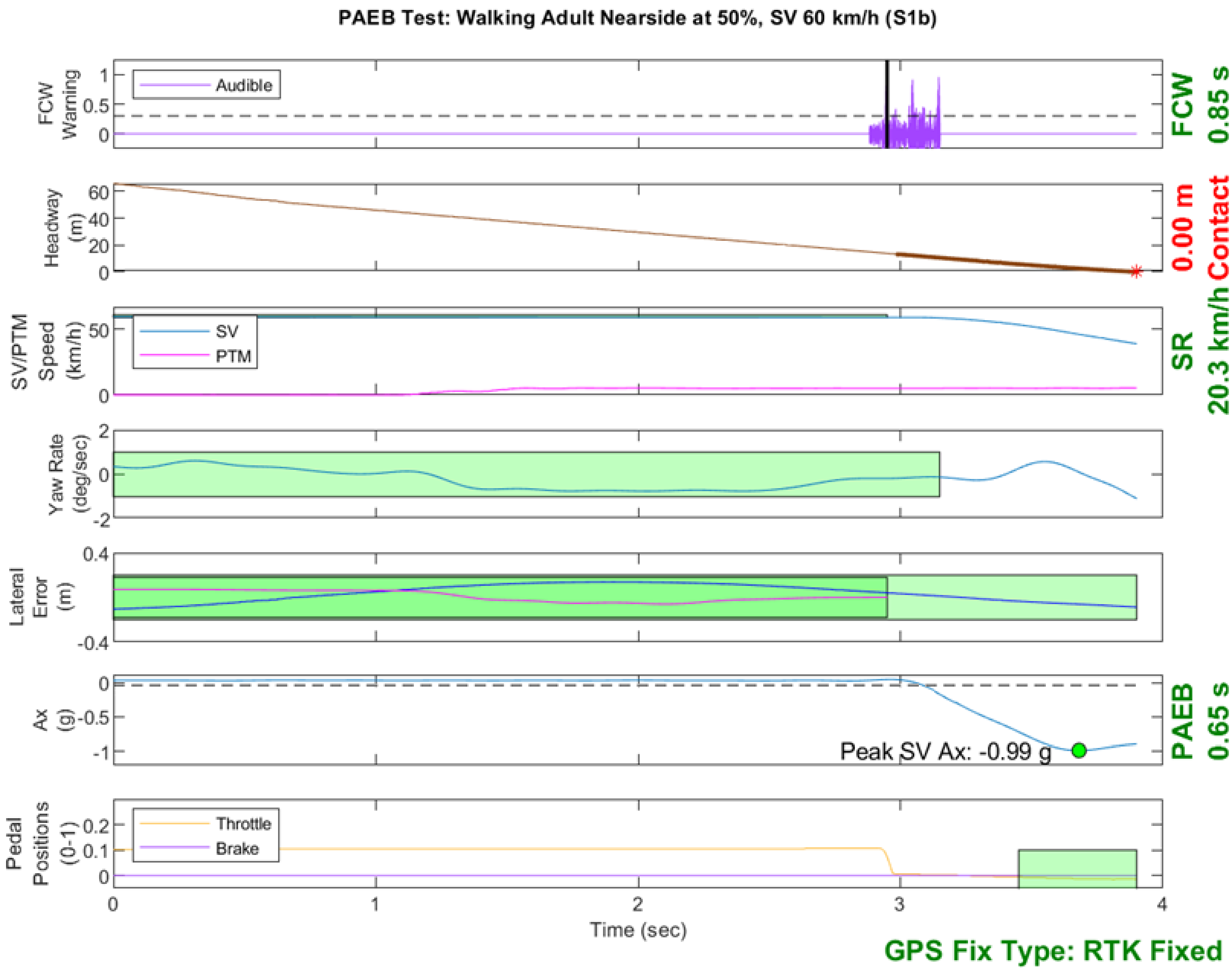

Figure D2. Example Time History for a Failed Run

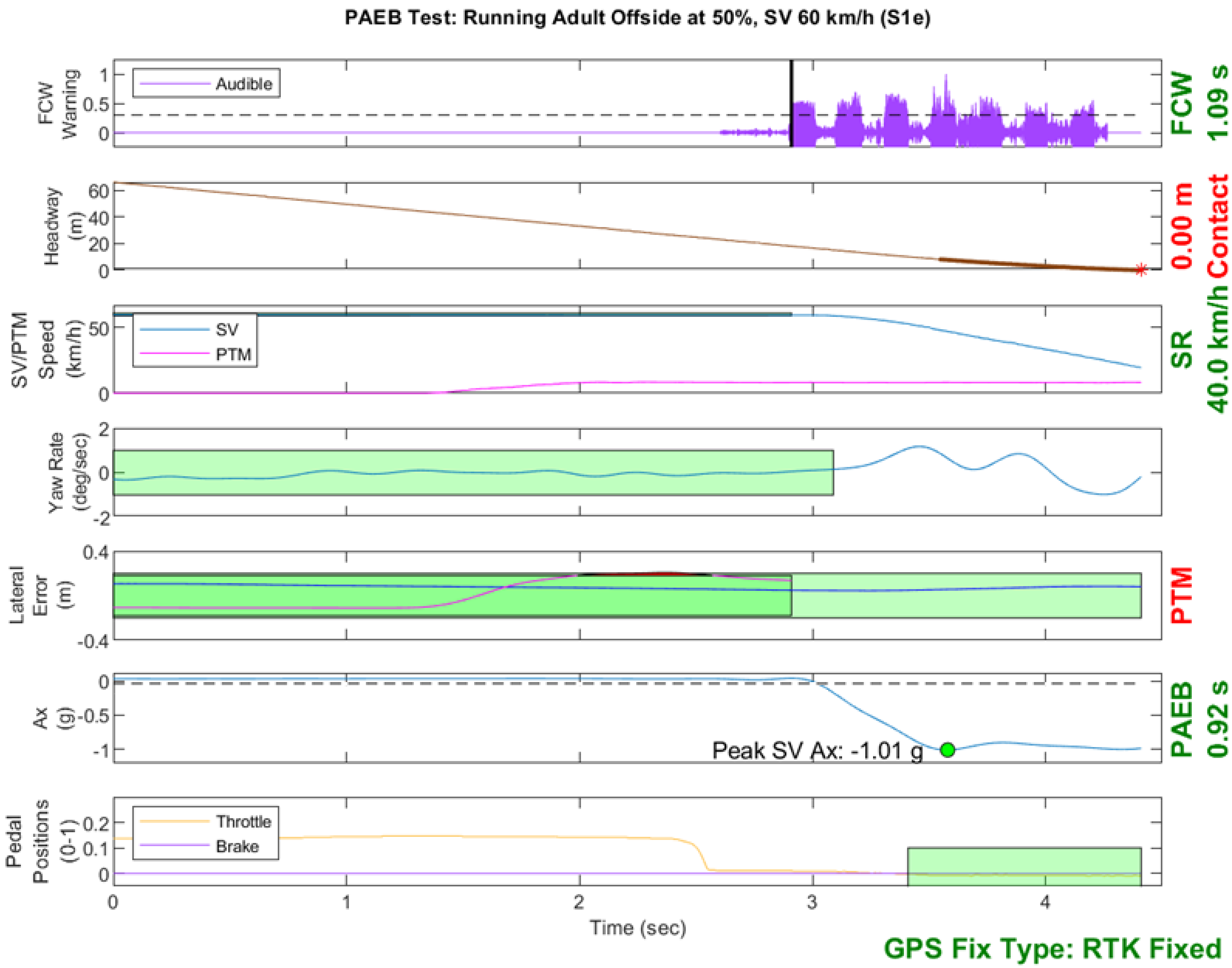

Figure D3. Example Time History for an Invalid Run Due to PTM Lateral Error

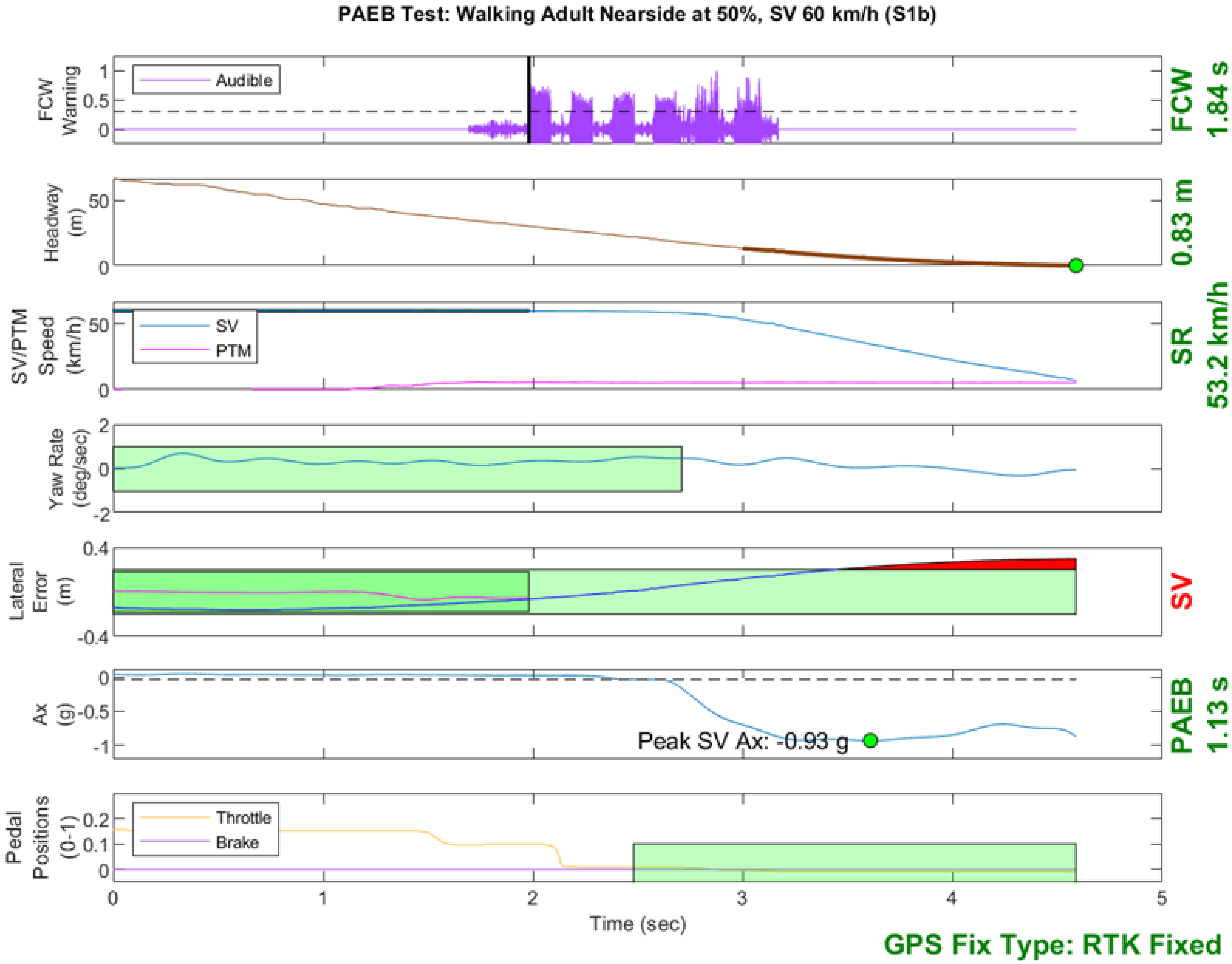

Figure D4. Example Time History for an Invalid Run Due to SV Lateral Error

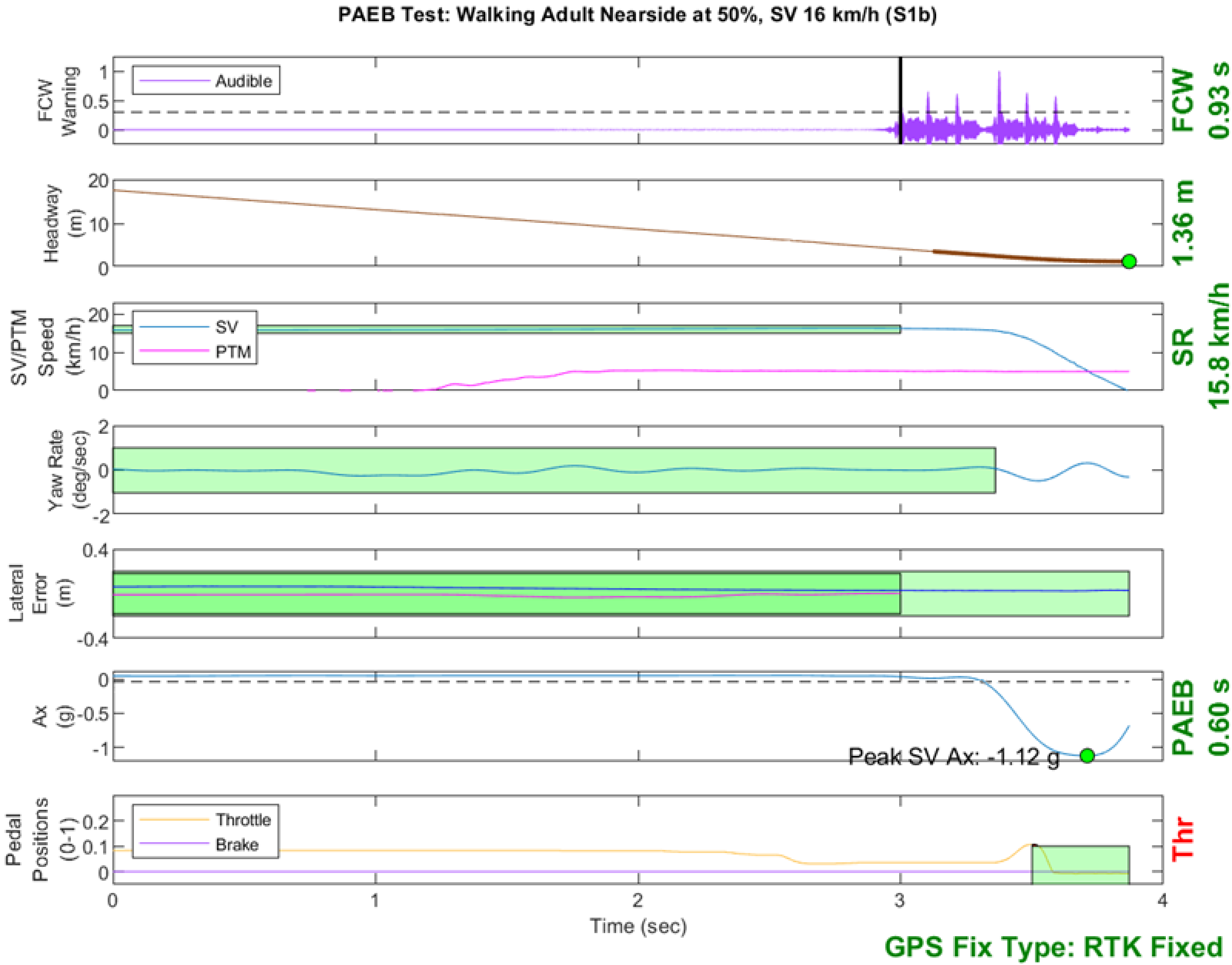

Figure D5. Example Time History for an Invalid Run Due to Throttle Error

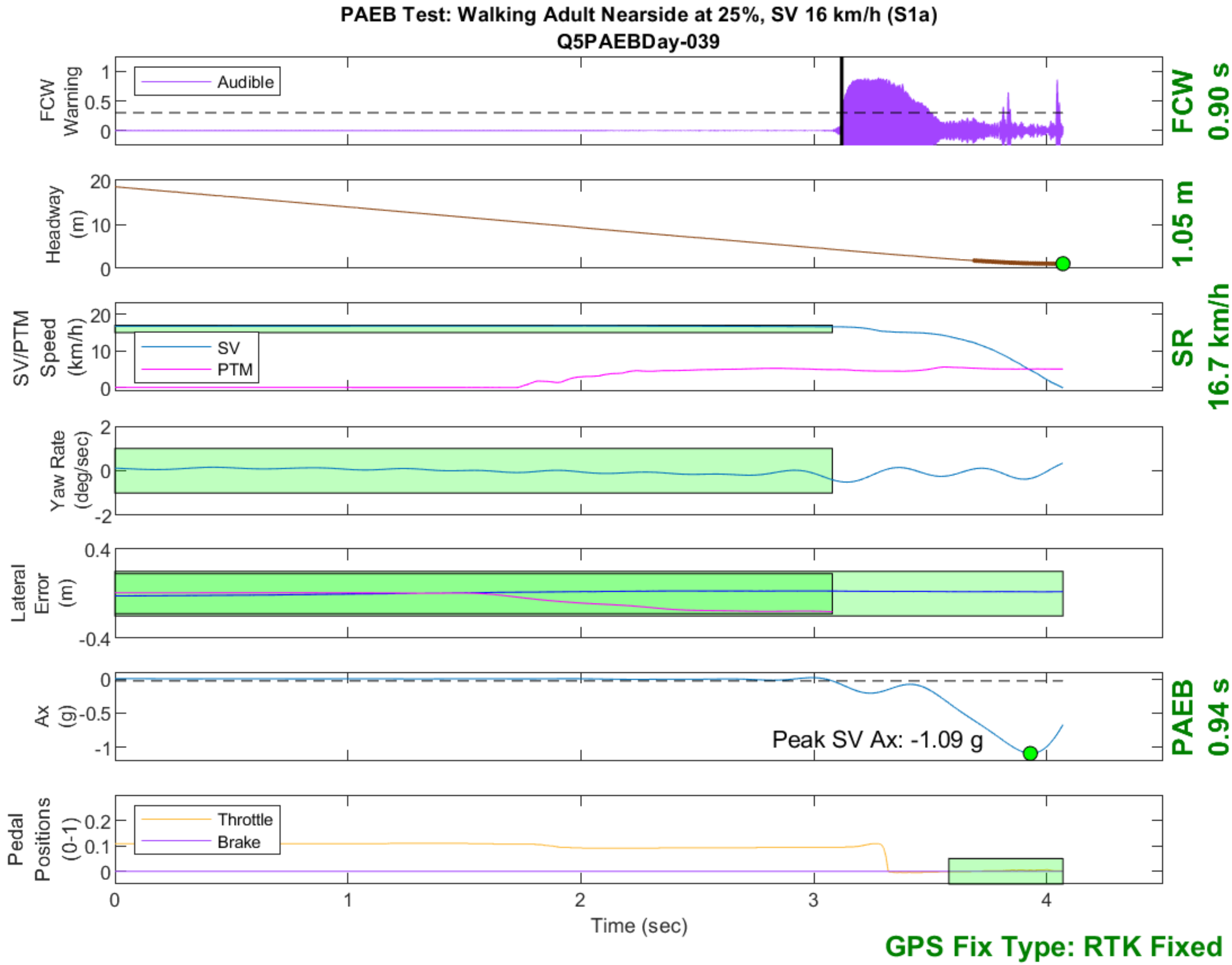

Figure D6. Time History for PAEB Run 39, S1a, Daytime, 16 km/h

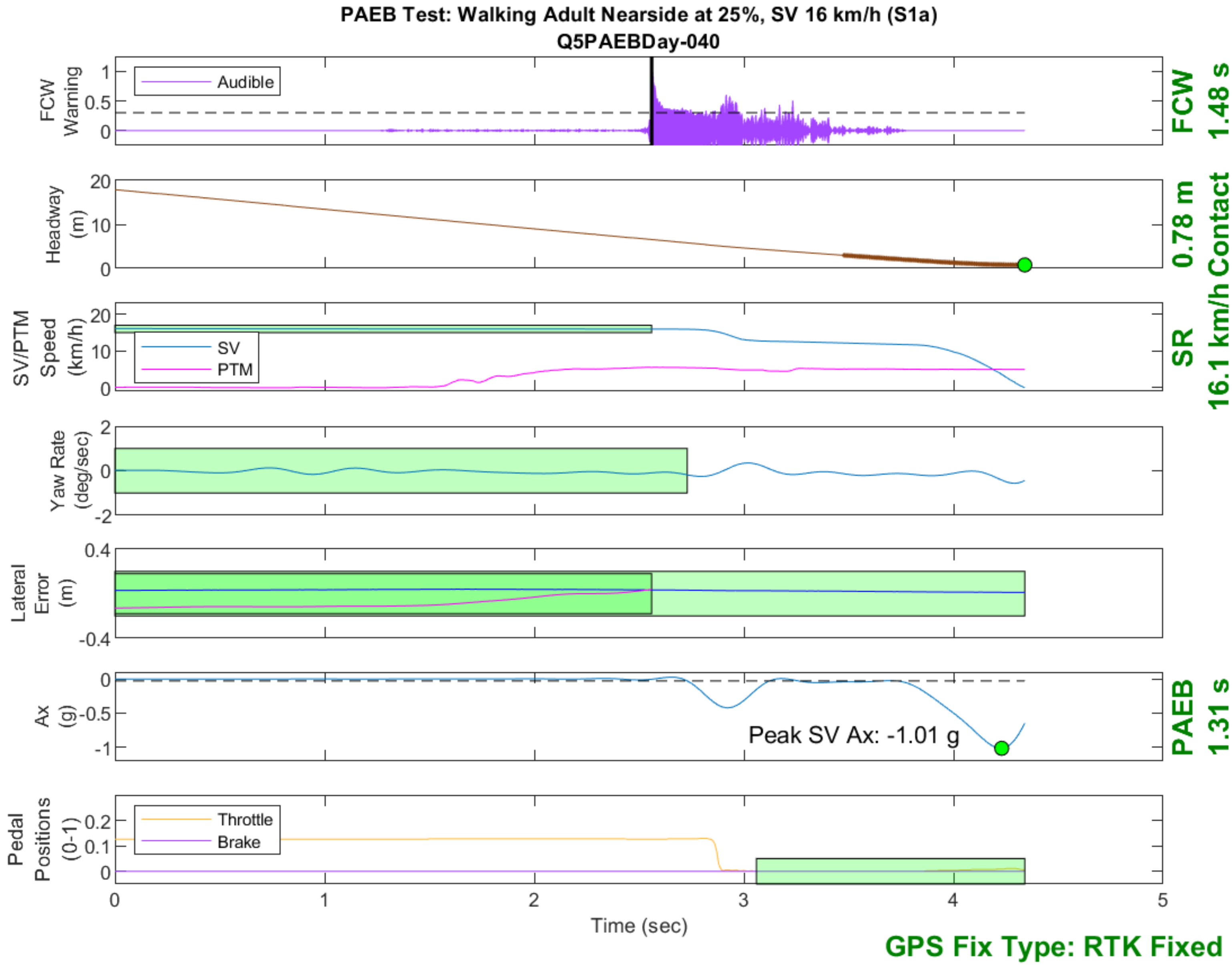

Figure D7. Time History for PAEB Run 40, S1a, Daytime, 16 km/h

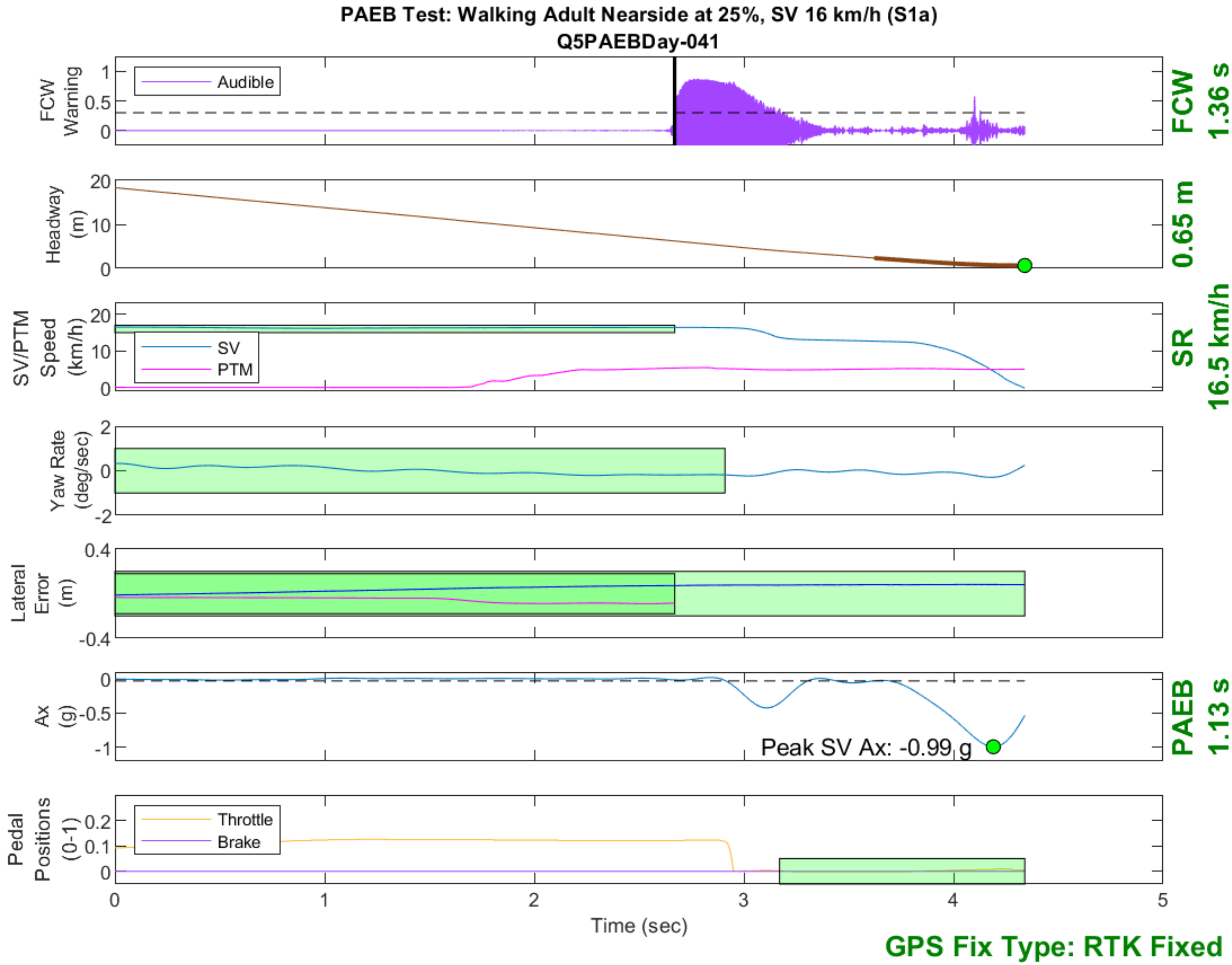

Figure D8. Time History for PAEB Run 41, S1a, Daytime, 16 km/h

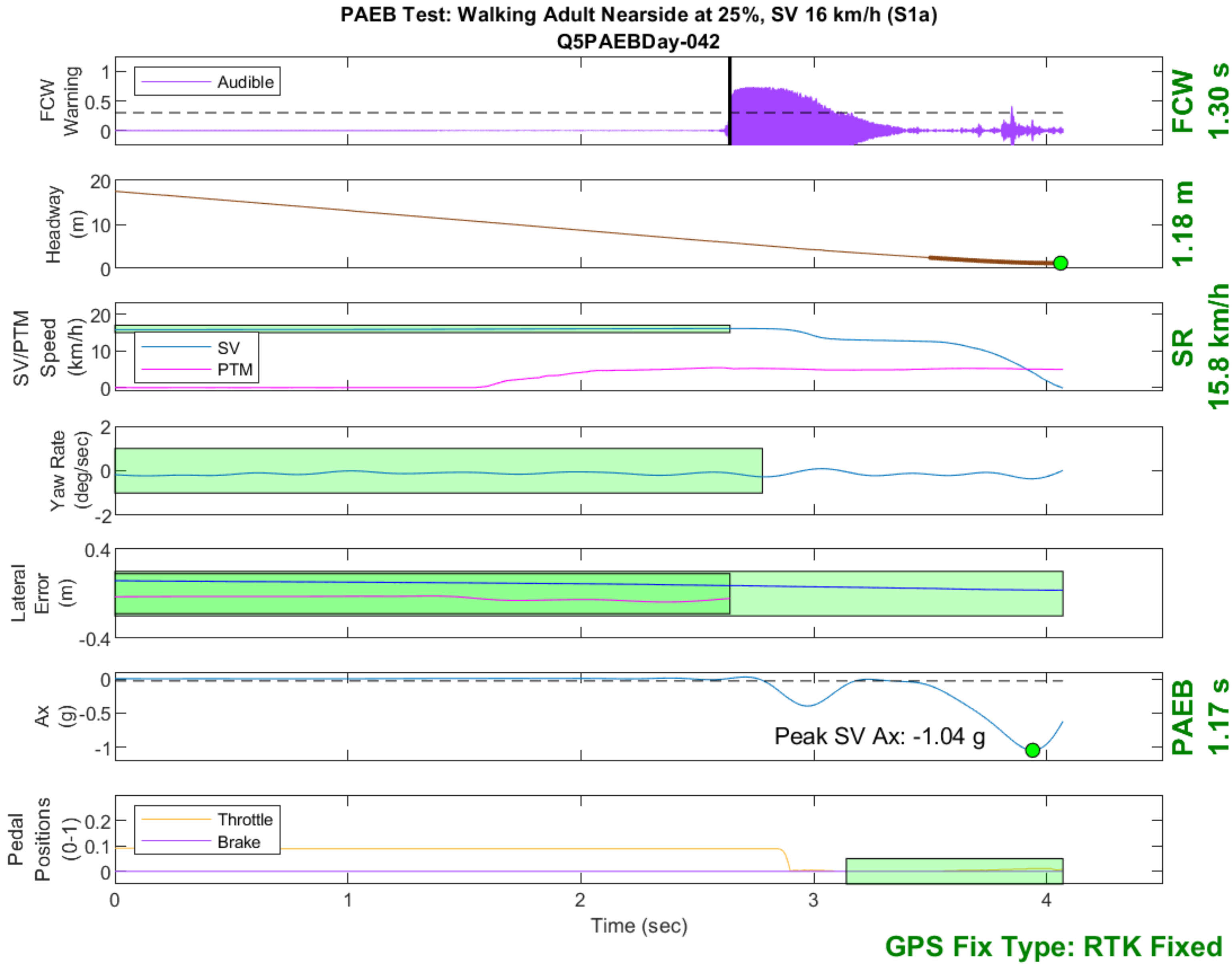

Figure D9. Time History for PAEB Run 42, S1a, Daytime, 16 km/h

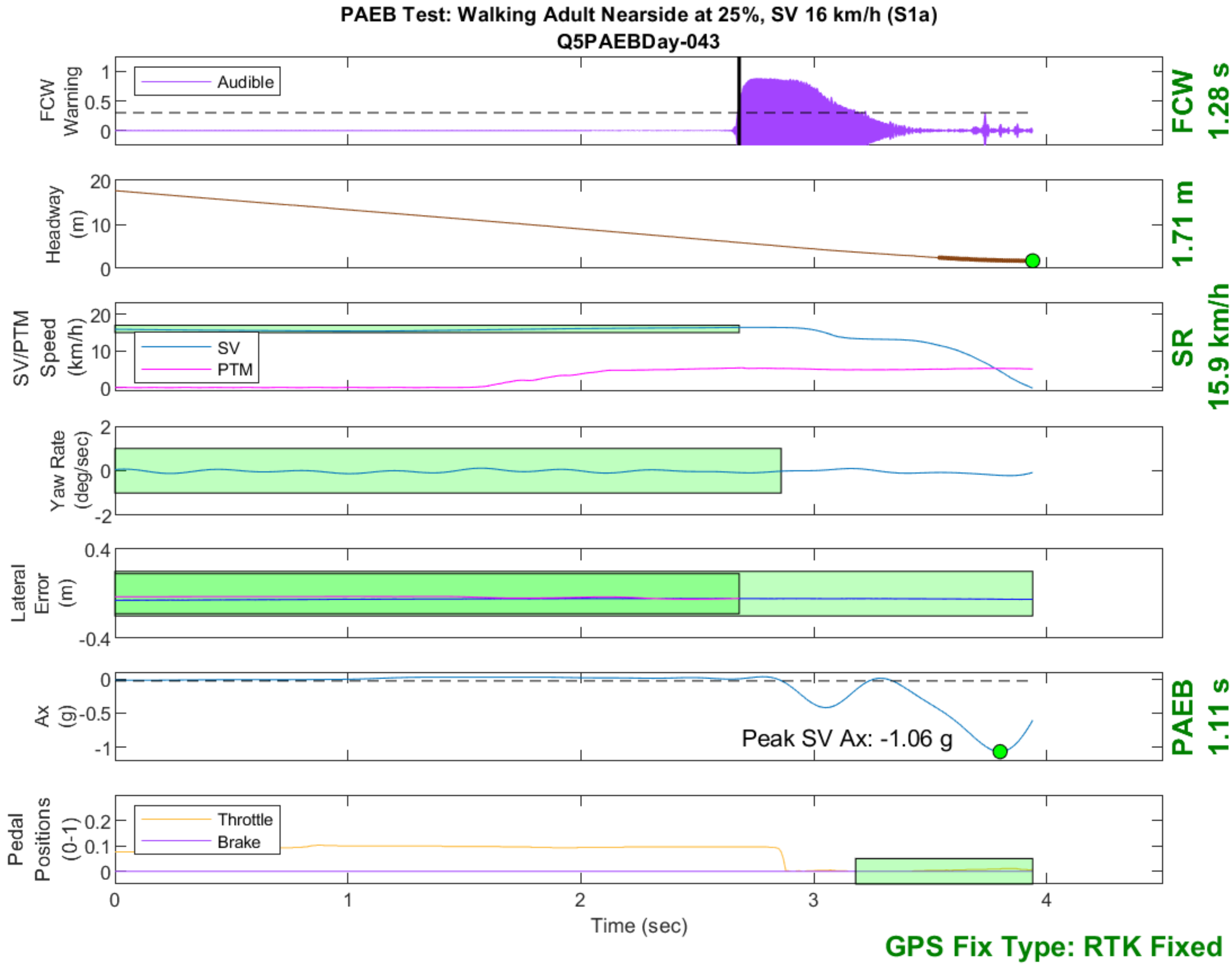

Figure D10. Time History for PAEB Run 43, S1a, Daytime, 16 km/h

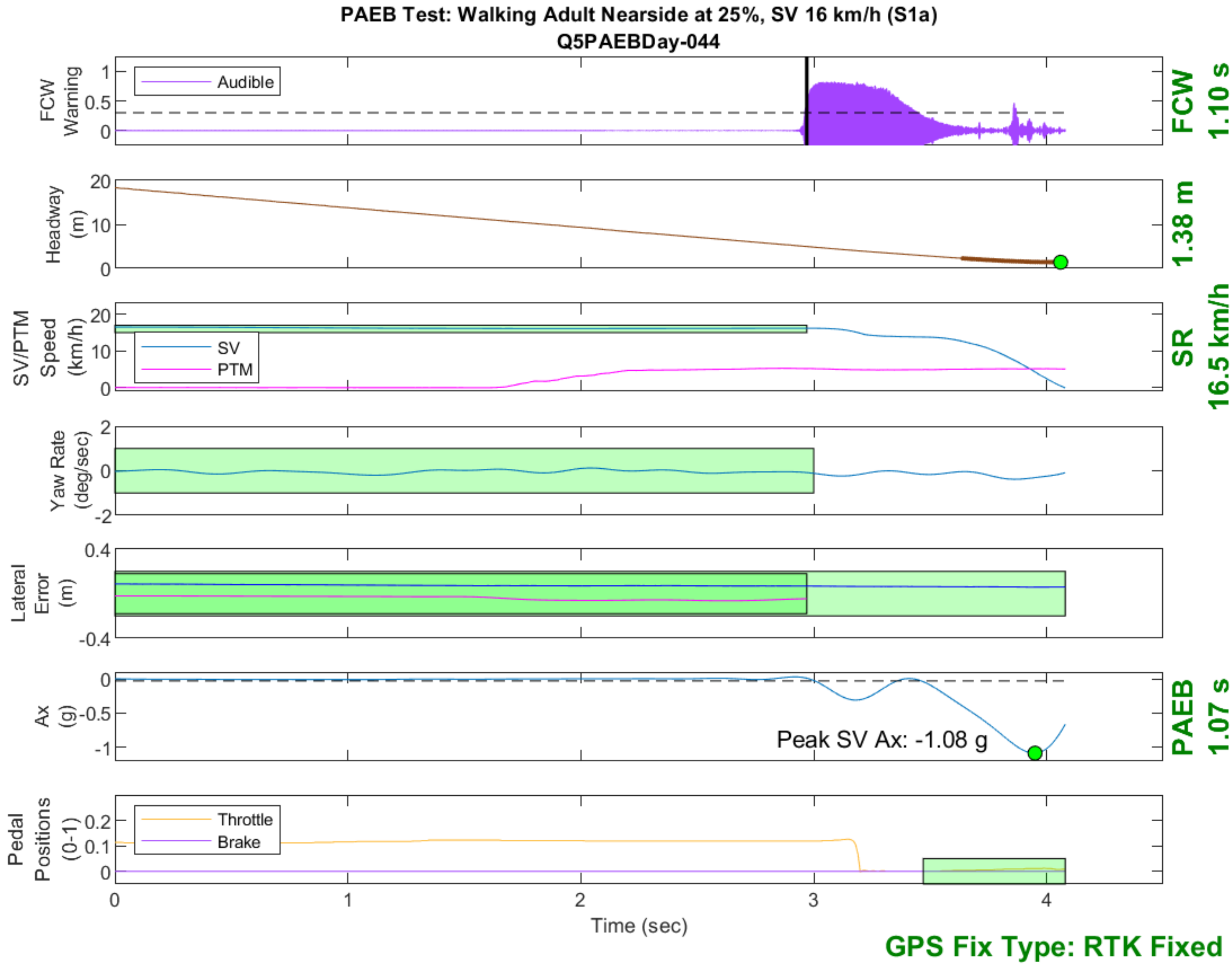

Figure D11. Time History for PAEB Run 44, S1a, Daytime, 16 km/h

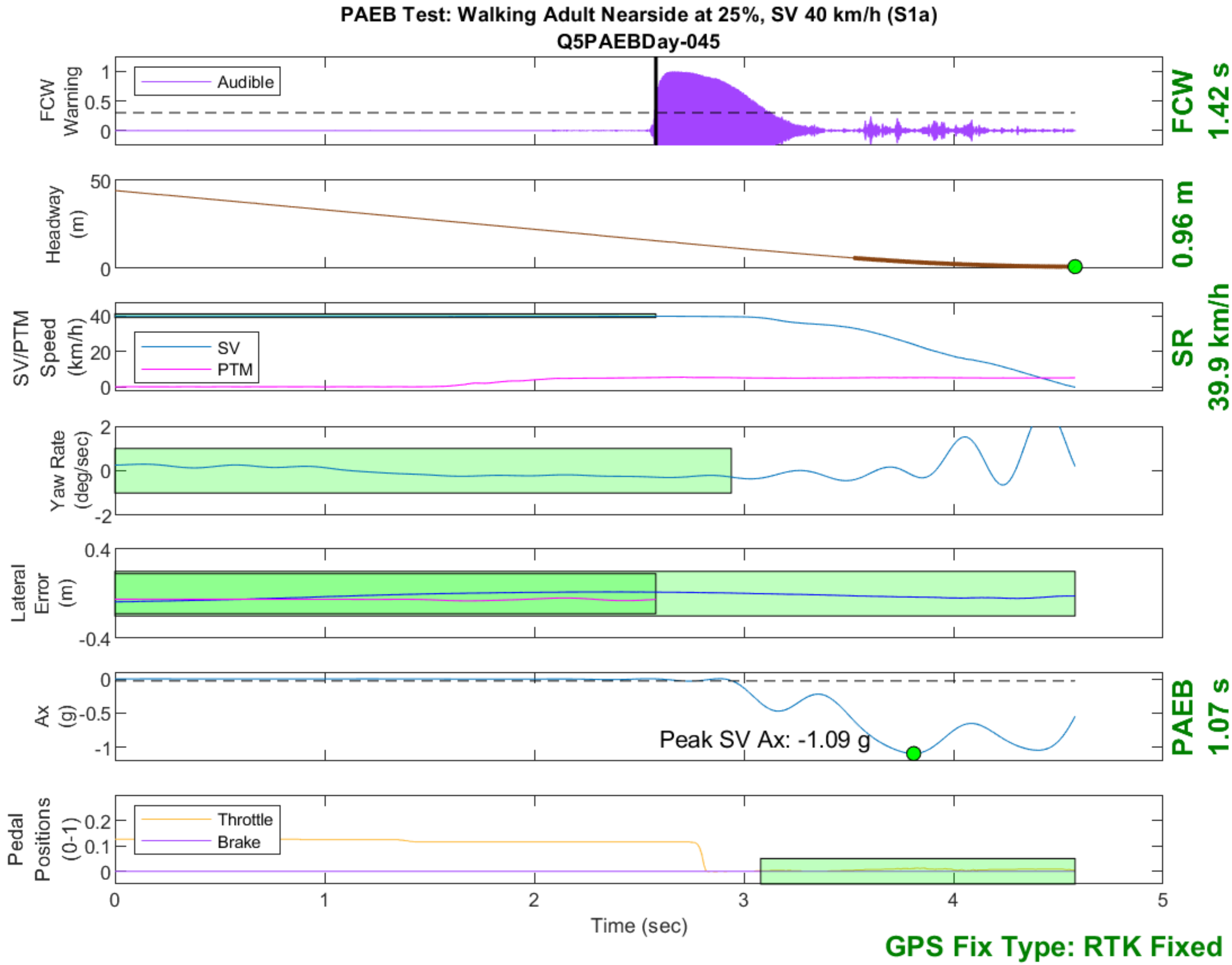

Figure D12. Time History for PAEB Run 45, S1a, Daytime, 40 km/h

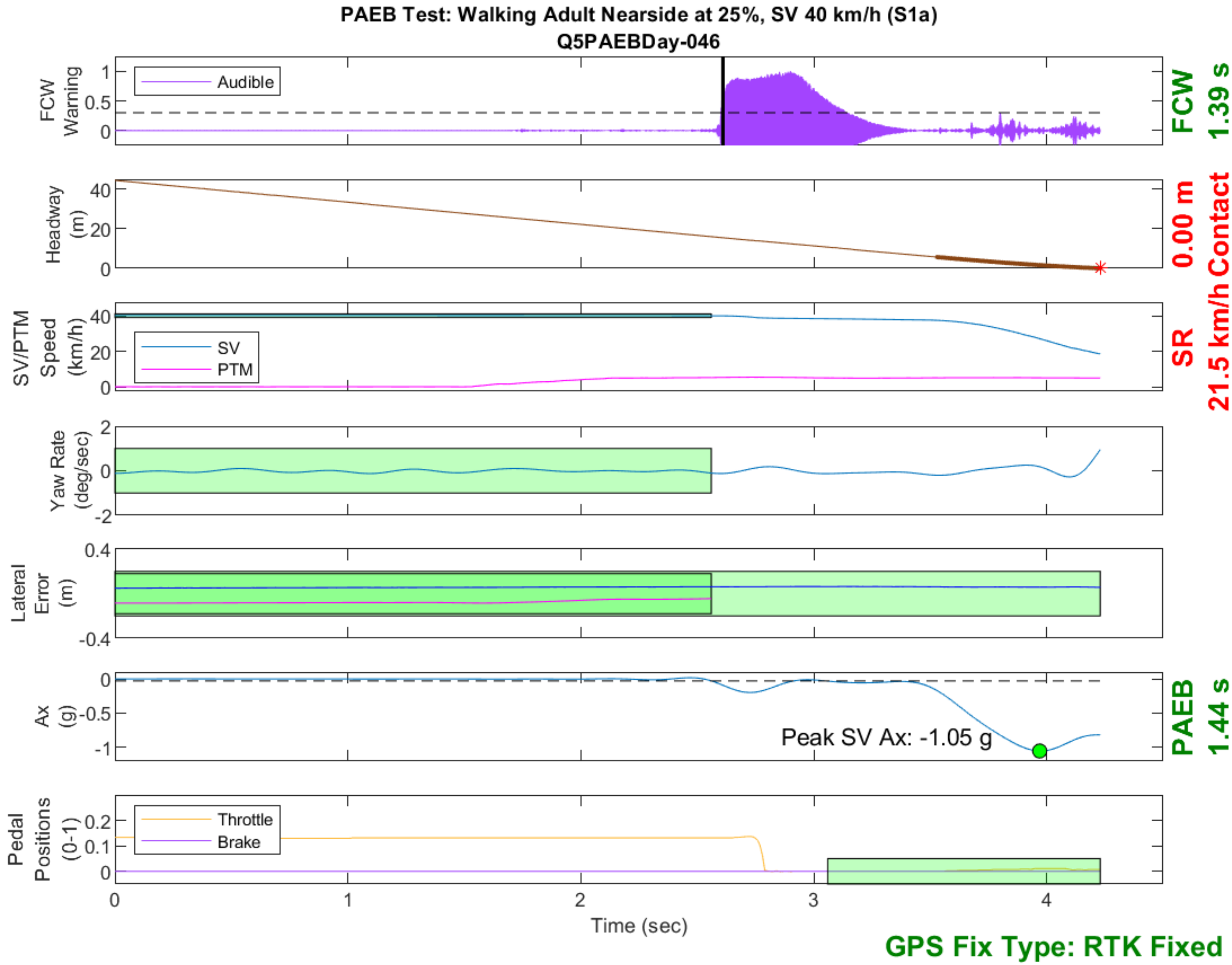

Figure D13. Time History for PAEB Run 46, S1a, Daytime, 40 km/h

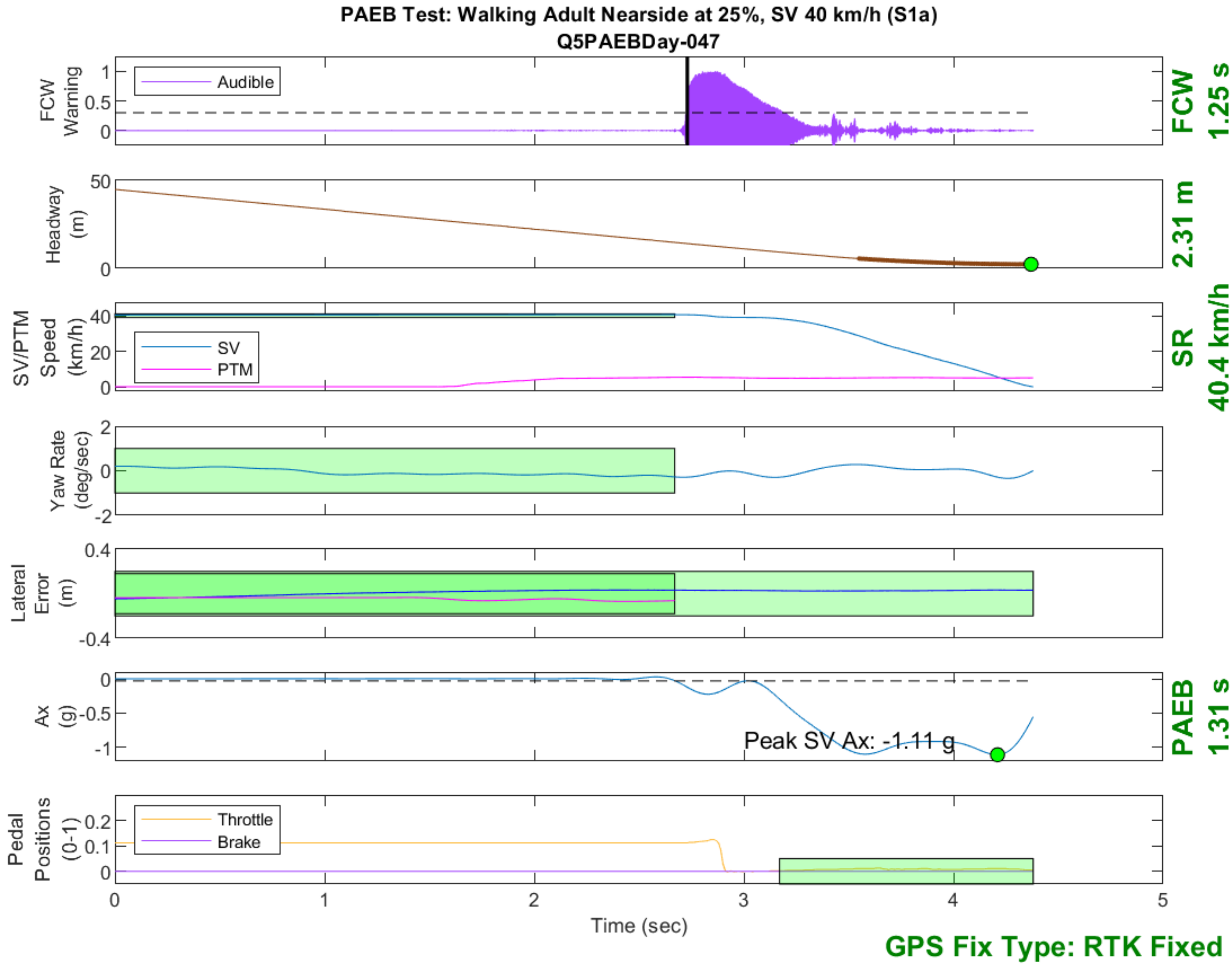

Figure D14. Time History for PAEB Run 47, S1a, Daytime, 40 km/h

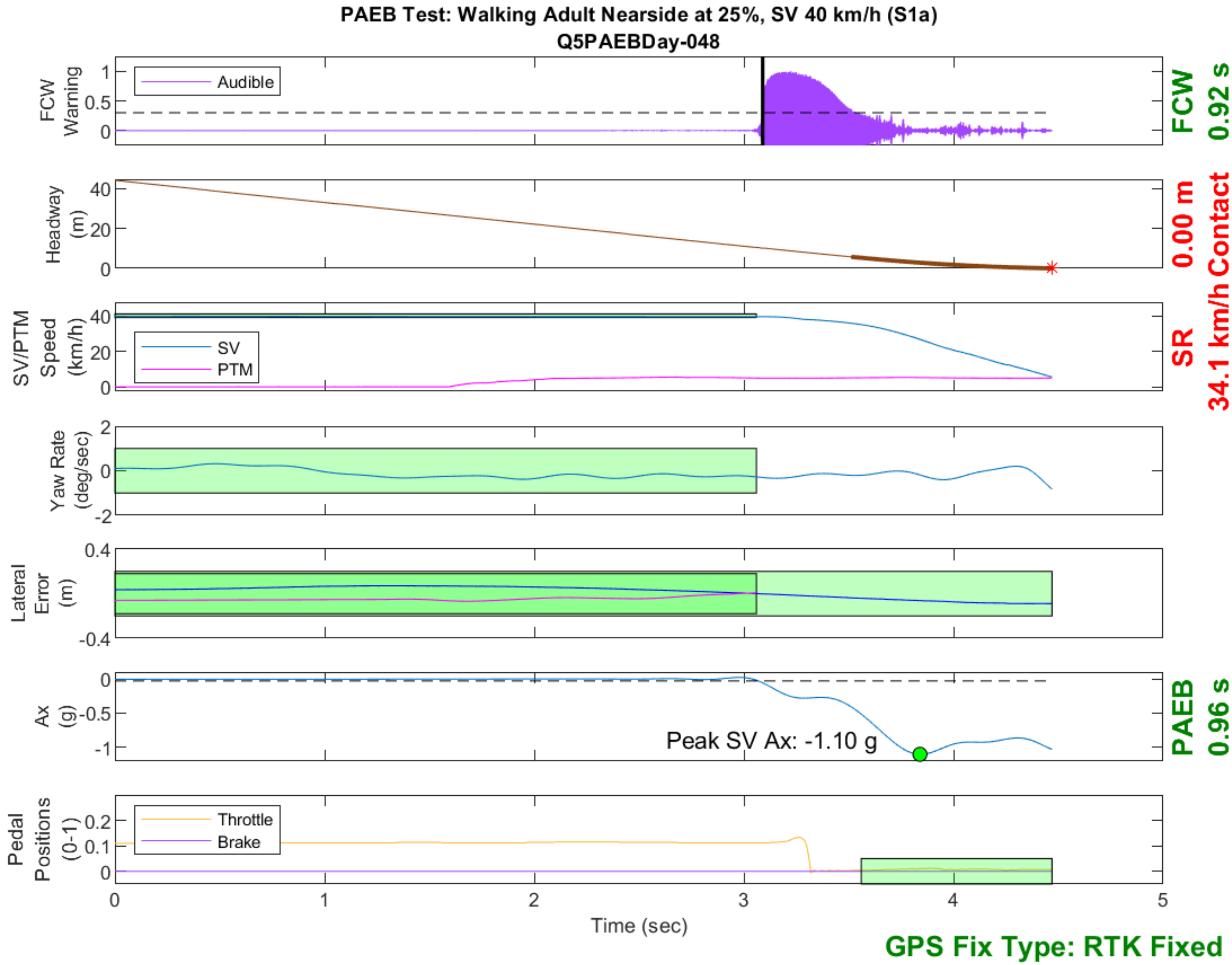

Figure D15. Time History for PAEB Run 48, S1a, Daytime, 40 km/h

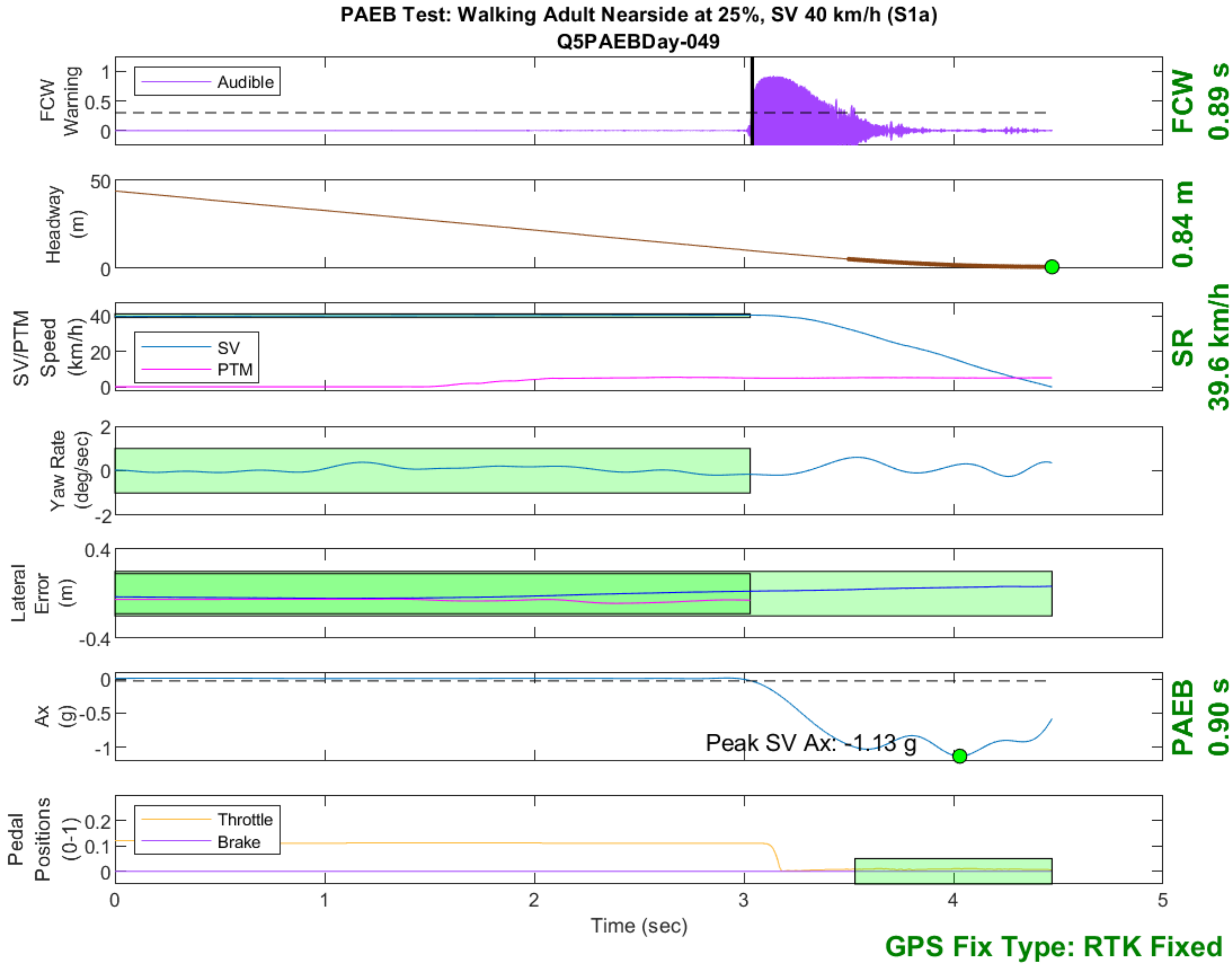

Figure D16. Time History for PAEB Run 49, S1a, Daytime, 40 km/h

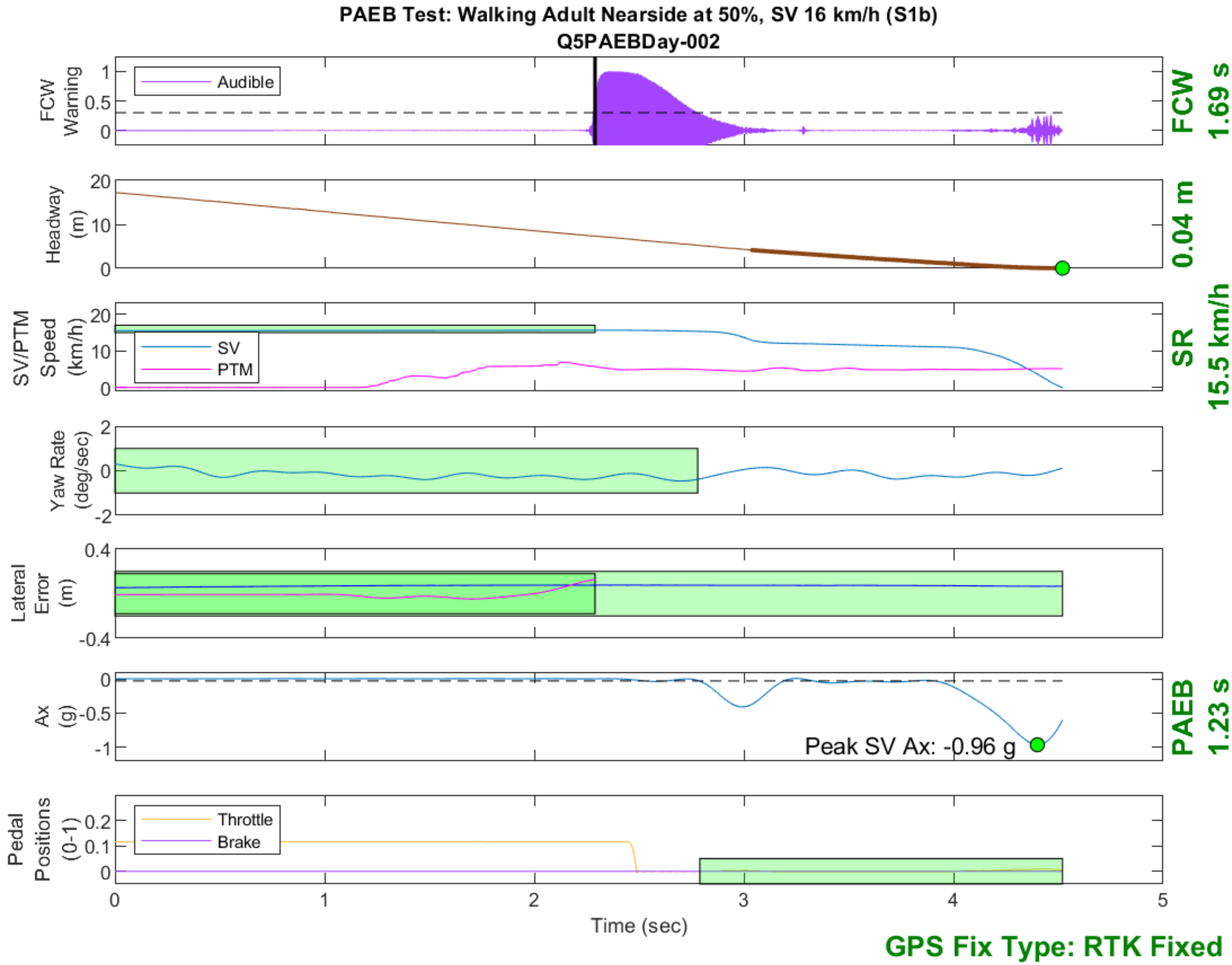

Figure D17. Time History for PAEB Run 2, S1b, Daytime, 16 km/h

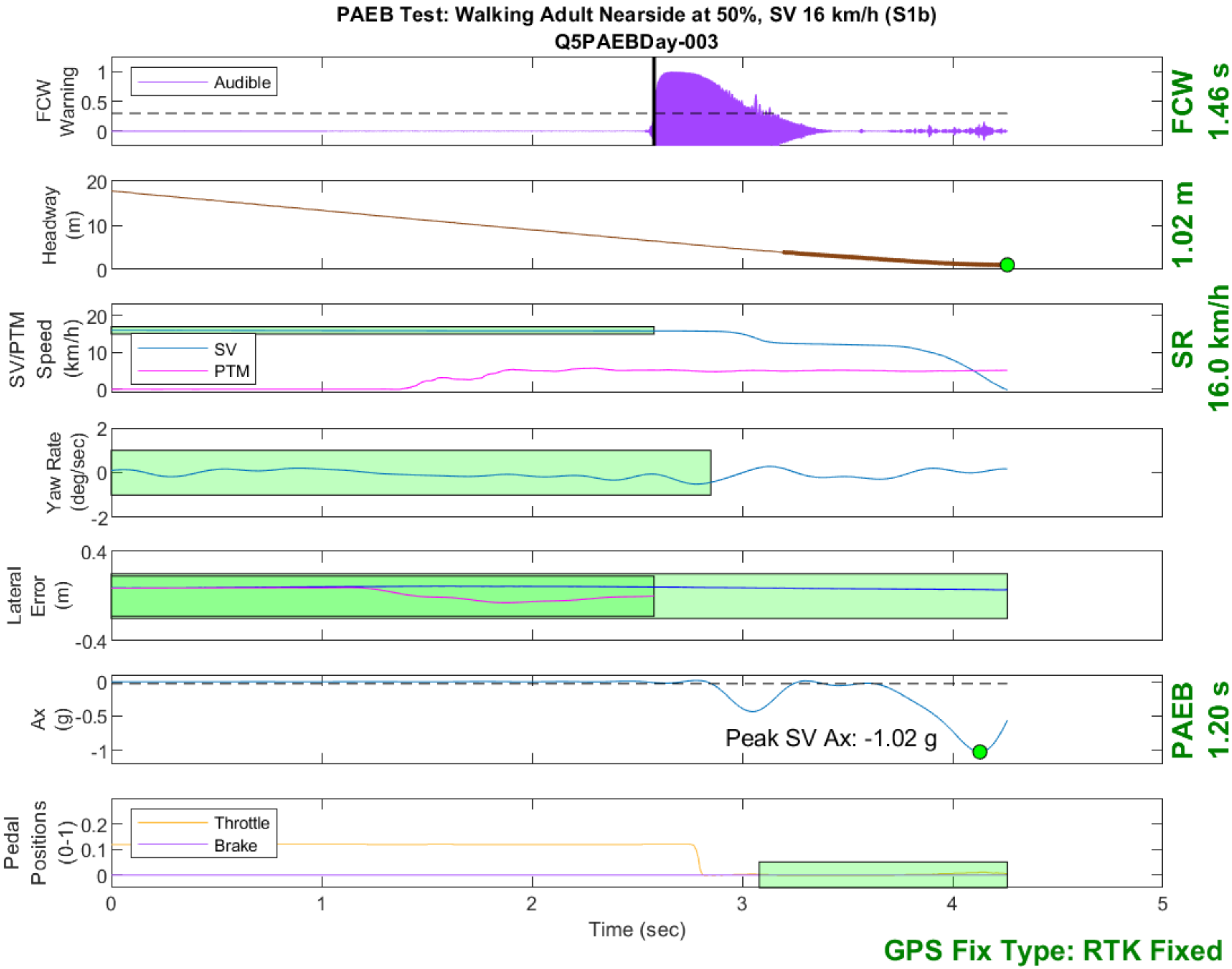

Figure D18. Time History for PAEB Run 3, S1b, Daytime, 16 km/h

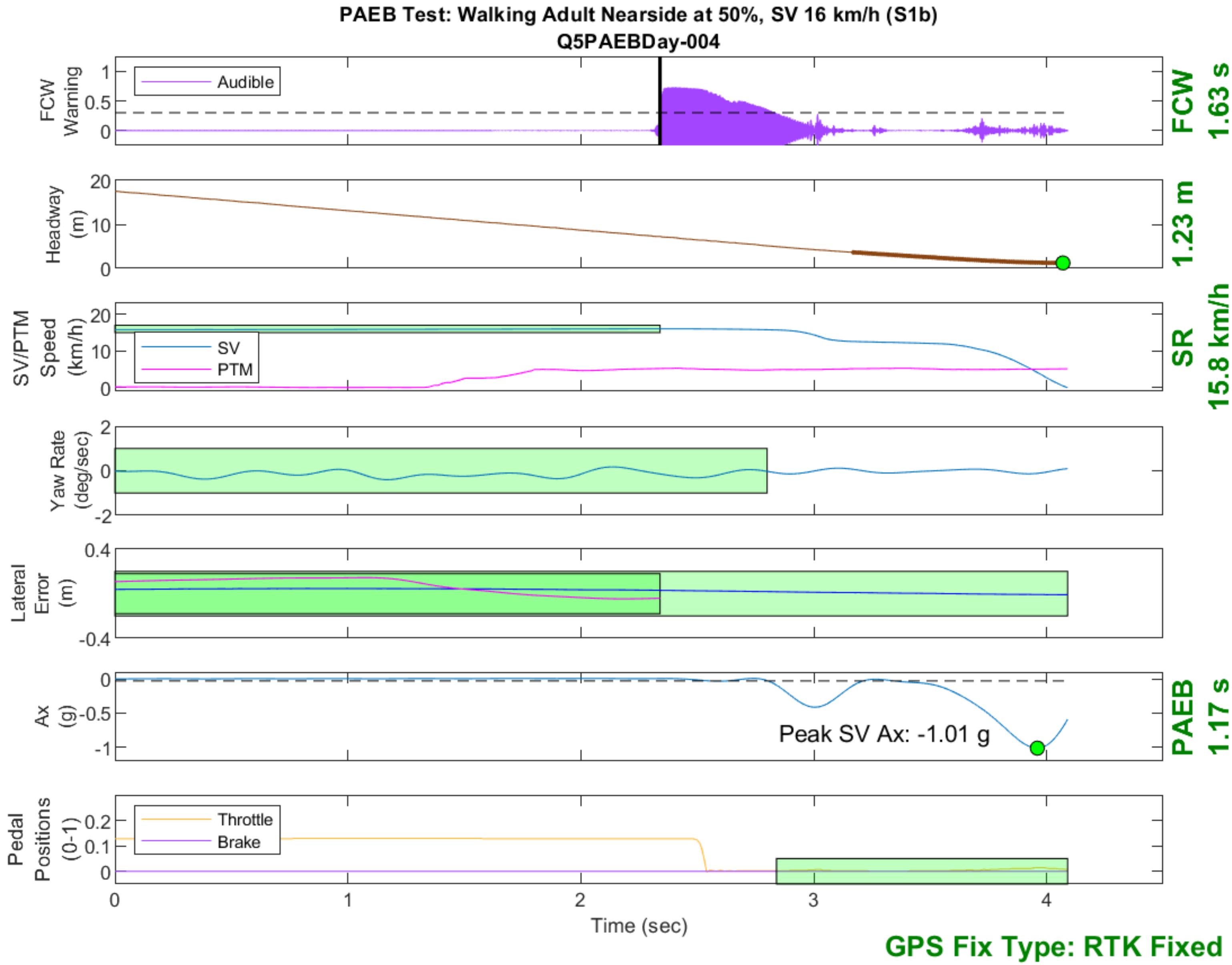

Figure D19. Time History for PAEB Run 4, S1b, Daytime, 16 km/h

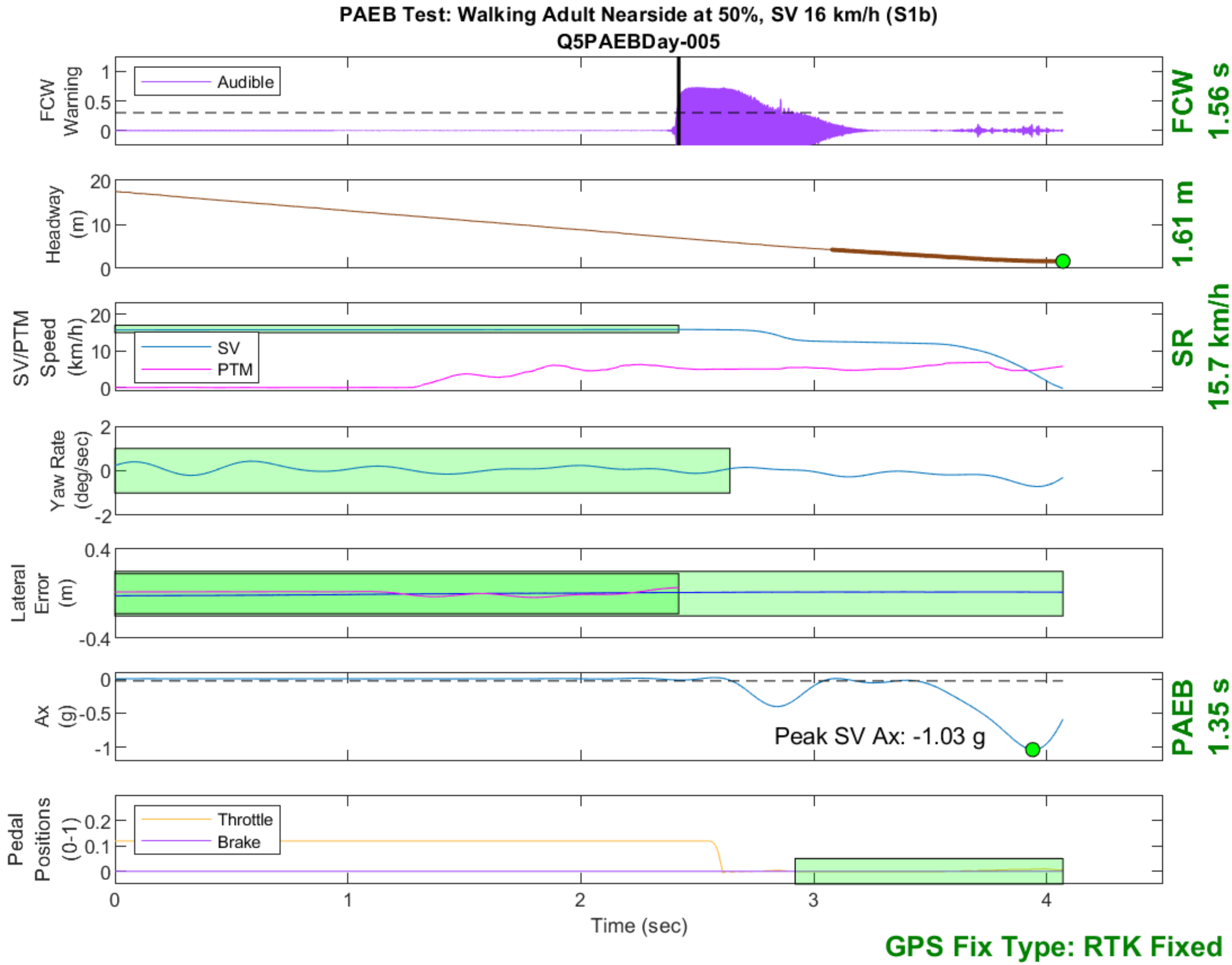

Figure D20. Time History for PAEB Run 5, S1b, Daytime, 16 km/h

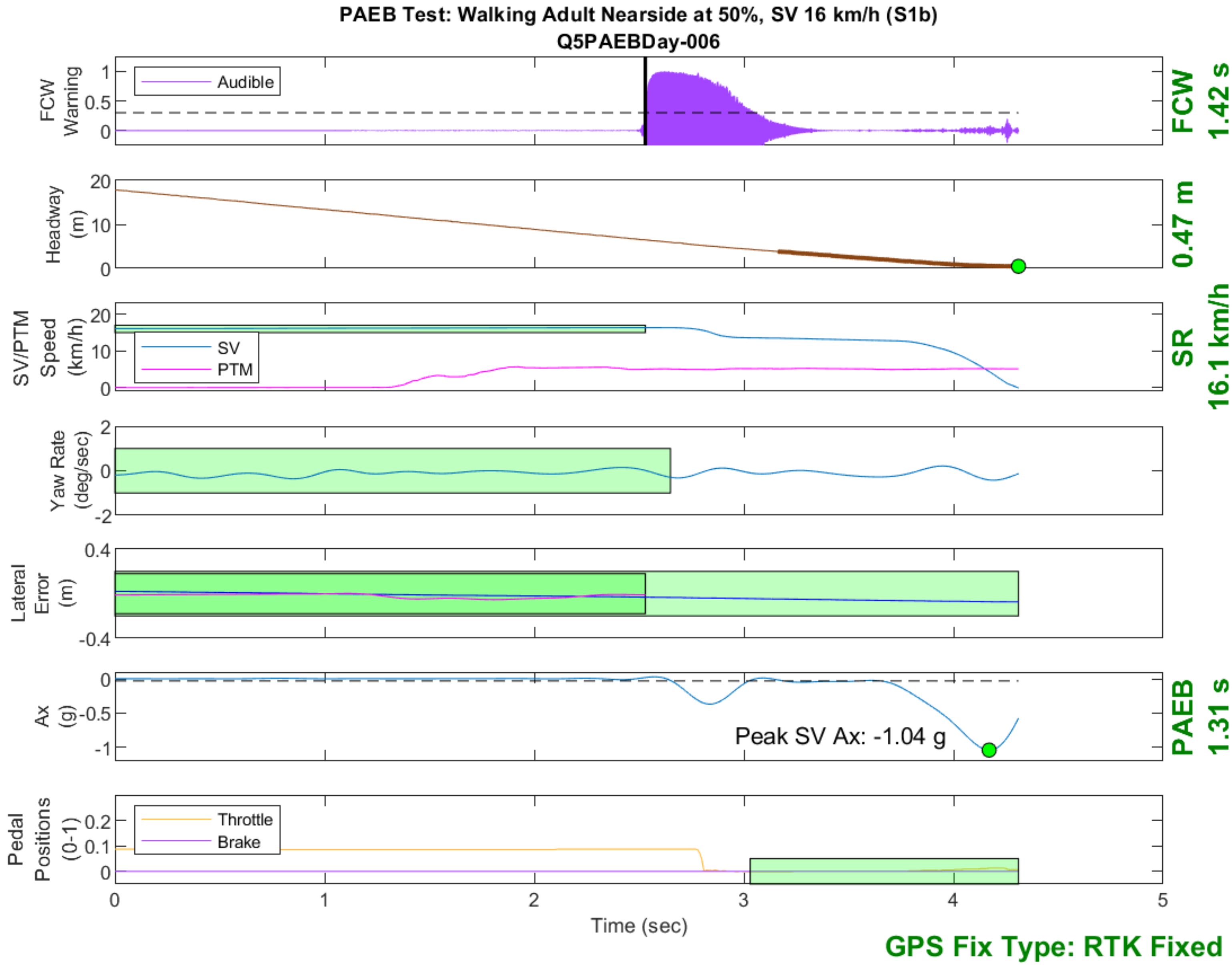

Figure D21. Time History for PAEB Run 6, S1b, Daytime, 16 km/h

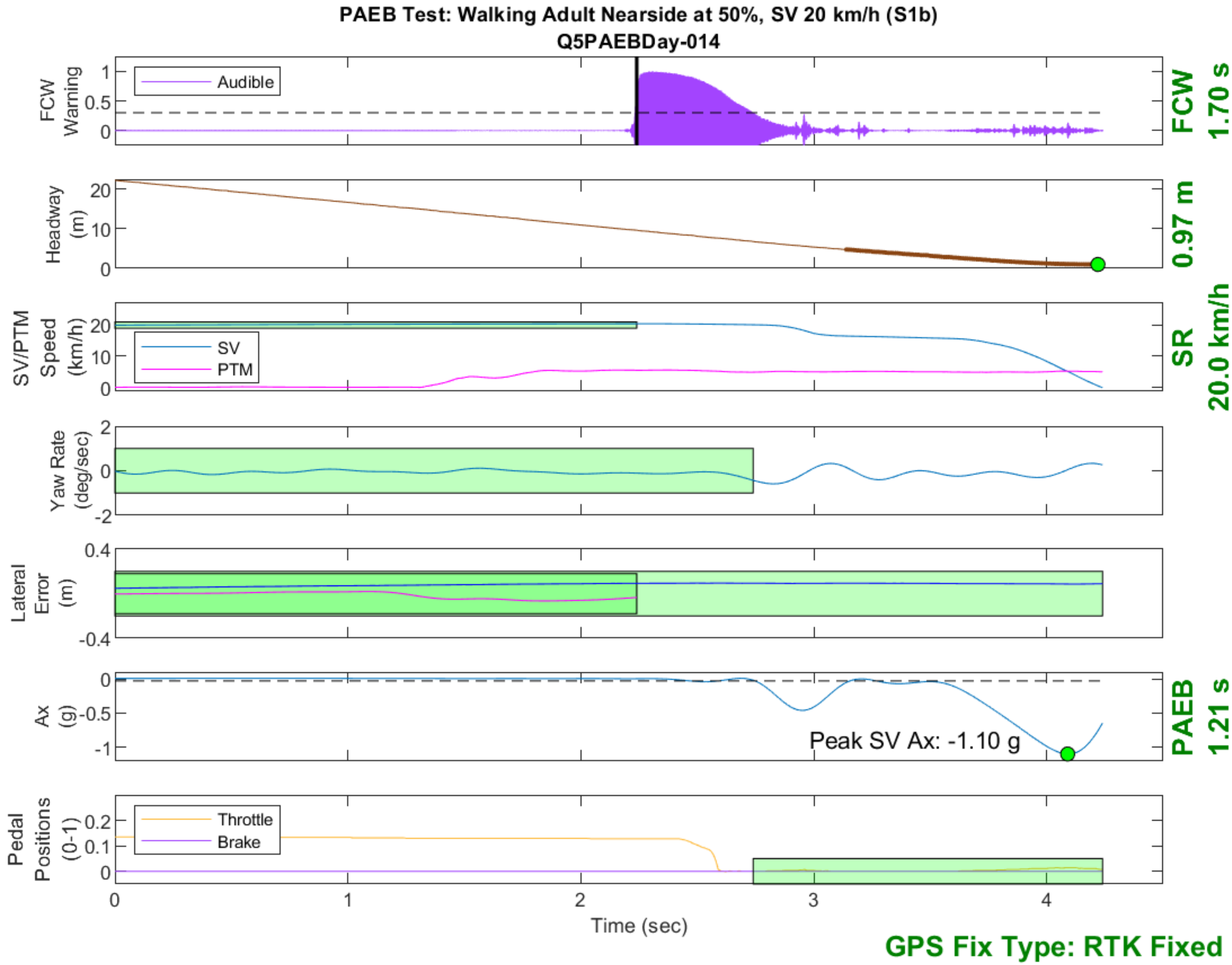

Figure D22. Time History for PAEB Run 14, S1b, Daytime, 20 km/h

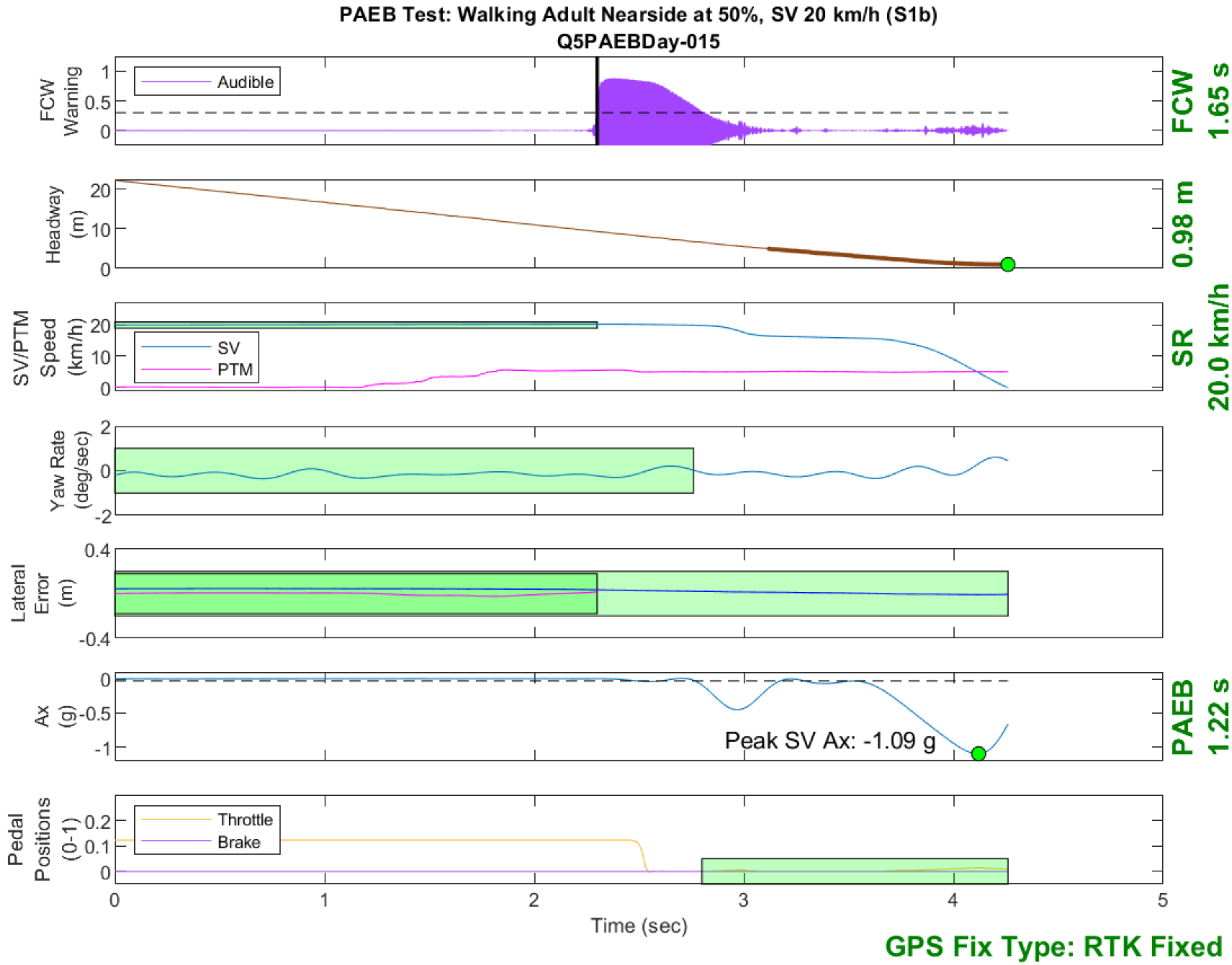

Figure D23. Time History for PAEB Run 15, S1b, Daytime, 20 km/h

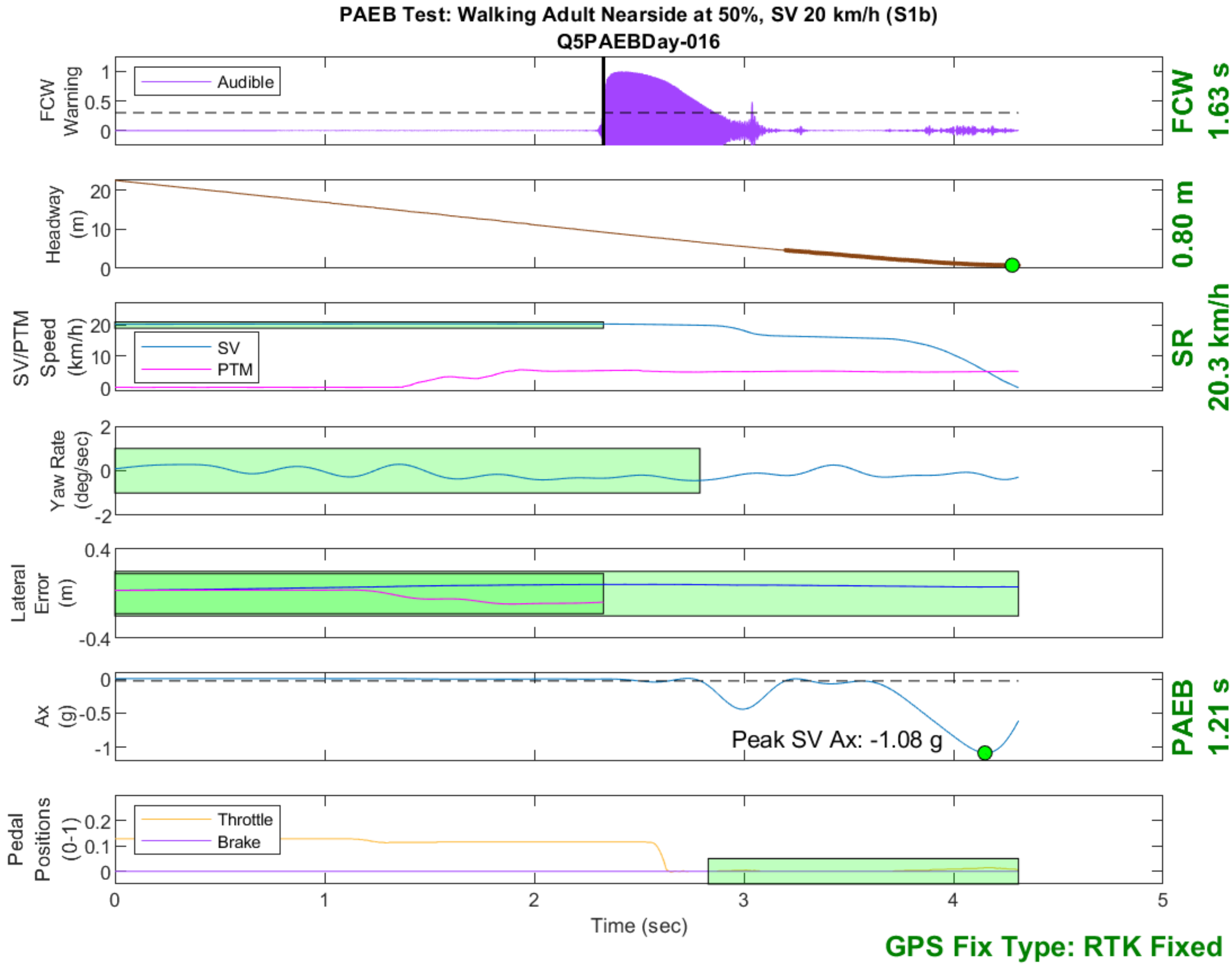

Figure D24. Time History for PAEB Run 16, S1b, Daytime, 20 km/h

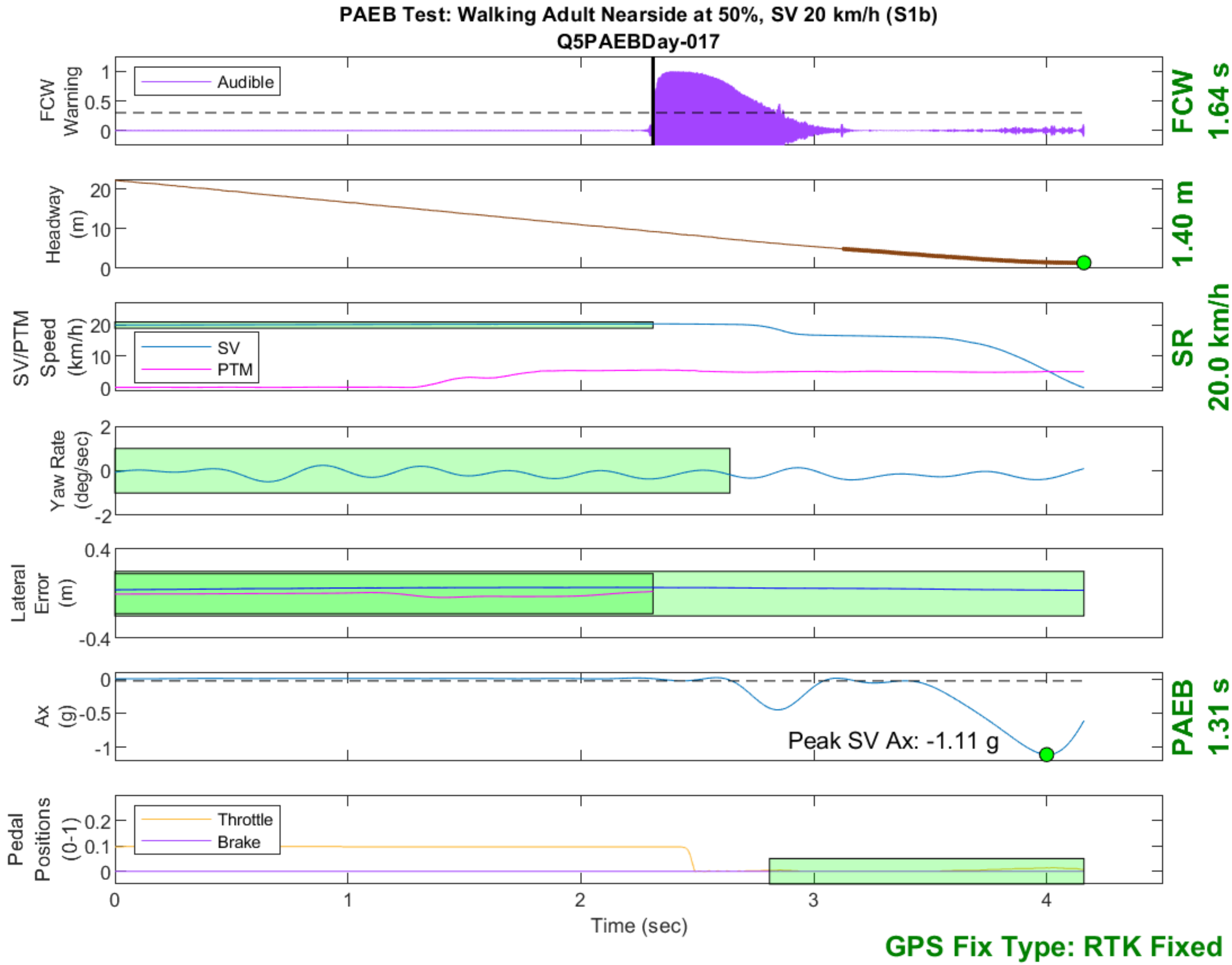

Figure D25. Time History for PAEB Run 17, S1b, Daytime, 20 km/h

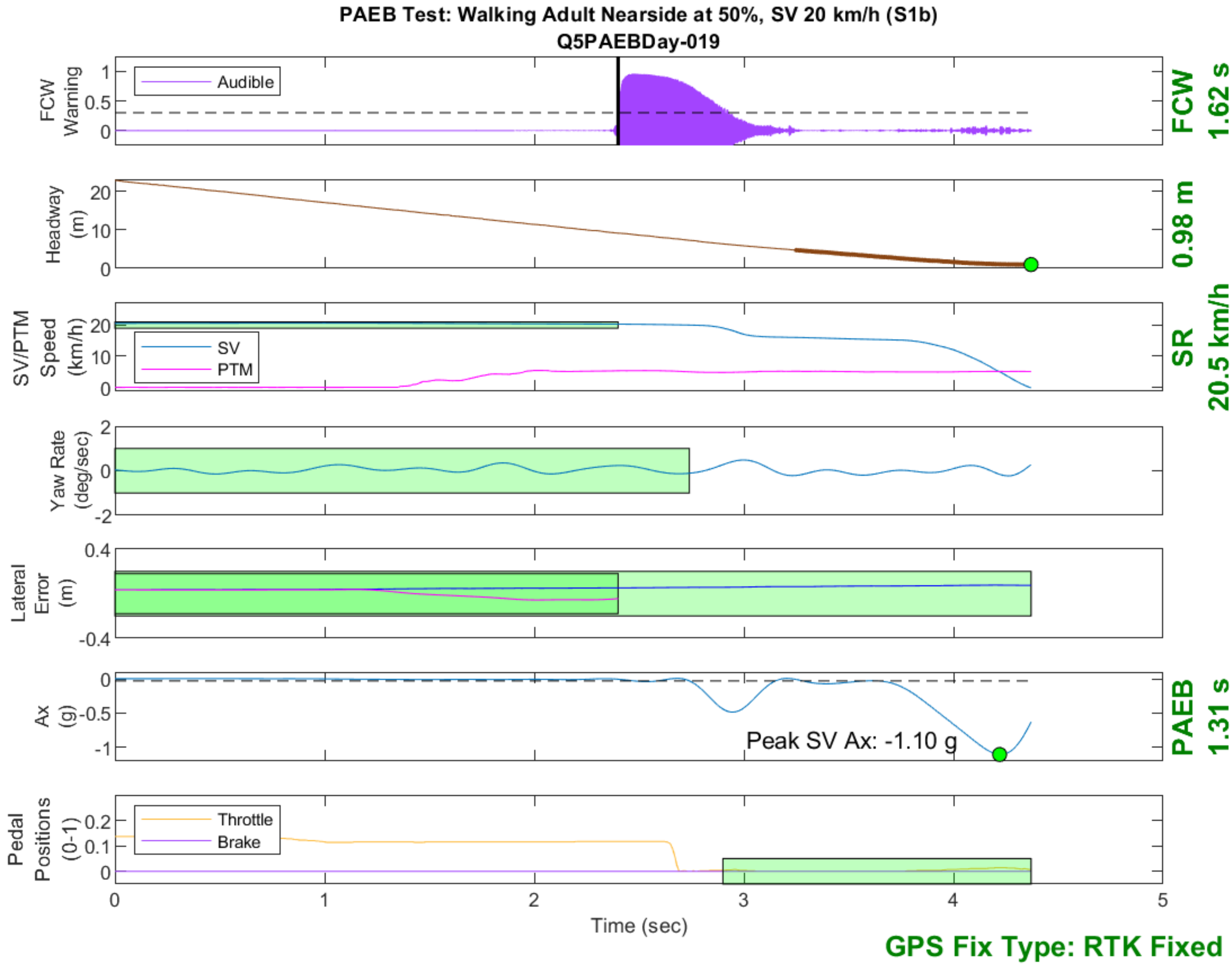

Figure D26. Time History for PAEB Run 19, S1b, Daytime, 20 km/h

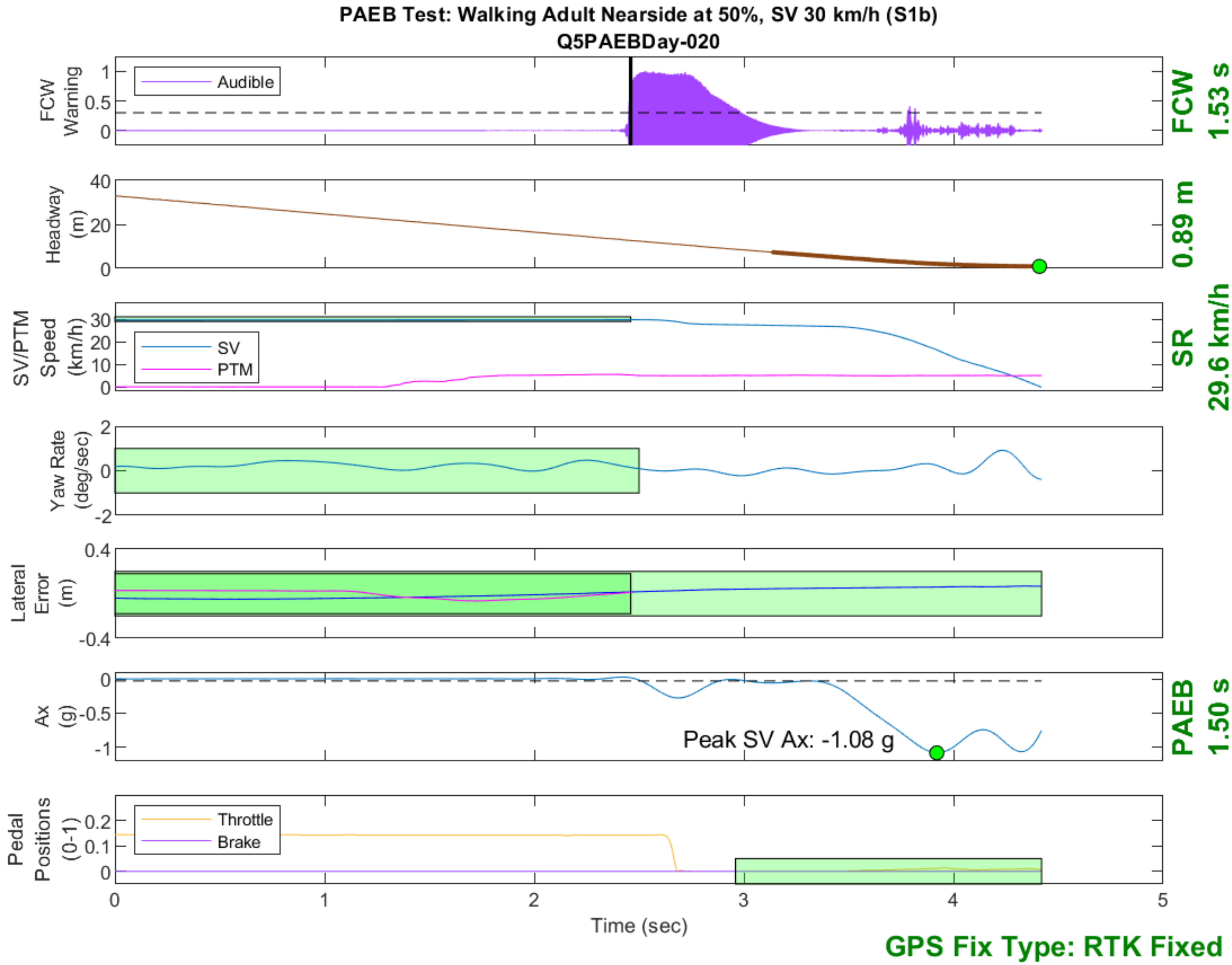

Figure D27. Time History for PAEB Run 20, S1b, Daytime, 30 km/h

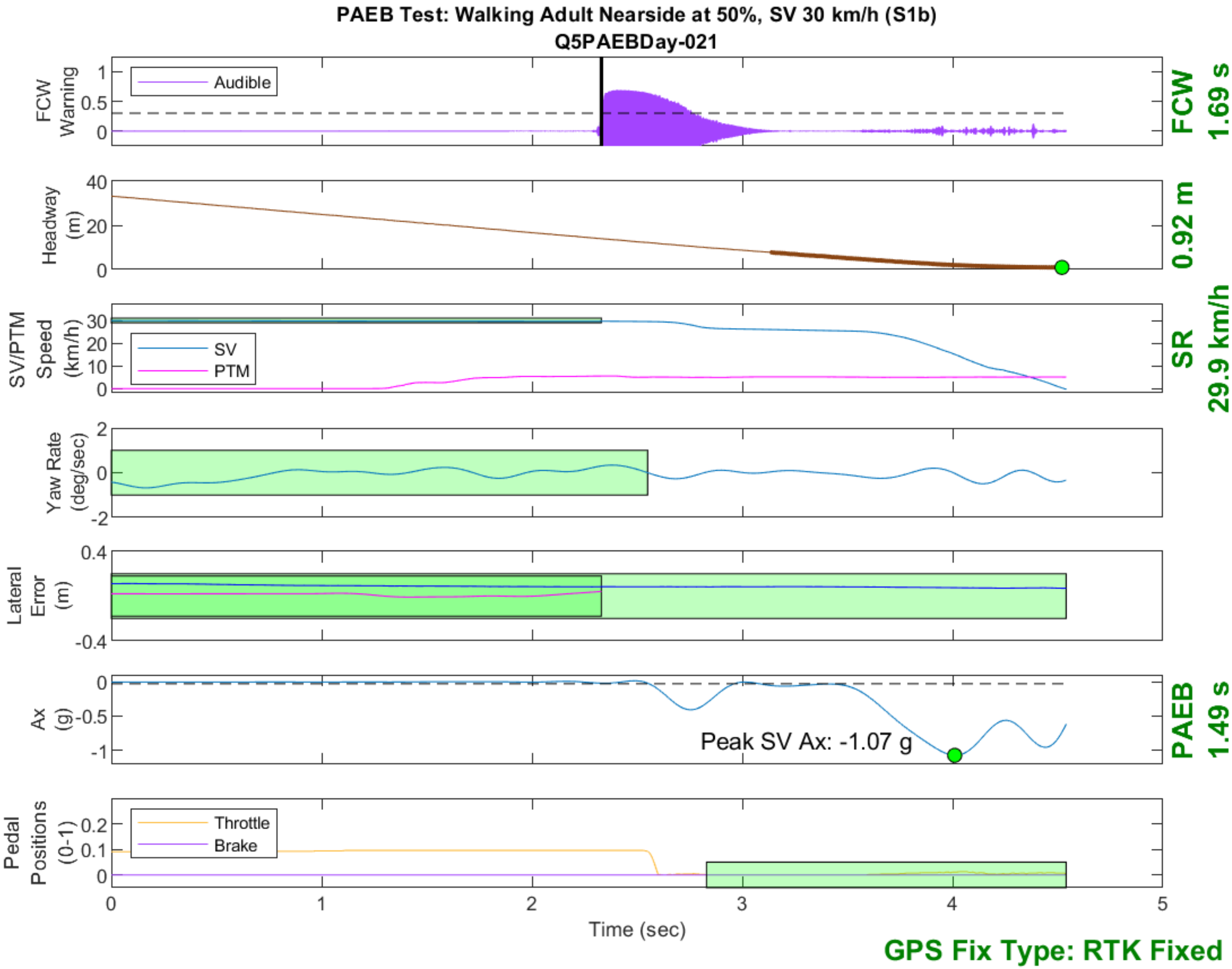

Figure D28. Time History for PAEB Run 21, S1b, Daytime, 30 km/h

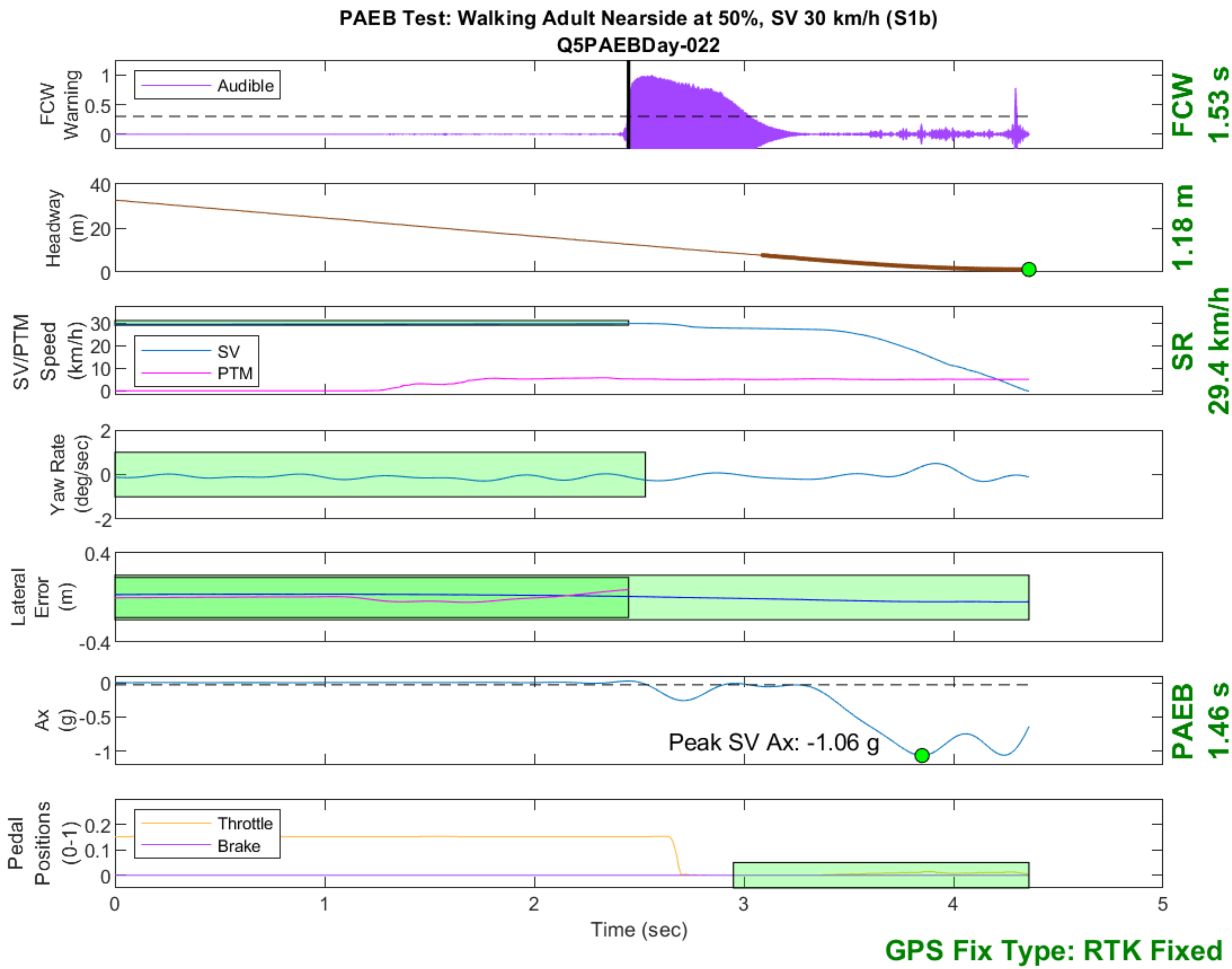

Figure D29. Time History for PAEB Run 22, S1b, Daytime, 30 km/h

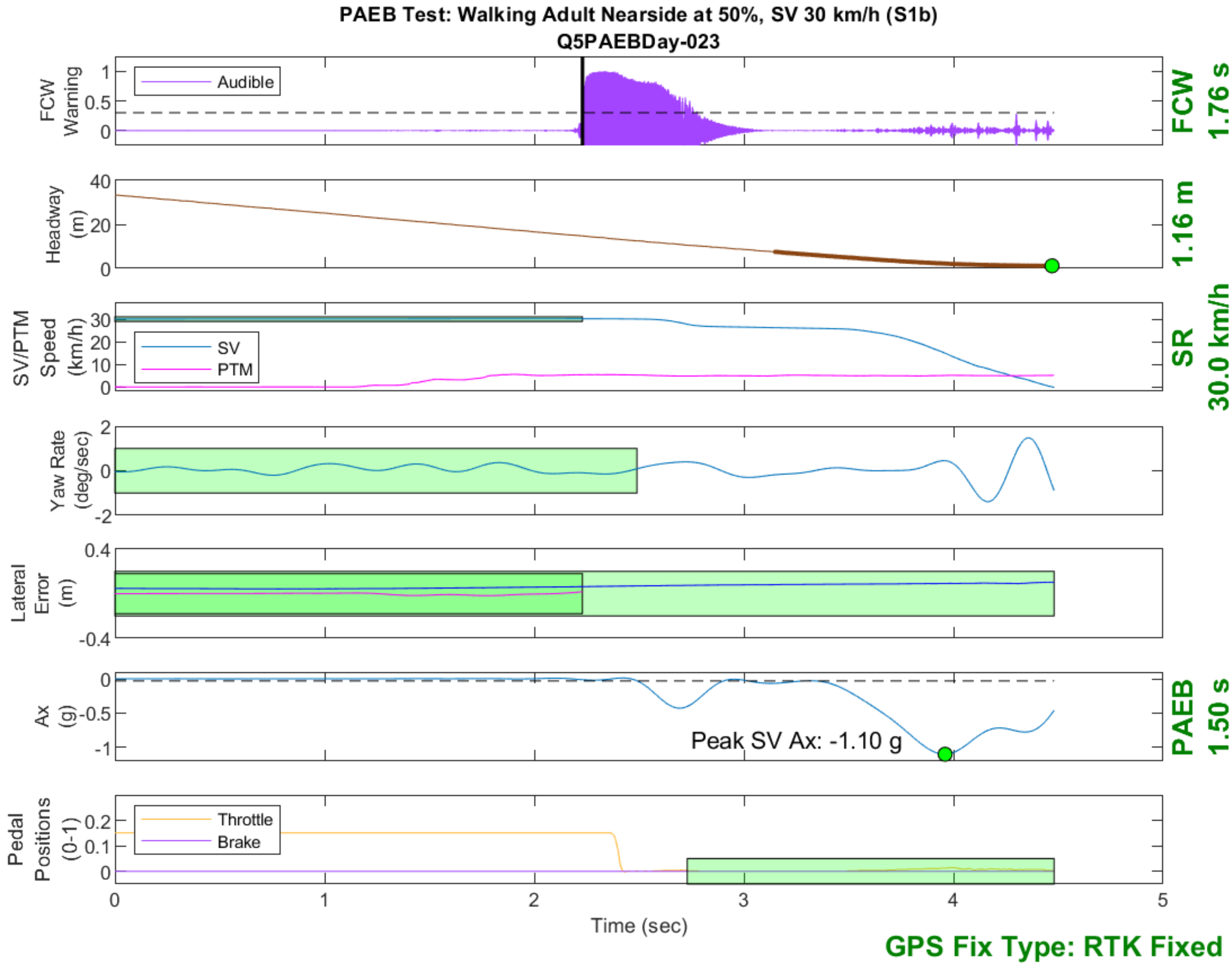

Figure D30. Time History for PAEB Run 23, S1b, Daytime, 30 km/h

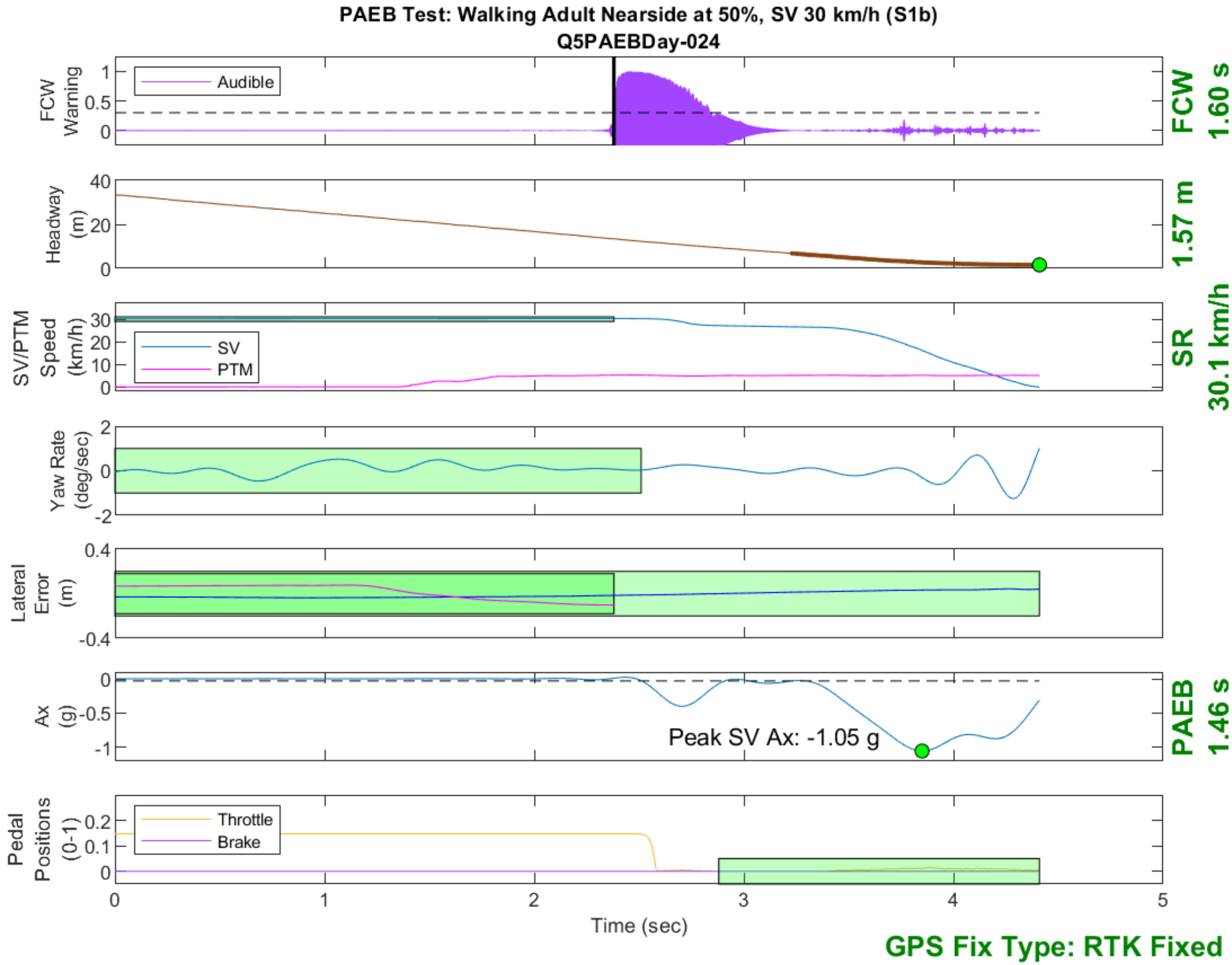

Figure D31. Time History for PAEB Run 24, S1b, Daytime, 30 km/h

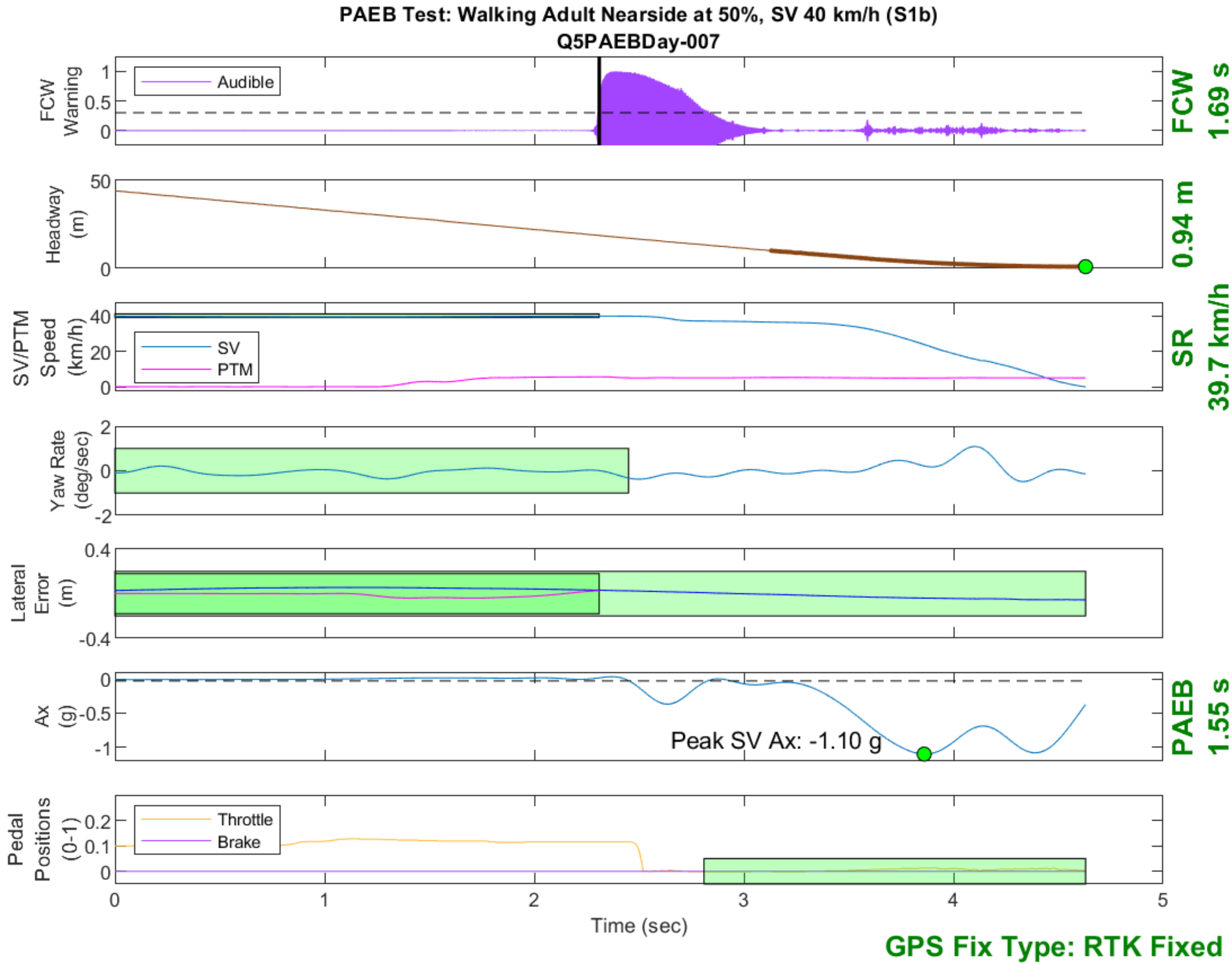

Figure D32. Time History for PAEB Run 7, S1b, Daytime, 40 km/h

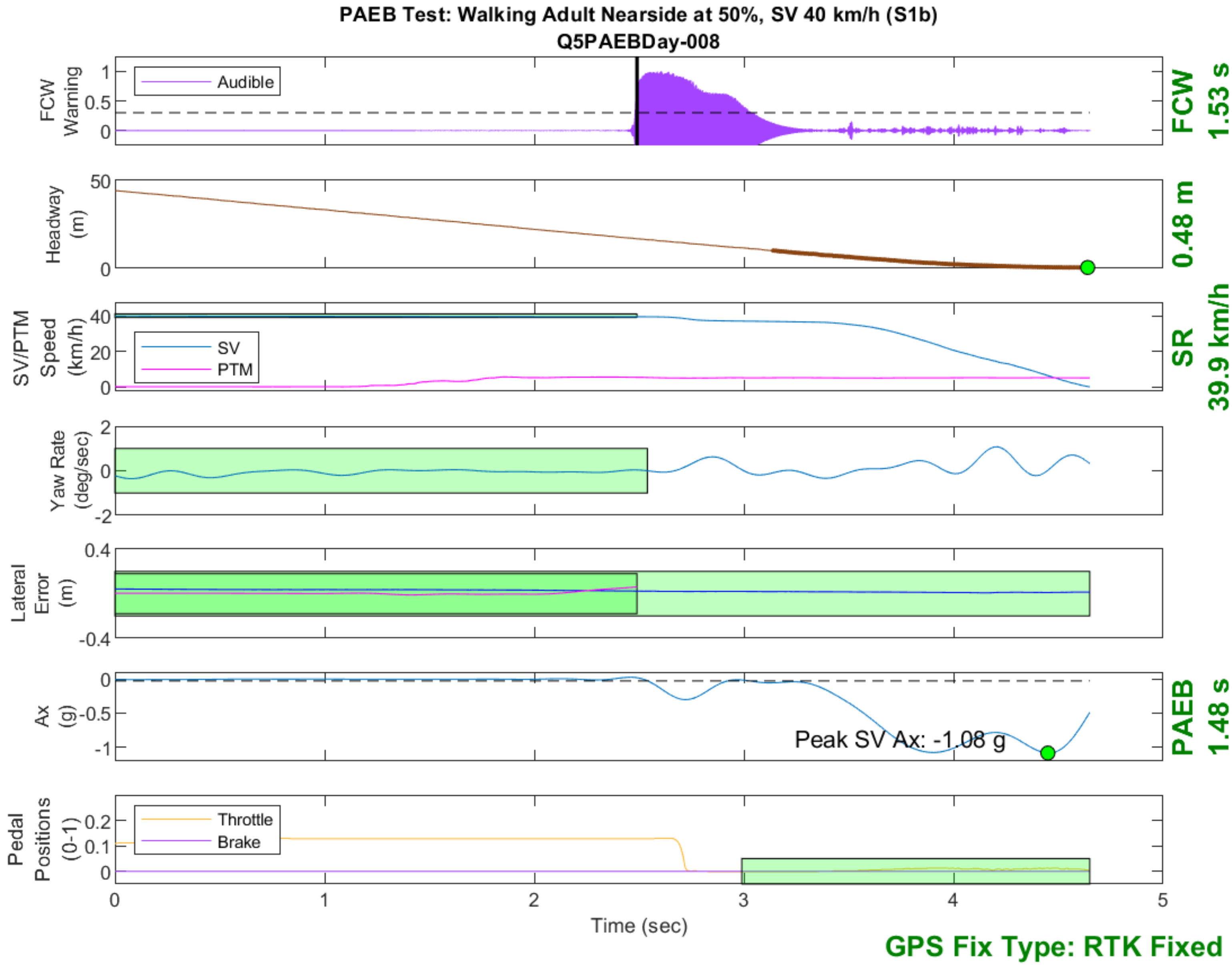

Figure D33. Time History for PAEB Run 8, S1b, Daytime, 40 km/h

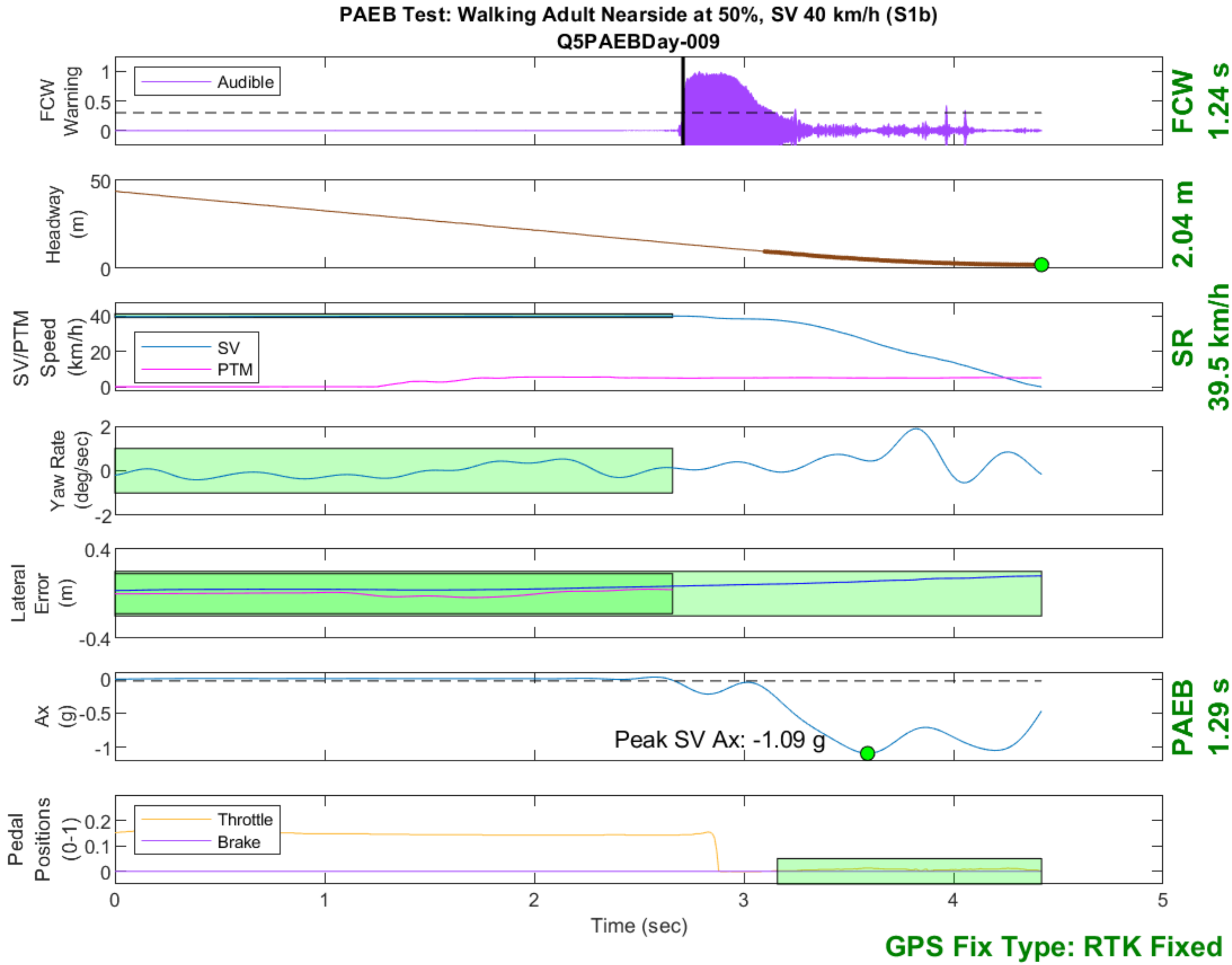

Figure D34. Time History for PAEB Run 9, S1b, Daytime, 40 km/h

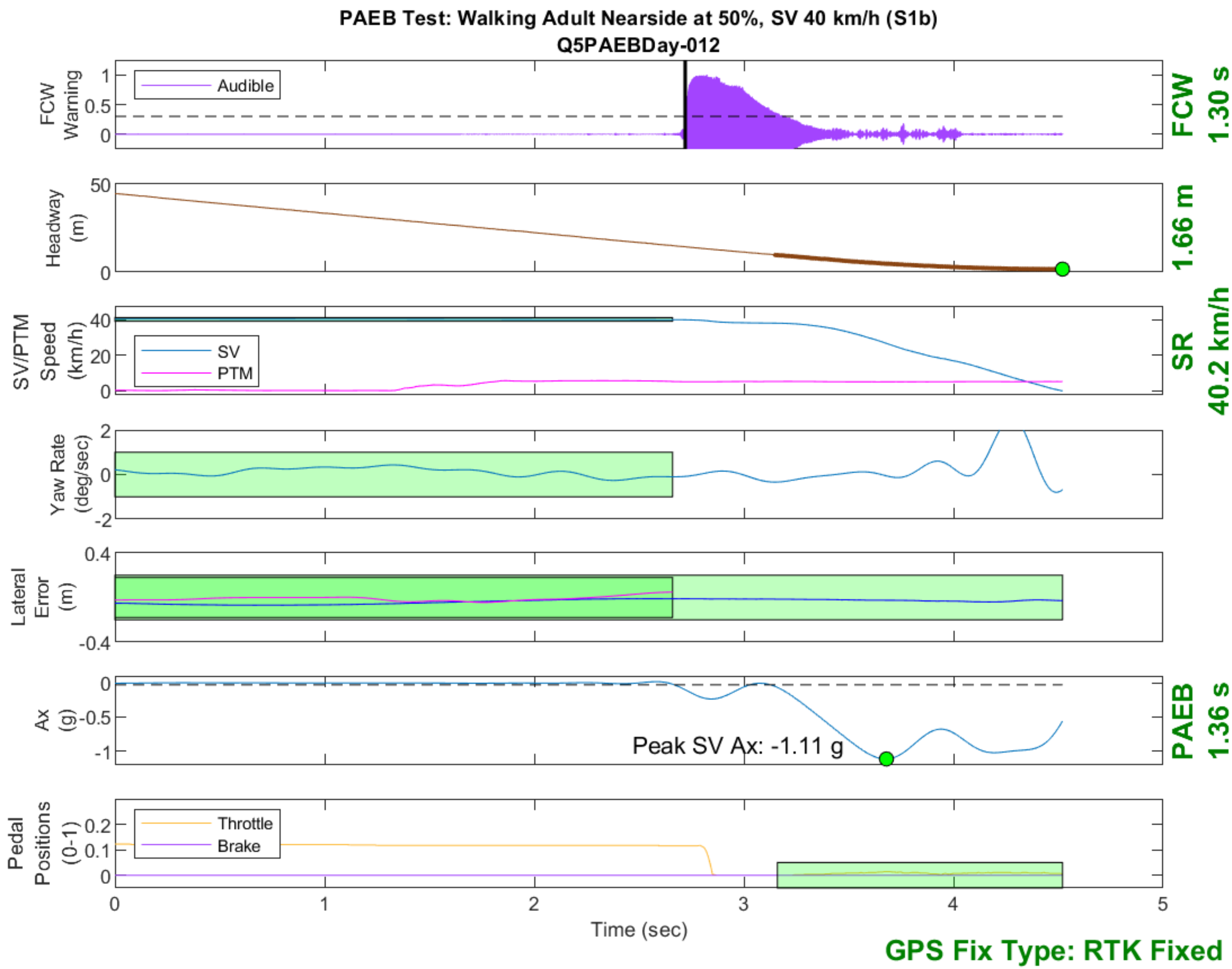

Figure D35. Time History for PAEB Run 12, S1b, Daytime, 40 km/h

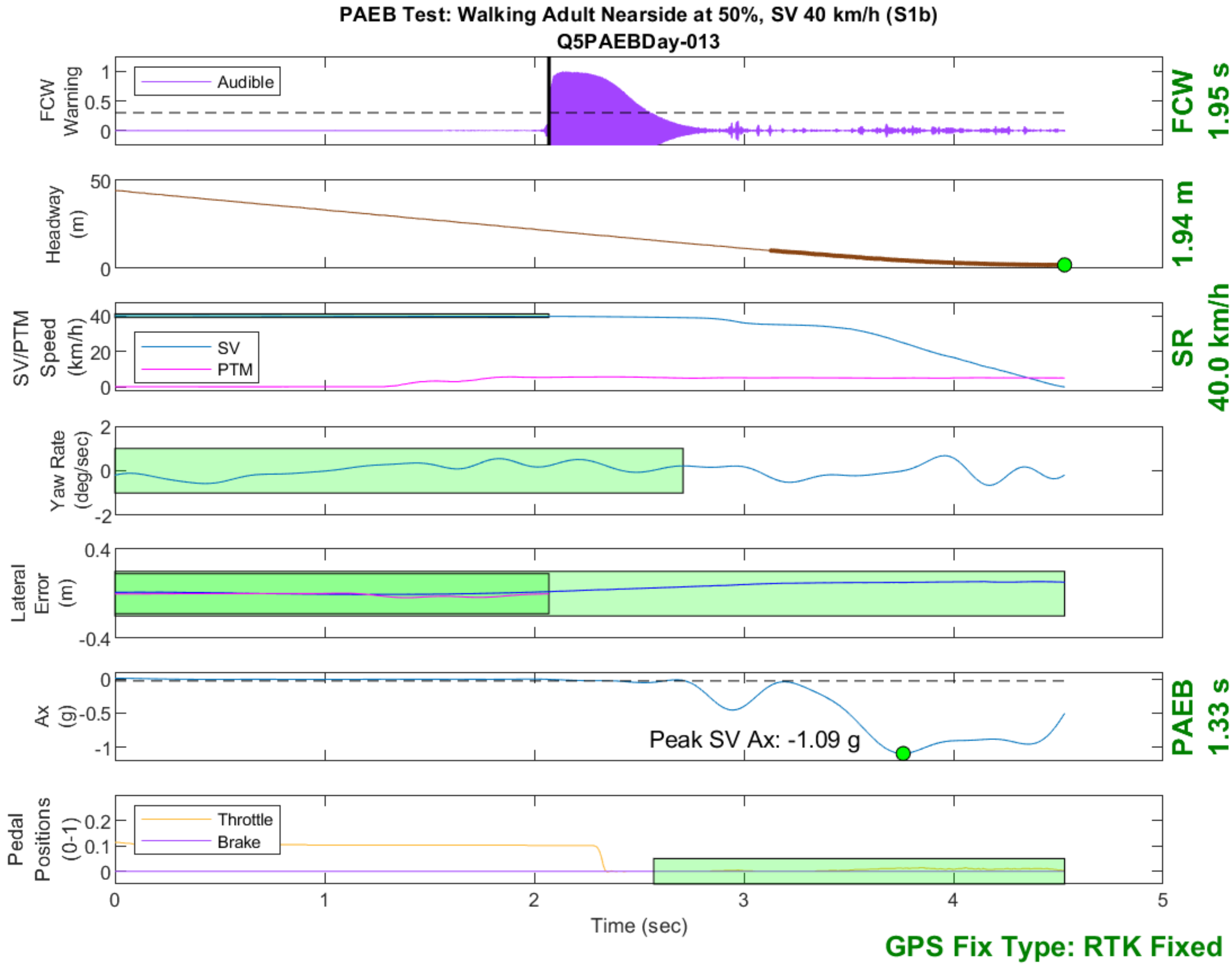

Figure D36. Time History for PAEB Run 13, S1b, Daytime, 40 km/h

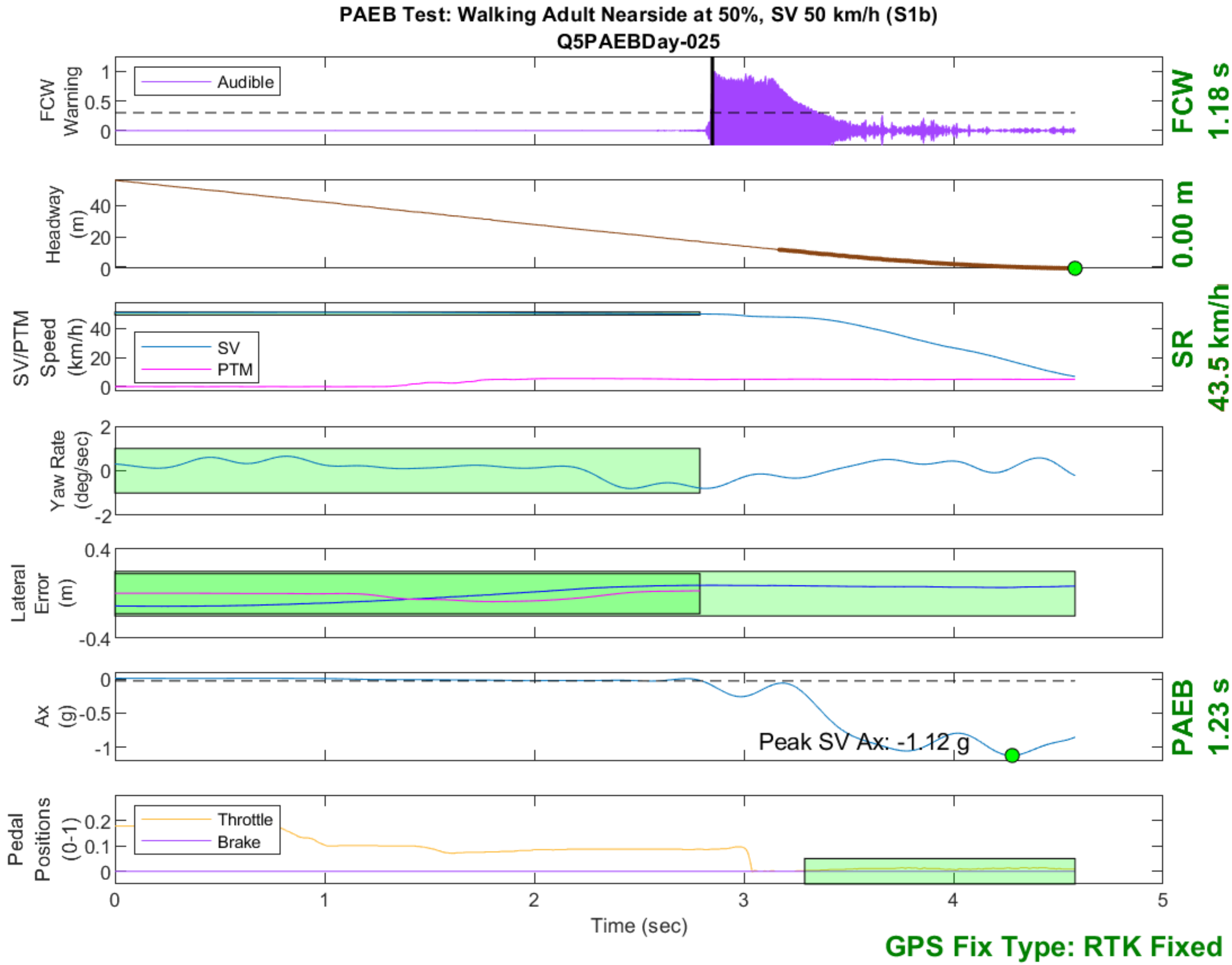

Figure D37. Time History for PAEB Run 25, S1b, Daytime, 50 km/h

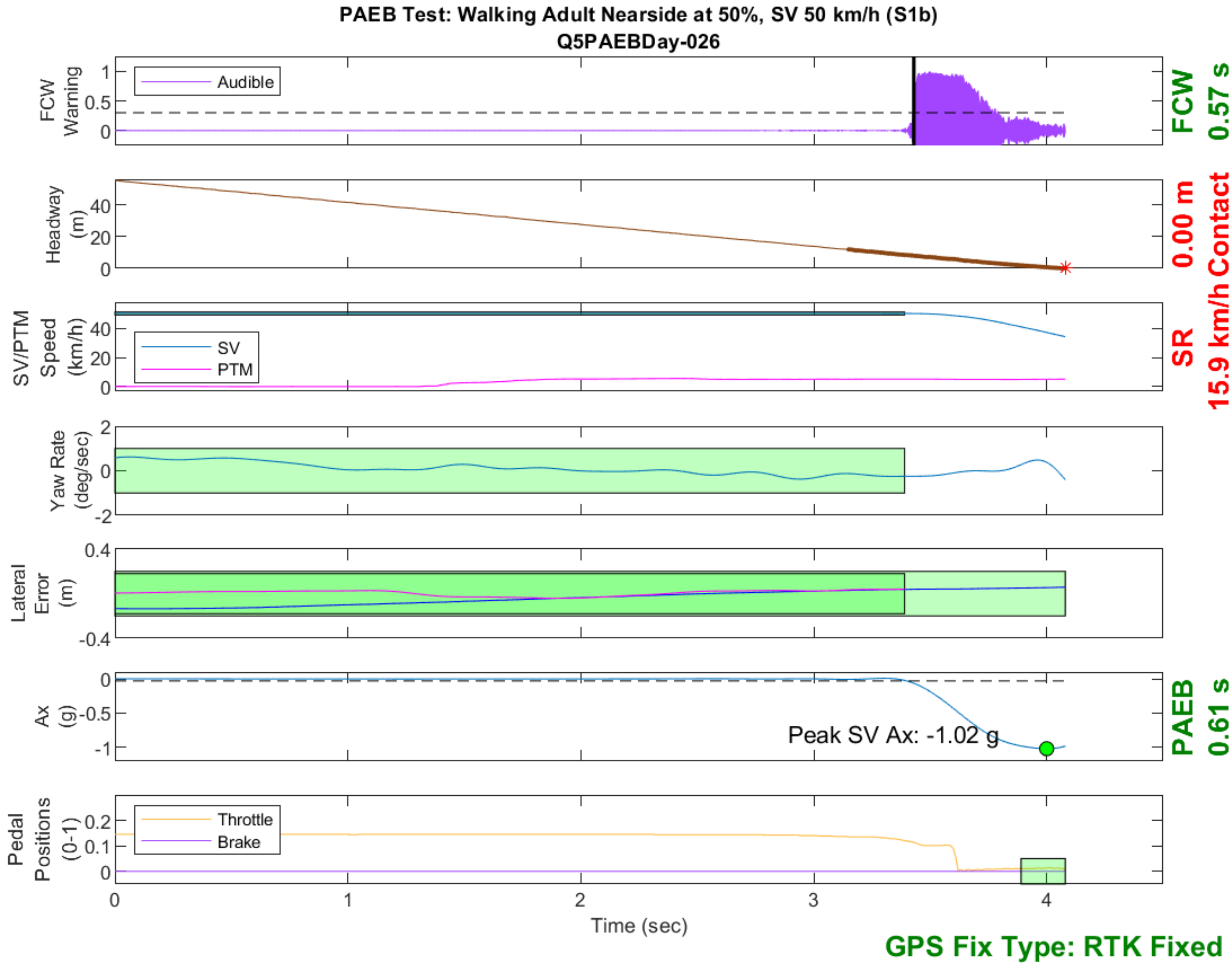

Figure D38. Time History for PAEB Run 26, S1b, Daytime, 50 km/h

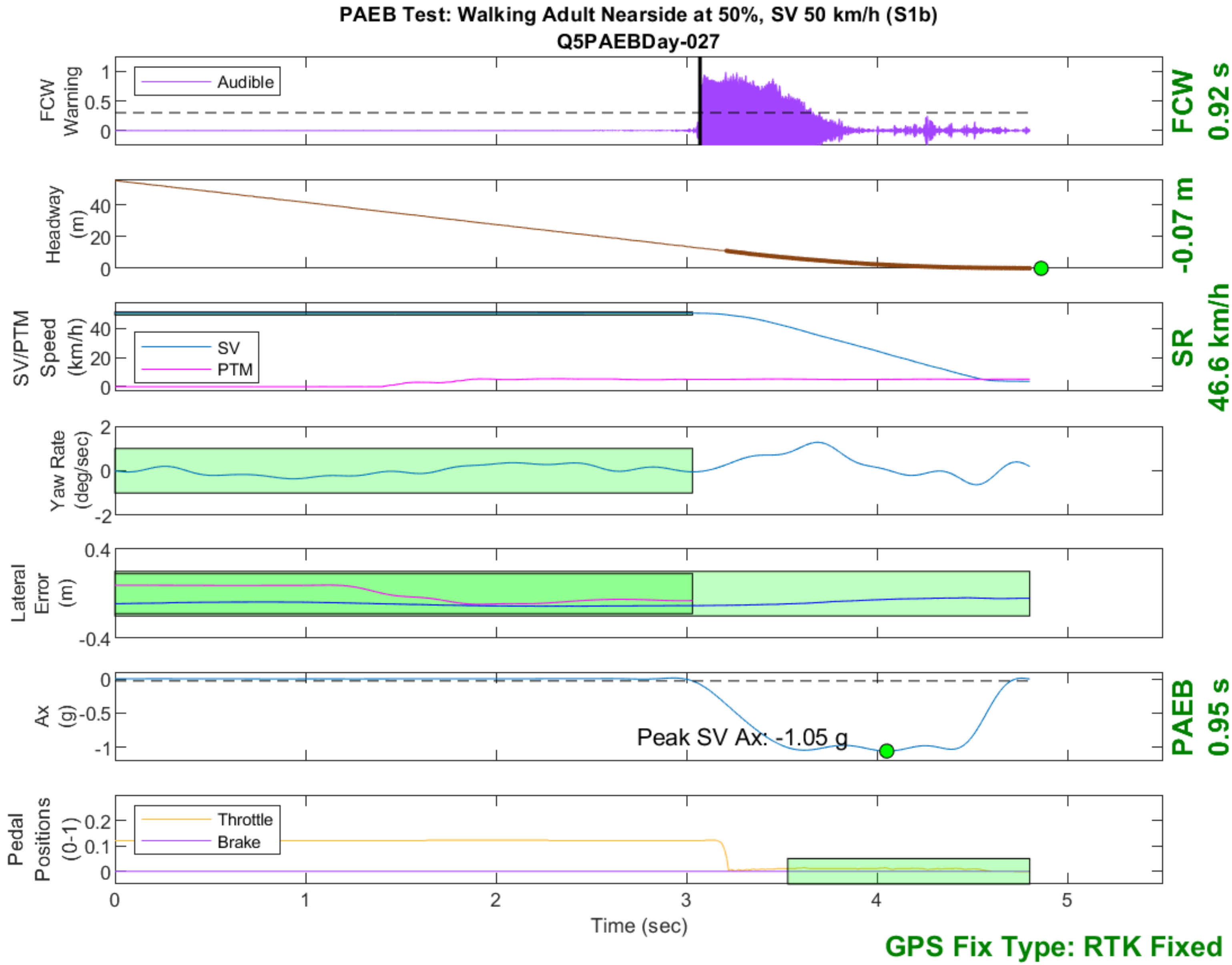

Figure D39. Time History for PAEB Run 27, S1b, Daytime, 50 km/h

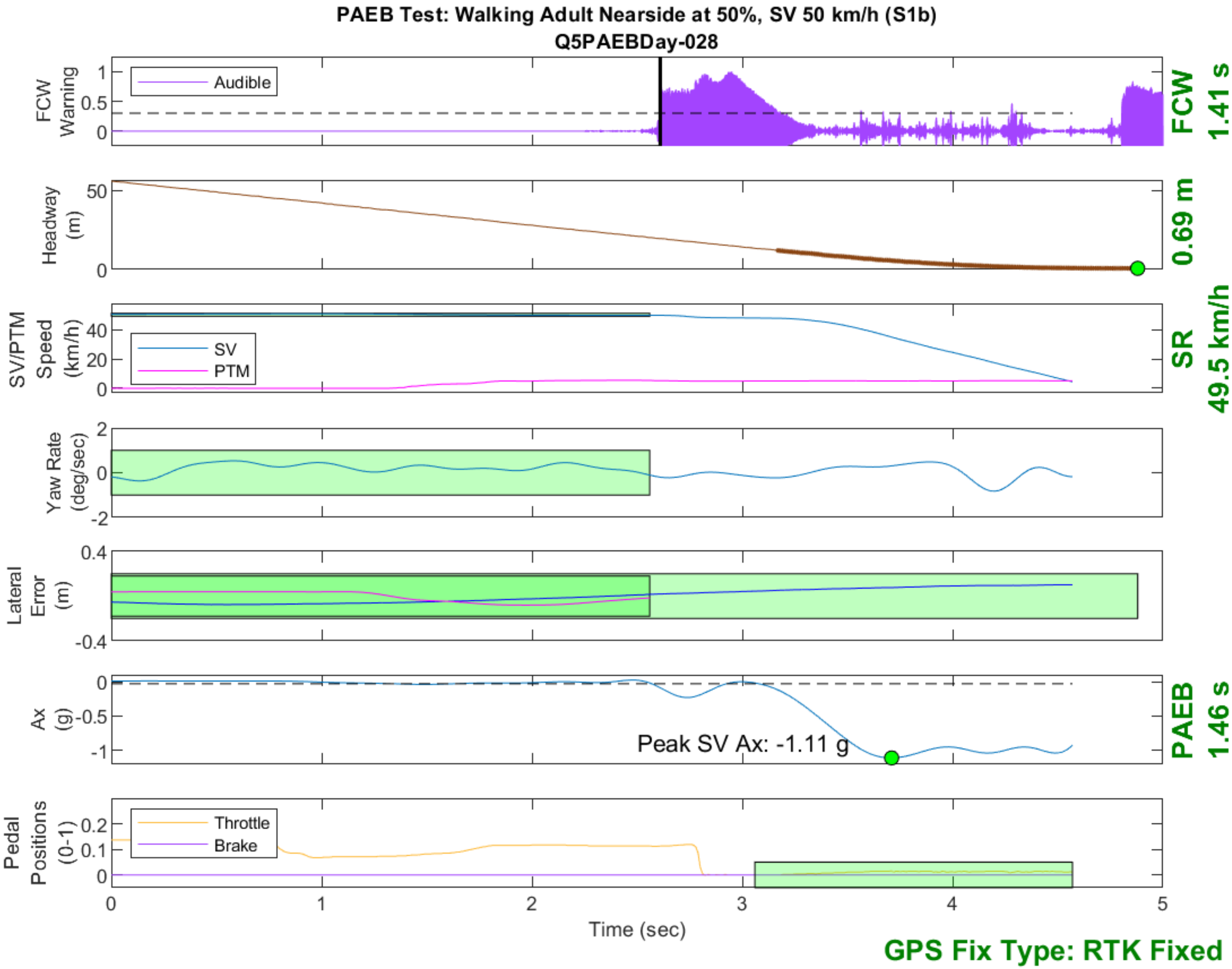

Figure D40. Time History for PAEB Run 28, S1b, Daytime, 50 km/h

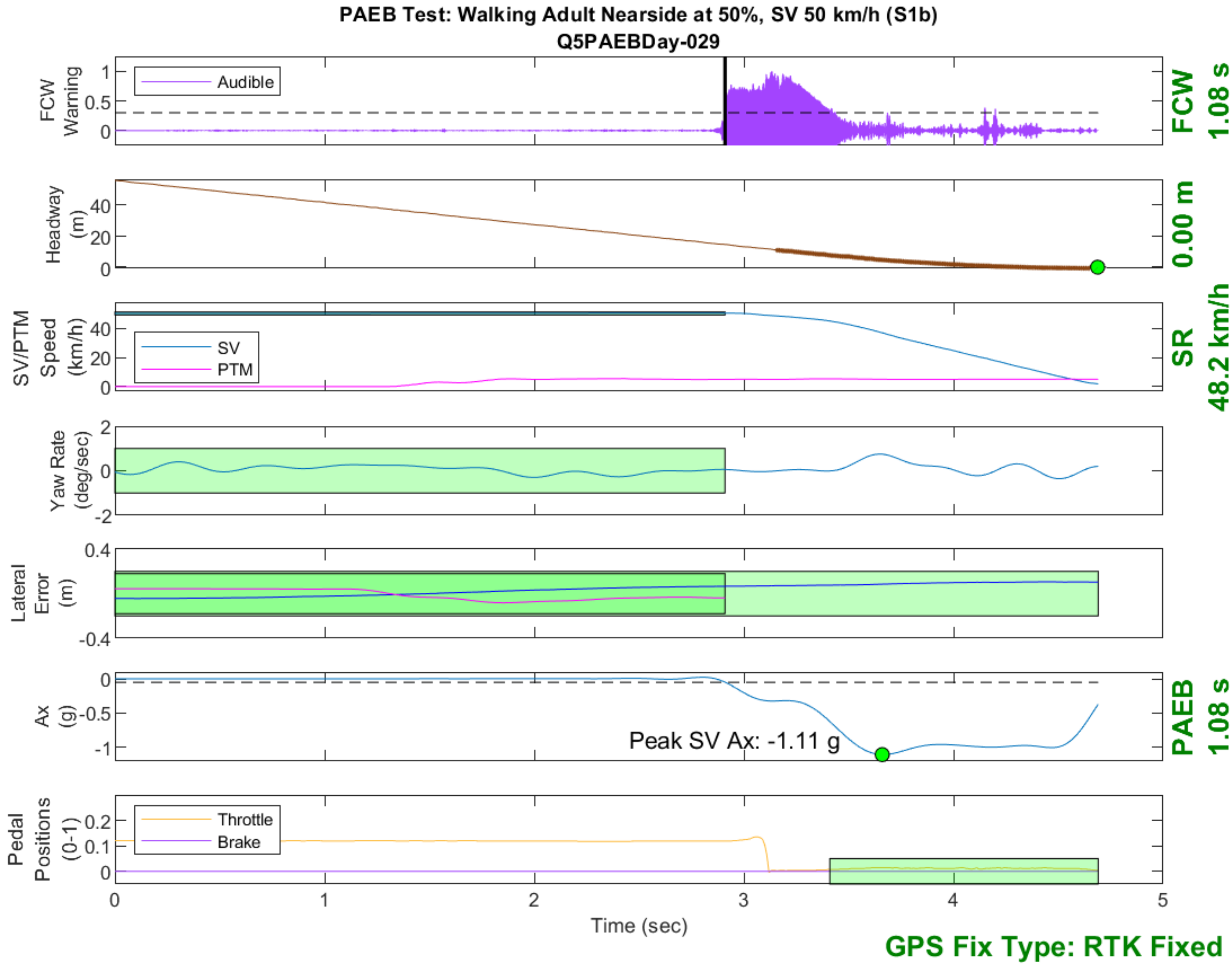

Figure D41. Time History for PAEB Run 29, S1b, Daytime, 50 km/h

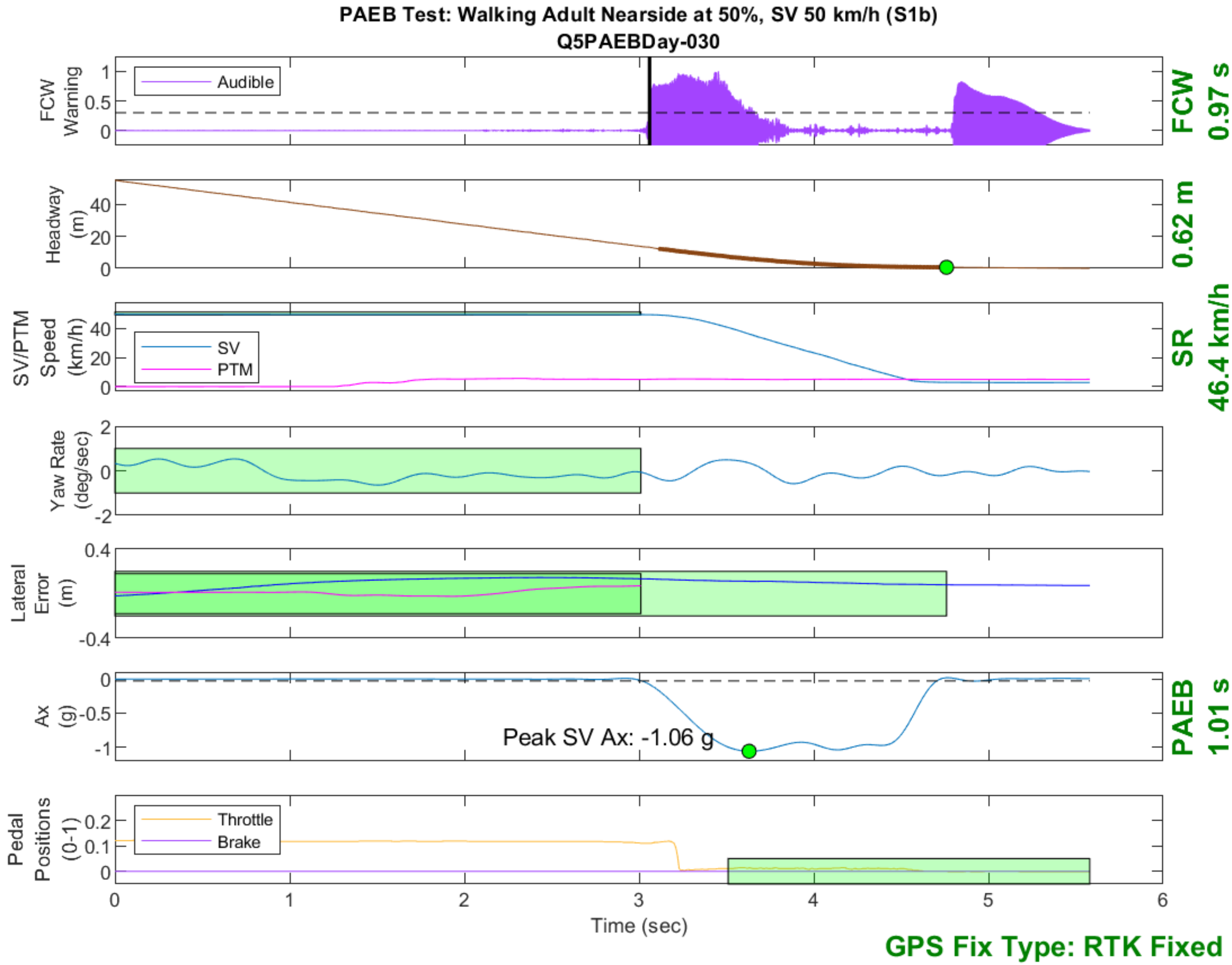

Figure D42. Time History for PAEB Run 30, S1b, Daytime, 50 km/h

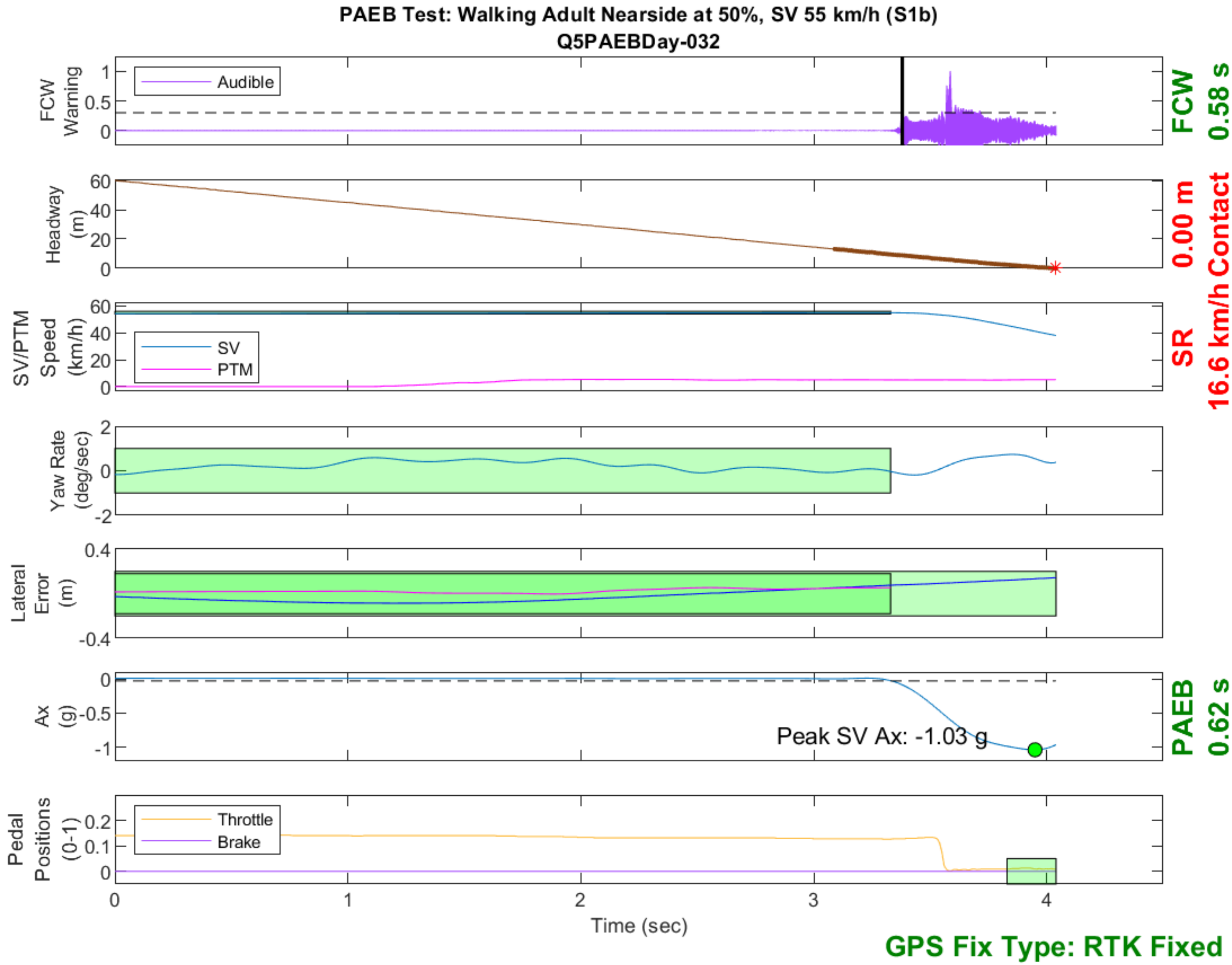

Figure D43. Time History for PAEB Run 32, S1b, Daytime, 55 km/h

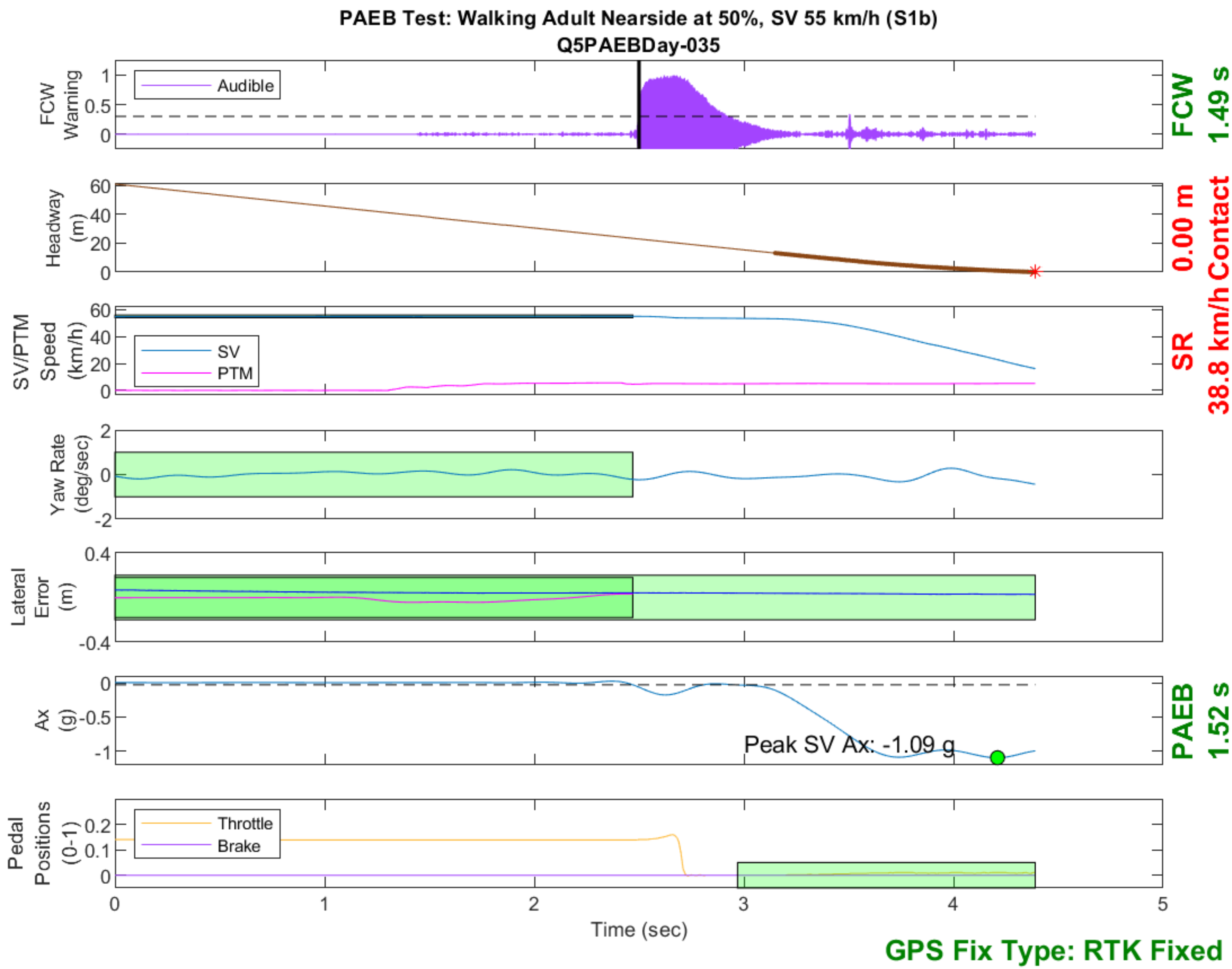

Figure D44. Time History for PAEB Run 35, S1b, Daytime, 55 km/h

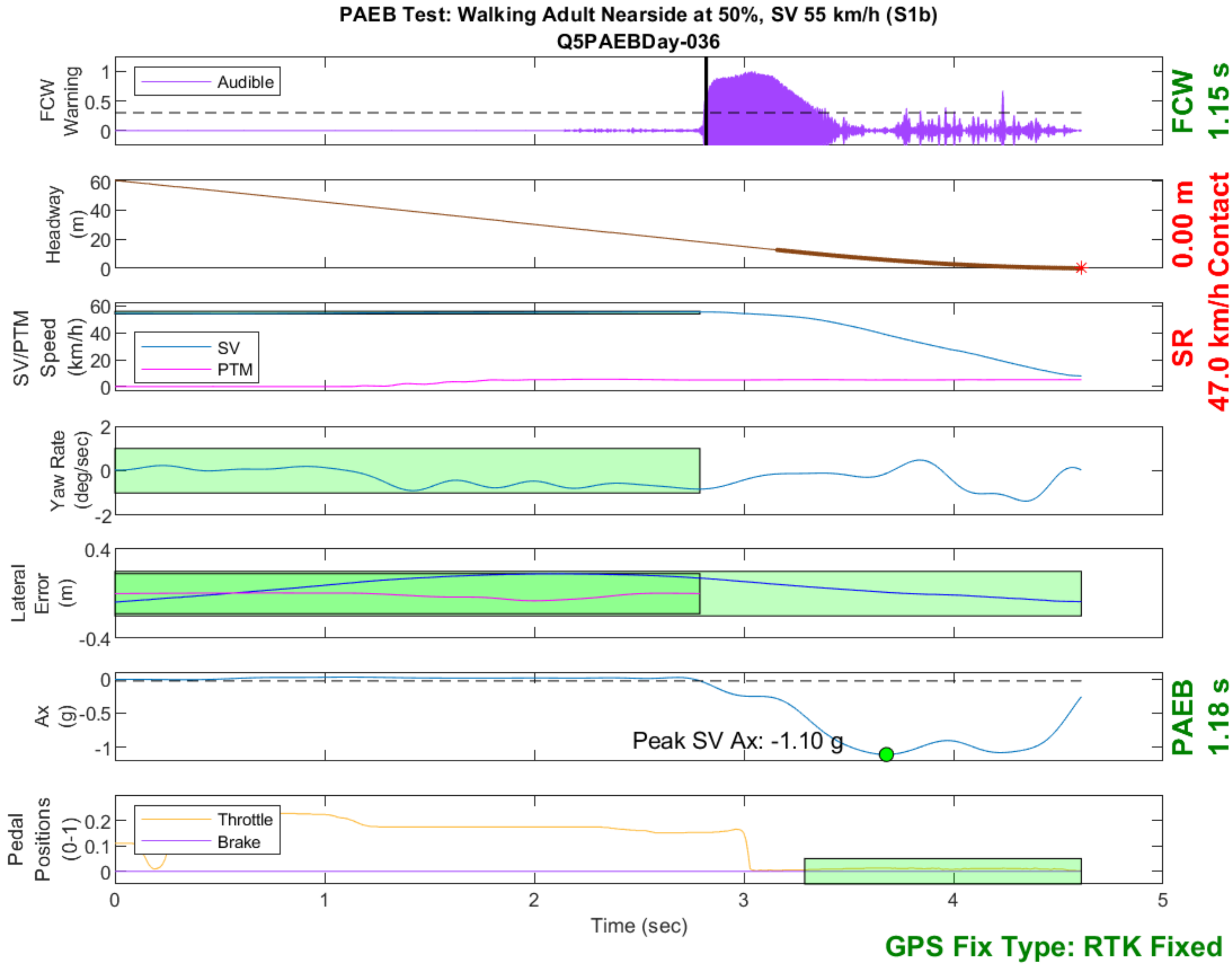

Figure D45. Time History for PAEB Run 36, S1b, Daytime, 55 km/h

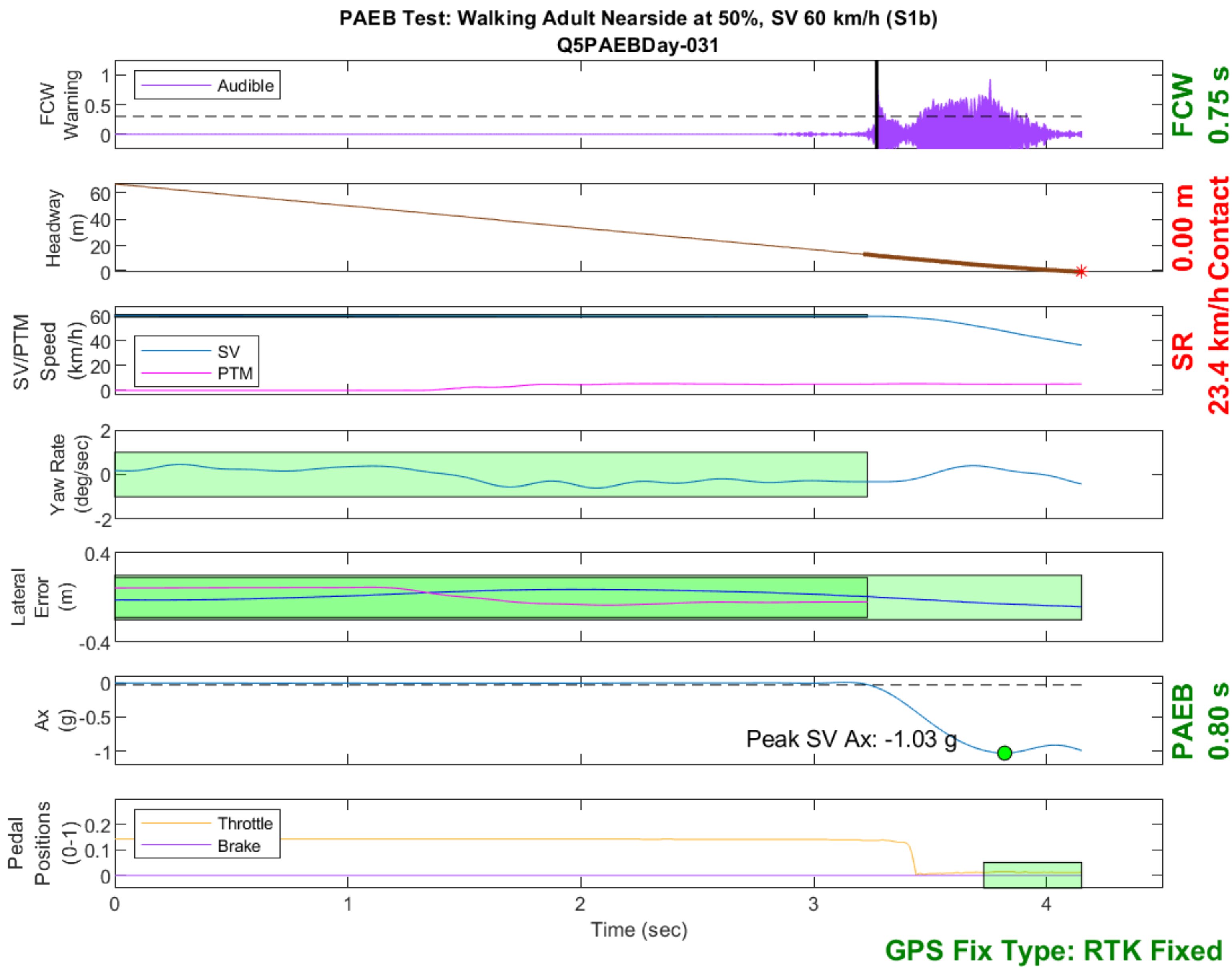

Figure D46. Time History for PAEB Run 31, S1b, Daytime, 60 km/h

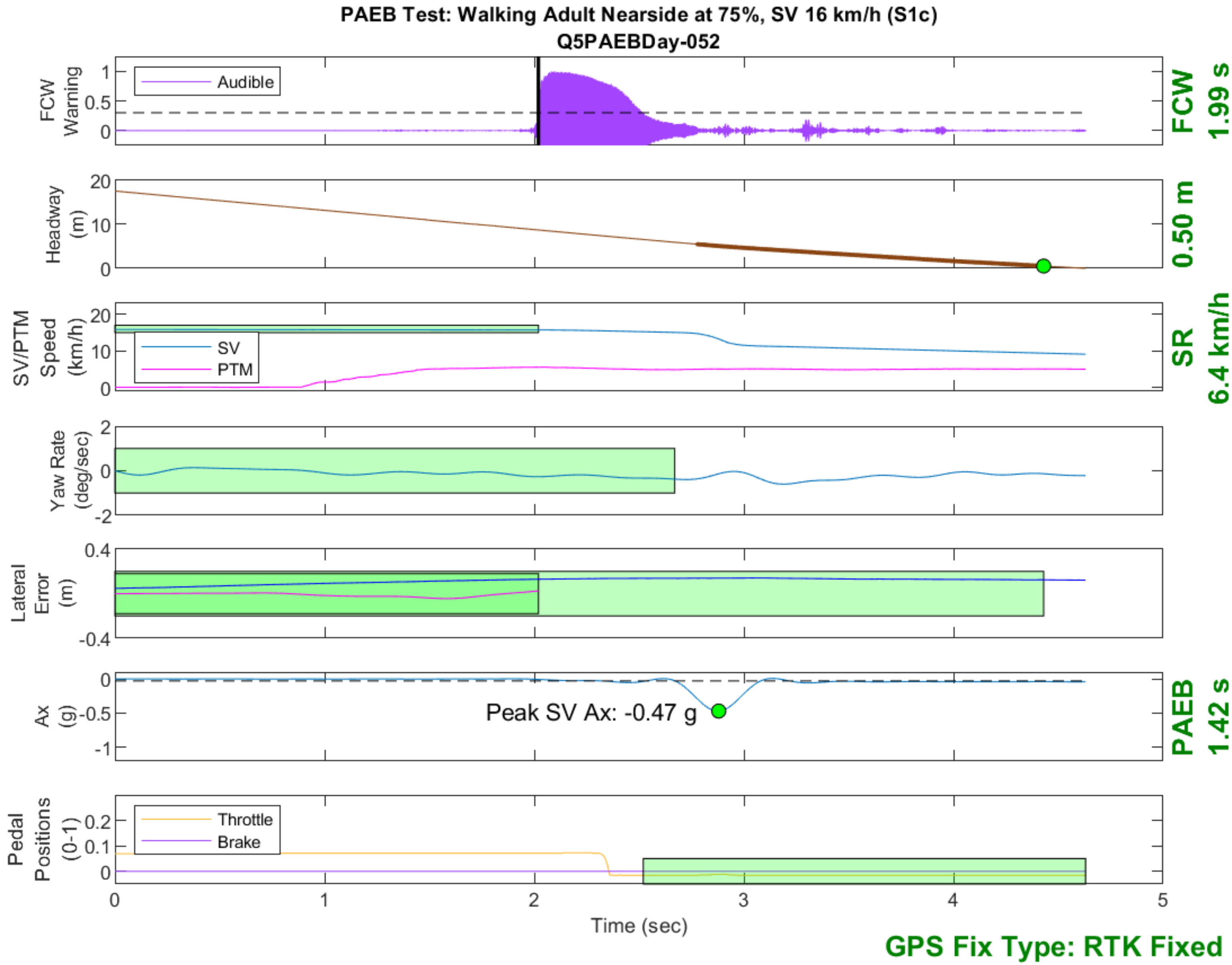

Figure D47. Time History for PAEB Run 52, S1c, Daytime, 16 km/h

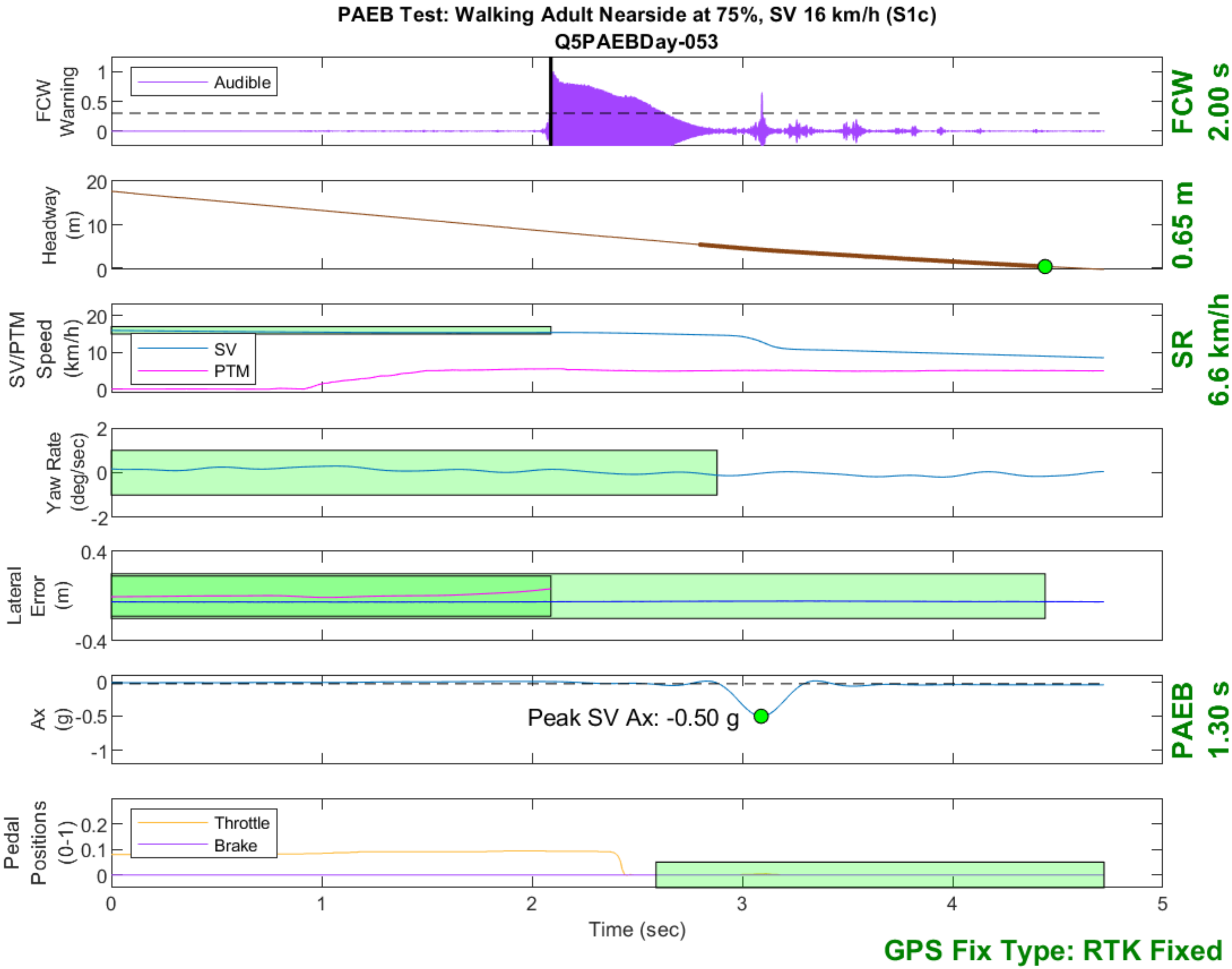

Figure D48. Time History for PAEB Run 53, S1c, Daytime, 16 km/h

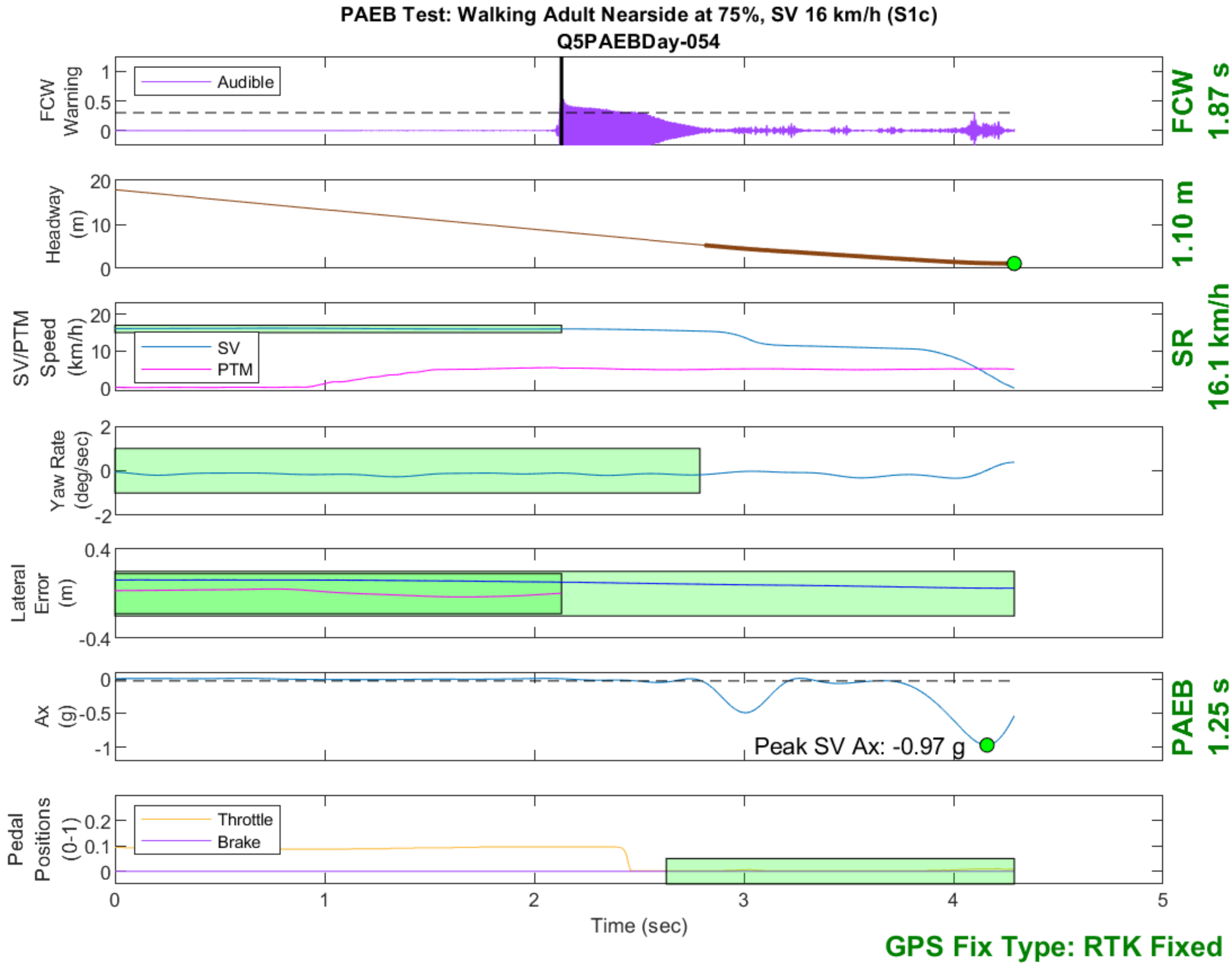

Figure D49. Time History for PAEB Run 54, S1c, Daytime, 16 km/h

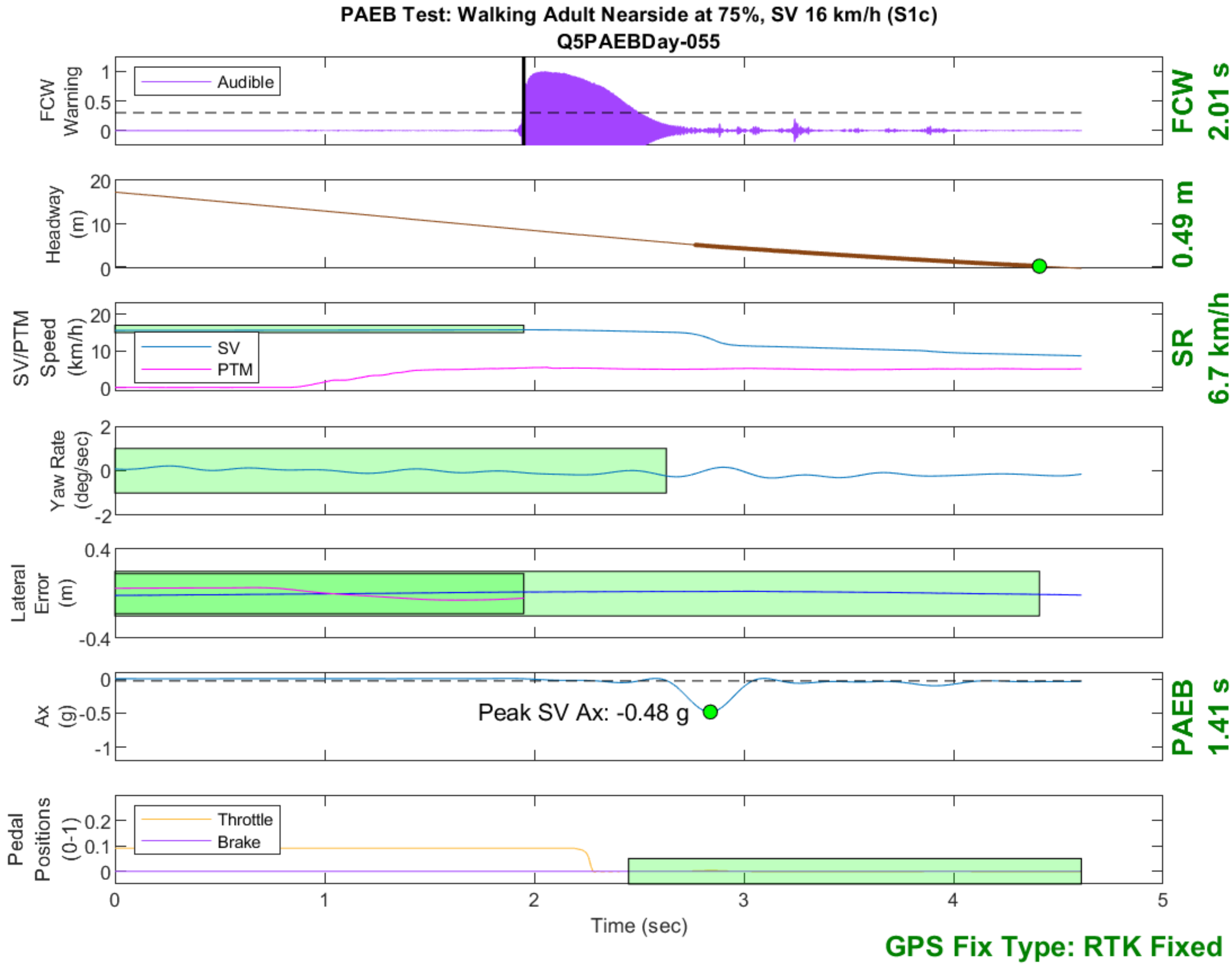

Figure D50. Time History for PAEB Run 55, S1c, Daytime, 16 km/h

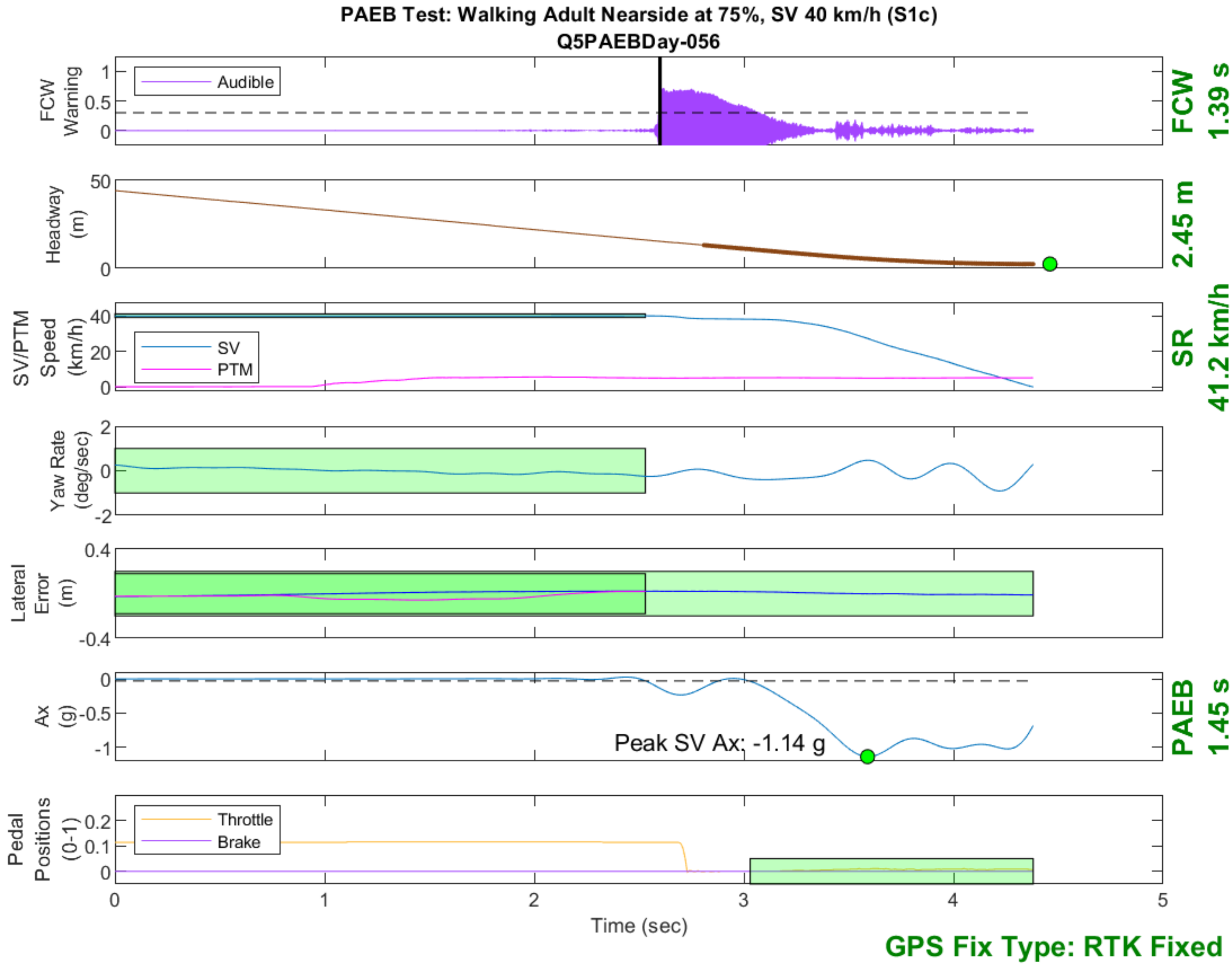

Figure D51. Time History for PAEB Run 56, S1c, Daytime, 40 km/h

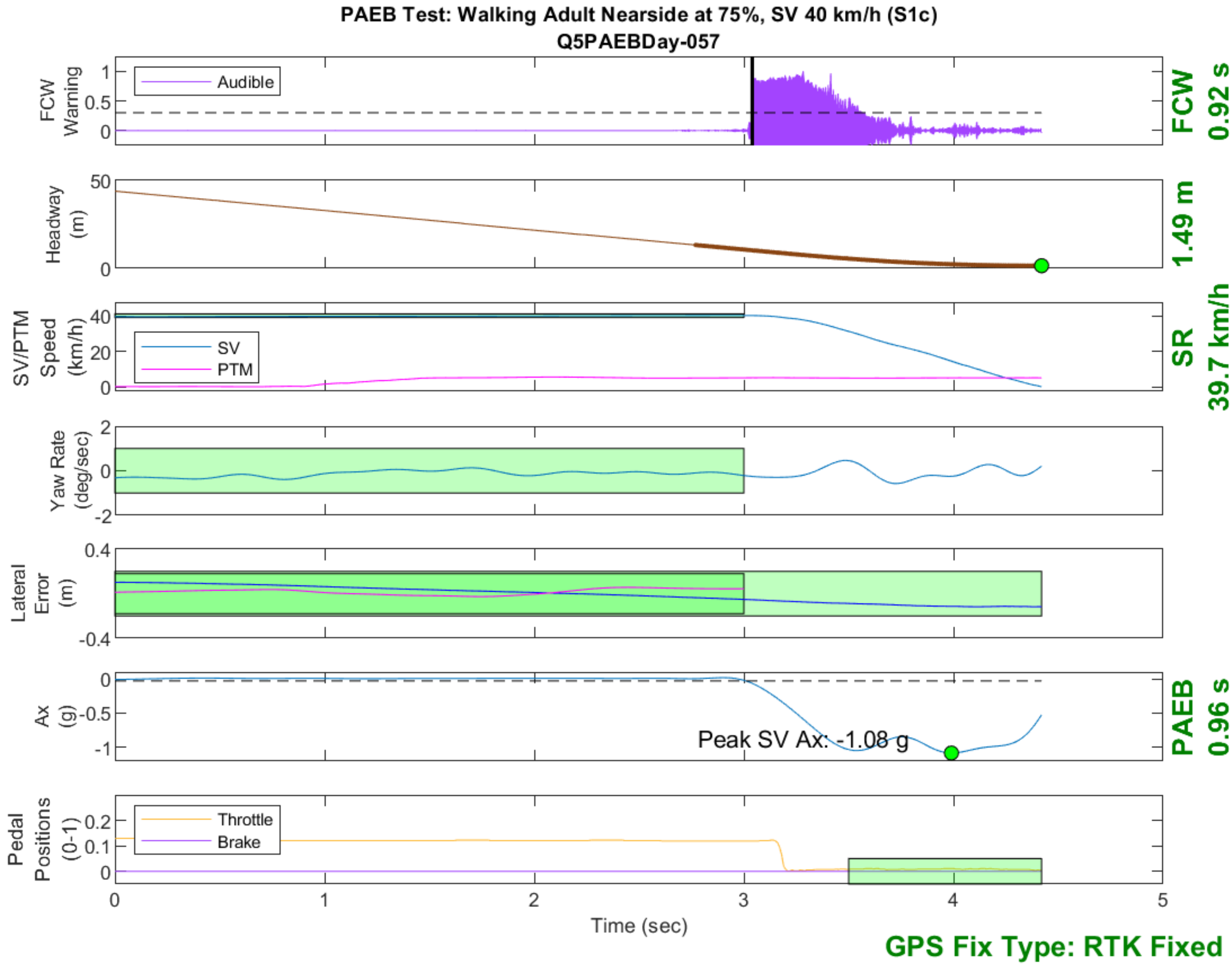

Figure D52. Time History for PAEB Run 57, S1c, Daytime, 40 km/h

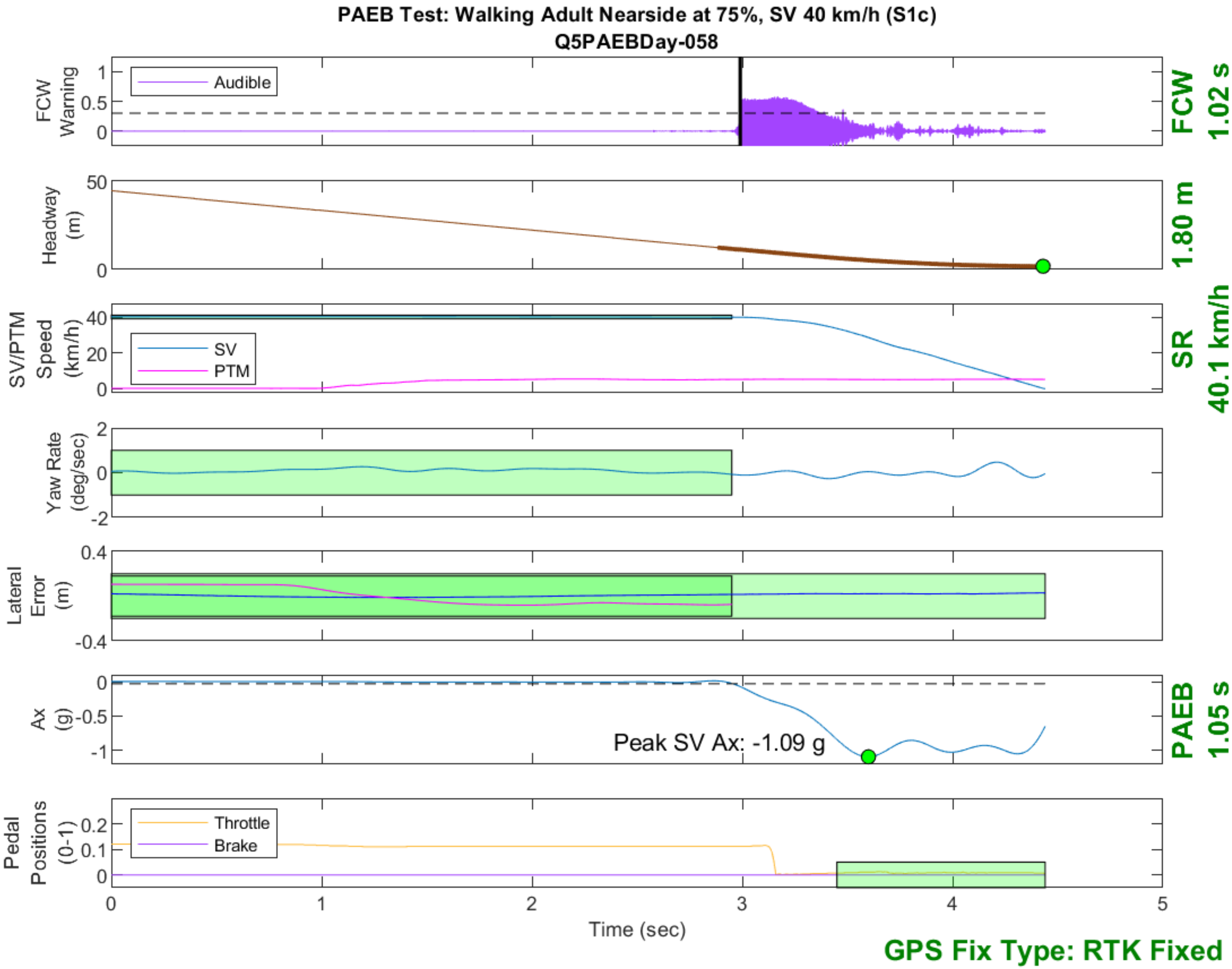

Figure D53. Time History for PAEB Run 58, S1c, Daytime, 40 km/h

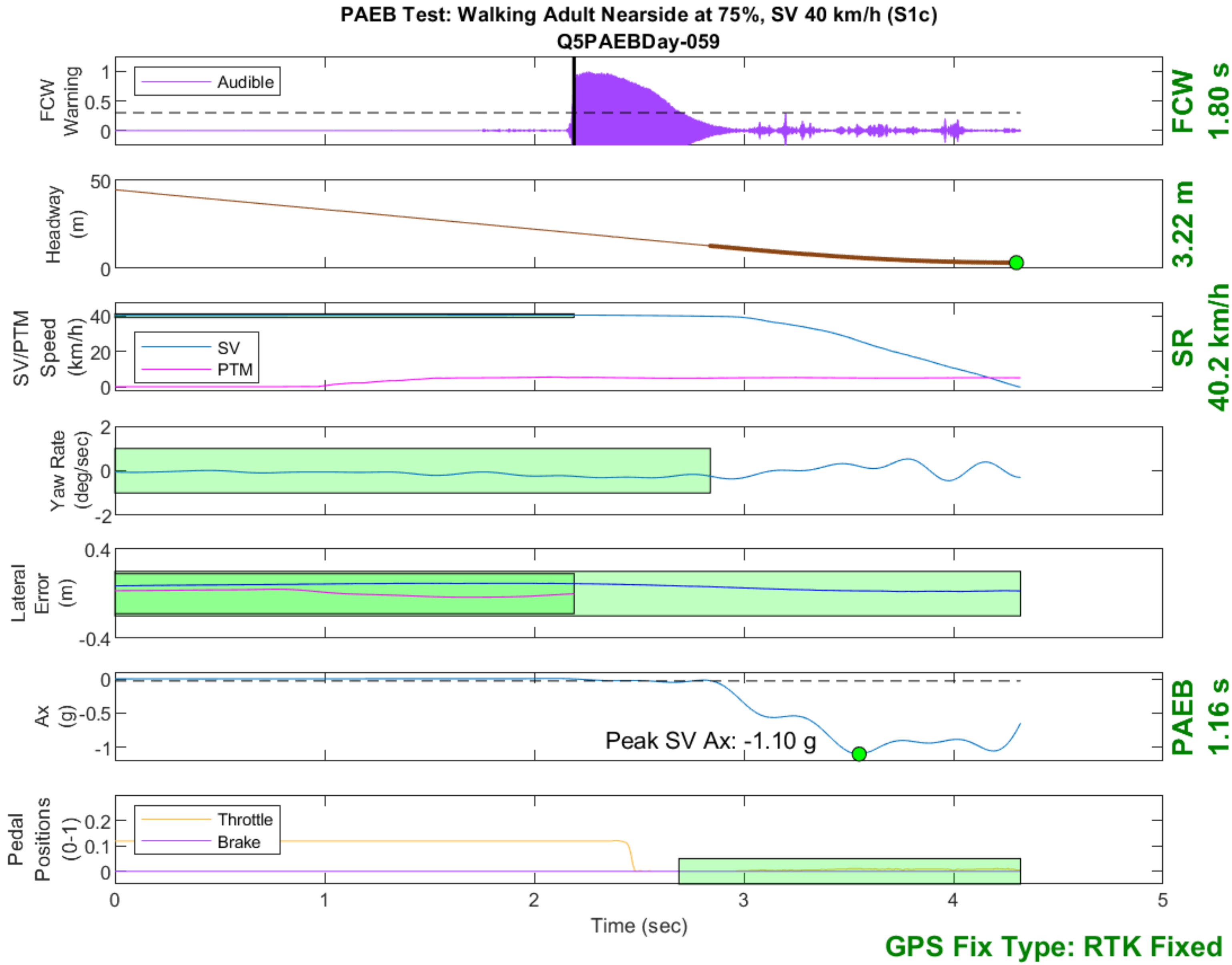

Figure D54. Time History for PAEB Run 59, S1c, Daytime, 40 km/h

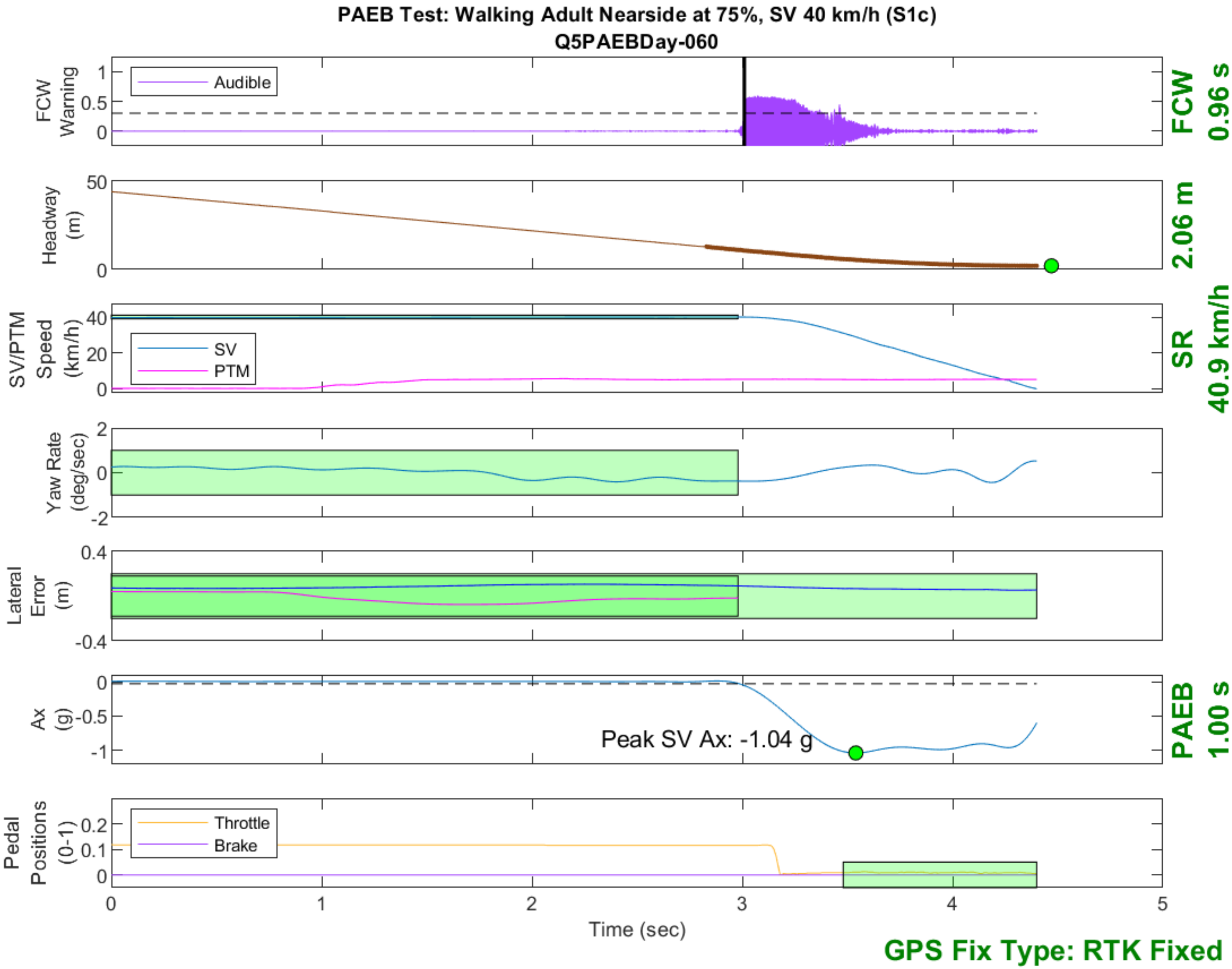

Figure D55. Time History for PAEB Run 60, S1c, Daytime, 40 km/h

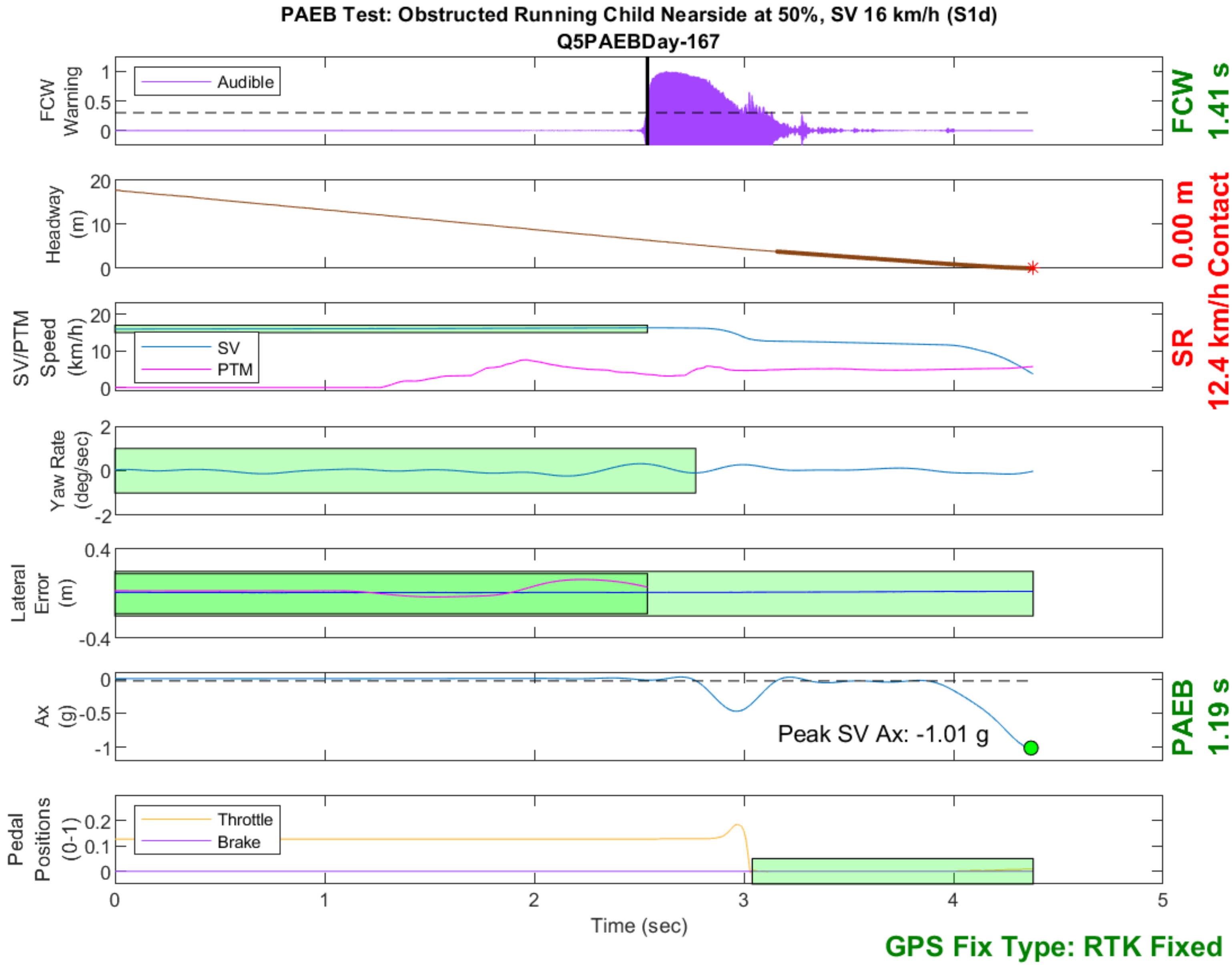

Figure D56. Time History for PAEB Run 167, S1d, Daytime, 16 km/h

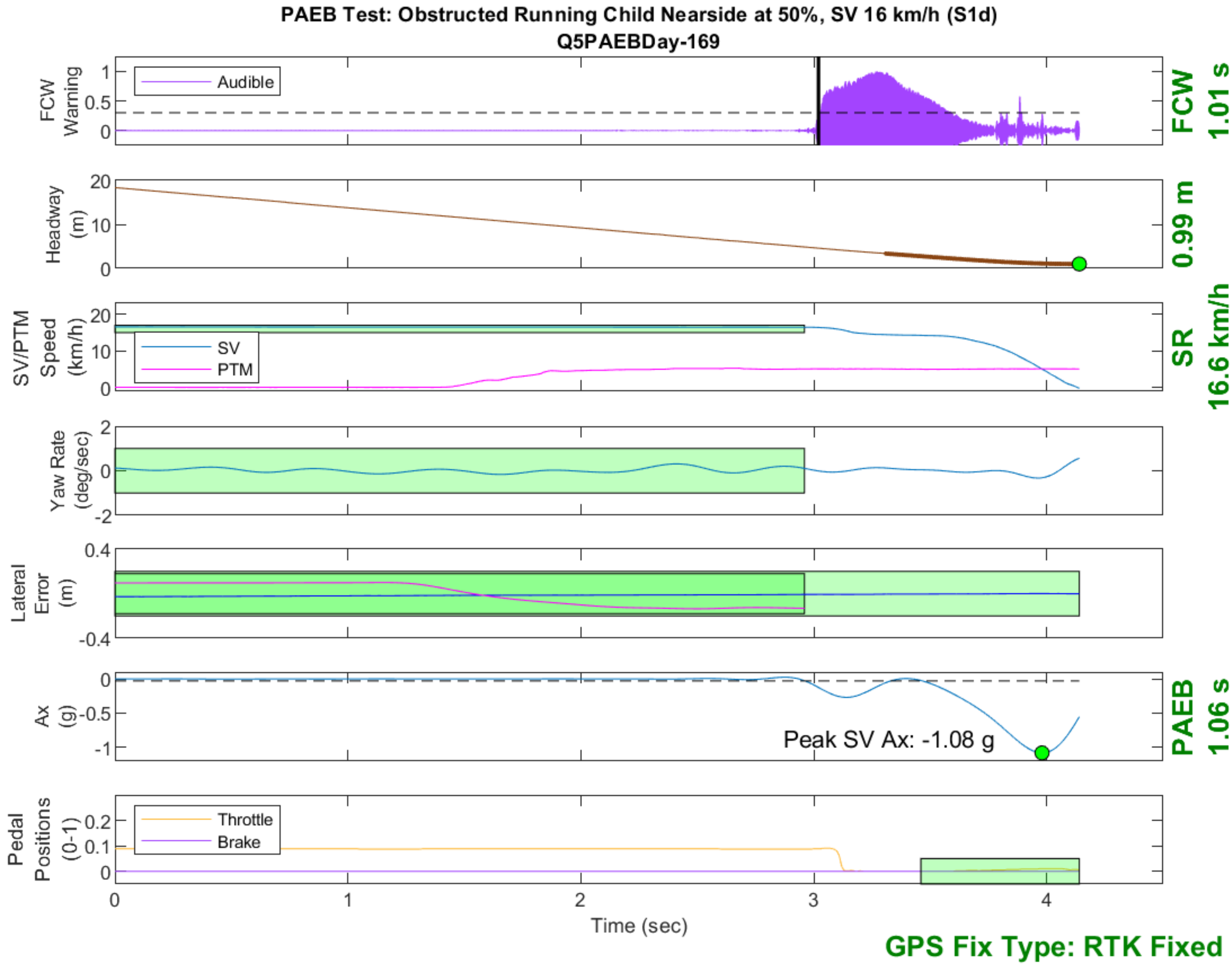

Figure D57. Time History for PAEB Run 169, S1d, Daytime, 16 km/h

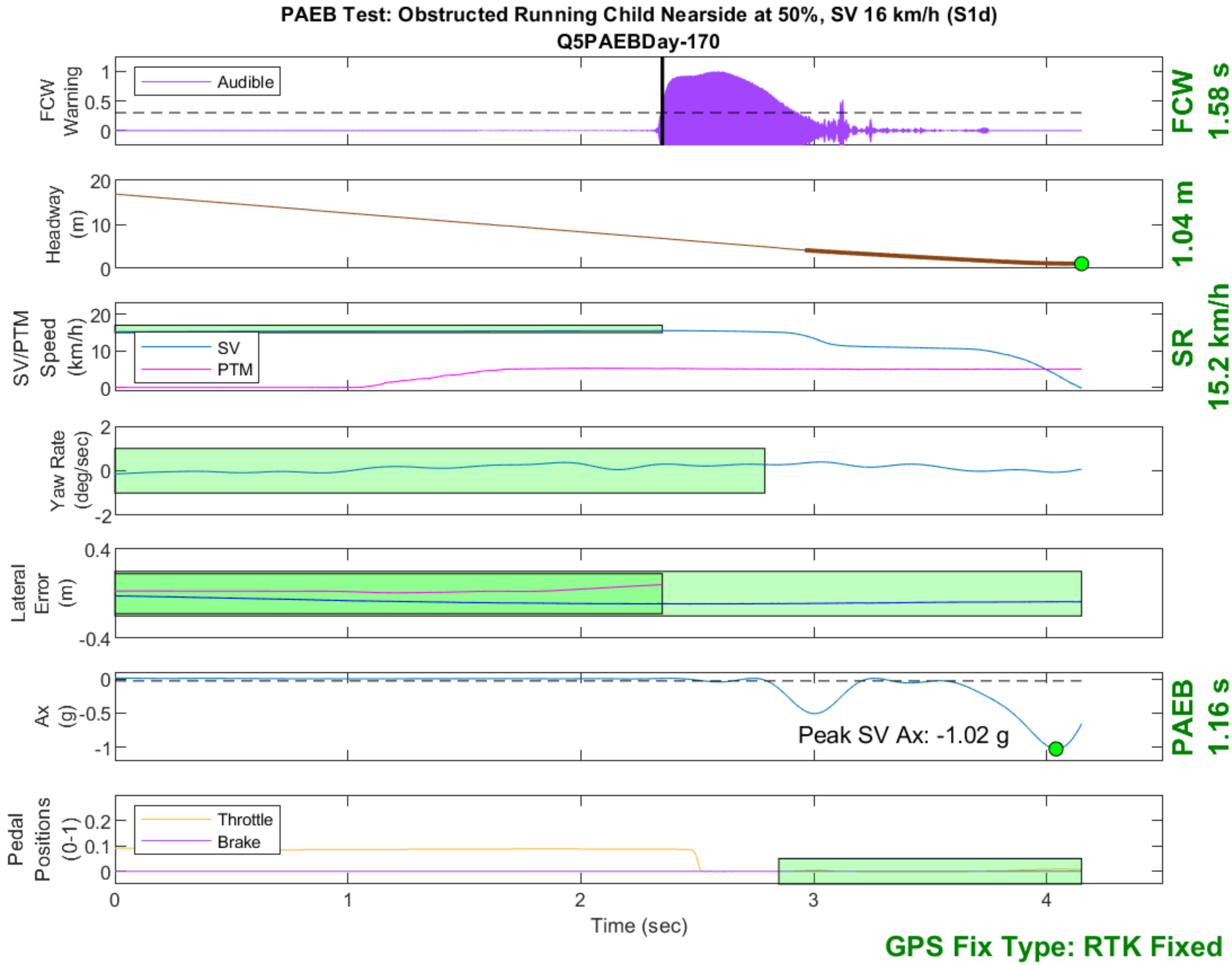

Figure D58. Time History for PAEB Run 170, S1d, Daytime, 16 km/h

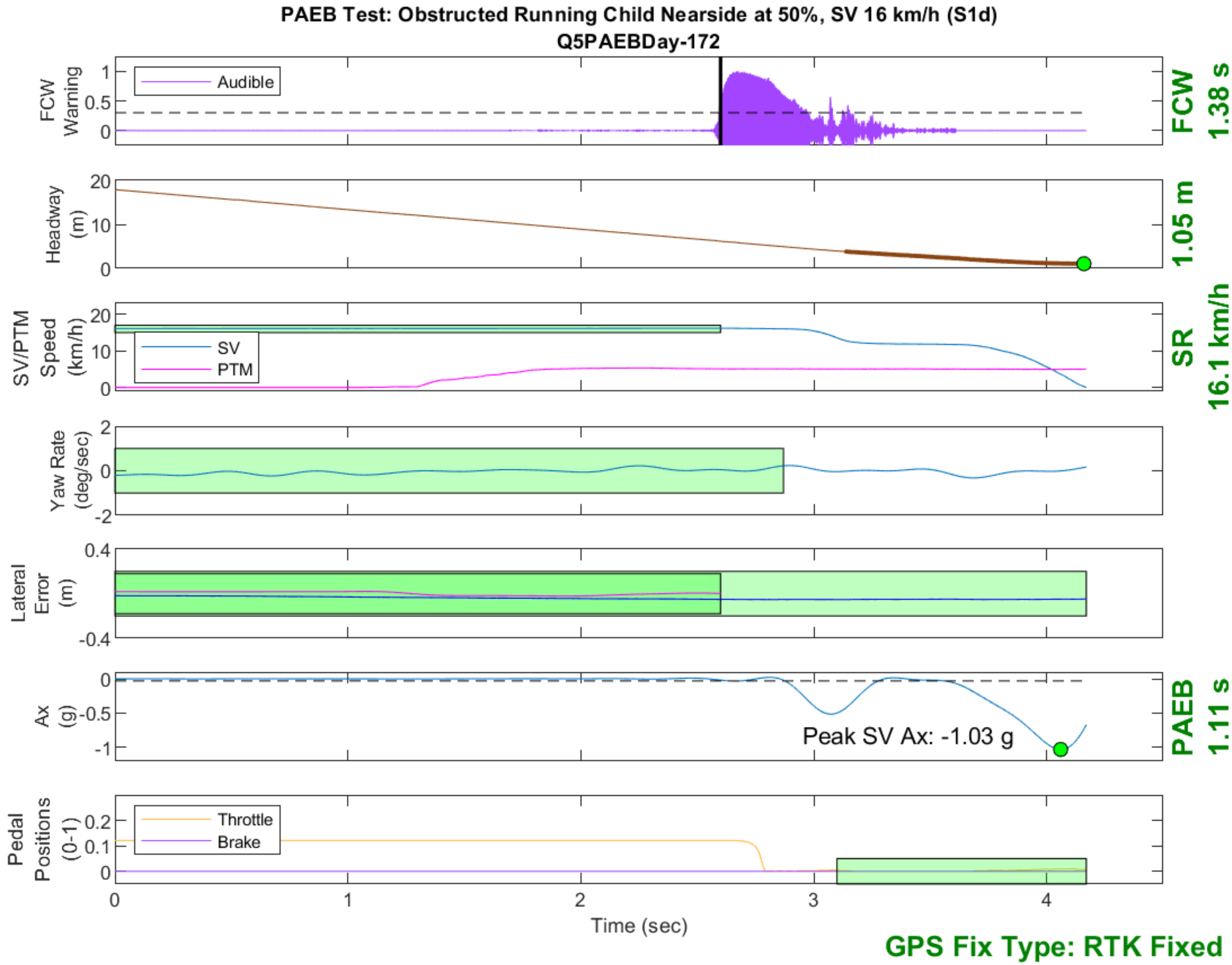

Figure D59. Time History for PAEB Run 172, S1d, Daytime, 16 km/h

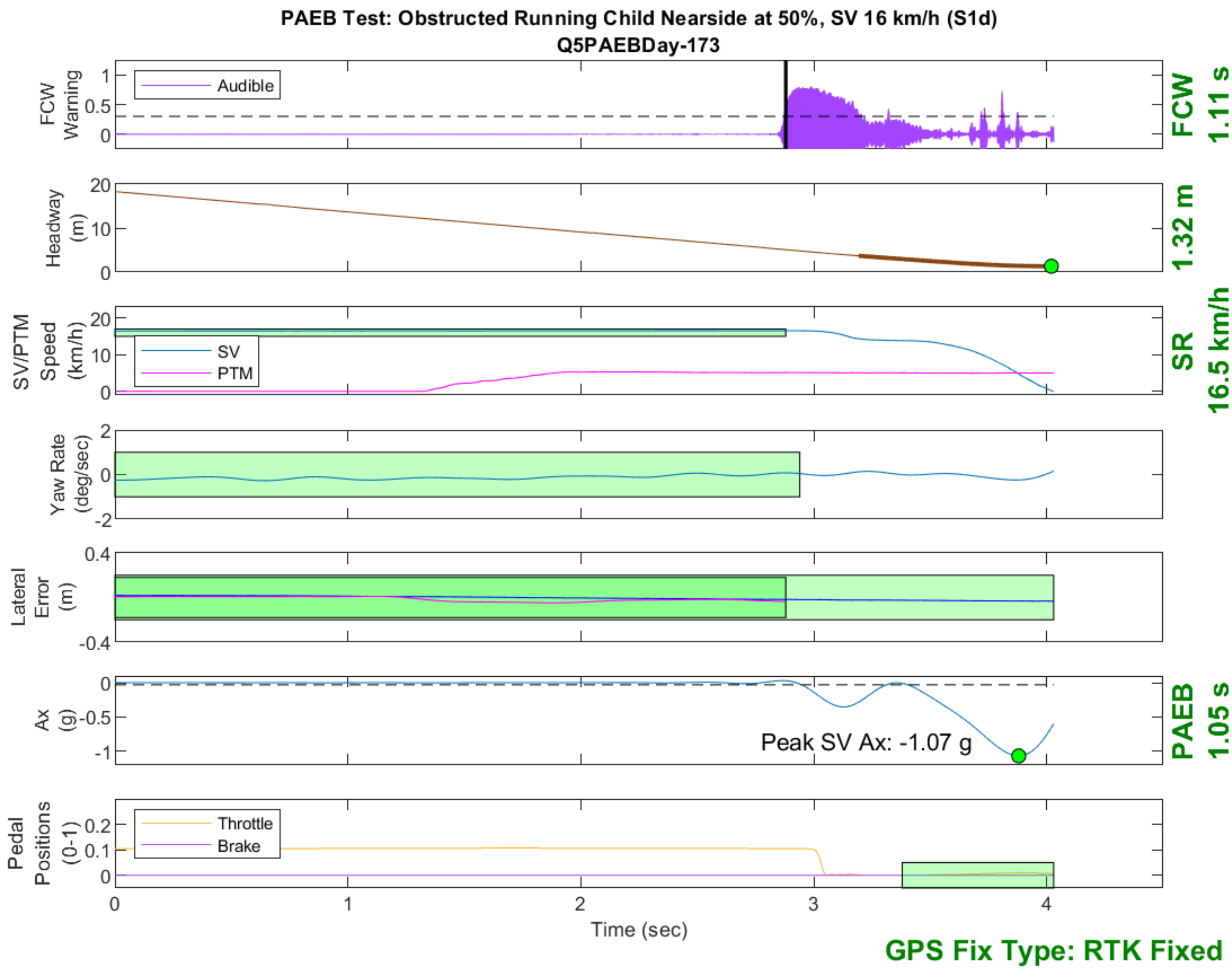

Figure D60. Time History for PAEB Run 173, S1d, Daytime, 16 km/h

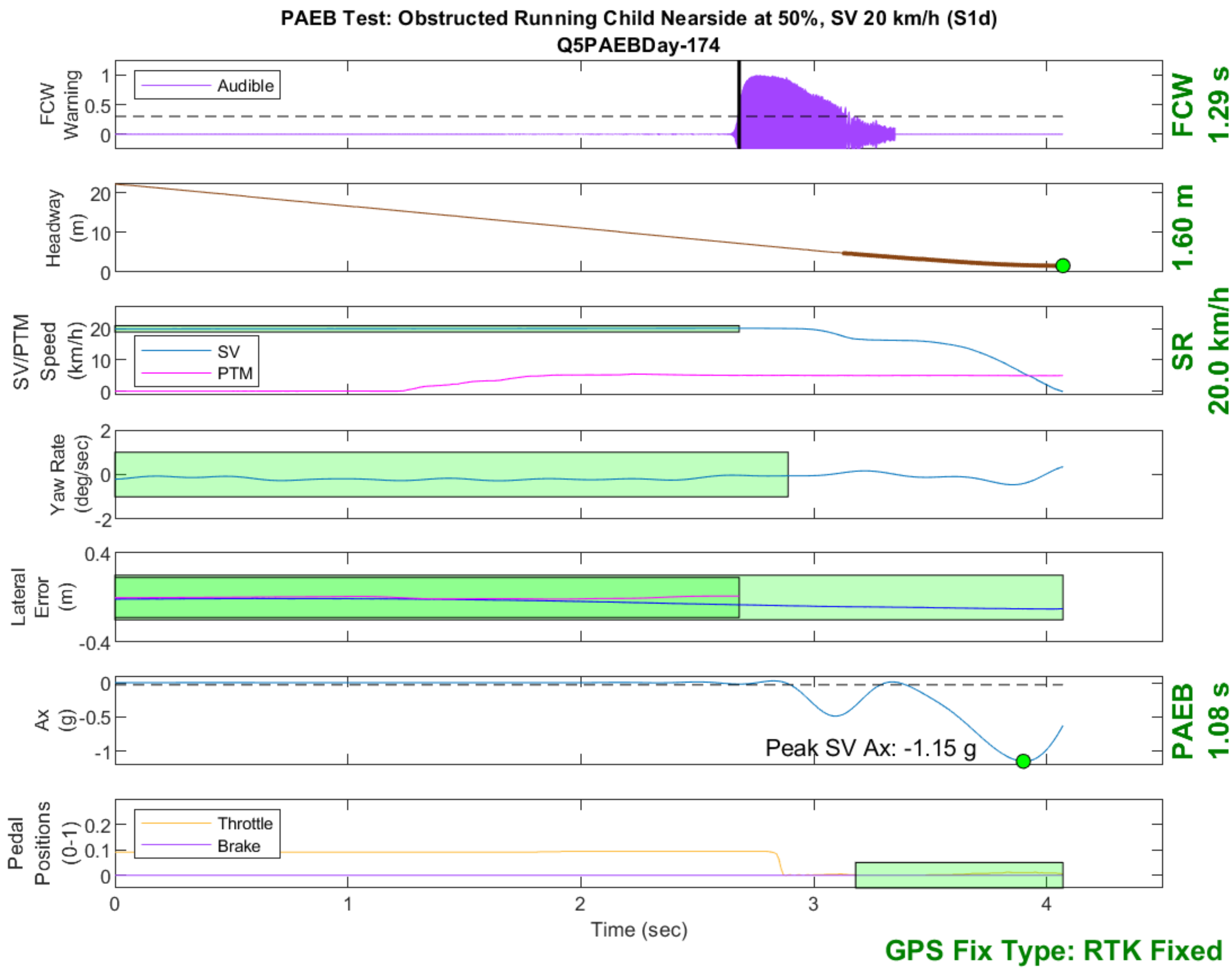

Figure D61. Time History for PAEB Run 174, S1d, Daytime, 20 km/h

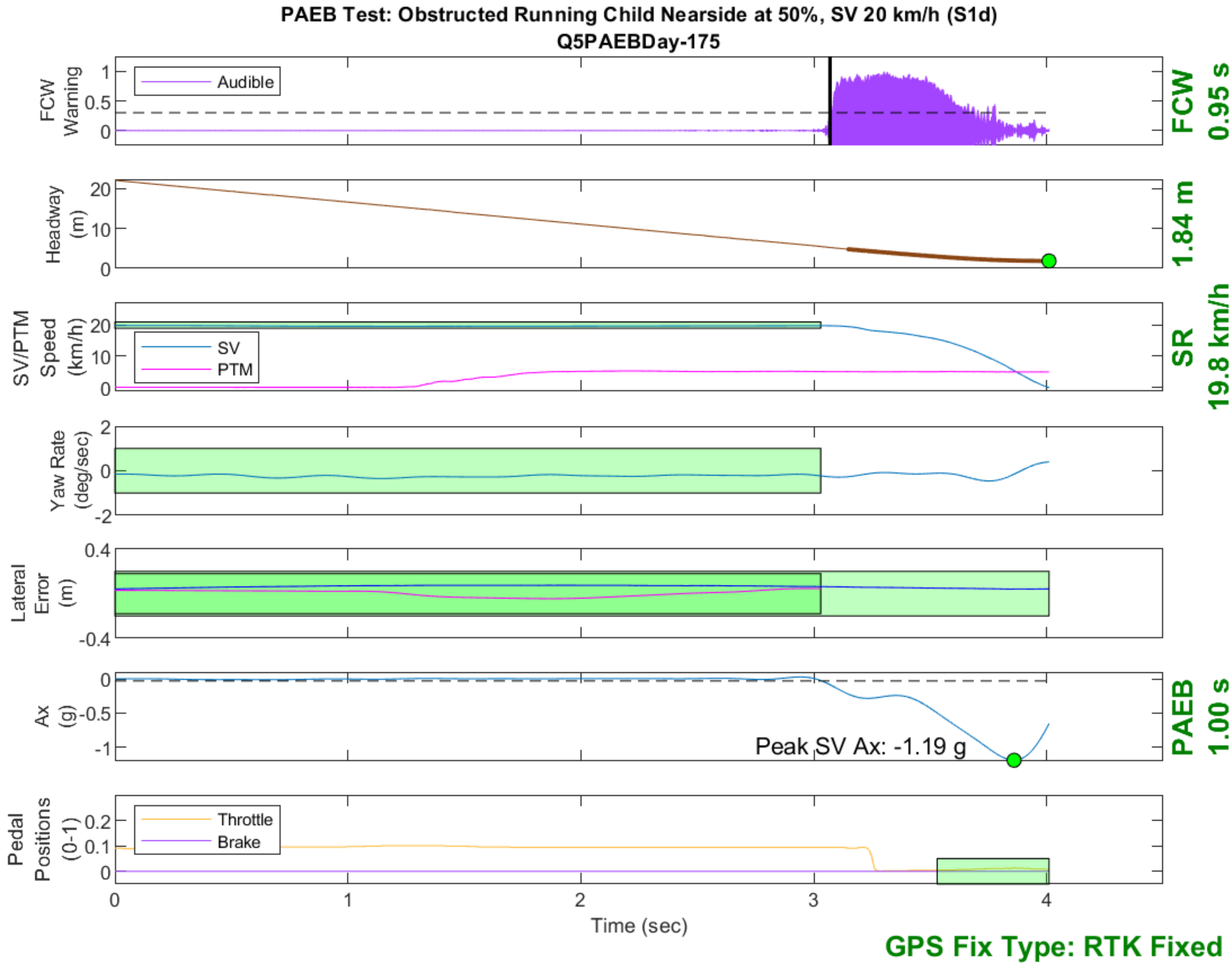

Figure D62. Time History for PAEB Run 175, S1d, Daytime, 20 km/h

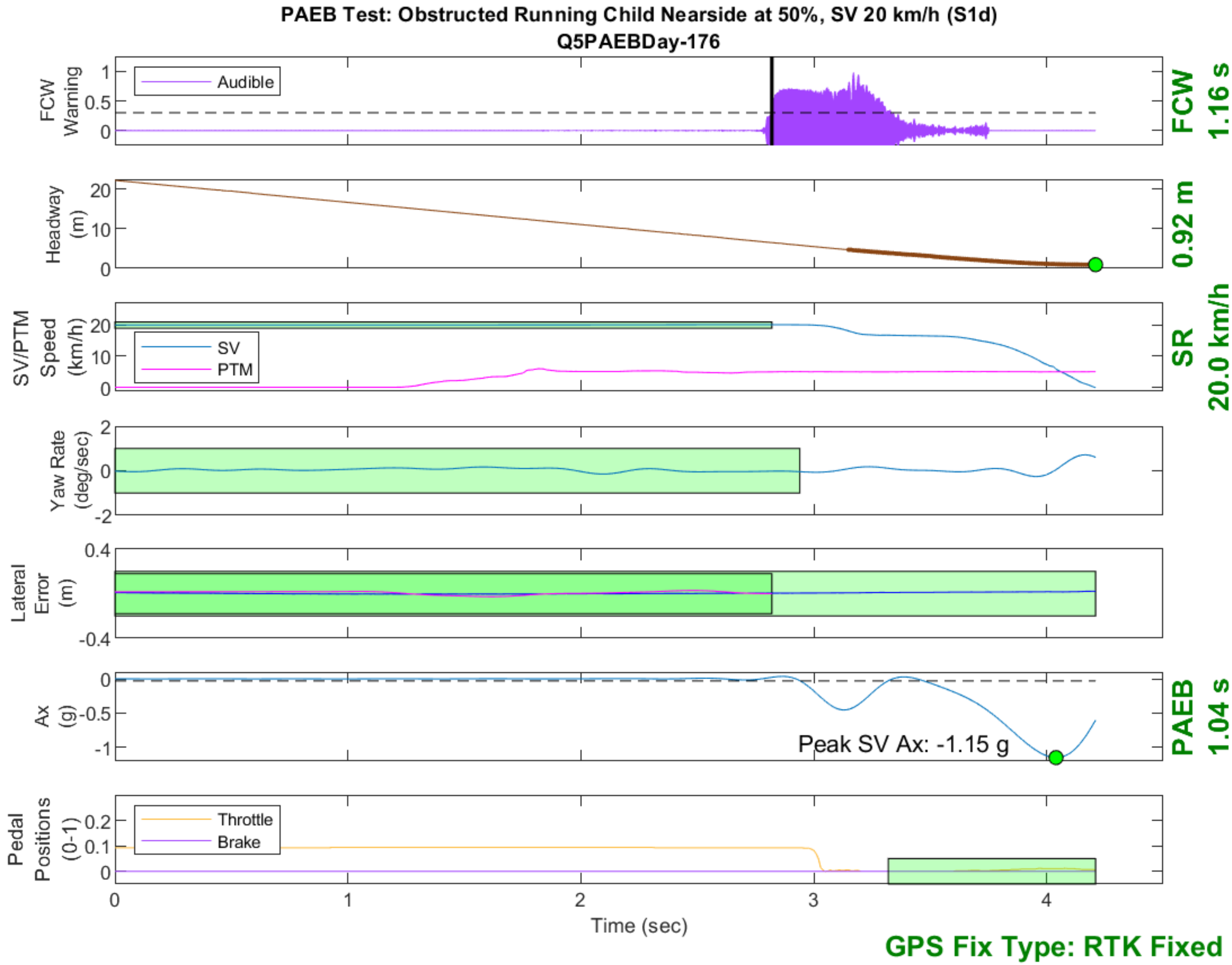

Figure D63. Time History for PAEB Run 176, S1d, Daytime, 20 km/h

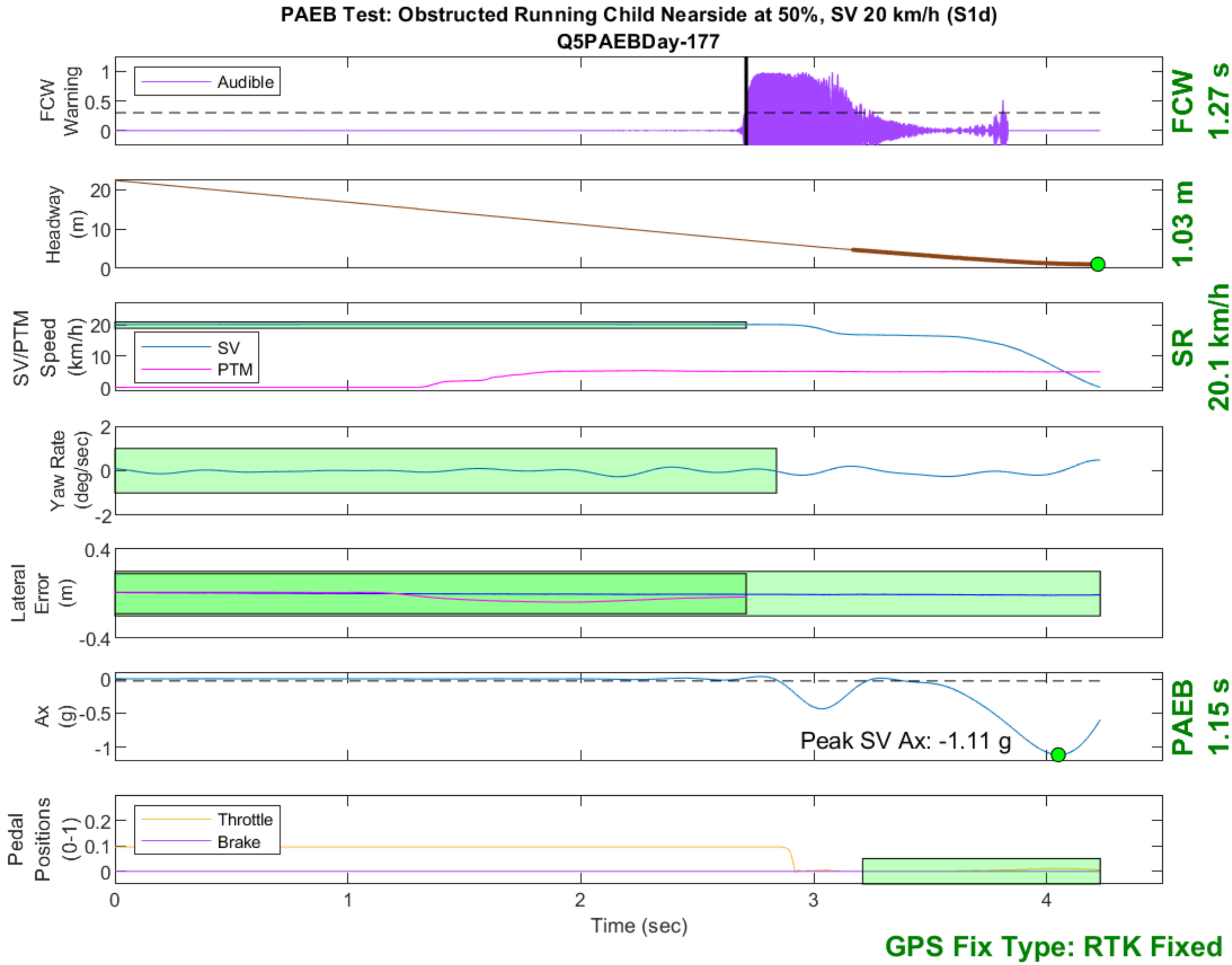

Figure D64. Time History for PAEB Run 177, S1d, Daytime, 20 km/h

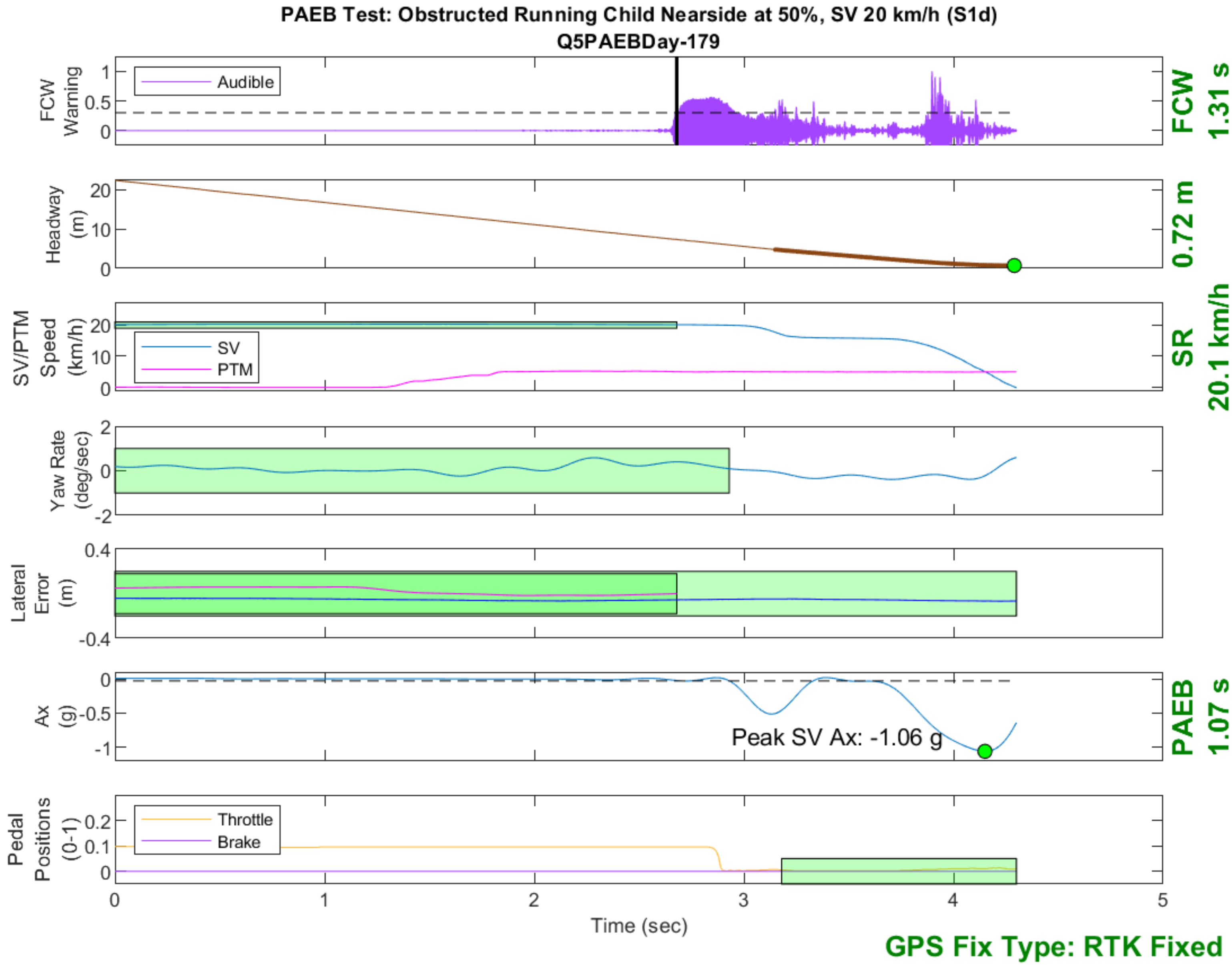

Figure D65. Time History for PAEB Run 179, S1d, Daytime, 20 km/h

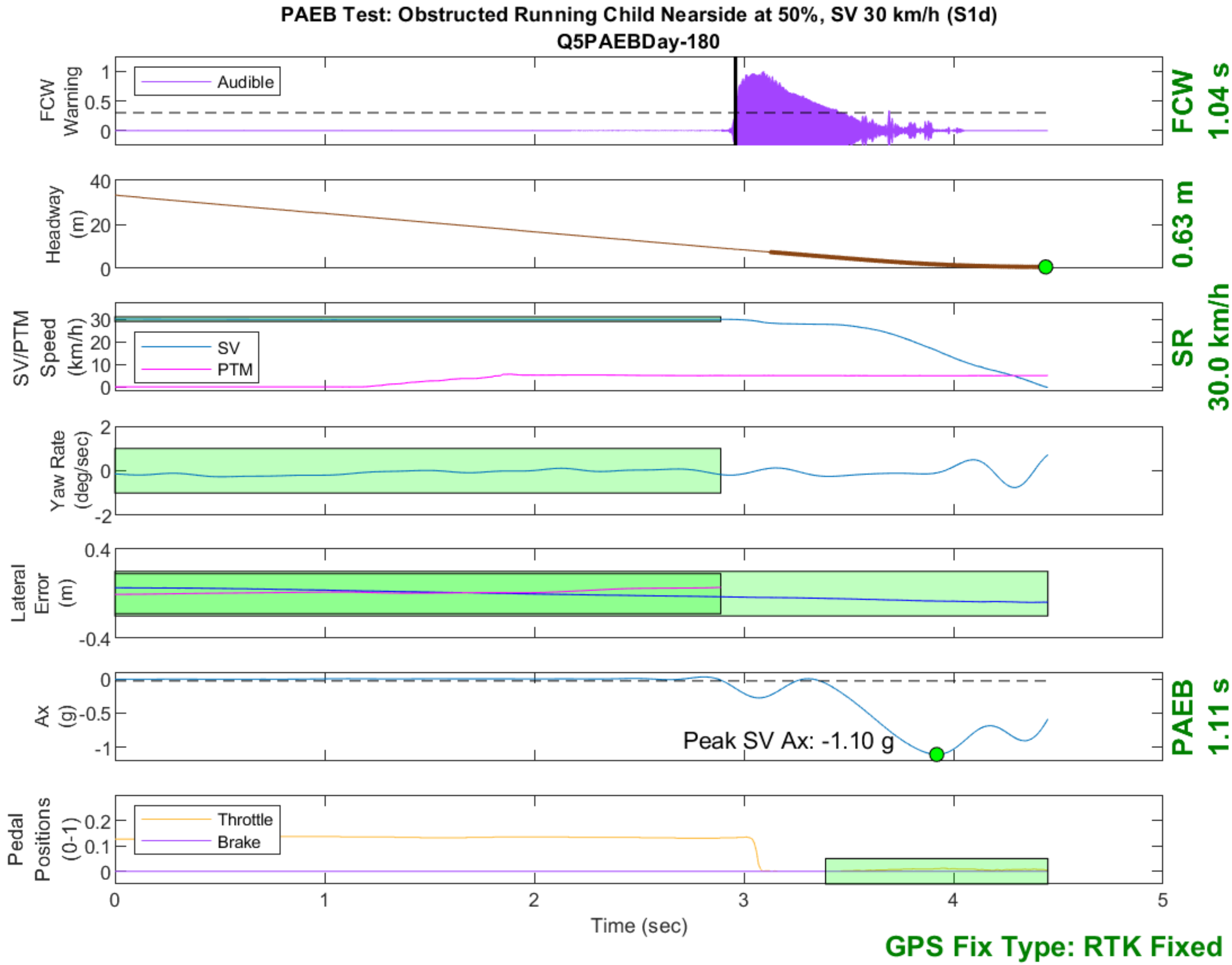

Figure D66. Time History for PAEB Run 180, S1d, Daytime, 30 km/h

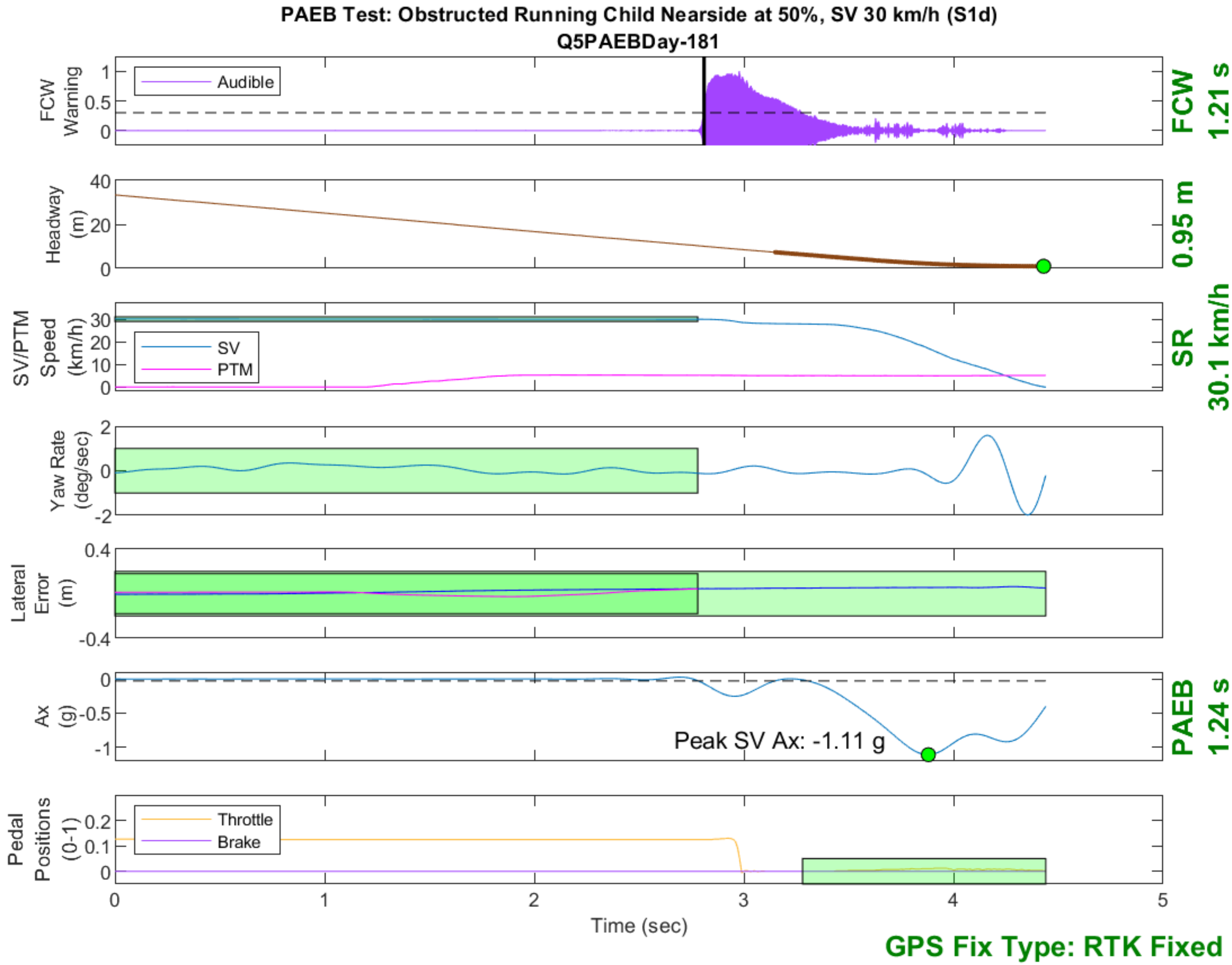

Figure D67. Time History for PAEB Run 181, S1d, Daytime, 30 km/h

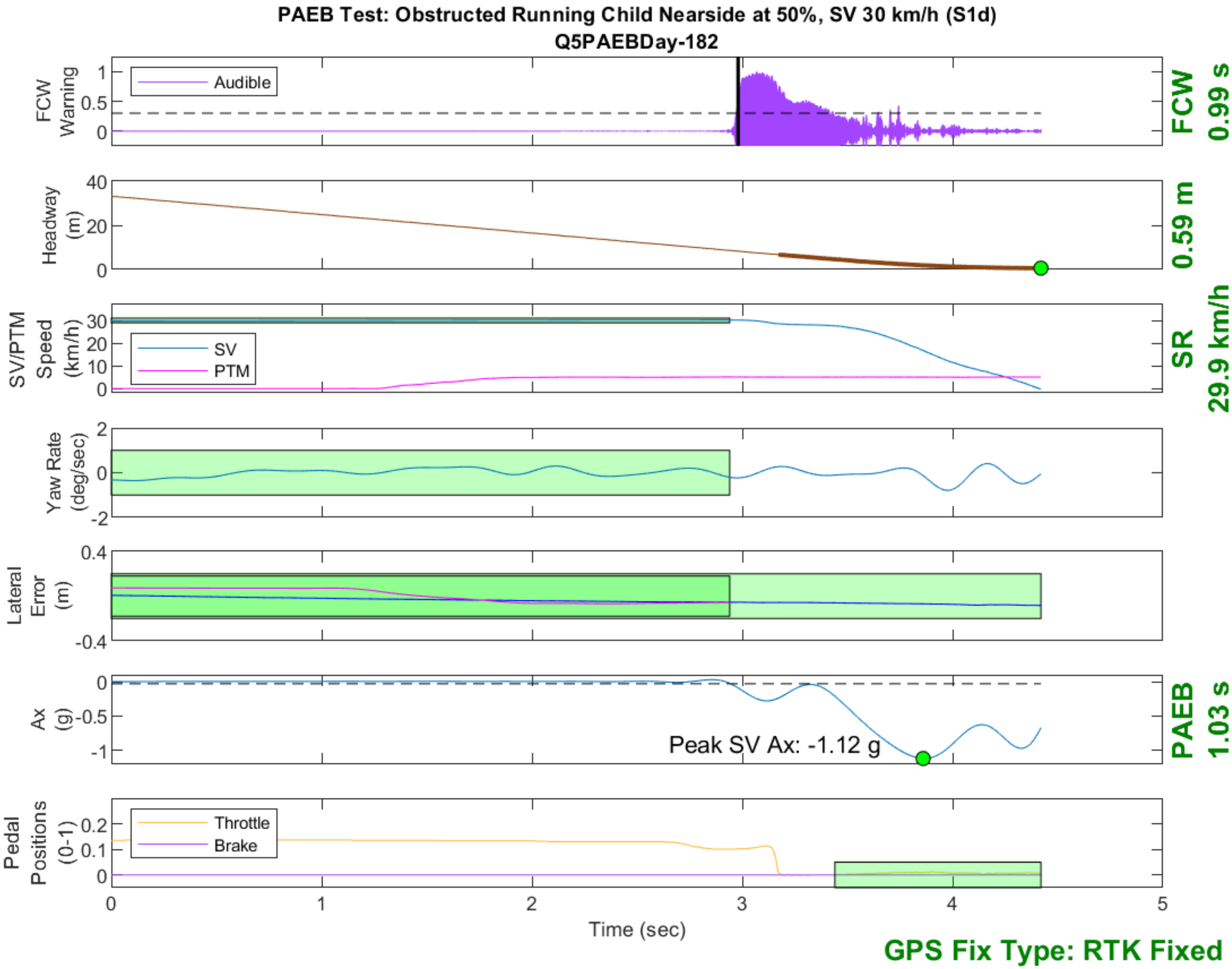

Figure D68. Time History for PAEB Run 182, S1d, Daytime, 30 km/h

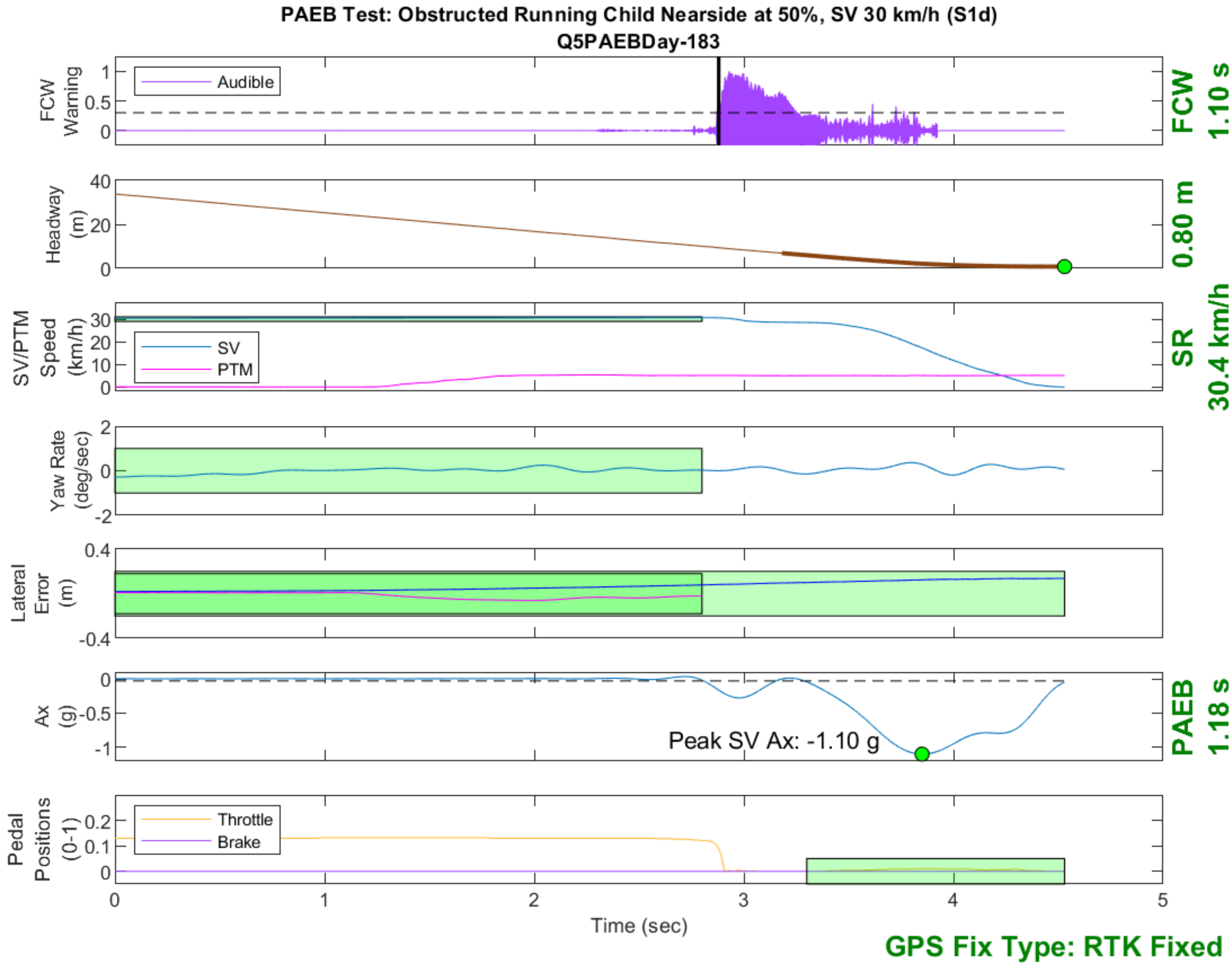

Figure D69. Time History for PAEB Run 183, S1d, Daytime, 30 km/h

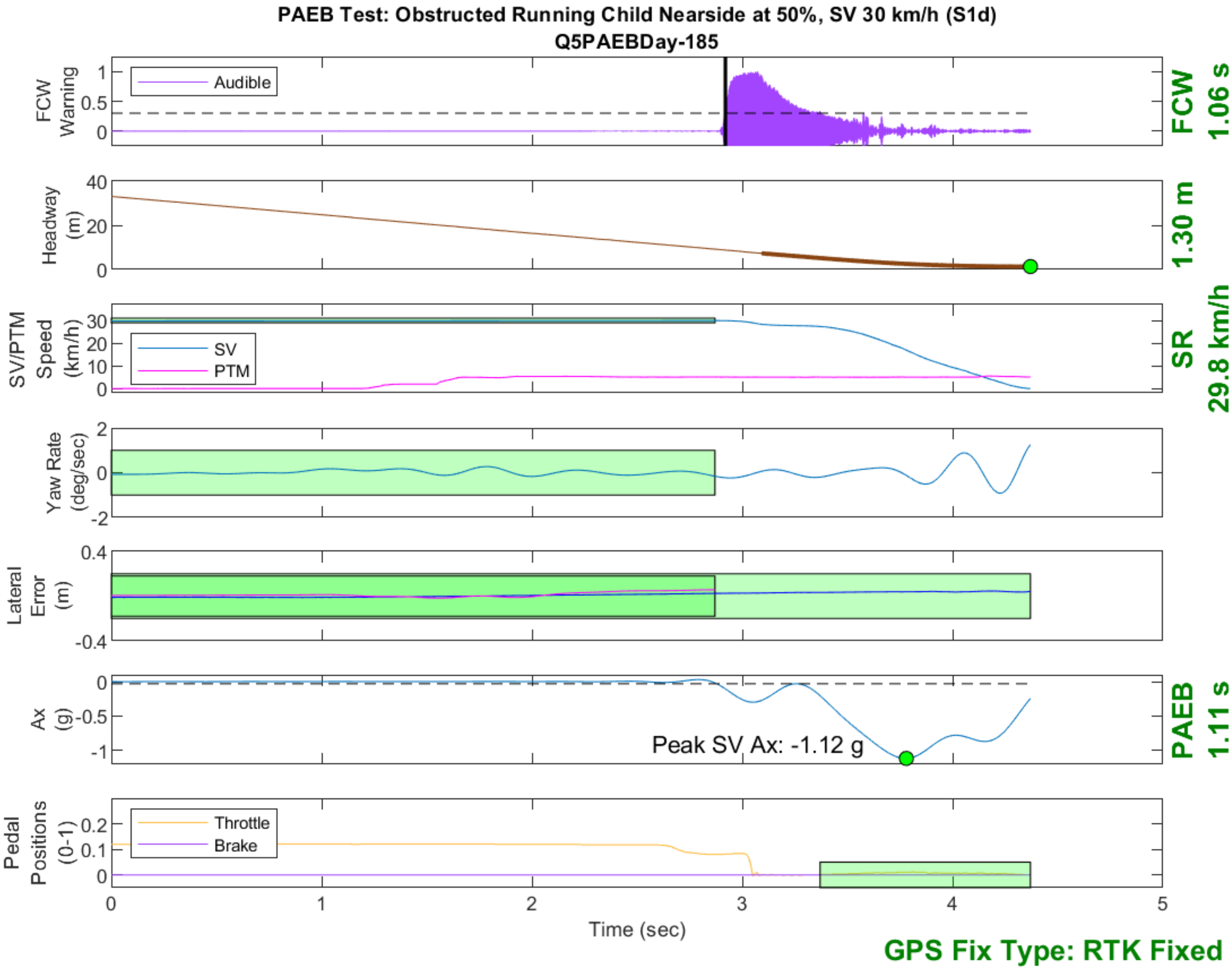

Figure D70. Time History for PAEB Run 185, S1d, Daytime, 30 km/h

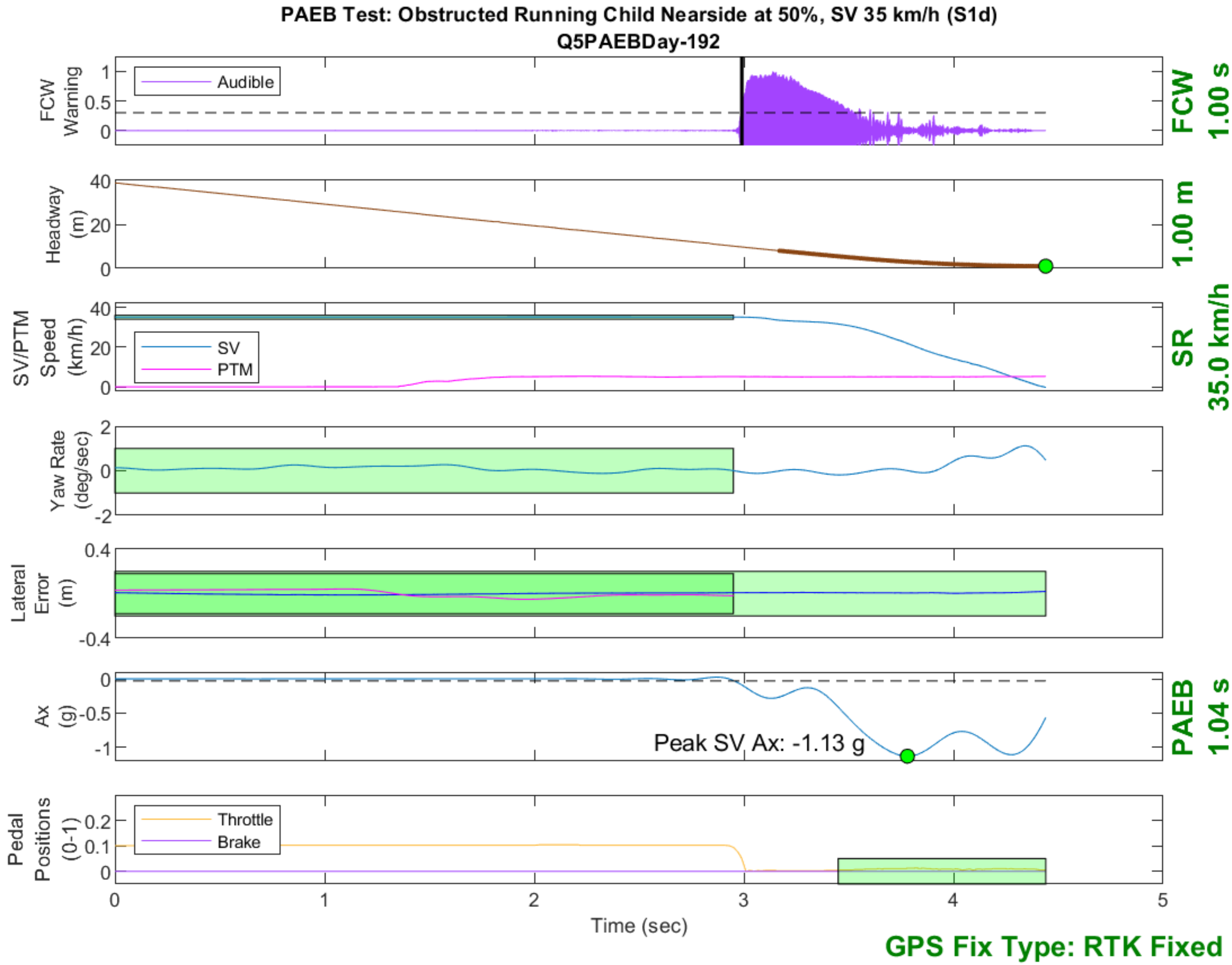

Figure D71. Time History for PAEB Run 192, S1d, Daytime, 35 km/h

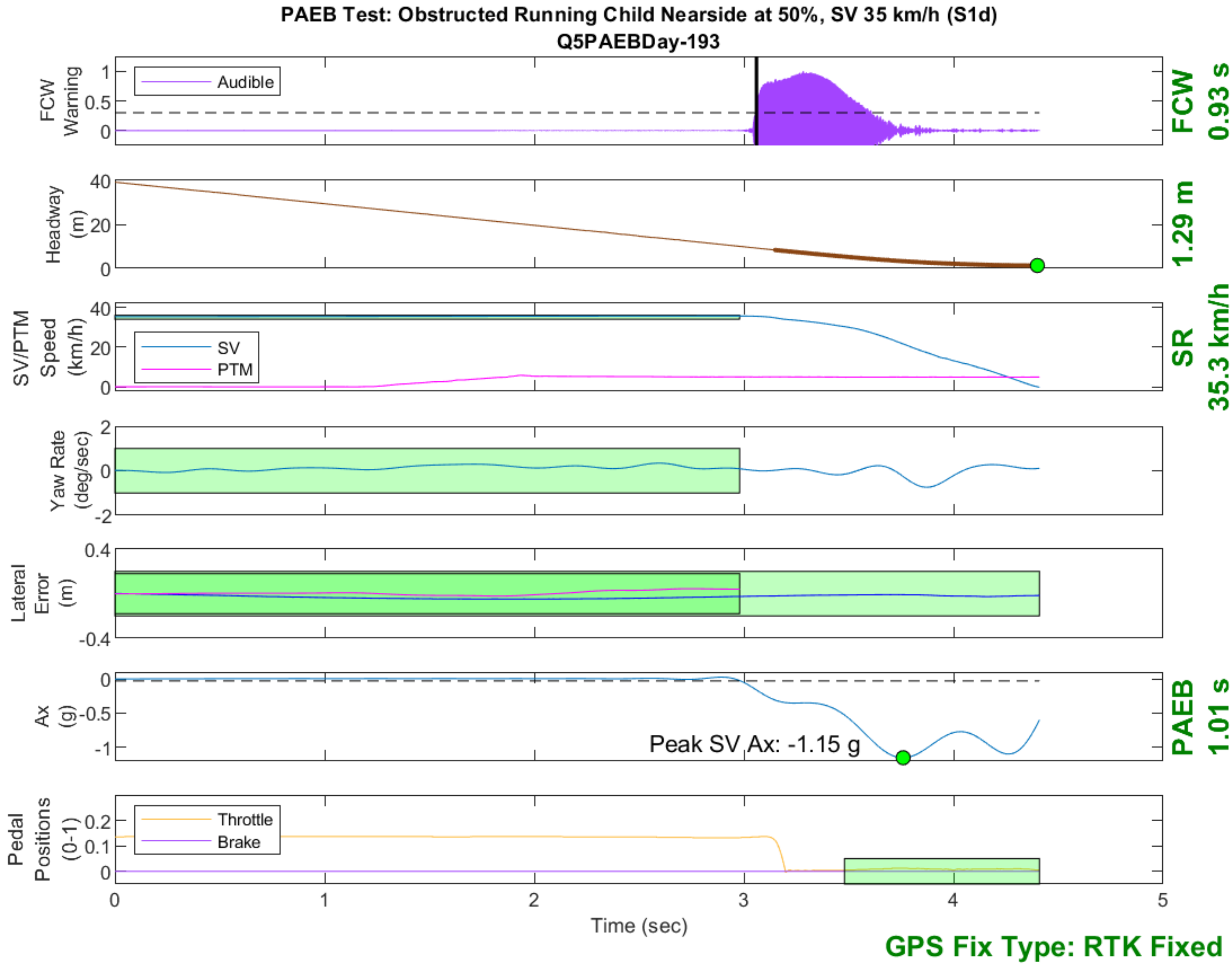

Figure D72. Time History for PAEB Run 193, S1d, Daytime, 35 km/h

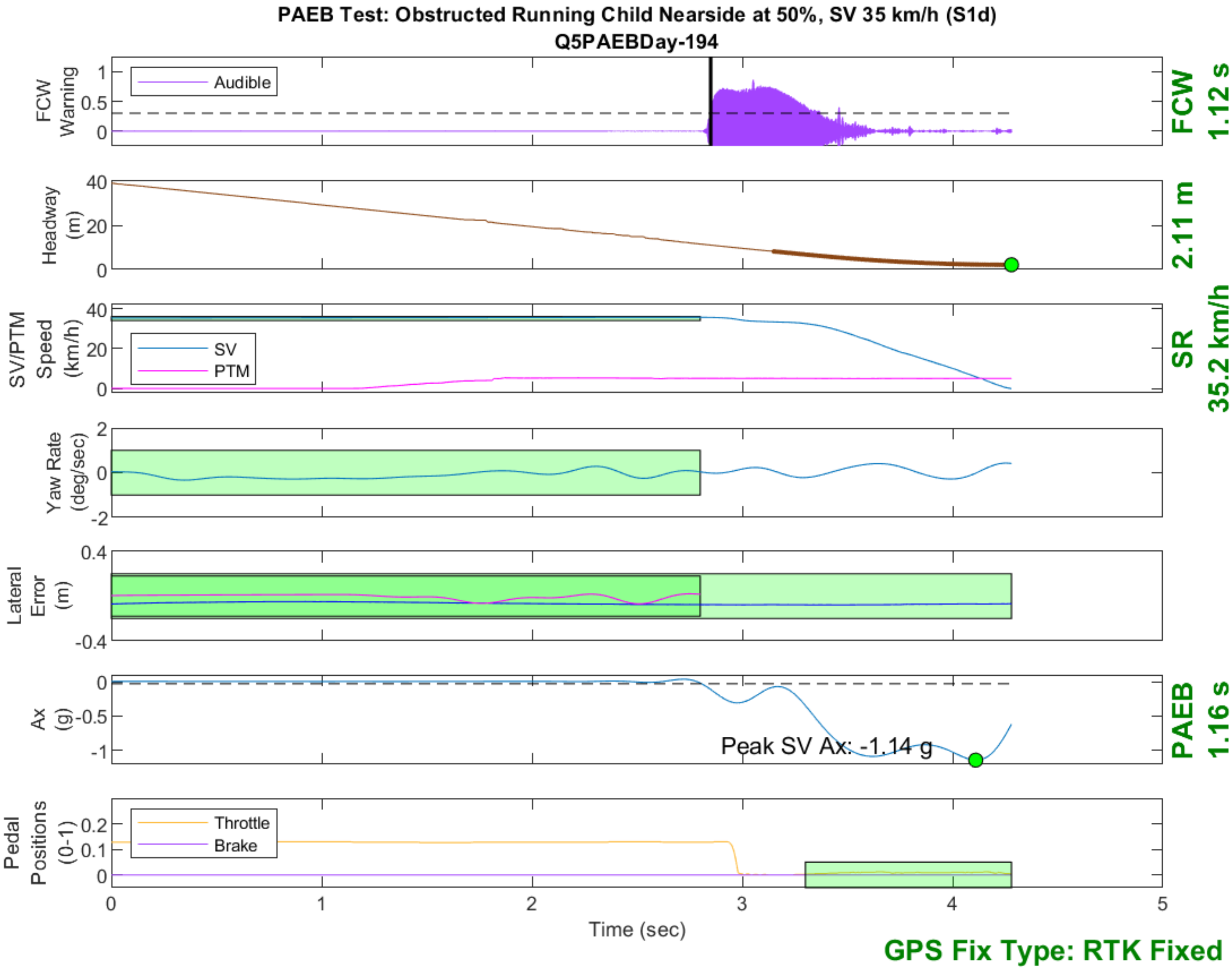

Figure D73. Time History for PAEB Run 194, S1d, Daytime, 35 km/h

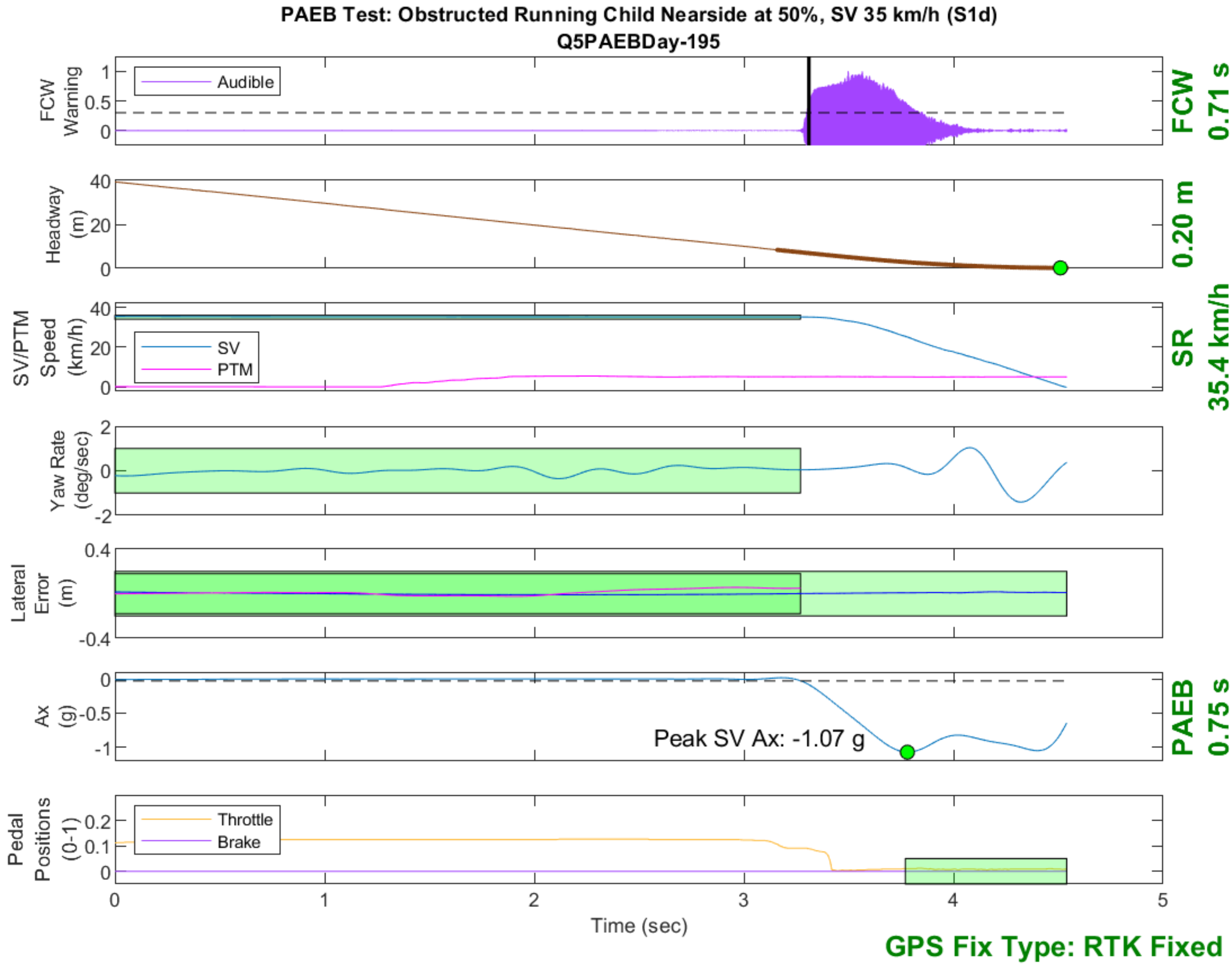

Figure D74. Time History for PAEB Run 195, S1d, Daytime, 35 km/h

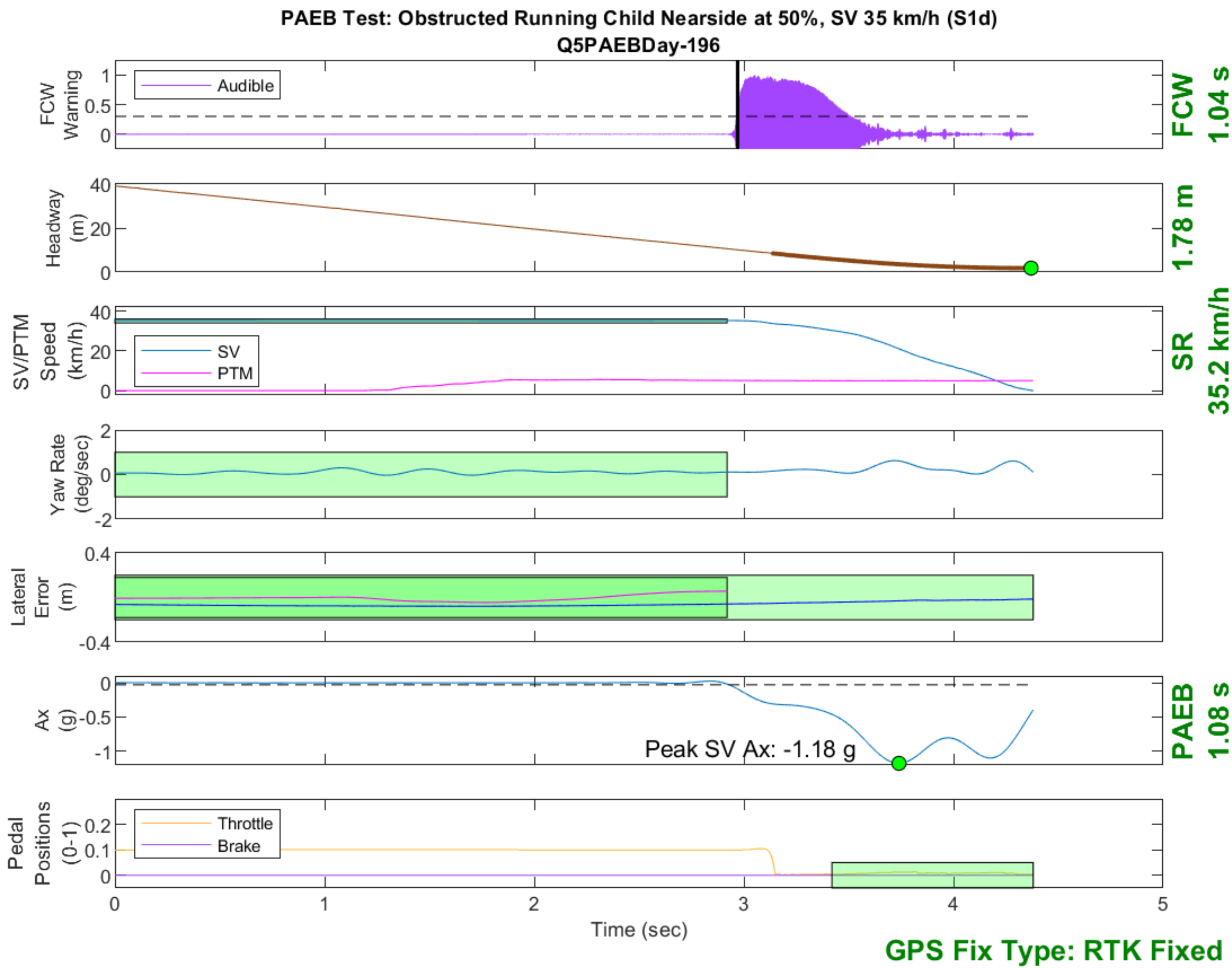

Figure D75. Time History for PAEB Run 196, S1d, Daytime, 35 km/h

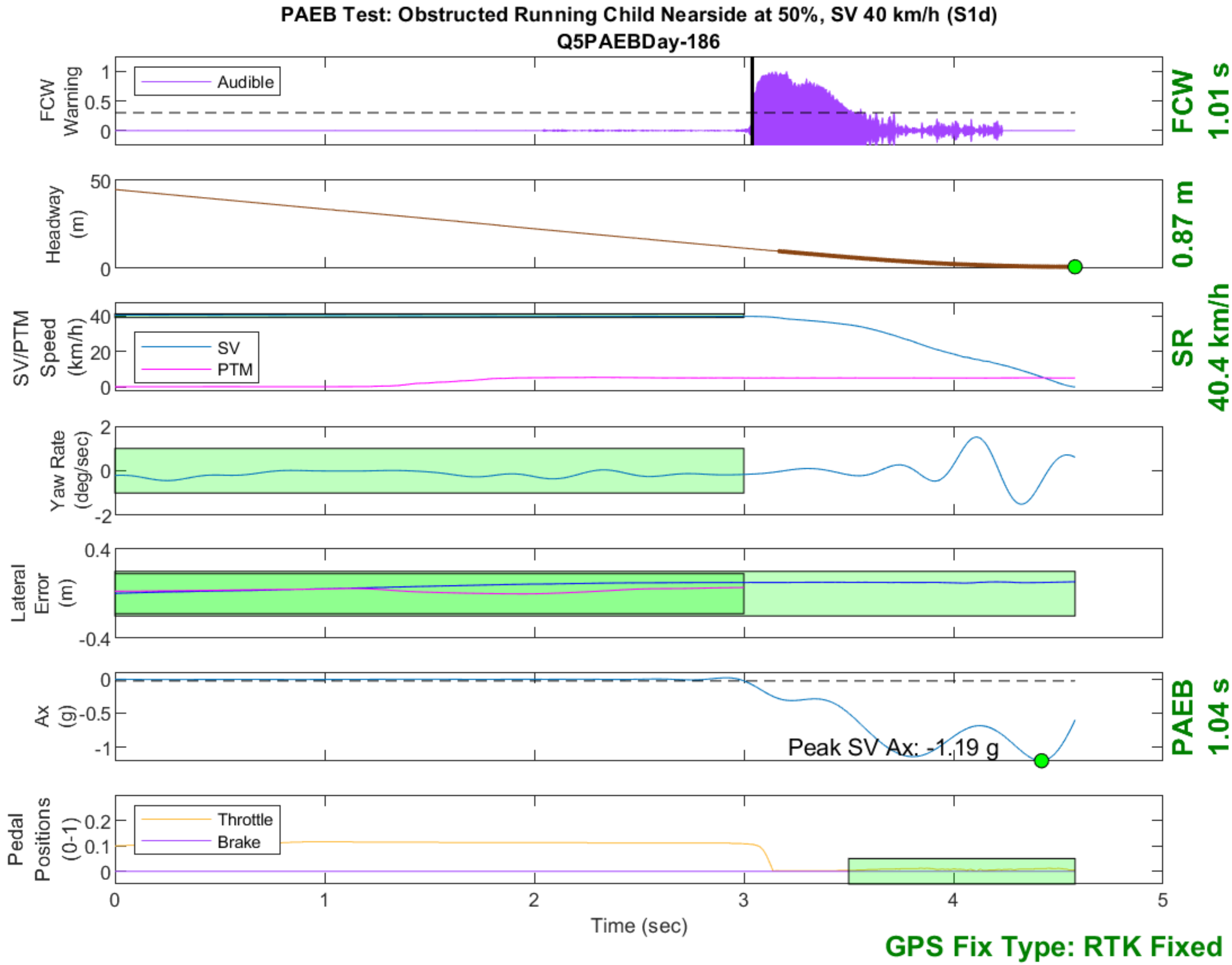

Figure D76. Time History for PAEB Run 186, S1d, Daytime, 40 km/h

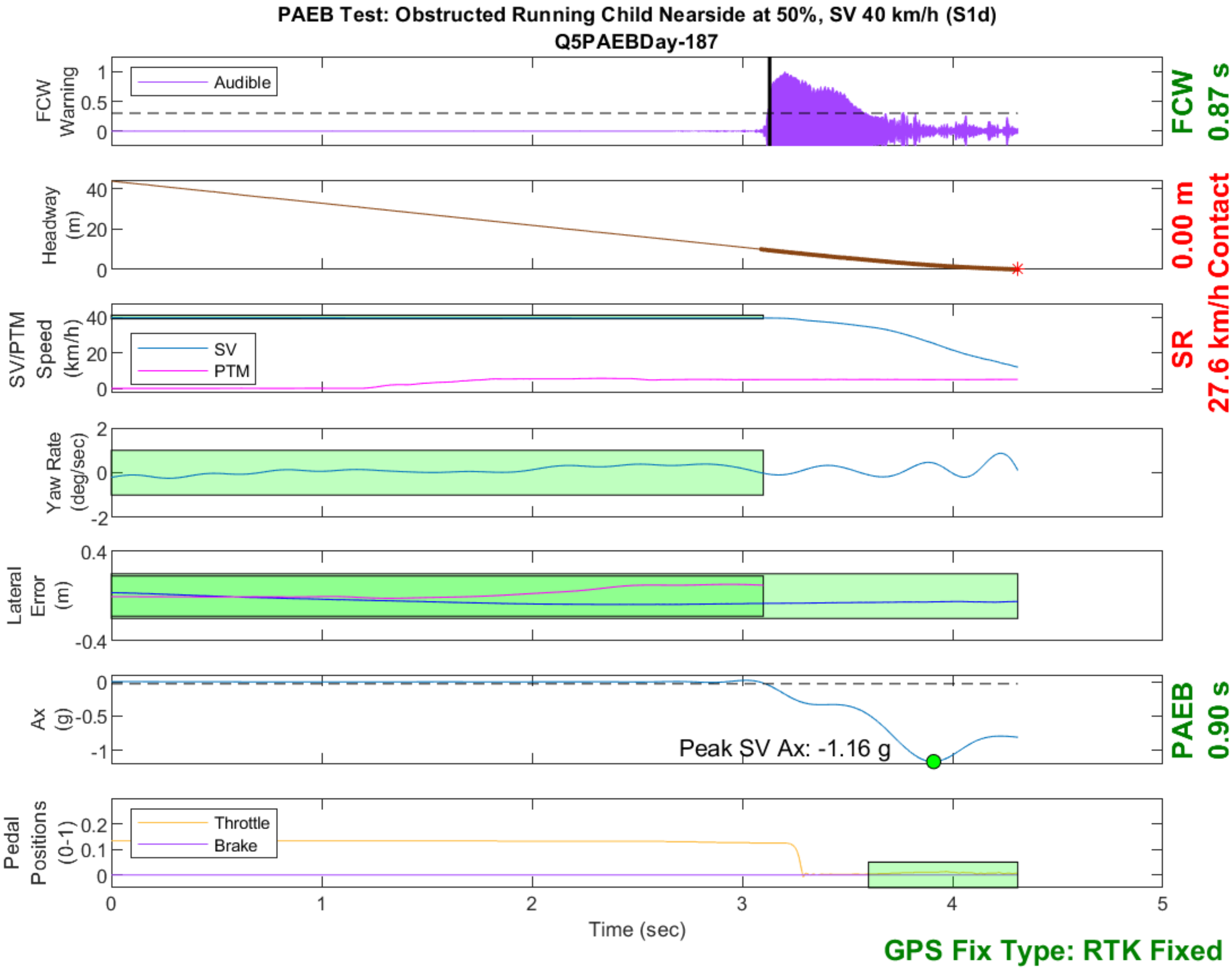

Figure D77. Time History for PAEB Run 187, S1d, Daytime, 40 km/h

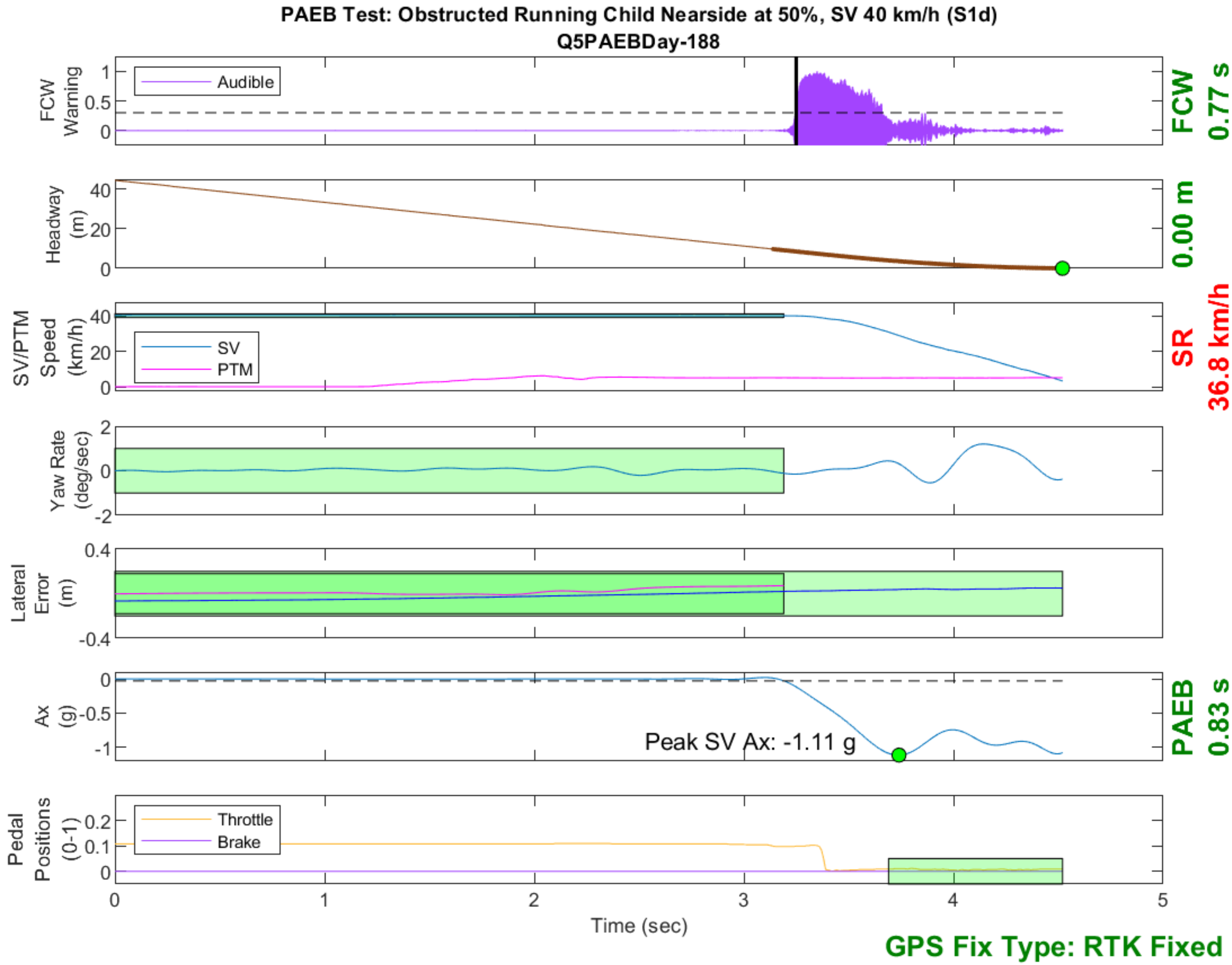

Figure D78. Time History for PAEB Run 188, S1d, Daytime, 40 km/h

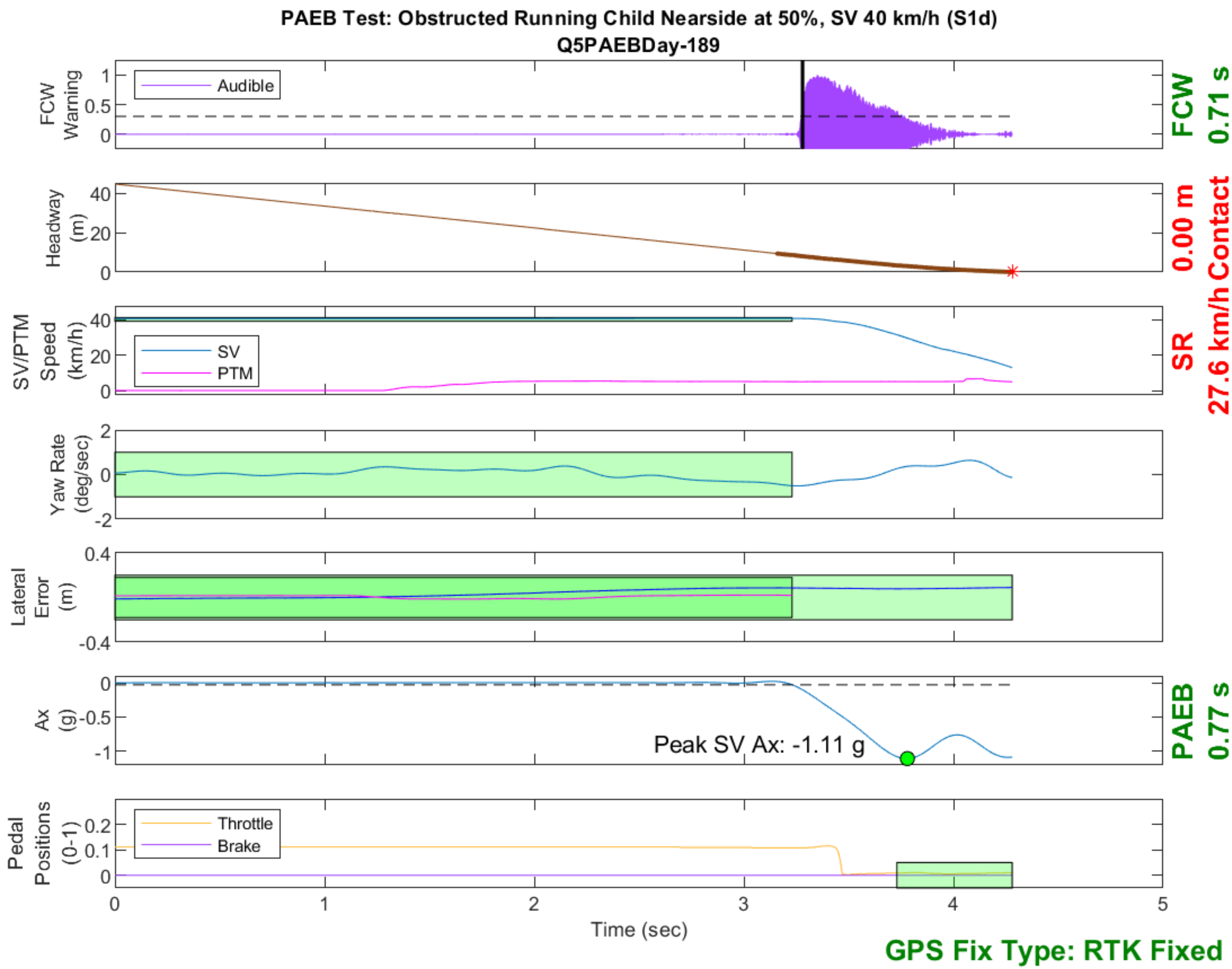

Figure D79. Time History for PAEB Run 189, S1d, Daytime, 40 km/h

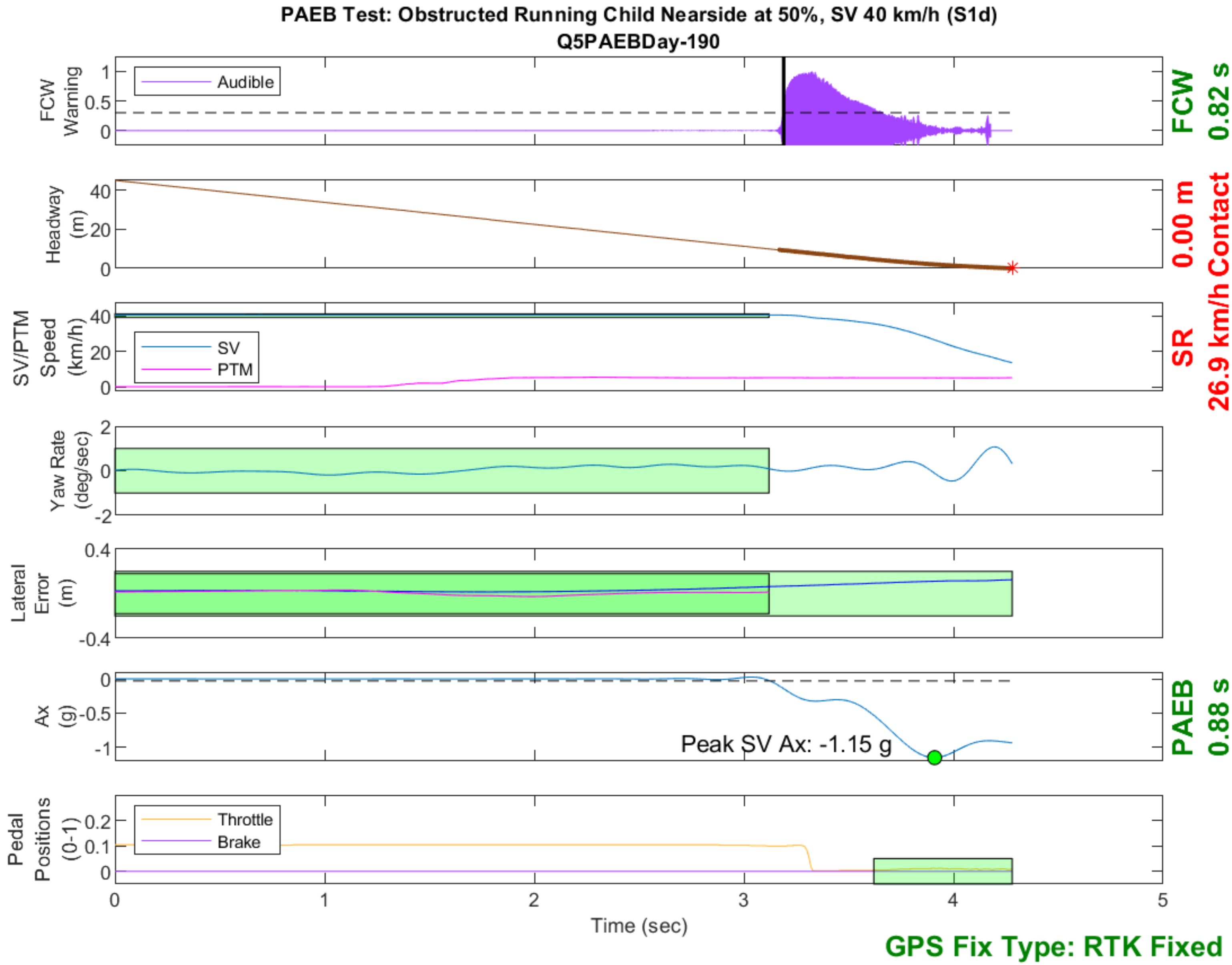

Figure D80. Time History for PAEB Run 190, S1d, Daytime, 40 km/h

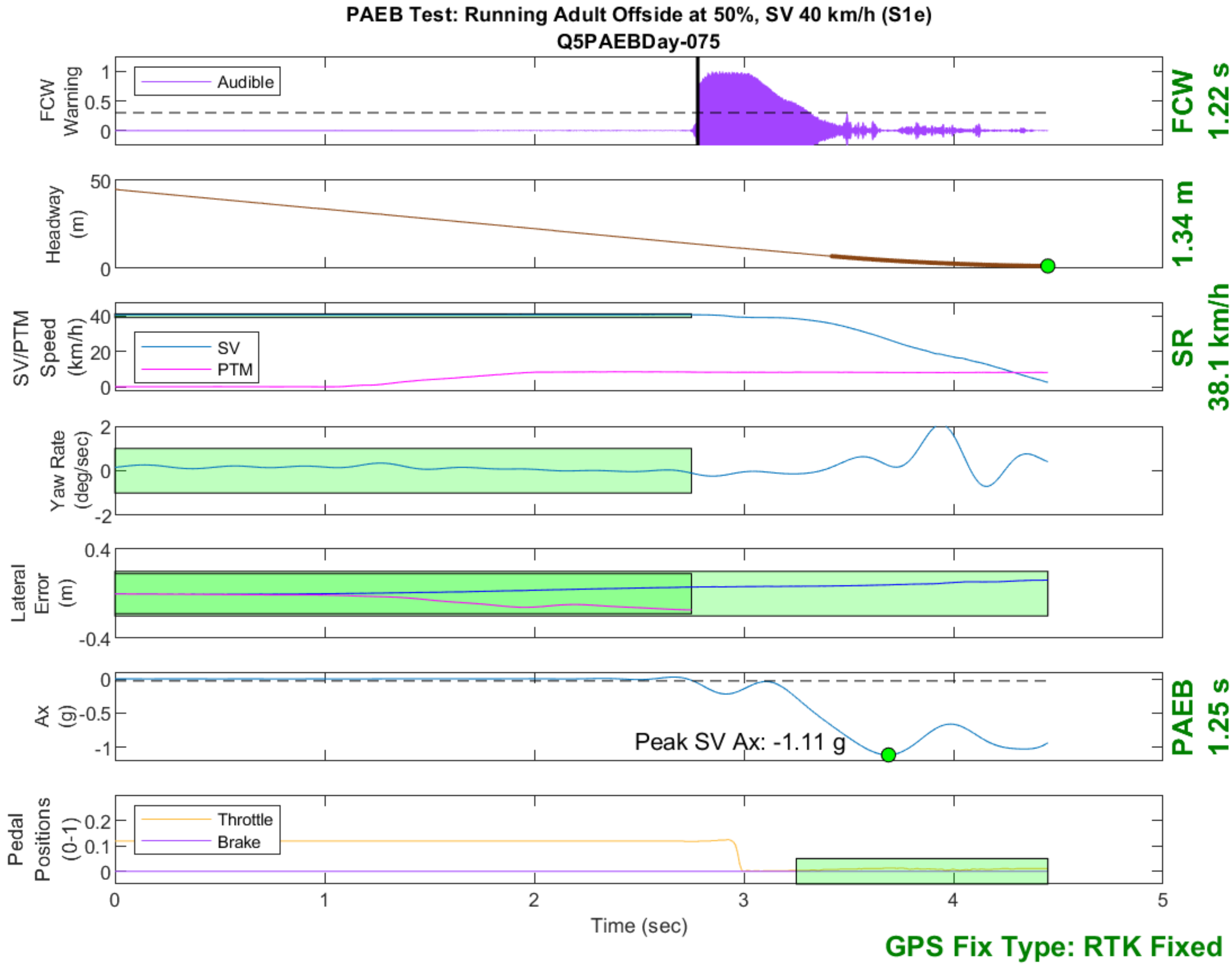

Figure D81. Time History for PAEB Run 75, S1e, Daytime, 40 km/h

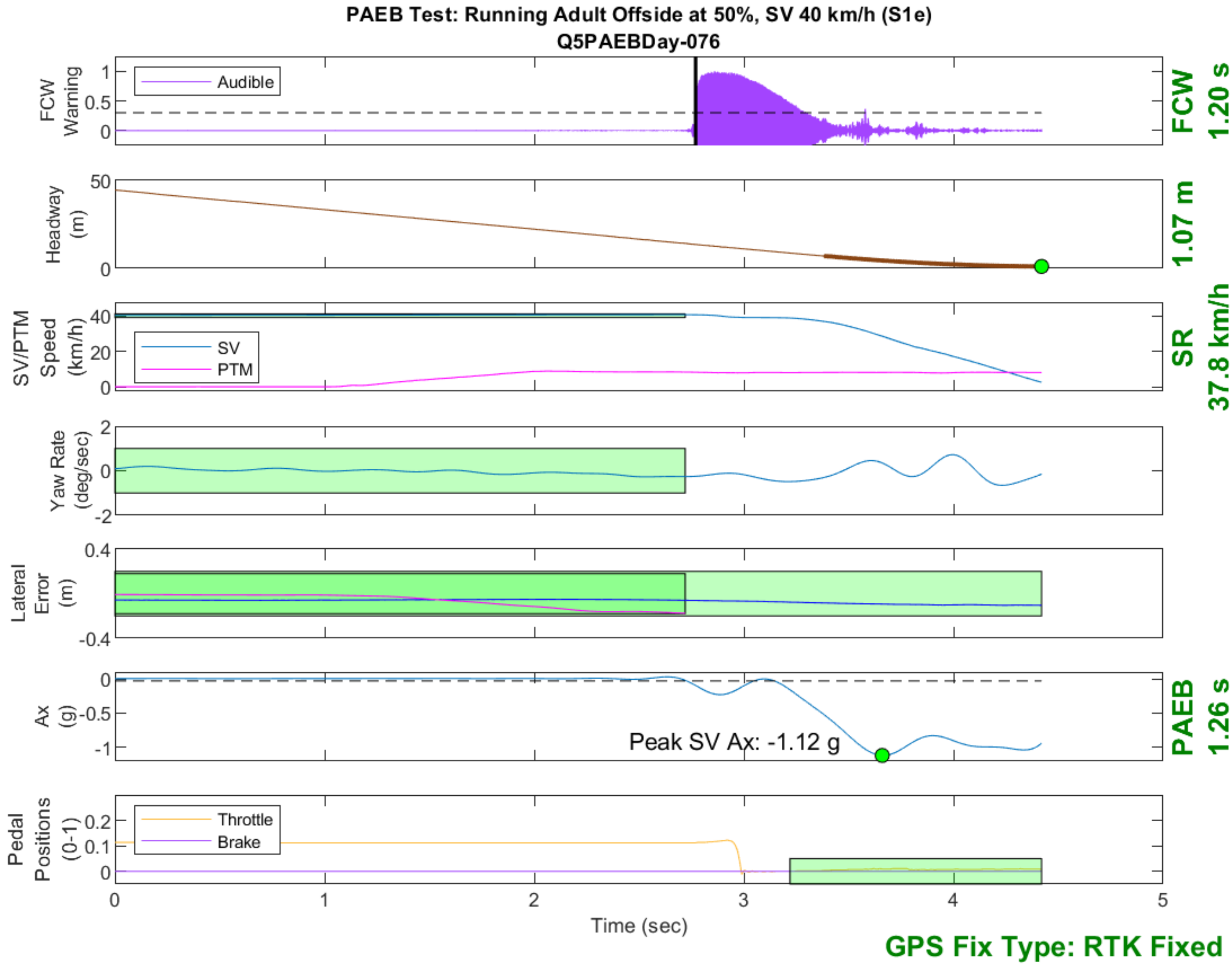

Figure D82. Time History for PAEB Run 76, S1e, Daytime, 40 km/h

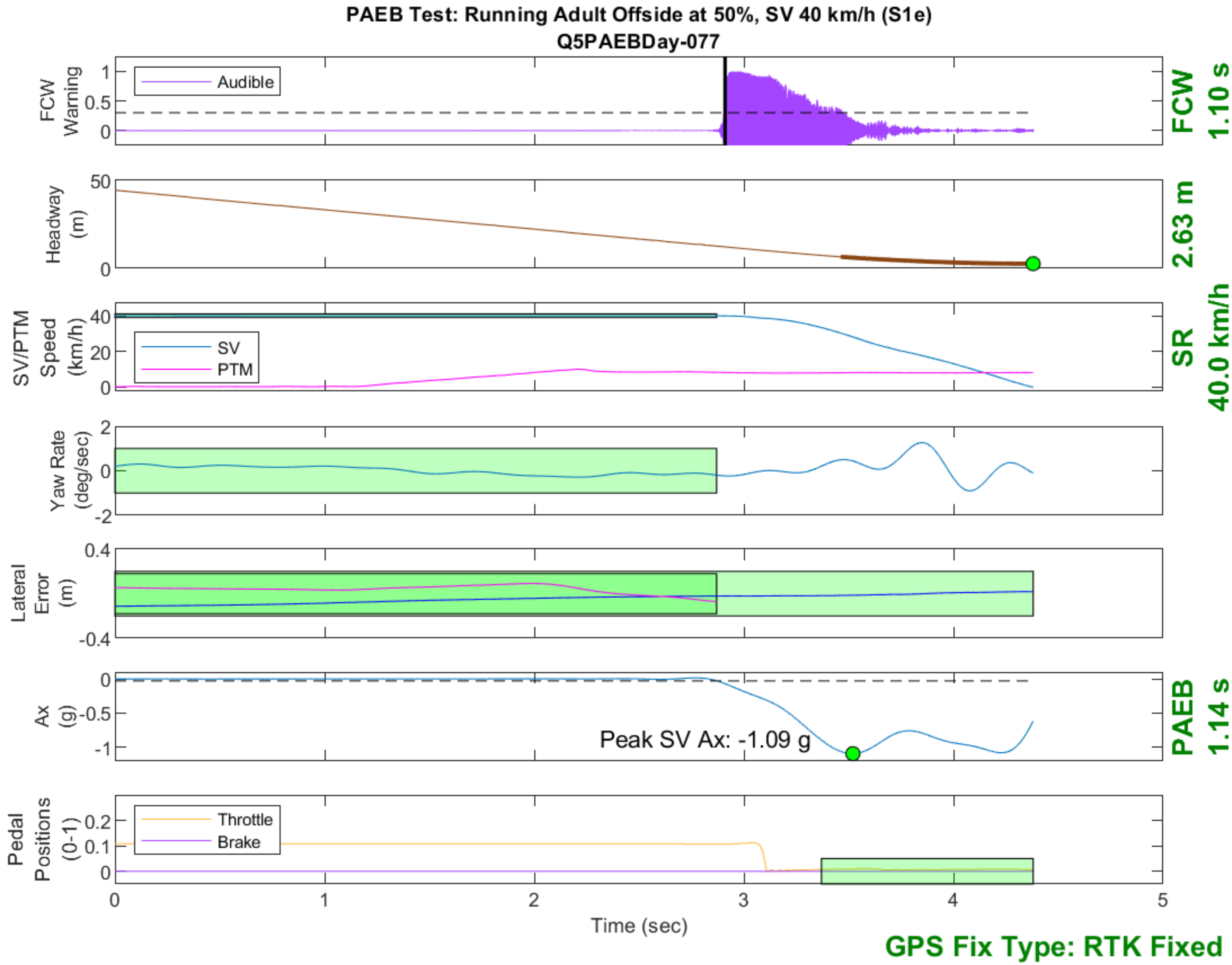

Figure D83. Time History for PAEB Run 77, S1e, Daytime, 40 km/h

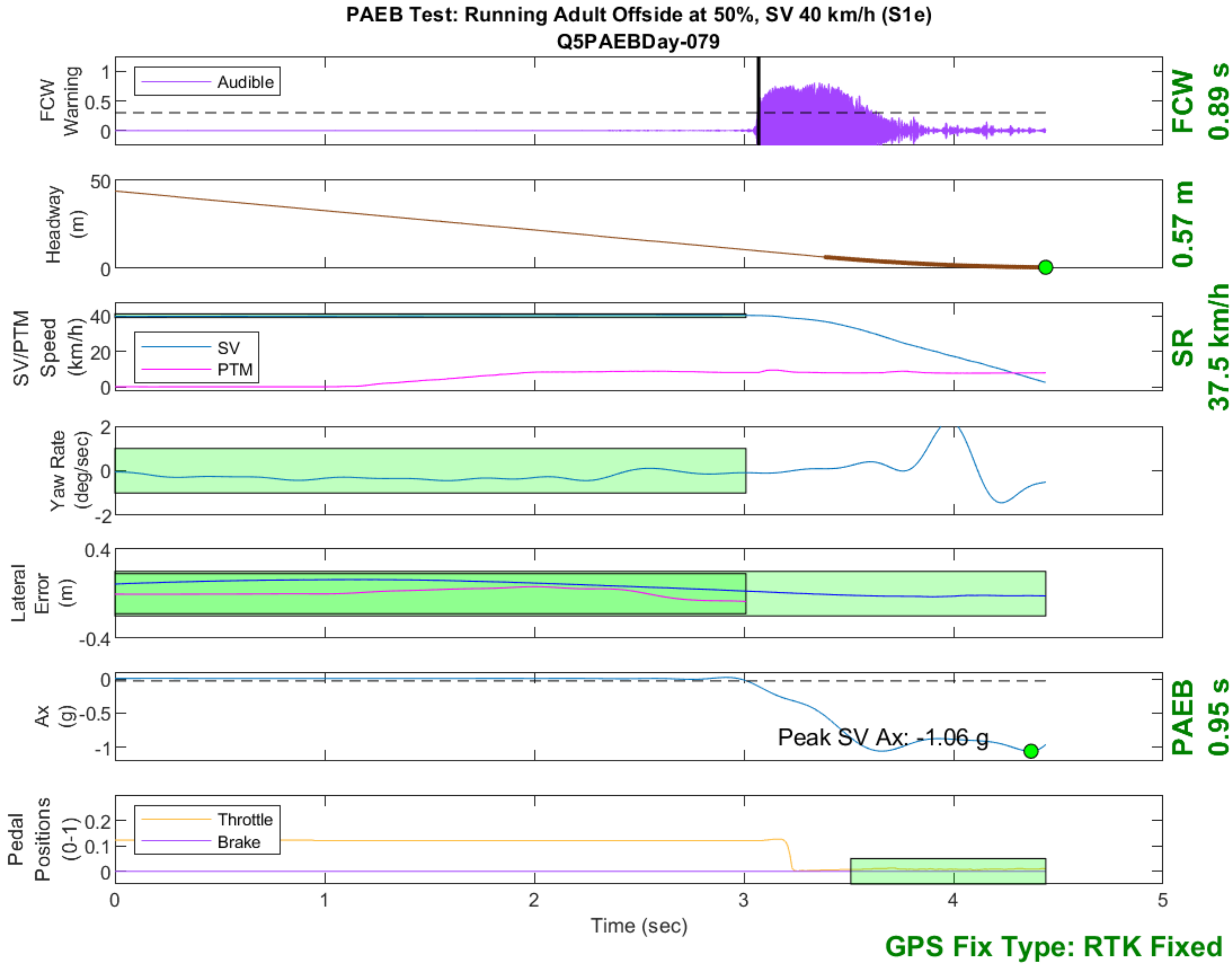

Figure D84. Time History for PAEB Run 79, S1e, Daytime, 40 km/h

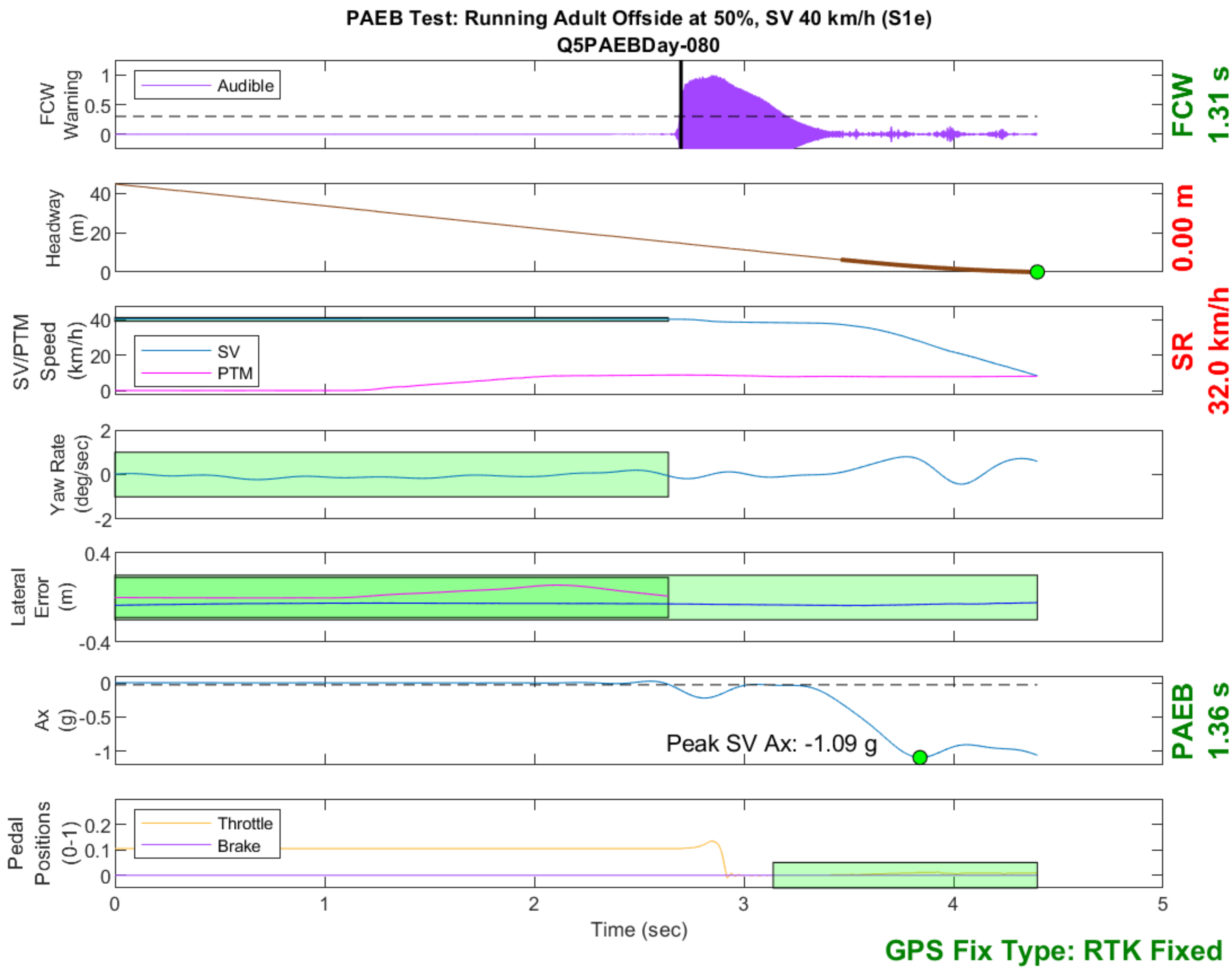

Figure D85. Time History for PAEB Run 80, S1e, Daytime, 40 km/h

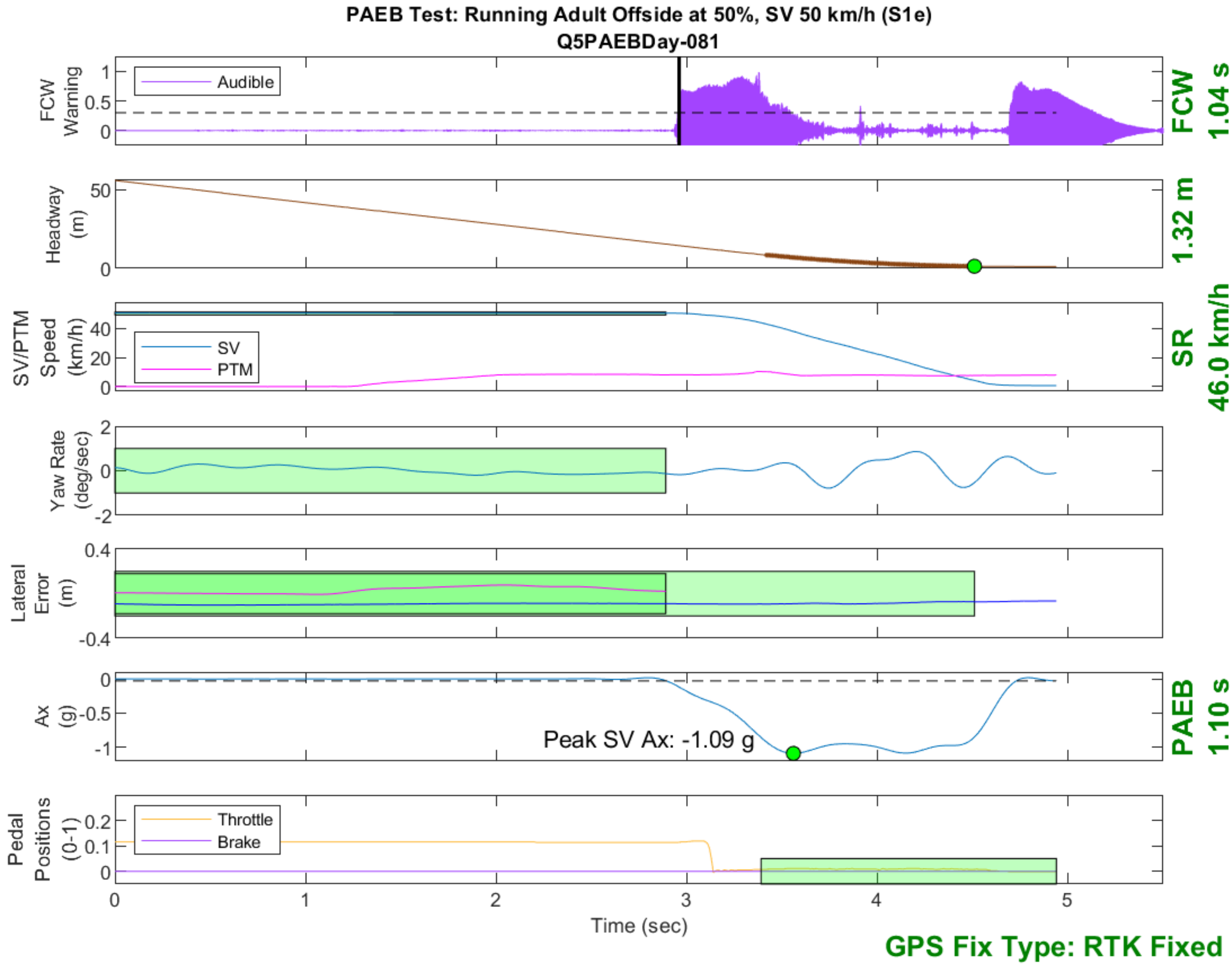

Figure D86. Time History for PAEB Run 81, S1e, Daytime, 50 km/h

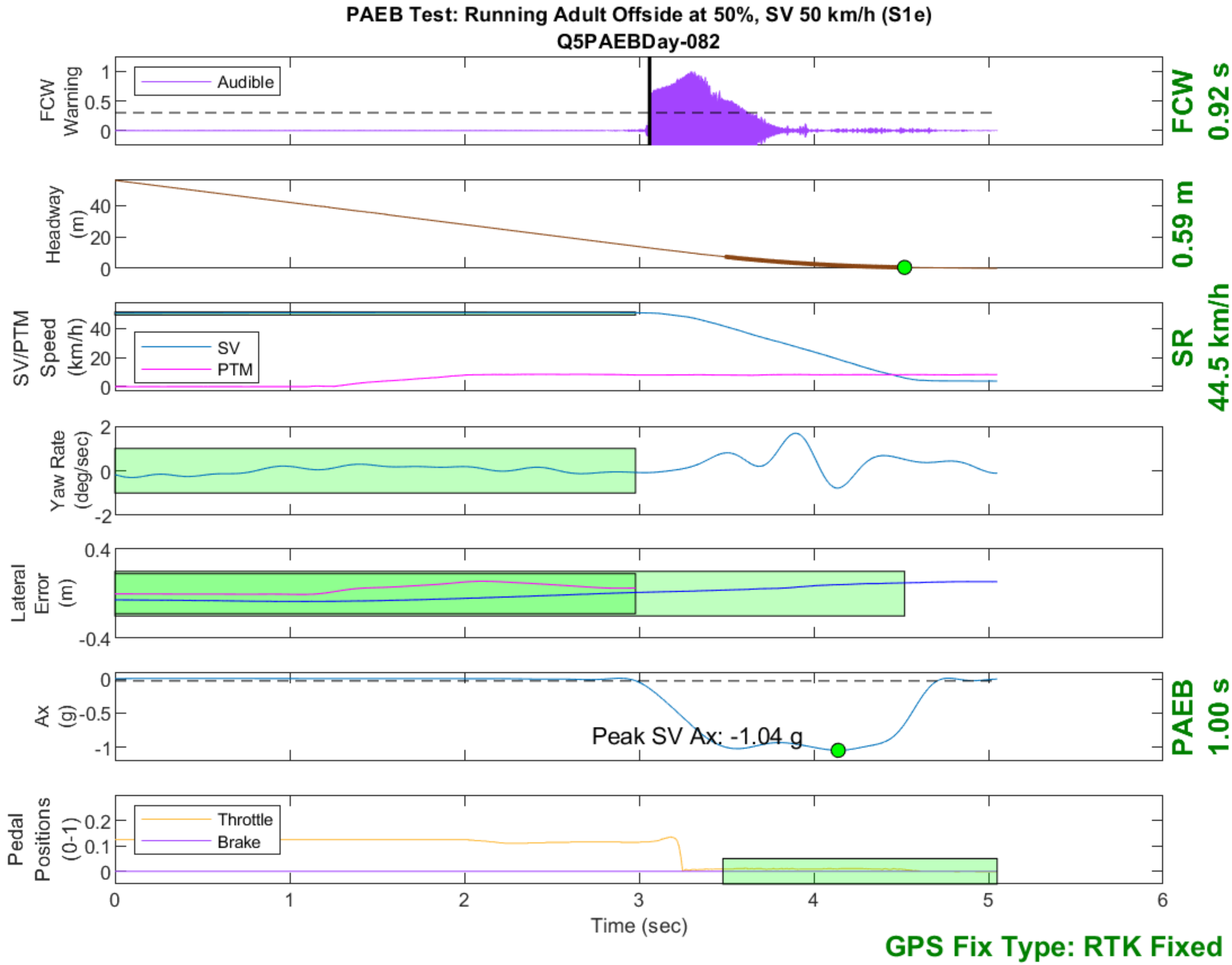

Figure D87. Time History for PAEB Run 82, S1e, Daytime, 50 km/h

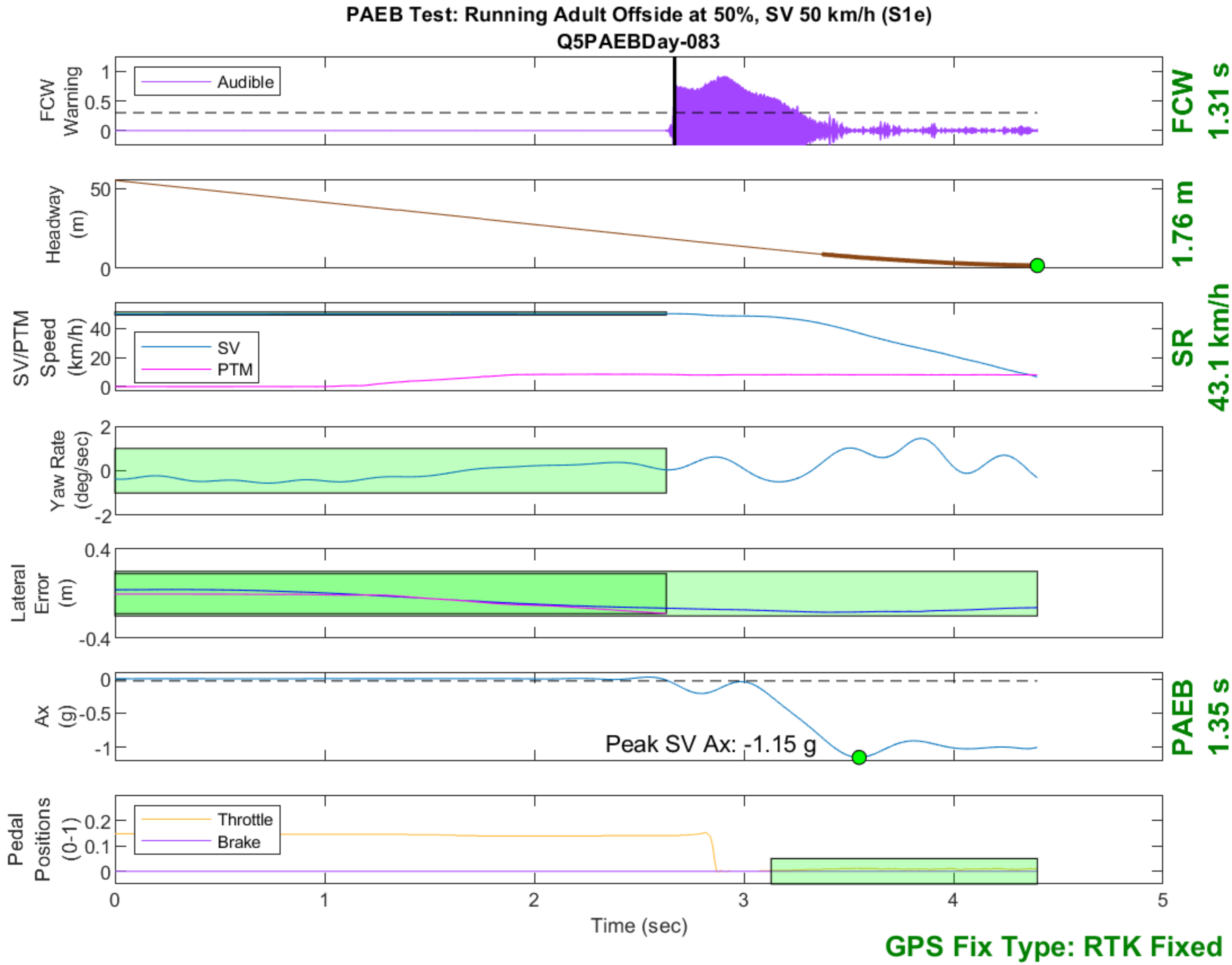

Figure D88. Time History for PAEB Run 83, S1e, Daytime, 50 km/h

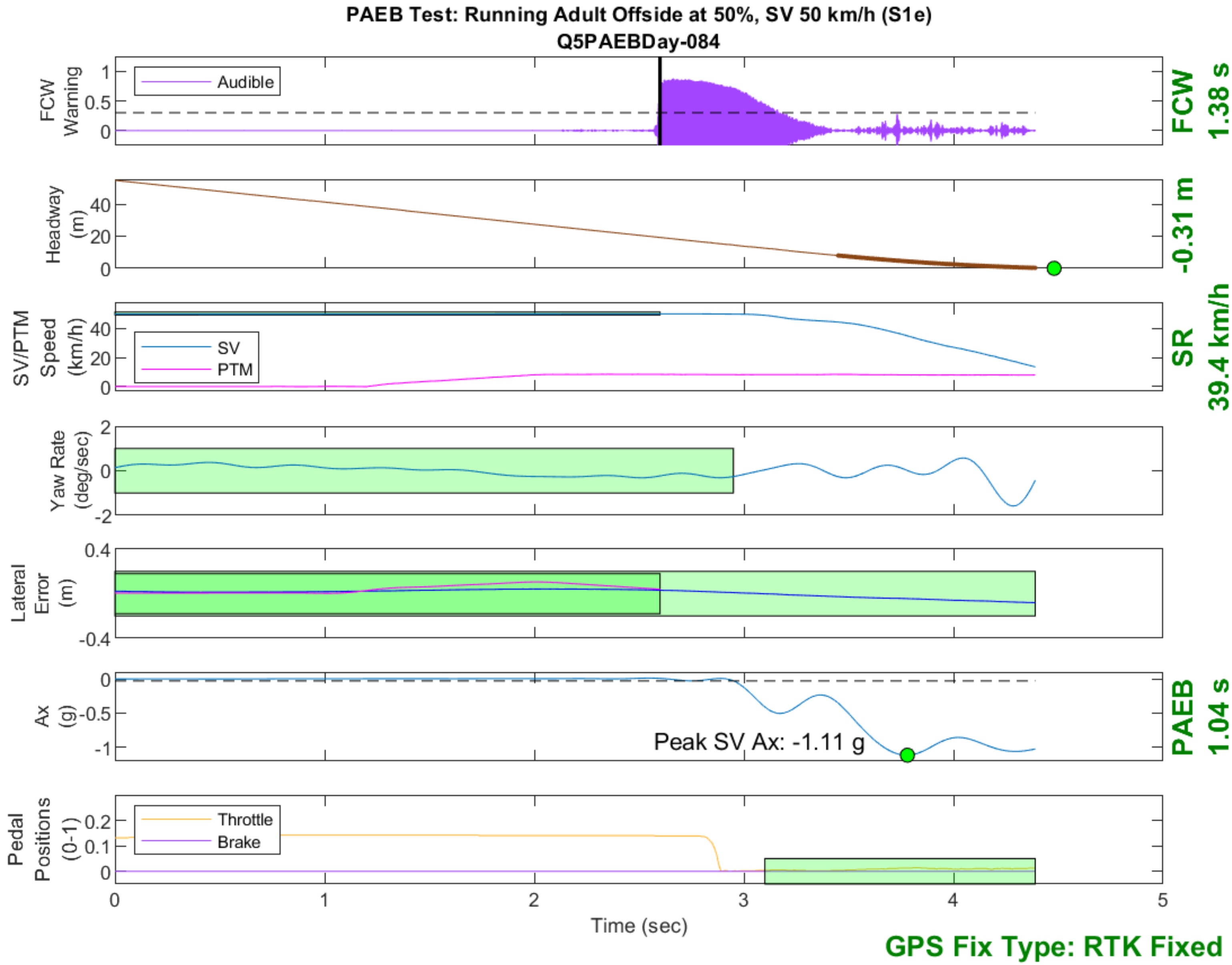

Figure D89. Time History for PAEB Run 84, S1e, Daytime, 50 km/h

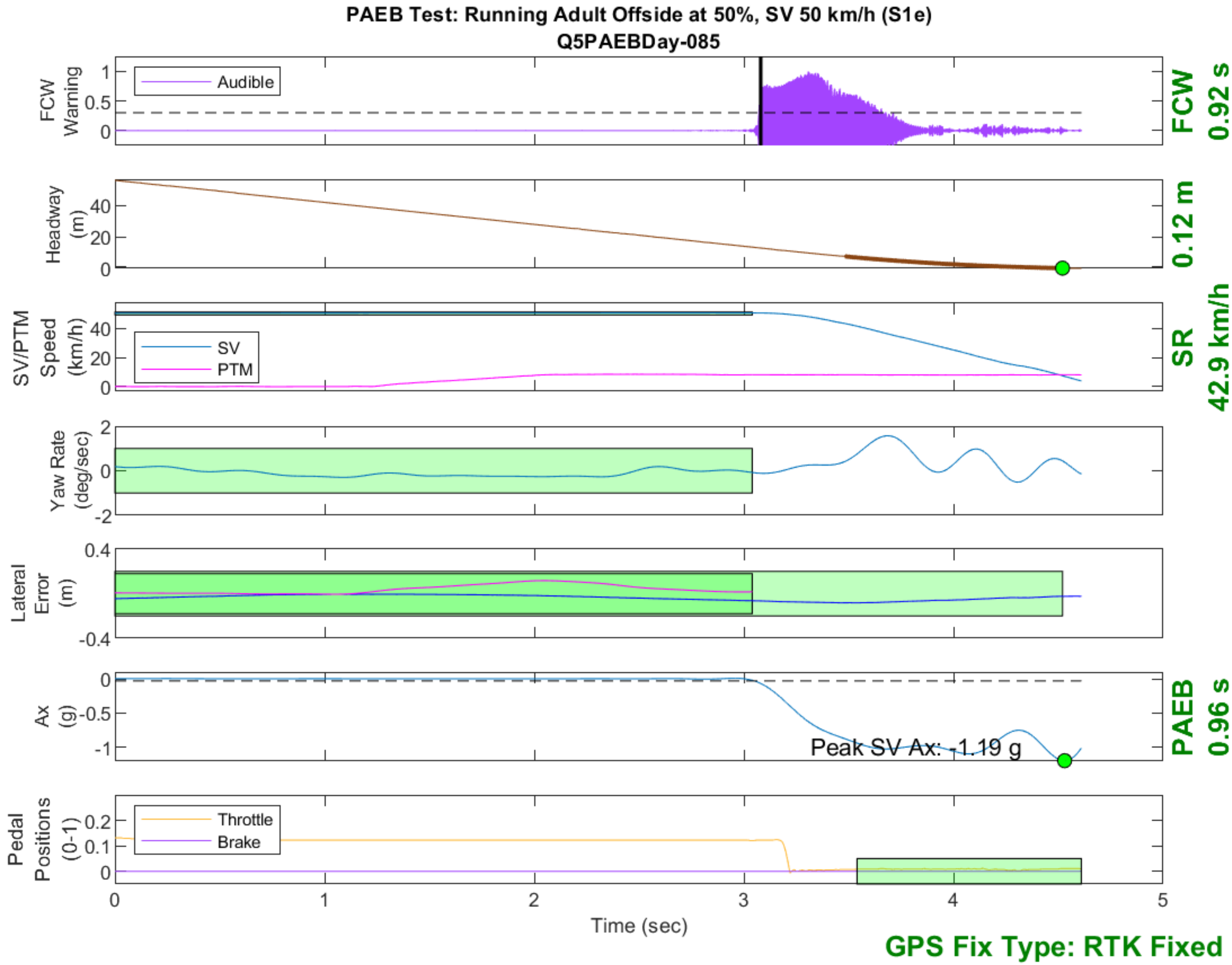

Figure D90. Time History for PAEB Run 85, S1e, Daytime, 50 km/h

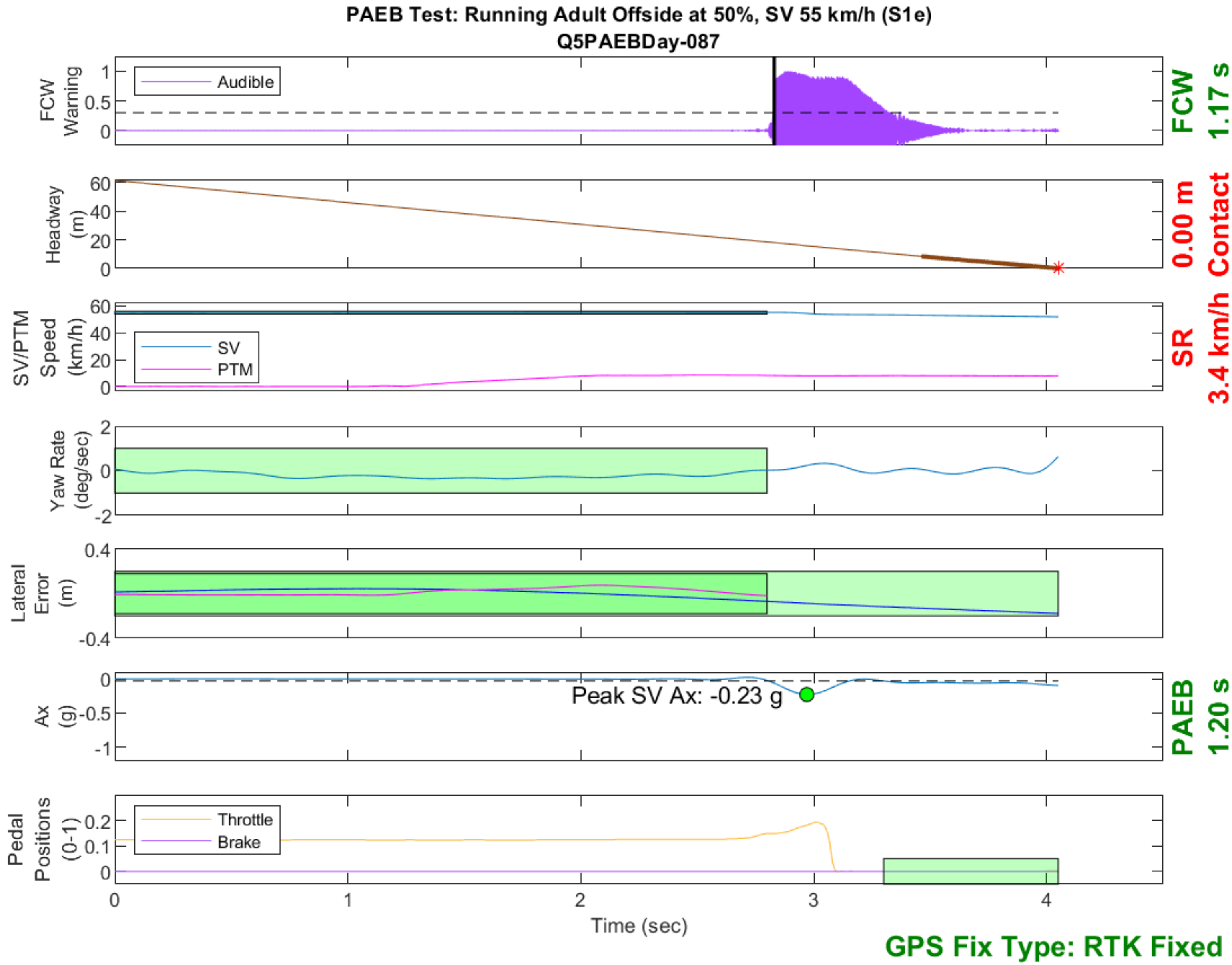

Figure D91. Time History for PAEB Run 87, S1e, Daytime, 55 km/h

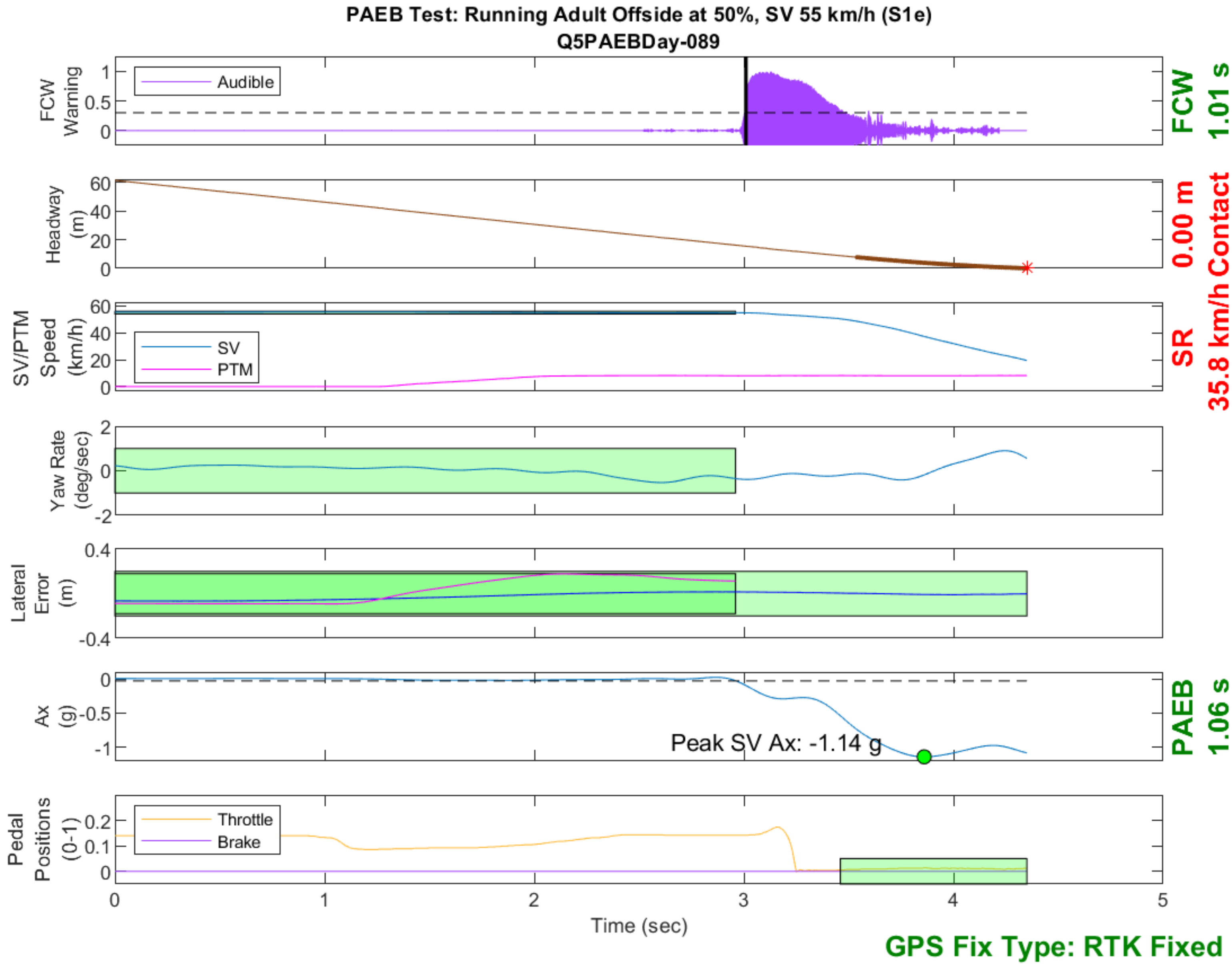

Figure D92. Time History for PAEB Run 89, S1e, Daytime, 55 km/h

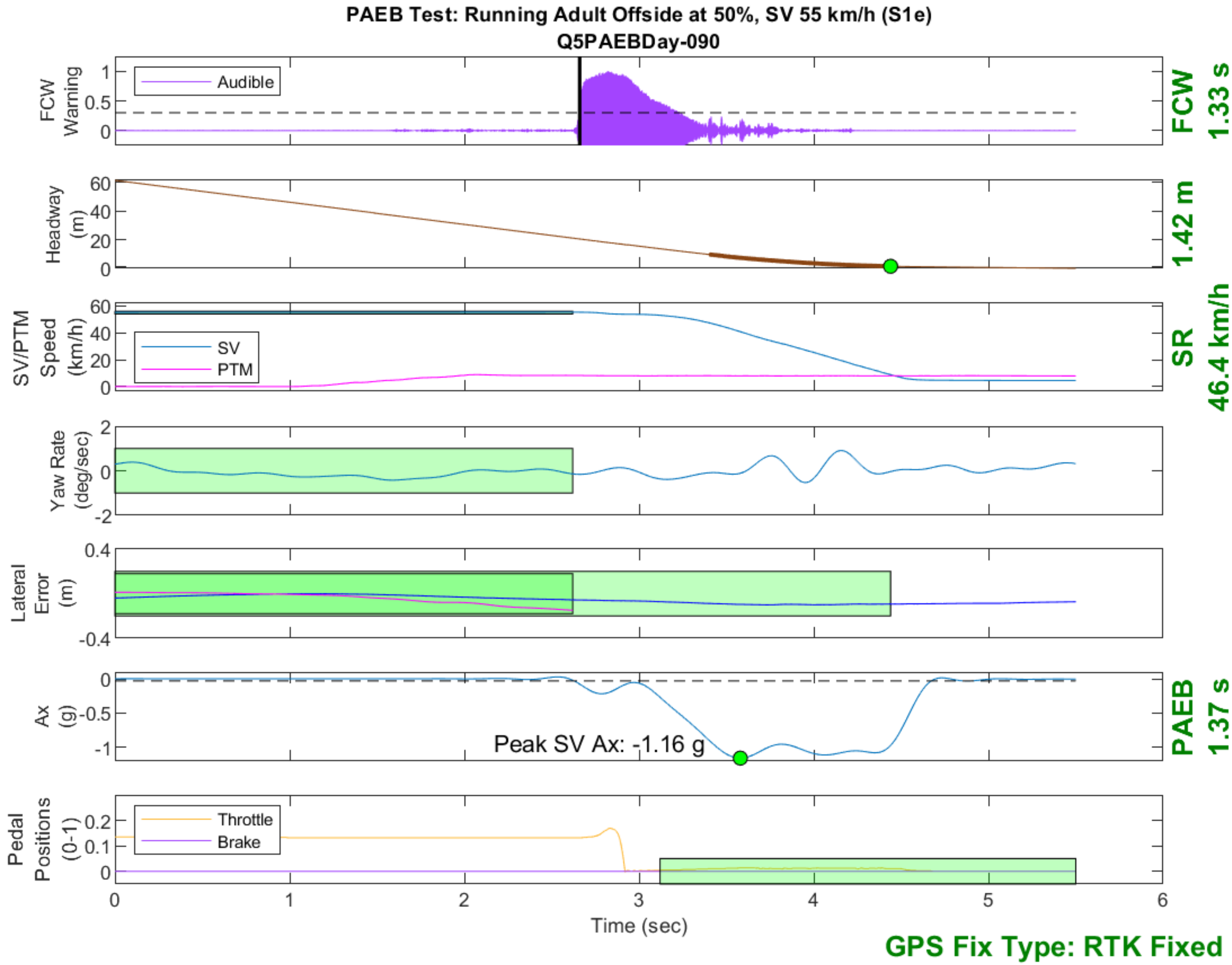

Figure D93. Time History for PAEB Run 90, S1e, Daytime, 55 km/h

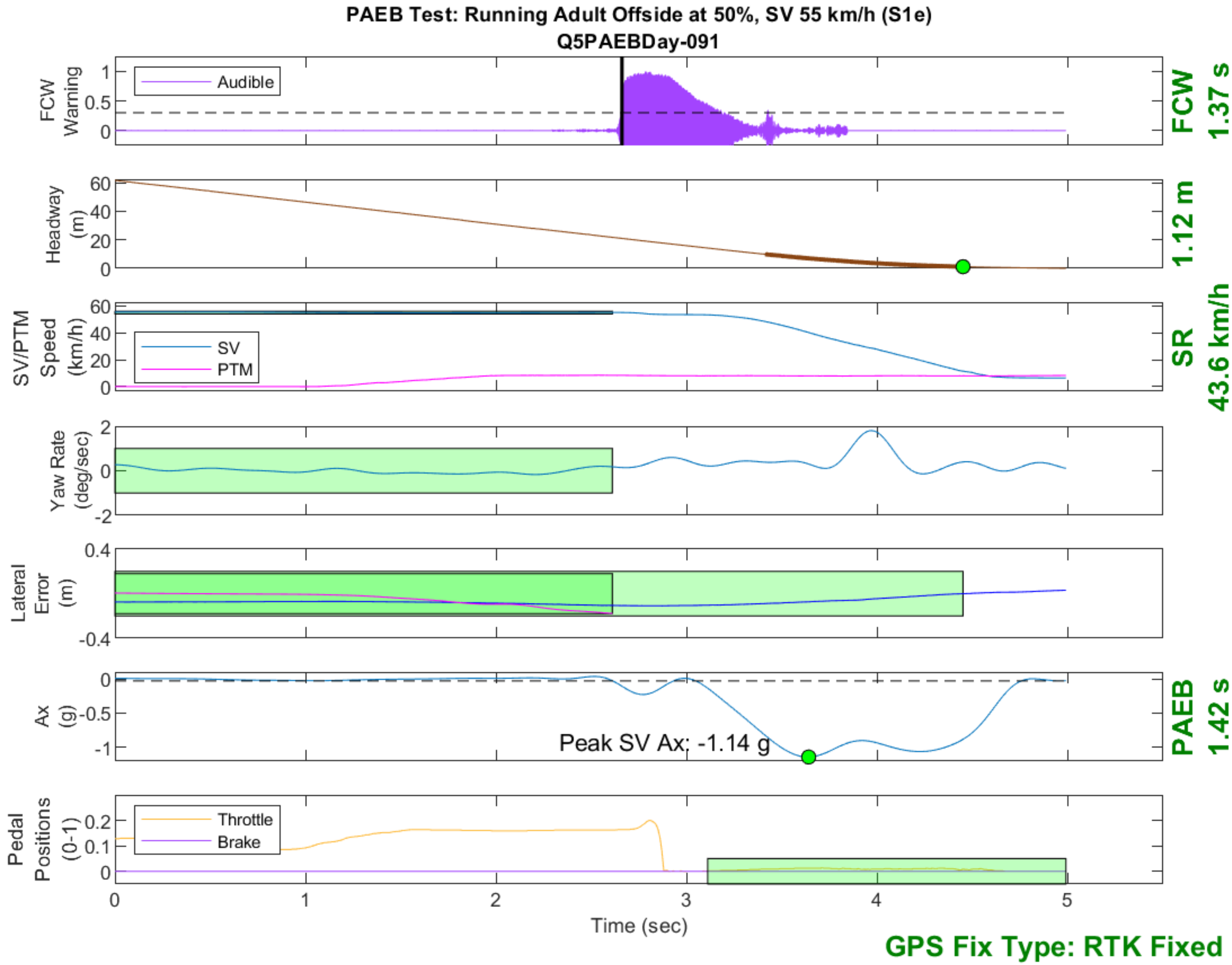

Figure D94. Time History for PAEB Run 91, S1e, Daytime, 55 km/h

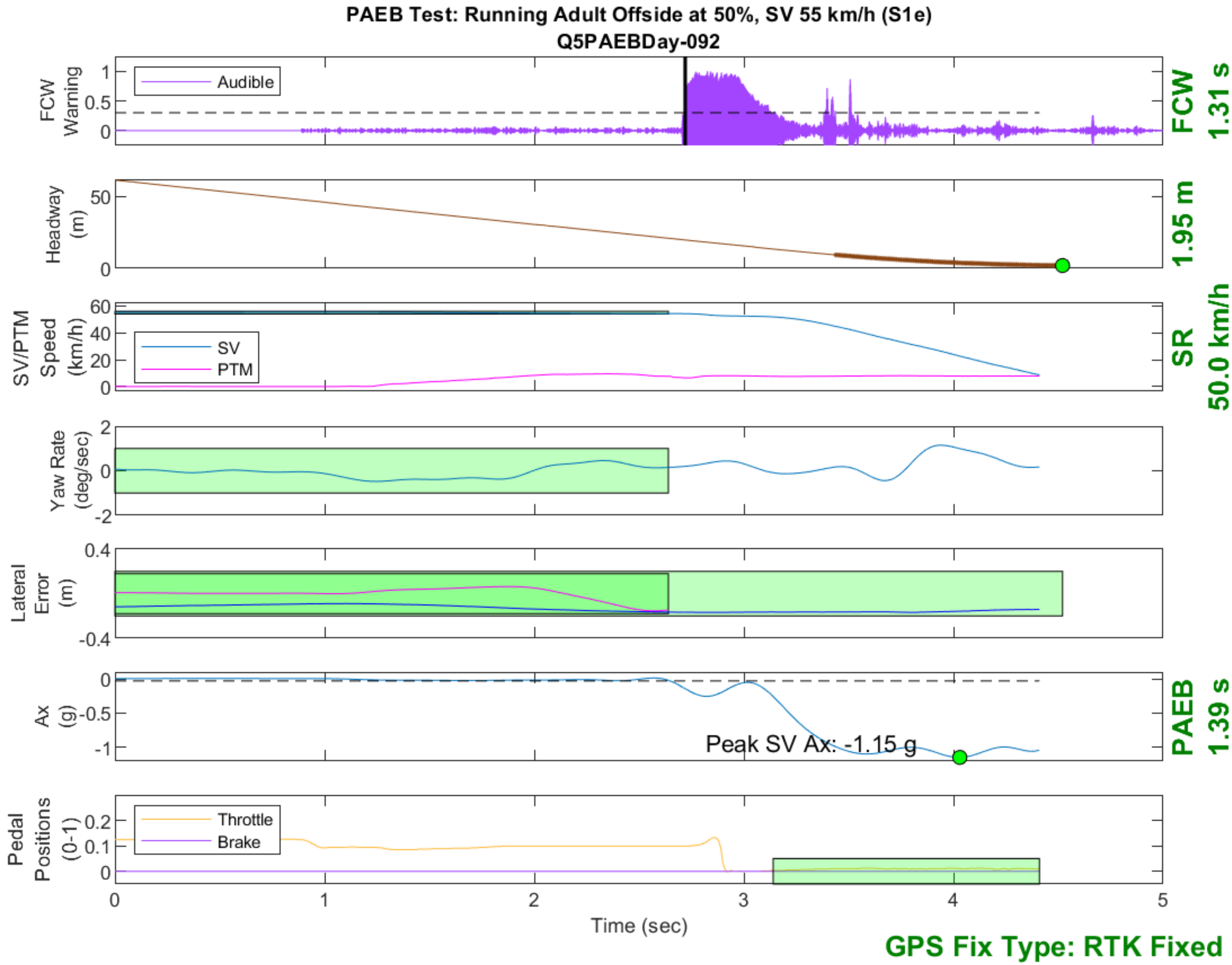

Figure D95. Time History for PAEB Run 92, S1e, Daytime, 55 km/h

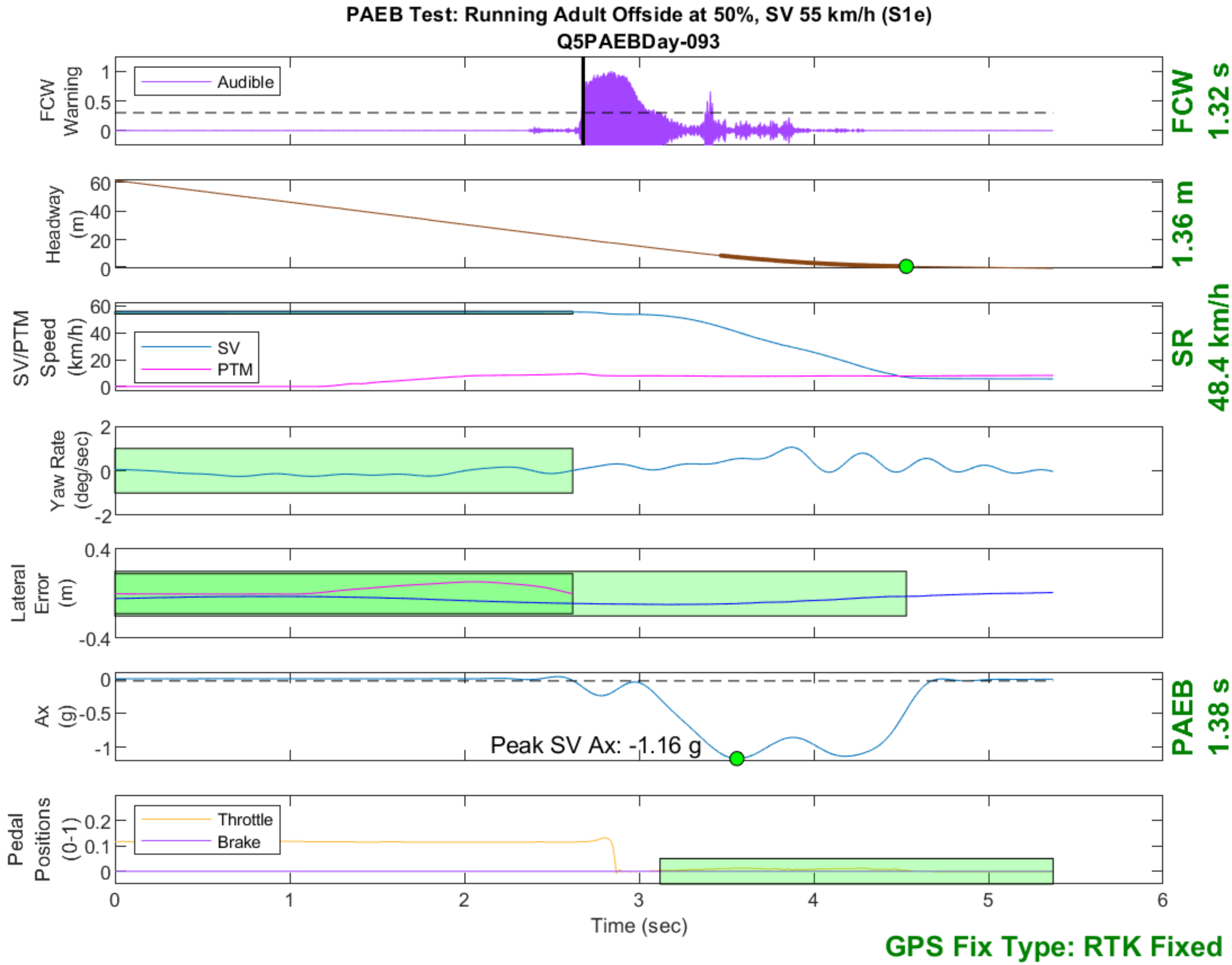

Figure D96. Time History for PAEB Run 93, S1e, Daytime, 55 km/h

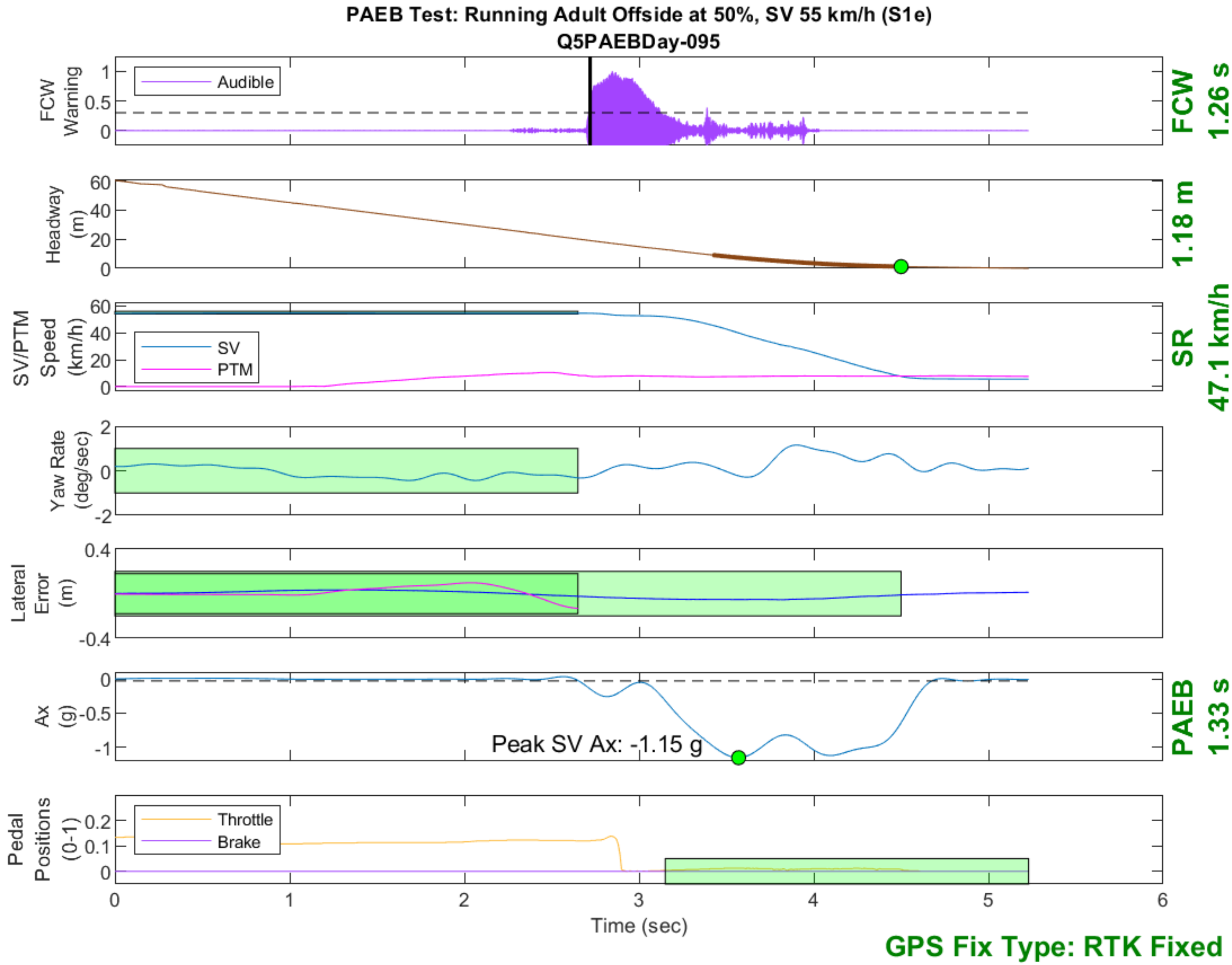

Figure D97. Time History for PAEB Run 95, S1e, Daytime, 55 km/h

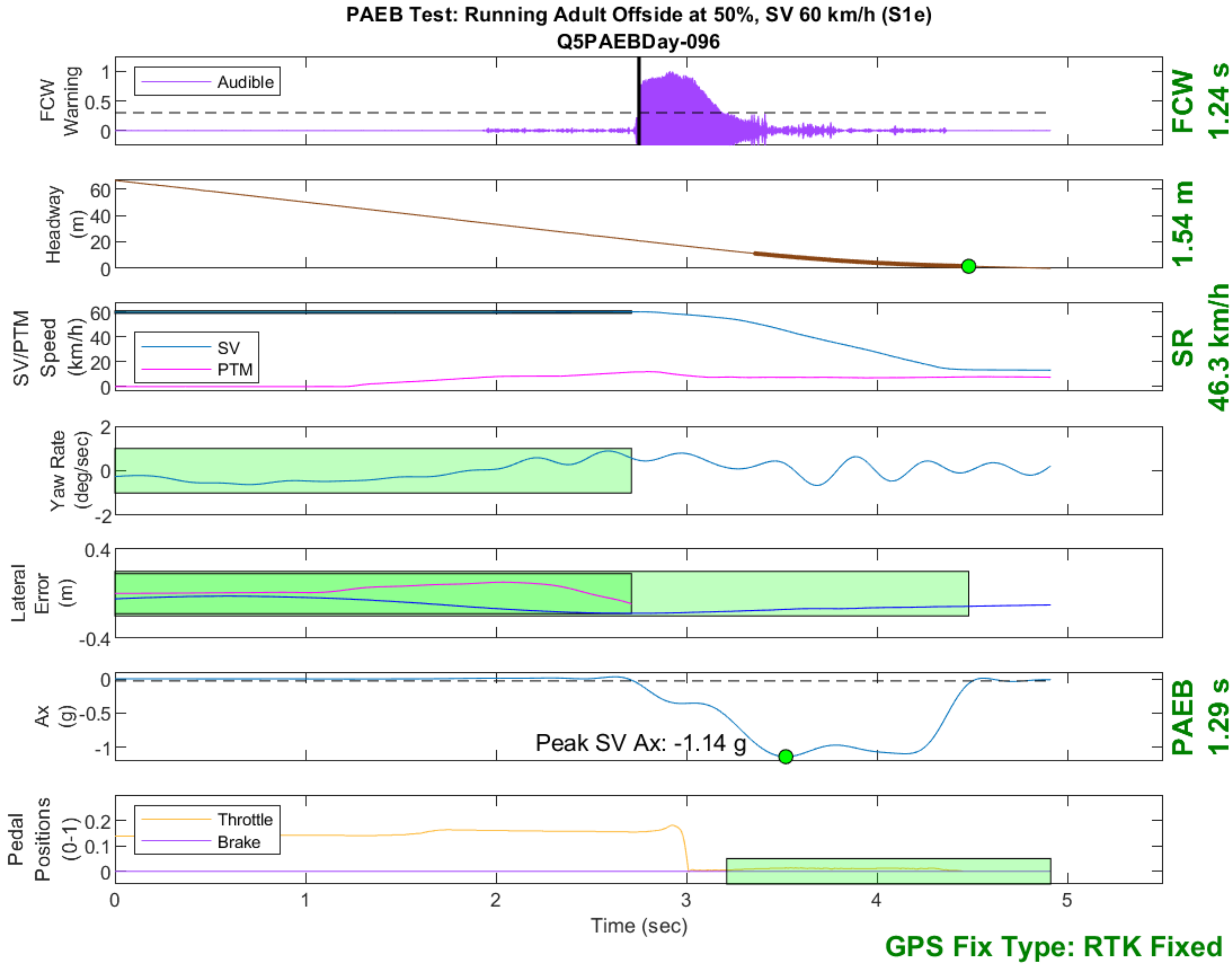

Figure D98. Time History for PAEB Run 96, S1e, Daytime, 60 km/h

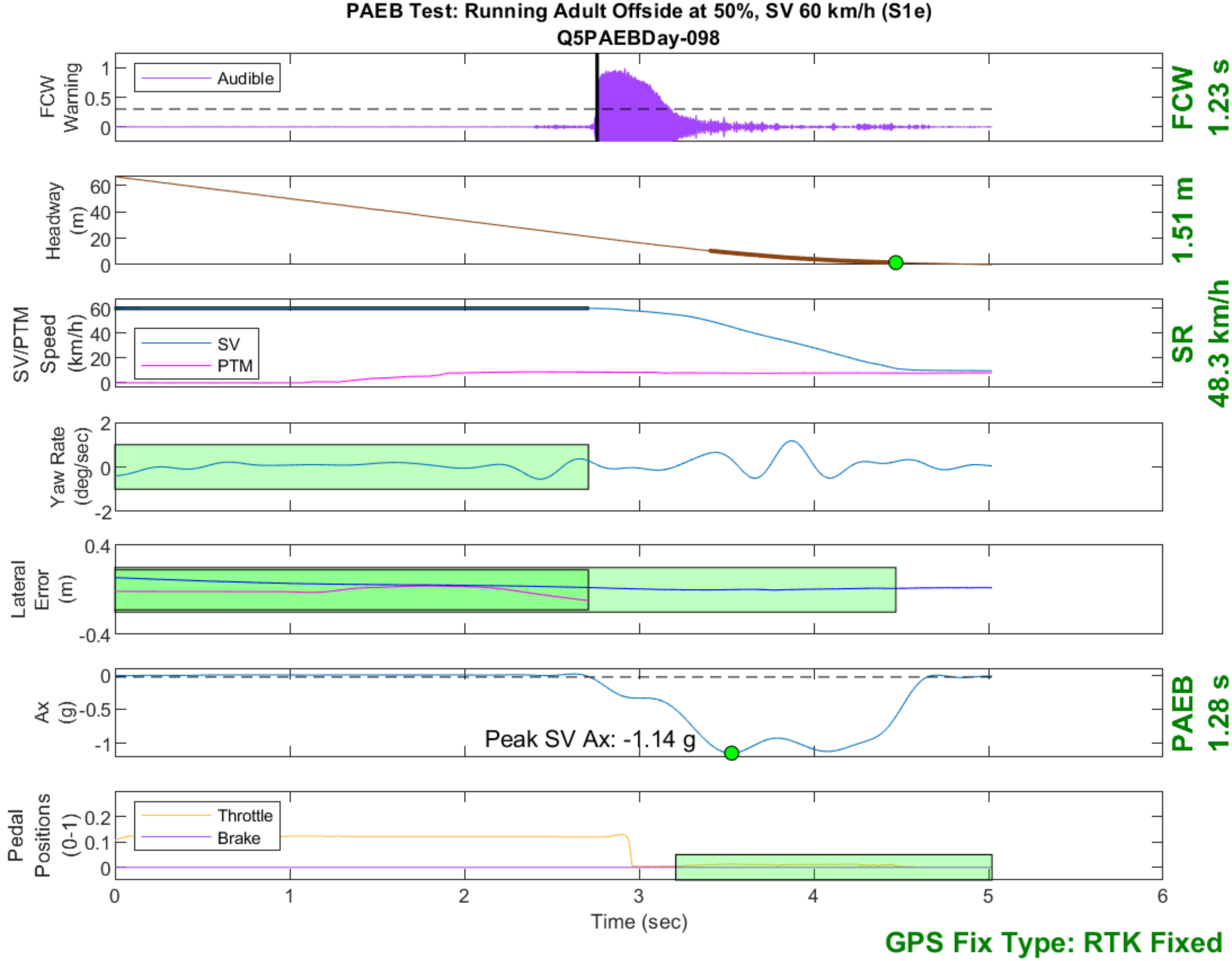

Figure D99. Time History for PAEB Run 98, S1e, Daytime, 60 km/h

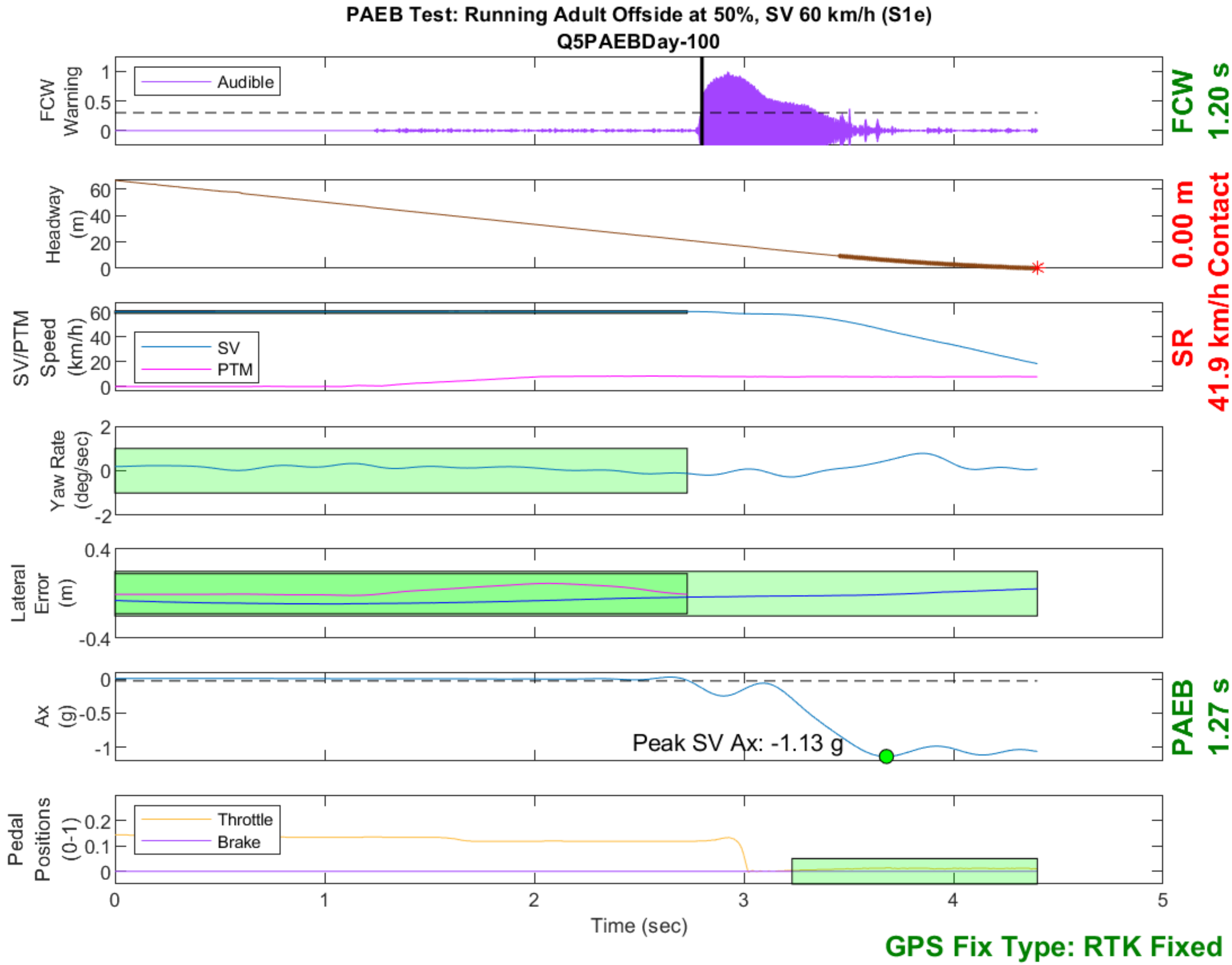

Figure D100. Time History for PAEB Run 100, S1e, Daytime, 60 km/h

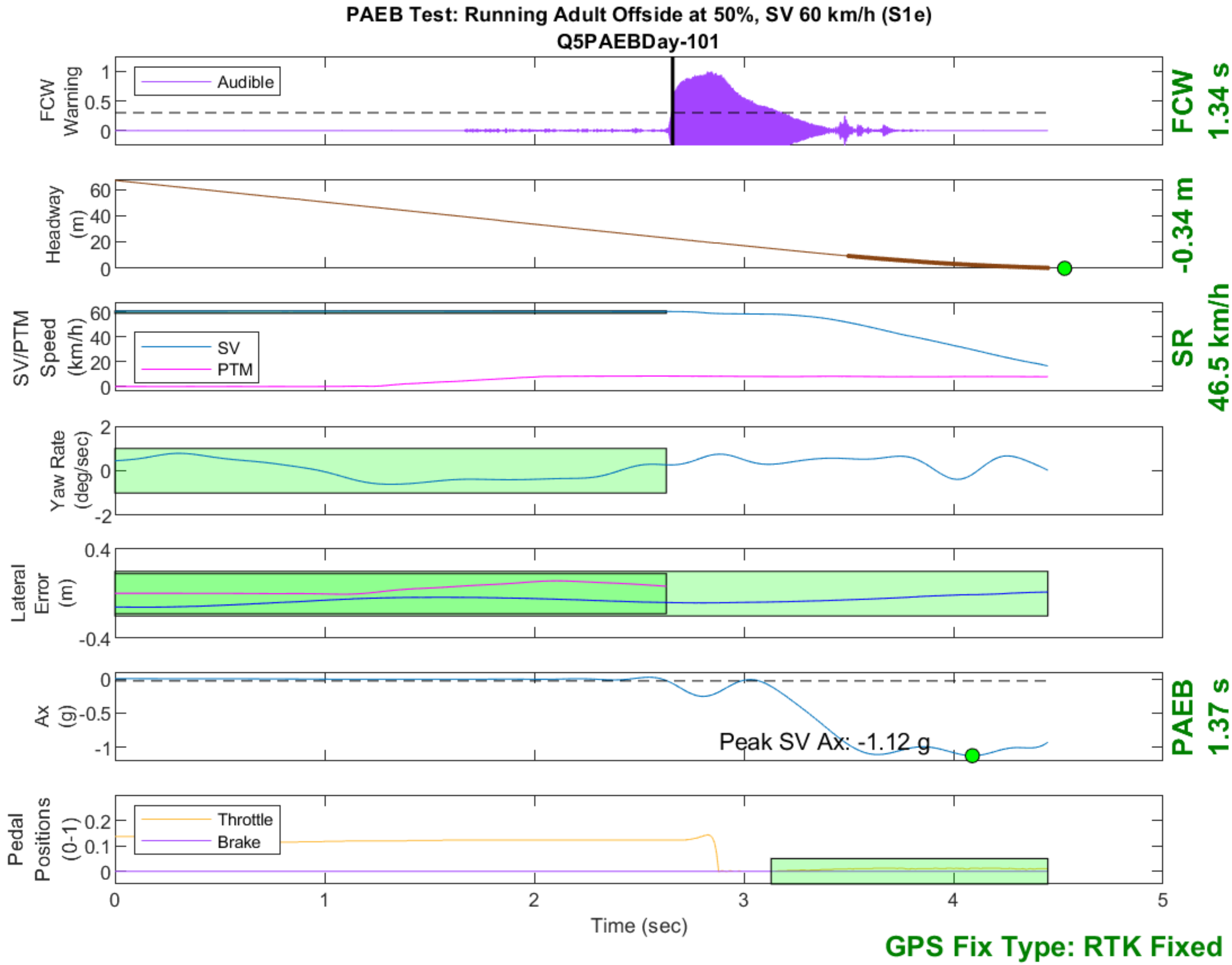

Figure D101. Time History for PAEB Run 101, S1e, Daytime, 60 km/h

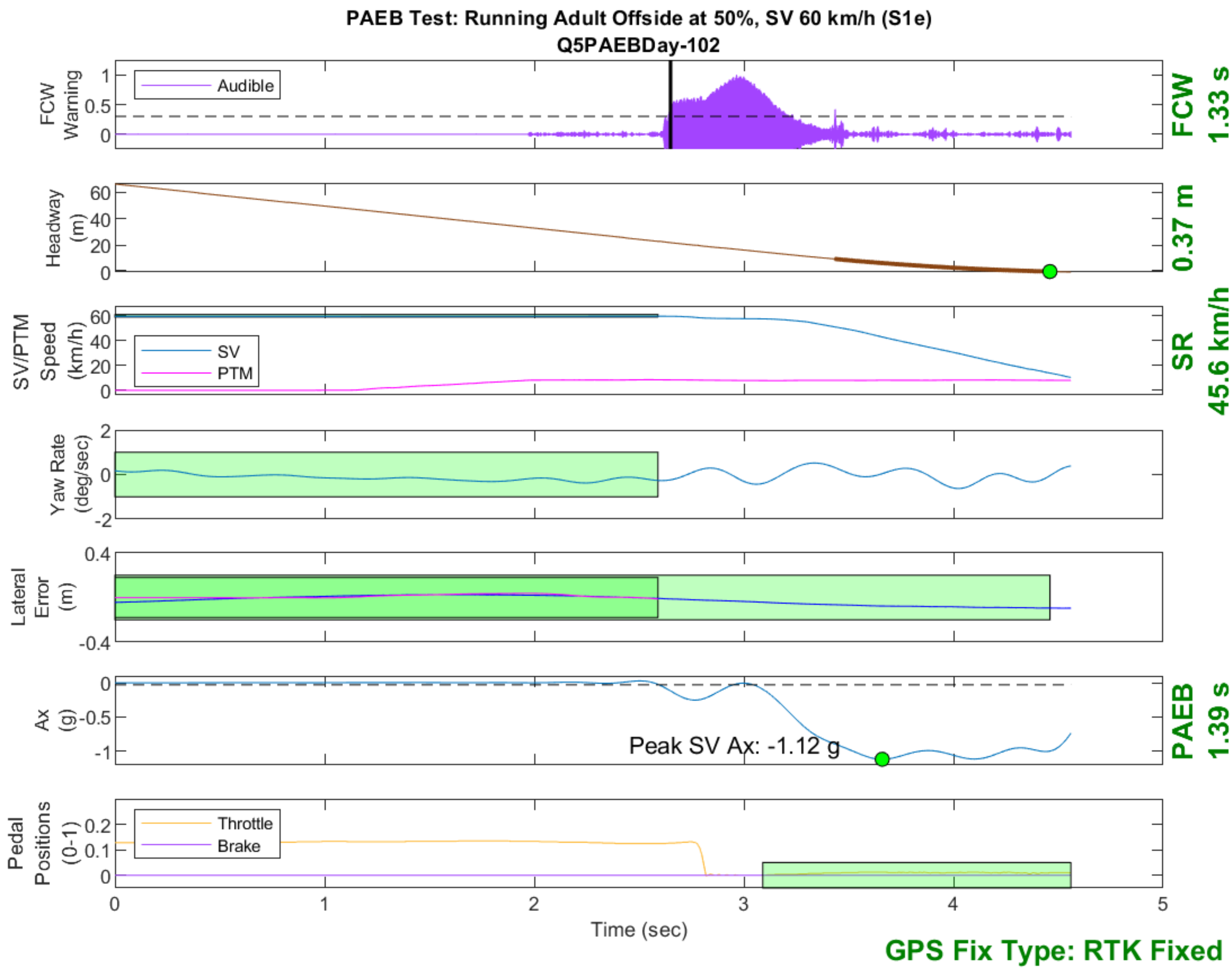

Figure D102. Time History for PAEB Run 102, S1e, Daytime, 60 km/h

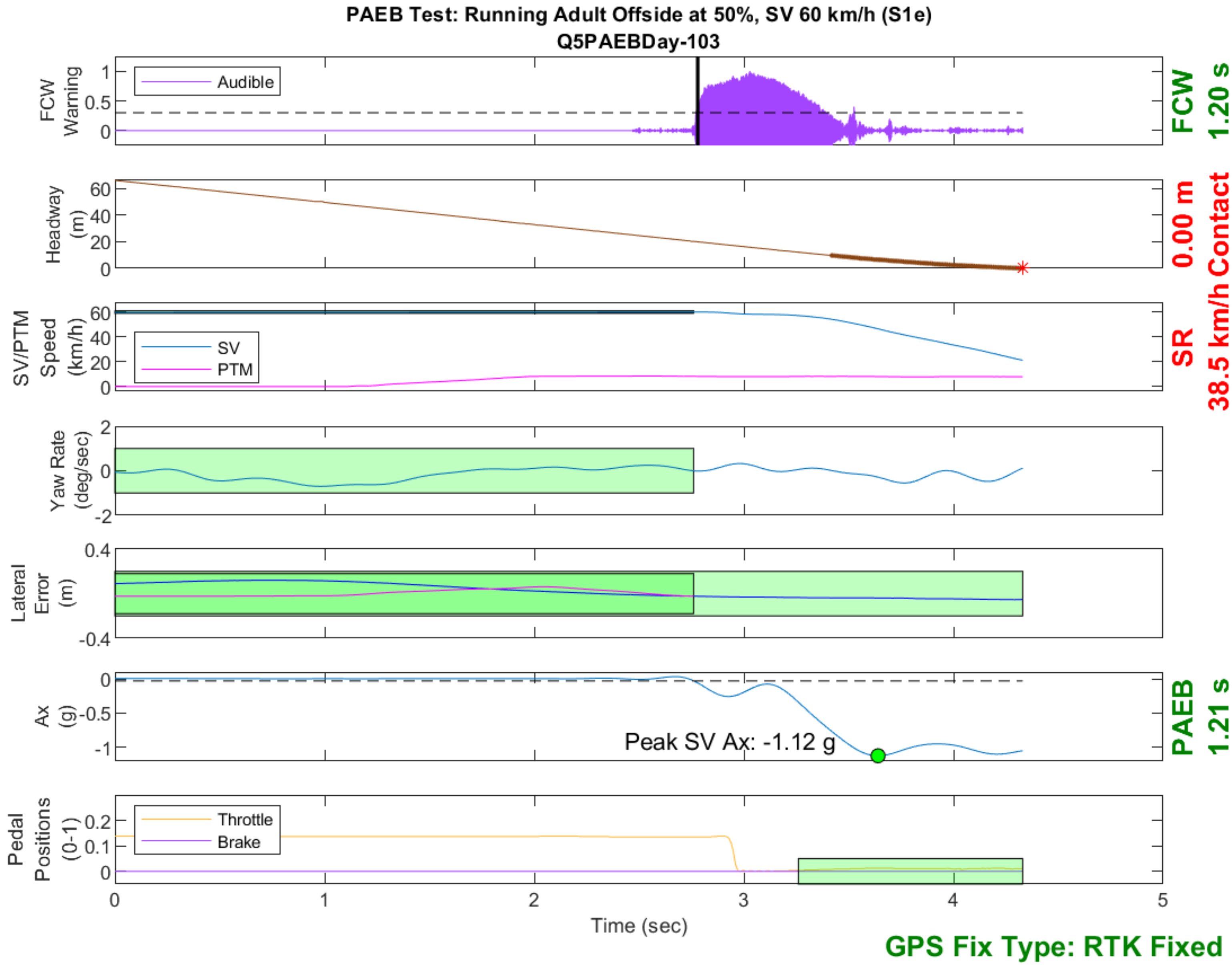

Figure D103. Time History for PAEB Run 103, S1e, Daytime, 60 km/h

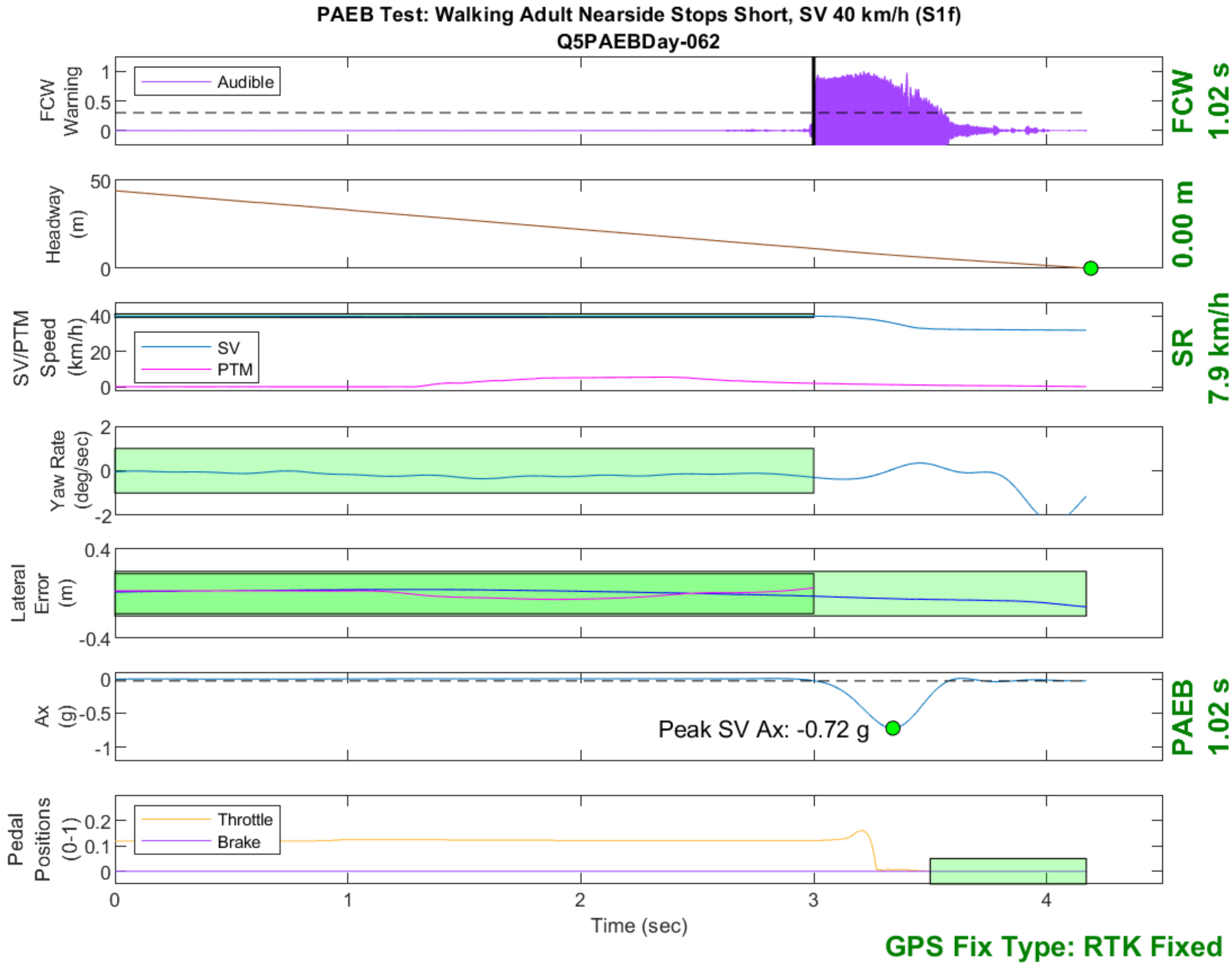

Figure D104. Time History for PAEB Run 62, S1f, Daytime, 40 km/h

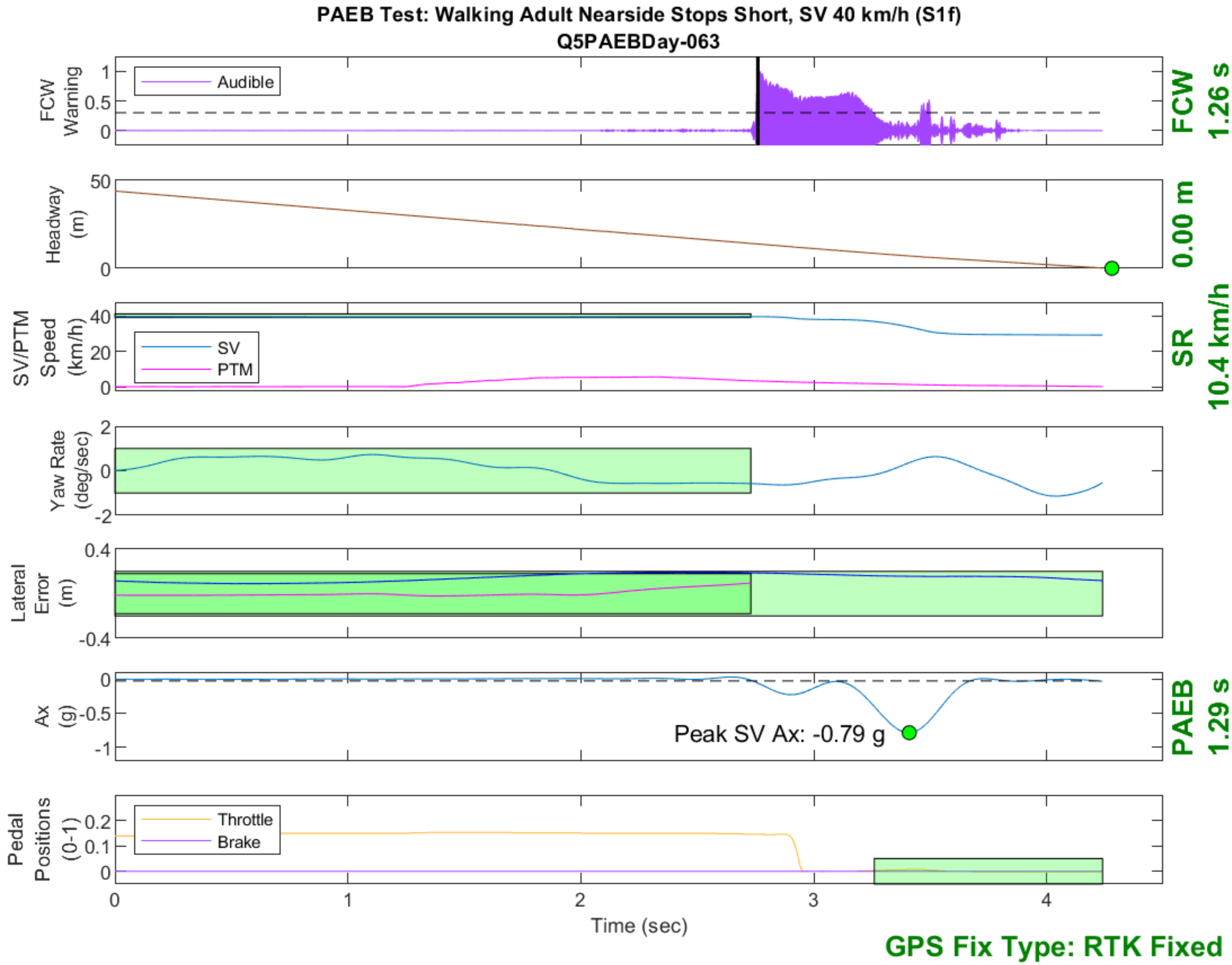

Figure D105. Time History for PAEB Run 63, S1f, Daytime, 40 km/h

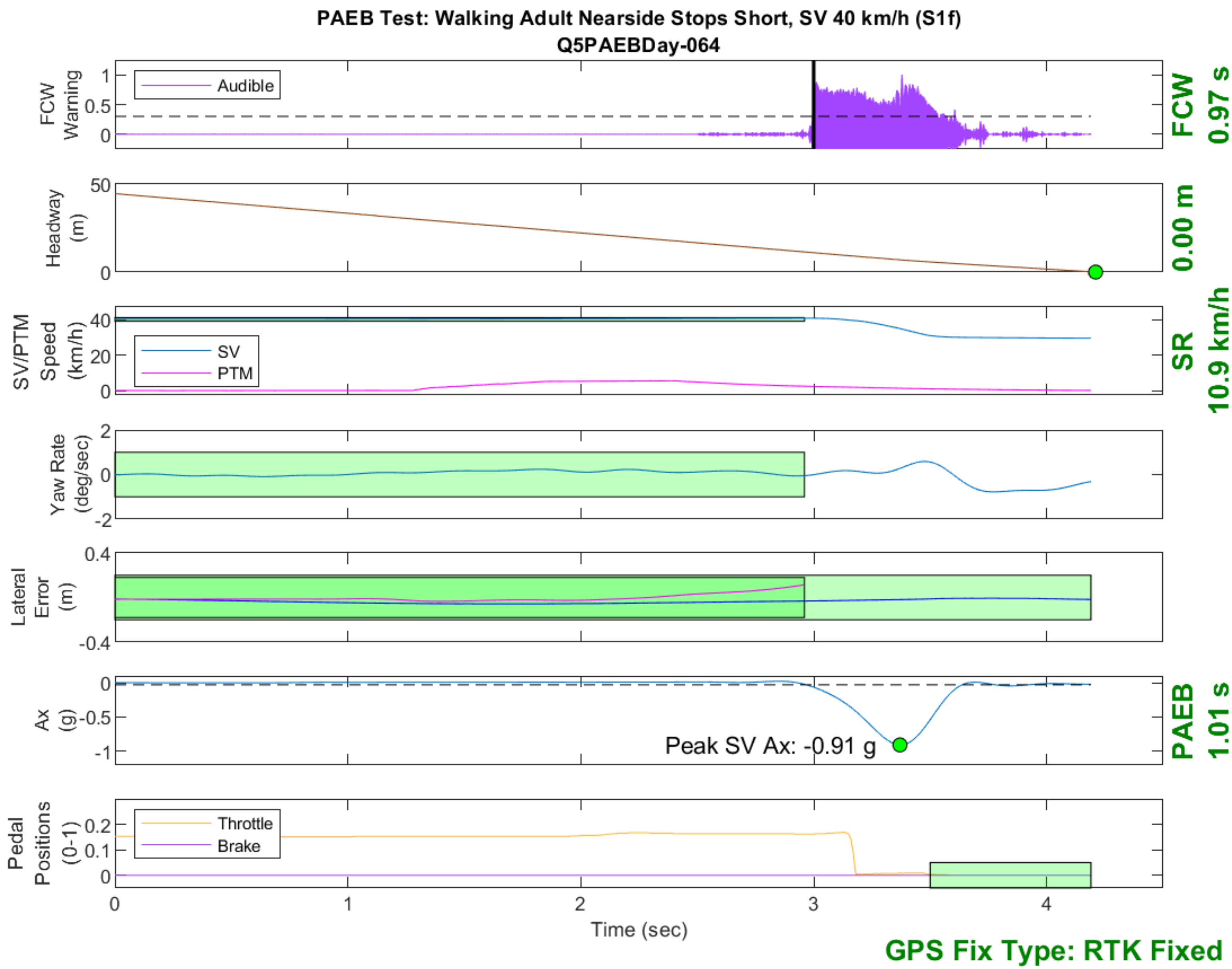

Figure D106. Time History for PAEB Run 64, S1f, Daytime, 40 km/h

Figure D107. Time History for PAEB Run 65, S1f, Daytime, 40 km/h

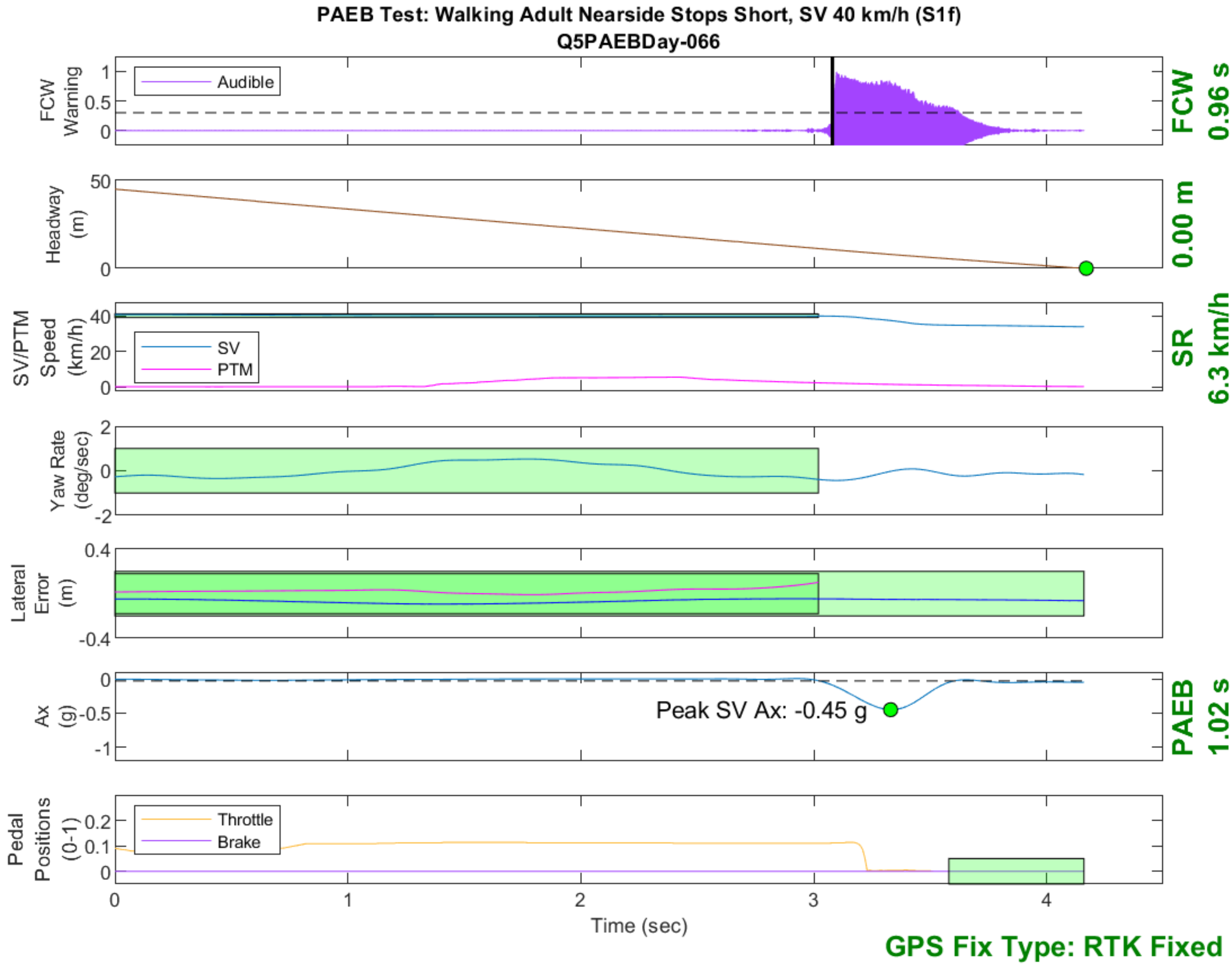

Figure D108. Time History for PAEB Run 66, S1f, Daytime, 40 km/h

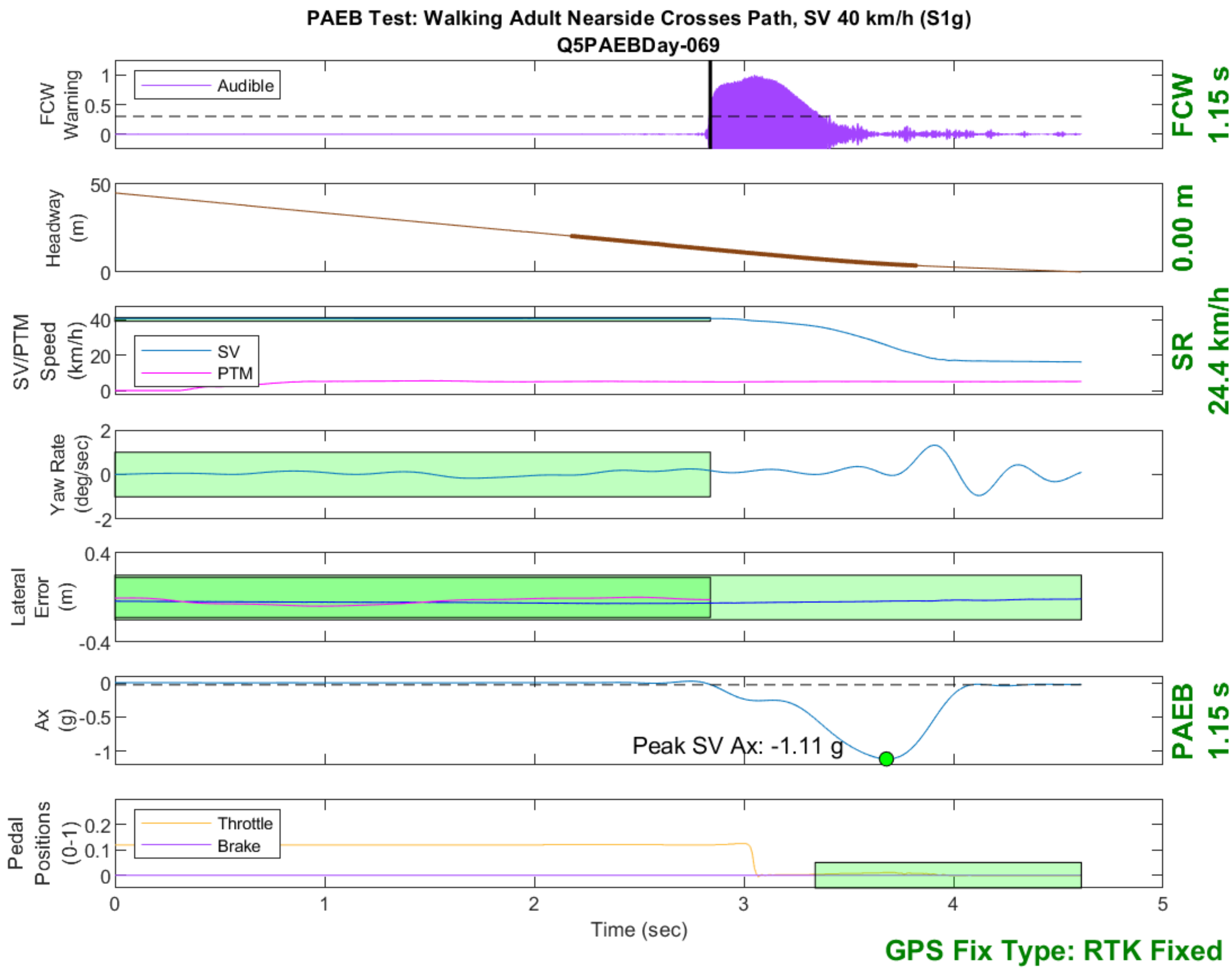

Figure D109. Time History for PAEB Run 69, S1g, Daytime, 40 km/h

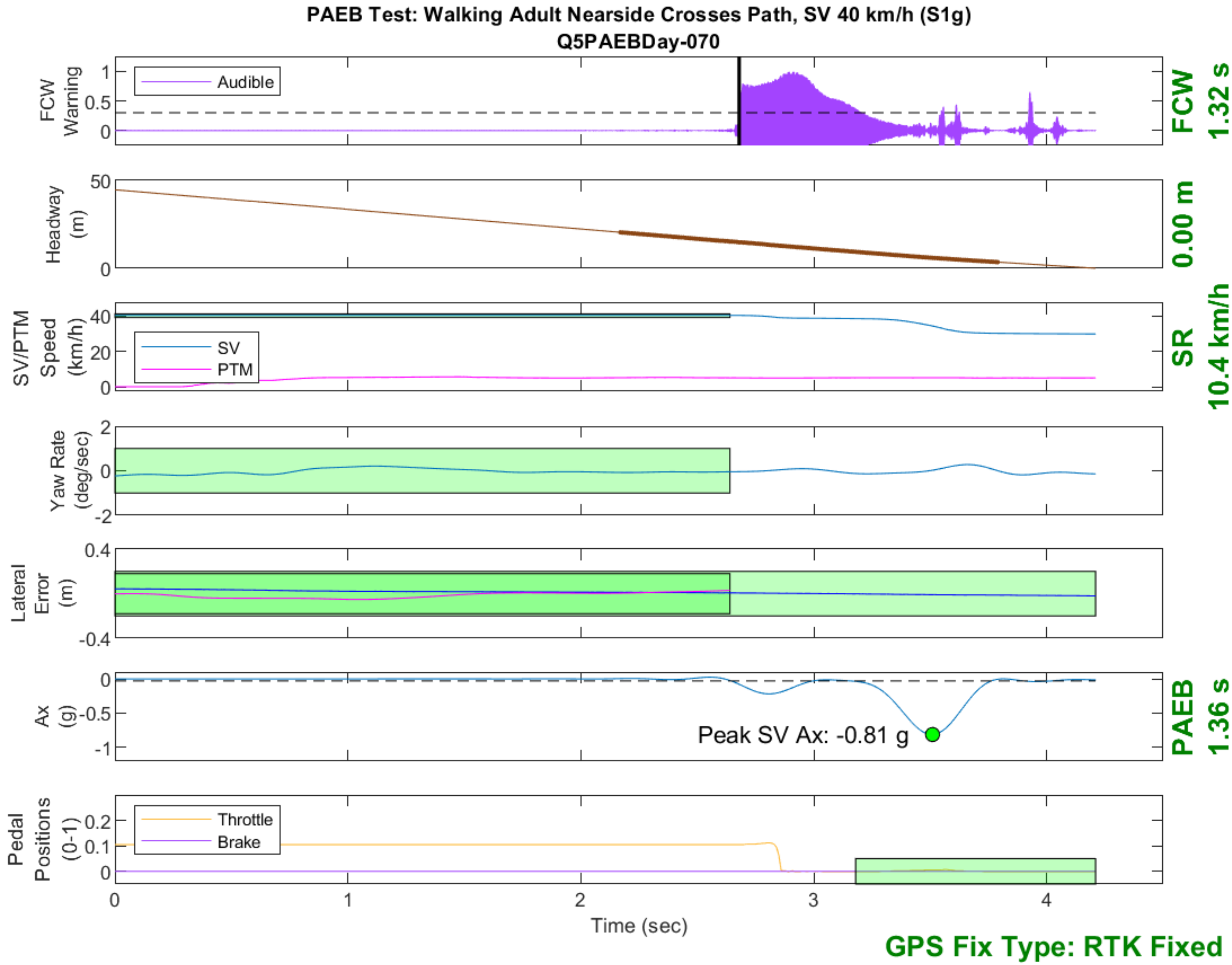

Figure D110. Time History for PAEB Run 70, S1g, Daytime, 40 km/h

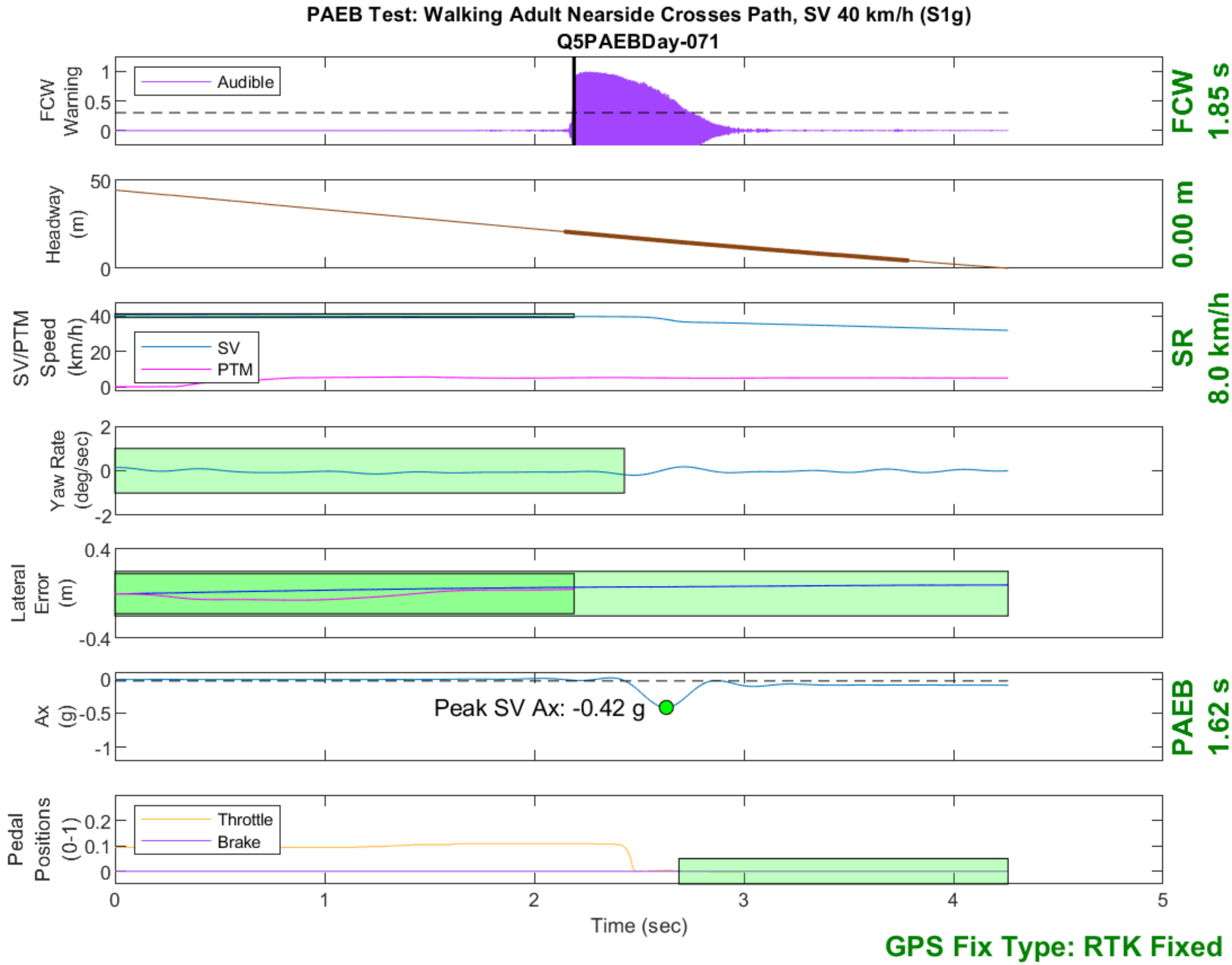

Figure D111. Time History for PAEB Run 71, S1g, Daytime, 40 km/h

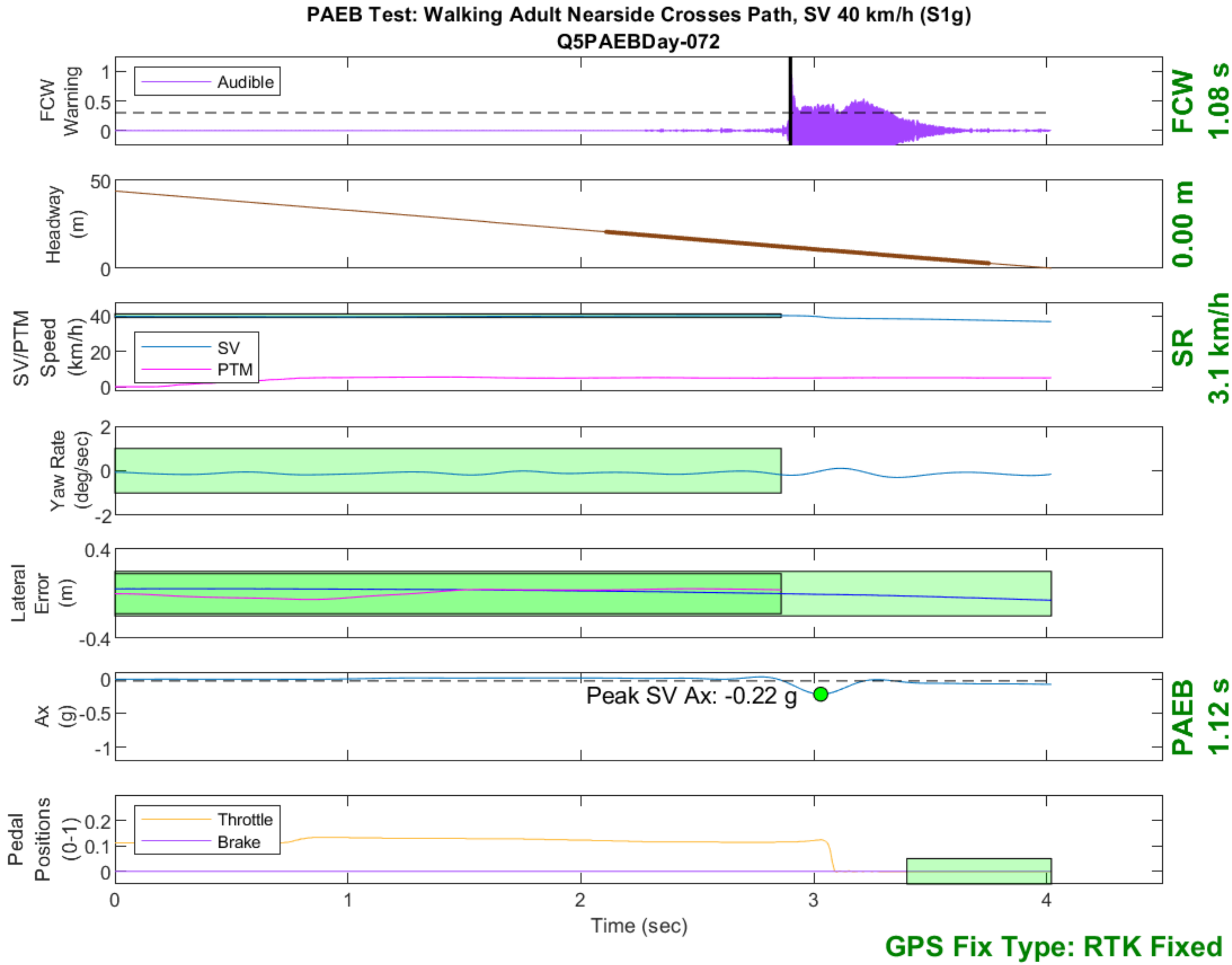

Figure D112. Time History for PAEB Run 72, S1g, Daytime, 40 km/h

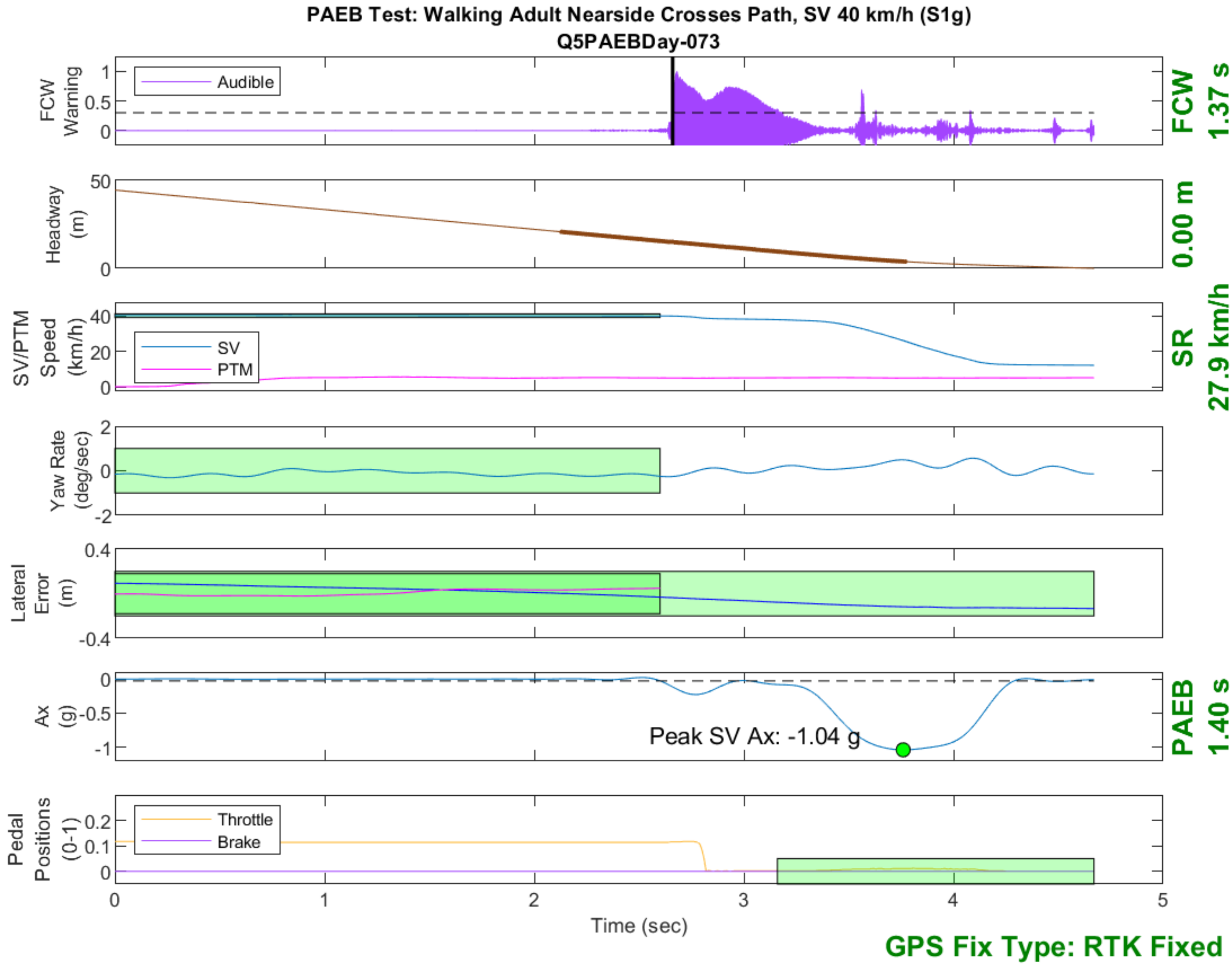

Figure D113. Time History for PAEB Run 73, S1g, Daytime, 40 km/h

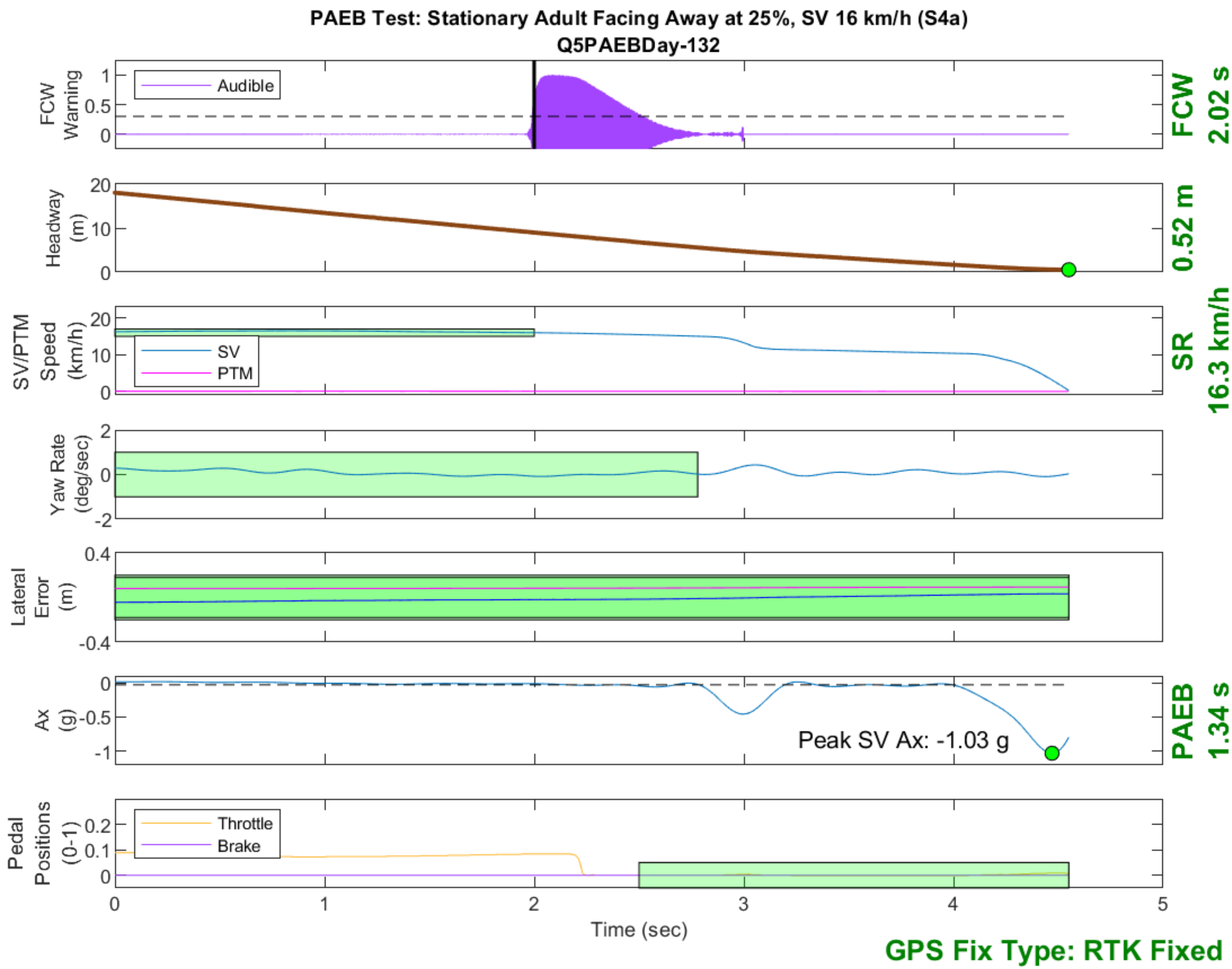

Figure D114. Time History for PAEB Run 132, S4a, Daytime, 16 km/h

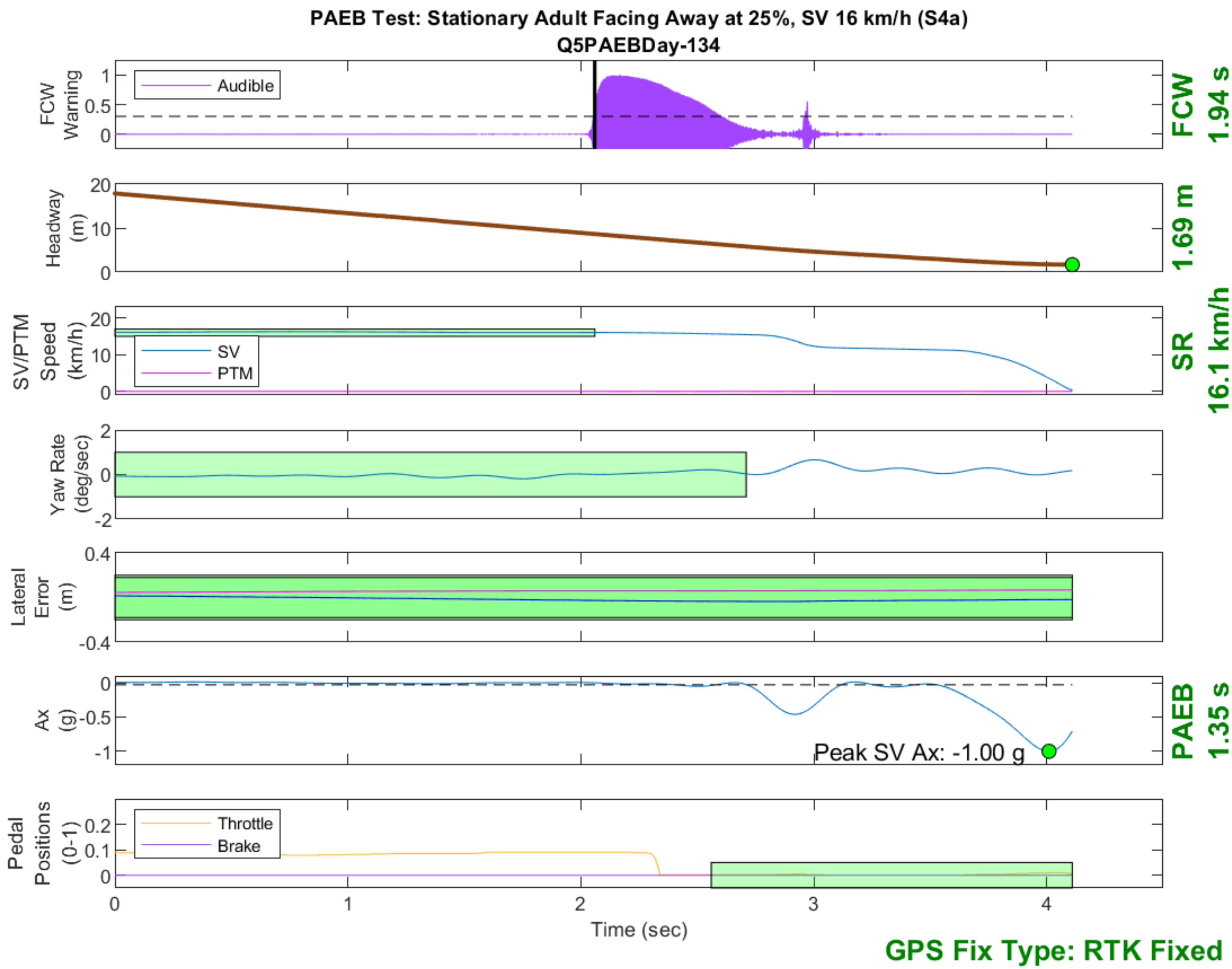

Figure D115. Time History for PAEB Run 134, S4a, Daytime, 16 km/h

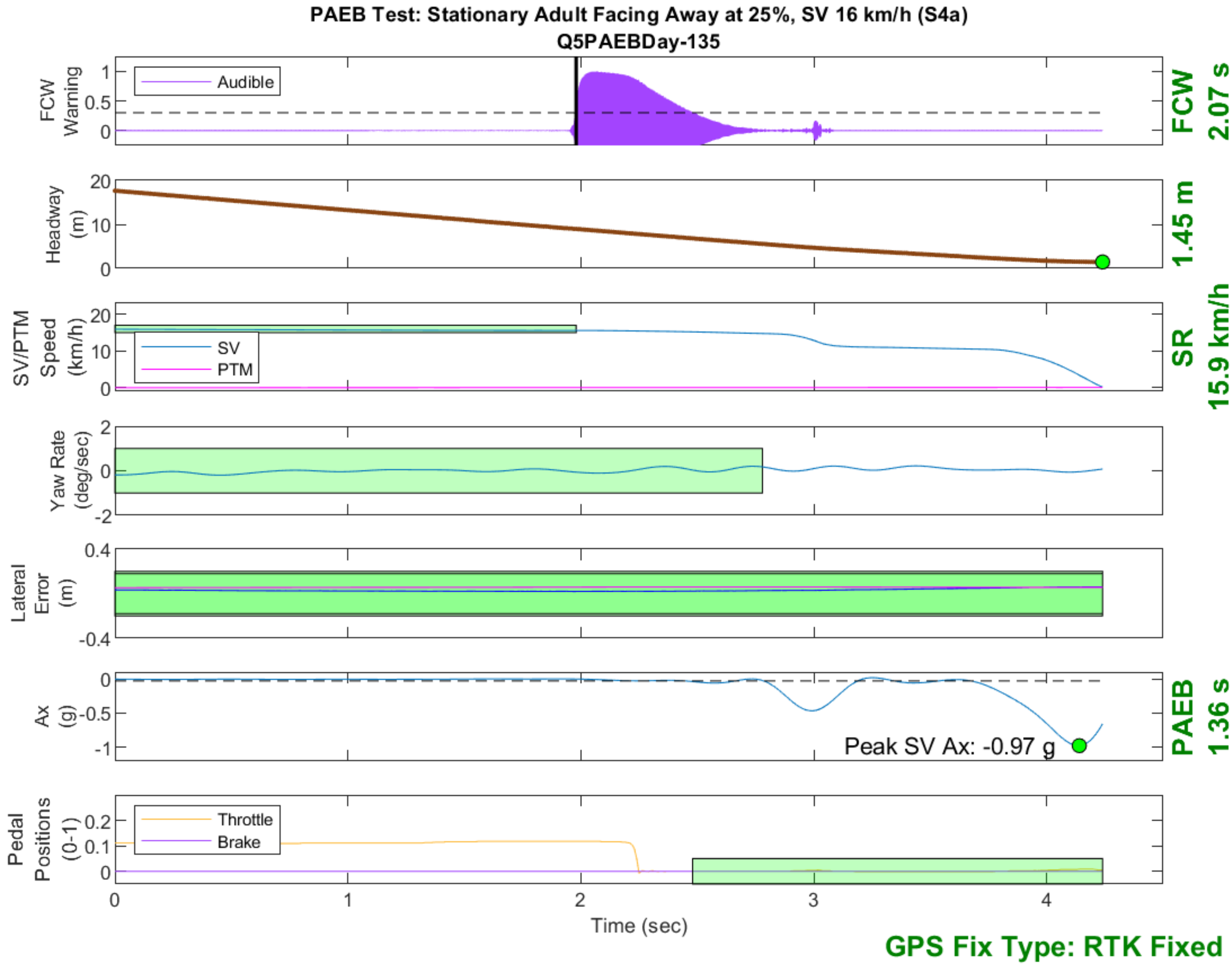

Figure D116. Time History for PAEB Run 135, S4a, Daytime, 16 km/h

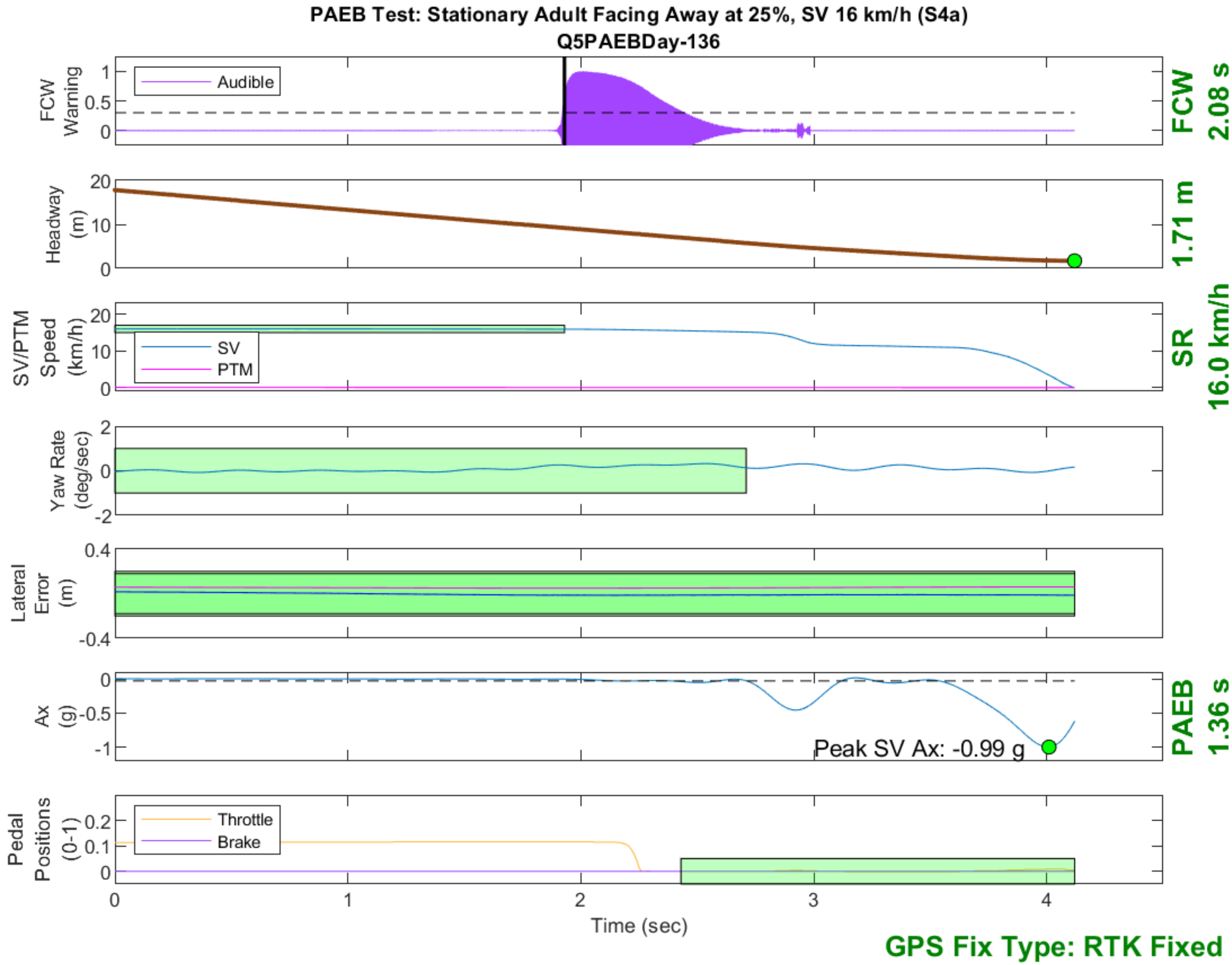

Figure D117. Time History for PAEB Run 136, S4a, Daytime, 16 km/h

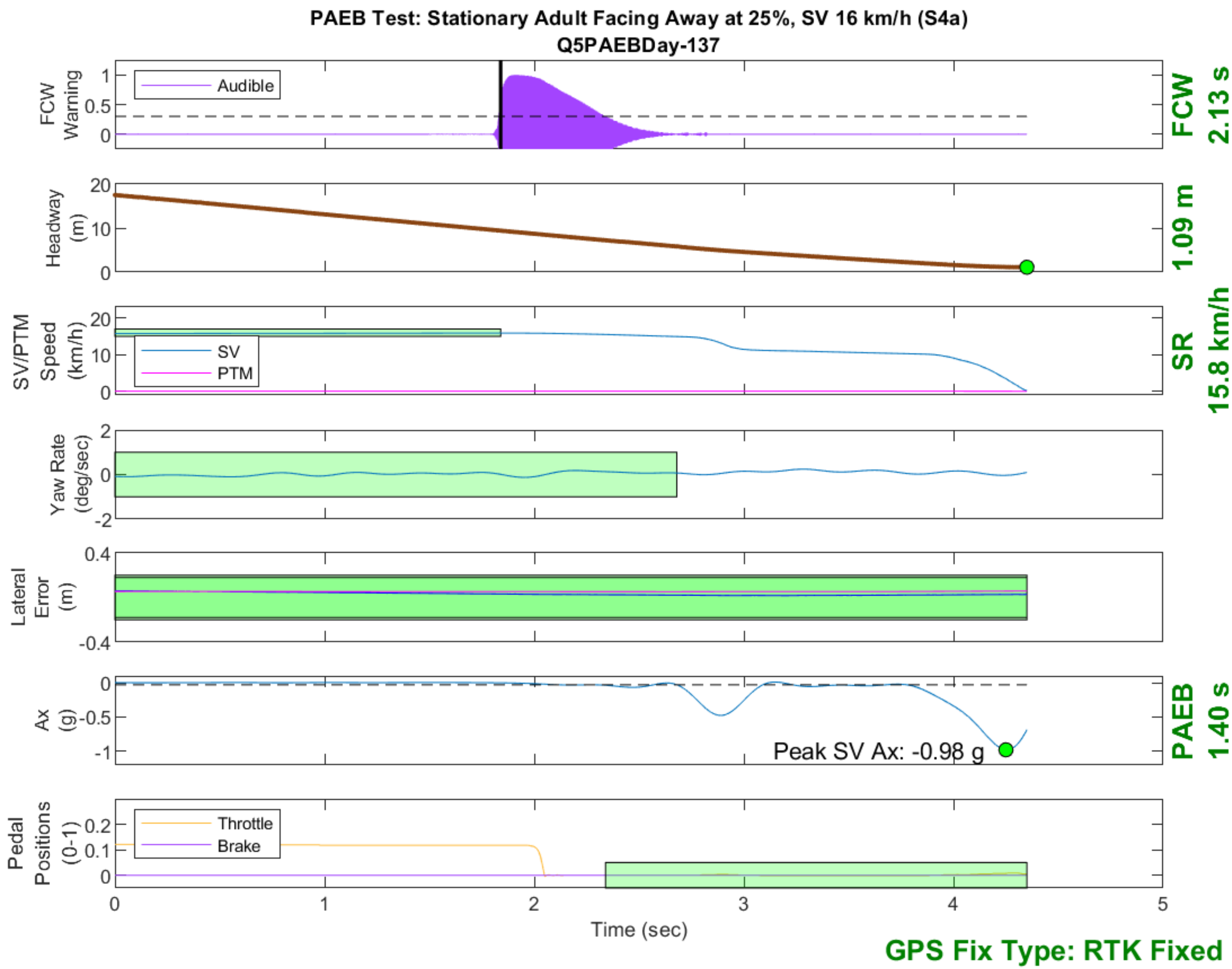

Figure D118. Time History for PAEB Run 137, S4a, Daytime, 16 km/h

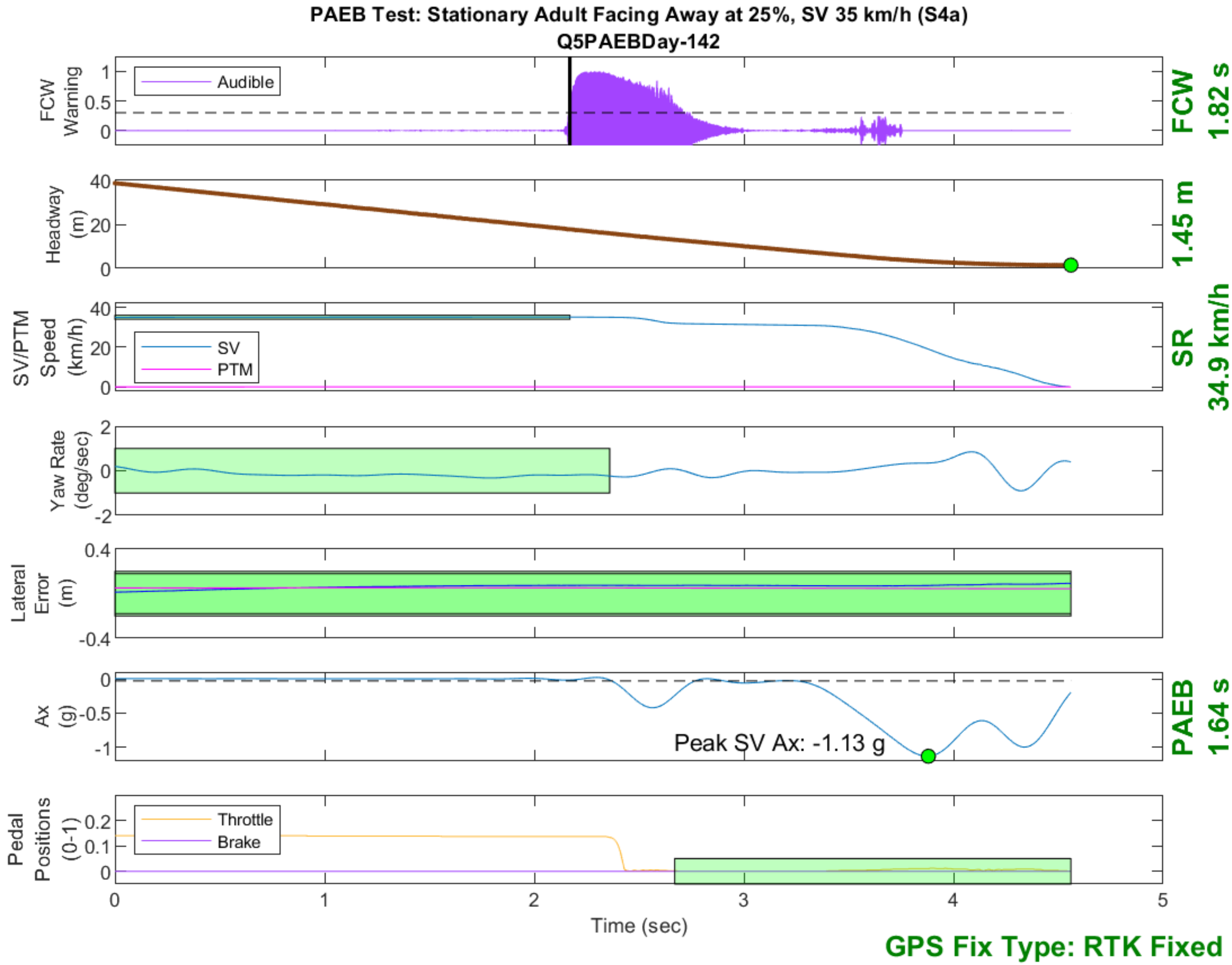

Figure D119. Time History for PAEB Run 142, S4a, Daytime, 35 km/h

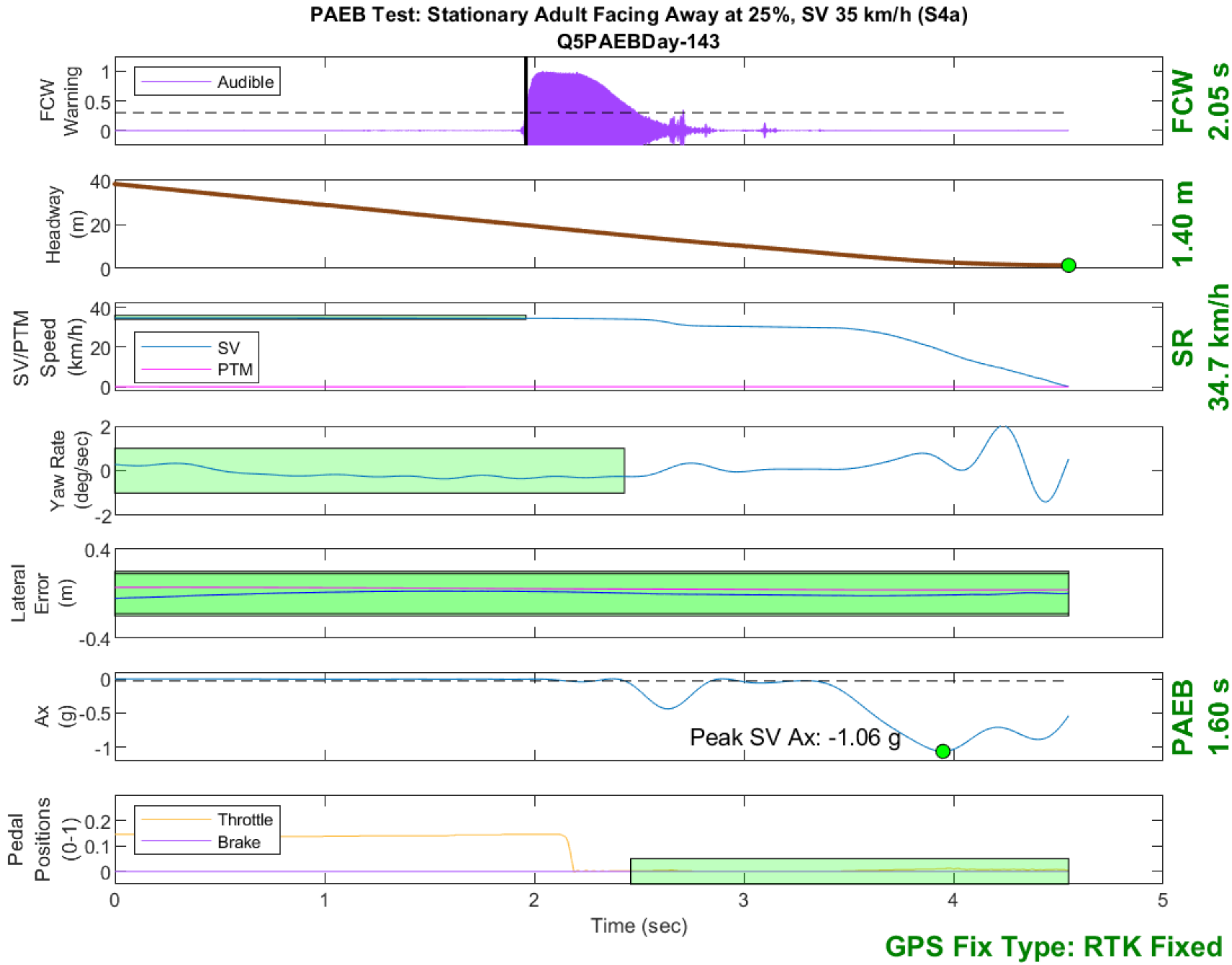

Figure D120. Time History for PAEB Run 143, S4a, Daytime, 35 km/h

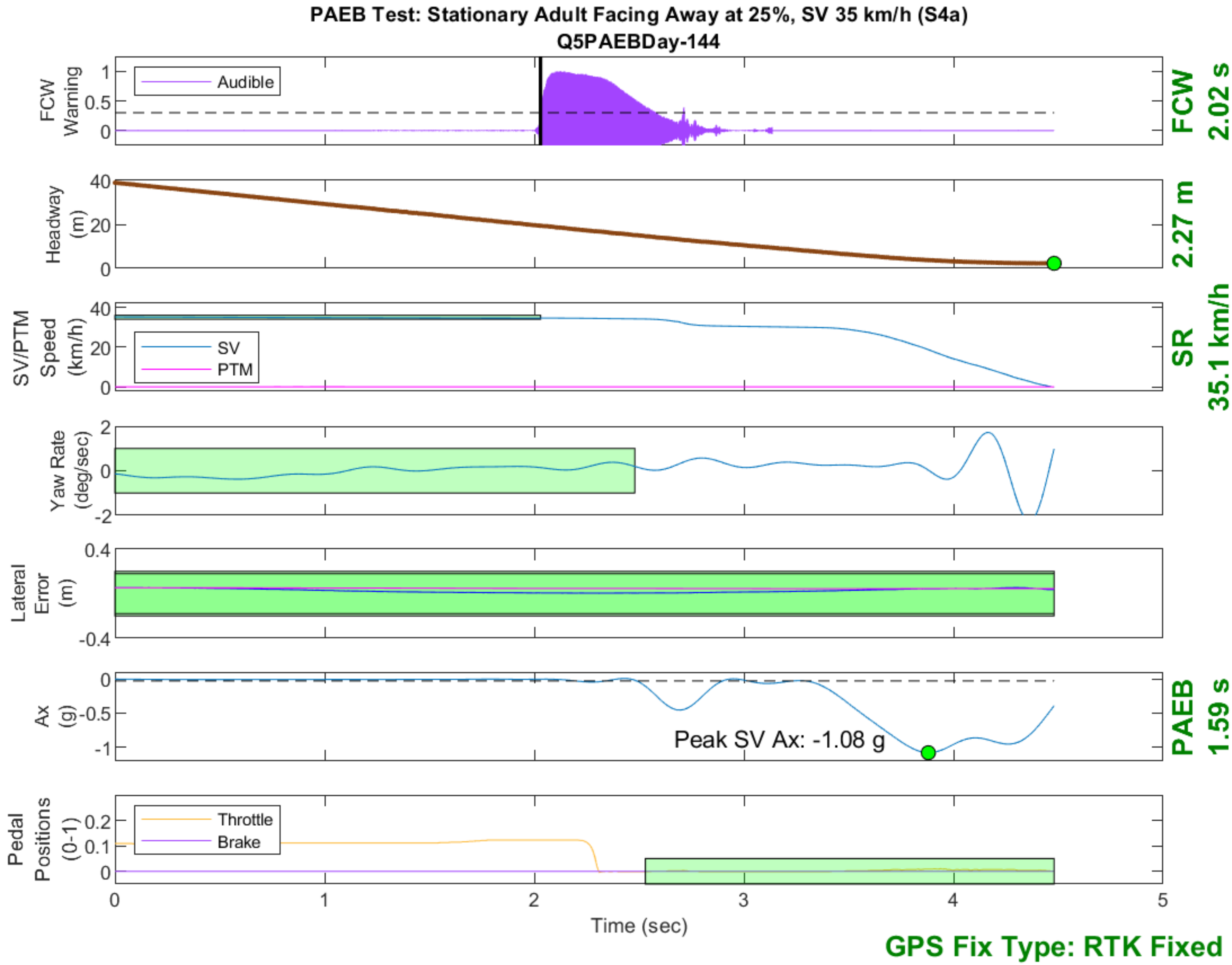

Figure D121. Time History for PAEB Run 144, S4a, Daytime, 35 km/h

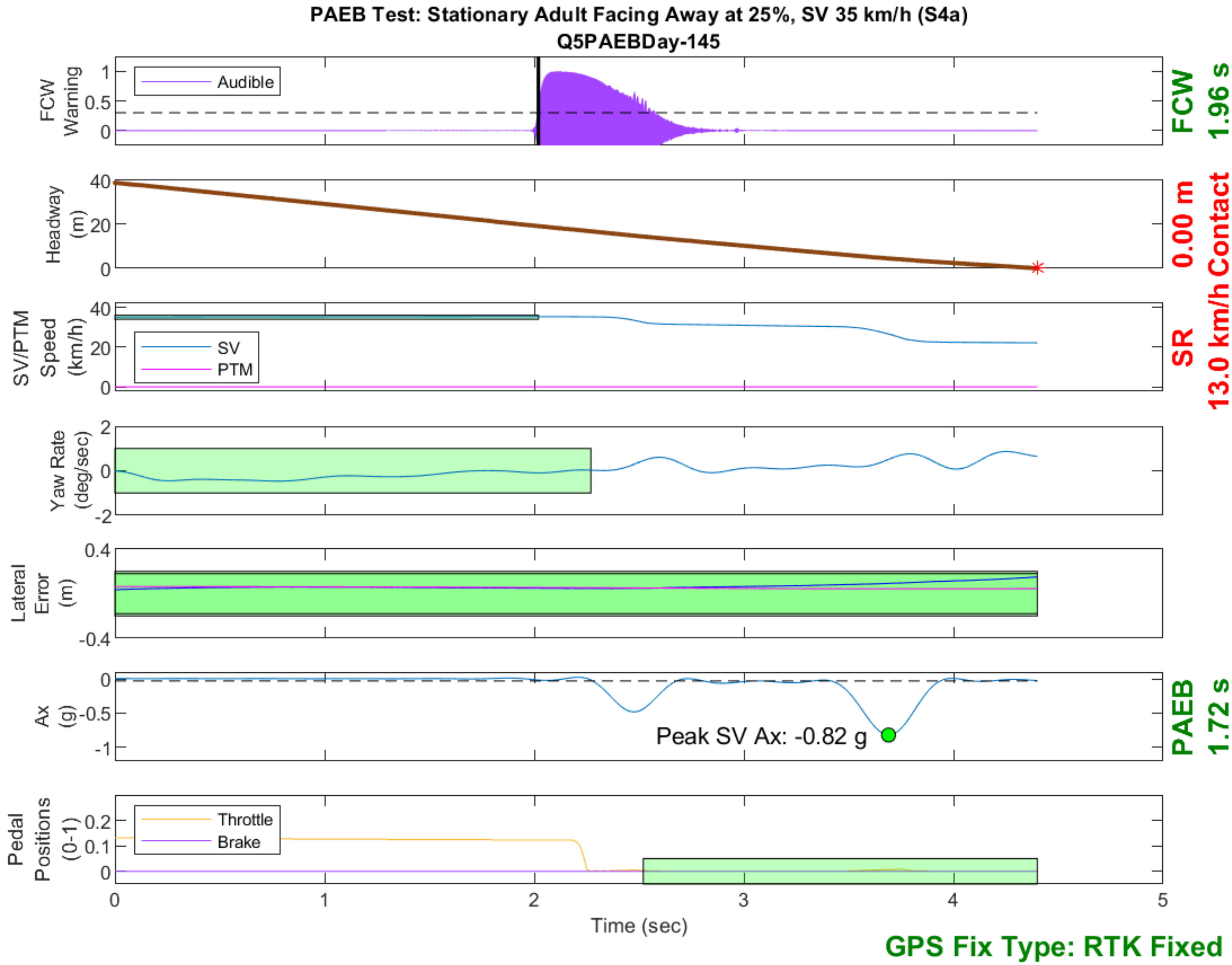

Figure D122. Time History for PAEB Run 145, S4a, Daytime, 35 km/h

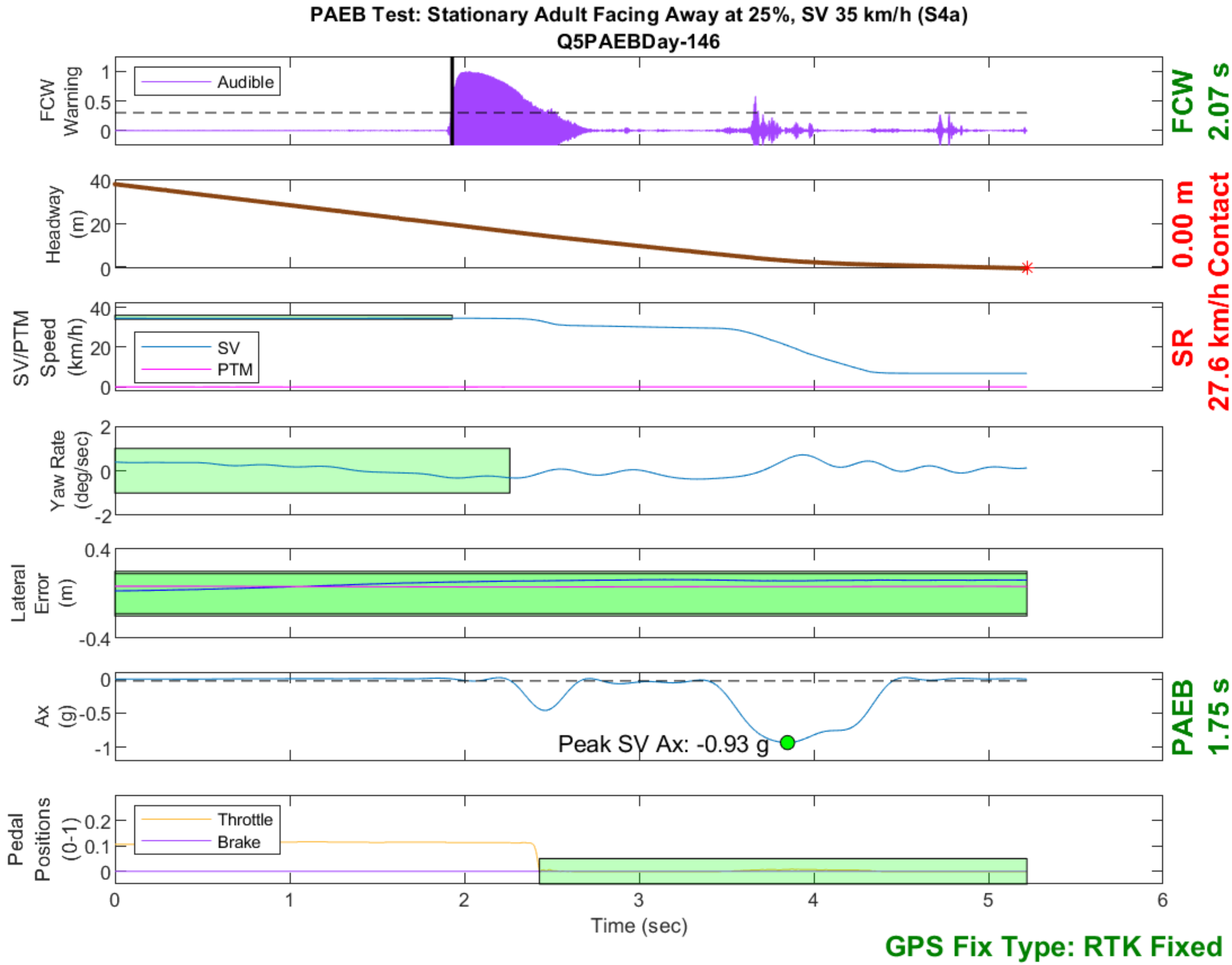

Figure D123. Time History for PAEB Run 146, S4a, Daytime, 35 km/h

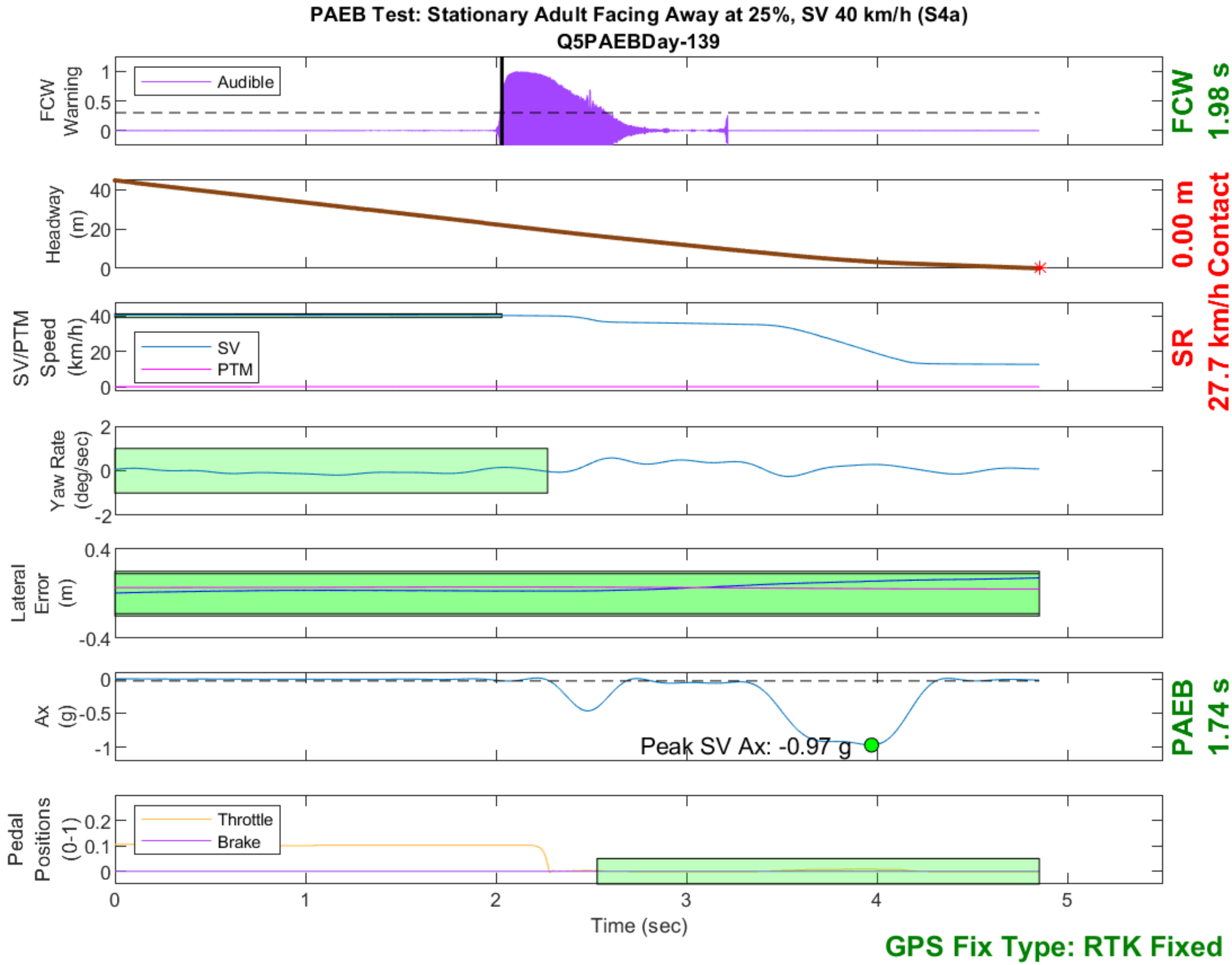

Figure D124. Time History for PAEB Run 139, S4a, Daytime, 40 km/h

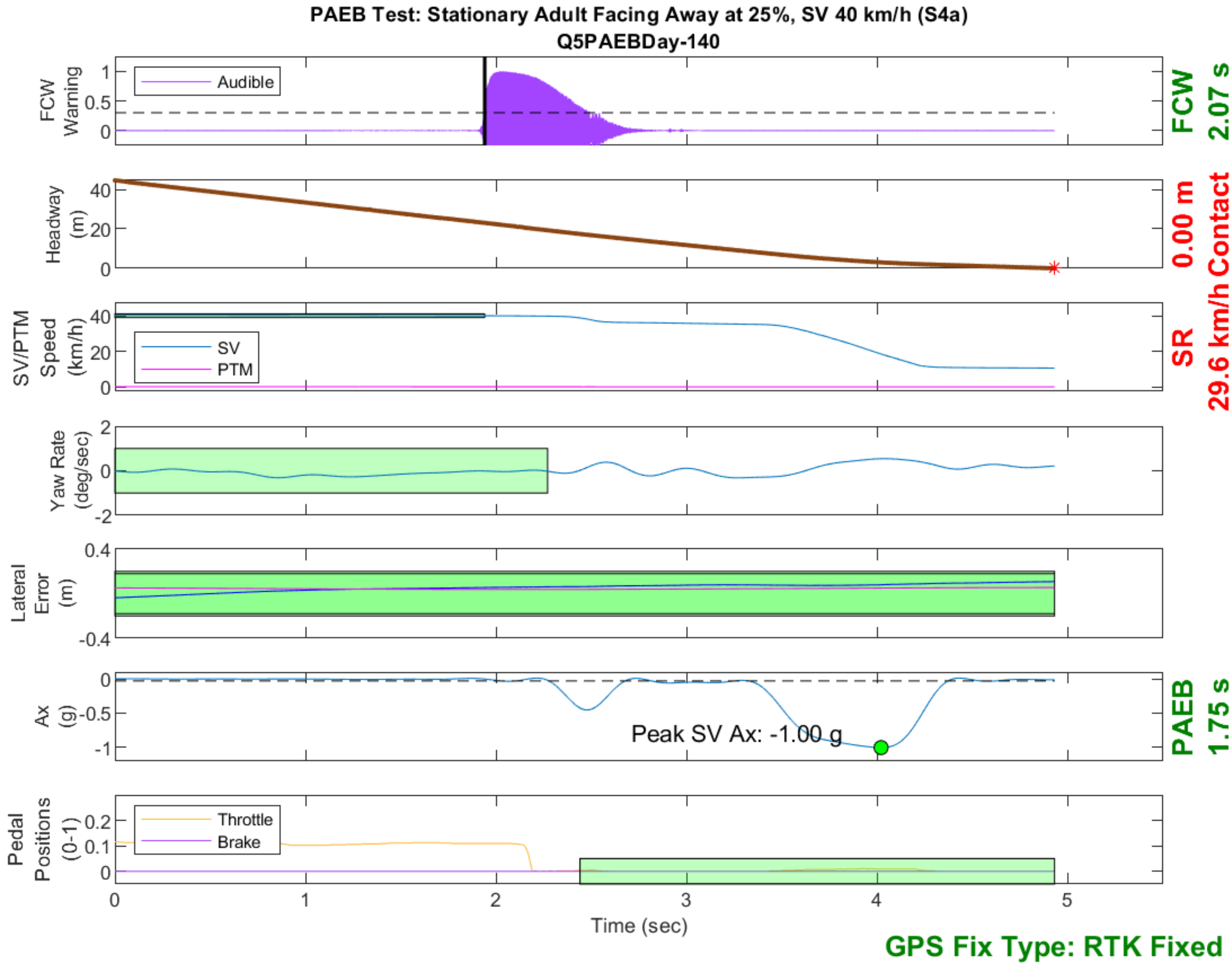

Figure D125. Time History for PAEB Run 140, S4a, Daytime, 40 km/h

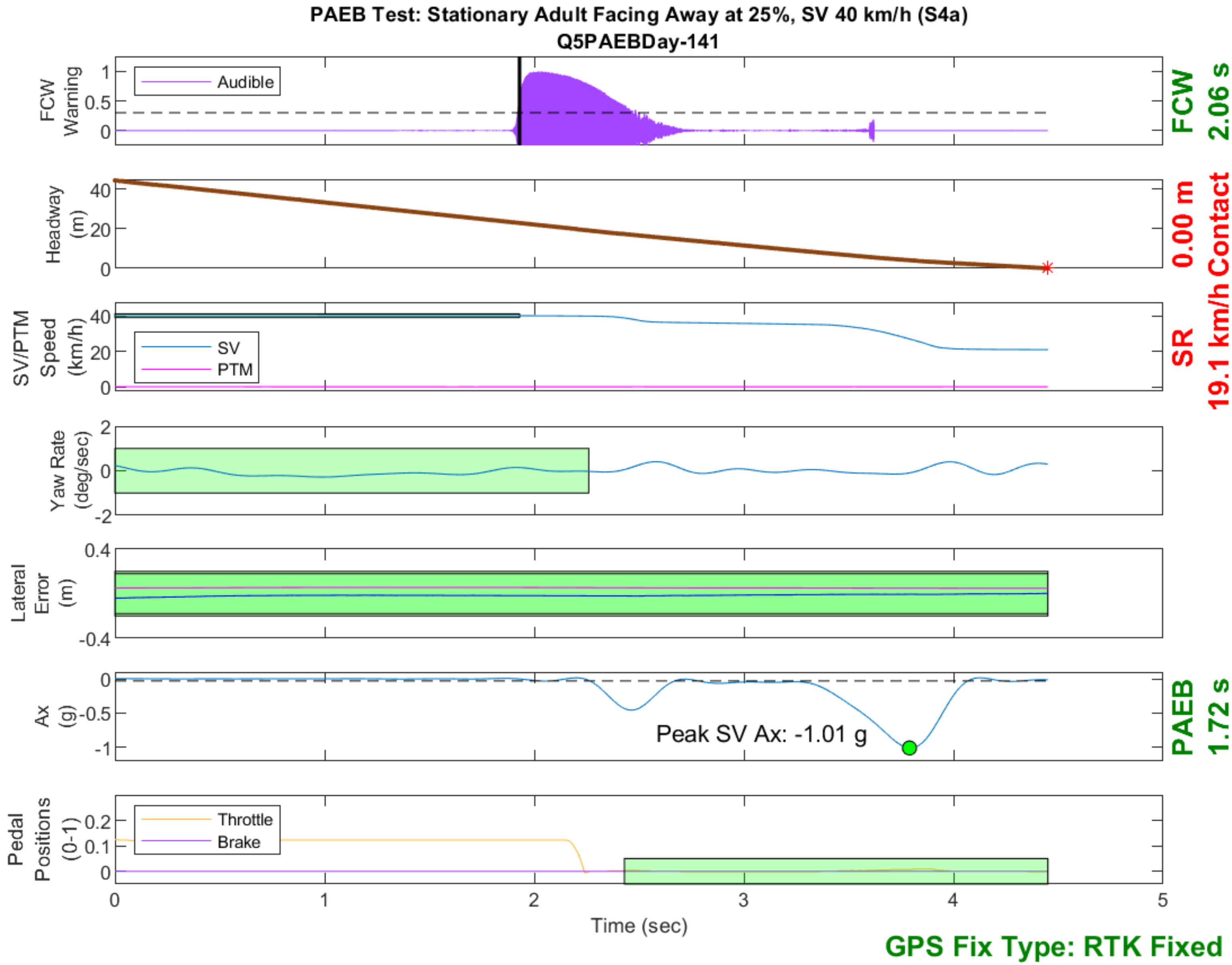

Figure D126. Time History for PAEB Run 141, S4a, Daytime, 40 km/h

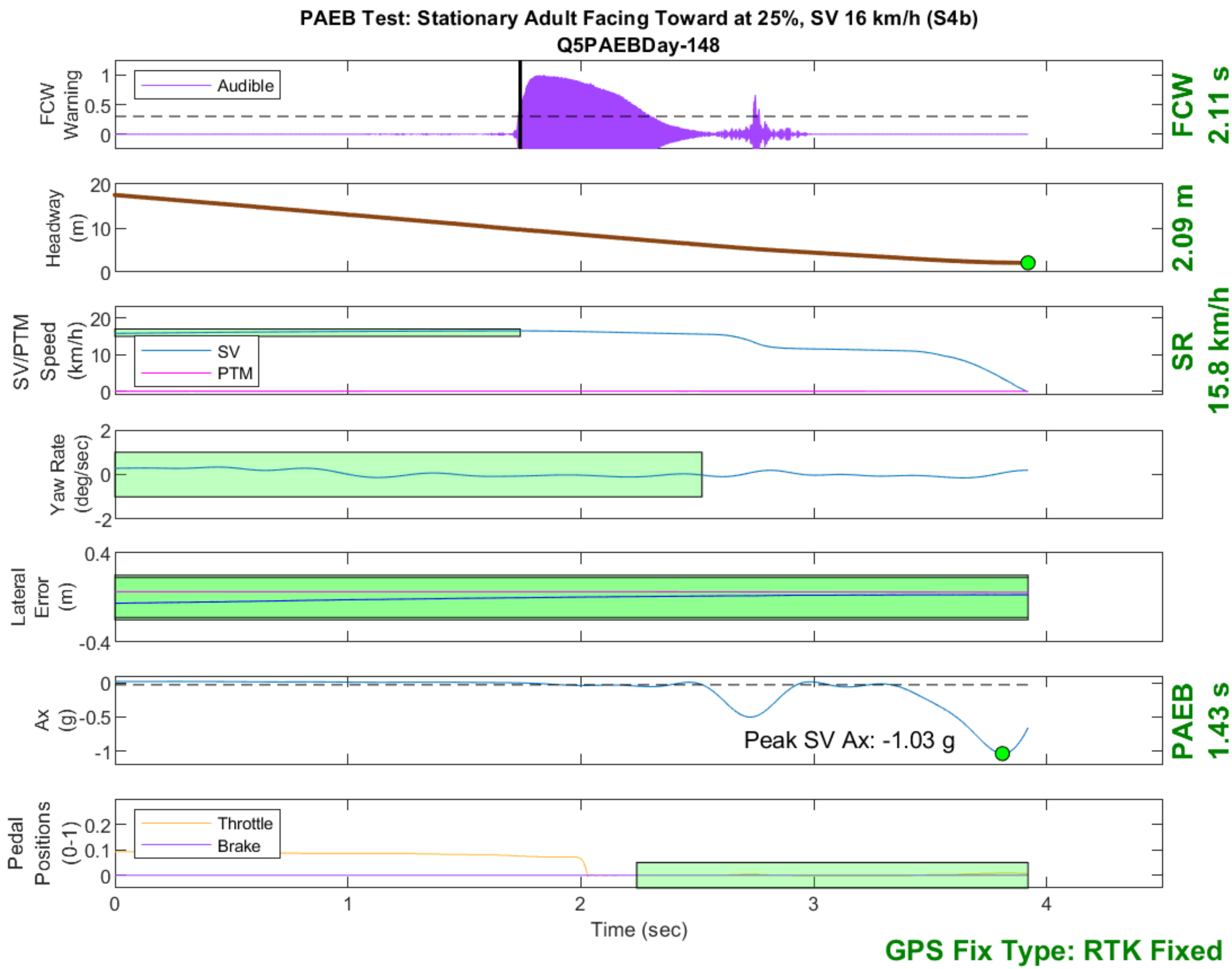

Figure D127. Time History for PAEB Run 148, S4b, Daytime, 16 km/h

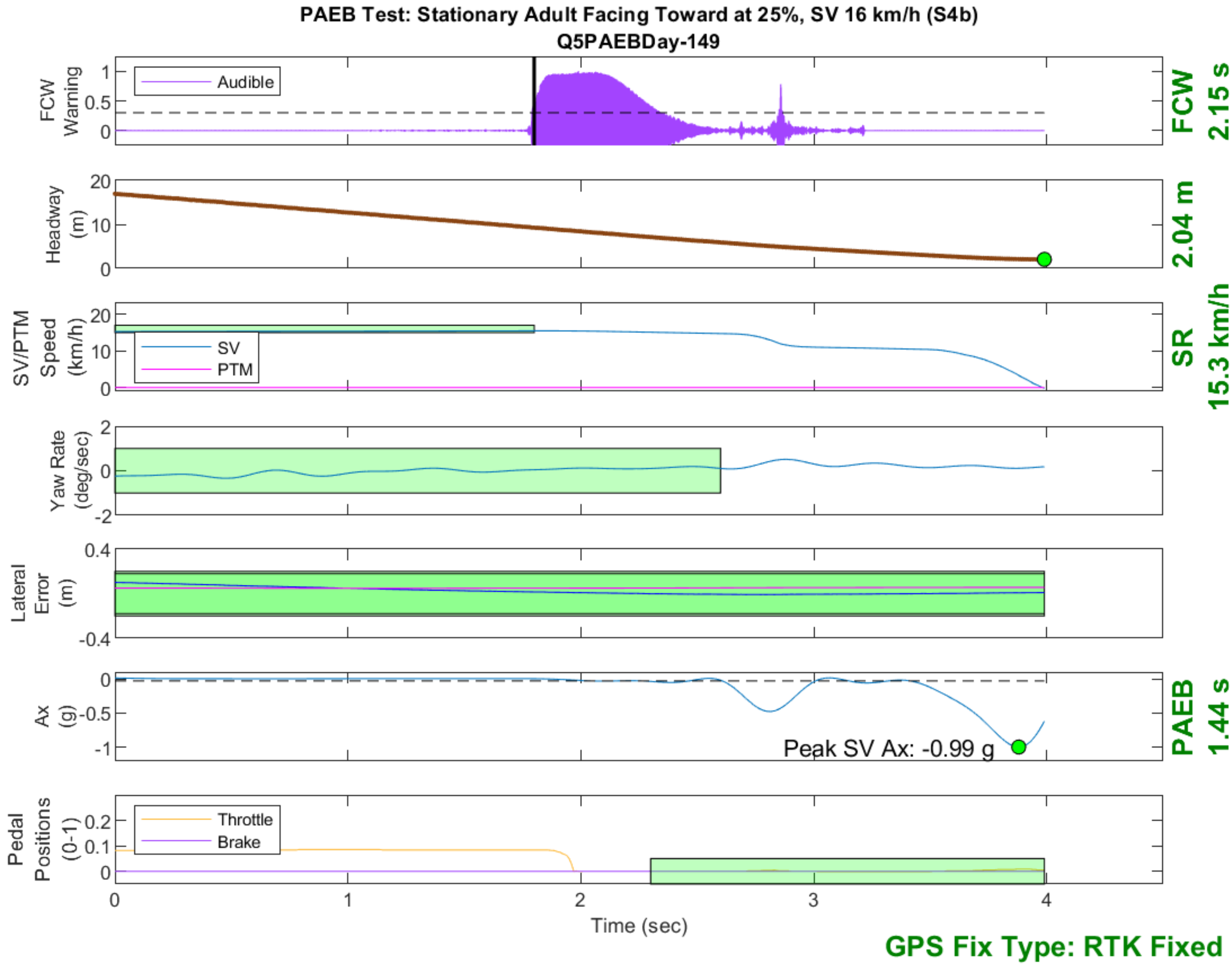

Figure D128. Time History for PAEB Run 149, S4b, Daytime, 16 km/h

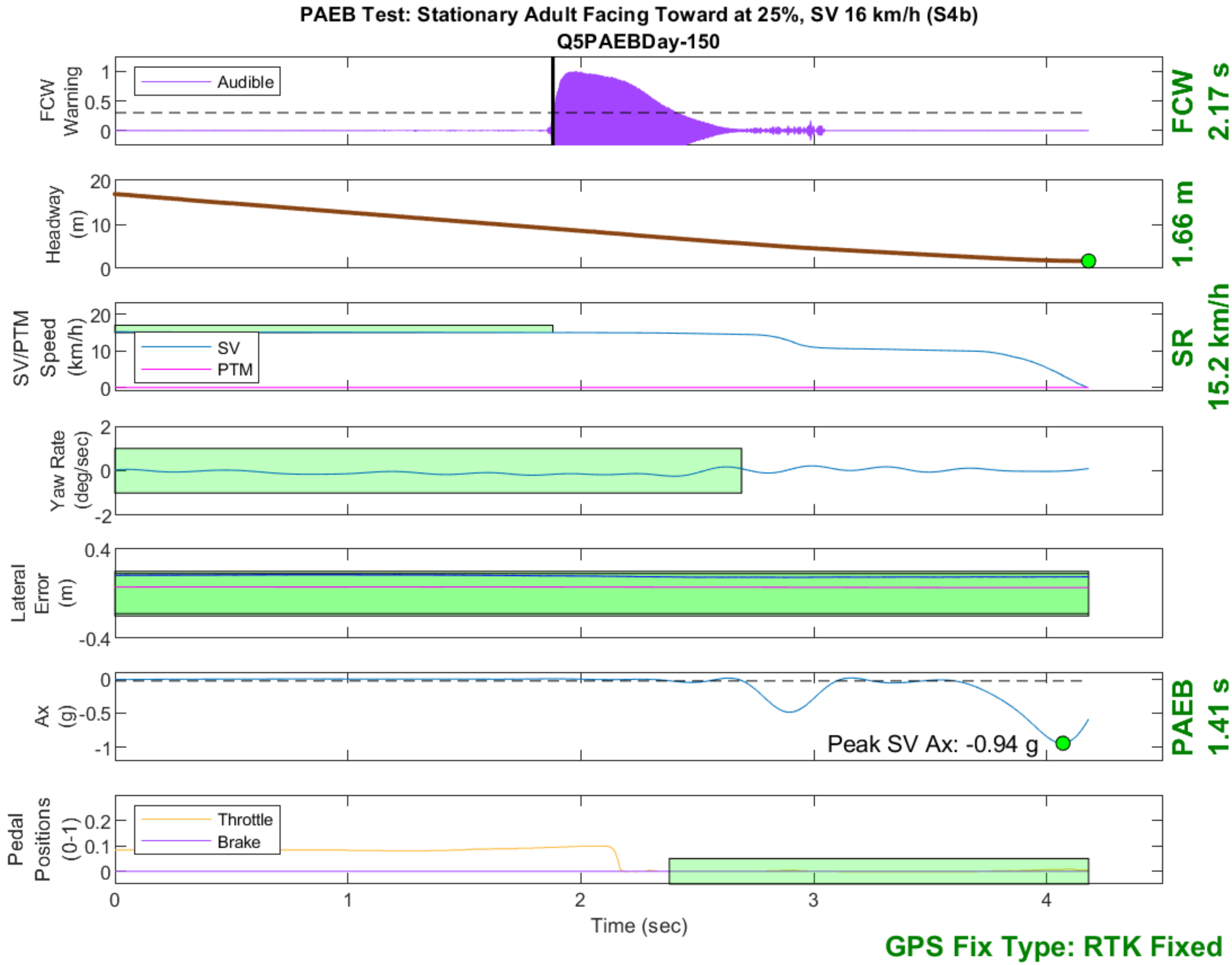

Figure D129. Time History for PAEB Run 150, S4b, Daytime, 16 km/h

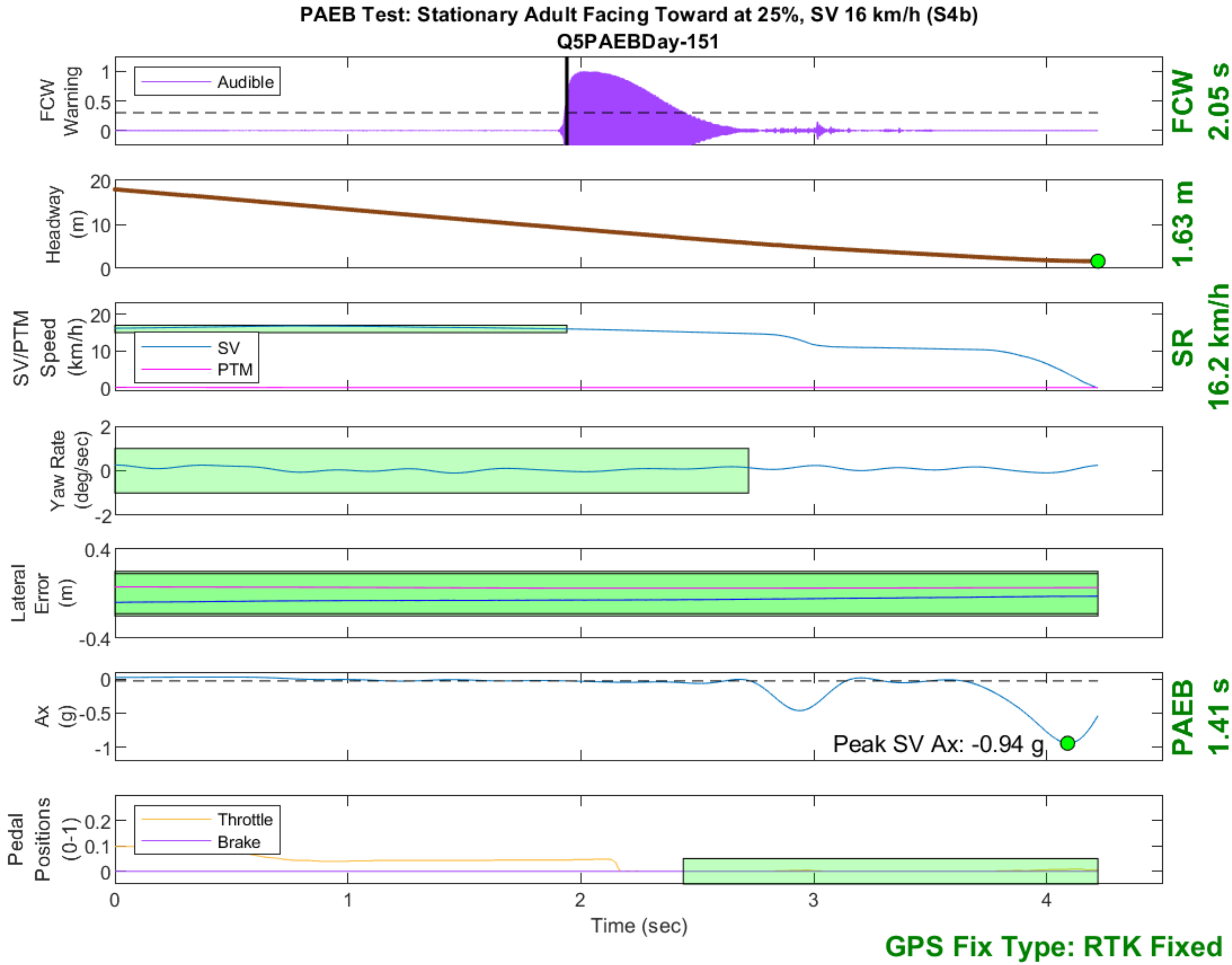

Figure D130. Time History for PAEB Run 151, S4b, Daytime, 16 km/h

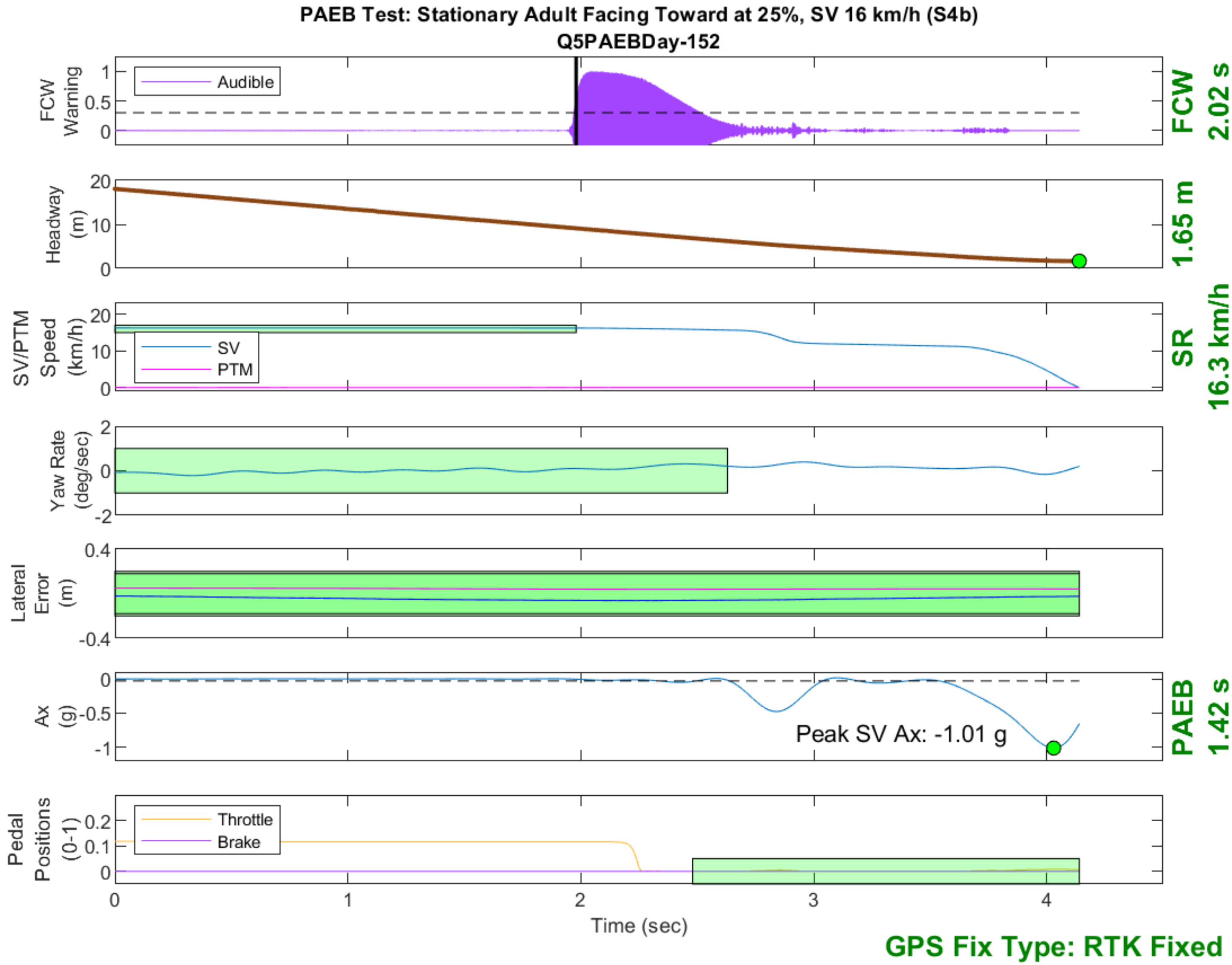

Figure D131. Time History for PAEB Run 152, S4b, Daytime, 16 km/h

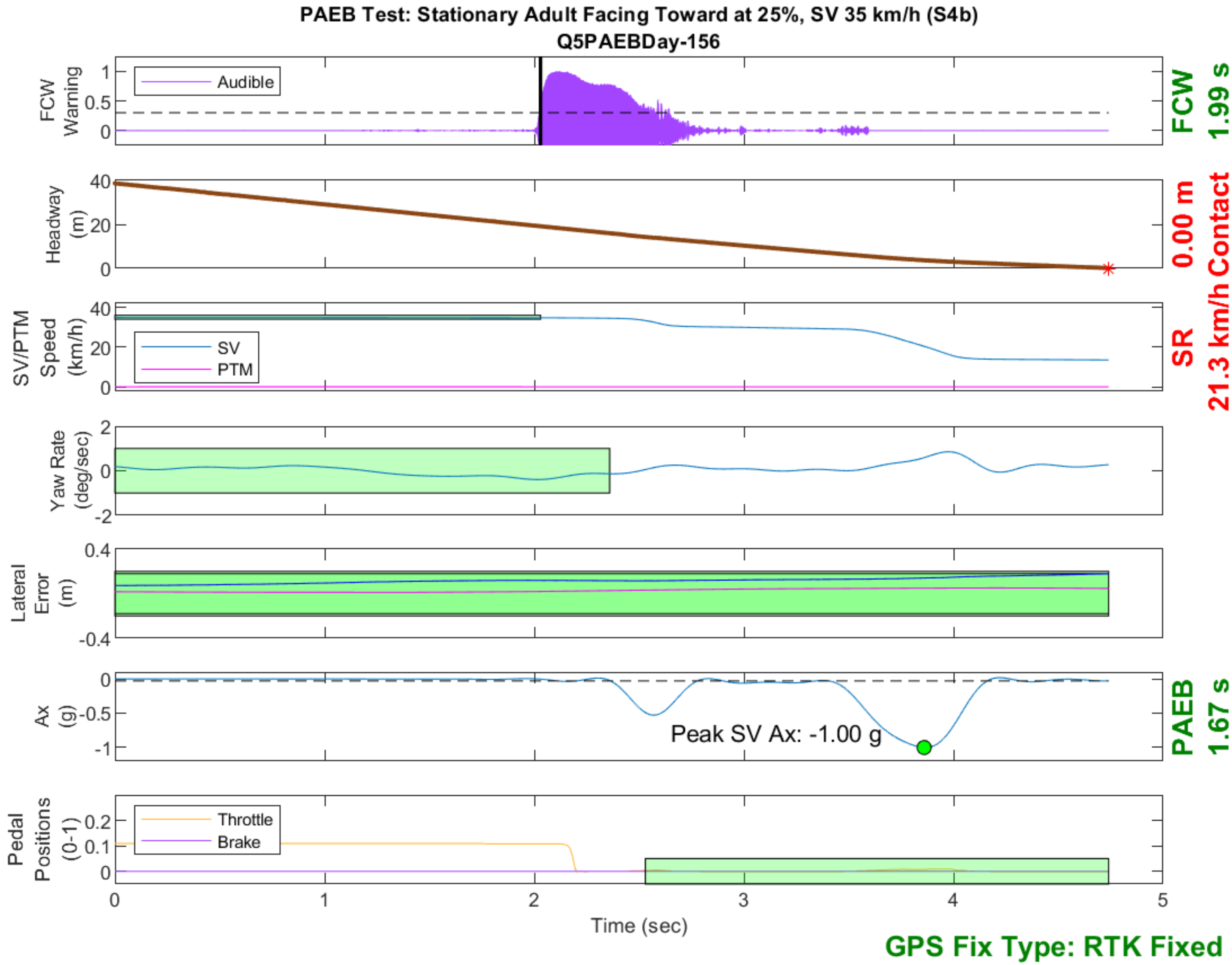

Figure D132. Time History for PAEB Run 156, S4b, Daytime, 35 km/h

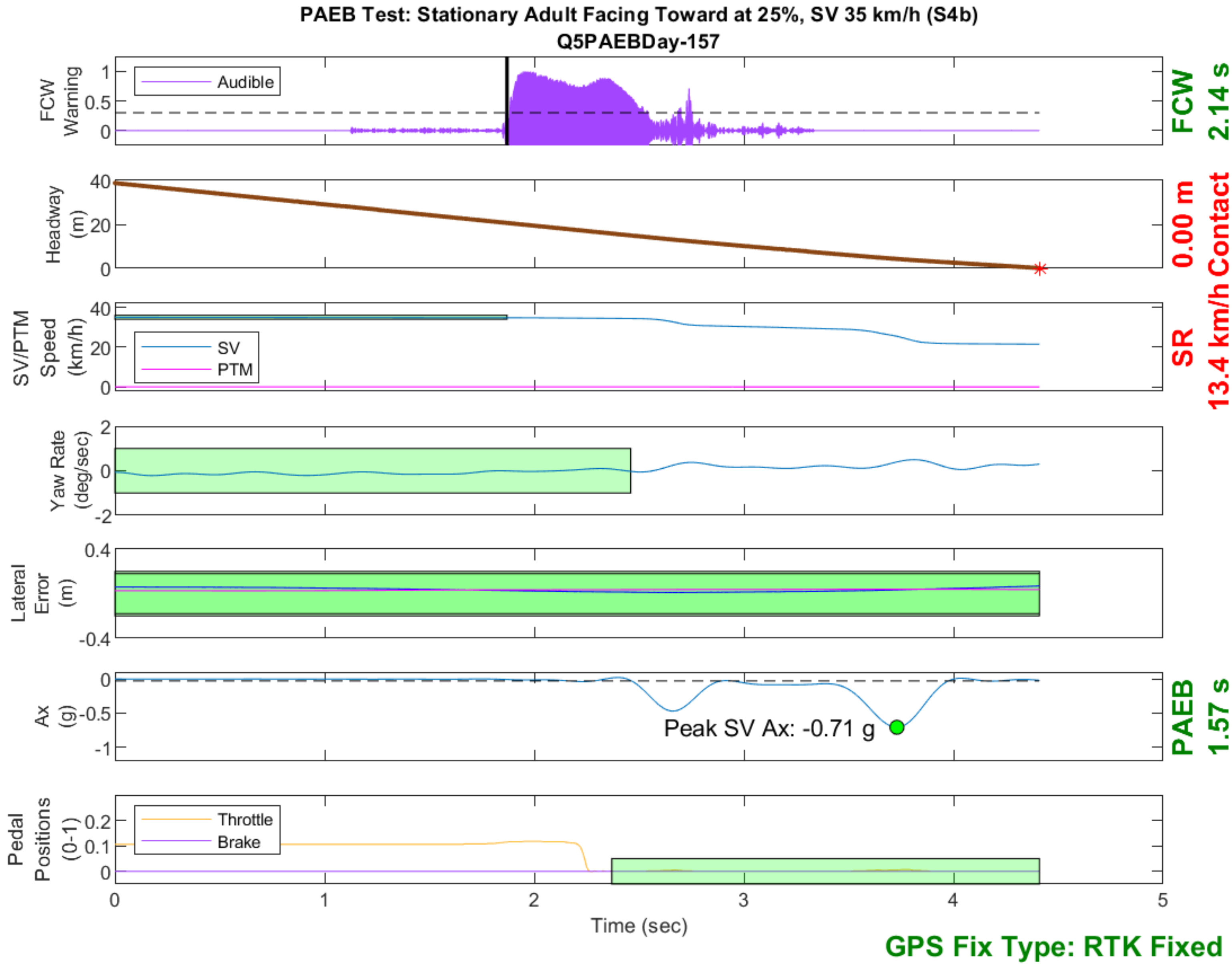

Figure D133. Time History for PAEB Run 157, S4b, Daytime, 35 km/h

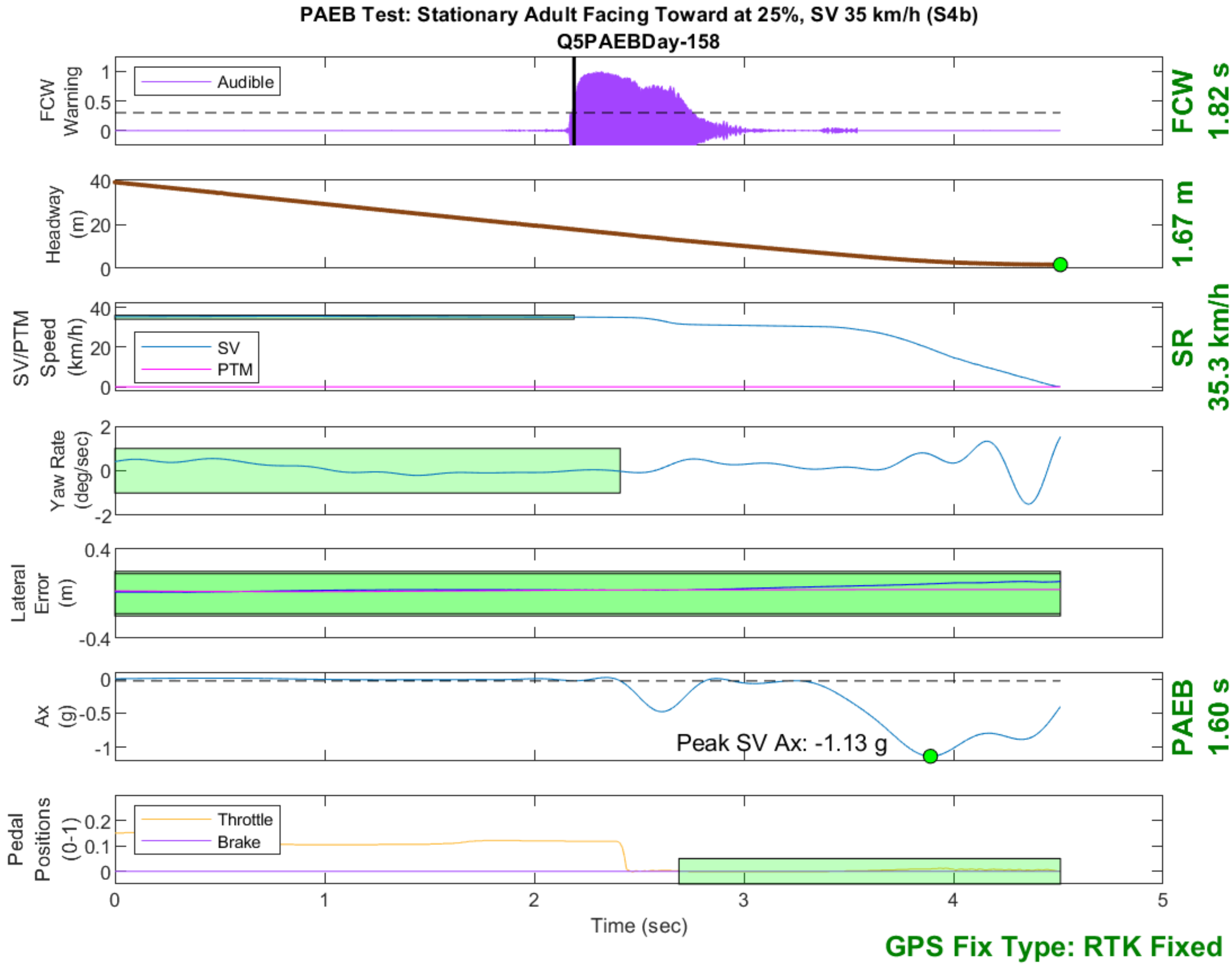

Figure D134. Time History for PAEB Run 158, S4b, Daytime, 35 km/h

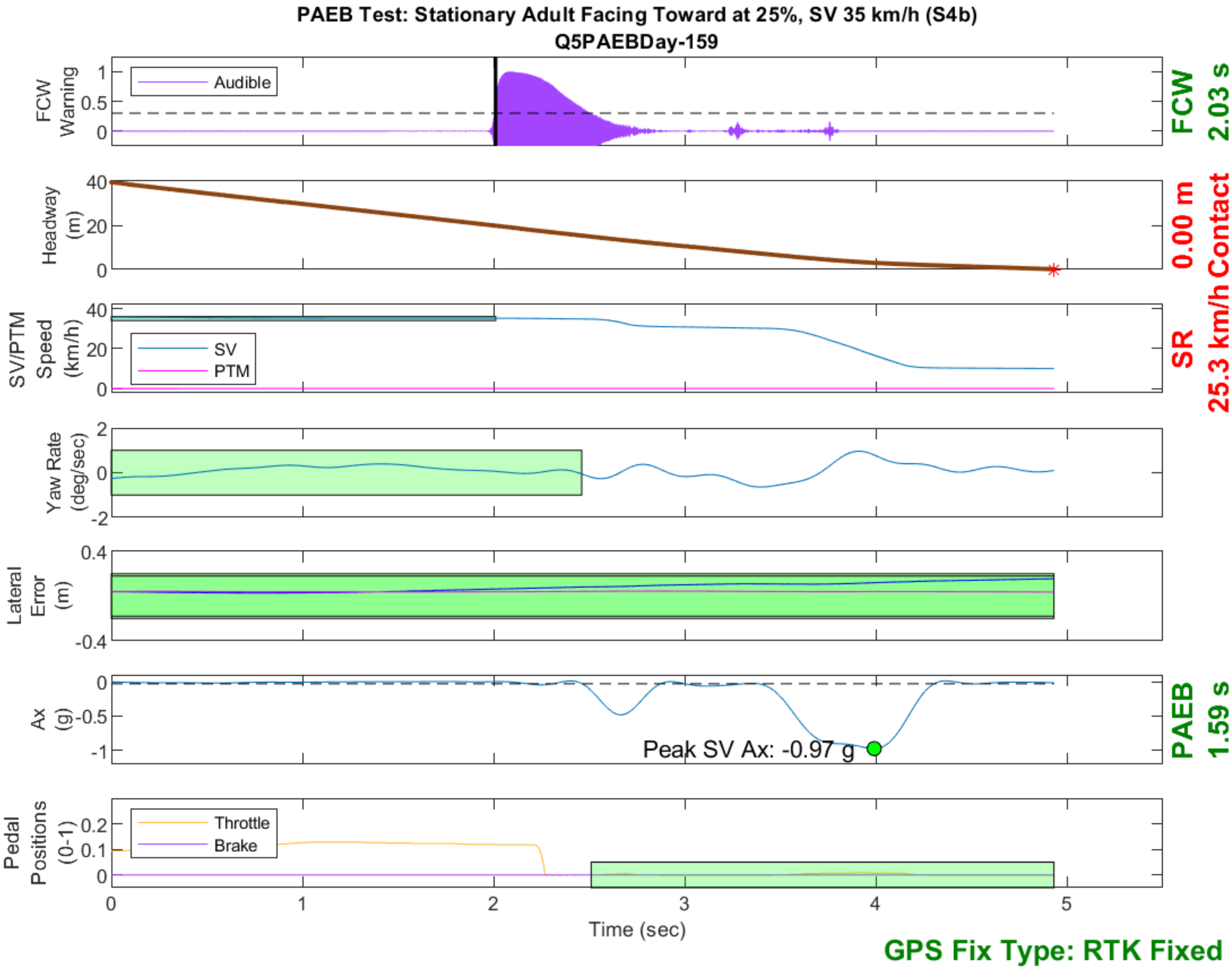

Figure D135. Time History for PAEB Run 159, S4b, Daytime, 35 km/h

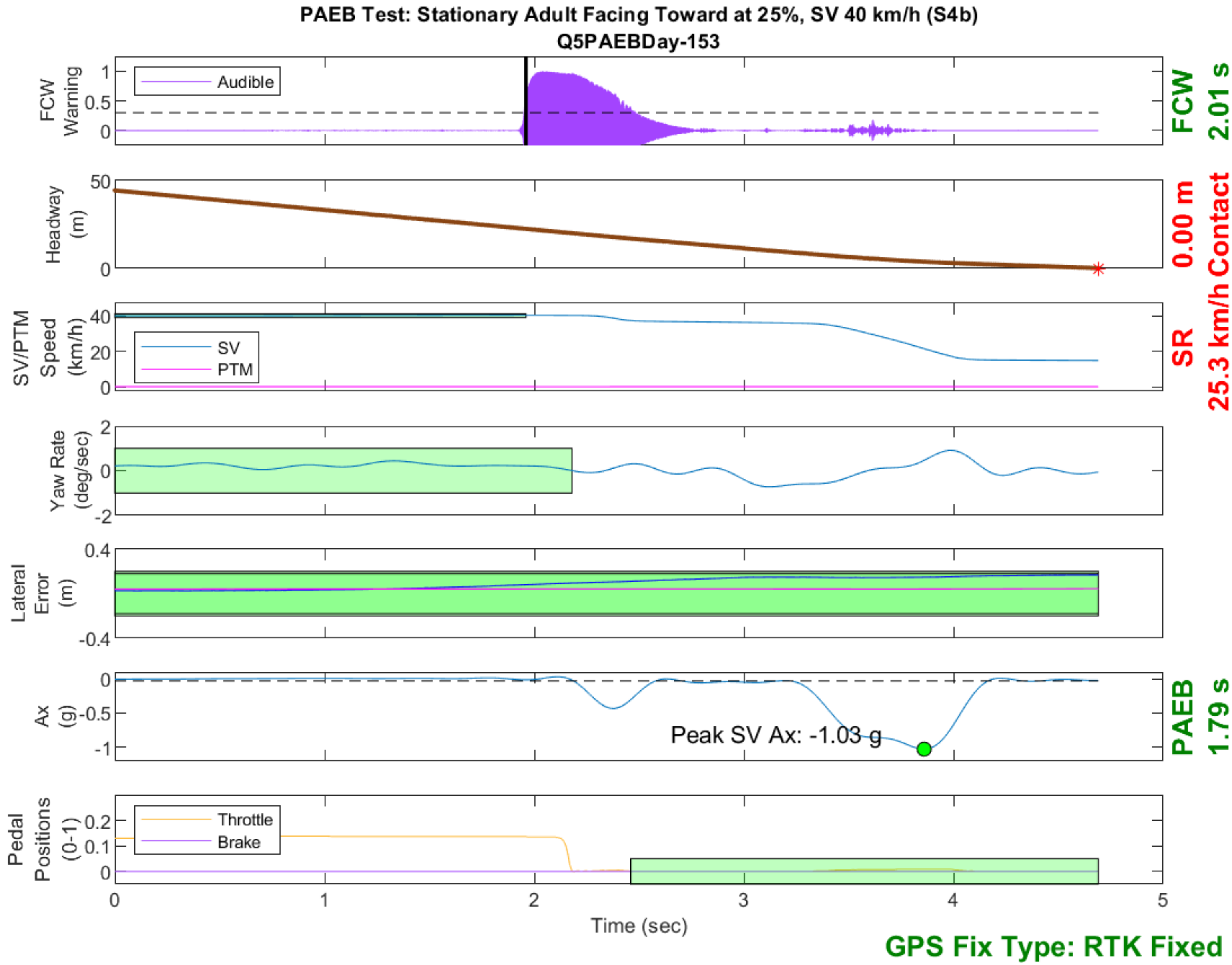

Figure D136. Time History for PAEB Run 153, S4b, Daytime, 40 km/h

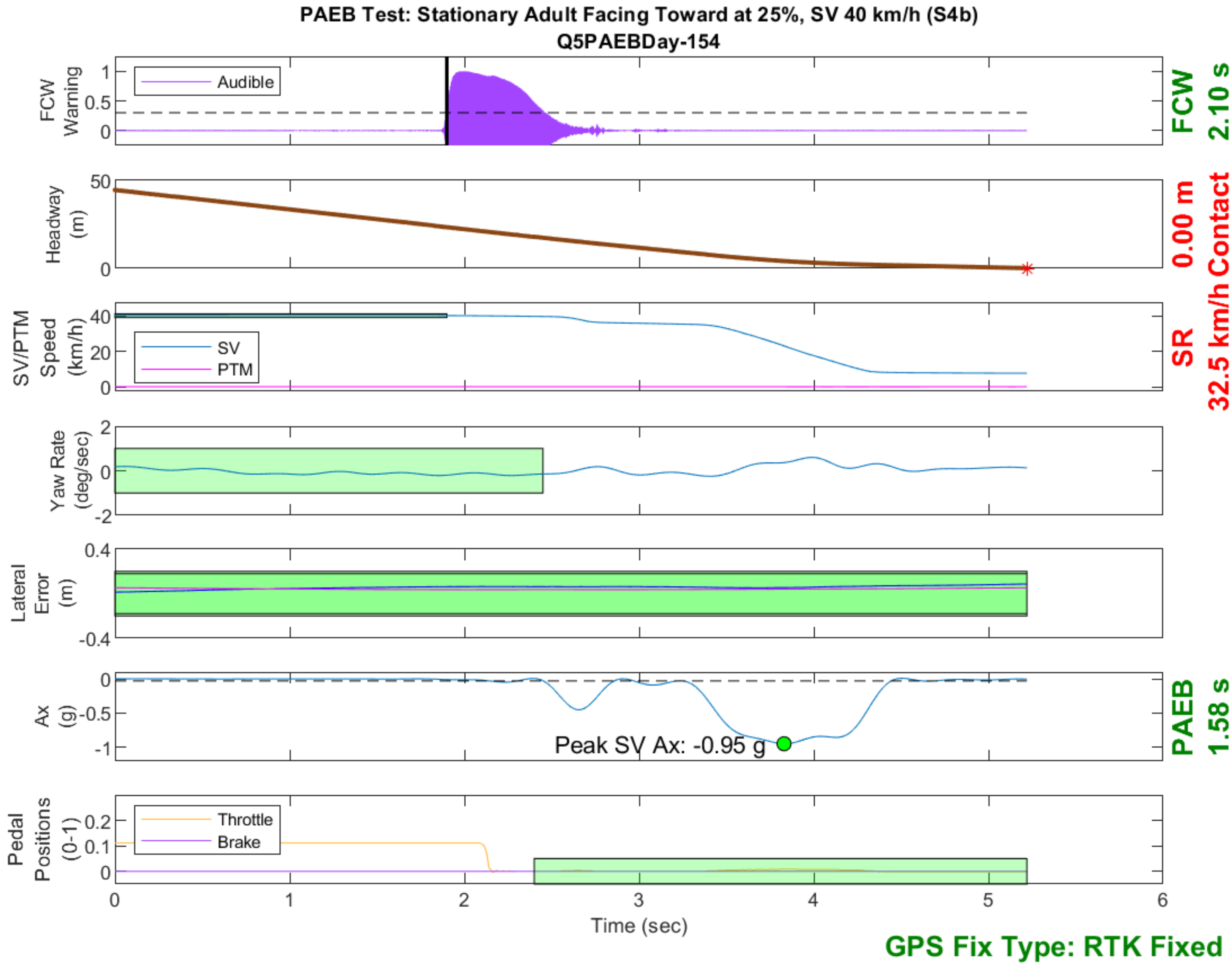

Figure D137. Time History for PAEB Run 154, S4b, Daytime, 40 km/h

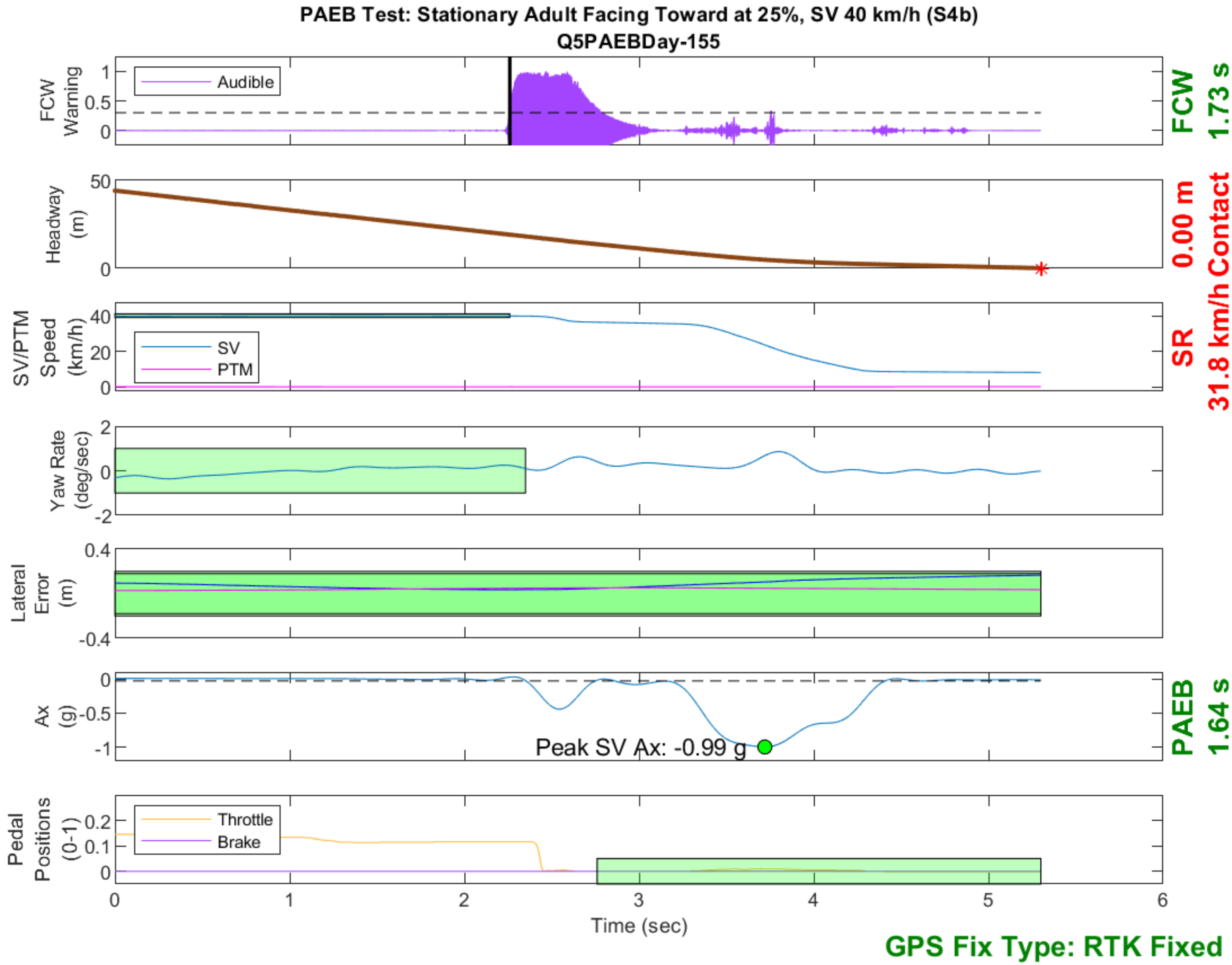

Figure D138. Time History for PAEB Run 155, S4b, Daytime, 40 km/h

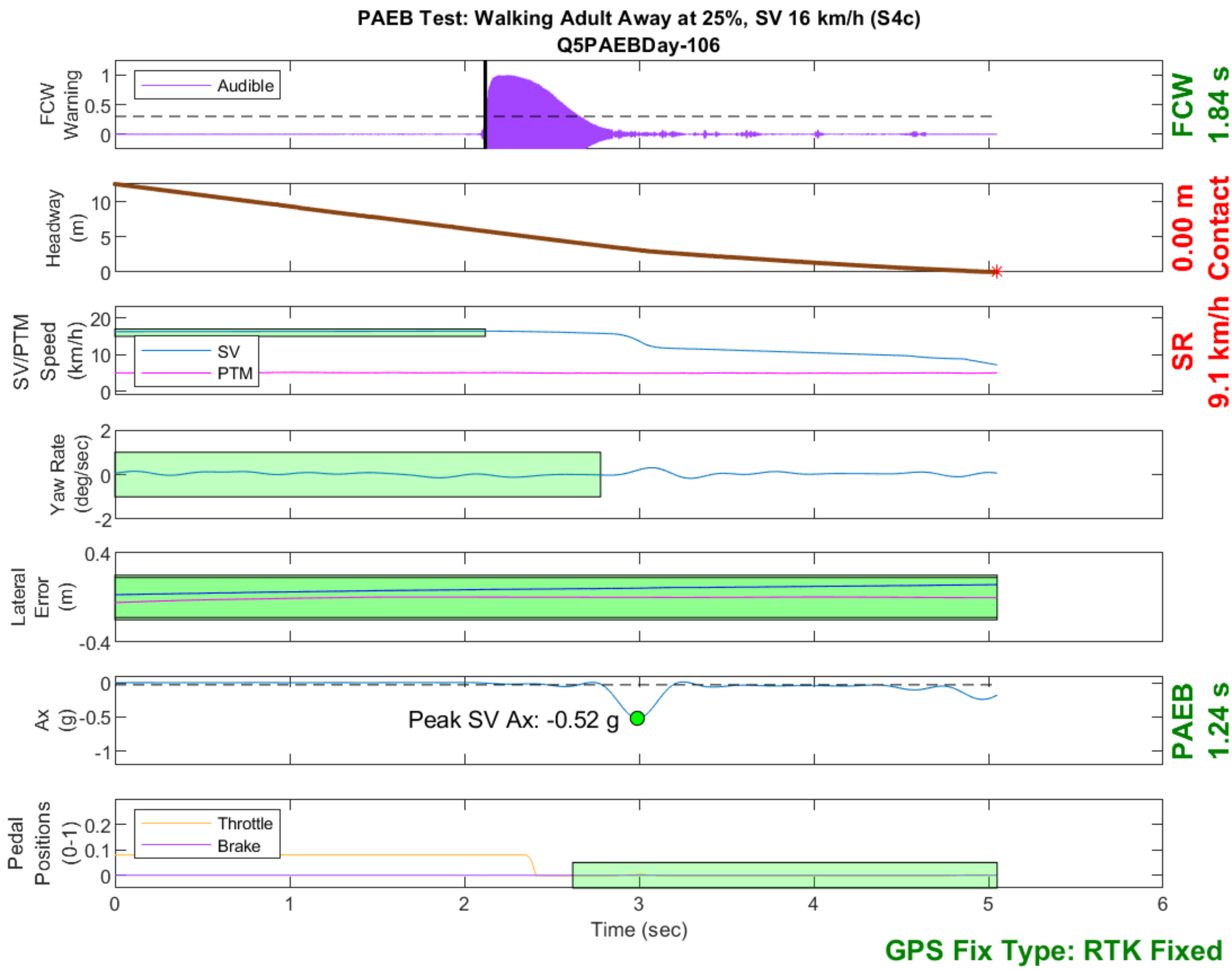

Figure D139. Time History for PAEB Run 106, S4c, Daytime, 16 km/h

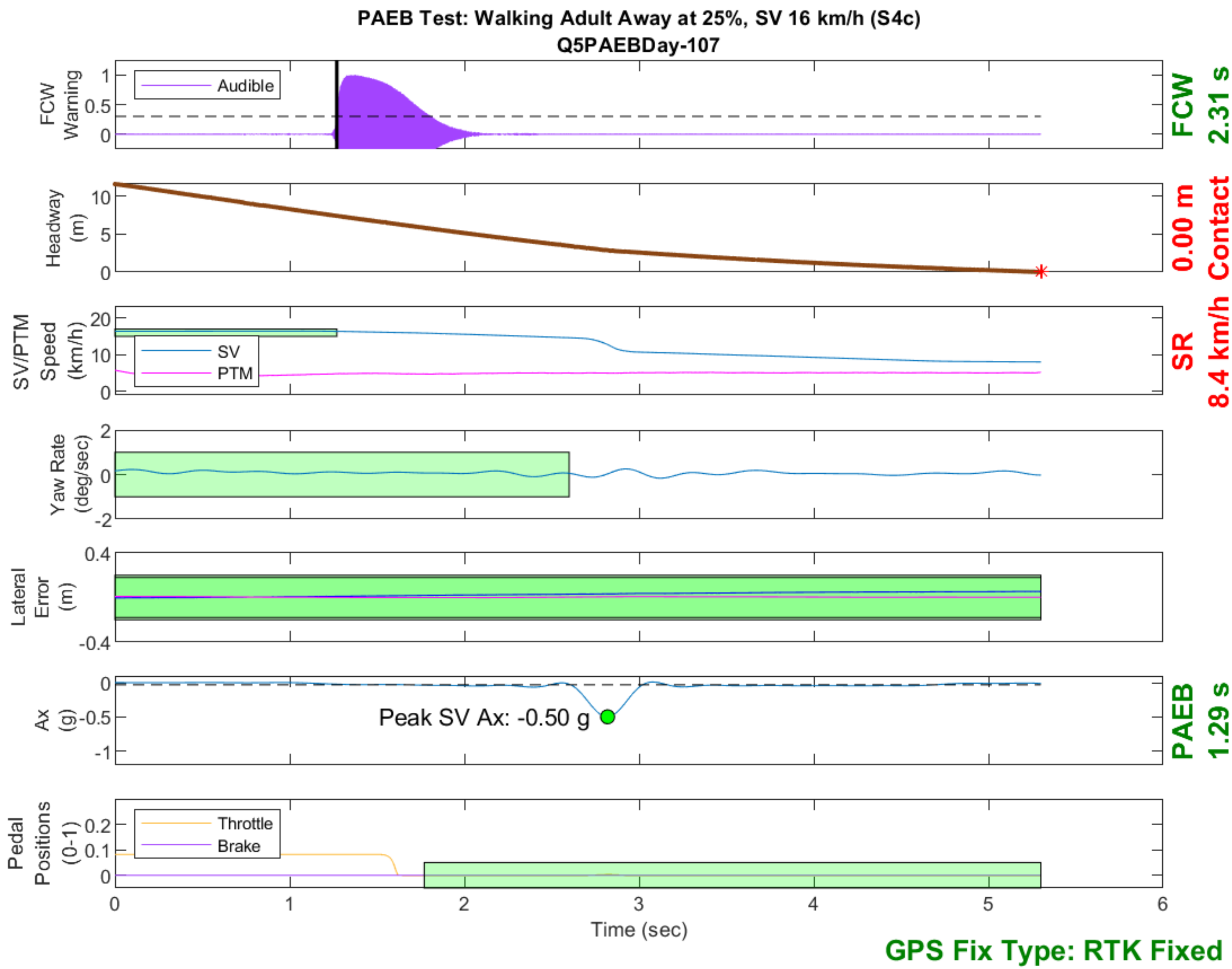

Figure D140. Time History for PAEB Run 107, S4c, Daytime, 16 km/h

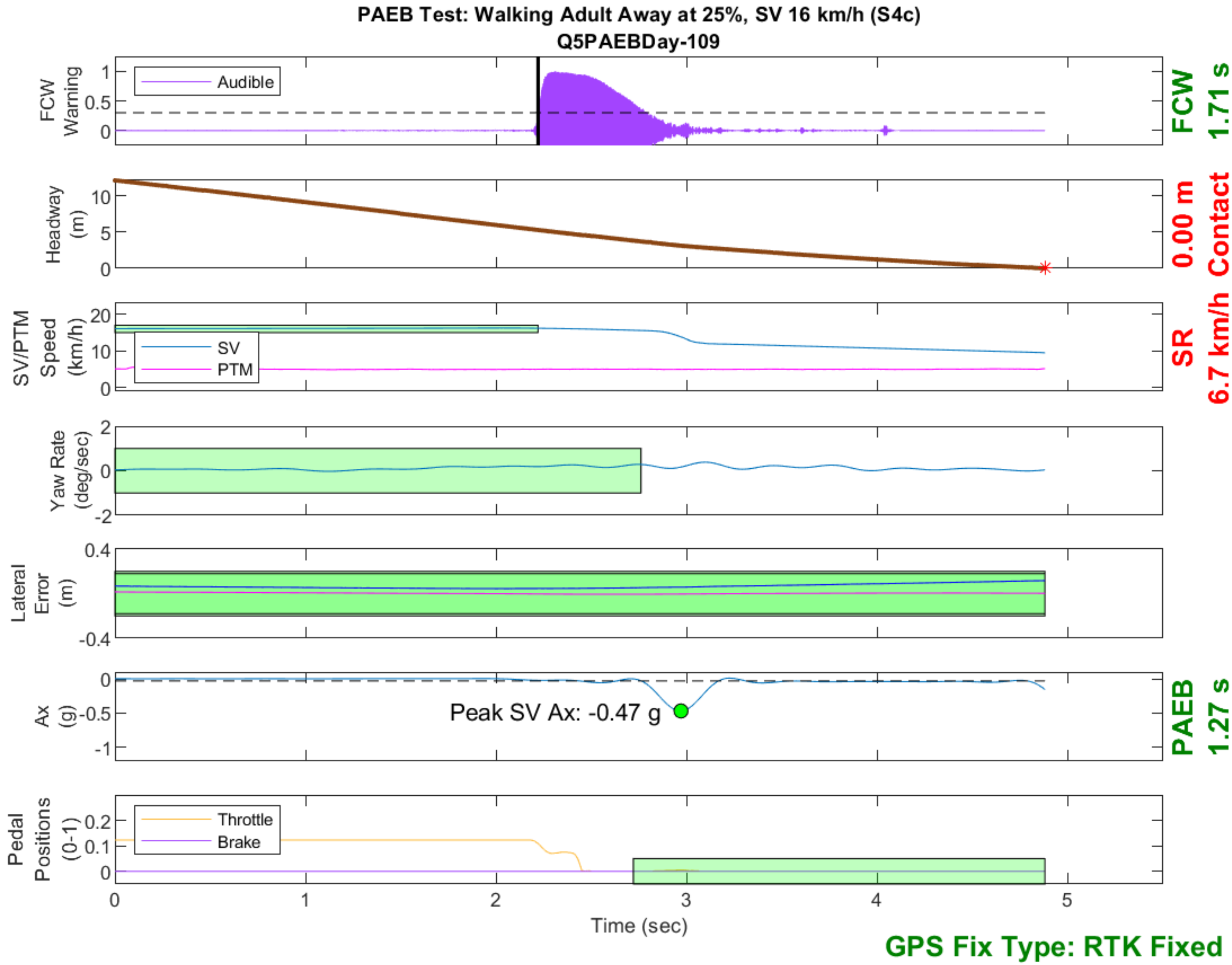

Figure D141. Time History for PAEB Run 109, S4c, Daytime, 16 km/h

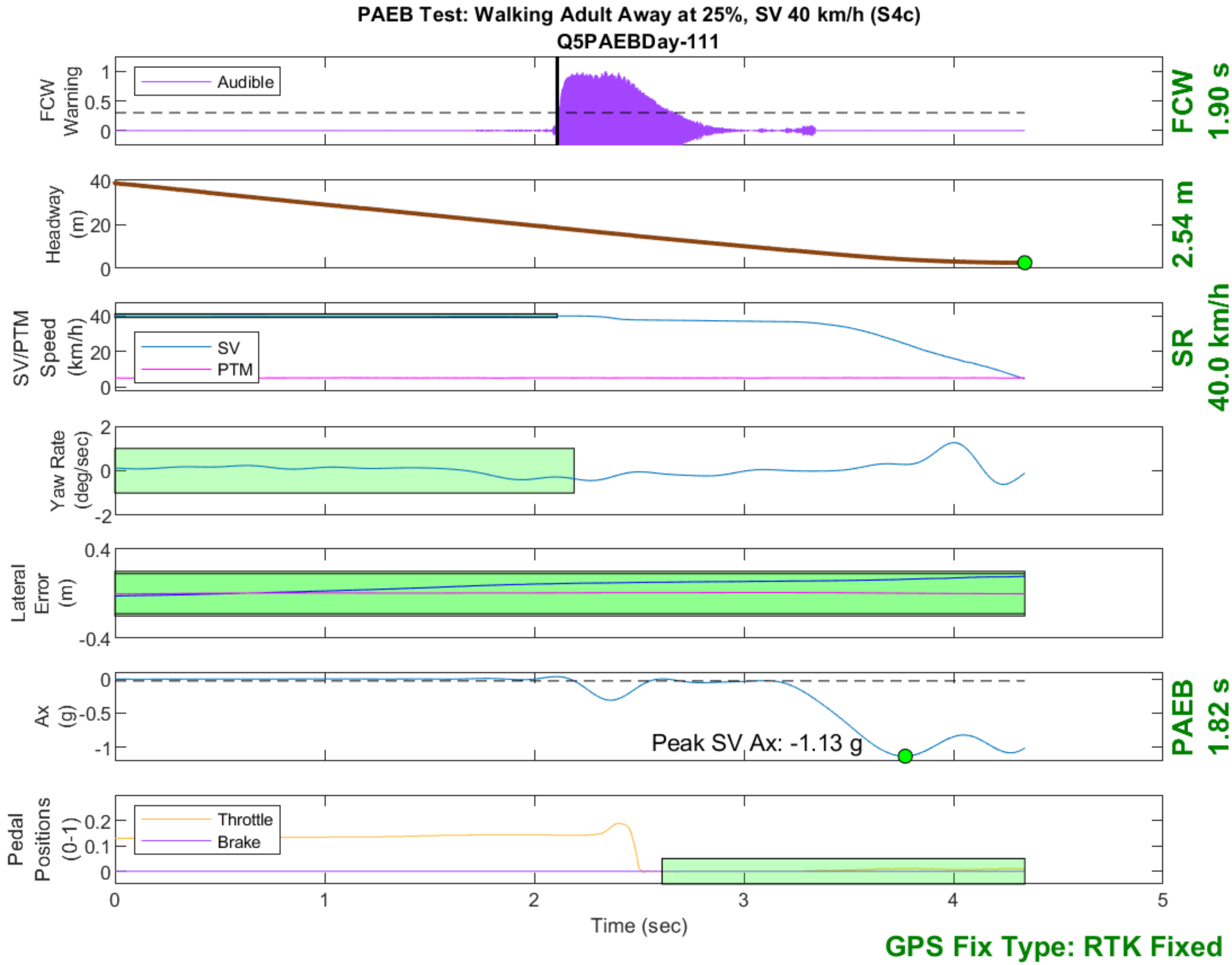

Figure D142. Time History for PAEB Run 111, S4c, Daytime, 40 km/h

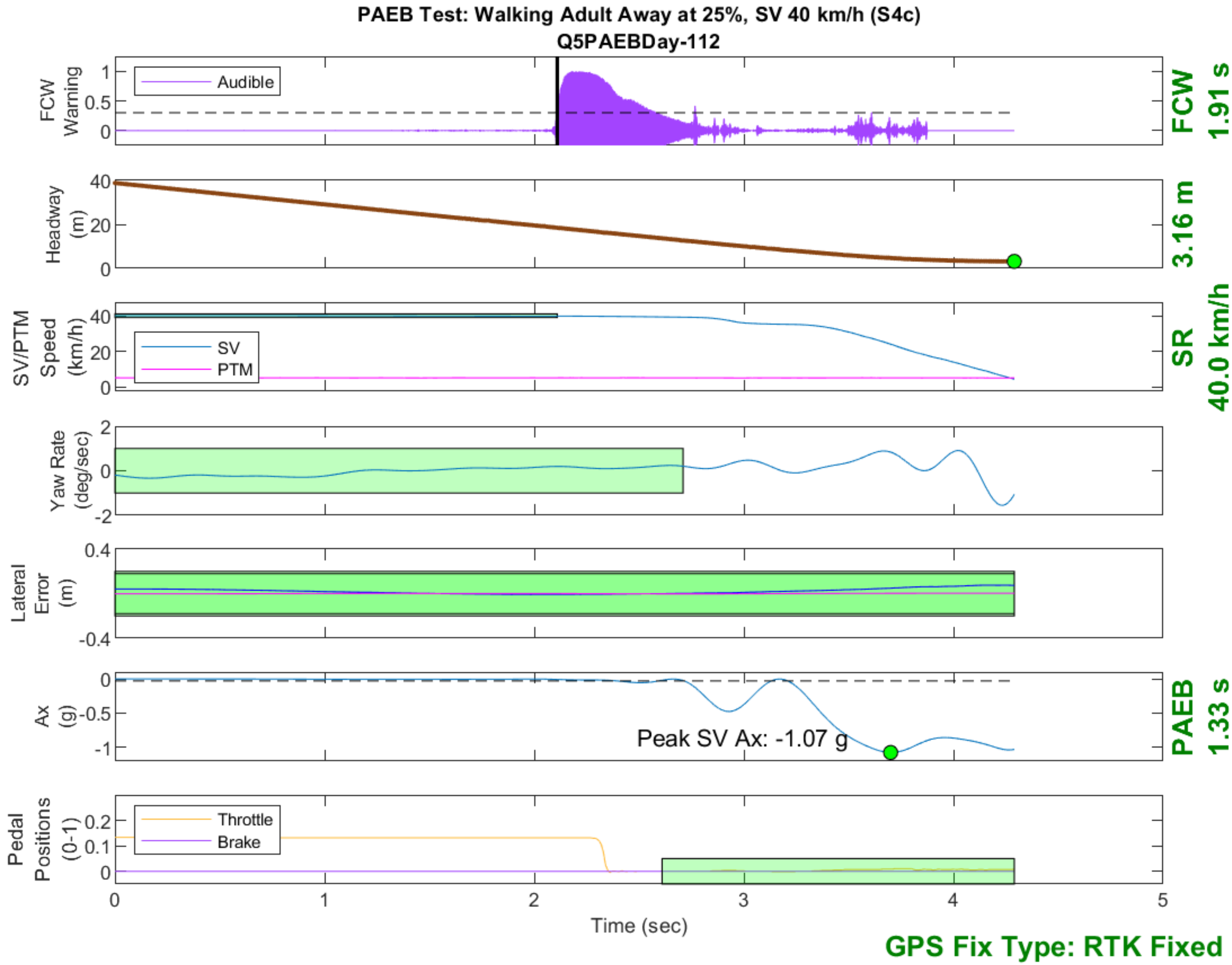

Figure D143. Time History for PAEB Run 112, S4c, Daytime, 40 km/h

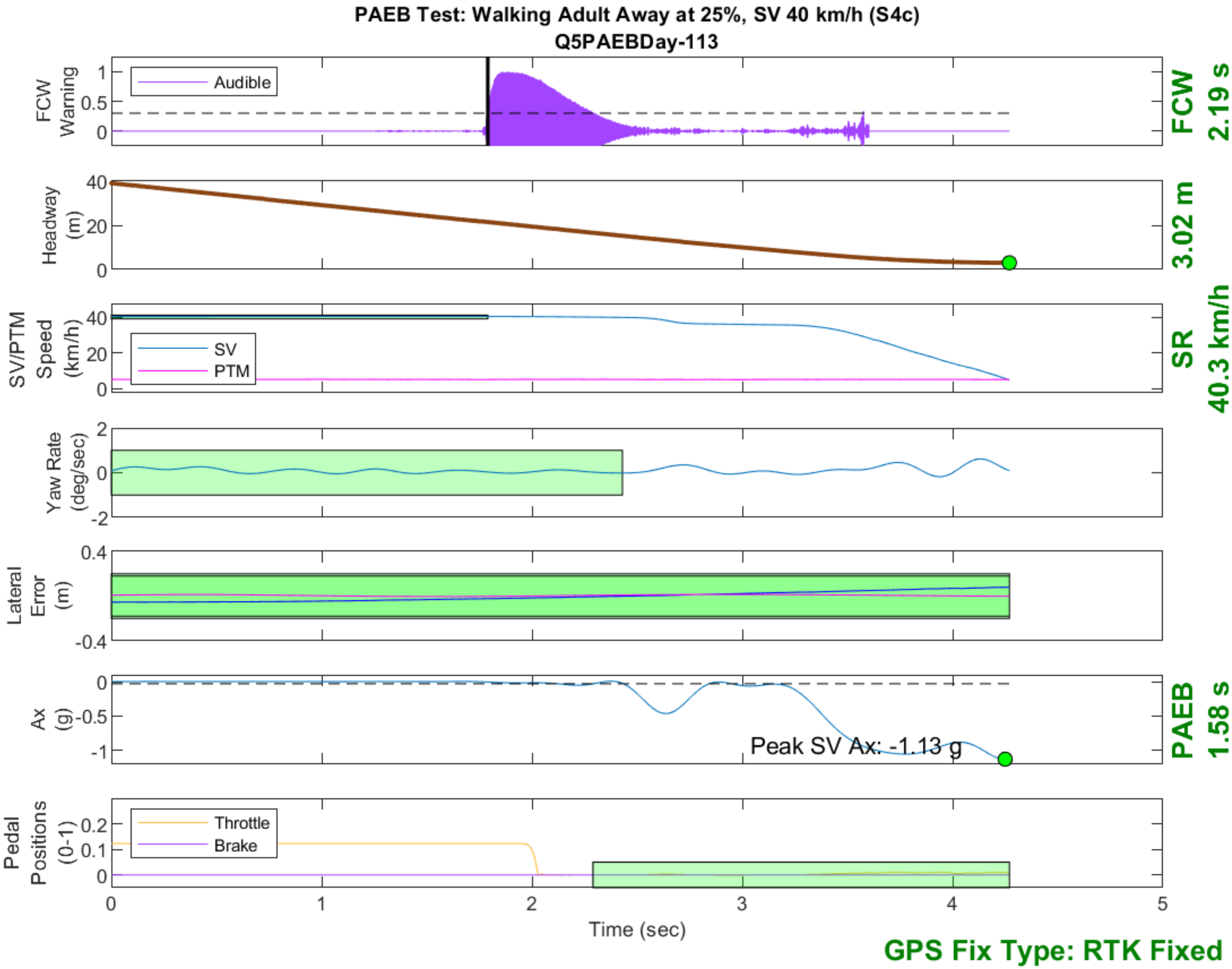

Figure D144. Time History for PAEB Run 113, S4c, Daytime, 40 km/h

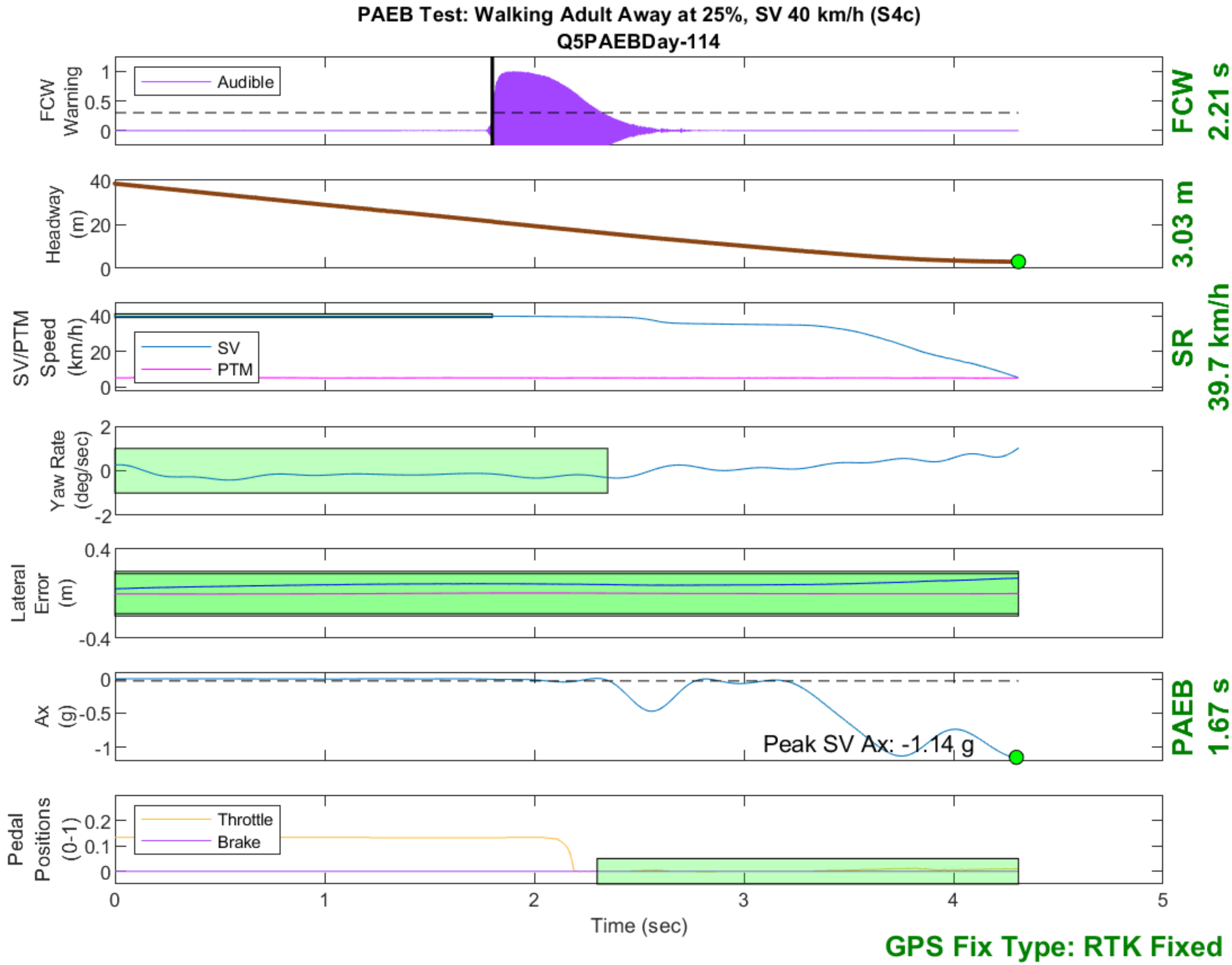

Figure D145. Time History for PAEB Run 114, S4c, Daytime, 40 km/h

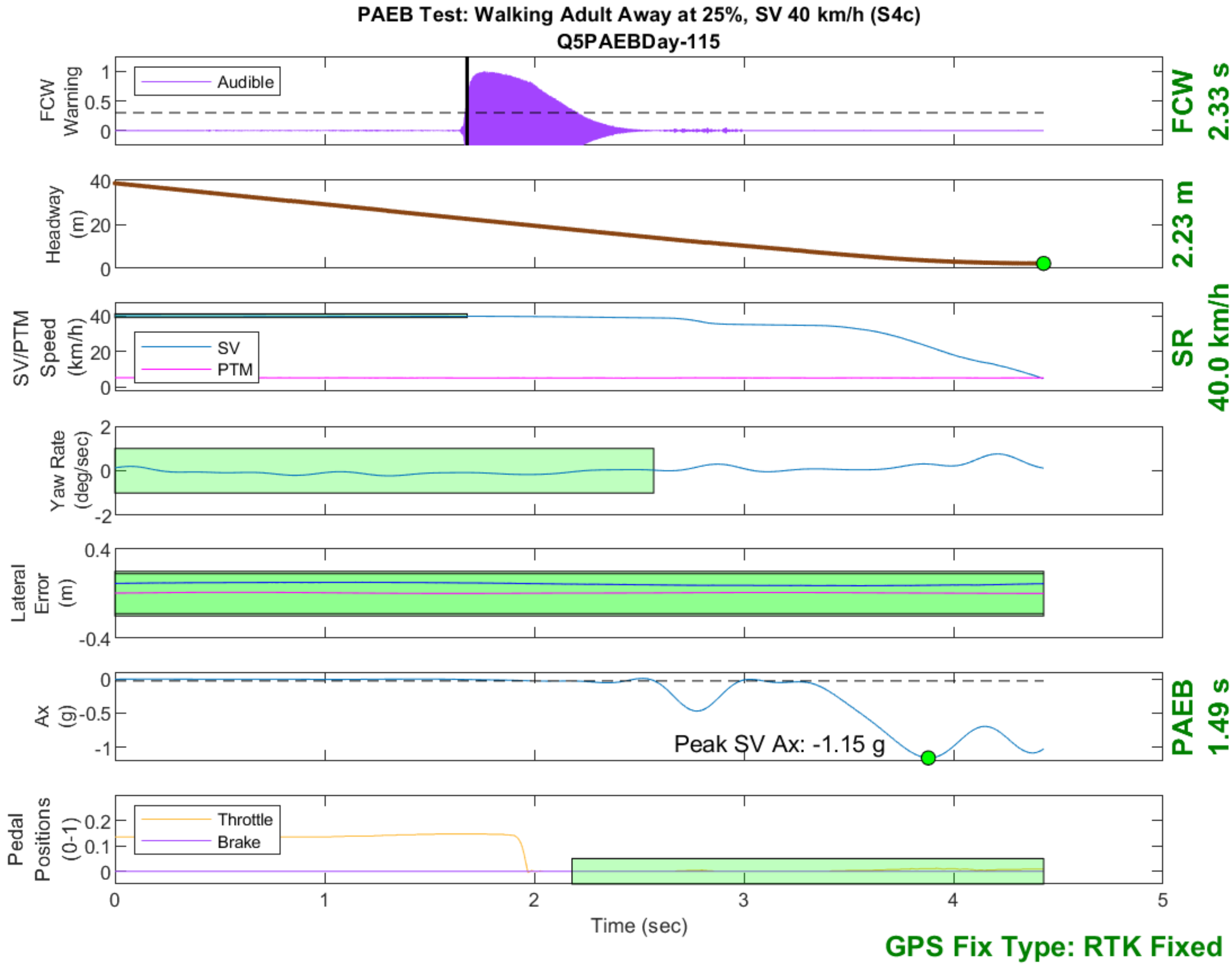

Figure D146. Time History for PAEB Run 115, S4c, Daytime, 40 km/h

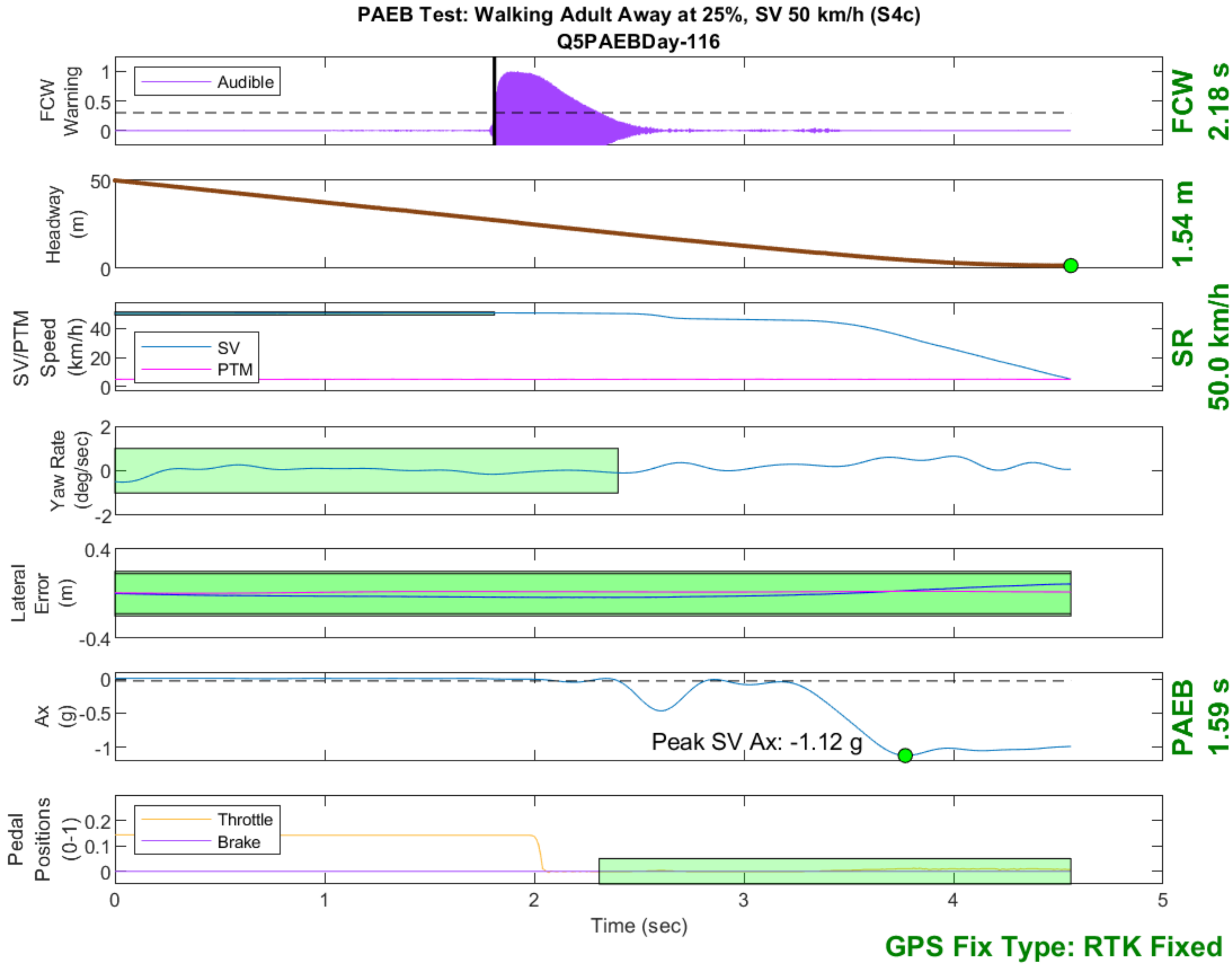

Figure D147. Time History for PAEB Run 116, S4c, Daytime, 50 km/h

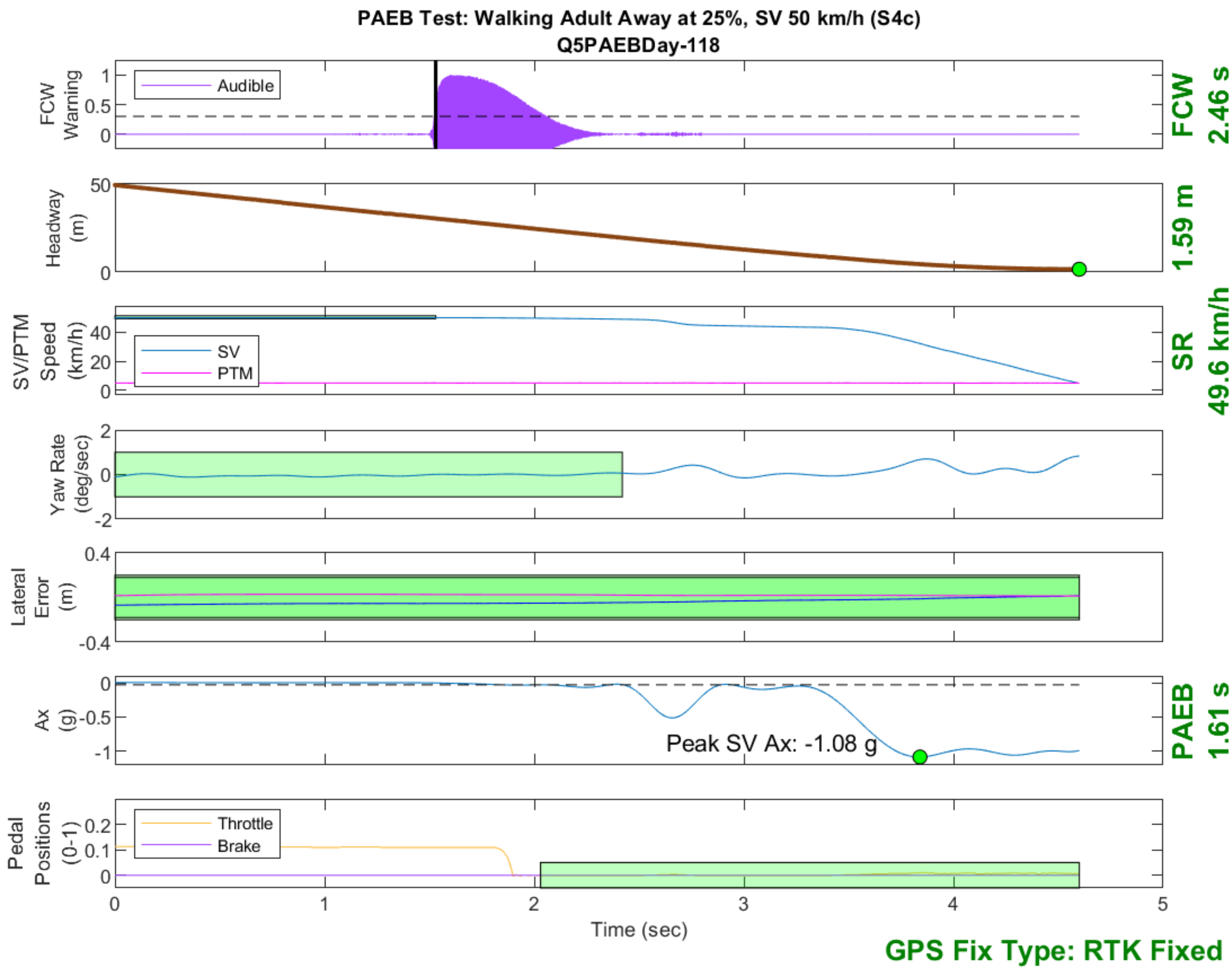

Figure D148. Time History for PAEB Run 118, S4c, Daytime, 50 km/h

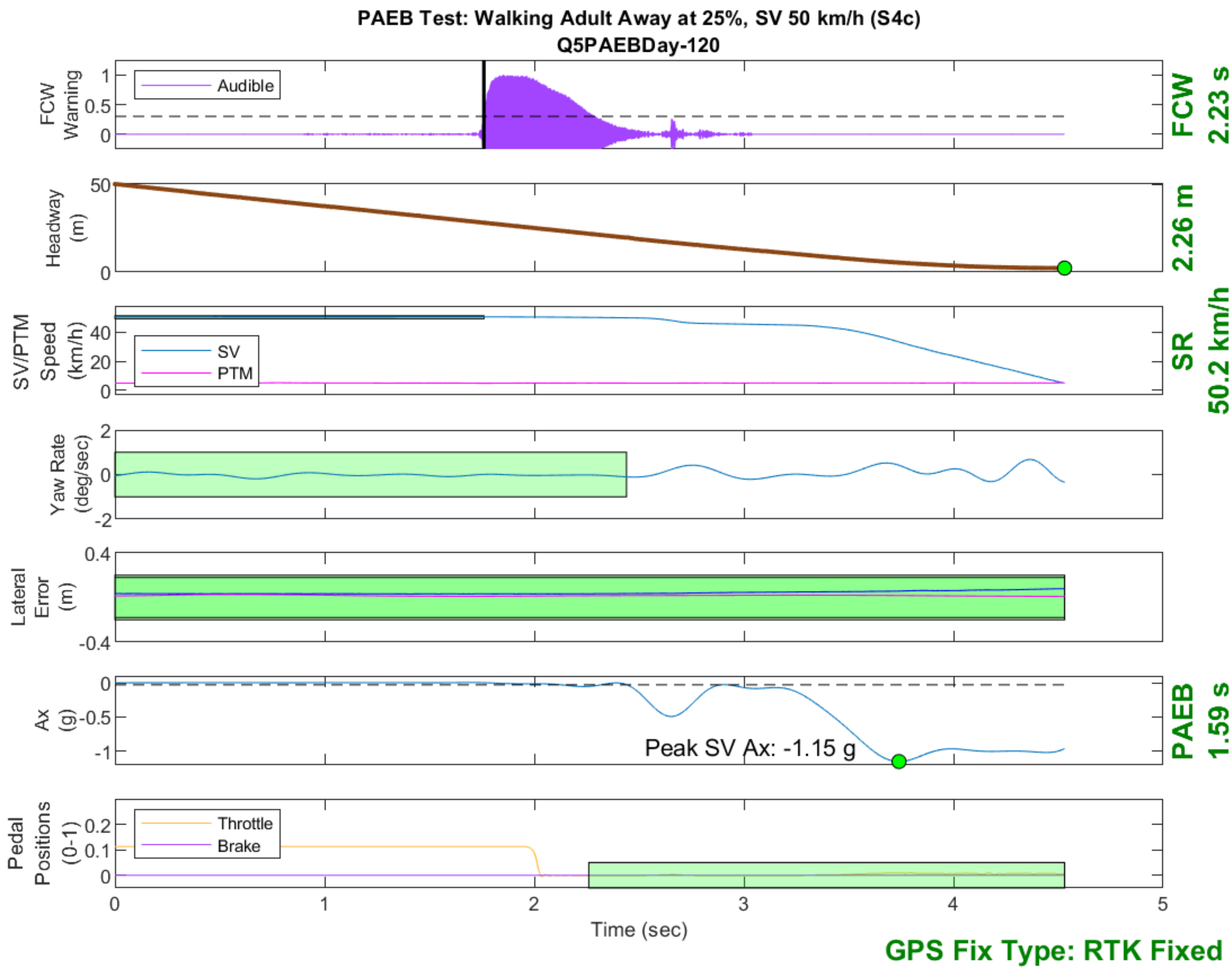

Figure D149. Time History for PAEB Run 120, S4c, Daytime, 50 km/h

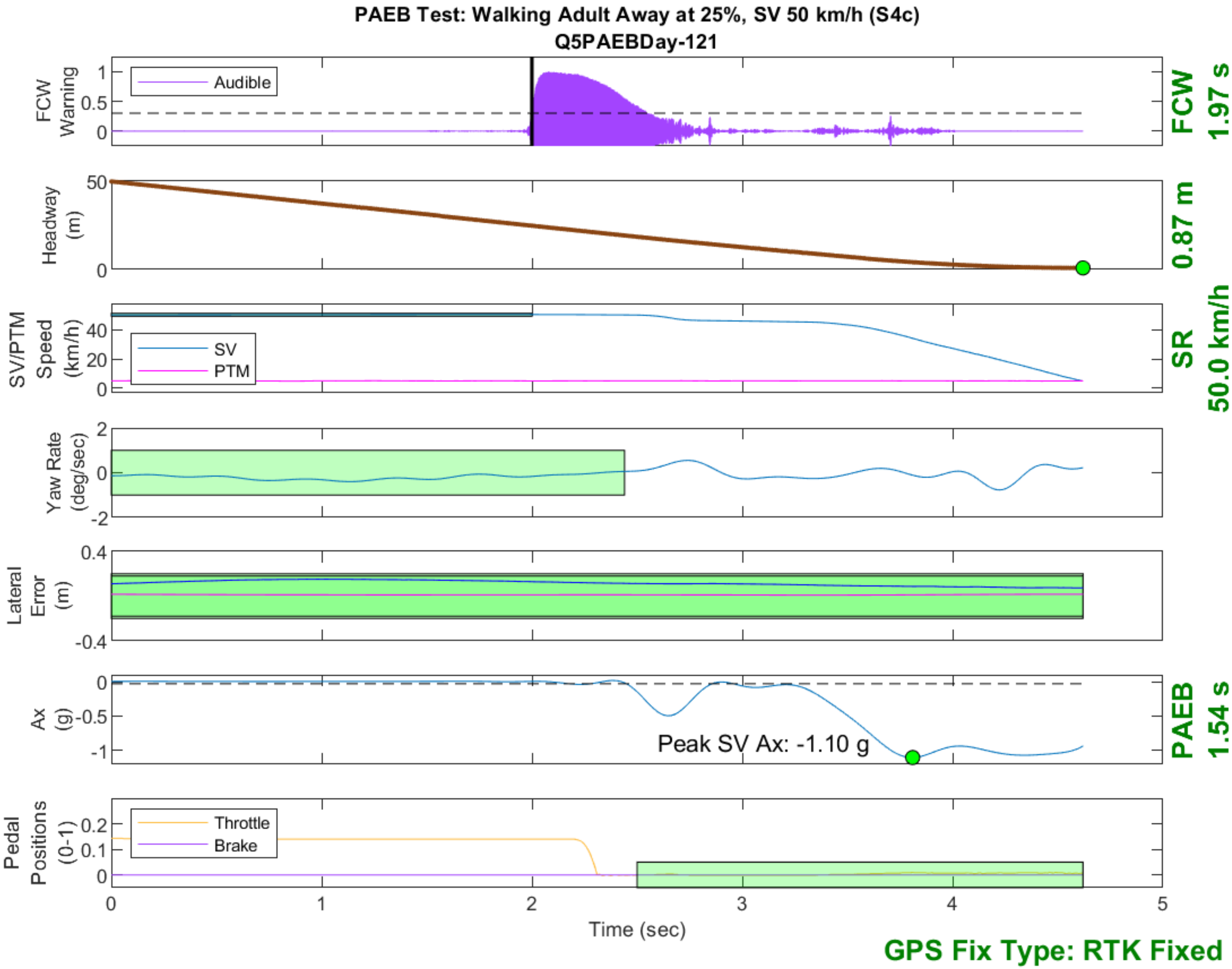

Figure D150. Time History for PAEB Run 121, S4c, Daytime, 50 km/h

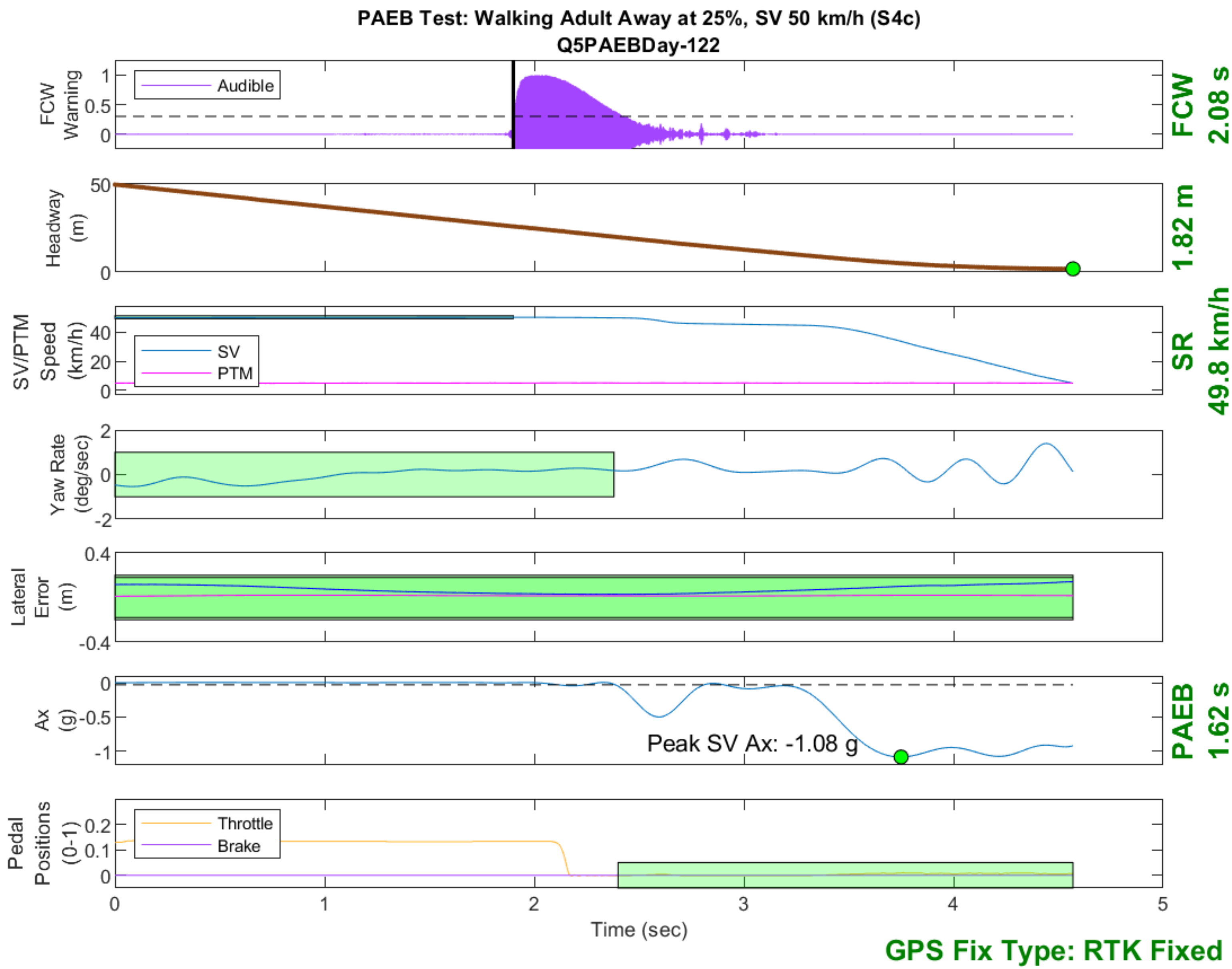

Figure D151. Time History for PAEB Run 122, S4c, Daytime, 50 km/h

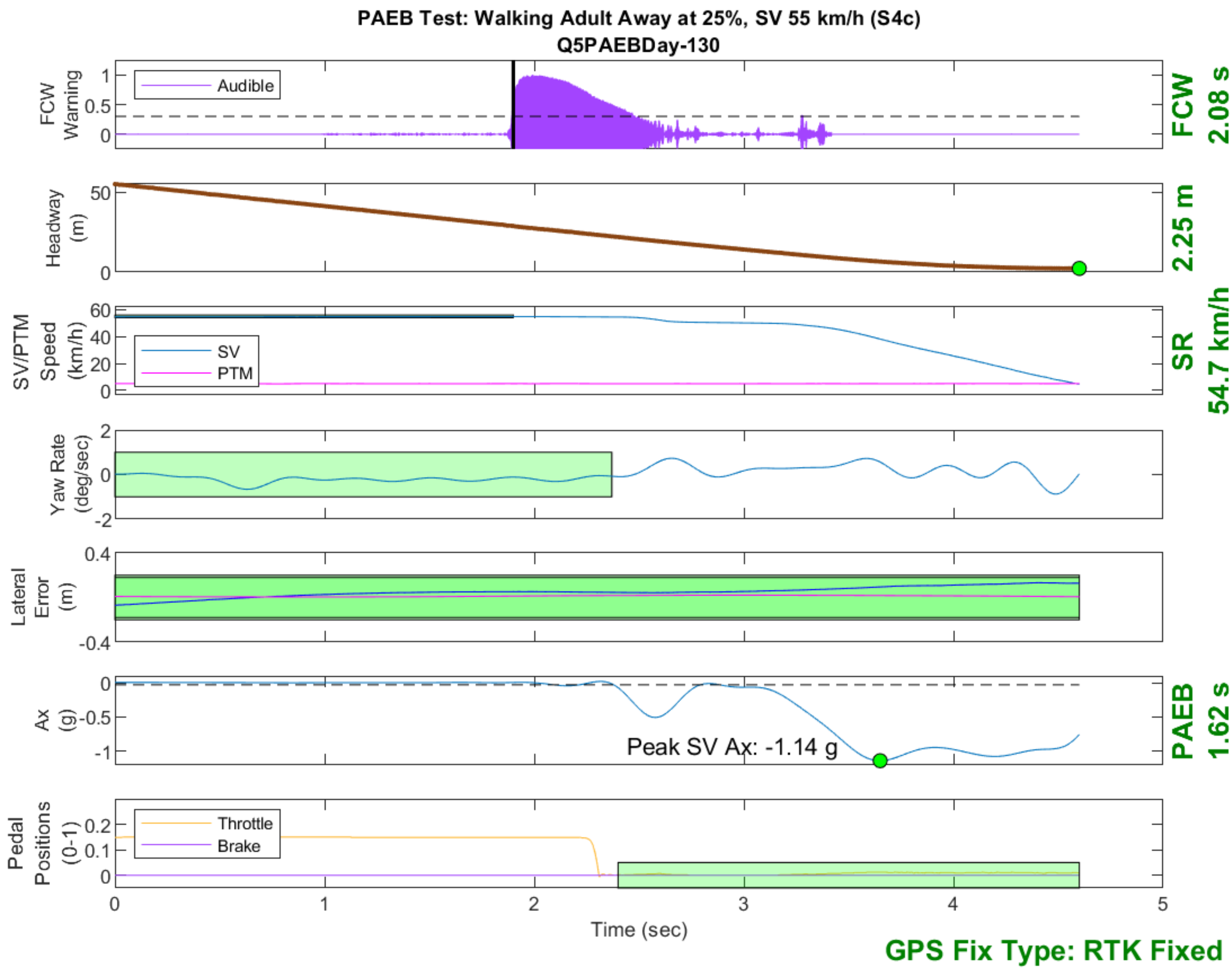

Figure D152. Time History for PAEB Run 130, S4c, Daytime, 55 km/h

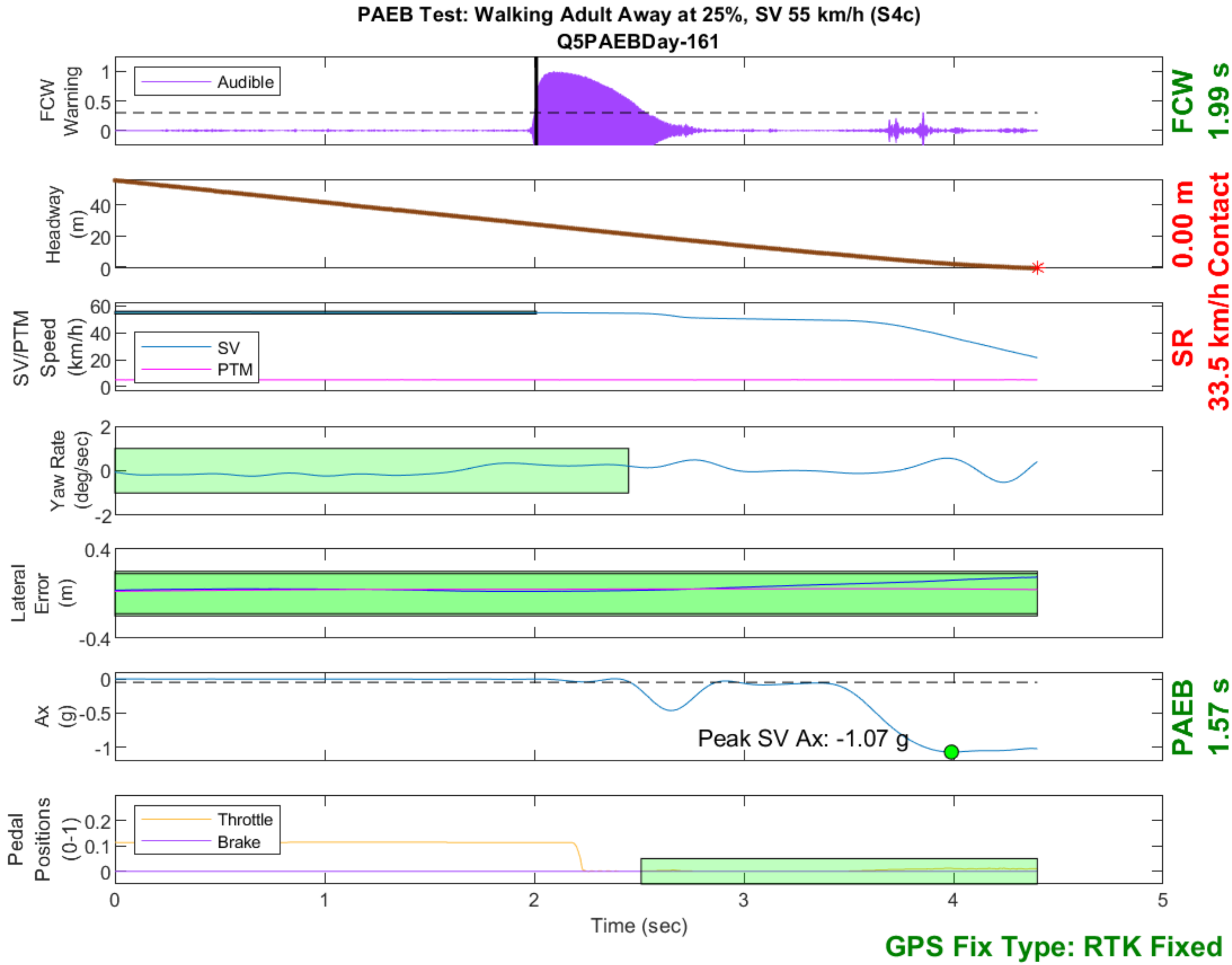

Figure D153. Time History for PAEB Run 161, S4c, Daytime, 55 km/h

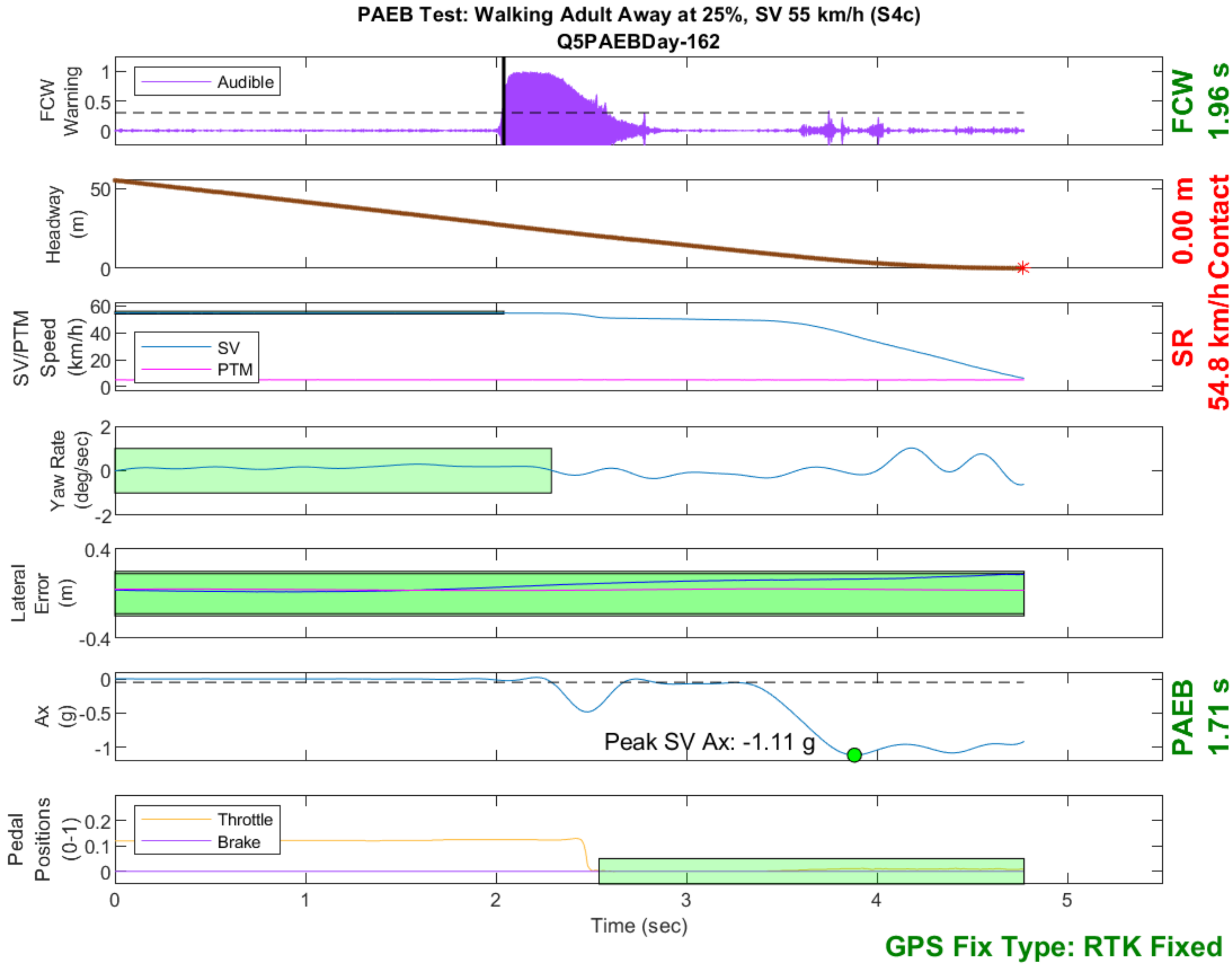

Figure D154. Time History for PAEB Run 162, S4c, Daytime, 55 km/h

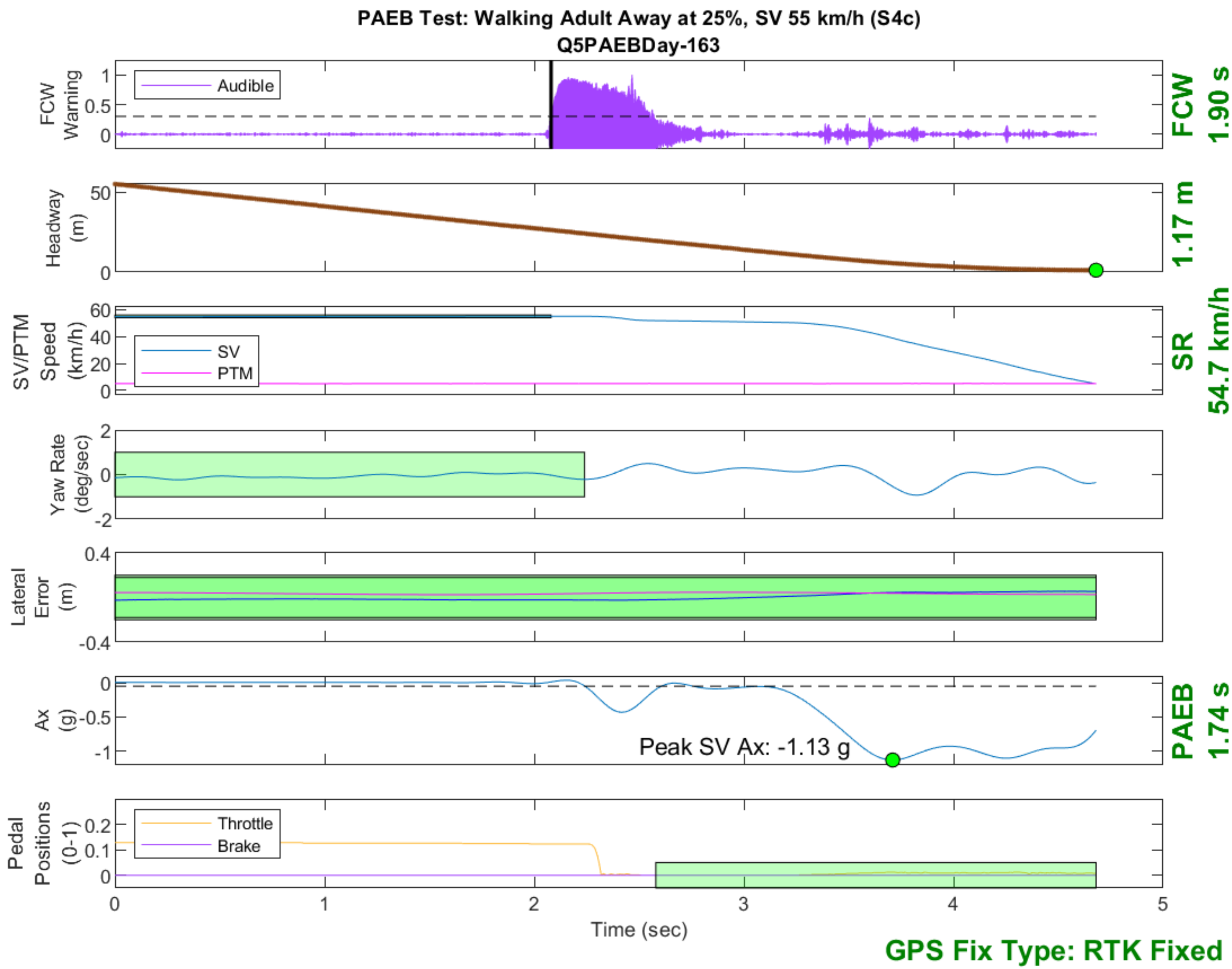

Figure D155. Time History for PAEB Run 163, S4c, Daytime, 55 km/h

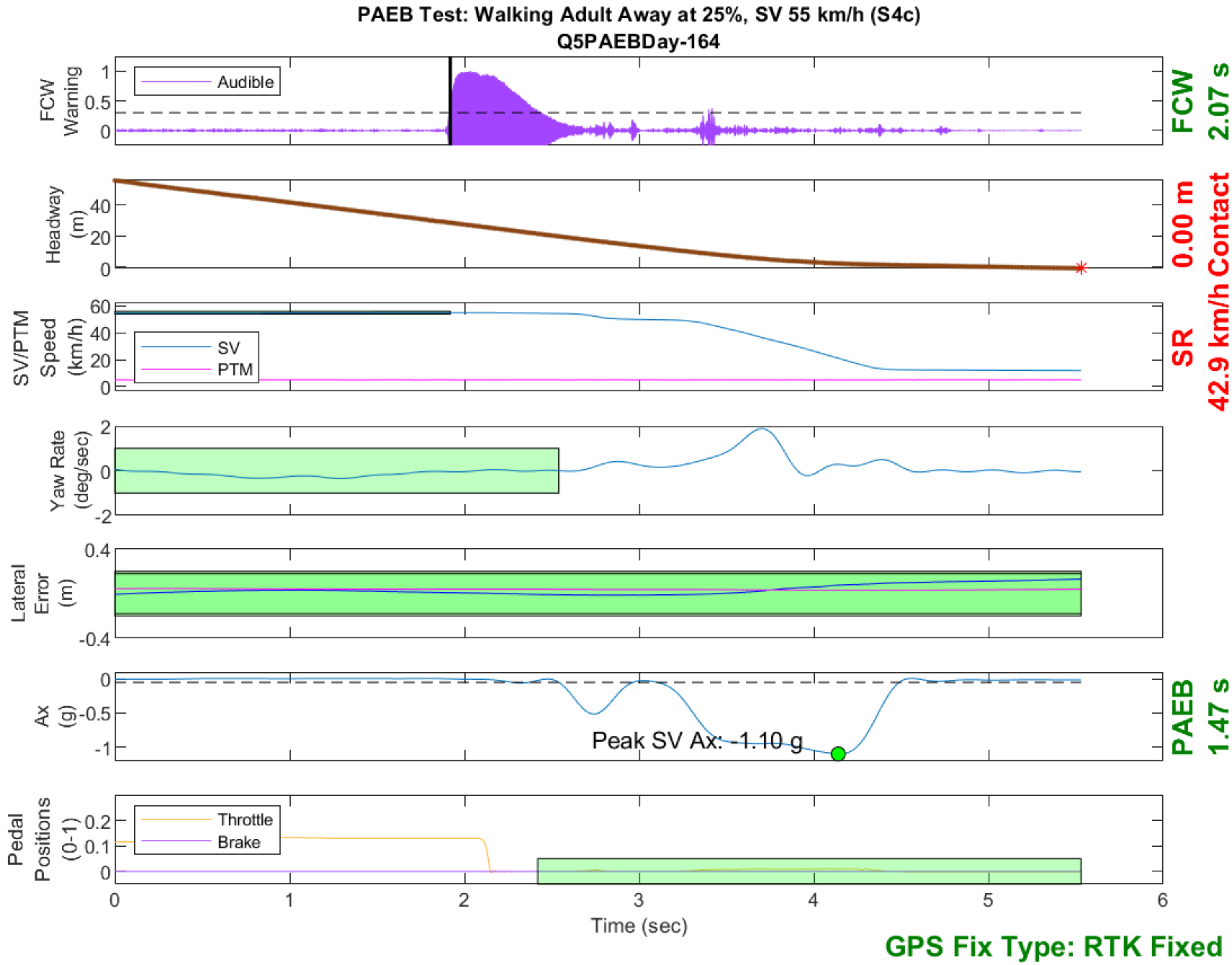

Figure D156. Time History for PAEB Run 164, S4c, Daytime, 55 km/h

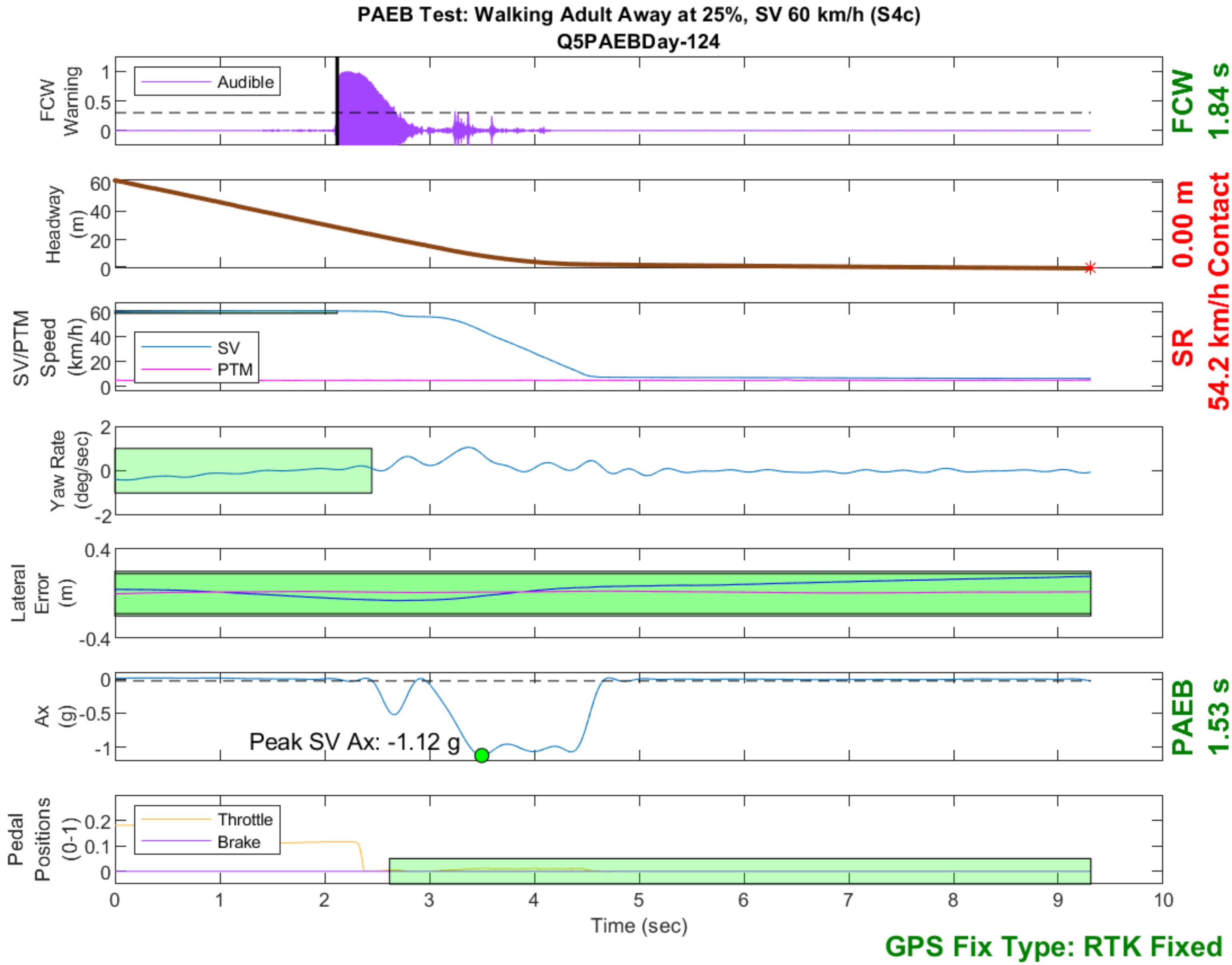

Figure D157. Time History for PAEB Run 124, S4c, Daytime, 60 km/h

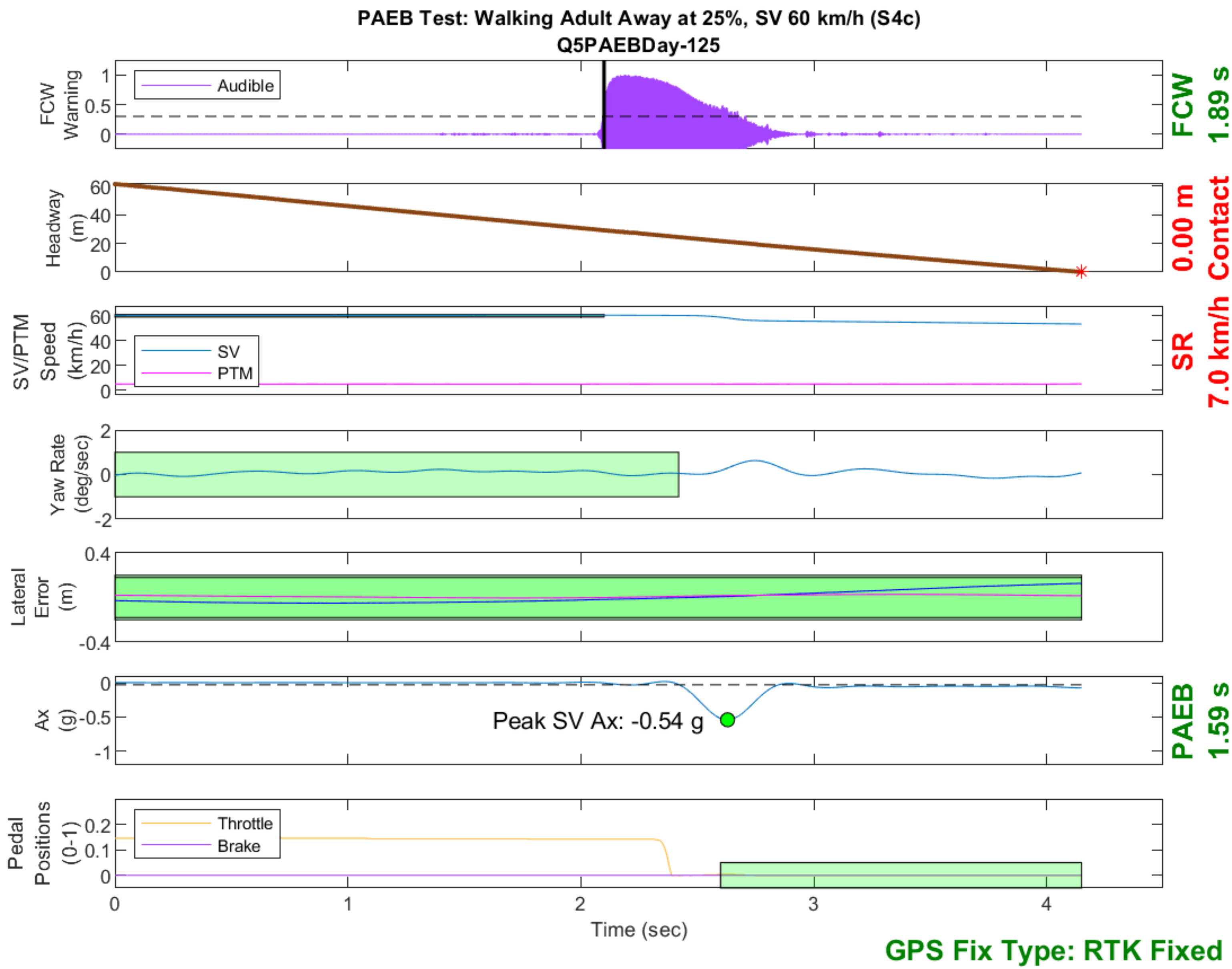

Figure D158. Time History for PAEB Run 125, S4c, Daytime, 60 km/h

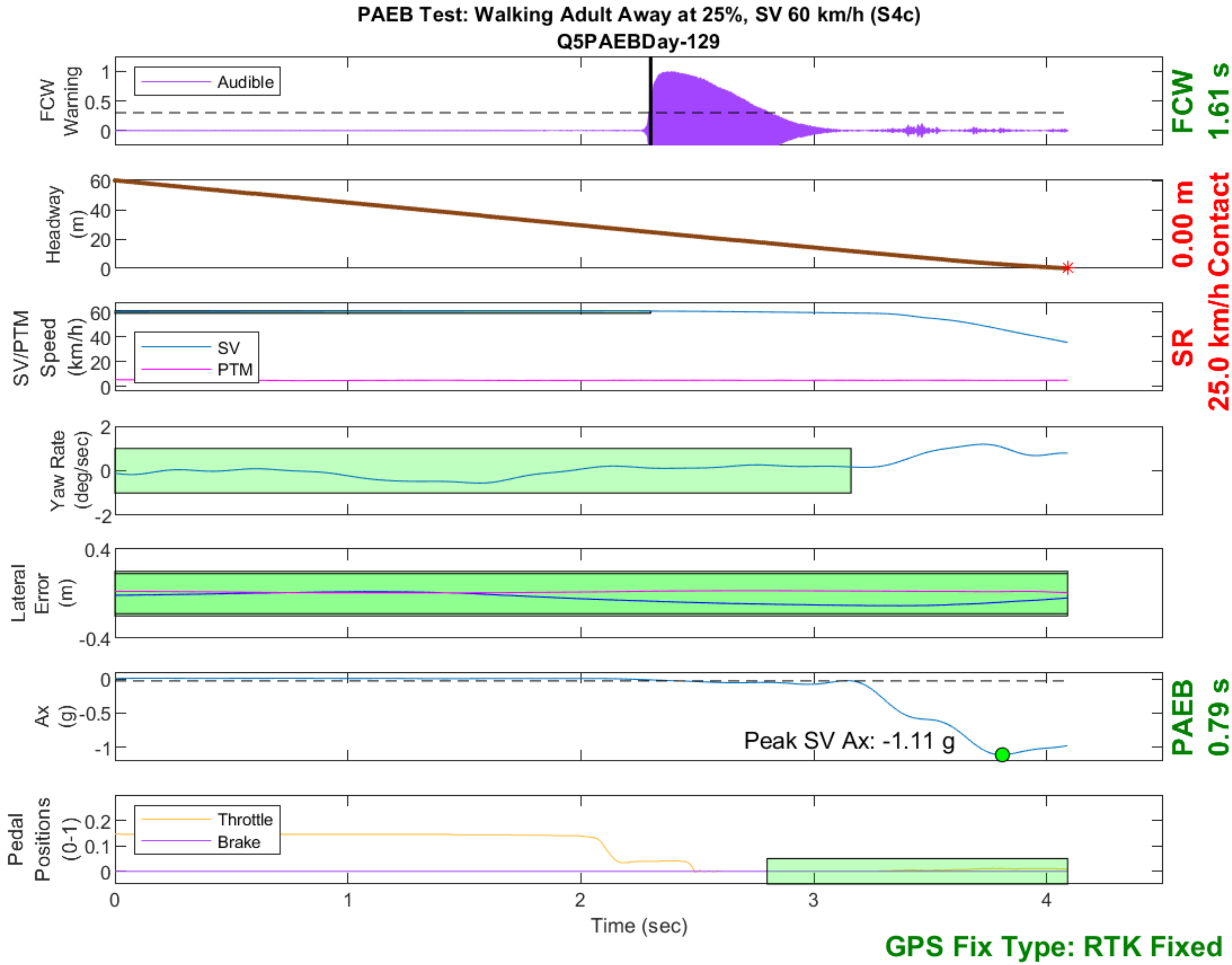

Figure D159. Time History for PAEB Run 129, S4c, Daytime, 60 km/h

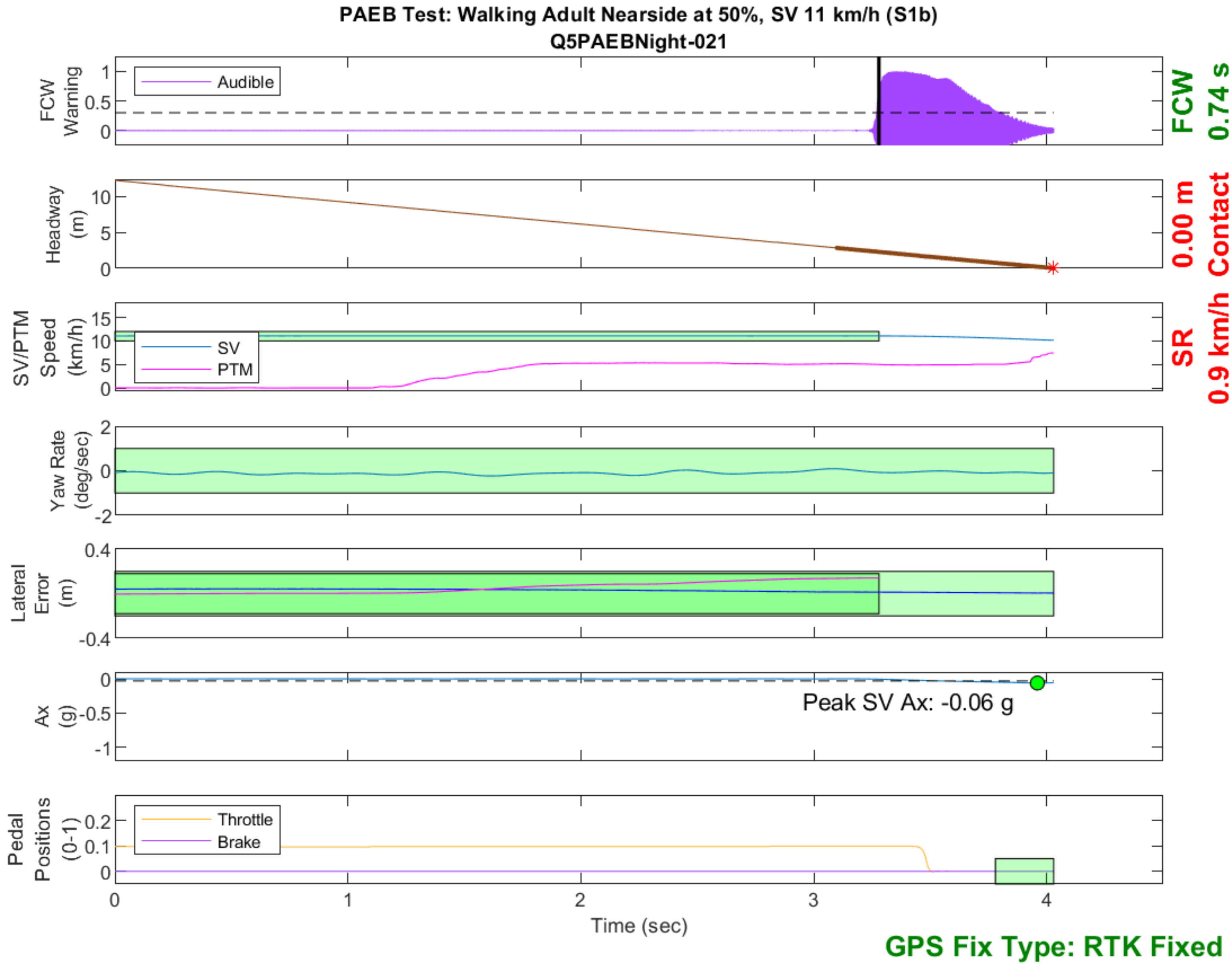

Figure D160. Time History for PAEB Run 21, S1b, Night, High Beam, 11 km/h

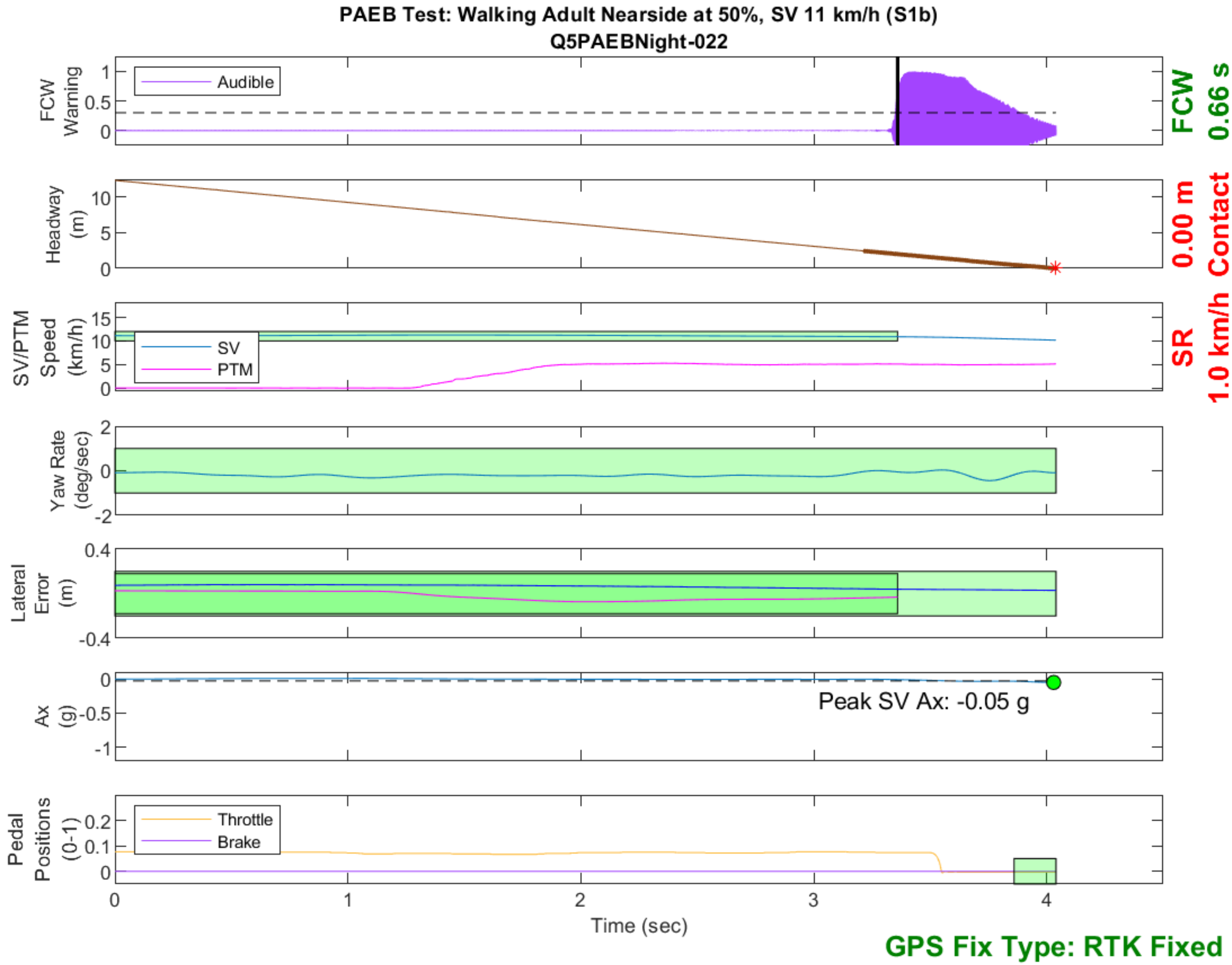

Figure D161. Time History for PAEB Run 22, S1b, Night, High Beam, 11 km/h

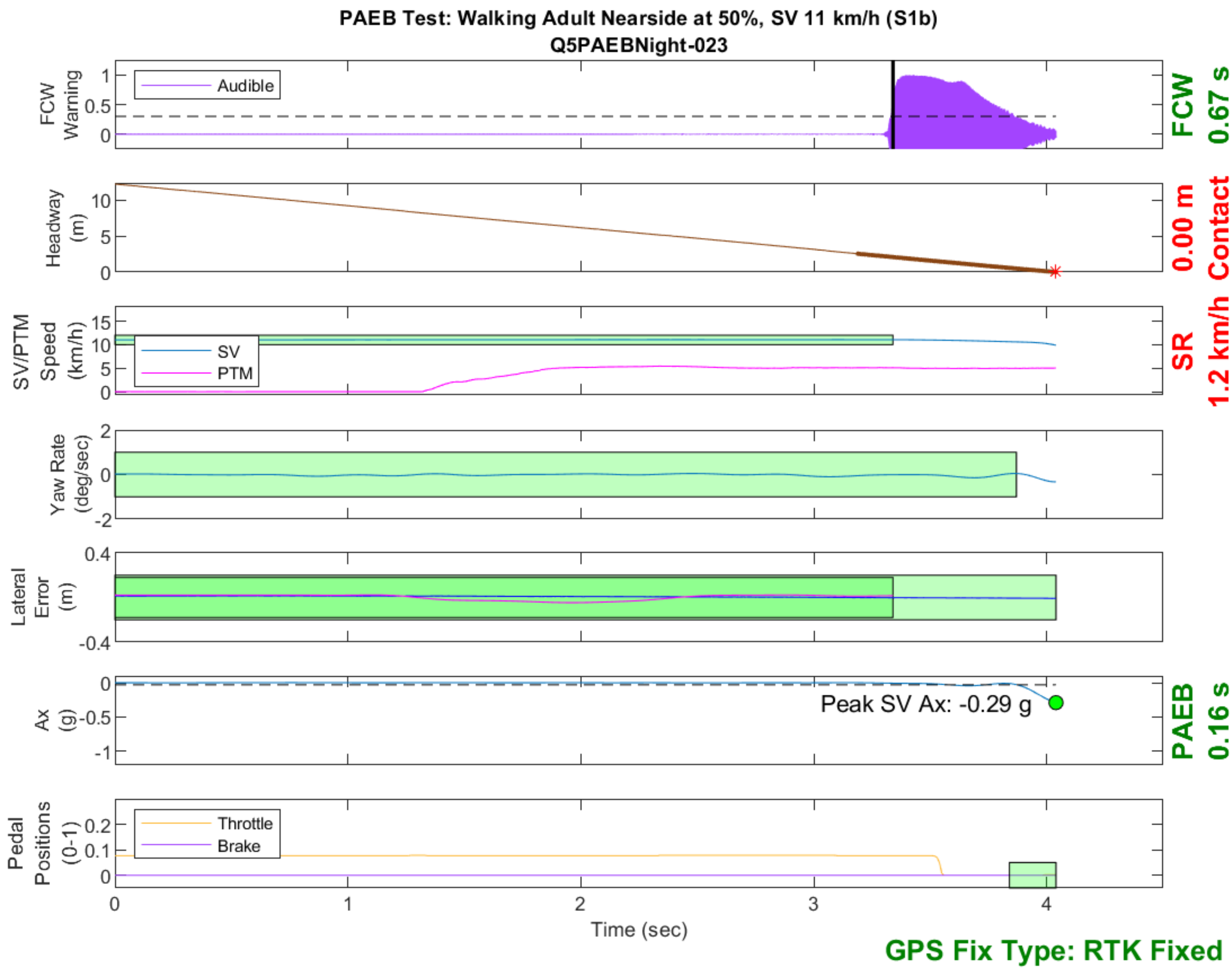

Figure D162. Time History for PAEB Run 23, S1b, Night, High Beam, 11 km/h

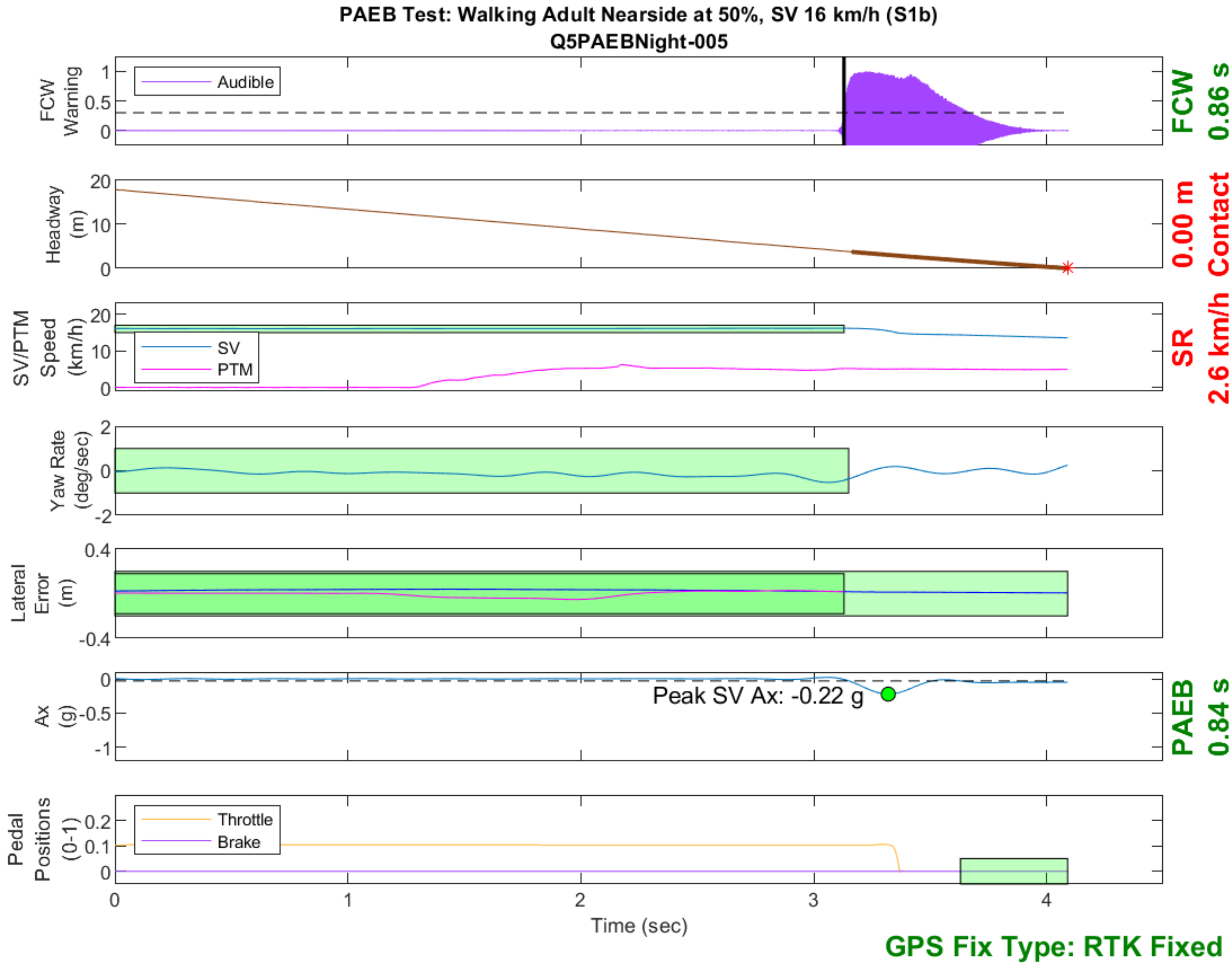

Figure D163. Time History for PAEB Run 5, S1b, Night, High Beam, 16 km/h

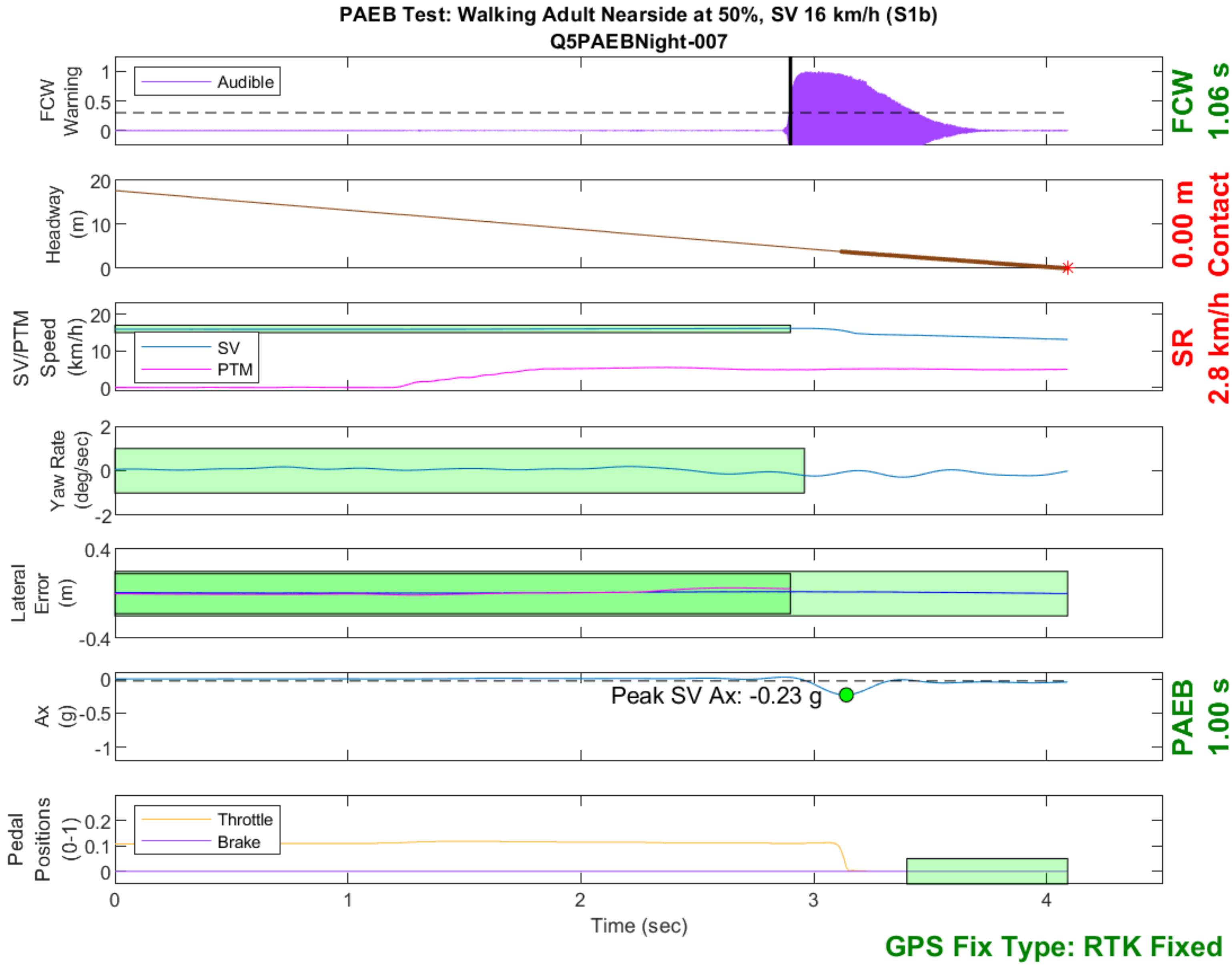

Figure D164. Time History for PAEB Run 7, S1b, Night, High Beam, 16 km/h

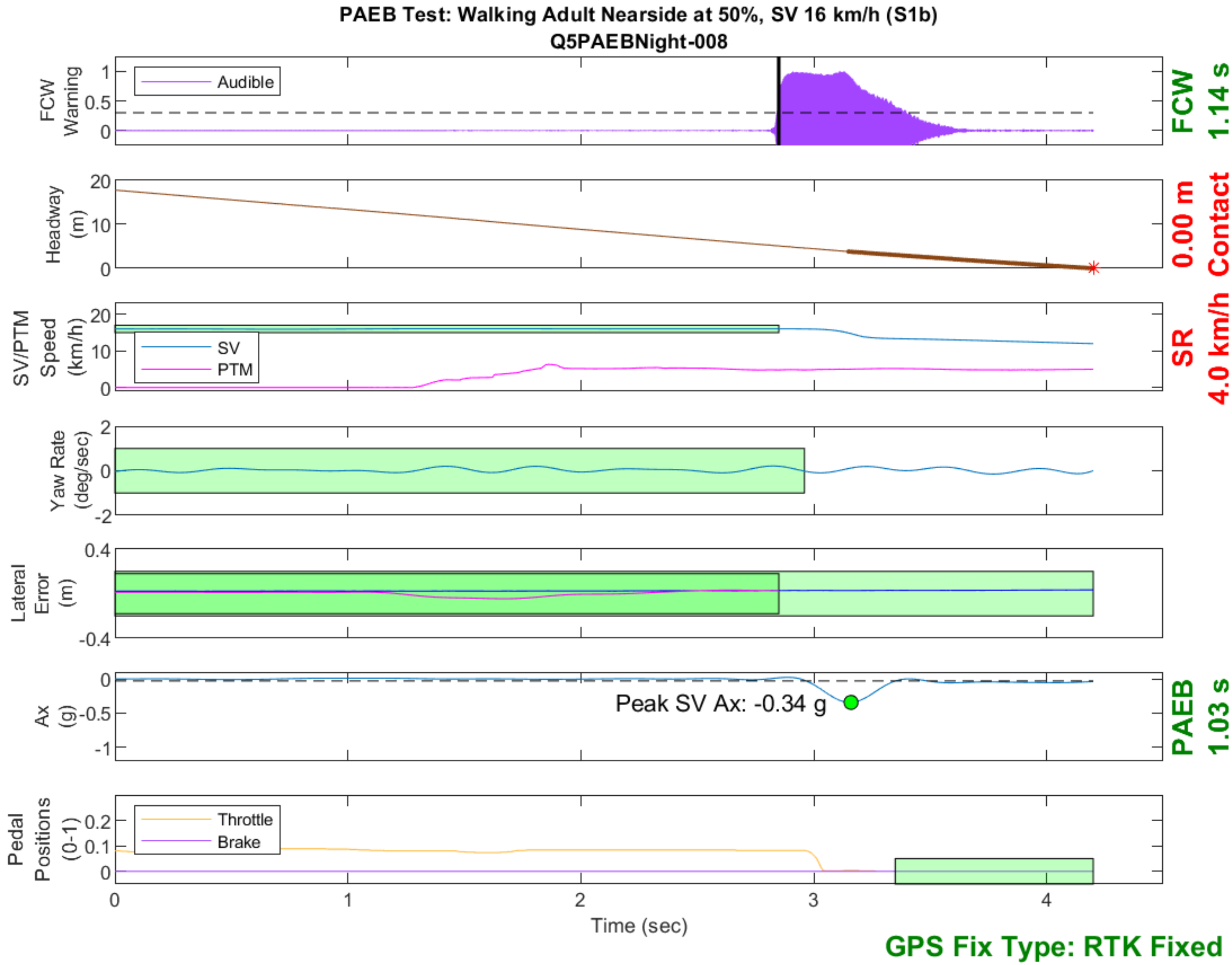

Figure D165. Time History for PAEB Run 8, S1b, Night, High Beam, 16 km/h

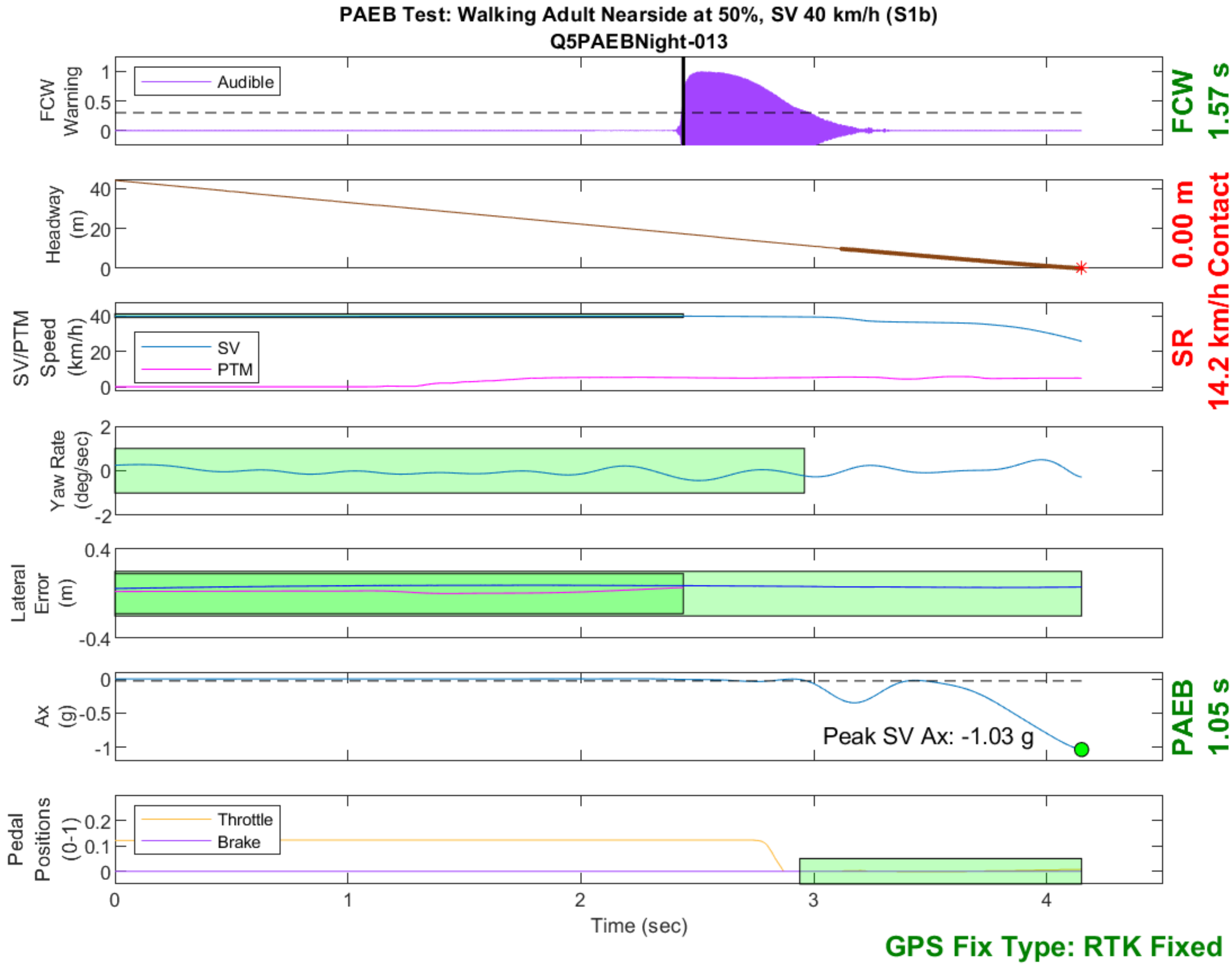

Figure D166. Time History for PAEB Run 13, S1b, Night, High Beam, 40 km/h

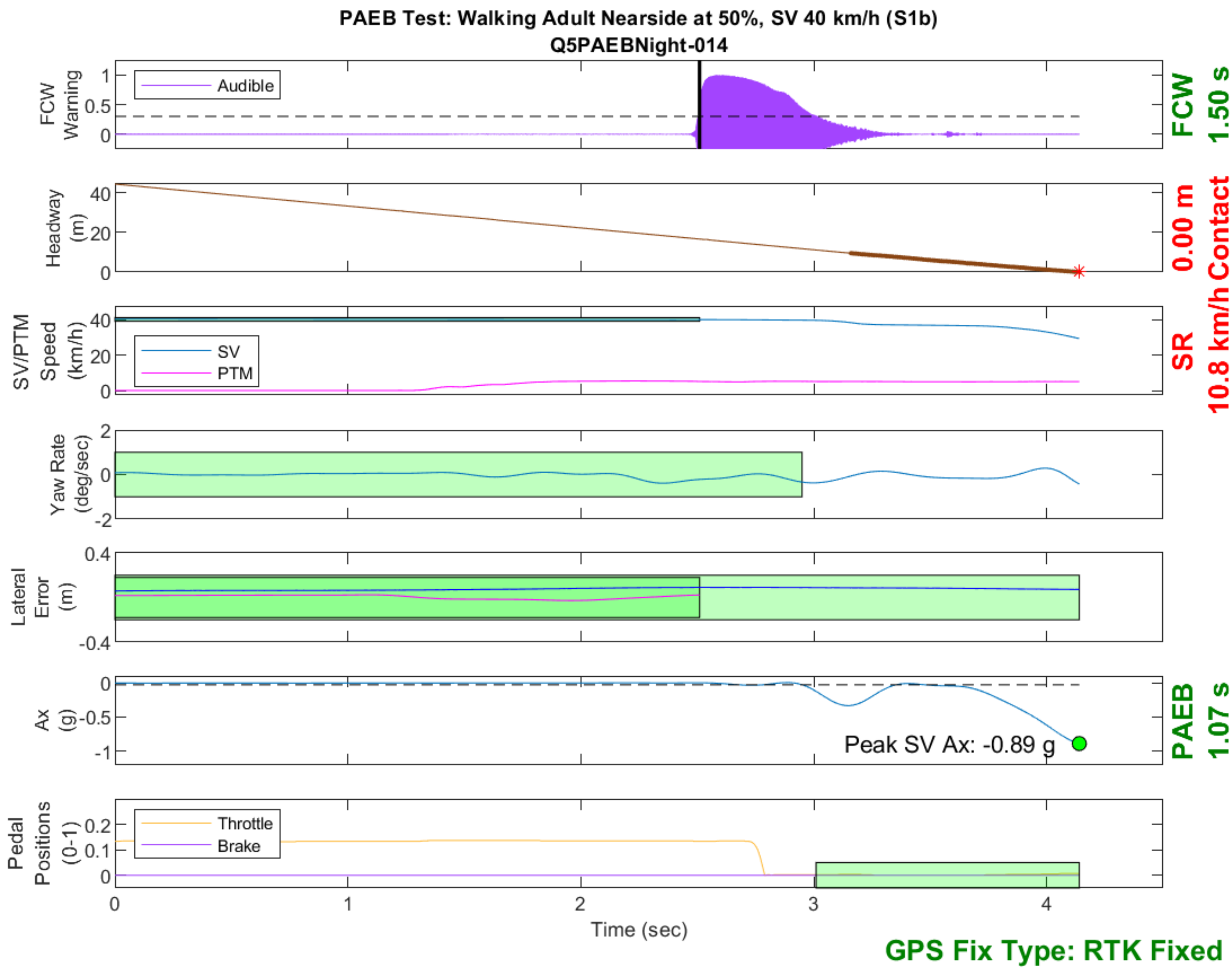

Figure D167. Time History for PAEB Run 14, S1b, Night, High Beam, 40 km/h

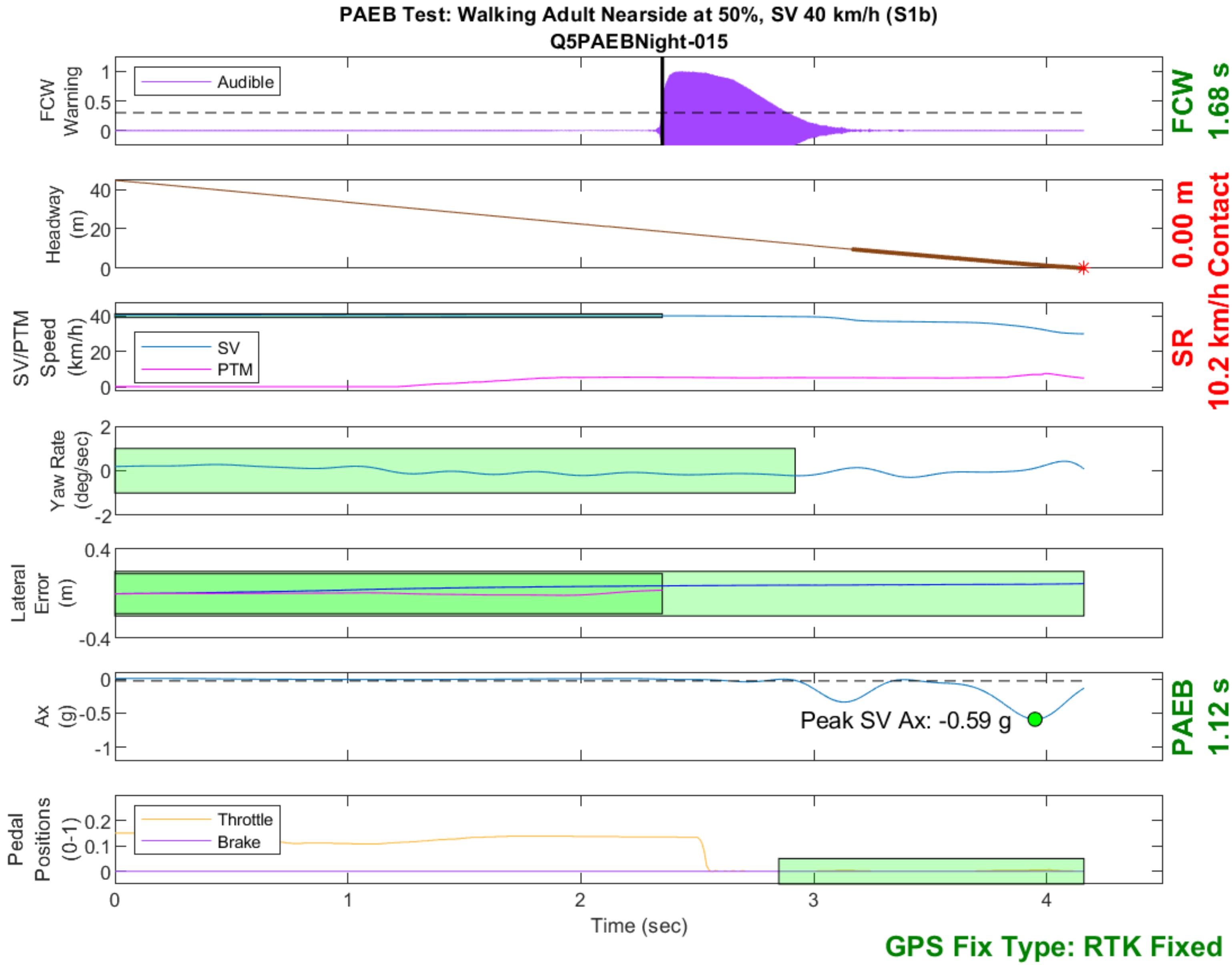

Figure D168. Time History for PAEB Run 15, S1b, Night, High Beam, 40 km/h

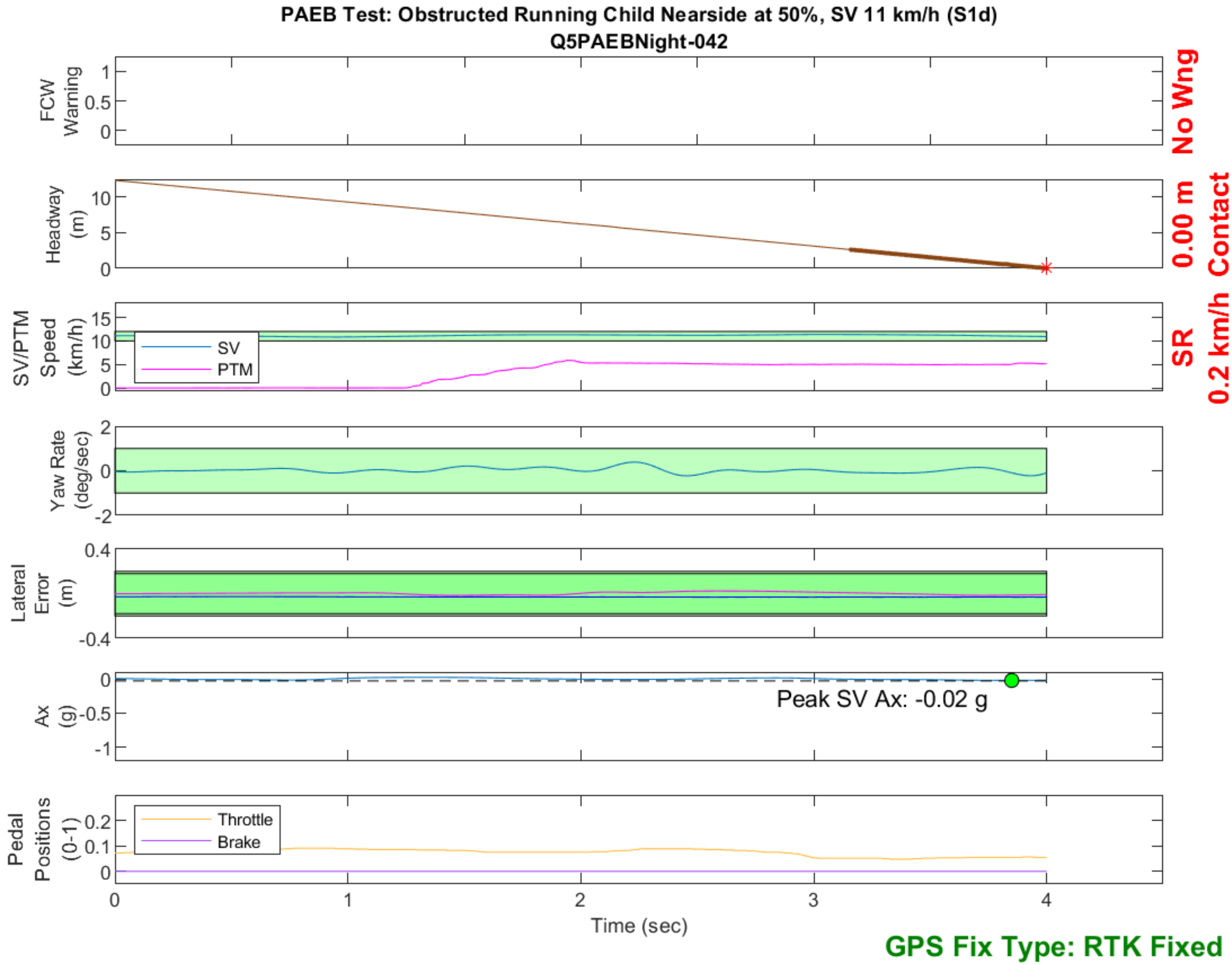

Figure D169. Time History for PAEB Run 42, S1d, Night, High Beam, 11 km/h

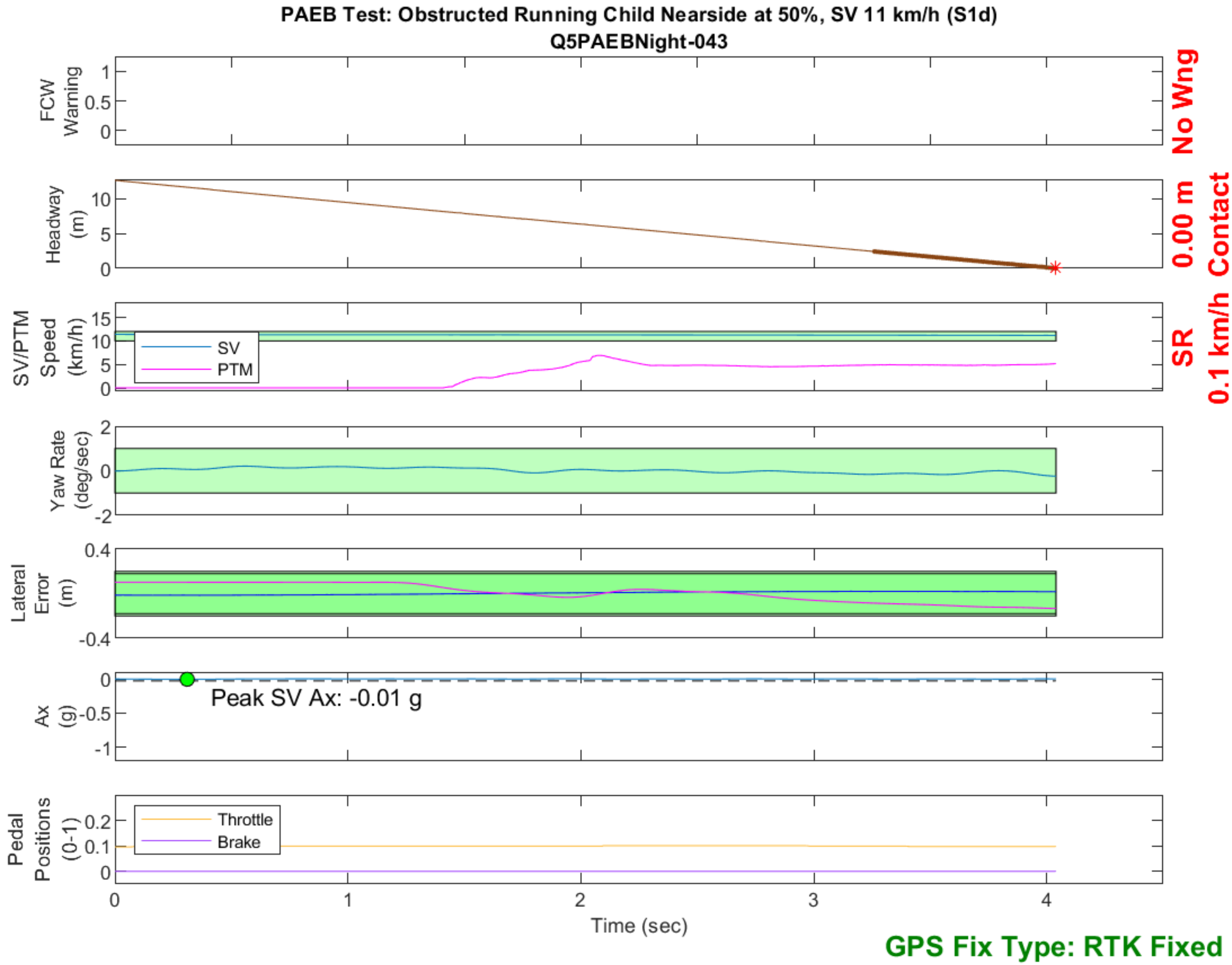

Figure D170. Time History for PAEB Run 43, S1d, Night, High Beam, 11 km/h

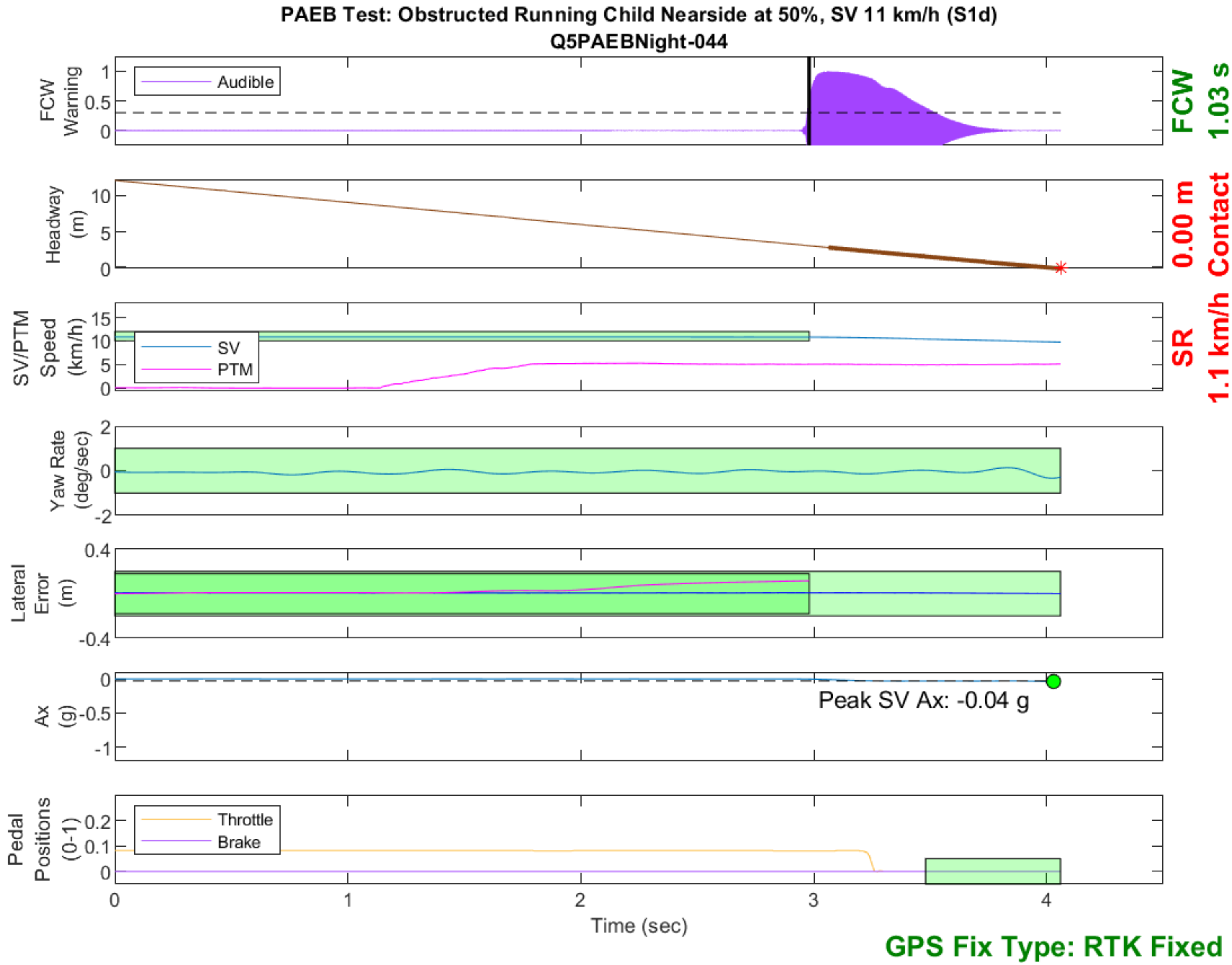

Figure D171. Time History for PAEB Run 44, S1d, Night, High Beam, 11 km/h

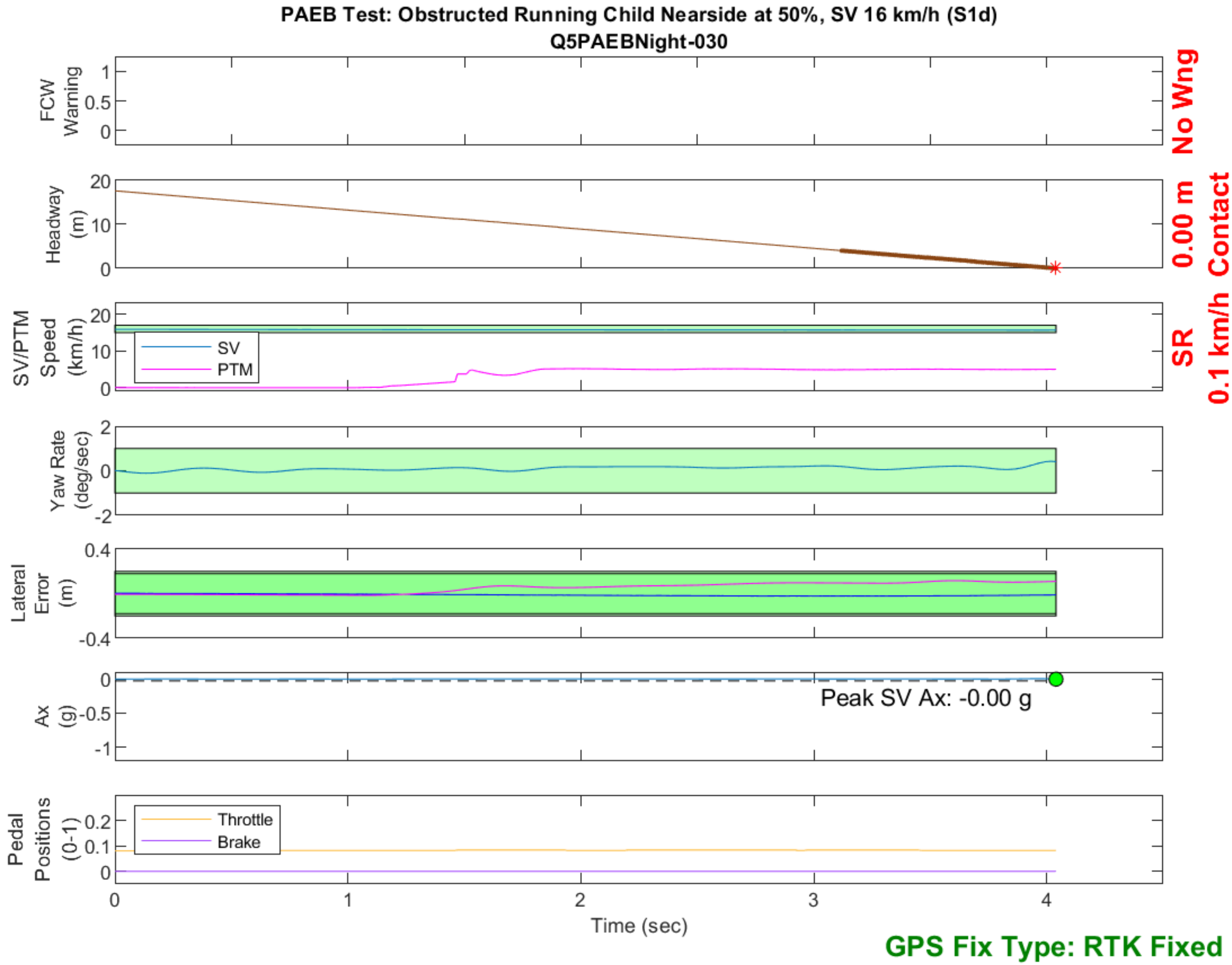

Figure D172. Time History for PAEB Run 30, S1d, Night, High Beam, 16 km/h

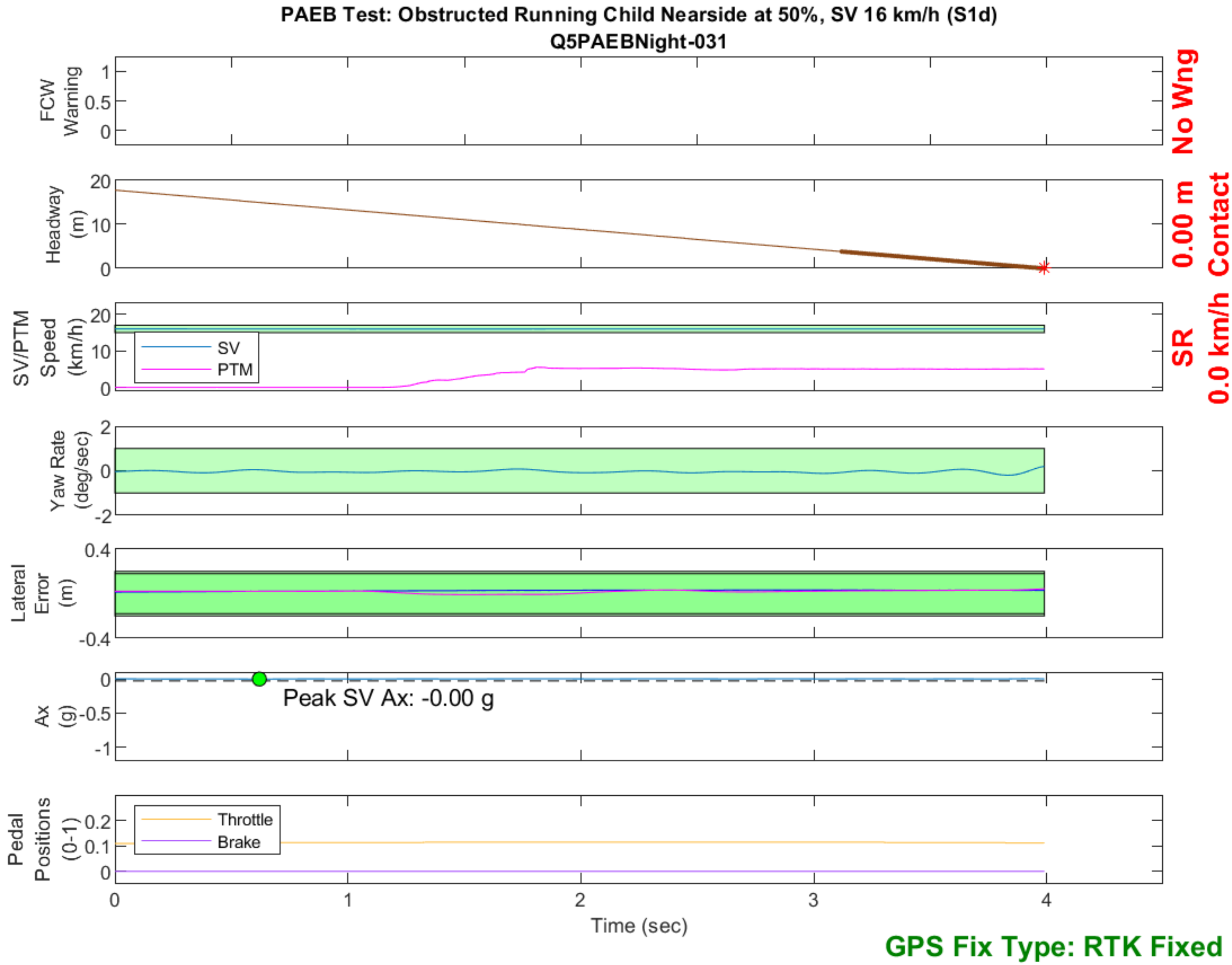

Figure D173. Time History for PAEB Run 31, S1d, Night, High Beam, 16 km/h

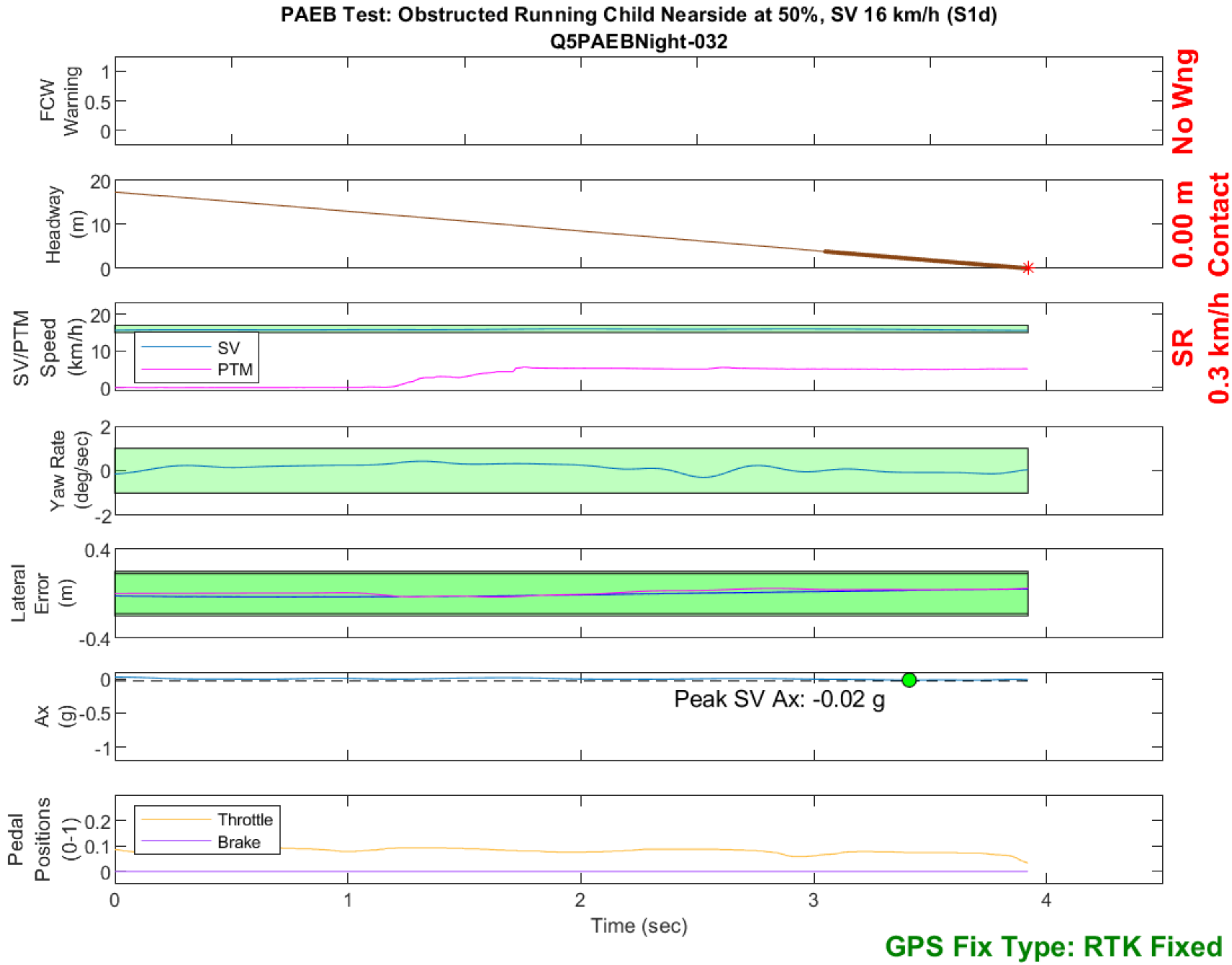

Figure D174. Time History for PAEB Run 32, S1d, Night, High Beam, 16 km/h

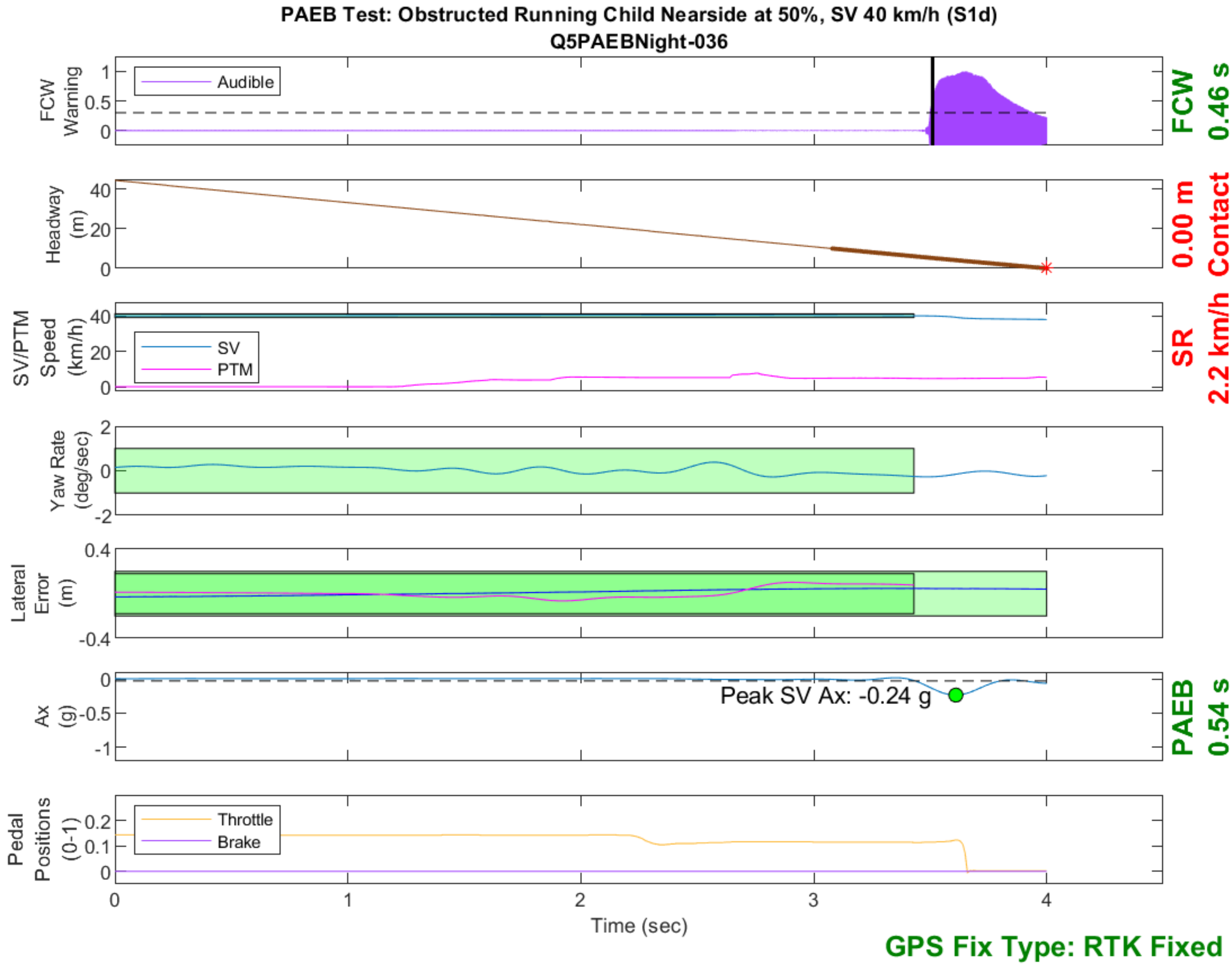

Figure D175. Time History for PAEB Run 36, S1d, Night, High Beam, 40 km/h

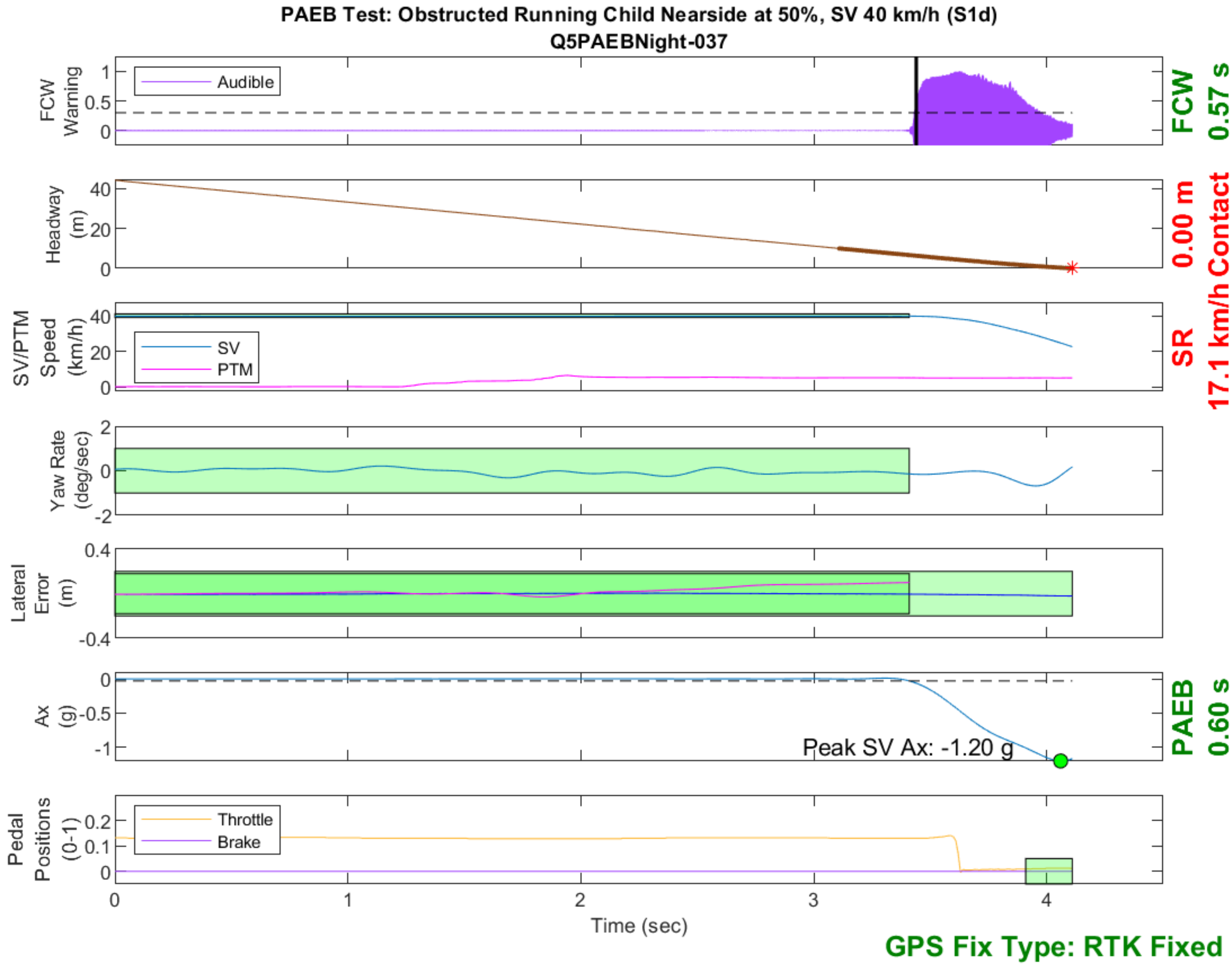

Figure D176. Time History for PAEB Run 37, S1d, Night, High Beam, 40 km/h

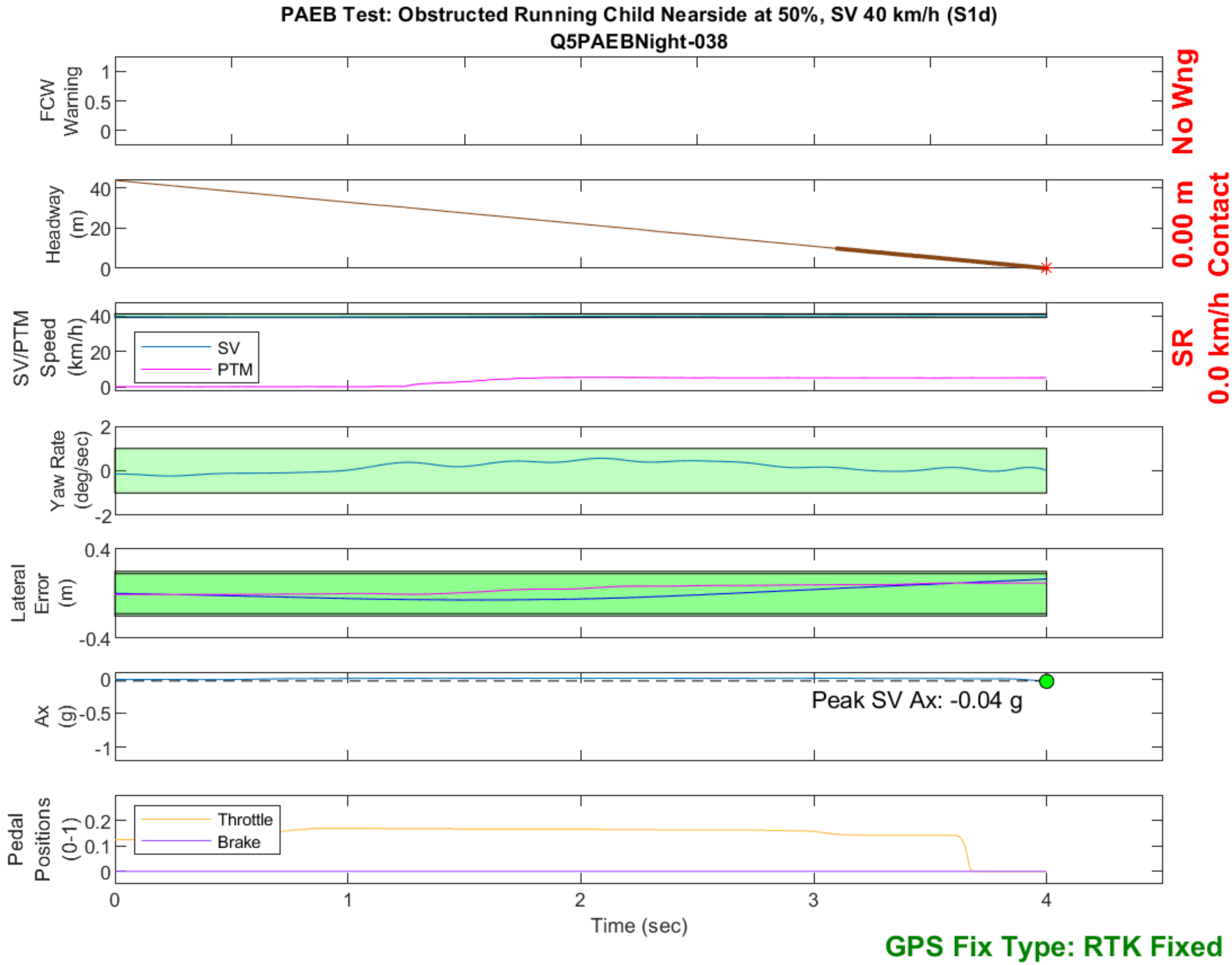

Figure D177. Time History for PAEB Run 38, S1d, Night, High Beam, 40 km/h

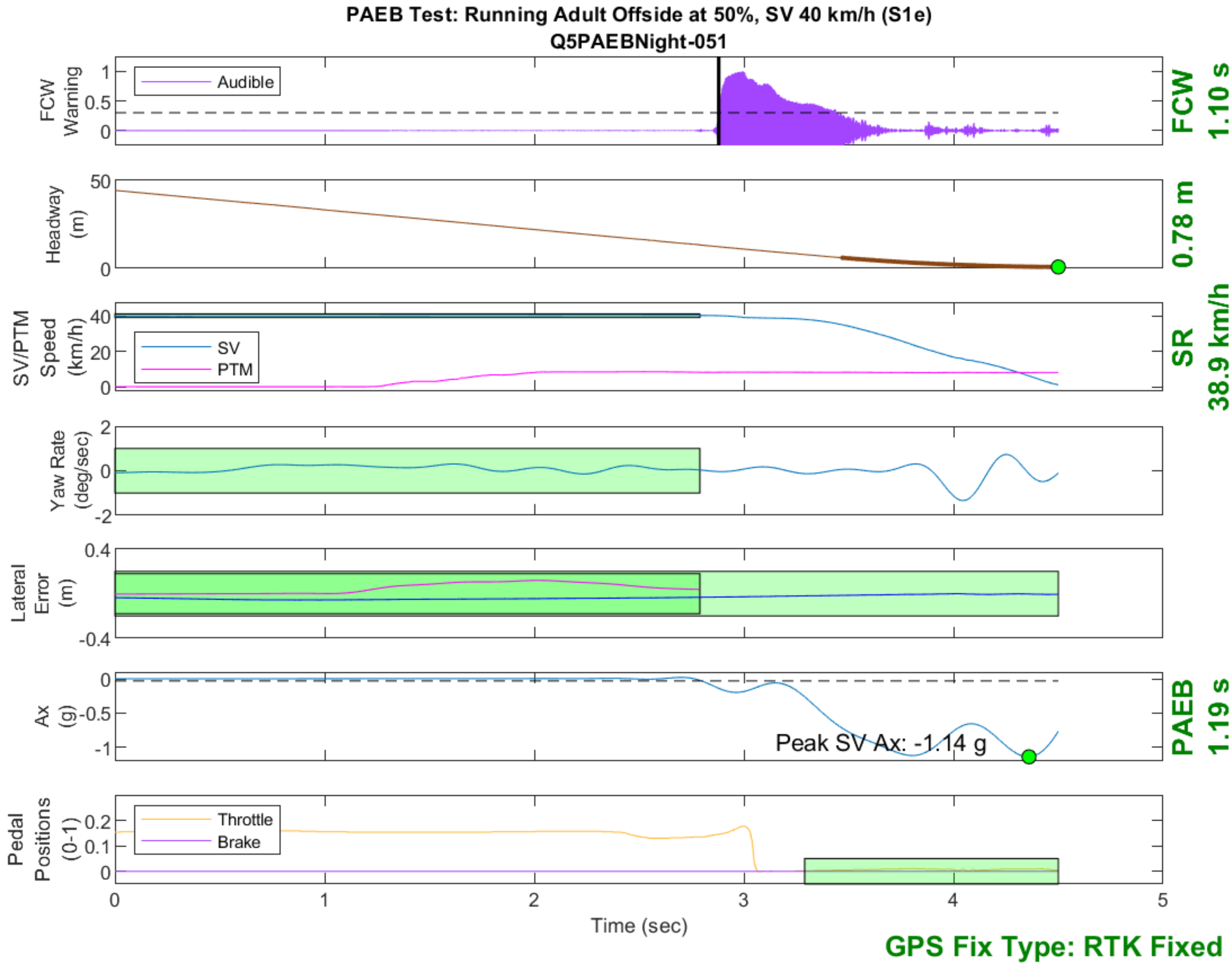

Figure D178. Time History for PAEB Run 51, S1e, Night, High Beam, 40 km/h

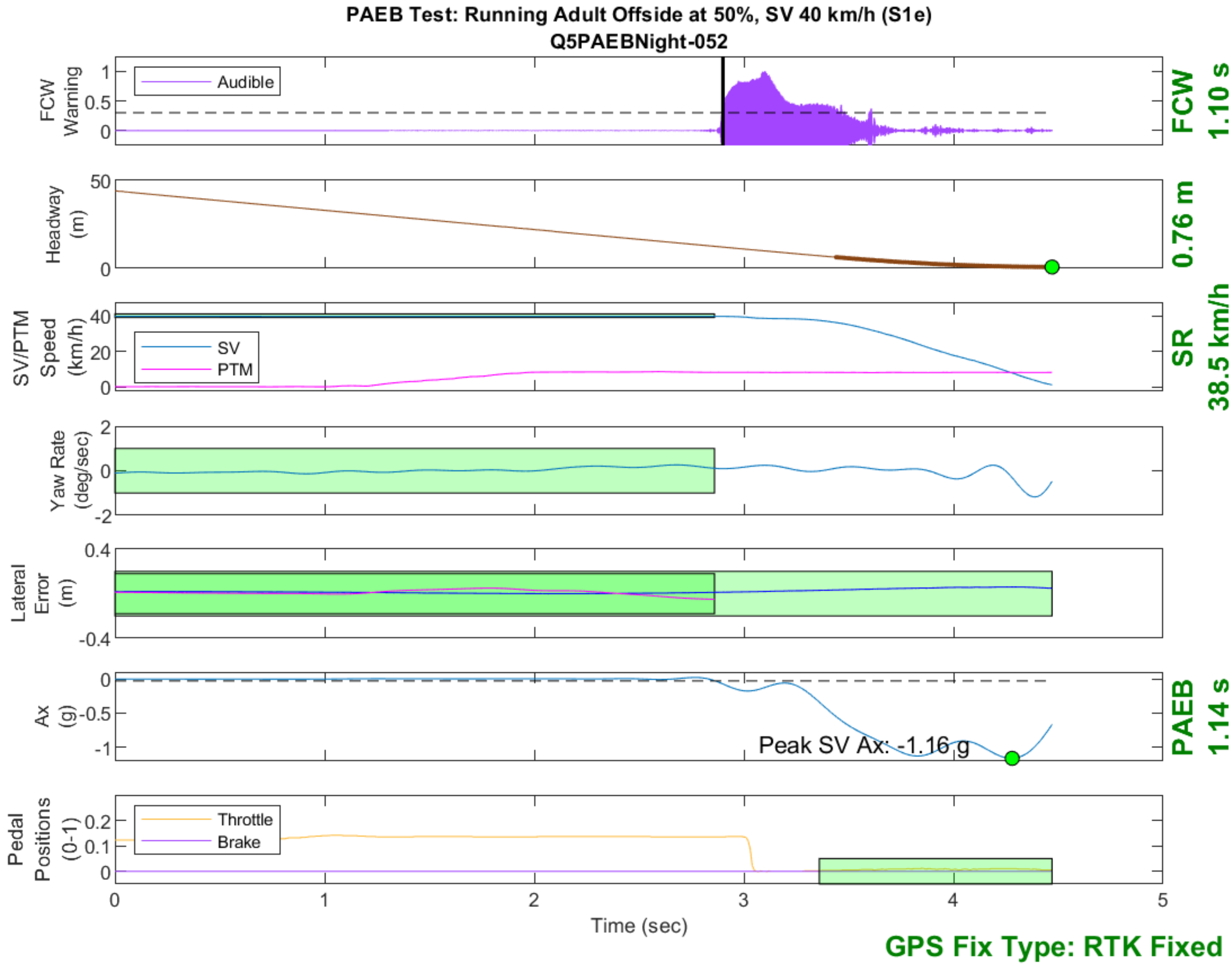

Figure D179. Time History for PAEB Run 52, S1e, Night, High Beam, 40 km/h

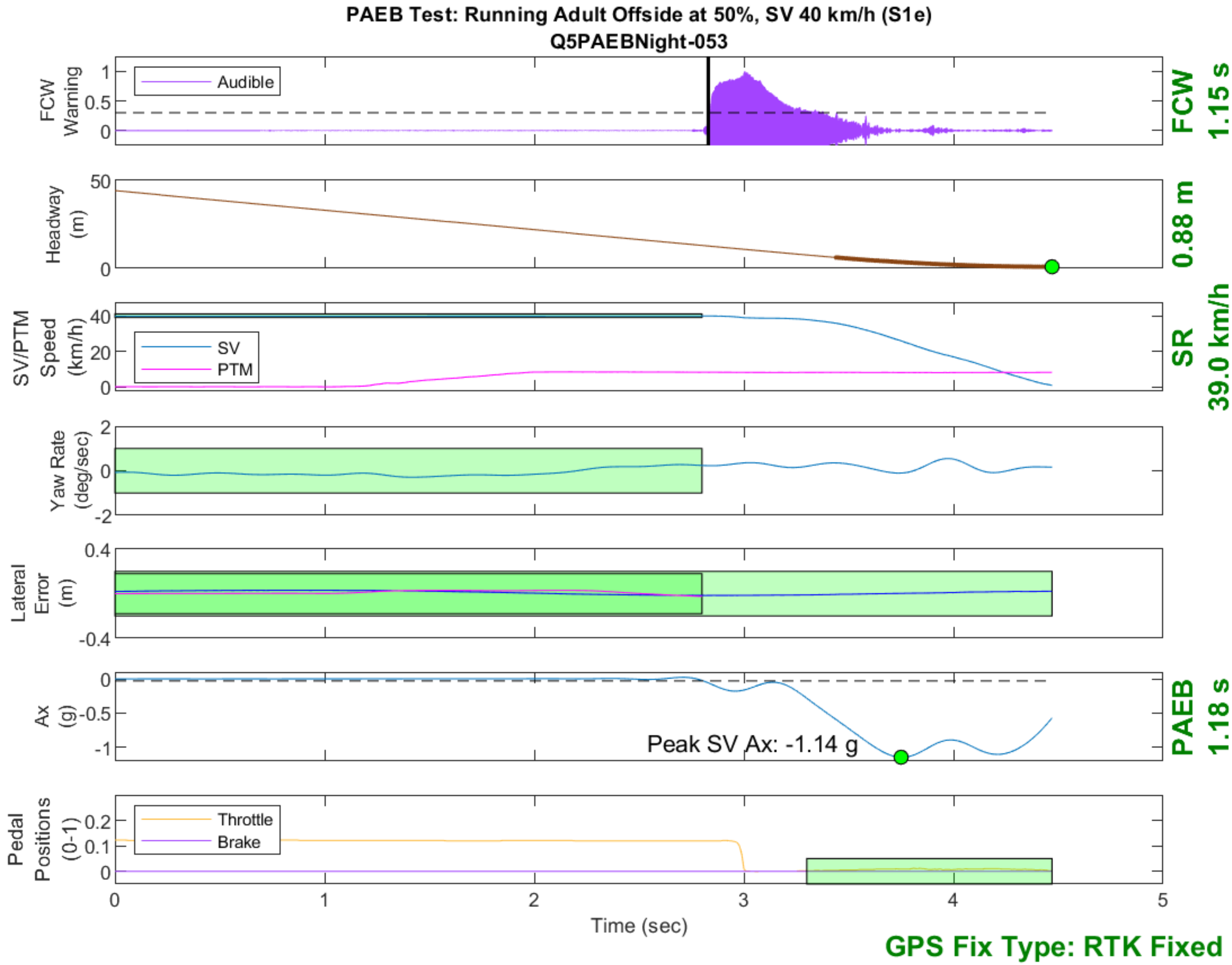

Figure D180. Time History for PAEB Run 53, S1e, Night, High Beam, 40 km/h

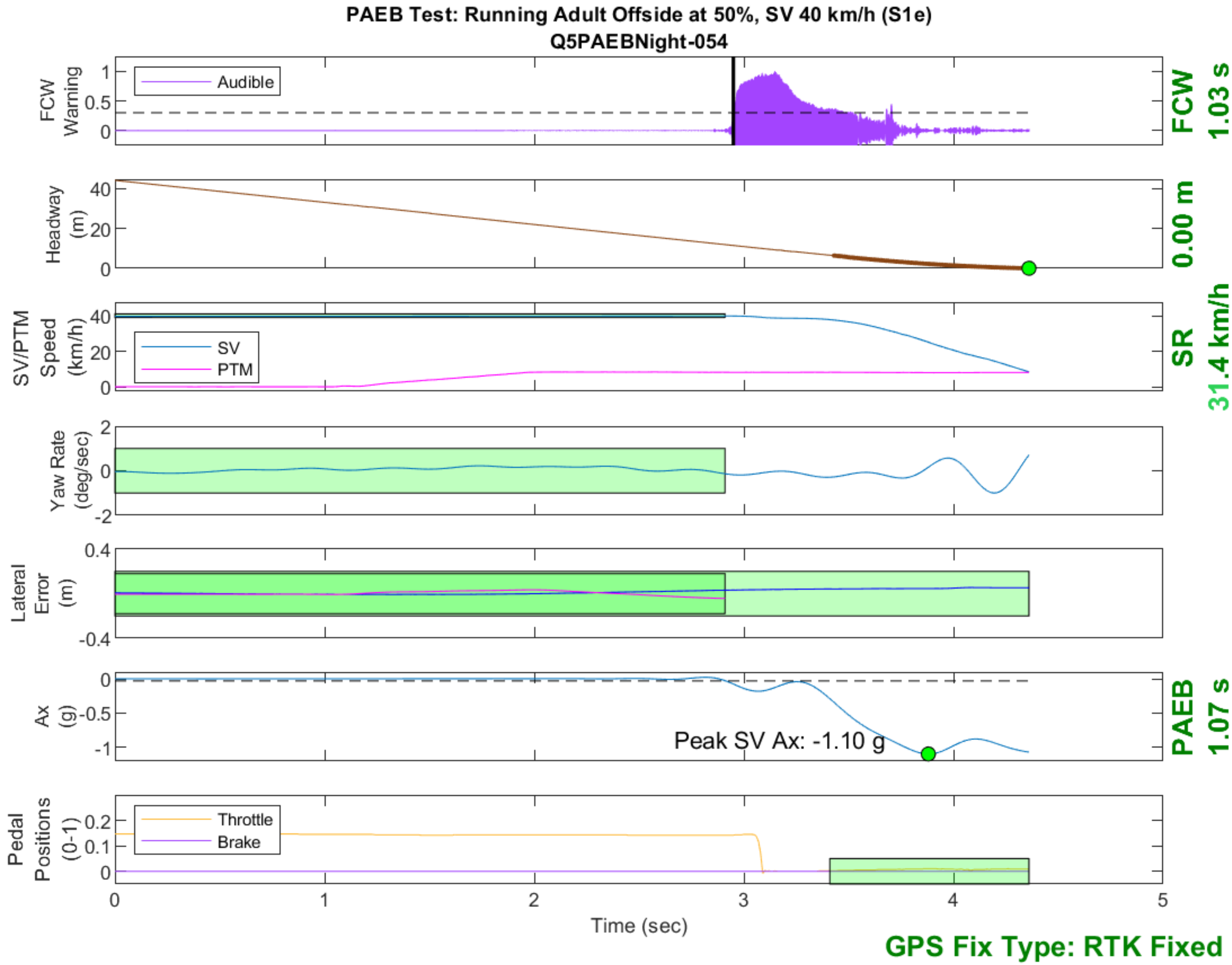

Figure D181. Time History for PAEB Run 54, S1e, Night, High Beam, 40 km/h

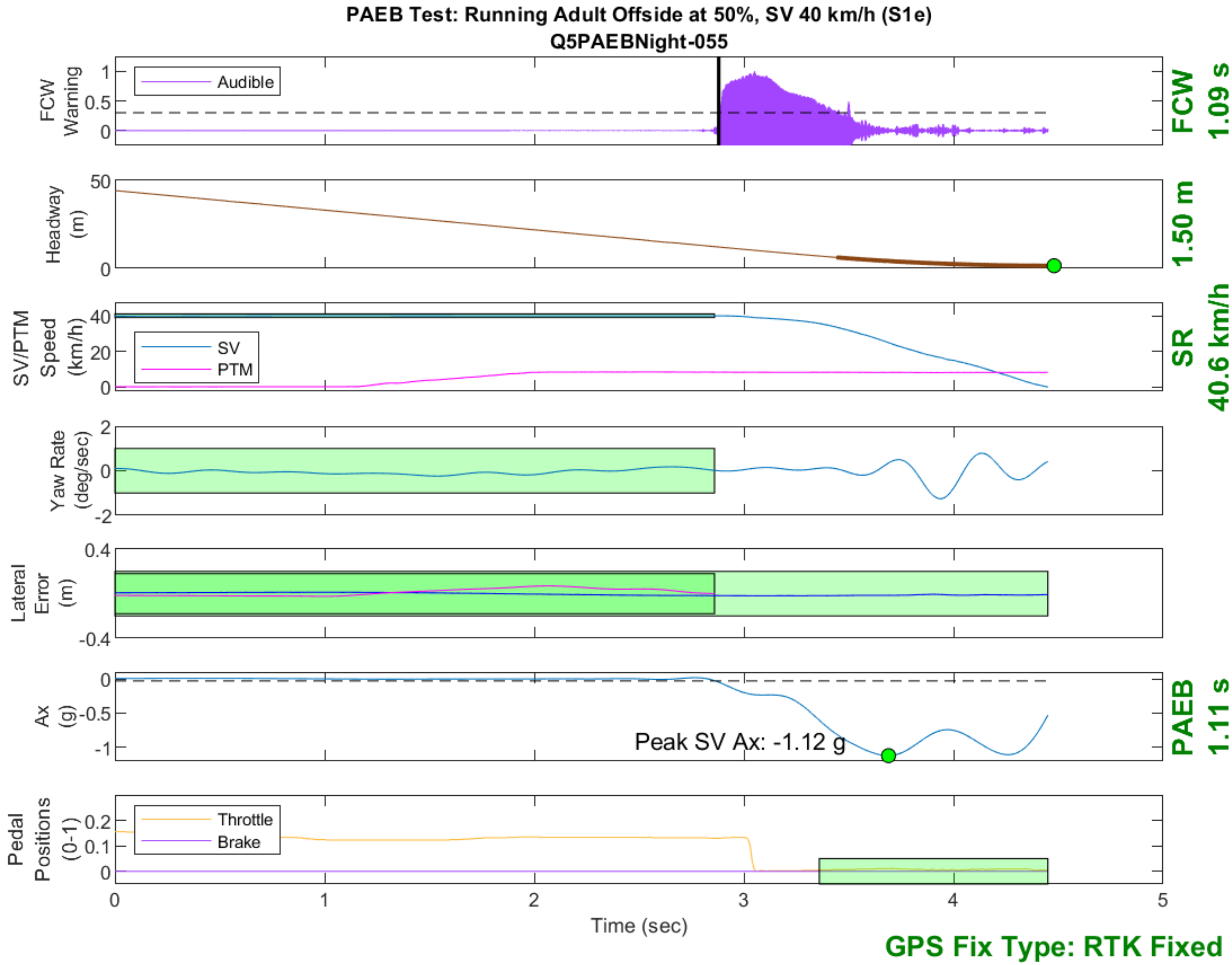

Figure D182. Time History for PAEB Run 55, S1e, Night, High Beam, 40 km/h

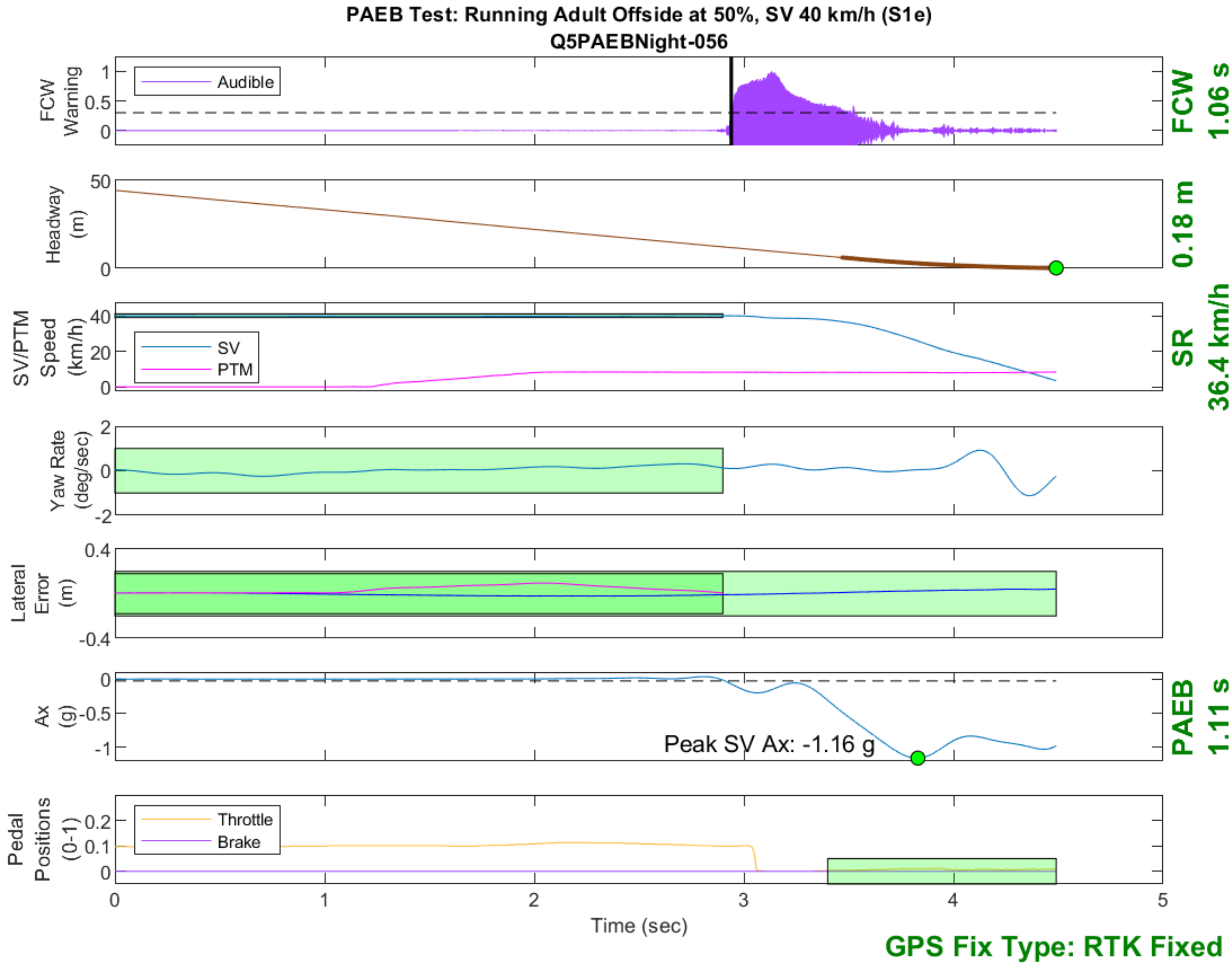

Figure D183. Time History for PAEB Run 56, S1e, Night, High Beam, 40 km/h

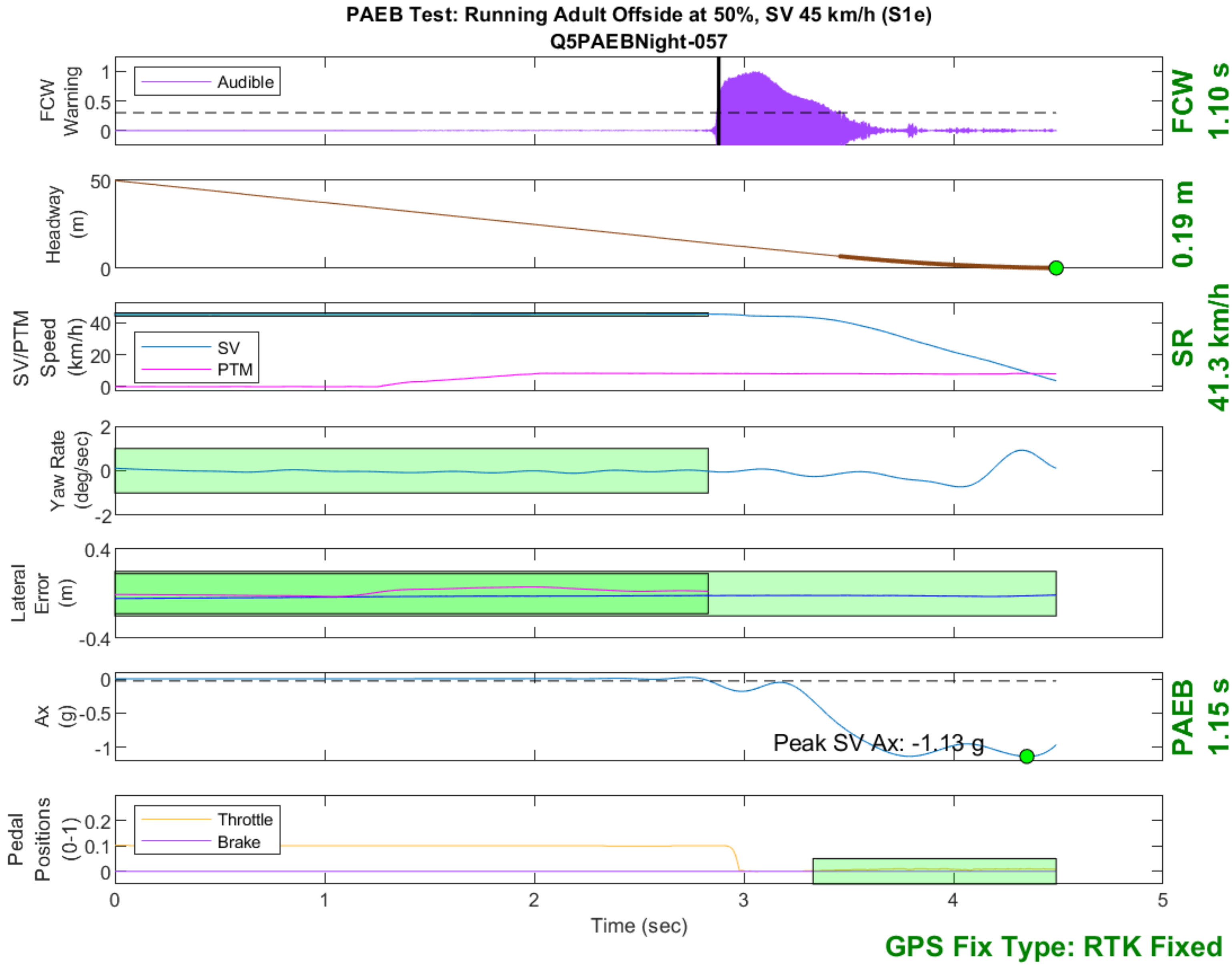

Figure D184. Time History for PAEB Run 57, S1e, Night, High Beam, 45 km/h

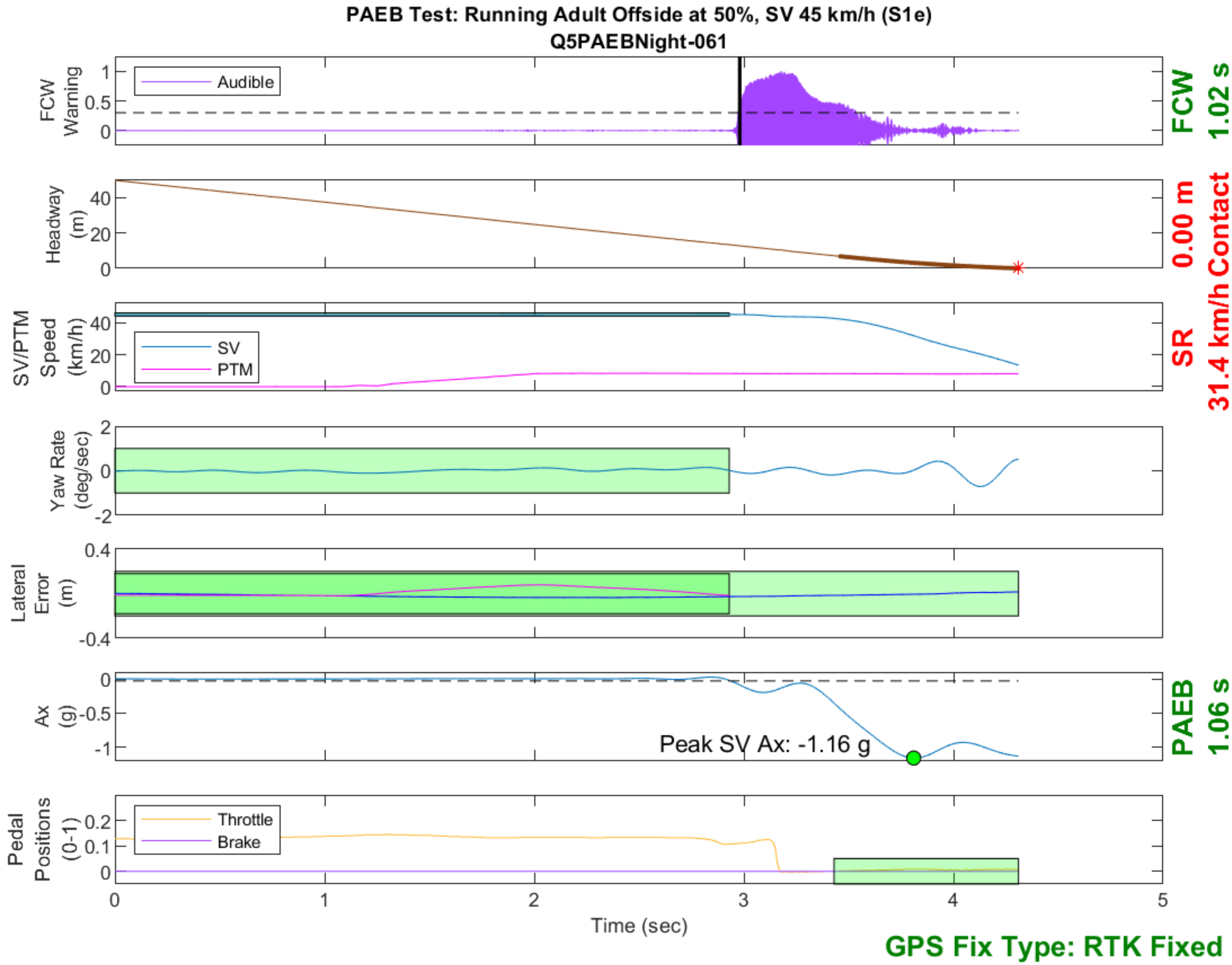

Figure D185. Time History for PAEB Run 61, S1e, Night, High Beam, 45 km/h

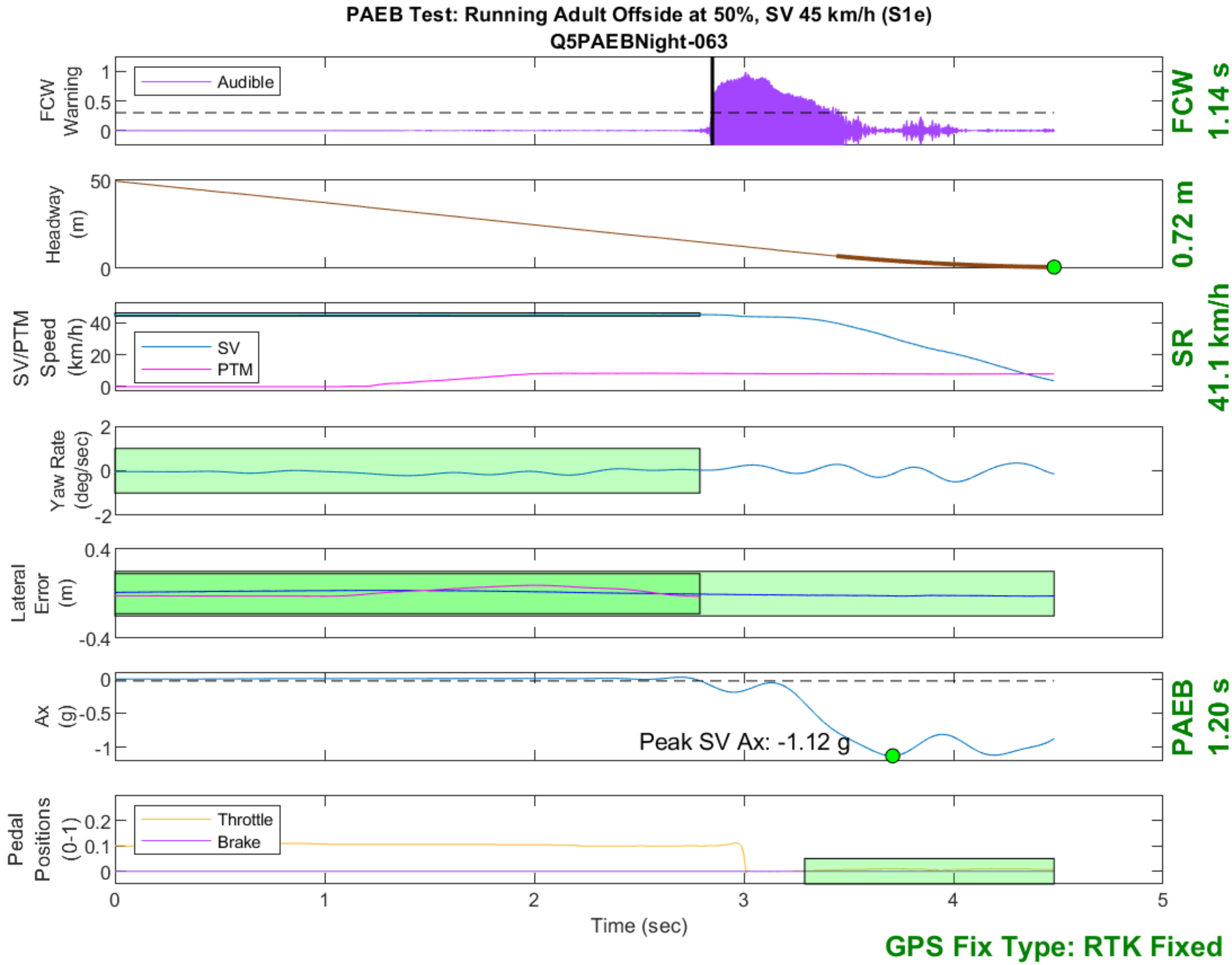

Figure D186. Time History for PAEB Run 63, S1e, Night, High Beam, 45 km/h

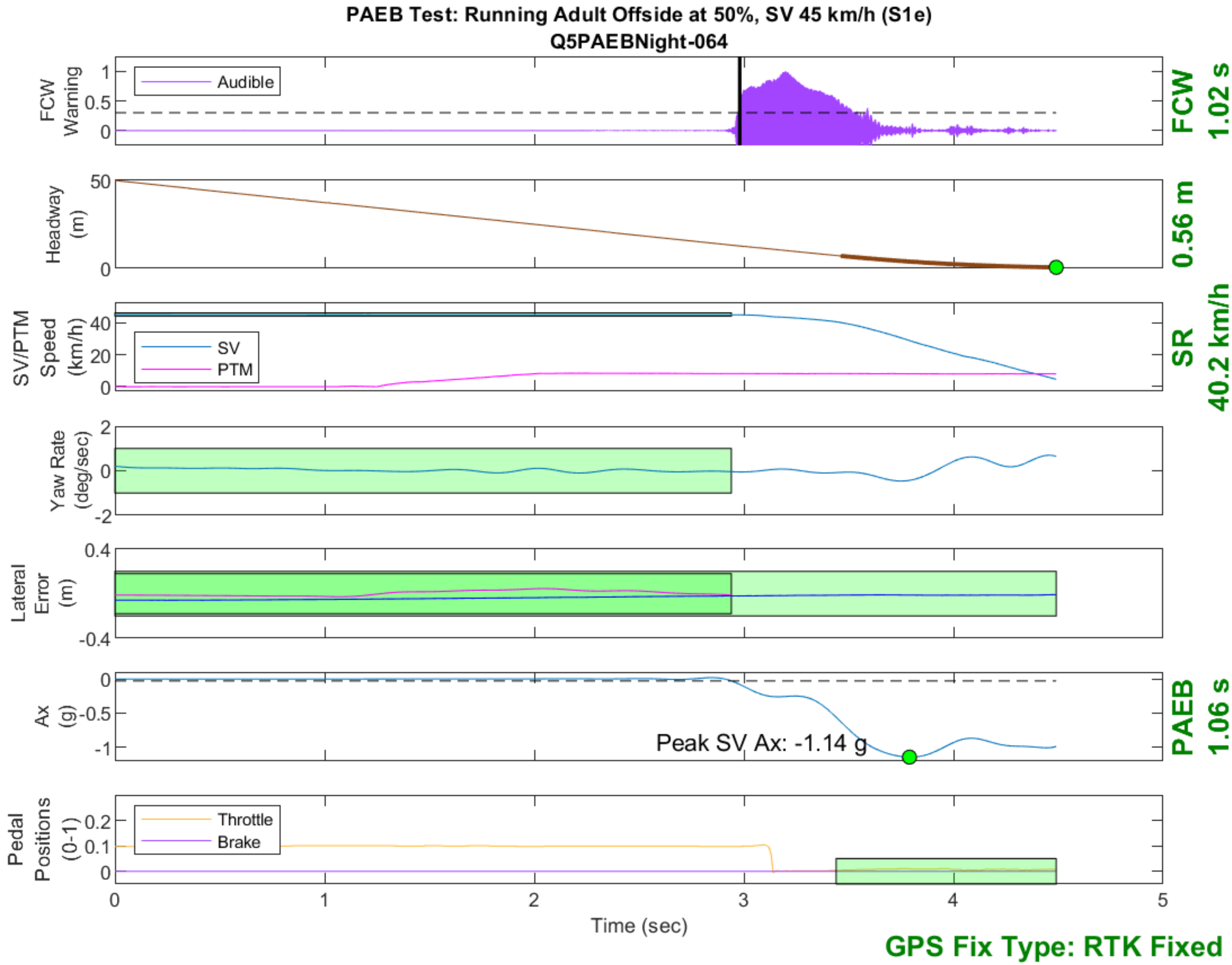

Figure D187. Time History for PAEB Run 64, S1e, Night, High Beam, 45 km/h

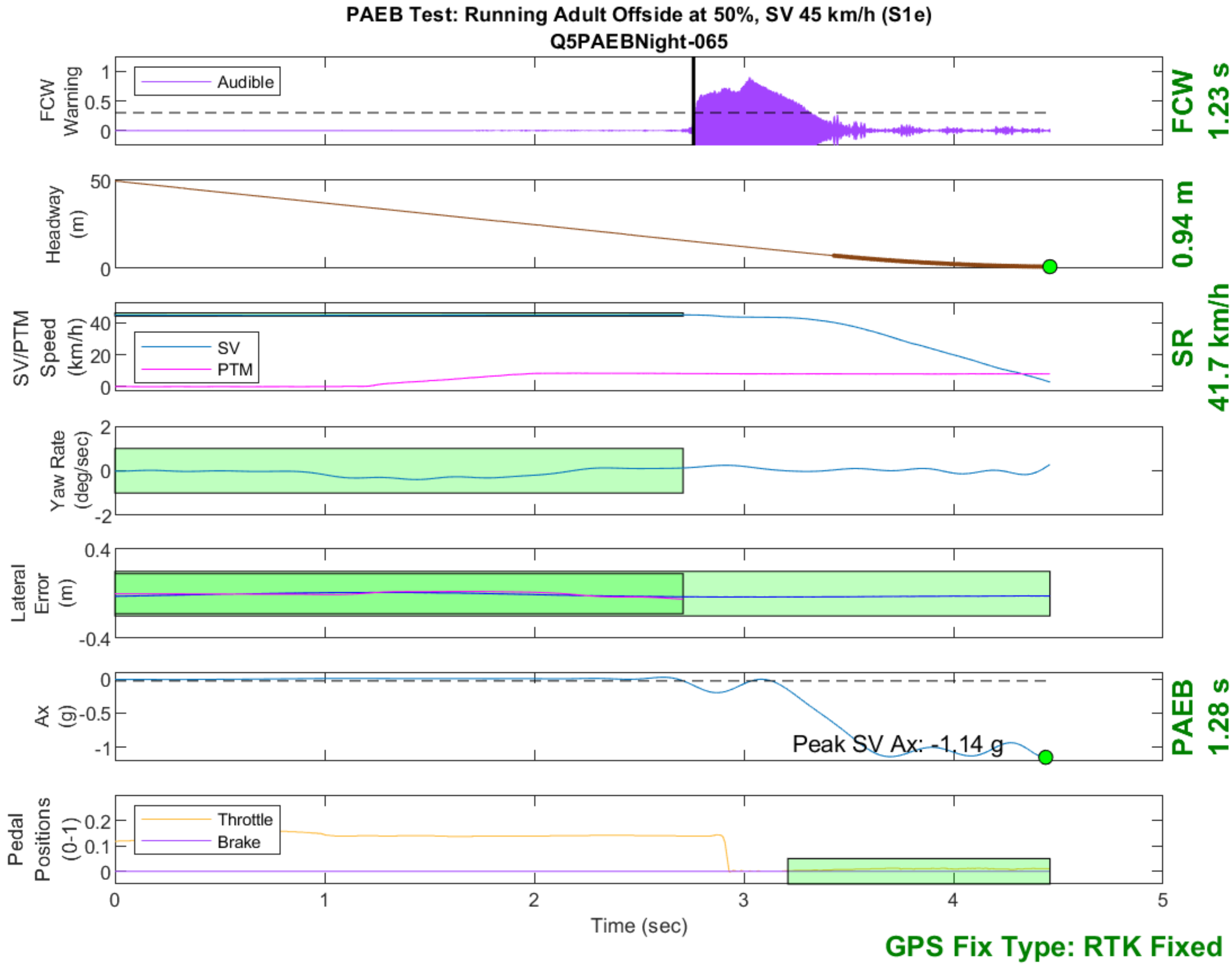

Figure D188. Time History for PAEB Run 65, S1e, Night, High Beam, 45 km/h

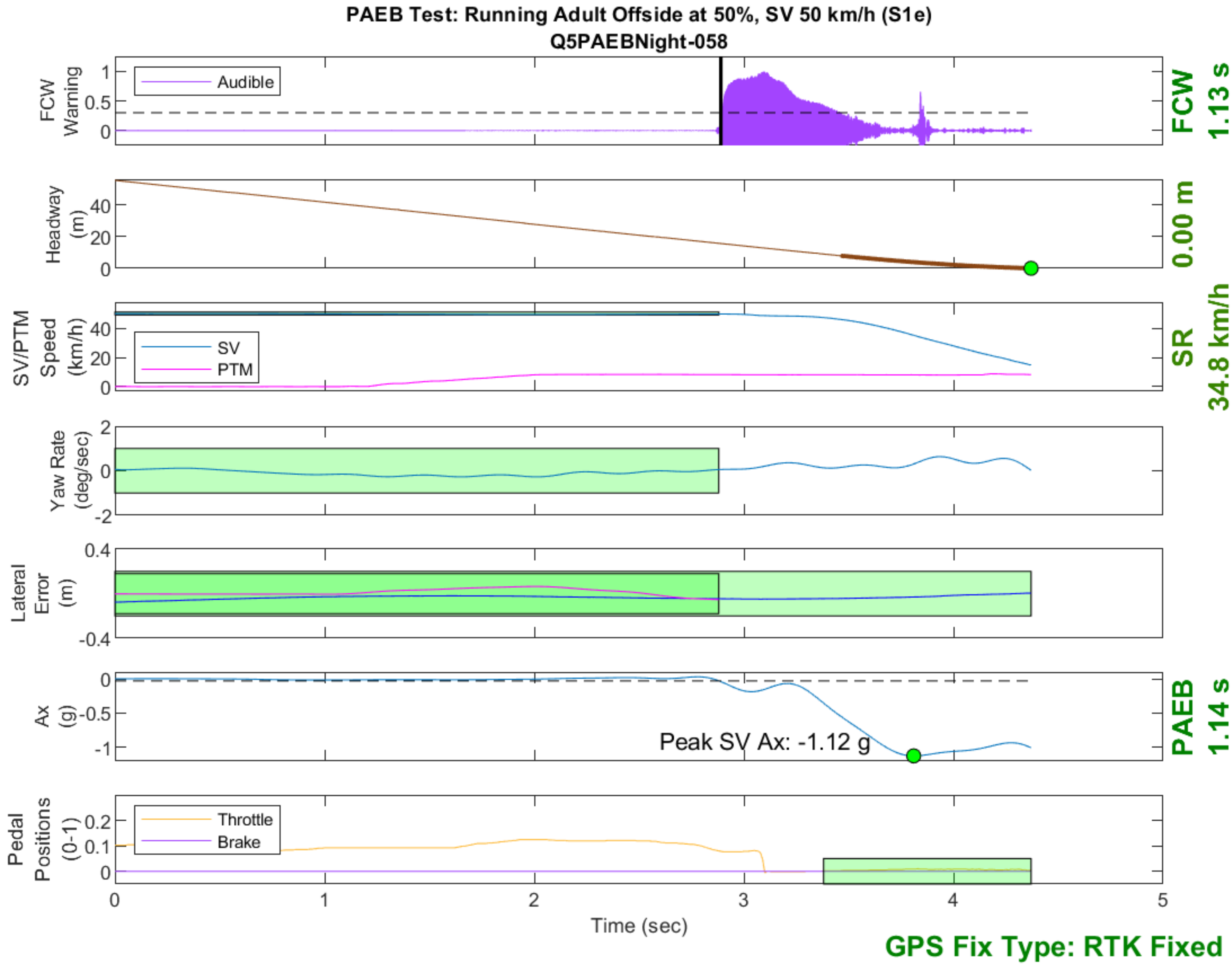

Figure D189. Time History for PAEB Run 58, S1e, Night, High Beam, 50 km/h

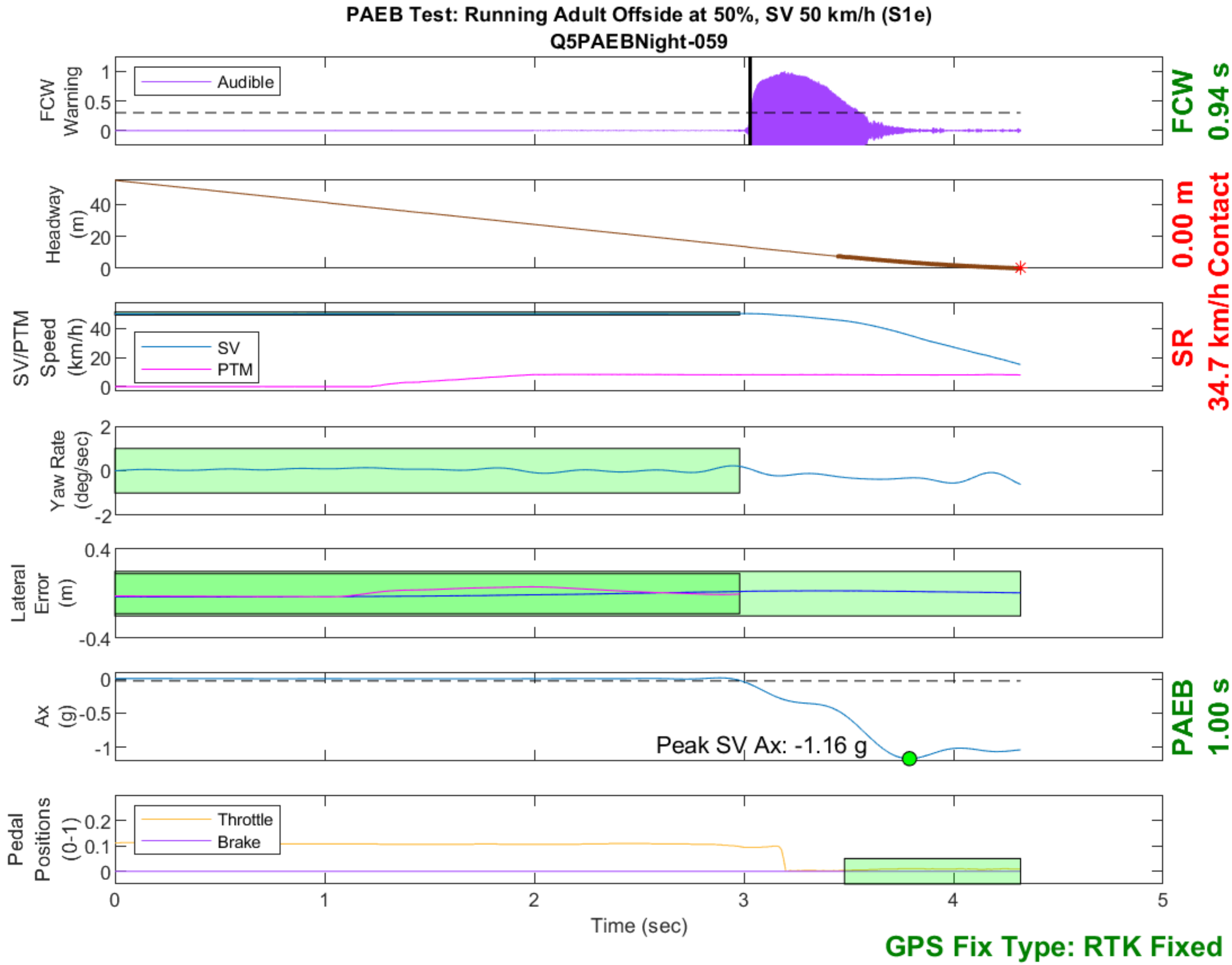

Figure D190. Time History for PAEB Run 59, S1e, Night, High Beam, 50 km/h

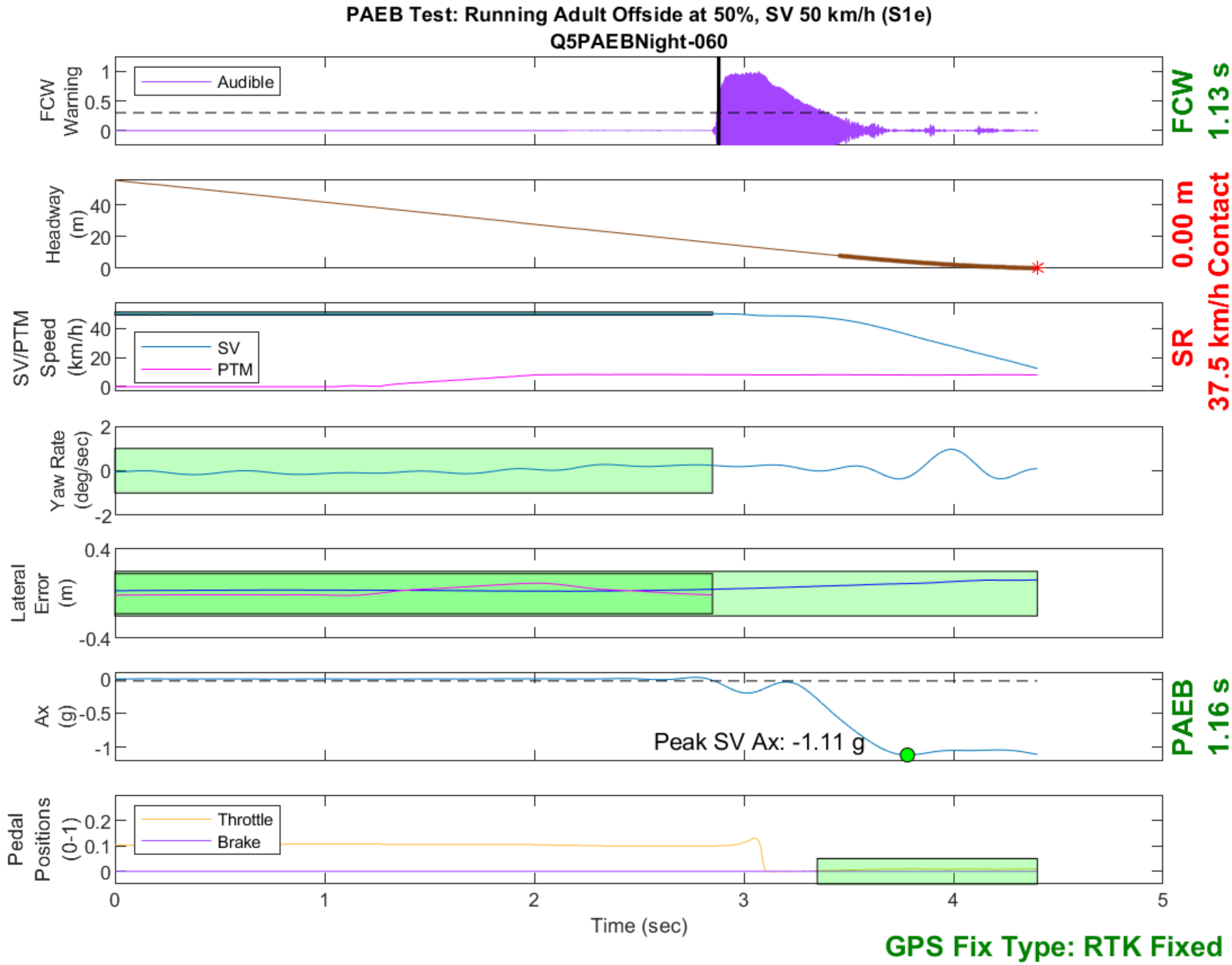

Figure D191. Time History for PAEB Run 60, S1e, Night, High Beam, 50 km/h

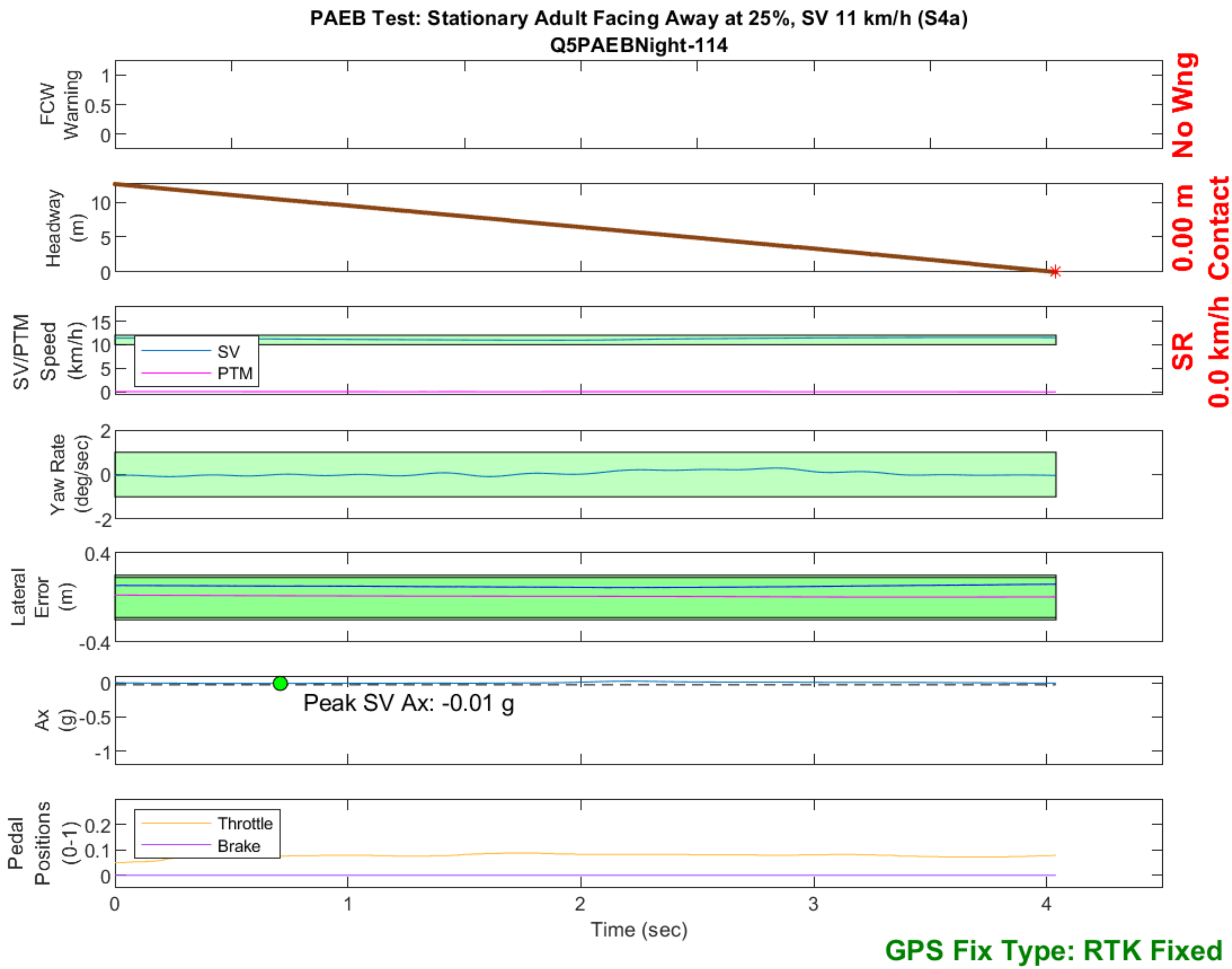

Figure D192. Time History for PAEB Run 114, S4a, Night, High Beam, 11 km/h

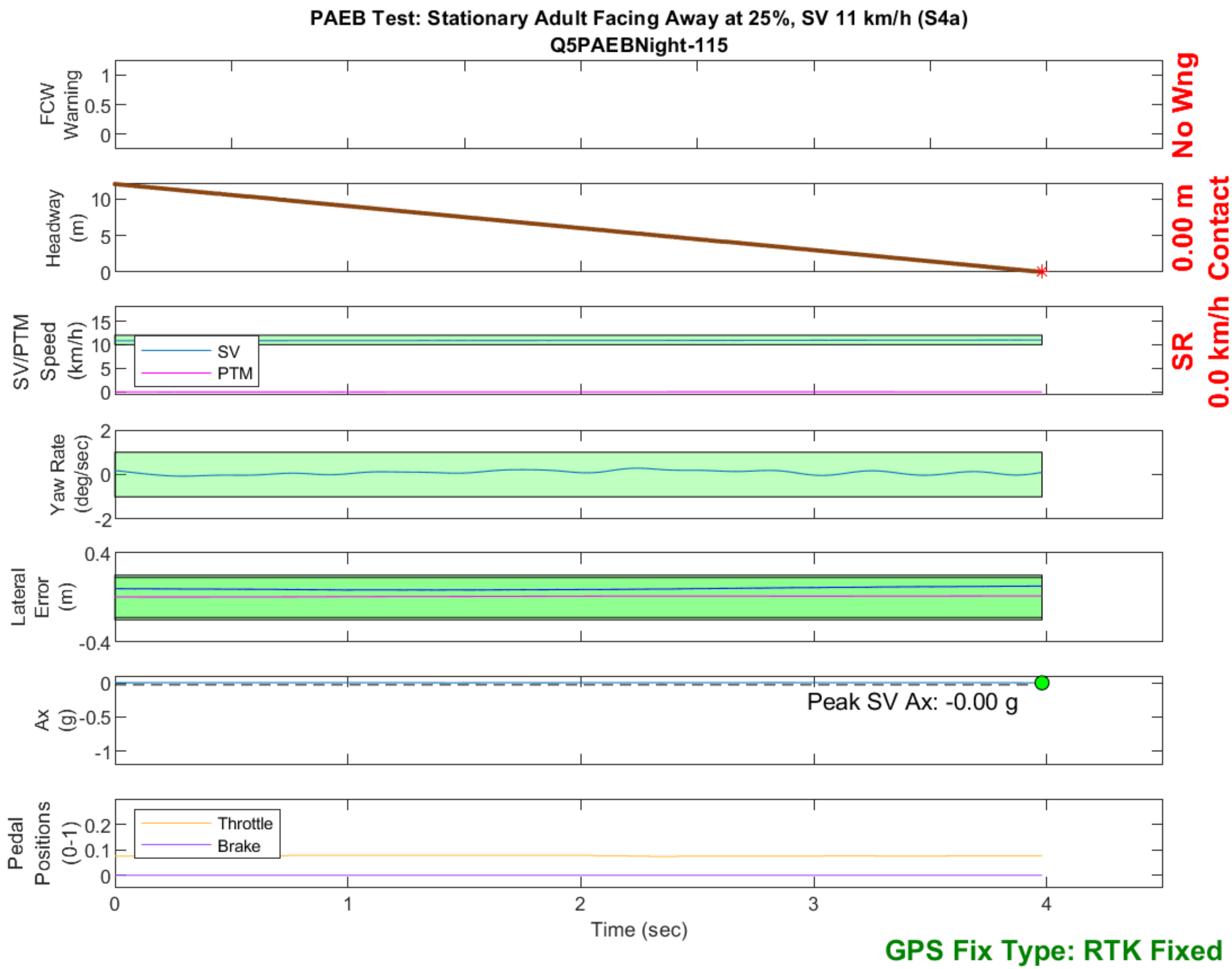

Figure D193. Time History for PAEB Run 115, S4a, Night, High Beam, 11 km/h

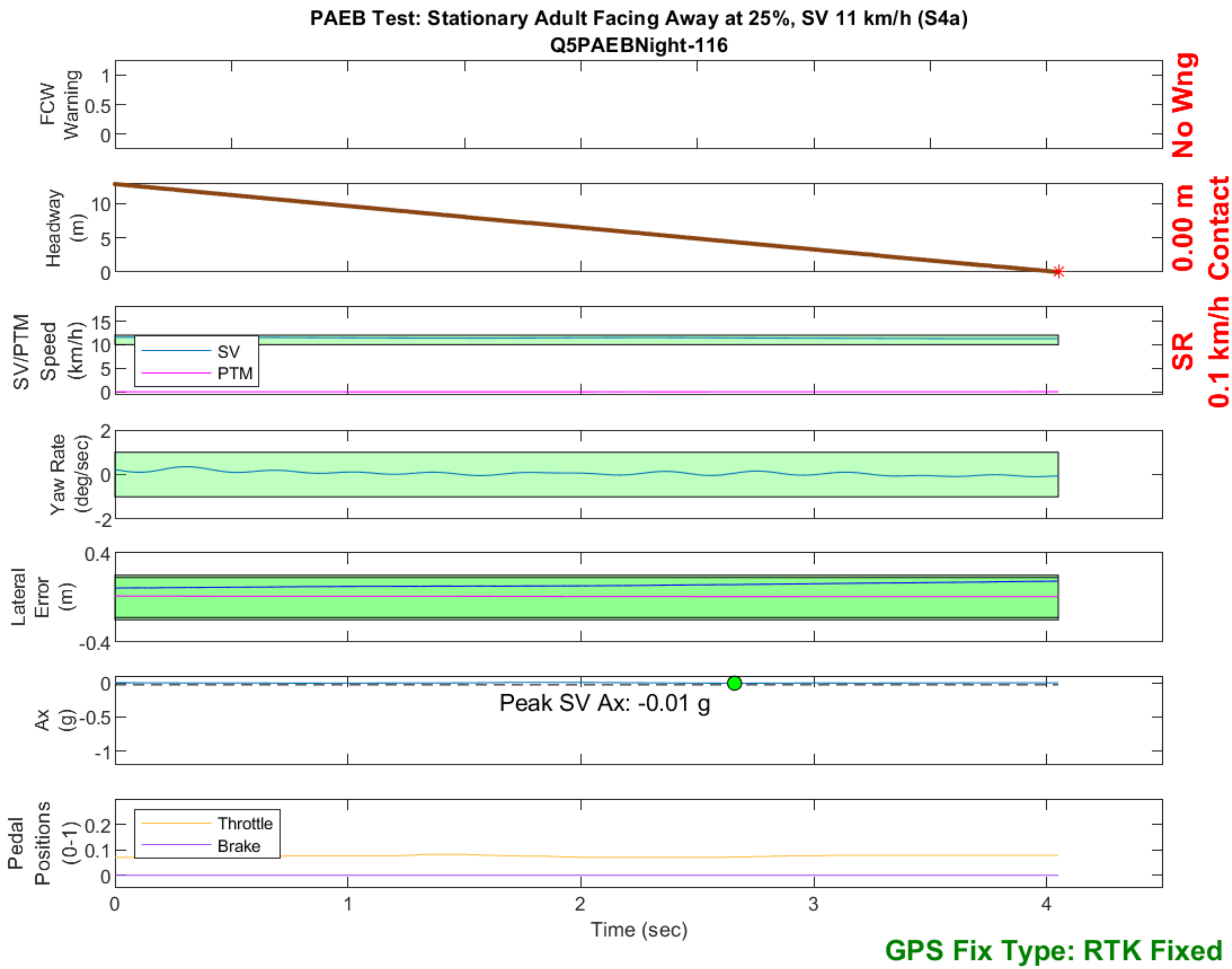

Figure D194. Time History for PAEB Run 116, S4a, Night, High Beam, 11 km/h

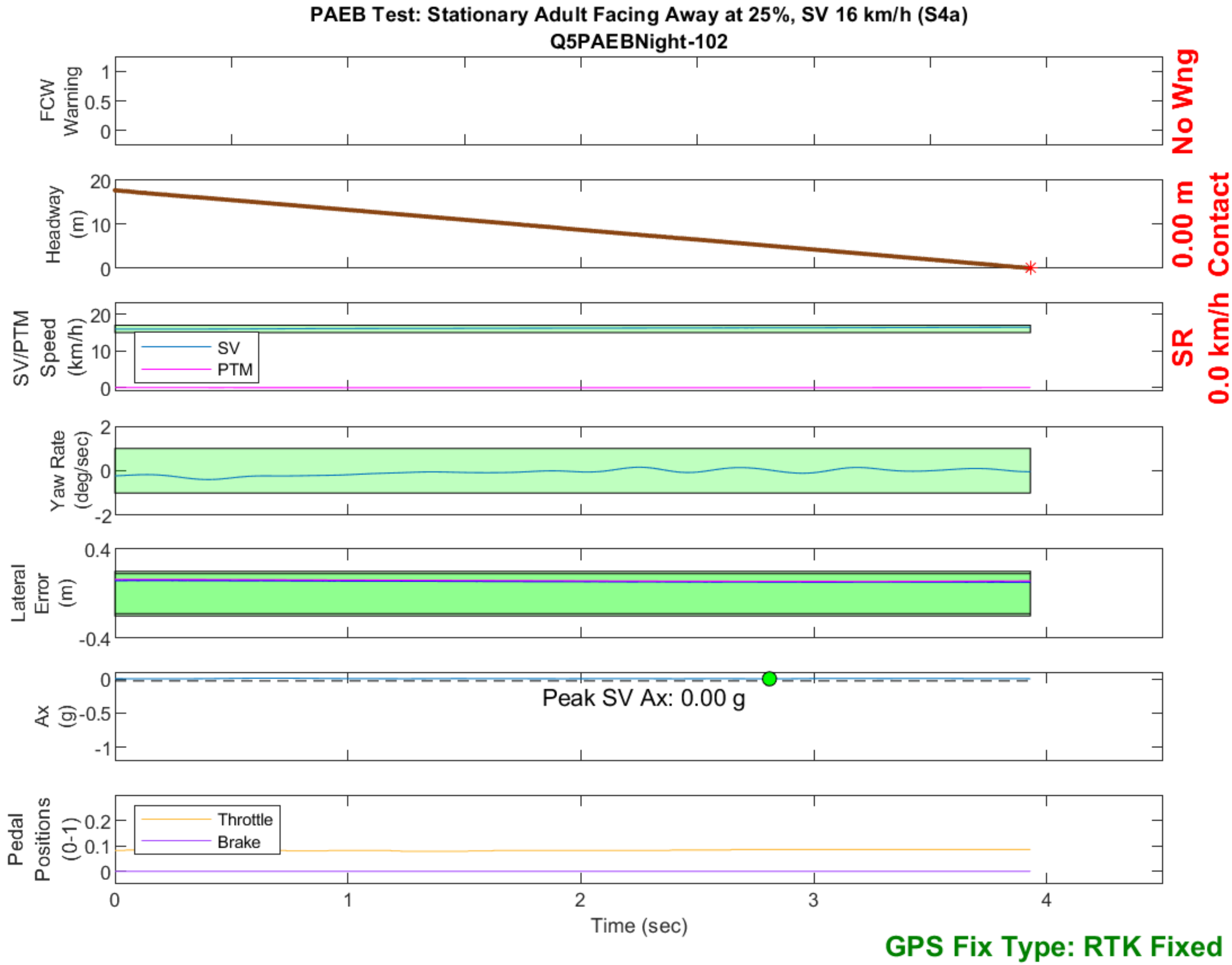

Figure D195. Time History for PAEB Run 102, S4a, Night, High Beam, 16 km/h

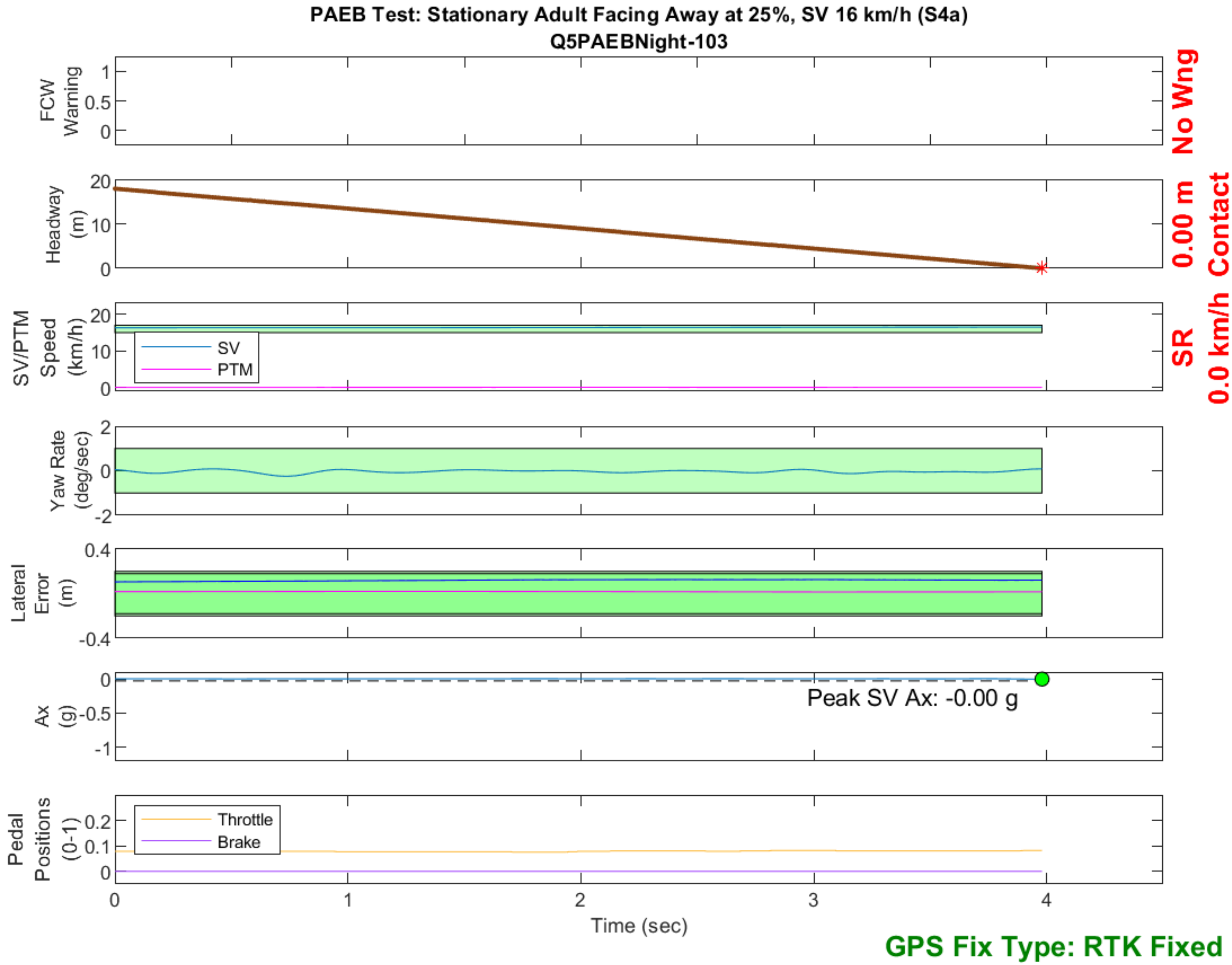

Figure D196. Time History for PAEB Run 103, S4a, Night, High Beam, 16 km/h

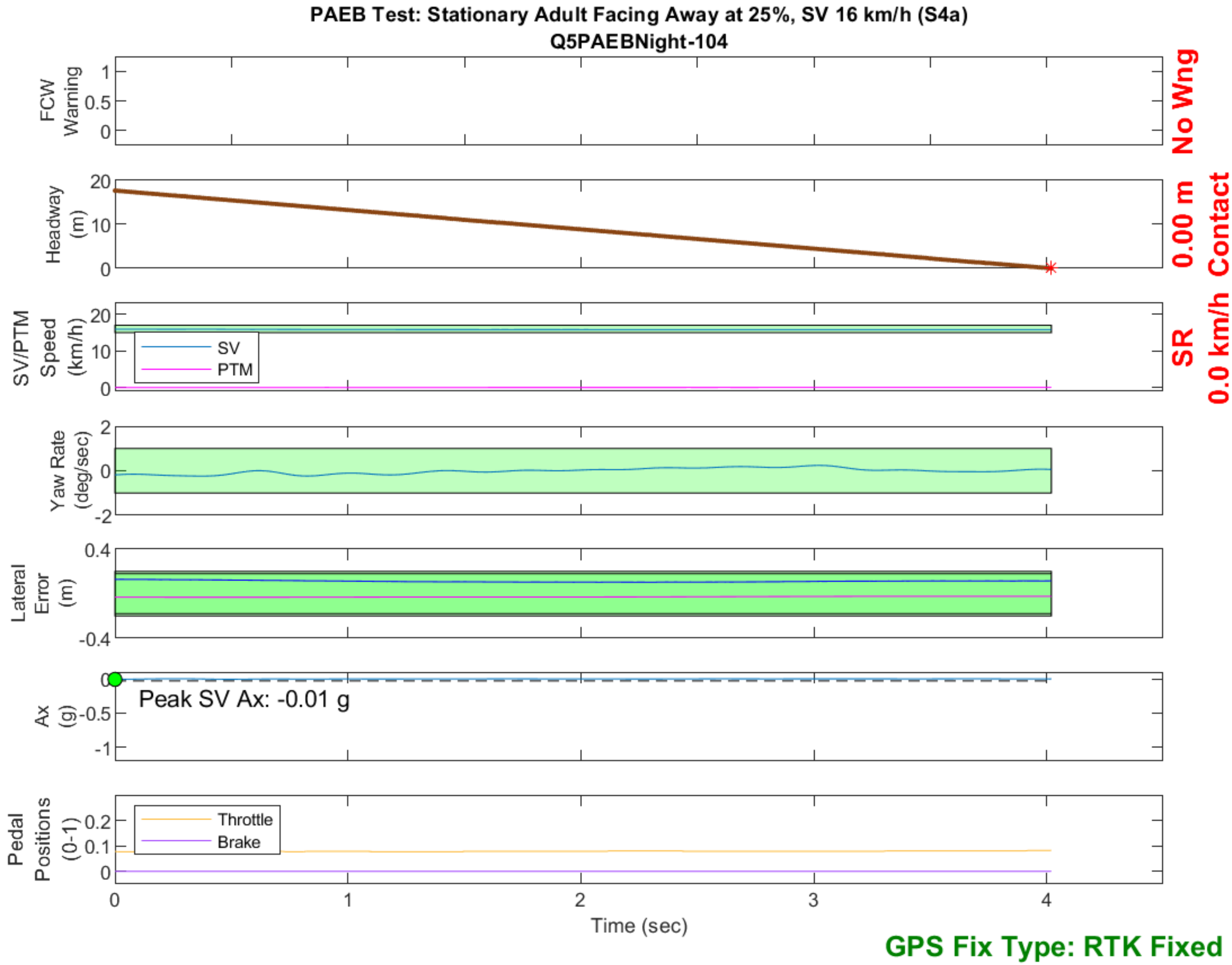

Figure D197. Time History for PAEB Run 104, S4a, Night, High Beam, 16 km/h

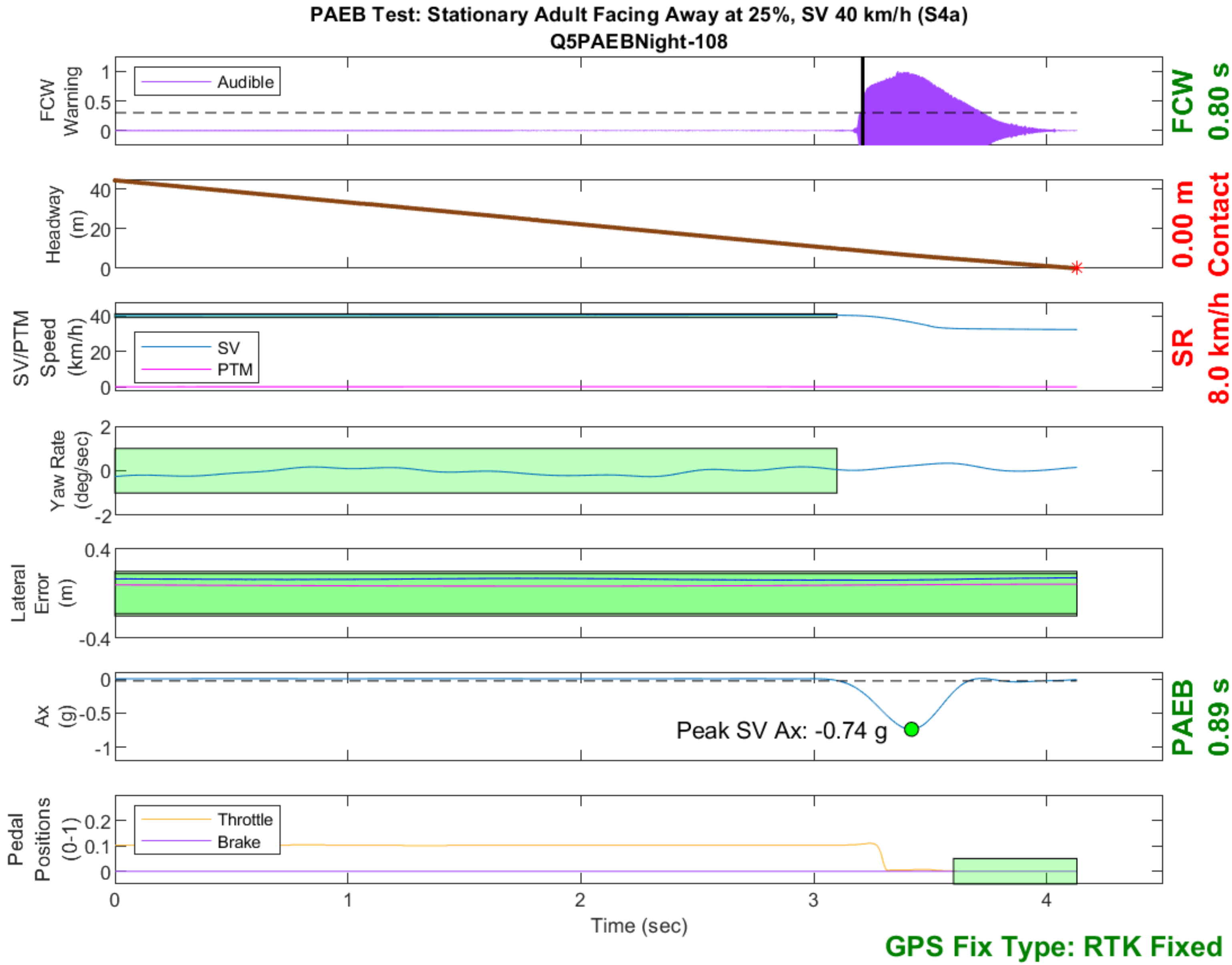

Figure D198. Time History for PAEB Run 108, S4a, Night, High Beam, 40 km/h

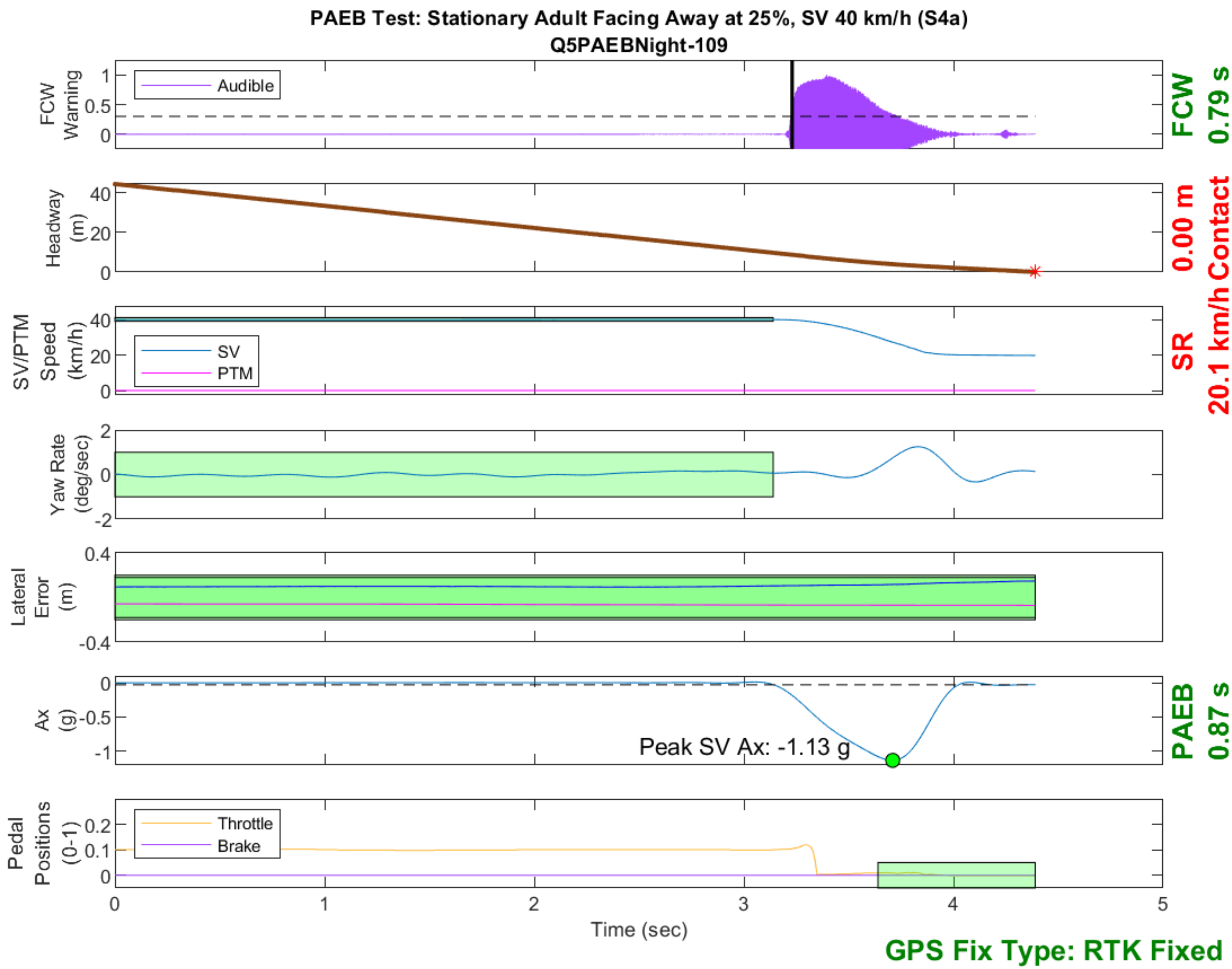

Figure D199. Time History for PAEB Run 109, S4a, Night, High Beam, 40 km/h

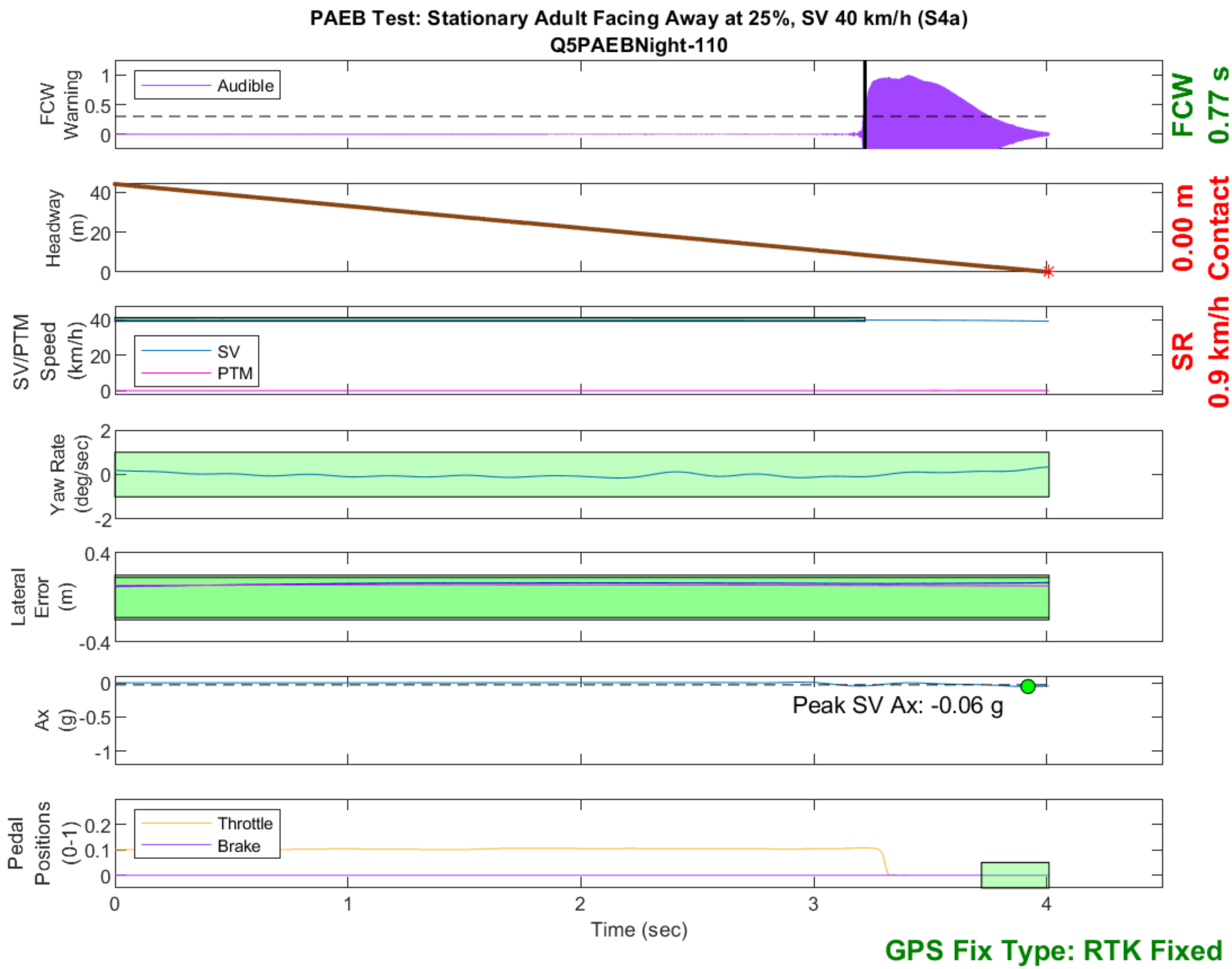

Figure D200. Time History for PAEB Run 110, S4a, Night, High Beam, 40 km/h

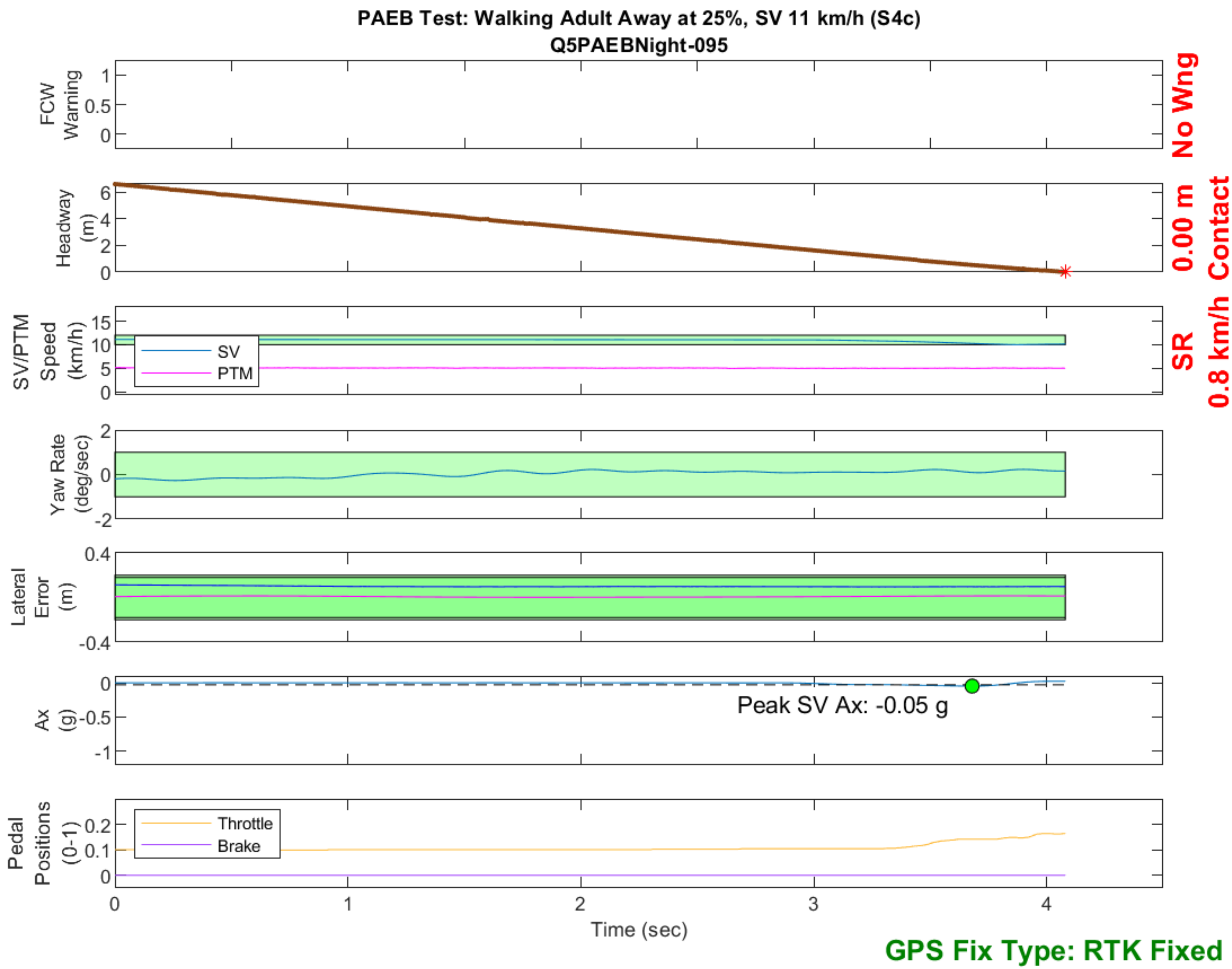

Figure D201. Time History for PAEB Run 95, S4c, Night, High Beam, 11 km/h

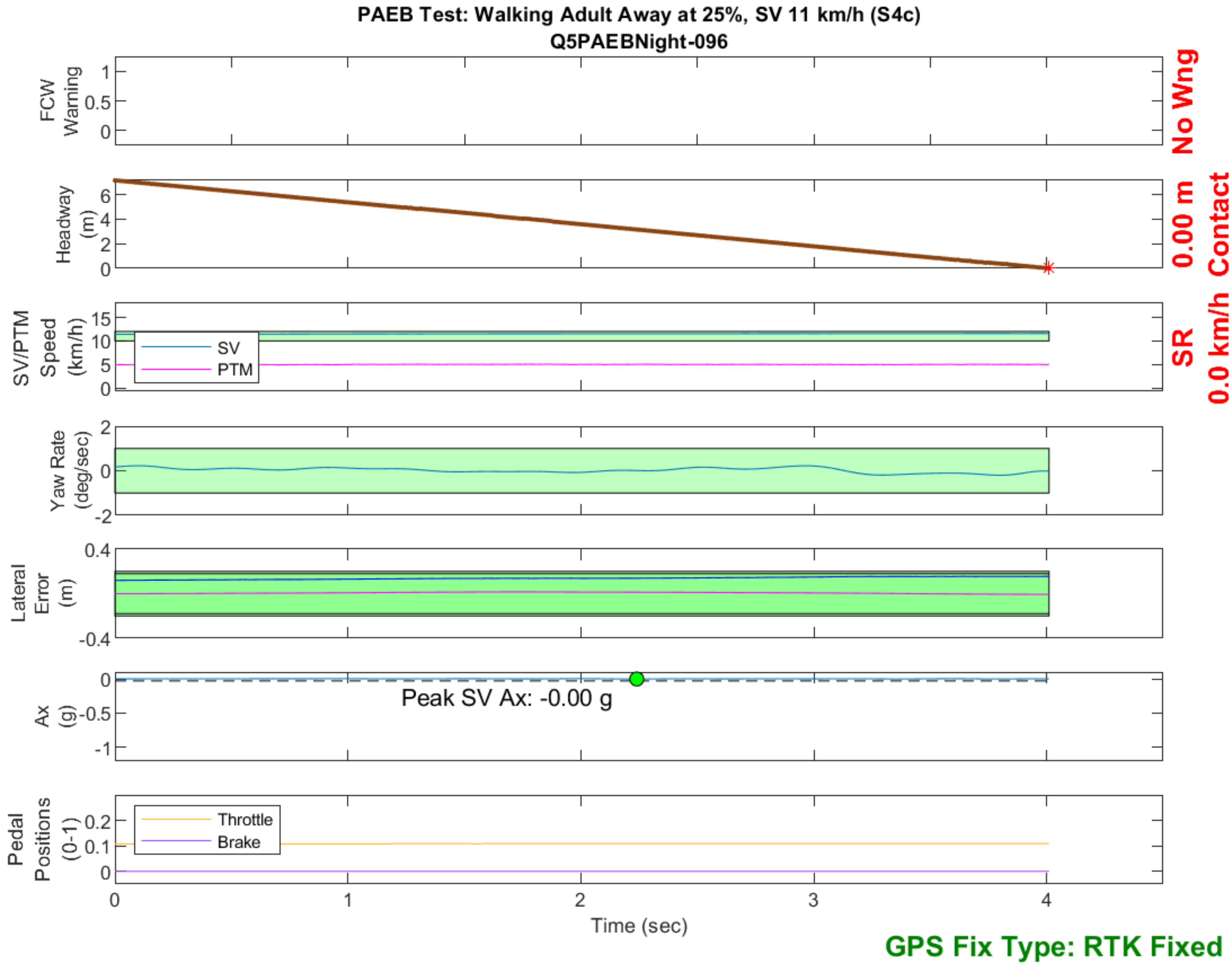

Figure D202. Time History for PAEB Run 96, S4c, Night, High Beam, 11 km/h

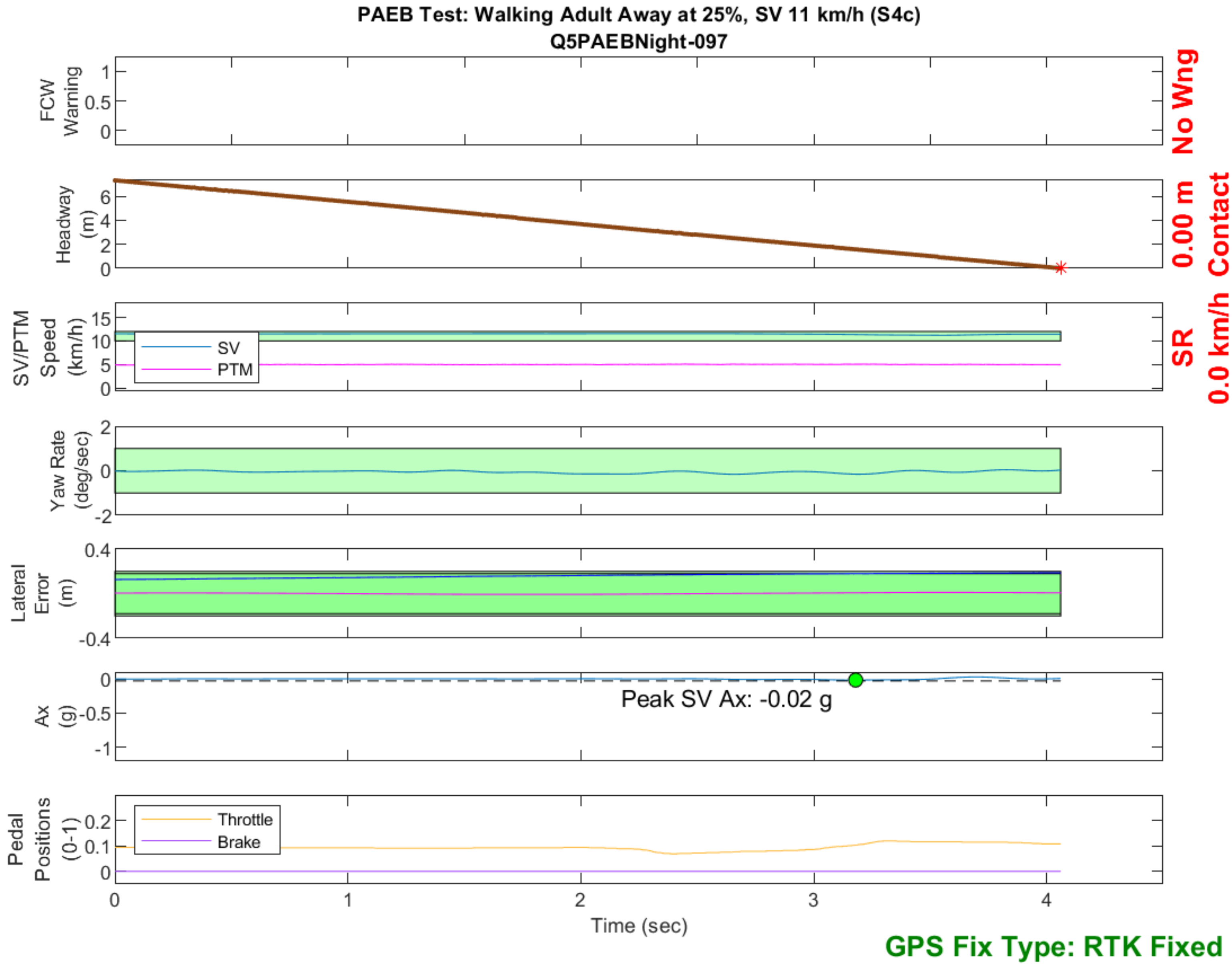

Figure D203. Time History for PAEB Run 97, S4c, Night, High Beam, 11 km/h

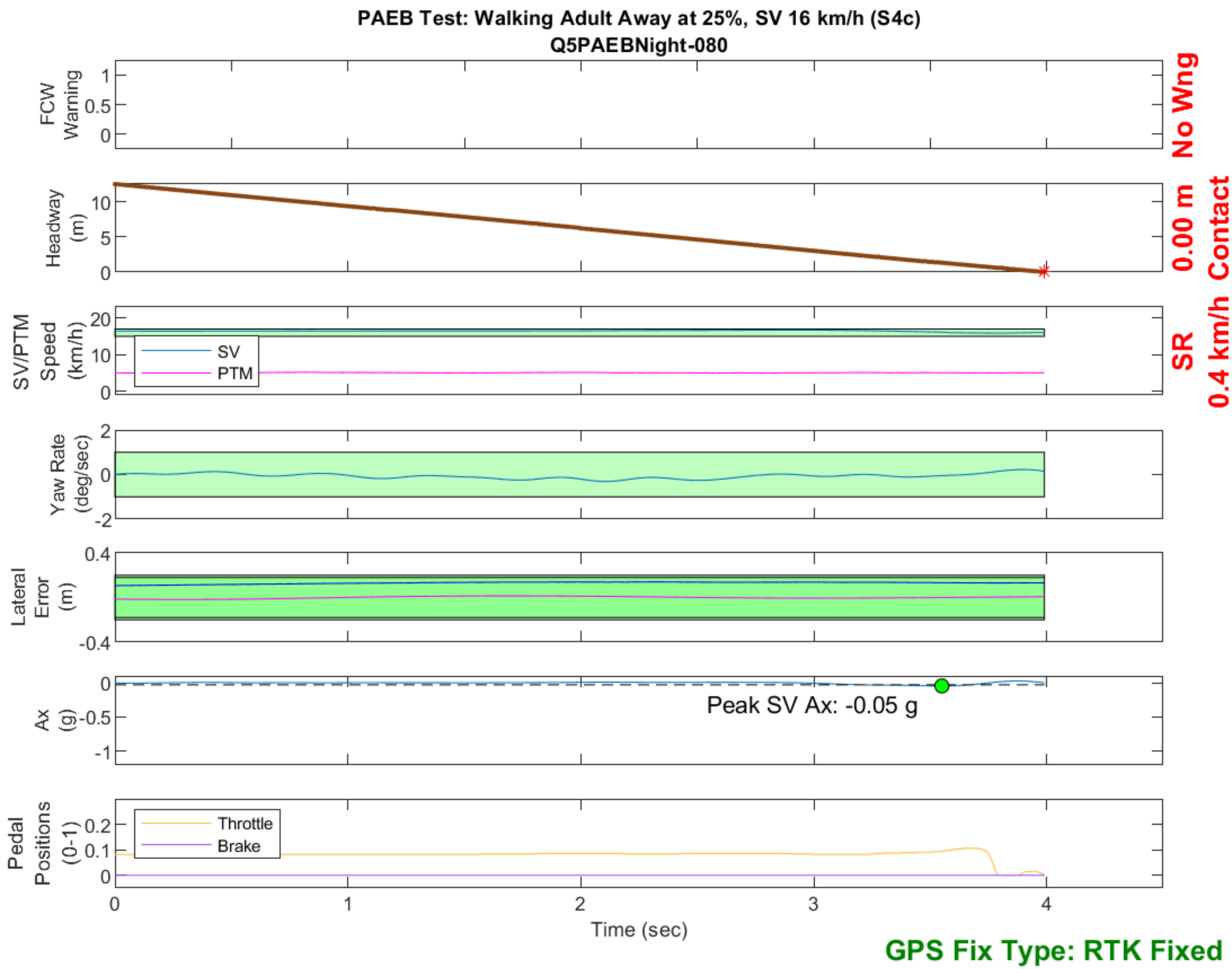

Figure D204. Time History for PAEB Run 80, S4c, Night, High Beam, 16 km/h

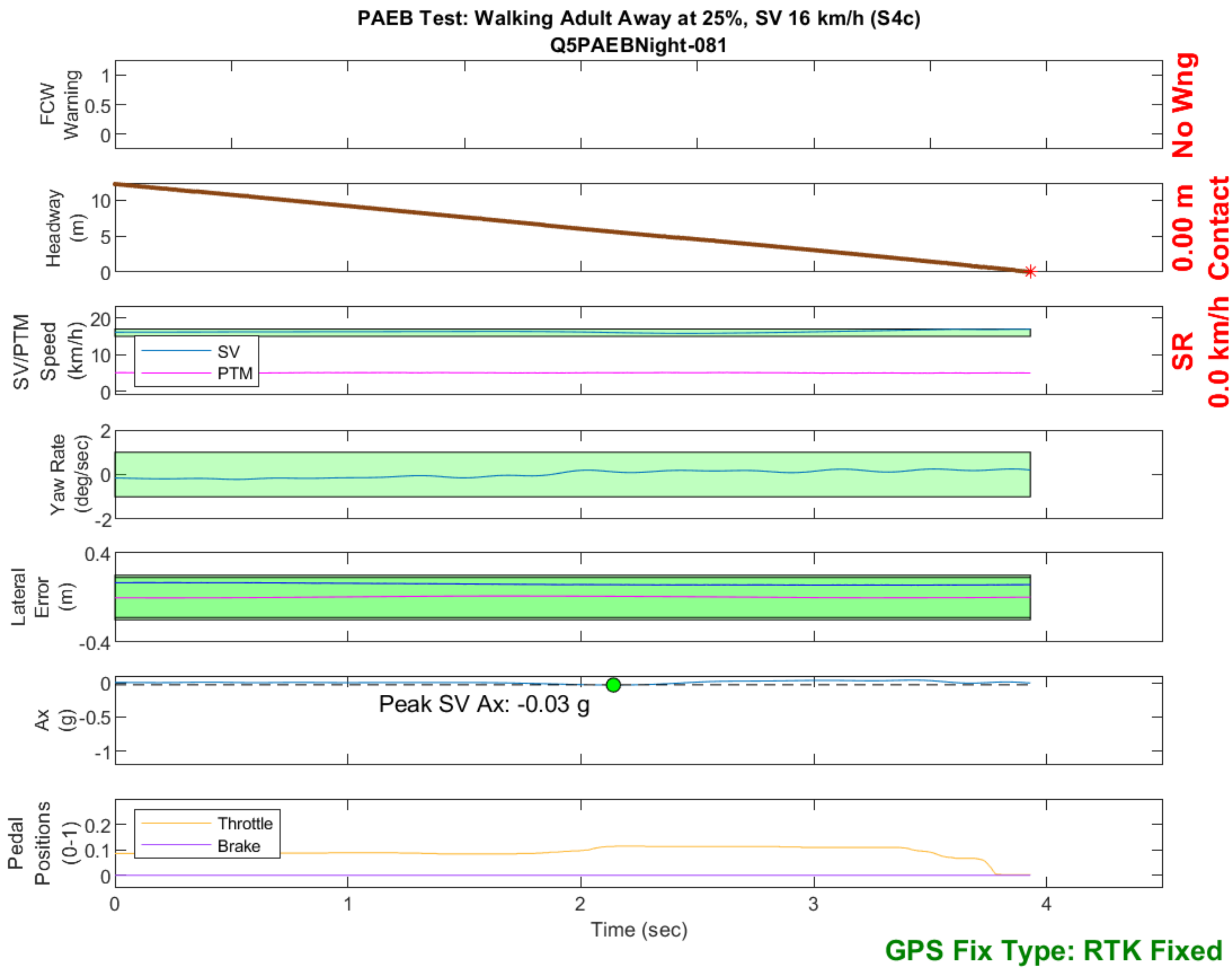

Figure D205. Time History for PAEB Run 81, S4c, Night, High Beam, 16 km/h

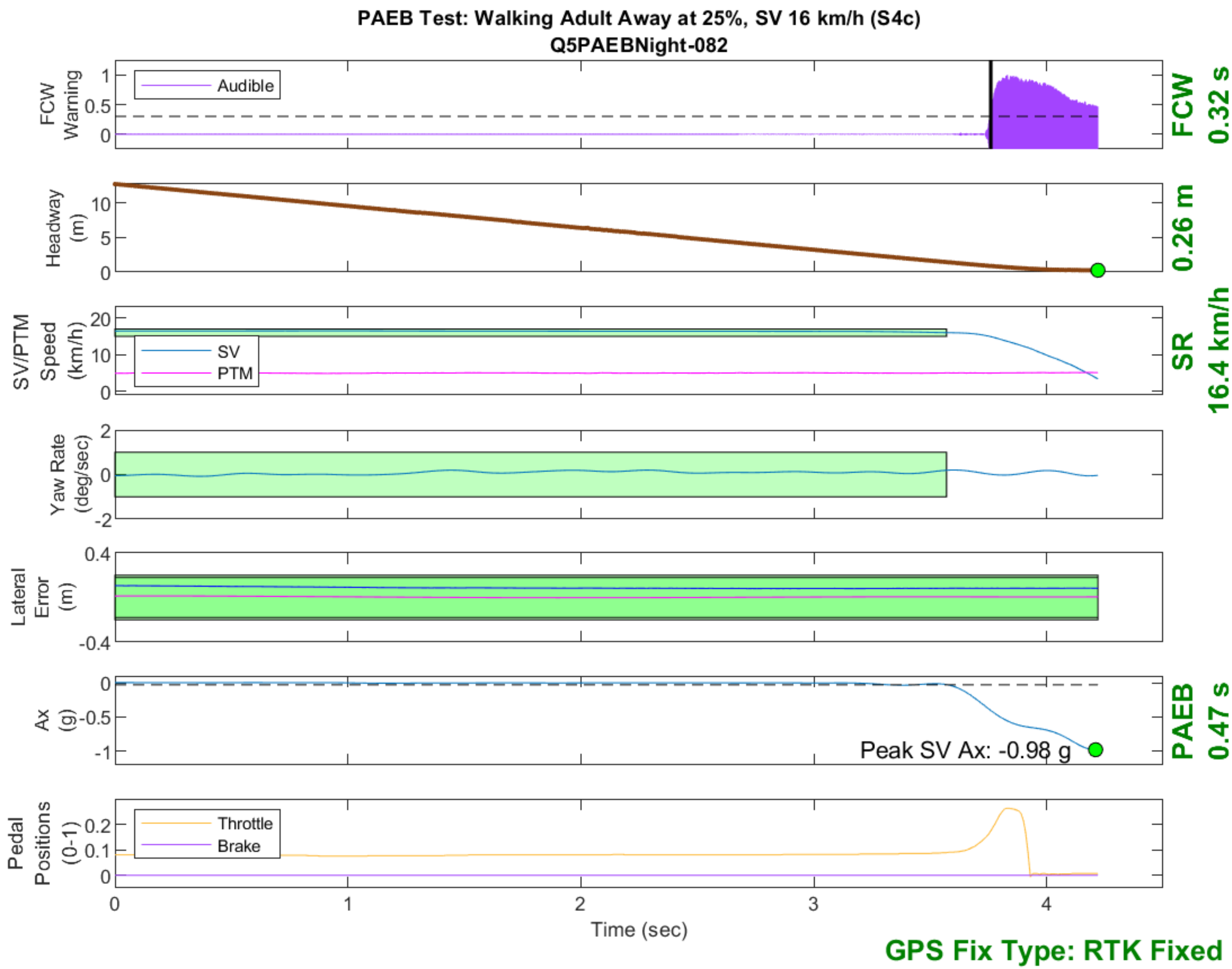

Figure D206. Time History for PAEB Run 82, S4c, Night, High Beam, 16 km/h

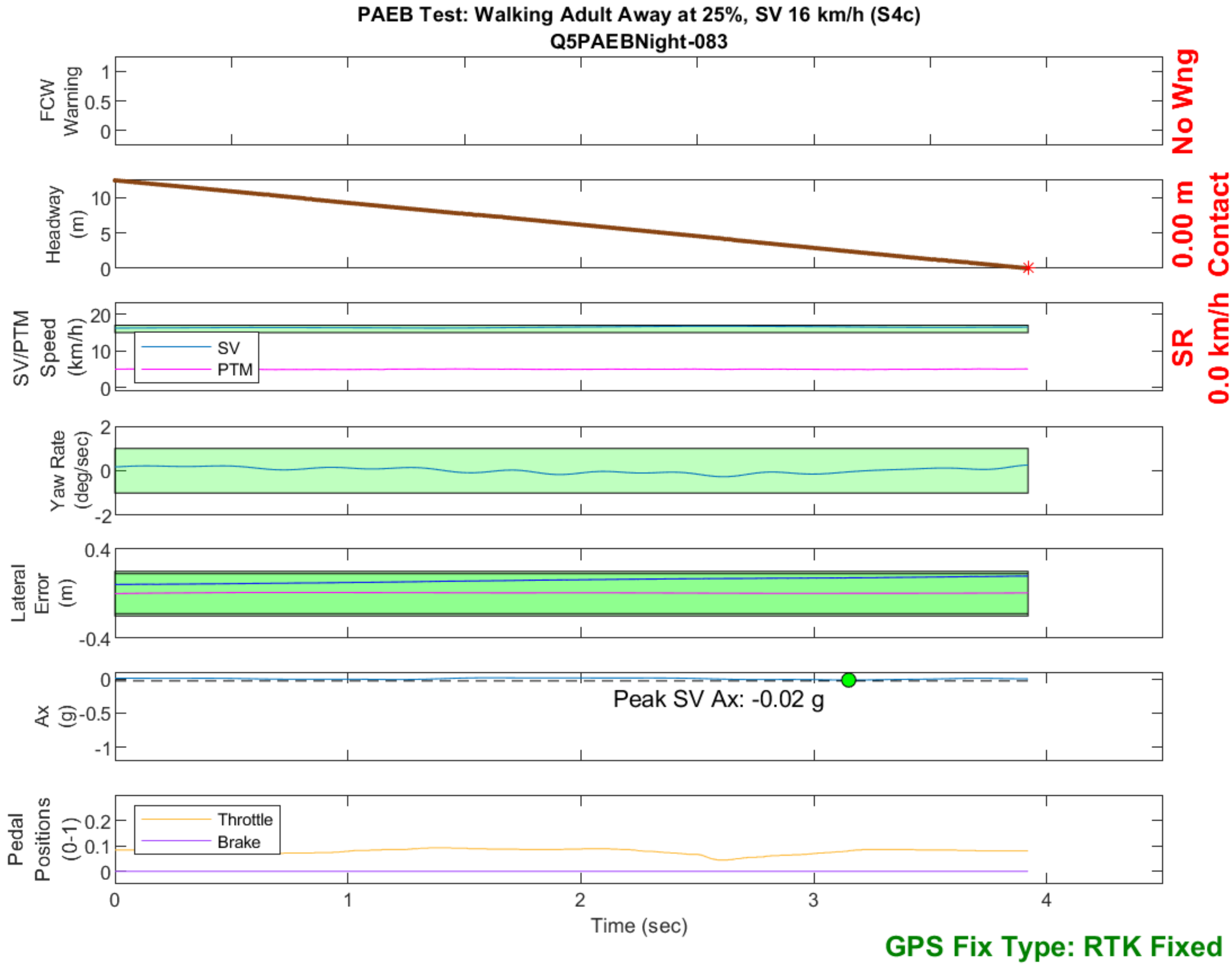

Figure D207. Time History for PAEB Run 83, S4c, Night, High Beam, 16 km/h

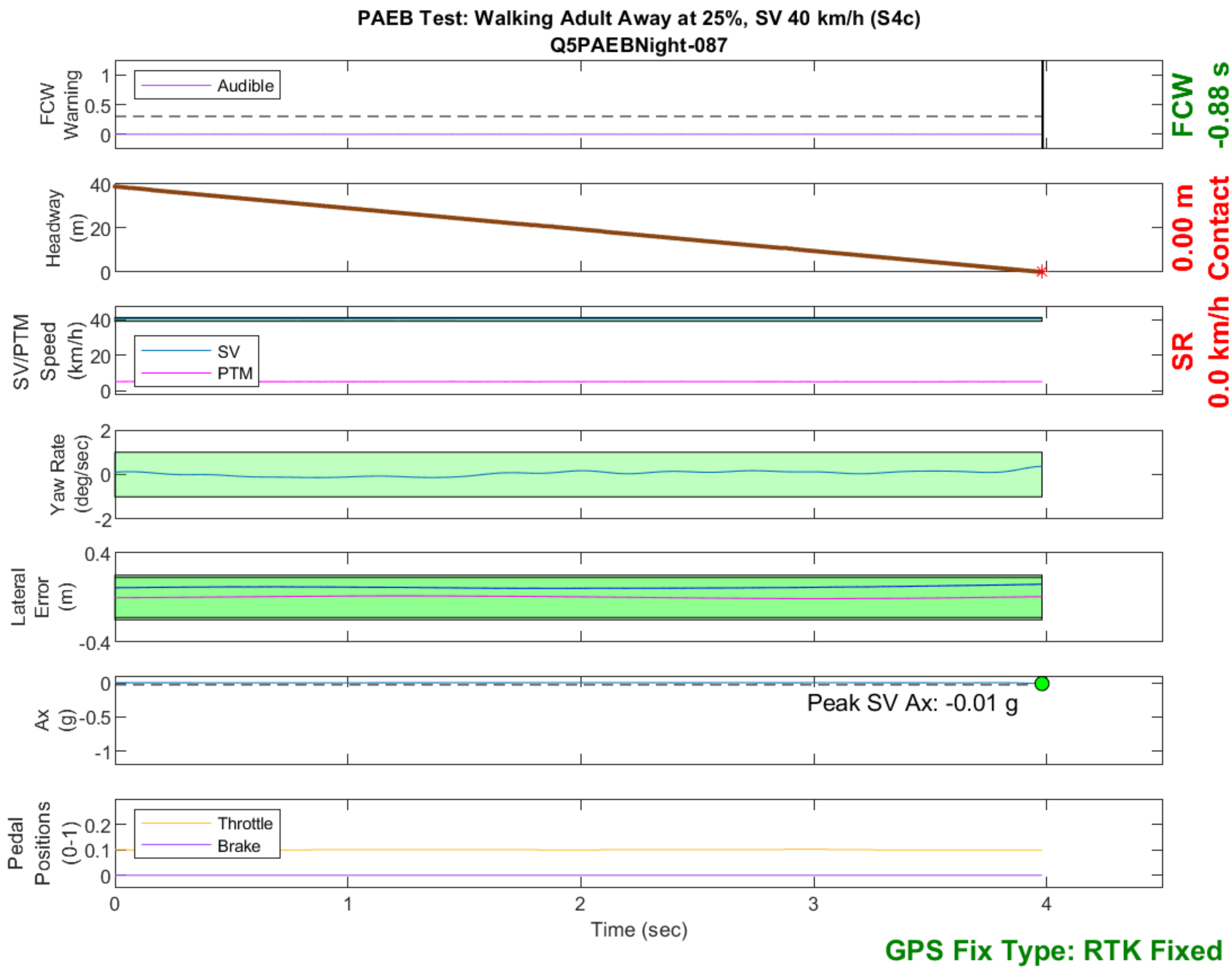

Figure D208. Time History for PAEB Run 87, S4c, Night, High Beam, 40 km/h

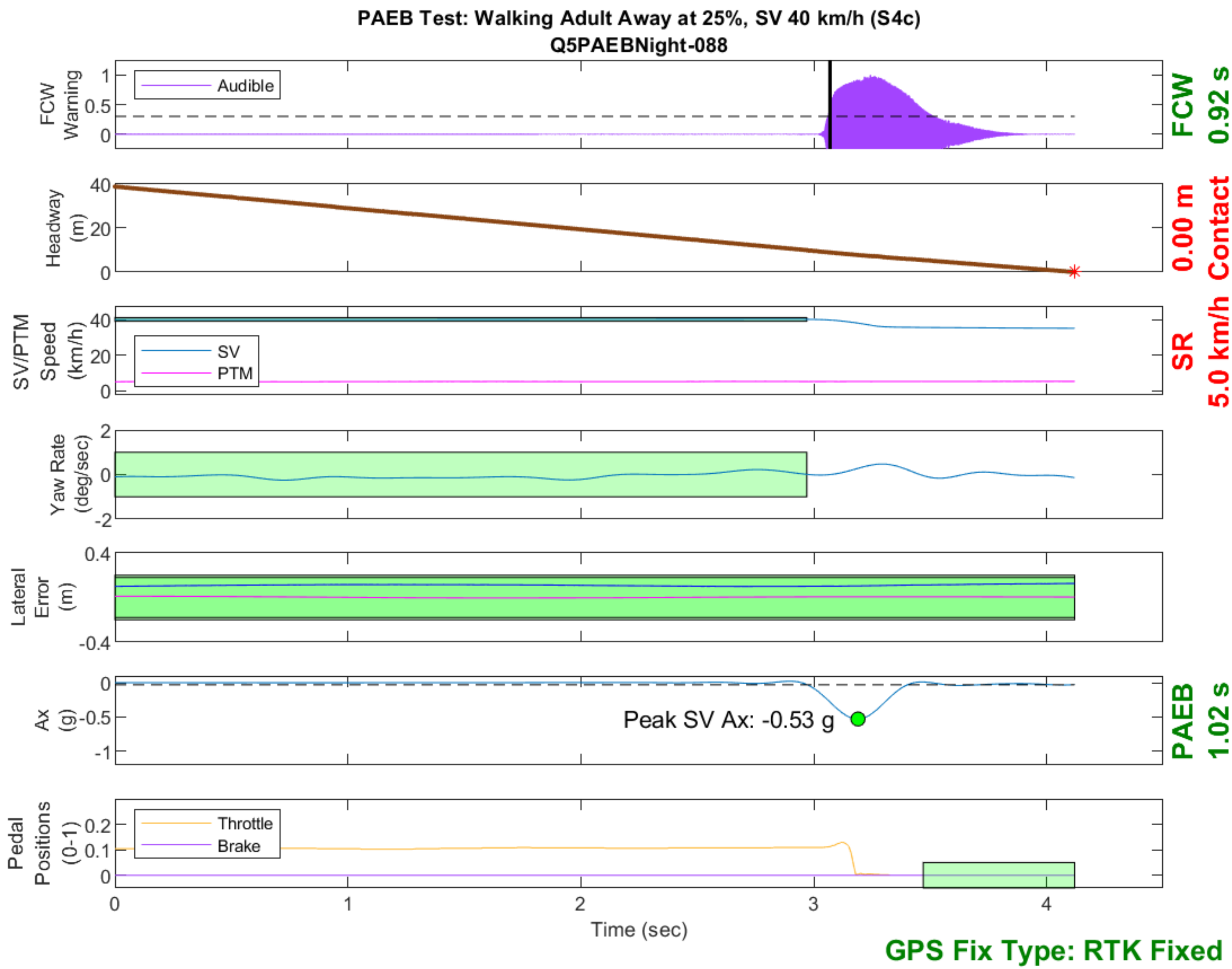

Figure D209. Time History for PAEB Run 88, S4c, Night, High Beam, 40 km/h

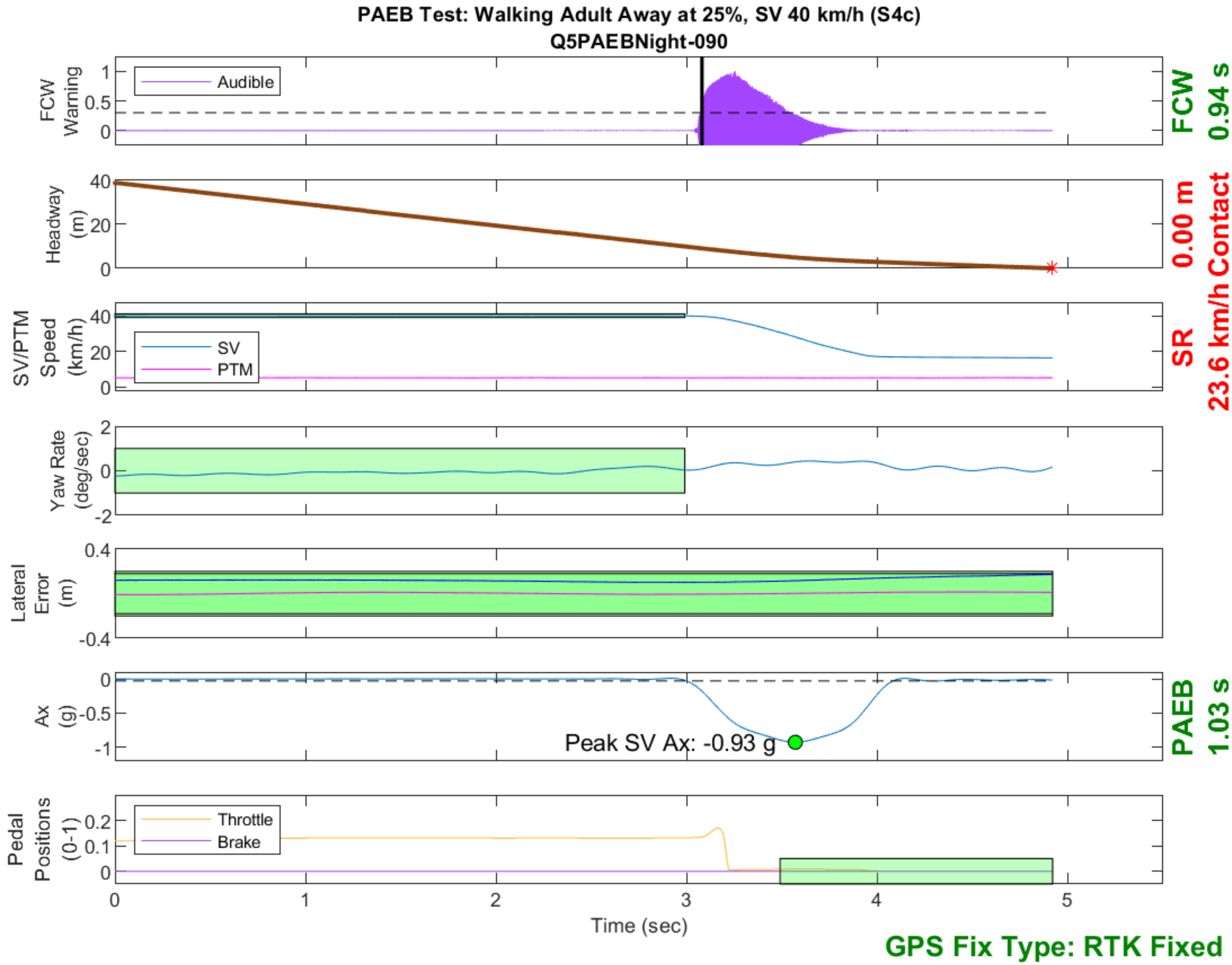

Figure D210. Time History for PAEB Run 90, S4c, Night, High Beam, 40 km/h

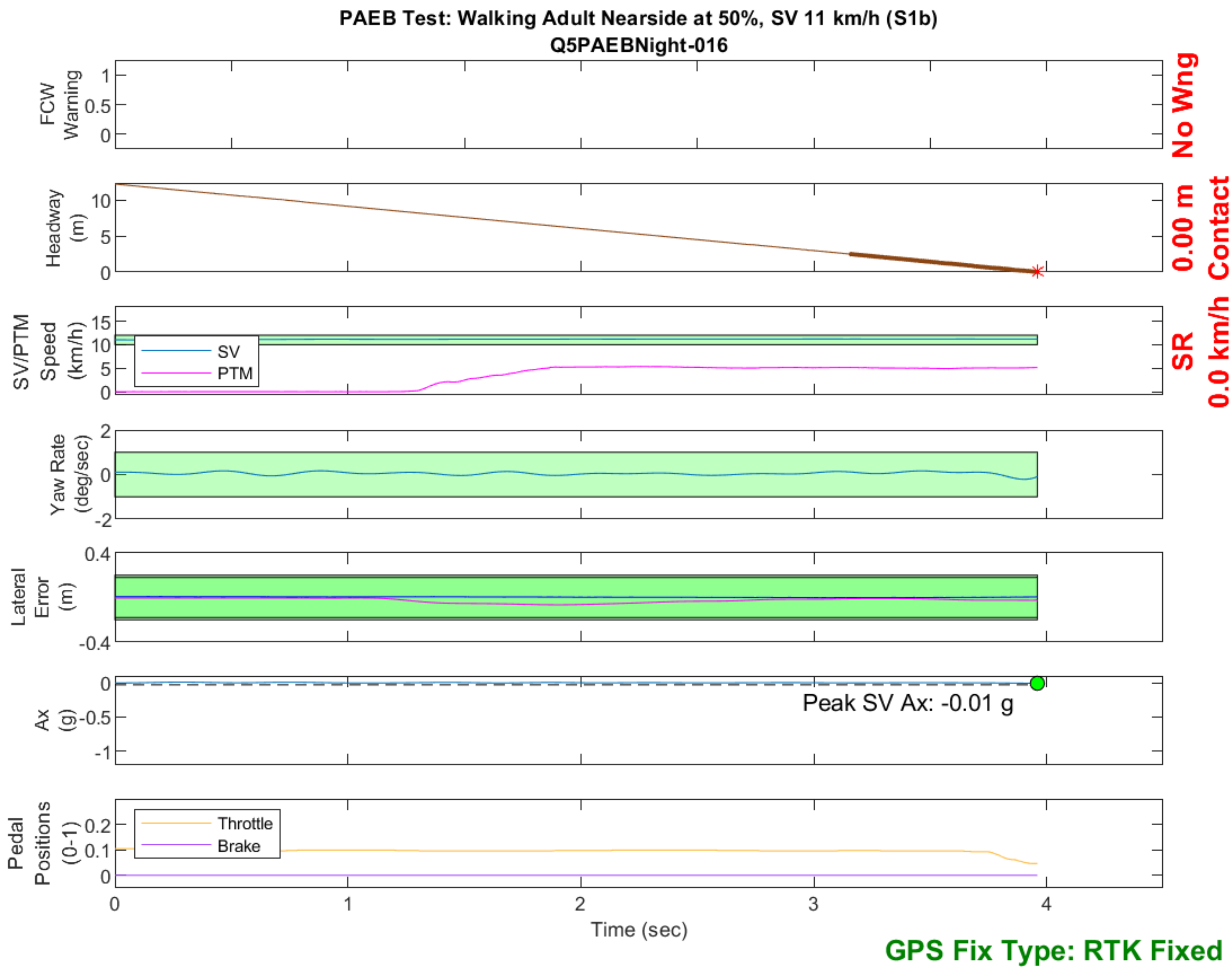

Figure D211. Time History for PAEB Run 16, S1b, Night, Low Beam, 11 km/h

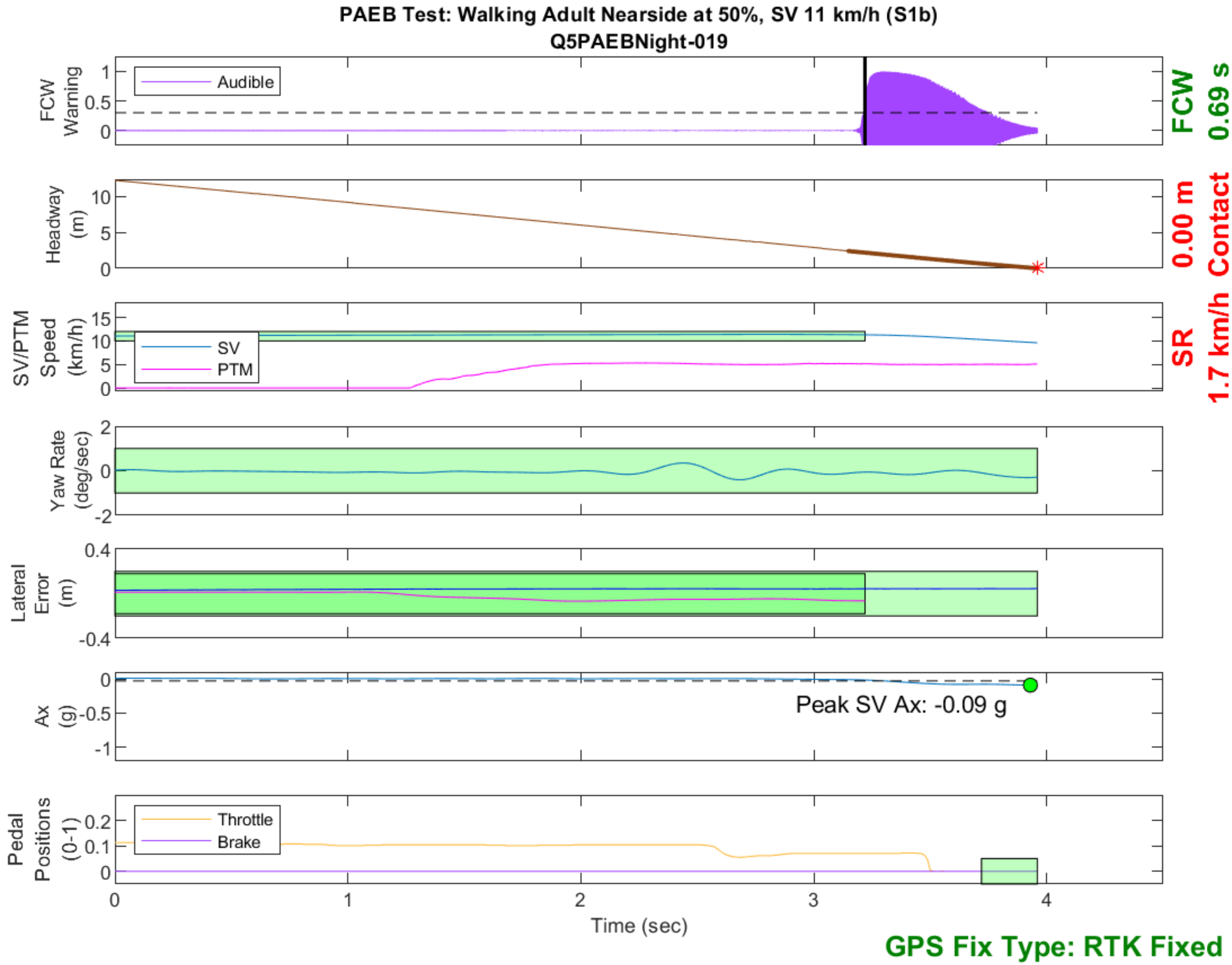

Figure D212. Time History for PAEB Run 19, S1b, Night, Low Beam, 11 km/h

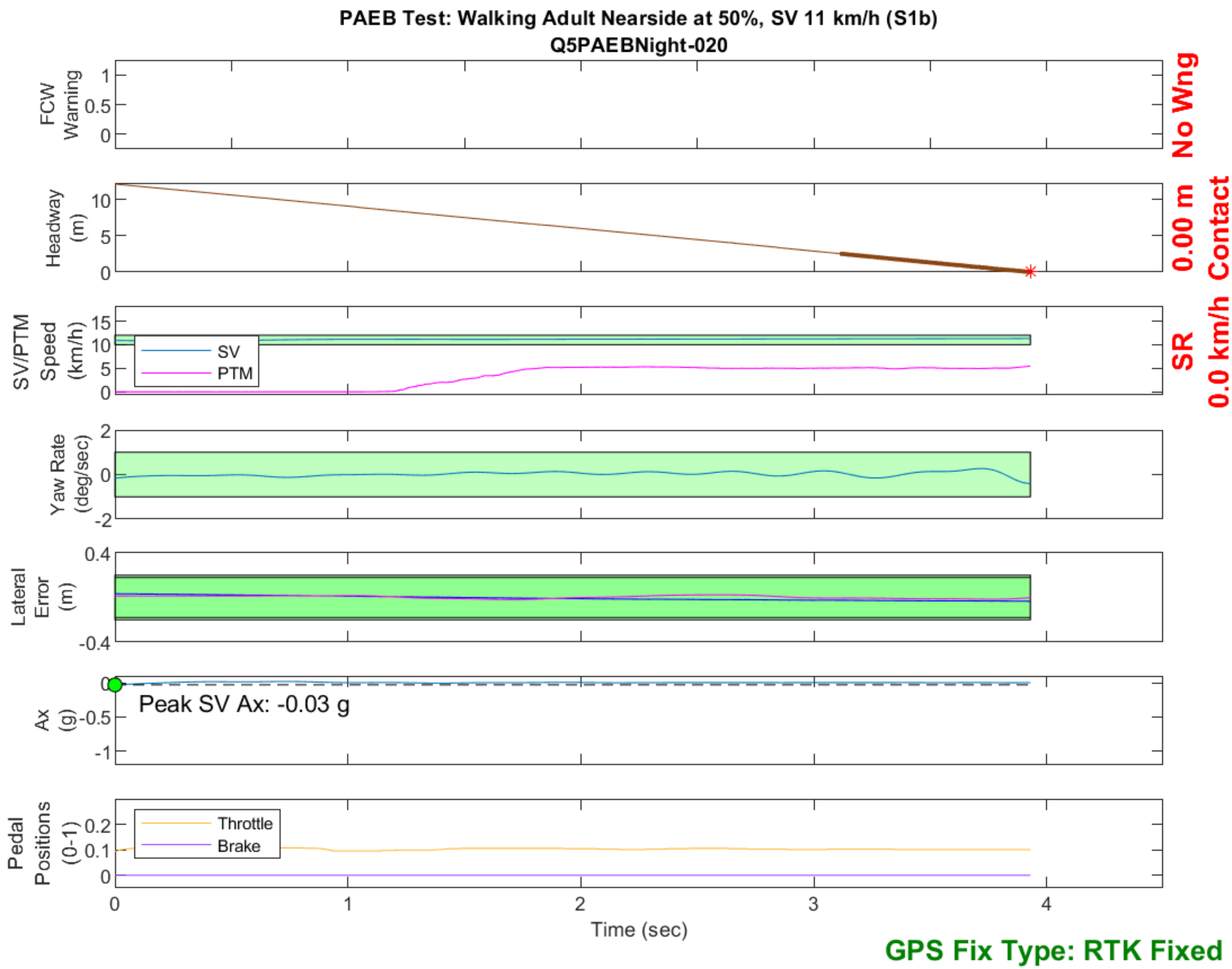

Figure D213. Time History for PAEB Run 20, S1b, Night, Low Beam, 11 km/h

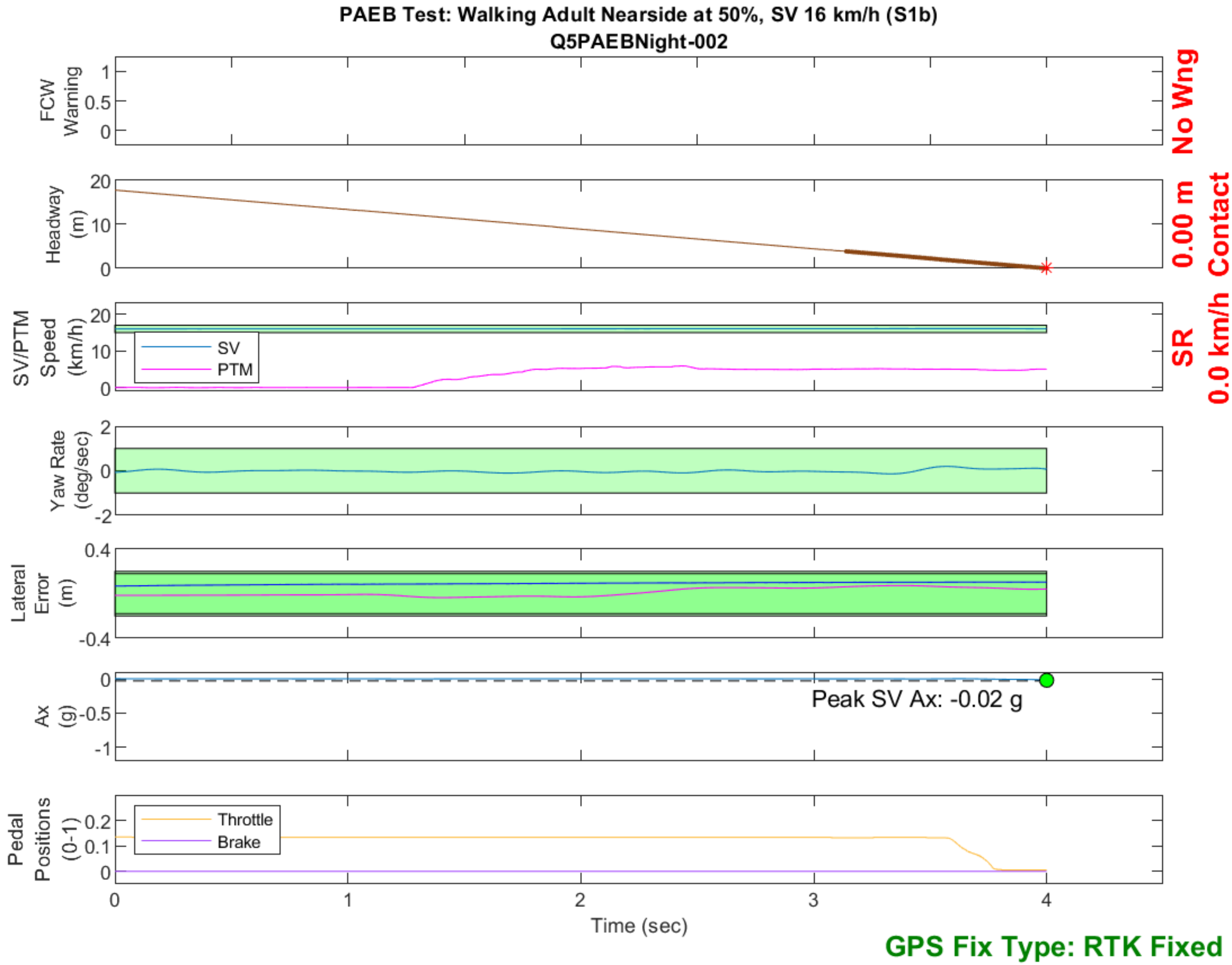

Figure D214. Time History for PAEB Run 2, S1b, Night, Low Beam, 16 km/h

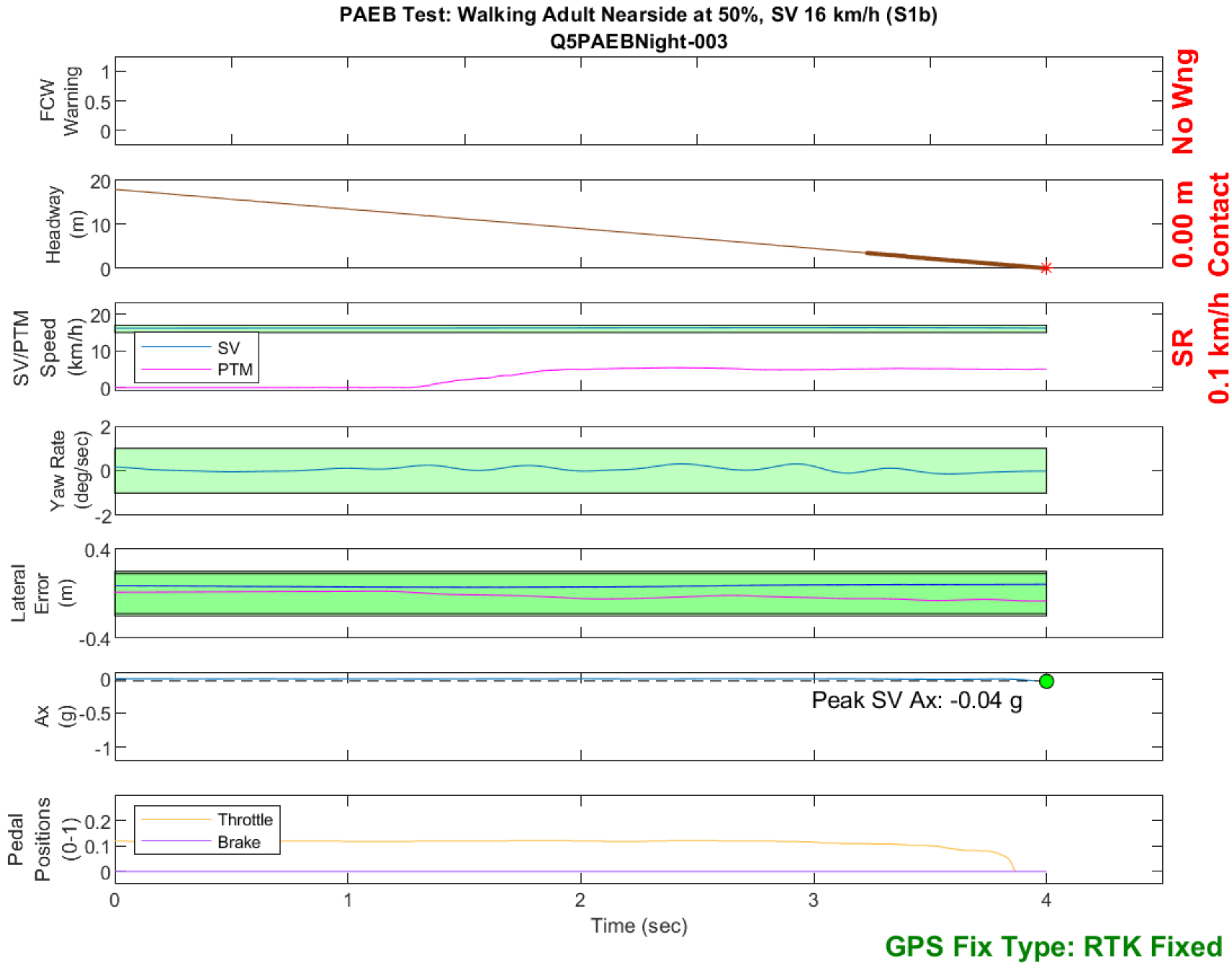

Figure D215. Time History for PAEB Run 3, S1b, Night, Low Beam, 16 km/h

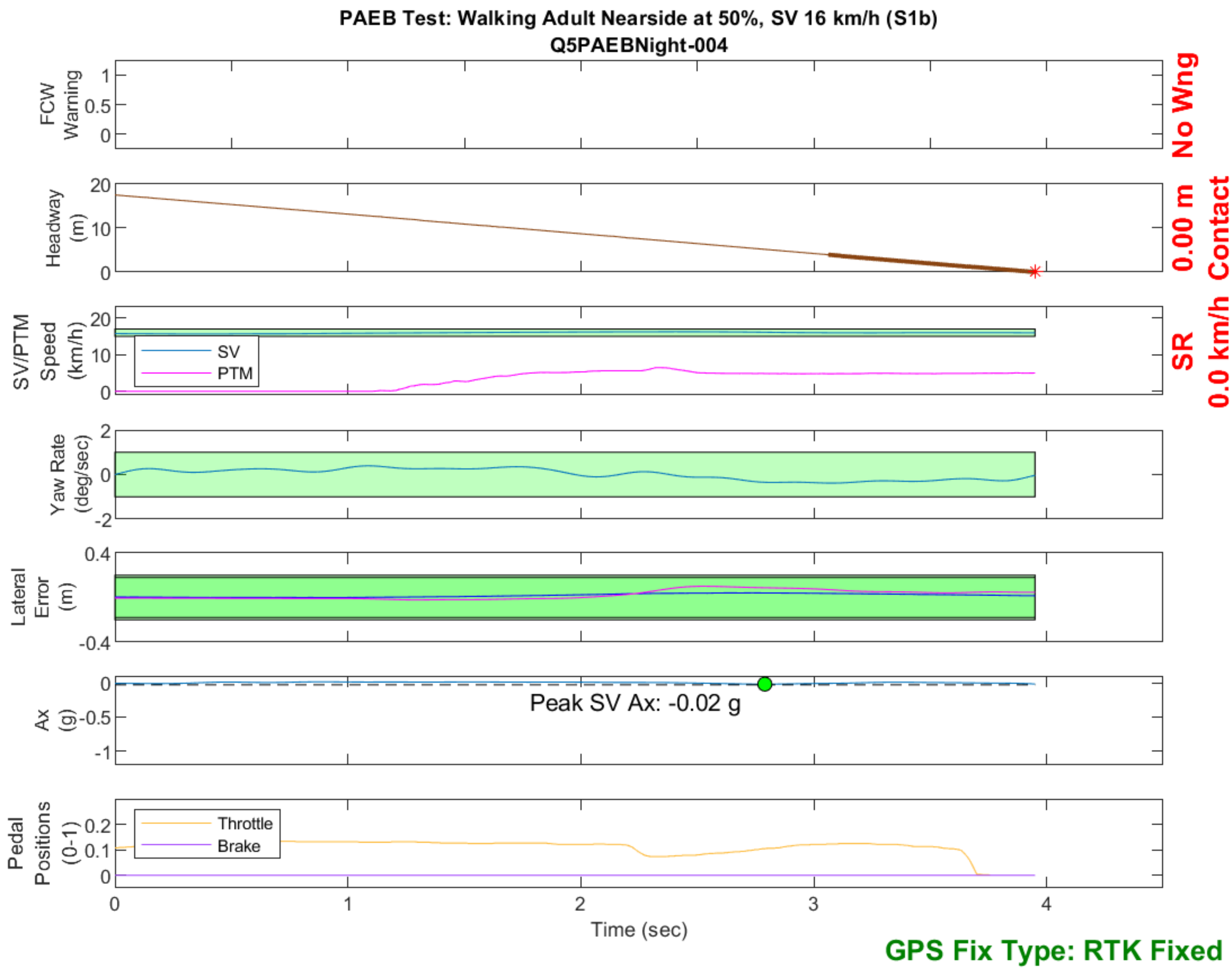

Figure D216. Time History for PAEB Run 4, S1b, Night, Low Beam, 16 km/h

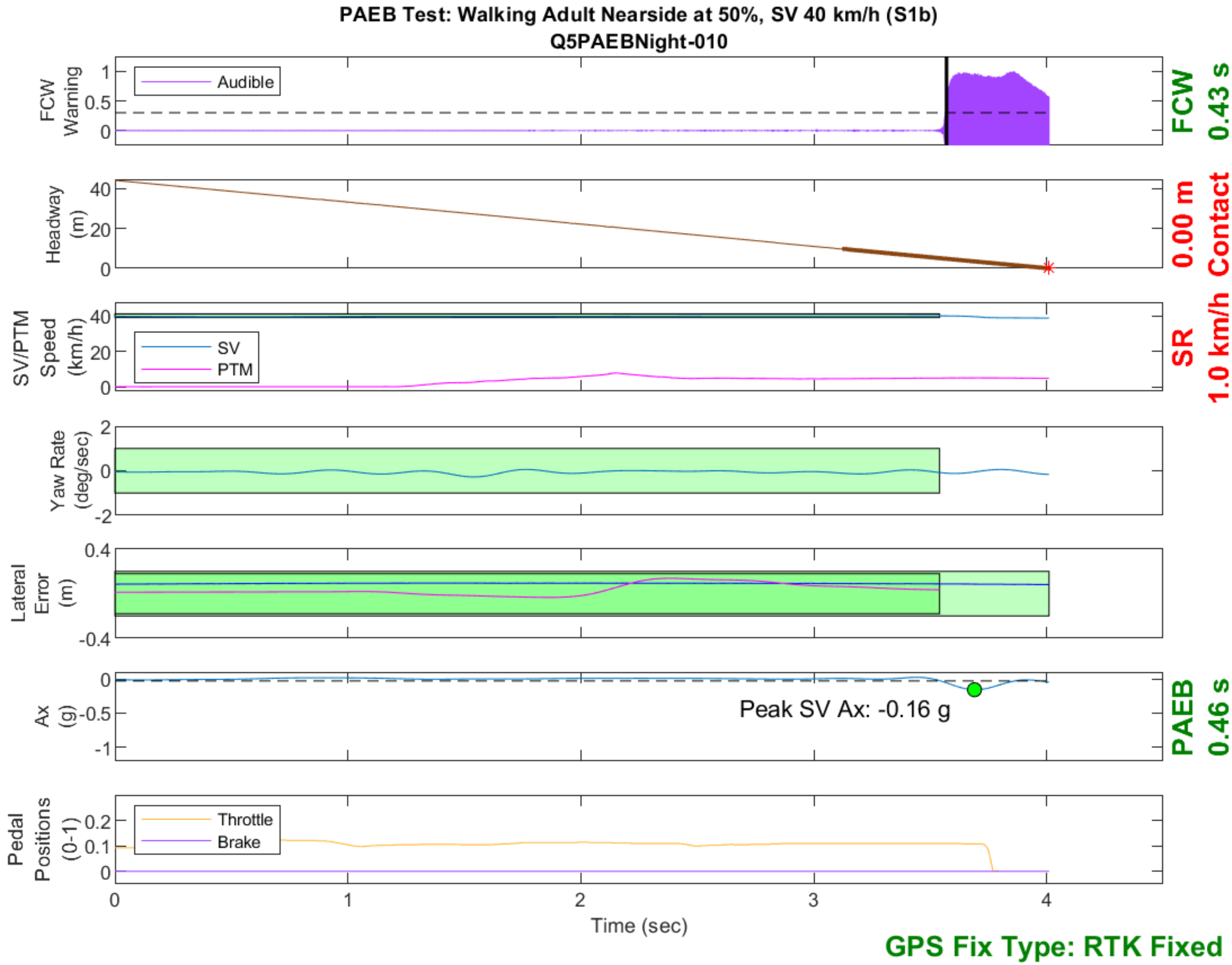

Figure D217. Time History for PAEB Run 10, S1b, Night, Low Beam, 40 km/h

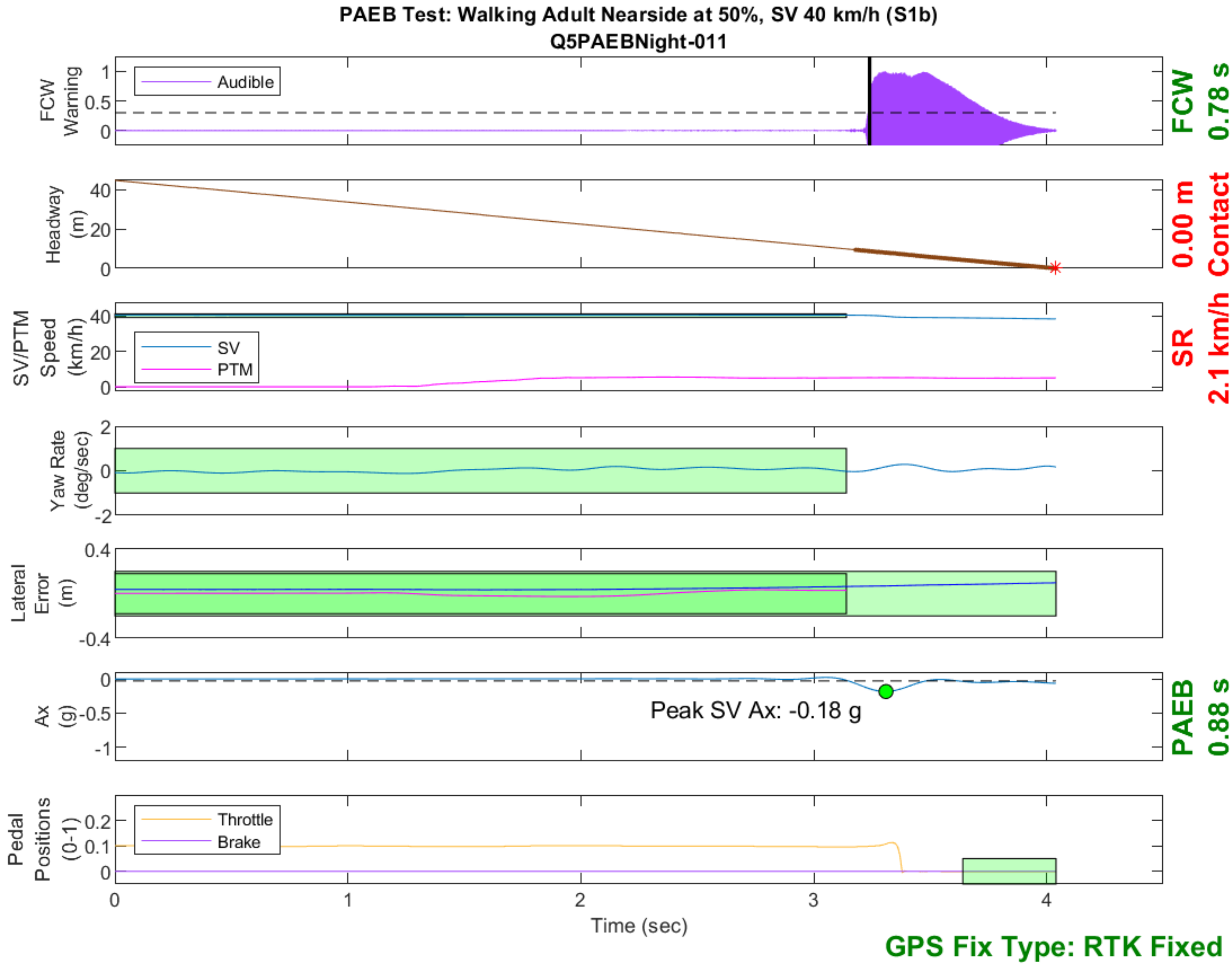

Figure D218. Time History for PAEB Run 11, S1b, Night, Low Beam, 40 km/h

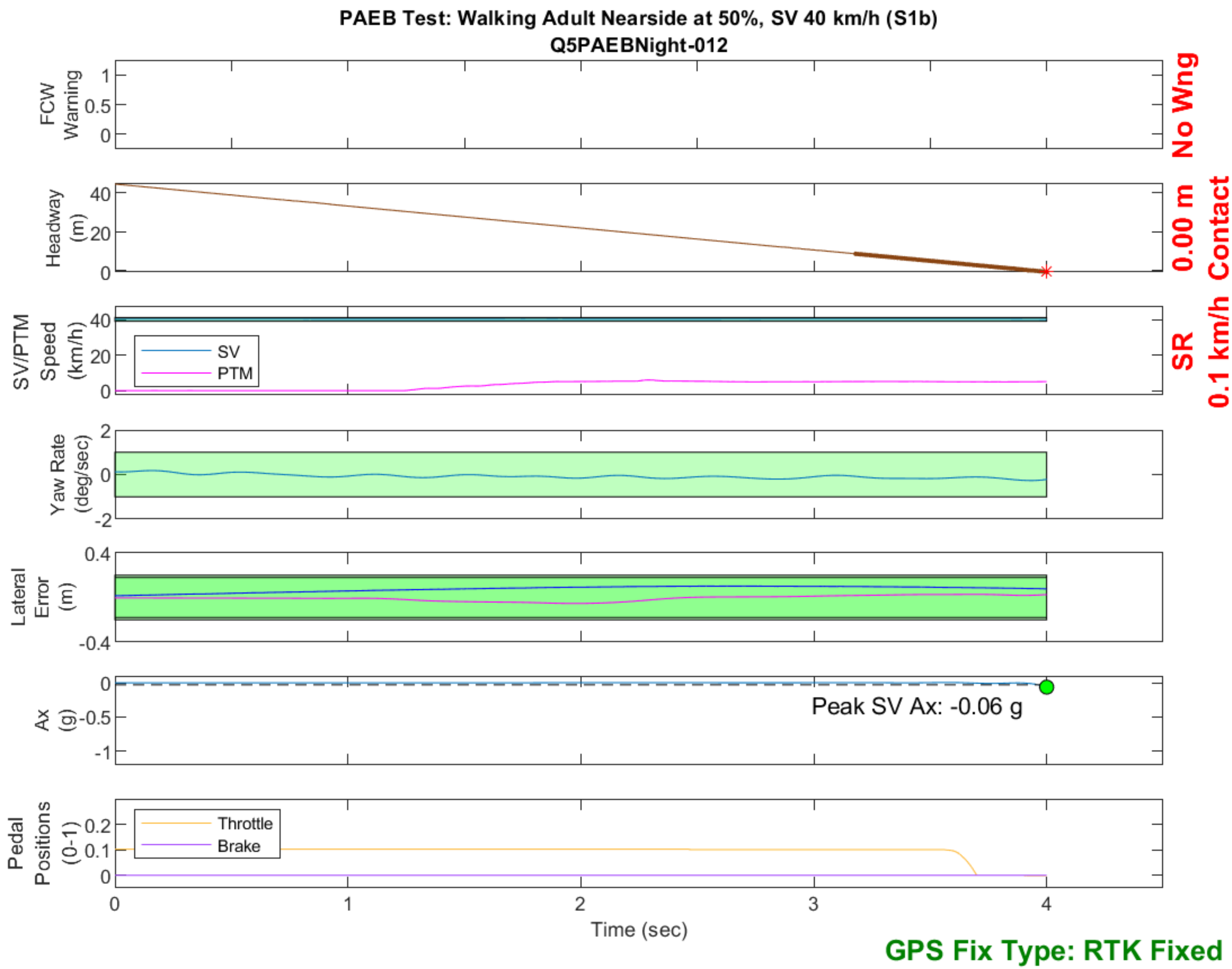

Figure D219. Time History for PAEB Run 12, S1b, Night, Low Beam, 40 km/h

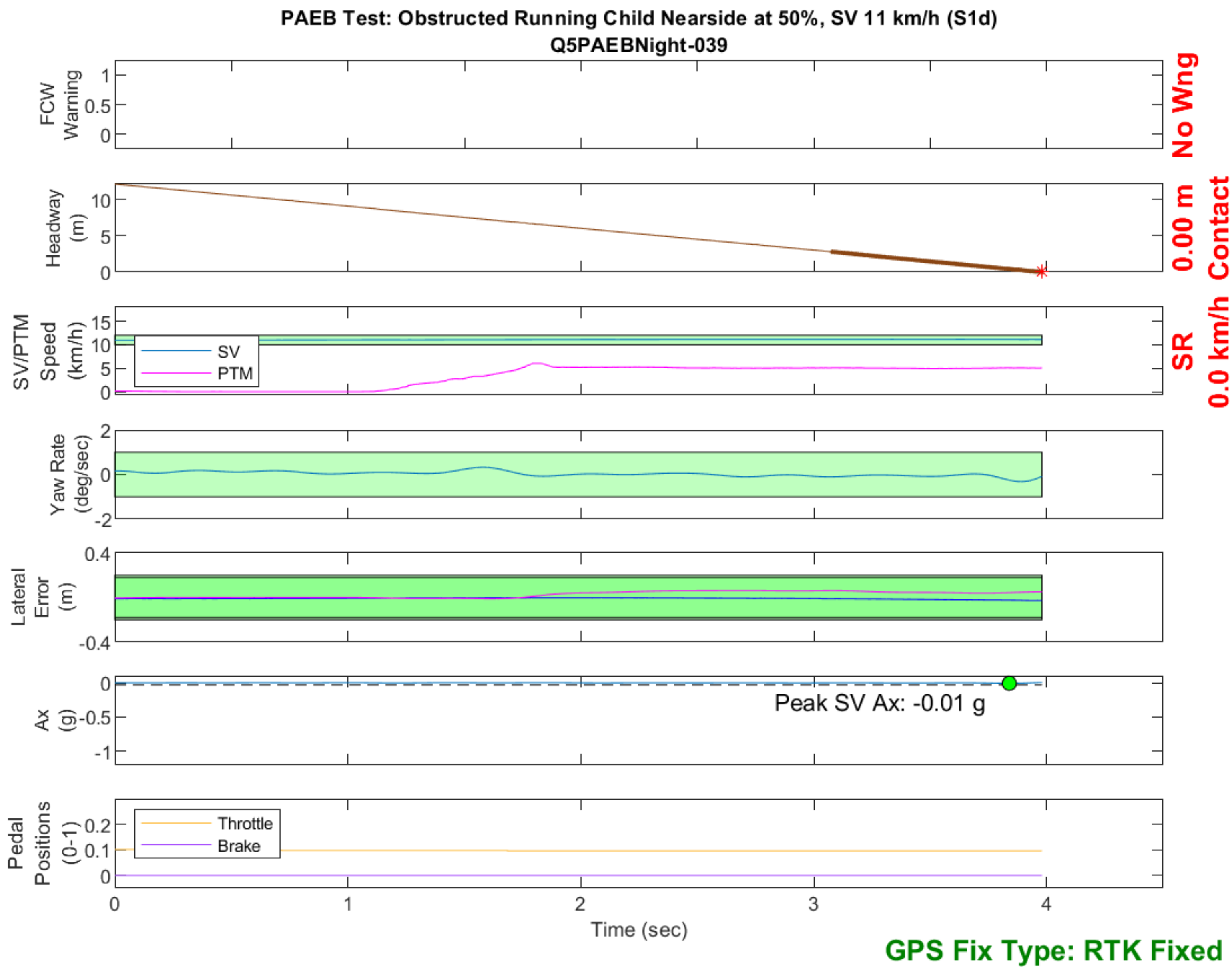

Figure D220. Time History for PAEB Run 39, S1d, Night, Low Beam, 11 km/h

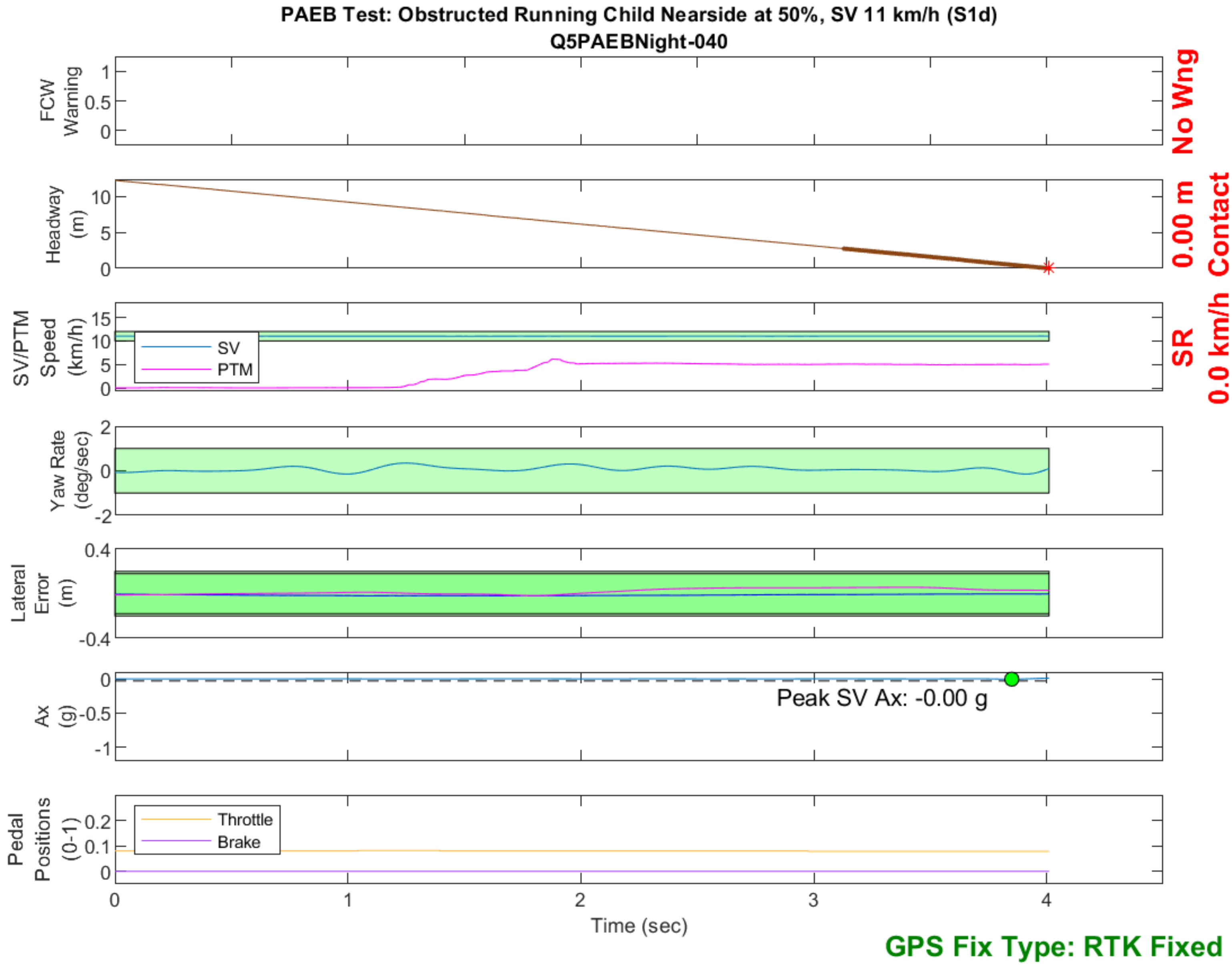

Figure D221. Time History for PAEB Run 40, S1d, Night, Low Beam, 11 km/h

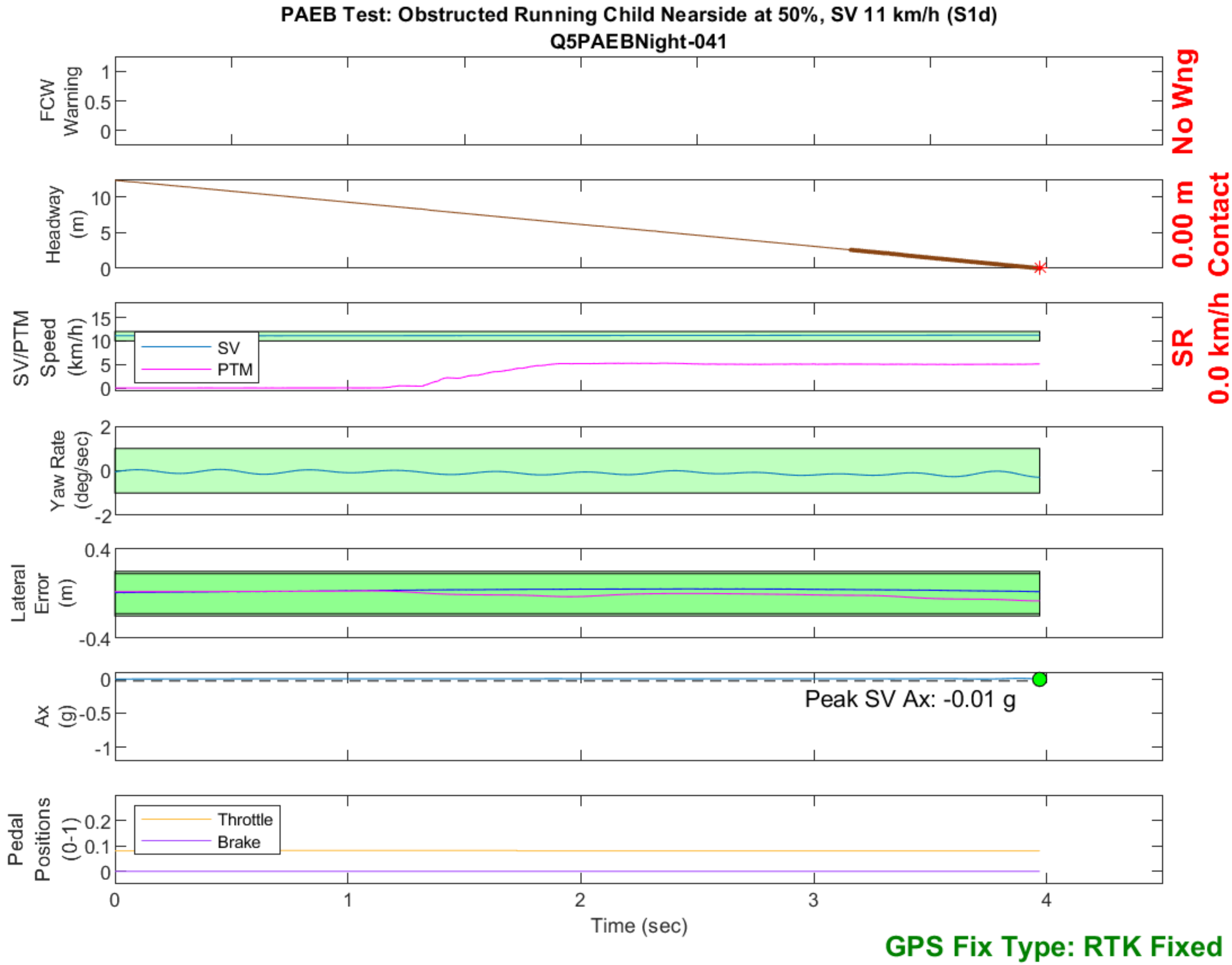

Figure D222. Time History for PAEB Run 41, S1d, Night, Low Beam, 11 km/h

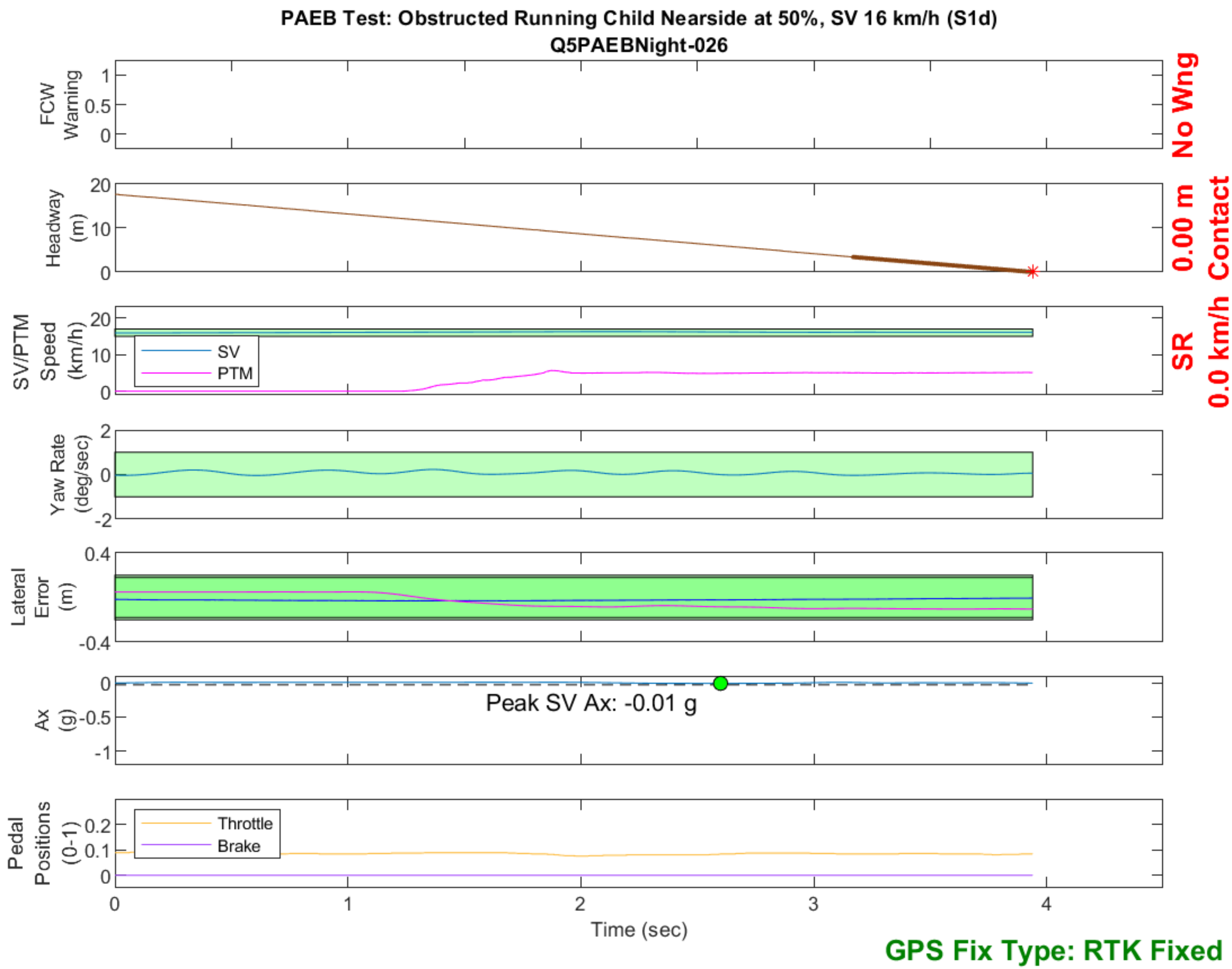

Figure D223. Time History for PAEB Run 26, S1d, Night, Low Beam, 16 km/h

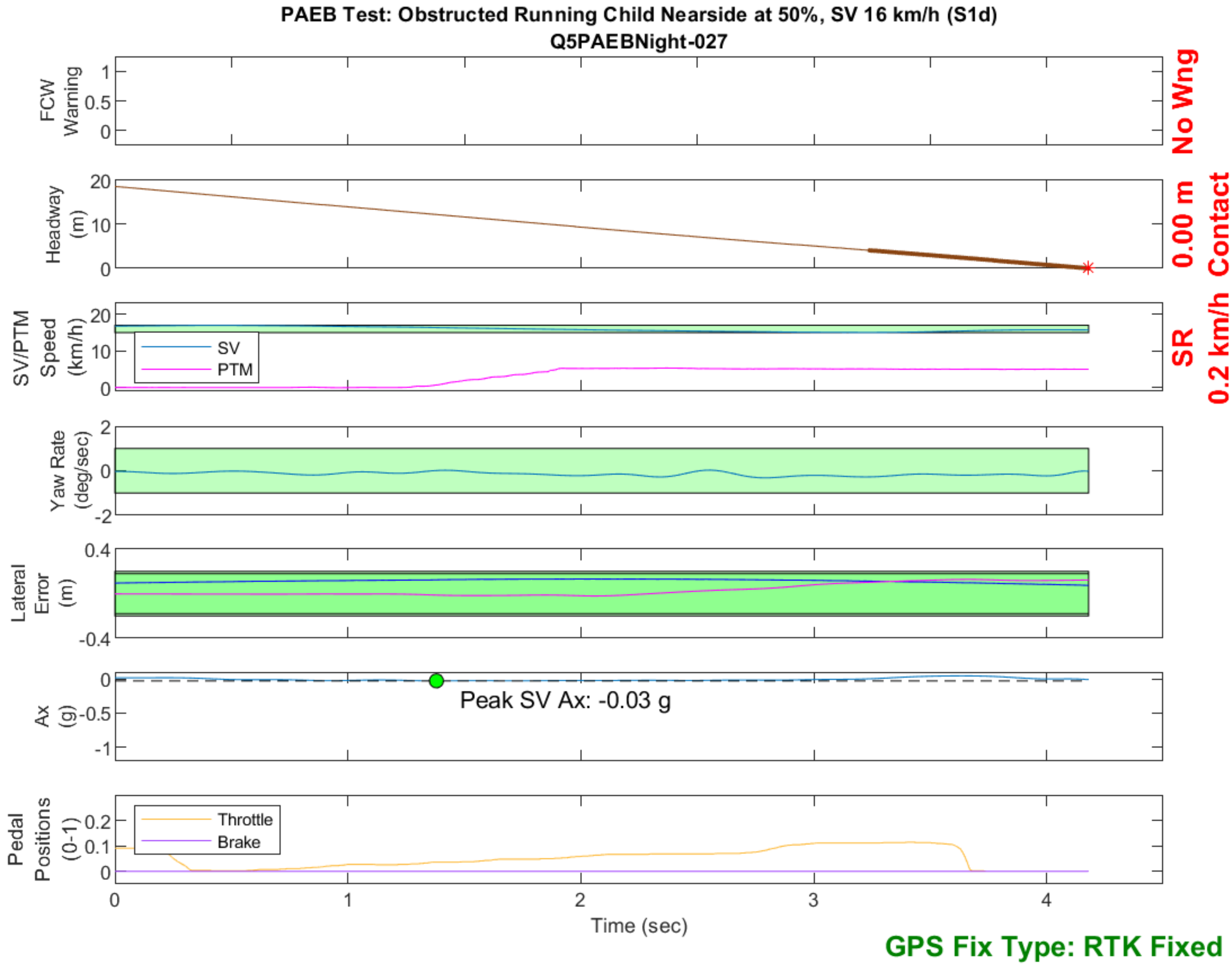

Figure D224. Time History for PAEB Run 27, S1d, Night, Low Beam, 16 km/h

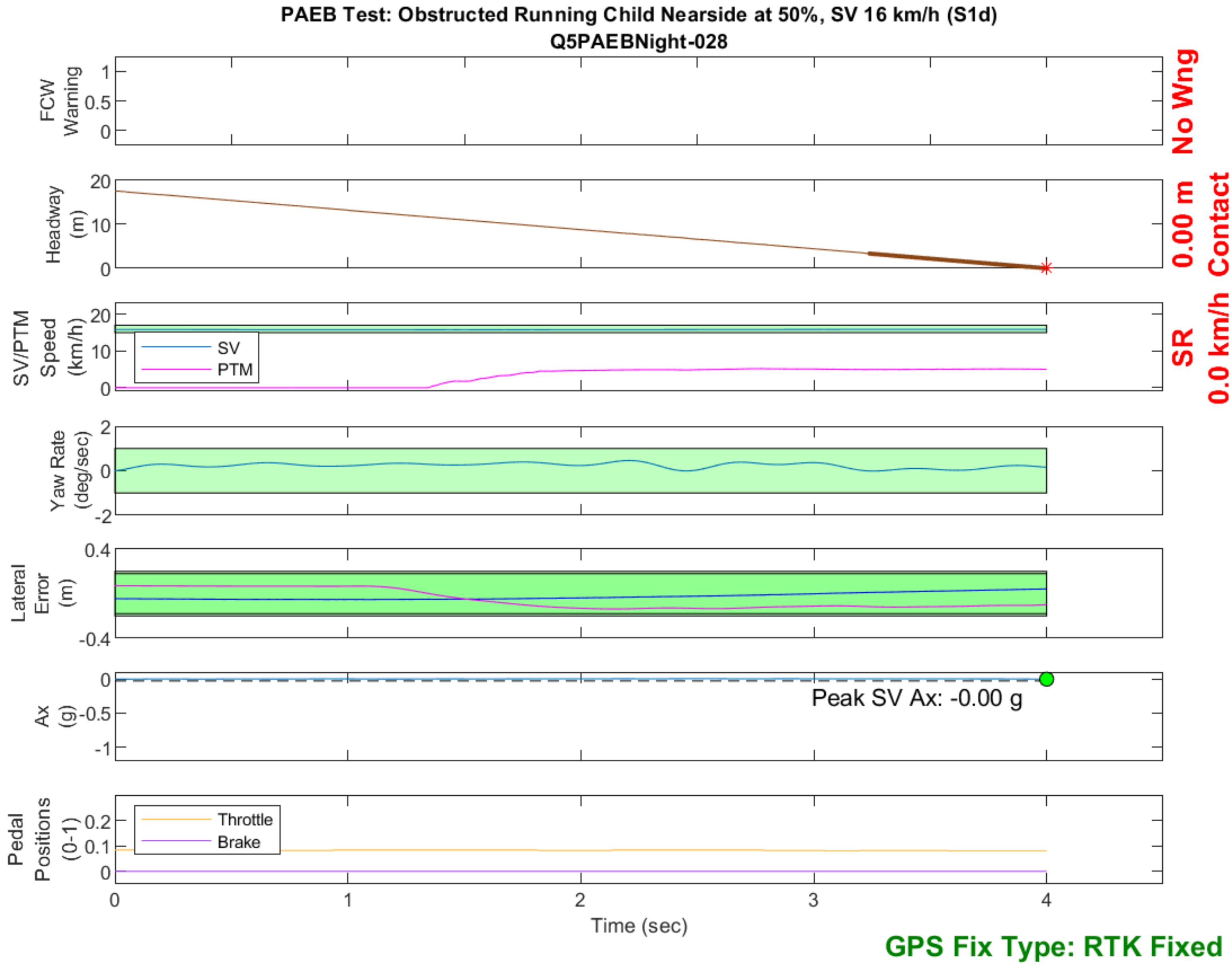

Figure D225. Time History for PAEB Run 28, S1d, Night, Low Beam, 16 km/h

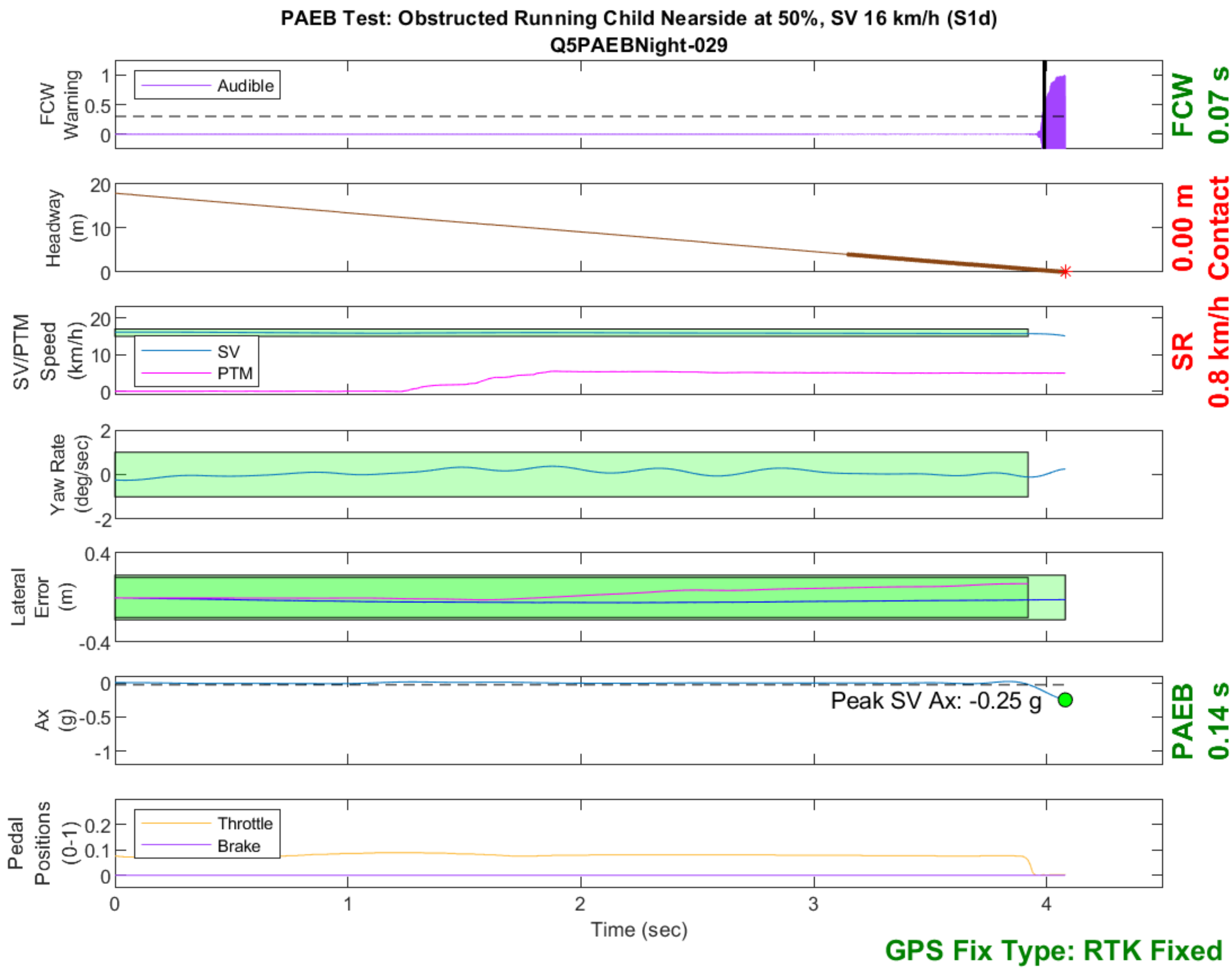

Figure D226. Time History for PAEB Run 29, S1d, Night, Low Beam, 16 km/h

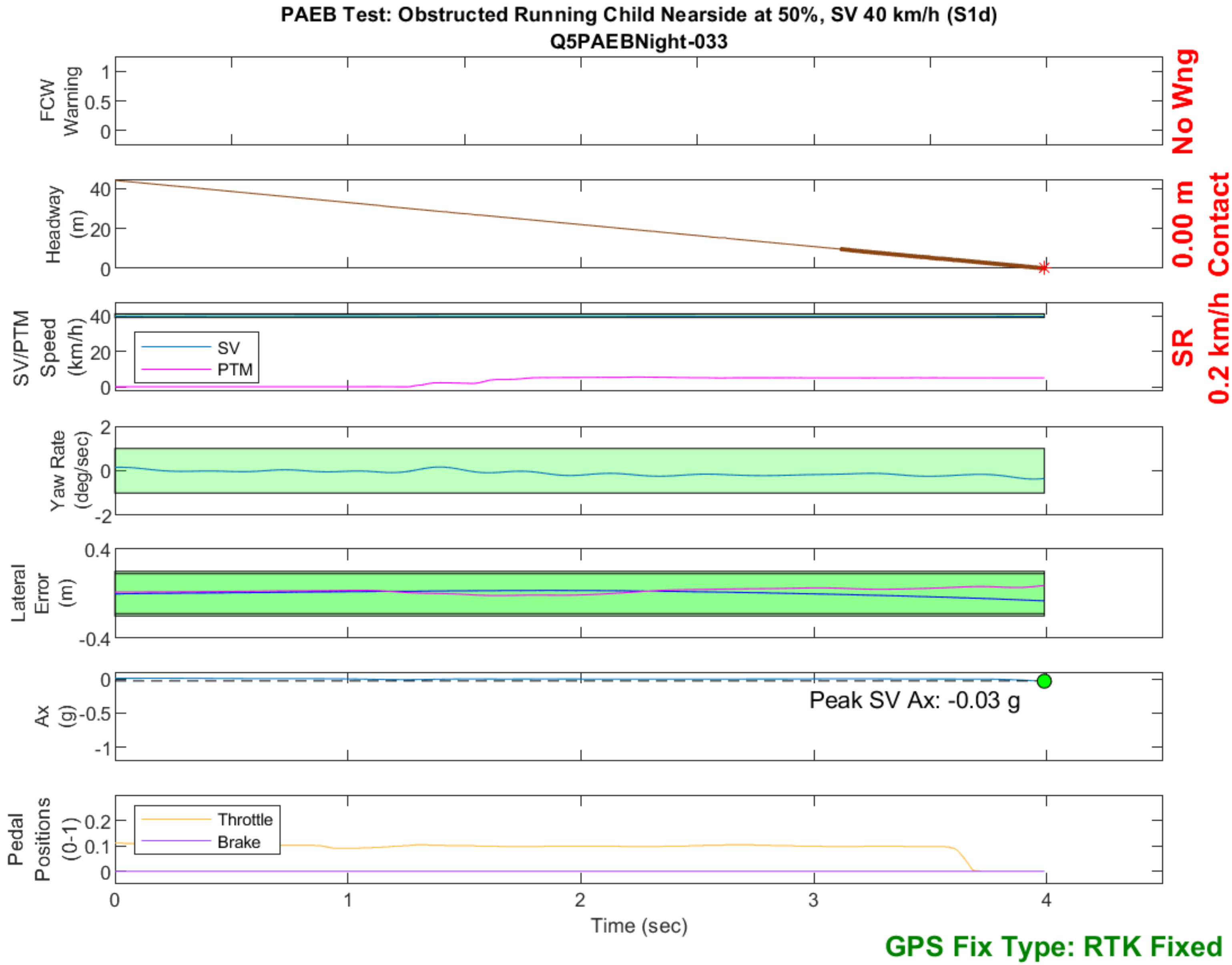

Figure D227. Time History for PAEB Run 33, S1d, Night, Low Beam, 40 km/h

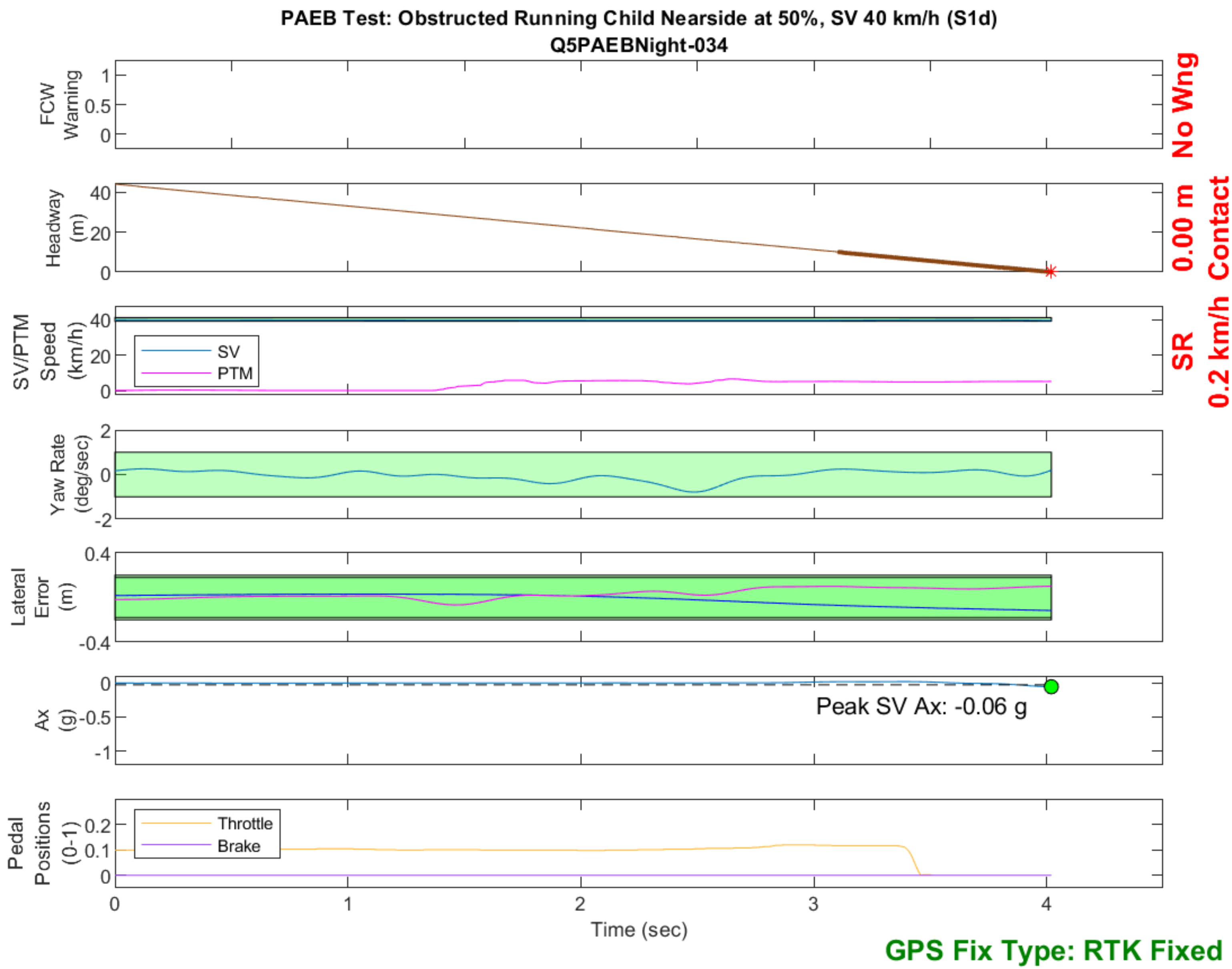

Figure D228. Time History for PAEB Run 34, S1d, Night, Low Beam, 40 km/h

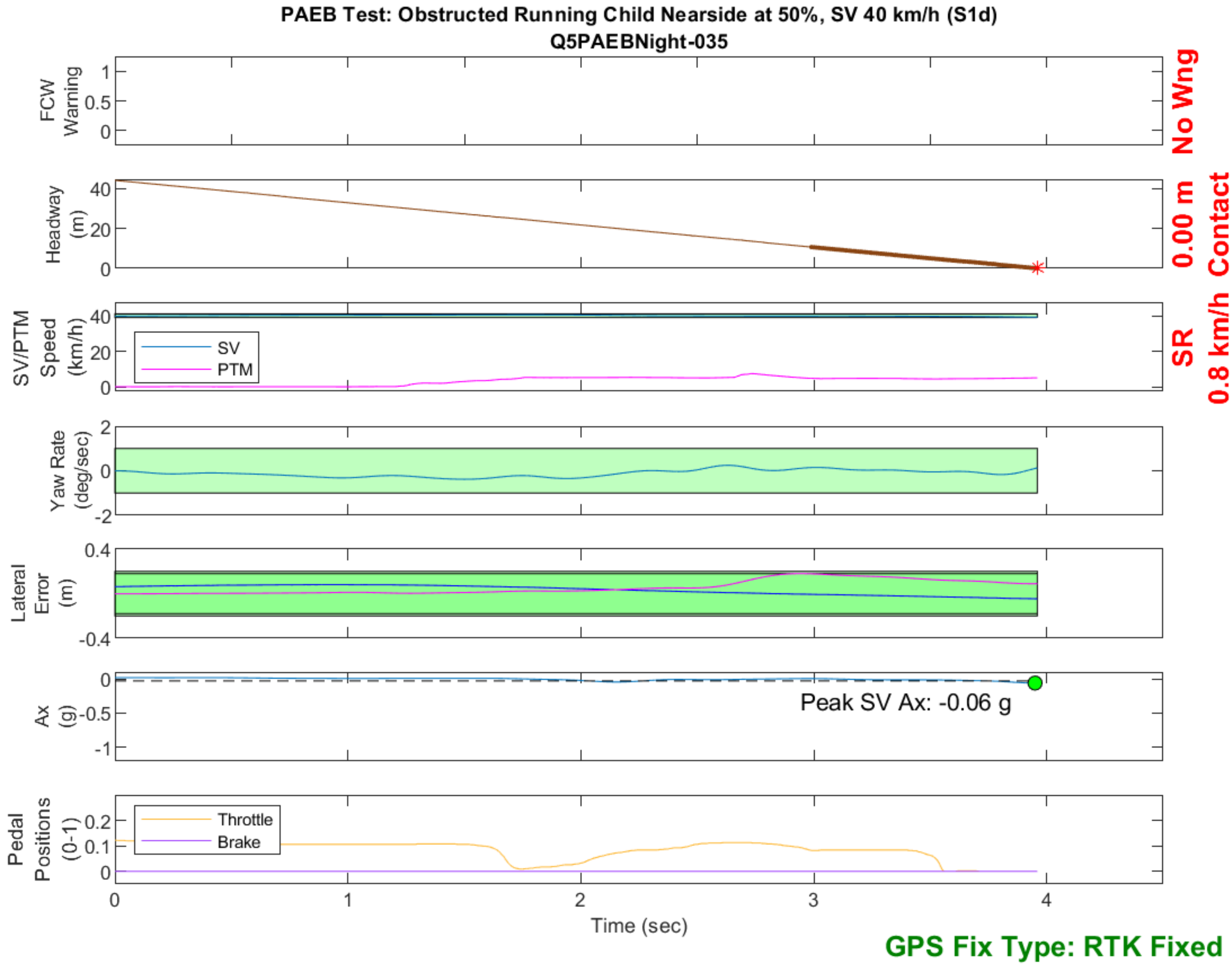

Figure D229. Time History for PAEB Run 35, S1d, Night, Low Beam, 40 km/h

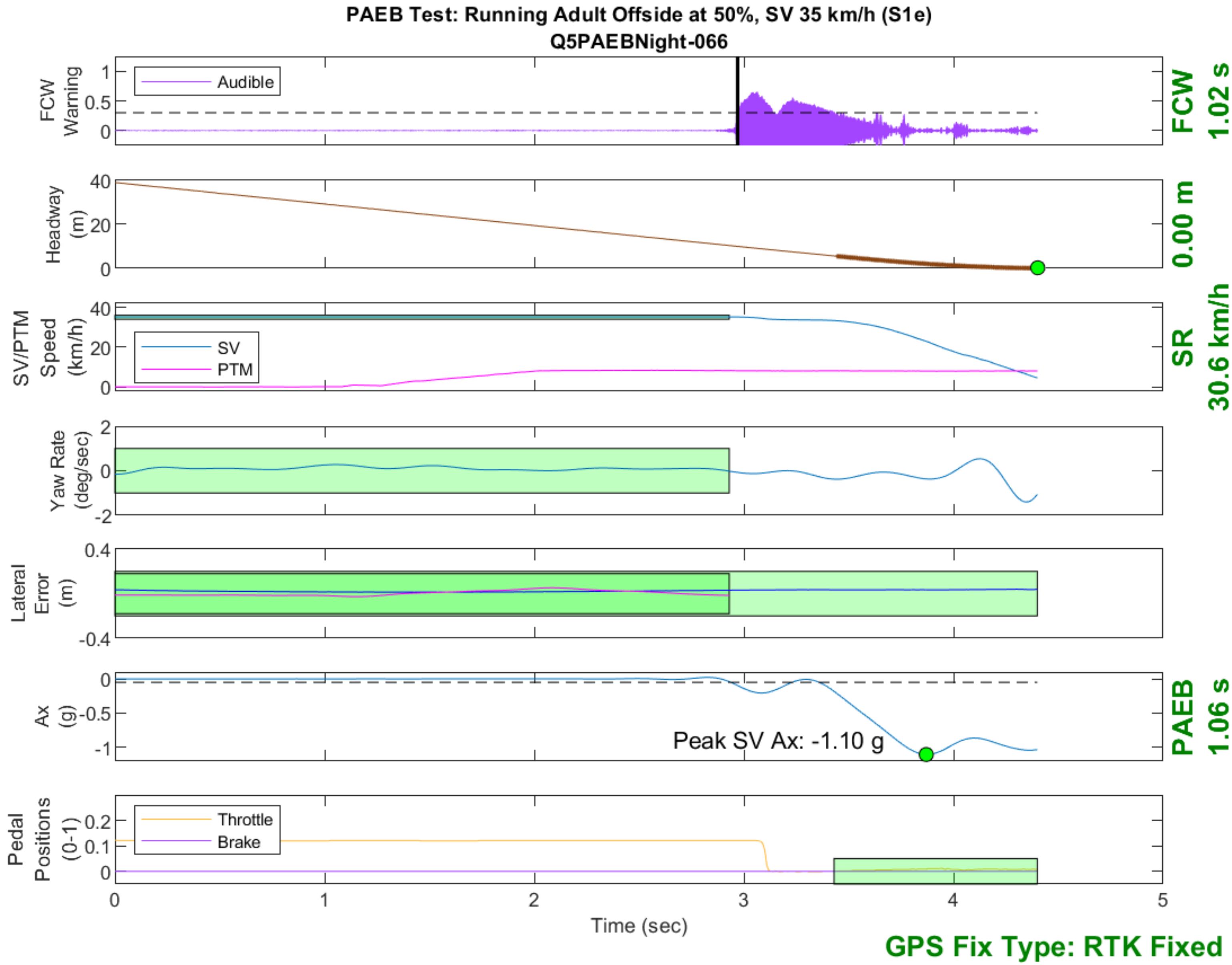

Figure D230. Time History for PAEB Run 66, S1e, Night, Low Beam, 35 km/h

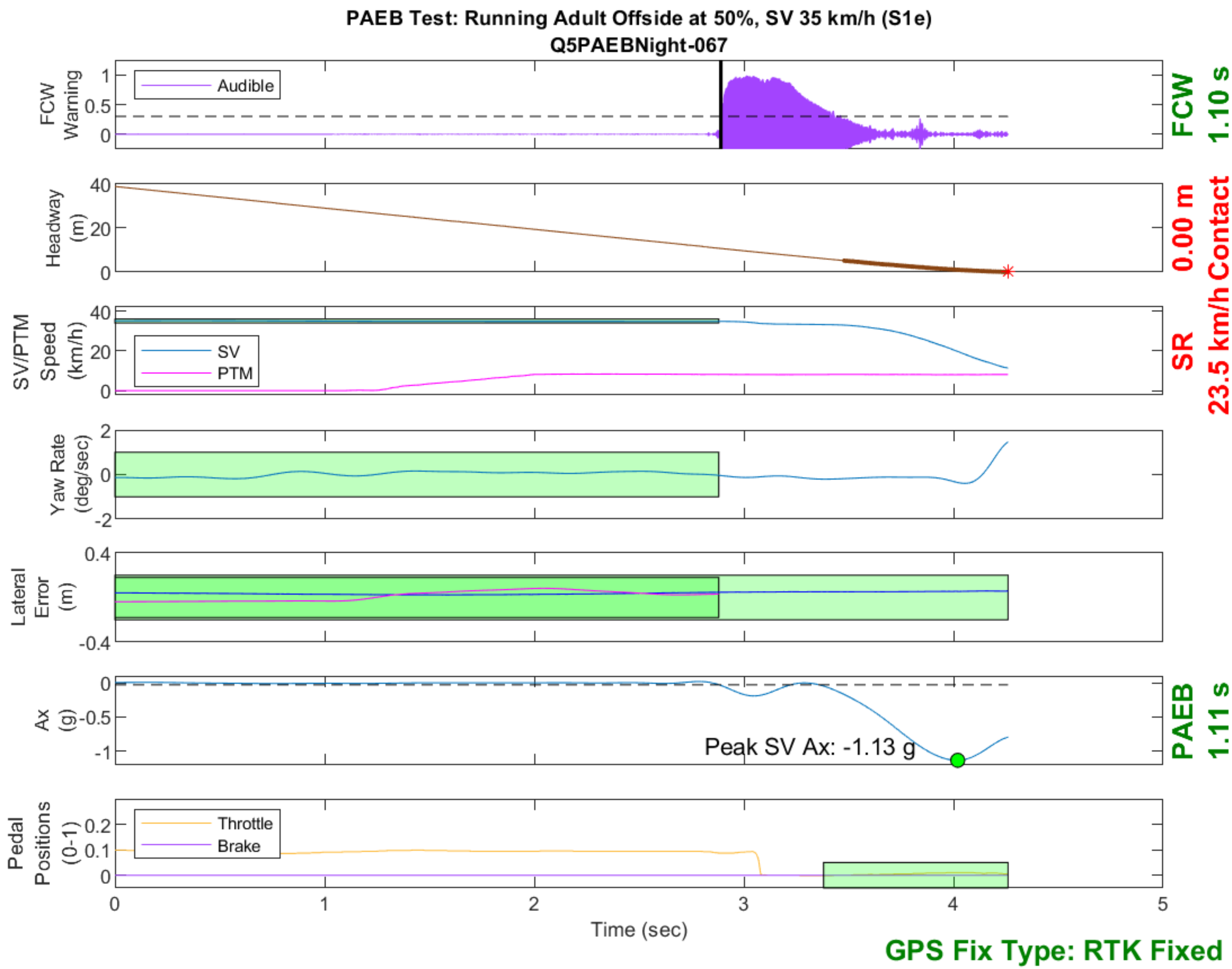

Figure D231. Time History for PAEB Run 67, S1e, Night, Low Beam, 35 km/h

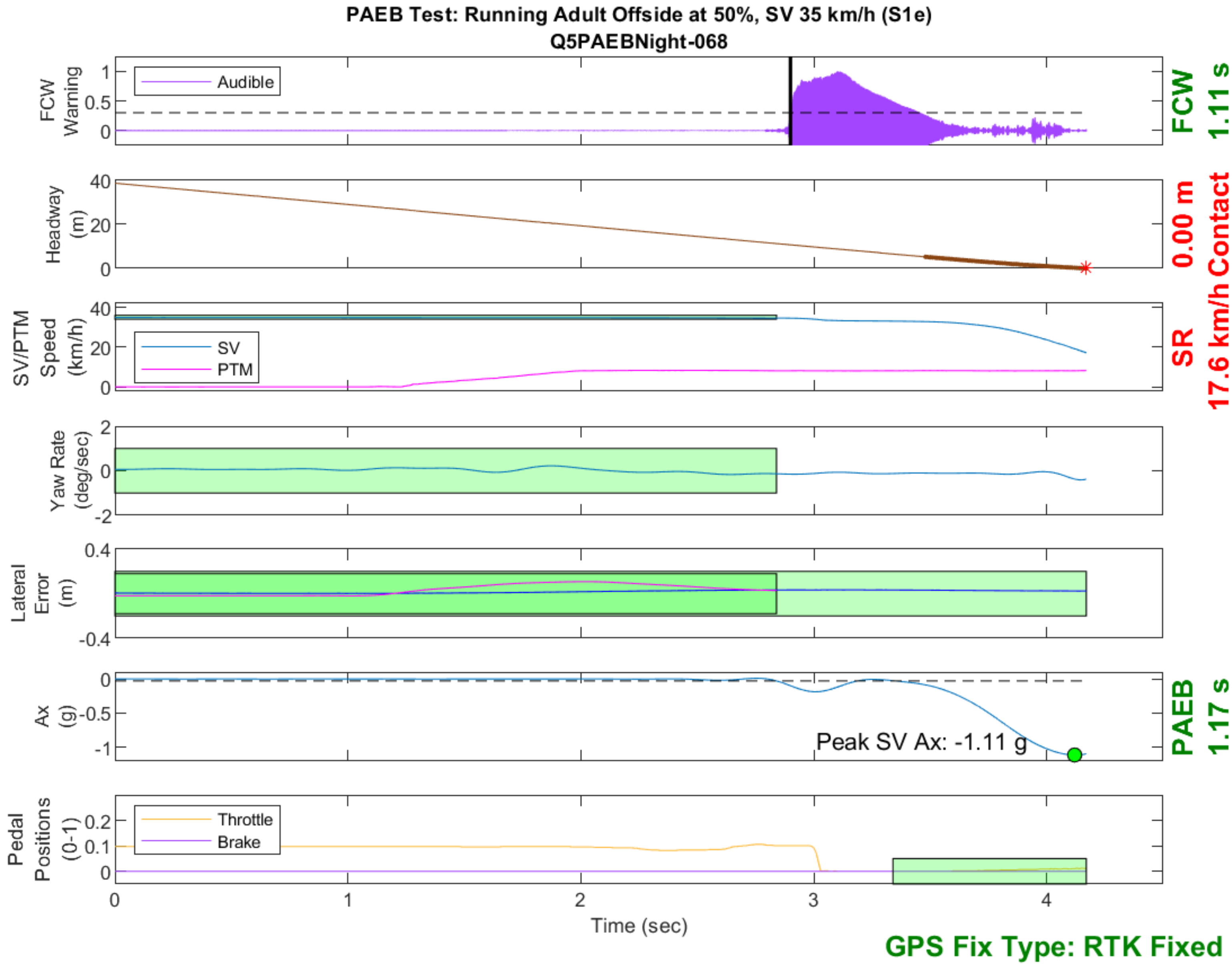

Figure D232. Time History for PAEB Run 68, S1e, Night, Low Beam, 35 km/h

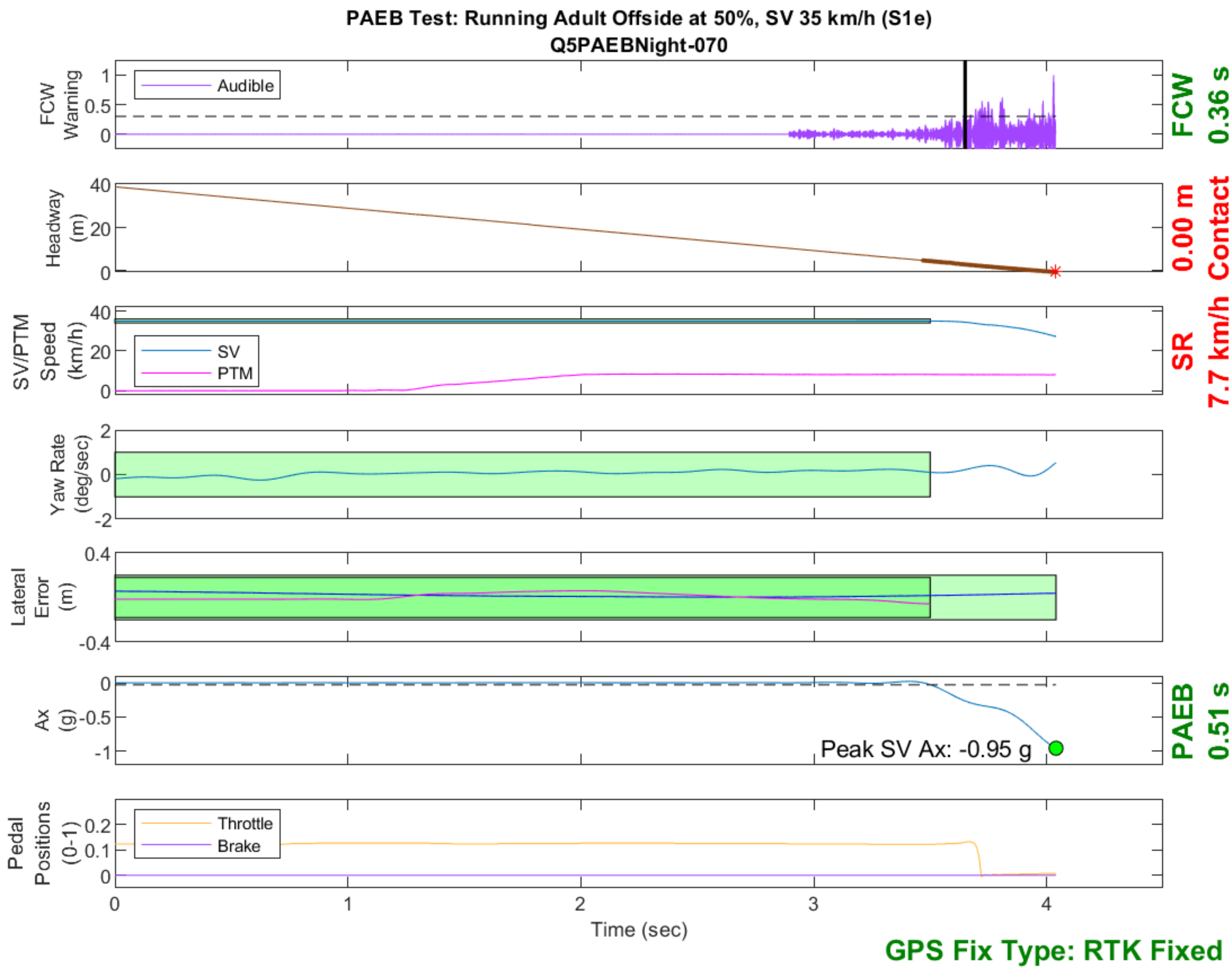

Figure D233. Time History for PAEB Run 70, S1e, Night, Low Beam, 35 km/h

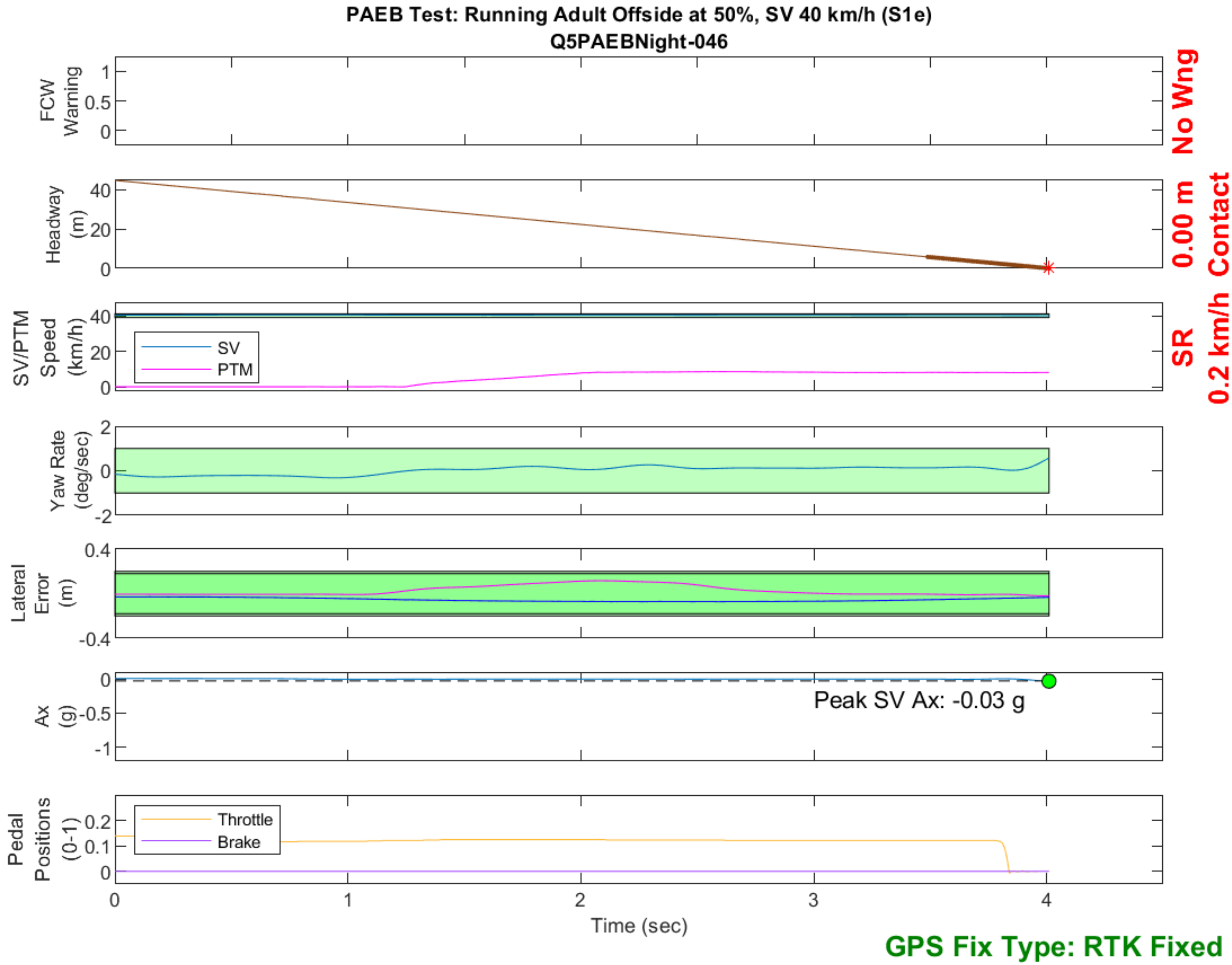

Figure D234. Time History for PAEB Run 46, S1e, Night, Low Beam, 40 km/h

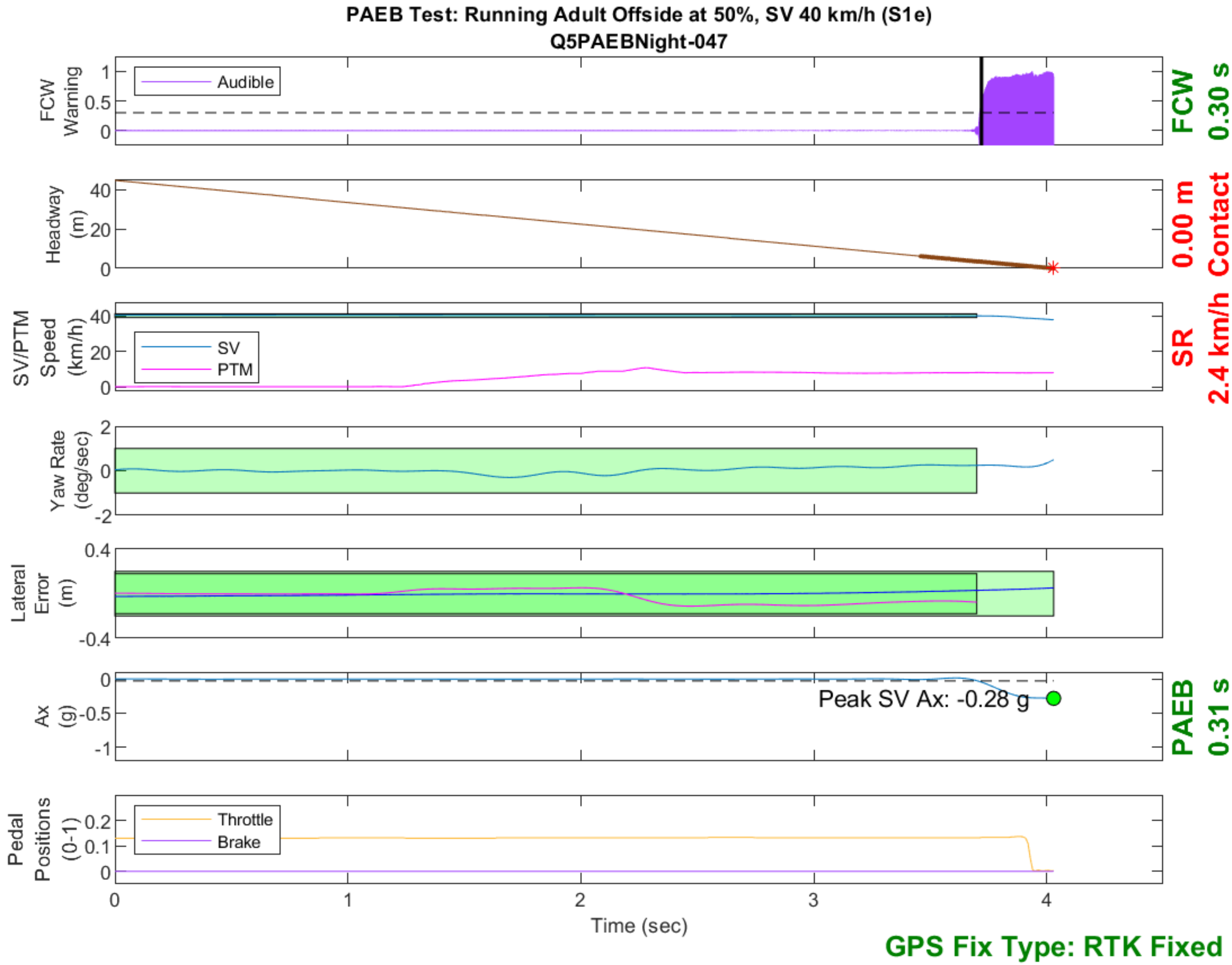

Figure D235. Time History for PAEB Run 47, S1e, Night, Low Beam, 40 km/h

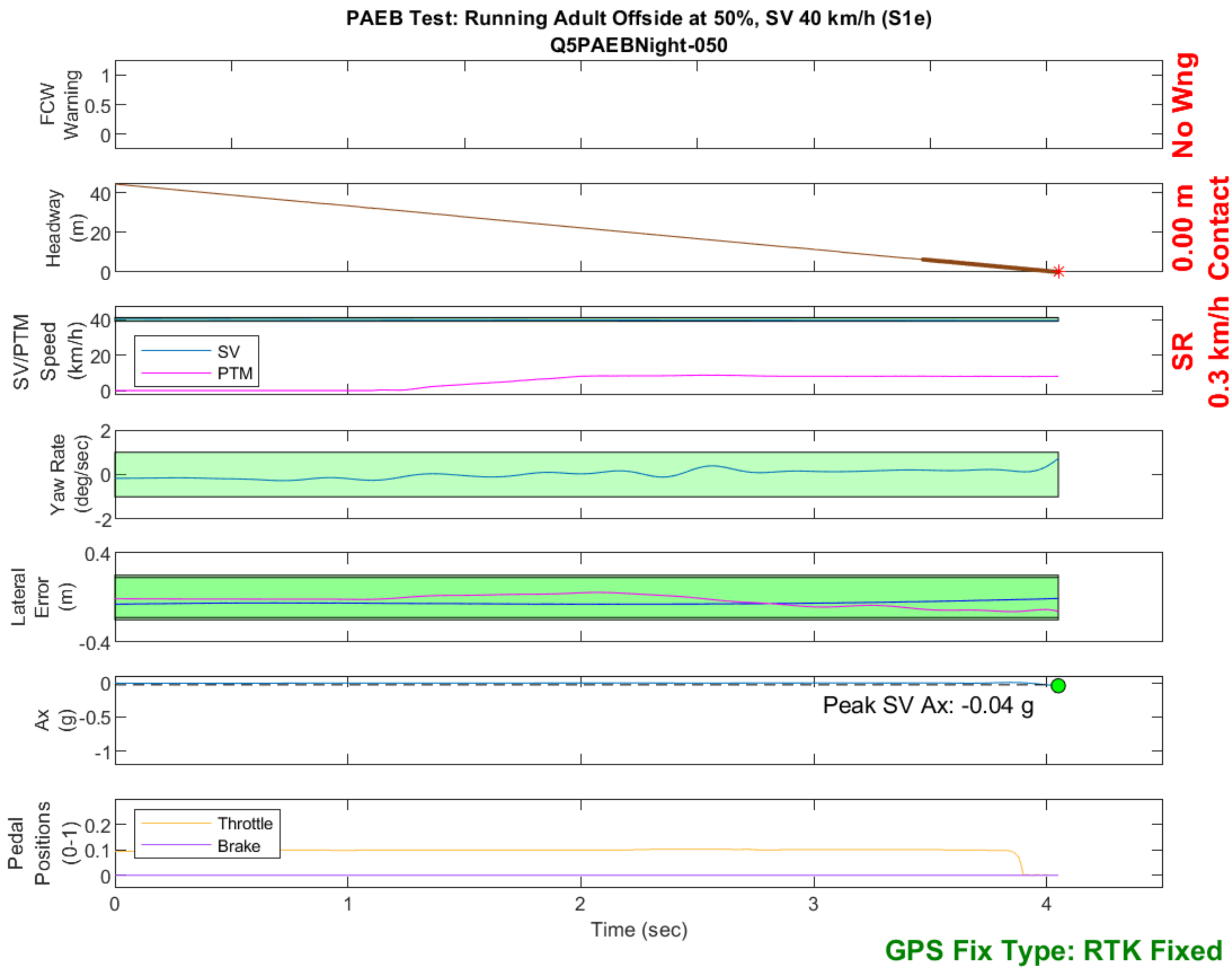

Figure D236. Time History for PAEB Run 50, S1e, Night, Low Beam, 40 km/h

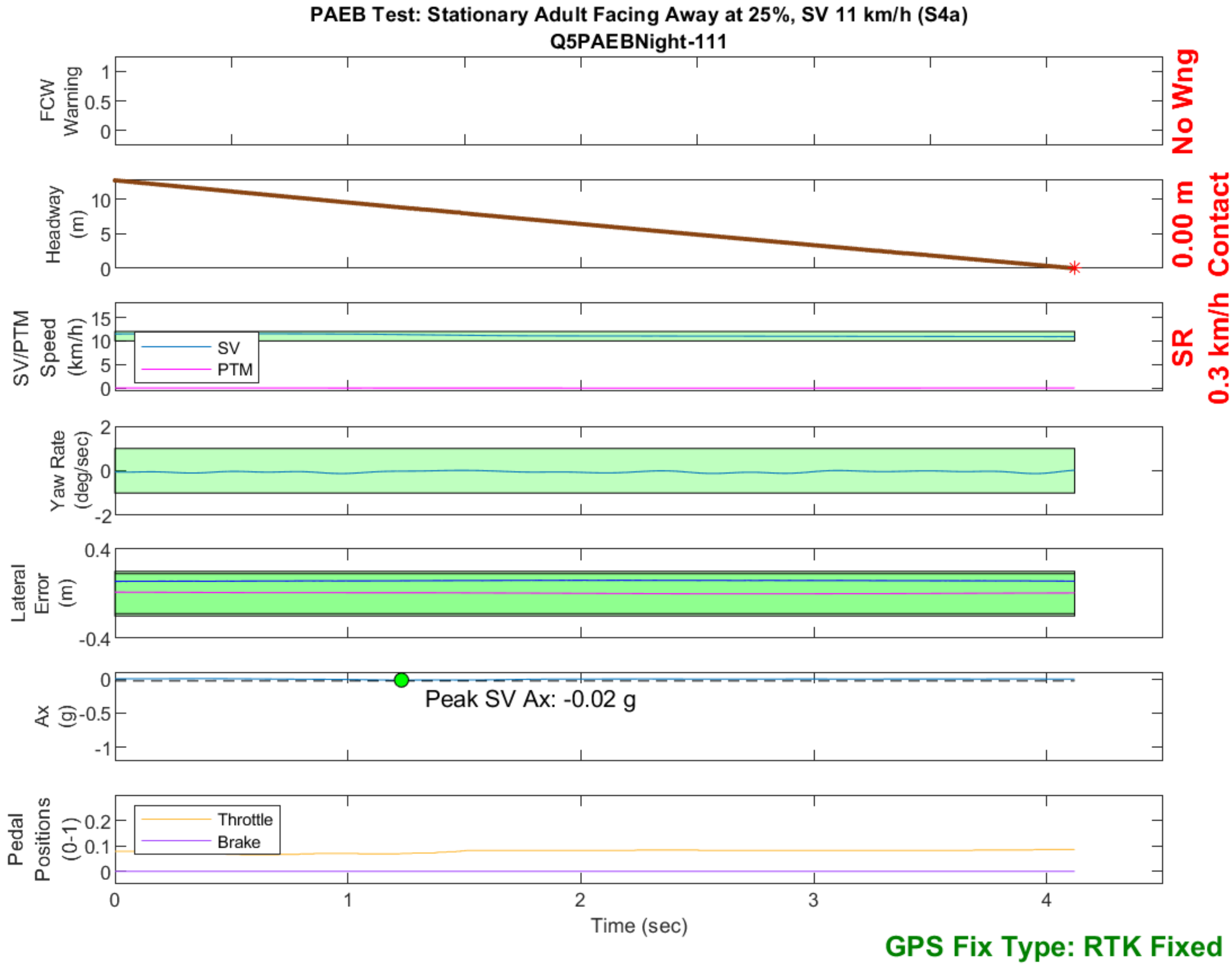

Figure D237. Time History for PAEB Run 111, S4a, Night, Low Beam, 11 km/h

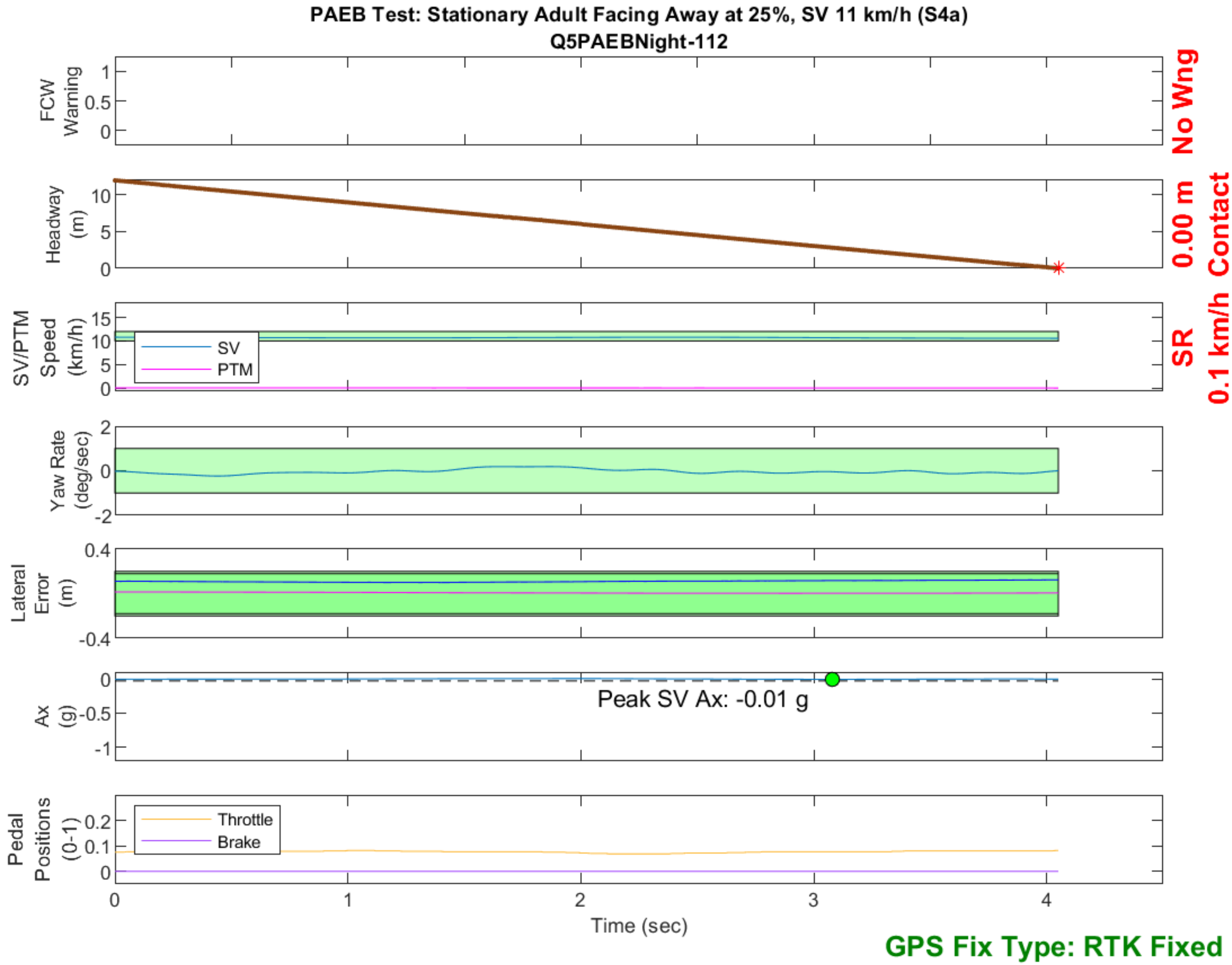

Figure D238. Time History for PAEB Run 112, S4a, Night, Low Beam, 11 km/h

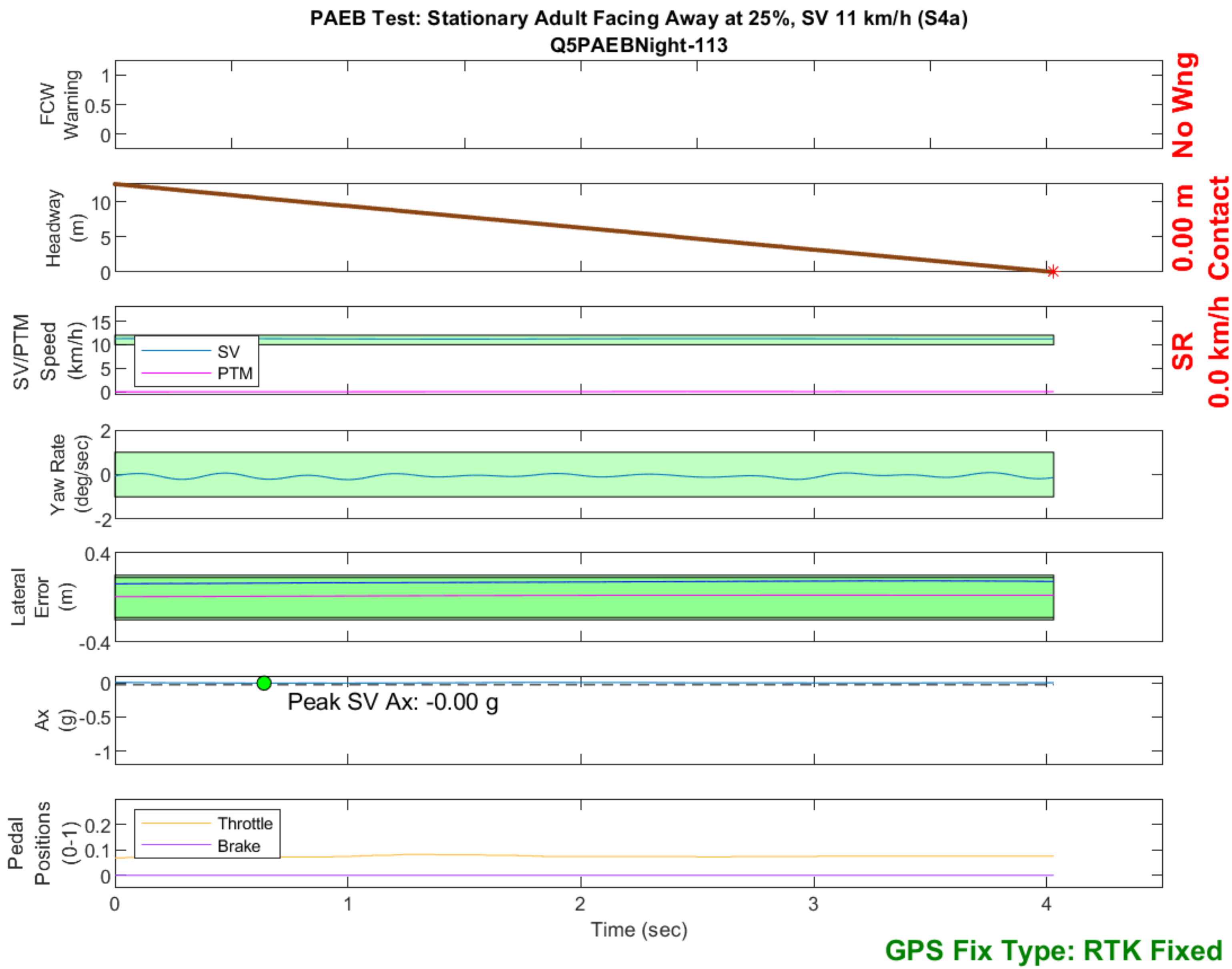

Figure D239. Time History for PAEB Run 113, S4a, Night, Low Beam, 11 km/h

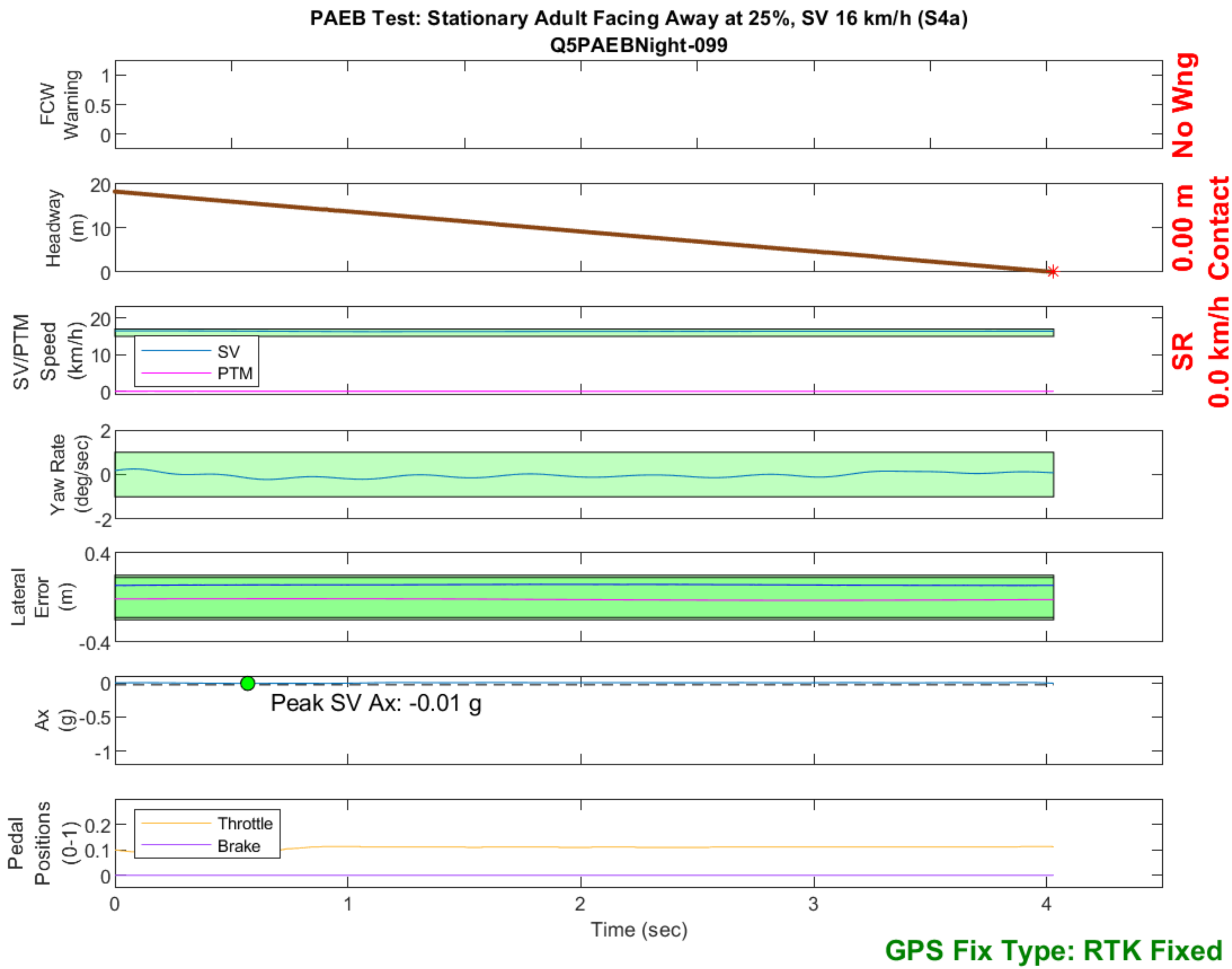

Figure D240. Time History for PAEB Run 99, S4a, Night, Low Beam, 16 km/h

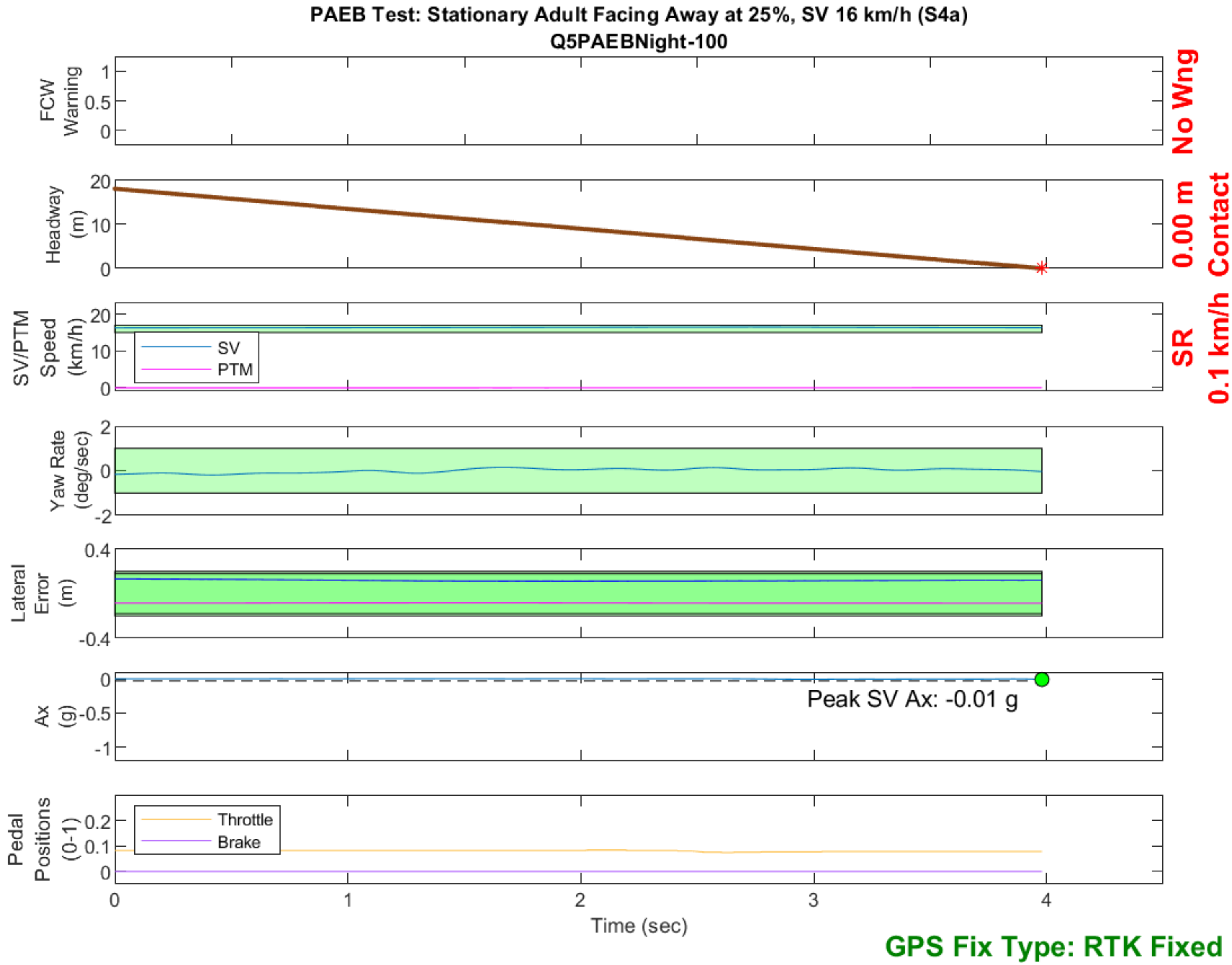

Figure D241. Time History for PAEB Run 100, S4a, Night, Low Beam, 16 km/h

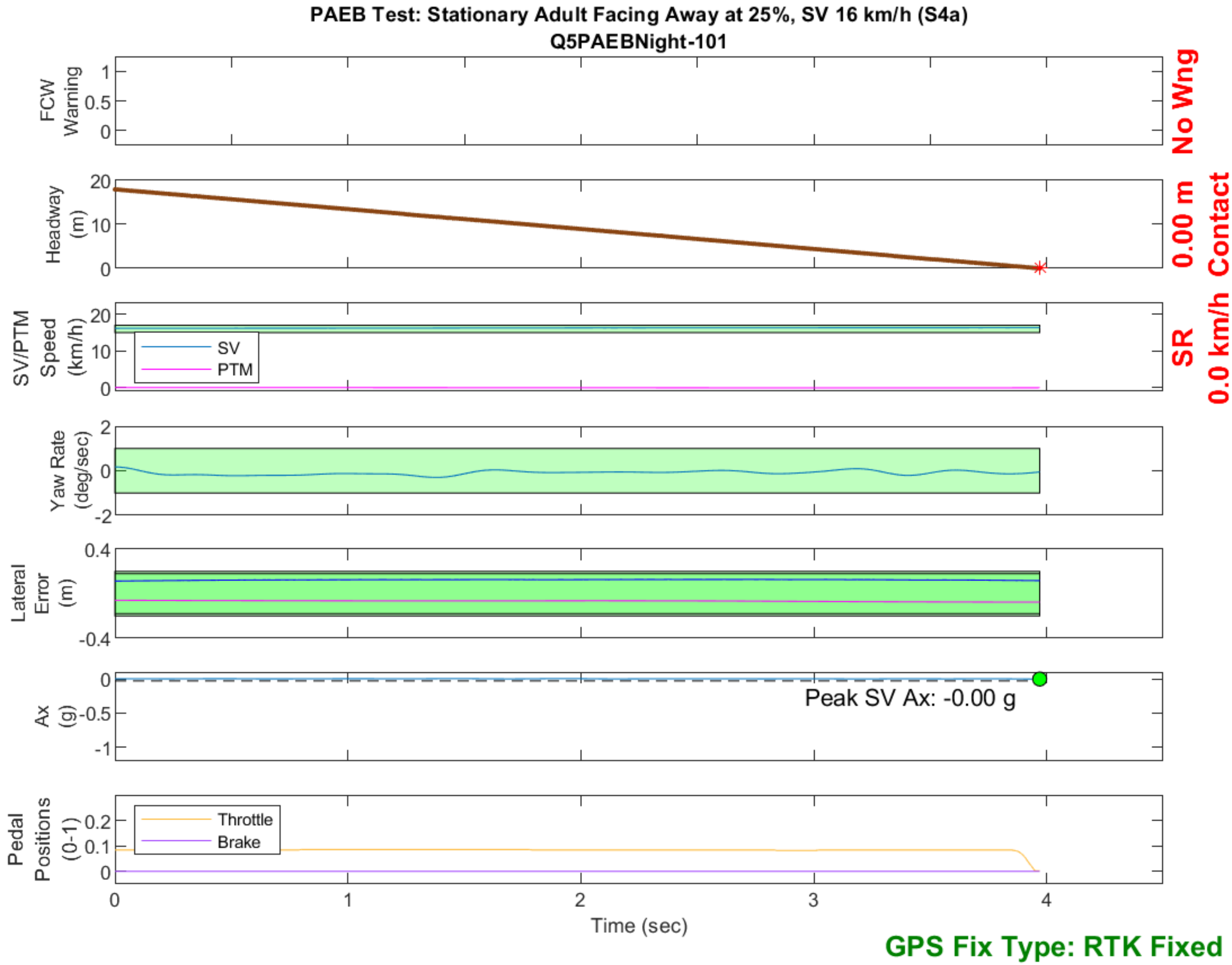

Figure D242. Time History for PAEB Run 101, S4a, Night, Low Beam, 16 km/h

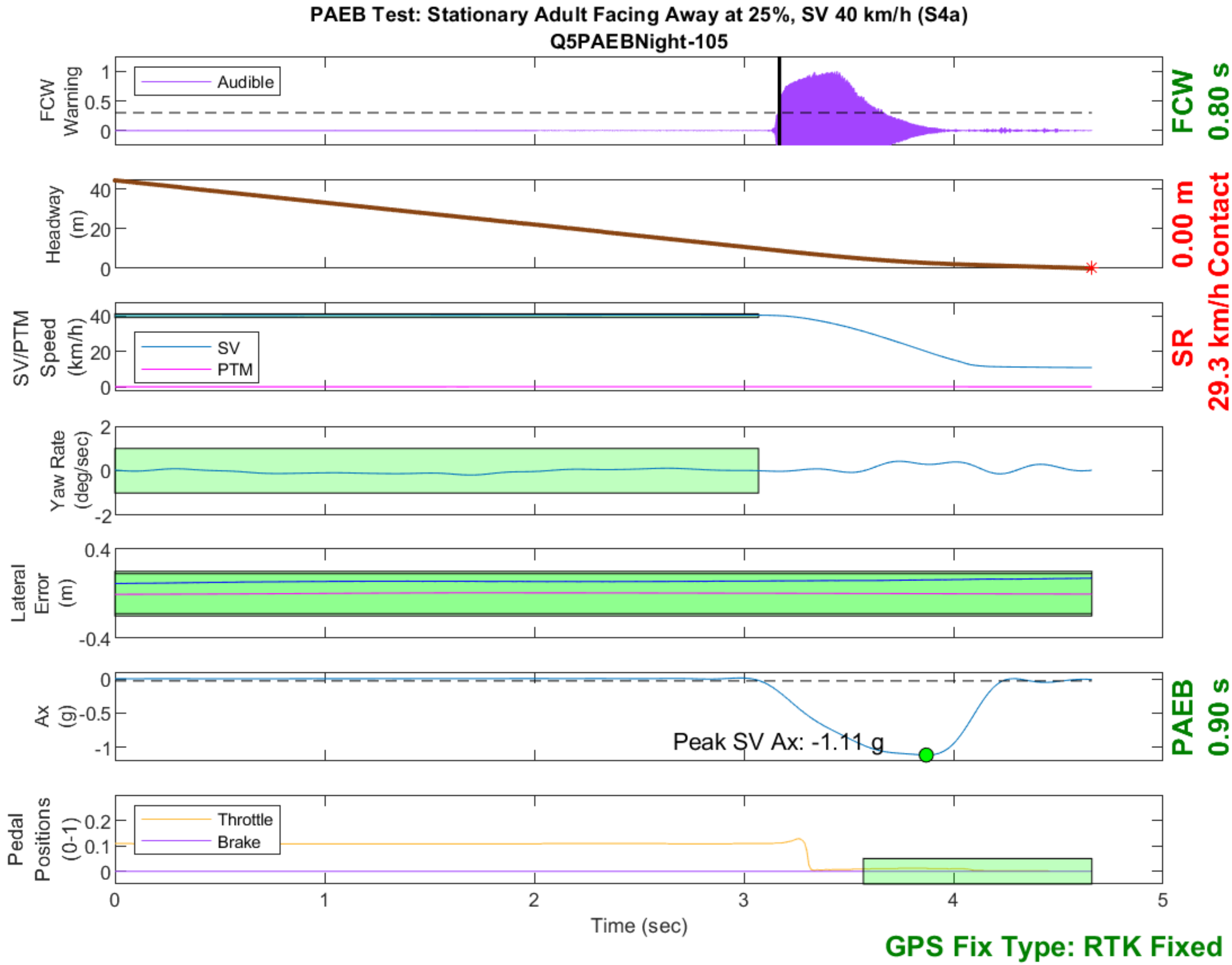

Figure D243. Time History for PAEB Run 105, S4a, Night, Low Beam, 40 km/h

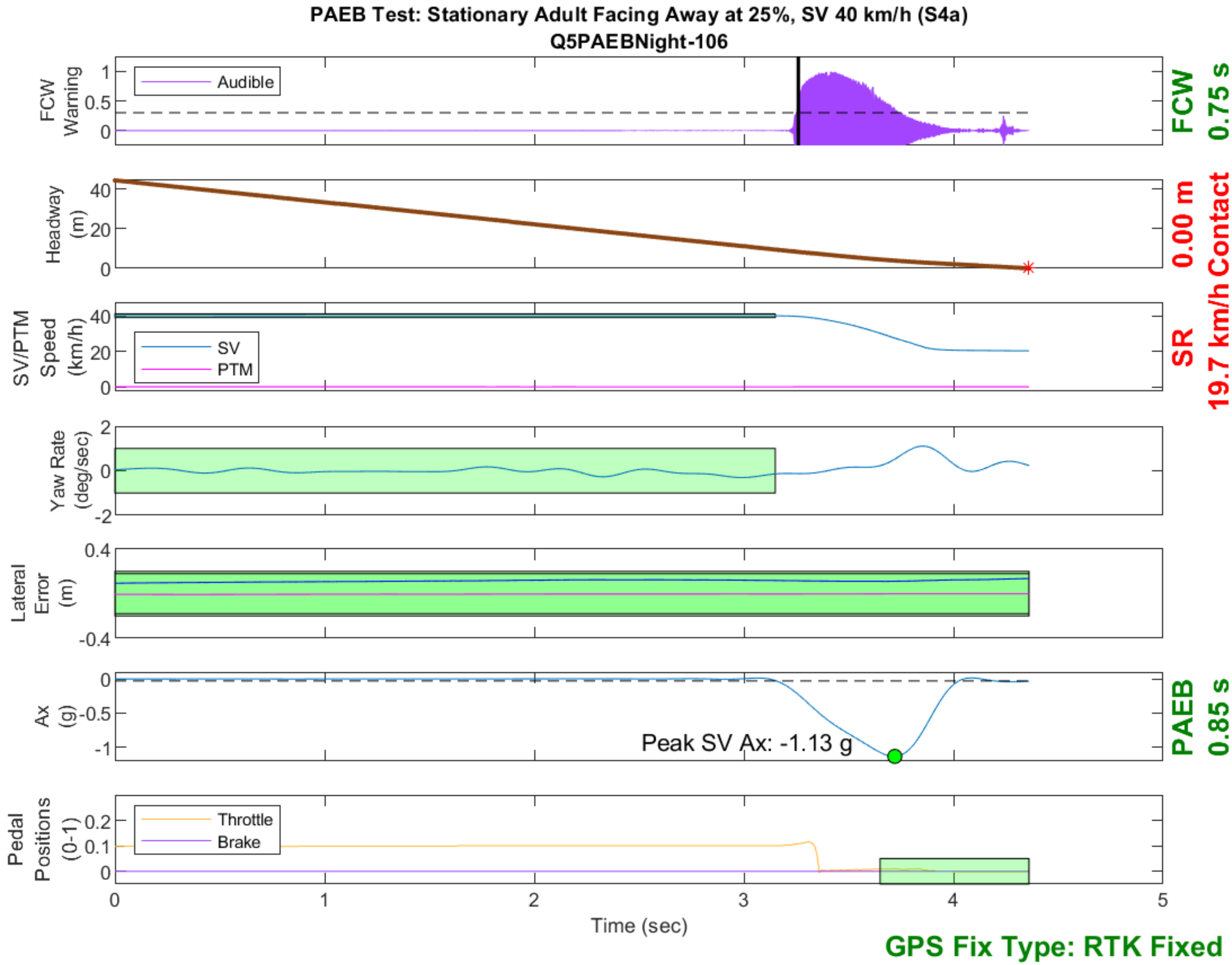

Figure D244. Time History for PAEB Run 106, S4a, Night, Low Beam, 40 km/h

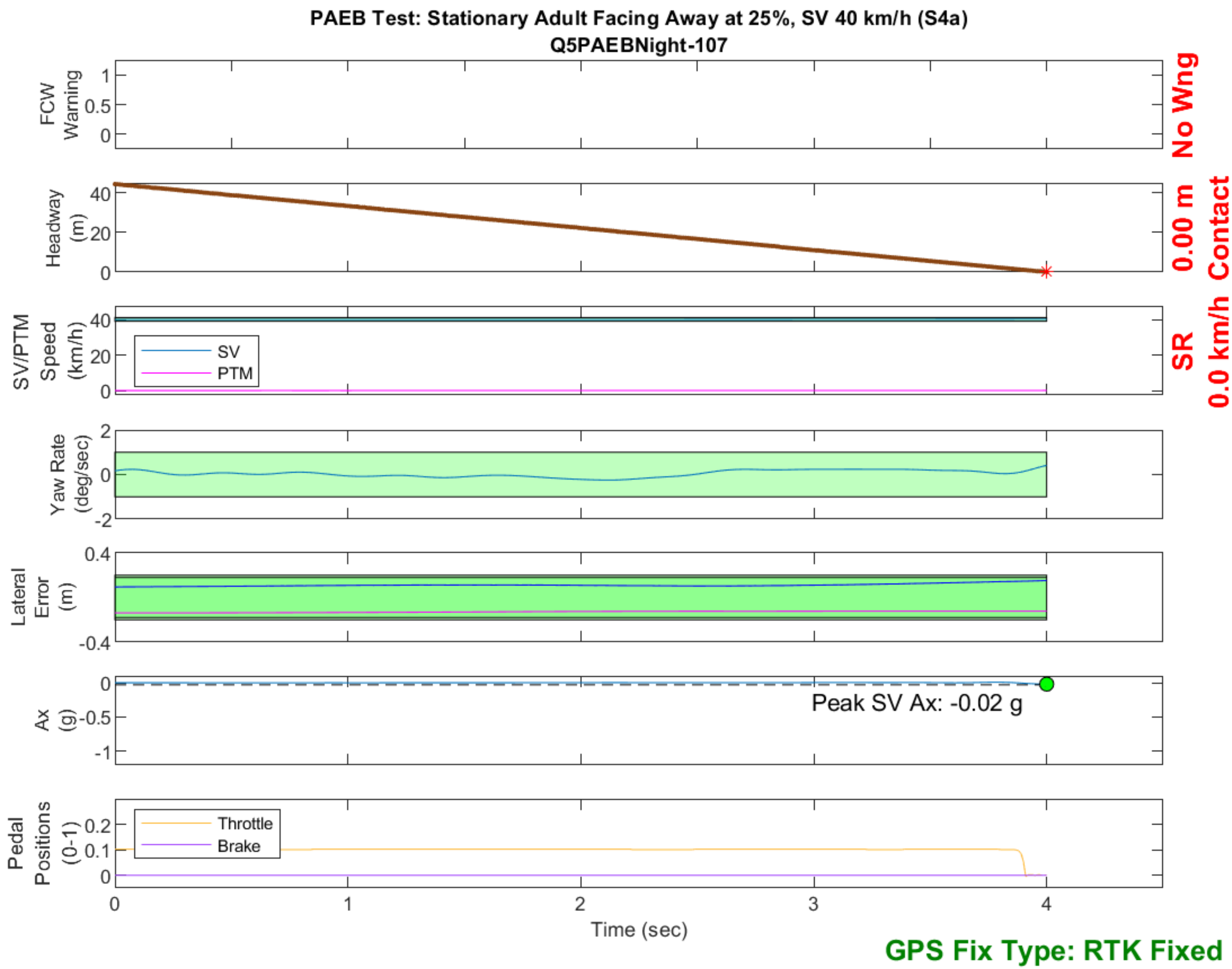

Figure D245. Time History for PAEB Run 107, S4a, Night, Low Beam, 40 km/h

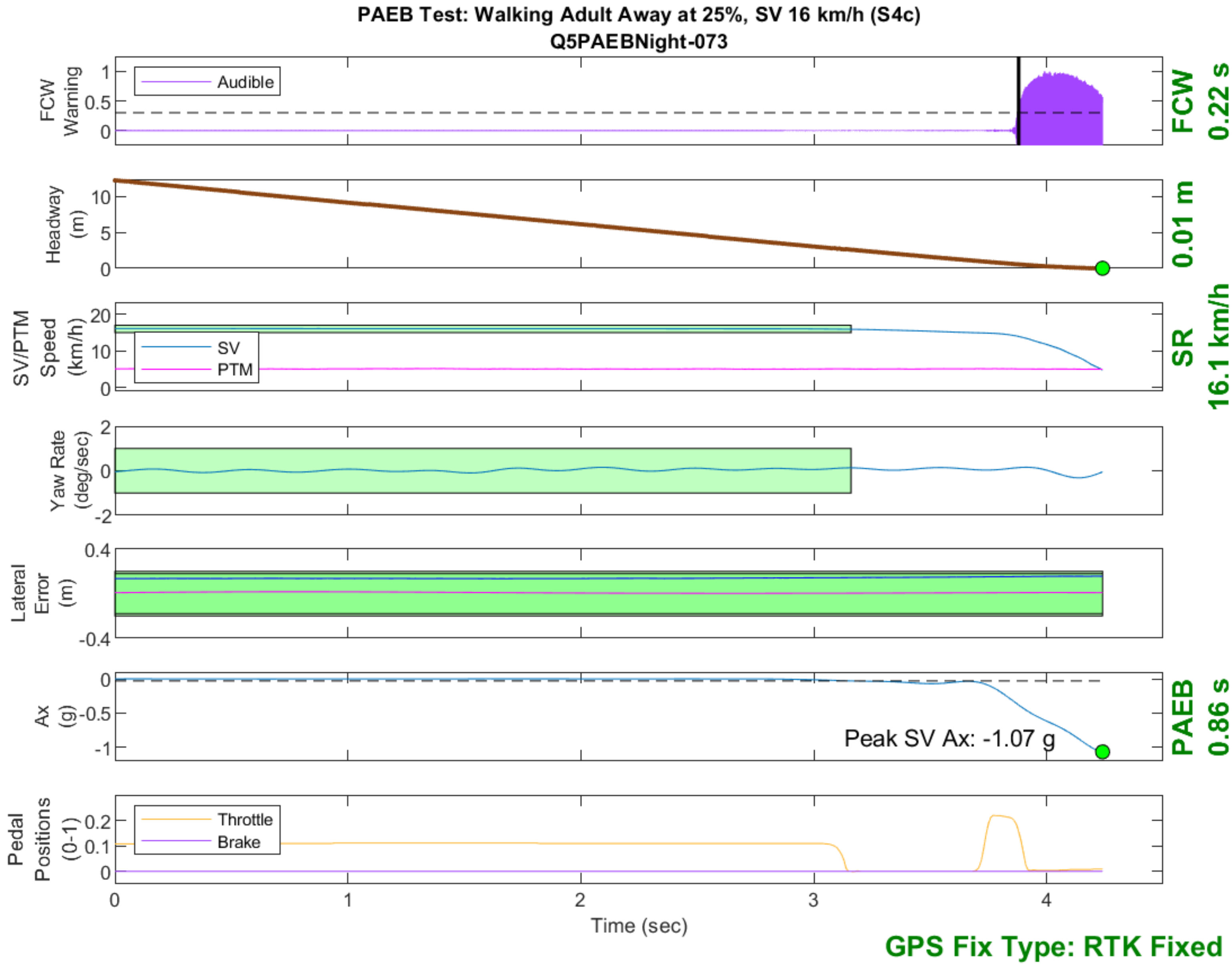

Figure D246. Time History for PAEB Run 73, S4c, Night, Low Beam, 16 km/h

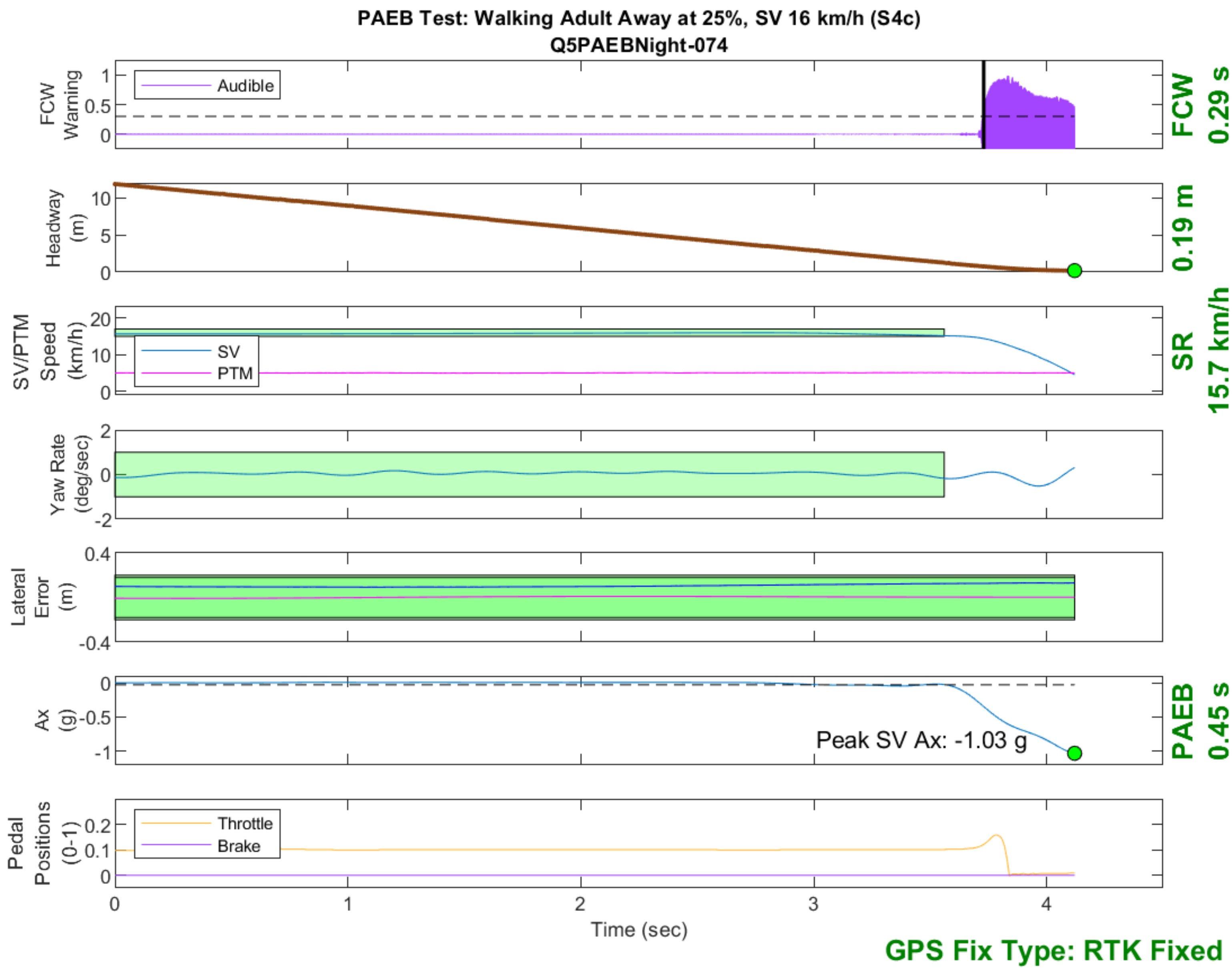

Figure D247. Time History for PAEB Run 74, S4c, Night, Low Beam, 16 km/h

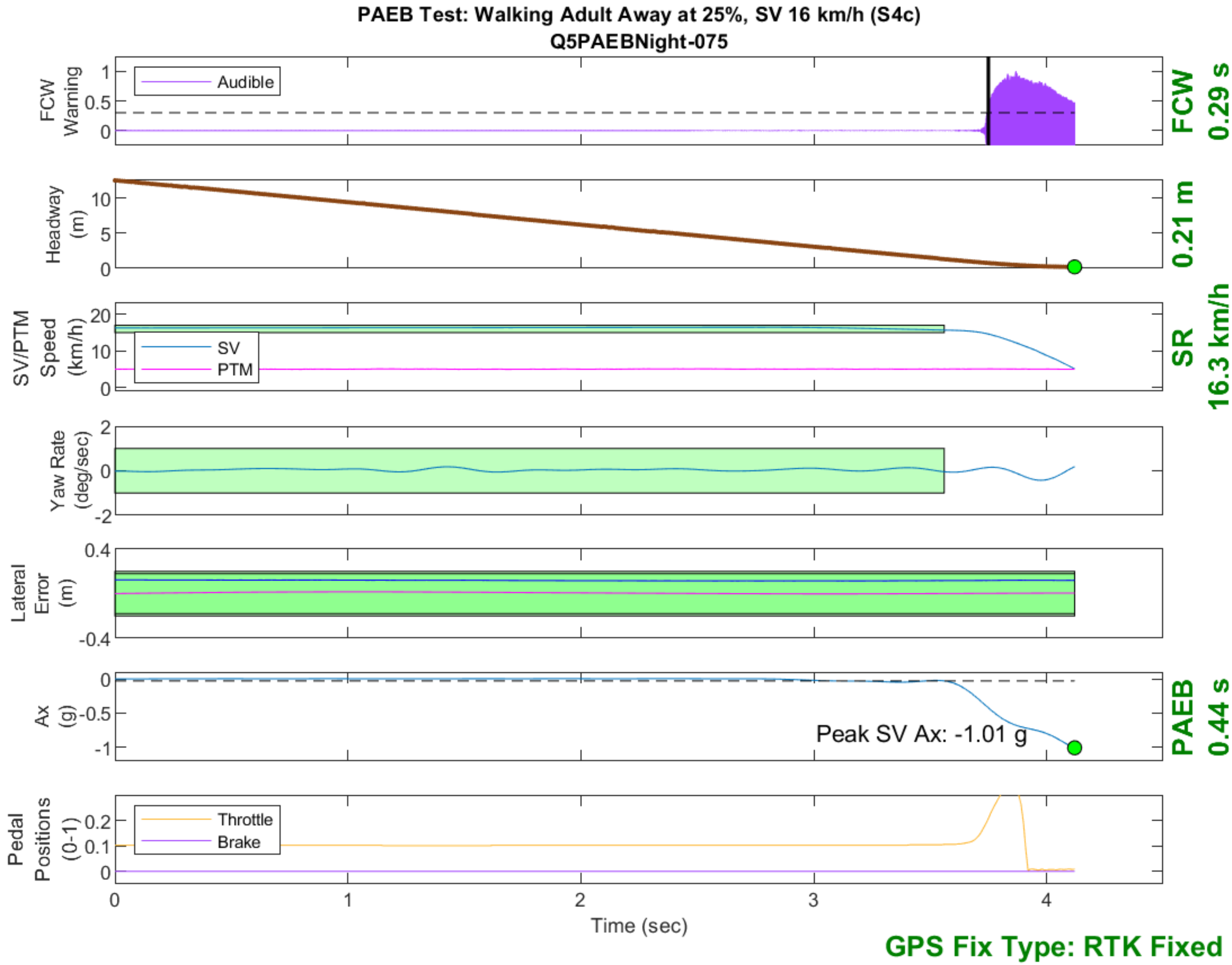

Figure D248. Time History for PAEB Run 75, S4c, Night, Low Beam, 16 km/h

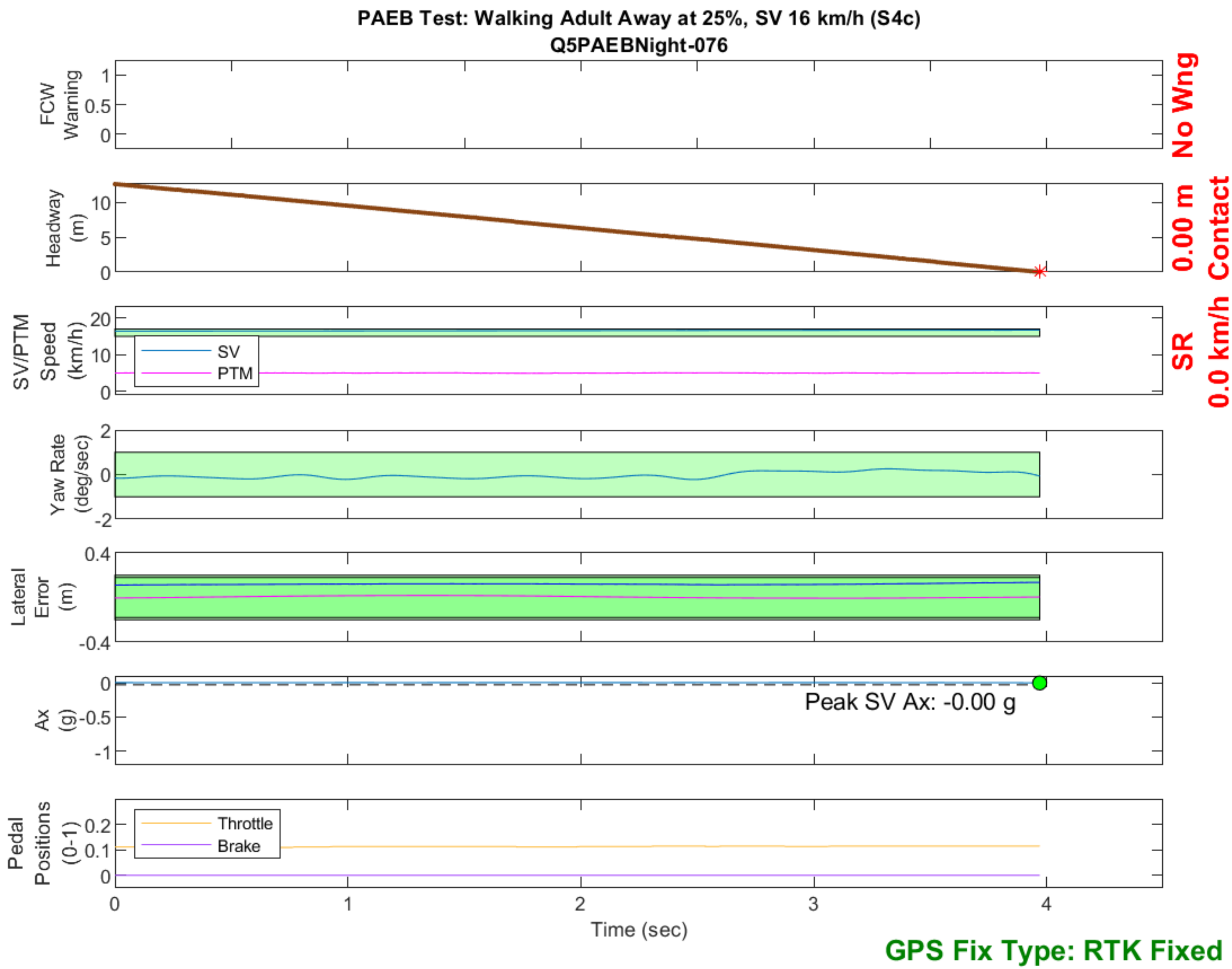

Figure D249. Time History for PAEB Run 76, S4c, Night, Low Beam, 16 km/h

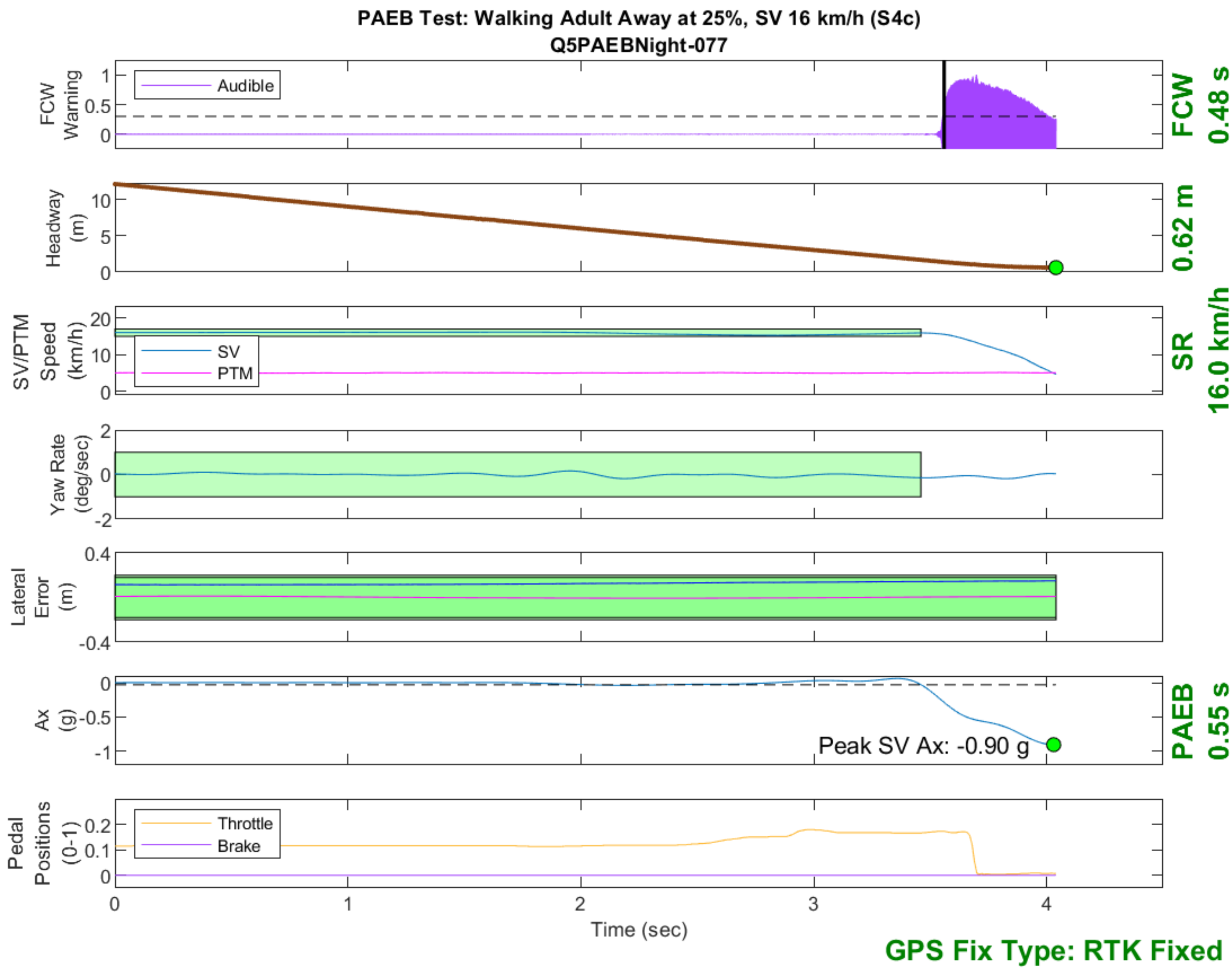

Figure D250. Time History for PAEB Run 77, S4c, Night, Low Beam, 16 km/h

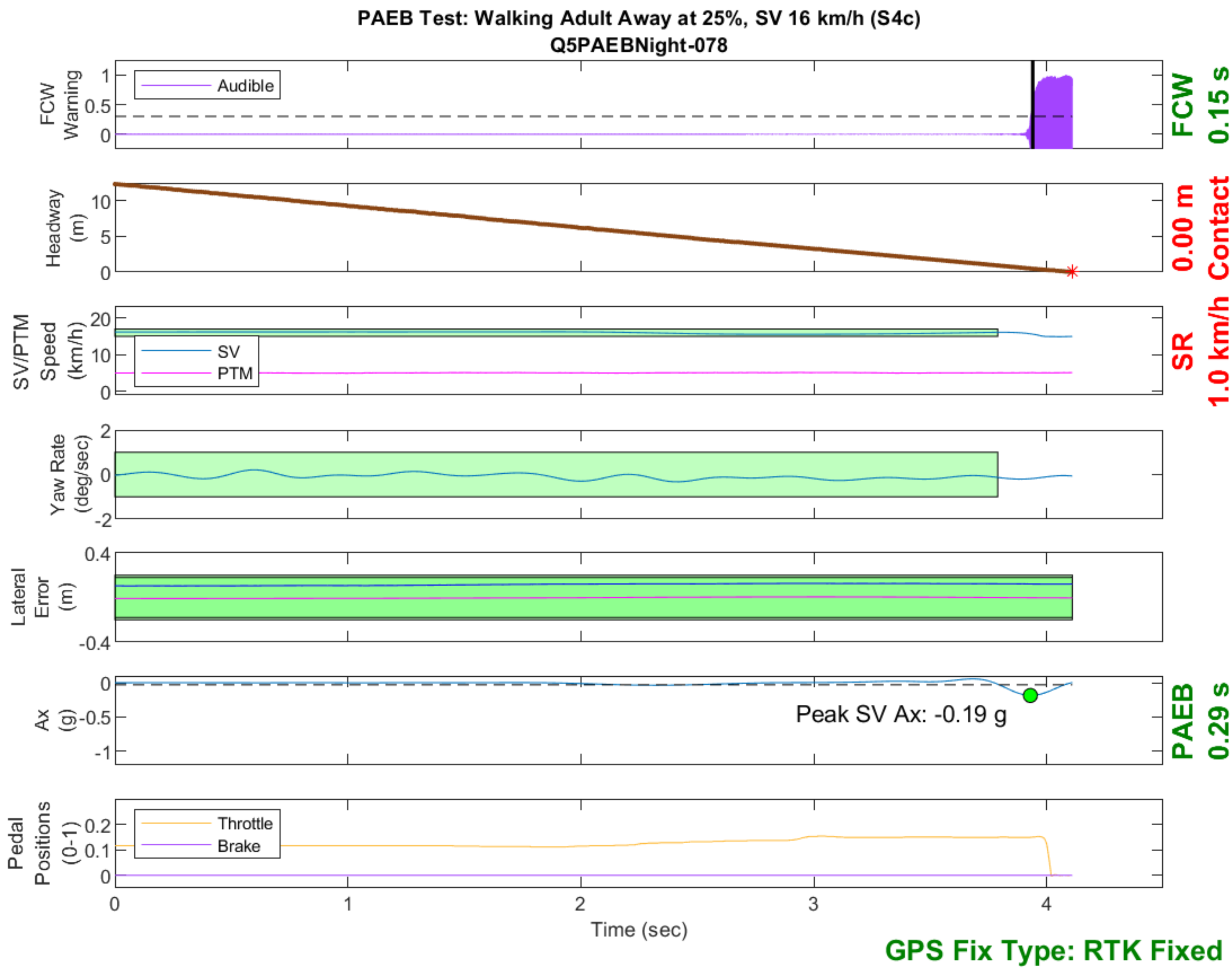

Figure D251. Time History for PAEB Run 78, S4c, Night, Low Beam, 16 km/h

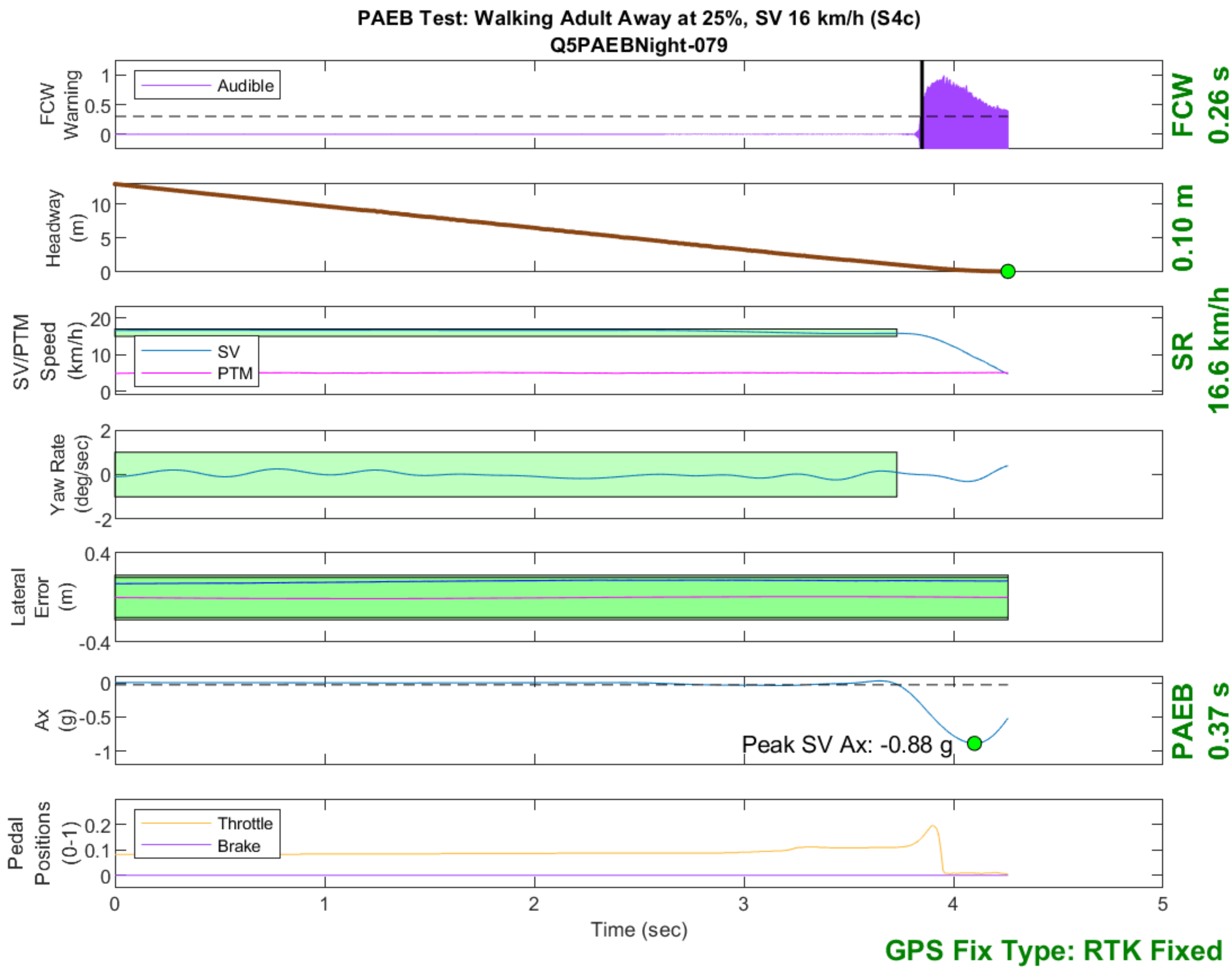

Figure D252. Time History for PAEB Run 79, S4c, Night, Low Beam, 16 km/h

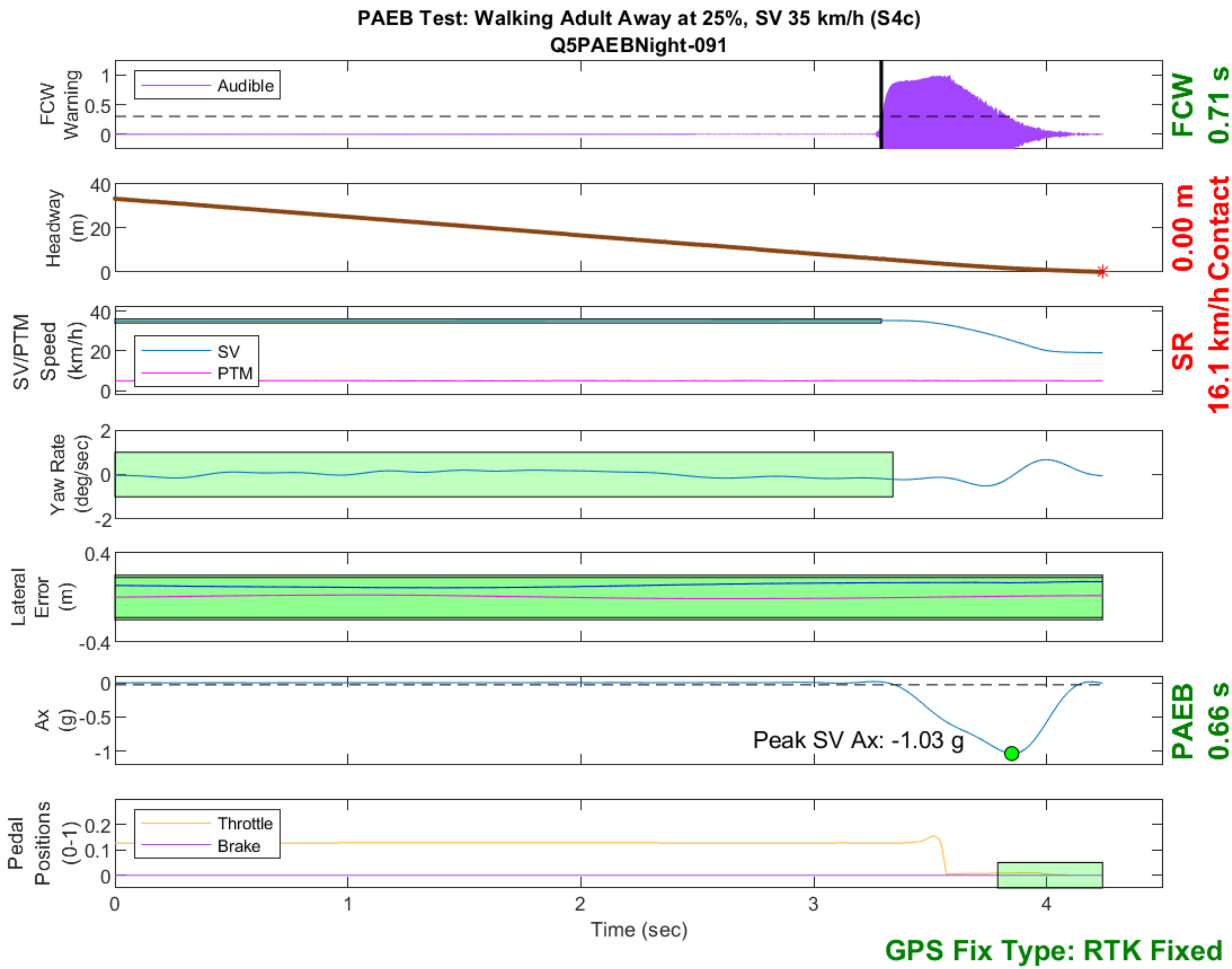

Figure D253. Time History for PAEB Run 91, S4c, Night, Low Beam, 35 km/h

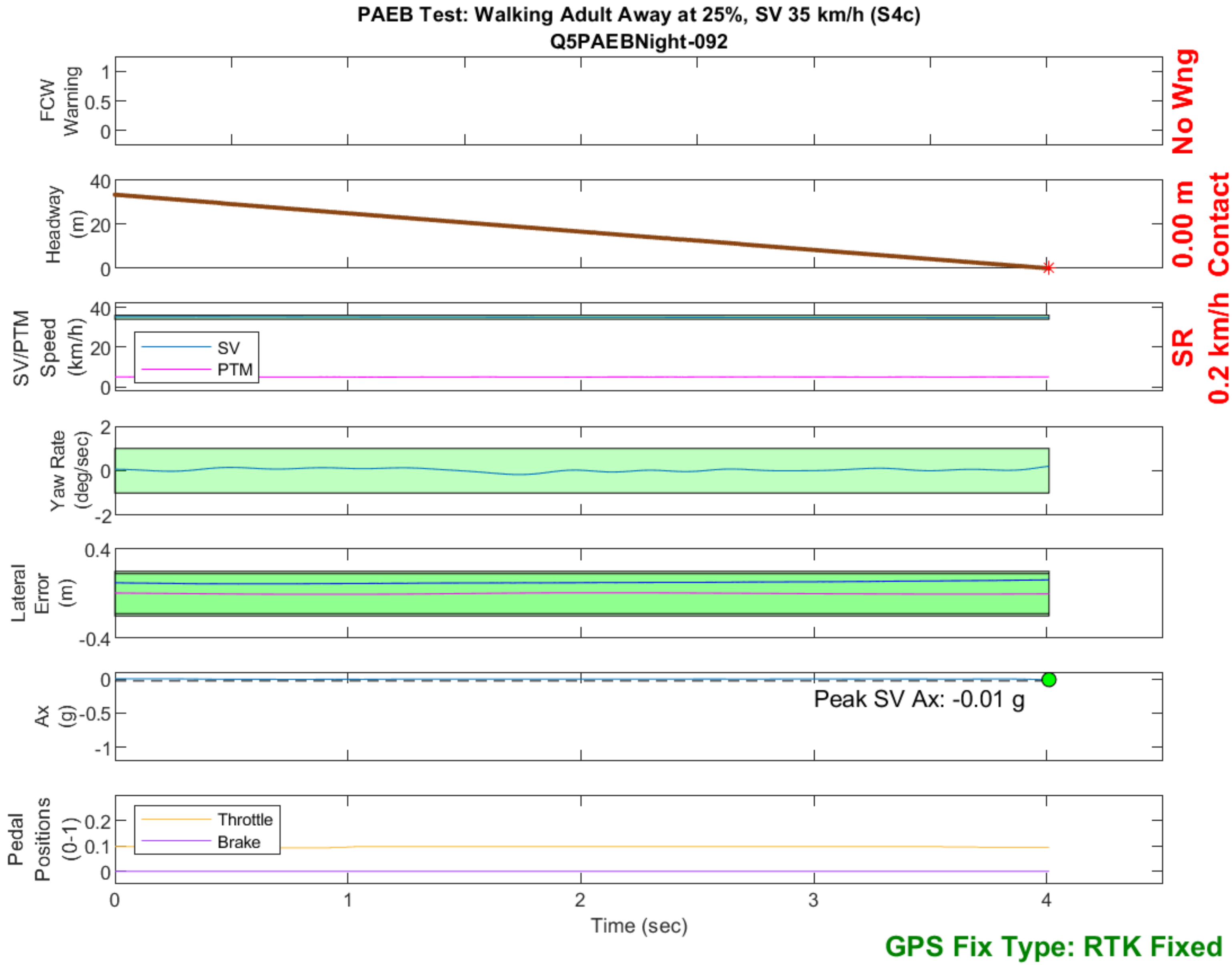

Figure D254. Time History for PAEB Run 92, S4c, Night, Low Beam, 35 km/h

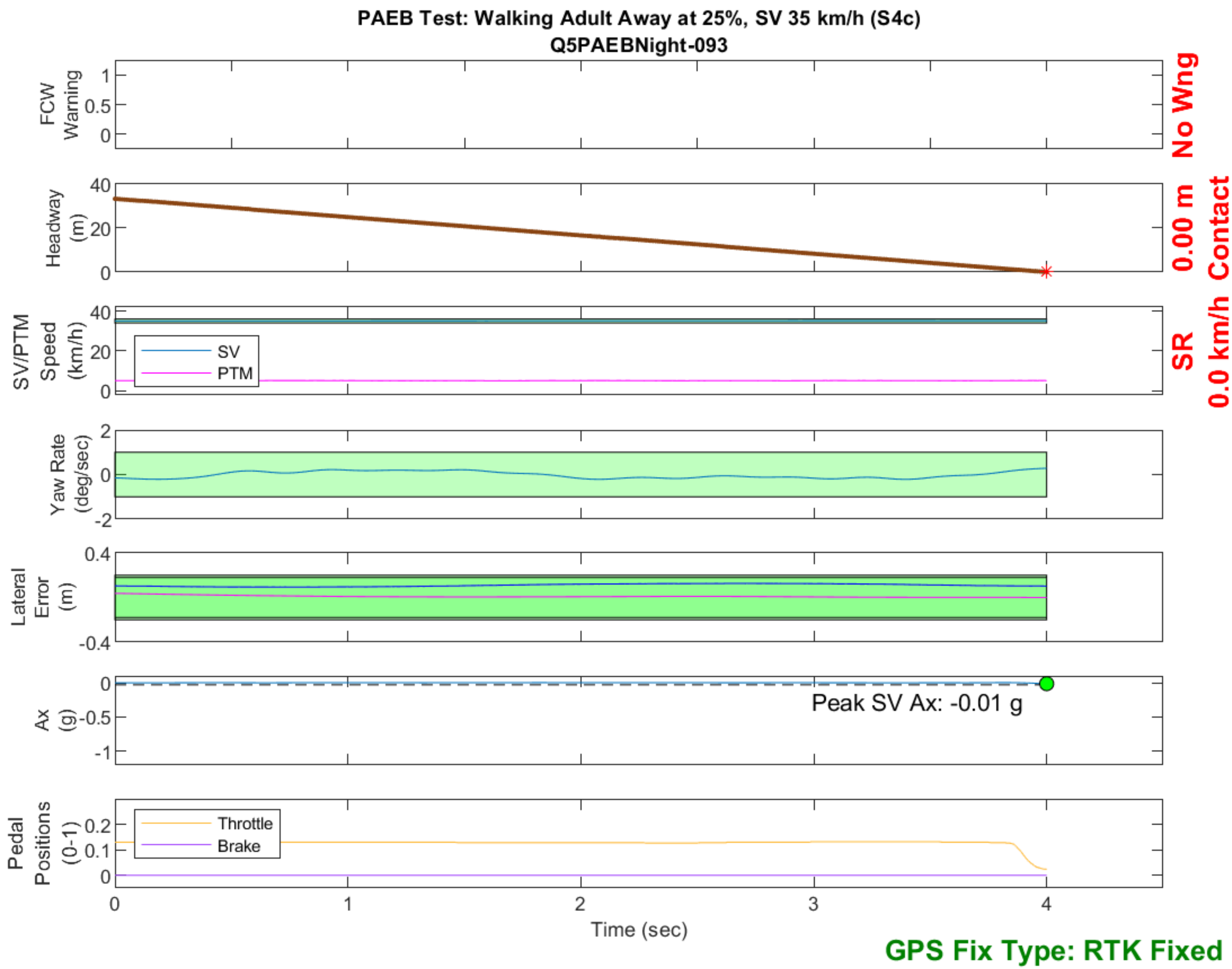

Figure D255. Time History for PAEB Run 93, S4c, Night, Low Beam, 35 km/h

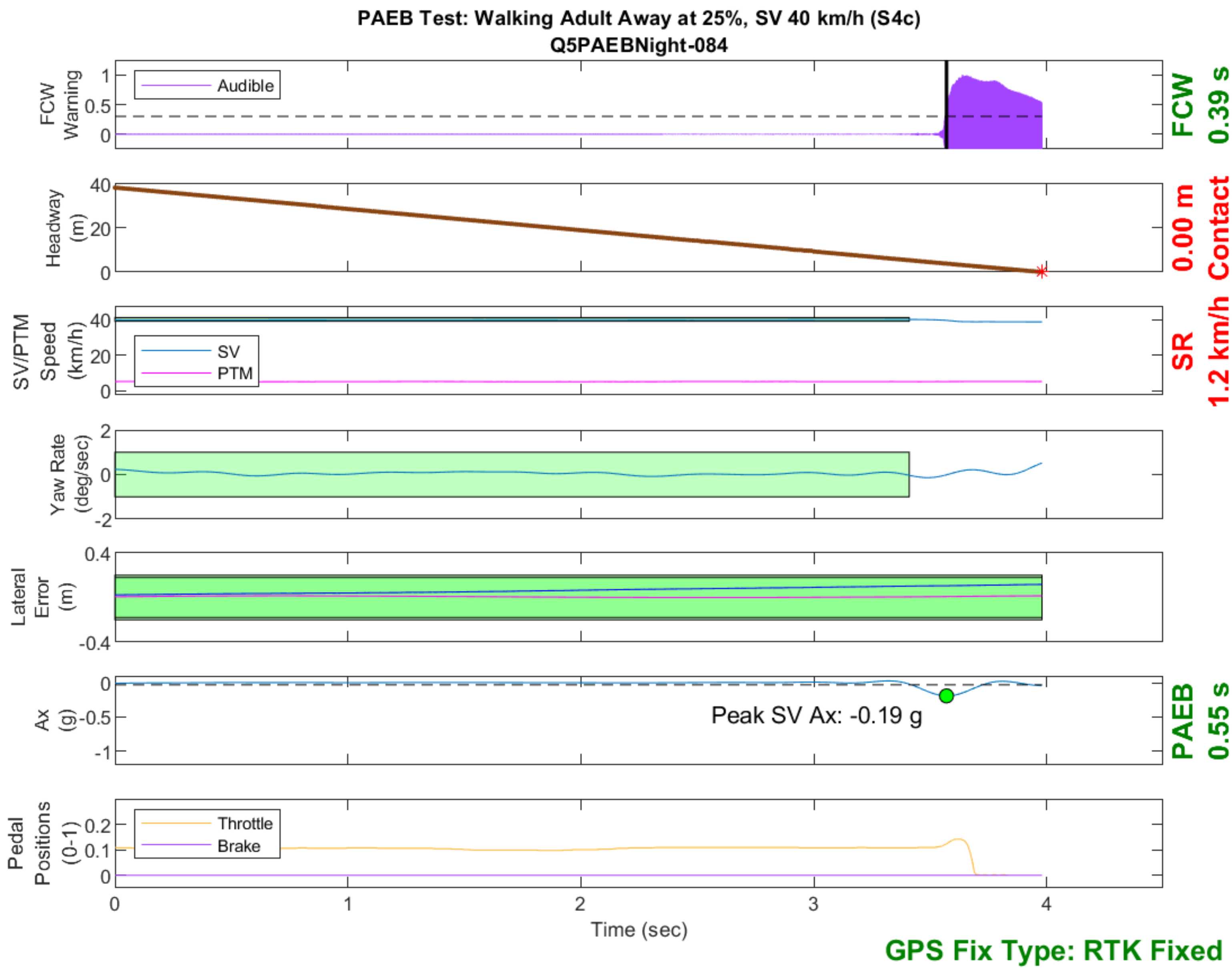

Figure D256. Time History for PAEB Run 84, S4c, Night, Low Beam, 40 km/h

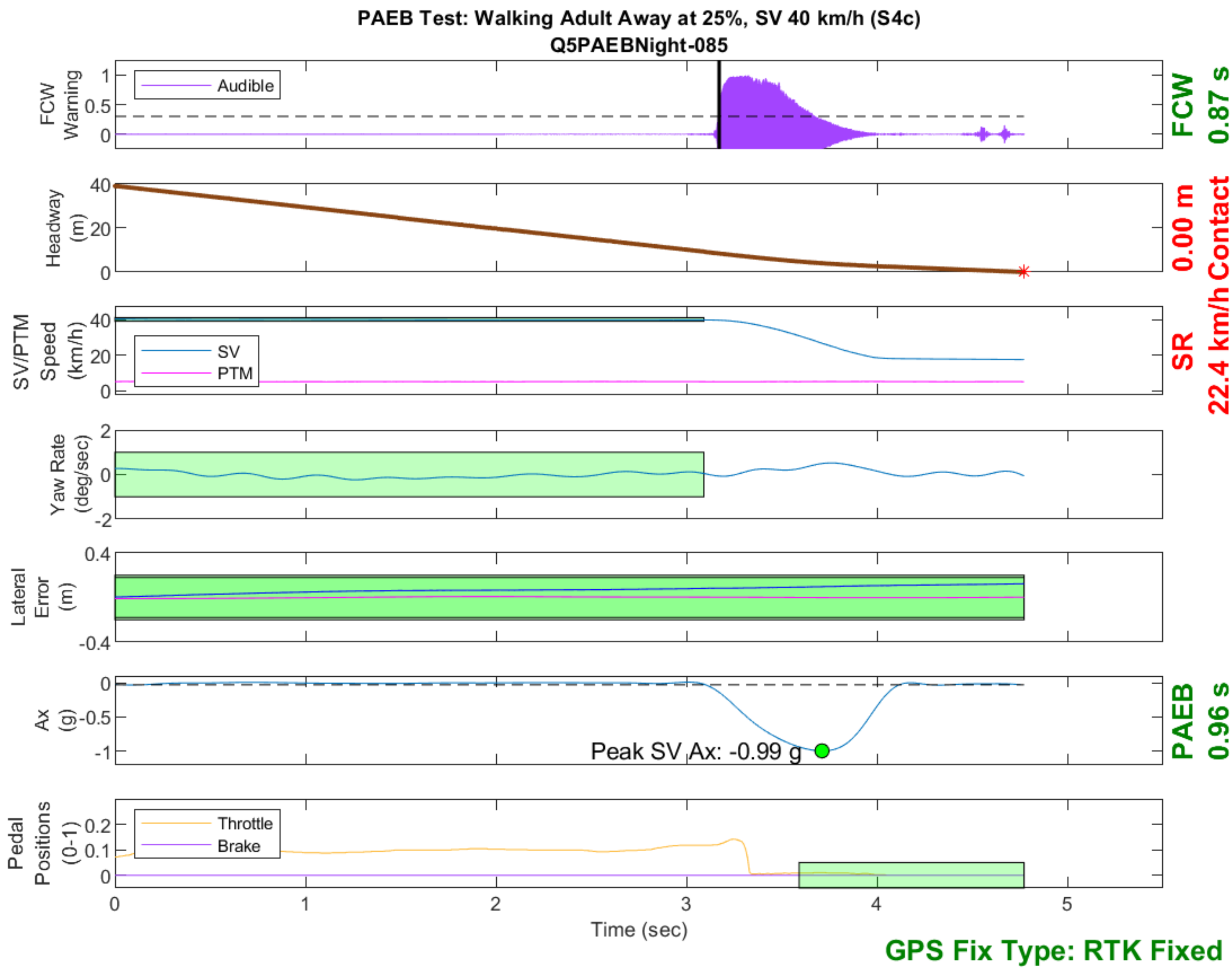

Figure D257. Time History for PAEB Run 85, S4c, Night, Low Beam, 40 km/h

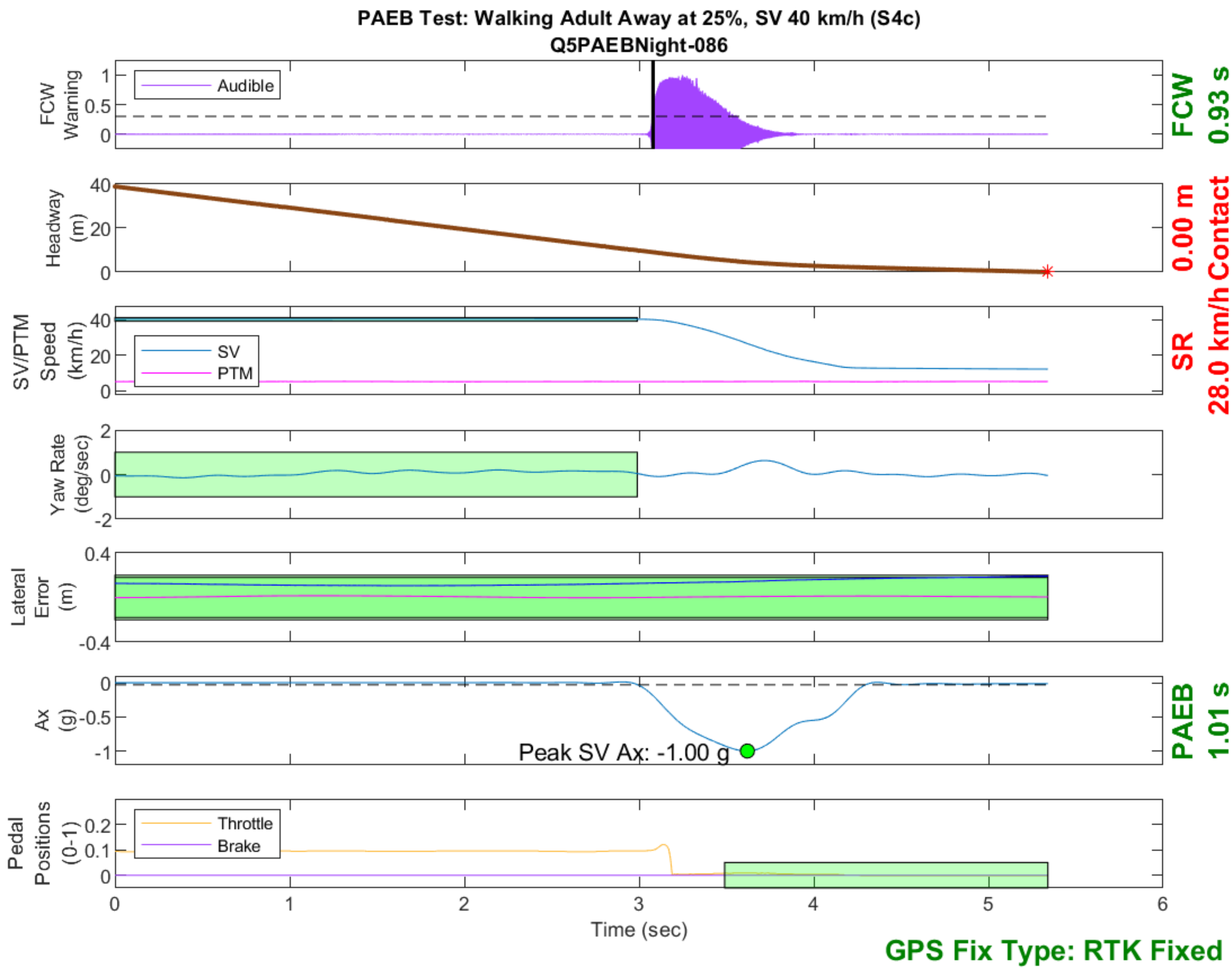

Figure D258. Time History for PAEB Run 86, S4c, Night, Low Beam, 40 km/h