PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM RESEARCH TEST
NCAP-DRI-PAEB-20-10

2020 Toyota Corolla LE

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Final Report

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16. Abstract These research tests were conducted on the subject 2020 Toyota Corolla LE 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 50th 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 Toyota Corolla LE. 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 -0.15 g threshold

Section II

DATA SHEETS

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Toyota Corolla LE

VIN: *JTDEPRAE1LJ11xxxx*

Day Test Date: *4/27/2020*

Night Test Date: *4/28/2020*

System Setting: *Far*

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	60	60	45
S1c	40		
S1d	60	*	*
S1e	55	50	35
S1f			
S1g			
S4a	55	55	55
S4b	40		
S4c	60	60	60

* 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	5	5	16.4						
40	5	5	39.7						

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	
16	5	5	16.3	5	5	16.1	5	5	16.0
20	5	5	20.0	5	5	20.1	5	5	20.2
30	5	5	30.2	5	5	30.1	5	5	30.0
40	5	5	40.7	5	5	40.6	5	4	39.0
45	-	-	-	-	-	-	5	3	34.8
50	5	5	45.6	5	5	44.9	4	2	28.9
60	5	4	46.6	5	5	50.2	-	-	-

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	5	5	16.1						
40	5	5	30.8						

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	0.2	3	0	0.4
16	5	5	15.9	3	0	0.0	3	0	0.4
20	5	5	20.2	-	-	-	-	-	-
30	5	5	29.3	-	-	-	-	-	-
40	5	5	39.7	4	1	10.4	3	0	12.4
50	5	5	43.6	-	-	-	-	-	
60	5	4	54.0	-	-	-	-	-	-

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	-	-	-	-	-	-	5	4	26.5
40	5	5	32.5	5	4	23.1	5	3	23.5
50	5	5	40.0	5	4	37.0	-	-	-
55	5	5	42.5	-	-	-	-	-	-
60	3	1	40.0	5	2	43.0	-	-	-

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	0.30	0.03
2	0.03	0.00
3	0.32	0.00
4	0.04	0.03
5		0.03

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	
16	5	5	16.0	5	5	16.4	5	5	16.4
40	5	5	39.9	5	5	40.1	5	5	40.0
50	5	5	50.0	5	5	49.8	5	5	49.8
55	5	5	54.8	5	5	54.8	5	4	50.5
60	3	0	42.4	3	0	48.4	3	0	48.5

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	16.4						
40	5	5	40.3						

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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	
16	5	5	16.1	5	5	16.4	5	5	15.9
40	5	5	39.7	5	5	39.8	5	4	35.3
50	5	5	50.1	5	4	45.7	5	2	35.3
60	5	5	60.0	5	4	52.5	5	5	60.3
65	3	0	44.7	4	1	56.5	3	0	21.8
70	3	0	36.0	-	-	-	-	-	-

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 2: VEHICLE DATA

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2020 Toyota Corolla LE

TEST VEHICLE INFORMATION

VIN: *JTDEPRAE1LJ11xxxx*

Body Style: *Sedan* Color: *Black Sand Pearl*

Date Received: *4/13/2020* Odometer Reading: *22 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Toyota Motor Corporation*

Date of manufacture: *02/20*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *205/55 R16*

Rear: *205/55 R16*

Recommended cold tire pressure: Front: *240 kPa (35 psi)*

Rear: *230 kPa (33 psi)*

TIRES

Tire manufacturer and model: *Dunlop Enasave 01A/S*

Front tire size: *205/55 R16 91H*

Rear tire size: *205/55 R16 91H*

Front tire DOT prefix: *EU8K 3MMR*

Rear tire DOT prefix: *EU8K 3MMR*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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DAYTIME TEST GENERAL INFORMATION

Test date: *4/27/2020*

AMBIENT CONDITIONS

Air temperature: *30.0 C (86 F)*

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

X Wind speed ≤ 10 m/s (22 mph)

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

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

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 SYSTEM

DATA SHEET 3: TEST CONDITIONS

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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: *240 kPa (35 psi)*

Rear: *230 kPa (33 psi)*

NIGHTTIME TEST GENERAL INFORMATION

Test date: *4/28/2020*

AMBIENT CONDITIONS

Air temperature: *21.1 C (70 F)*

Wind speed: *1.0 m/s (2.3 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*

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: *240 kPa (35 psi)*

Rear: *230 kPa (33 psi)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*447.7 kg (987 lb)*	Right Front:	*420.9 kg (928 lb)*
Left Rear:	*299.8 kg (661 lb)*	Right Rear:	*294.4 kg (649 lb)*
		Total:	*1462.8 kg (3225 lb)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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

Pre-Collision System (PCS) as part of Toyota Safety Sense 2.0 (TSS 2.0)

Type and location of sensors the system uses:

Millimeter wave Radar located behind the front emblem (or grille) and mono 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.

Buttons on the left side of the steering wheel are used to interact with the system menus. The hierarchy is:

Settings

Vehicle

PCS (Pre-Collision System)

Adjust alert timing - Select "Far", "Middle" or "Near"

See Appendix A, Figures A14 and A15, also Appendix B, Pages B-20 and B-21.

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

How is the PAEB alert presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

___ Vibration

___ Other

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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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.

When the system determines that the possibility of a frontal collision is high, a buzzer will sound, and a warning message will be displayed on the multi-information display. The visual alert is presented in the display area adjacent to the speedometer and displays "BRAKE!" in white on a red background.

The auditory alert is presented as a pulsed tone of 2389 Hz pulsed at approximately five times per second.

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

_____ No

If yes, please provide a full description.

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

- *Drive along a marked lane for more than 1 km driving at a speed at greater than 35 mph.*
- *1 km distance driving is not necessarily continuous driving, but split driving in total of 1 km distance is OK.*
- *Lane markings should be present on both sides of the vehicle; it does not matter whether it is a solid line or dotted line.*
- *It is ideal to put several vehicles (2-3 vehicles) beside the driving lane to be detected by camera.*
- *No sensor calibration completed indication will be displayed to the driver.*

Sensor calibration must be accomplished after each ignition cycle.

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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

Minimum: *10 km/h (7 mph)*

Maximum: *80 km/h (50 mph)*

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

____ Yes

X No

If yes, please provide a full description.

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.

Buttons on the left side of the steering wheel are used to interact with the system menus. The hierarchy is:

Settings

Vehicle

PCS (Pre-Collision System) - Select "On" or "Off"

See Appendix A, Figures A14 and A15, also Appendix B, Pages B-20 and B-21.

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.

Limitations of the system are described in the Owner's Manual, Pages 188 and 189 shown in Appendix B, Pages B-13 and B-14.

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

Scenario	Nominal SV Speeds (km/h)								Lighting Condition		
									Day	Night	
	16	20	30	40	50	60	70	80		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.

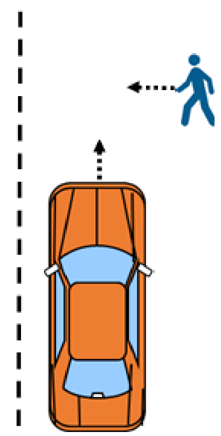


Figure 1. Scenarios S1a, b, c; Nearside Crossing Adult Pedestrian Walking 25/50/75% Overlap

- 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.

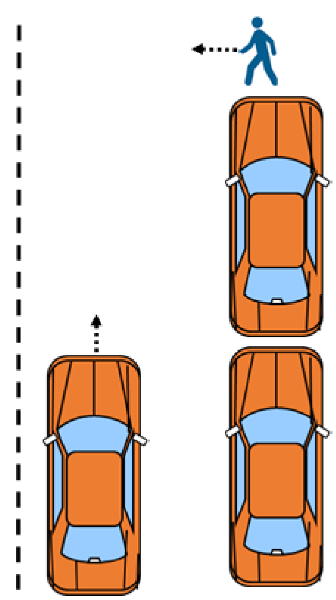


Figure 2. Scenario S1d; Nearside Obstructed Crossing Child Running, 50% Overlap

- 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.

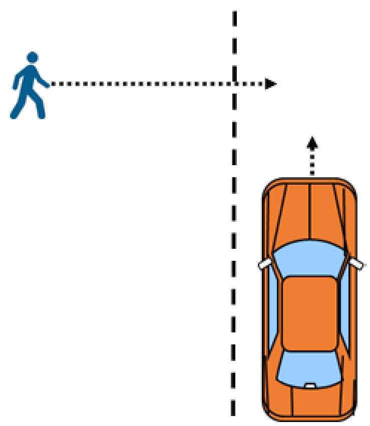


Figure 3. Scenario S1e Offside Crossing Adult Running 50% Overlap

- 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.

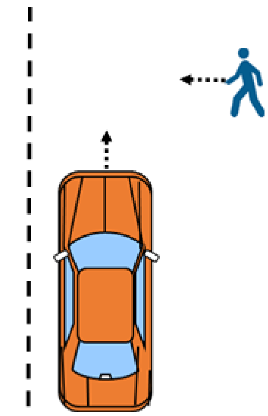


Figure 4. Scenario S1f; Nearside Crossing Adult Walking Stops Short

- 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.

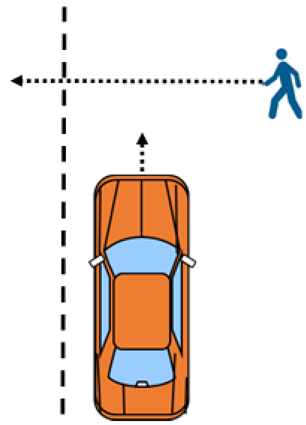


Figure 5. Scenario S1g; Nearside Crossing Adult Walking Clears Path

- 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).

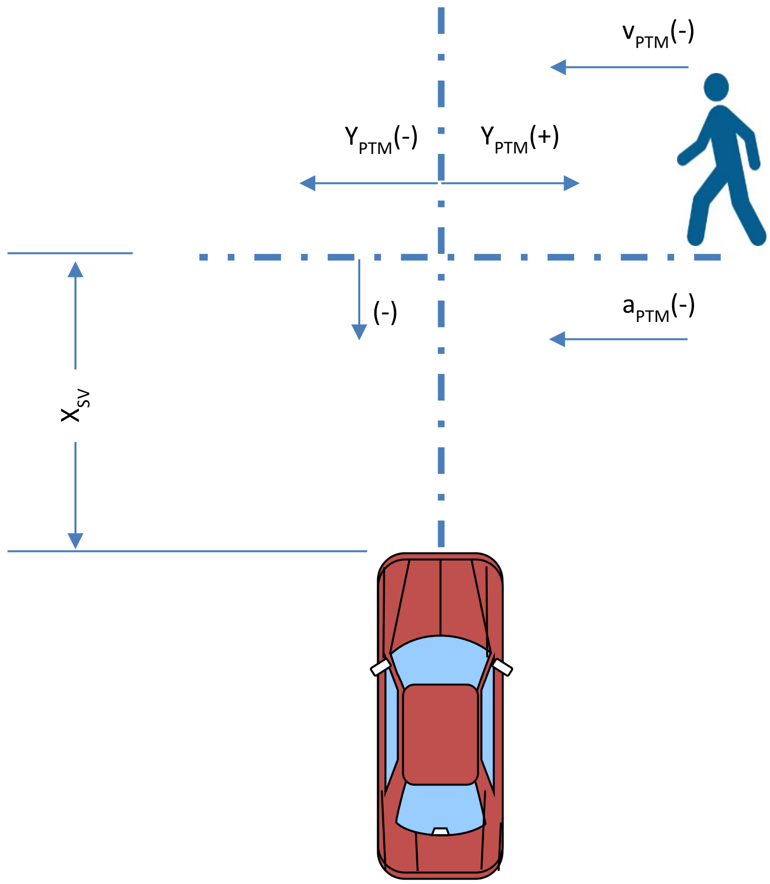


Figure 6. Coordinate System for Validation of Scenario 1

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.

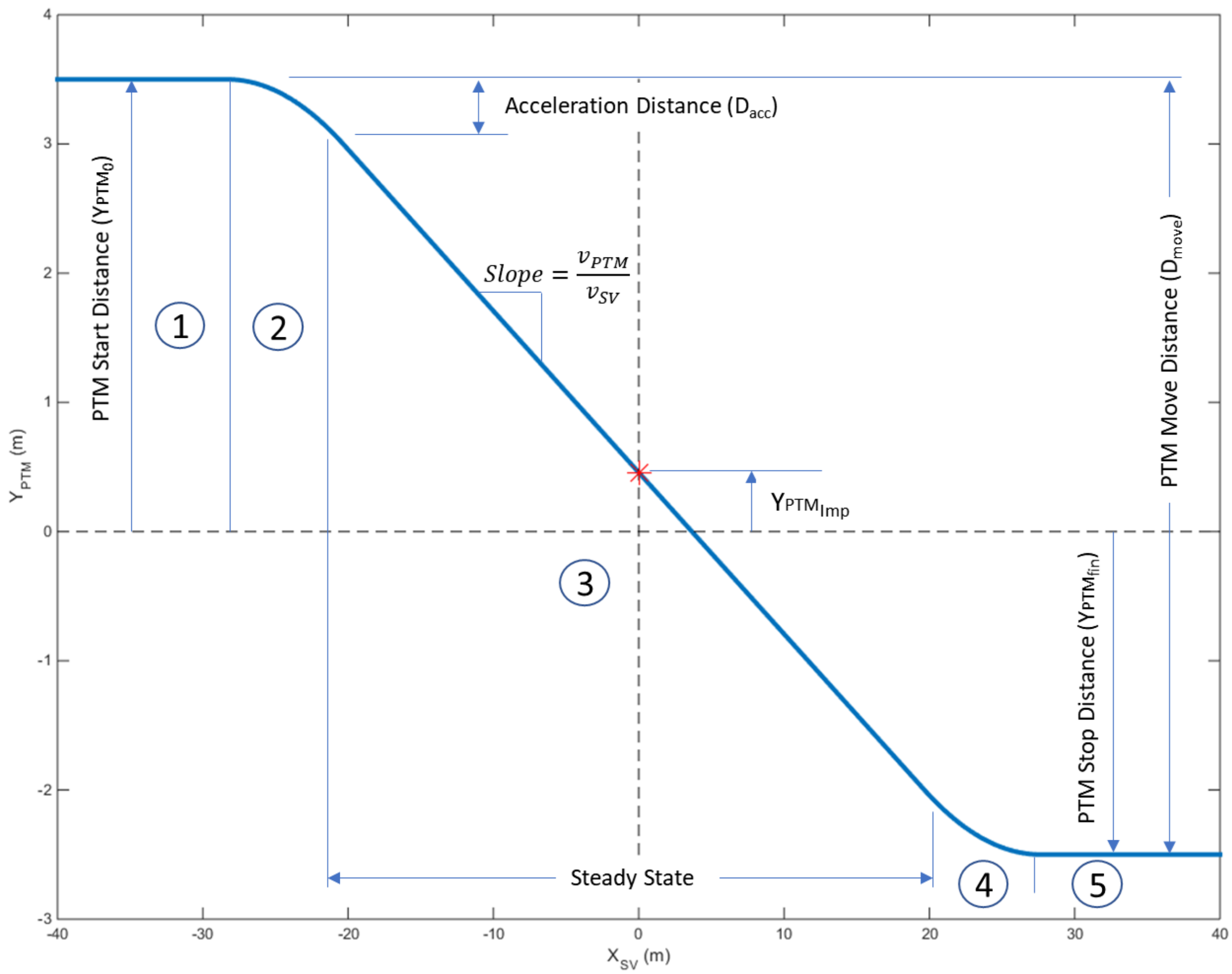


Figure 7. PTM Lateral Lane Position as a Function of SV Longitudinal Lane Position

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.

[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 SV was driven at the nominal speed specified for each test. The speed tolerance was ±1.0 km/h.
- 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 crossed 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. S4 TEST SCENARIOS

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.

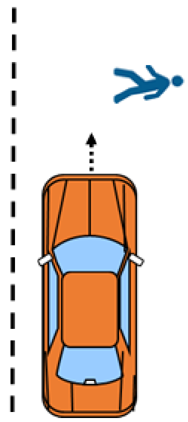


Figure 8. Scenario S4a; Nearside Standing Adult Facing Away From SV, 25% Overlap

- 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.

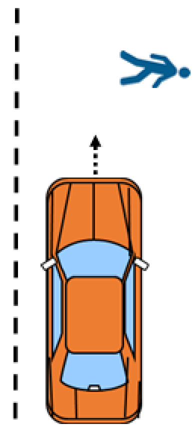


Figure 9. Scenario S4b; Nearside Standing Adult Facing Towards SV, 25% Overlap

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

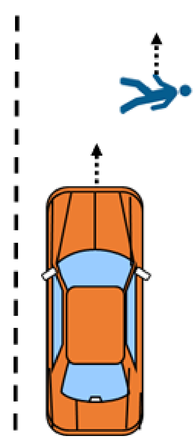


Figure 10. Scenario S4c; Nearside Walking Adult Away From SV, 25% Overlap

- 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 msec 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):
    - Scenario 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.

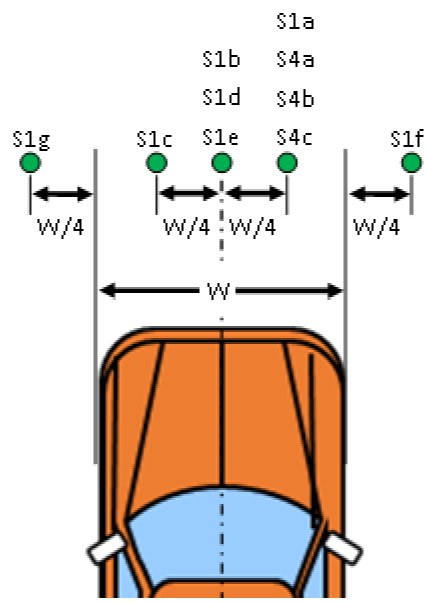


Figure 11. Offset Conditions

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 (600ft)	
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).)*	44m (145 ft)	
Obstruction *(S1d only)*	PV1D1	1m (3.2 ft)
	PV2D1	
	PVD1	

Drawing illustrates setup but is not to scale

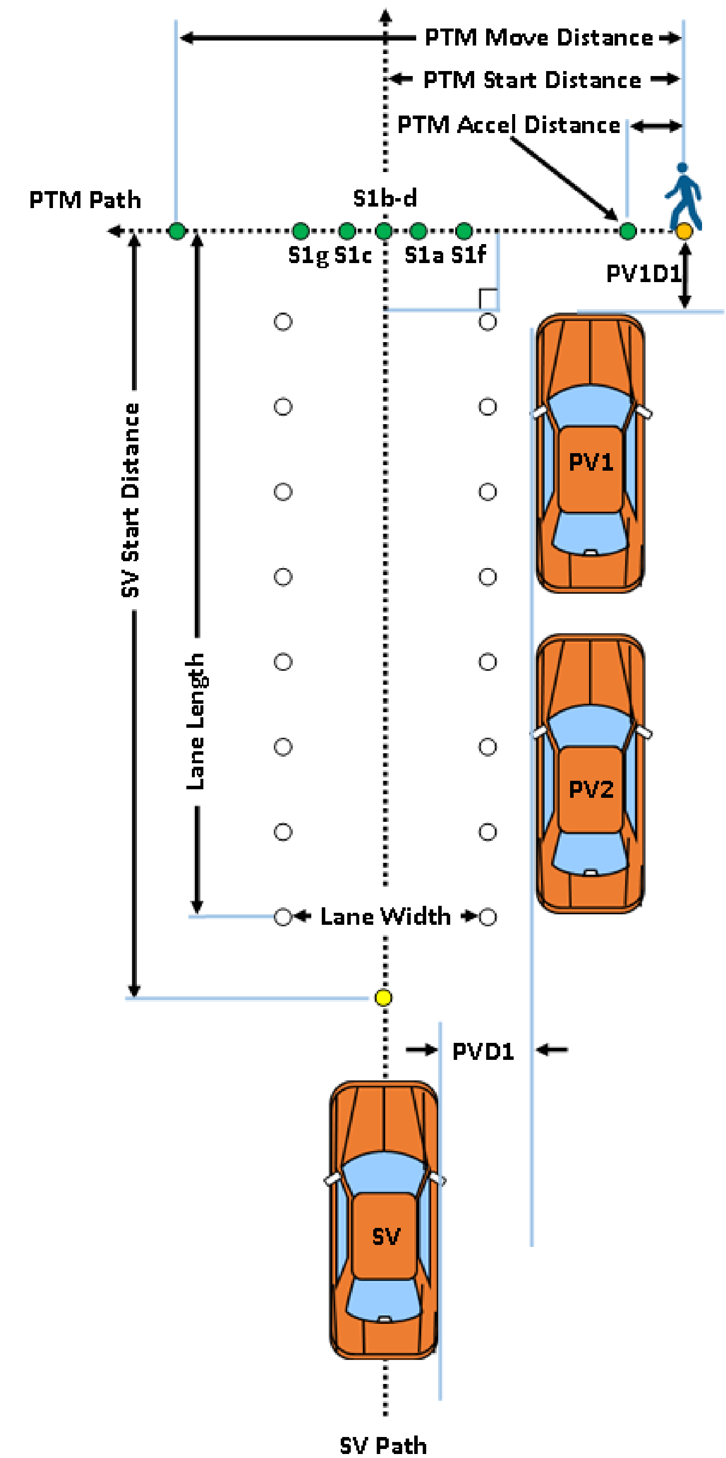


Table 4. Summary of S1e Scenario Setup

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 (600ft)	
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).)*	44m (145 ft)	

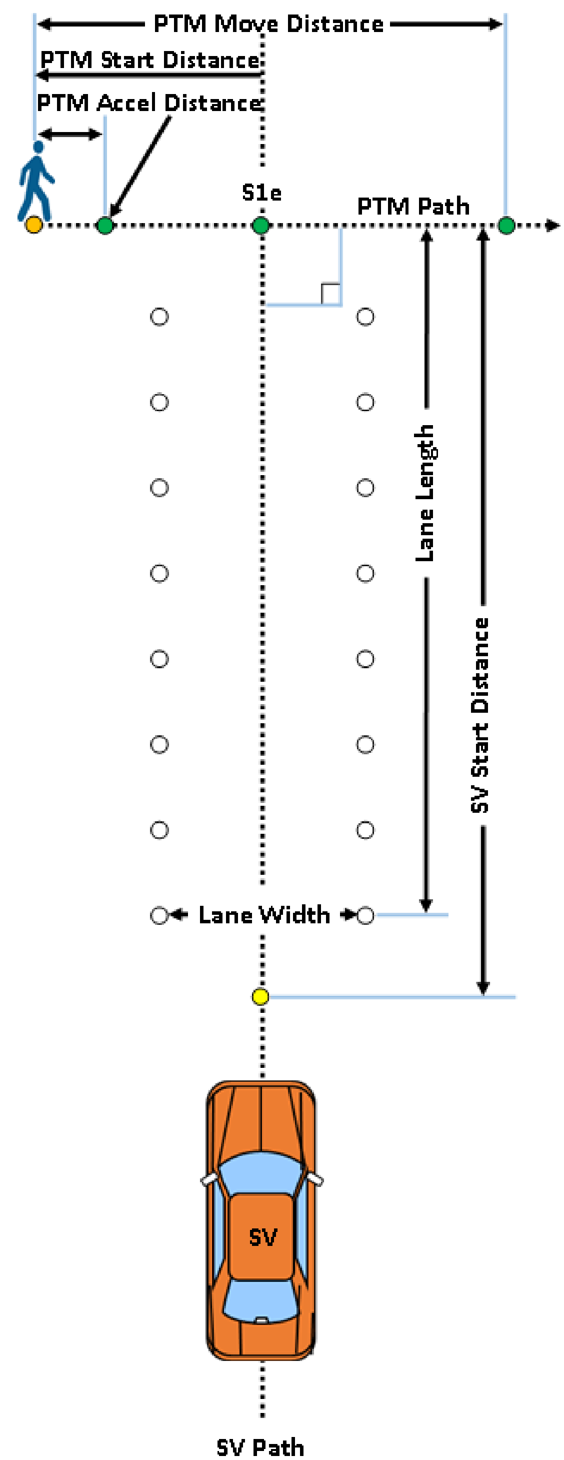


Table 5. Summary of S4a-b Scenarios Setup

S4a-b Scenario		
PTM Type	Adult	
PTM Location	Nearside In-Path	
PTM Action	S4a	Stationary Facing Away
	S4b	Stationary Facing Towards
PTM Move Distance	NA	
PTM Start Distance	NA	
PTM Acceleration Distance	NA	
Overlap *(Determined from the SV width. Measurement transferred to the location on the PTM path.)*	25%	
SV Start Distance	182 m (600ft)	
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).)*	44m (145 ft)	

Drawing illustrates setup but is not to scale

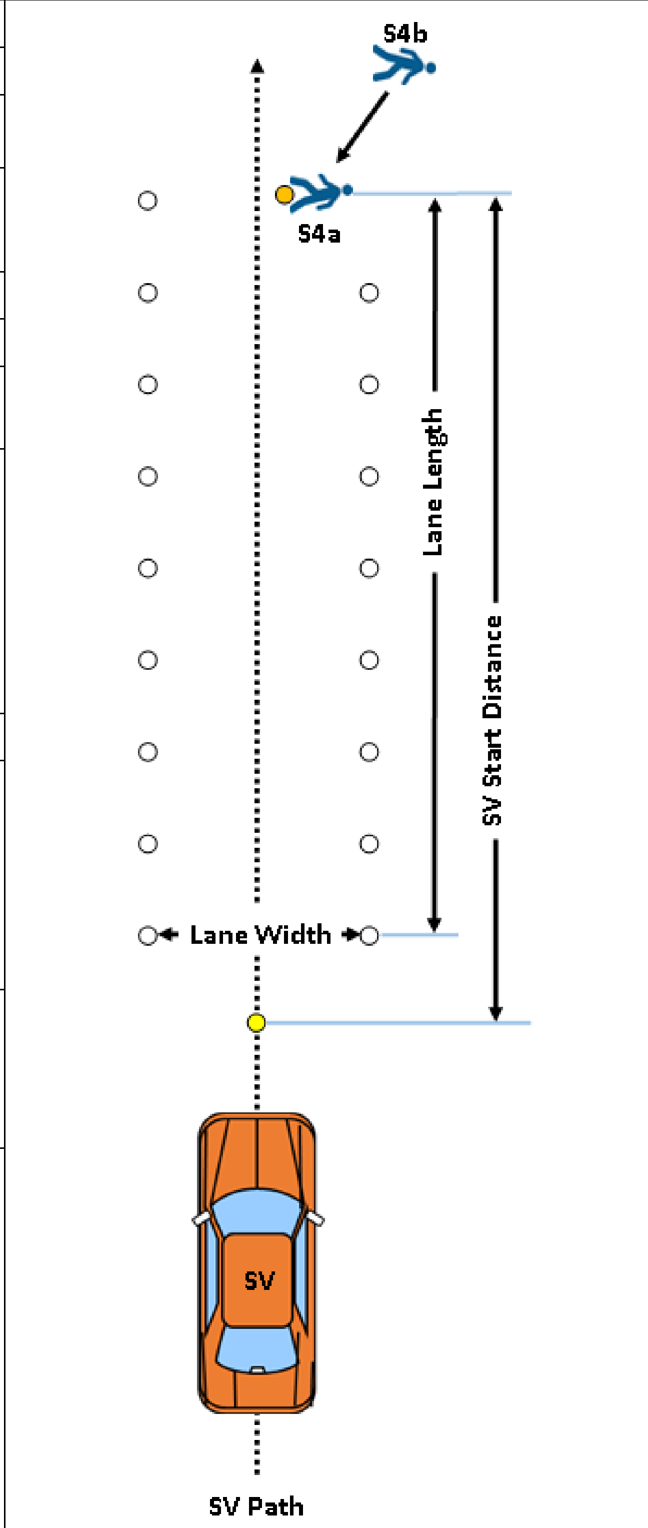
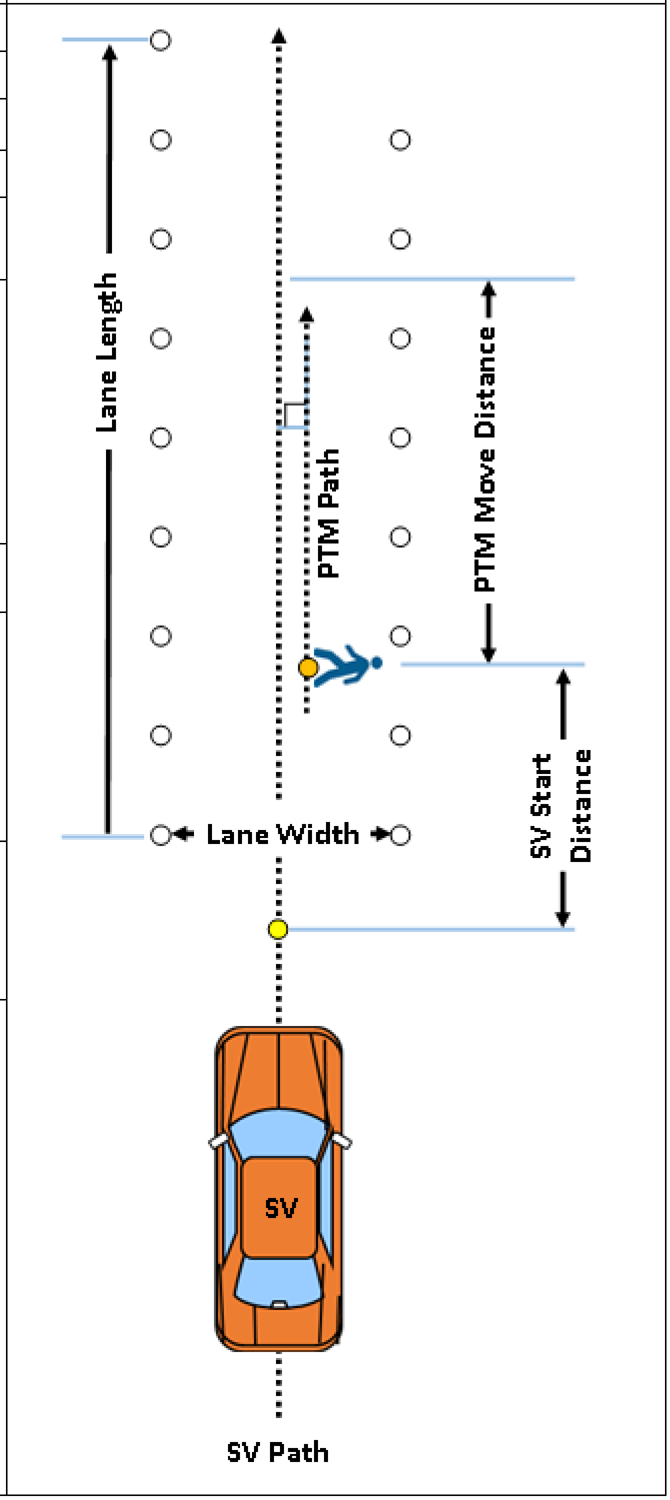


Table 6. Summary of S4c Scenario Setup

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	NA	
PTM Acceleration Distance	1m (3.28 ft)	
Overlap *(Determined from the SV width. Measurement transferred to the location on the PTM path.*	25%	
SV Start Distance	182 m (600ft)	
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).)*	44m (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. SV BRAKE WARM-UP AND TEMPERATURE MAINTENANCE DURING TESTING

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 50th 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

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/6/2020 Due: 1/6/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 5/10/2019 Due: 5/10/2020
SV Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90º Longitude: ±180º Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±5g Angular Rate: ±300 º/s Angular Disp: ±180º	Position: ±2 cm Velocity: 0.1 km/h Accel: ≤ 0.05% Angular Rate: ≤ 0.05% Roll/Pitch Angle: ±0.05º Heading Angle: ±0.1º	Oxford xNAV 550	015477	By: Oxford Technical Solutions Date: 9/12/2018 Due: 9/12/2020
PTT Multi-Axis Inertial Sensing System					24538	By: Oxford Technical Solutions Date: 2/24/2020 Due: 2/24/2022

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	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA

Type	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

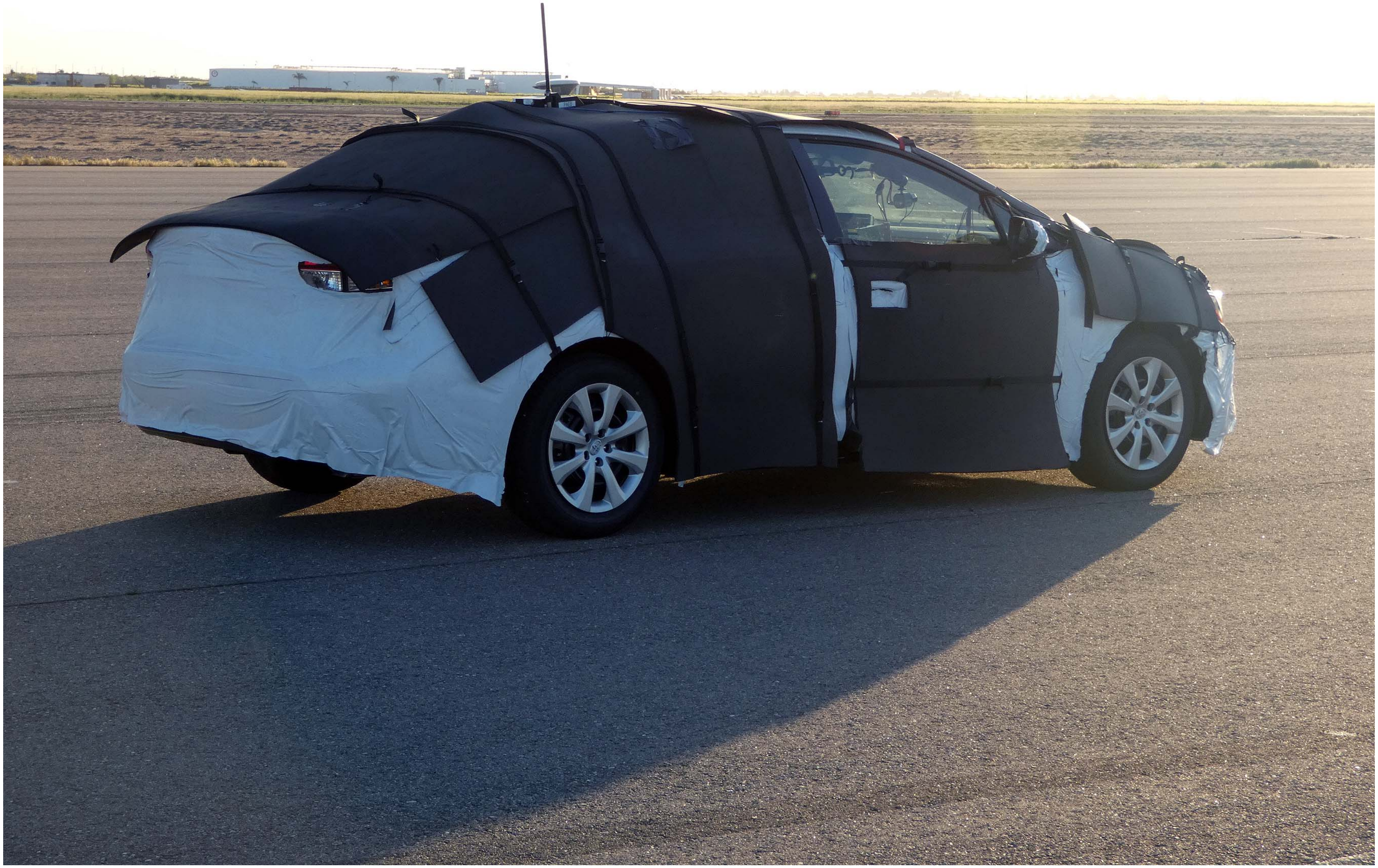


Figure A4. Rear View of Subject Vehicle As-Tested

Figure A5. Window Sticker (Monroney Label)

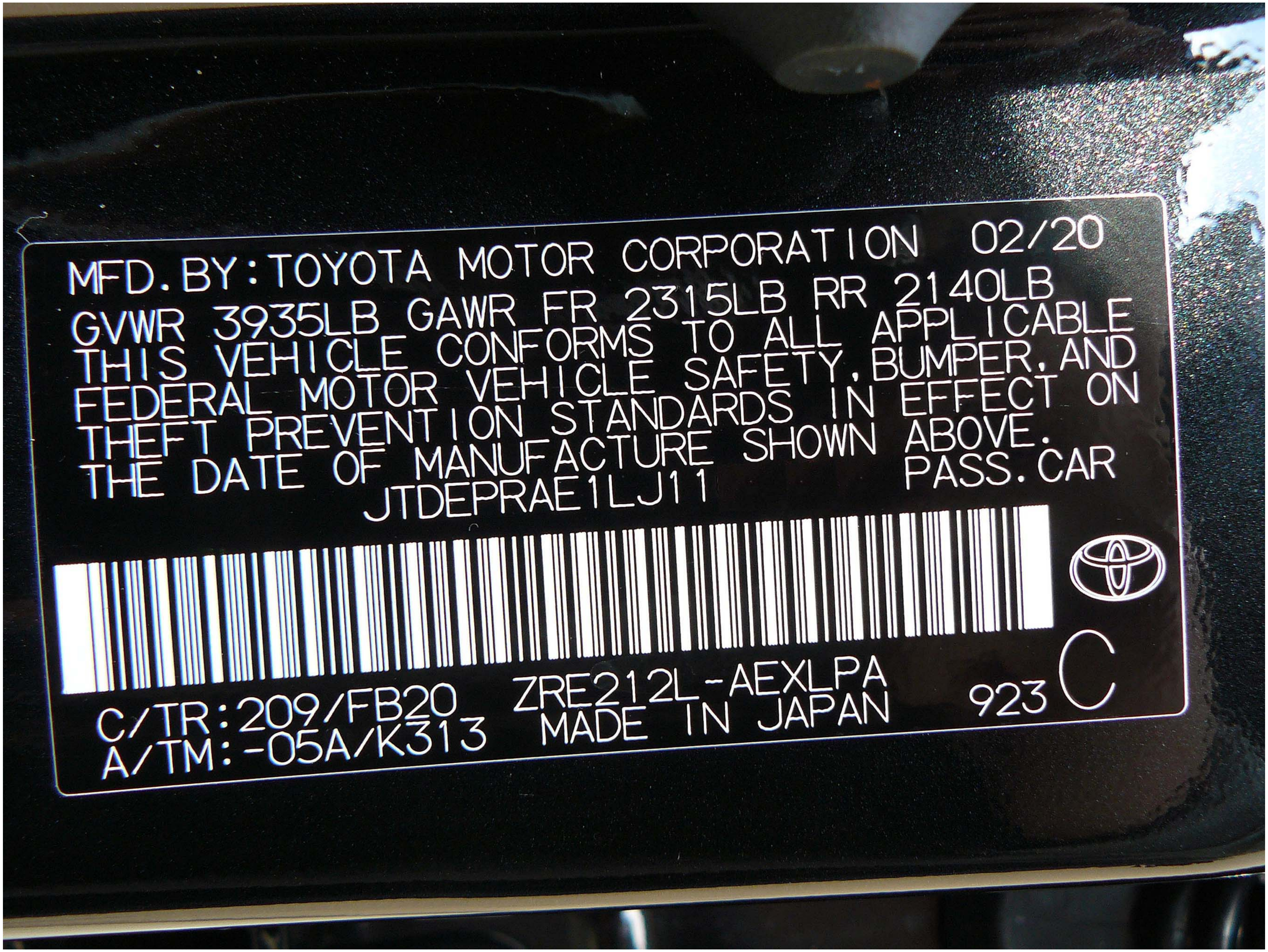


Figure A6. Vehicle Certification Label

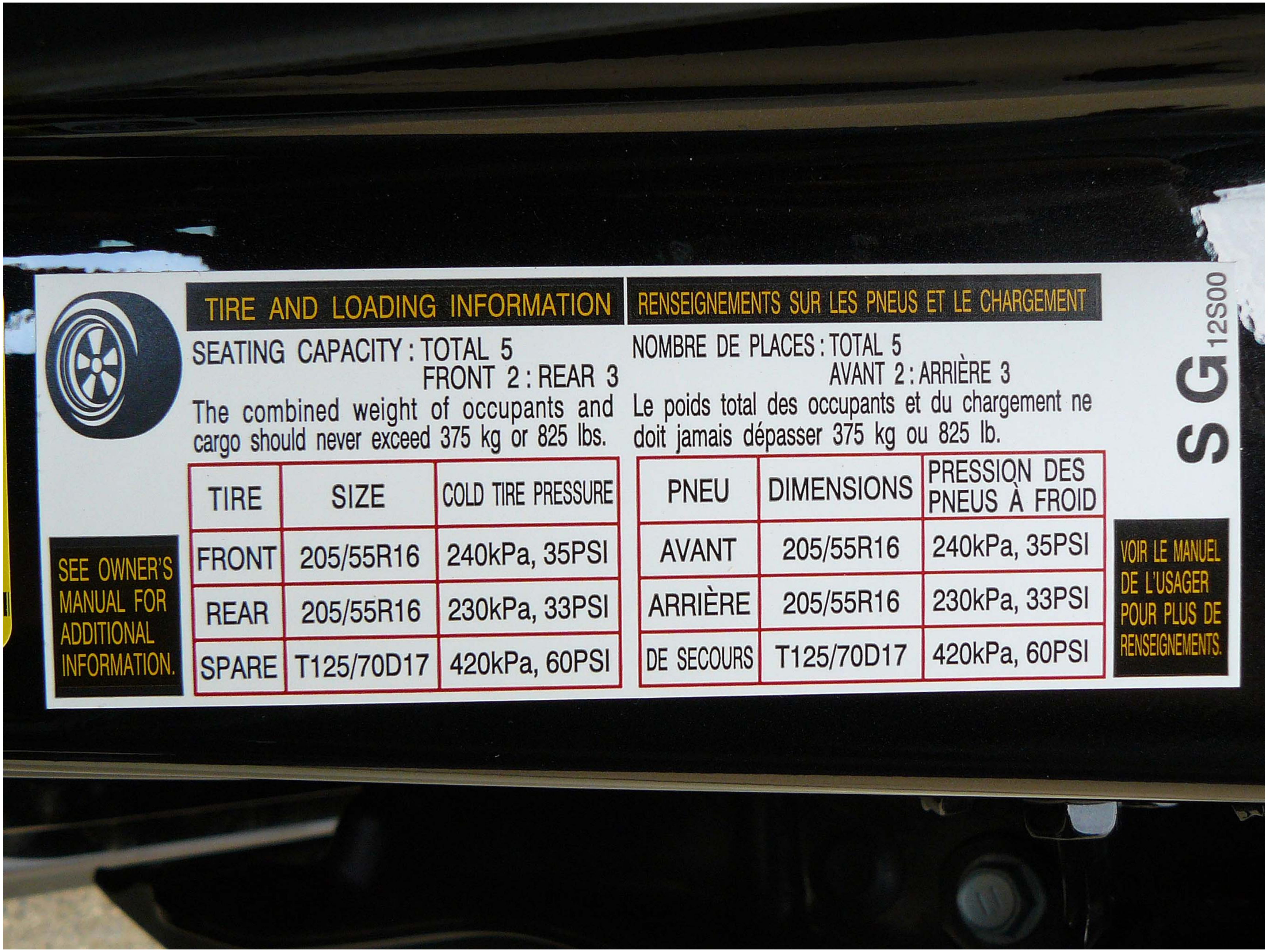


Figure A7. Tire Placard

Figure A8. Adult and Child Pedestrian Surrogates and Motion Platform

Figure A9. Child Pedestrian Surrogate and Obstructing Vehicles for Scenario S1d

Figure A10. Obstruction Vehicles

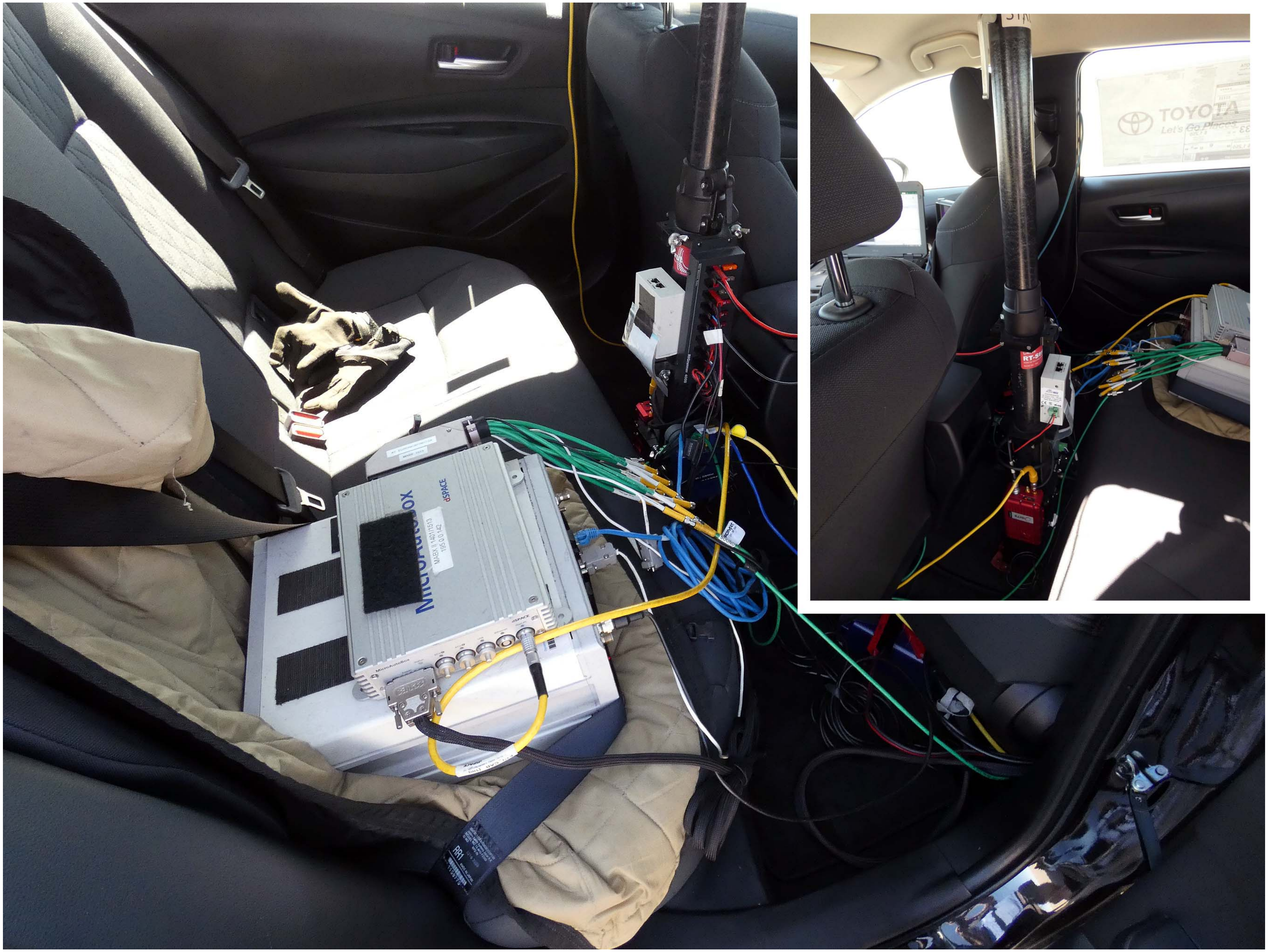


Figure A11. DGPS, Inertial Measurement Unit and MicroAutoBox Installed in Subject Vehicle

Figure A12. Sensor for Detecting Auditory Alert

Figure A13. Sensor for Detecting Visual Alert

Figure A14. Computer Installed in Subject Vehicle

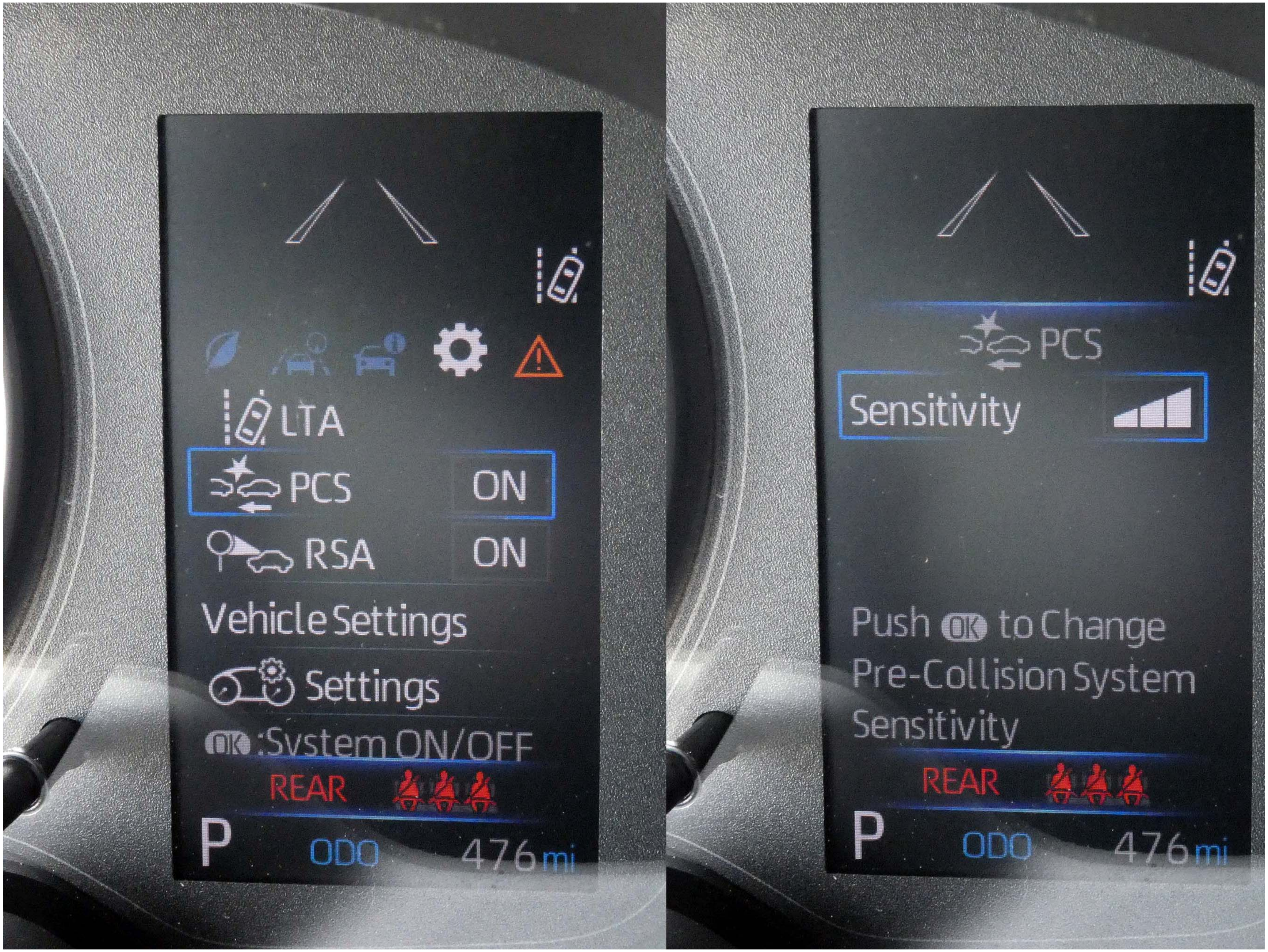


Figure A15. PAEB Setup Menus

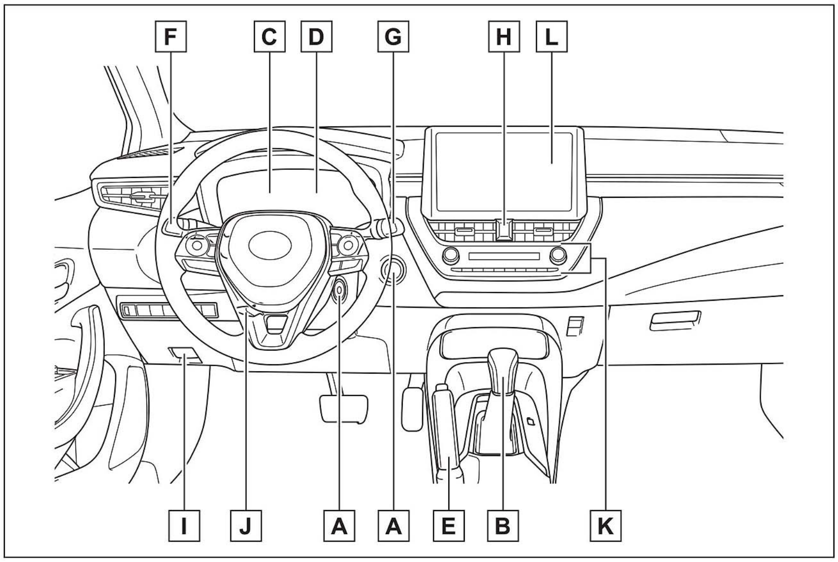
Figure A16. Controls for Changing Vehicle Parameters

Figure A17. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

■Instrument panel



▶ 7-inch display (when digital speedometer is displayed)

Warning lights

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

- BRAKE (U.S.A.) — Brake system warning light*1 (→P.481)
- (Red) (Canada) — Brake system warning light*1 (→P.481)
- (Yellow) — Brake system warning light*1 (→P.481)
- High coolant temperature warning light*2 (→P.481)
- Charging system warning light*1 (→P.482)
- Low engine oil pressure warning light*2 (→P.482)
- CHECK (U.S.A.) — Malfunction indicator lamp*1 (→P.482)
- (Canada) — Malfunction indicator lamp*1 (→P.482)
- SRS warning light*1 (→P.482)
- ABS (U.S.A.) — ABS warning light*1 (→P.483)
- (Canada) — ABS warning light*1 (→P.483)
- Brake Override System warning light/Drive-Start Control warning light*2 (→P.483)
- (Red) — Electric power steering system warning light*1 (→P.484)
- (Yellow) — Electric power steering system warning light*1 (→P.484)
- Low fuel level warning light (→P.484)
- Driver's and front passenger's seat belt reminder light (→P.484)

REAR	Rear passengers' seat belt reminder lights (→P.485)
	Tire pressure warning light*1 (if equipped) (→P.485)
(Orange)	LTA indicator (if equipped) (→P.485) LDA indicator (if equipped) (→P.485)
OFF (Flashes or illuminates)	PCS warning light*1 (→P.486)
	Slip indicator*1 (→P.486)
PARK (Flashes) (U.S.A.)	Parking brake indicator (→P.486)
(P) (Flashes) (Canada)	Parking brake indicator (→P.486)
HOLD (Flashes)	Brake hold operated indicator*1 (if equipped) (→P.487)
iMT (Orange)	iMT indicator*1 (if equipped) (→P.487)

*1: These lights come on when the engine switch is turned to ON to indicate that a system check is being performed. They will turn off after the engine is started, or after a few seconds. There may be a malfunction in a system if the lights do not come on, or turn off. Have the vehicle inspected by your Toyota dealer.

*2: This light illuminates on the multi-information display.

⚠ WARNING

■If a safety system warning light does not come on

Should a safety system light such as the ABS and SRS warning light not come on when you start the engine, this could mean that these systems are not available to help protect you in an accident, which could result in death or serious injury. Have the vehicle inspected by your Toyota dealer immediately if this occurs.

Indicators

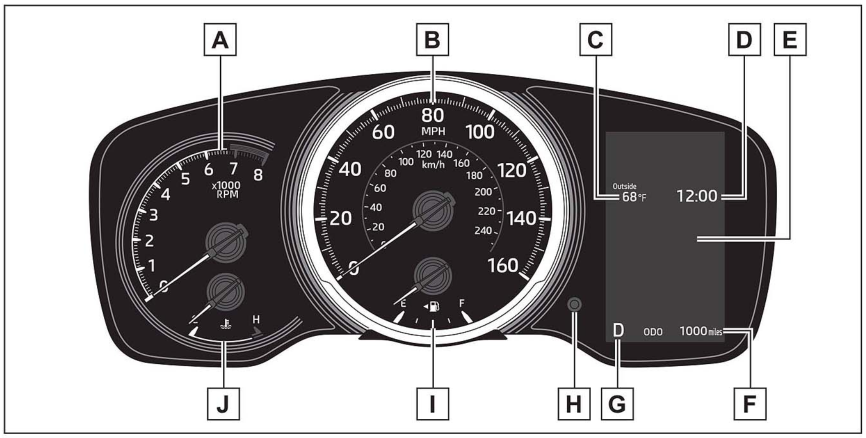
The indicators inform the driver of the operating state of the vehicle's various systems.

	Turn signal indicator (→P.162)
(U.S.A.)	Headlight indicator (→P.170)
(Canada)	Tail light indicator (→P.170)
	Headlight high beam indicator (→P.172)
	Automatic High Beam indicator (→P.173)
OFF	PCS warning light*1, 2 (→P.189)
	Cruise control indicator (→P.213, 223)
	Dynamic radar cruise control indicator (→P.213, 223)
SET	Cruise control "SET" indicator (→P.213, 223)

Gauges and meters (4.2-inch display)

Meter display

■ Locations of gauges and meters



The units of measure may differ depending on the intended destination of the vehicle.

A Tachometer

Displays the engine speed in revolutions per minute

B Speedometer

C Outside temperature

Displays the outside temperature within the range of -40°F (-40°C) to 122°F (50°C)

D Clock (→P.79)

E Multi-information display

Presents the driver with a variety of vehicle data (→P.86)
Displays warning messages if a malfunction occurs (→P.490)

F Odometer and trip meter display (→P.78)

G Shift position indicator (→P.153)

H Display change button (→P.78)

I Fuel gauge

Displays the quantity of fuel remaining in the tank

J Engine coolant temperature gauge

Displays the engine coolant temperature

Toyota Safety Sense 2.0

The Toyota Safety Sense 2.0 consists of the following drive assist systems and contributes to a safe and comfortable driving experience:

Driving assist system

■ **PCS (Pre-Collision System)**

→P.187

■ **LTA (Lane Tracing Assist)***

→P.195

*: If equipped

■ **LDA (Lane Departure Alert with steering control)***

→P.205

*: If equipped

■ **Automatic High Beam**

→P.173

■ **RSA (Road Sign Assist)***

→P.233

*: If equipped

■ **Dynamic radar cruise control with full-speed range***

→P.213

*: If equipped

■ **Dynamic radar cruise control***

→P.223

*: If equipped

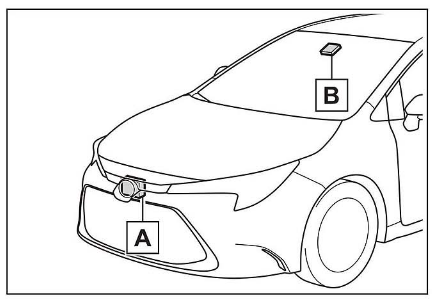
WARNING

■ **Toyota Safety Sense 2.0**

The Toyota Safety Sense 2.0 is designed to operate under the assumption that the driver will drive safely, and is designed to help reduce the impact to the occupants and the vehicle in the case of a collision or assist the driver in normal driving conditions.
As there is a limit to the degree of recognition accuracy and control performance that this system can provide, do not overly rely on this system. The driver is always responsible for paying attention to the vehicle's surroundings and driving safely.

Sensors

Two types of sensors, located behind the front grille and windshield, detect information necessary to operate the drive assist systems.



A Radar sensor

B Front camera

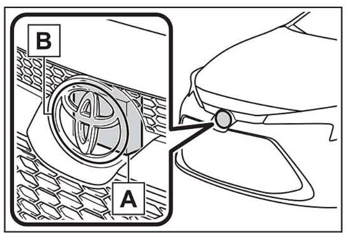
WARNING

■ **To avoid malfunction of the radar sensor**

Observe the following precautions.
Otherwise, the radar sensor may not operate properly, possibly leading to an accident resulting in death or serious injury.

● Keep the radar sensor and the grille cover clean at all times.

▶ 1.8 L 4-cylinder (2ZR-FAE) engine



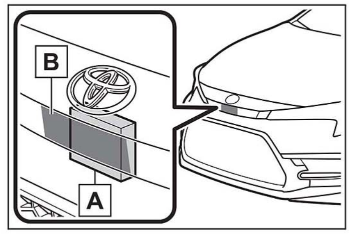
A Radar sensor

B Grille cover

If the front of the radar sensor or the front or back of the grille cover is dirty or covered with water droplets, snow, etc., clean it.

Clean the radar sensor and grille cover with a soft cloth to avoid damaging them.

▶ 2.0 L 4-cylinder (M20A-FKS) engine



A Radar sensor

B Grille cover

If the front of the radar sensor or the front or back of the grille cover is dirty or covered with water droplets, snow, etc., clean it.

Clean the radar sensor and grille cover with a soft cloth to avoid damaging them.

● Do not attach accessories, stickers (including transparent stickers) or other items to the radar sensor, grille cover or surrounding area.

● Do not subject the radar sensor or its surrounding area to a strong impact.
If the radar sensor, front grille, or front bumper has been subjected to a strong impact, have the vehicle inspected by your Toyota dealer.

● Do not disassemble the radar sensor.

● Do not modify or paint the radar sensor or grille cover.

● If the radar sensor, front grille, or front bumper needs to be removed and installed, or replaced, contact your Toyota dealer.

WARNING

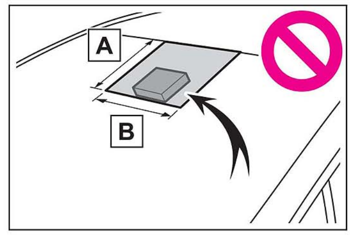
■To avoid malfunction of the front camera

Observe the following precautions.
Otherwise, the front camera may not operate properly, possibly leading to an accident resulting in death or serious injury.

●Keep the windshield clean at all times.

- If the windshield is dirty or covered with an oily film, water droplets, snow, etc., clean the windshield.
- If a glass coating agent is applied to the windshield, it will still be necessary to use the windshield wipers to remove water droplets, etc. from the area of the windshield in front of the front camera.
- If the inner side of the windshield where the front camera is installed is dirty, contact your Toyota dealer.

●Do not attach objects, such as stickers, transparent stickers, etc., to the outer side of the windshield in front of the front camera (shaded area in the illustration).



A From the top of the windshield to approximately 0.4 in. (1 cm) below the bottom of the front camera

B Approximately 7.9 in. (20 cm) (Approximately 4.0 in. [10 cm] to the right and left from the center of the front camera)

●If the part of the windshield in front of the front camera is fogged up or covered with condensation, or ice, use the windshield defogger to remove the fog, condensation, or ice. (→P.387, 392)

●If water droplets cannot be properly removed from the area of the windshield in front of the front camera by the windshield wipers, replace the wiper insert or wiper blade.

If the wiper inserts or wiper blades need to be replaced, contact your Toyota dealer.

●Do not attach window tint to the windshield.

●Replace the windshield if it is damaged or cracked.
If the windshield needs to be replaced, contact your Toyota dealer.

WARNING

- Do not allow liquids to contact the front camera.
- Do not allow bright lights to shine into the front camera.
- Do not dirty or damage the front camera.
  When cleaning the inside of the windshield, do not allow glass cleaner to contact the lens of the front camera. Also, do not touch the lens.
  If the lens is dirty or damaged, contact your Toyota dealer.
- Do not subject the front camera to a strong impact.
- Do not change the installation position or direction of the front camera or remove it.
- Do not disassemble the front camera.
- Do not modify any components of the vehicle around the front camera (inside rear view mirror, etc.) or ceiling.
- Do not attach any accessories to the hood, front grille or front bumper that may obstruct the front camera. Contact your Toyota dealer for details.
- If a surfboard or other long object is to be mounted on the roof, make sure that it will not obstruct the front camera.
- Do not modify the headlights or other lights.

NOTE:
Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage; (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé et respecte les règles d'exposition aux fréquences radioélectriques (RF) CNR-102 de l'IC. Cet équipement doit être installé et utilisé en gardant une distance de 20 cm ou plus entre le dispositif rayonnant et le corps.

■ **If a warning message is displayed on the multi-information display**

A system may be temporarily unavailable or there may be a malfunction in the system.

● In the following situations, perform the actions specified in the table. When the normal operating conditions are detected, the message will disappear and the system will become operational.

If the message does not disappear, contact your Toyota dealer.

Situation	Actions
When the area around a sensor is covered with dirt, moisture (fogged up, covered with condensation, ice, etc.), or other foreign matter	To clean the part of the windshield in front of the front camera, use the windshield wipers or the windshield defogger of the air conditioning system (→P.387, 392).

<table>
<tr><th>Situation</th><th>Actions</th></tr>
<tr><td rowspan="2">When the temperature around the front camera is outside of the operational range, such as when the vehicle is in the sun or in an extremely cold environment</td><td>If the front camera is hot, such as after the vehicle had been parked in the sun, use the air conditioning system to decrease the temperature around the front camera.

If a sunshade was used when the vehicle was parked, depending on its type, the sunlight reflected from the surface of the sunshade may cause the temperature of the front camera to become excessively high.</td></tr>
<tr><td>If the front camera is cold, such after the vehicle is parked in an extremely cold environment, use the air conditioning system to increase the temperature around the front camera.</td></tr>
<tr><td>The area in front of the front camera is obstructed, such as when the hood is open or a sticker is attached to the part of the windshield in front of the front camera.</td><td>Close the hood, remove the sticker, etc. to clear the obstruction.</td></tr>
</table>

● In the following situations, if the situation has changed (or the vehicle has been driven for some time) and the normal operating conditions are detected, the message will disappear and the system will become operational.

If the message does not disappear, contact your Toyota dealer.

- When the temperature around the radar sensor is outside of the operational range, such as when the vehicle is in the sun or in an extremely cold environment
- When the front camera cannot detect objects in front of the vehicle, such as when driving in the dark, snow, or fog, or when bright lights are shining into the front camera

PCS (Pre-Collision System)

The pre-collision system uses a radar sensor and front camera to detect objects (→P.190) in front of the vehicle. When the system determines that the possibility of a frontal collision with an object is high, a warning operates to urge the driver to take evasive action and the potential brake pressure is increased to help the driver avoid the collision. If the system determines that the possibility of a frontal collision with an object is extremely high, the brakes are automatically applied to help avoid the collision or help reduce the impact of the collision.

The pre-collision system can be disabled/enabled and the warning timing can be changed. (→P.189)

Detectable objects

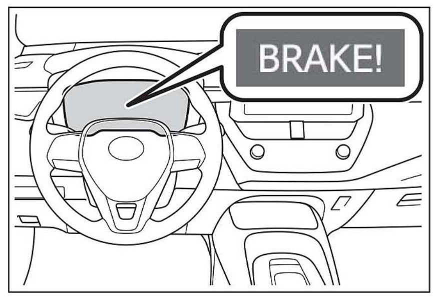
The system can detect the following:

- Vehicles
- Bicyclists
- Pedestrians

System functions

■ Pre-collision warning

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



■ Pre-collision brake assist

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

■ Pre-collision braking

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

WARNING

■ **Limitations of the pre-collision system**

- The driver is solely responsible for safe driving. Always drive safely, taking care to observe your surroundings.
  Do not use the pre-collision system instead of normal braking operations under any circumstances. This system will not prevent collisions or lessen collision damage or injury in every situation. Do not overly rely on this system. Failure to do so may lead to an accident, resulting in death or serious injury.
- Although this system is designed to help avoid a collision or help reduce the impact of the collision, its effectiveness may change according to various conditions, therefore the system may not always be able to achieve the same level of performance.
  Read the following conditions carefully. Do not overly rely on this system and always drive carefully.
  - Conditions under which the system may operate even if there is no possibility of a collision: →P.191
  - Conditions under which the system may not operate properly: →P.192
- Do not attempt to test the operation of the pre-collision system yourself.
  Depending on the objects used for testing (dummies, cardboard objects imitating detectable objects, etc.), the system may not operate properly, possibly leading to an accident.

■ **Pre-collision braking**

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

■ **When to disable the pre-collision system**

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

- When the vehicle is being towed

WARNING

- When your vehicle is towing another vehicle
- When transporting the vehicle via truck, boat, train or similar means of transportation
- When the vehicle is raised on a lift with the engine running and the tires are allowed to rotate freely
- When inspecting the vehicle using a drum tester such as a chassis dynamometer or speedometer tester, or when using an on vehicle wheel balancer
- When a strong impact is applied to the front bumper or front grille, due to an accident or other reasons
- If the vehicle cannot be driven in a stable manner, such as when the vehicle has been in an accident or is malfunctioning
- When the vehicle is driven in a sporty manner or off-road
- When the tires are not properly inflated
- When the tires are very worn
- When tires of a size other than specified are installed
- When tire chains are installed
- When a compact spare tire or an emergency tire puncture repair kit is used
- If equipment (snow plow, etc.) that may obstruct the radar sensor or front camera is temporarily installed to the vehicle

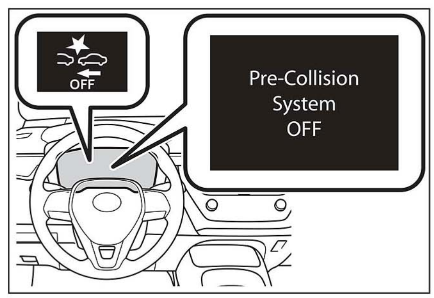
Changing settings of the pre-collision system

Enabling/disabling the pre-collision system

The pre-collision system can be enabled/disabled on ⚙ (→P.548) of the multi-information display.

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

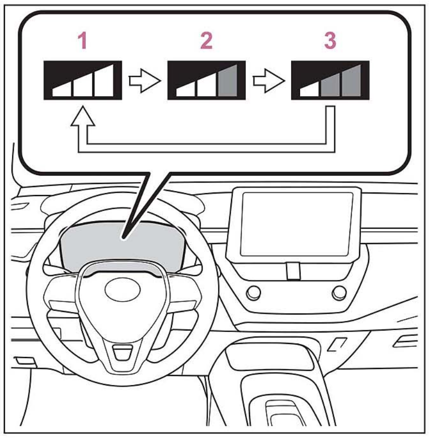
If the system is disabled, the PCS warning light will turn on and a message will be displayed on the multi-information display.



Changing the pre-collision warning timing

The pre-collision warning timing can be changed on ⚙ (→P.548) of the multi-information display.

The warning timing setting is retained when the engine switch is turned off. However, if the pre-collision system is disabled and re-enabled, the operation timing will return to the default setting (middle).



1 Early

2 Middle

This is the default setting.

3 Late

Operational conditions

The pre-collision system is enabled and the system determines that the possibility of a frontal collision with a detected object is high.
Each function is operational at the following speed

- Pre-collision warning

Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 7 to 110 mph (10 to 180 km/h)	Approx. 7 to 110 mph (10 to 180 km/h)
Bicyclists and pedestrians	Approx. 7 to 50 mph (10 to 80 km/h)	Approx. 7 to 50 mph (10 to 80 km/h)

- Pre-collision brake assist

Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 20 to 110 mph (30 to 180 km/h)	Approx. 20 to 110 mph (30 to 180 km/h)
Bicyclists and pedestrians	Approx. 20 to 50 mph (30 to 80 km/h)	Approx. 20 to 50 mph (30 to 80 km/h)

- Pre-collision braking

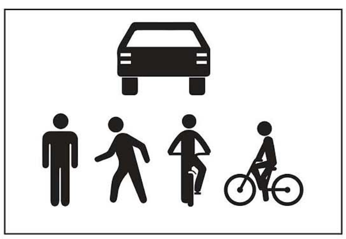
Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 7 to 110 mph (10 to 180 km/h)	Approx. 7 to 110 mph (10 to 180 km/h)
Bicyclists and pedestrians	Approx. 7 to 50 mph (10 to 80 km/h)	Approx. 7 to 50 mph (10 to 80 km/h)

The system may not operate in the following situations:

- If a battery terminal has been disconnected and reconnected and then the vehicle has not been driven for a certain amount of time
- If the shift lever is in R
- When the VSC OFF indicator is illuminated (only the pre-collision warning function will be operational)

Object detection function

The system detects objects based on their size, profile, motion, etc. However, an object may not be detected depending on the surrounding brightness and the motion, posture, and angle of the detected object, preventing the system from operating properly. (→P.192)
The illustration shows an image of detectable objects.



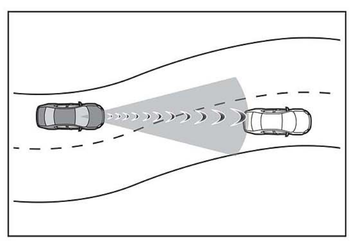
Cancelation of the pre-collision braking

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

- The accelerator pedal is depressed strongly.
- The steering wheel is turned sharply or abruptly.

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

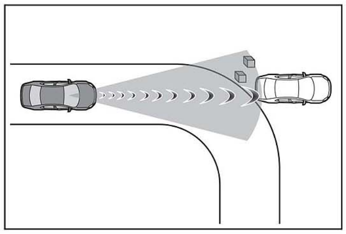
- In some situations such as the following, the system may determine that there is a possibility of a frontal collision and operate.
  - When passing a detectable object, etc.
  - When changing lanes while overtaking a detectable object, etc.
  - When approaching a detectable object in an adjacent lane or on the roadside, such as when changing the course of travel or driving on a winding road



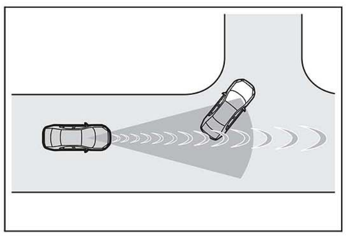
  - When rapidly closing on a detectable object, etc.
  - When approaching objects on the roadside, such as detectable objects, guardrails, utility poles, trees, or walls
  - When there is a detectable object or other object by the roadside at the entrance of a curve

4

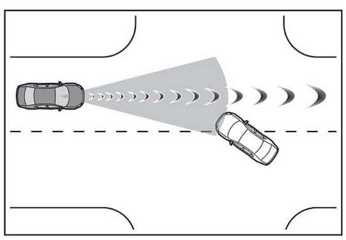
Driving



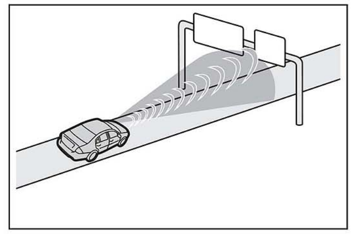
- When there are patterns or paint in front of your vehicle that may be mistaken for a detectable object
- When the front of your vehicle is hit by water, snow, dust, etc.
- When overtaking a detectable object that is changing lanes or making a right/left turn



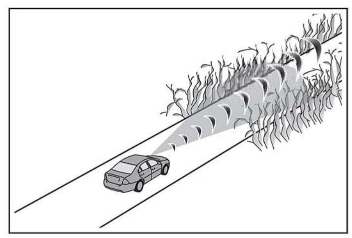
- When passing a detectable object in an oncoming lane that is stopped to make a right/left turn



- When a detectable object approaches very close and then stops before entering the path of your vehicle
- If the front of your vehicle is raised or lowered, such as when on an uneven or undulating road surface
- When driving on a road surrounded by a structure, such as in a tunnel or on an iron bridge
- When there is a metal object (manhole cover, steel plate, etc.), steps, or a protrusion in front of your vehicle
- When passing under an object (road sign, billboard, etc.)



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



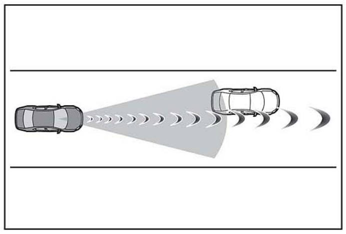
- When driving through steam or smoke
- When driving near an object that reflects radio waves, such as a large truck or guardrail
- When driving near a TV tower, broadcasting station, electric power plant, or other location where strong radio waves or electrical noise may be present

■ **Situations in which the system may not operate properly**

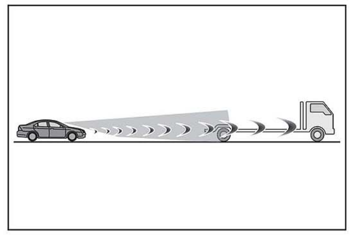
● In some situations such as the following, an object may not be detected by the radar sensor and front camera, preventing the system from operating properly:

- When a detectable object is approaching your vehicle
- When your vehicle or a detectable object is wobbling
- If a detectable object makes an abrupt maneuver (such as sudden

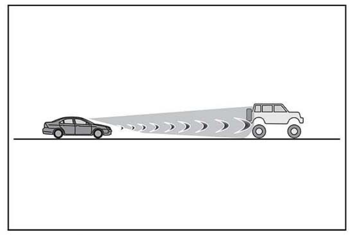
swerving, acceleration or deceleration)
- When your vehicle approaches a detectable object rapidly
- When a detectable object is not directly in front of your vehicle



- When a detectable object is near a wall, fence, guardrail, manhole cover, vehicle, steel plate on the road, etc.
- When a detectable object is under a structure
- When part of a detectable object is hidden by an object, such as large baggage, an umbrella, or guardrail
- When multiple detectable objects are close together
- If the sun or other light is shining directly on a detectable object
- When a detectable object is a shade of white and looks extremely bright
- When a detectable object appears to be nearly the same color or brightness as its surroundings
- If a detectable object cuts or suddenly emerges in front of your vehicle
- When the front of your vehicle is hit by water, snow, dust, etc.
- When a very bright light ahead, such as the sun or the headlights of oncoming traffic, shines directly into the front camera
- When approaching the side or front of a vehicle ahead
- If a vehicle ahead is a motorcycle
- If a vehicle ahead is narrow, such as a personal mobility vehicle
- If a preceding vehicle has a small rear end, such as an unloaded truck
- If a preceding vehicle has a low rear end, such as a low bed trailer

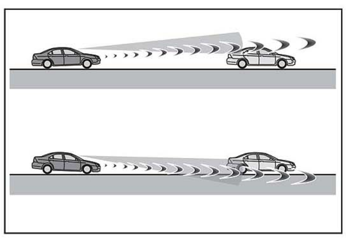


- If a vehicle ahead has extremely high ground clearance



- If a vehicle ahead is carrying a load which protrudes past its rear bumper
- If a vehicle ahead is irregularly shaped, such as a tractor or side car
- If a vehicle ahead is a child sized bicycle, a bicycle that is carrying a large load, a bicycle ridden by more than one person, or a uniquely shaped bicycle (bicycle with a child seat, tandem bicycle, etc.)
- If a pedestrian/or the riding height of a bicyclist ahead is shorter than approximately 3.2 ft. (1 m) or taller than approximately 6.5 ft. (2 m)
- If a pedestrian/bicyclist is wearing oversized clothing (a rain coat, long skirt, etc.), making their silhouette obscure
- If a pedestrian is bending forward or squatting or bicyclist is bending forward
- If a pedestrian/bicyclist is moving fast
- If a pedestrian is pushing a stroller, wheelchair, bicycle or other vehicle
- When driving in inclement weather such as heavy rain, fog, snow or a sandstorm

- When driving through steam or smoke
- When the surrounding area is dim, such as at dawn or dusk, or while at night or in a tunnel, making a detectable object appear to be nearly the same color as its surroundings
- When driving in a place where the surrounding brightness changes suddenly, such as at the entrance or exit of a tunnel
- After the engine has started the vehicle has not been driven for a certain amount of time
- While making a left/right turn and for a few seconds after making a left/right turn
- While driving on a curve and for a few seconds after driving on a curve
- If your vehicle is skidding
- If the front of the vehicle is raised or lowered



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

● In some situations such as the following, sufficient braking force may not be obtained, preventing the system from performing properly:

- If the braking functions cannot operate to their full extent, such as when the brake parts are extremely cold, extremely hot, or wet
- If the vehicle is not properly maintained (brakes or tires are excessively worn, improper tire inflation pressure, etc.)
- When the vehicle is being driven on a gravel road or other slippery surface

■ **If VSC is disabled**

● If VSC is disabled (→P.252), the pre-collision brake assist and pre-collision braking functions are also disabled.

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

Customizable features

Your vehicle includes a variety of electronic features that can be personalized to suit your preferences. The settings of these features can be changed using the multi-information display, the audio system screen, or at your Toyota dealer.

Customizing vehicle features

■ **Changing by using the audio system screen**

1 Press the “MENU” button.

2 Select “Setup” on the “Menu” screen.

3 Select “General” or “Vehicle” on the “Setup” screen.

Various setting can be changed. Refer to the list of settings that can be changed for details.

■ **Changing by using the meter control switches**

1 Press ‹ or › of the meter control switch to select ⚙.

2 Press ˄ or ˅ of the meter control switch to select the desired item to be customized.

3 Press or press and hold OK .

The available settings will differ depending on if OK is pressed or pressed and held. Follow the instructions on the display.

⚠ WARNING

■ **During customization**

As the engine needs to be running during customization, ensure that the vehicle is parked in a place with adequate ventilation. In a closed area such as a garage, exhaust gases including harmful carbon monoxide (CO) may collect and enter the vehicle. This may lead to death or a serious health hazard.

NOTICE

■ **During customization**

To prevent battery discharge, ensure that the engine is running while customizing features.

Customizable features

Some function settings are changed simultaneously with other functions being customized. Contact your Toyota dealer for further details.

A Settings that can be changed using the audio system screen

B Settings that can be changed using the meter control switches

■ Lights (→P.170)

Function	Default setting	Customized setting	A	B	C
Daytime running light system	On	Off*1	O	—	O
AFS (Adaptive Front-lighting System)*2	On	Off	—	—	O

*1: Except for Canada

*2: If equipped

■ PCS (Pre-Collision System) (→P.187)

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

■ LTA (Lane Tracing Assist)*/LDA (Lane Departure Alert with steering control)* (→P.195, 205)

Function	Default setting	Customized setting	A	B	C
Lane centering function*	On	Off	—	O	—
Steering assist function	On	Off	—	O	—
Alert sensitivity	High	Standard	—	O	—
Vehicle sway warning function	On	Off	—	O	—
Vehicle sway warning sensitivity	Standard	High	—	O	—
		Low			

*: If equipped

■ RSA (Road Sign Assist)* (→P.233)

Function	Default setting	Customized setting	A	B	C
RSA (Road Sign Assist)	On	Off	—	O	—

APPENDIX C

Run Log

Run Log for Daytime Tests

Subject Vehicle: 2020 Toyota Corolla LE

Test Date: 4/27/2020

Adult Pedestrian Test Mannequin: Articulated 4A Adult

Test Driver: N. Wong

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
110	S1a	16	Day	Y	1.56	1.09	16.90	1.06	0.57	NC	
111	S1a	16	Day	Y	1.52	1.17	16.40	0.91	0.60	NC	
112	S1a	16	Day	N							PTT speed
113	S1a	16	Day	N							PTT speed
114	S1a	16	Day	Y	1.58	1.14	16.10	1.00	0.59	NC	No video
115	S1a	16	Day	Y	1.59	1.13	16.00	1.05	0.59	NC	
116	S1a	16	Day	Y	1.60	1.03	16.50	1.03	0.56	NC	
117	S1a	40	Day	Y	1.48	0.60	39.60	1.13	0.93	NC	
118	S1a	40	Day	Y	1.71	0.67	39.70	1.12	0.92	NC	
119	S1a	40	Day	Y	1.60	0.74	39.70	0.86	0.97	NC	
120	S1a	40	Day	Y	1.31	0.67	39.90	1.13	1.10	NC	
121	S1a	40	Day	Y	1.40	0.62	39.40	1.14	0.96	NC	
74	Static		Day								

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
75	S1b	16	Day	N							PTT speed
76	S1b	16	Day	Y	1.69	1.07	16.20	1.13	0.58	NC	
77	S1b	16	Day	N							PTT speed
78	S1b	16	Day	Y	1.46	1.01	16.20	1.10	0.57	NC	
79	S1b	16	Day	Y	1.71	1.04	16.60	0.98	0.58	NC	
80	S1b	16	Day	Y	1.62	1.04	16.60	1.07	0.58	NC	
81	S1b	16	Day	Y	1.62	0.98	15.70	1.10	0.56	NC	
99	S1b	20	Day	Y	1.75	0.96	19.50	0.86	0.66	NC	
100	S1b	20	Day	Y	1.62	1.05	19.80	0.91	0.60	NC	
101	S1b	20	Day	Y	1.87	0.90	20.20	0.86	0.63	NC	
102	S1b	20	Day	Y	1.75	1.18	20.40	0.88	0.65	NC	
103	S1b	20	Day	Y	1.85	1.05	20.20	0.85	0.63	NC	
104	S1b	30	Day	Y	1.60	0.60	30.10	1.09	0.78	NC	
105	S1b	30	Day	Y	1.76	0.56	30.50	0.94	0.78	NC	
106	S1b	30	Day	Y	1.85	0.66	29.80	0.99	0.78	NC	
107	S1b	30	Day	Y	1.74	0.59	30.30	0.90	0.77	NC	
108	S1b	30	Day	Y	1.76	0.57	30.50	0.96	0.78	NC	
82	S1b	40	Day	Y	1.85	0.62	40.10	1.13	0.95	NC	
83	S1b	40	Day	Y	1.84	0.59	42.00	1.14	0.92	NC	
84	S1b	40	Day	Y	1.84	0.62	41.90	1.12	0.94	NC	
85	S1b	40	Day	Y	2.01	0.52	38.30	1.08	0.93	NC	
86	S1b	40	Day	Y	1.87	0.52	41.10	1.11	0.95	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
87	S1b	50	Day	Y	1.90	0.60	47.00	1.13	1.12	NC	
88	S1b	50	Day	Y	1.75	0.97	45.30	0.74	1.16	NC	
89	S1b	50	Day	Y	1.93	0.80	44.40	0.87	1.12	NC	
90	S1b	50	Day	Y	1.99	0.81	45.50	0.77	1.14	NC	
91	S1b	50	Day	Y	1.93	0.53	45.70	0.99	1.13	NC	
92	S1b	60	Day	Y	0.85	0.00	20.30	0.99	0.65	Contact	
93	S1b	60	Day	Y	1.82	0.80	53.60	0.94	1.13	NC	
94	S1b	60	Day	N							Lateral offset
95	S1b	60	Day	N							Comm errors
96	S1b	60	Day	Y	1.85	0.85	53.60	0.92	1.16	NC	
97	S1b	60	Day	Y	1.91	0.53	53.00	1.03	1.15	NC	
98	S1b	60	Day	Y	1.57	0.60	52.70	0.98	1.15	NC	
122	Static		Day								
123	S1c	16	Day	N							PTT lateral error
124	S1c	16	Day	N							PTT speed
125	S1c	16	Day	Y	1.61	1.07	16.20	0.85	0.60	NC	
126	S1c	16	Day	Y	1.53	1.10	15.90	0.92	0.59	NC	
127	S1c	16	Day	N							PTT speed, comm errors
128	S1c	16	Day	Y	1.77	1.04	16.50	0.85	0.59	NC	
129	S1c	16	Day	Y	1.56	1.08	16.20	0.84	0.60	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
130	S1c	16	Day	Y	1.40	1.11	15.90	0.91	0.59	NC	
131	S1c	40	Day	Y	2.21	0.96	30.50	0.74	0.94	NC	
132	S1c	40	Day	Y	2.15	0.88	30.70	0.78	0.92	NC	
133	S1c	40	Day	N							PTT speed
134	S1c	40	Day	N							PTT speed
135	S1c	40	Day	N							SV speed
136	S1c	40	Day	Y	2.11	0.80	32.80	0.95	0.90	NC	
137	S1c	40	Day	Y	1.95	0.83	30.80	0.76	0.99	NC	
138	S1c	40	Day	Y	2.04	1.08	29.40	0.74	0.96	NC	
192	Static		Day								
193	S1d	16	Day	Y	1.12	1.17	16.20	1.03	0.59	NC	
194	S1d	16	Day	Y	1.29	1.08	16.10	0.93	0.57	NC	
195	S1d	16	Day	Y	1.10	1.08	15.90	0.95	0.59	NC	
196	S1d	16	Day	Y	0.93	1.03	15.30	0.87	0.58	NC	
197	S1d	16	Day	N							PTT speed
198	S1d	16	Day	Y	1.21	0.99	16.10	0.89	0.56	NC	
199	S1d	20	Day	Y	1.29	0.90	20.20	0.87	0.66	NC	
200	S1d	20	Day	Y	1.25	1.00	20.10	0.88	0.62	NC	
201	S1d	20	Day	Y	1.30	1.03	20.30	0.92	0.58	NC	
202	S1d	20	Day	Y	1.22	0.96	20.20	0.87	0.64	NC	
203	S1d	20	Day	Y	1.16	1.02	20.30	0.87	0.67	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
204	S1d	30	Day	N							PTT speed
205	S1d	30	Day	Y	1.17	0.67	29.40	0.89	0.74	NC	
206	S1d	30	Day	Y	1.20	0.67	28.40	0.69	0.93	NC	
207	S1d	30	Day	Y	1.12	0.55	29.60	0.84	0.91	NC	
208	S1d	30	Day	Y	1.27	0.75	30.50	1.14	0.85	NC	
209	S1d	30	Day	Y	1.21	0.79	28.50	0.66	0.94	NC	
210	S1d	40	Day	Y	1.31	0.65	40.80	1.19	1.05	NC	
211	S1d	40	Day	Y	1.28	0.56	41.70	0.97	0.84	NC	
212	S1d	40	Day	Y	1.33	0.59	37.90	1.10	1.03	NC	
213	S1d	40	Day	Y	1.41	0.61	37.30	1.06	1.09	NC	
214	S1d	40	Day	Y	1.30	0.57	40.80	1.21	1.10	NC	
215	S1d	50	Day	N							SV lateral offset
216	S1d	50	Day	Y	1.44	1.00	39.10	0.97	1.13	NC	
217	S1d	50	Day	Y	1.38	0.69	40.50	1.00	1.10	NC	
218	S1d	50	Day	Y	1.31	0.49	48.40	1.16	1.09	NC	
219	S1d	50	Day	Y	1.43	0.57	43.40	1.05	1.16	NC	
220	S1d	50	Day	Y	1.44	0.60	46.50	1.05	1.15	NC	
221	S1d	60	Day	N							SV lateral offset
222	S1d	60	Day	Y	1.41	0.53	53.30	1.02	1.14	NC	
223	S1d	60	Day	N							SV lateral offset
224	S1d	60	Day	Y	1.28	0.00	50.30	1.06	1.01	Contact	Just tapped PTT
225	S1d	60	Day	Y	1.25	0.41	57.80	1.06	1.09	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
226	S1d	60	Day	Y	1.32	0.61	55.30	1.08	1.08	NC	
227	S1d	60	Day	Y	1.34	0.49	53.10	1.07	1.08	NC	
228	Static		Day								
157	Static		Day								
158	S1e	40	Day	Y	1.13	0.85	32.10	0.81	0.96	NC	
159	S1e	40	Day	N							PTT lateral error
160	S1e	40	Day	Y	1.07	1.25	33.20	0.98	0.90	NC	
161	S1e	40	Day	N							PTT lateral error
162	S1e	40	Day	Y	1.00	0.83	34.30	0.99	0.88	NC	
163	S1e	40	Day	Y	1.18	0.90	31.60	0.76	1.02	NC	
164	S1e	40	Day	N							PTT lateral error
165	S1e	40	Day	Y	1.14	1.61	31.10	0.87	1.00	NC	
166	S1e	50	Day	Y	1.16	1.10	37.90	0.97	1.03	NC	
167	S1e	50	Day	Y	1.06	0.72	43.00	1.02	0.92	NC	
168	S1e	50	Day	N							SV lateral offset
169	S1e	50	Day	Y	1.13	0.96	39.20	0.98	1.02	NC	
170	S1e	50	Day	N							PTT lateral error
171	S1e	50	Day	N							PTT lateral error
172	S1e	50	Day	Y	1.11	1.02	39.80	0.96	0.98	NC	
173	S1e	50	Day	Y	1.09	1.01	40.00	0.98	0.98	NC	
181	S1e	55	Day	N							Yaw rate

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
182	S1e	55	Day	N							SV lateral offset
183	S1e	55	Day	N							SV speed
184	S1e	55	Day	N							Audible alert not valid
185	S1e	55	Day	Y	1.22	1.32	40.60	0.95	1.05	NC	
186	S1e	55	Day	Y	1.16	1.16	42.90	1.01	1.02	NC	
187	S1e	55	Day	N							PTT lateral error
188	S1e	55	Day	Y	1.18	1.26	42.20	1.00	1.04	NC	
189	S1e	55	Day	Y	1.10	0.33	44.70	1.05	0.95	NC	
190	S1e	55	Day	Y	1.18	1.14	42.20	1.04	1.01	NC	
191	Static		Day								
174	S1e	60	Day	Y	1.06	0.00	37.80	1.03	0.90	Contact	
175	S1e	60	Day	Y	1.05	0.00	36.20	1.02	0.90	Contact	
176	S1e	60	Day	N							SV Lateral Offset, Legs not working
177	S1e	60	Day	N							PTT lateral error
178	S1e	60	Day	Y	1.17	0.81	46.10	1.04	1.04	NC	
179	S1e	60	Day	N							Throttle, Due to 3 contacts, reduce speed to 55 km/h
180	Static										
139	Static		Day								
140	S1f	40	Day	N						N/A	Throttle

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
141	S1f	40	Day	Y	1.85	0.00	4.00	0.30	0.96	N/A	
142	S1f	40	Day	Y	1.49	0.00	1.20	0.03		N/A	
143	S1f	40	Day	Y	1.78	0.00	3.90	0.32	0.97	N/A	
144	S1f	40	Day	Y	1.74	0.00	1.80	0.04		N/A	
145	Static		Day								
146	S1g	40	Day	N							PTT legs not moving
147	S1g	40	Day	N							SV speed
148	S1g	40	Day	Y		0.00	-0.30	0.03		N/A	
149	S1g	40	Day	Y		0.00	-0.60	0.00		N/A	
150	S1g	40	Day	Y		0.00	0.00	0.00		N/A	
151	S1g	40	Day	N							SV speed
152	S1g	40	Day	Y		0.00	-0.20	0.03		N/A	
153	S1g	40	Day	N							PTT speed
154	S1g	40	Day	N							PTT legs not moving
155	S1g	40	Day	N							SV speed
156	S1g	40	Day	Y		0.00	-0.40	0.03		N/A	
1	Static		Day								
2	S4a	16	Day	Y	1.38	1.12	15.90	0.74	0.69	NC	
3	S4a	16	Day	Y	1.47	1.16	16.60	0.77	0.65	NC	
4	S4a	16	Day	N							SV speed

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
5	S4a	16	Day	N							SV speed
6	S4a	16	Day	Y	1.37	1.18	15.50	0.73	0.70	NC	
7	S4a	16	Day	Y	1.44	1.29	16.40	0.79	0.69	NC	
8	S4a	16	Day	Y	1.54	1.11	15.70	0.76	0.66	NC	
9	S4a	40	Day	Y	2.31	0.60	39.80	1.13	1.05	NC	
10	S4a	40	Day	Y	2.29	0.60	40.10	1.13	1.06	NC	
11	S4a	40	Day	Y	2.30	0.59	40.10	1.12	1.06	NC	
12	S4a	40	Day	Y	2.28	0.61	39.70	1.15	1.04	NC	
13	S4a	40	Day	Y	2.29	0.57	40.00	1.13	1.03	NC	
14	S4a	50	Day	Y	2.26	0.55	49.90	1.09	1.04	NC	
15	S4a	50	Day	Y	2.33	0.61	50.00	1.07	1.06	NC	
16	S4a	50	Day	Y	1.98	0.59	50.30	1.08	1.03	NC	
17	S4a	50	Day	N							Lateral offset
18	S4a	50	Day	Y	2.19	0.59	49.90	1.05	1.06	NC	
19	S4a	50	Day	Y	1.99	0.60	49.70	1.05	1.05	NC	
23	S4a	55	Day	Y	2.13	0.68	54.60	1.10	1.05	NC	
24	S4a	55	Day	N							Lateral offset
25	S4a	55	Day	Y	2.20	0.62	54.80	0.98	1.08	NC	
26	S4a	55	Day	Y	2.14	0.68	55.00	1.05	1.04	NC	IP camera fell at end of run
27	S4a	55	Day	Y	2.08	0.62	55.20	1.07	1.08	NC	
28	S4a	55	Day	Y	1.92	0.53	54.50	0.99	1.05	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
20	S4a	60	Day	Y	1.50	0.00	40.30	1.00	1.00	Contact	
21	S4a	60	Day	Y	1.85	0.00	42.80	0.97	1.07	Contact	
22	S4a	60	Day	Y	2.22	0.00	44.20	0.97	1.08	Contact	Due to 3 contact runs at 60, speed reduced to 55 km/h
29	Static	60	Day								
30	S4b	16	Day	Y	1.55	1.28	16.60	0.82	0.67	NC	
31	S4b	16	Day	Y	1.59	1.30	16.00	0.82	0.68	NC	
32	S4b	16	Day	Y	1.40	1.44	16.10	0.80	0.73	NC	
33	S4b	16	Day	Y	1.53	1.29	16.60	0.73	0.73	NC	
34	S4b	16	Day	Y	1.33	1.41	16.50	0.77	0.74	NC	
35	S4b	40	Day	Y	2.30	0.75	40.30	1.13	1.07	NC	
36	S4b	40	Day	Y	2.27	0.74	40.90	1.11	1.06	NC	
37	S4b	40	Day	Y	2.11	0.66	39.50	1.10	1.04	NC	
38	S4b	40	Day	Y	2.27	0.63	40.40	1.14	1.07	NC	
39	S4b	40	Day	Y	2.30	0.80	40.30	1.13	1.11	NC	
40	Static		Day								
41	S4c	16	Day	N							PTT speed
42	S4c	16	Day	N							GPS fix type
43	S4c	16	Day	Y	1.13	0.76	16.10	1.09	0.52	NC	
44	S4c	16	Day	Y	1.16	0.50	16.40	1.05	0.44	NC	Video cutouts

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
45	S4c	16	Day	Y	1.15	0.52	15.70	1.04	0.45	NC	
46	S4c	16	Day	Y	1.12	0.92	16.10	1.01	0.57	NC	
47	S4c	16	Day	Y	1.17	1.09	16.40	0.70	0.65	NC	
48	S4c	40	Day	Y	2.22	0.29	39.90	1.07	1.03	NC	
49	S4c	40	Day	N							Lateral offset
50	S4c	40	Day	Y	2.27	0.46	39.20	1.09	0.98	NC	
51	S4c	40	Day	Y	2.26	0.48	40.10	0.70	0.99	NC	
52	S4c	40	Day	Y	2.32	0.69	39.70	1.01	1.02	NC	
53	S4c	40	Day	Y	2.28	2.46	39.70	1.01	0.97	NC	
54	S4c	50	Day	Y	2.24	0.56	50.70	0.98	1.07	NC	
55	S4c	50	Day	N							SV speed
56	S4c	50	Day	Y	2.25	0.44	50.10	0.98	1.07	NC	
57	S4c	50	Day	Y	2.29	1.46	49.80	0.95	1.05	NC	
58	S4c	50	Day	Y	2.26	0.66	49.90	0.98	1.10	NC	
59	S4c	50	Day	Y	2.32	0.68	49.90	0.86	1.05	NC	
60	S4c	60	Day	Y	2.33	0.33	60.10	0.97	1.07	NC	
61	S4c	60	Day	Y	2.32	1.07	59.60	1.03	1.09	NC	
62	S4c	60	Day	Y	2.29	0.56	60.00	1.08	1.07	NC	
63	S4c	60	Day	Y	2.24	0.34	60.10	1.01	1.05	NC	
64	S4c	60	Day	Y	1.99	0.47	60.20	1.09	1.11	NC	
70	S4c	65	Day	Y	1.89	0.00	48.30	0.99	1.08	Contact	
71	S4c	65	Day	Y	2.03	0.00	41.80	0.99	1.05	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
72	S4c	65	Day	Y	2.06	0.00	44.00	1.01	1.03	Contact	
73	Static		Day								
65	S4c	70	Day	Y	1.93	0.00	37.90	0.95	1.04	Contact	
66	S4c	70	Day	N							PTT speed, comm error
67	S4c	70	Day	Y	1.95	0.00	35.10	0.97	1.03	Contact	
68	S4c	70	Day	N							Comm error
69	S4c	70	Day	Y	2.13	0.00	34.90	0.95	1.02	Contact	Move down to 65 km/h due to 3 contacts

Run Log for Nighttime Tests

Subject Vehicle: *2020 Toyota Corolla LE*

Test Date: *4/28/2020*

Adult Pedestrian Test Mannequin: *Articulated 4A Adult*

Test Driver: *S. Rhim*

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
121	S1b	16	High	Y	1.80	1.07	16.30	0.85	0.59	NC	
122	S1b	16	High	Y	1.54	1.14	15.70	0.84	0.62	NC	
123	S1b	16	High	Y	1.60	1.00	16.10	0.88	0.57	NC	
124	S1b	16	High	Y	1.47	1.03	16.10	0.98	0.58	NC	
125	S1b	16	High	Y	1.61	1.15	16.20	1.08	0.59	NC	
142	S1b	20	High	Y	1.81	1.21	19.80	0.89	0.62	NC	
143	S1b	20	High	Y	1.78	0.94	19.80	0.82	0.66	NC	
144	S1b	20	High	N							Lateral error
145	S1b	20	High	Y	1.88	1.10	20.30	0.87	0.63	NC	
146	S1b	20	High	Y	1.73	1.11	20.20	0.83	0.65	NC	
147	S1b	20	High	Y	1.76	0.96	20.40	0.87	0.60	NC	
153	S1b	30	High	Y	1.81	0.53	30.60	0.80	0.78	NC	
154	S1b	30	High	Y	1.78	1.12	30.40	0.95	0.72	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
155	S1b	30	High	Y	1.83	0.47	30.80	0.83	0.75	NC	
156	S1b	30	High	Y	1.92	0.58	30.00	0.89	0.77	NC	
157	S1b	30	High	Y	1.65	0.53	28.90	0.85	0.75	NC	
131	S1b	40	High	Y	1.72	0.64	41.60	1.26	0.97	NC	
132	S1b	40	High	N							Lateral error
133	S1b	40	High	Y	1.87	0.51	40.90	1.27	0.93	NC	
134	S1b	40	High	Y	1.73	0.62	41.20	1.24	1.00	NC	
135	S1b	40	High	Y	1.57	0.58	38.60	0.85	1.00	NC	
136	S1b	40	High	Y	1.64	0.63	40.50	1.19	0.96	NC	
162	S1b	50	High	Y	1.67	0.58	45.70	1.21	1.16	NC	
163	S1b	50	High	Y	1.87	0.79	46.50	1.11	1.16	NC	
164	S1b	50	High	Y	1.74	0.69	45.40	1.23	1.18	NC	
165	S1b	50	High	Y	1.93	0.84	43.60	0.86	1.19	NC	
166	S1b	50	High	Y	1.93	0.90	43.20	0.81	1.13	NC	
173	S1b	60	High	Y	1.95	0.80	51.80	0.91	1.18	NC	
174	S1b	60	High	N							Lateral error
175	S1b	60	High	N							PTT speed
176	S1b	60	High	N							PTT speed
177	S1b	60	High	N							Lateral error
178	S1b	60	High	Y	1.69	0.61	54.00	1.08	1.13	NC	
179	S1b	60	High	Y	1.59	0.62	53.80	1.05	1.13	NC	
180	S1b	60	High	Y	1.84	0.76	53.40	0.90	1.15	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
181	S1b	60	High	Y	1.89	0.00	37.90	0.90	1.14	NC	
182	Static										
230	S1d	11	High	N							Lateral error
231	S1d	11	High	N							Lateral error
232	S1d	11	High	Y		0.00	1.00	0.01		Contact	No warning, no intervention
233	S1d	11	High	Y		0.00	-0.50	0.01		Contact	No warning, no intervention
234	S1d	11	High	Y	0.69	0.00	0.20	0.01		Contact	
223	S1d	16	High	Y	0.93	0.00	-0.10	0.00		Contact	
224	S1d	16	High	Y		0.00	-0.10	0.01		Contact	No warning, no intervention
225	S1d	16	High	Y		0.00	0.10	0.01		Contact	No warning, no intervention
238	S1d	40	High	Y	0.94	0.60	40.40	1.15	0.76	NC	
239	S1d	40	High	Y	0.97	0.00	0.50	0.01		Contact	
240	S1d	40	High	N							SV speed, no warning
241	S1d	40	High	Y		0.00	0.20	0.08		Contact	No warning, no intervention
242	S1d	40	High	Y		0.00	0.50	0.04		Contact	No warning, no intervention
243			High	N							S1d Check Run using Static Child Used to confirm system is still functioning

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
192	S1e	40	High	N							Lateral error
193	S1e	40	High	Y	1.24	0.80	32.30	0.90	0.89	NC	
194	S1e	40	High	N							Lateral error
195	S1e	40	High	Y	1.16	0.85	30.40	0.79	0.98	NC	
196	S1e	40	High	Y	1.13	0.30	21.00	0.88	0.96	NC	
197	S1e	40	High	Y		0.00	0.40	0.01		Contact	No warning, no intervention
198	S1e	40	High	Y	1.11	1.41	31.30	0.94	0.95	NC	
206	S1e	50	High	Y	1.21	0.93	40.50	0.99	0.97	NC	
207	S1e	50	High	N							Lateral error
208	S1e	50	High	Y	1.12	0.00	26.50	0.99	0.96	Contact	
209	S1e	50	High	Y	1.16	0.95	39.50	0.93	0.98	NC	
210	S1e	50	High	N							Lateral error
211	S1e	50	High	Y	1.16	0.92	39.00	0.94	0.97	NC	
212	S1e	50	High	Y	1.17	0.87	39.50	0.96	1.01	NC	
213	S1e	60	High	Y	1.11	0.19	45.20	1.11	0.93	NC	
214	S1e	60	High	Y	1.08	0.00	41.30	1.11	0.91	Contact	
215	S1e	60	High	Y	1.15	0.21	45.70	1.07	0.97	NC	
216	S1e	60	High	Y	1.08	0.00	38.90	1.07	0.89	Contact	
217	S1e	60	High	Y	1.12	0.00	44.00	1.07	0.95	Contact	
218	Static		High								

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
7	S4a	16	High	Y	1.55	1.20	16.40	0.74	0.70	NC	
8	S4a	16	High	Y	1.46	1.07	15.70	0.76	0.66	NC	
9	S4a	16	High	Y	1.56	1.16	16.60	0.75	0.69	NC	
10	S4a	16	High	Y	1.56	1.15	16.70	0.74	0.69	NC	
11	S4a	16	High	Y	1.53	1.07	16.80	0.79	0.63	NC	
19	S4a	40	High	Y	2.30	0.60	40.00	1.21	1.07	NC	
20	S4a	40	High	Y	2.26	0.59	40.20	1.22	1.07	NC	
21	S4a	40	High	Y	2.32	0.60	40.20	1.22	1.08	NC	
22	S4a	40	High	Y	2.29	0.58	40.10	1.18	1.03	NC	
23	S4a	40	High	Y	2.06	0.59	40.10	1.17	1.03	NC	
29	S4a	50	High	Y	1.91	0.48	49.80	1.09	1.06	NC	
30	S4a	50	High	Y	2.16	0.46	49.50	1.05	1.08	NC	
31	S4a	50	High	Y	2.14	0.46	50.00	1.10	1.08	NC	
32	S4a	50	High	Y	2.19	0.50	50.10	1.04	1.07	NC	
33	S4a	50	High	Y	2.28	0.45	49.70	1.02	1.08	NC	
34	S4a	50	High	N	2.31	0.64	49.80	1.06	1.07		Static pedestrian used to compare results with articulating pedestrian
35	S4a	50	High	N	2.33	0.52	49.60	1.11	1.09		“
36	S4a	50	High	N	2.32	0.72	49.70	1.12	1.05		“
48	S4a	55	High	Y	1.66	0.46	54.40	1.06	1.05	NC	IP camera fixed

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
49	S4a	55	High	Y	2.19	0.54	55.00	1.12	1.08	NC	
50	S4a	55	High	Y	2.04	0.54	54.70	1.13	1.00	NC	
51	S4a	55	High	Y	2.28	0.56	54.80	1.10	1.03	NC	
52	S4a	55	High	Y	2.30	0.43	55.00	1.05	1.08	NC	
43	S4a	60	High	N							SV speed
44	S4a	60	High	N							Lateral error
45	S4a	60	High	Y	2.30	0.00	51.90	1.04	1.08	Contact	
46	S4a	60	High	Y	2.21	0.00	47.40	1.00	1.07	Contact	
47	S4a	60	High	Y	2.30	0.00	45.80	1.03	1.06	Contact	
63	S4c	16	High	Y	1.23	0.70	16.20	1.21	0.50	NC	
64	S4c	16	High	Y	1.12	1.11	16.90	1.22	0.65	NC	
65	S4c	16	High	Y	1.29	0.85	16.20	0.92	0.58	NC	
66	S4c	16	High	Y	1.30	0.84	16.40	1.19	0.56	NC	
67	S4c	16	High	Y	1.12	0.73	16.40	1.09	0.50	NC	
73	S4c	40	High	Y	2.29	0.56	39.50	1.14	1.01	NC	
74	S4c	40	High	Y	2.19	0.65	39.80	1.21	1.00	NC	
75	S4c	40	High	Y	2.31	0.53	39.80	1.22	1.00	NC	
76	S4c	40	High	Y	2.35	0.97	40.20	0.77	0.98	NC	
77	S4c	40	High	Y	2.28	0.53	39.90	0.88	1.01	NC	
85	S4c	50	High	Y	2.35	0.00	28.70	0.84	1.02	Contact	
86	S4c	50	High	Y	2.35	0.53	49.80	0.92	1.04	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
87	S4c	50	High	N							GPS fix type
88	S4c	50	High	N							Data corrupted
89	S4c	50	High	N							Brake applied by driver
90	S4c	50	High	Y	2.28	0.51	49.80	1.01	1.05	NC	
91	S4c	50	High	Y	2.28	0.60	50.30	1.05	1.05	NC	
92	S4c	50	High	Y	2.18	0.38	49.70	1.01	1.03	NC	
93	S4c	60	High	Y	2.23	0.51	60.10	1.19	1.08	NC	
94	S4c	60	High	Y	2.36	0.00	23.00	1.00	0.65	Contact	
95	S4c	60	High	Y	2.32	0.62	59.40	1.04	1.10	NC	
96	S4c	60	High	Y	2.20	0.57	59.70	1.12	1.05	NC	
97	S4c	60	High	Y	2.36	0.94	60.10	1.07	1.08	NC	
110	S4c	65	High	Y	2.18	0.00	53.80	1.11	1.08	Contact	
111	S4c	65	High	Y	2.26	0.00	53.40	1.06	1.07	Contact	
112	S4c	65	High	N							PTT speed
113	S4c	65	High	Y	2.20	0.10	64.60	1.09	1.08	NC	
114	S4c	65	High	Y	2.08	0.00	54.00	1.06	1.04	Contact	
115	S1b	16	Low	N							Lateral error, PTT speed
116	S1b	16	Low	Y	1.39	1.15	16.00	0.89	0.58	NC	
117	S1b	16	Low	Y	1.77	0.54	16.60	1.20	0.44	NC	
118	S1b	16	Low	Y	1.57	1.01	15.60	0.80	0.62	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
119	S1b	16	Low	Y	1.58	1.12	15.50	1.12	0.57	NC	
120	S1b	16	Low	Y	1.72	1.12	16.40	0.81	0.63	NC	
137	S1b	20	Low	Y	1.96	0.90	20.10	0.84	0.63	NC	
138	S1b	20	Low	Y	1.78	0.98	20.50	0.86	0.63	NC	
139	S1b	20	Low	Y	1.82	1.06	19.80	0.83	0.62	NC	
140	S1b	20	Low	Y	1.79	0.92	20.30	0.85	0.65	NC	
141	S1b	20	Low	Y	1.86	0.92	20.50	0.83	0.65	NC	
148	S1b	30	Low	Y	1.94	0.72	29.60	0.96	0.76	NC	
149	S1b	30	Low	Y	1.86	0.59	30.20	0.99	0.78	NC	
150	S1b	30	Low	Y	1.64	0.52	30.50	1.05	0.77	NC	
151	S1b	30	Low	Y	1.78	0.58	31.20	0.79	0.78	NC	
152	S1b	30	Low	Y	1.91	0.59	28.70	0.80	0.77	NC	
126	S1b	40	Low	Y	1.63	0.59	40.00	1.24	0.99	NC	
127	S1b	40	Low	Y	1.77	0.56	42.30	1.16	0.95	NC	
128	S1b	40	Low	Y	0.84	0.00	29.90	1.07	0.66	Contact	
129	S1b	40	Low	Y	1.20	0.51	41.20	1.18	1.04	NC	
130	S1b	40	Low	Y	1.63	0.56	41.80	1.20	0.97	NC	
167	S1b	45	Low	Y	1.80	0.57	44.50	1.19	1.11	NC	
168	S1b	45	Low	Y	1.41	0.60	44.60	1.25	1.10	NC	
169	S1b	45	Low	Y	1.29	0.57	41.40	1.18	1.11	NC	
170	S1b	45	Low	N							Lateral error
171	S1b	45	Low	Y	1.33	0.00	12.80	0.75	1.07	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
172	S1b	45	Low	Y	0.86	0.00	30.70	1.07	0.69	Contact	
158	S1b	50	Low	Y	1.03	0.00	40.90	1.12	0.85	NC	
159	S1b	50	Low	Y	1.27	0.52	48.00	1.19	1.11	NC	
160	S1b	50	Low	Y	1.78	0.00	13.10	0.69	1.18	Contact	
161	S1b	50	Low	Y	1.27	0.00	13.40	0.85	1.10	Contact	
226	S1d	11	Low	Y	0.51	0.00	0.20	0.01		Contact	
227	S1d	11	Low	Y	0.58	0.00	0.00	0.01		Contact	
228	S1d	11	Low	N							Lateral error
229	S1d	11	Low	Y		0.00	1.00	0.01		Contact	No warning, no intervention
219	S1d	16	Low	Y	0.63	0.00	0.50	0.01		Contact	
220	S1d	16	Low	Y	0.50	0.00	0.50	0.01		Contact	
221	S1d	16	Low	N							SV speed, lateral error
222	S1d	16	Low	Y		0.00	0.20	0.01		Contact	No warning, no intervention
235	S1d	40	Low	Y	0.71	0.00	13.10	1.08	0.44	Contact	
236	S1d	40	Low	Y	0.44	0.00	5.50	0.78	0.26	Contact	
237	S1d	40	Low	Y	0.75	0.00	18.50	1.07	0.56	Contact	
183	Static		Low								
199	S1e	35	Low	Y	1.16	1.47	31.80	0.99	0.84	NC	
200	S1e	35	Low	N							SV 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
201	S1e	35	Low	Y	1.14	0.00	24.70	1.08	0.94	Contact	
202	S1e	35	Low	Y	1.06	1.38	29.50	0.87	0.91	NC	
203	S1e	35	Low	N							Lateral error
204	S1e	35	Low	Y	1.17	0.76	28.40	0.67	0.92	NC	
205	S1e	35	Low	Y	1.06	0.13	18.00	0.87	0.92	NC	
184	S1e	40	Low	N							Lateral error
185	S1e	40	Low	Y	1.13	0.00	16.20	1.00	0.49	Contact	
186	S1e	40	Low	N							Brake applied by driver
187	S1e	40	Low	N							Lateral error
188	S1e	40	Low	Y	1.16	0.00	28.60	1.03	0.66	NC	
189	S1e	40	Low	Y	0.75	0.00	20.80	1.04	0.59	Contact	
190	S1e	40	Low	Y	1.18	1.41	32.40	0.96	0.91	NC	
191	S1e	40	Low	Y	1.17	0.04	19.70	0.77	0.99	NC	
1	Static										
2	S4a	16	Low	Y	1.39	1.18	16.20	0.75	0.69	NC	
3	S4a	16	Low	Y	1.33	1.13	16.50	0.75	0.69	NC	
4	S4a	16	Low	Y	1.59	1.14	16.60	0.76	0.67	NC	
5	S4a	16	Low	Y	1.54	1.12	16.40	0.72	0.69	NC	
6	S4a	16	Low	Y	1.48	1.18	16.40	0.77	0.67	NC	
12	S4a	40	Low	Y	2.03	0.62	40.00	1.17	1.06	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
13	S4a	40	Low	N							SV lateral offset
14	S4a	40	Low	Y	2.29	0.62	39.80	1.16	1.03	NC	
15	S4a	40	Low	Y	2.30	0.59	40.10	1.20	1.10	NC	IP camera power lost
16	S4a	40	Low	N							SV speed
17	S4a	40	Low	Y	2.24	0.60	39.90	1.21	1.10	NC	
18	S4a	40	Low	Y	2.30	0.58	40.20	1.19	1.03	NC	
24	S4a	50	Low	Y	2.10	0.49	49.40	1.00	1.05	NC	
25	S4a	50	Low	Y	2.27	0.56	49.90	1.14	1.04	NC	
26	S4a	50	Low	Y	1.94	0.50	50.00	1.11	1.05	NC	
27	S4a	50	Low	Y	2.11	0.45	49.90	1.08	1.06	NC	
28	S4a	50	Low	Y	2.14	0.53	49.70	1.16	1.06	NC	
37	S4a	50	Low	N	2.00	0.51	50.20	1.15	1.05		Static pedestrian used to compare results with articulating pedestrian (keep values for comparison)
38	S4a	50	Low	N	2.13	0.59	49.70	1.01	1.09		“
39	S4a	50	Low	N	2.31	0.52	50.10	1.17	1.06		“
53	S4a	55	Low	Y	1.74	0.48	55.10	1.03	1.07	NC	
54	S4a	55	Low	Y	1.78	0.54	54.60	1.00	1.08	NC	
55	S4a	55	Low	Y	1.66	0.35	55.10	1.04	1.01	NC	
56	S4a	55	Low	Y	1.47	0.00	32.30	1.06	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
57	S4a	55	Low	Y	1.67	0.46	55.50	1.05	1.06	NC	
40	S4a	60	Low	Y	1.50	0.00	46.10	1.04	1.06	Contact	
41	S4a	60	Low	Y	1.56	0.00	50.70	1.02	1.07	Contact	
42	S4a	60	Low	Y	1.66	0.00	48.80	1.02	1.08	Contact	
58	S4c	16	Low	Y	1.17	0.68	16.50	1.12	0.49	NC	
59	S4c	16	Low	Y	1.19	0.93	16.50	1.15	0.58	NC	
60	S4c	16	Low	Y	1.15	1.40	15.20	0.74	0.76	NC	
61	S4c	16	Low	Y	1.05	0.98	15.90	1.25	0.61	NC	
62	S4c	16	Low	Y	1.17	0.68	15.40	0.76	0.51	NC	
68	S4c	40	Low	Y	2.31	0.00	15.70	0.81	1.01	Contact	
69	S4c	40	Low	Y	2.26	1.30	40.00	0.81	0.99	NC	
70	S4c	40	Low	Y	2.27	0.89	40.70	0.70	1.03	NC	
71	S4c	40	Low	Y	2.31	0.87	40.20	0.74	1.00	NC	
72	S4c	40	Low	Y	2.24	0.89	40.10	0.77	0.95	NC	
78	S4c	50	Low	N							Lateral error
79	S4c	50	Low	Y	1.98	0.00	23.80	0.76	1.09	Contact	
80	S4c	50	Low	Y	2.30	0.74	50.20	1.05	1.07	NC	
81	S4c	50	Low	Y	1.92	0.52	49.60	1.04	1.03	NC	
82	S4c	50	Low	Y	1.23	0.00	27.40	1.05	0.69	Contact	
83	S4c	50	Low	N							Brake applied by driver

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
84	S4c	50	Low	Y	2.34	0.00	25.40	0.87	1.02	Contact	
98	S4c	60	Low	Y	1.56	0.45	60.10	1.01	1.05	NC	
99	S4c	60	Low	N							Lateral error
100	S4c	60	Low	Y	1.65	0.44	60.60	1.06	1.05	NC	
101	S4c	60	Low	Y	1.64	0.46	60.20	1.06	1.11	NC	PTT speed
102	S4c	60	Low	Y	1.41	0.71	60.30	1.08	1.04	NC	
103	S4c	60	Low	Y	1.40	0.50	60.10	1.06	0.97	NC	
105	S4c	65	Low	N							Lateral error, Test speed dropped to 65 based on daytime results and failure of this run
106	S4c	65	Low	N							Brake applied by driver
107	S4c	65	Low	Y	1.11	0.00	1.40	0.05		Contact	
108	S4c	65	Low	Y	1.46	0.00	35.70	1.08	0.85	Contact	
109	S4c	65	Low	Y	1.09	0.00	28.30	1.07	0.78	Contact	
104	S4c	70	Low	N							PTT speed

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.

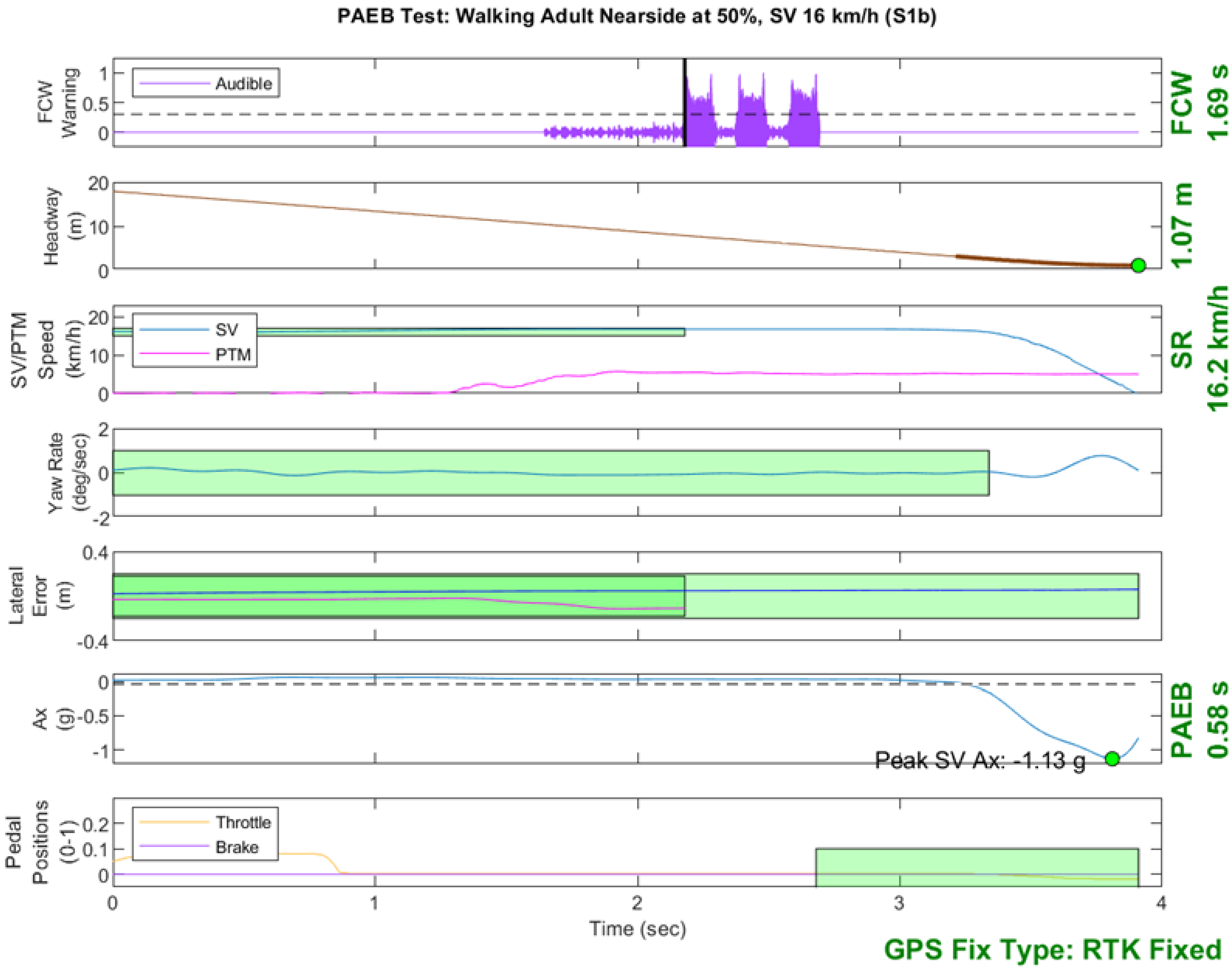


Figure D1. Example Time History for a Passing Run

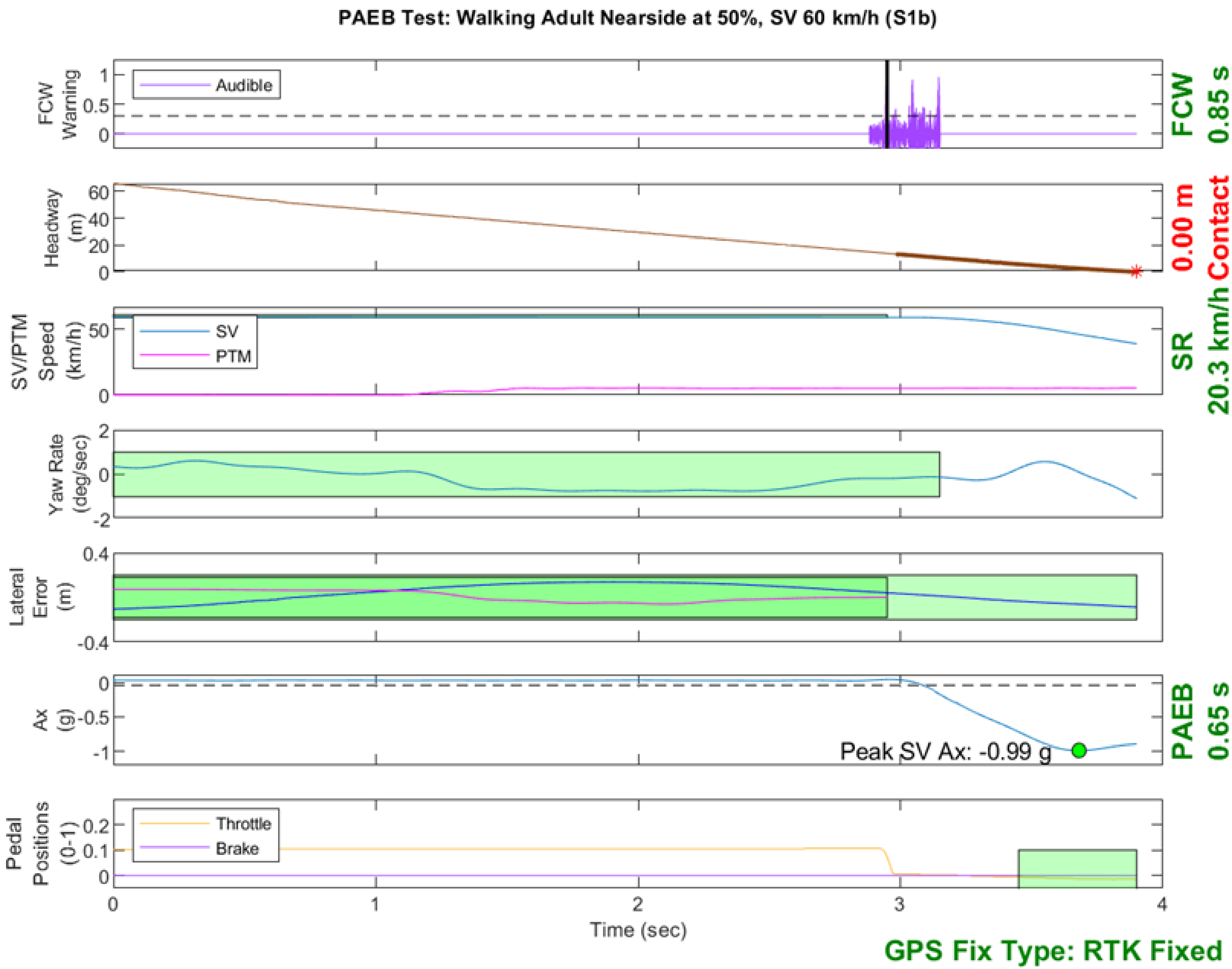


Figure D2. Example Time History for a Failed Run

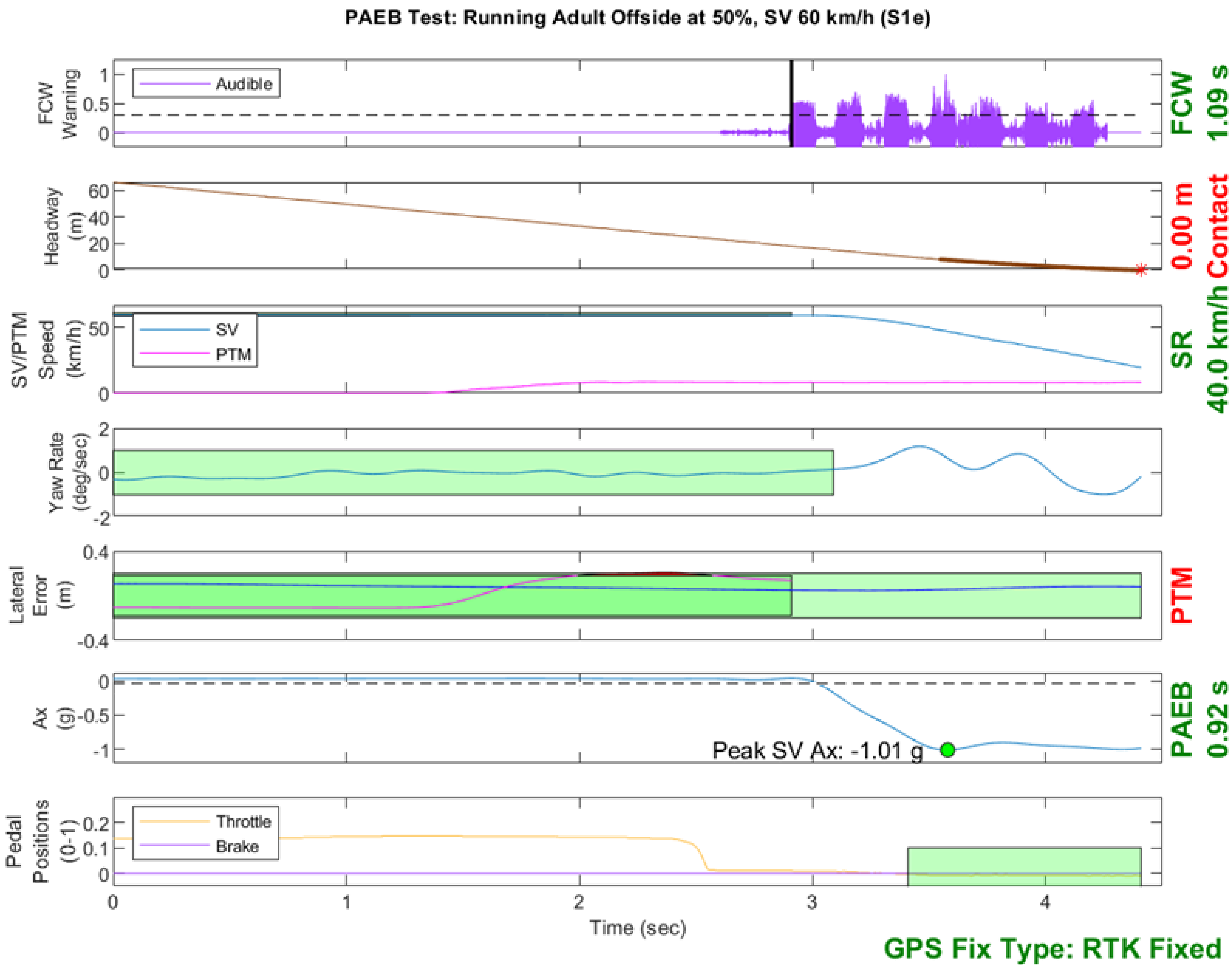


Figure D3. Example Time History for an Invalid Run Due to PTM Lateral Error

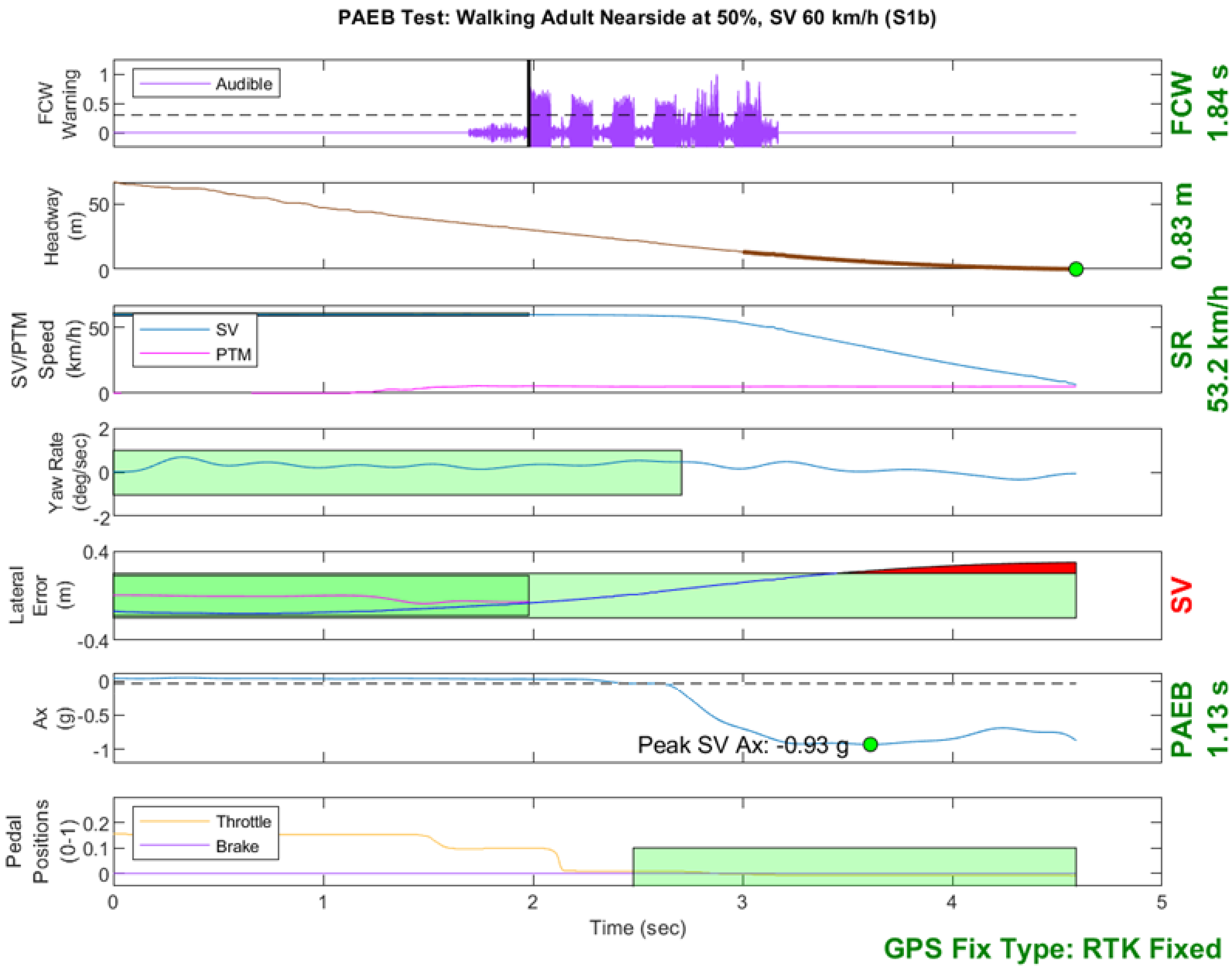


Figure D4. Example Time History for an Invalid Run Due to SV Lateral Error

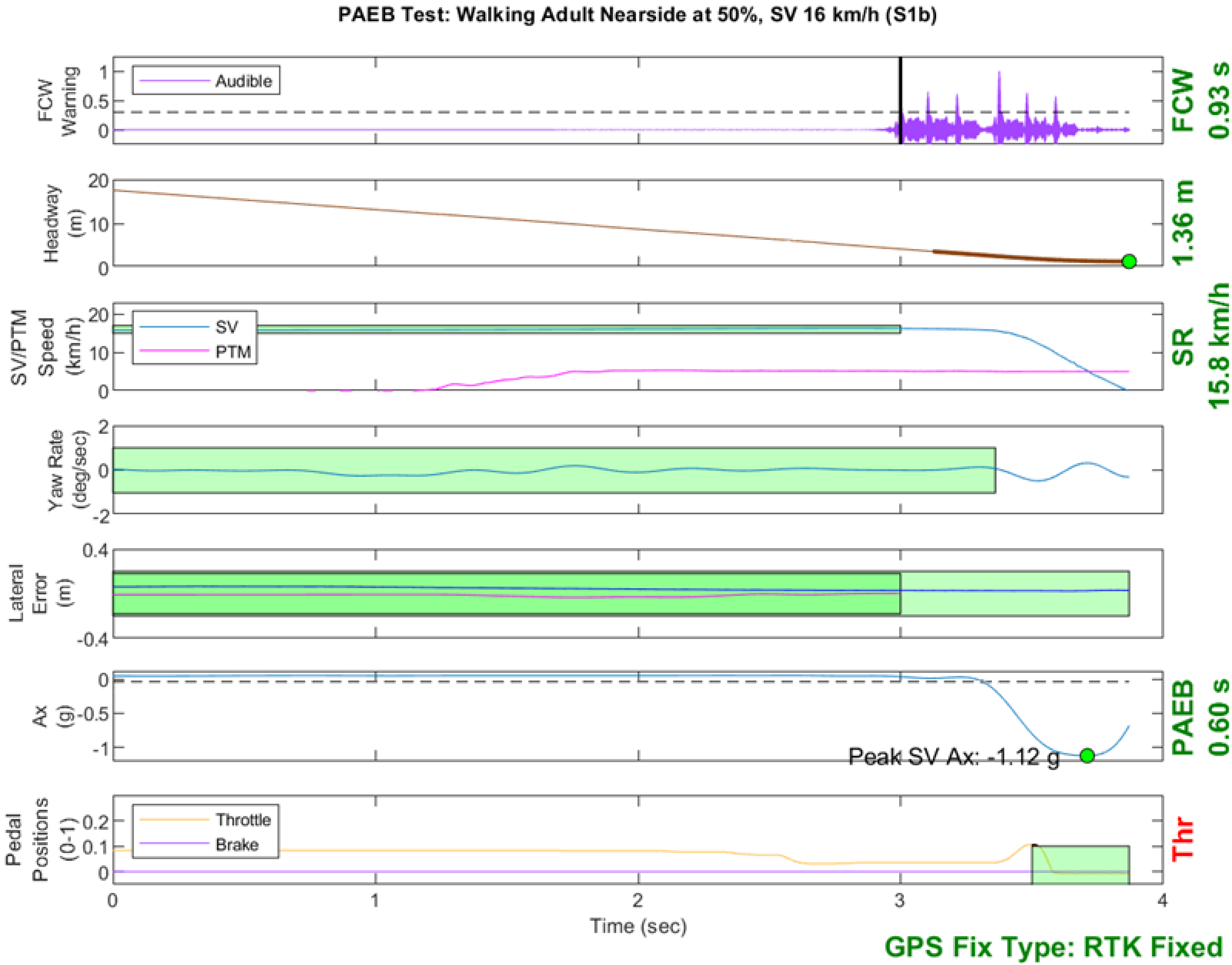


Figure D5. Example Time History for an Invalid Run Due to Throttle Error

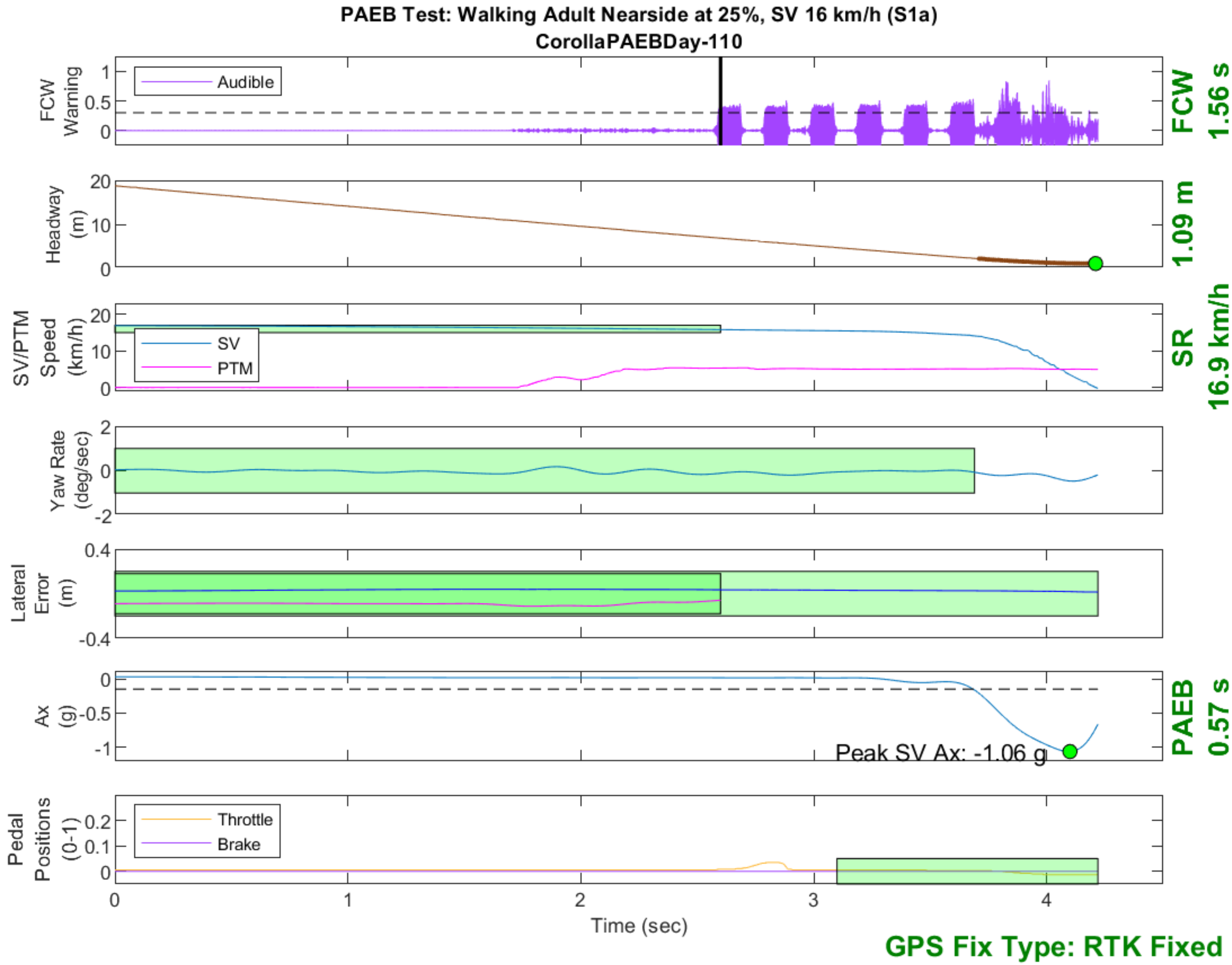


Figure D6. Time History for PAEB Run 110, S1a, Daytime, 16 km/h

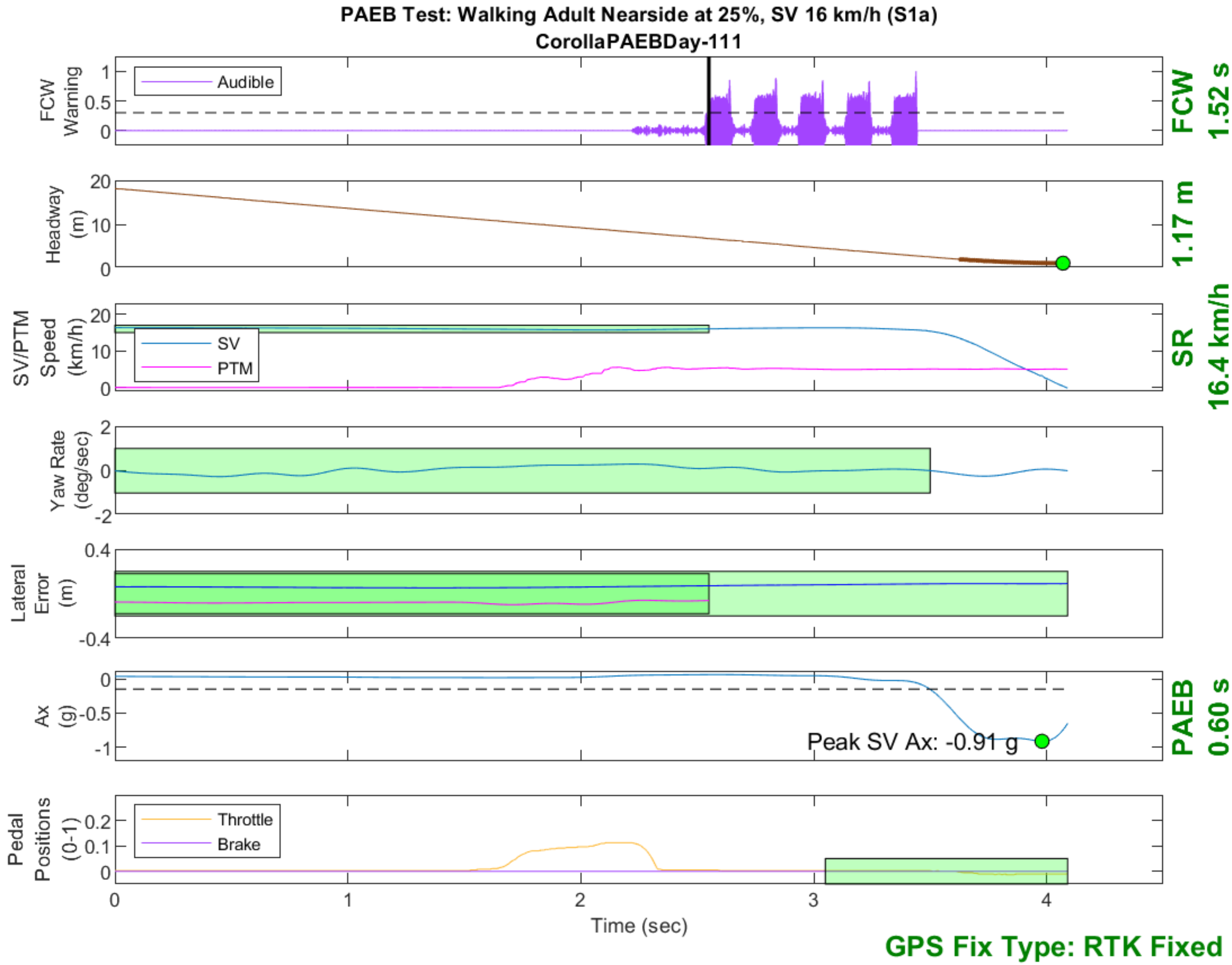


Figure D7. Time History for PAEB Run 111, S1a, Daytime, 16 km/h

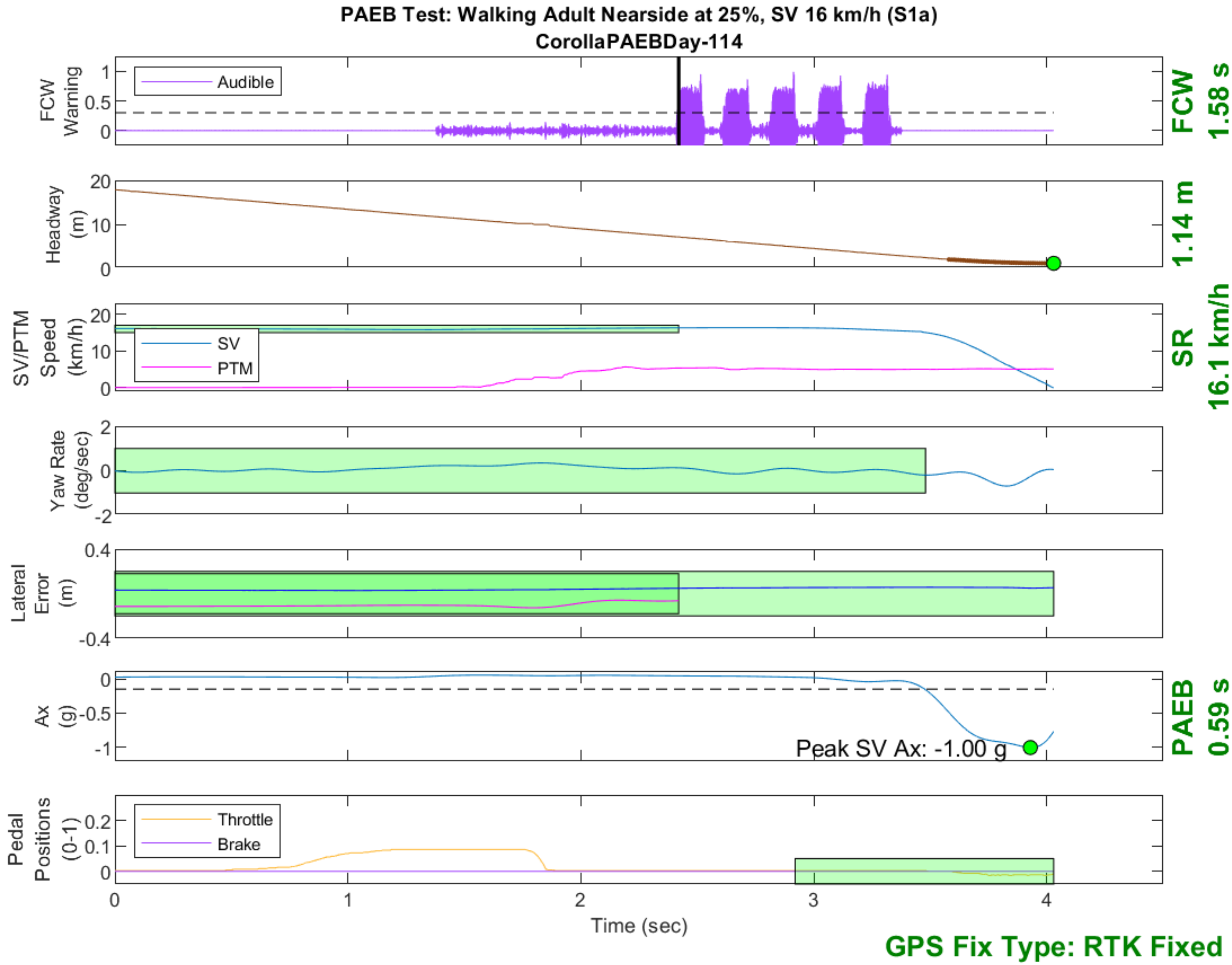


Figure D8. Time History for PAEB Run 114, S1a, Daytime, 16 km/h

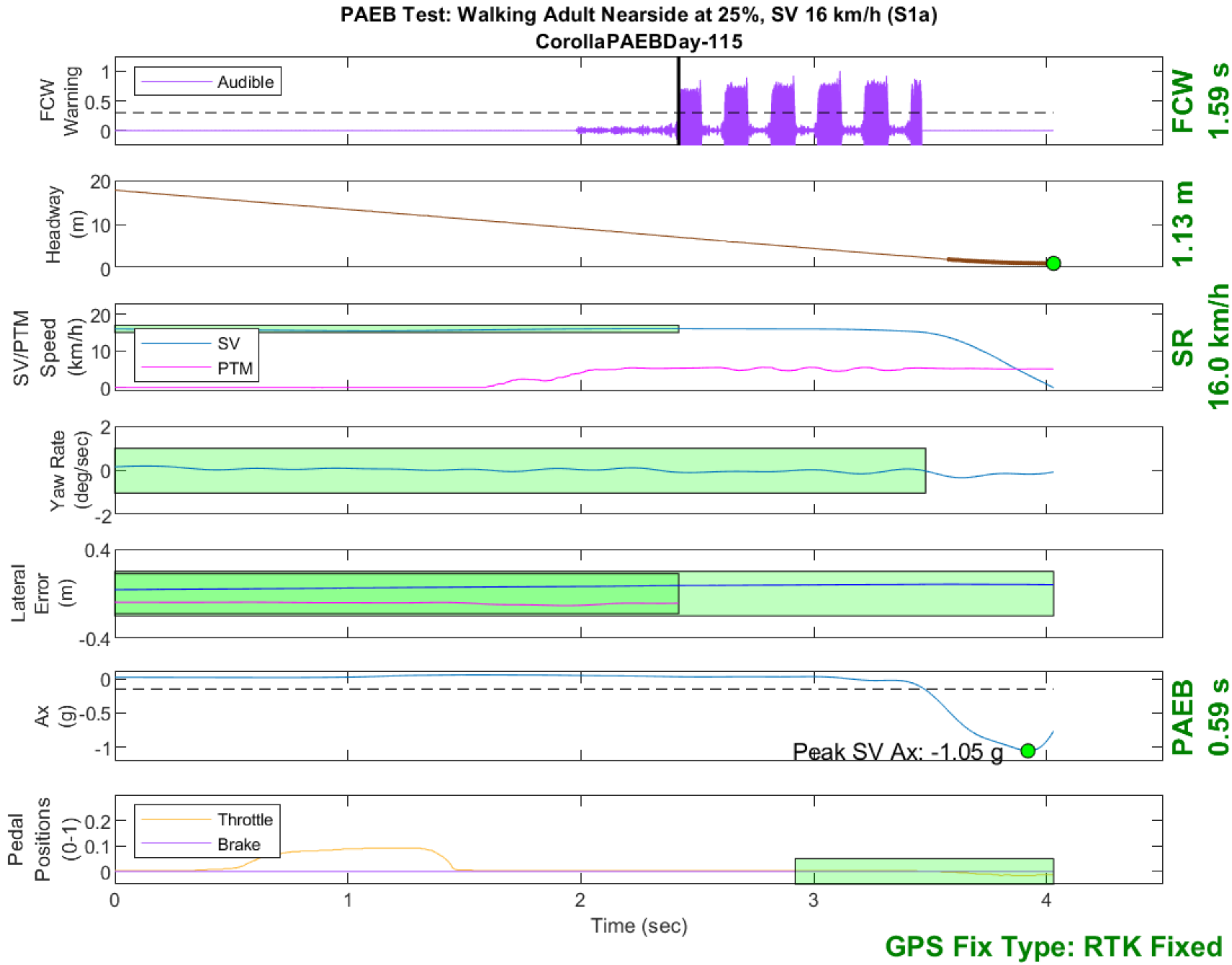


Figure D9. Time History for PAEB Run 115, S1a, Daytime, 16 km/h

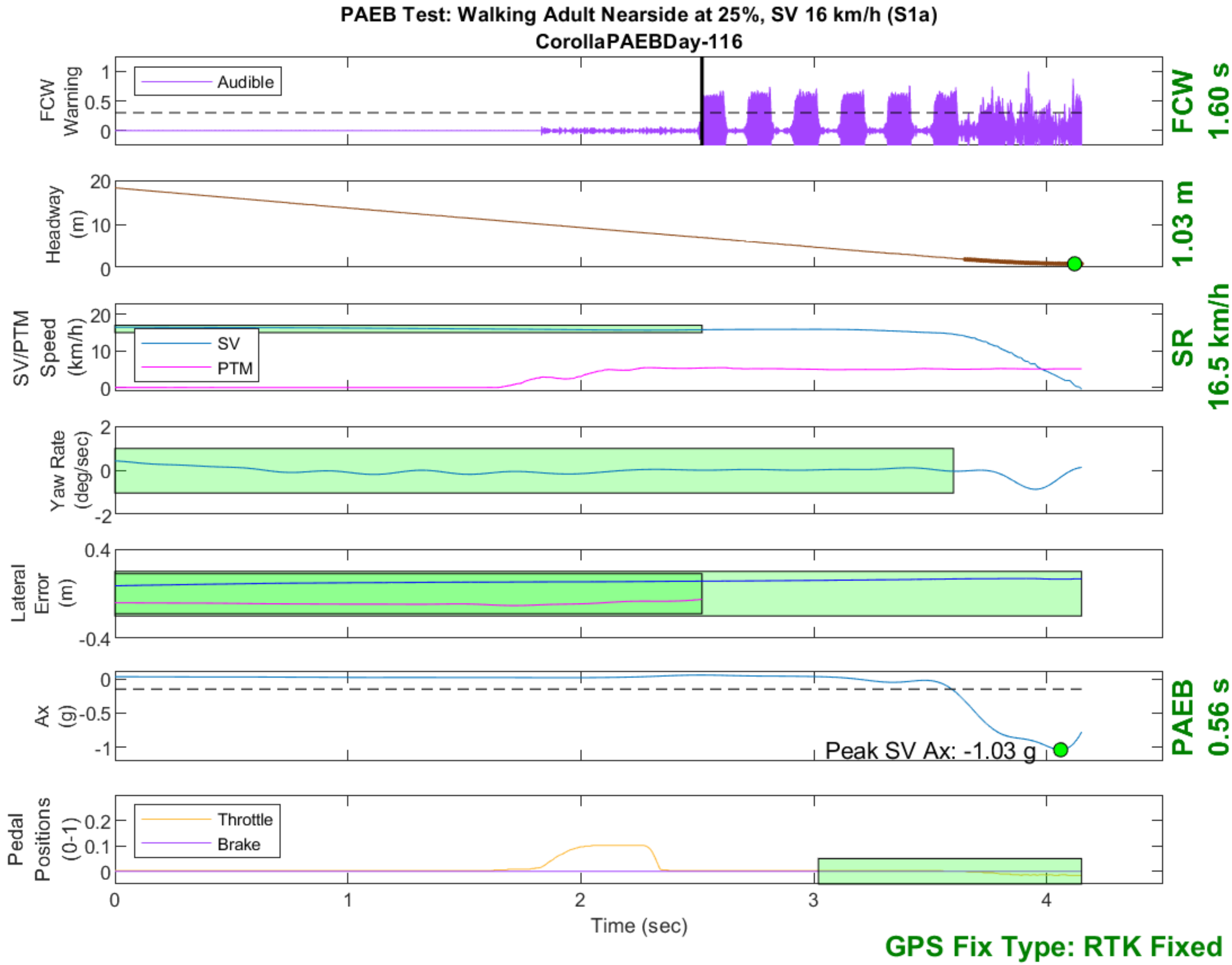


Figure D10. Time History for PAEB Run 116, S1a, Daytime, 16 km/h

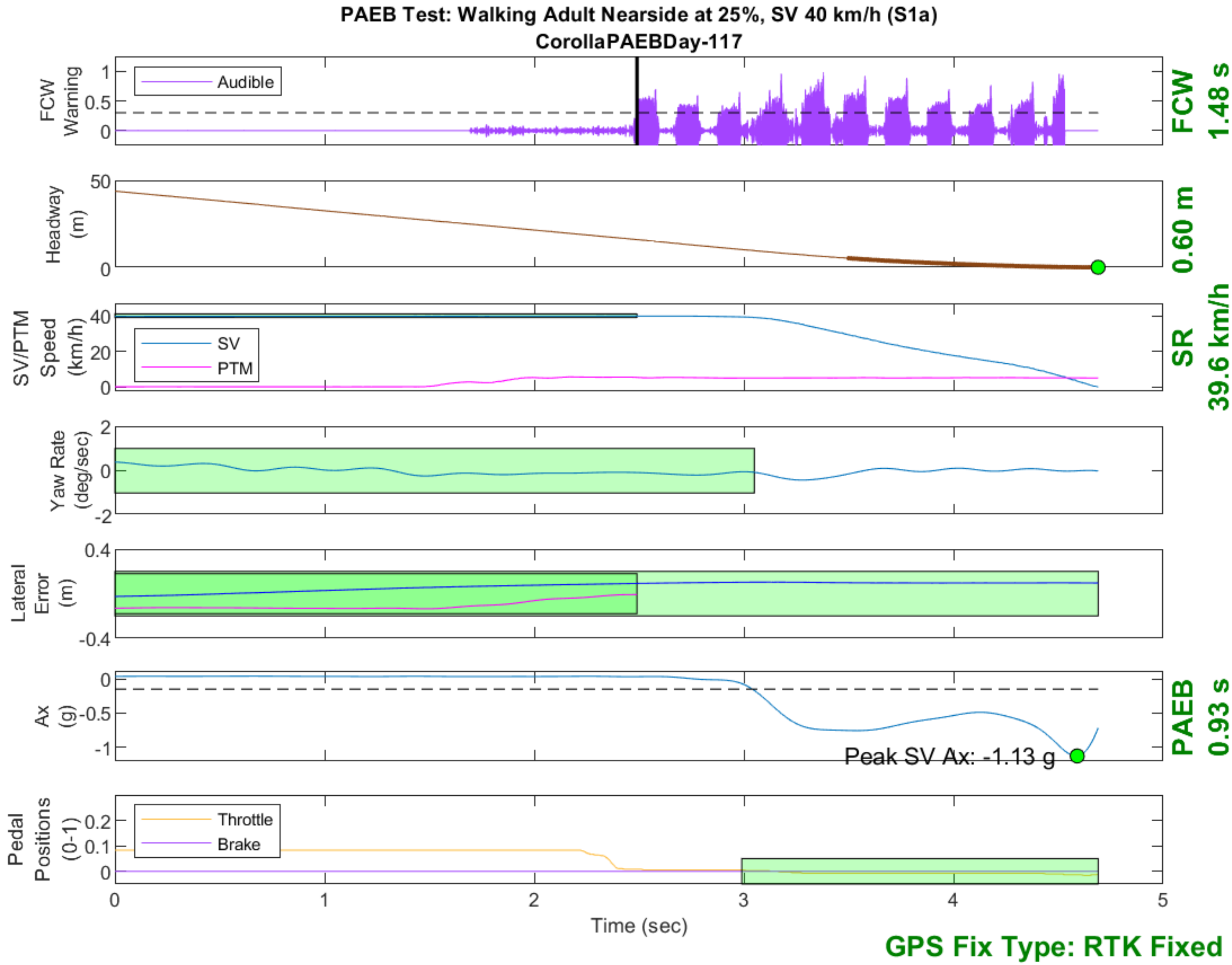


Figure D11. Time History for PAEB Run 117, S1a, Daytime, 40 km/h

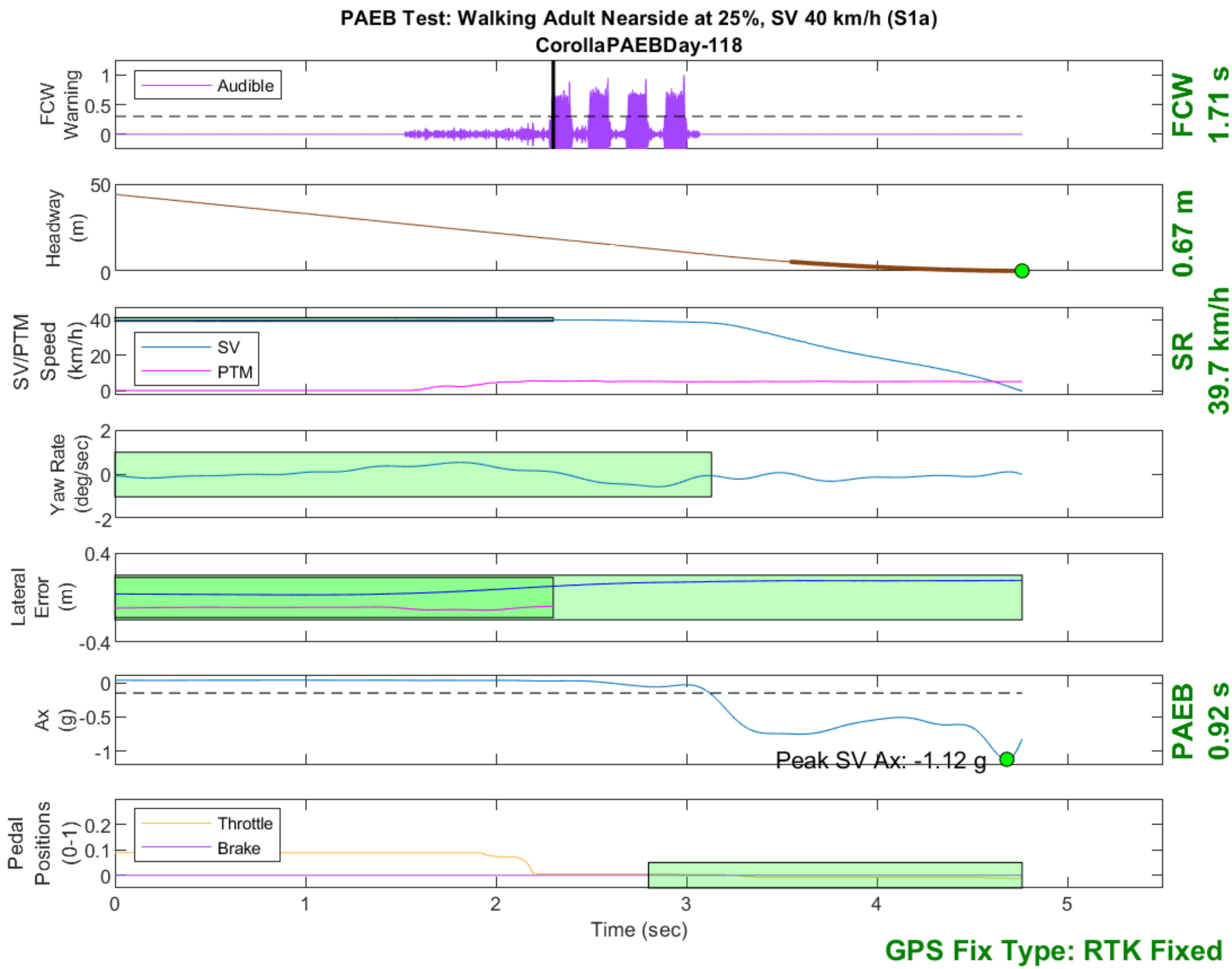


Figure D12. Time History for PAEB Run 118, S1a, Daytime, 40 km/h

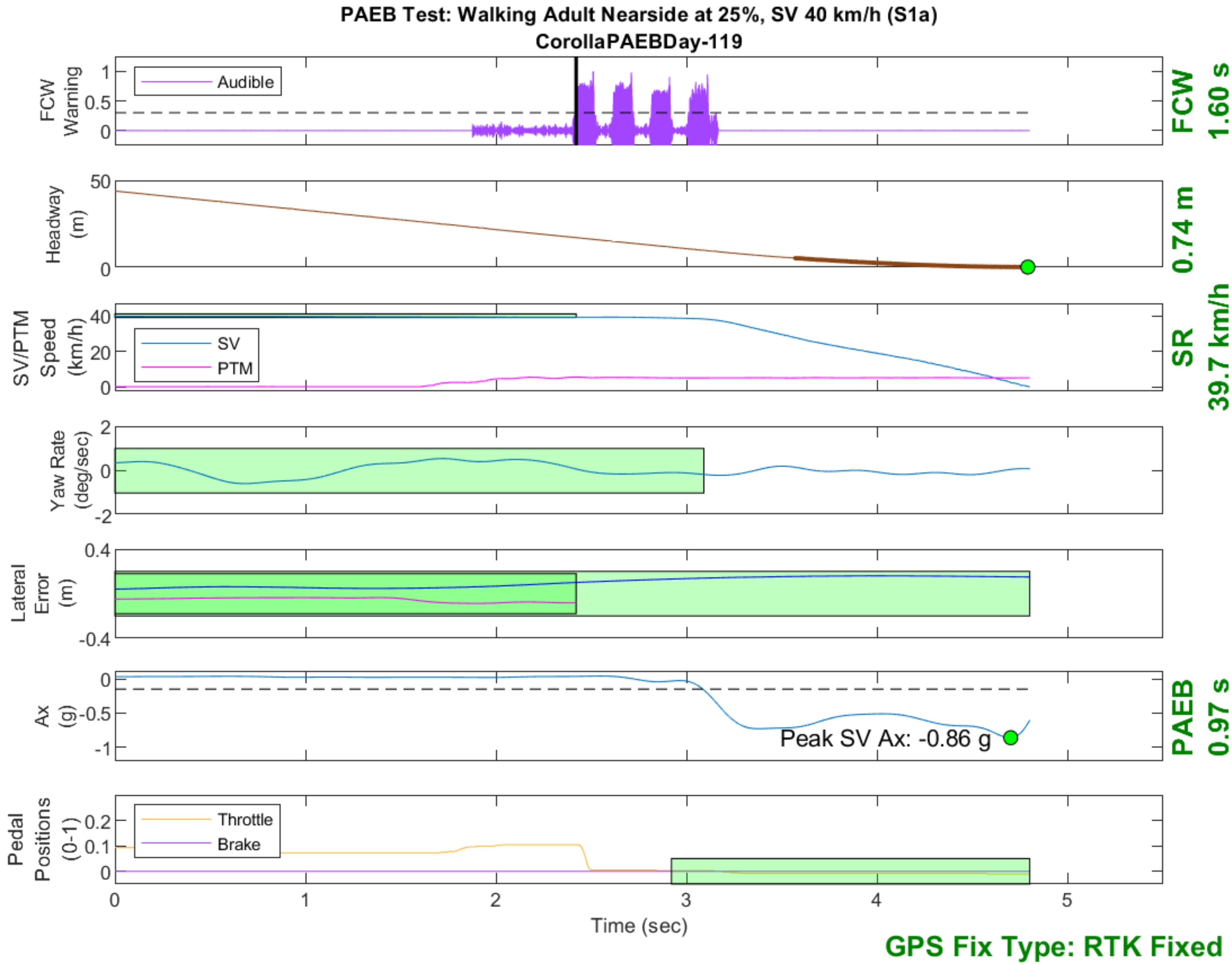


Figure D13. Time History for PAEB Run 119, S1a, Daytime, 40 km/h

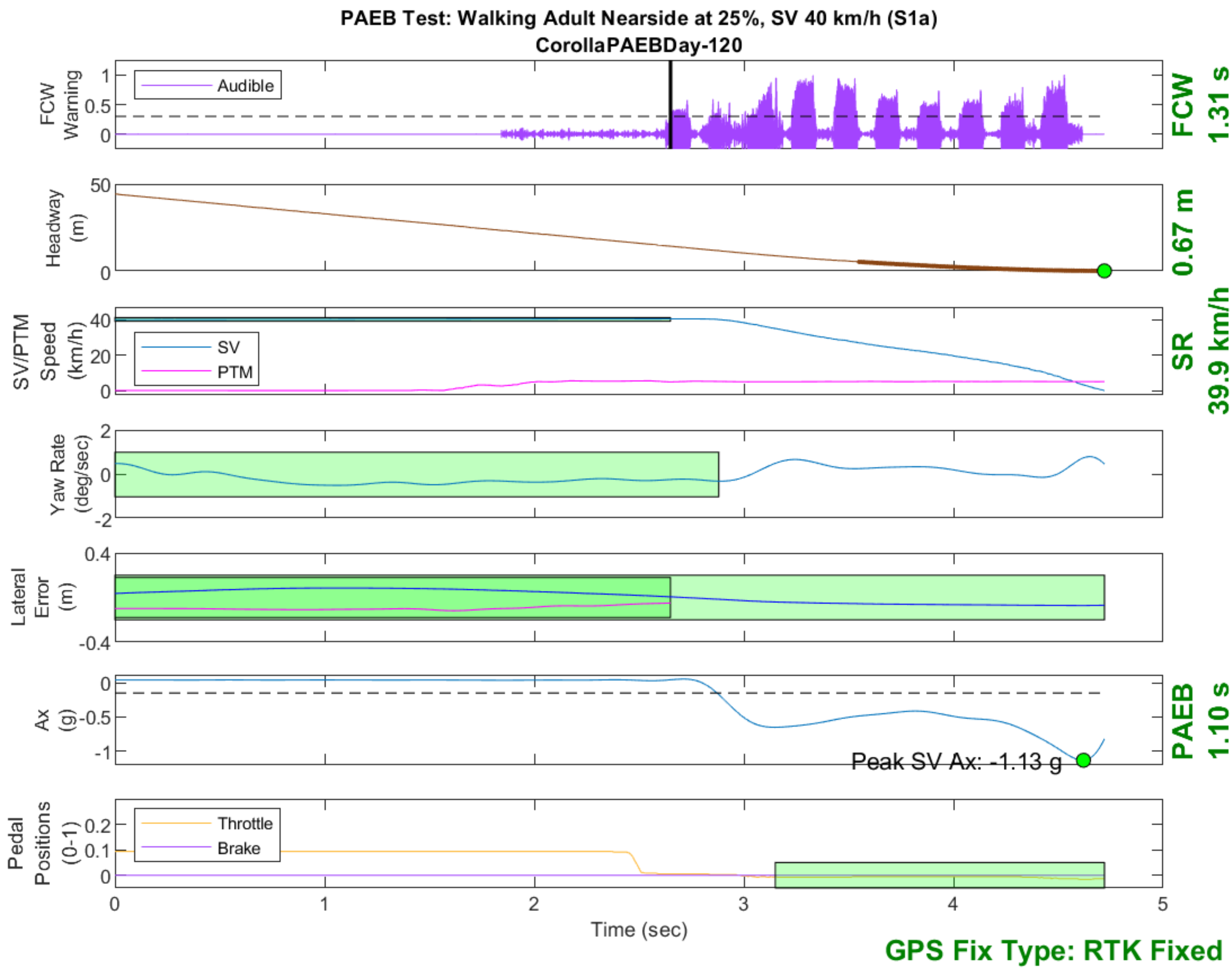


Figure D14. Time History for PAEB Run 120, S1a, Daytime, 40 km/h

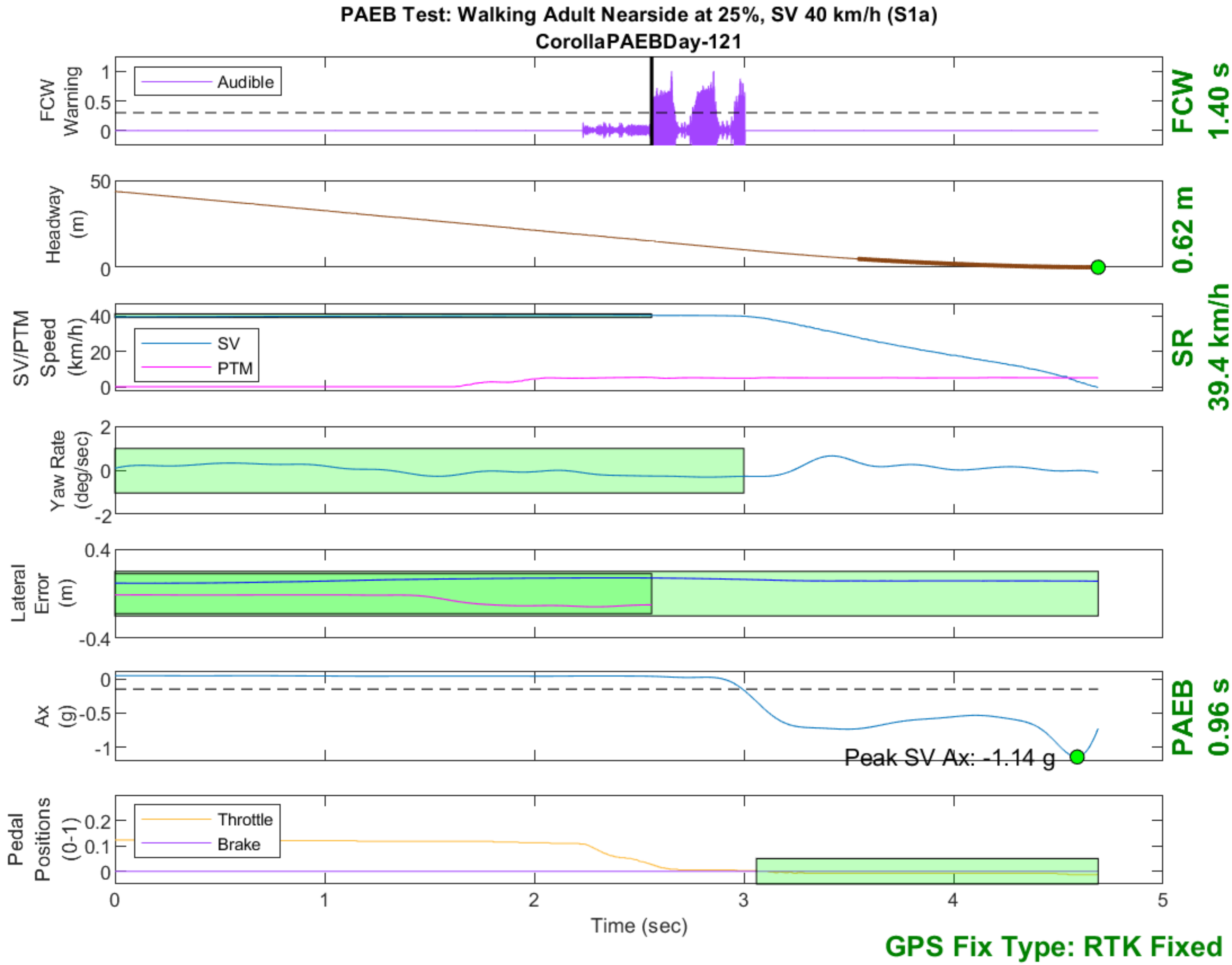


Figure D15. Time History for PAEB Run 121, S1a, Daytime, 40 km/h

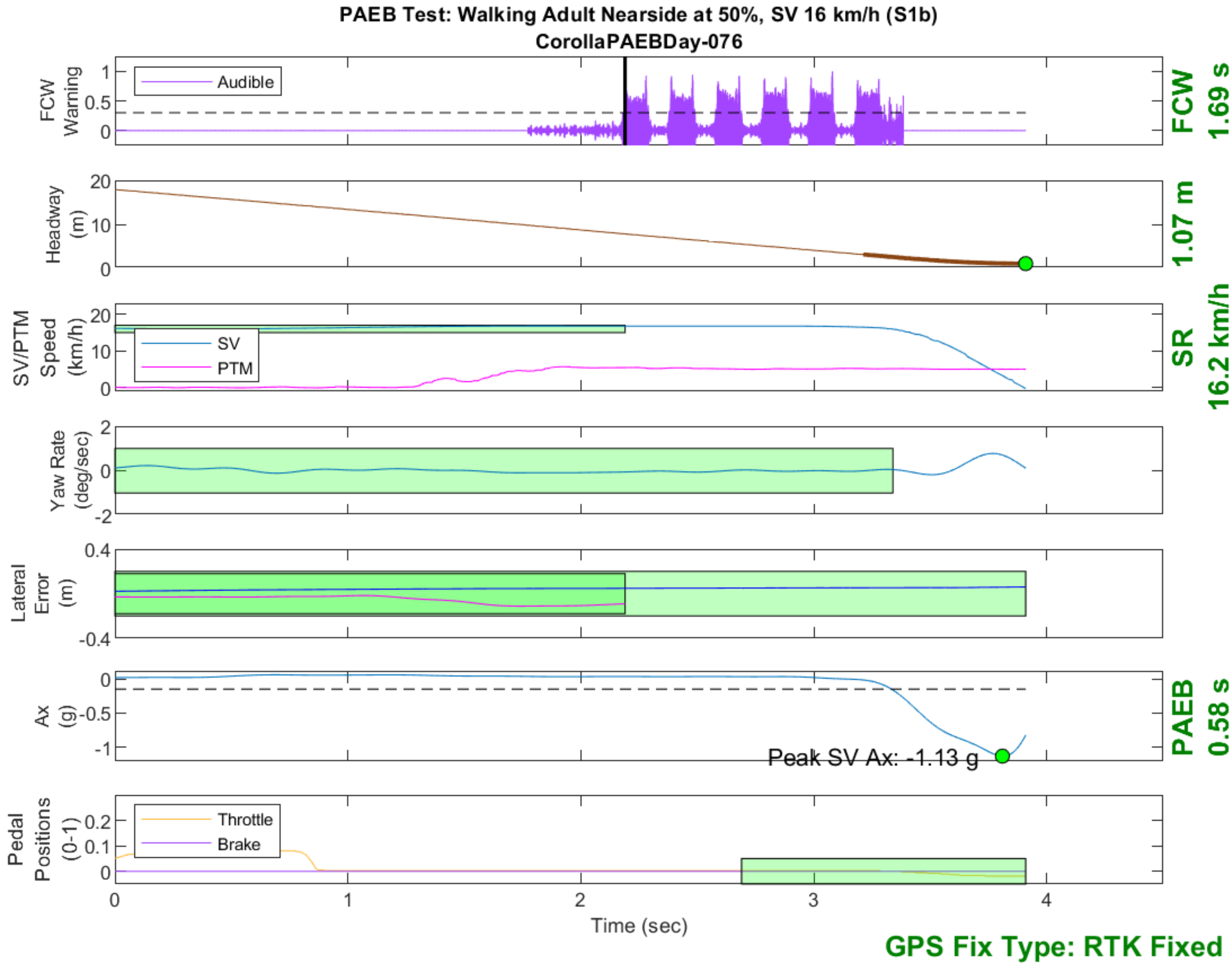


Figure D16. Time History for PAEB Run 76, S1b, Daytime, 16 km/h

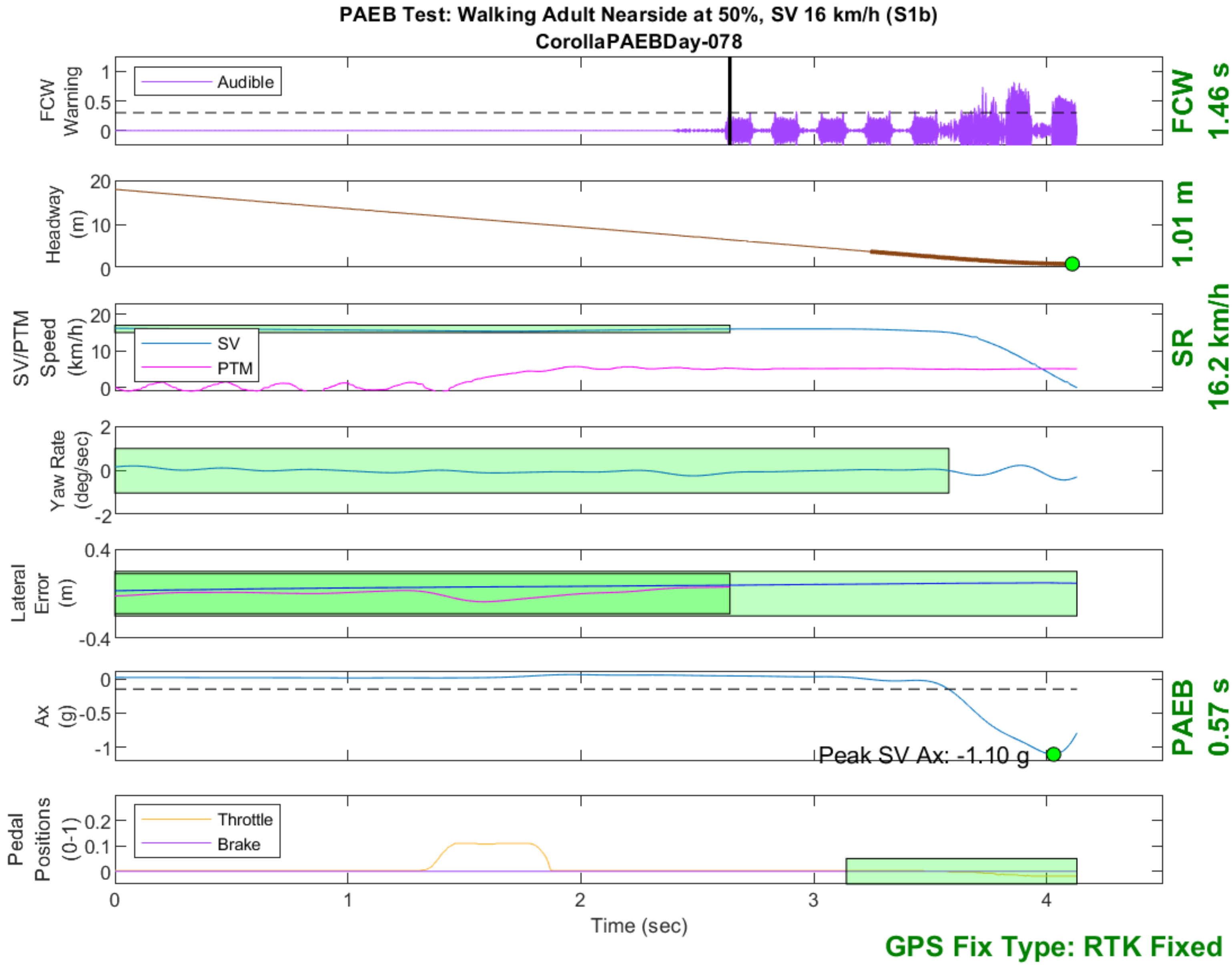


Figure D17. Time History for PAEB Run 78, S1b, Daytime, 16 km/h

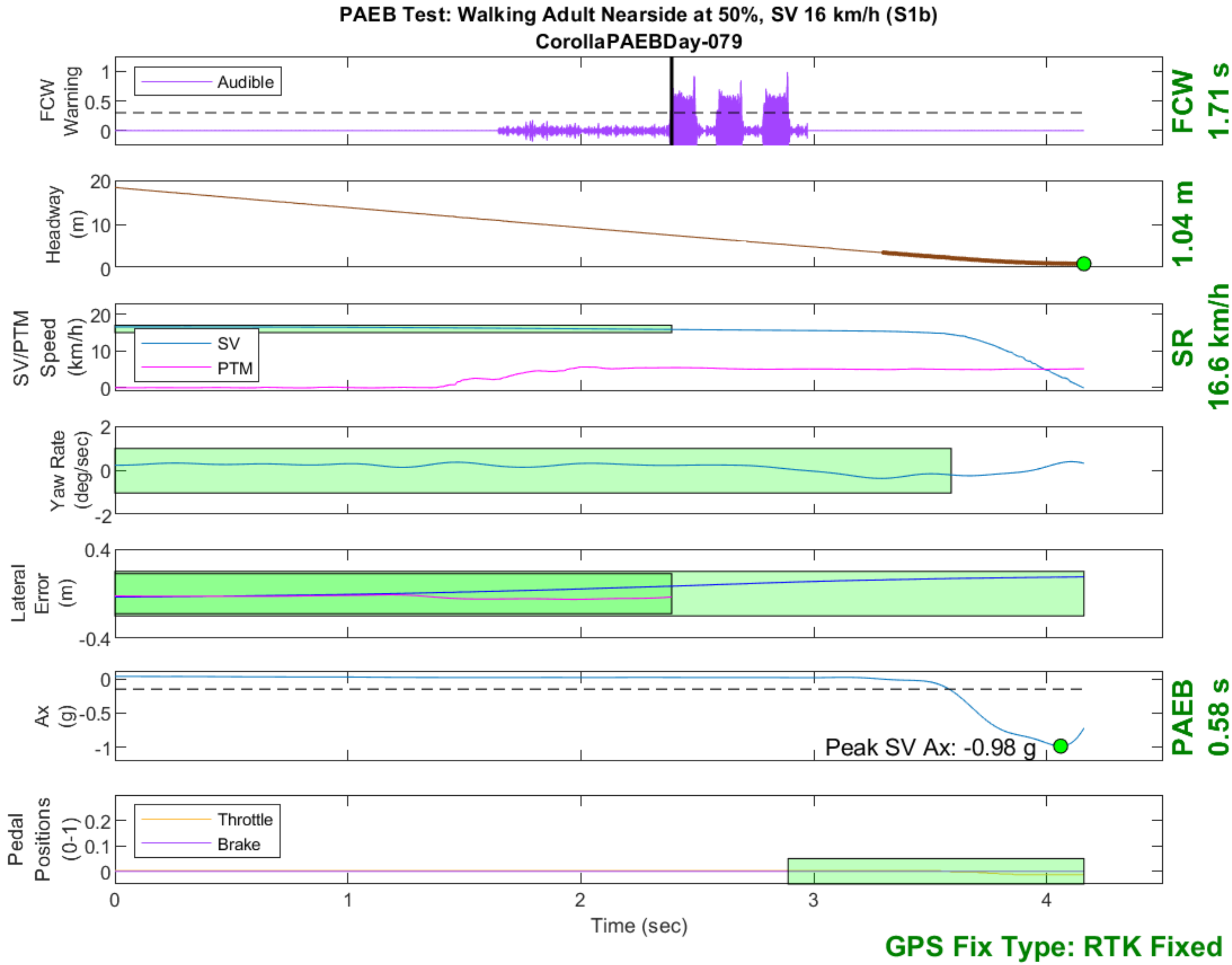


Figure D18. Time History for PAEB Run 79, S1b, Daytime, 16 km/h

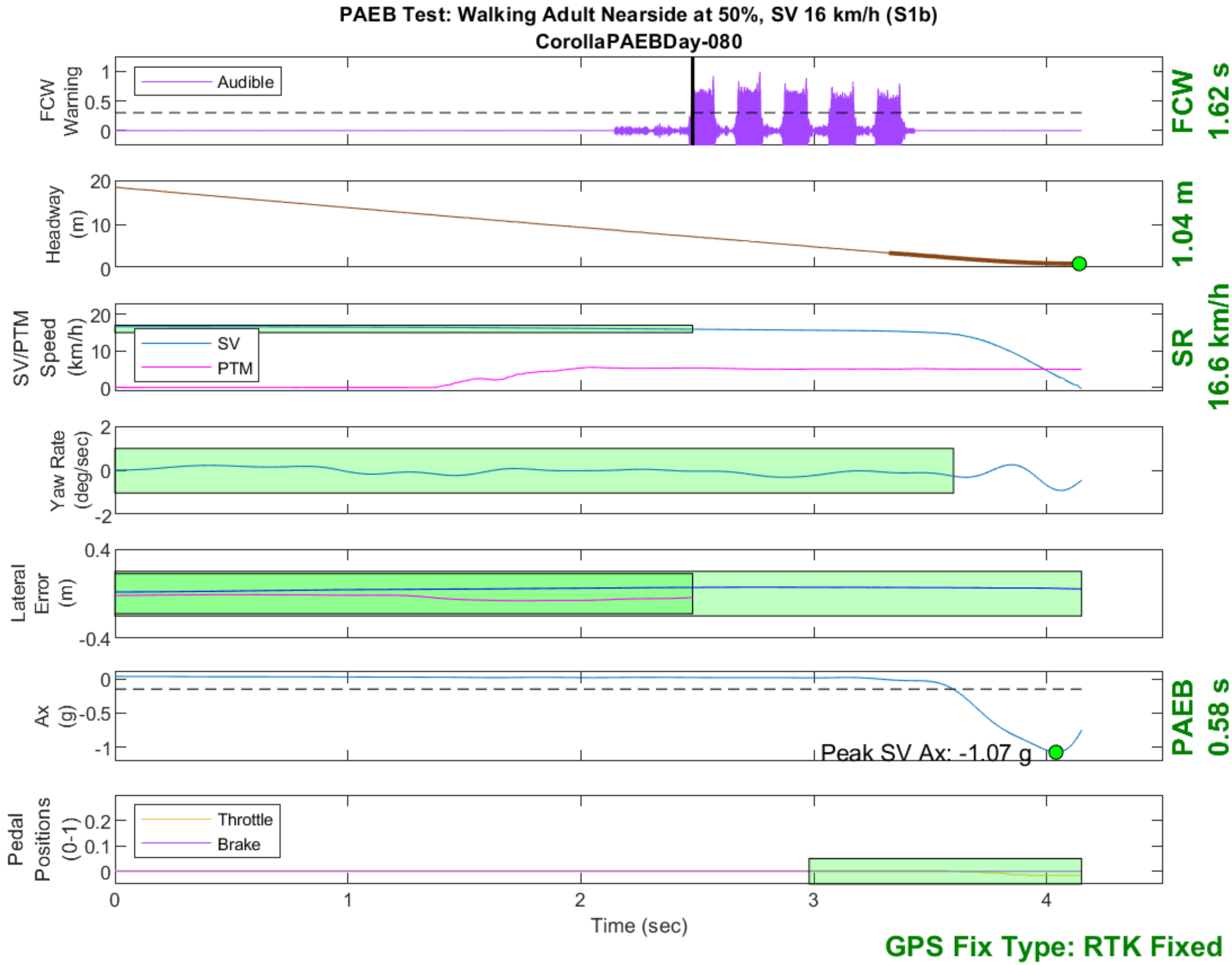


Figure D19. Time History for PAEB Run 80, S1b, Daytime, 16 km/h

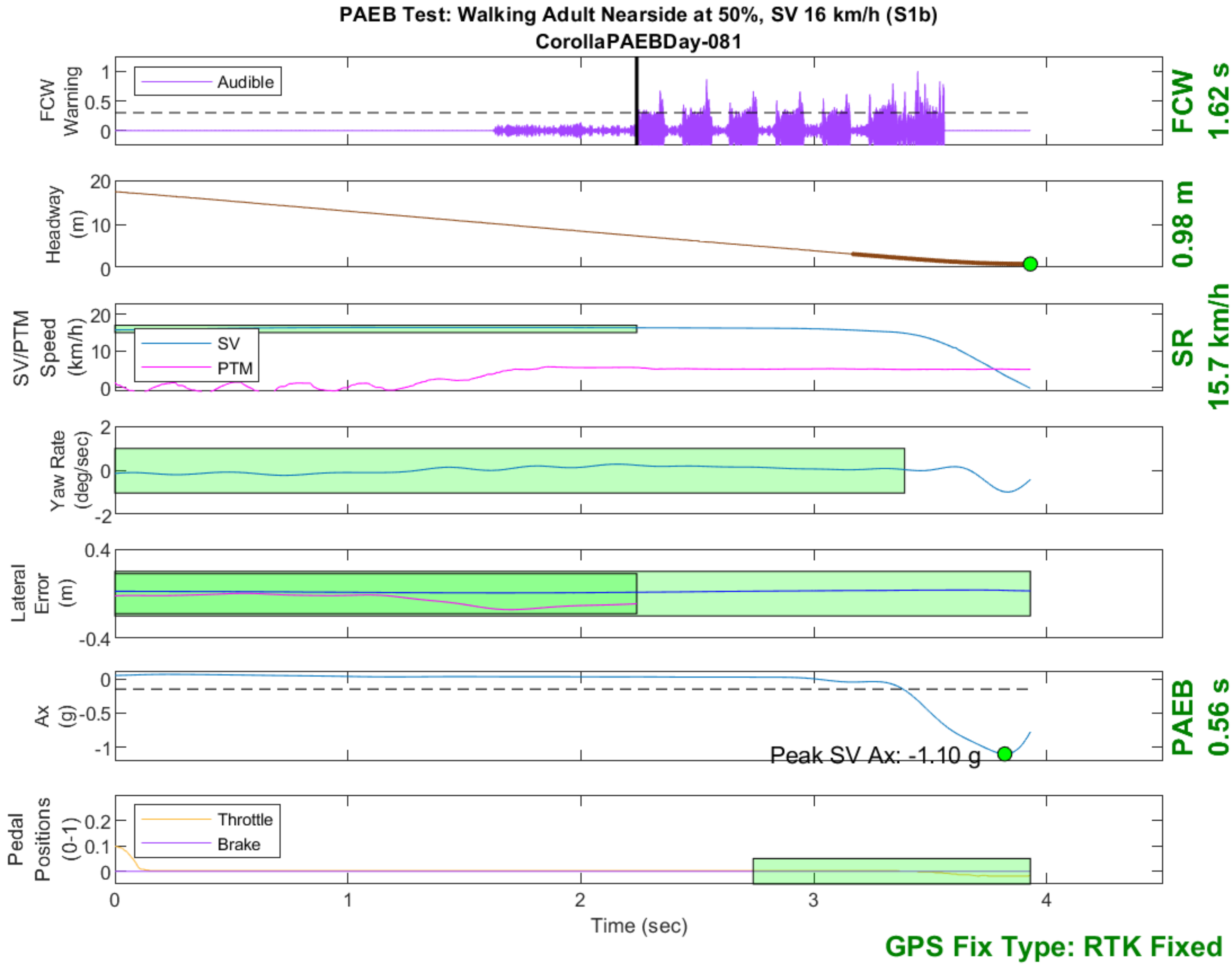


Figure D20. Time History for PAEB Run 81, S1b, Daytime, 16 km/h

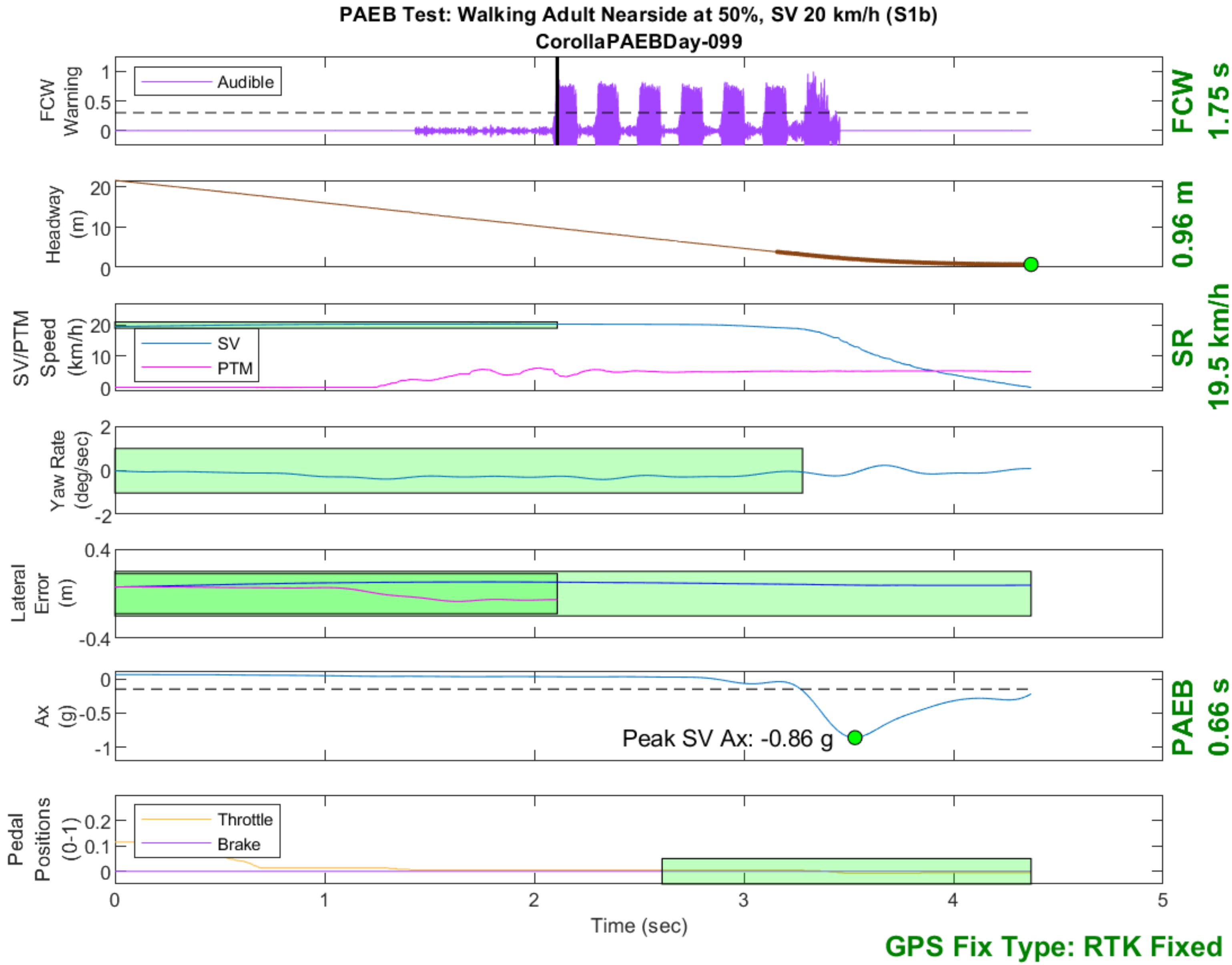


Figure D21. Time History for PAEB Run 99, S1b, Daytime, 20 km/h

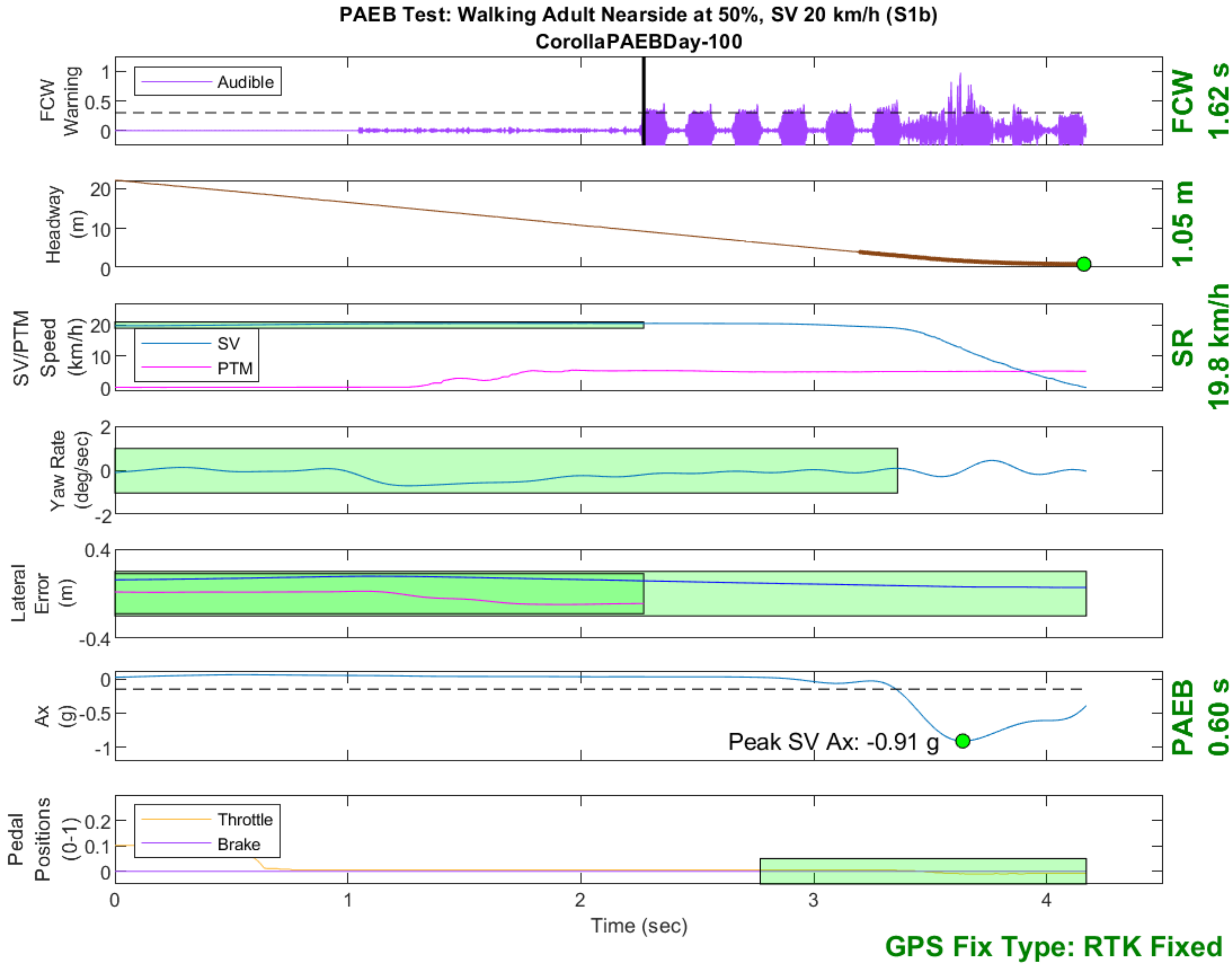


Figure D22. Time History for PAEB Run 100, S1b, Daytime, 20 km/h

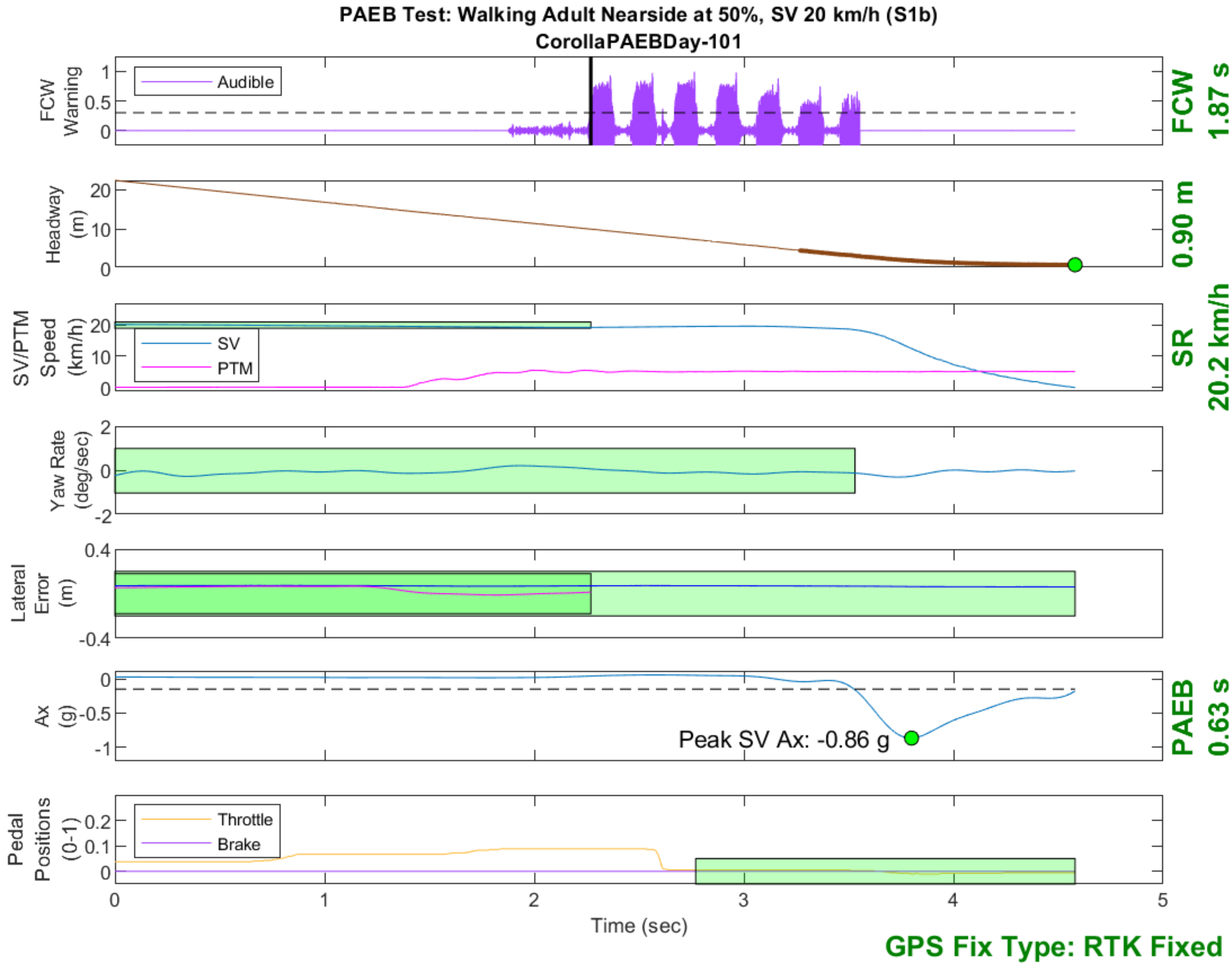


Figure D23. Time History for PAEB Run 101, S1b, Daytime, 20 km/h

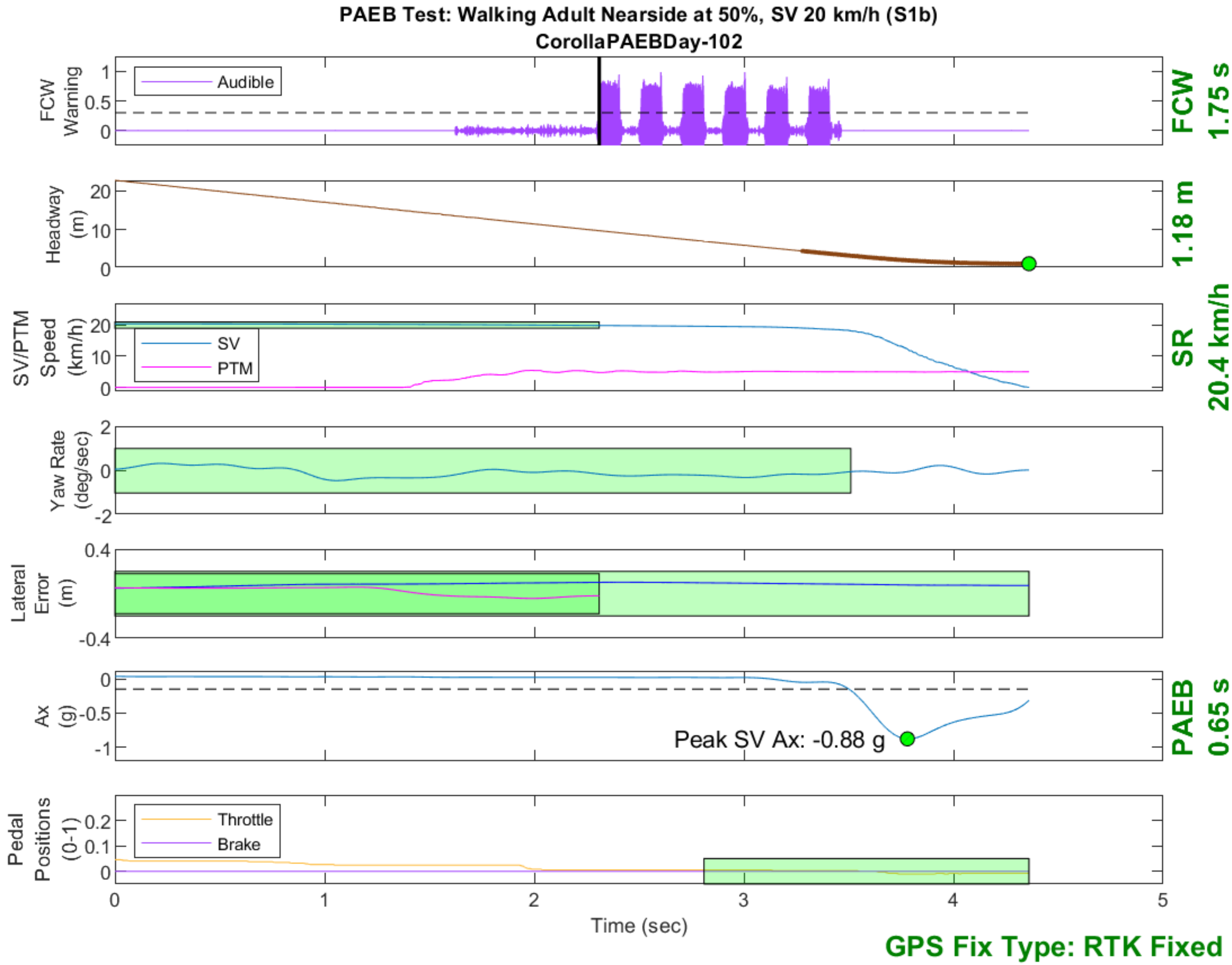


Figure D24. Time History for PAEB Run 102, S1b, Daytime, 20 km/h

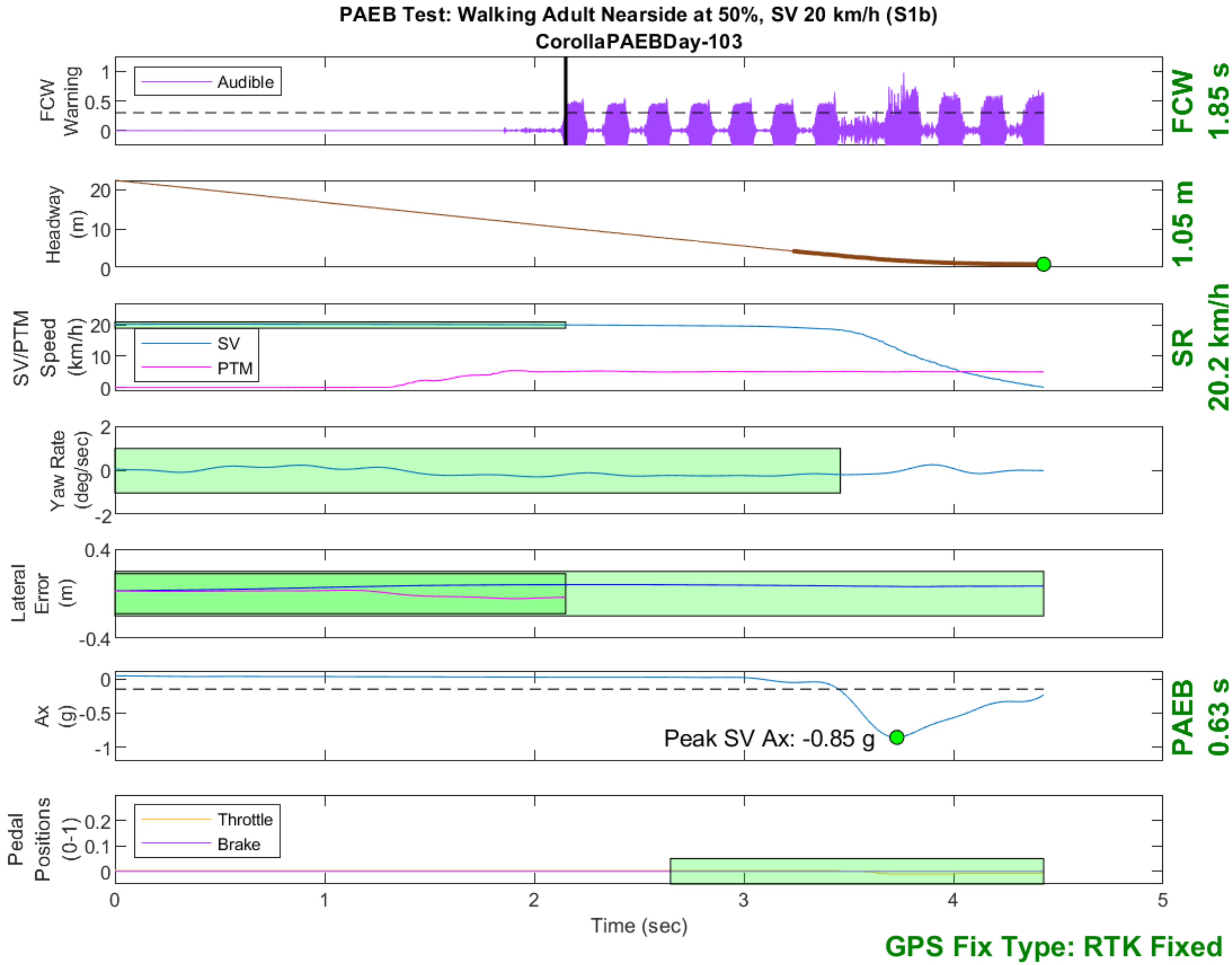


Figure D25. Time History for PAEB Run 103, S1b, Daytime, 20 km/h

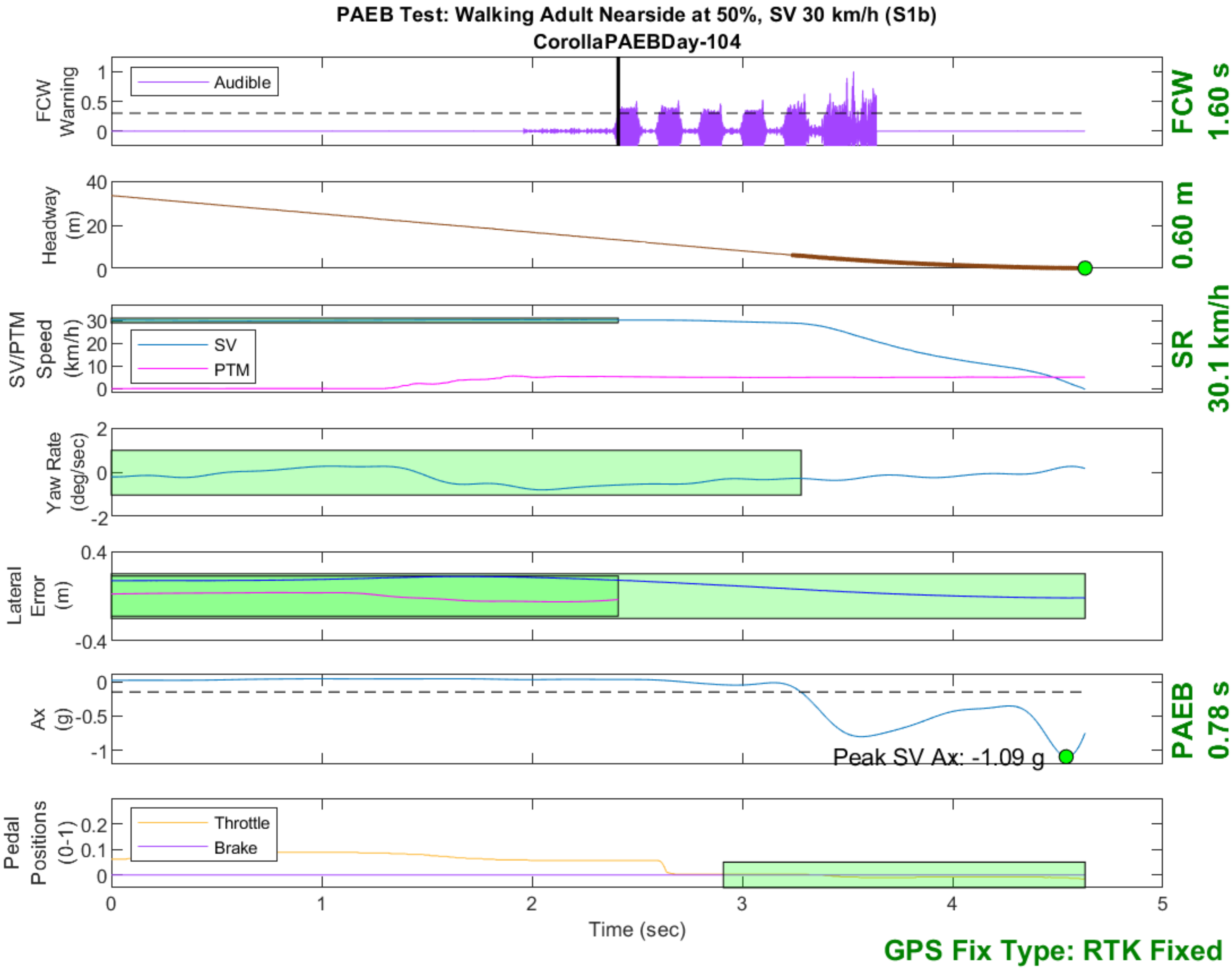


Figure D26. Time History for PAEB Run 104, S1b, Daytime, 30 km/h

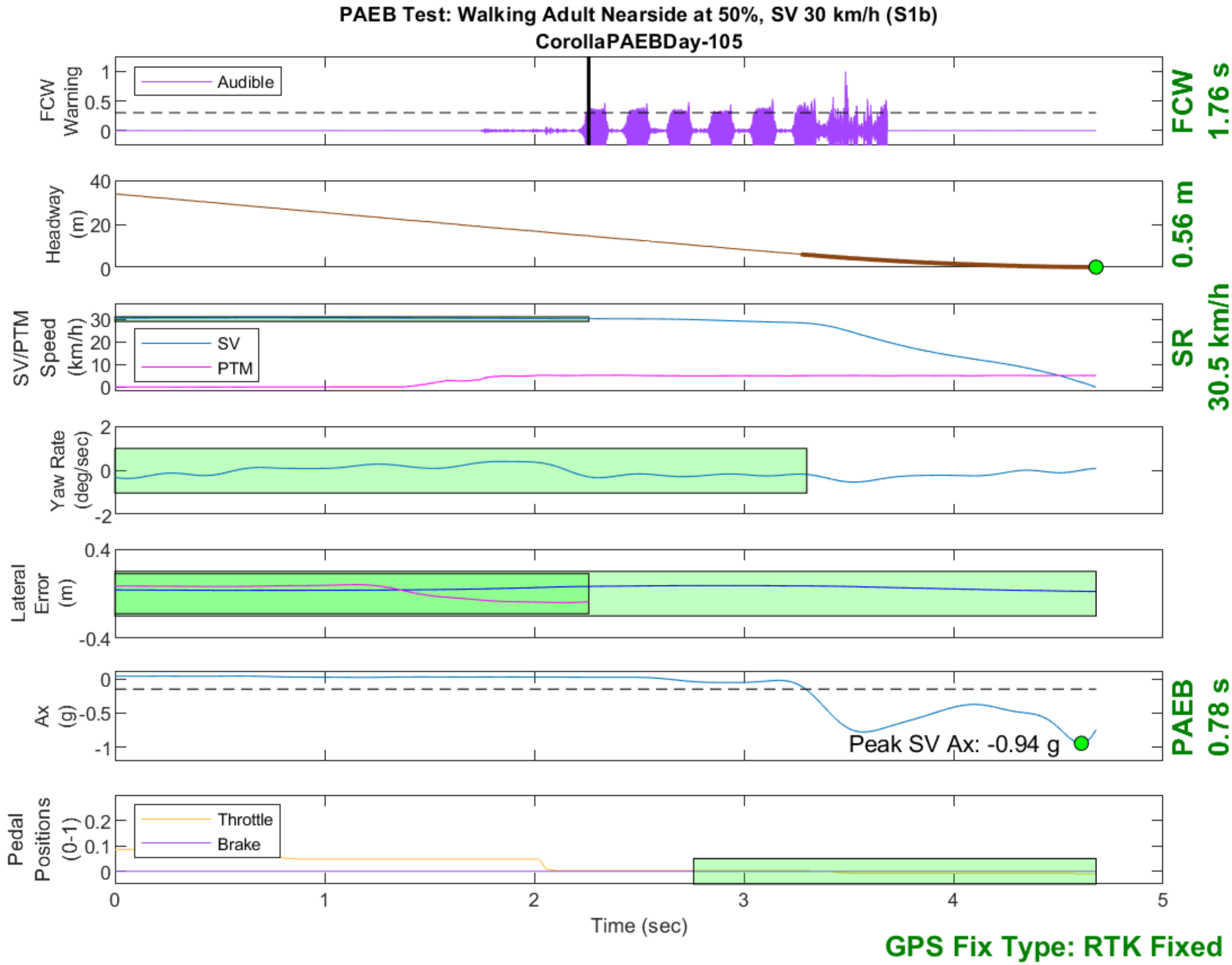


Figure D27. Time History for PAEB Run 105, S1b, Daytime, 30 km/h

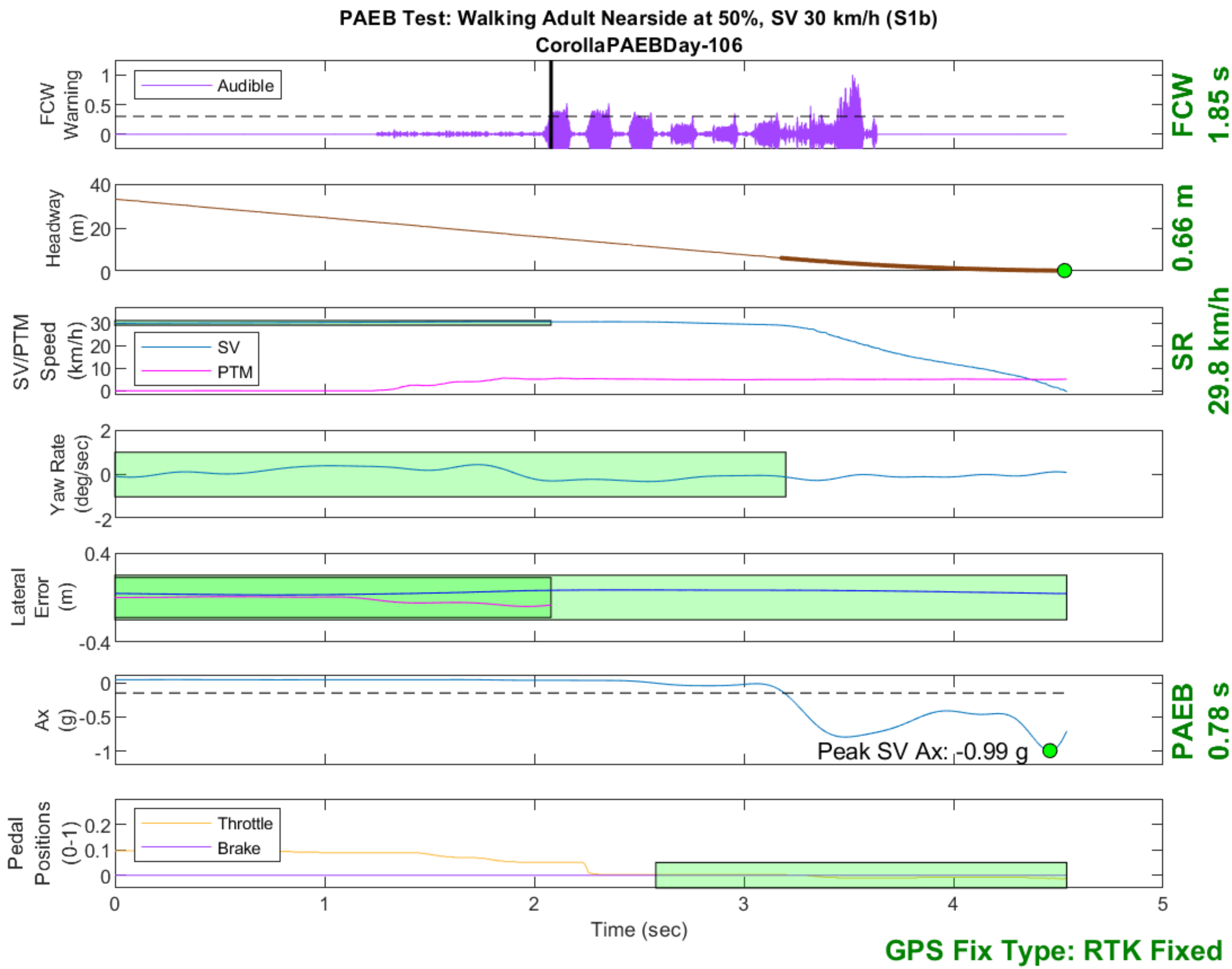


Figure D28. Time History for PAEB Run 106, S1b, Daytime, 30 km/h

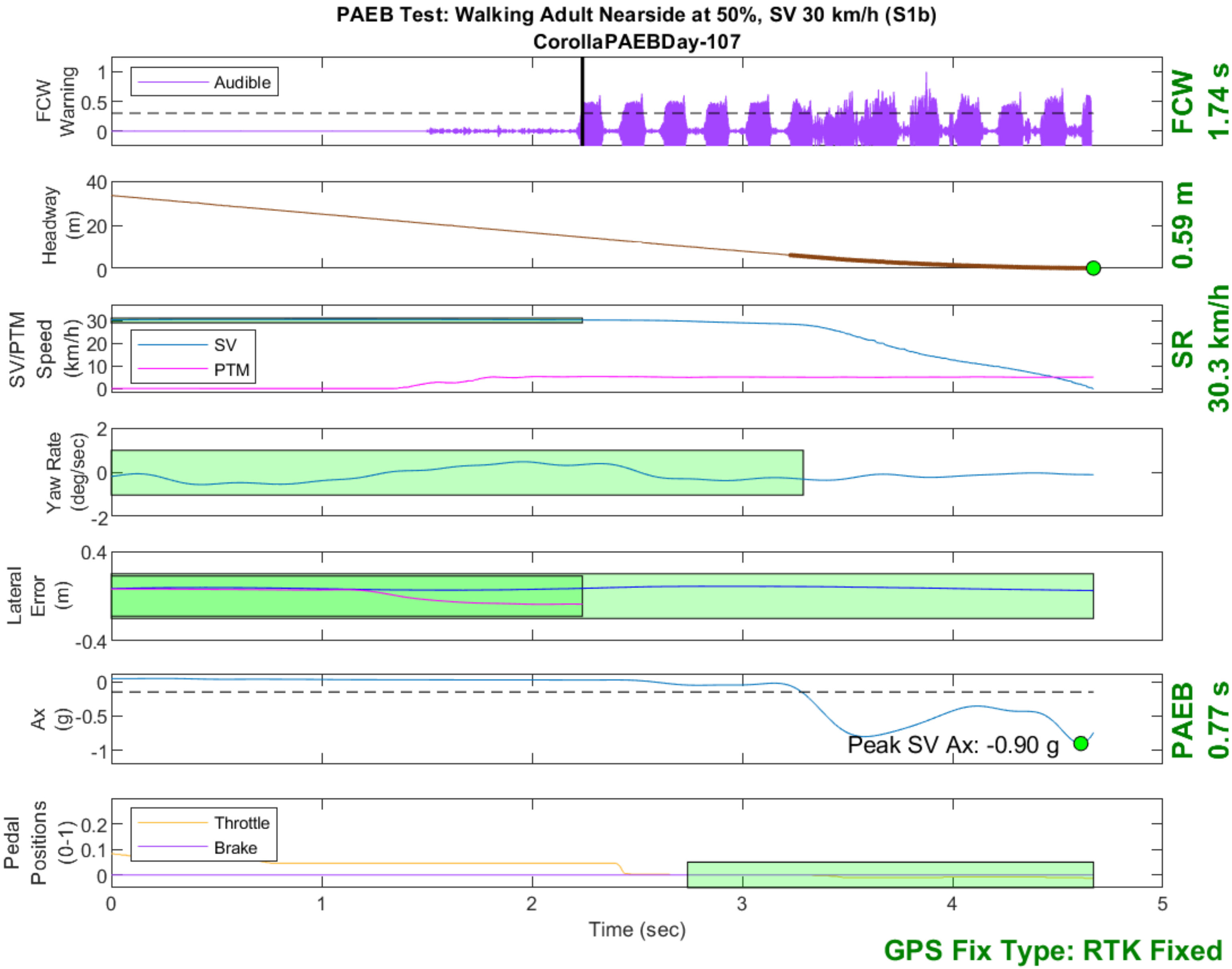


Figure D29. Time History for PAEB Run 107, S1b, Daytime, 30 km/h

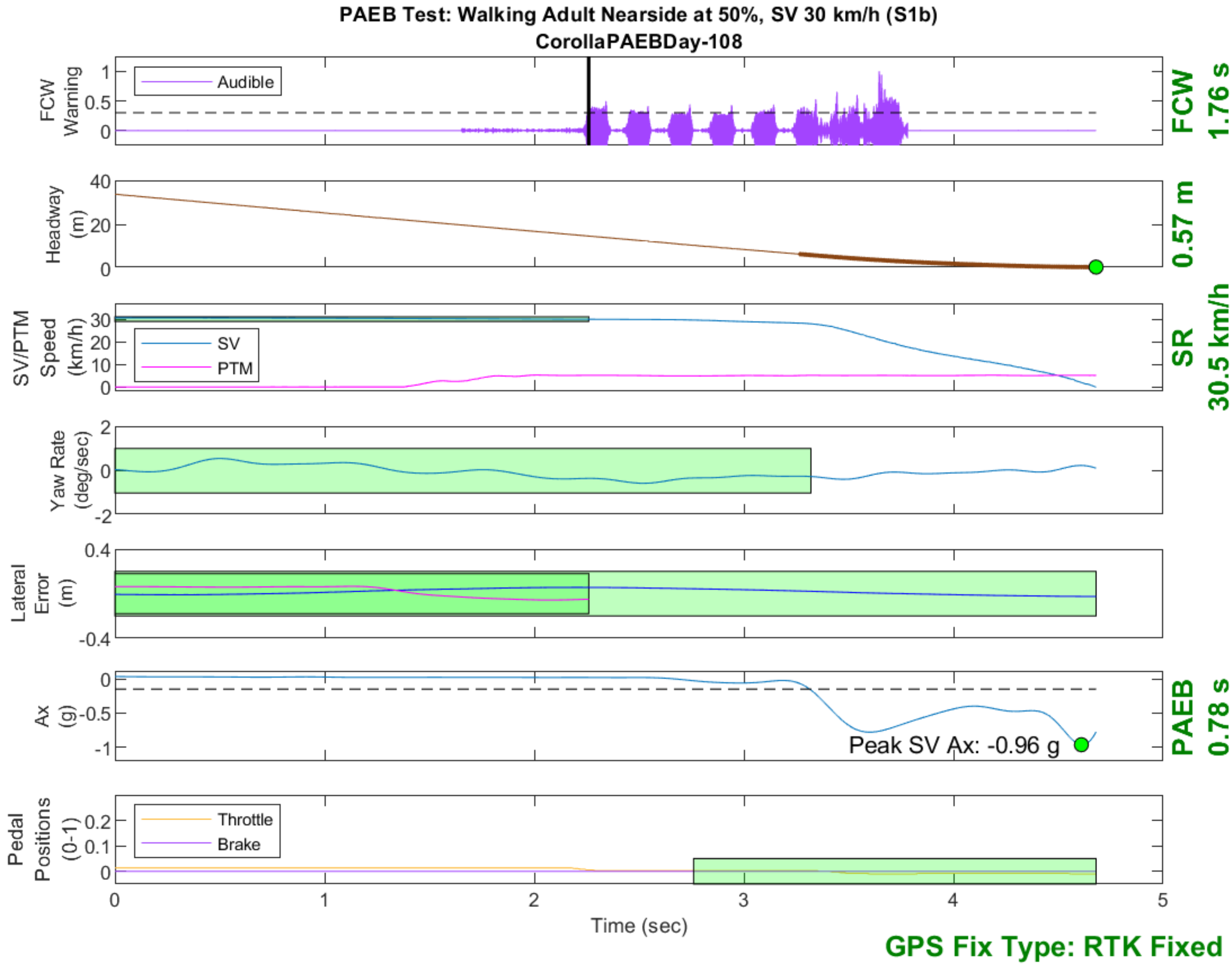


Figure D30. Time History for PAEB Run 108, S1b, Daytime, 30 km/h

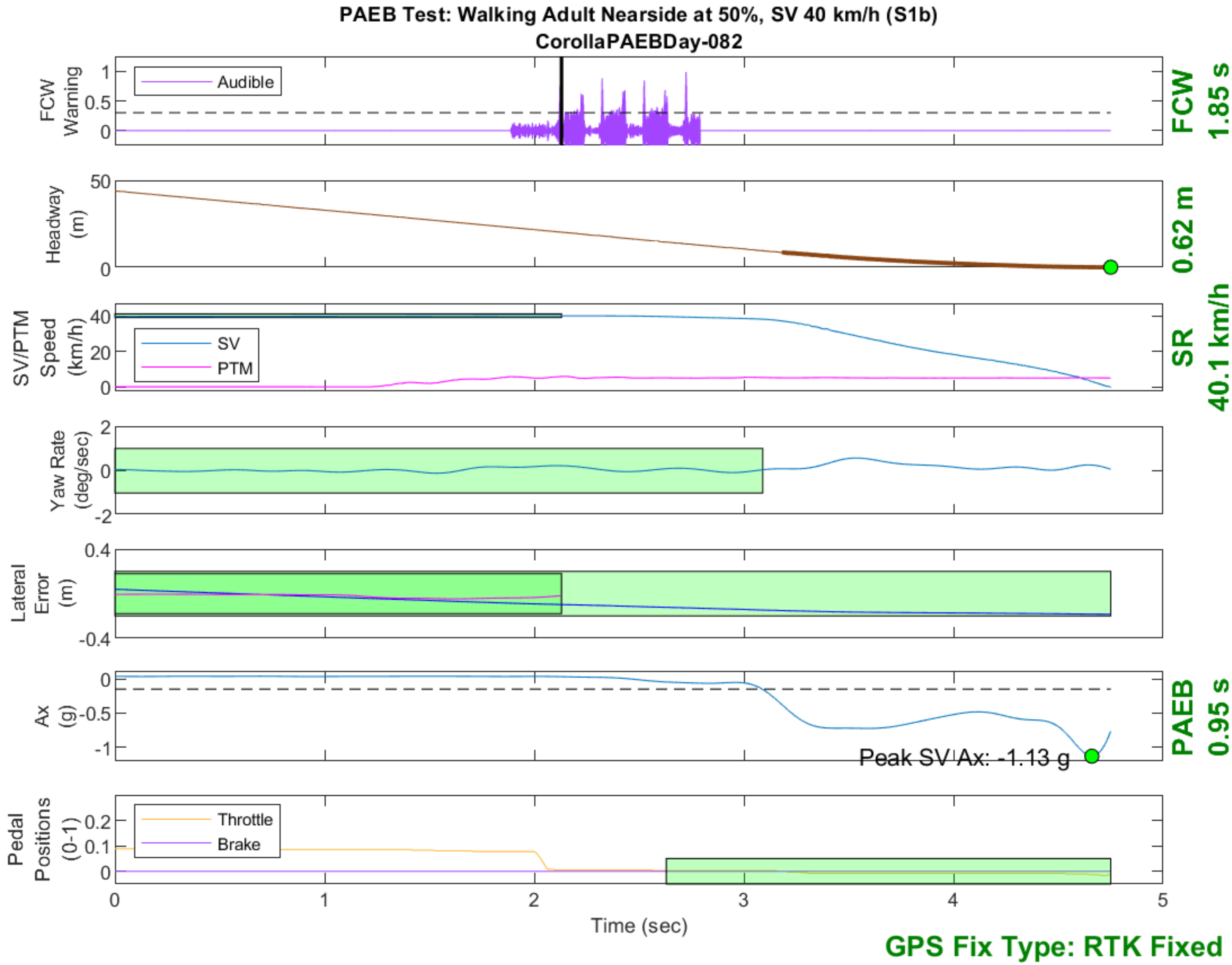


Figure D31. Time History for PAEB Run 82, S1b, Daytime, 40 km/h

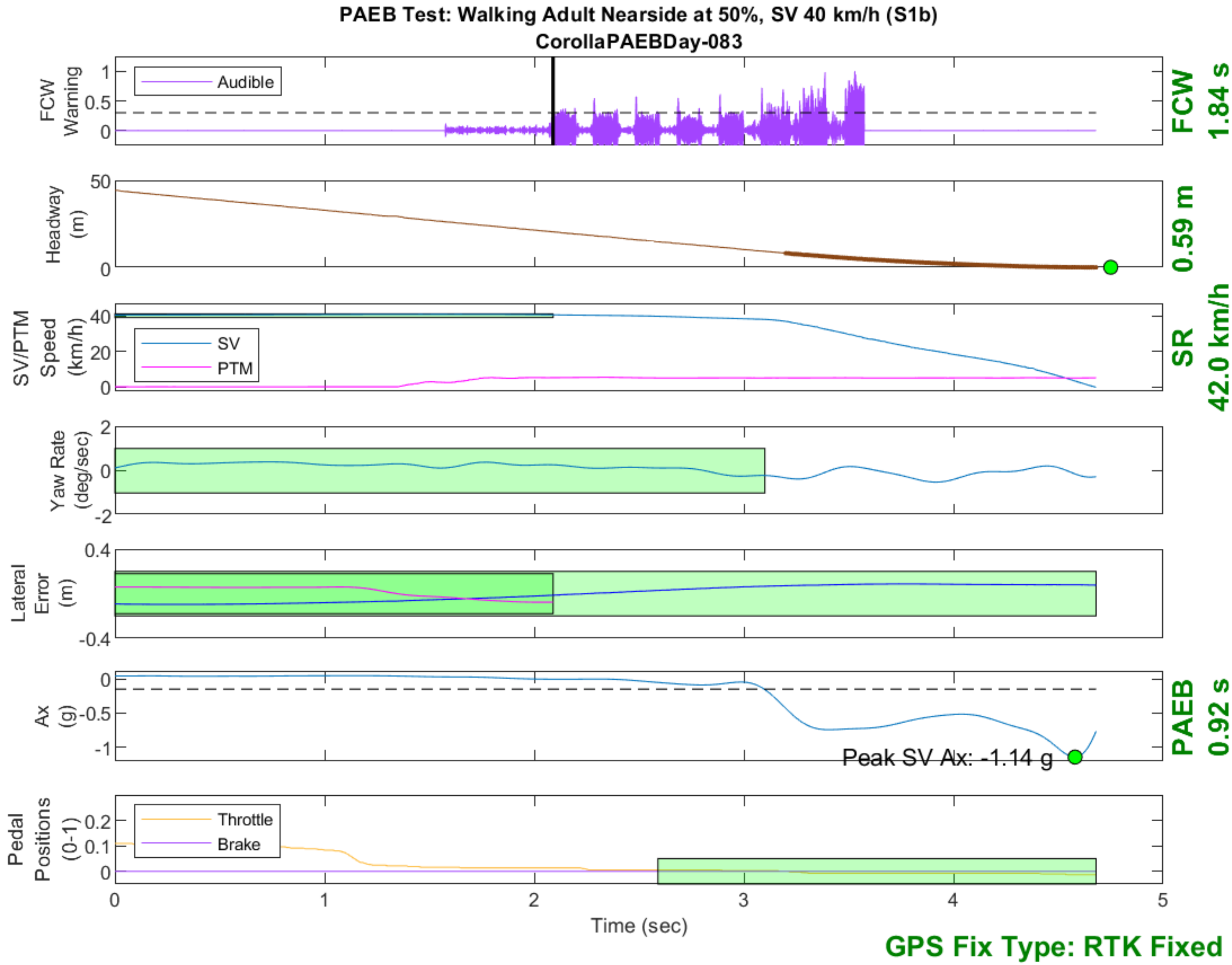


Figure D32. Time History for PAEB Run 83, S1b, Daytime, 40 km/h

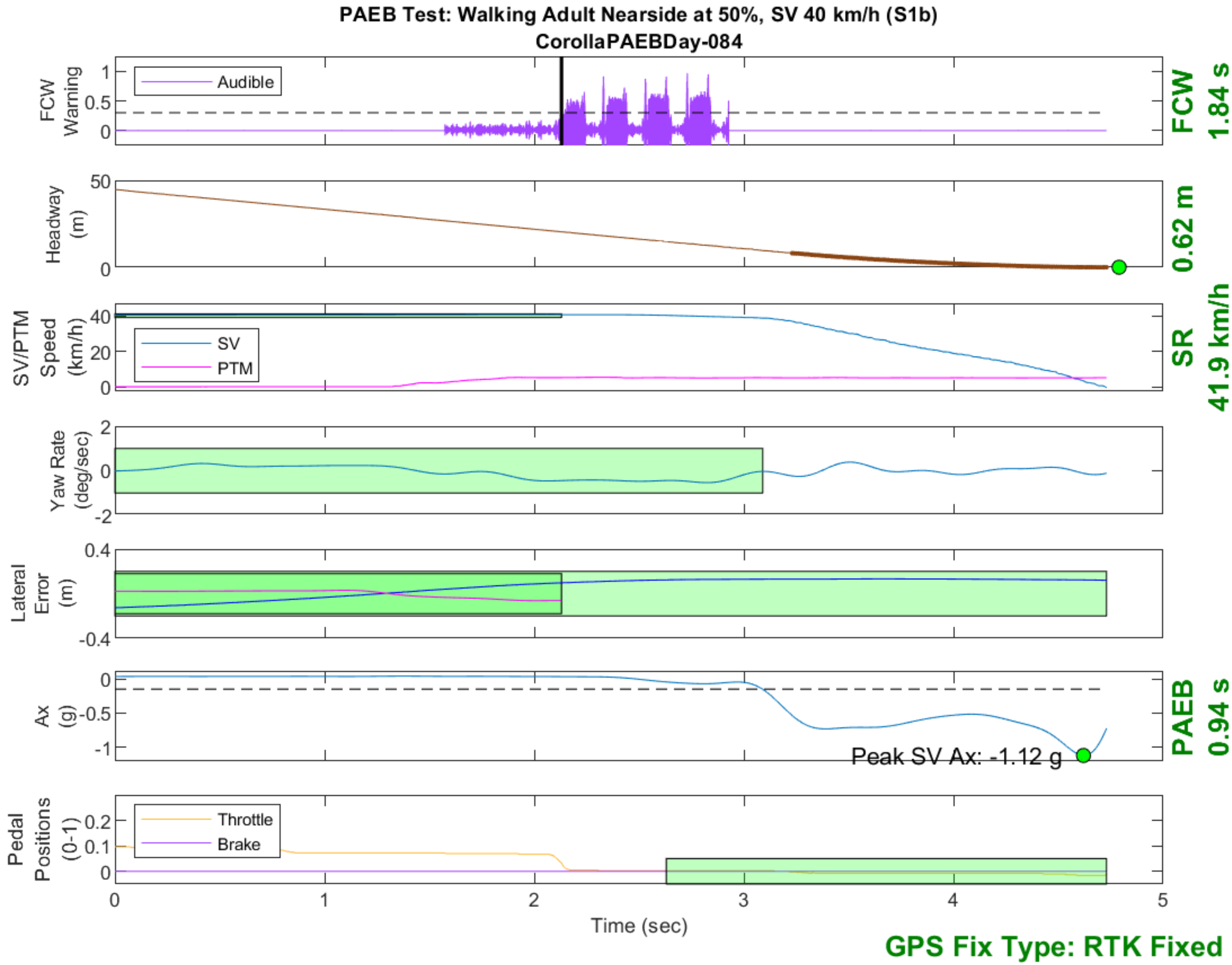


Figure D33. Time History for PAEB Run 84, S1b, Daytime, 40 km/h

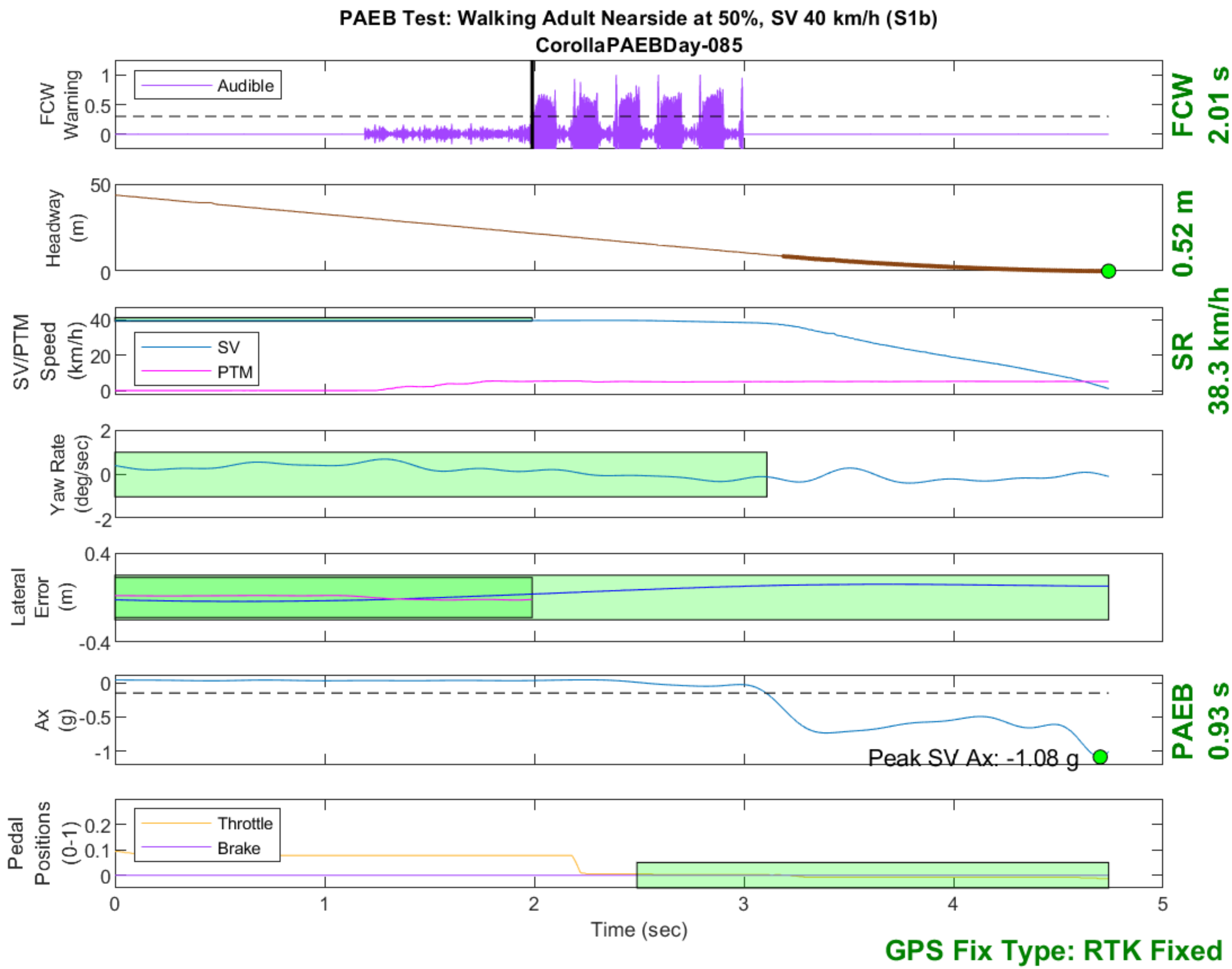


Figure D34. Time History for PAEB Run 85, S1b, Daytime, 40 km/h

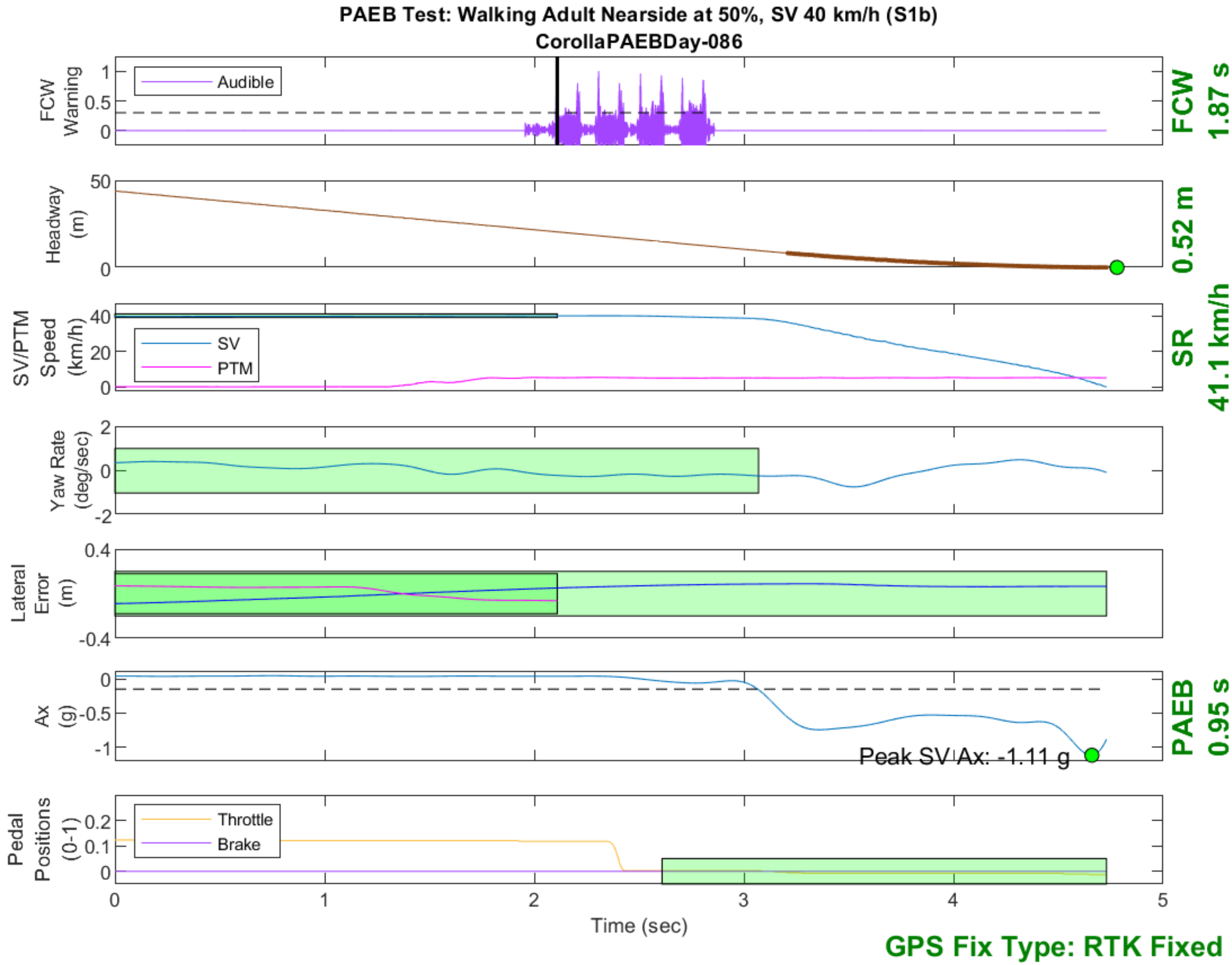


Figure D35. Time History for PAEB Run 86, S1b, Daytime, 40 km/h

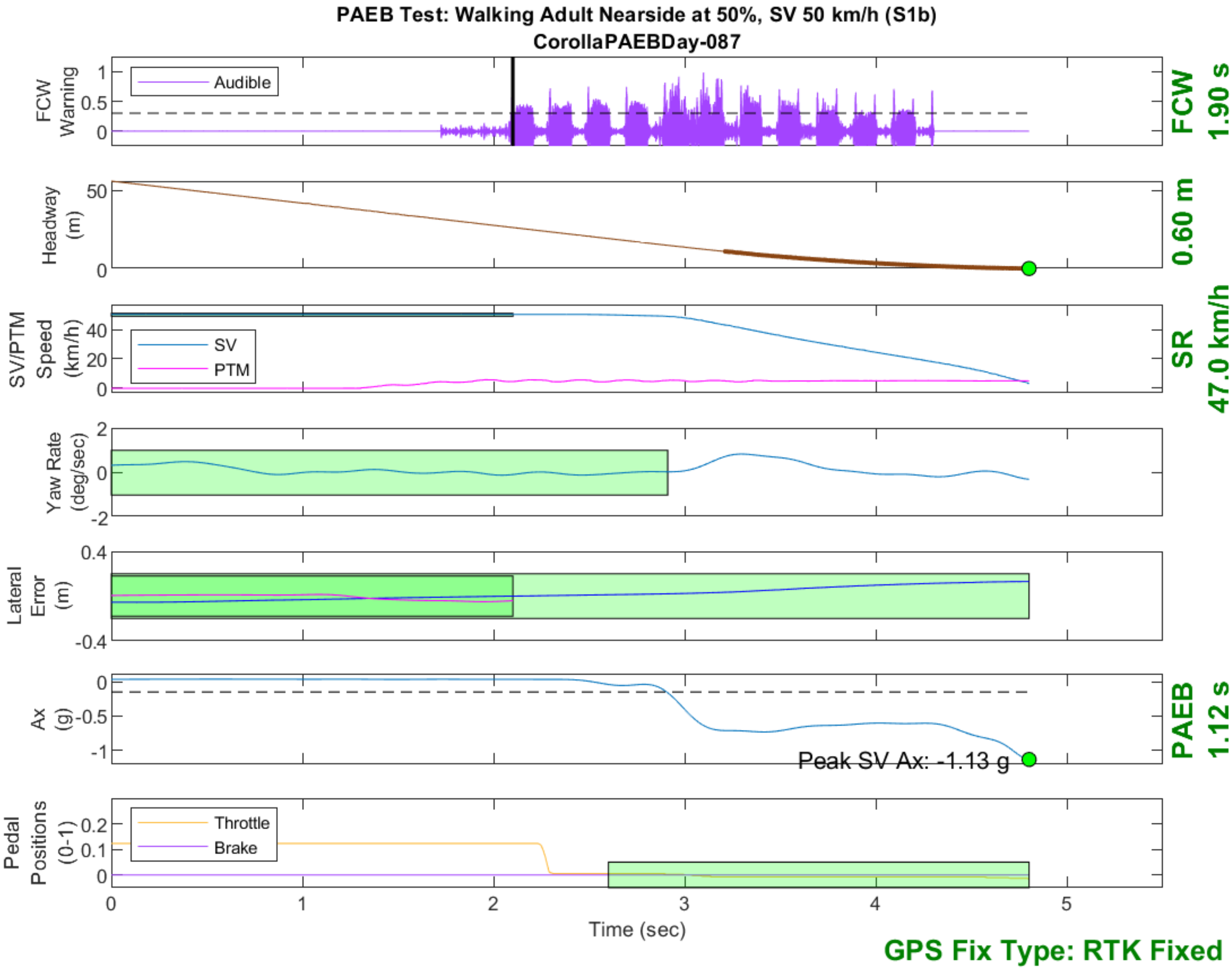


Figure D36. Time History for PAEB Run 87, S1b, Daytime, 50 km/h

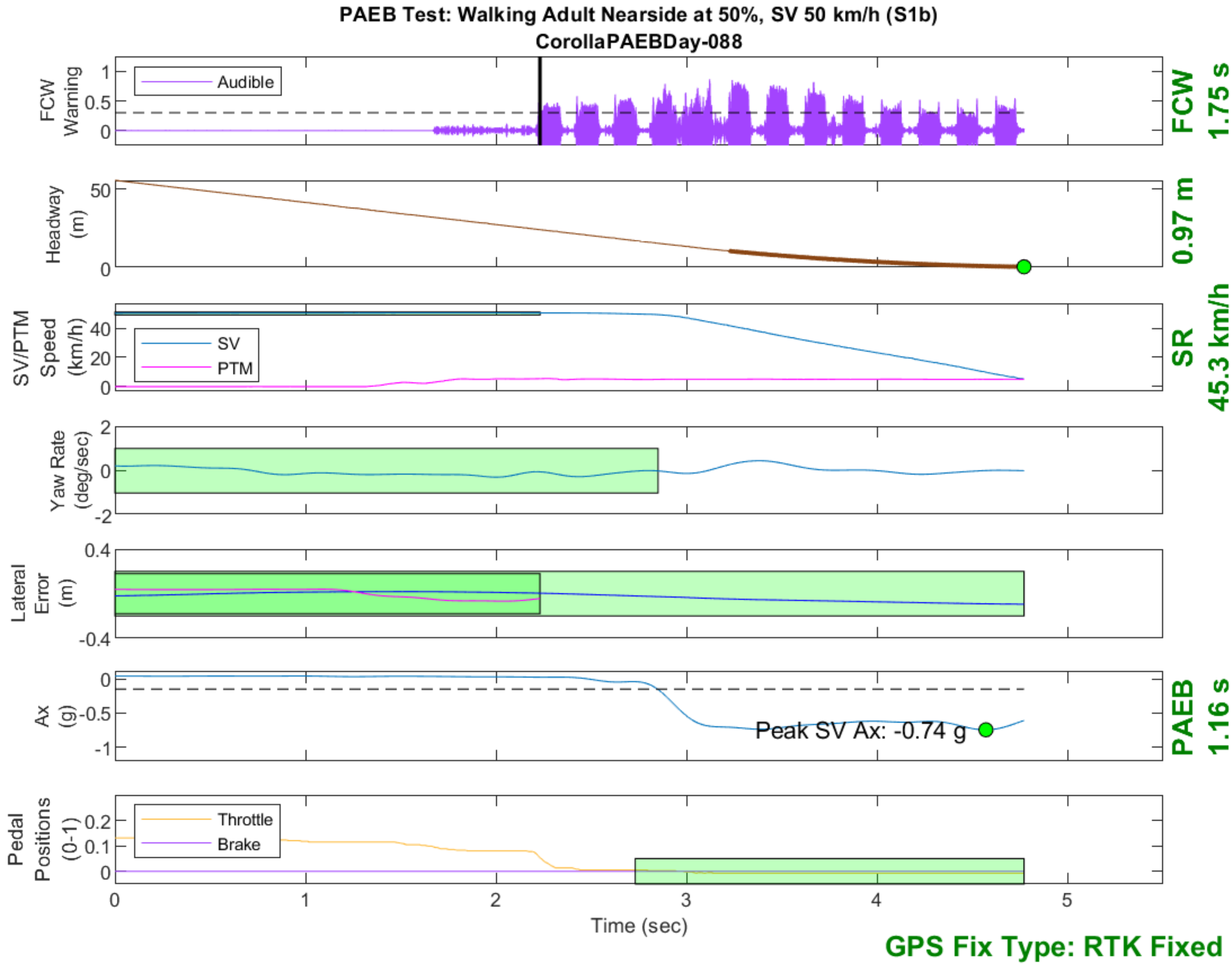


Figure D37. Time History for PAEB Run 88, S1b, Daytime, 50 km/h

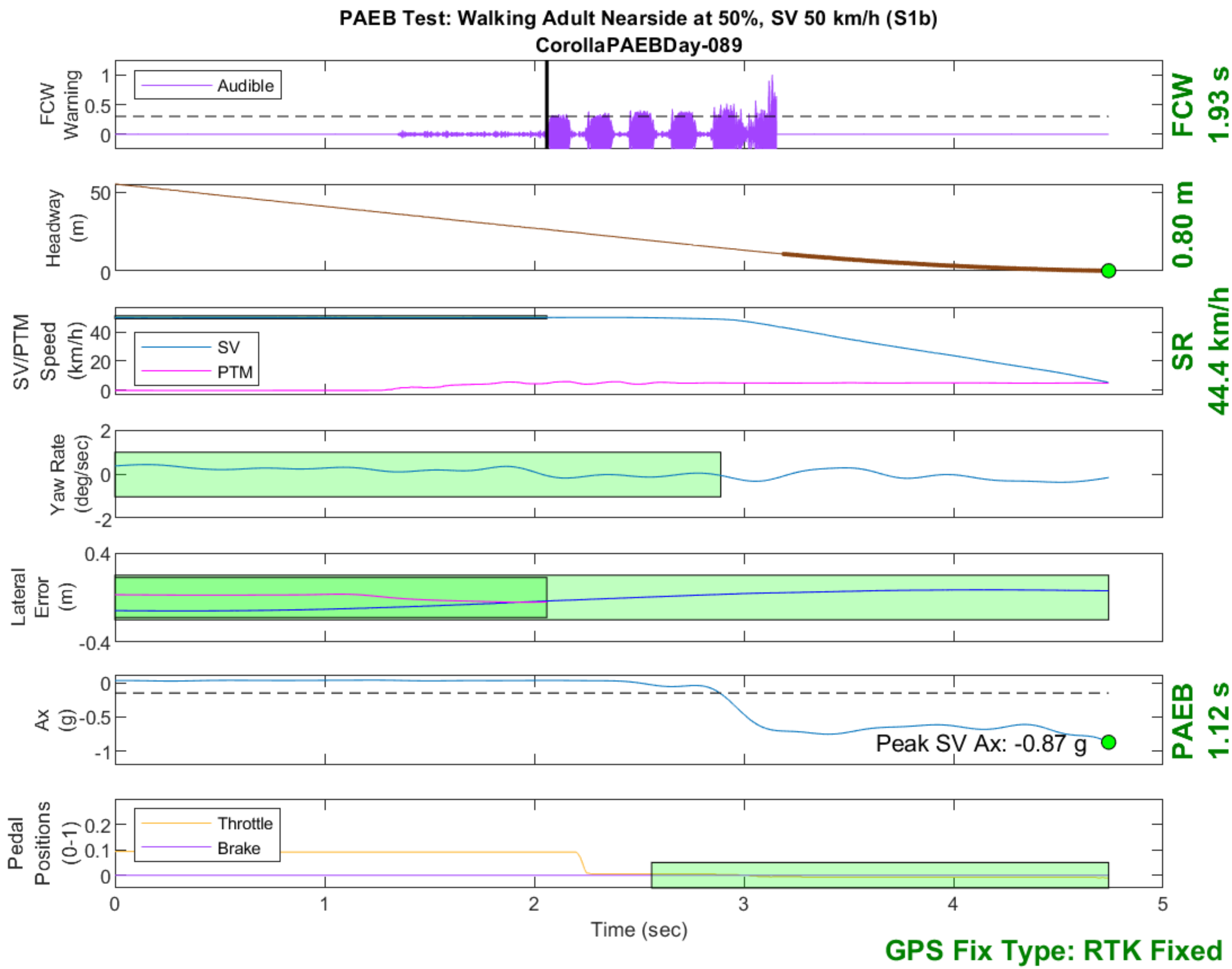


Figure D38. Time History for PAEB Run 89, S1b, Daytime, 50 km/h

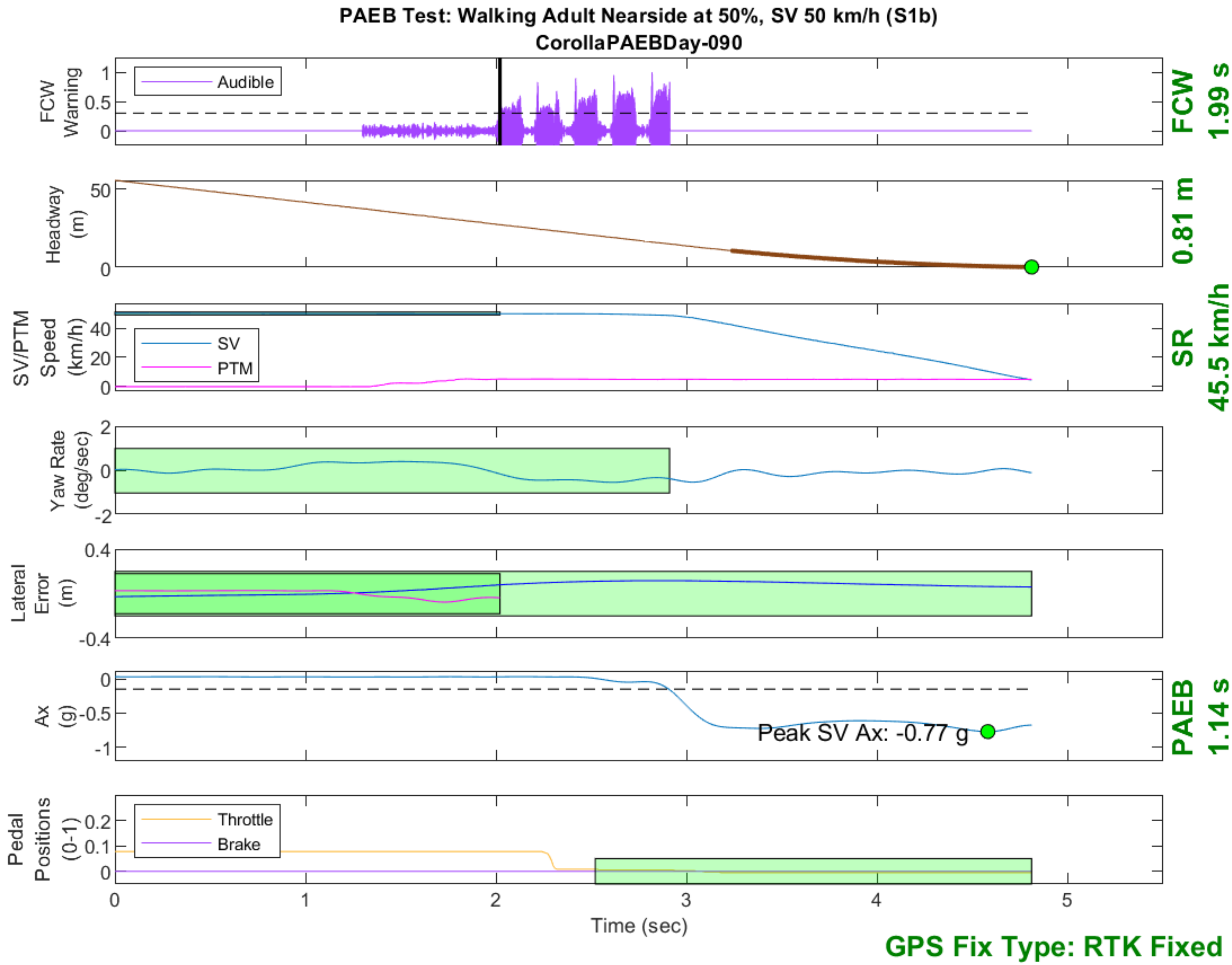


Figure D39. Time History for PAEB Run 90, S1b, Daytime, 50 km/h

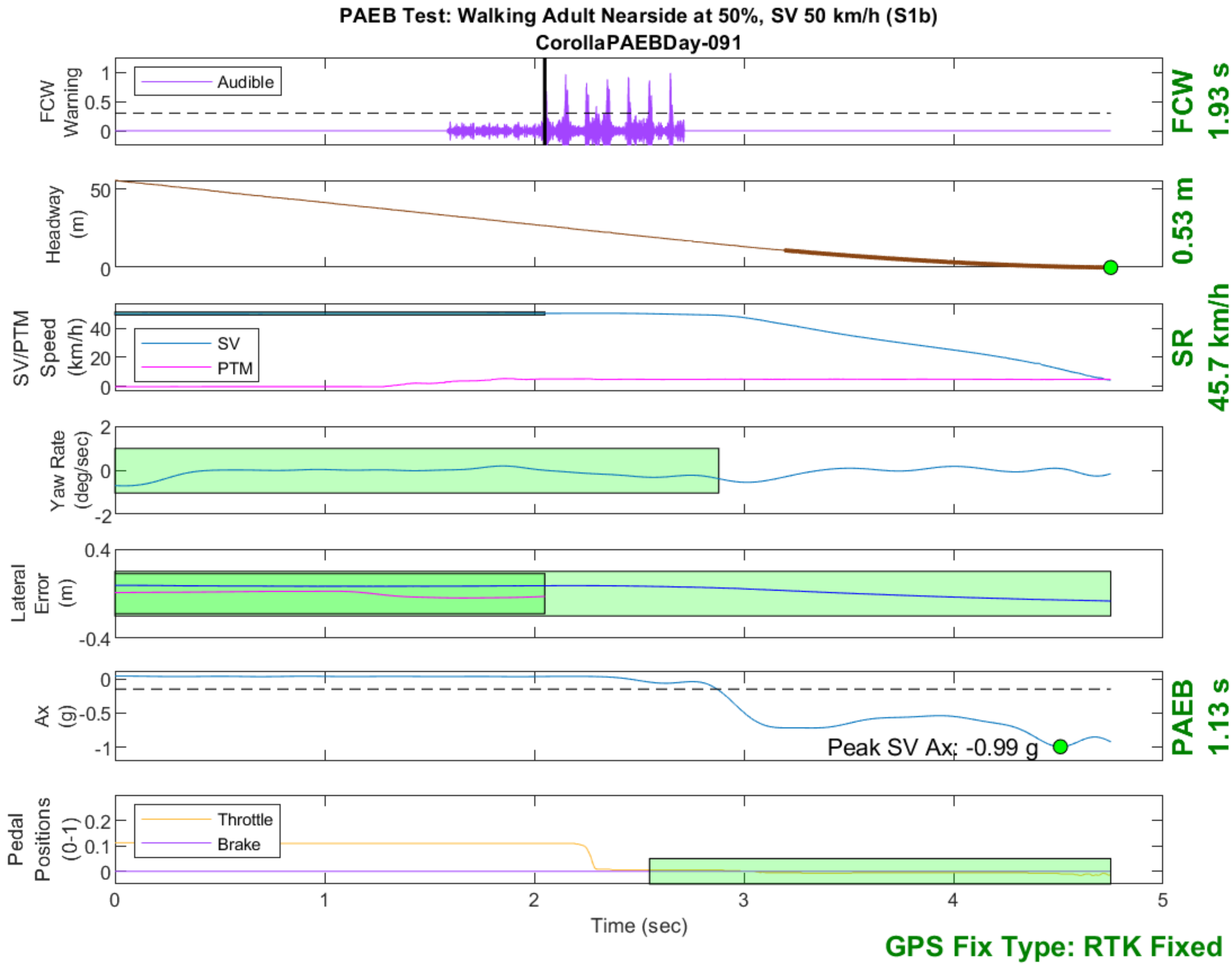


Figure D40. Time History for PAEB Run 91, S1b, Daytime, 50 km/h

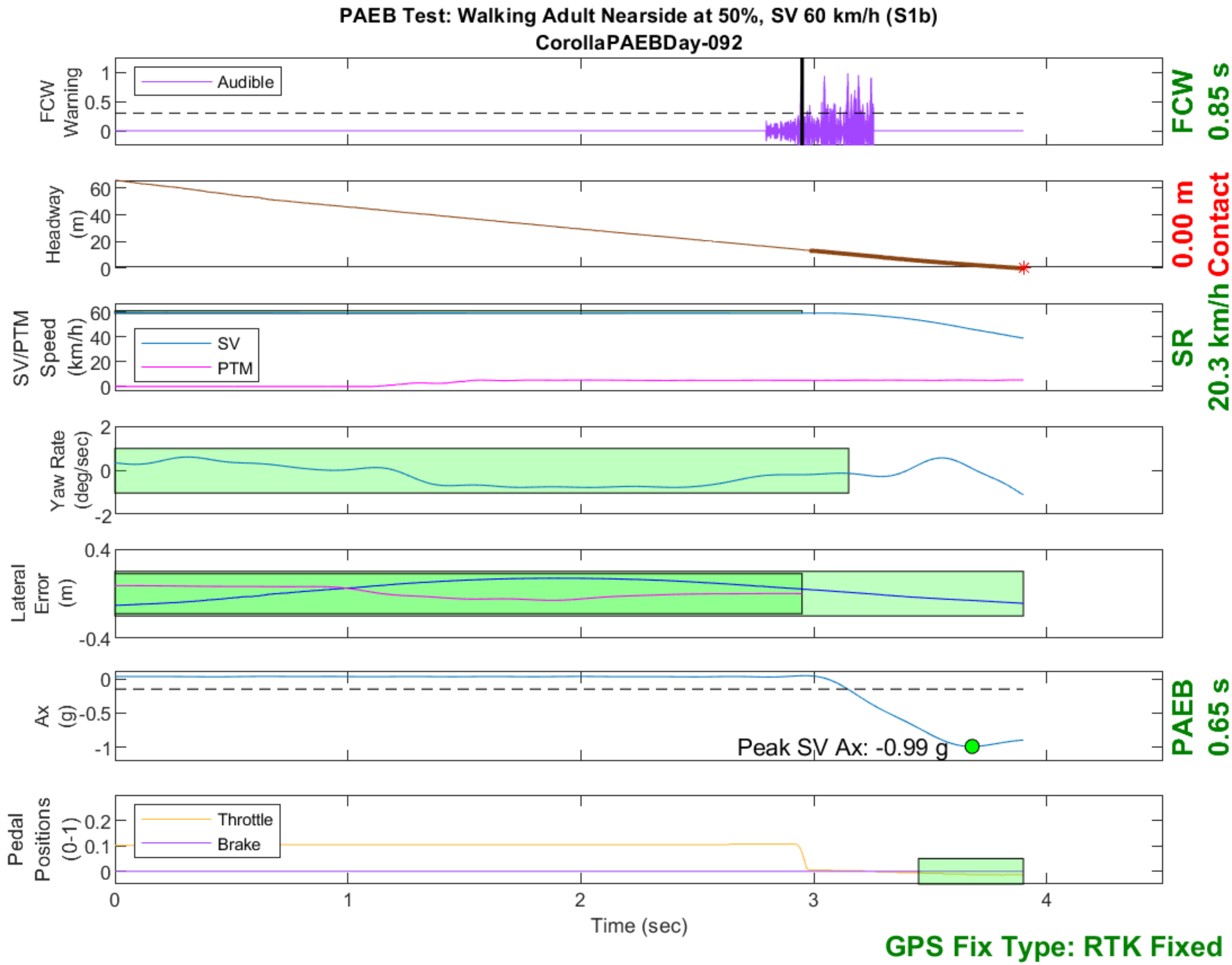


Figure D41. Time History for PAEB Run 92, S1b, Daytime, 60 km/h

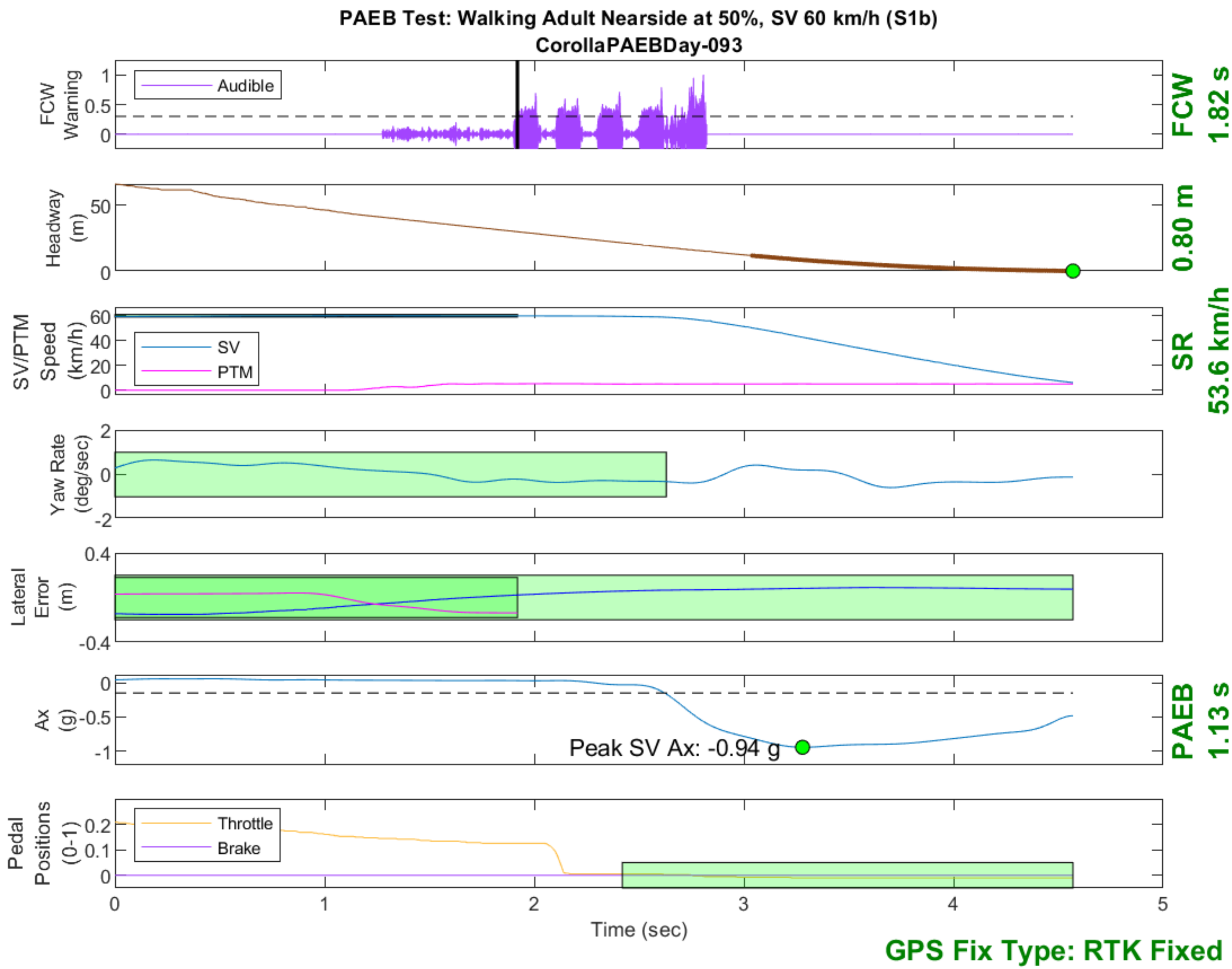


Figure D42. Time History for PAEB Run 93, S1b, Daytime, 60 km/h

Figure D43. Time History for PAEB Run 96, S1b, Daytime, 60 km/h

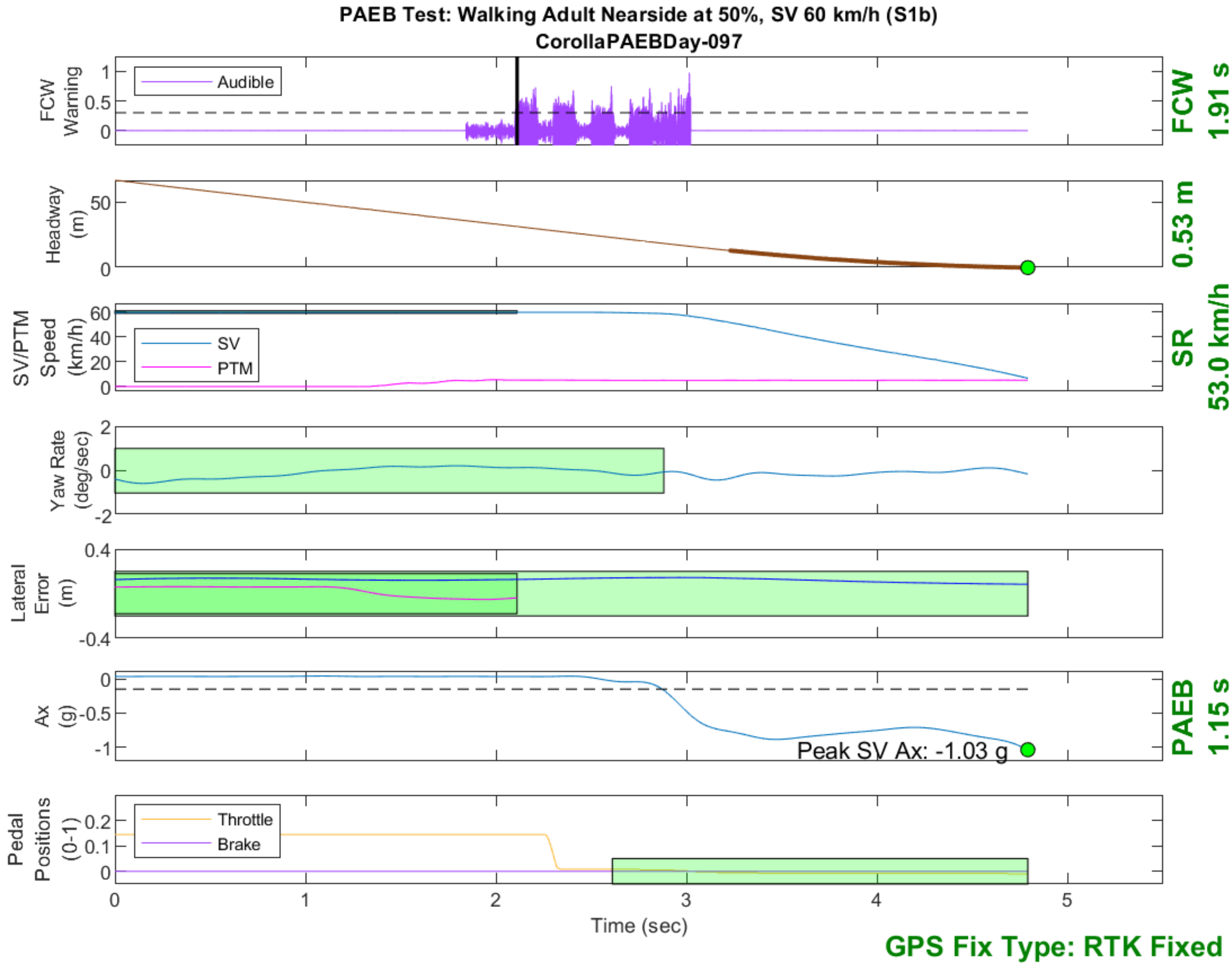


Figure D44. Time History for PAEB Run 97, S1b, Daytime, 60 km/h

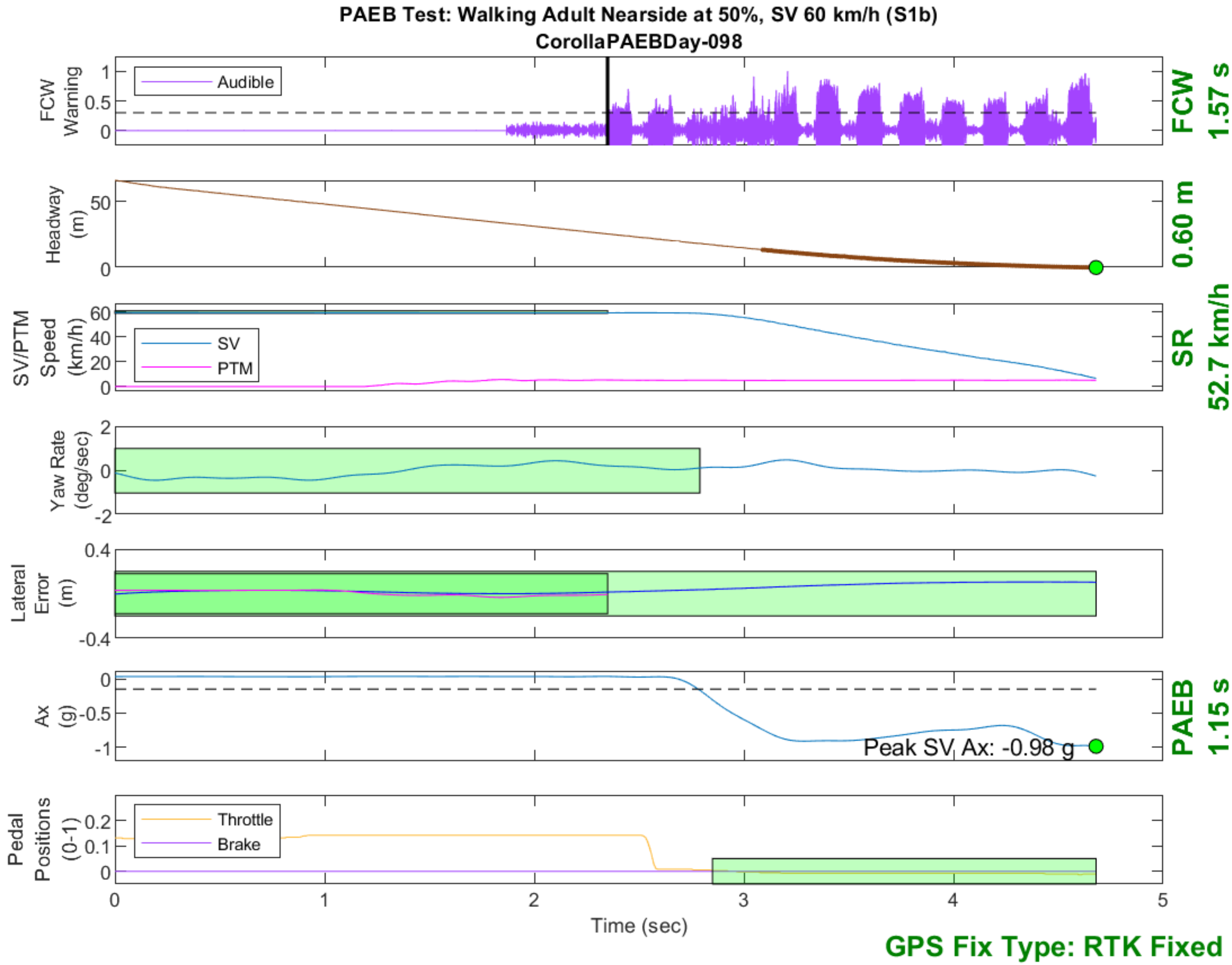


Figure D45. Time History for PAEB Run 98, S1b, Daytime, 60 km/h

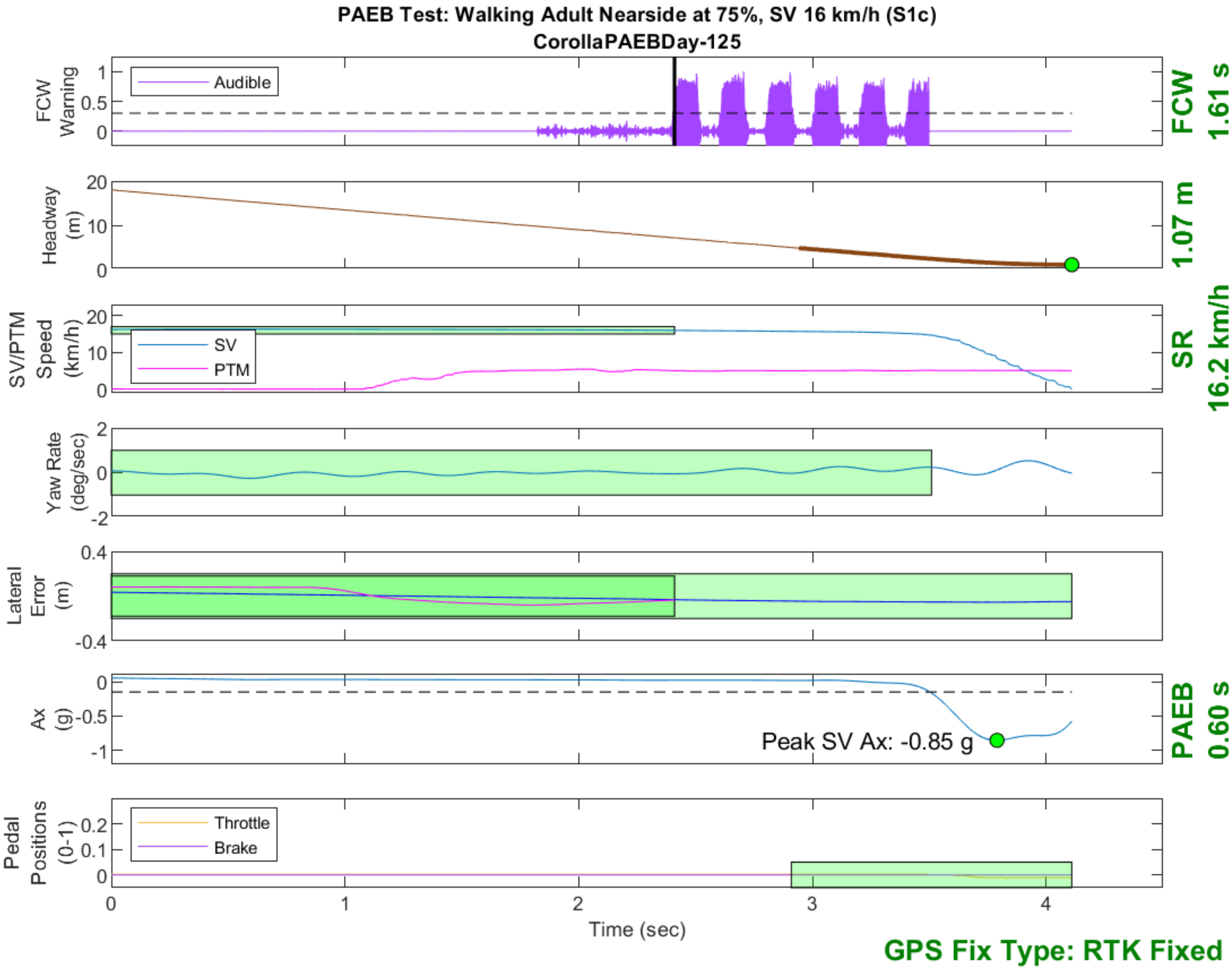


Figure D46. Time History for PAEB Run 125, S1c, Daytime, 16 km/h

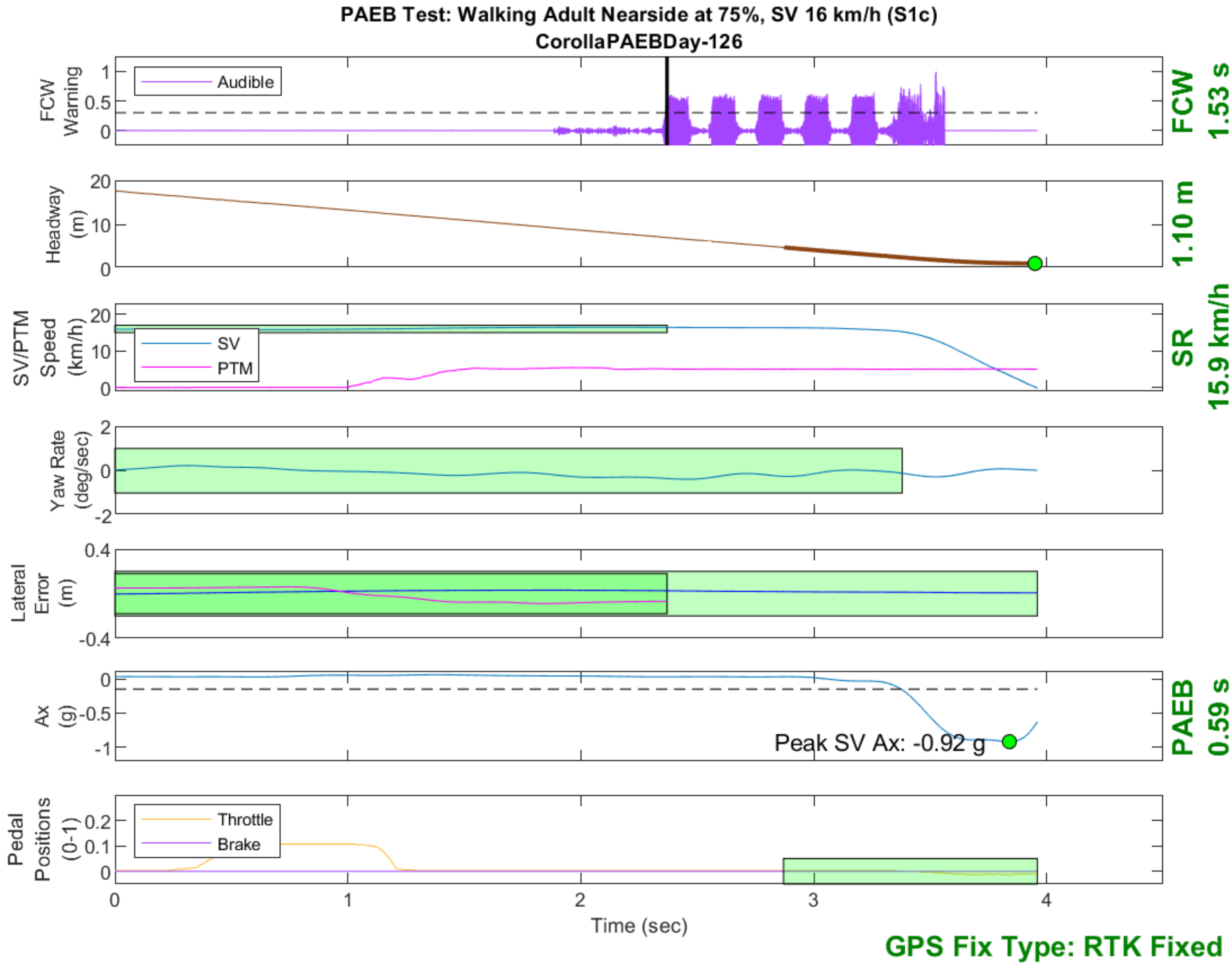


Figure D47. Time History for PAEB Run 126, S1c, Daytime, 16 km/h

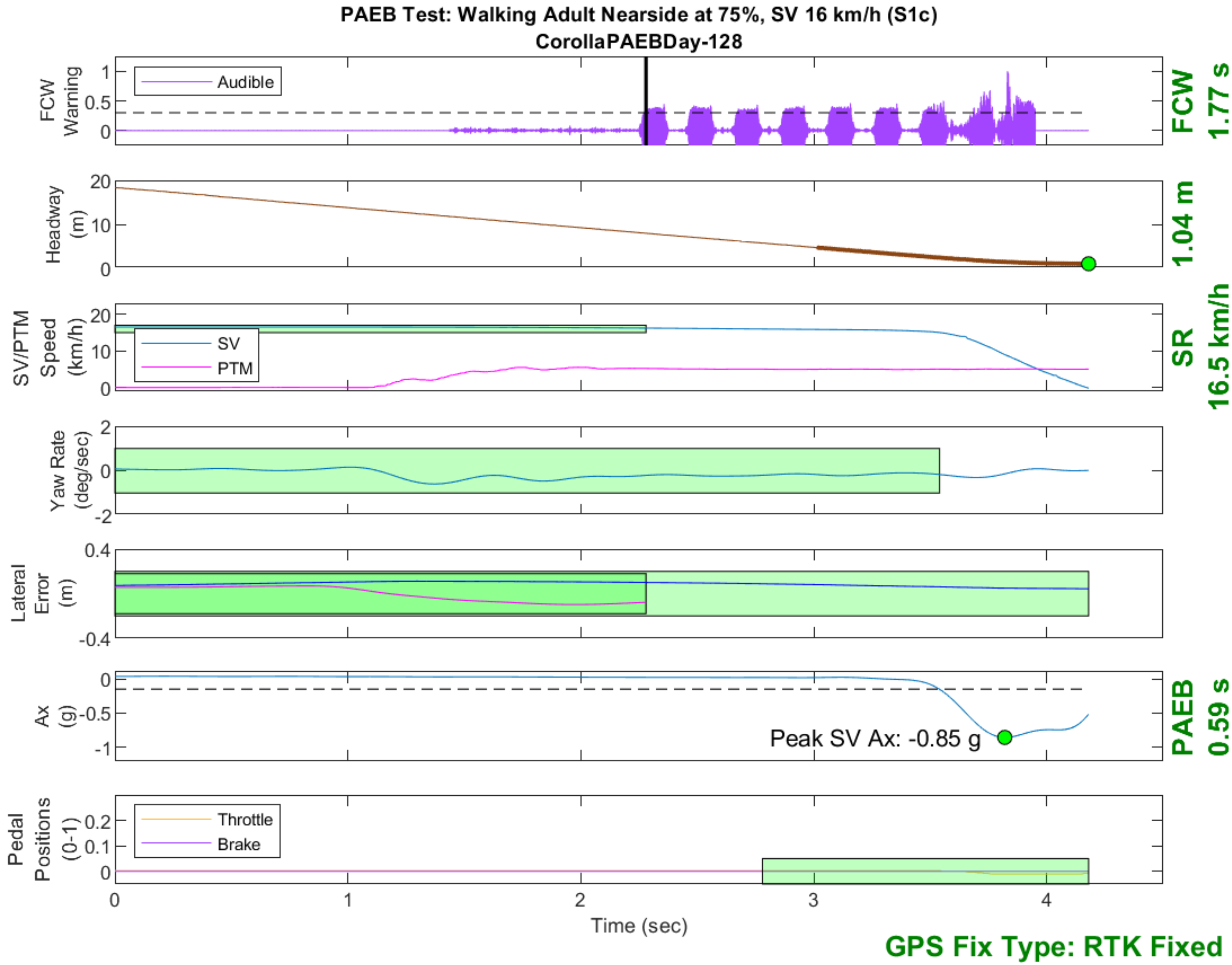


Figure D48. Time History for PAEB Run 128, S1c, Daytime, 16 km/h

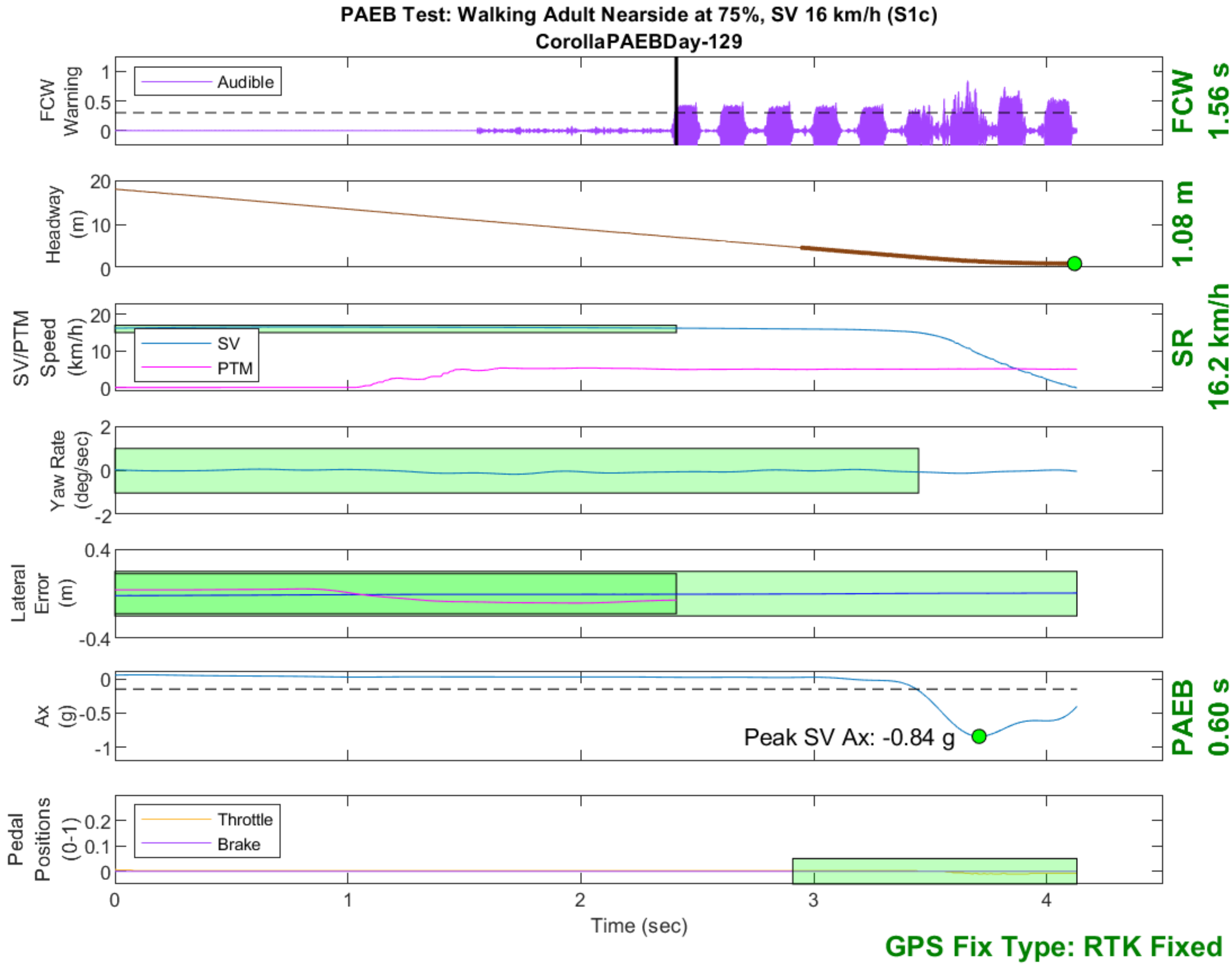


Figure D49. Time History for PAEB Run 129, S1c, Daytime, 16 km/h

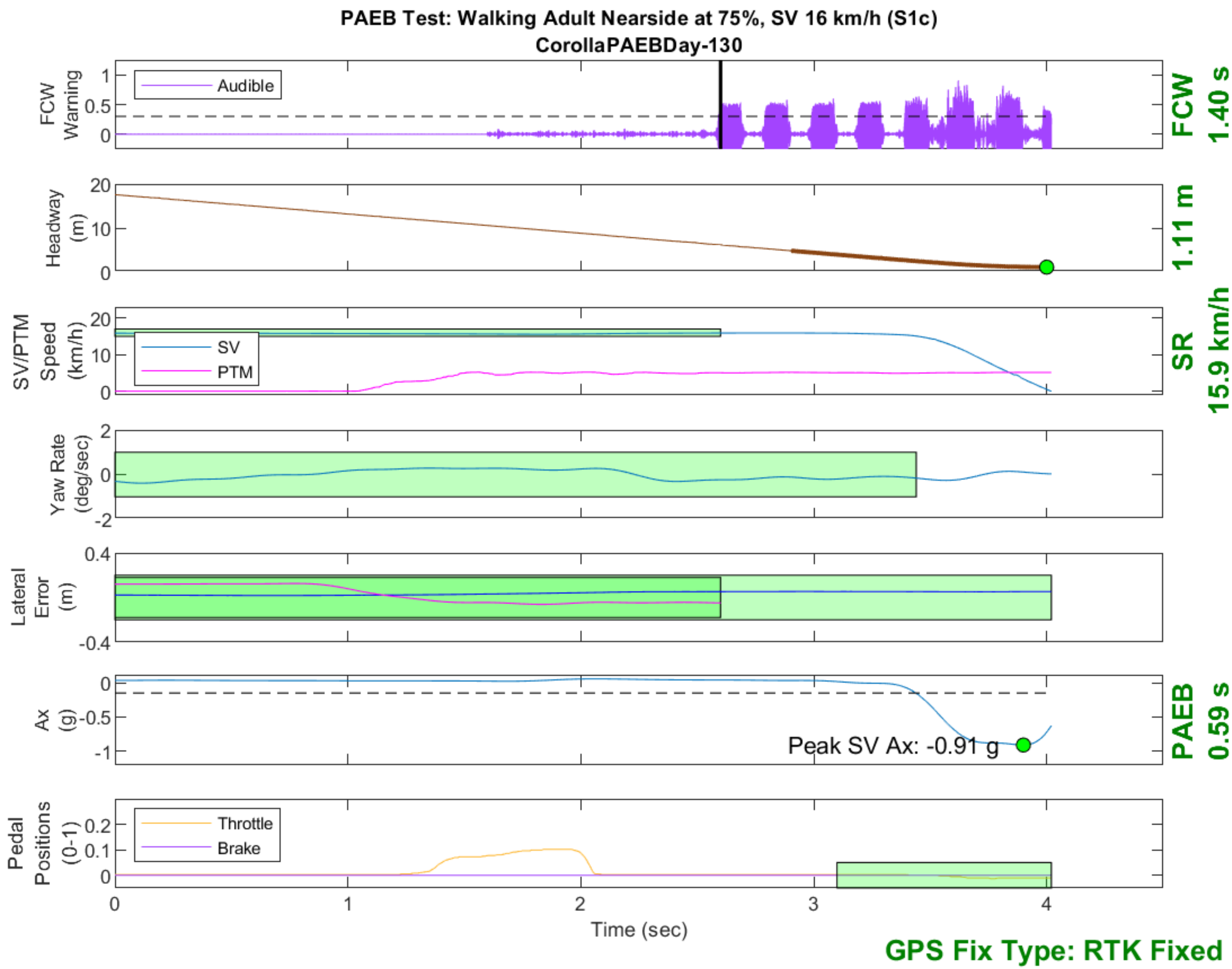


Figure D50. Time History for PAEB Run 130, S1c, Daytime, 16 km/h

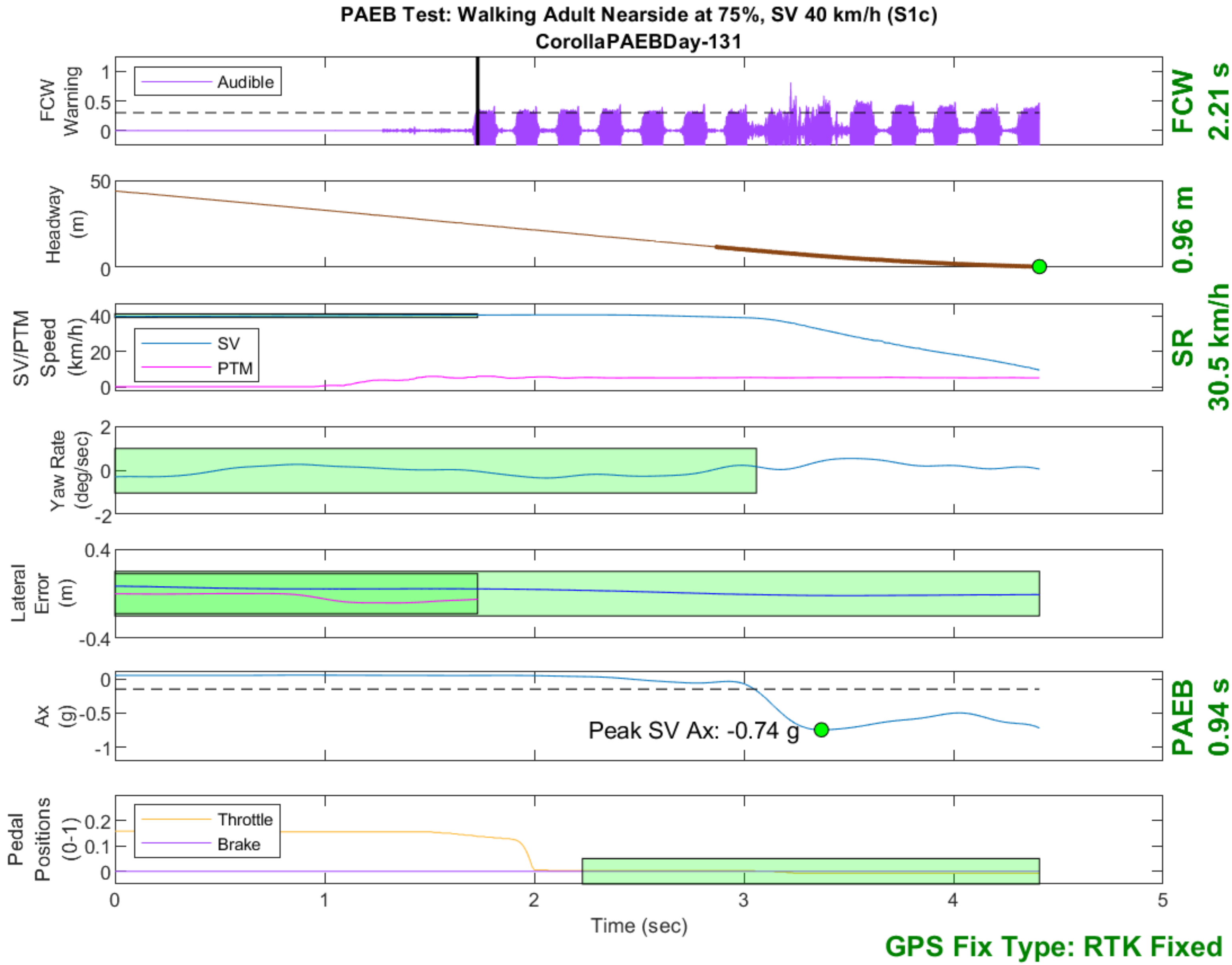


Figure D51. Time History for PAEB Run 131, S1c, Daytime, 40 km/h

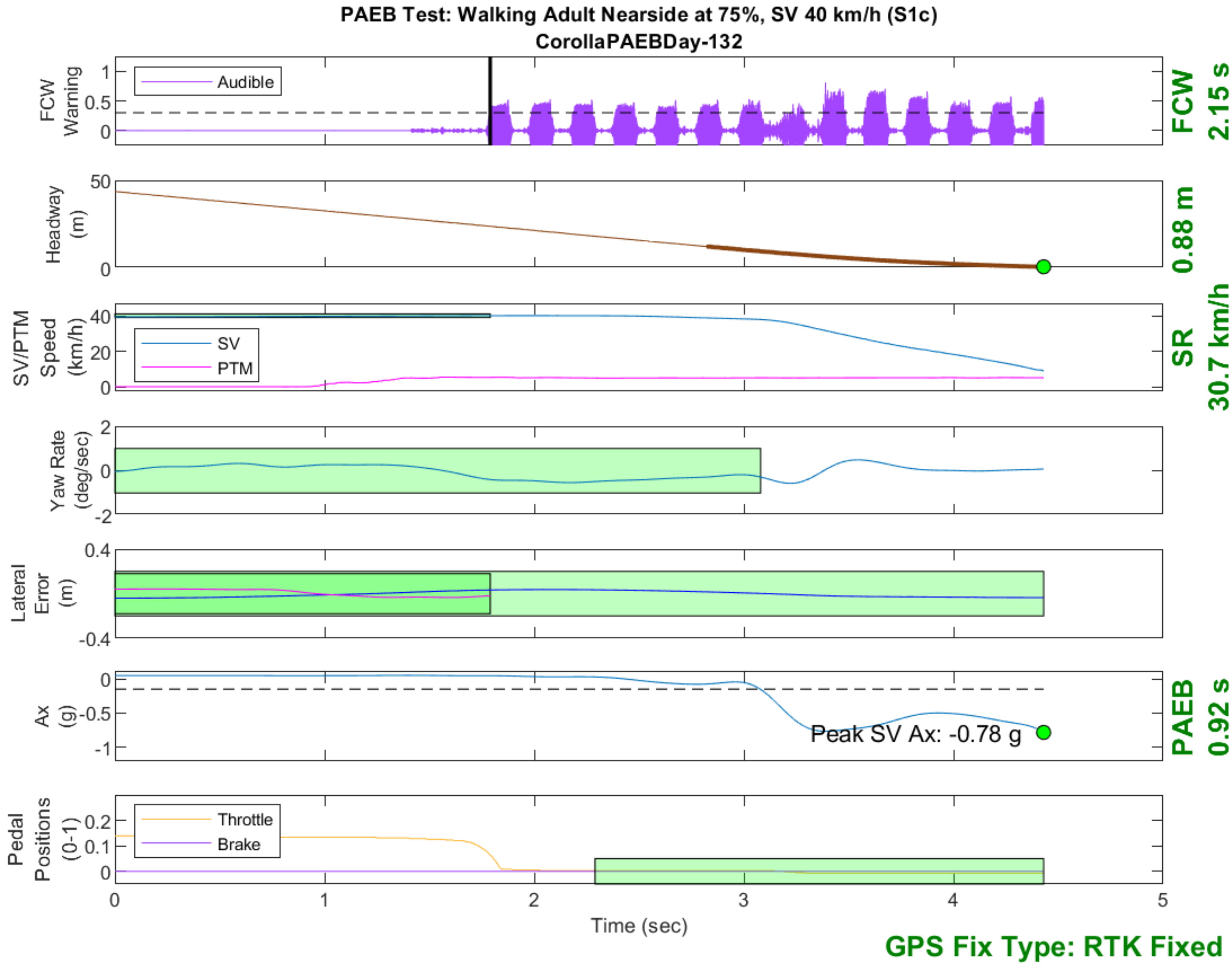


Figure D52. Time History for PAEB Run 132, S1c, Daytime, 40 km/h

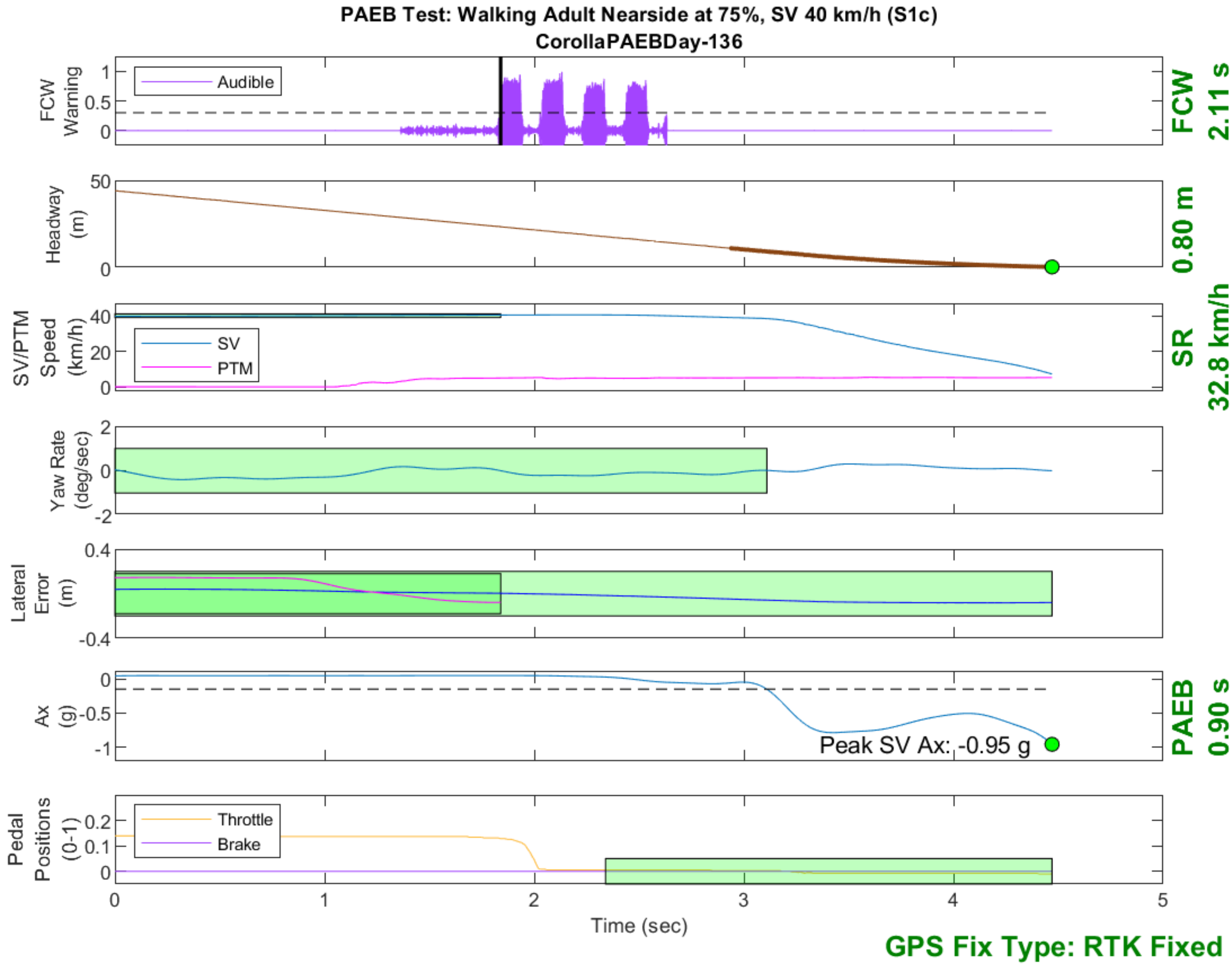


Figure D53. Time History for PAEB Run 136, S1c, Daytime, 40 km/h

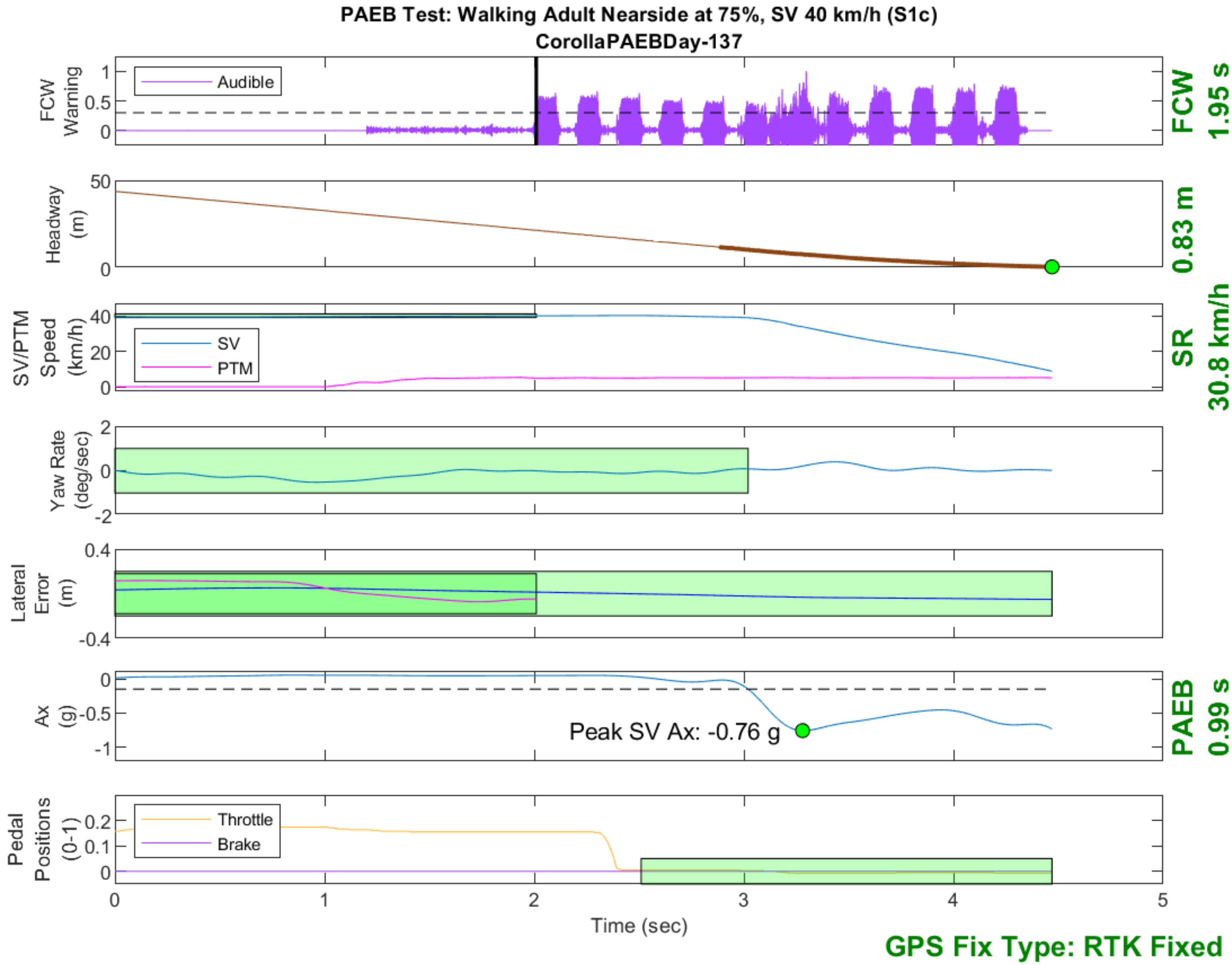


Figure D54. Time History for PAEB Run 137, S1c, Daytime, 40 km/h

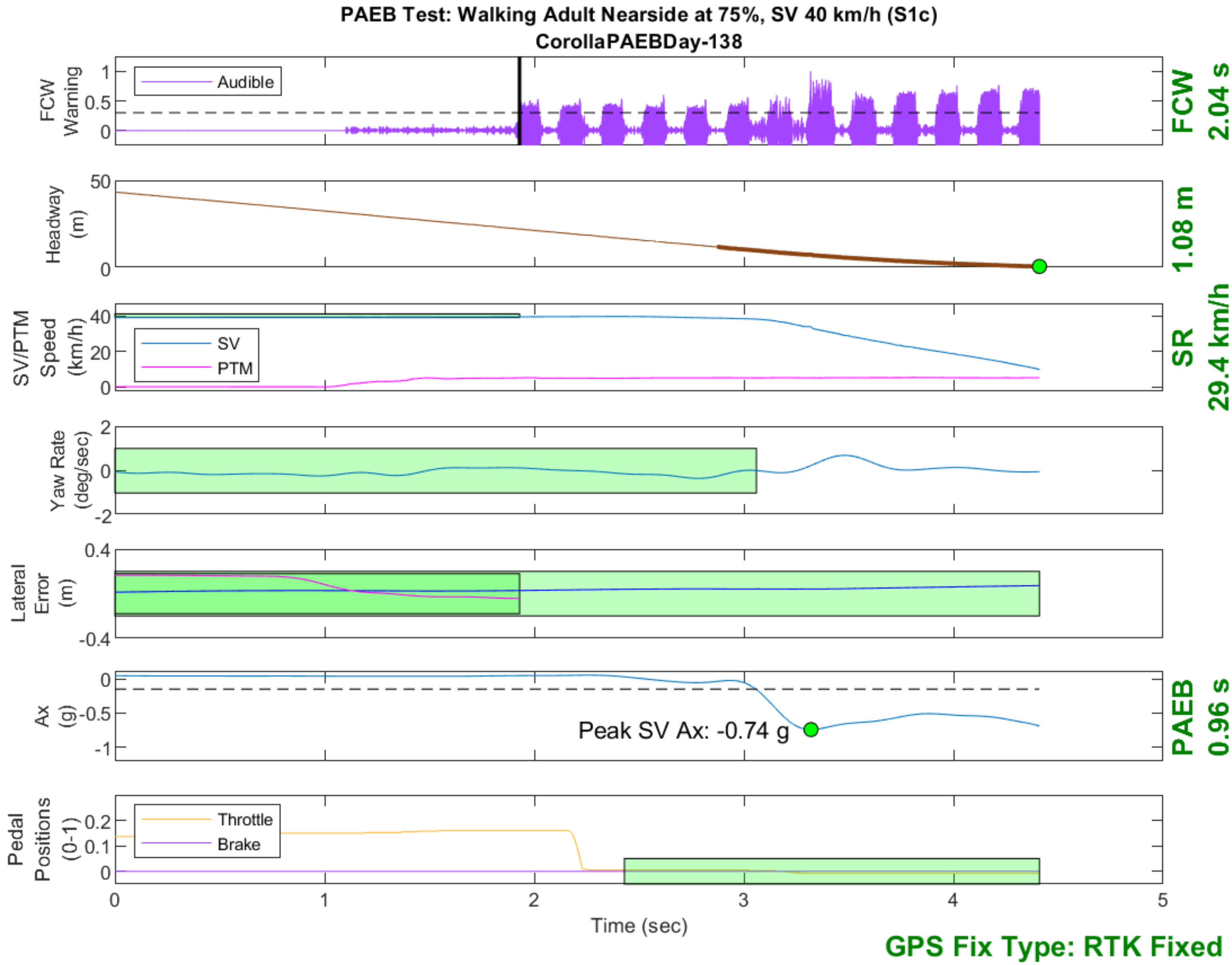


Figure D55. Time History for PAEB Run 138, S1c, Daytime, 40 km/h

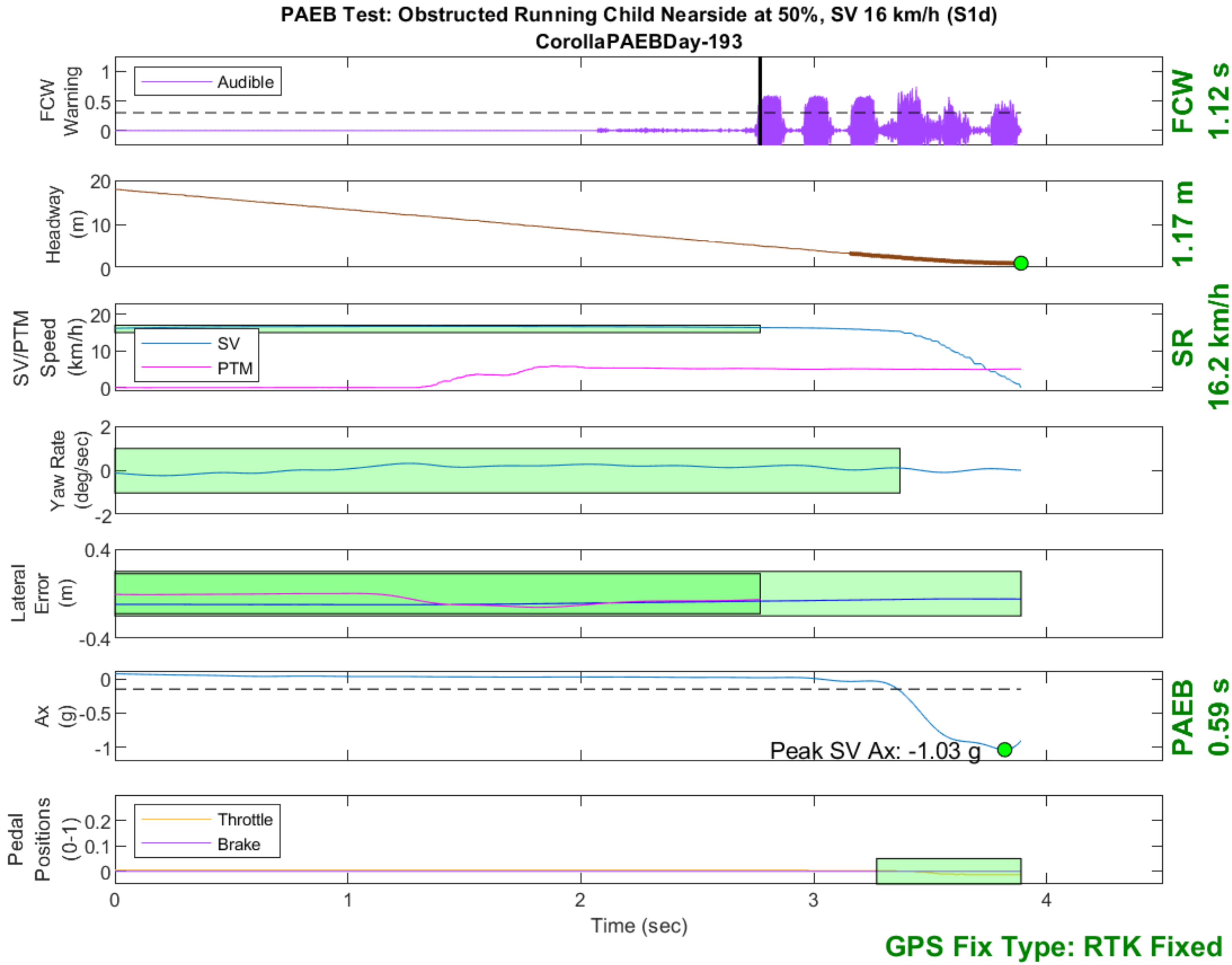


Figure D56. Time History for PAEB Run 193, S1d, Daytime, 16 km/h

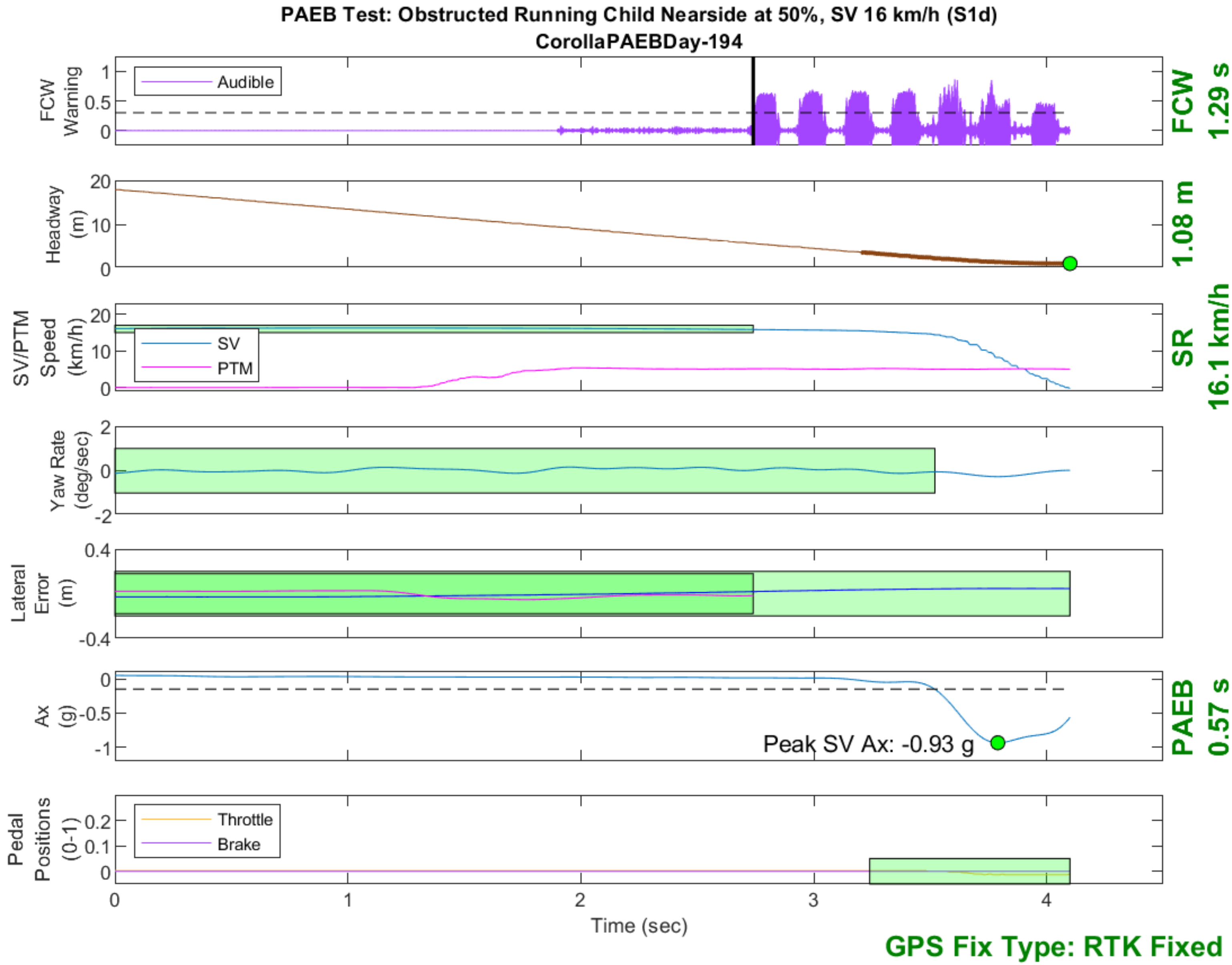


Figure D57. Time History for PAEB Run 194, S1d, Daytime, 16 km/h

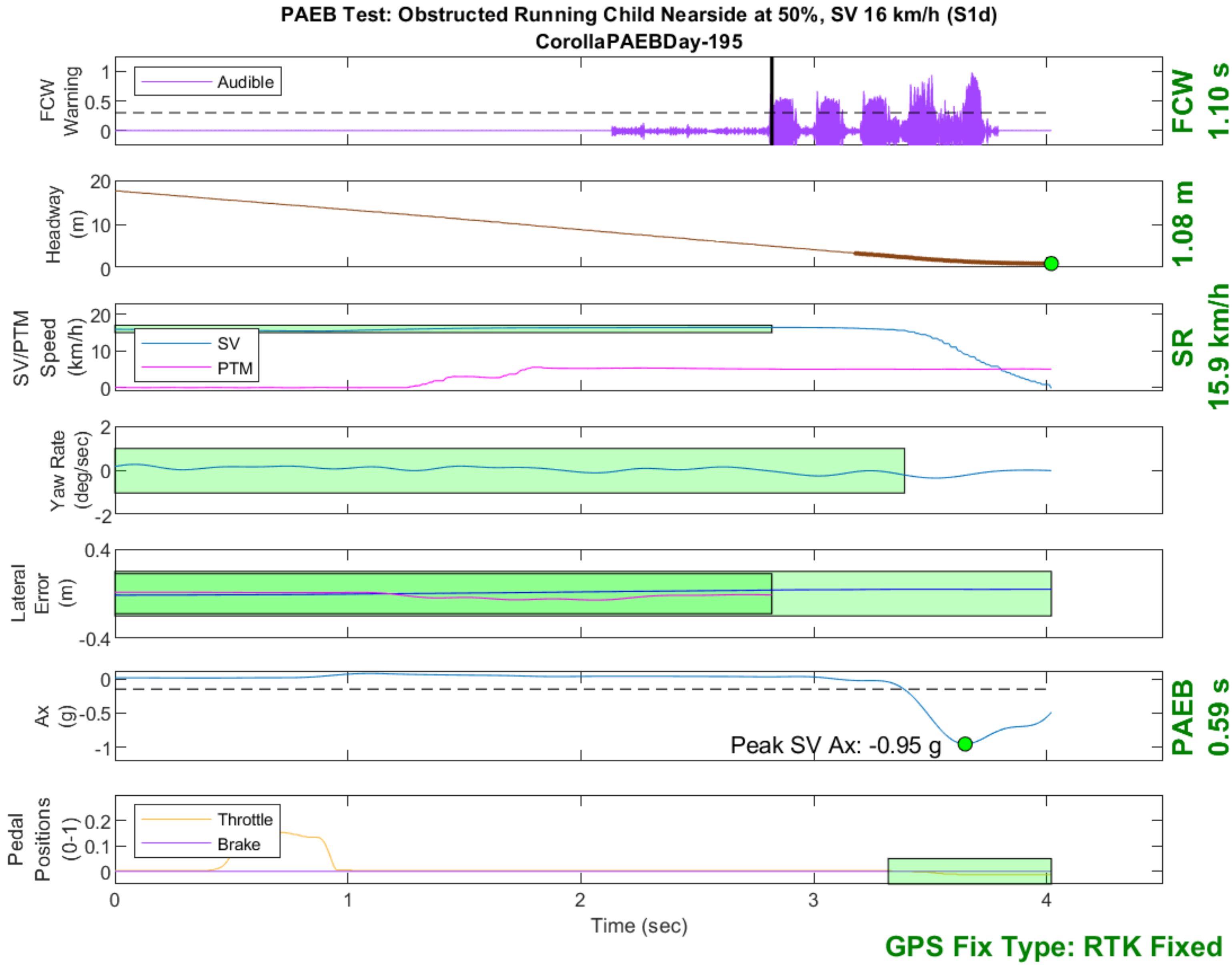


Figure D58. Time History for PAEB Run 195, S1d, Daytime, 16 km/h

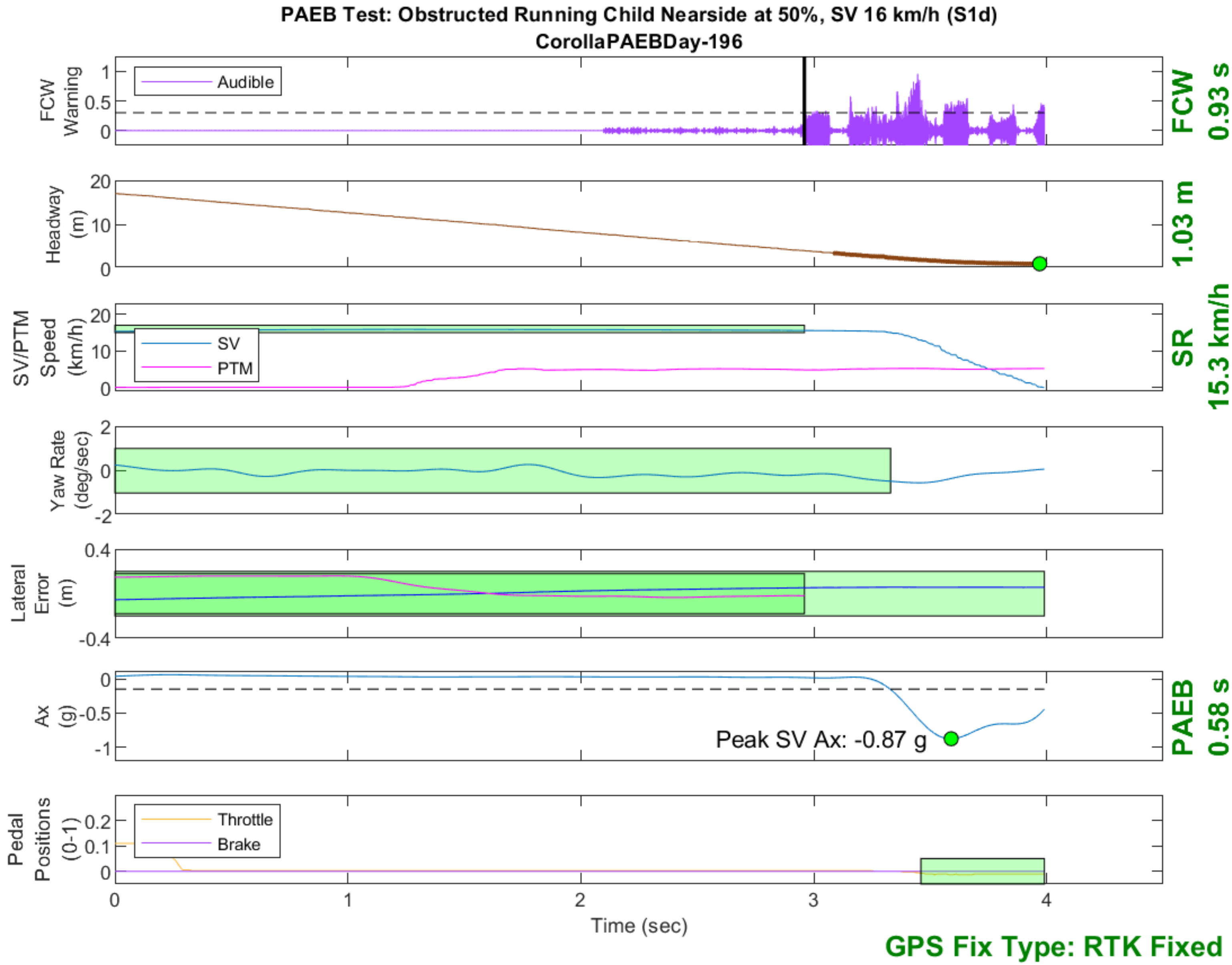


Figure D59. Time History for PAEB Run 196, S1d, Daytime, 16 km/h

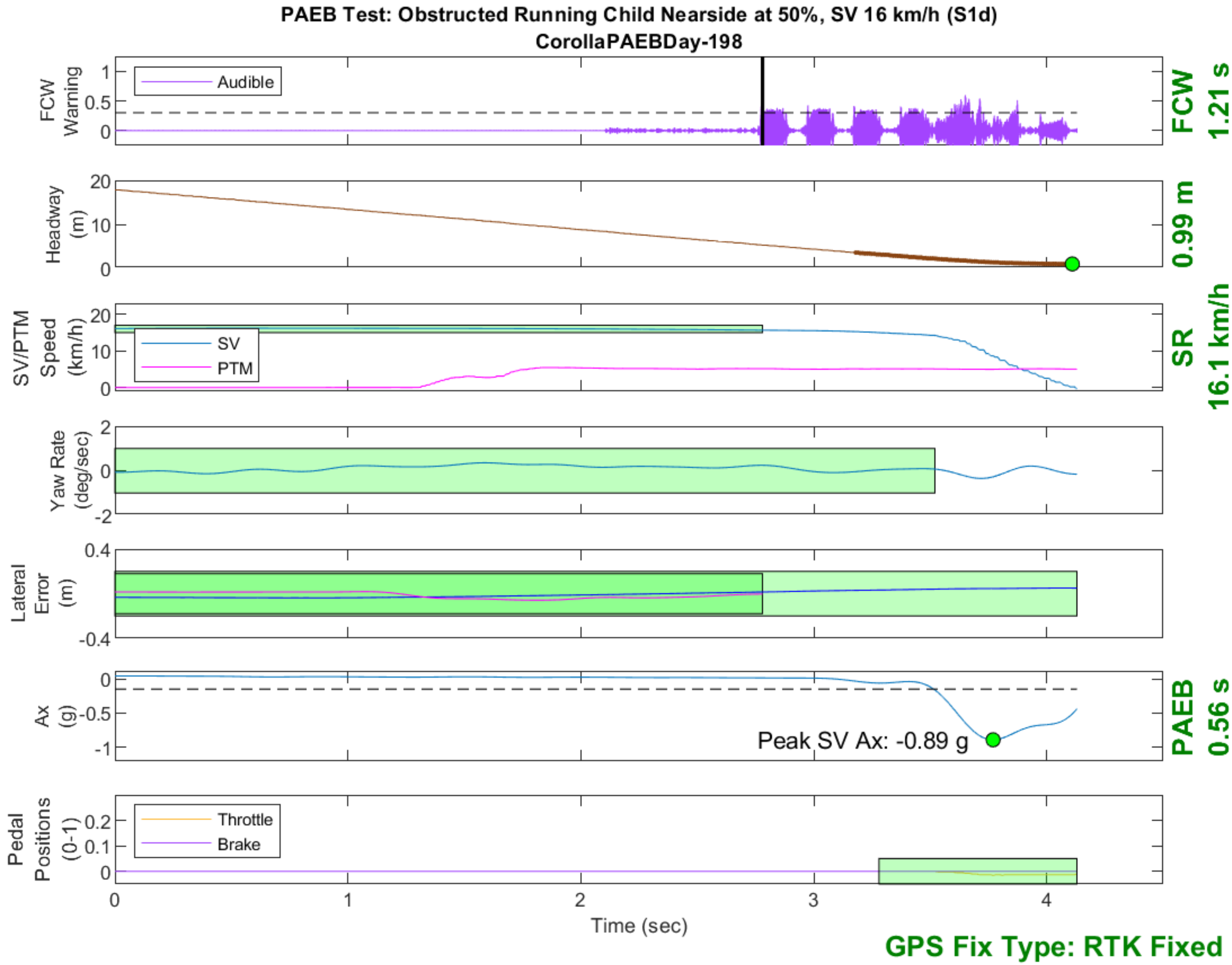


Figure D60. Time History for PAEB Run 198, S1d, Daytime, 16 km/h

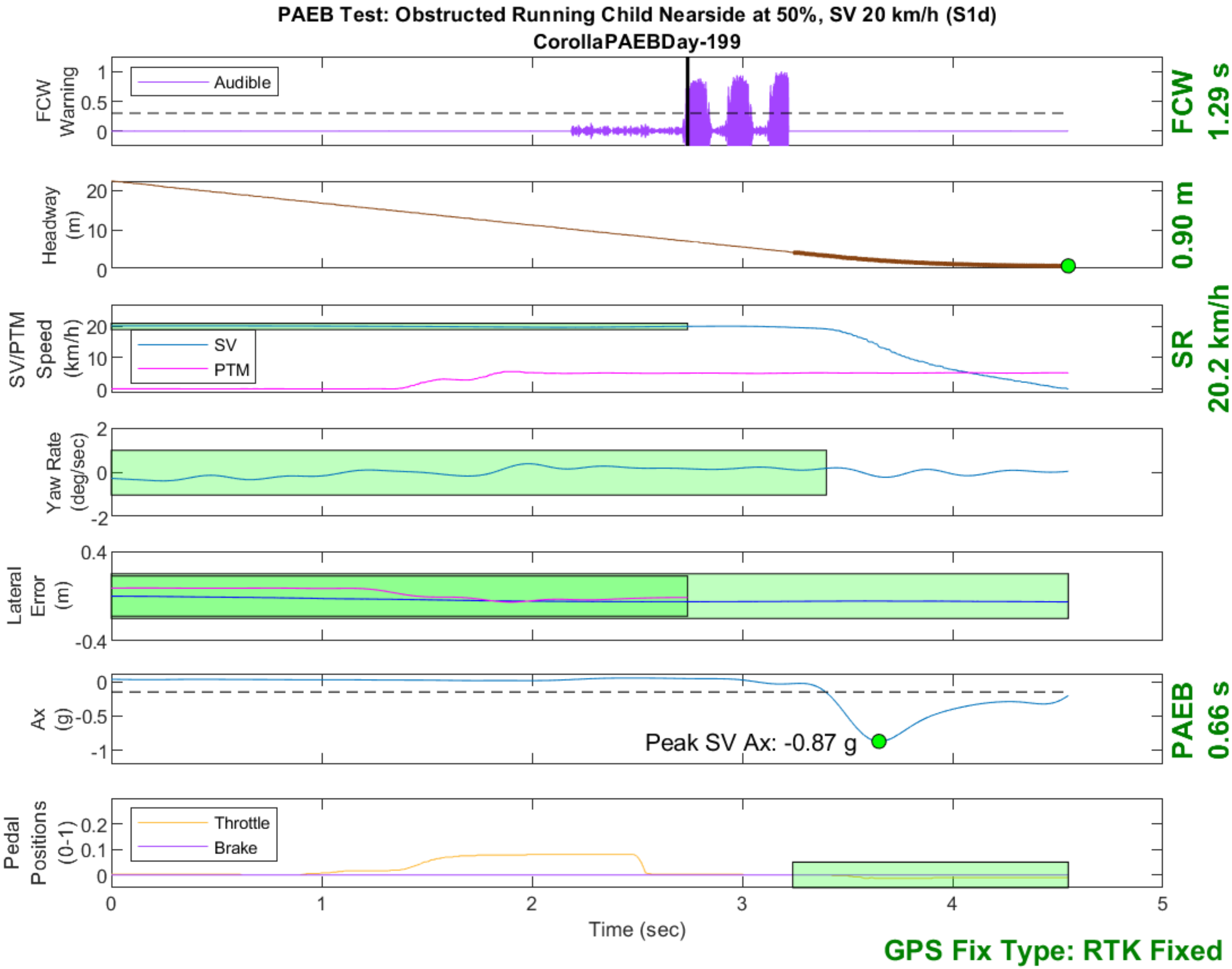


Figure D61. Time History for PAEB Run 199, S1d, Daytime, 20 km/h

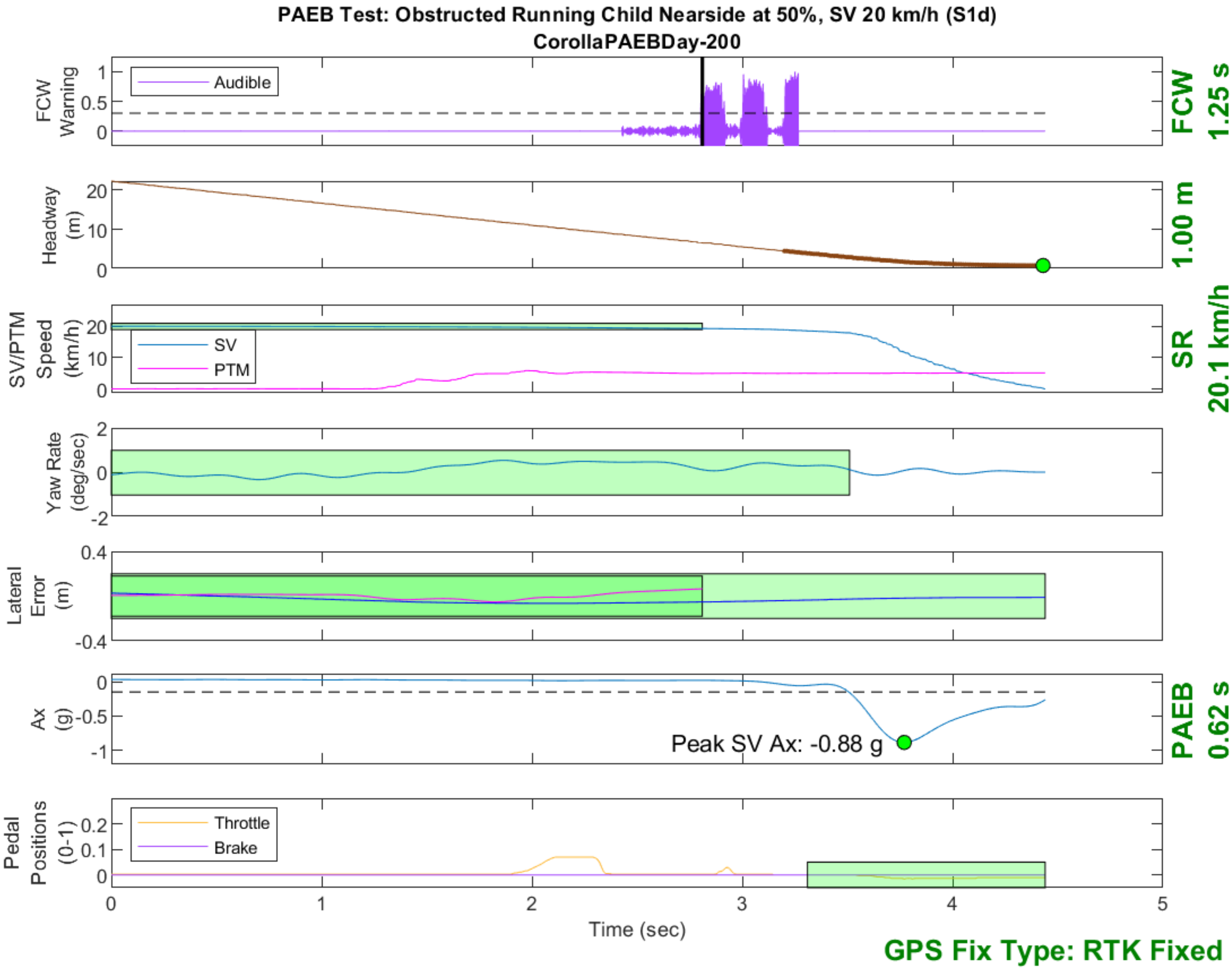


Figure D62. Time History for PAEB Run 200, S1d, Daytime, 20 km/h

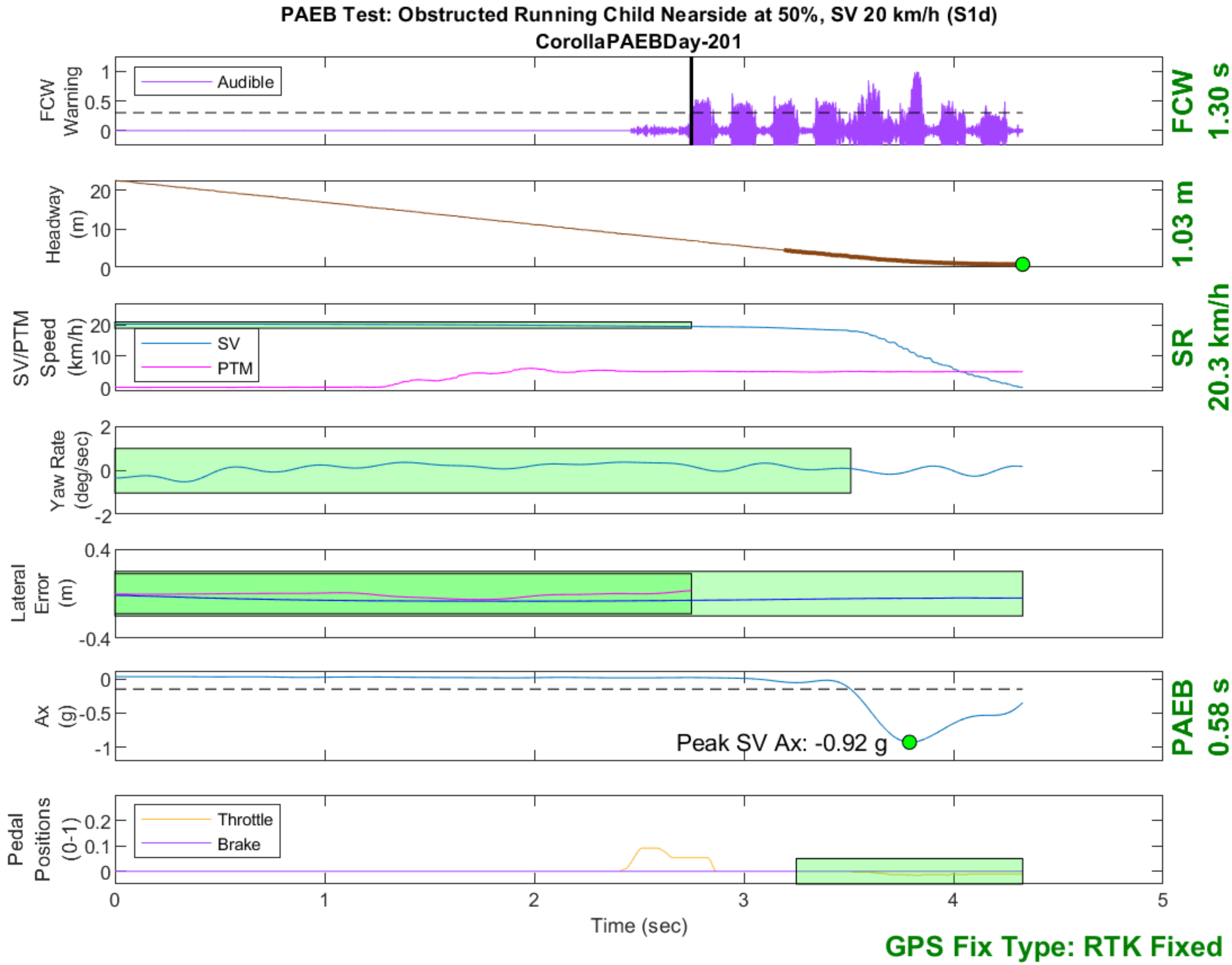


Figure D63. Time History for PAEB Run 201, S1d, Daytime, 20 km/h

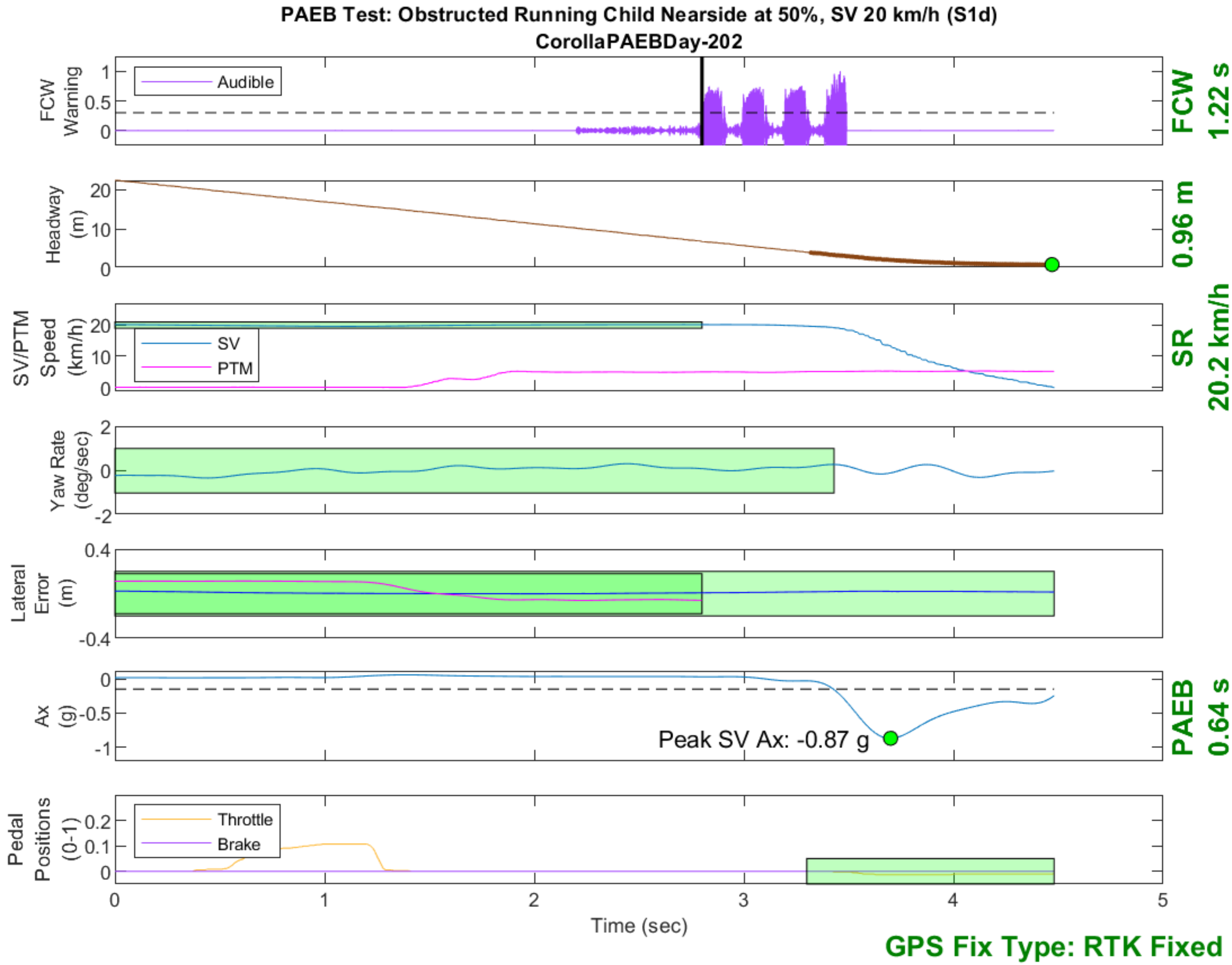


Figure D64. Time History for PAEB Run 202, S1d, Daytime, 20 km/h

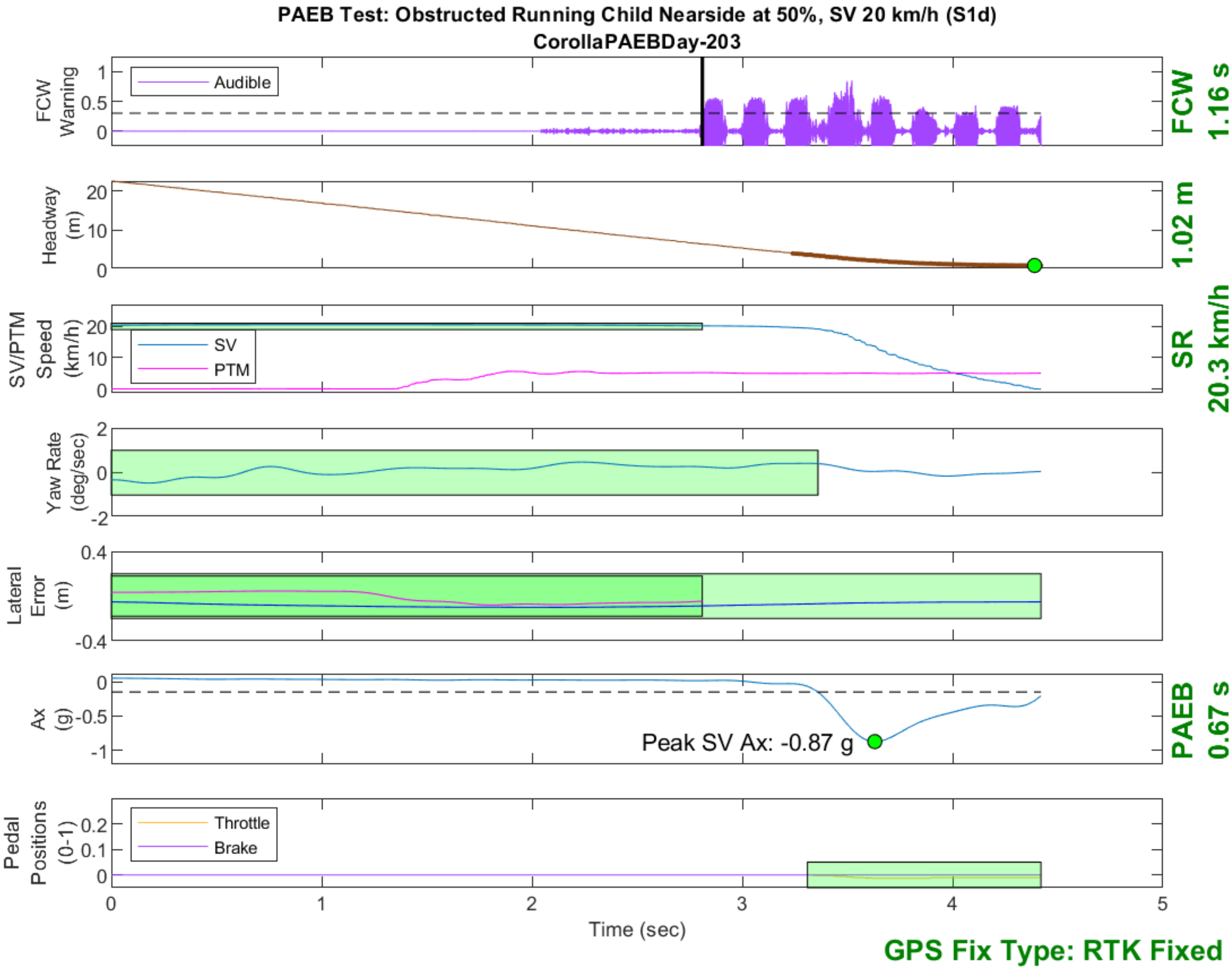


Figure D65. Time History for PAEB Run 203, S1d, Daytime, 20 km/h

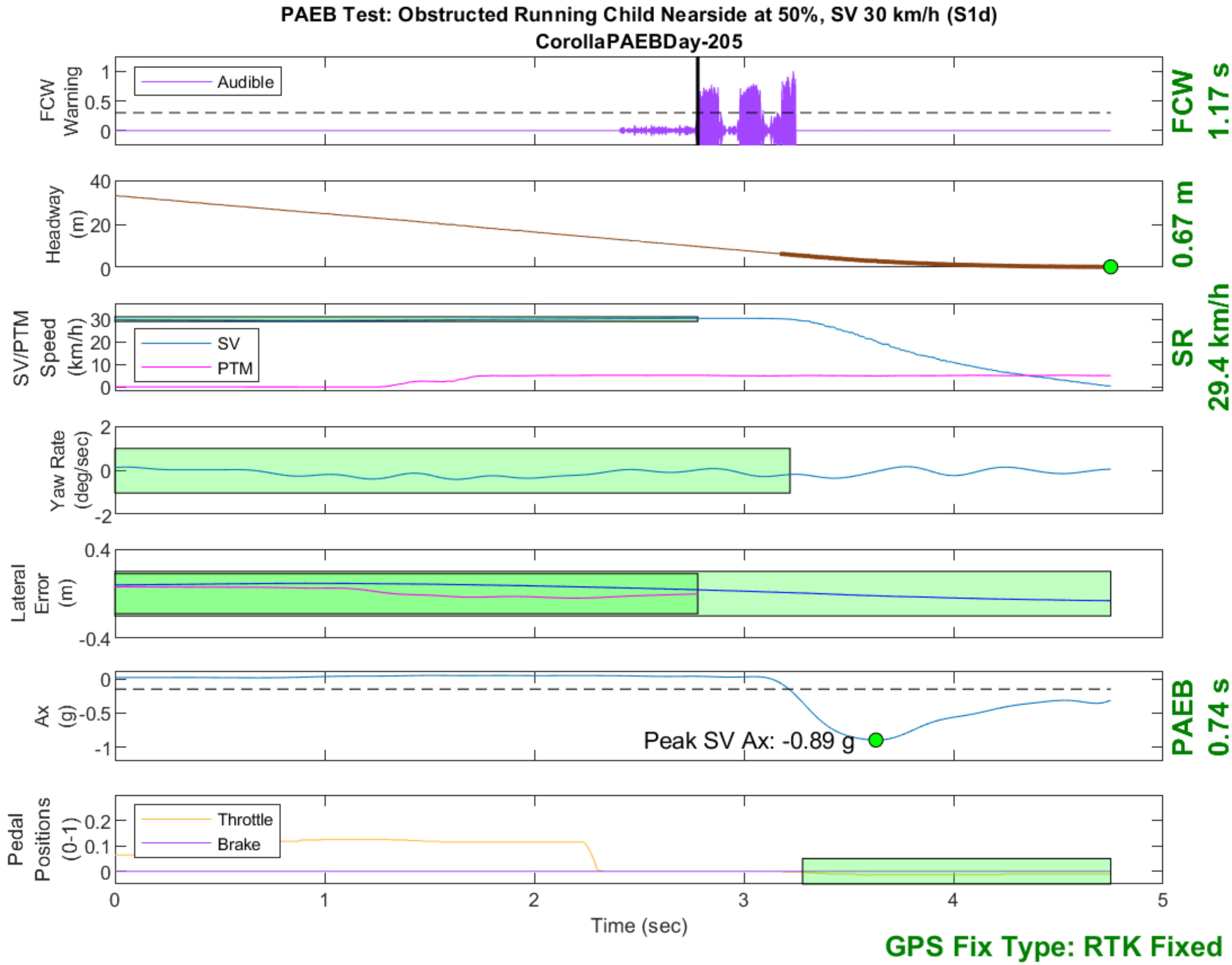


Figure D66. Time History for PAEB Run 205, S1d, Daytime, 30 km/h

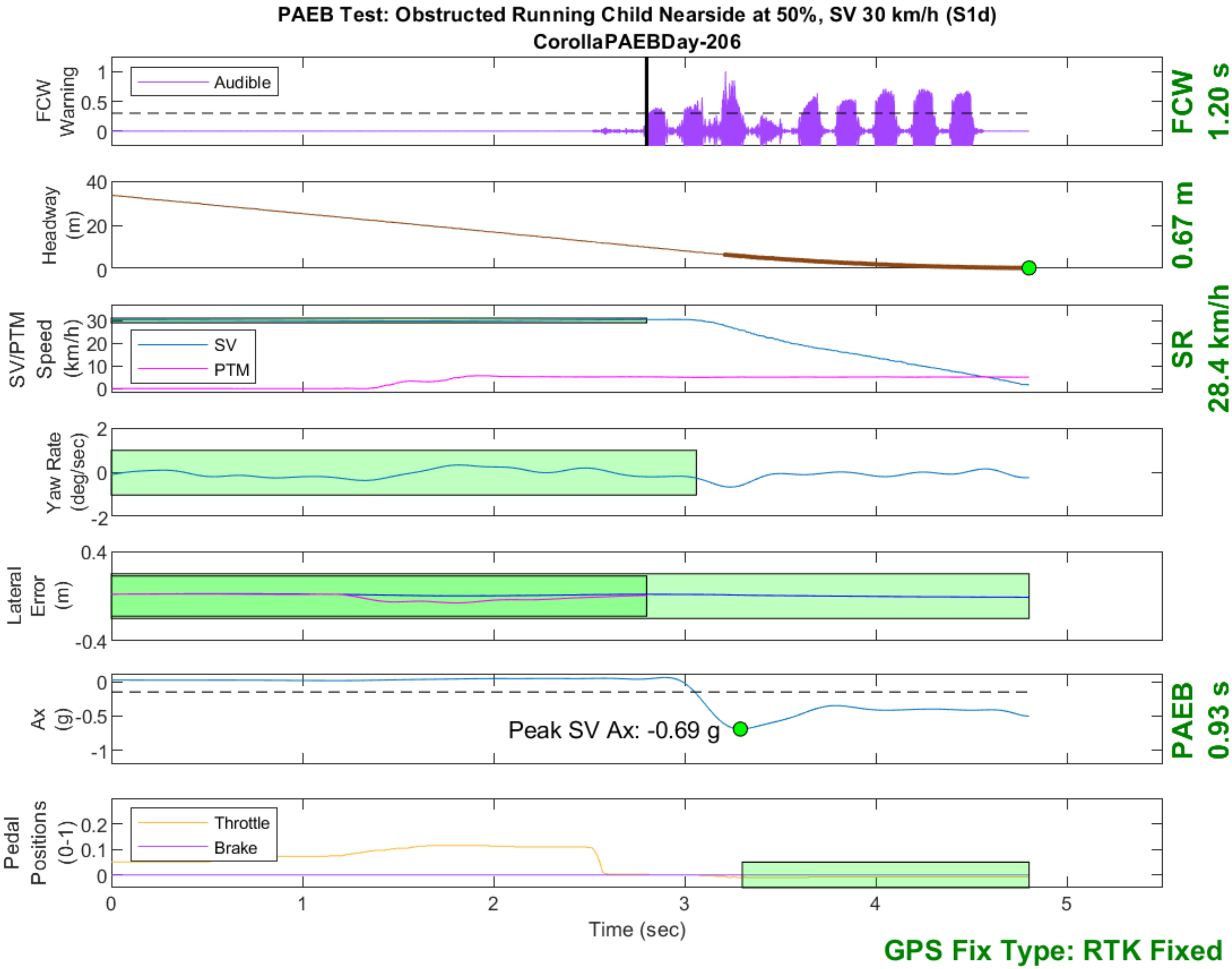


Figure D67. Time History for PAEB Run 206, S1d, Daytime, 30 km/h

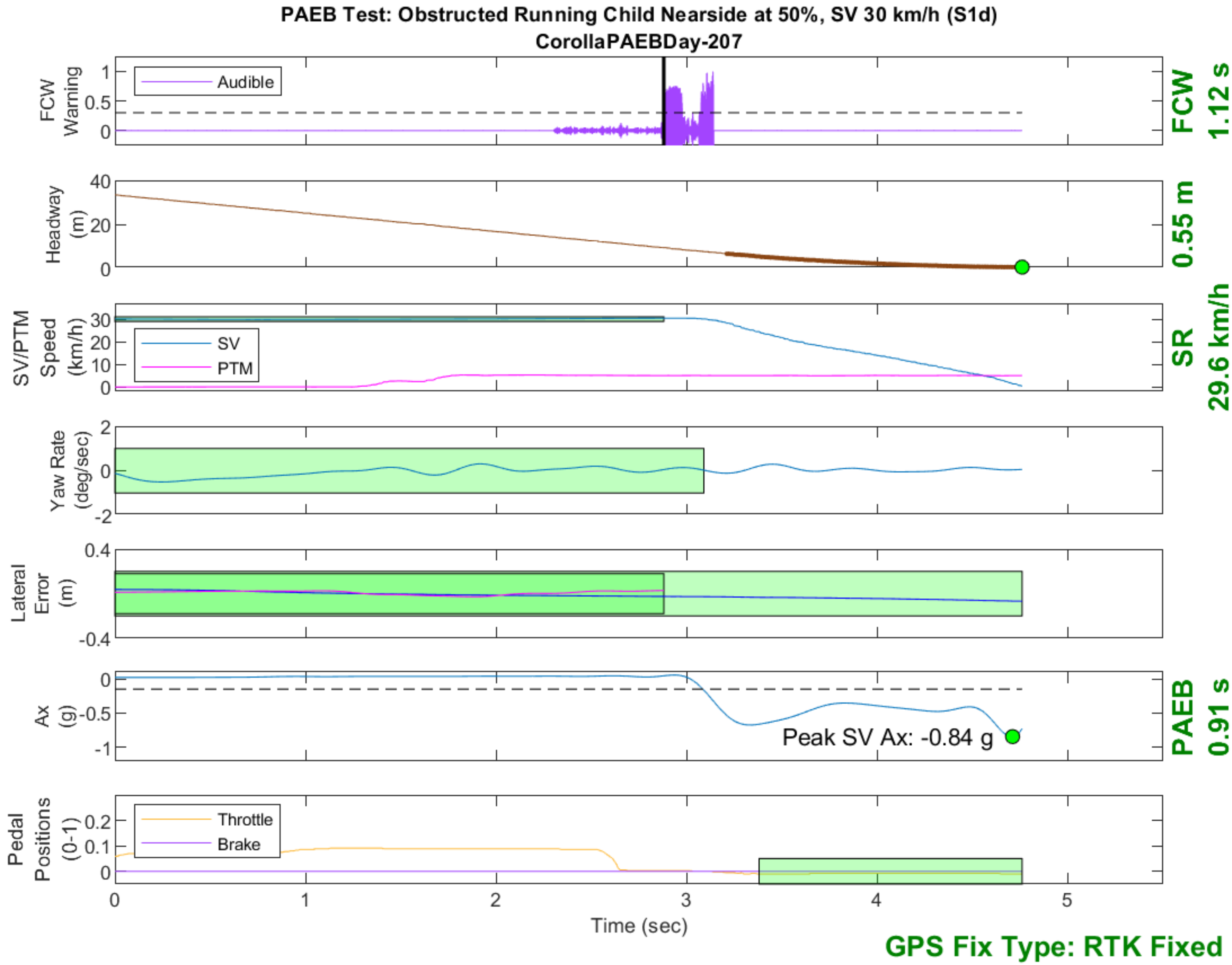


Figure D68. Time History for PAEB Run 207, S1d, Daytime, 30 km/h

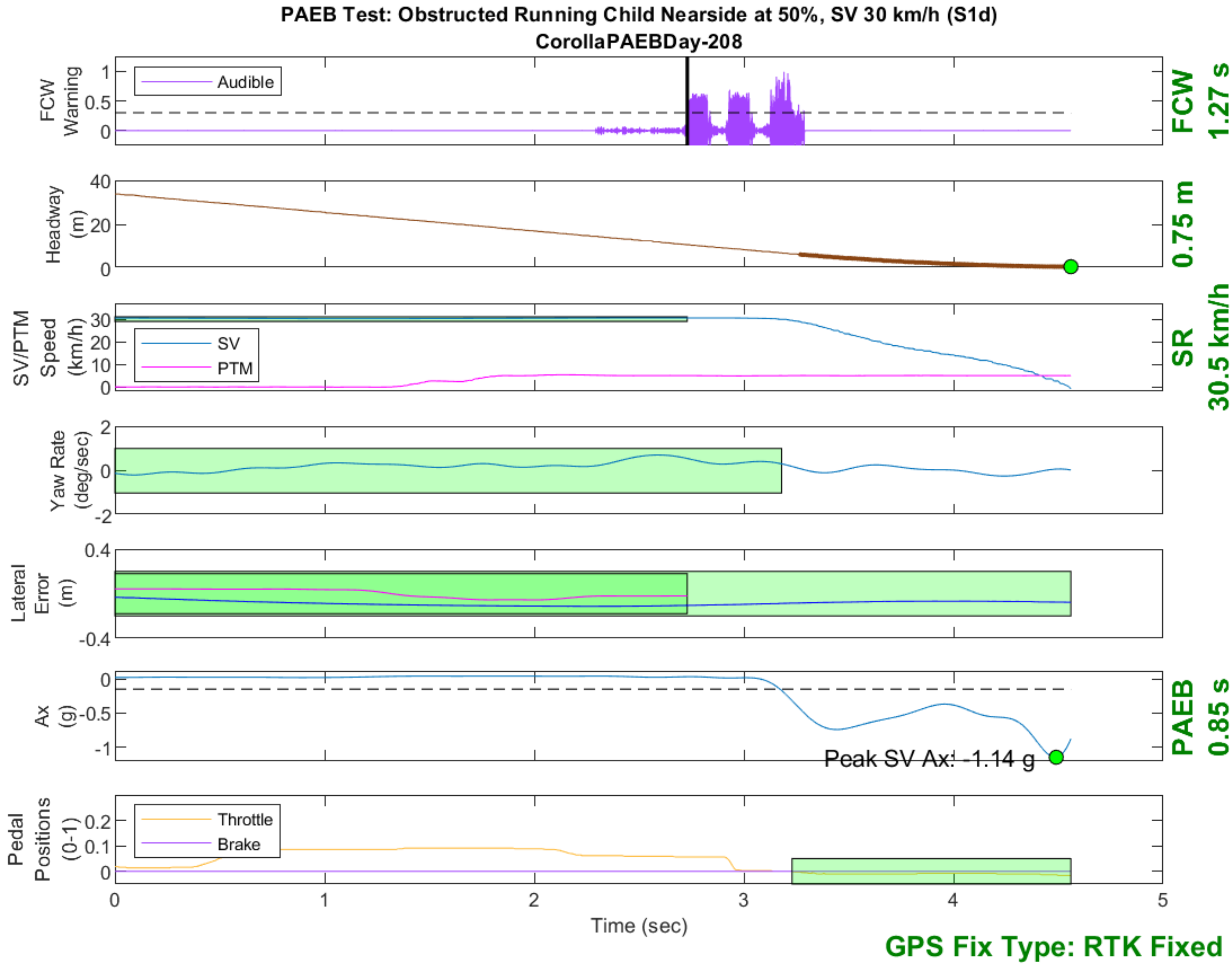


Figure D69. Time History for PAEB Run 208, S1d, Daytime, 30 km/h

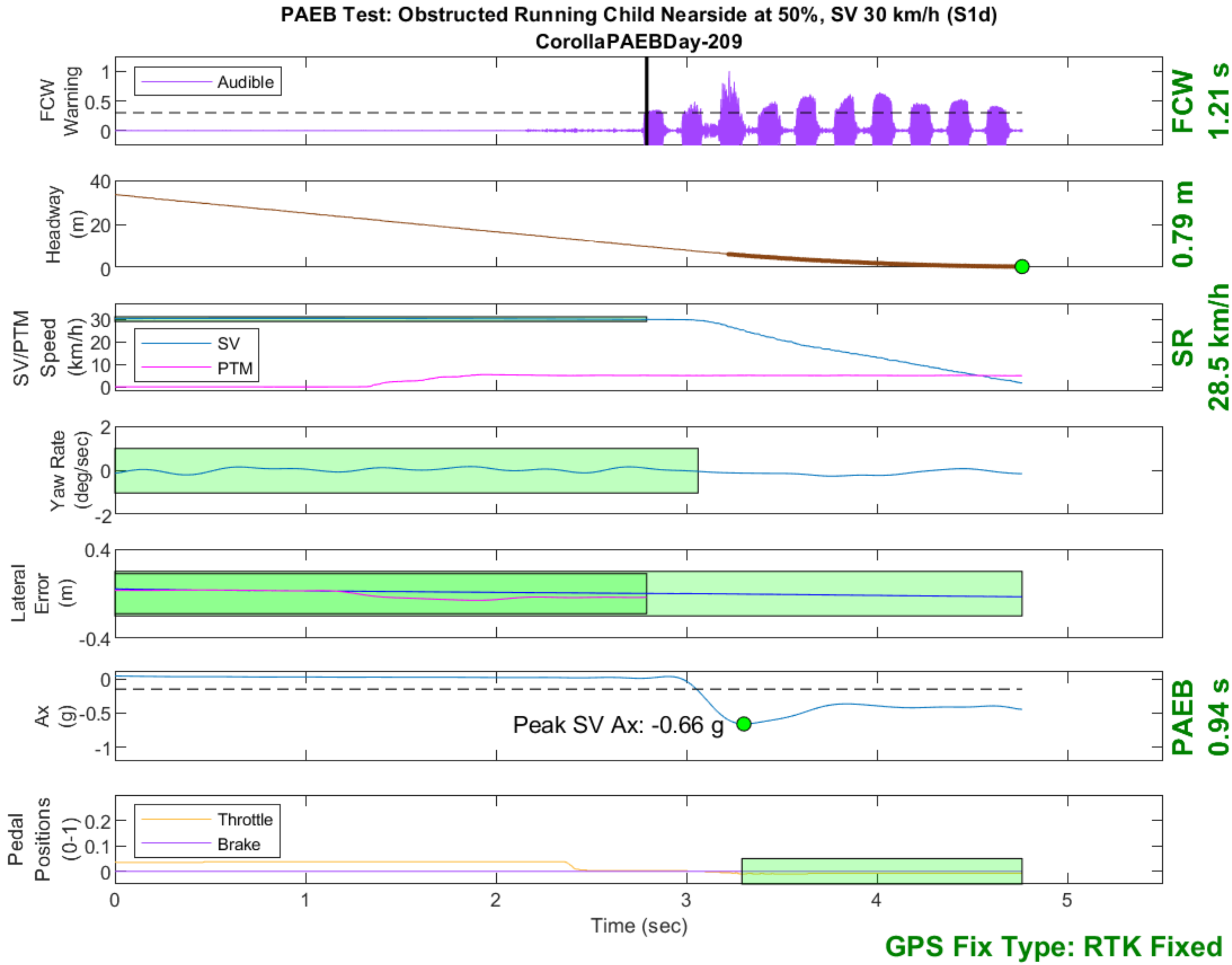


Figure D70. Time History for PAEB Run 209, S1d, Daytime, 30 km/h

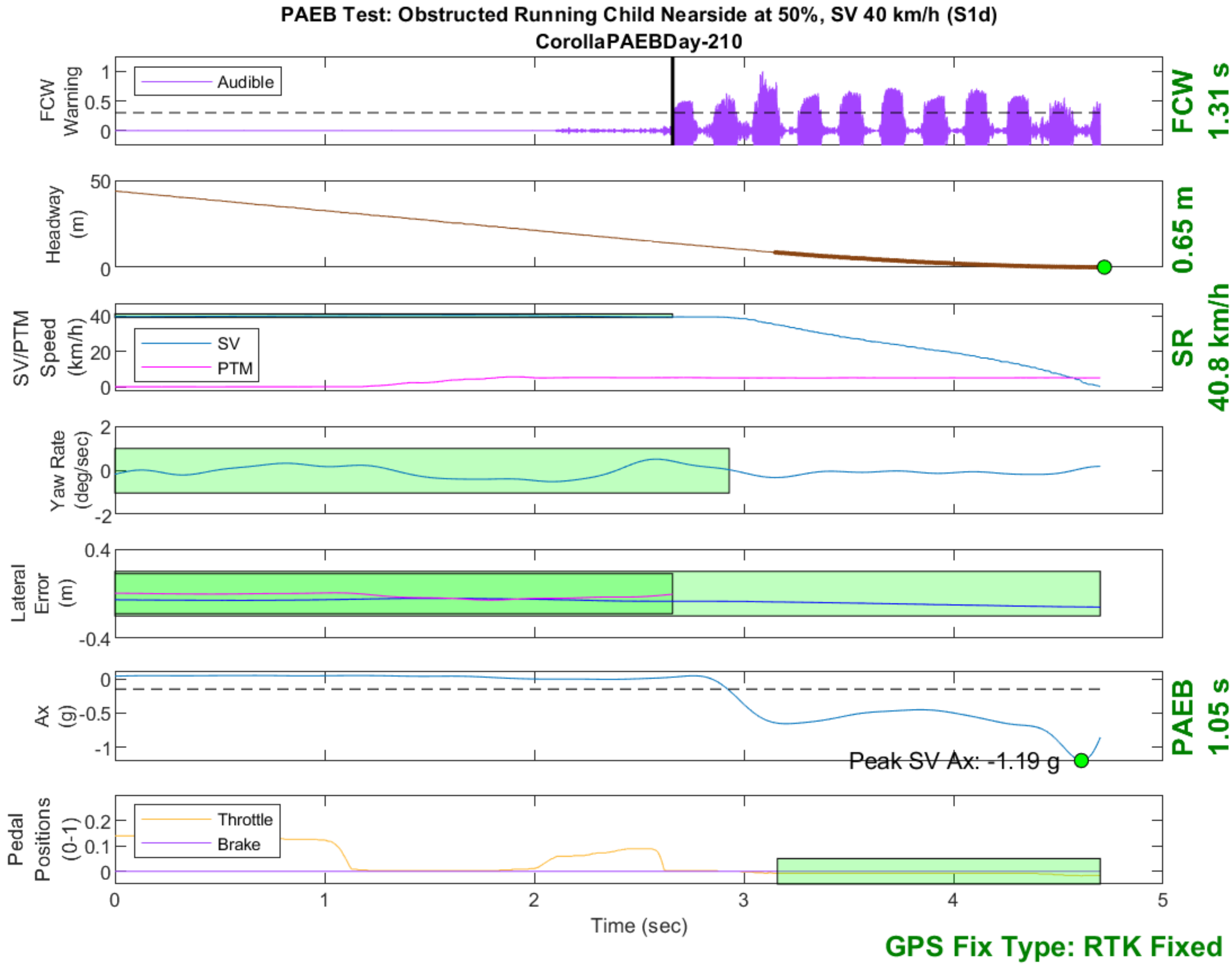


Figure D71. Time History for PAEB Run 210, S1d, Daytime, 40 km/h

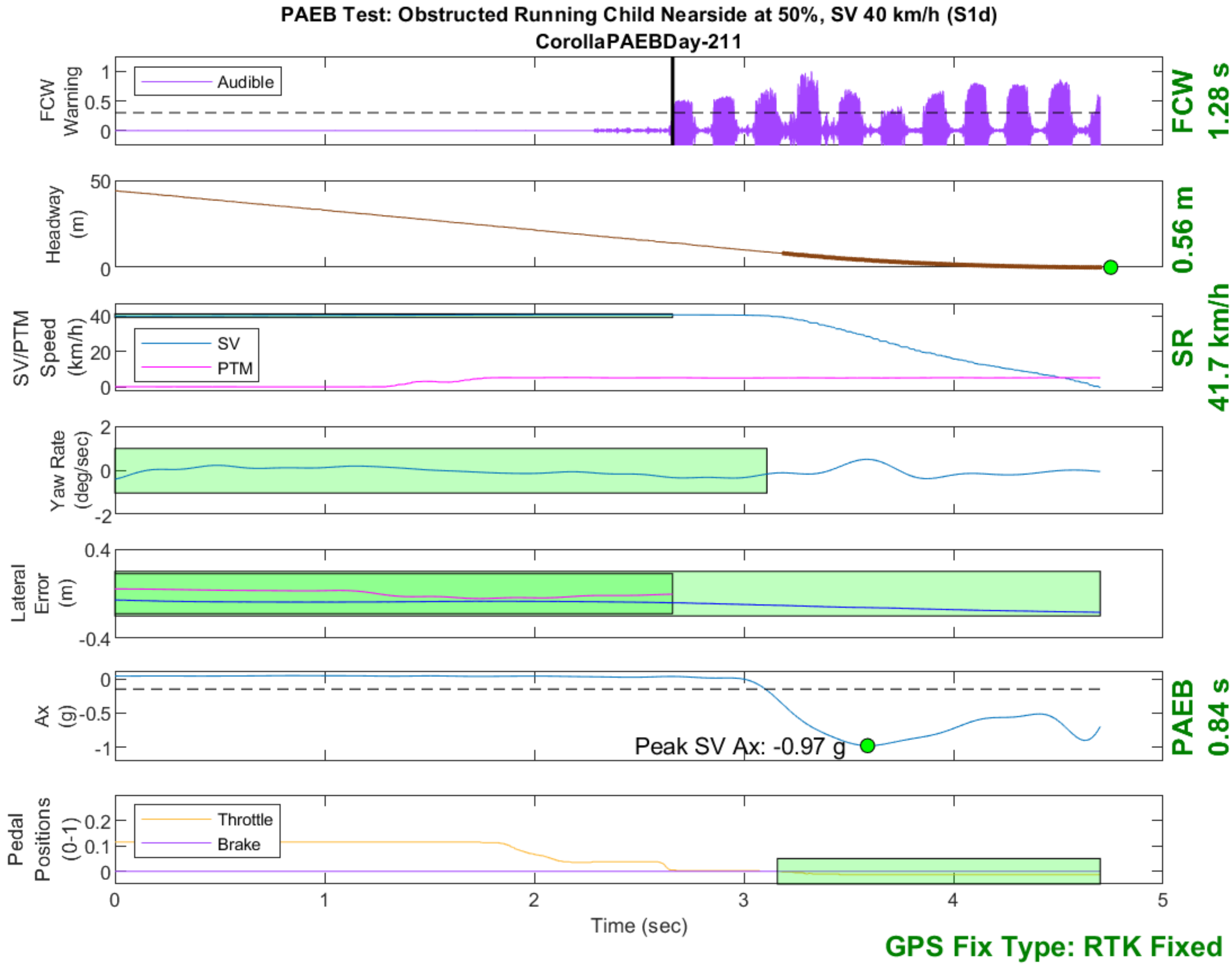


Figure D72. Time History for PAEB Run 211, S1d, Daytime, 40 km/h

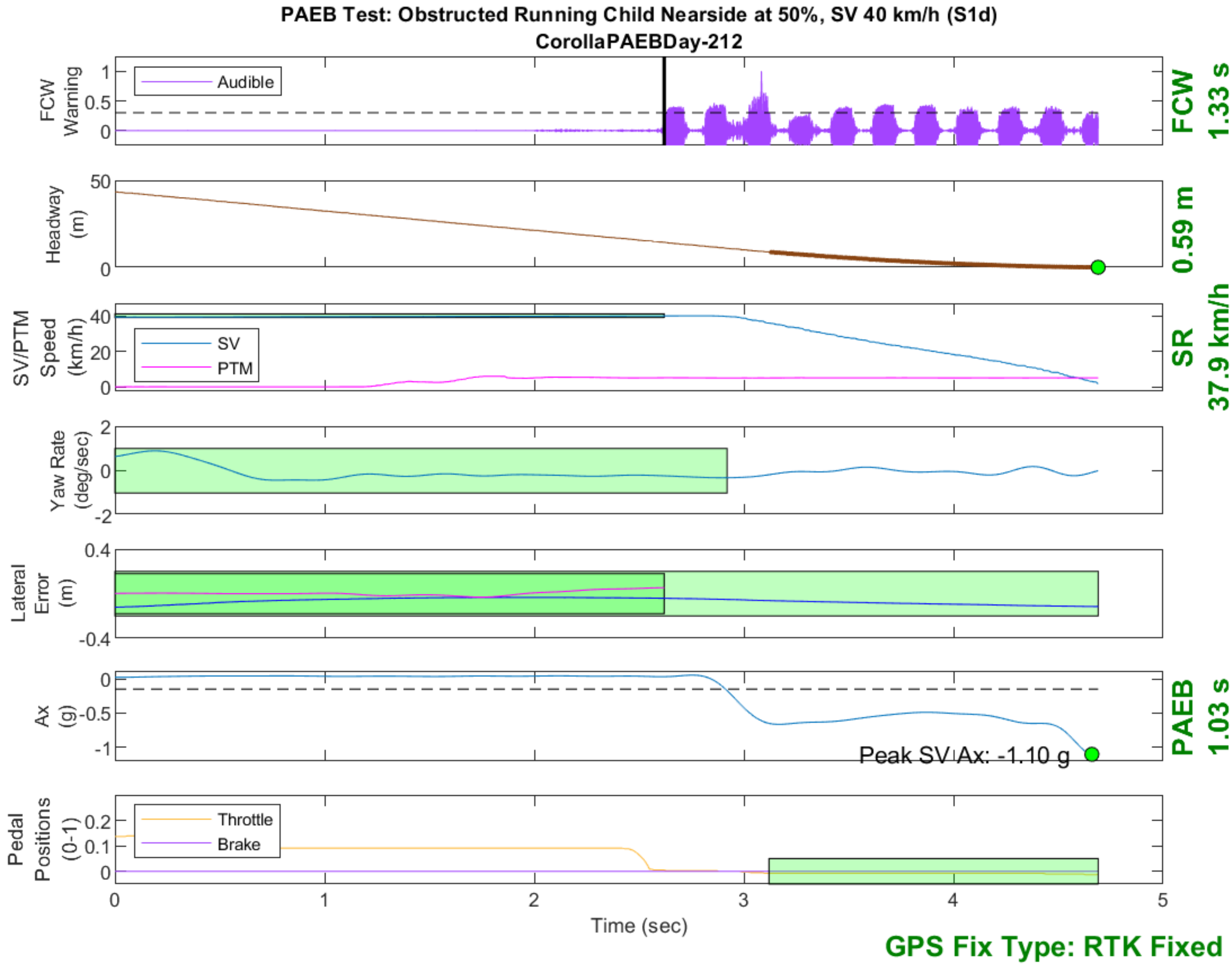


Figure D73. Time History for PAEB Run 212, S1d, Daytime, 40 km/h

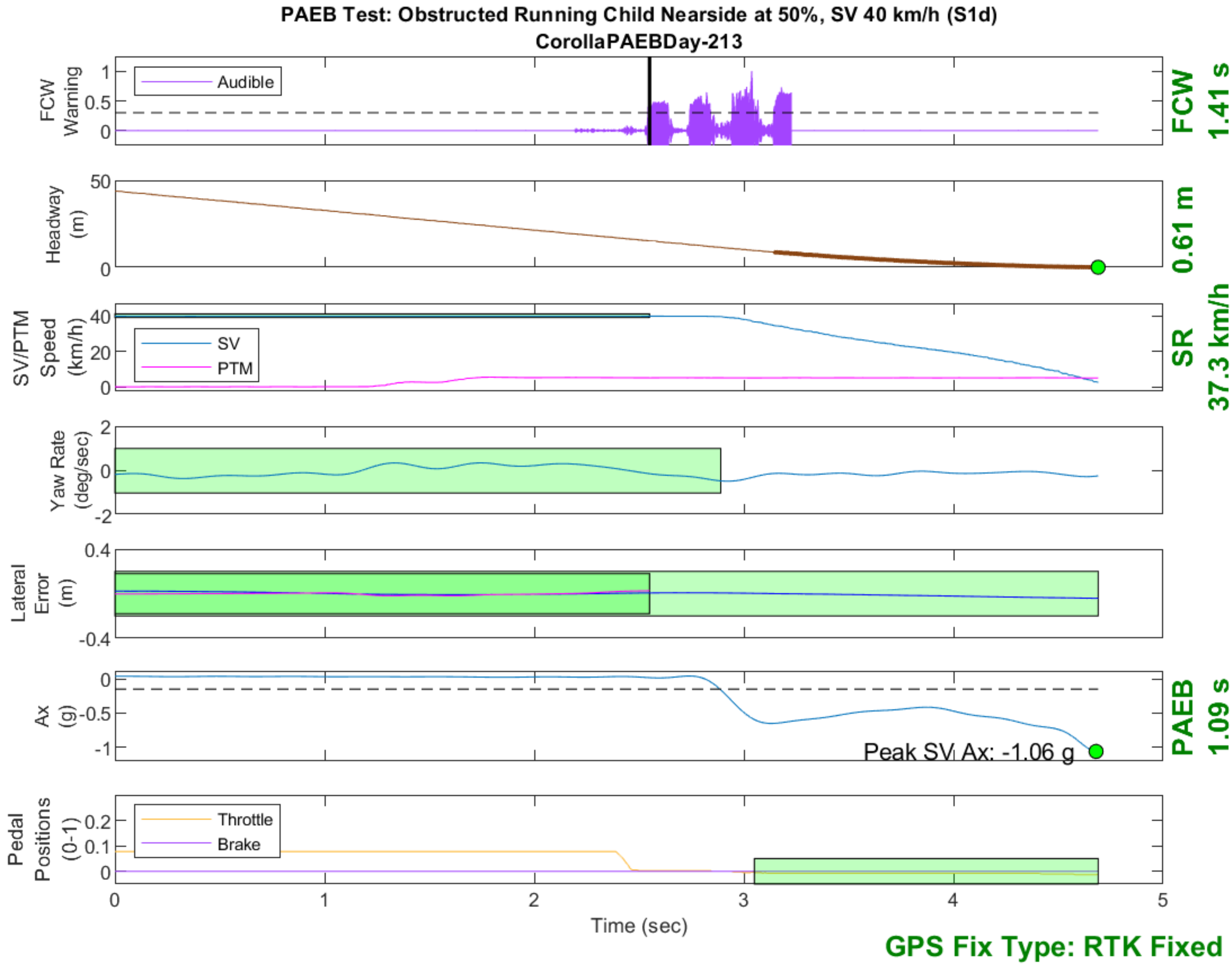


Figure D74. Time History for PAEB Run 213, S1d, Daytime, 40 km/h

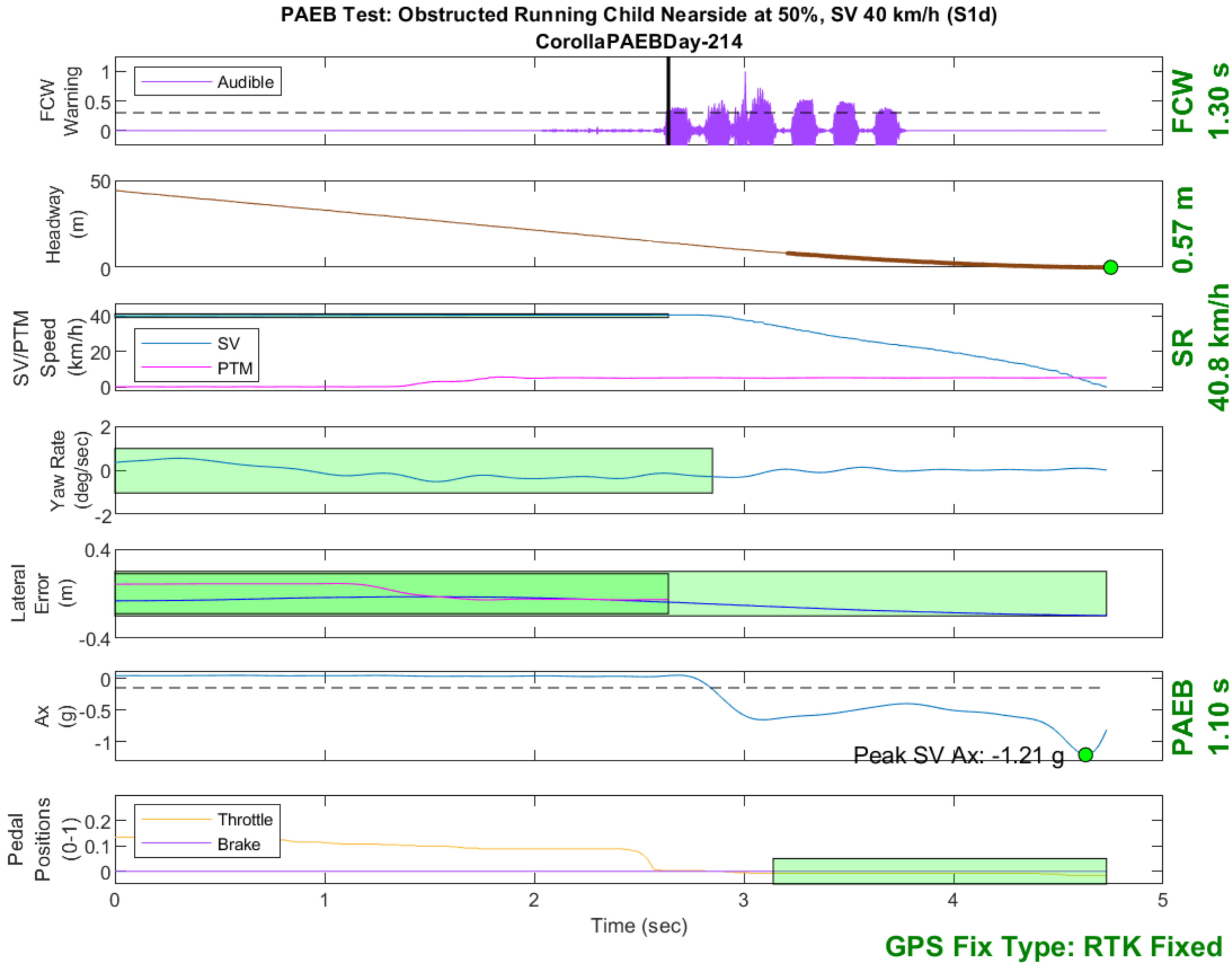


Figure D75. Time History for PAEB Run 214, S1d, Daytime, 40 km/h

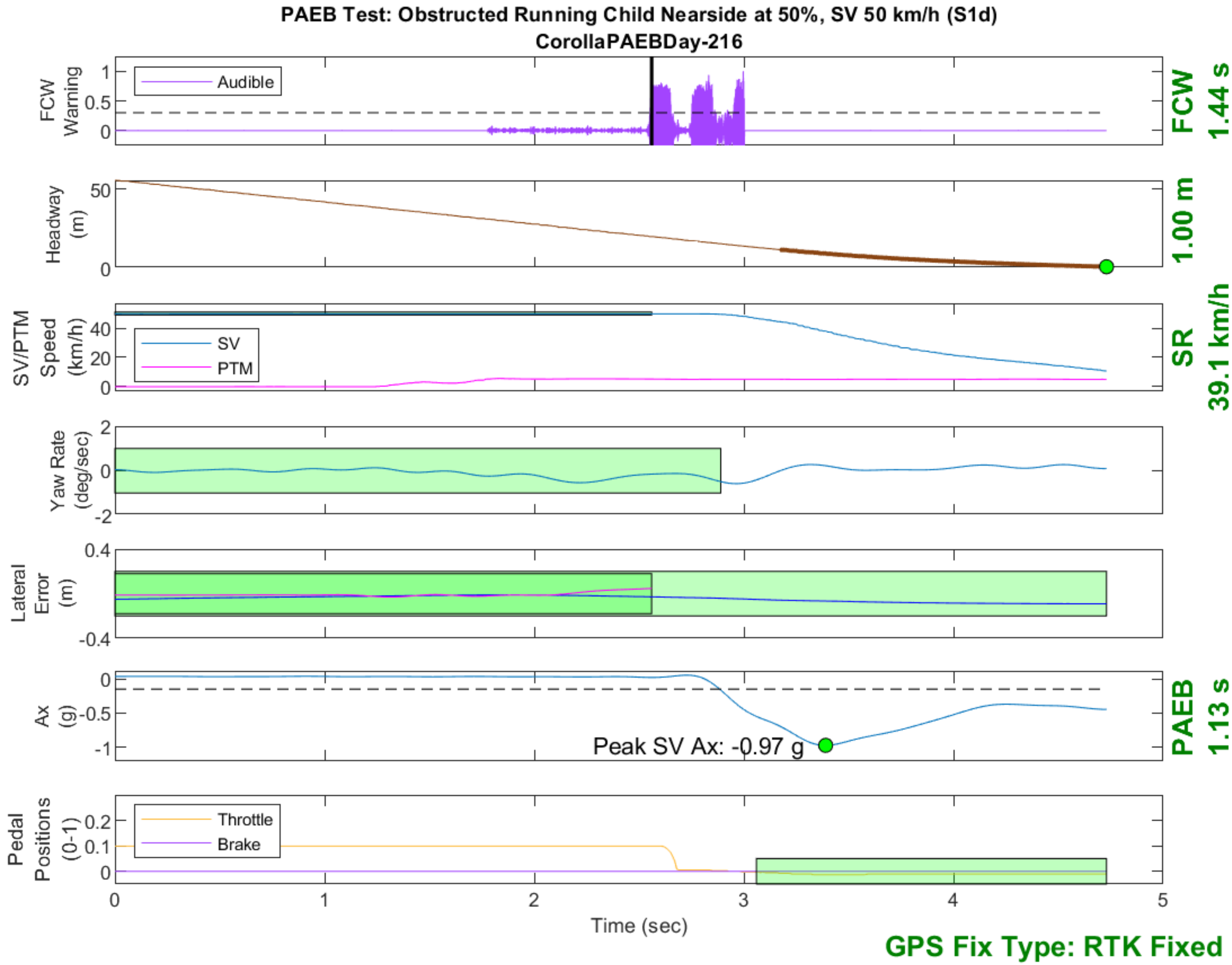


Figure D76. Time History for PAEB Run 216, S1d, Daytime, 50 km/h

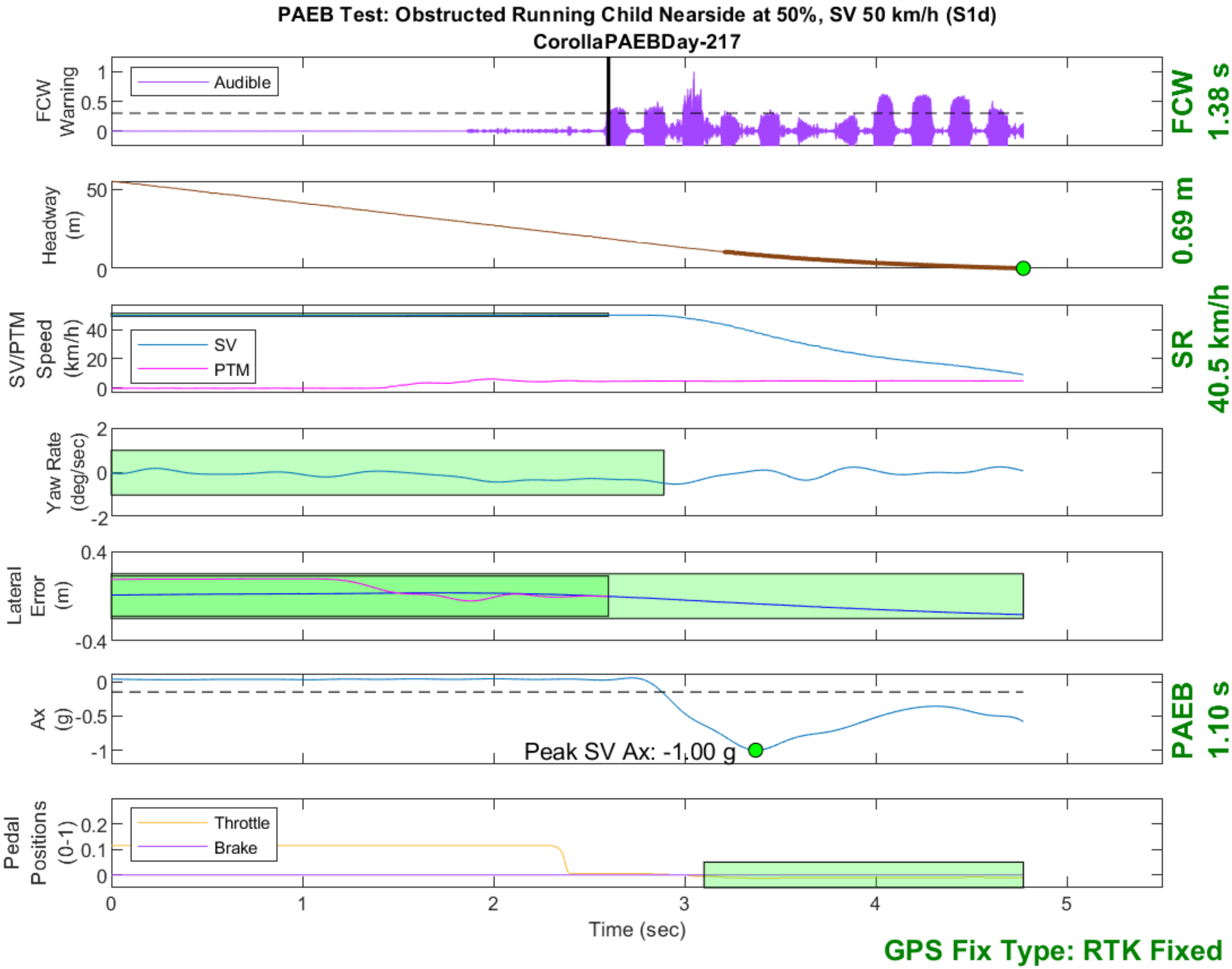


Figure D77. Time History for PAEB Run 217, S1d, Daytime, 50 km/h

Figure D78. Time History for PAEB Run 218, S1d, Daytime, 50 km/h

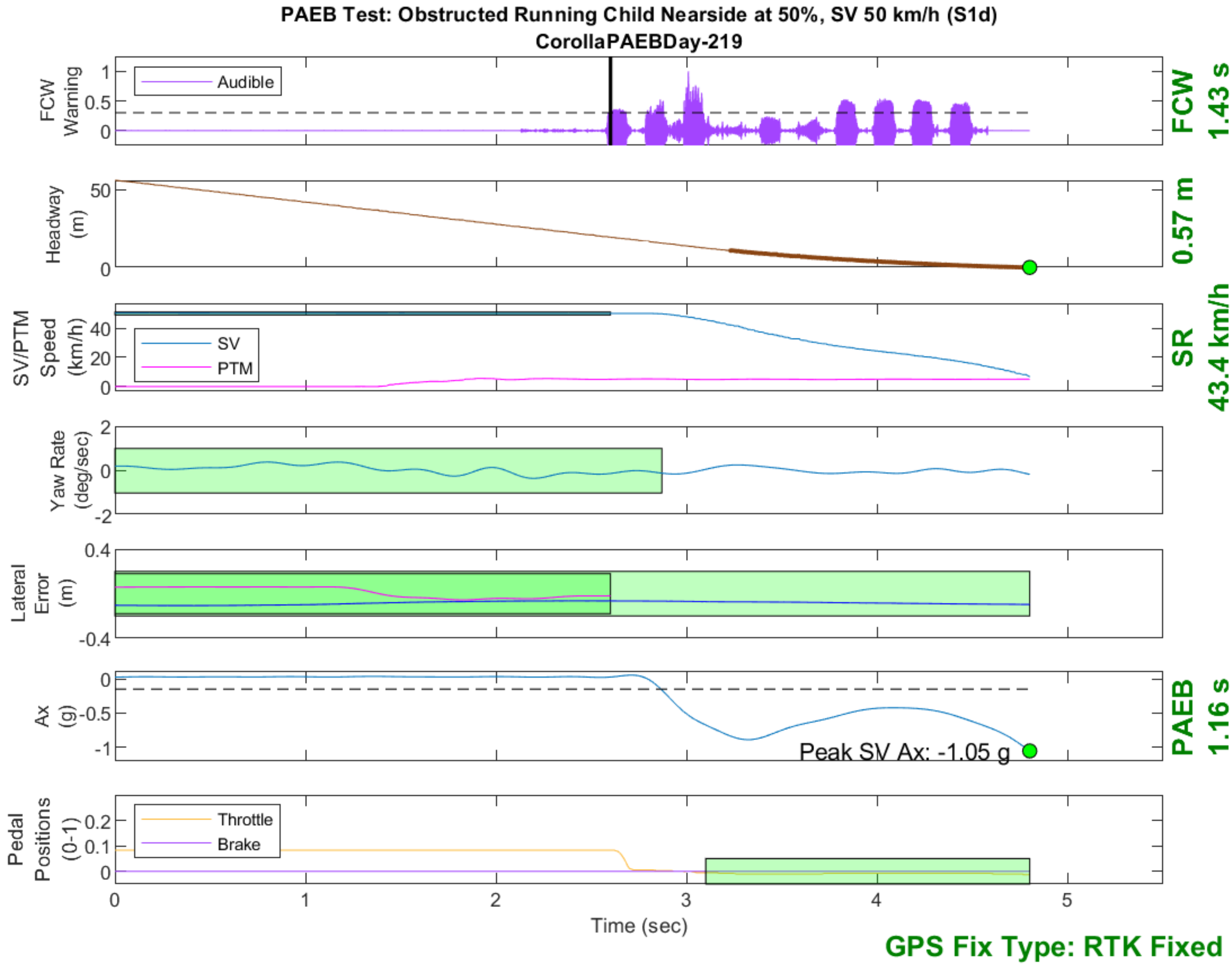


Figure D79. Time History for PAEB Run 219, S1d, Daytime, 50 km/h

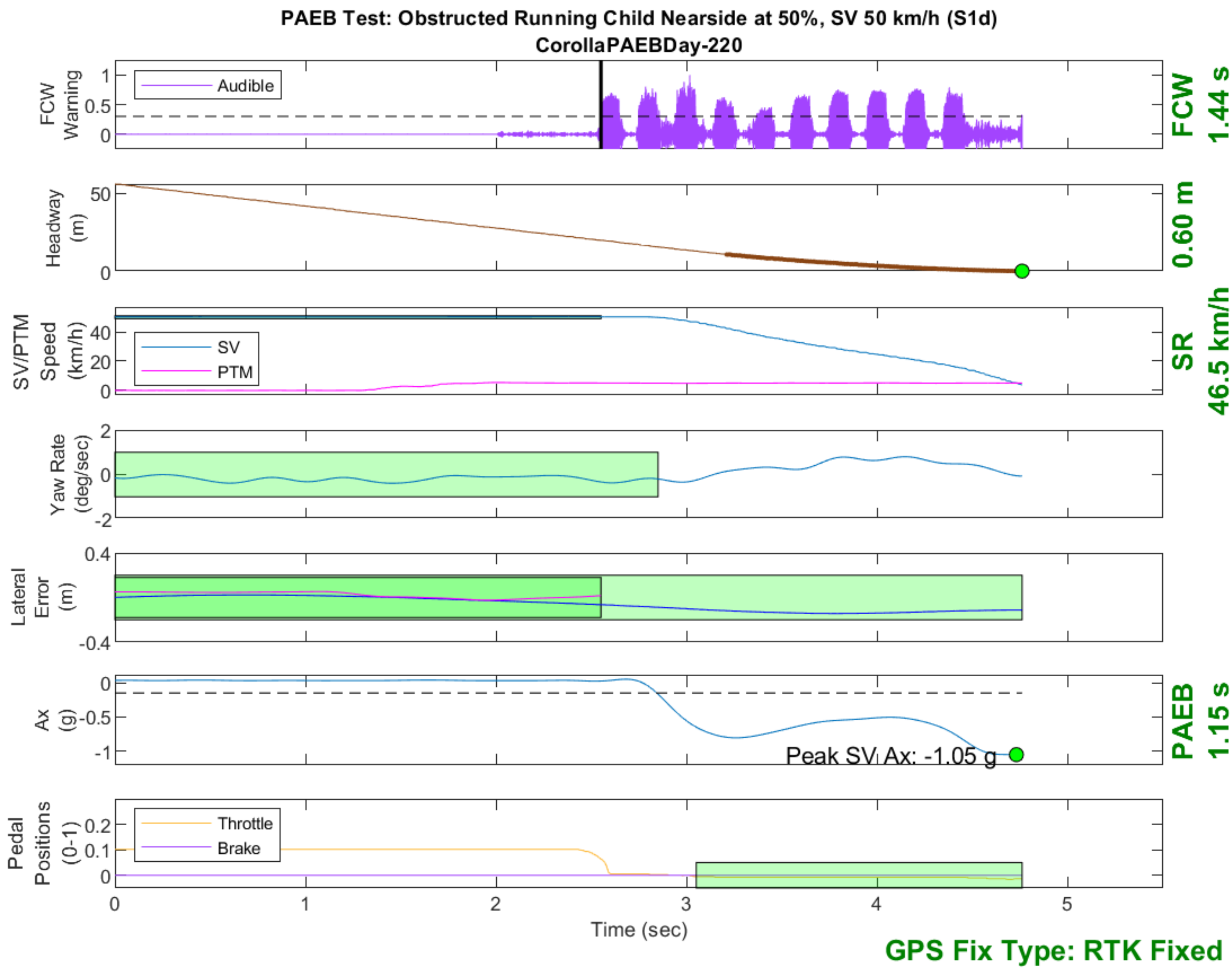


Figure D80. Time History for PAEB Run 220, S1d, Daytime, 50 km/h

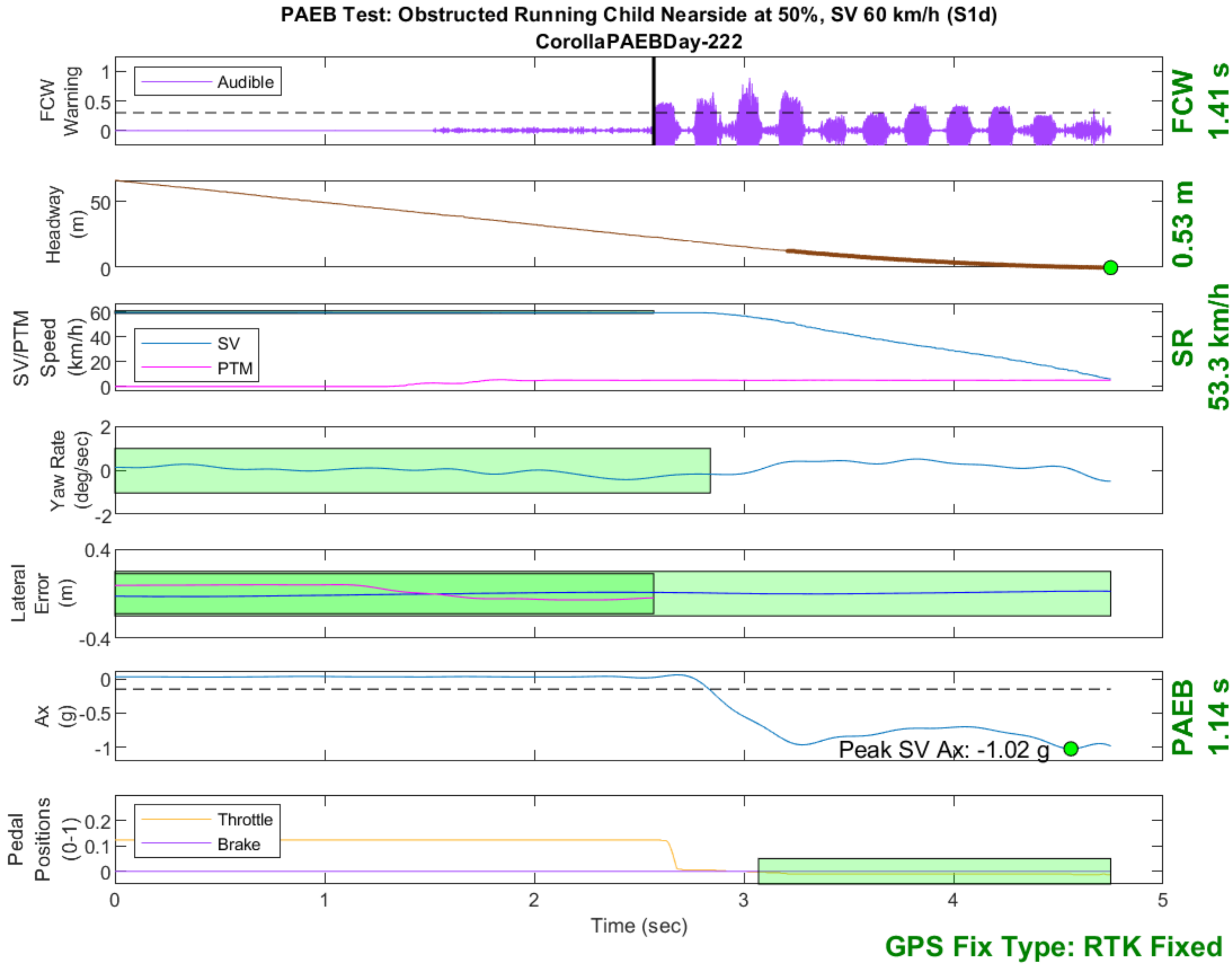


Figure D81. Time History for PAEB Run 222, S1d, Daytime, 60 km/h

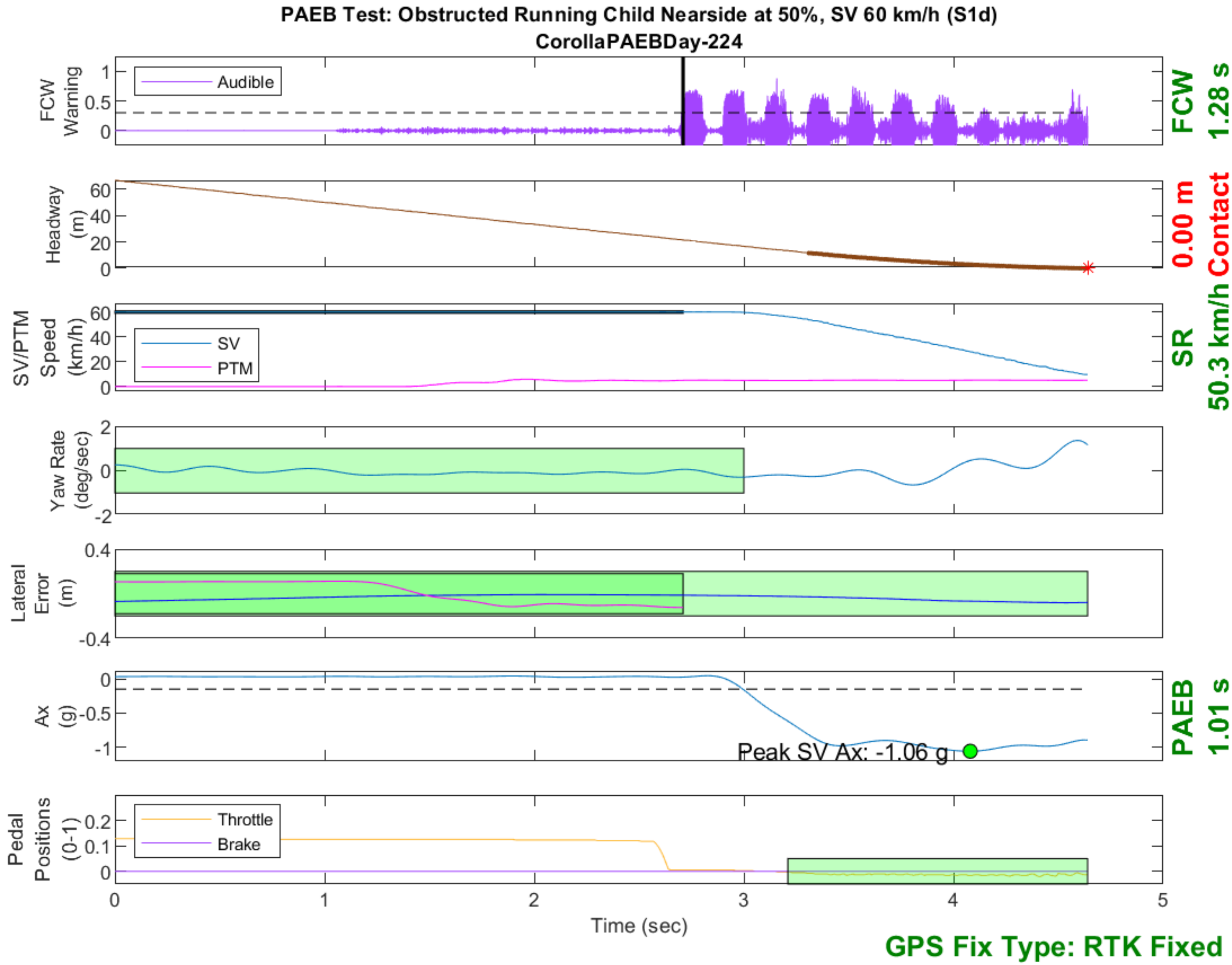


Figure D82. Time History for PAEB Run 224, S1d, Daytime, 60 km/h

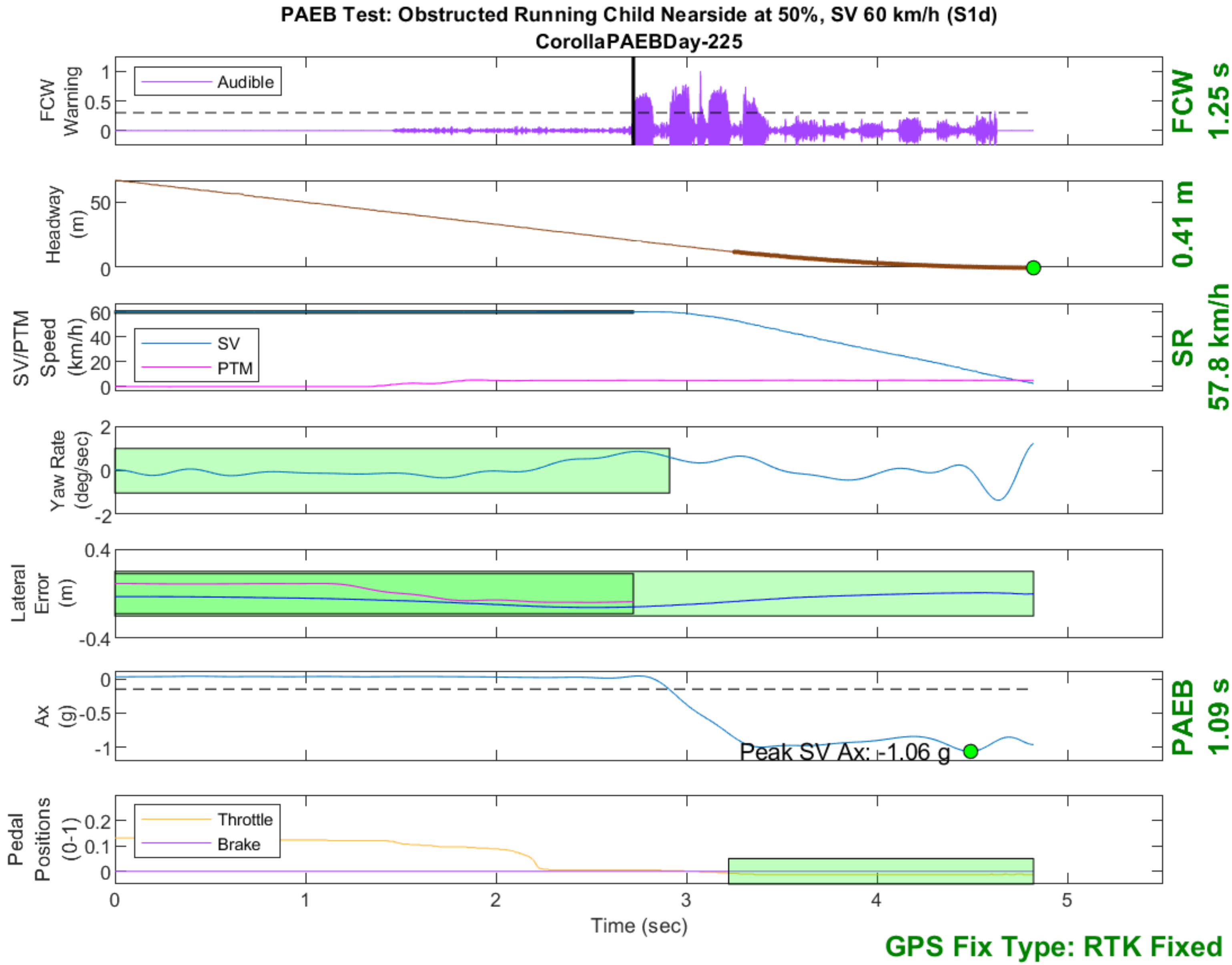


Figure D83. Time History for PAEB Run 225, S1d, Daytime, 60 km/h

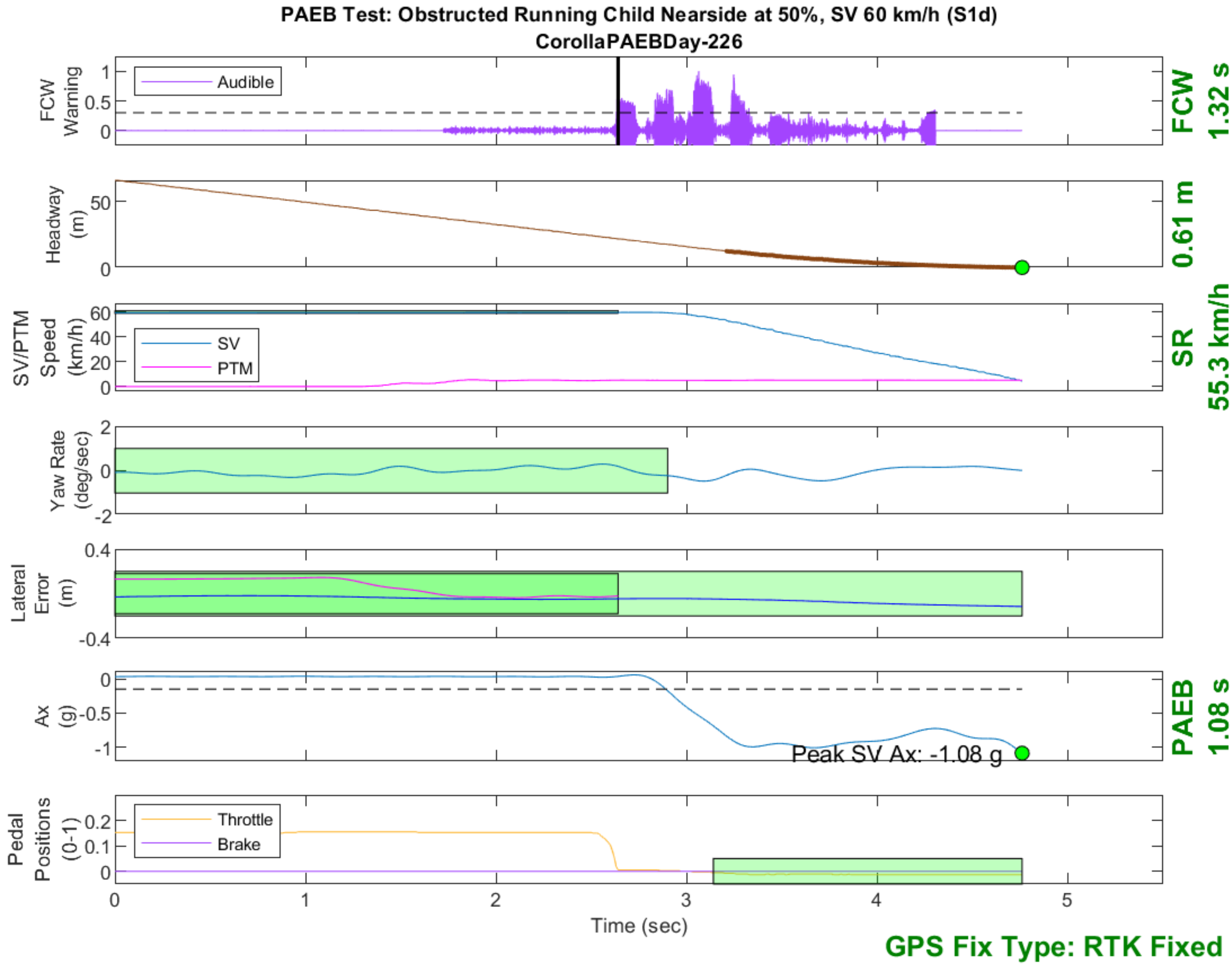


Figure D84. Time History for PAEB Run 226, S1d, Daytime, 60 km/h

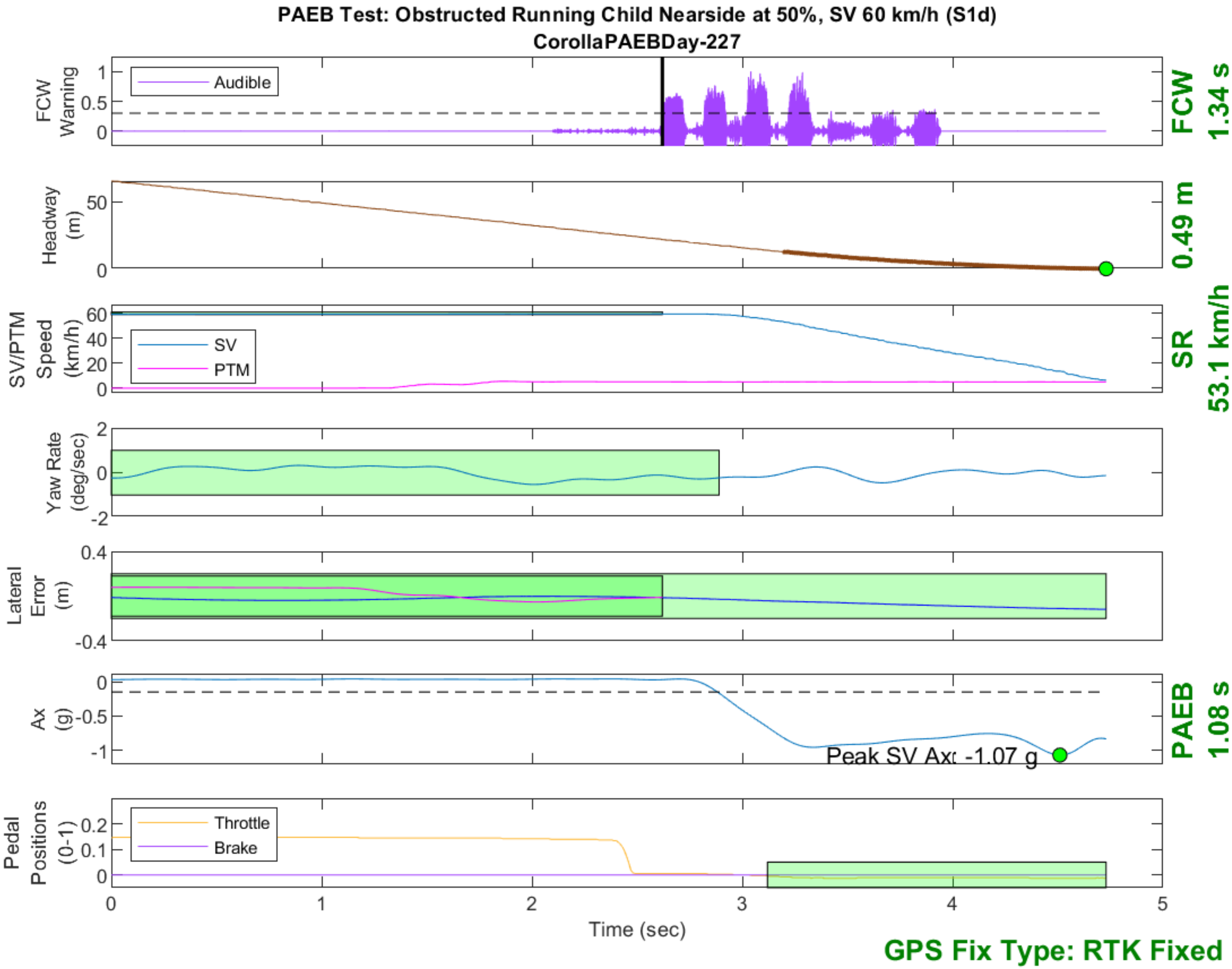


Figure D85. Time History for PAEB Run 227, S1d, Daytime, 60 km/h

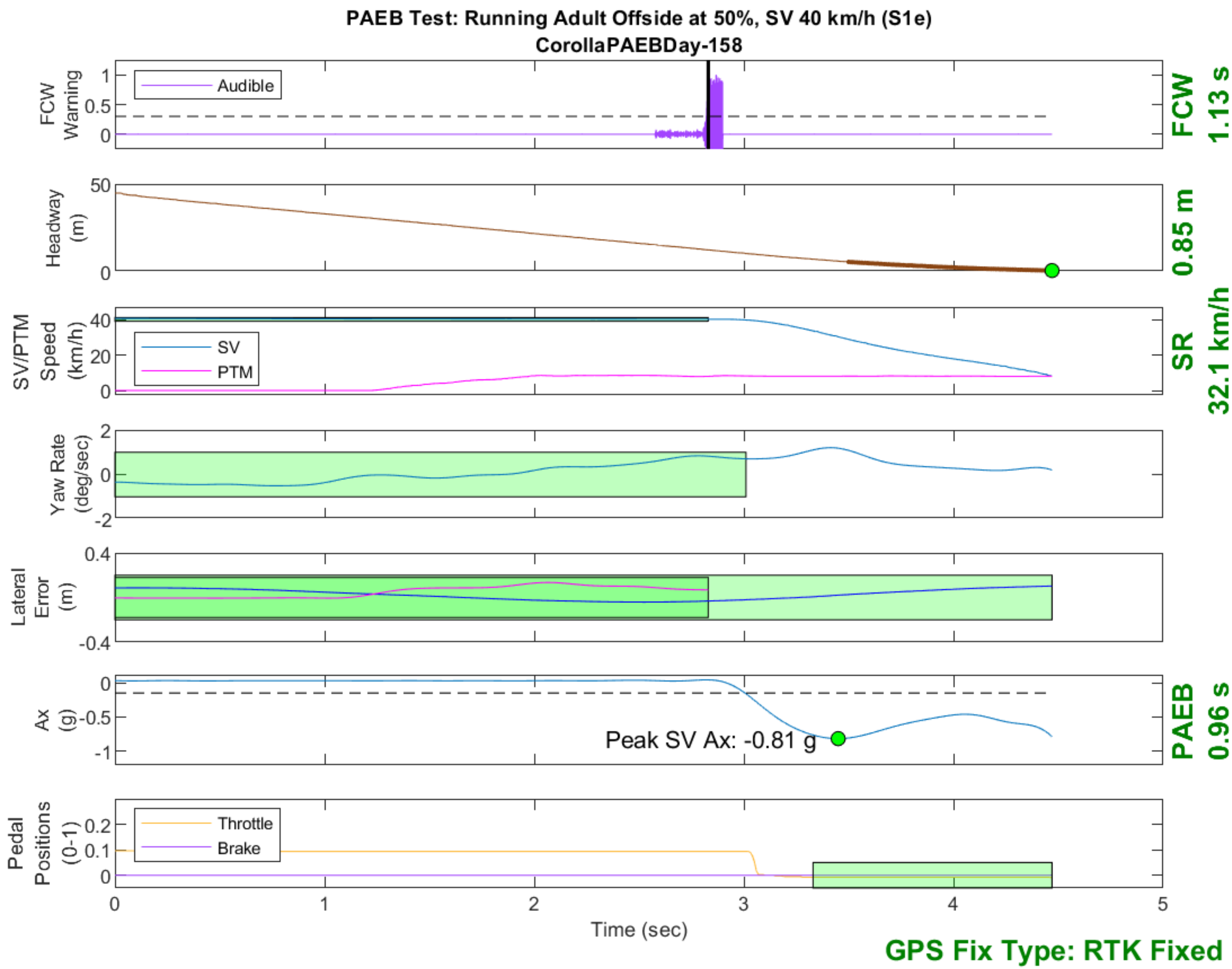


Figure D86. Time History for PAEB Run 158, S1e, Daytime, 40 km/h

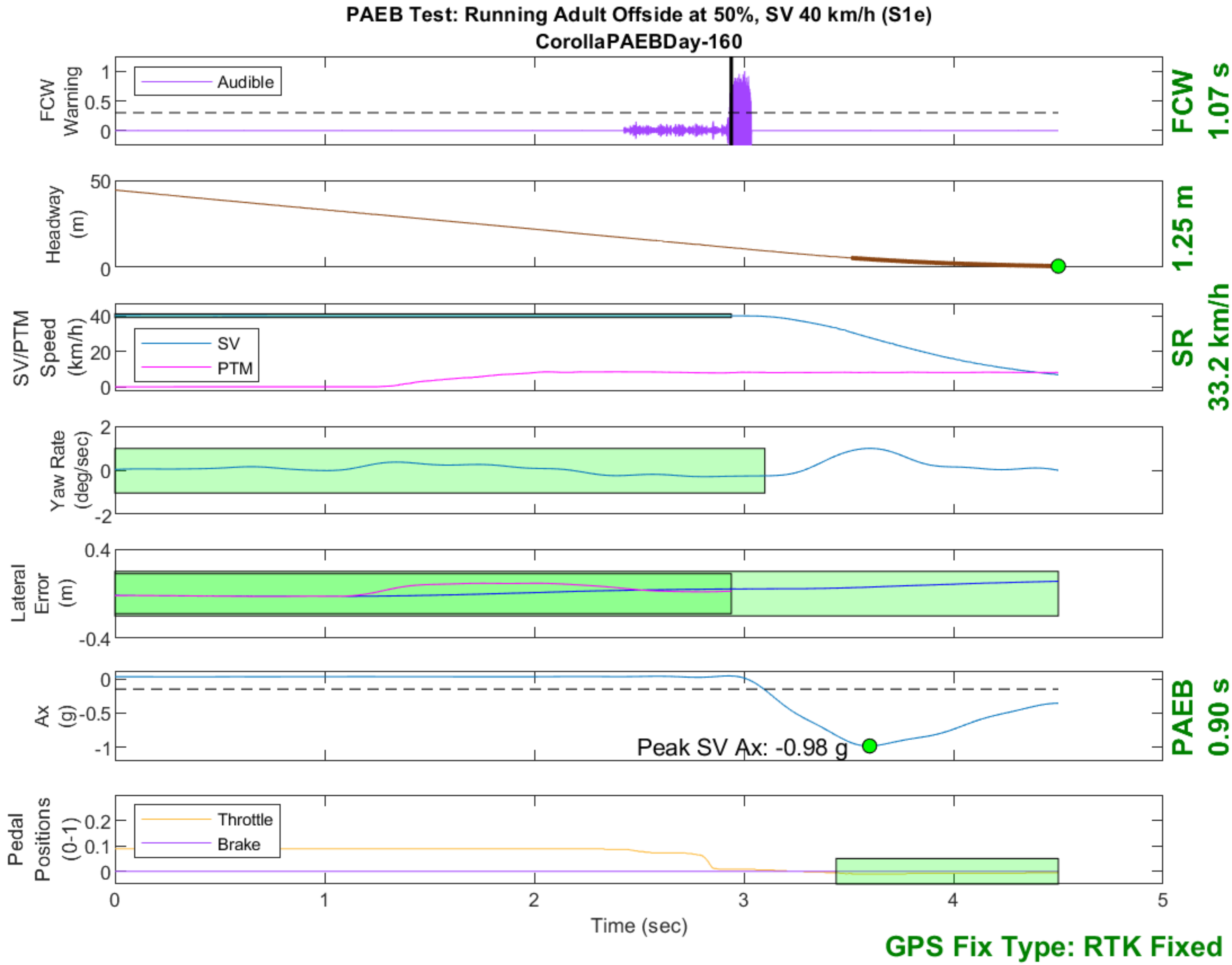


Figure D87. Time History for PAEB Run 160, S1e, Daytime, 40 km/h

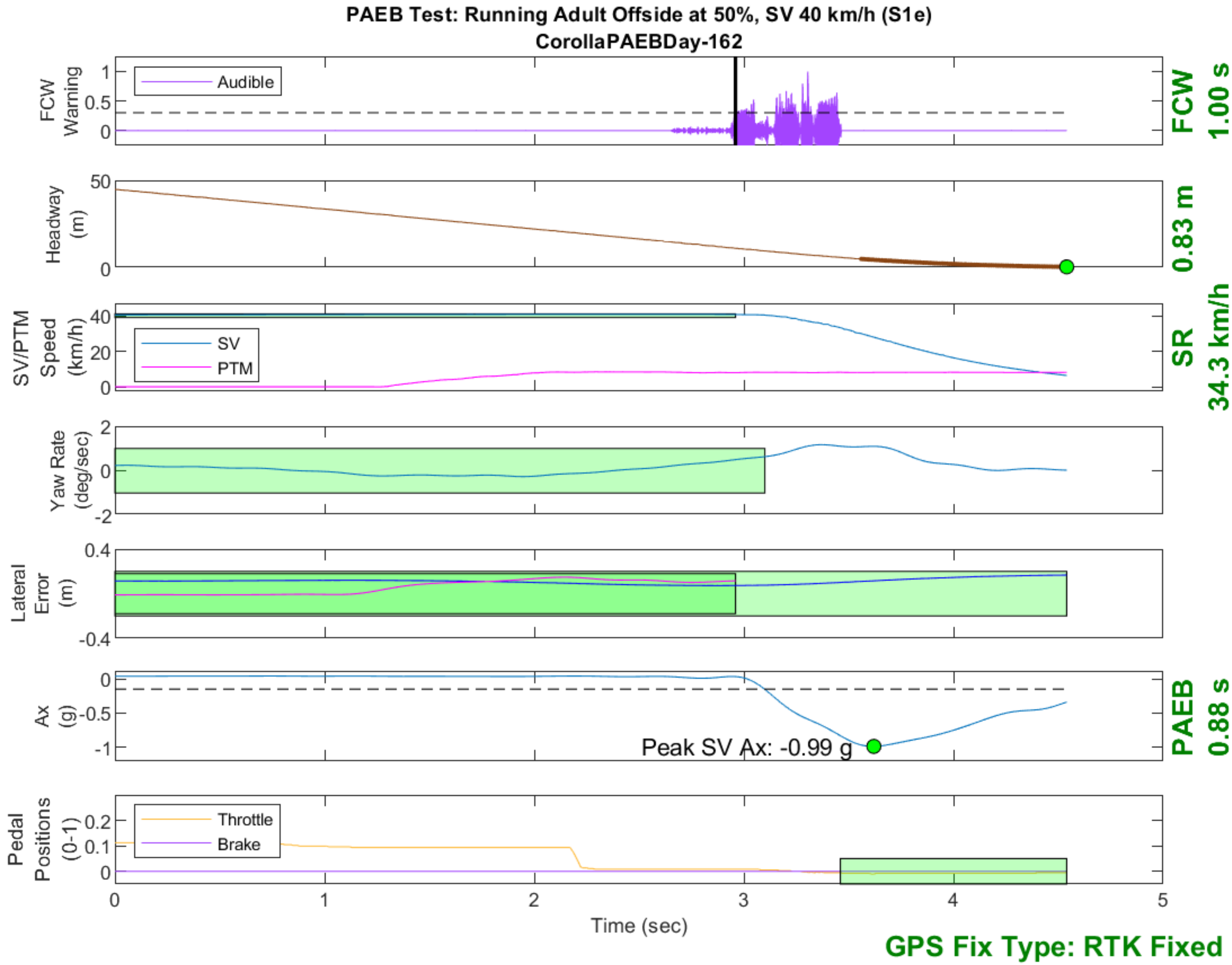


Figure D88. Time History for PAEB Run 162, S1e, Daytime, 40 km/h

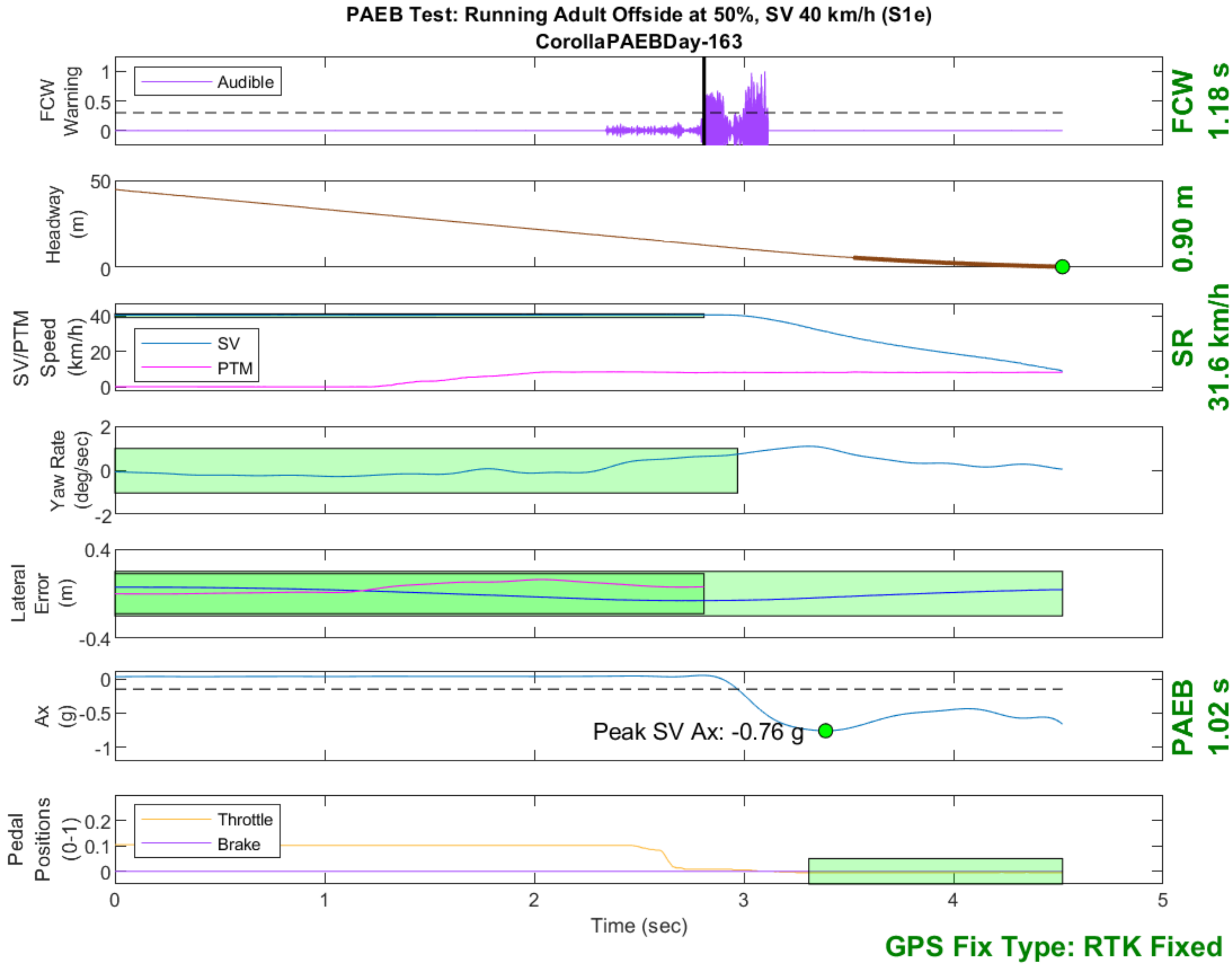


Figure D89. Time History for PAEB Run 163, S1e, Daytime, 40 km/h

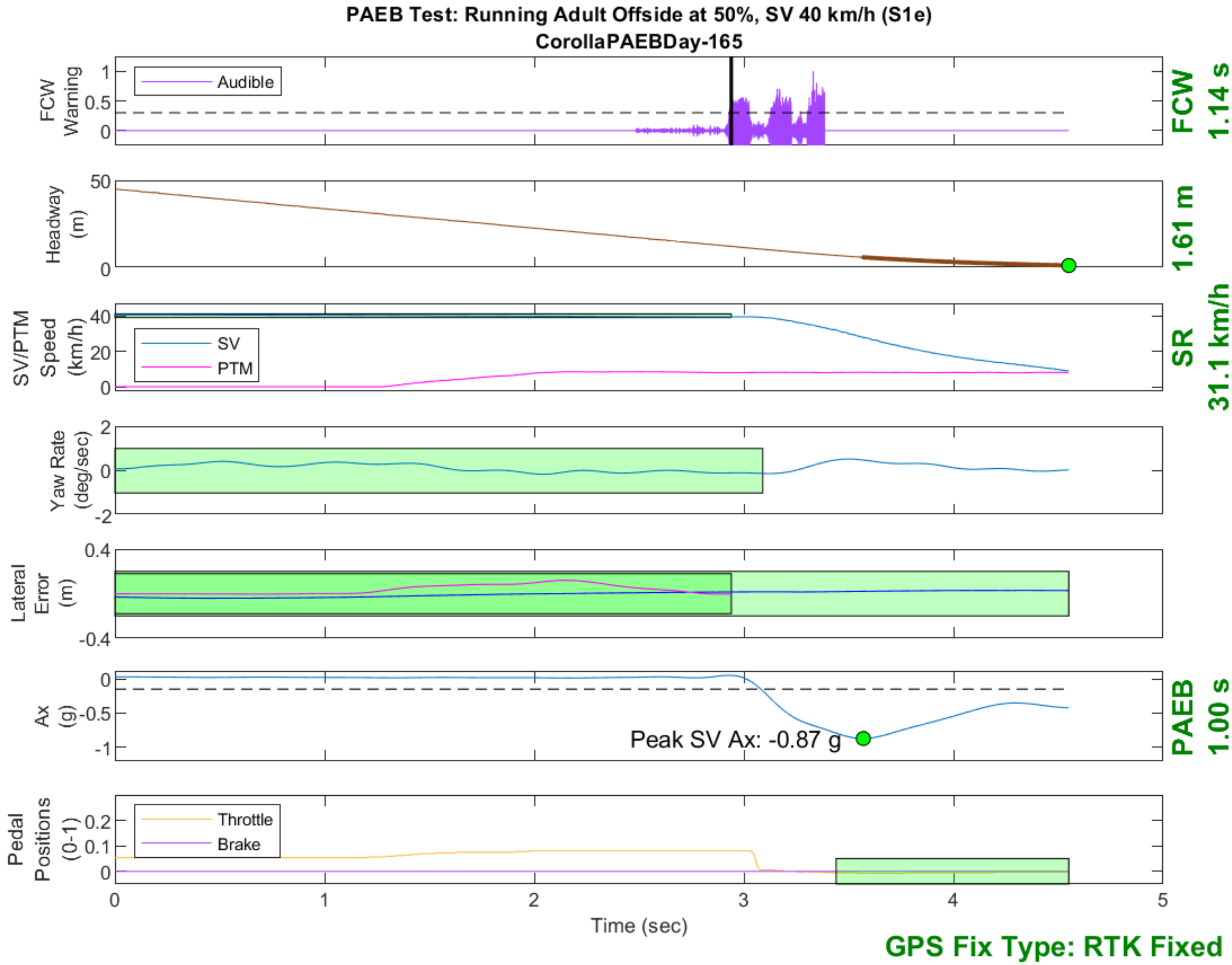


Figure D90. Time History for PAEB Run 165, S1e, Daytime, 40 km/h

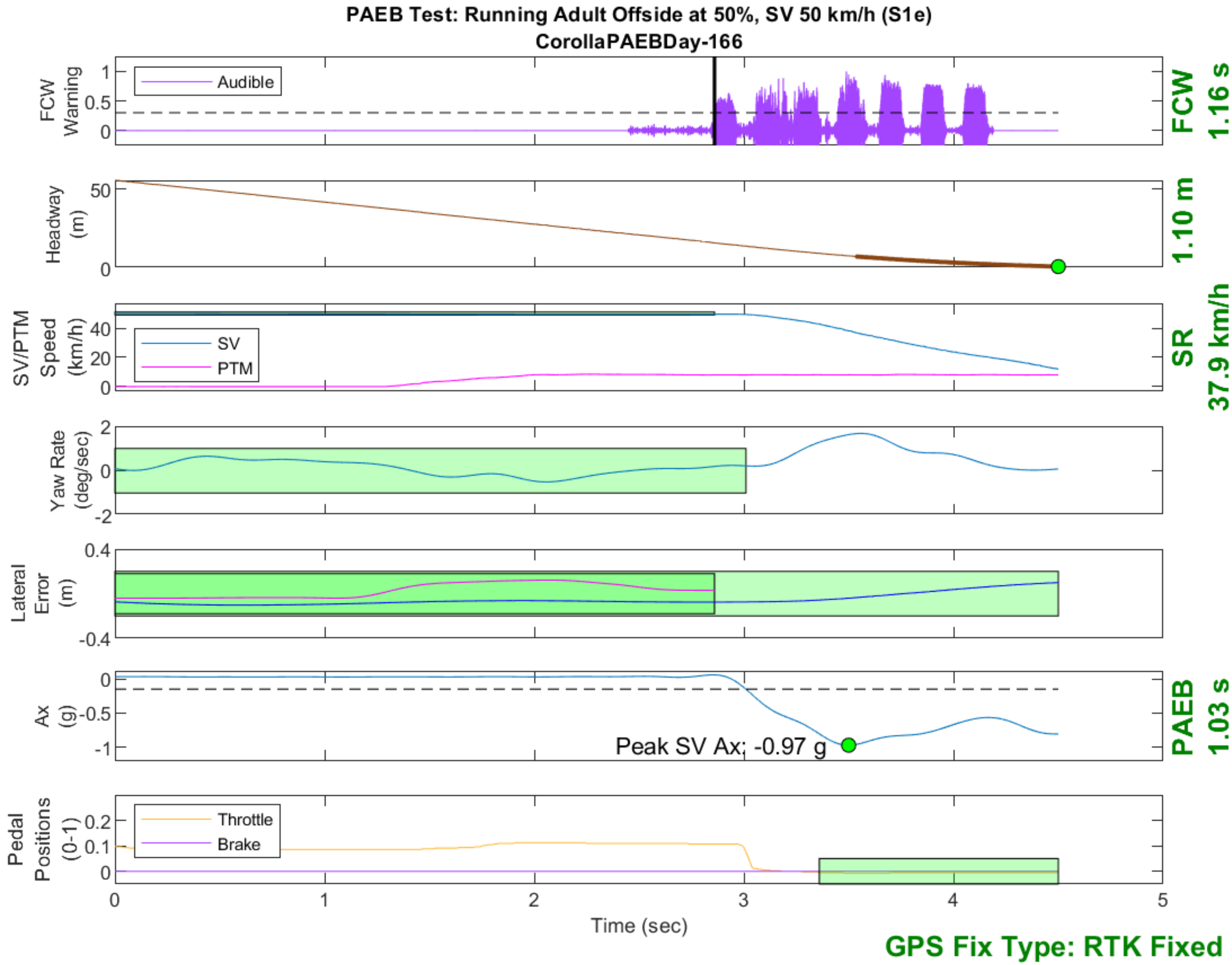


Figure D91. Time History for PAEB Run 166, S1e, Daytime, 50 km/h

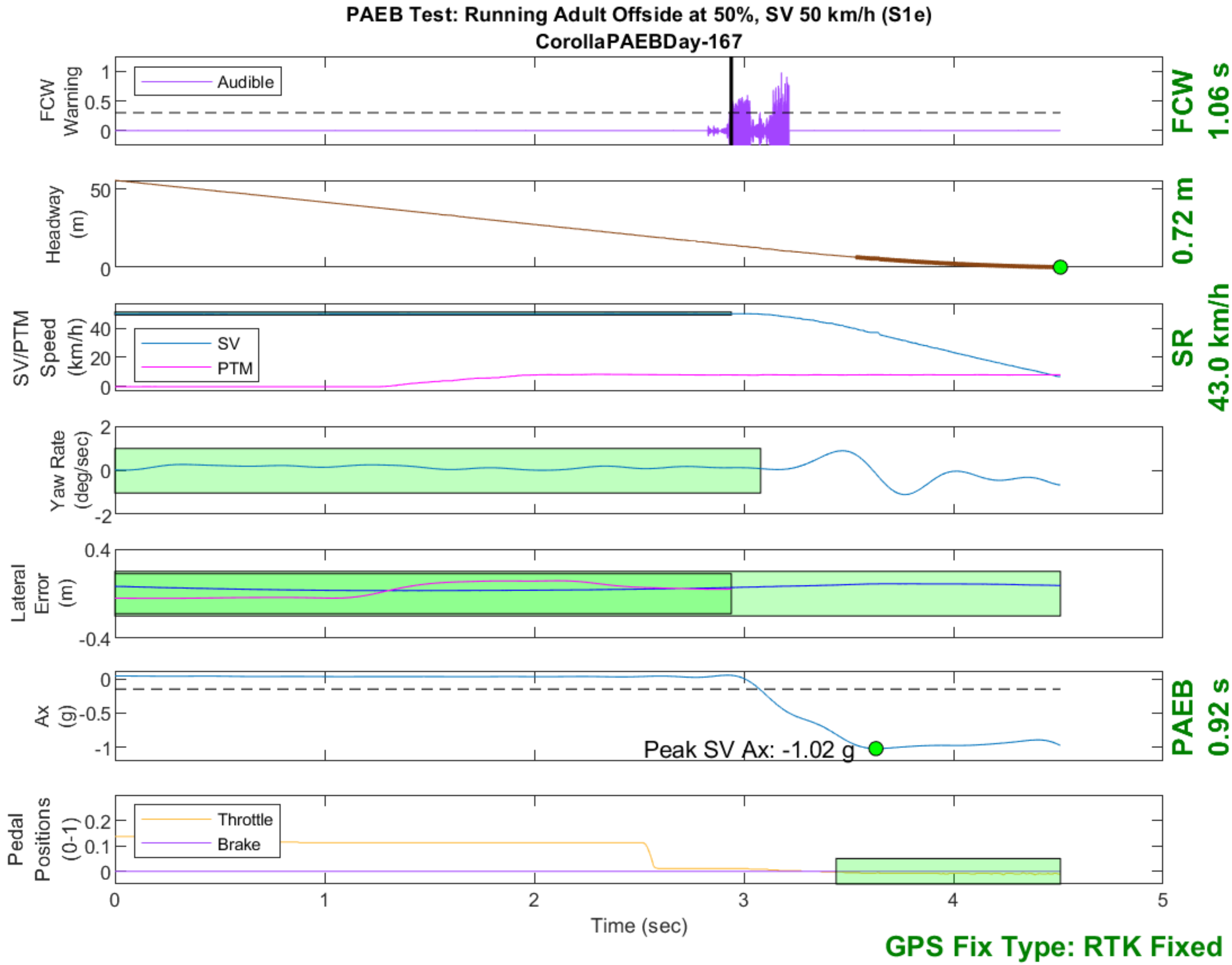


Figure D92. Time History for PAEB Run 167, S1e, Daytime, 50 km/h

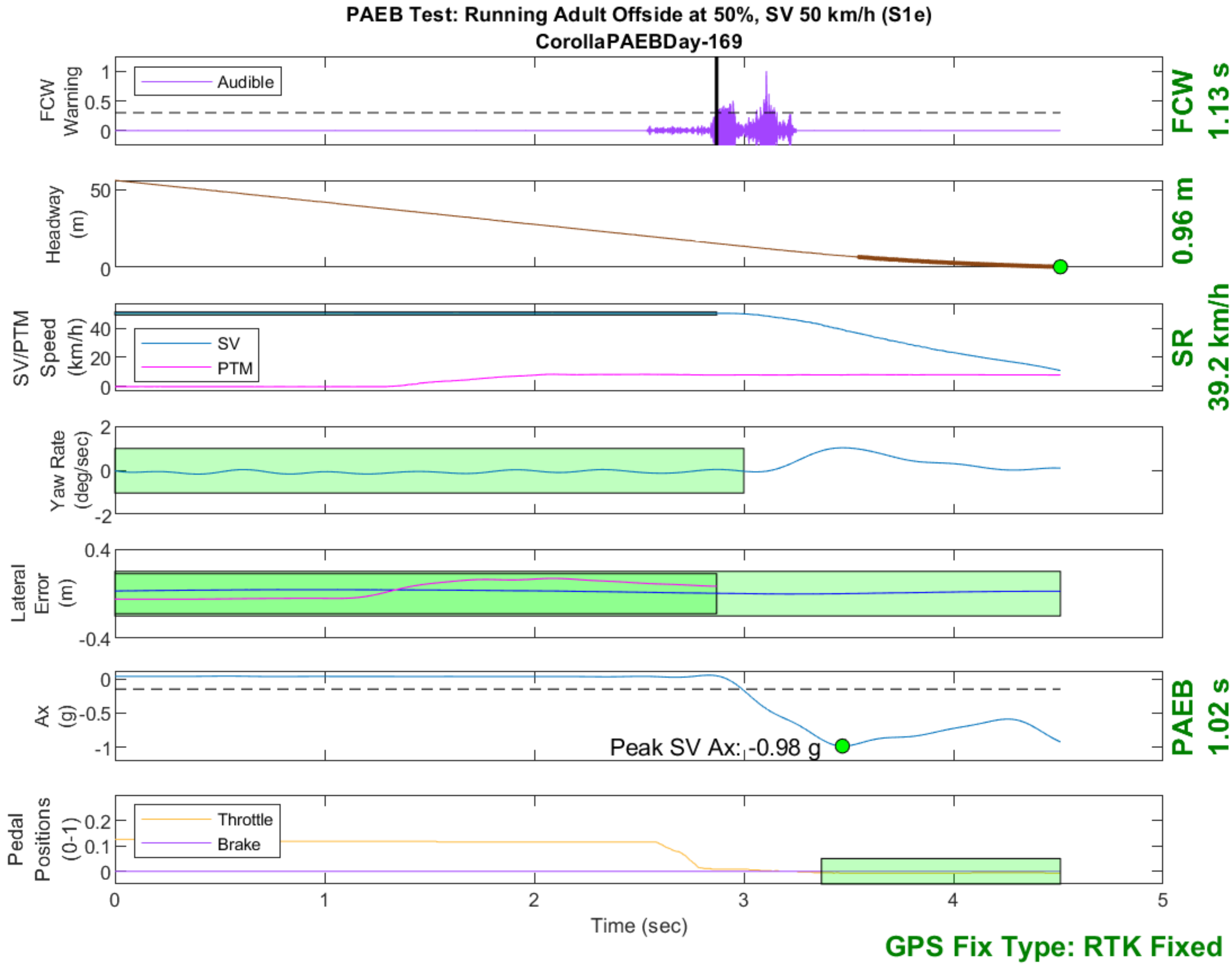


Figure D93. Time History for PAEB Run 169, S1e, Daytime, 50 km/h

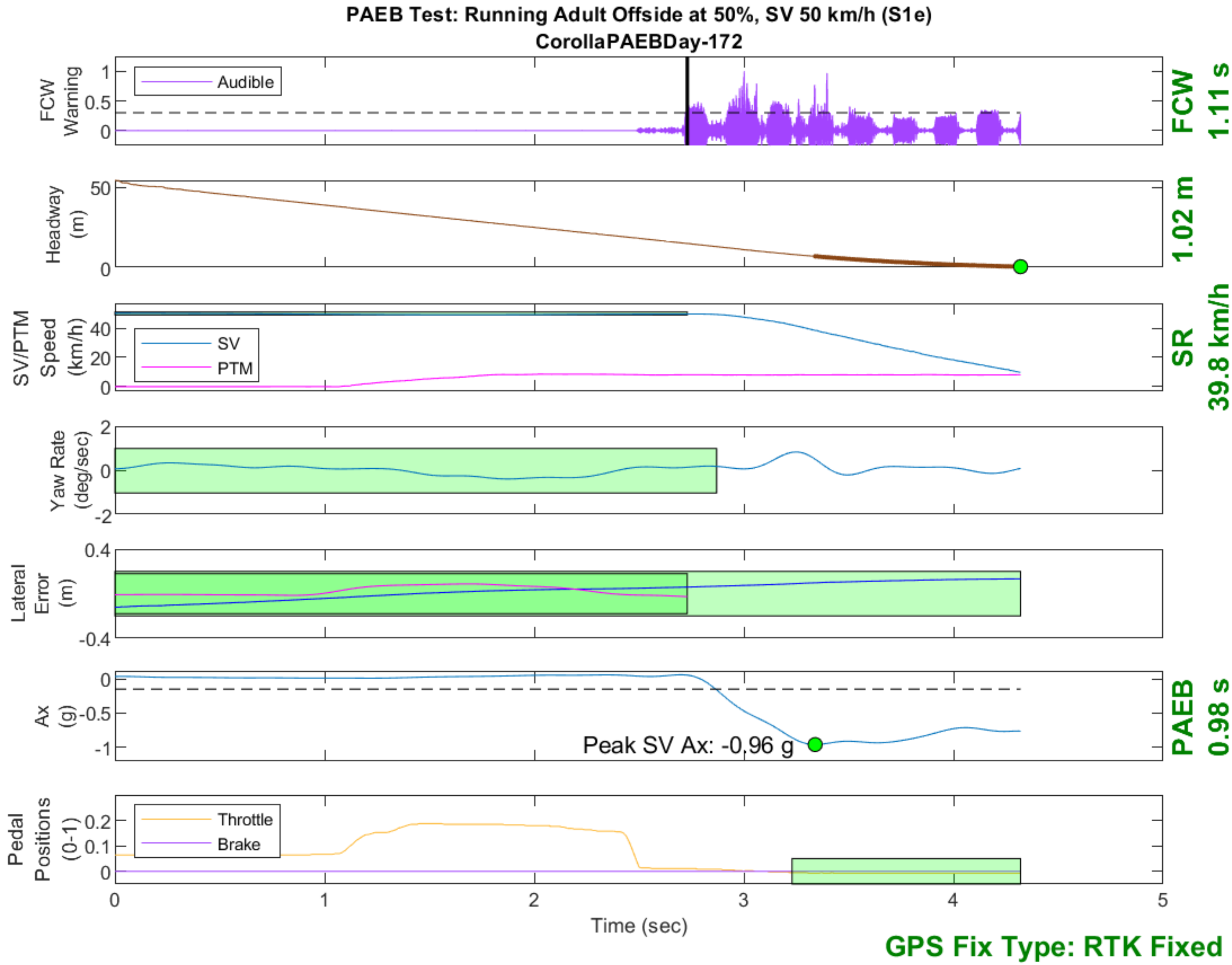


Figure D94. Time History for PAEB Run 172, S1e, Daytime, 50 km/h

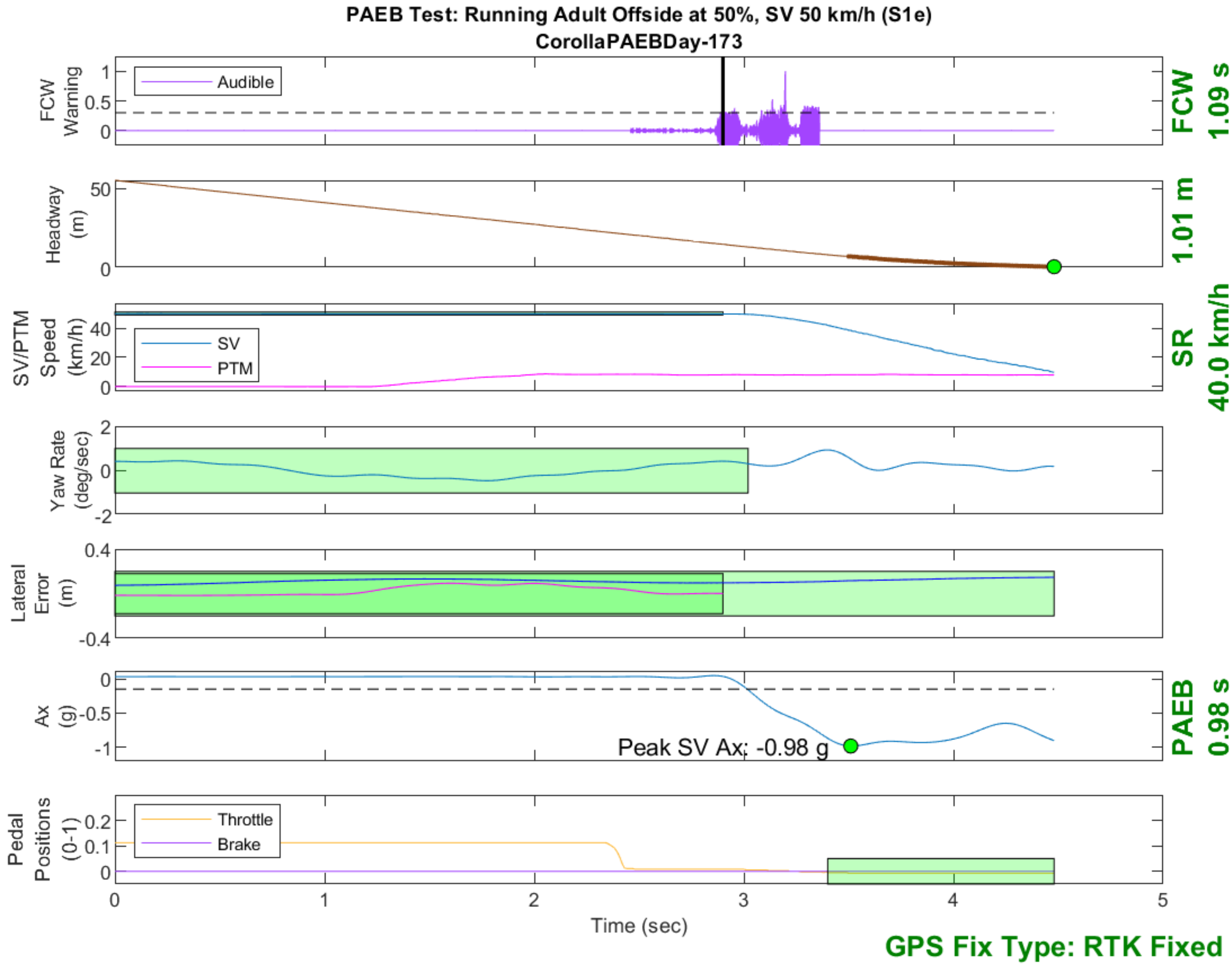


Figure D95. Time History for PAEB Run 173, S1e, Daytime, 50 km/h

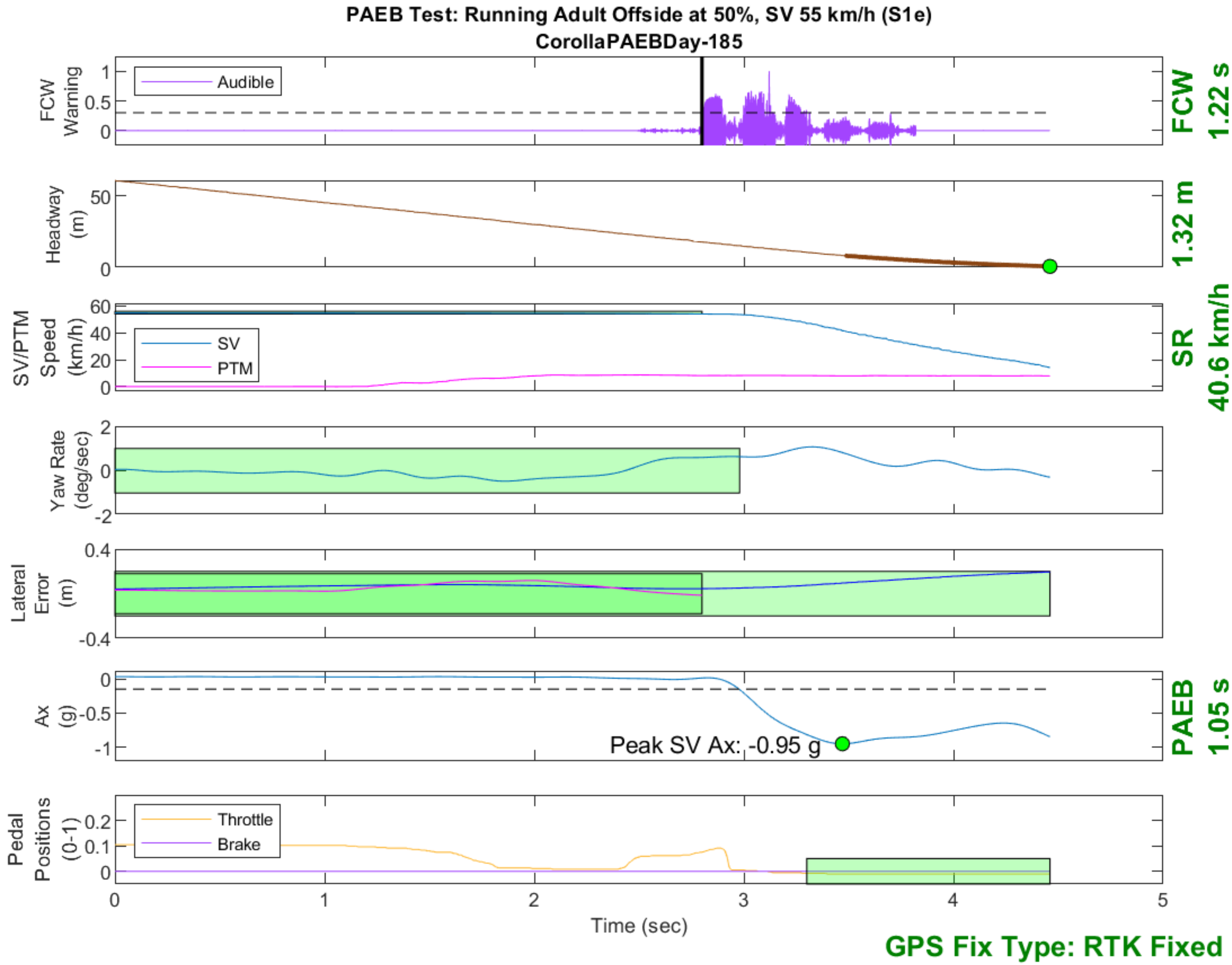


Figure D96. Time History for PAEB Run 185, S1e, Daytime, 55 km/h

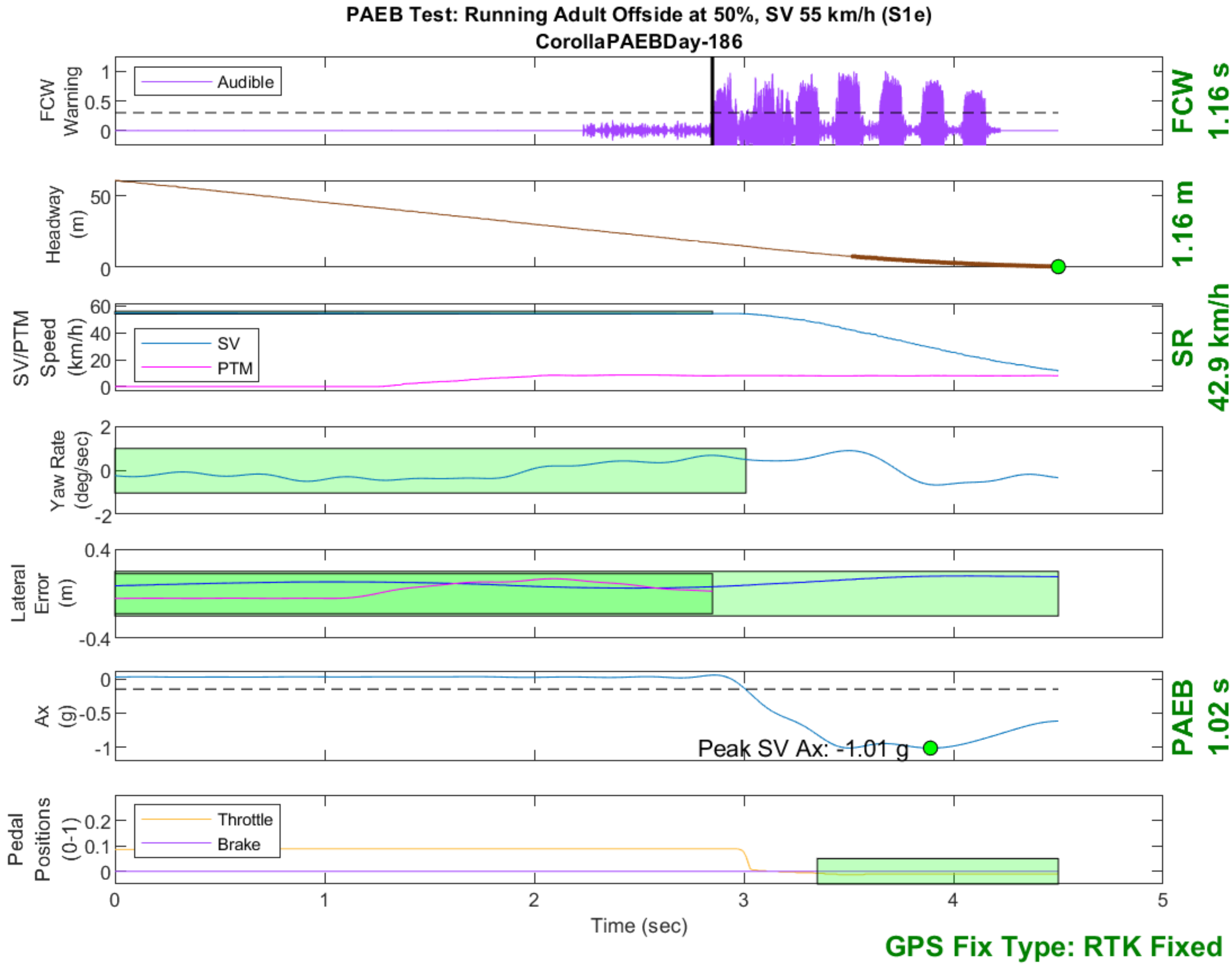


Figure D97. Time History for PAEB Run 186, S1e, Daytime, 55 km/h

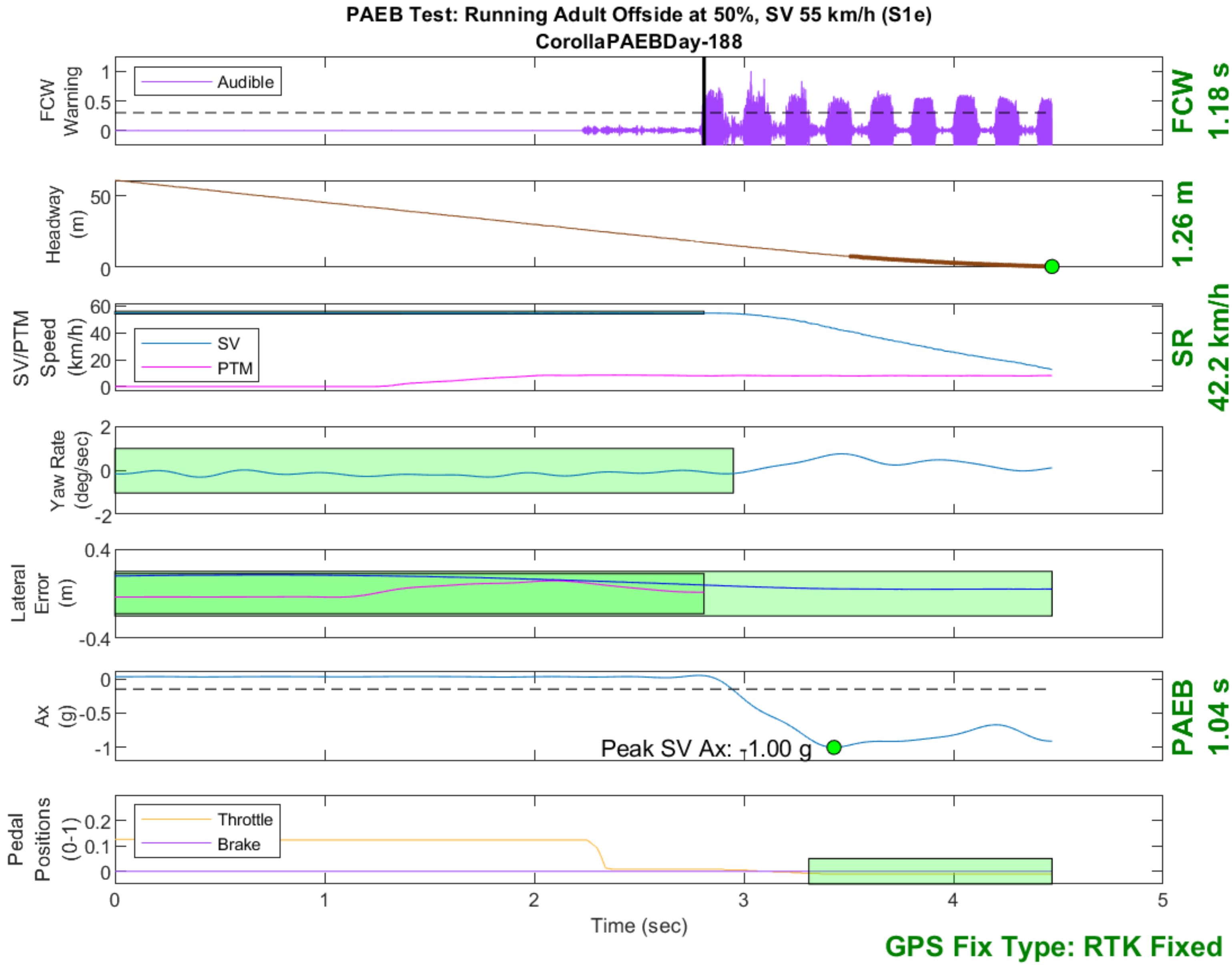


Figure D98. Time History for PAEB Run 188, S1e, Daytime, 55 km/h

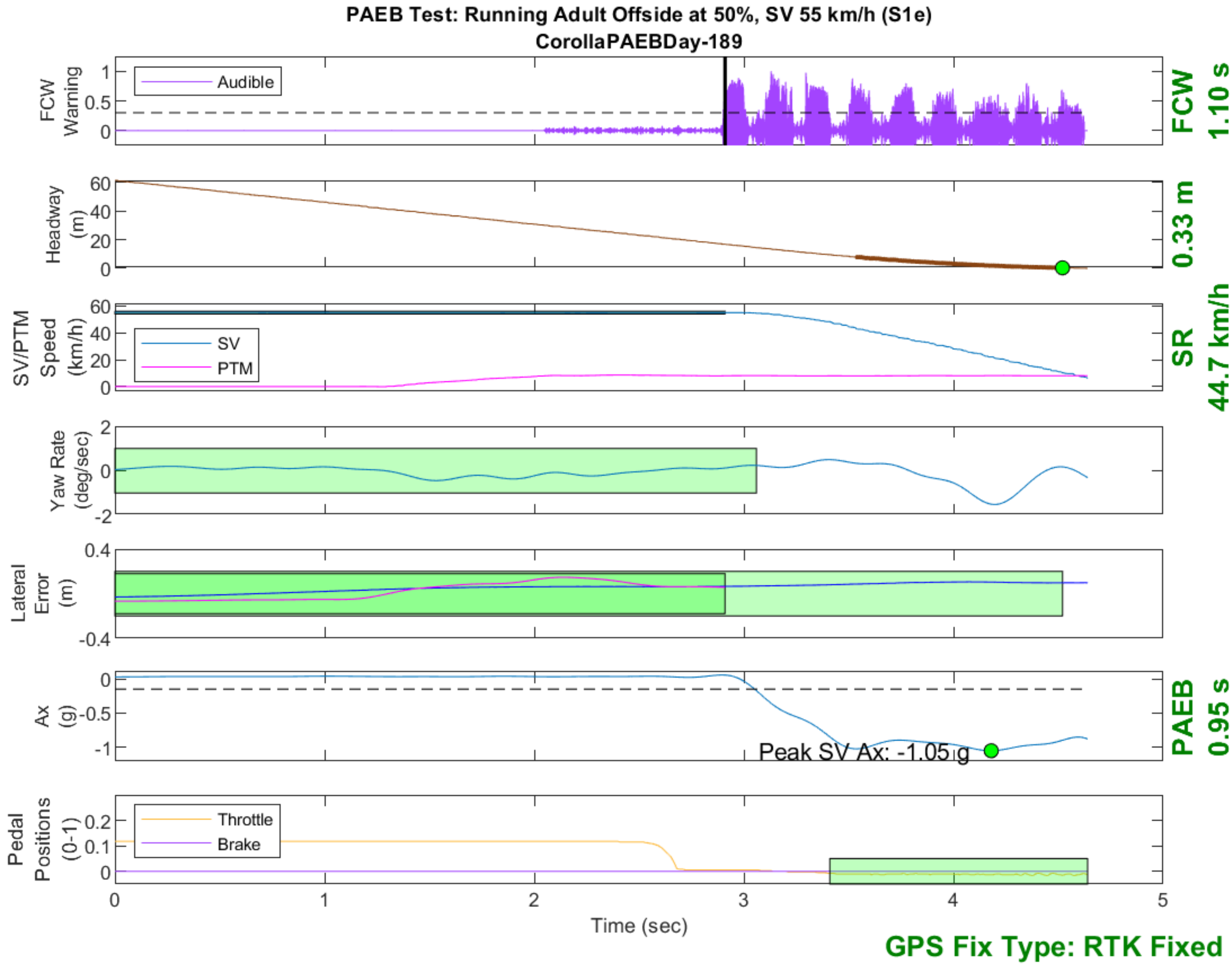


Figure D99. Time History for PAEB Run 189, S1e, Daytime, 55 km/h

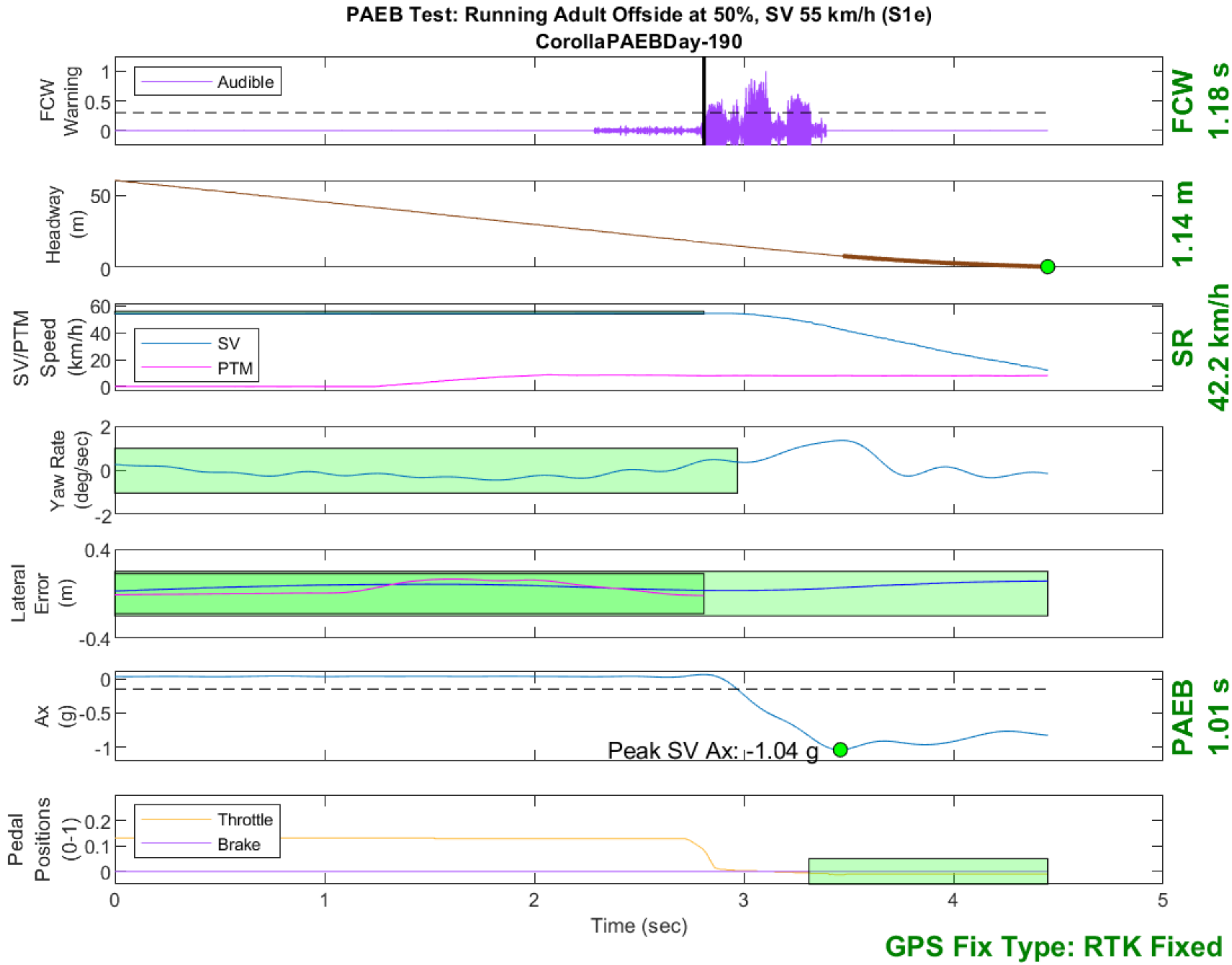


Figure D100. Time History for PAEB Run 190, S1e, Daytime, 55 km/h

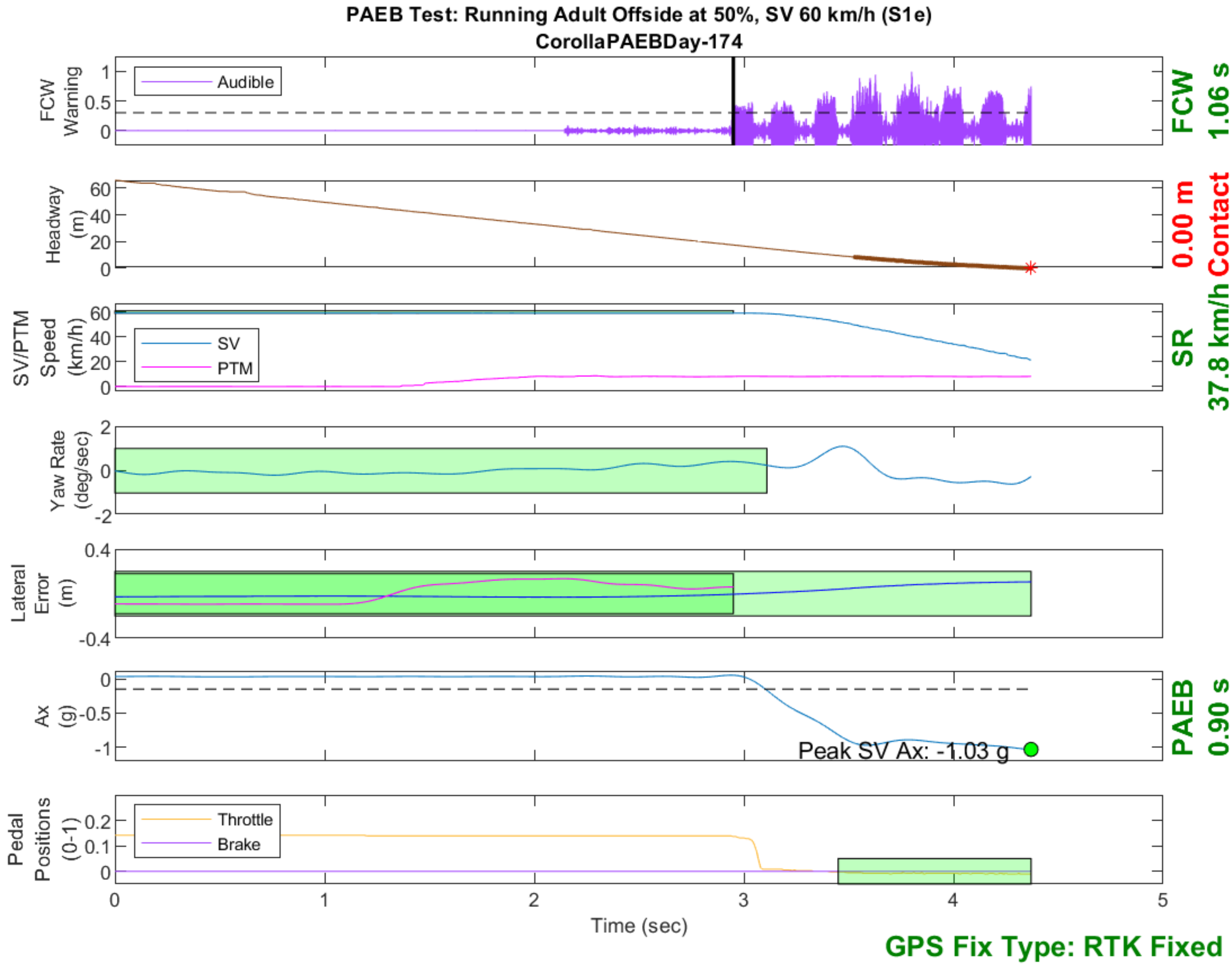


Figure D101. Time History for PAEB Run 174, S1e, Daytime, 60 km/h

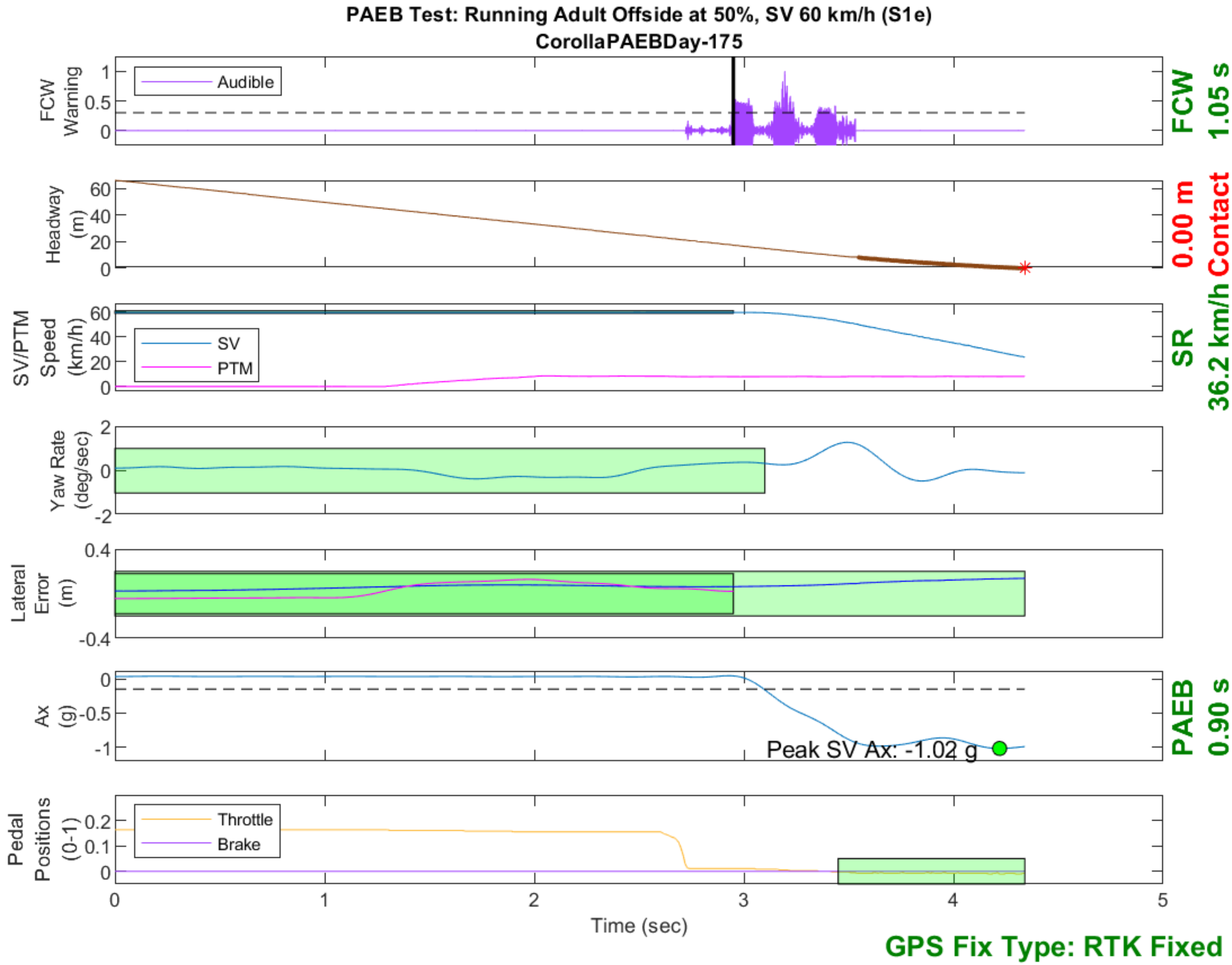


Figure D102. Time History for PAEB Run 175, S1e, Daytime, 60 km/h

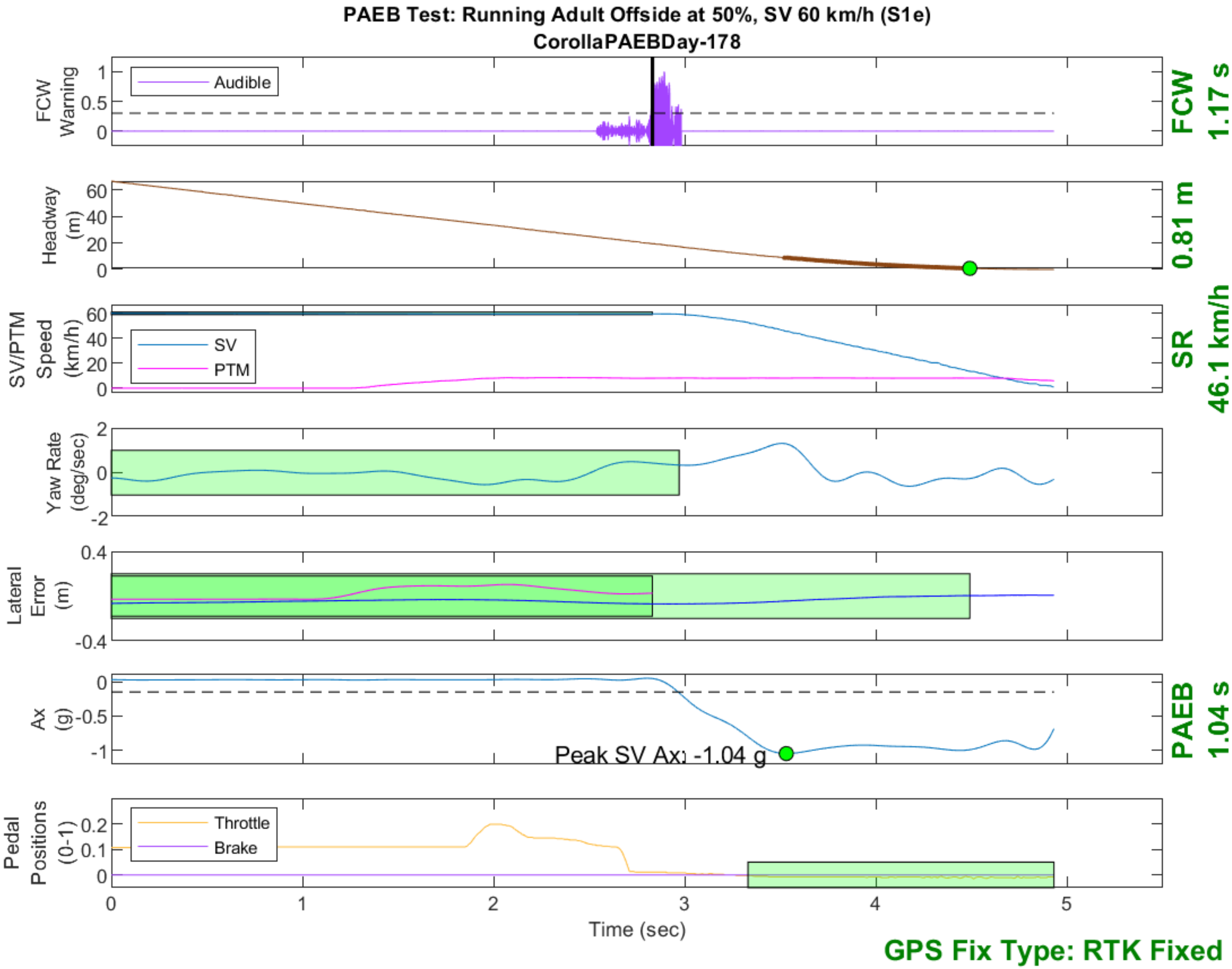


Figure D103. Time History for PAEB Run 178, S1e, Daytime, 60 km/h

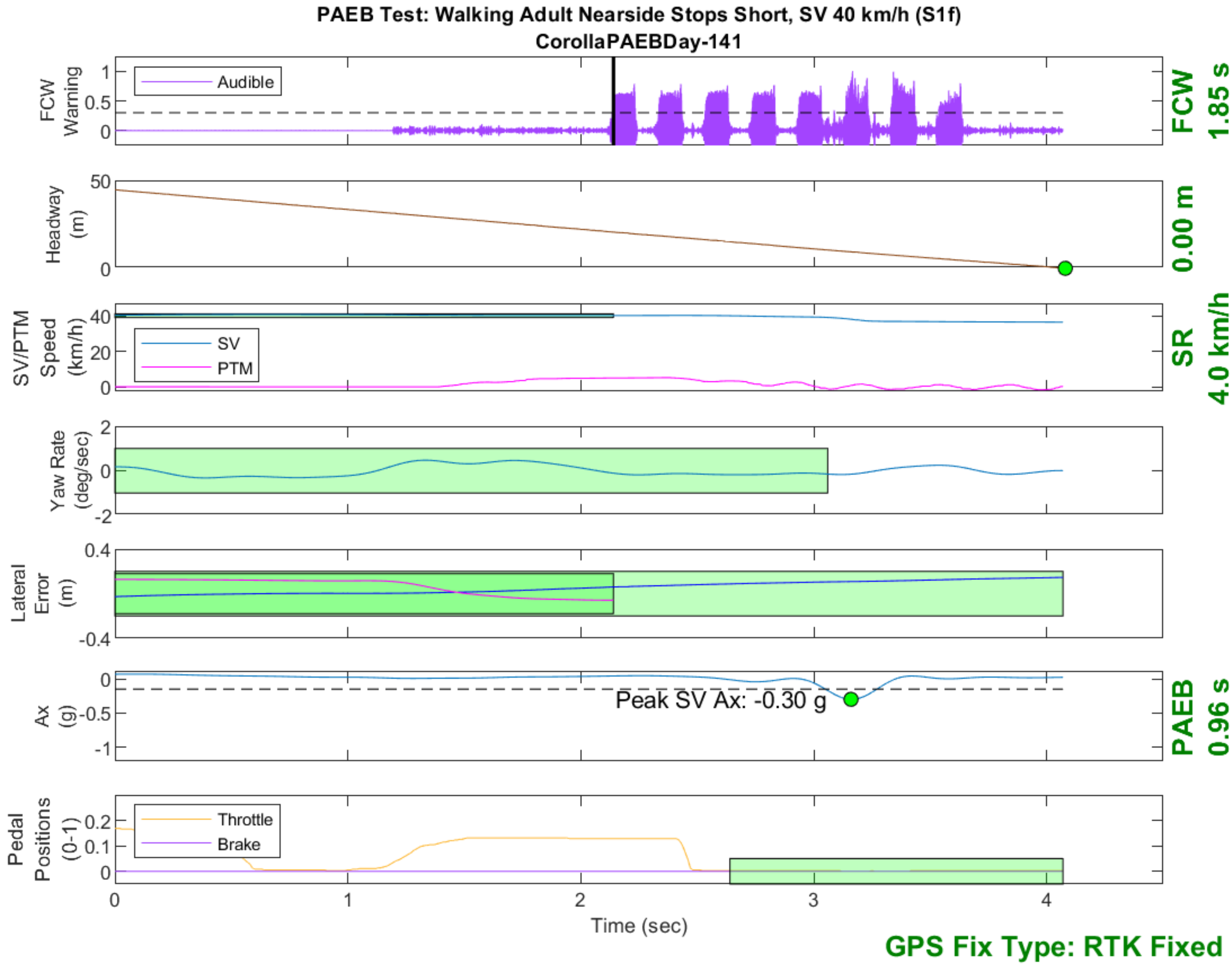


Figure D104. Time History for PAEB Run 141, S1f, Daytime, 40 km/h

Figure D105. Time History for PAEB Run 142, S1f, Daytime, 40 km/h

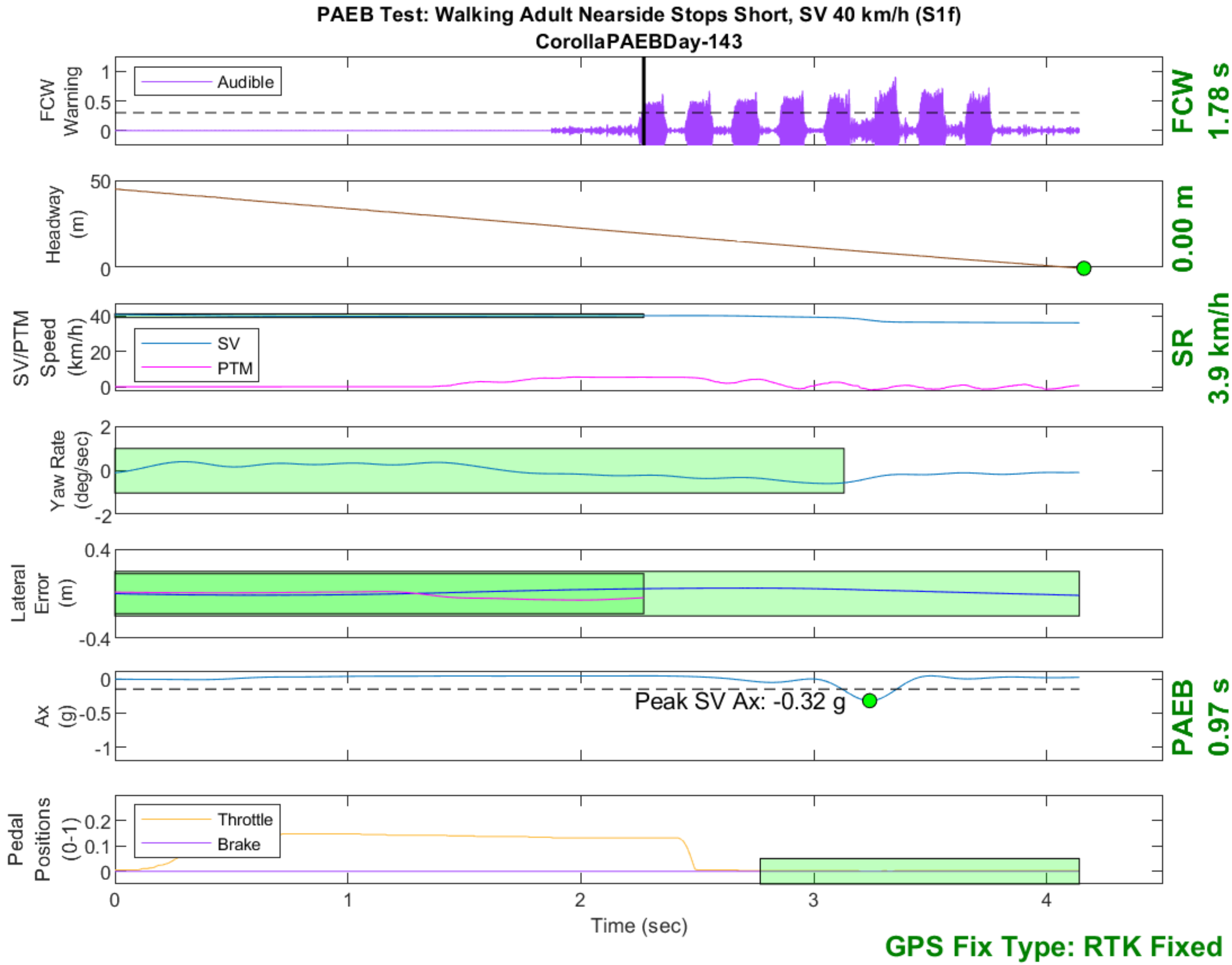


Figure D106. Time History for PAEB Run 143, S1f, Daytime, 40 km/h

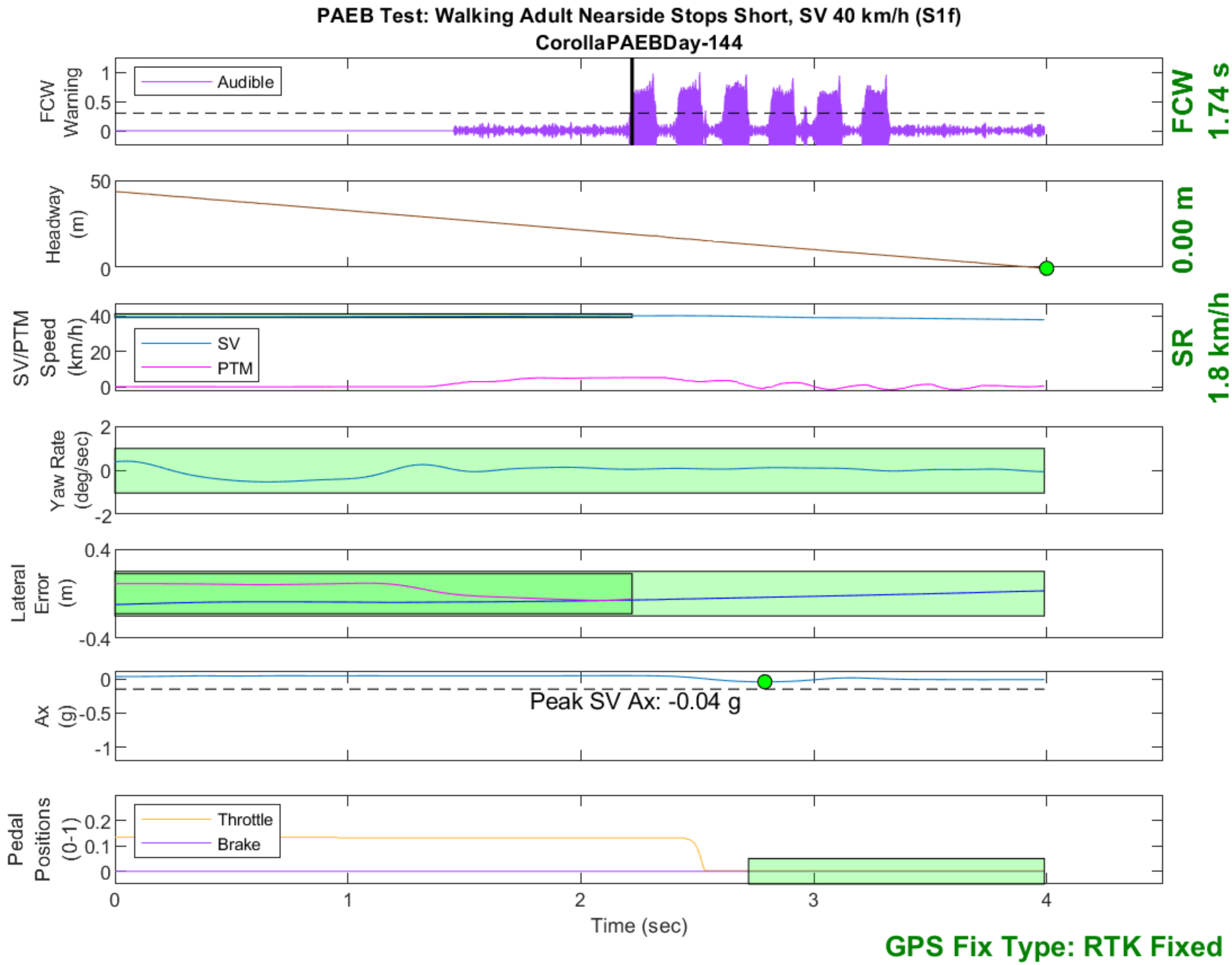


Figure D107. Time History for PAEB Run 144, S1f, Daytime, 40 km/h

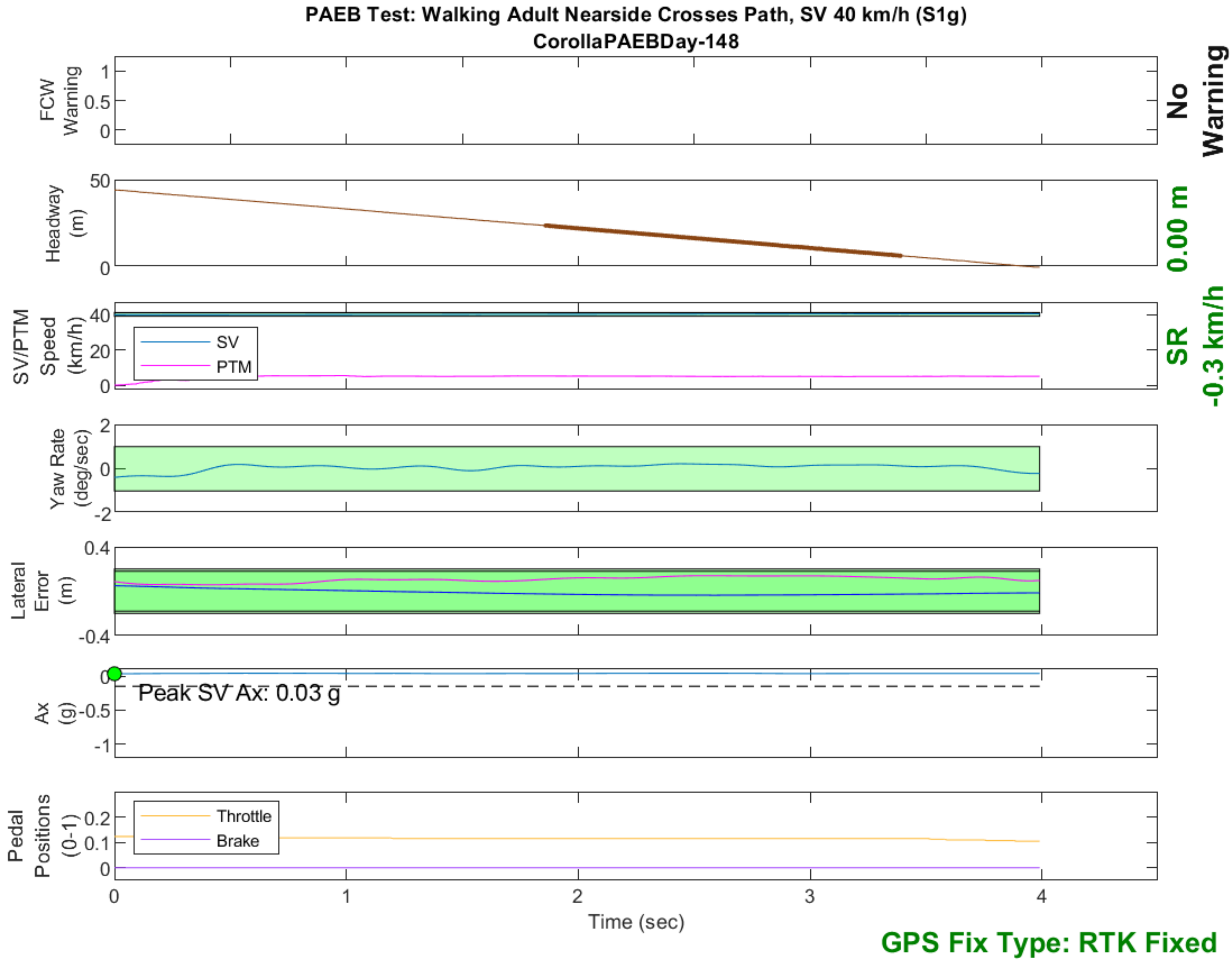


Figure D108. Time History for PAEB Run 148, S1g, Daytime, 40 km/h

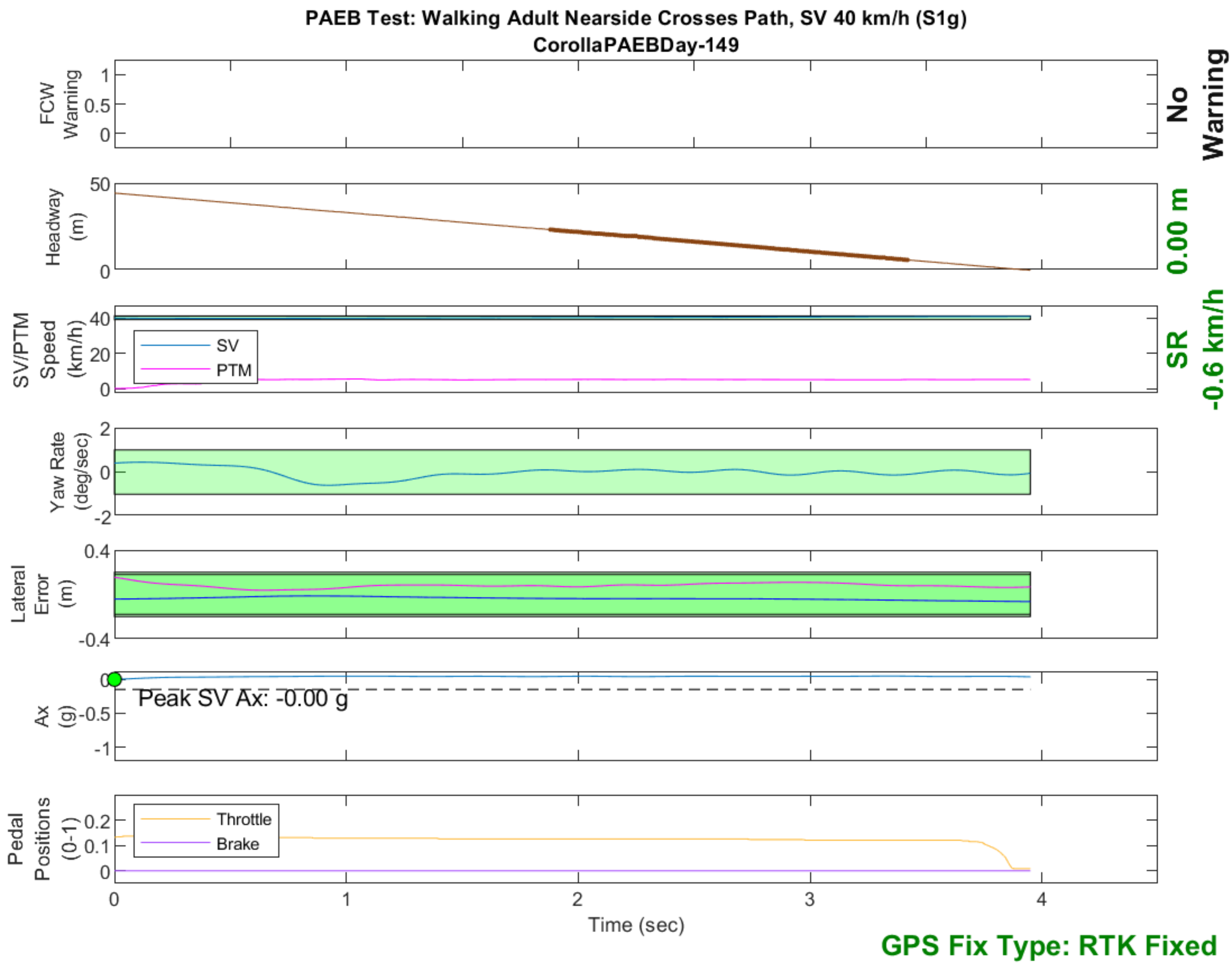


Figure D109. Time History for PAEB Run 149, S1g, Daytime, 40 km/h

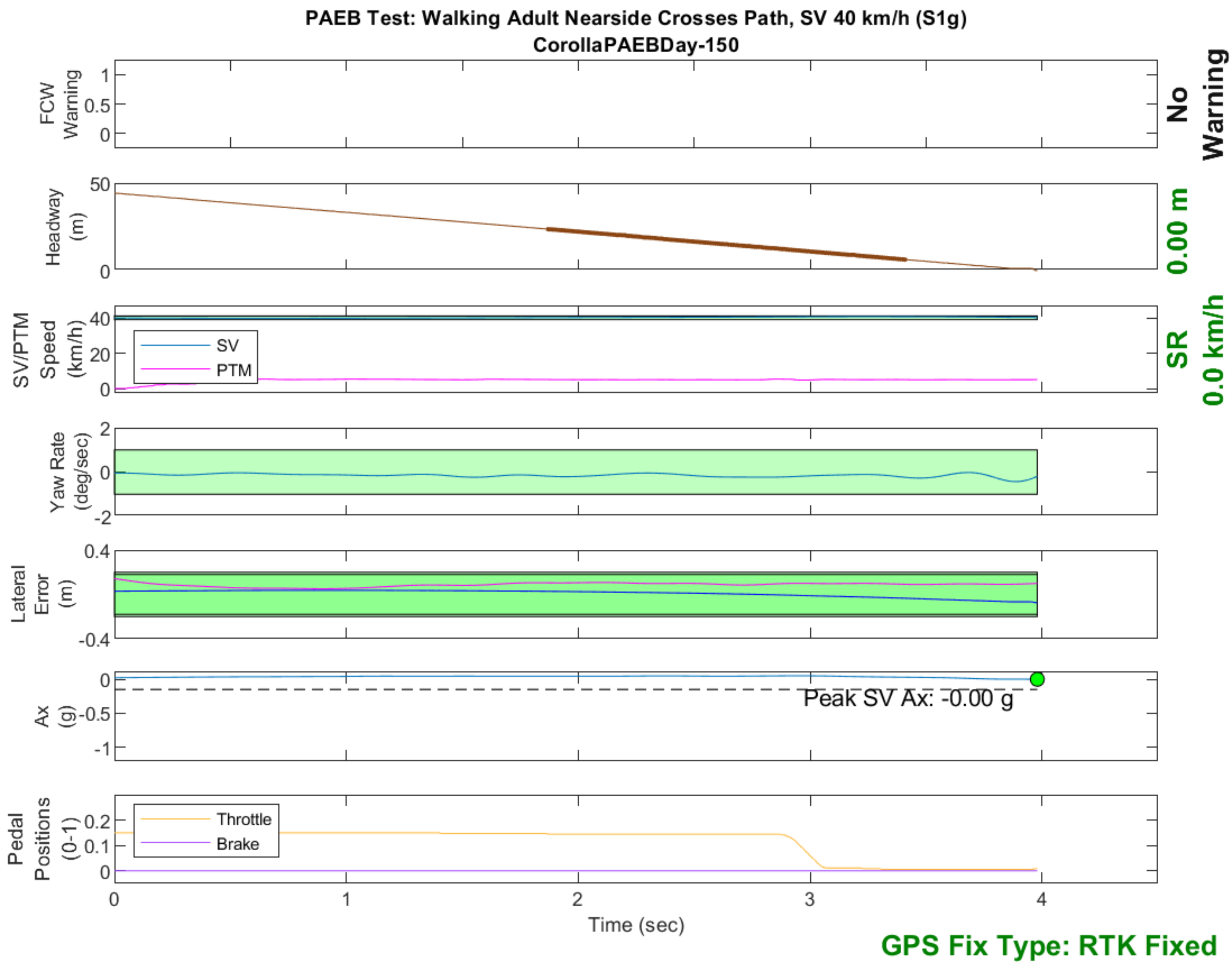


Figure D110. Time History for PAEB Run 150, S1g, Daytime, 40 km/h

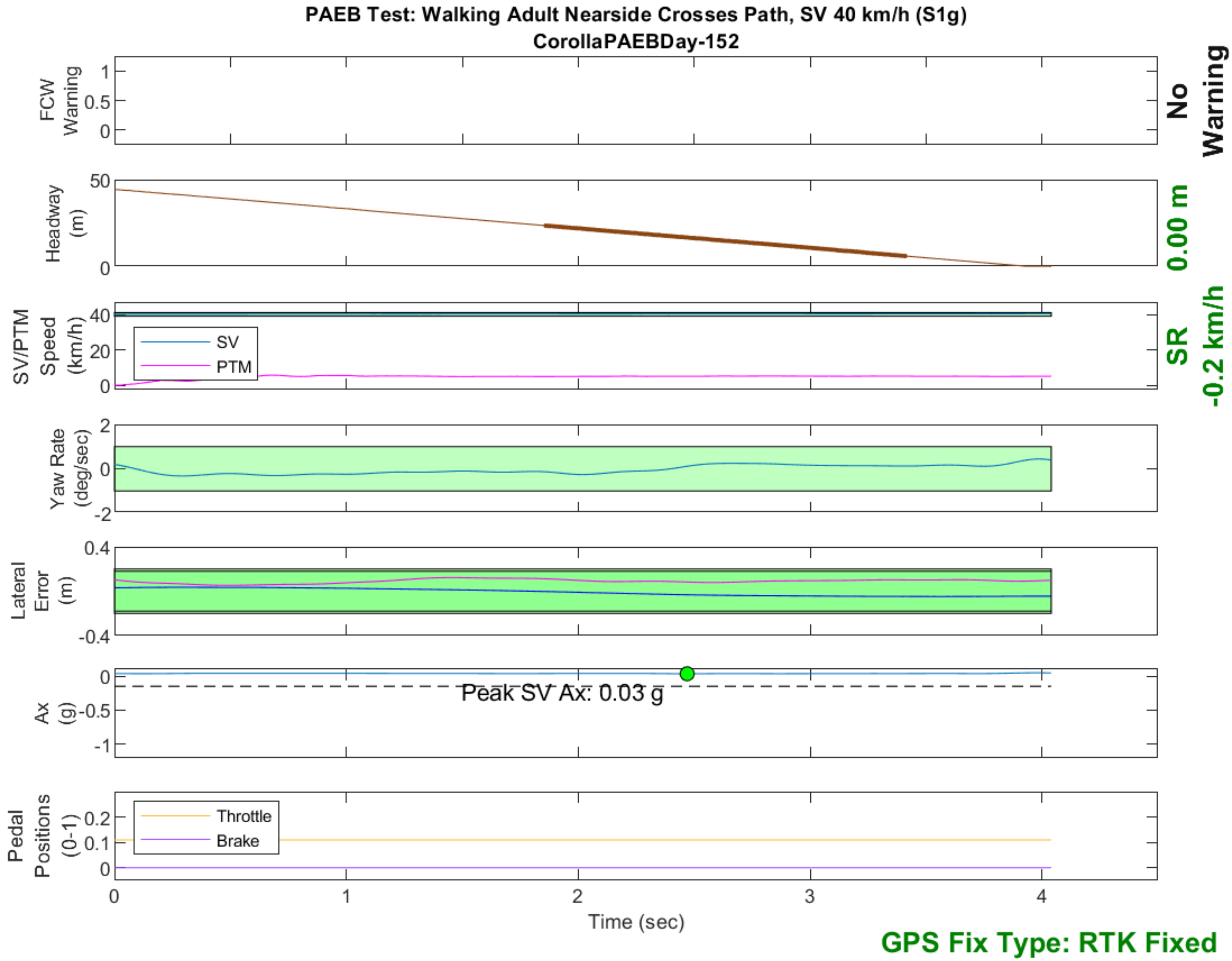


Figure D111. Time History for PAEB Run 152, S1g, Daytime, 40 km/h

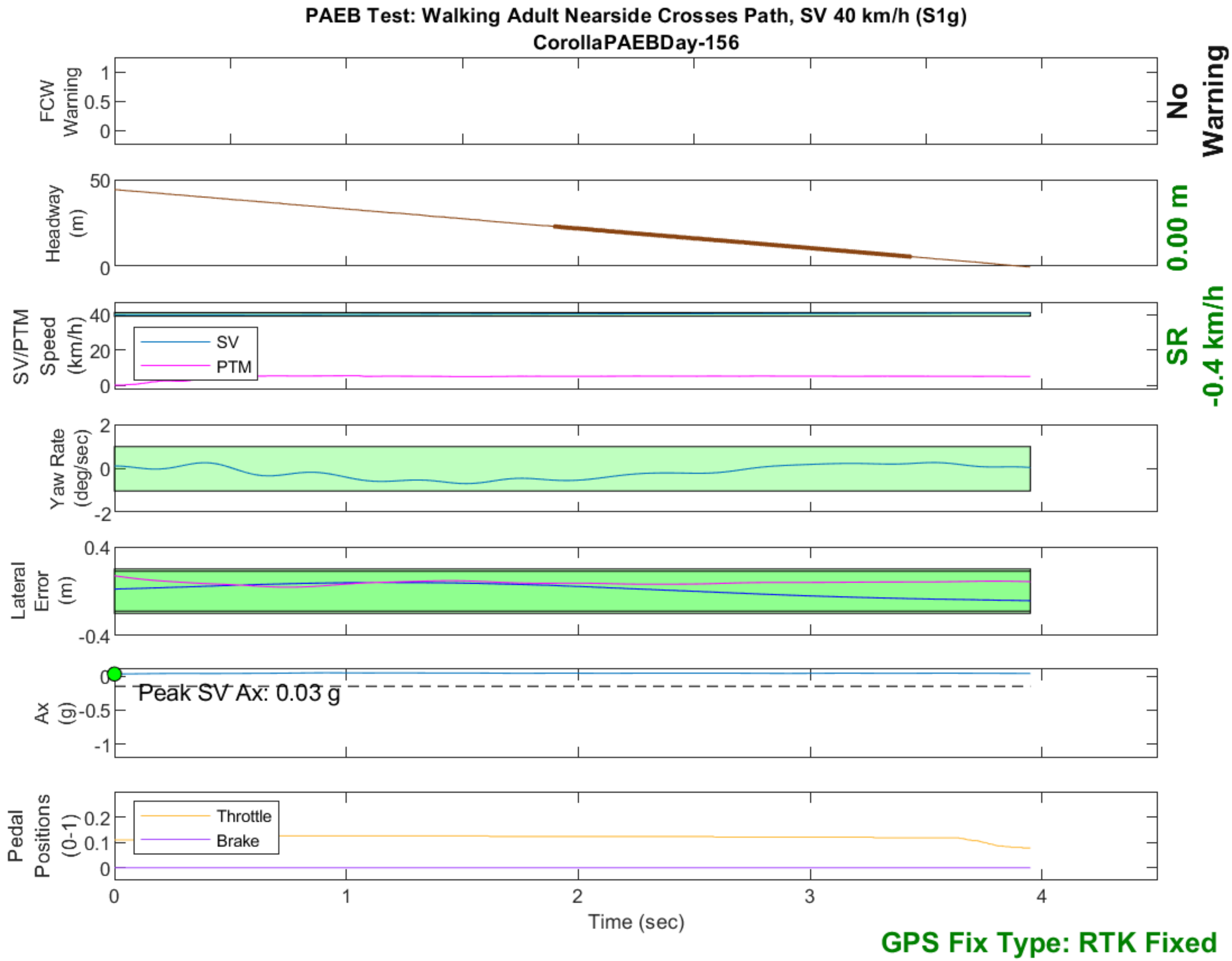


Figure D112. Time History for PAEB Run 156, S1g, Daytime, 40 km/h

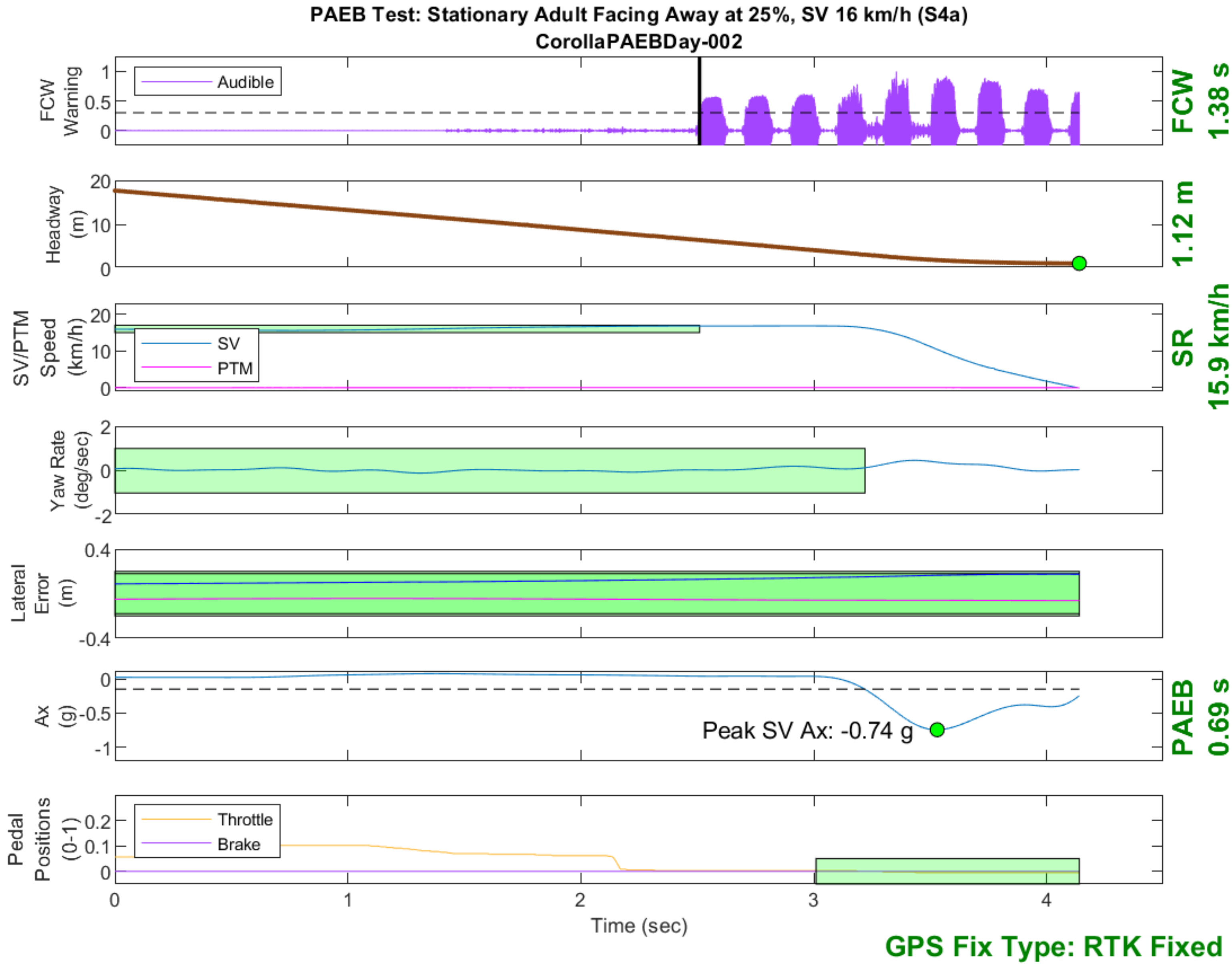


Figure D113. Time History for PAEB Run 2, S4a, Daytime, 16 km/h

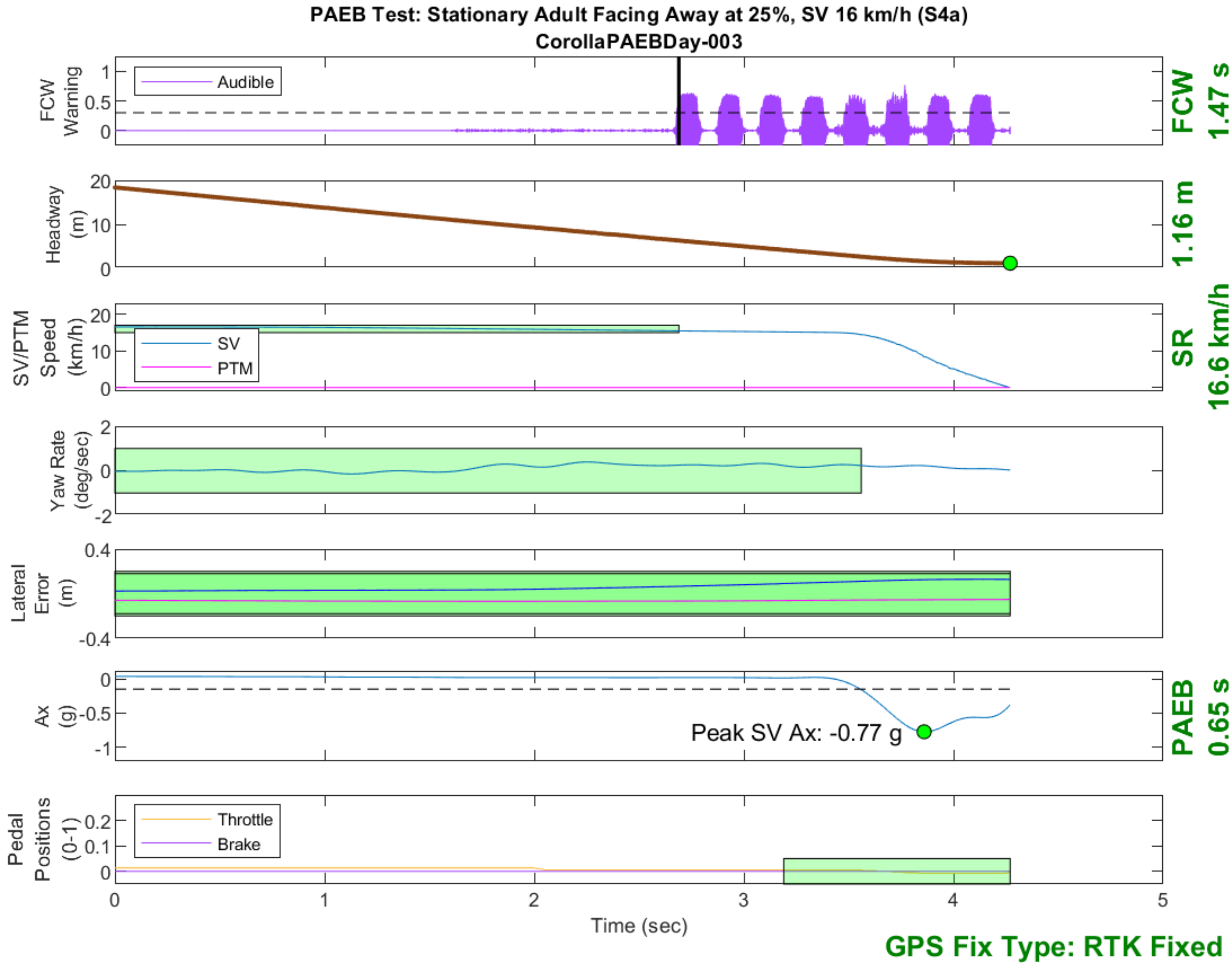


Figure D114. Time History for PAEB Run 3, S4a, Daytime, 16 km/h

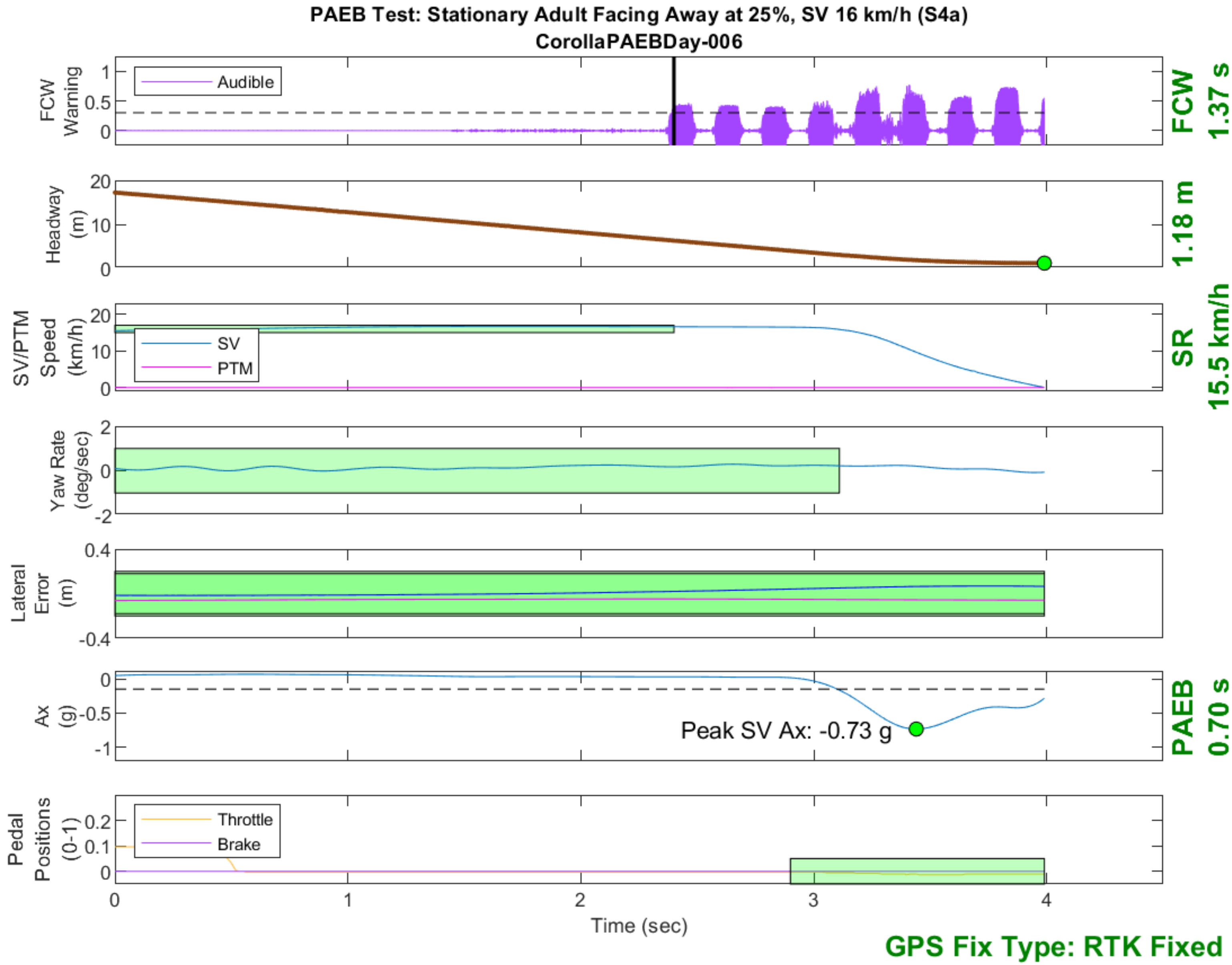


Figure D115. Time History for PAEB Run 6, S4a, Daytime, 16 km/h

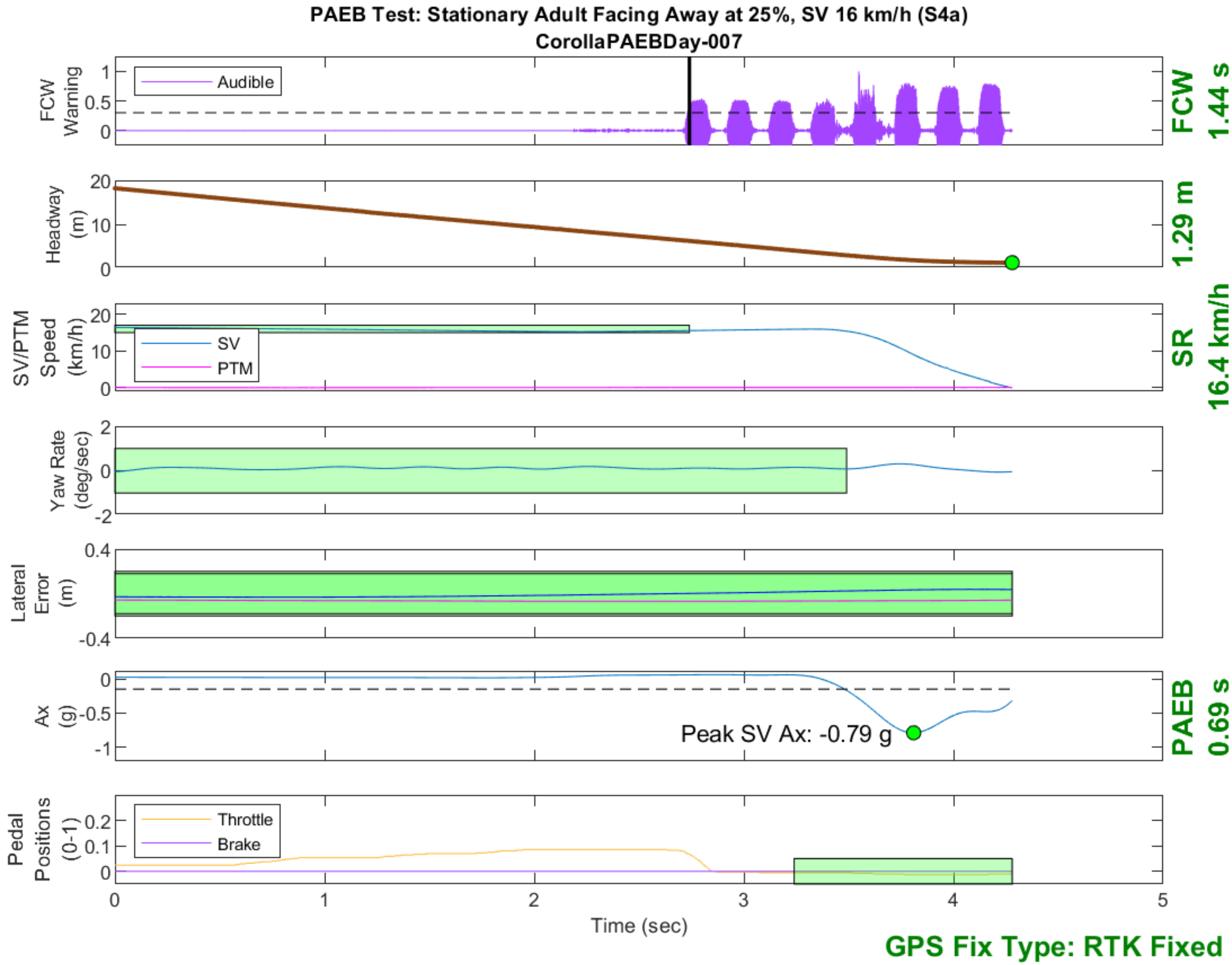


Figure D116. Time History for PAEB Run 7, S4a, Daytime, 16 km/h

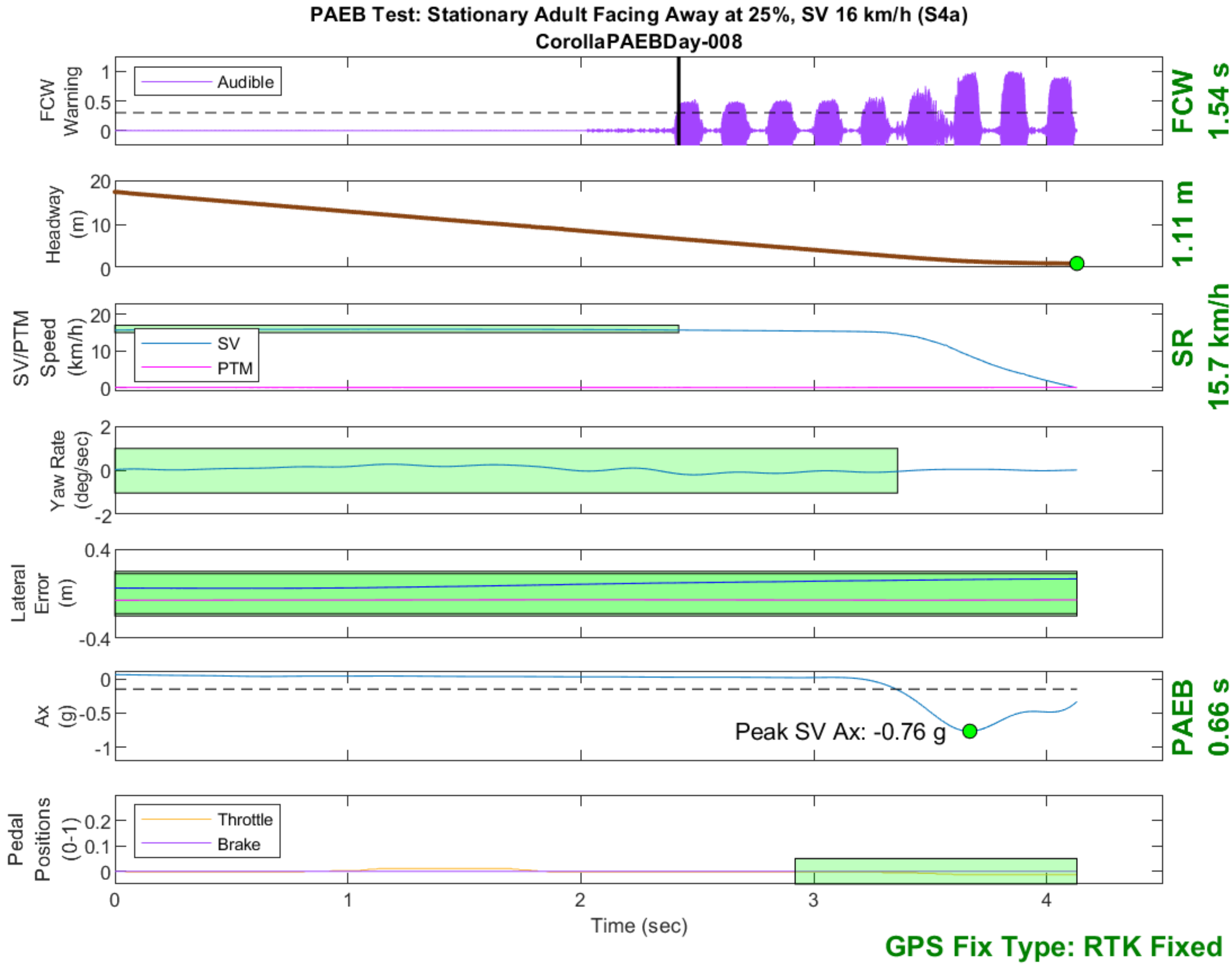


Figure D117. Time History for PAEB Run 8, S4a, Daytime, 16 km/h

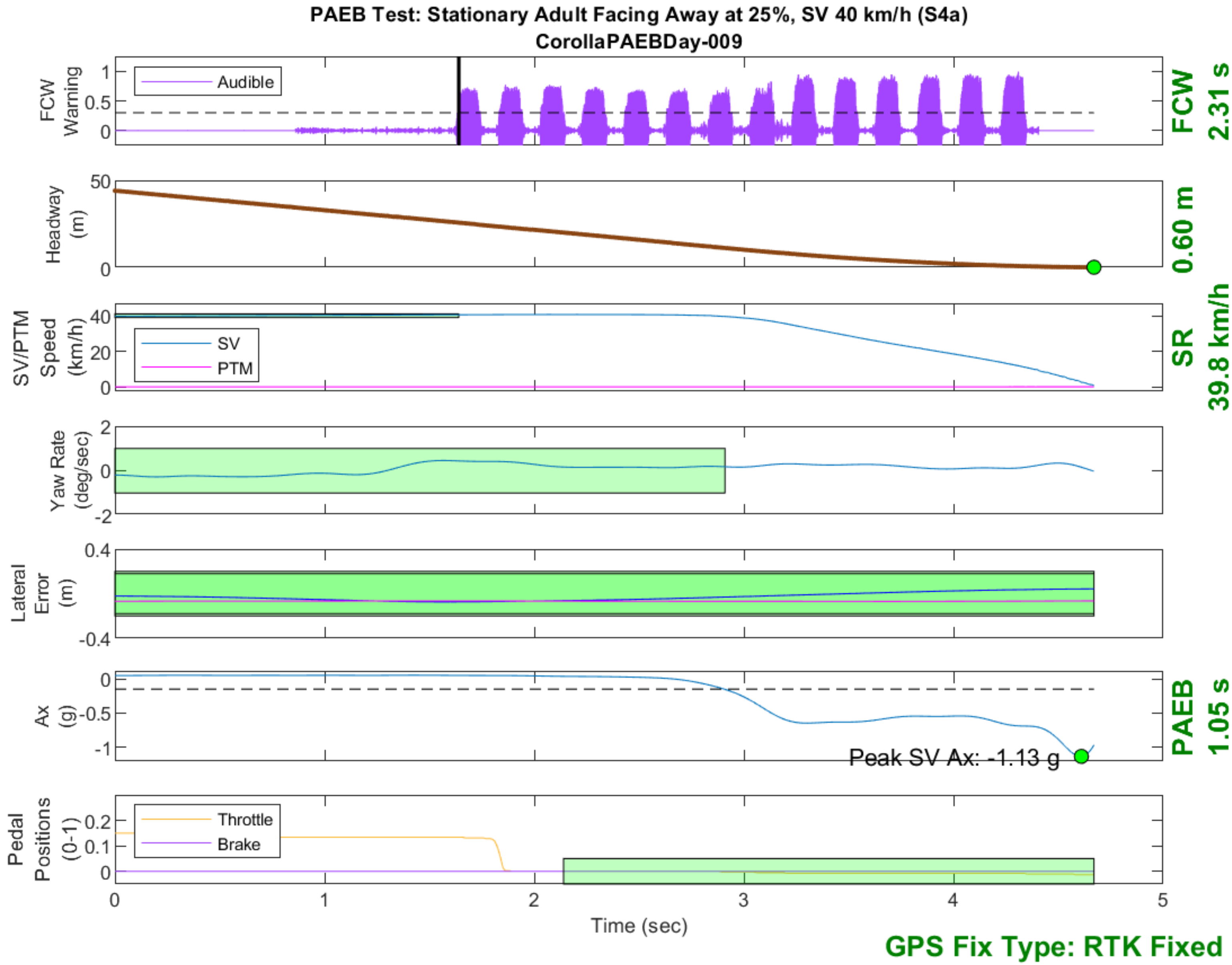


Figure D118. Time History for PAEB Run 9, S4a, Daytime, 40 km/h

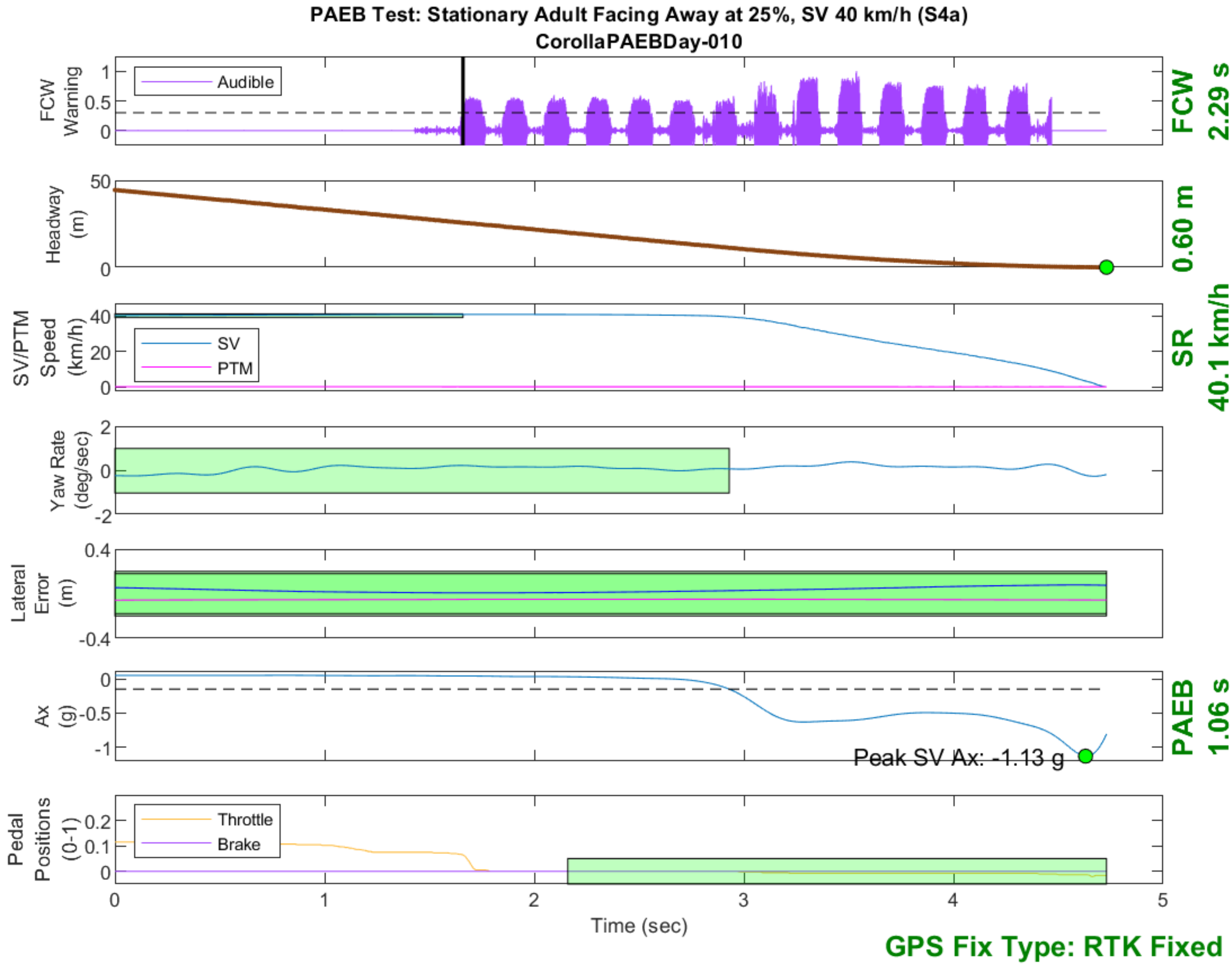


Figure D119. Time History for PAEB Run 10, S4a, Daytime, 40 km/h

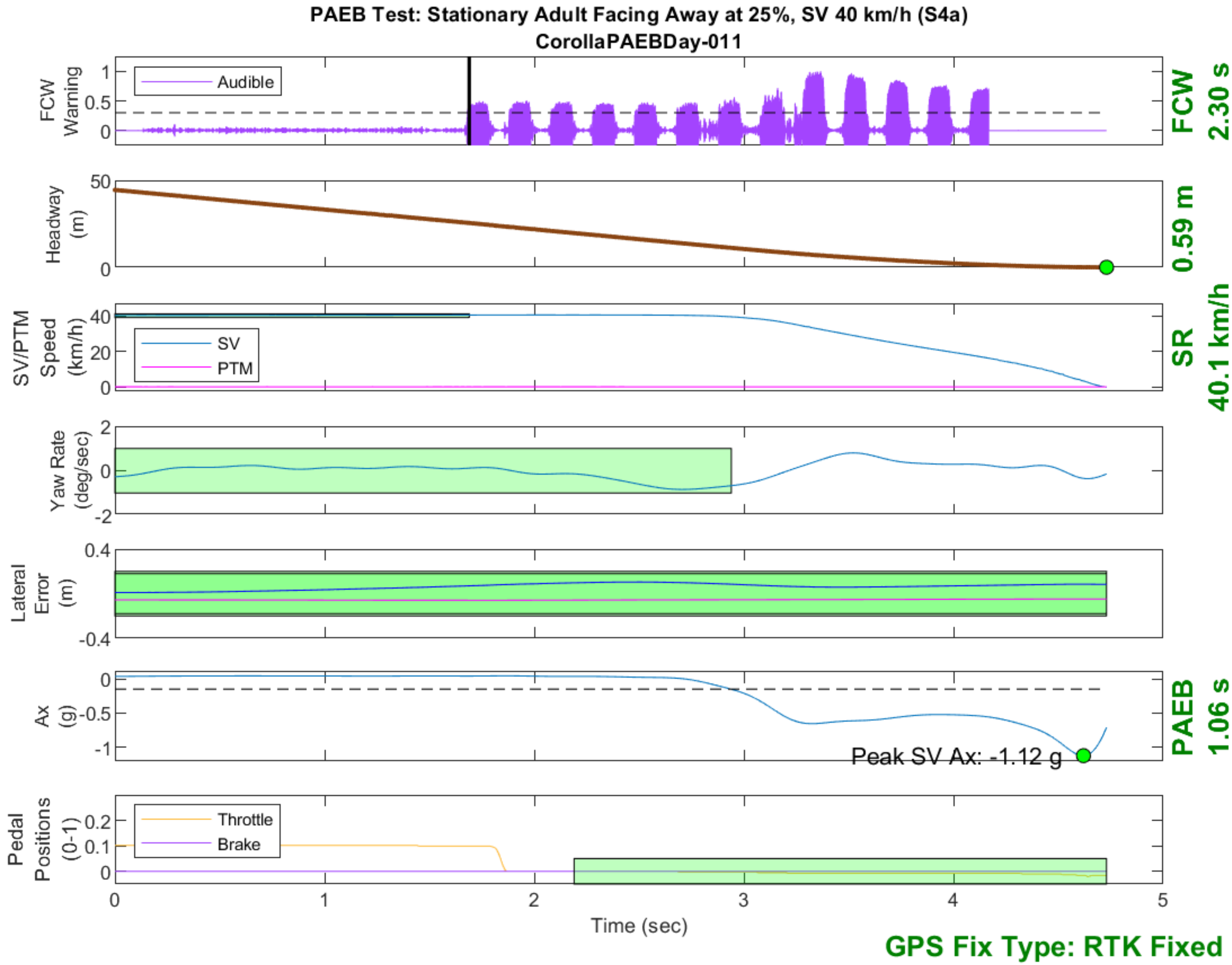


Figure D120. Time History for PAEB Run 11, S4a, Daytime, 40 km/h

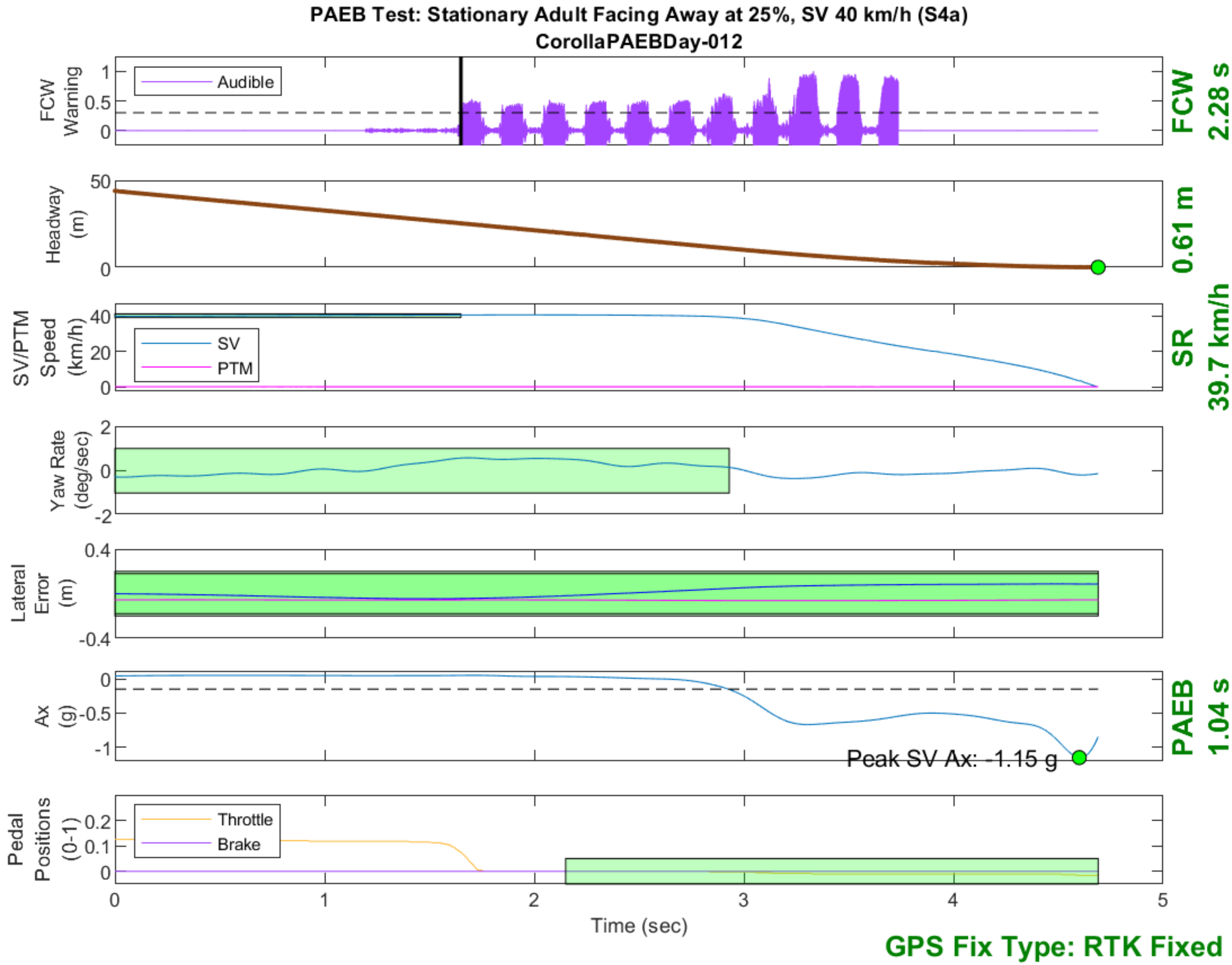


Figure D121. Time History for PAEB Run 12, S4a, Daytime, 40 km/h

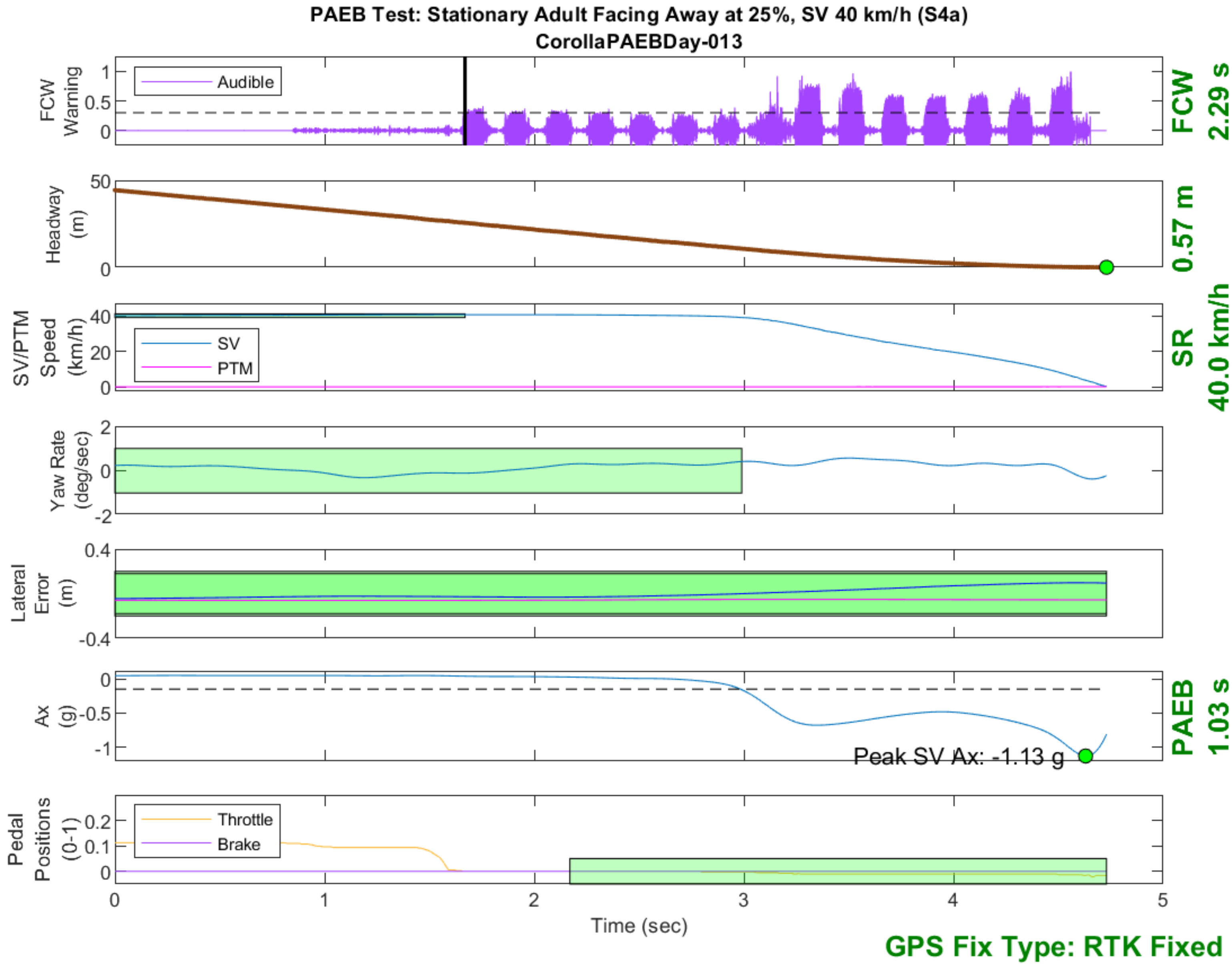


Figure D122. Time History for PAEB Run 13, S4a, Daytime, 40 km/h

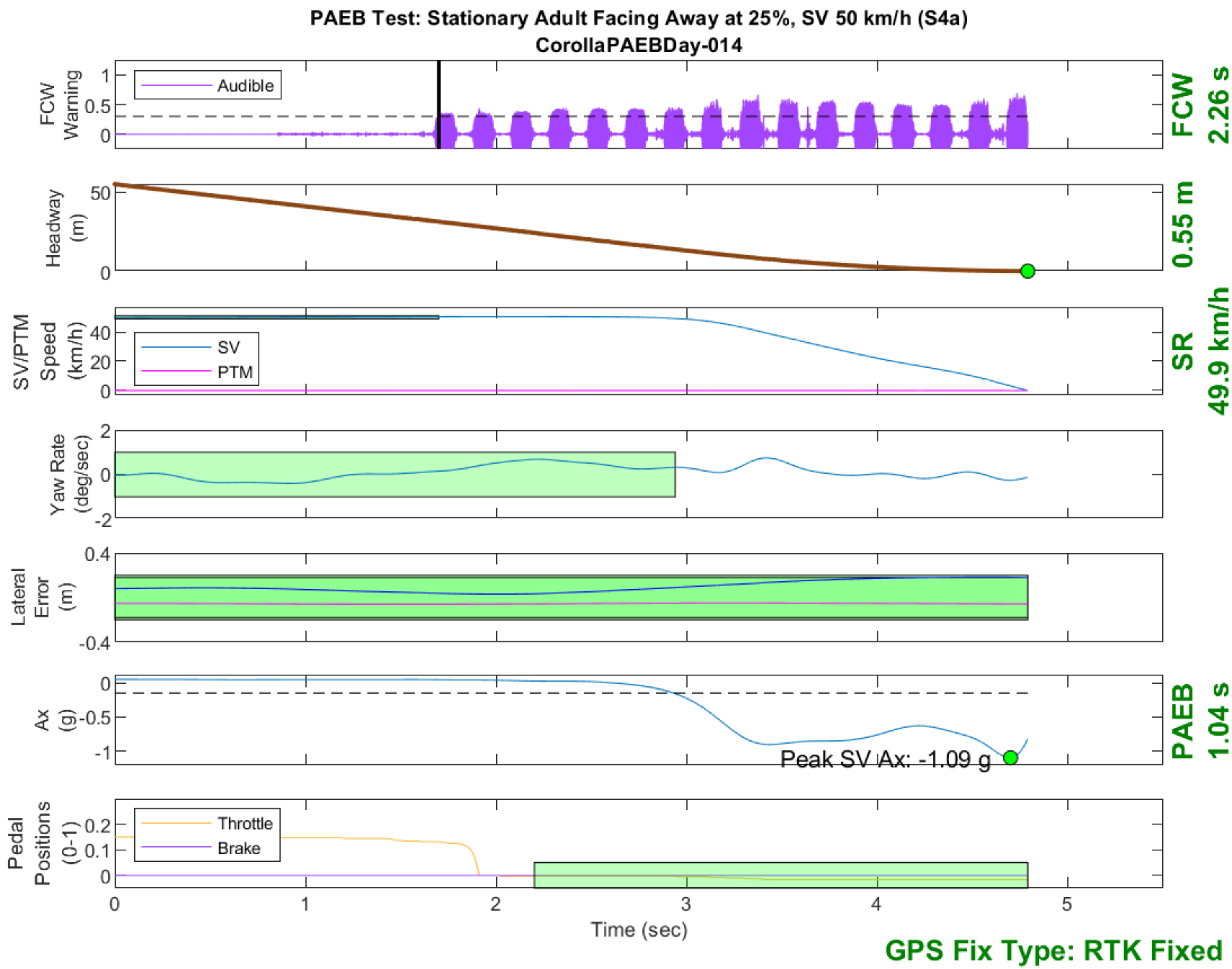


Figure D123. Time History for PAEB Run 14, S4a, Daytime, 50 km/h

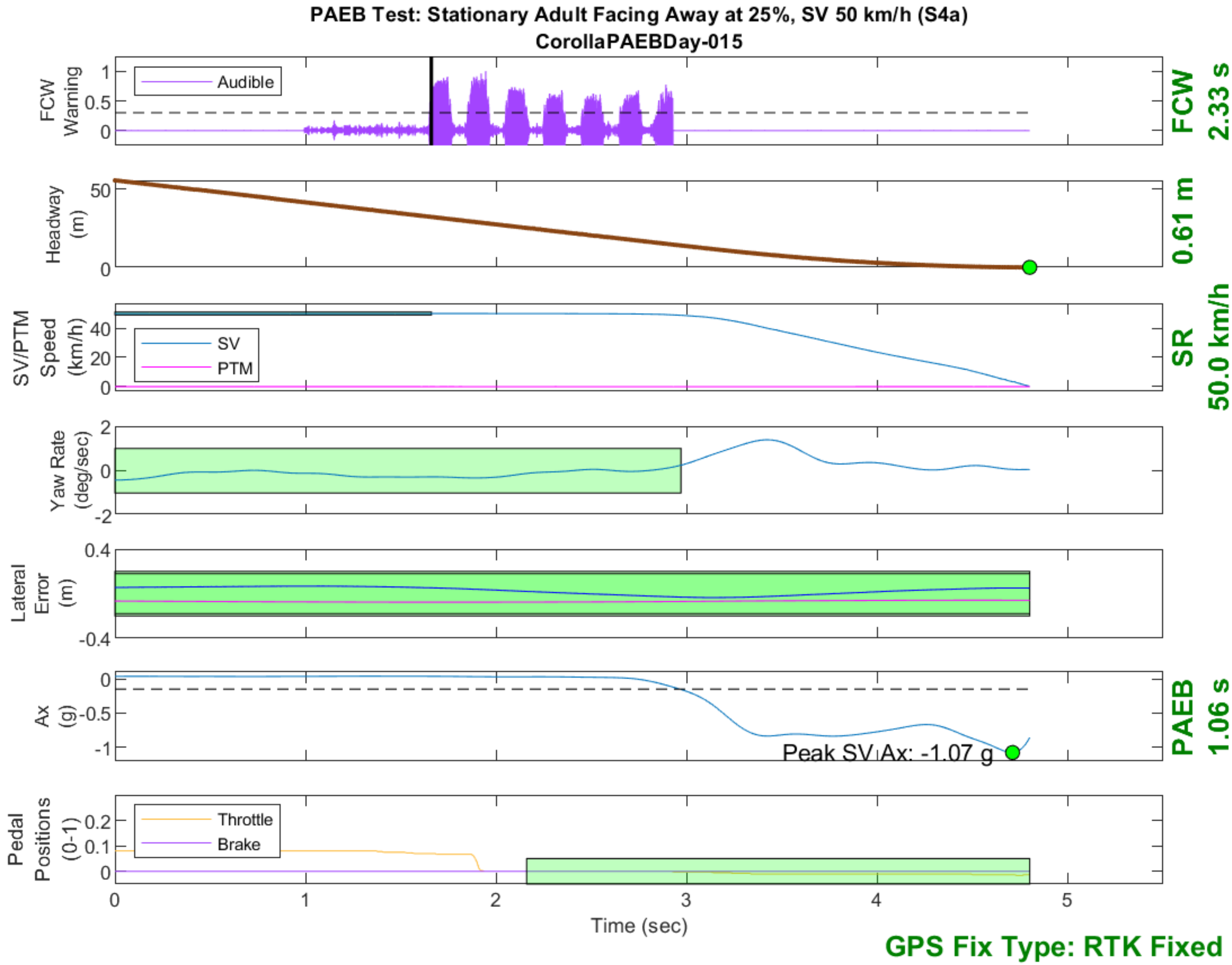


Figure D124. Time History for PAEB Run 15, S4a, Daytime, 50 km/h

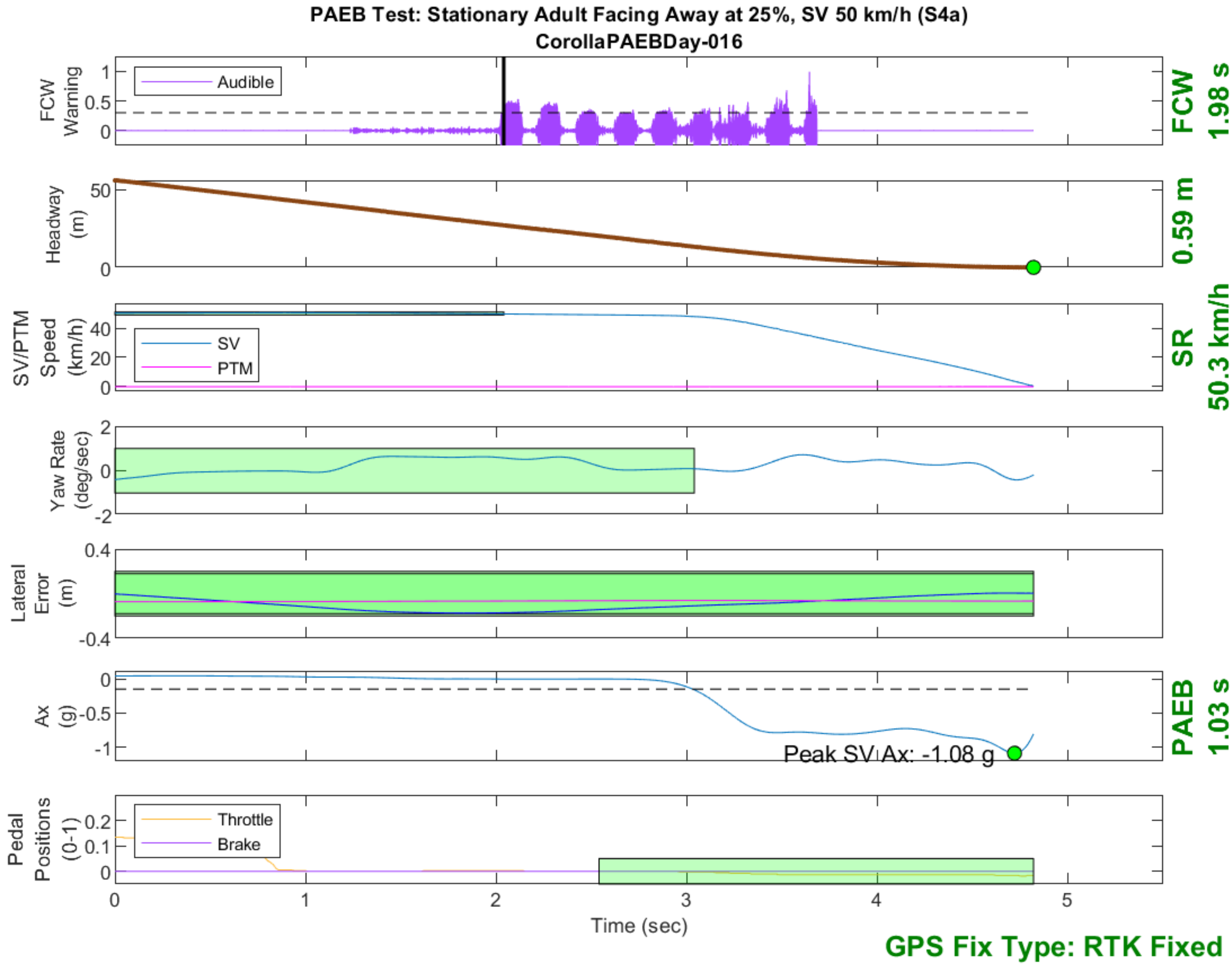


Figure D125. Time History for PAEB Run 16, S4a, Daytime, 50 km/h

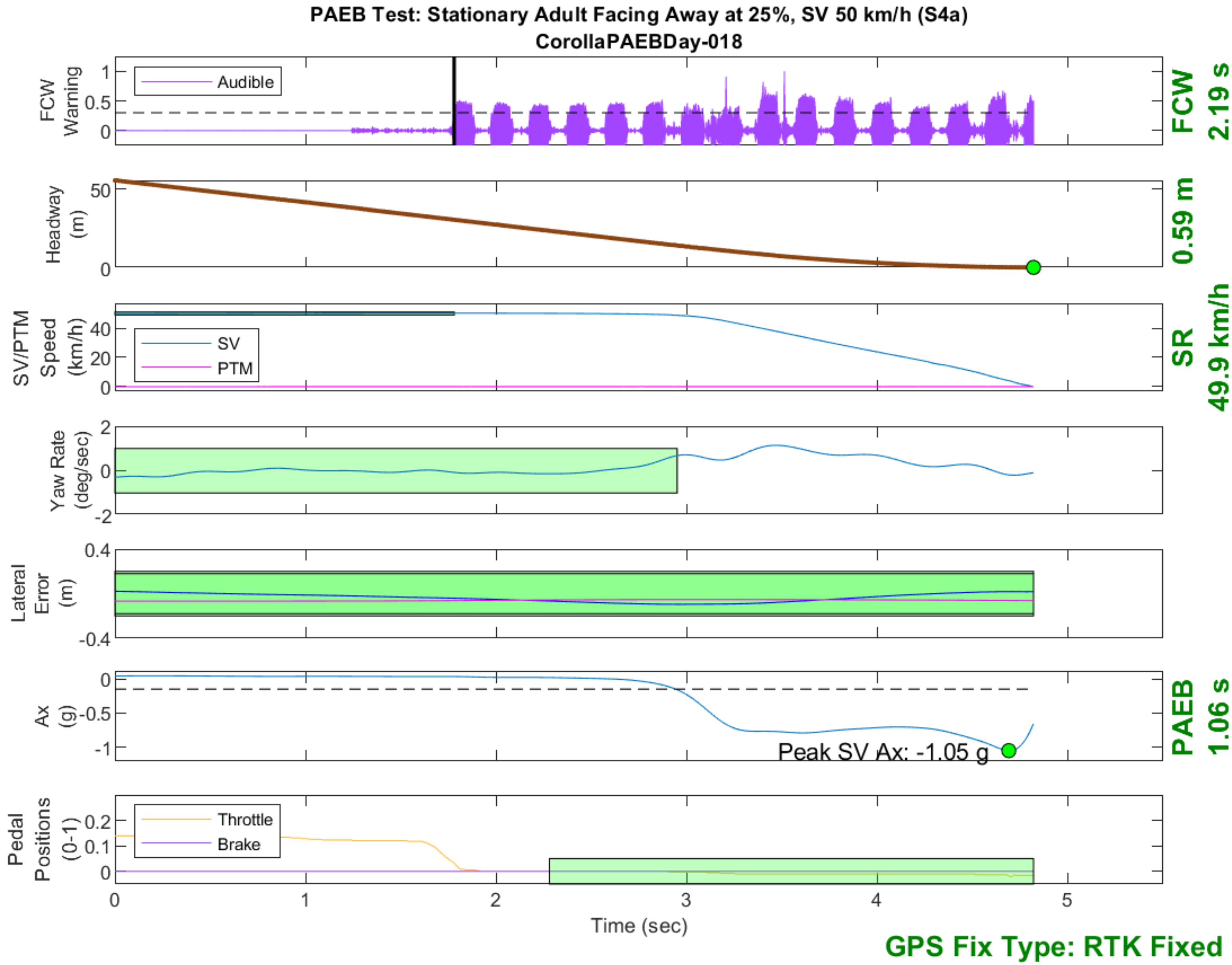


Figure D126. Time History for PAEB Run 18, S4a, Daytime, 50 km/h

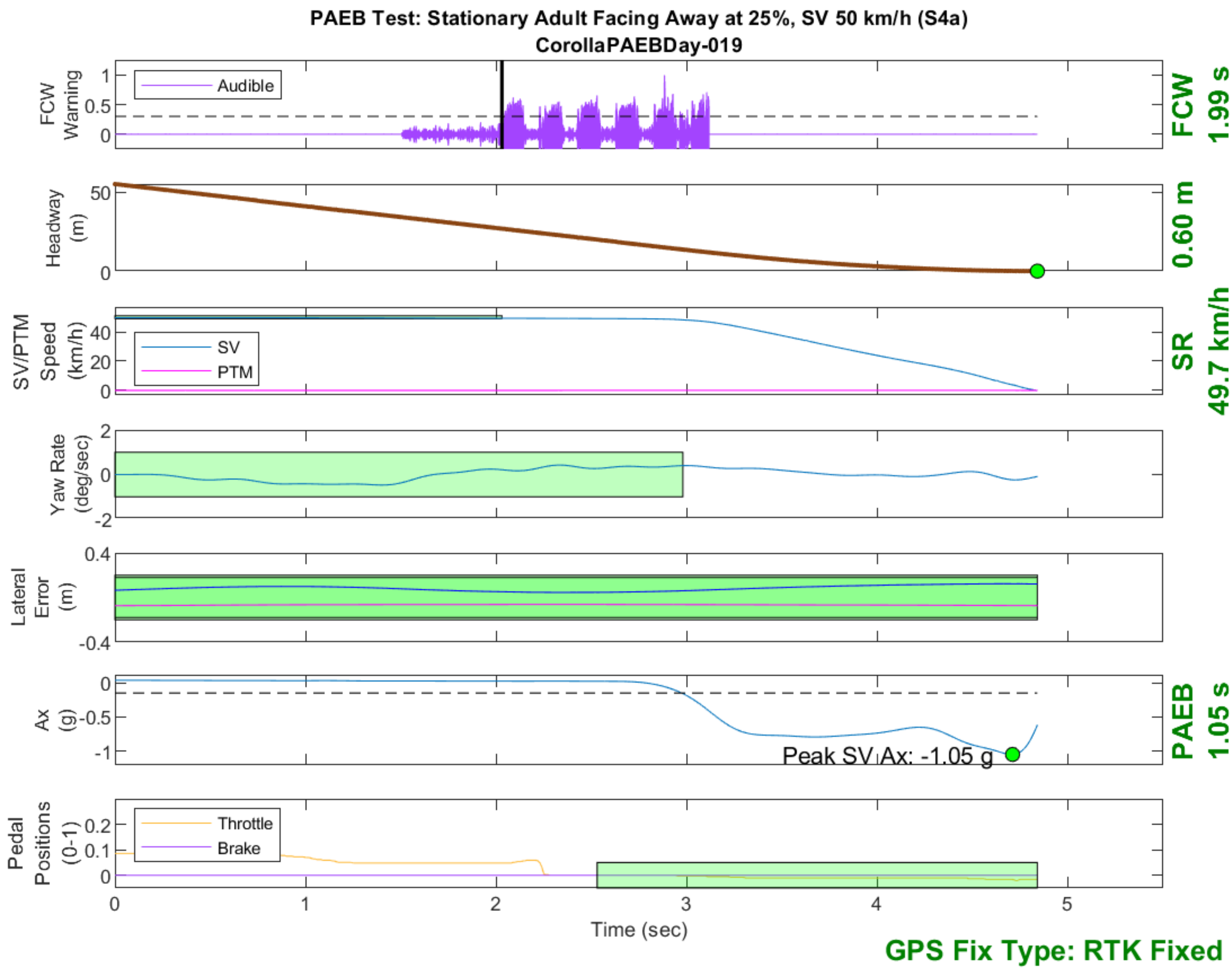


Figure D127. Time History for PAEB Run 19, S4a, Daytime, 50 km/h

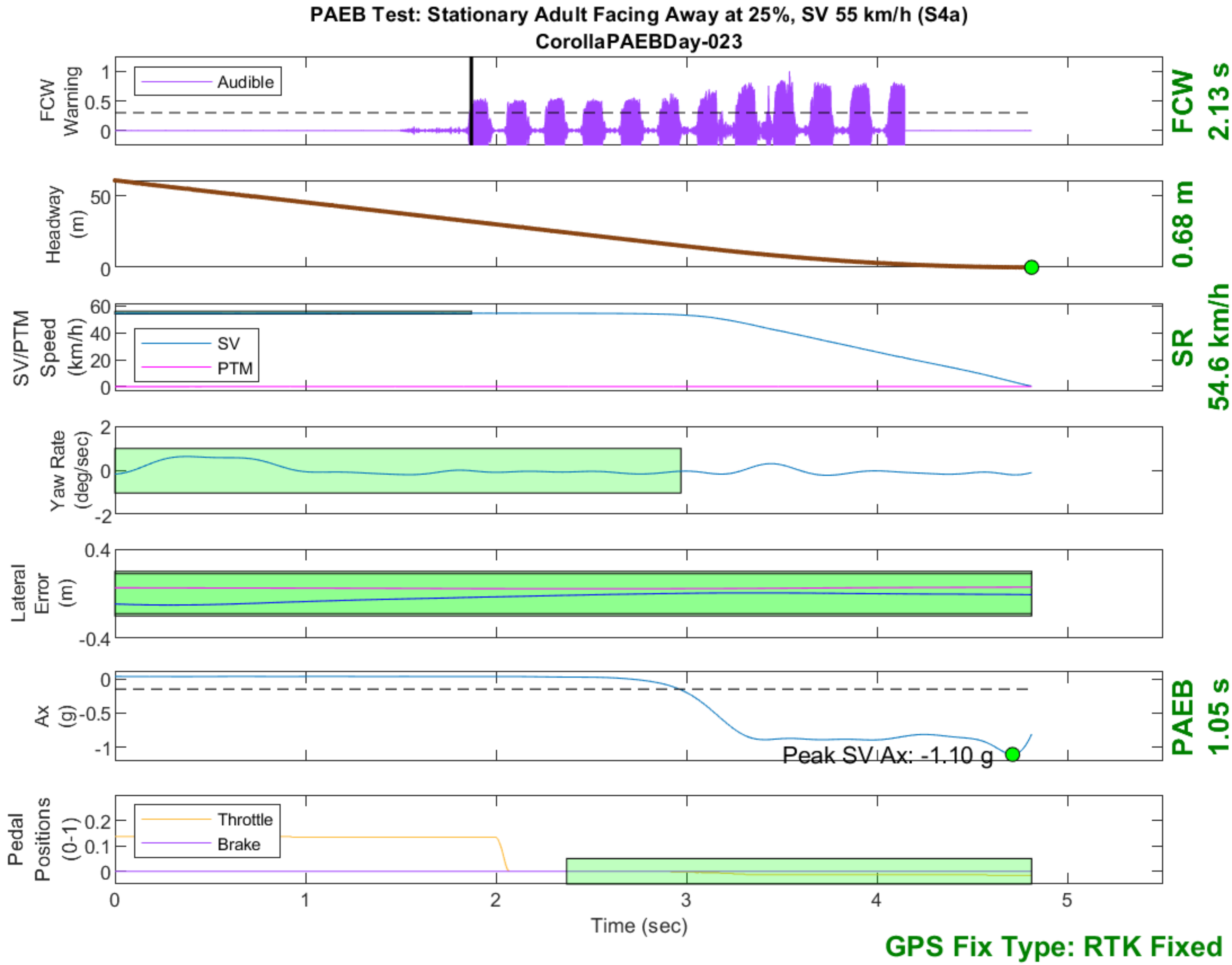


Figure D128. Time History for PAEB Run 23, S4a, Daytime, 55 km/h

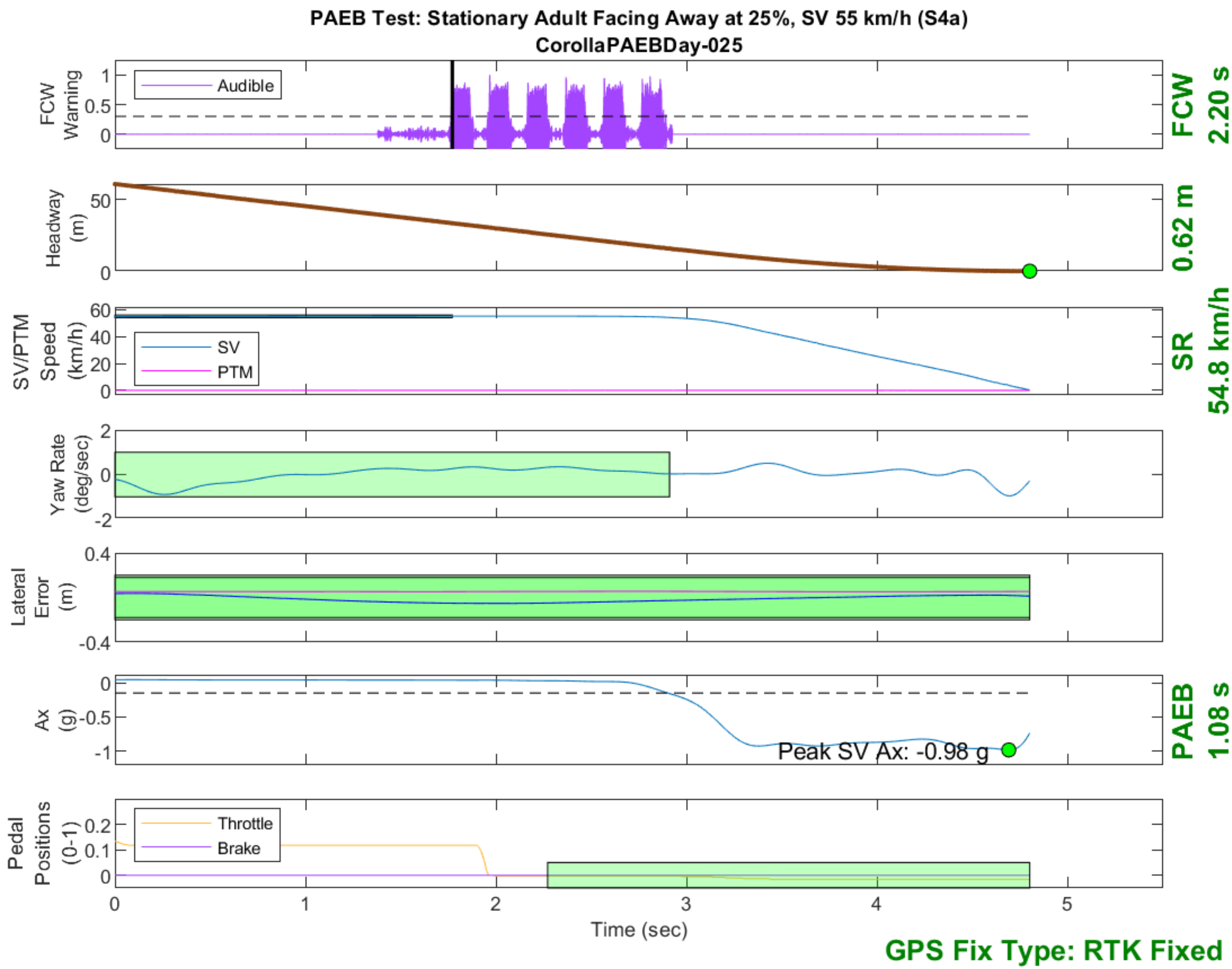


Figure D129. Time History for PAEB Run 25, S4a, Daytime, 55 km/h

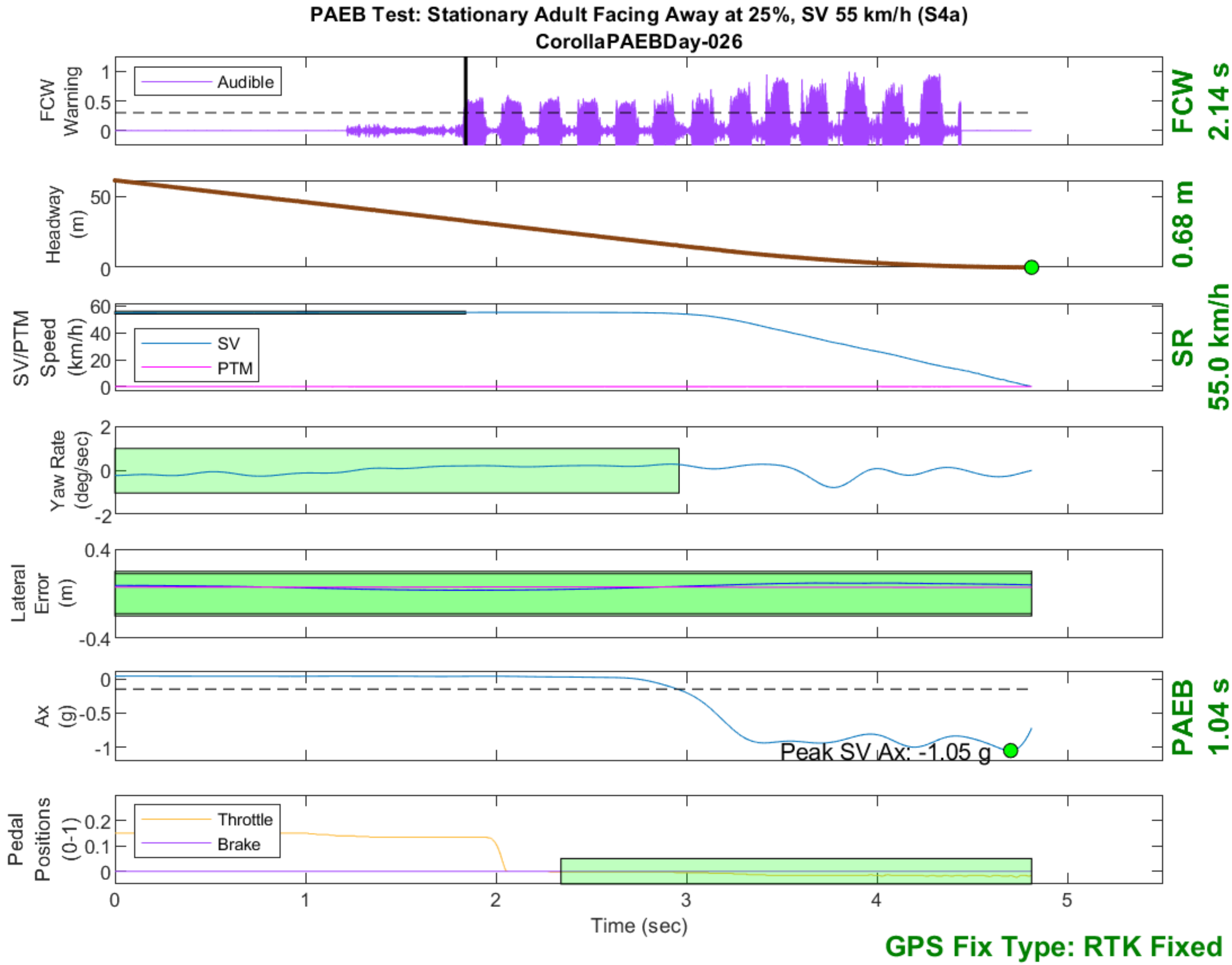


Figure D130. Time History for PAEB Run 26, S4a, Daytime, 55 km/h

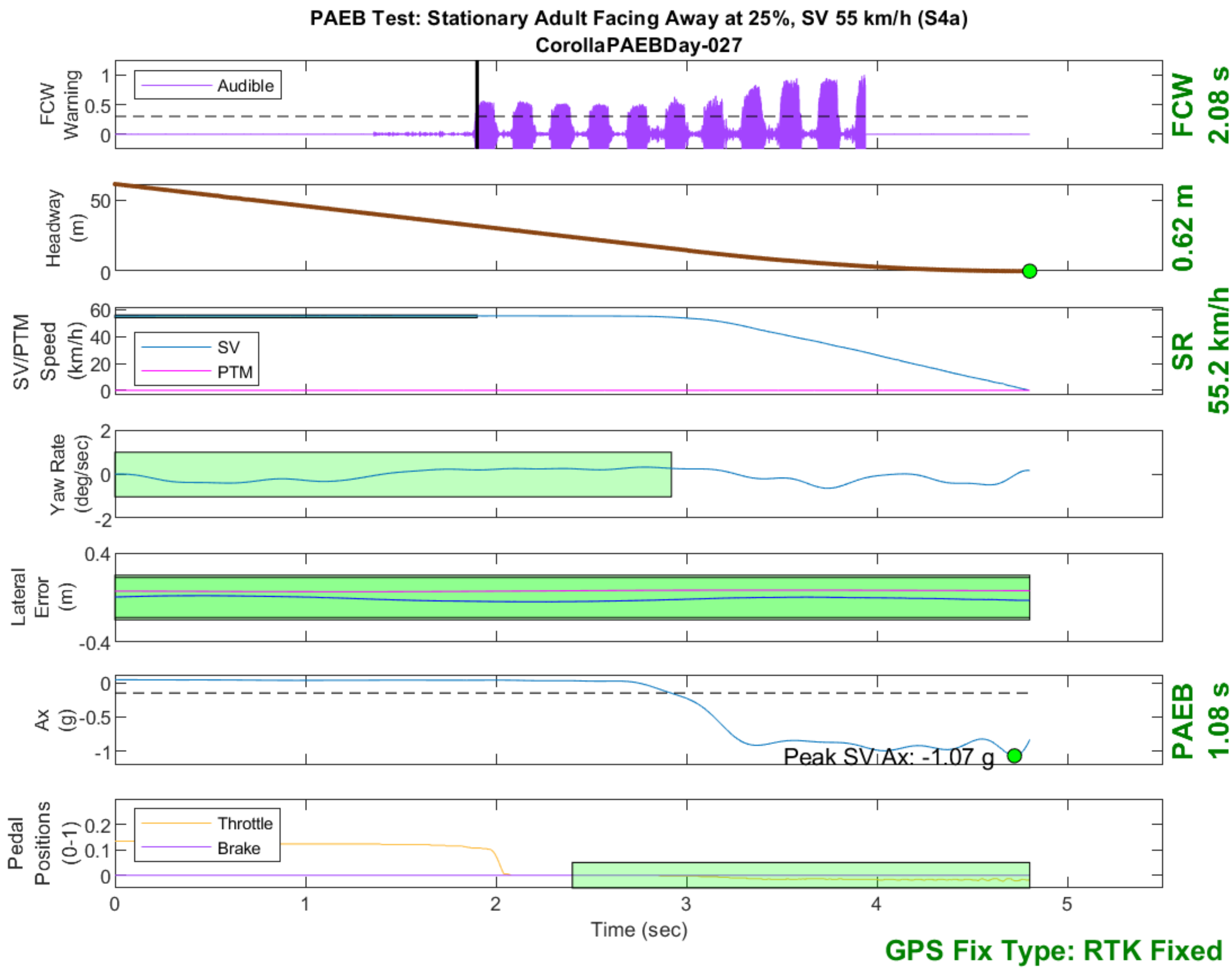


Figure D131. Time History for PAEB Run 27, S4a, Daytime, 55 km/h

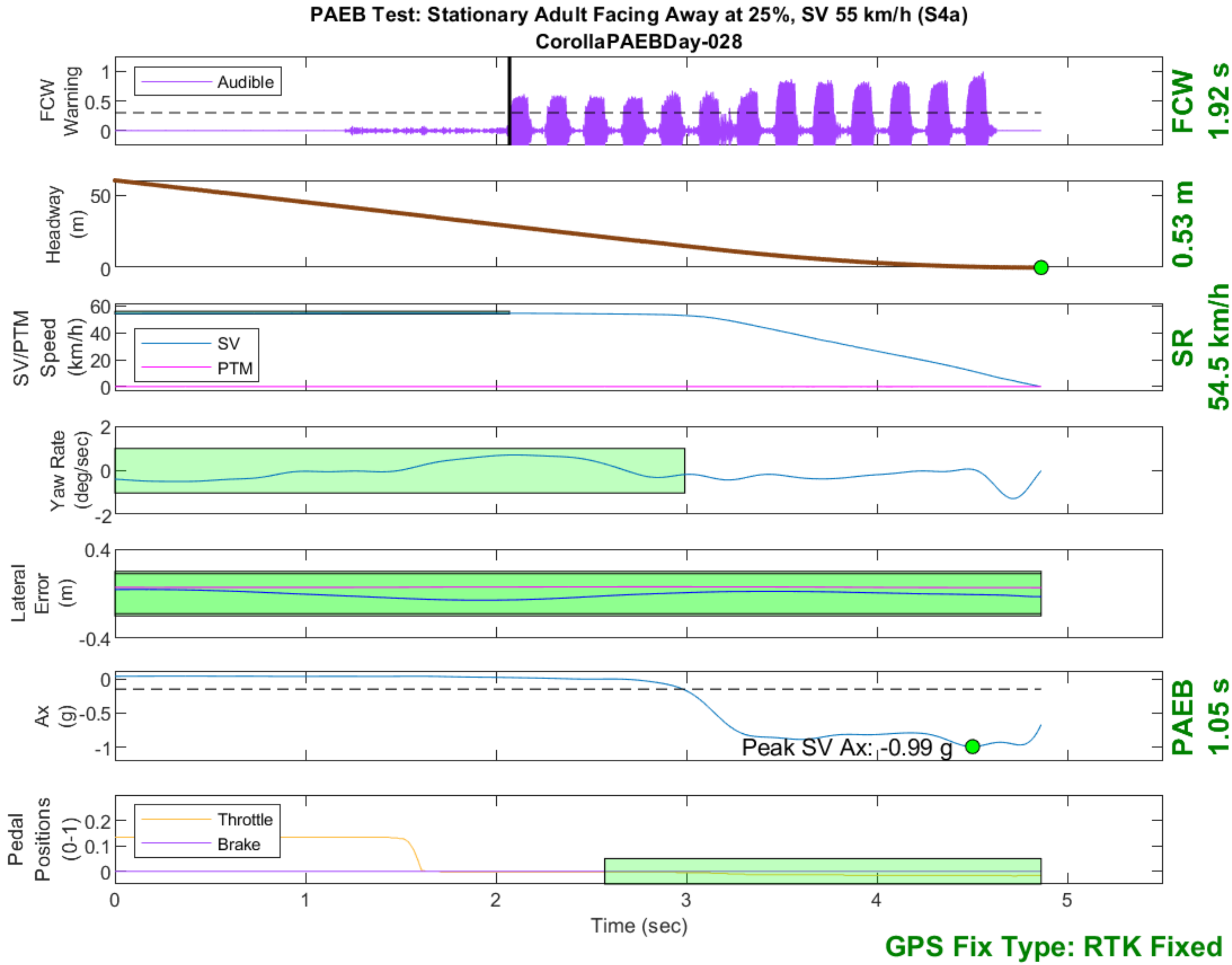


Figure D132. Time History for PAEB Run 28, S4a, Daytime, 55 km/h

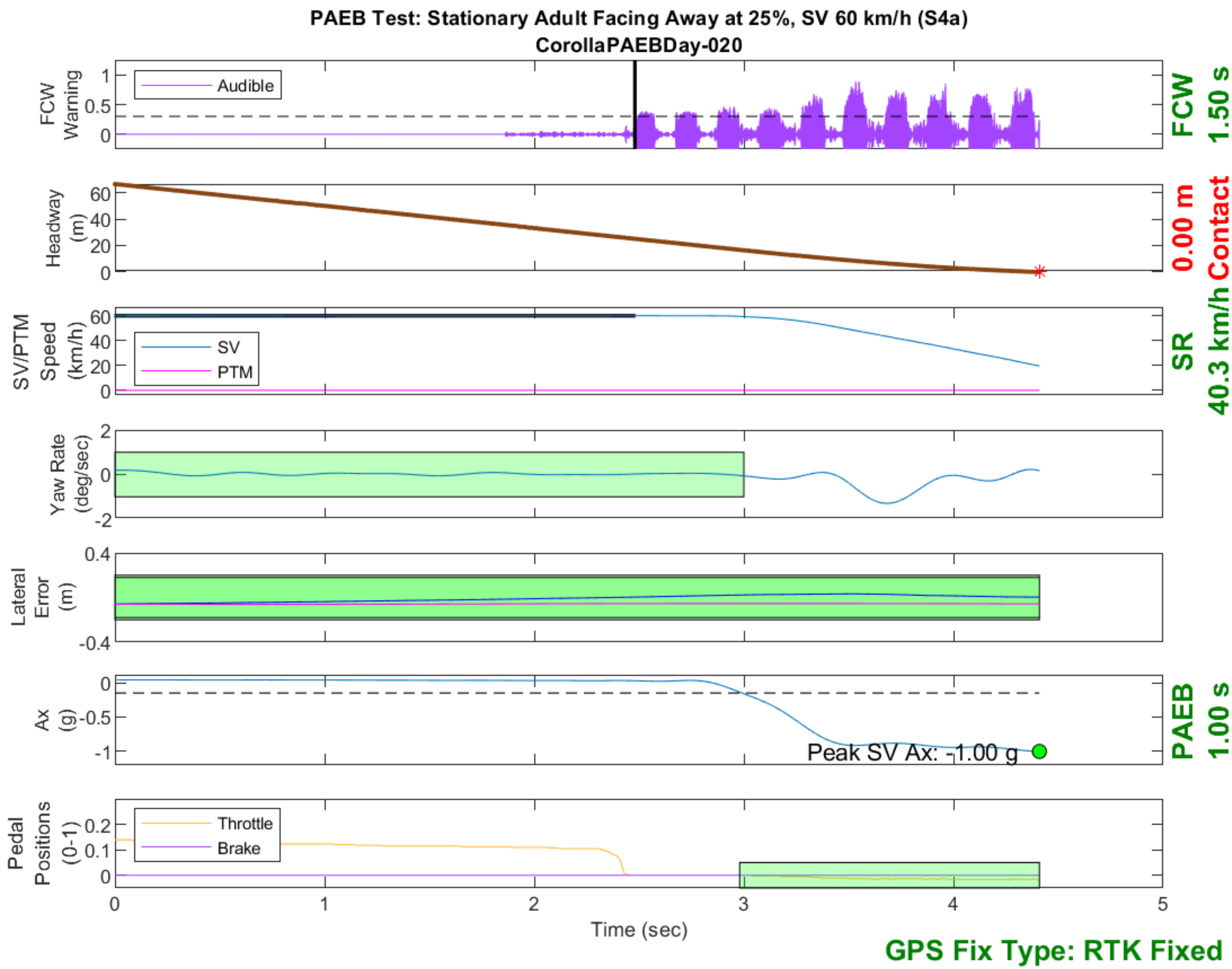


Figure D133. Time History for PAEB Run 20, S4a, Daytime, 60 km/h

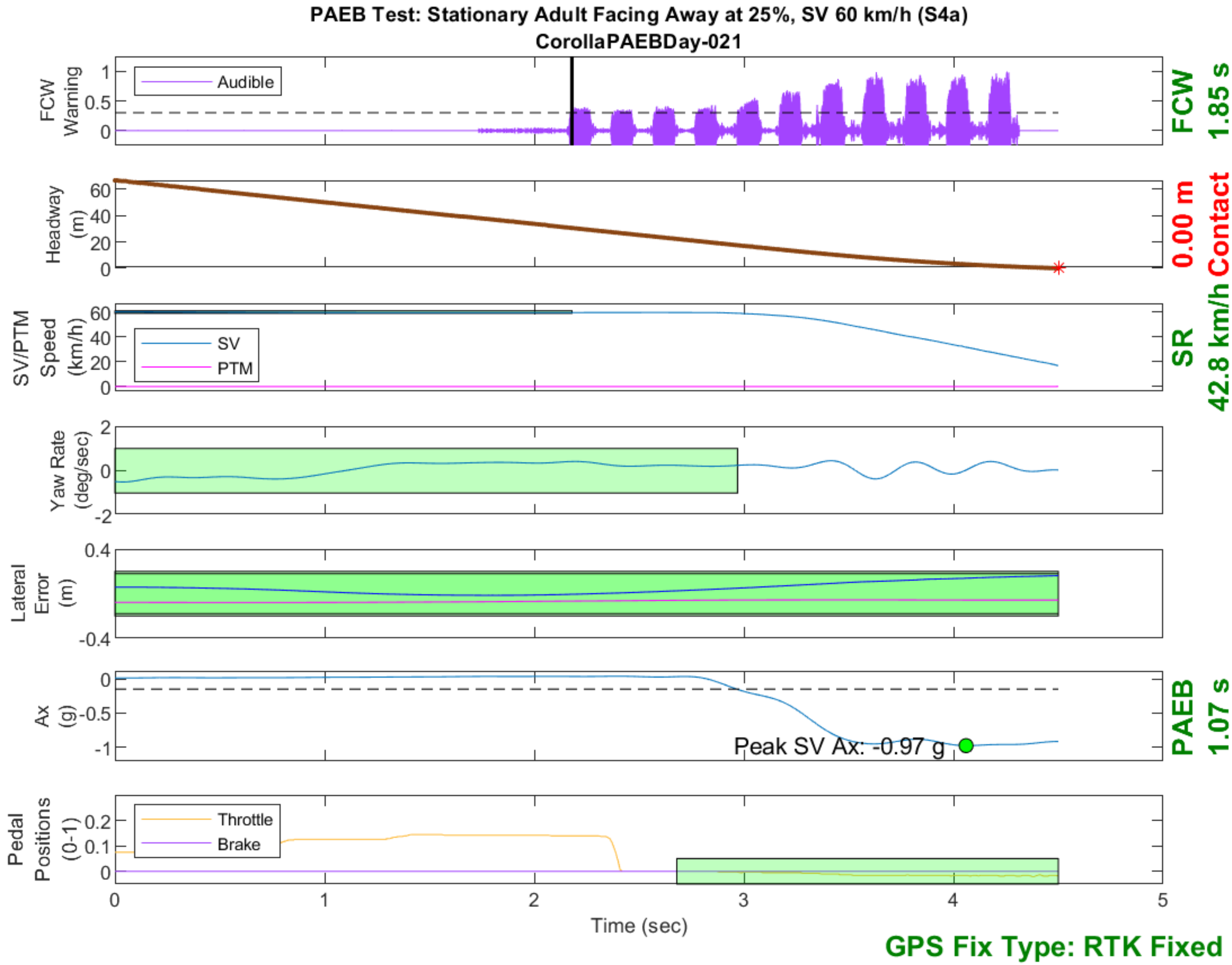


Figure D134. Time History for PAEB Run 21, S4a, Daytime, 60 km/h

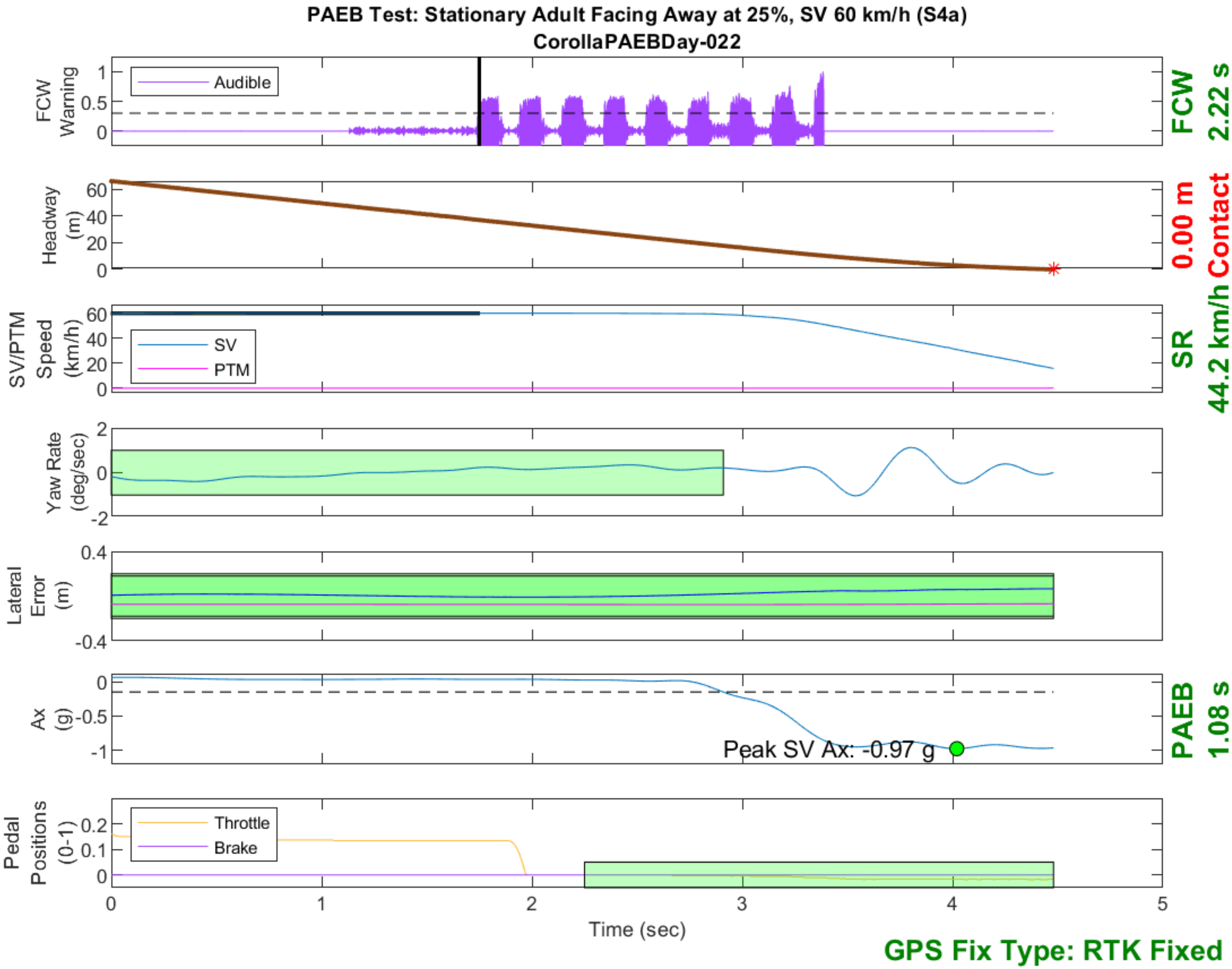


Figure D135. Time History for PAEB Run 22, S4a, Daytime, 60 km/h

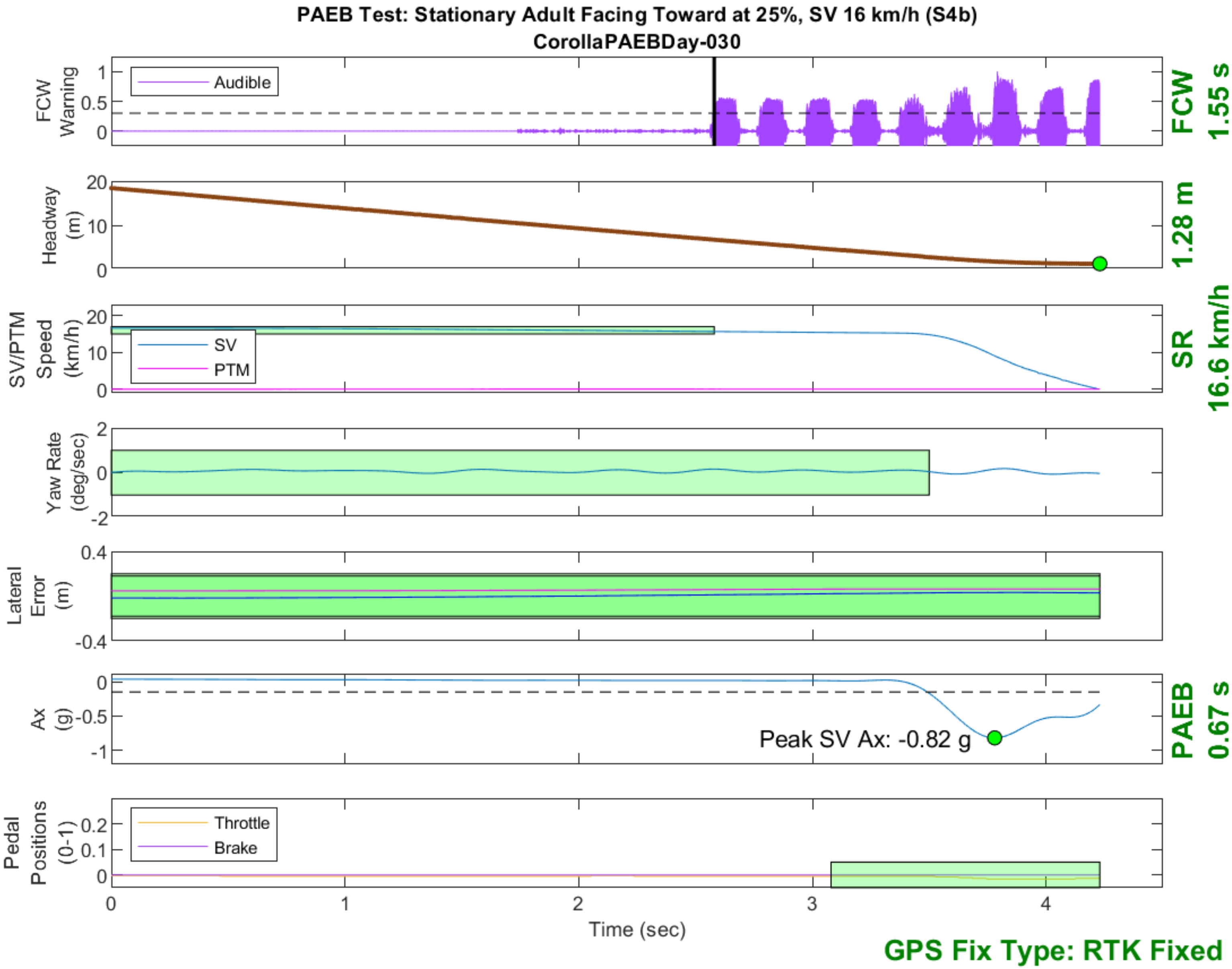


Figure D136. Time History for PAEB Run 30, S4b, Daytime, 16 km/h

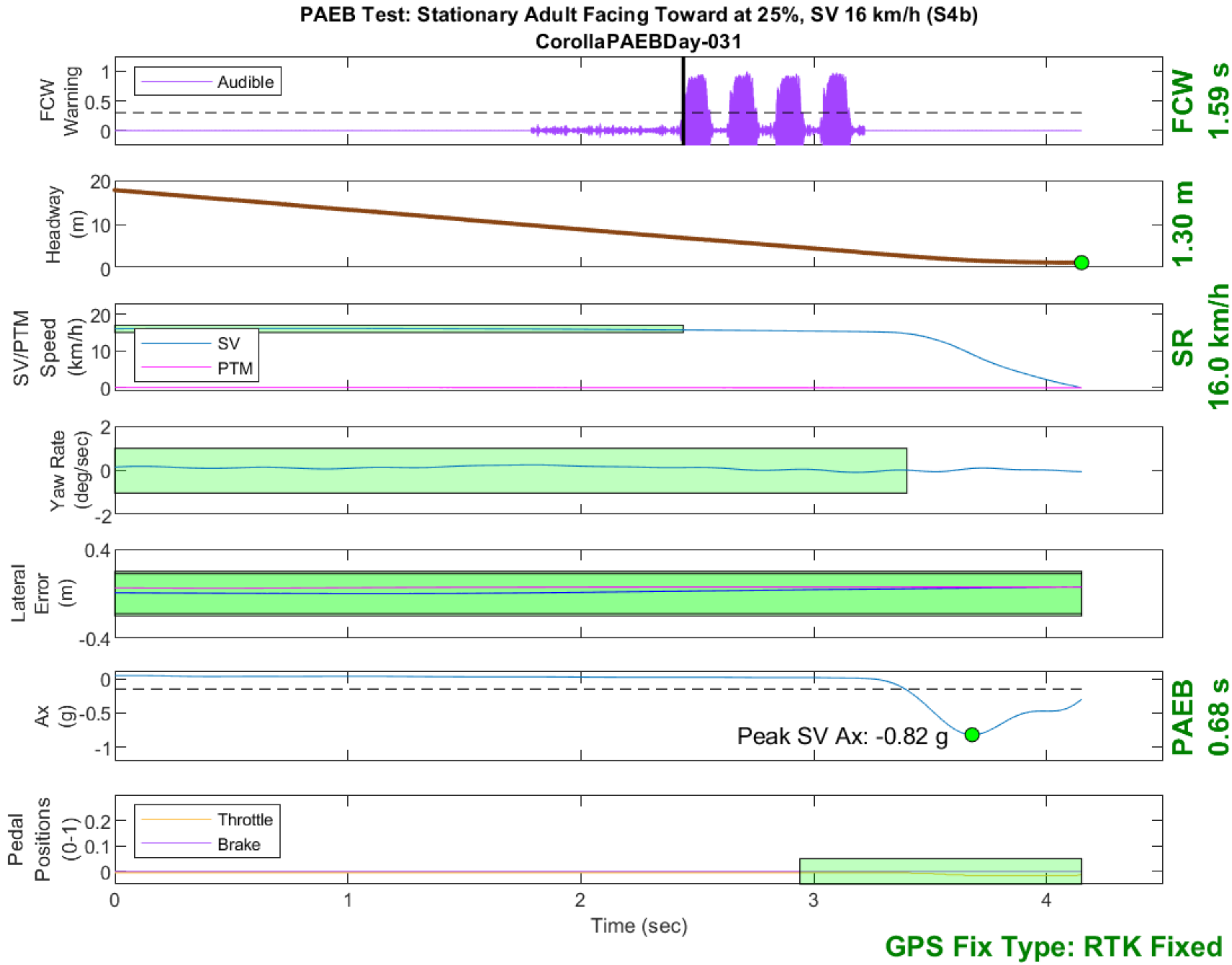


Figure D137. Time History for PAEB Run 31, S4b, Daytime, 16 km/h

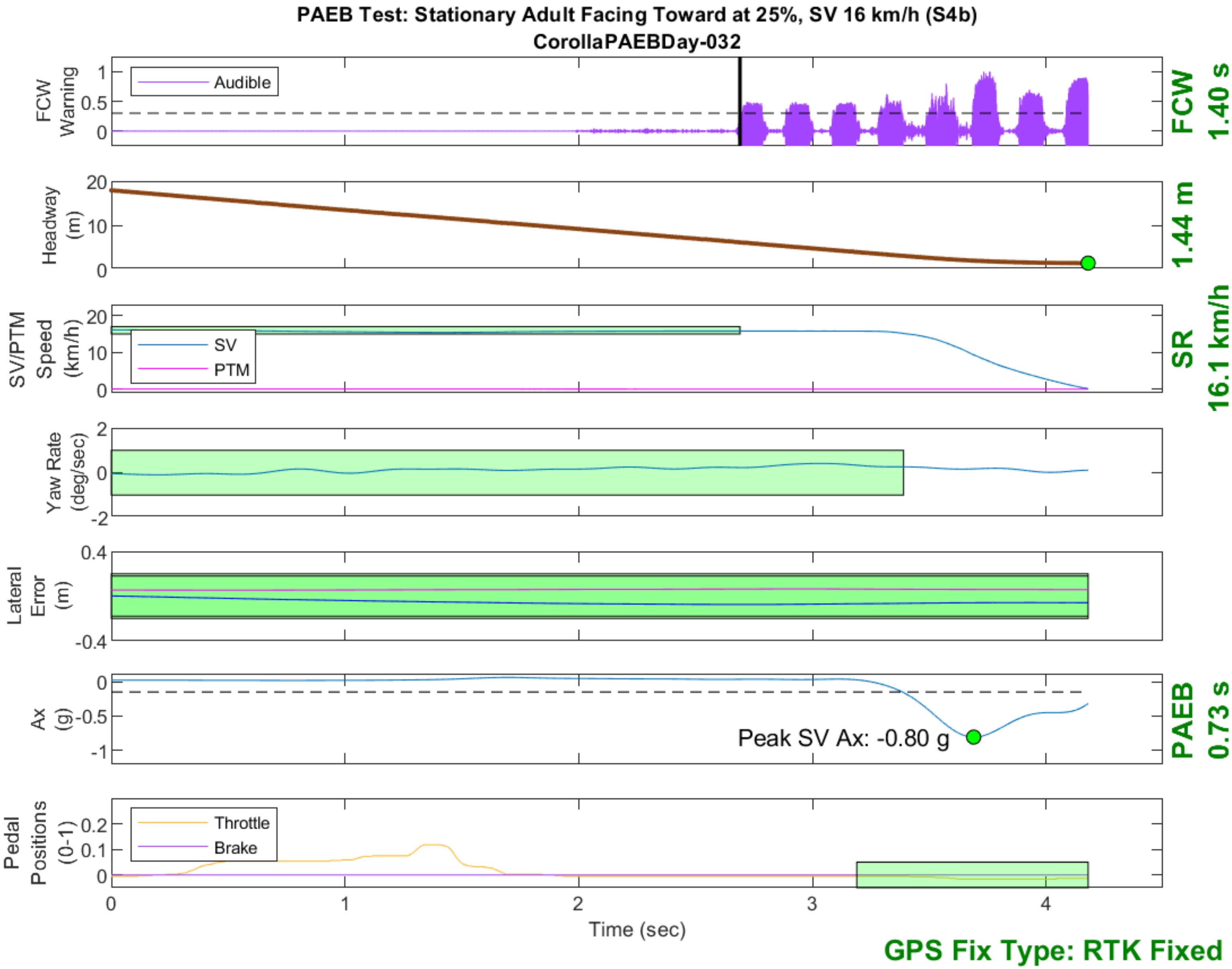


Figure D138. Time History for PAEB Run 32, S4b, Daytime, 16 km/h

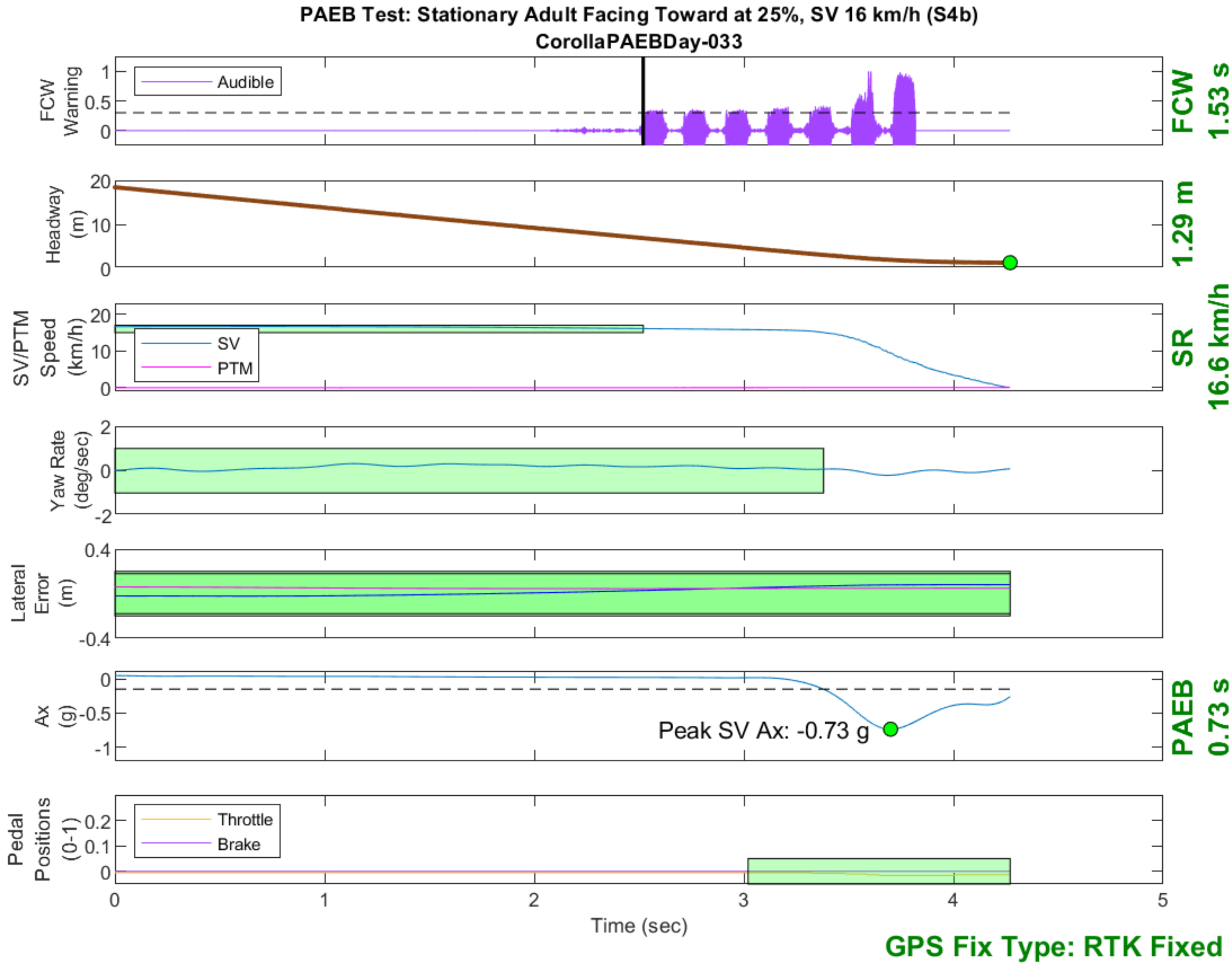


Figure D139. Time History for PAEB Run 33, S4b, Daytime, 16 km/h

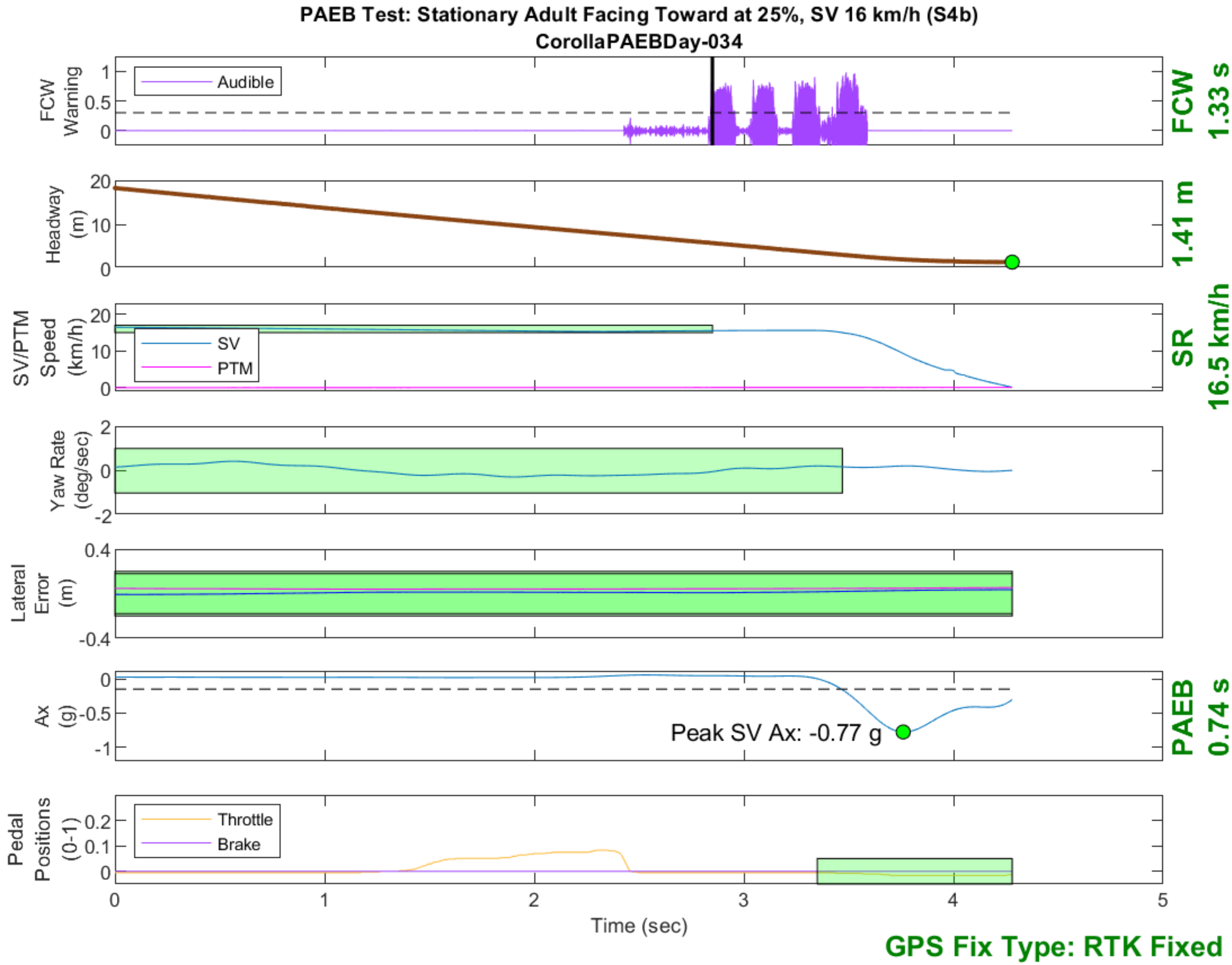


Figure D140. Time History for PAEB Run 34, S4b, Daytime, 16 km/h

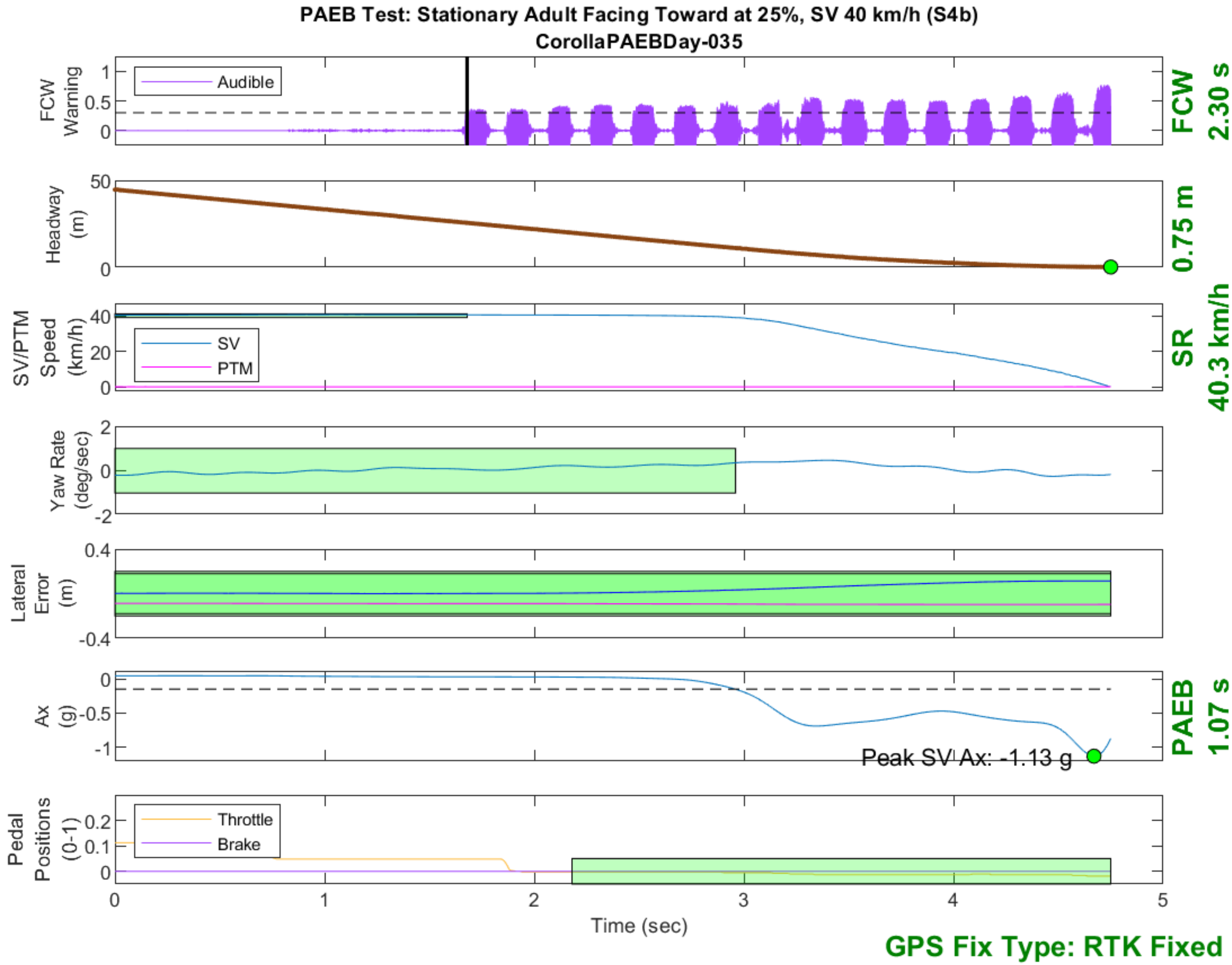


Figure D141. Time History for PAEB Run 35, S4b, Daytime, 40 km/h

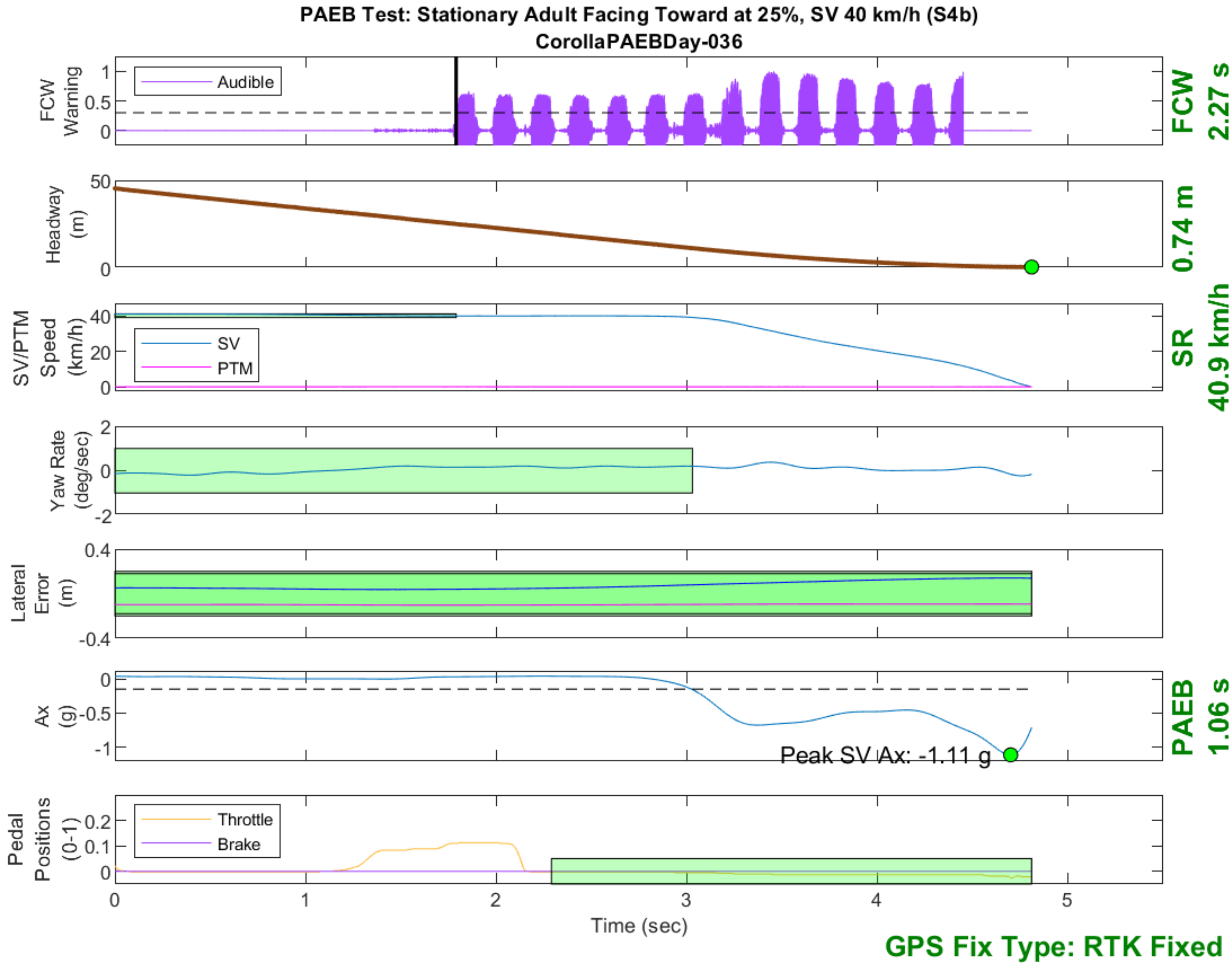


Figure D142. Time History for PAEB Run 36, S4b, Daytime, 40 km/h

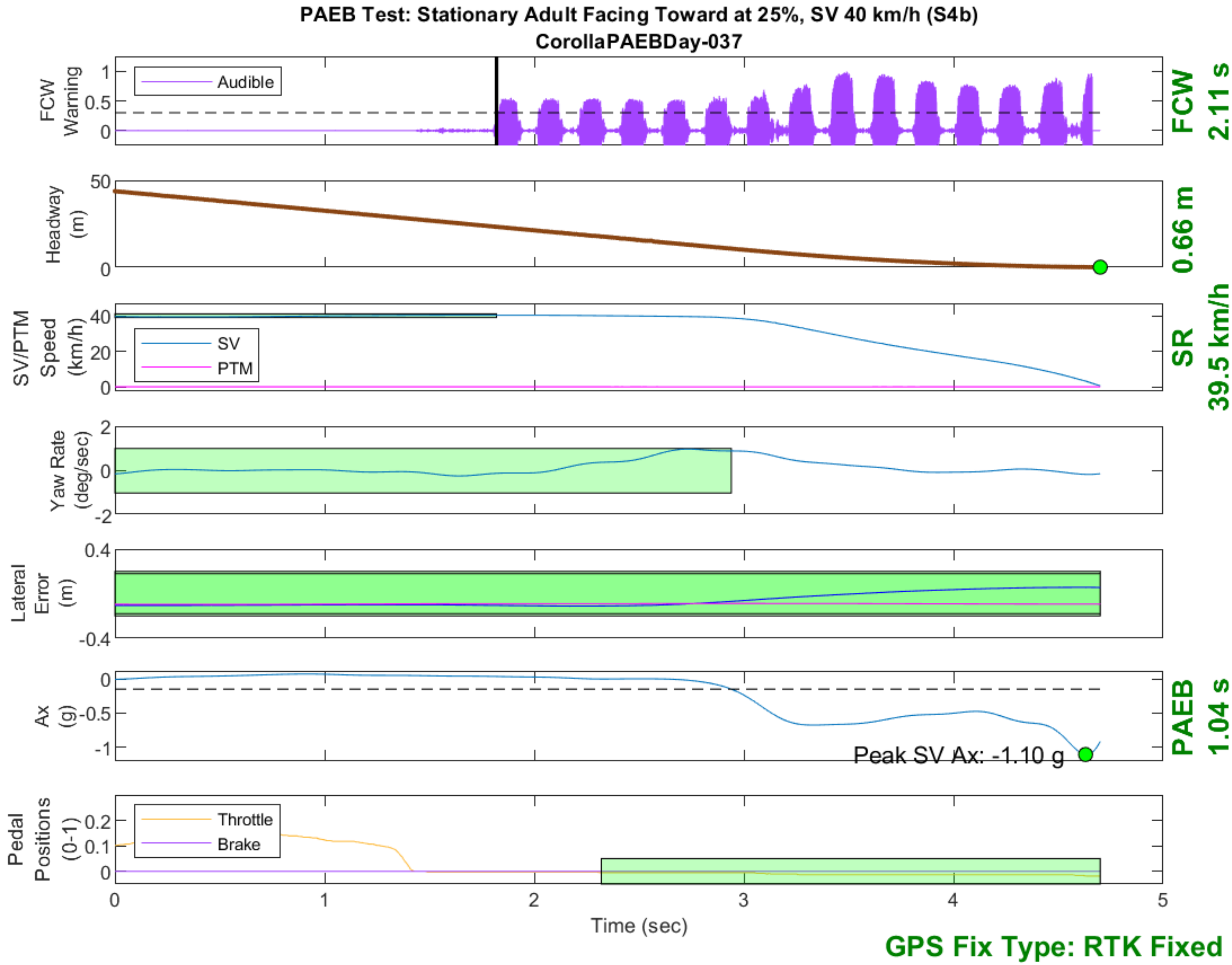


Figure D143. Time History for PAEB Run 37, S4b, Daytime, 40 km/h

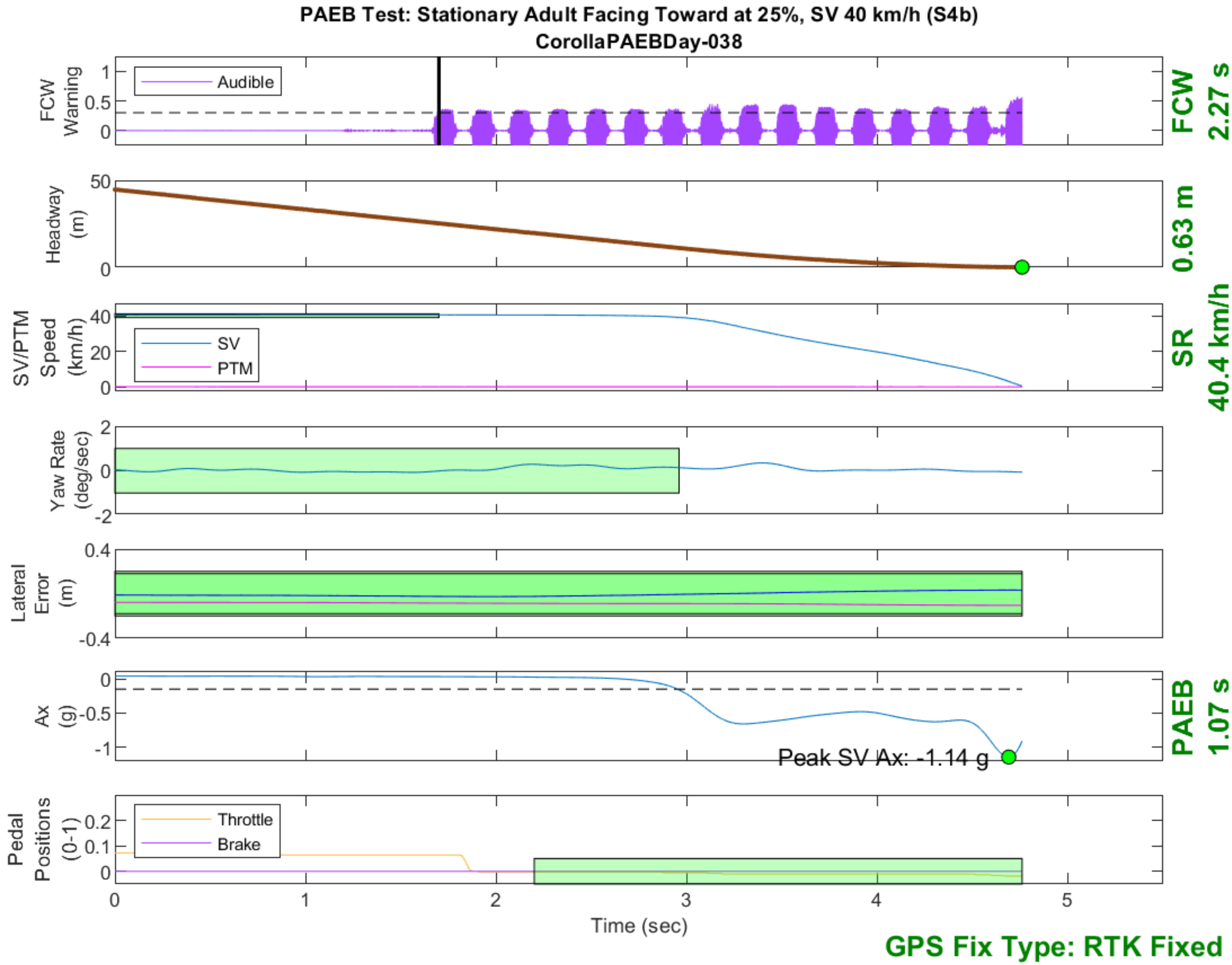


Figure D144. Time History for PAEB Run 38, S4b, Daytime, 40 km/h

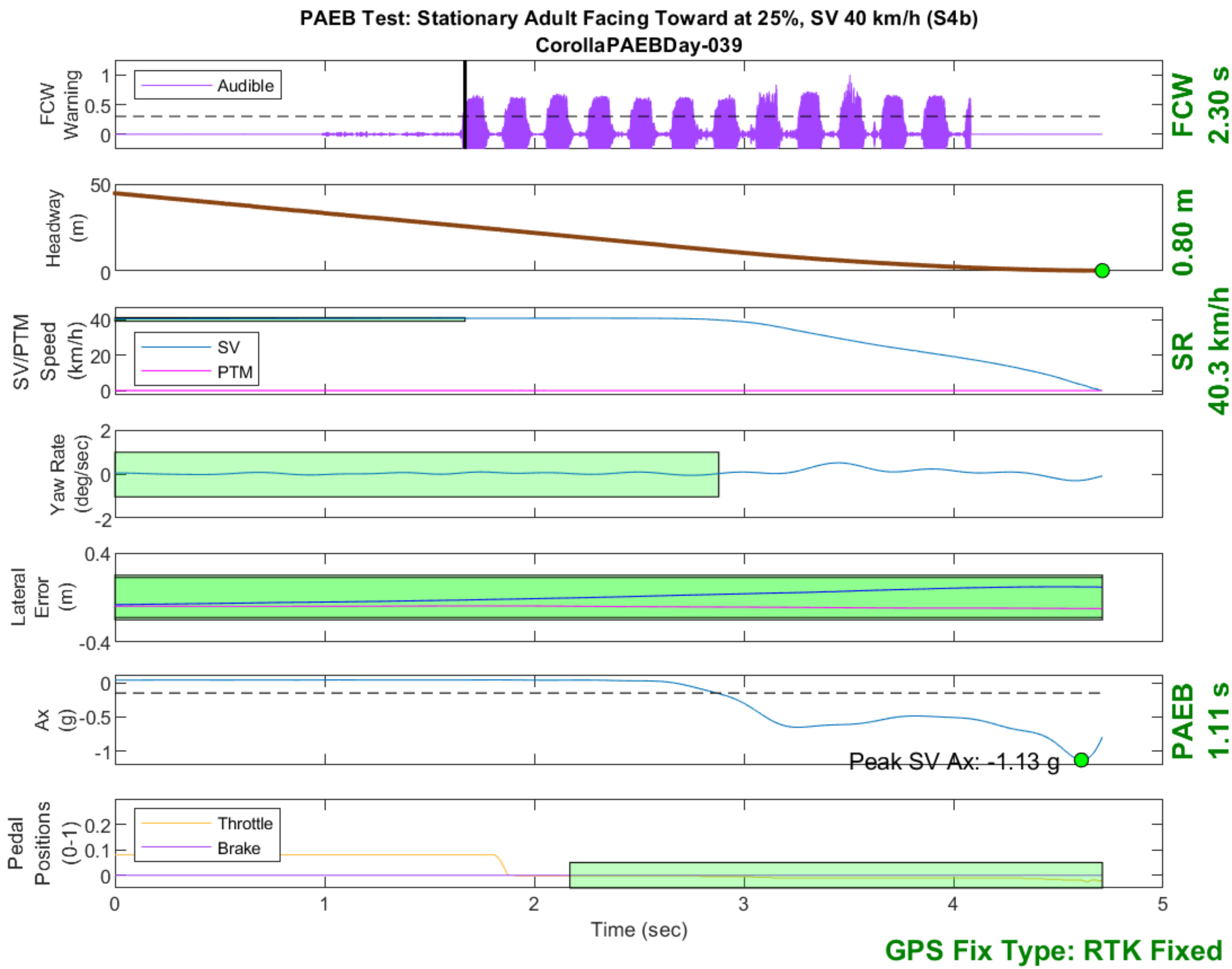


Figure D145. Time History for PAEB Run 39, S4b, Daytime, 40 km/h

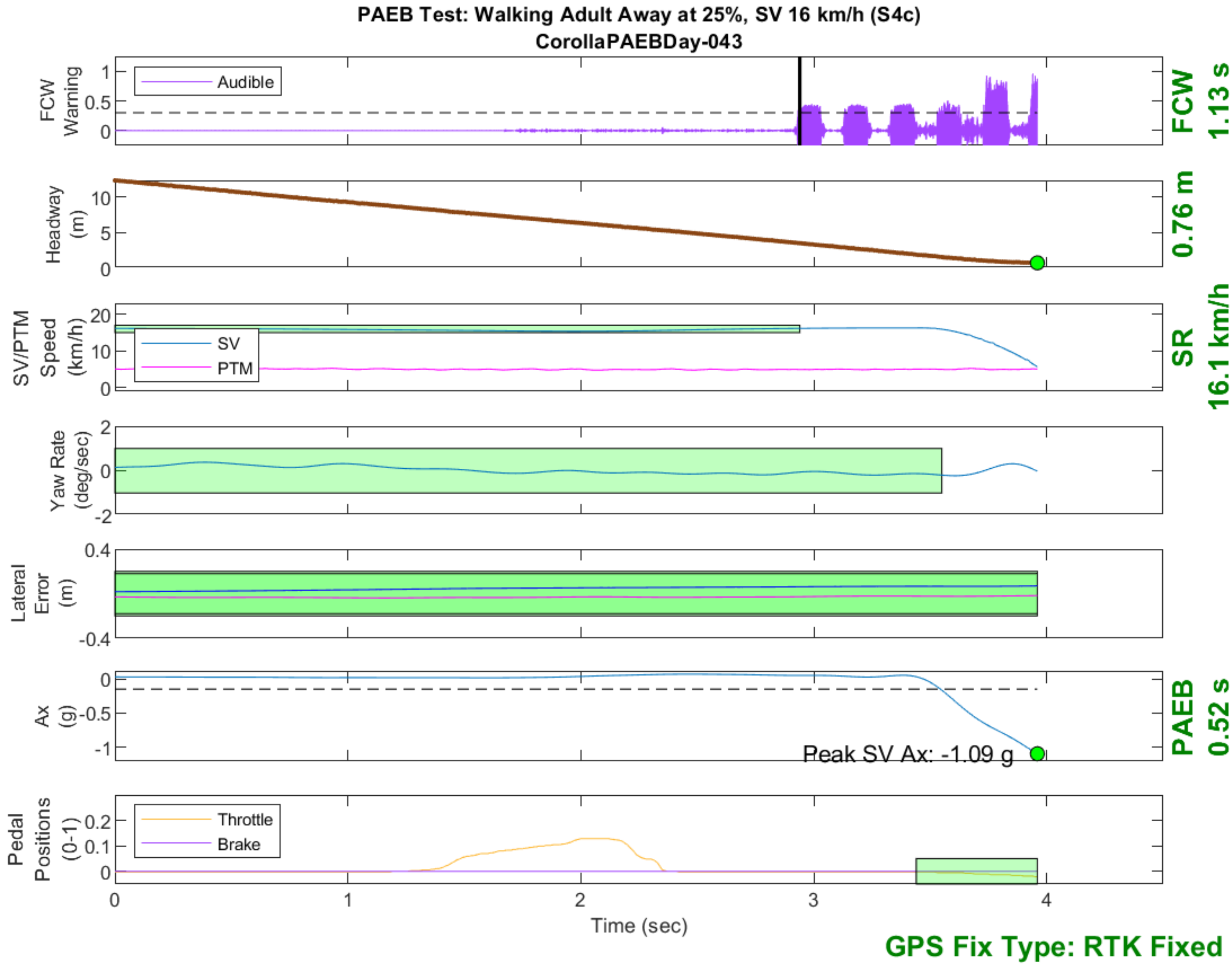


Figure D146. Time History for PAEB Run 43, S4c, Daytime, 16 km/h

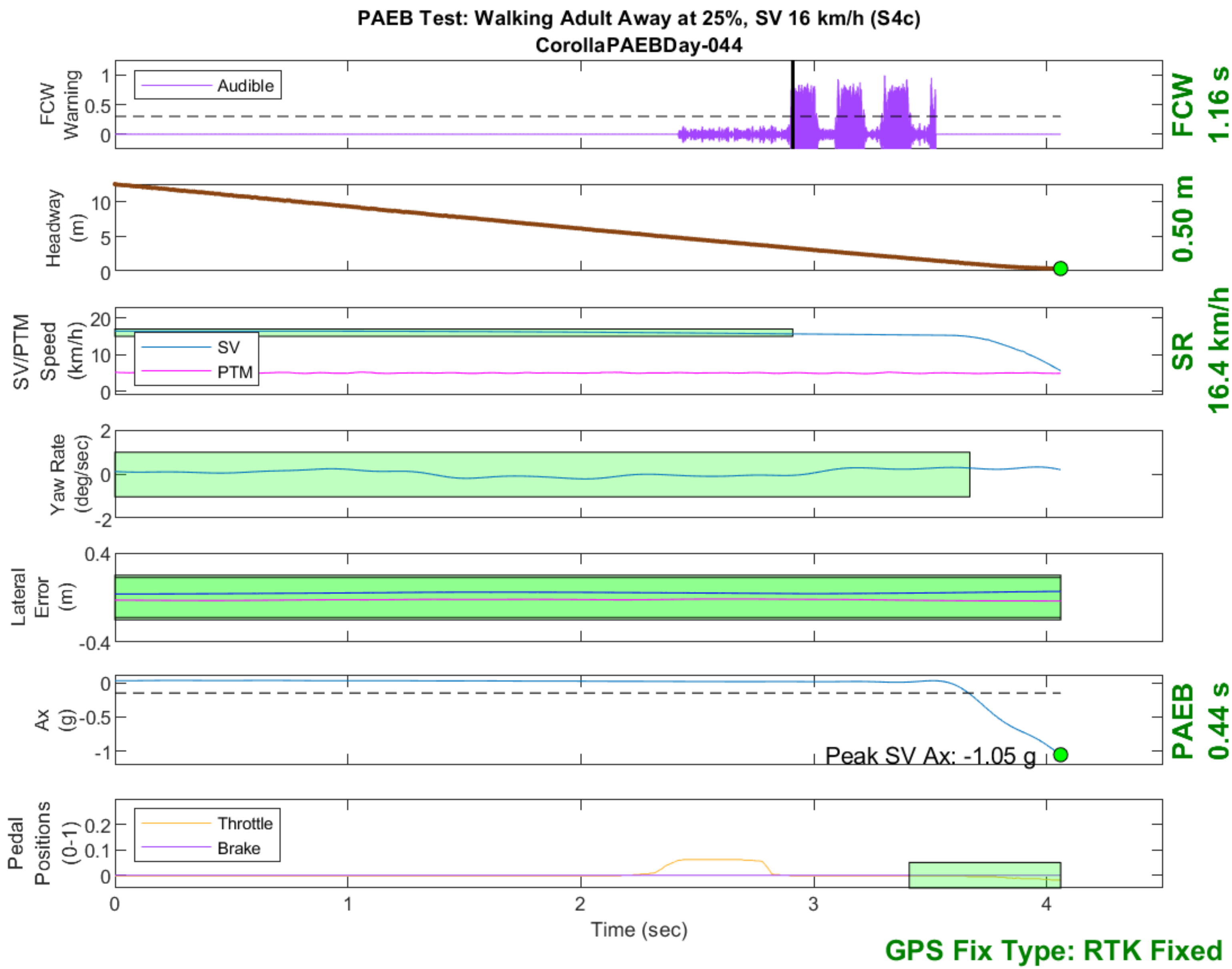


Figure D147. Time History for PAEB Run 44, S4c, Daytime, 16 km/h

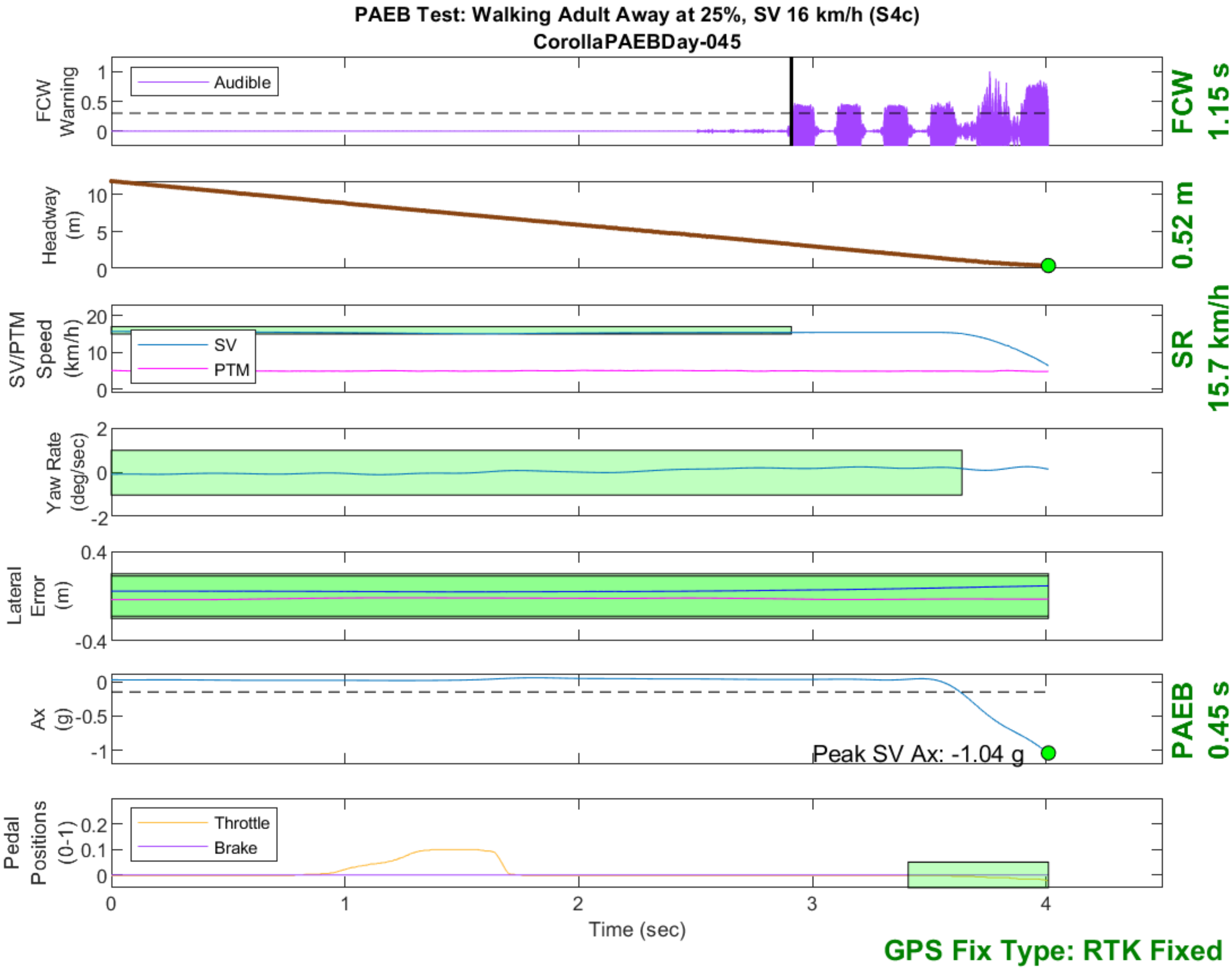


Figure D148. Time History for PAEB Run 45, S4c, Daytime, 16 km/h

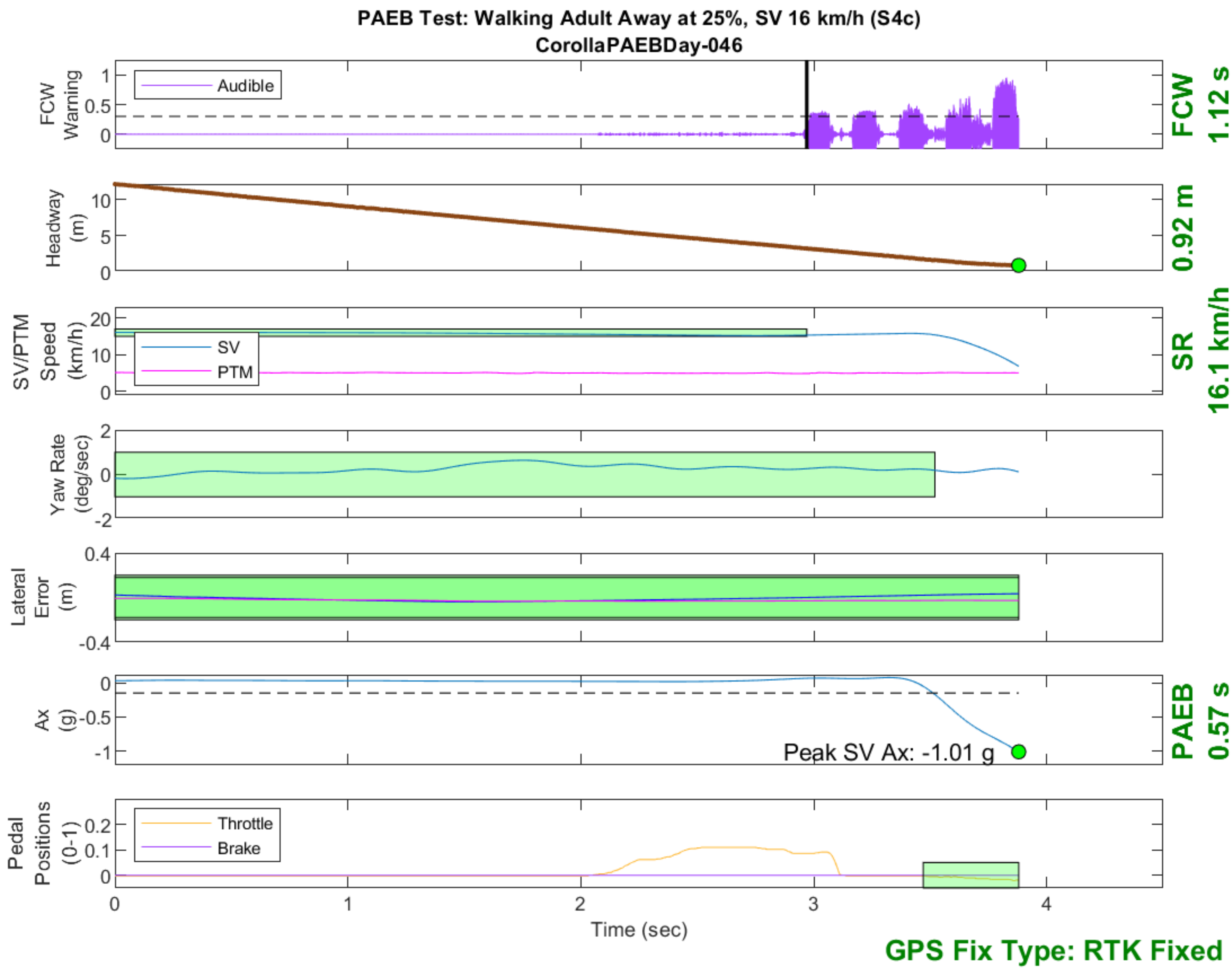


Figure D149. Time History for PAEB Run 46, S4c, Daytime, 16 km/h

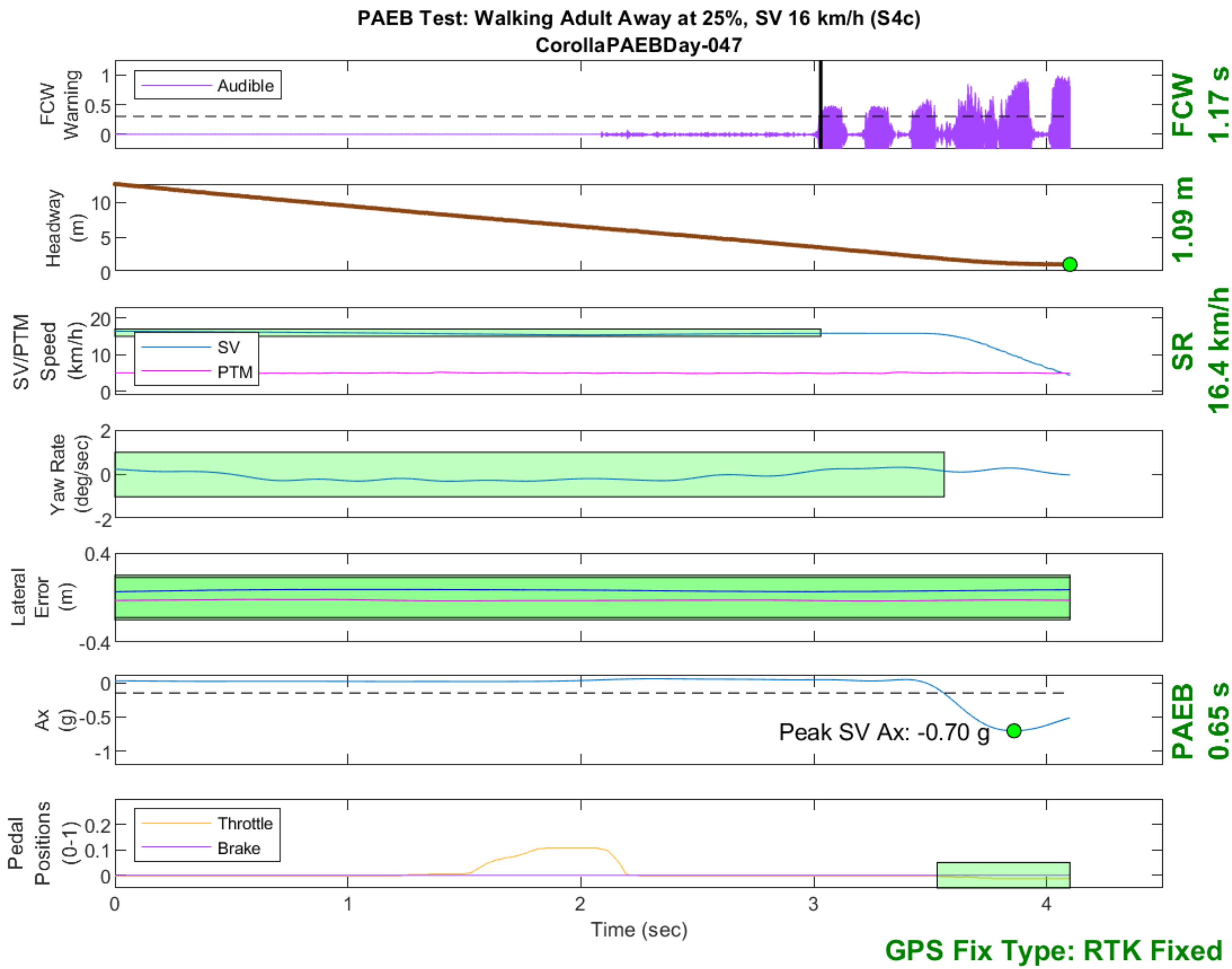


Figure D150. Time History for PAEB Run 47, S4c, Daytime, 16 km/h

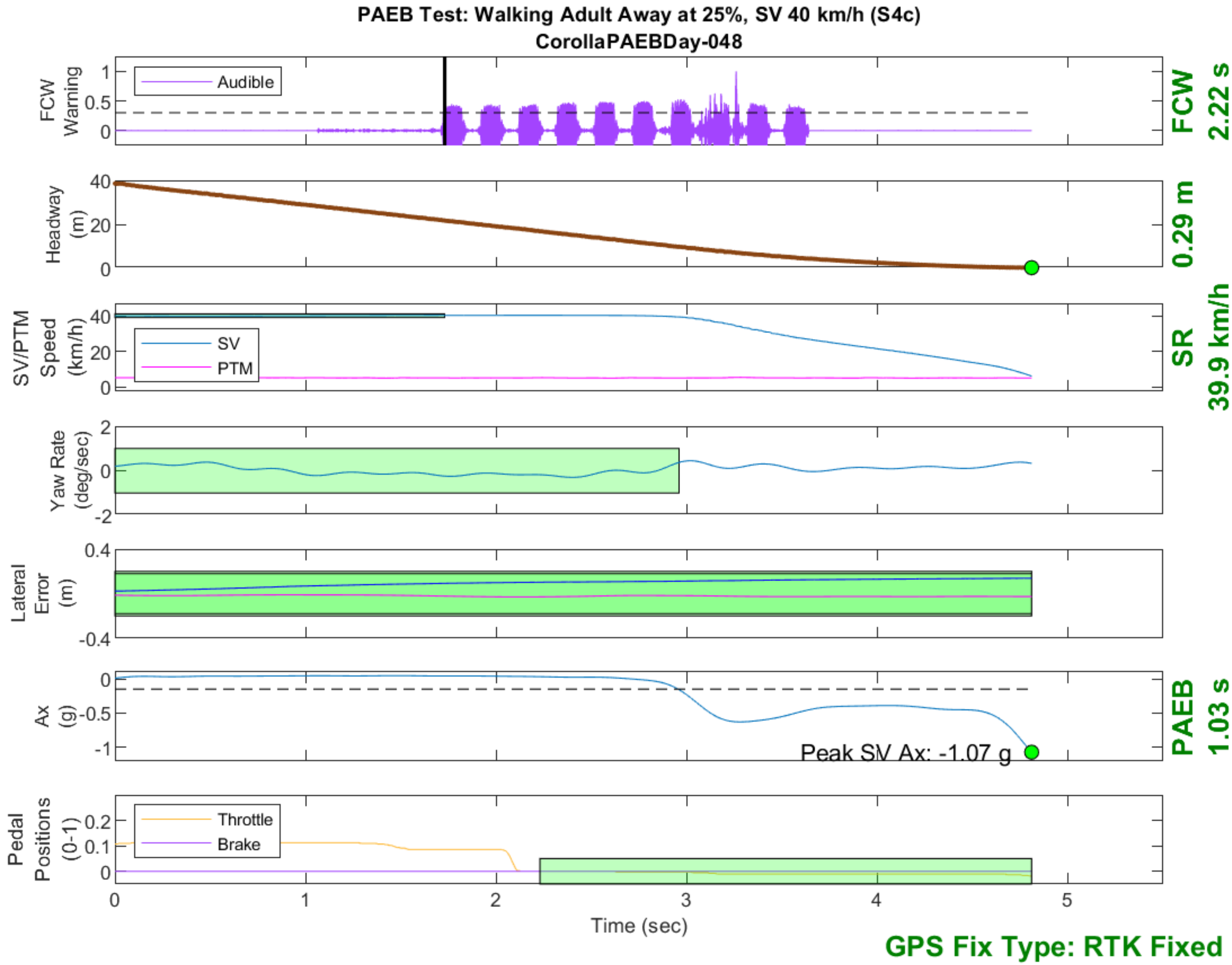


Figure D151. Time History for PAEB Run 48, S4c, Daytime, 40 km/h

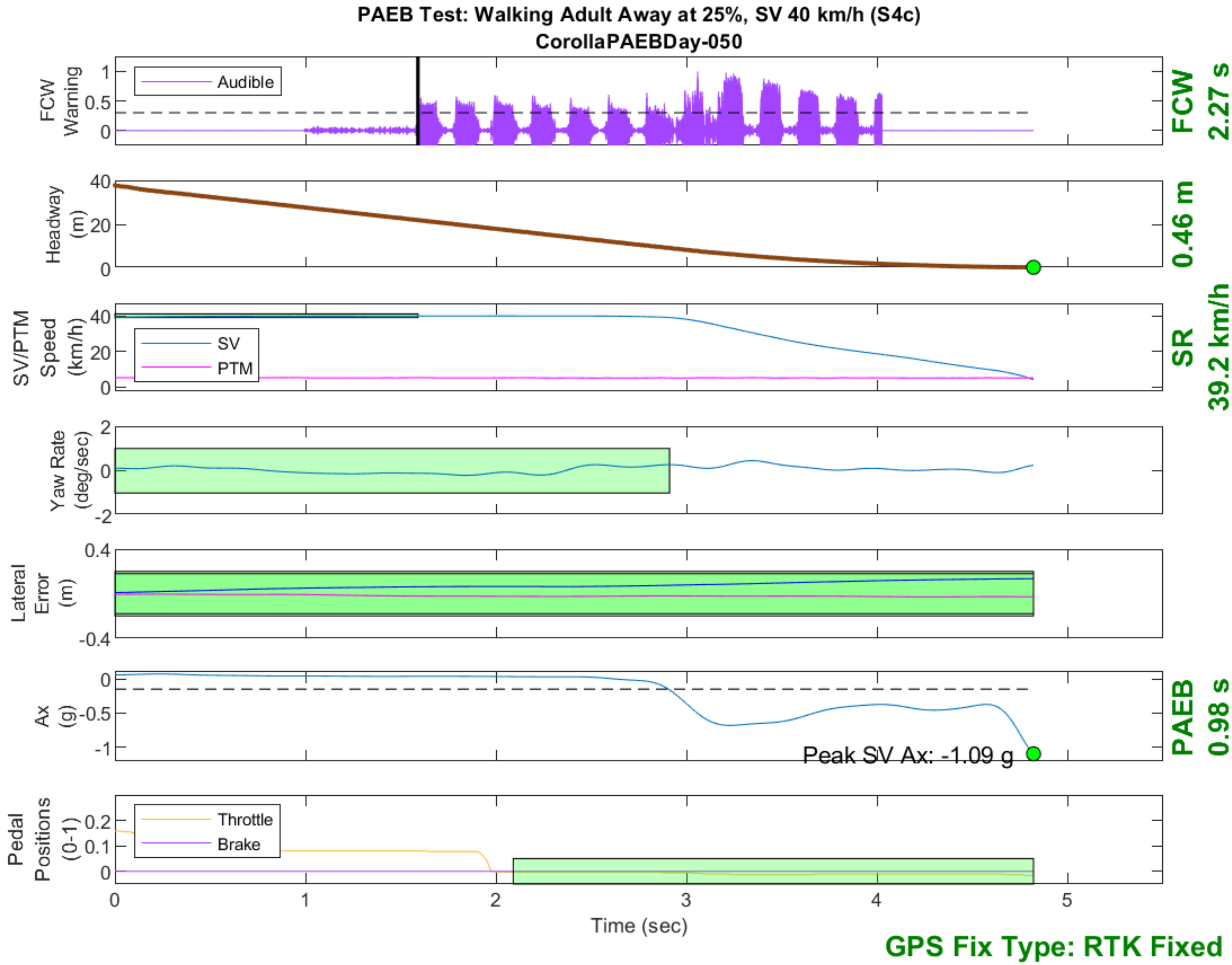


Figure D152. Time History for PAEB Run 50, S4c, Daytime, 40 km/h

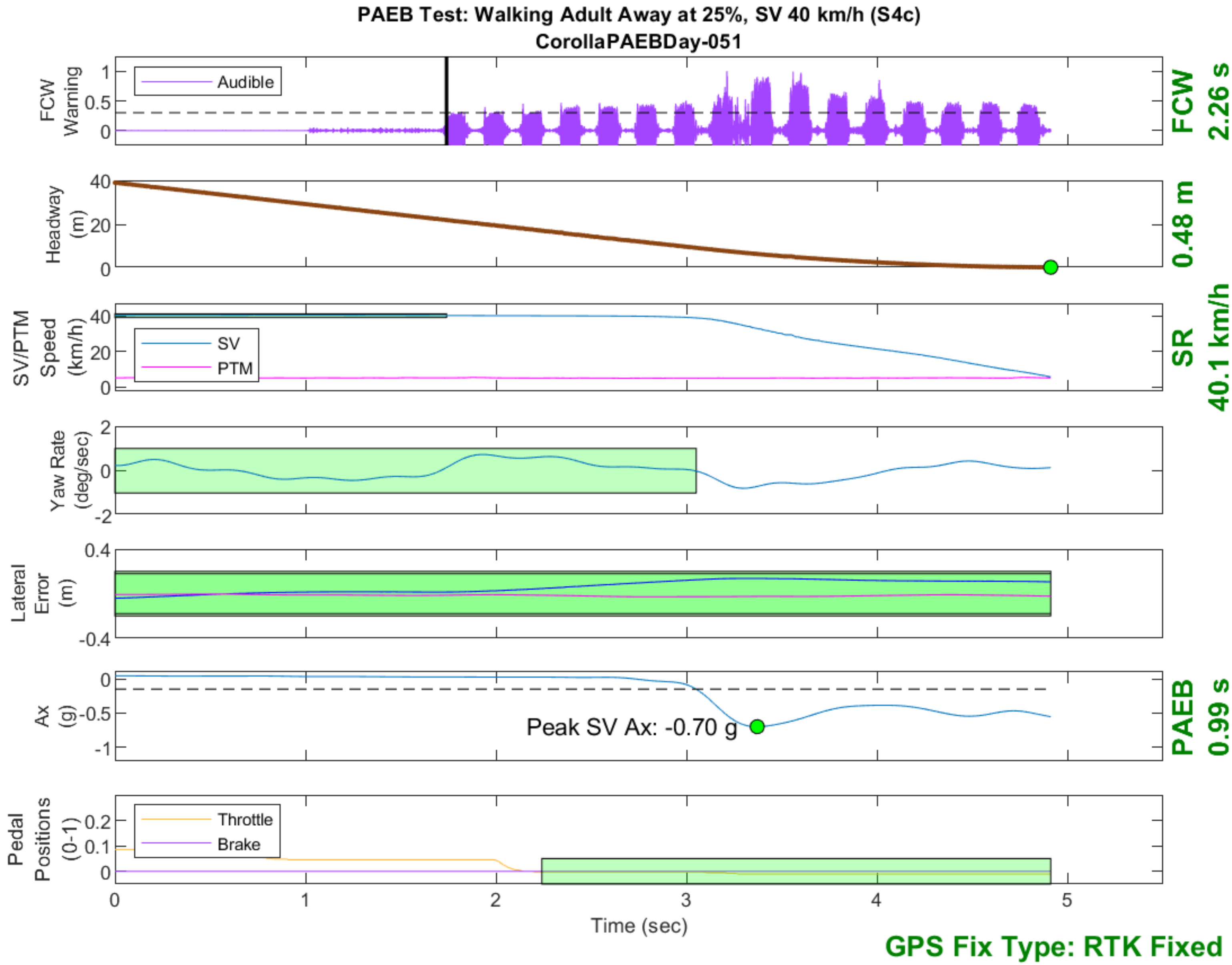


Figure D153. Time History for PAEB Run 51, S4c, Daytime, 40 km/h

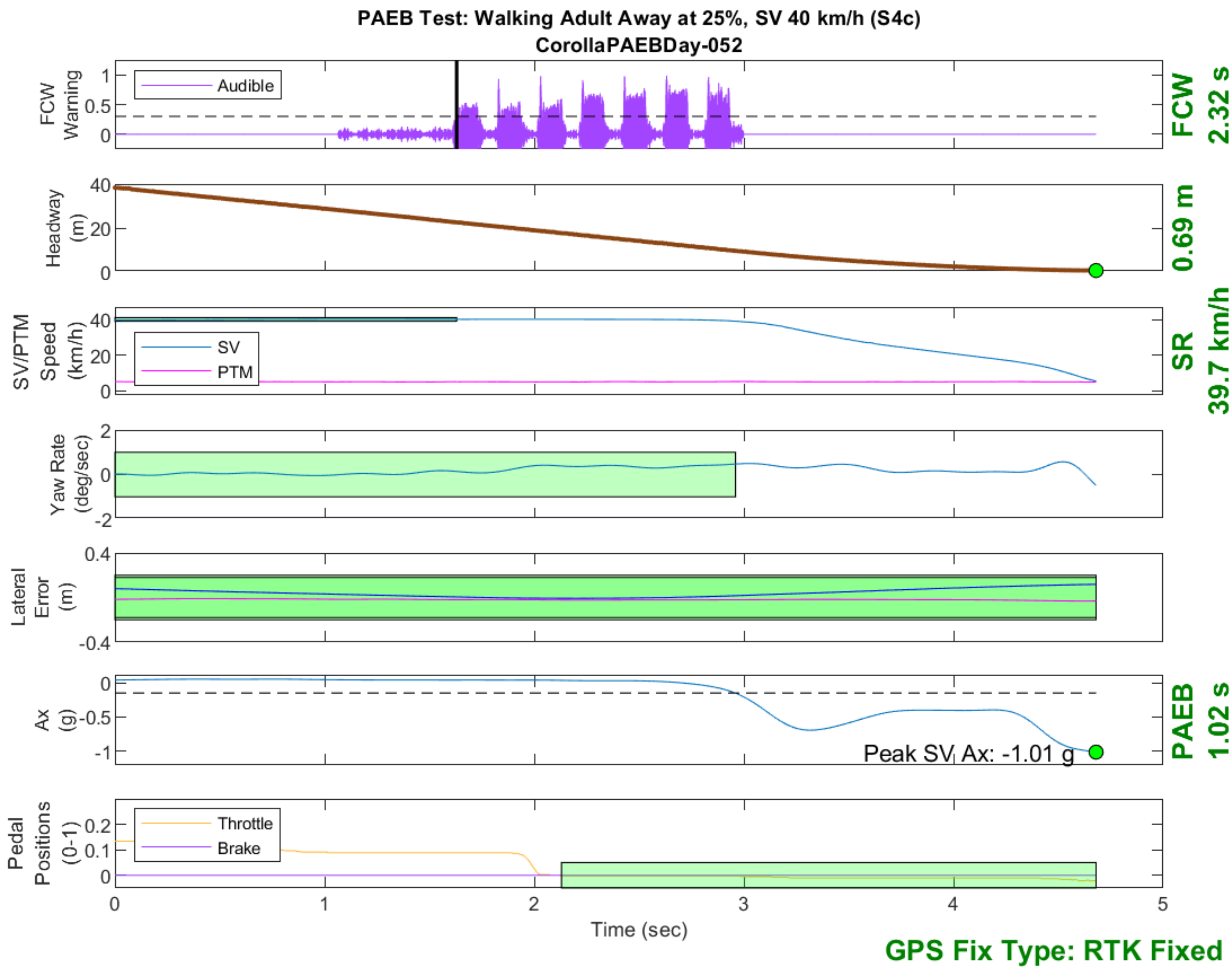


Figure D154. Time History for PAEB Run 52, S4c, Daytime, 40 km/h

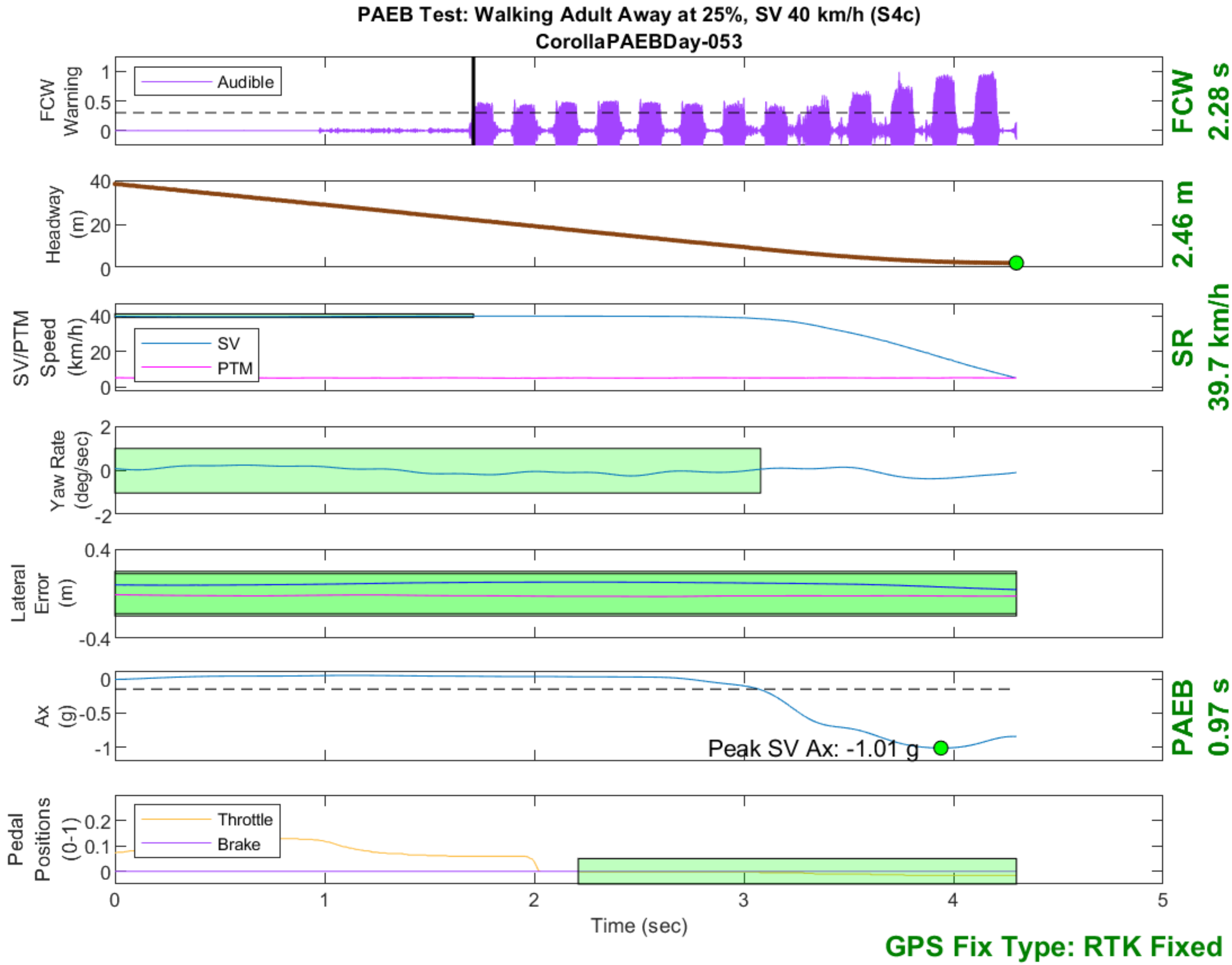


Figure D155. Time History for PAEB Run 53, S4c, Daytime, 40 km/h

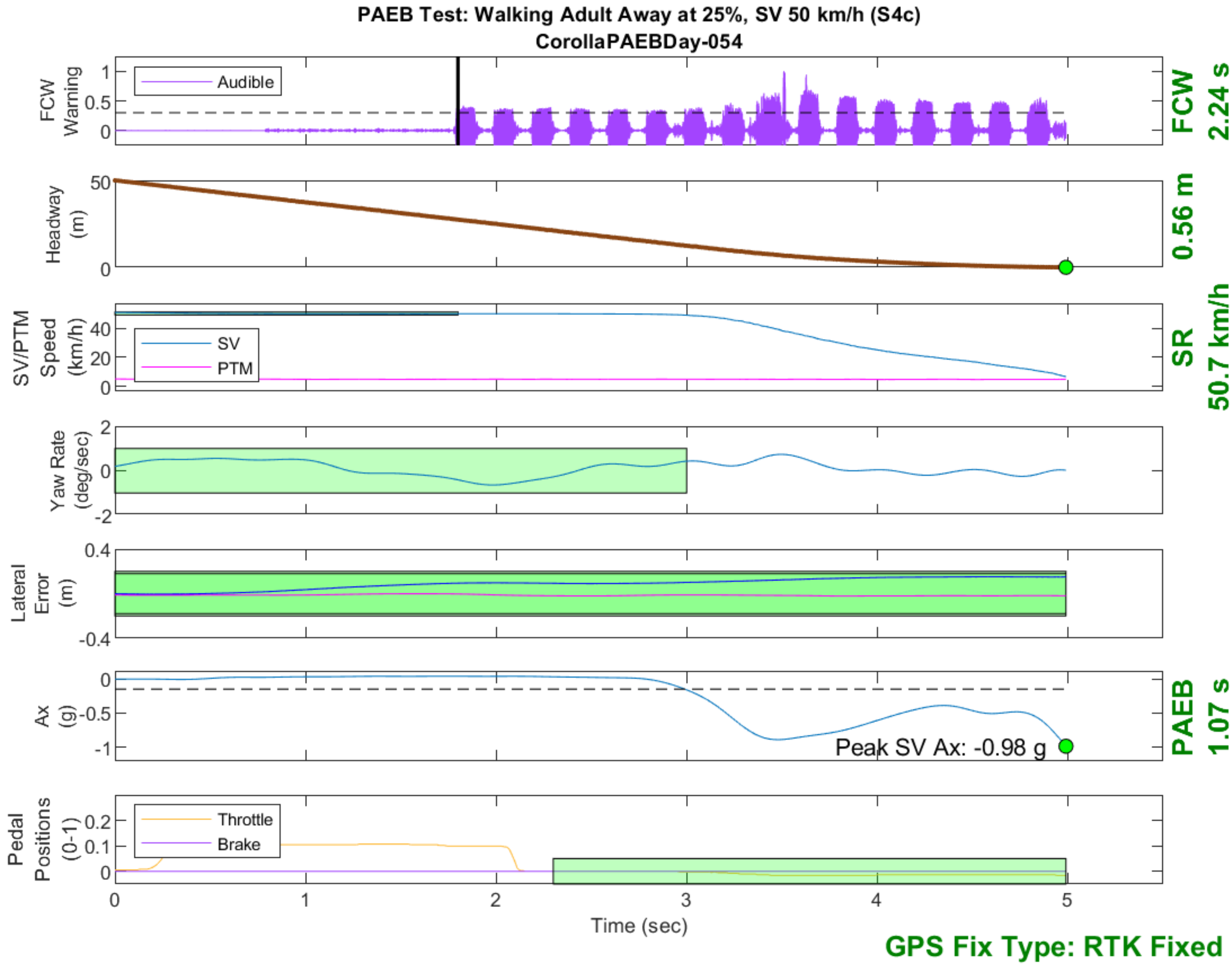


Figure D156. Time History for PAEB Run 54, S4c, Daytime, 50 km/h

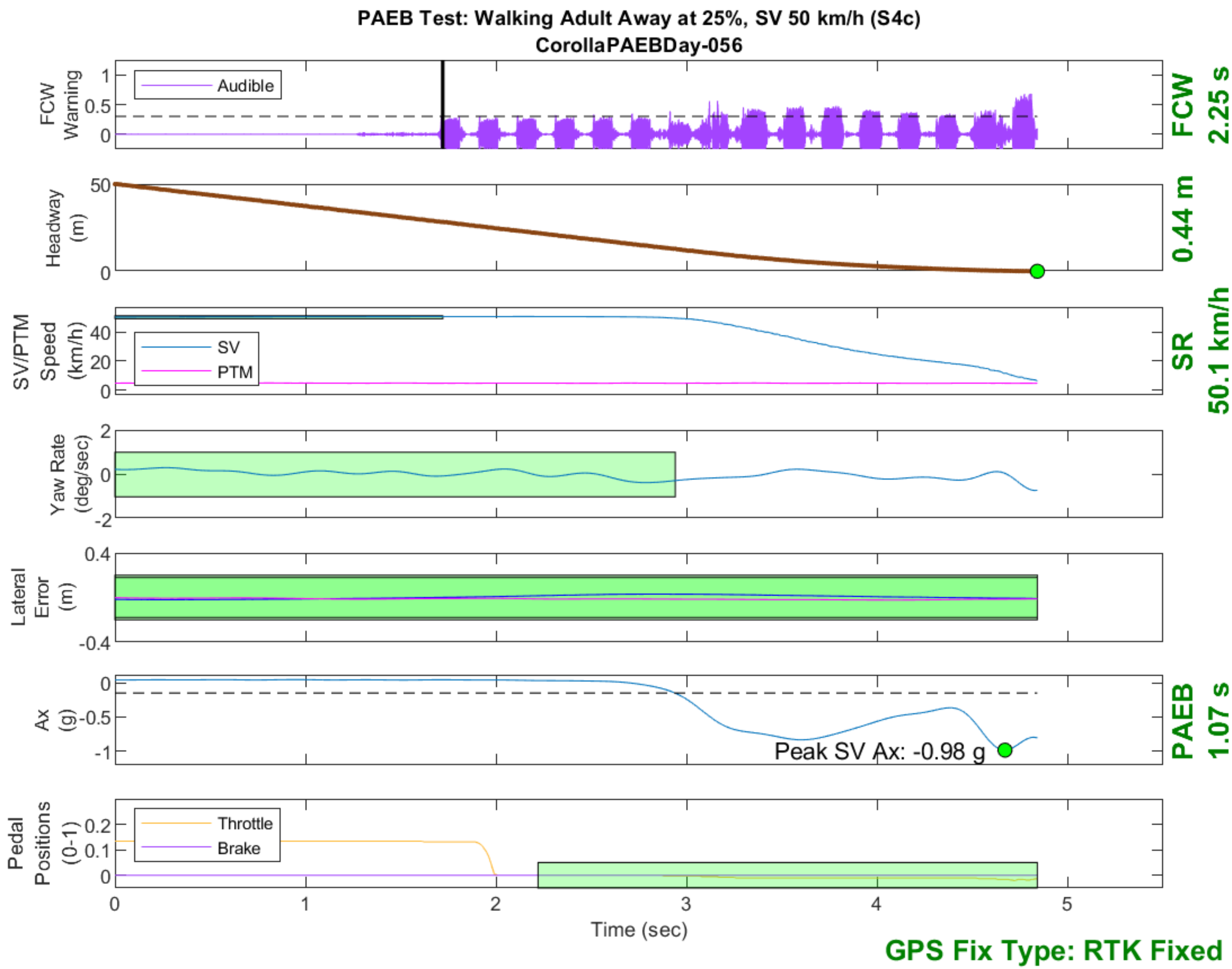


Figure D157. Time History for PAEB Run 56, S4c, Daytime, 50 km/h

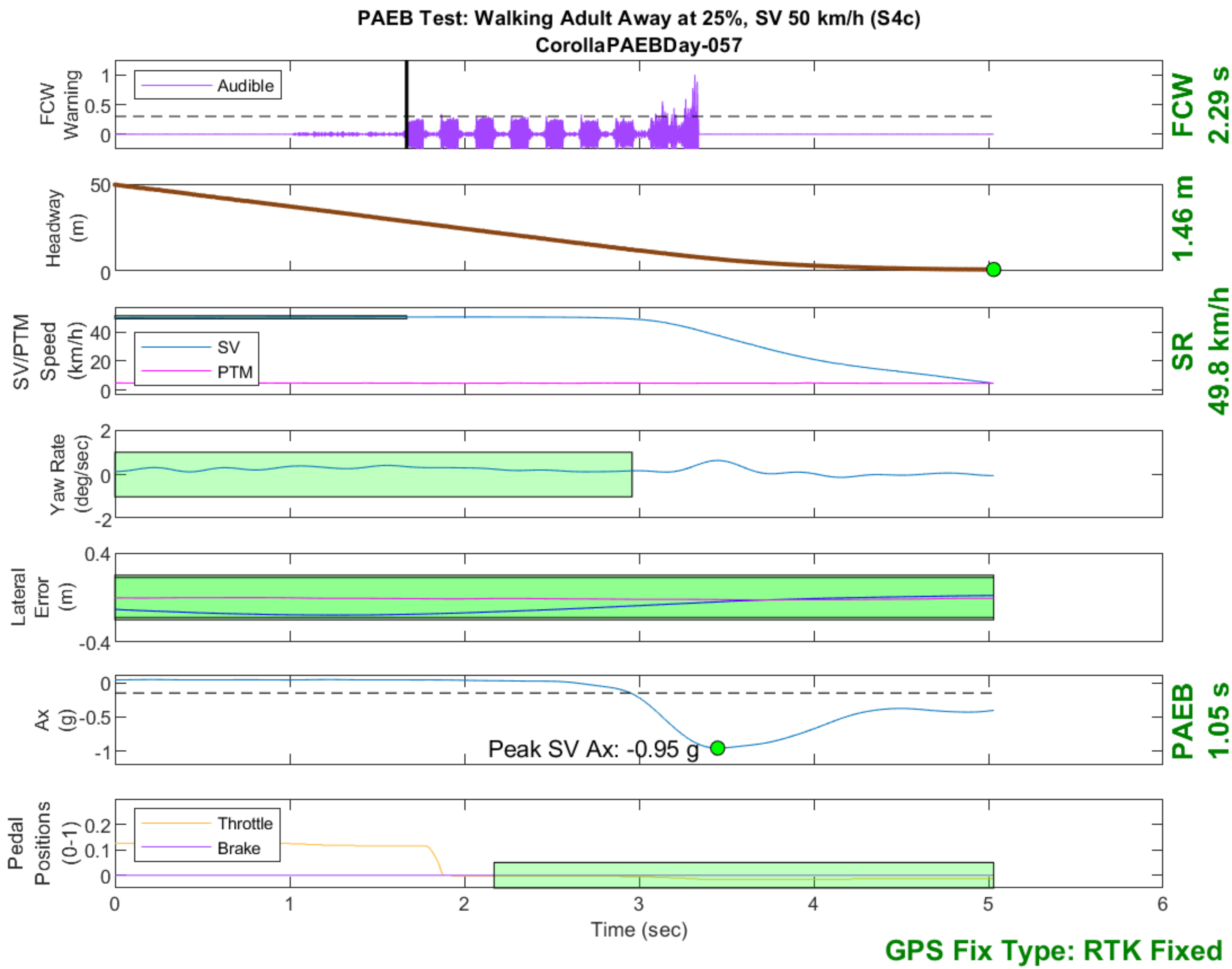


Figure D158. Time History for PAEB Run 57, S4c, Daytime, 50 km/h

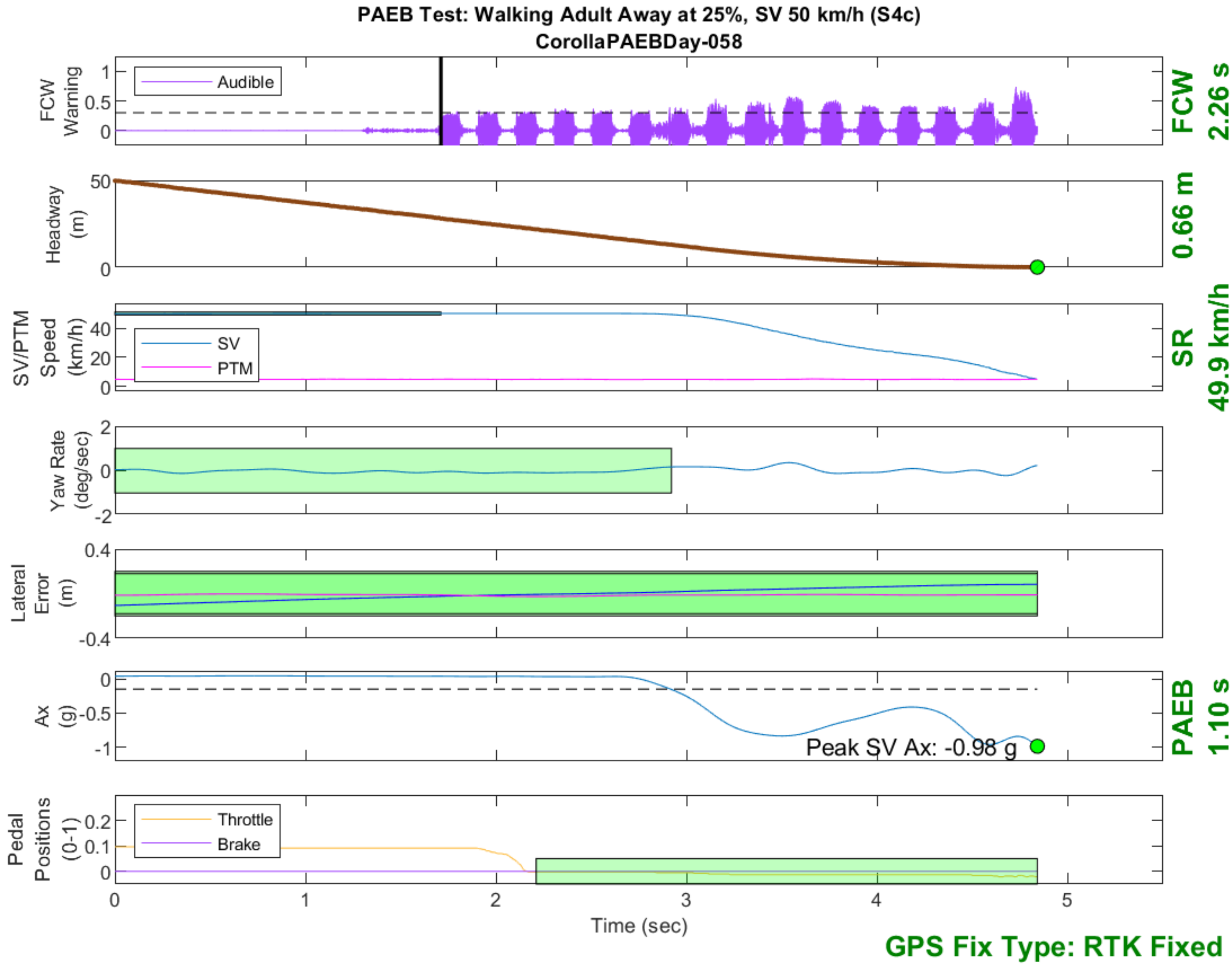


Figure D159. Time History for PAEB Run 58, S4c, Daytime, 50 km/h

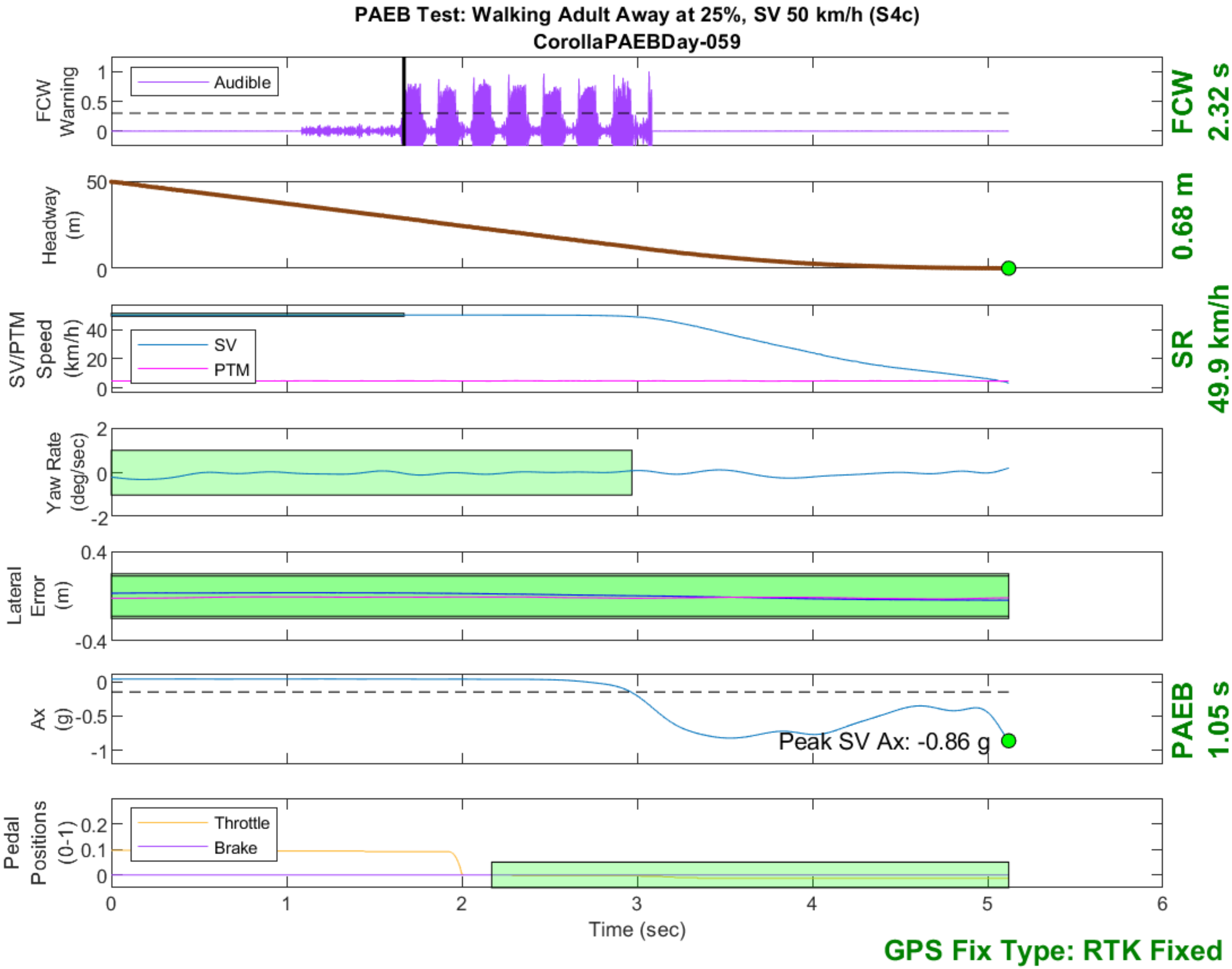


Figure D160. Time History for PAEB Run 59, S4c, Daytime, 50 km/h

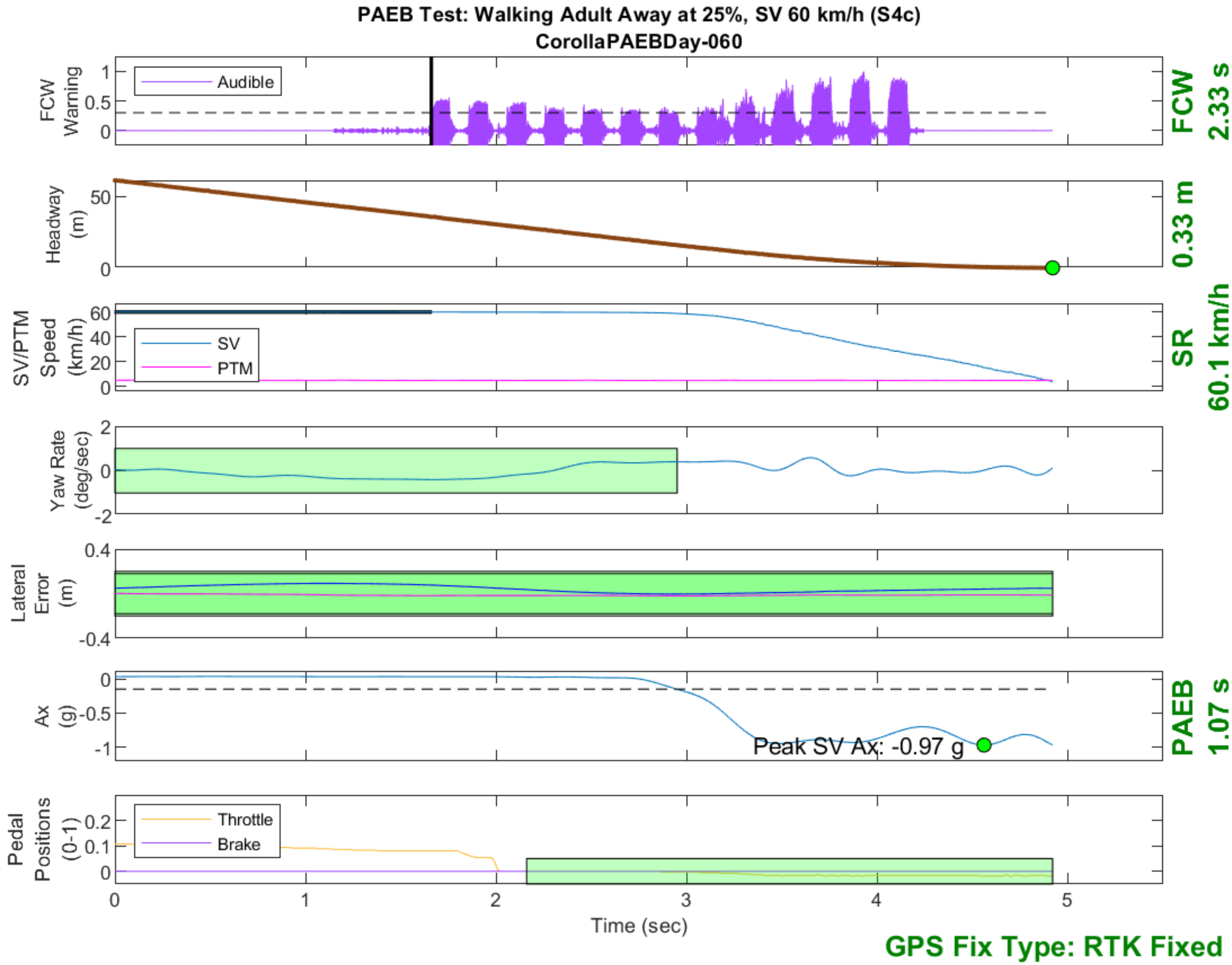


Figure D161. Time History for PAEB Run 60, S4c, Daytime, 60 km/h

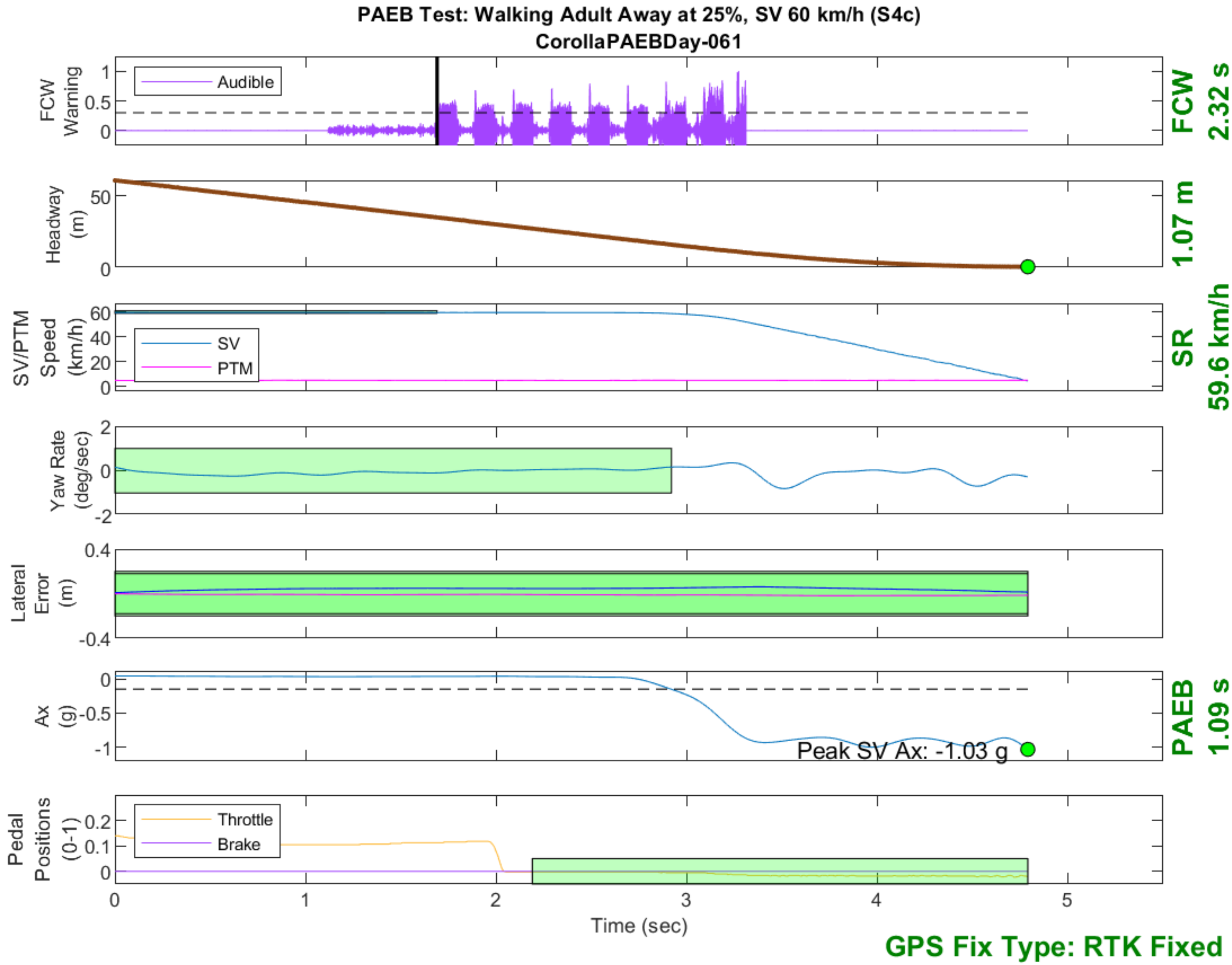


Figure D162. Time History for PAEB Run 61, S4c, Daytime, 60 km/h

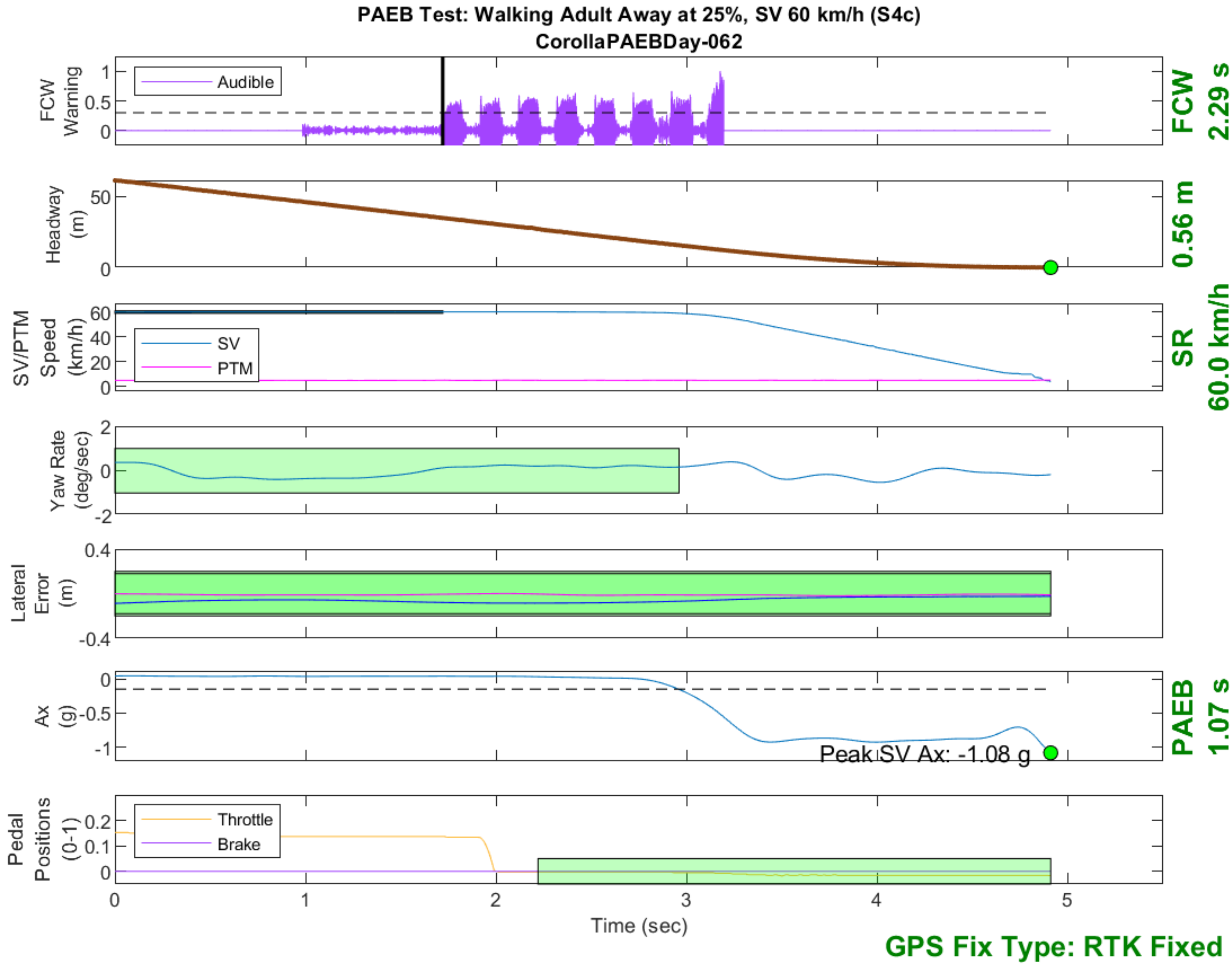


Figure D163. Time History for PAEB Run 62, S4c, Daytime, 60 km/h

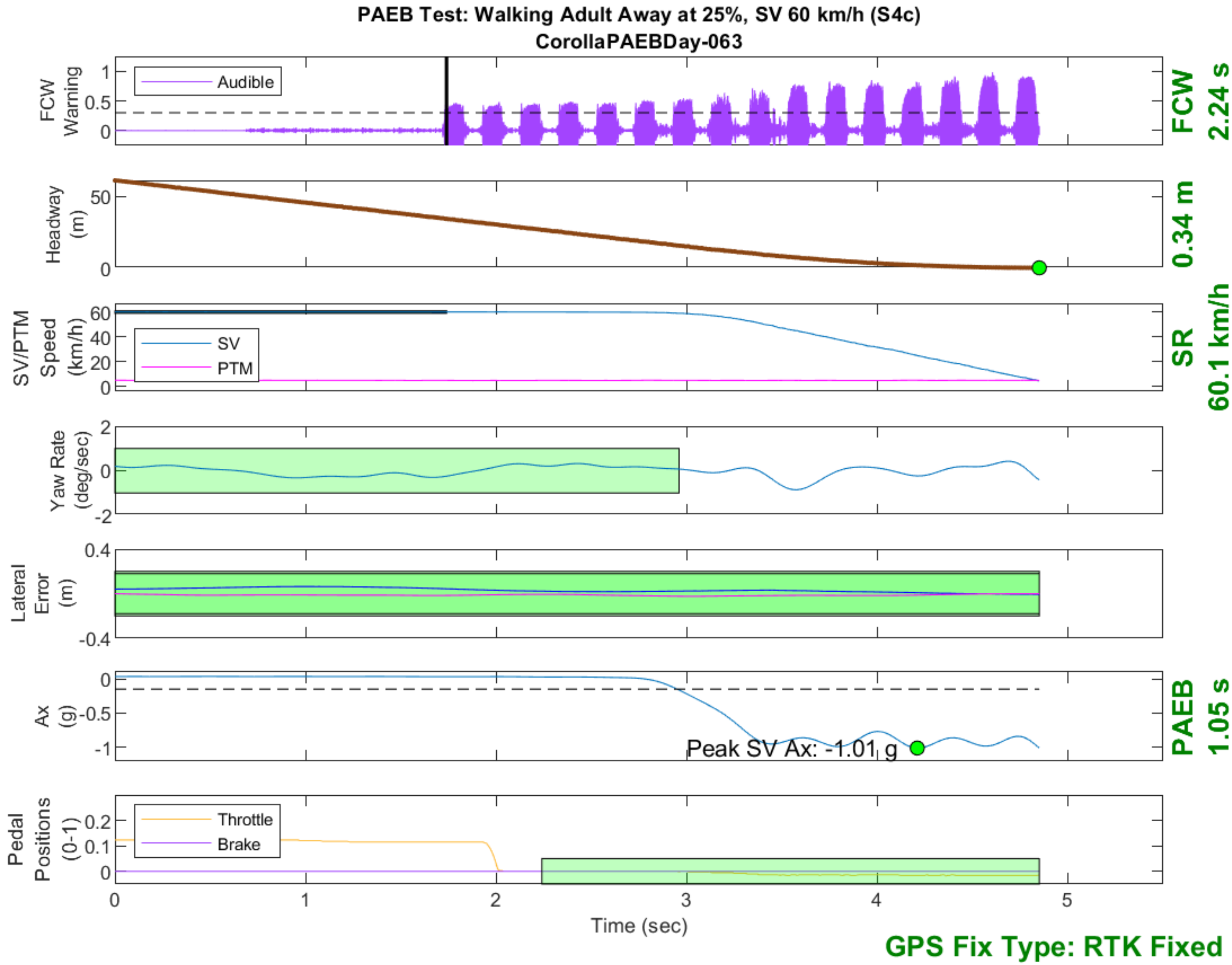


Figure D164. Time History for PAEB Run 63, S4c, Daytime, 60 km/h

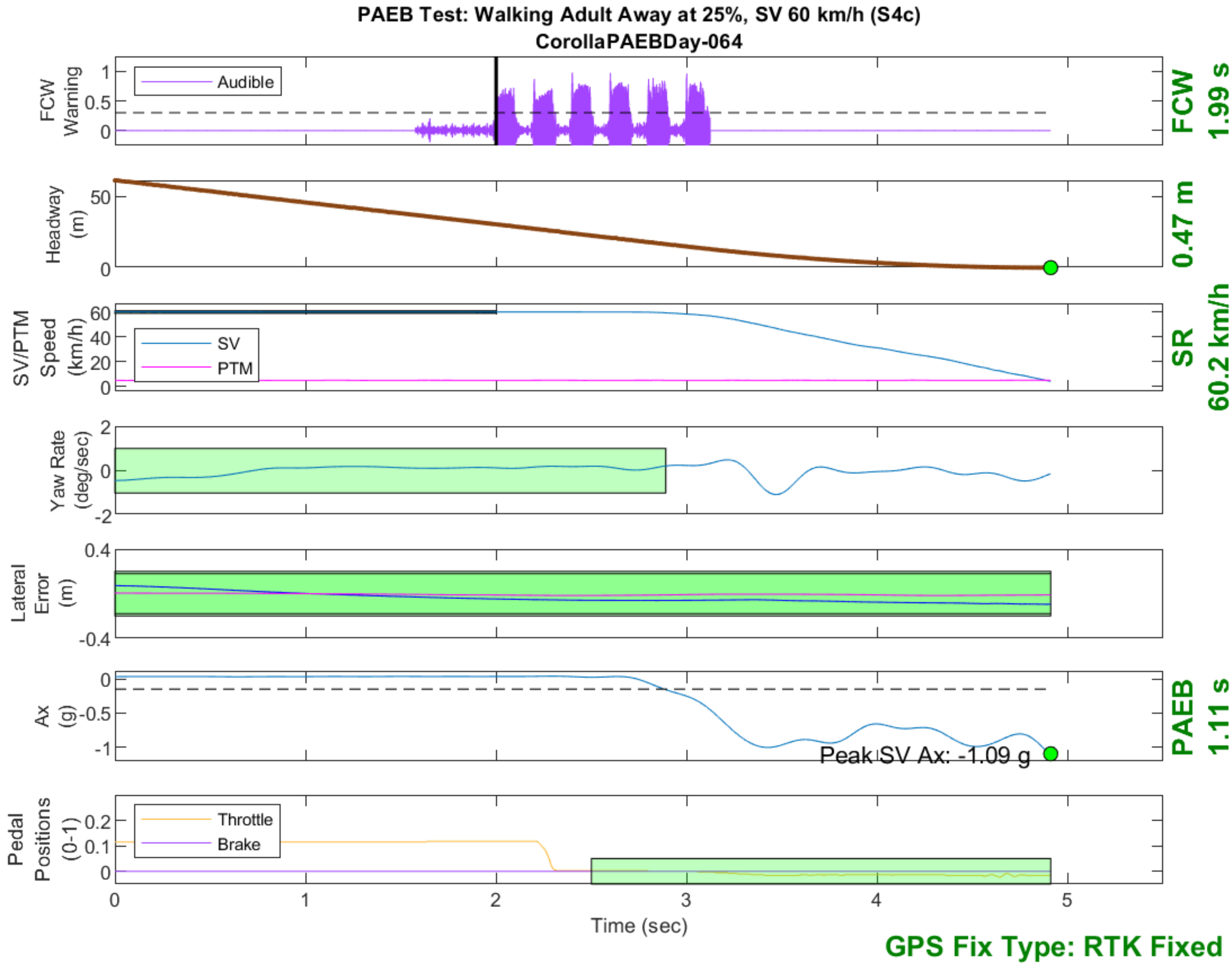


Figure D165. Time History for PAEB Run 64, S4c, Daytime, 60 km/h

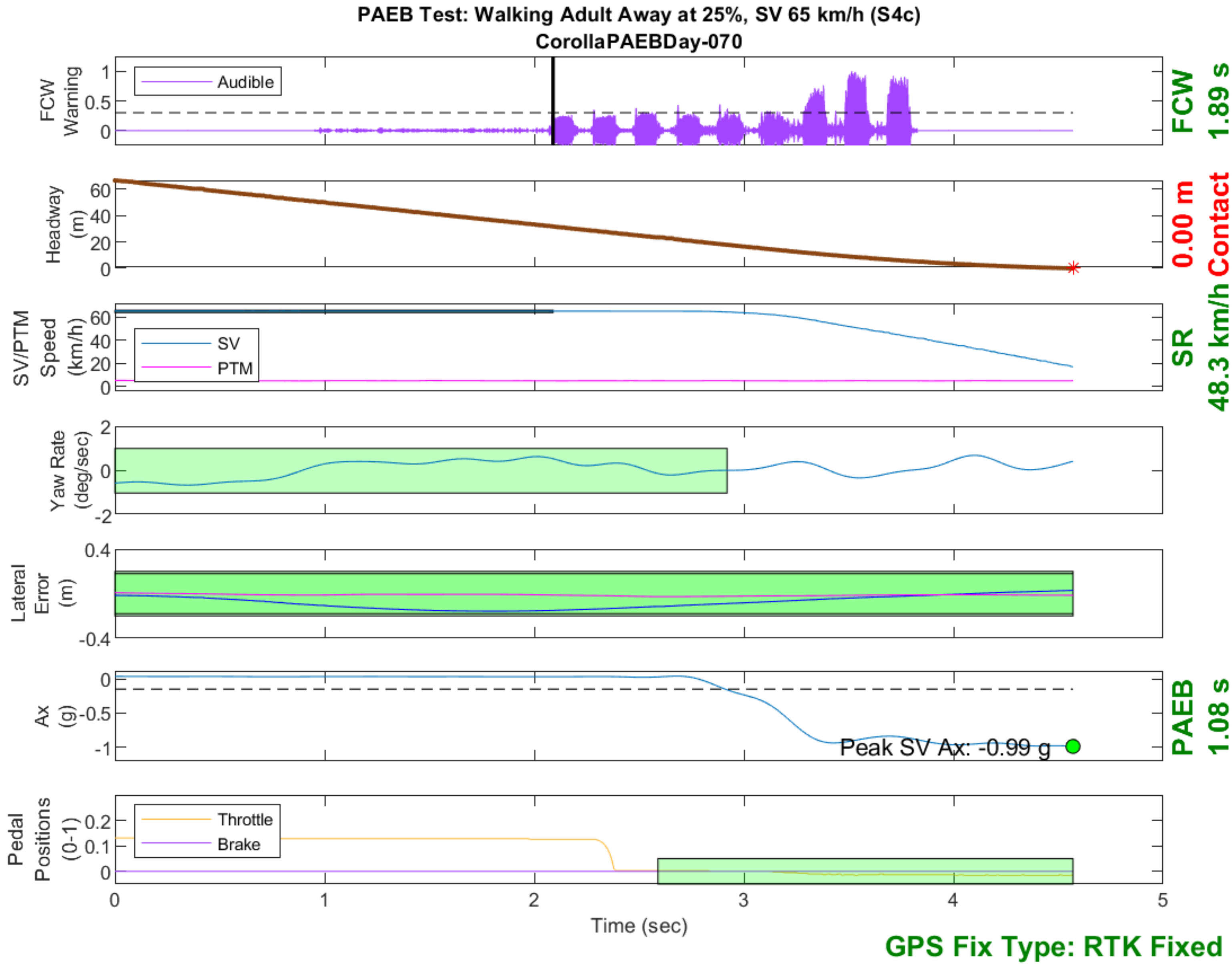


Figure D166. Time History for PAEB Run 70, S4c, Daytime, 65 km/h

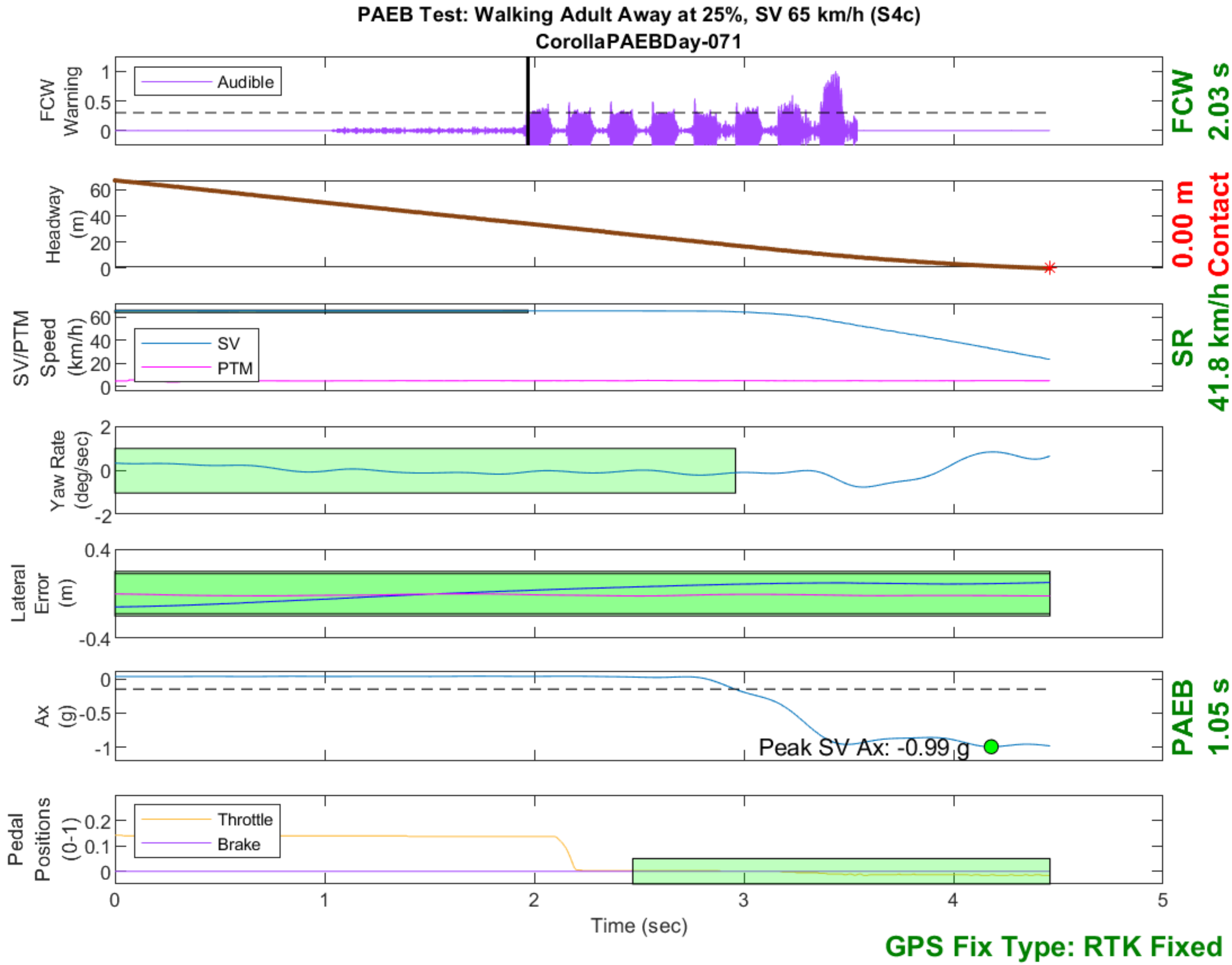


Figure D167. Time History for PAEB Run 71, S4c, Daytime, 65 km/h

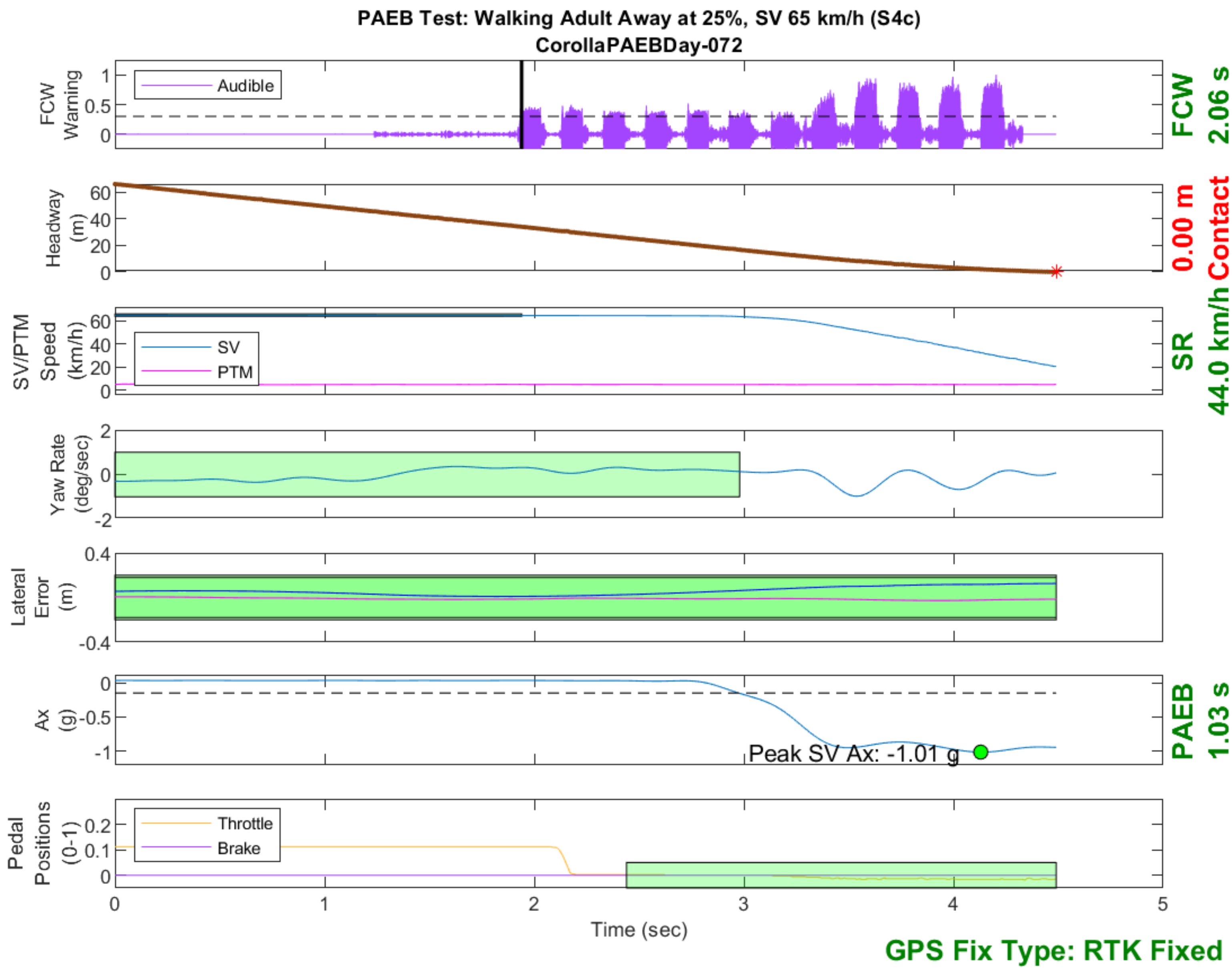


Figure D168. Time History for PAEB Run 72, S4c, Daytime, 65 km/h

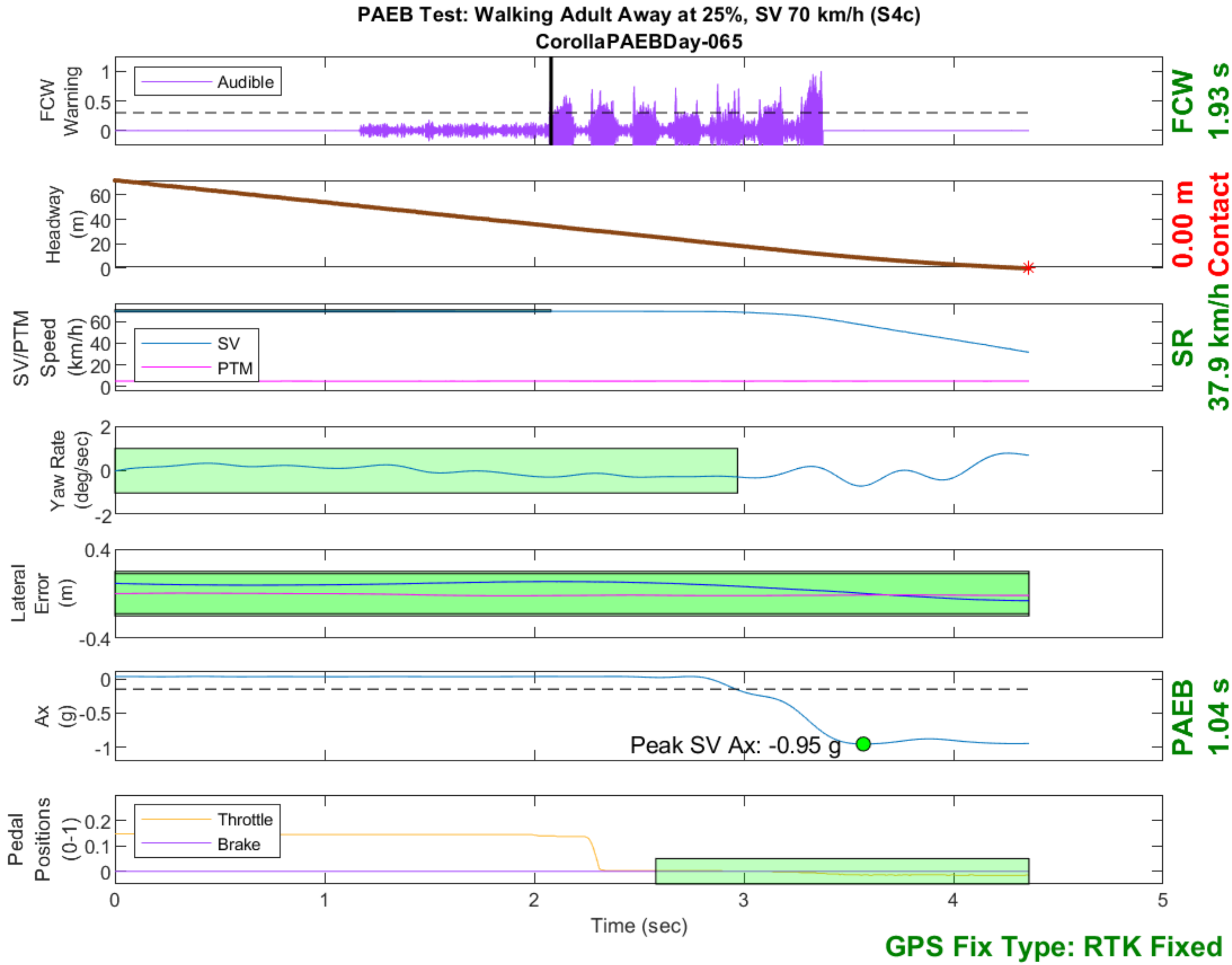


Figure D169. Time History for PAEB Run 65, S4c, Daytime, 70 km/h

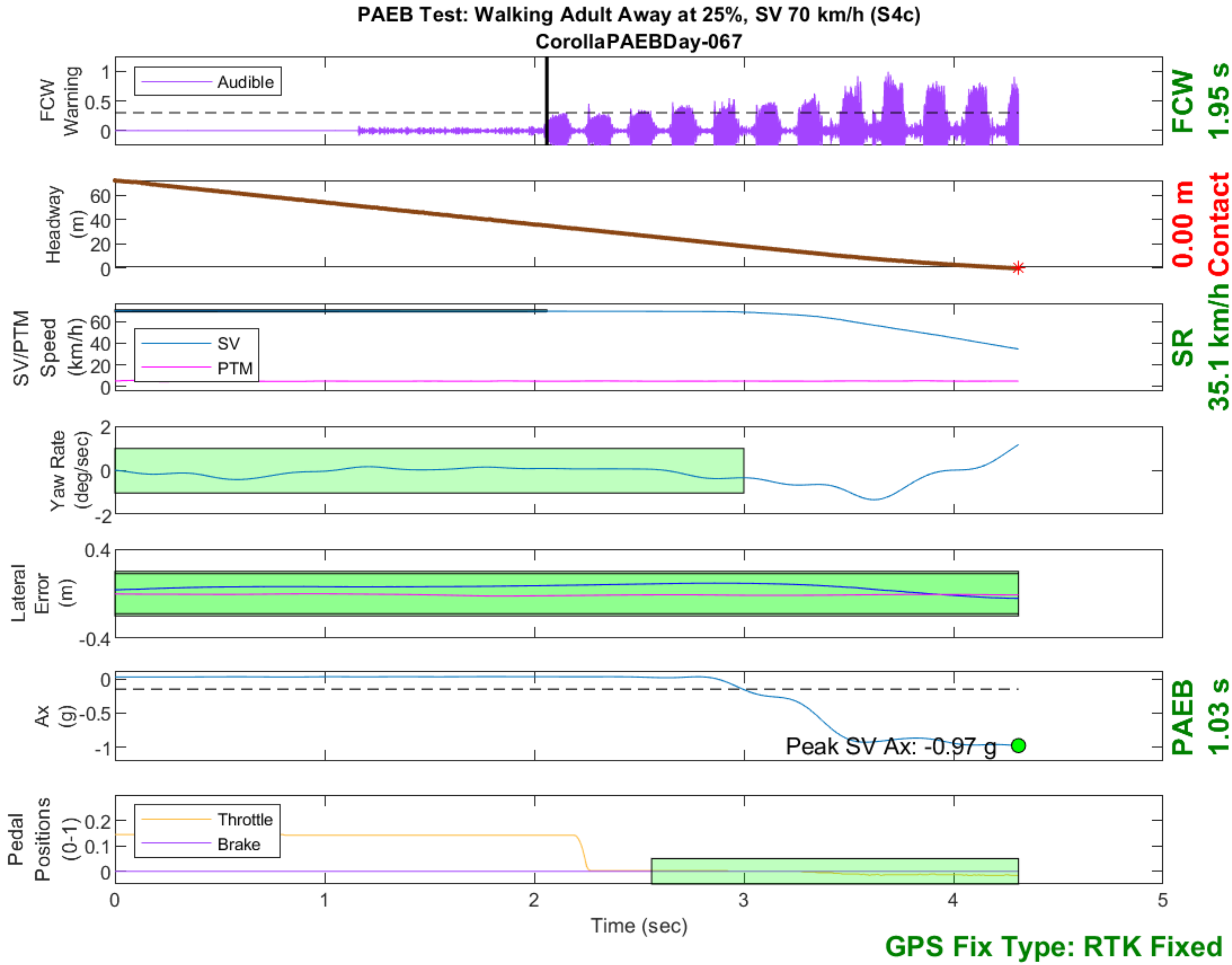


Figure D170. Time History for PAEB Run 67, S4c, Daytime, 70 km/h

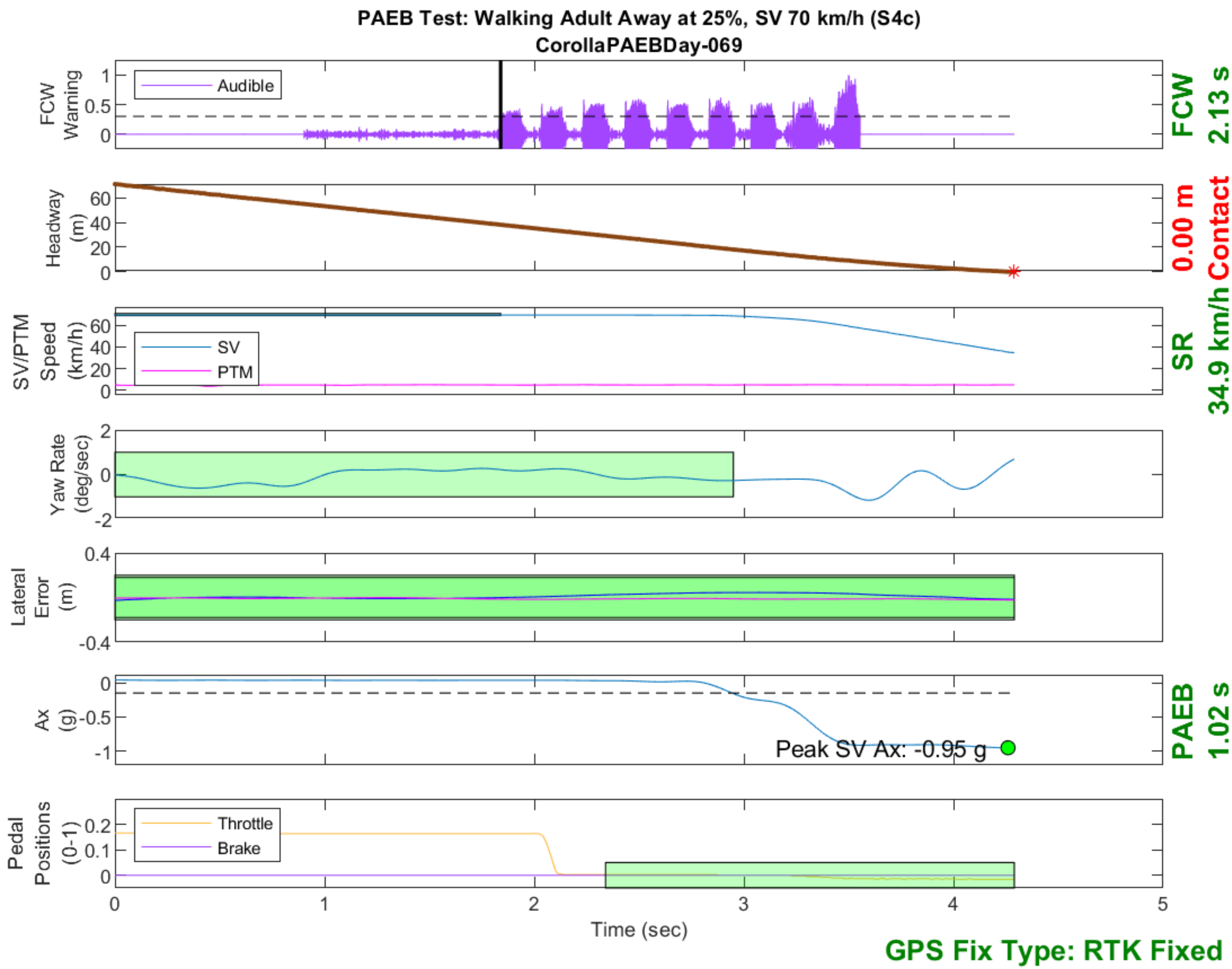


Figure D171. Time History for PAEB Run 69, S4c, Daytime, 70 km/h

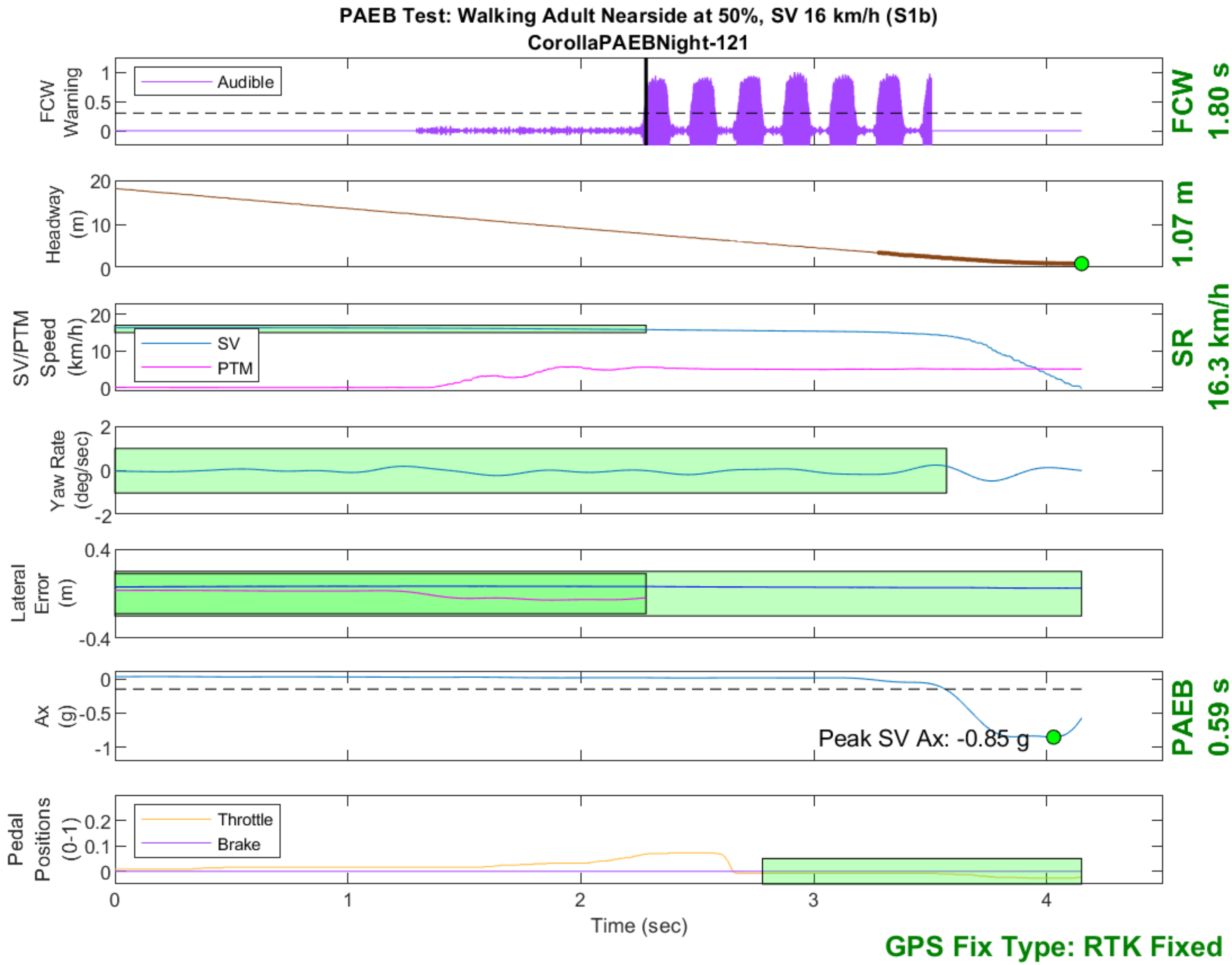


Figure D172. Time History for PAEB Run 121, S1b, Night, High Beam, 16 km/h

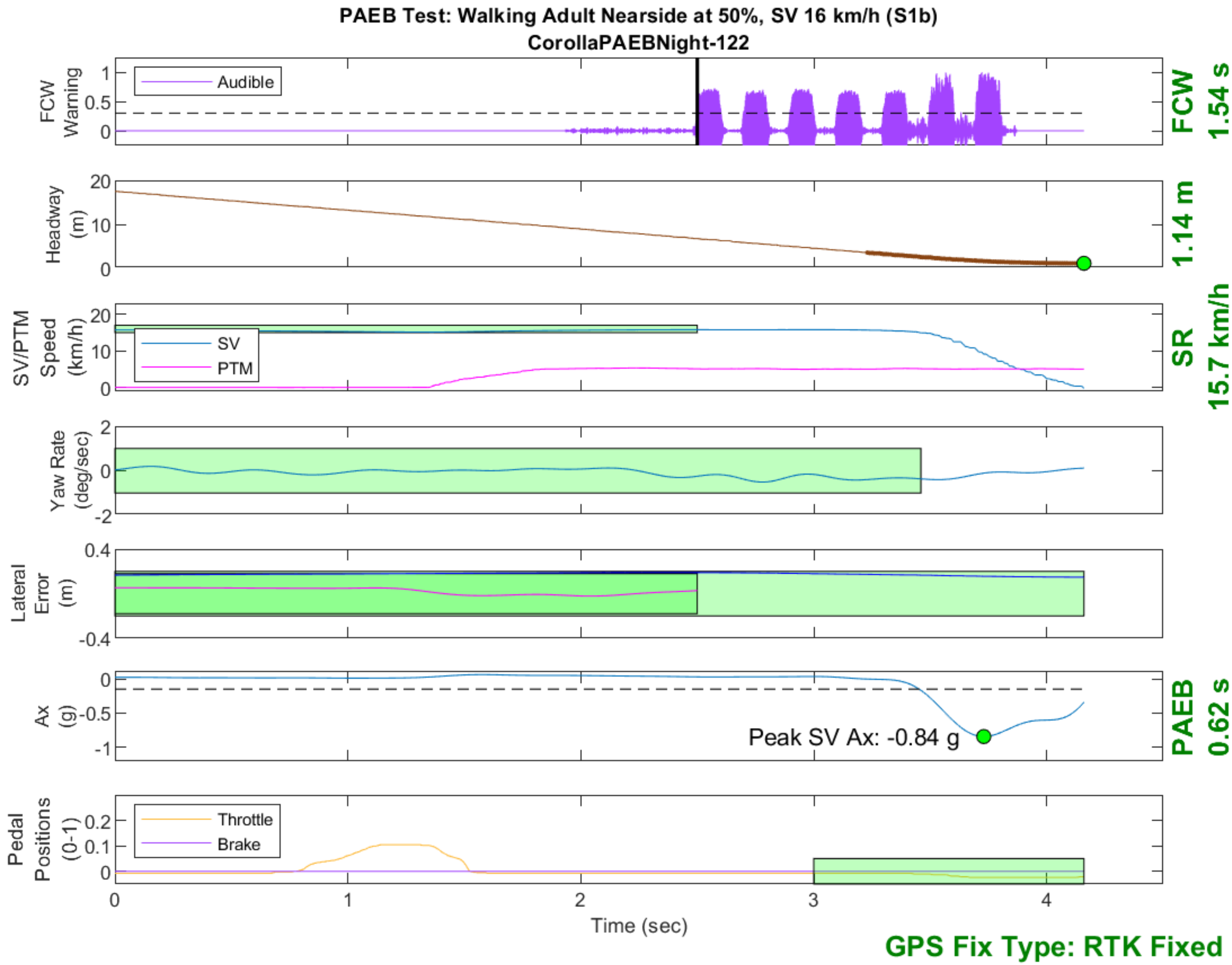


Figure D173. Time History for PAEB Run 122, S1b, Night, High Beam, 16 km/h

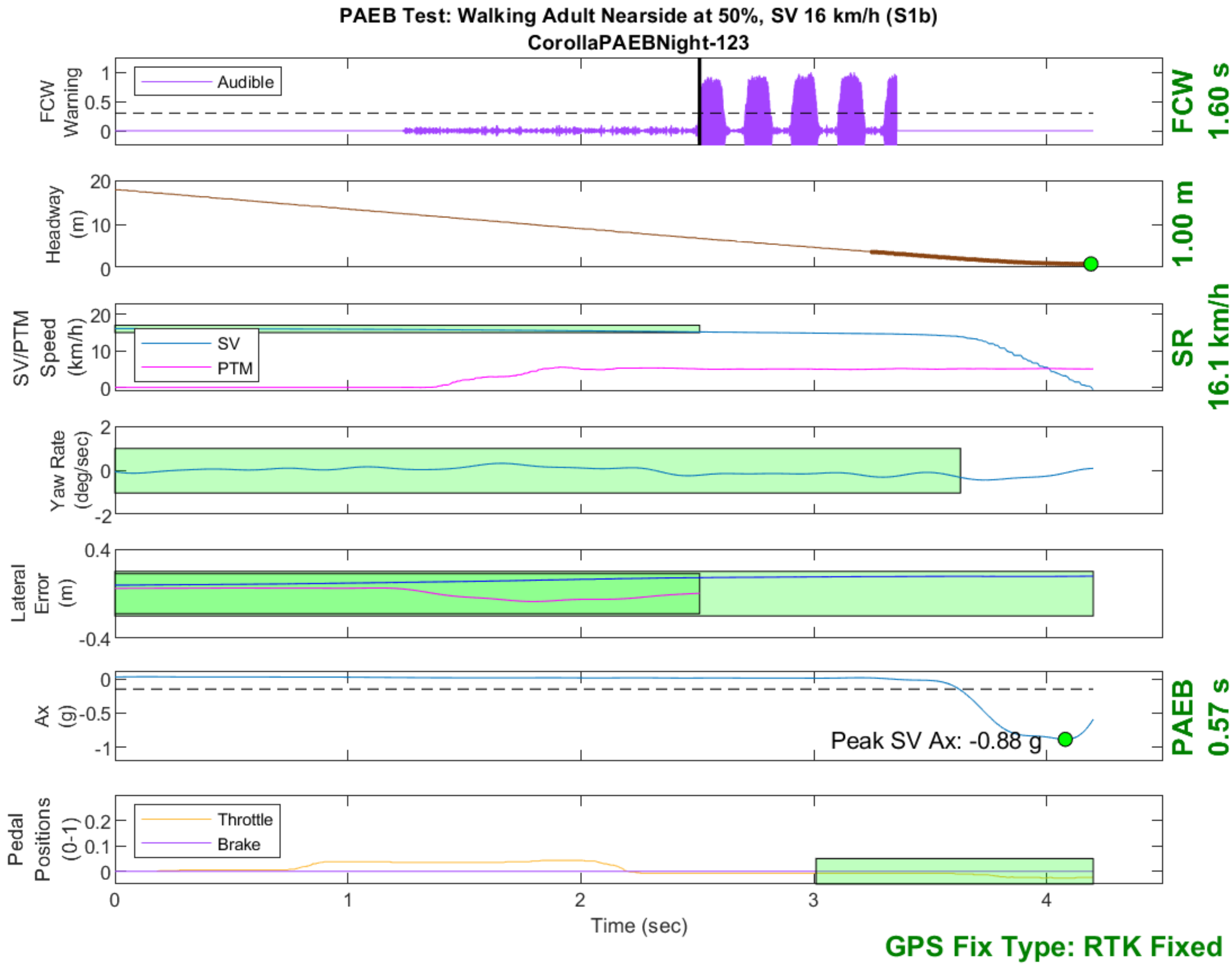


Figure D174. Time History for PAEB Run 123, S1b, Night, High Beam, 16 km/h

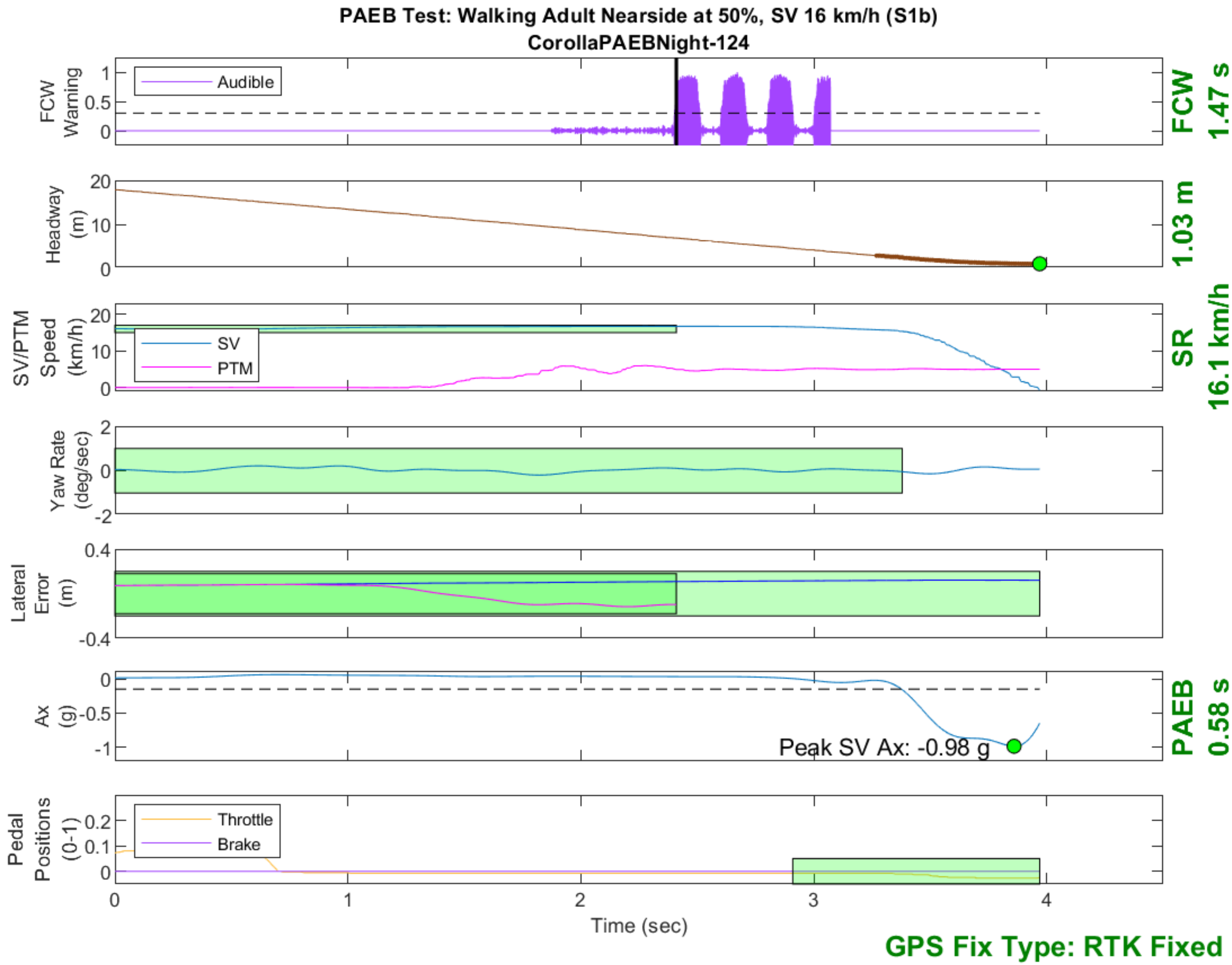


Figure D175. Time History for PAEB Run 124, S1b, Night, High Beam, 16 km/h

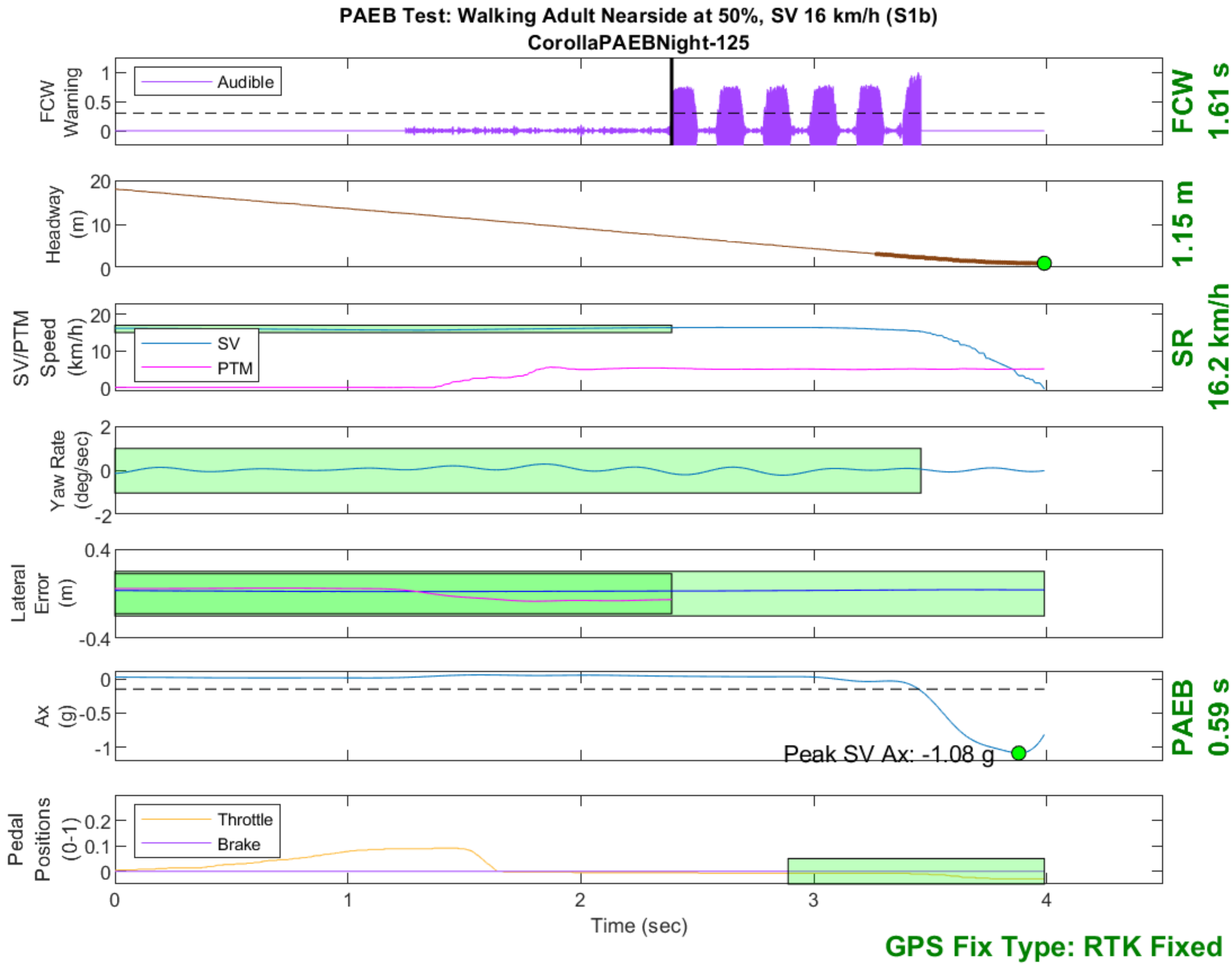


Figure D176. Time History for PAEB Run 125, S1b, Night, High Beam, 16 km/h

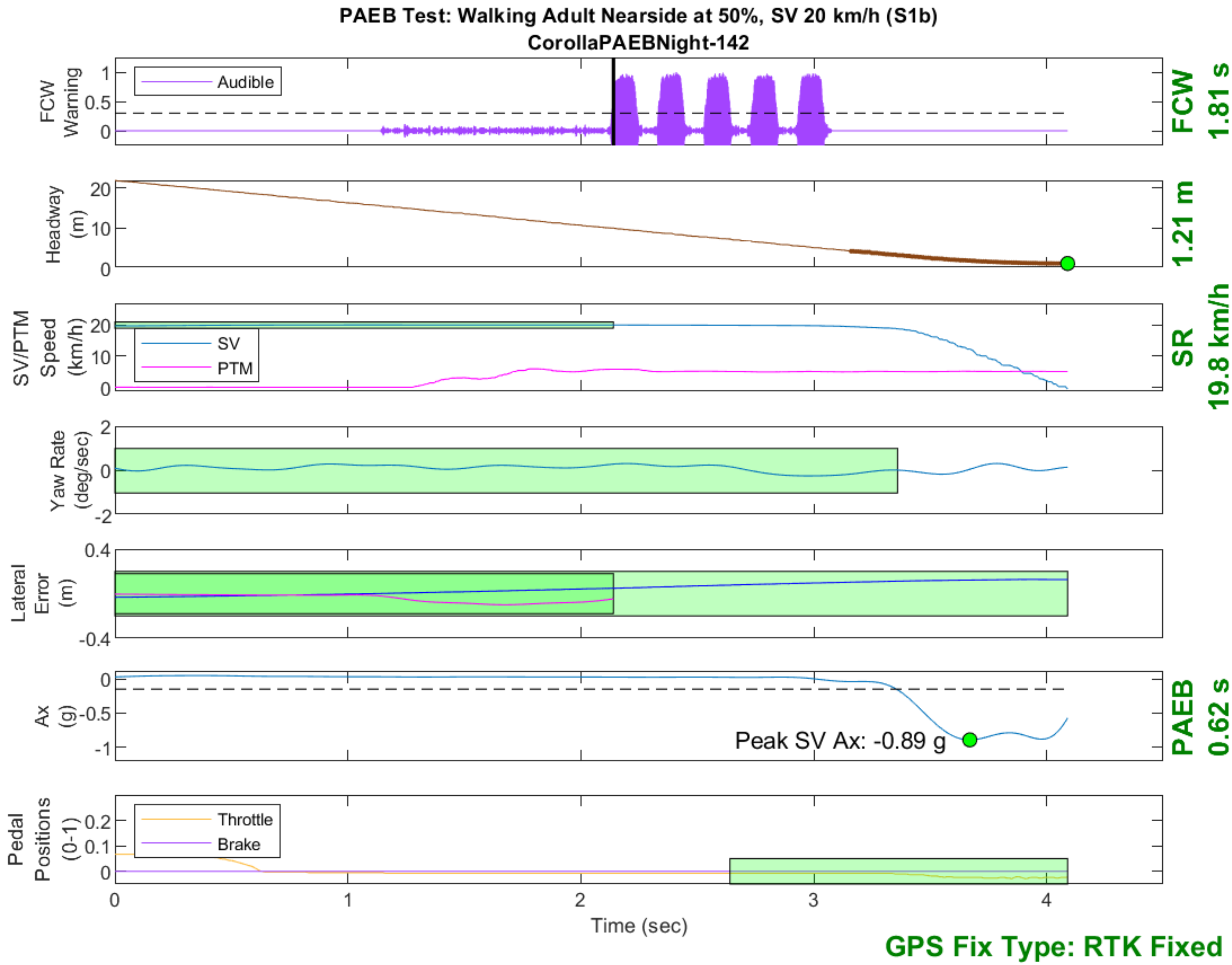


Figure D177. Time History for PAEB Run 142, S1b, Night, High Beam, 20 km/h

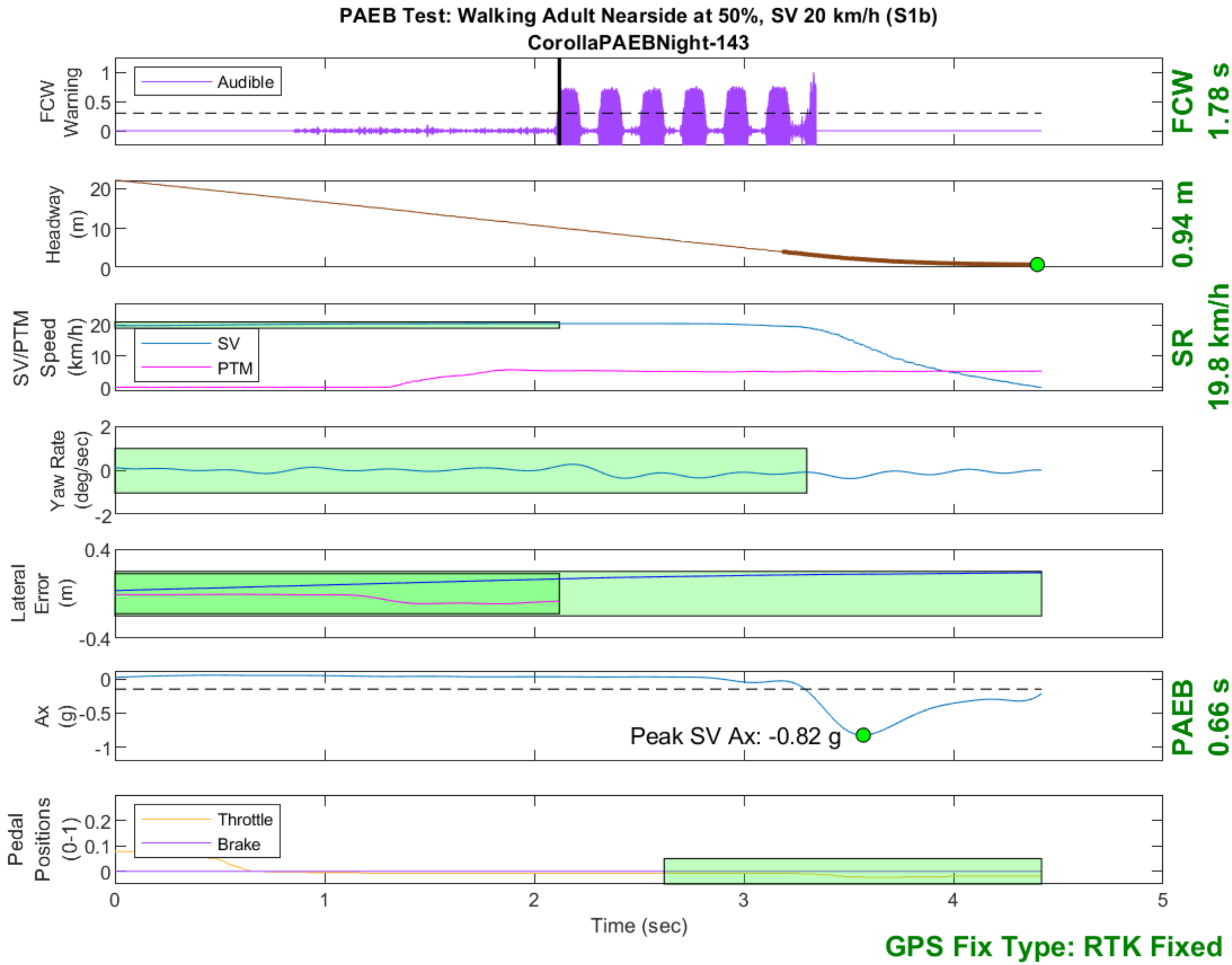


Figure D178. Time History for PAEB Run 143, S1b, Night, High Beam, 20 km/h

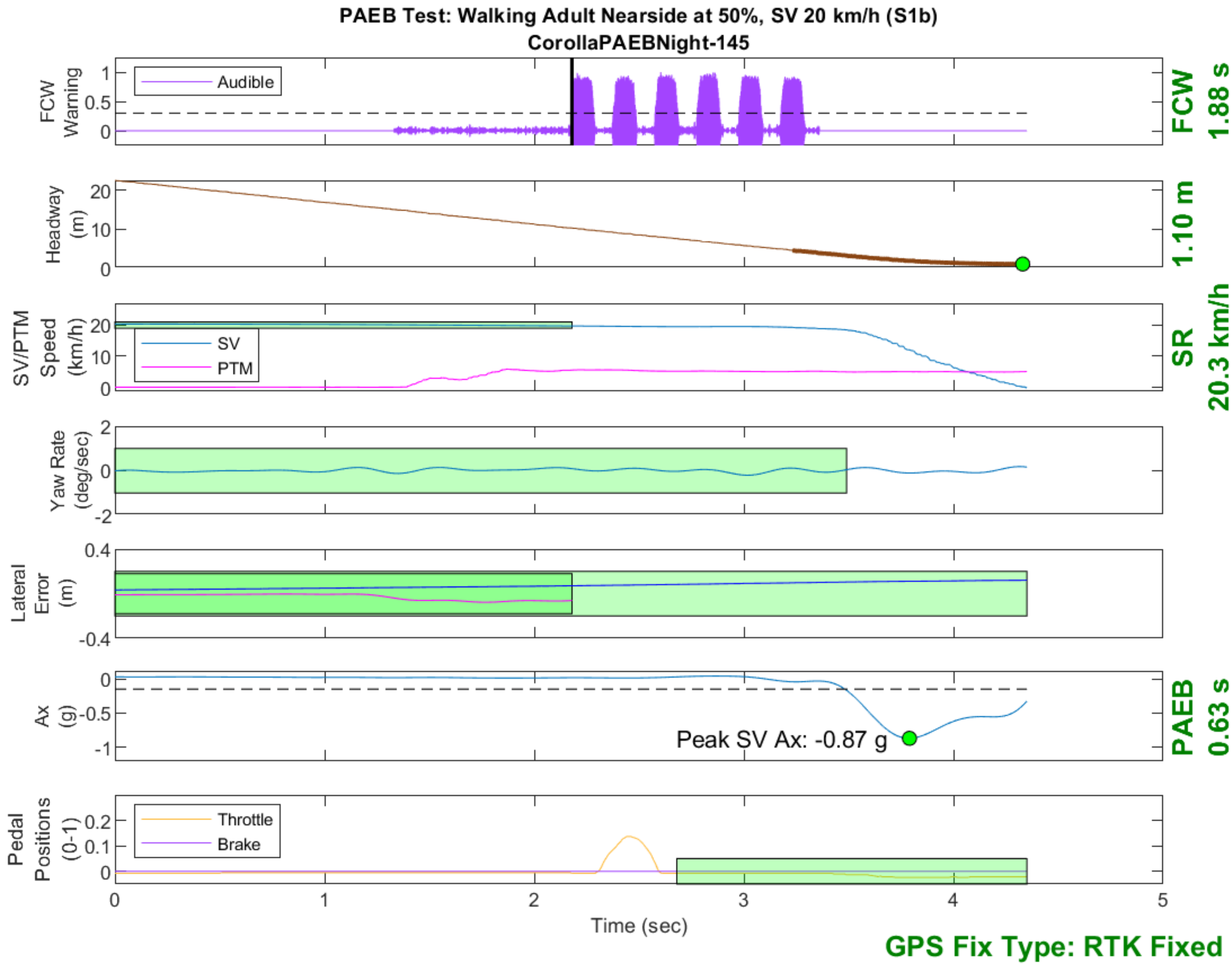


Figure D179. Time History for PAEB Run 145, S1b, Night, High Beam, 20 km/h

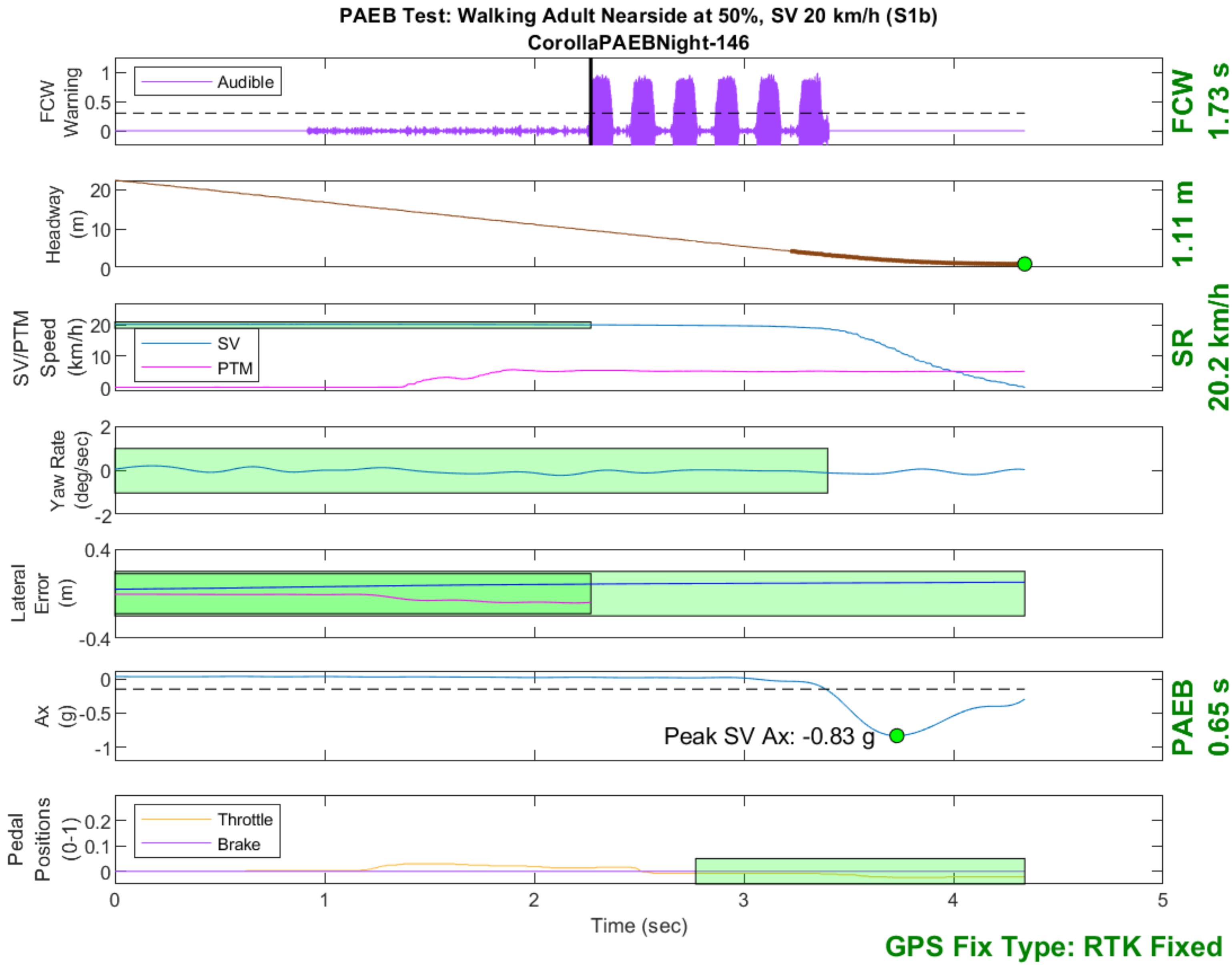


Figure D180. Time History for PAEB Run 146, S1b, Night, High Beam, 20 km/h

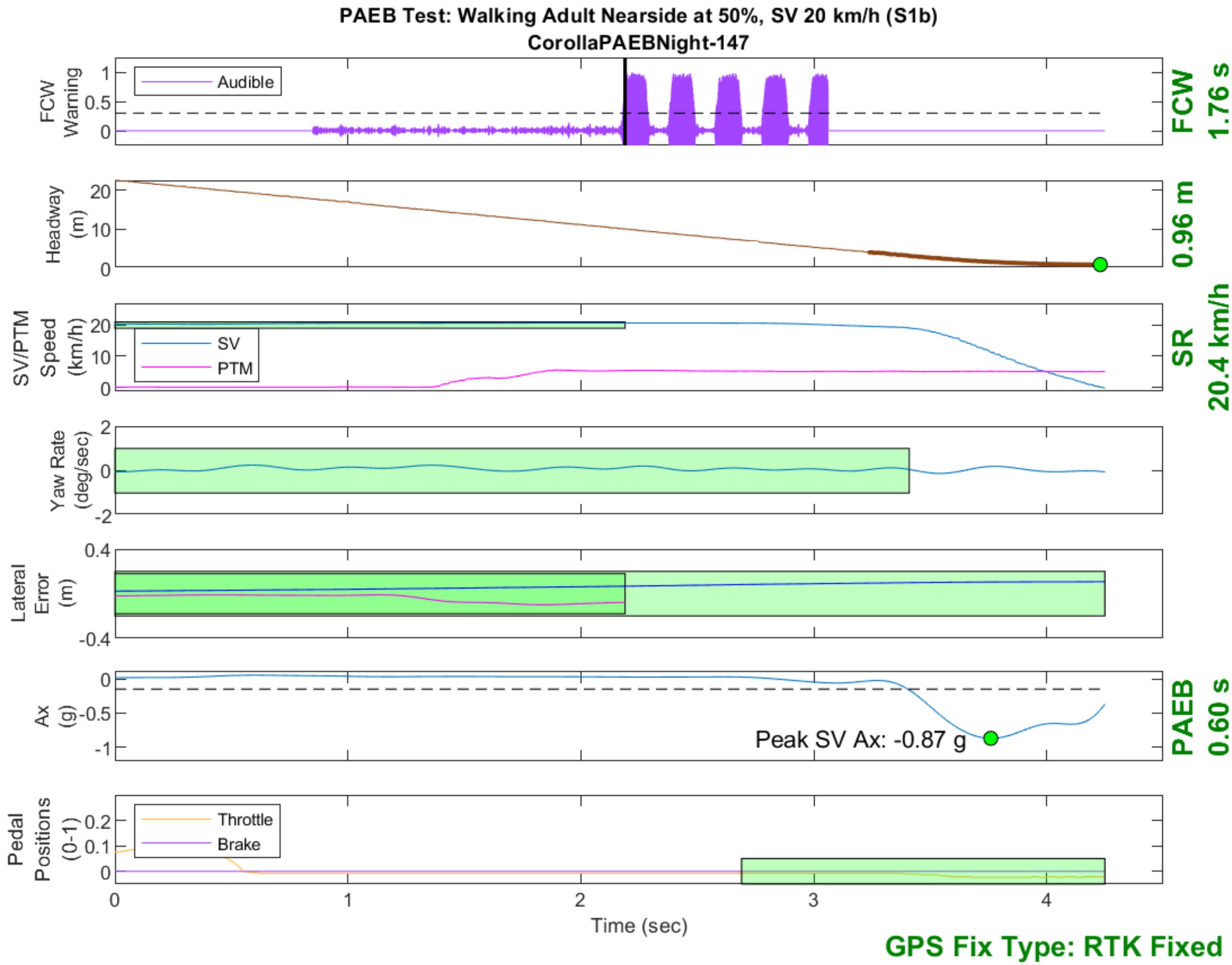


Figure D181. Time History for PAEB Run 147, S1b, Night, High Beam, 20 km/h

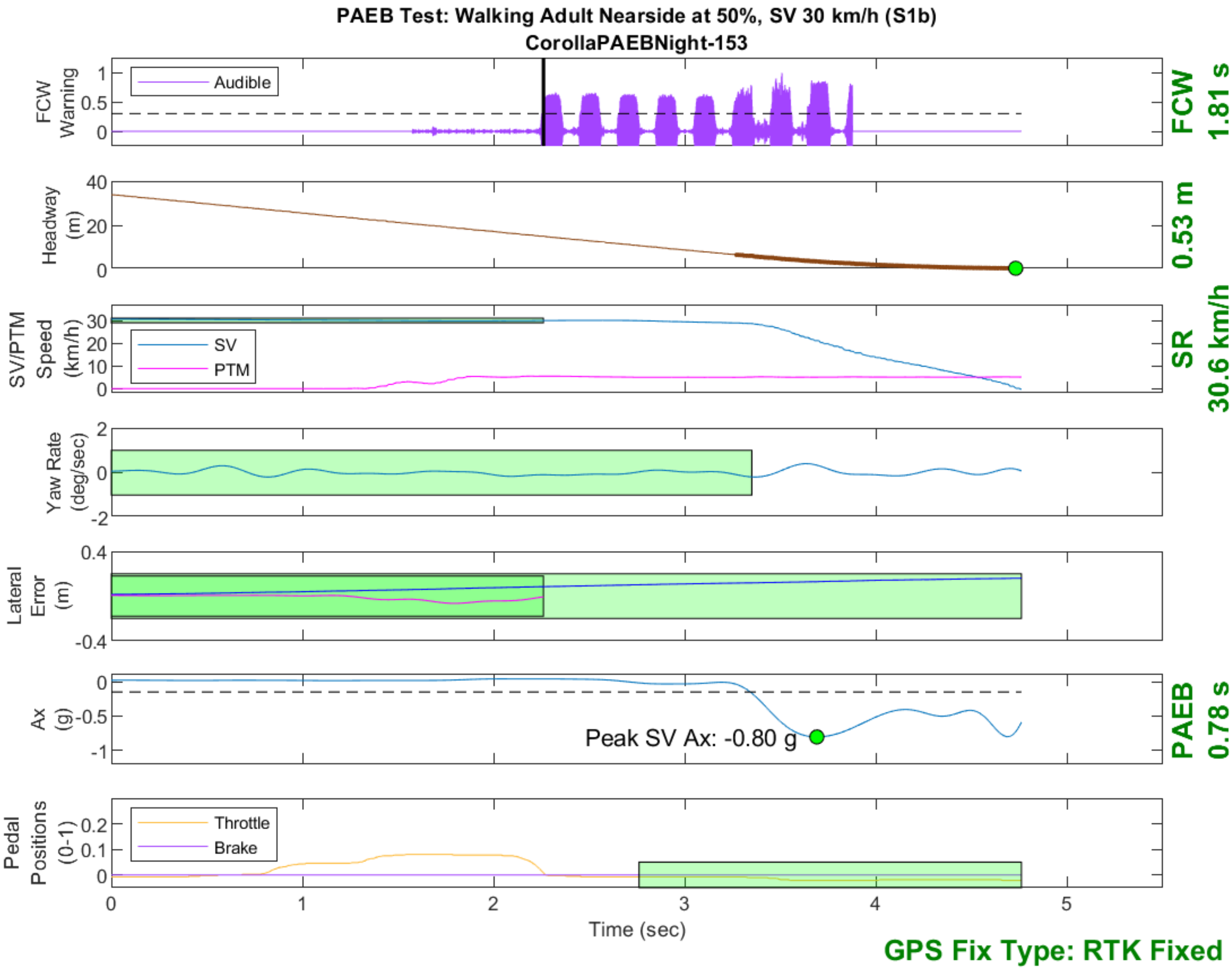


Figure D182. Time History for PAEB Run 153, S1b, Night, High Beam, 30 km/h

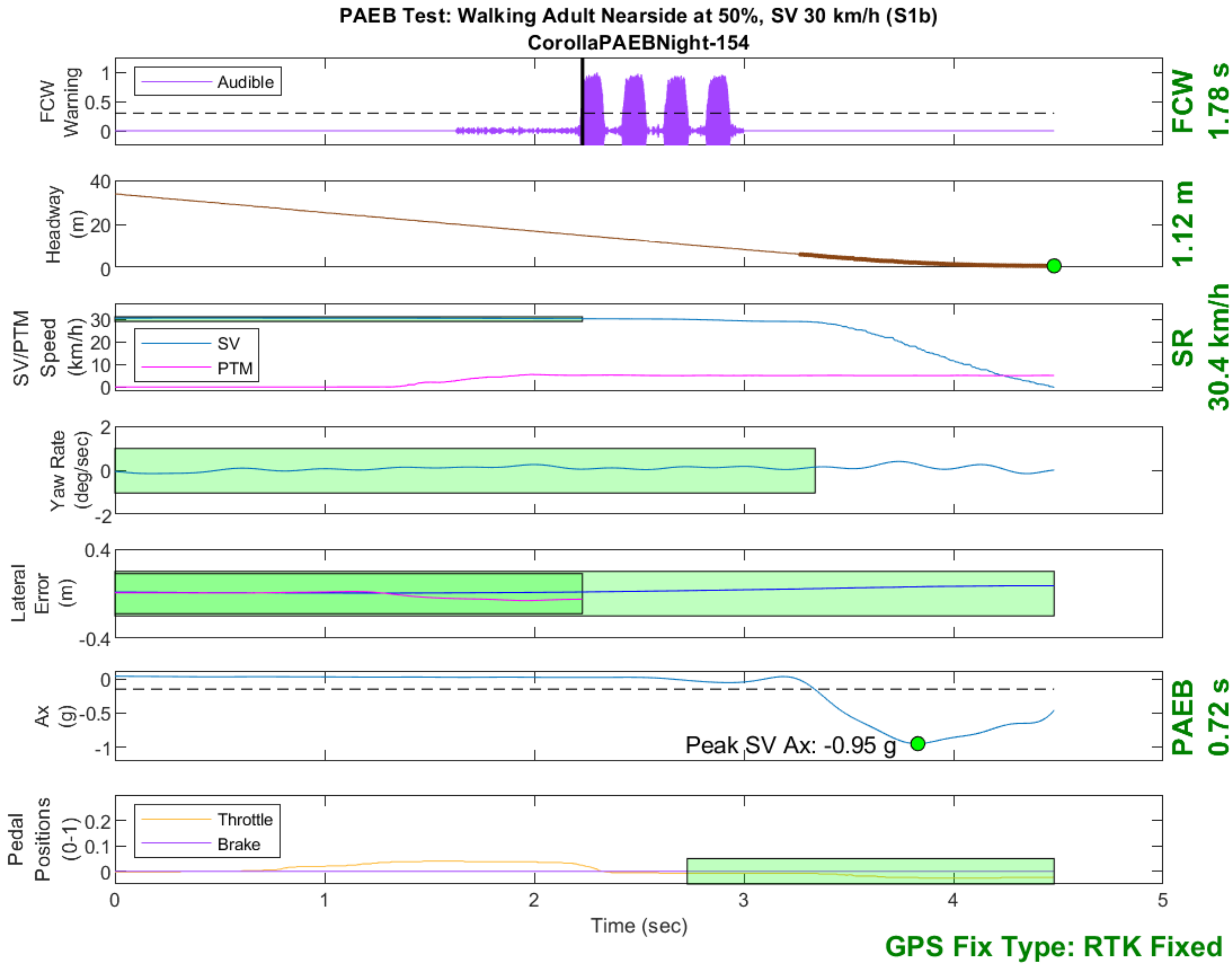


Figure D183. Time History for PAEB Run 154, S1b, Night, High Beam, 30 km/h

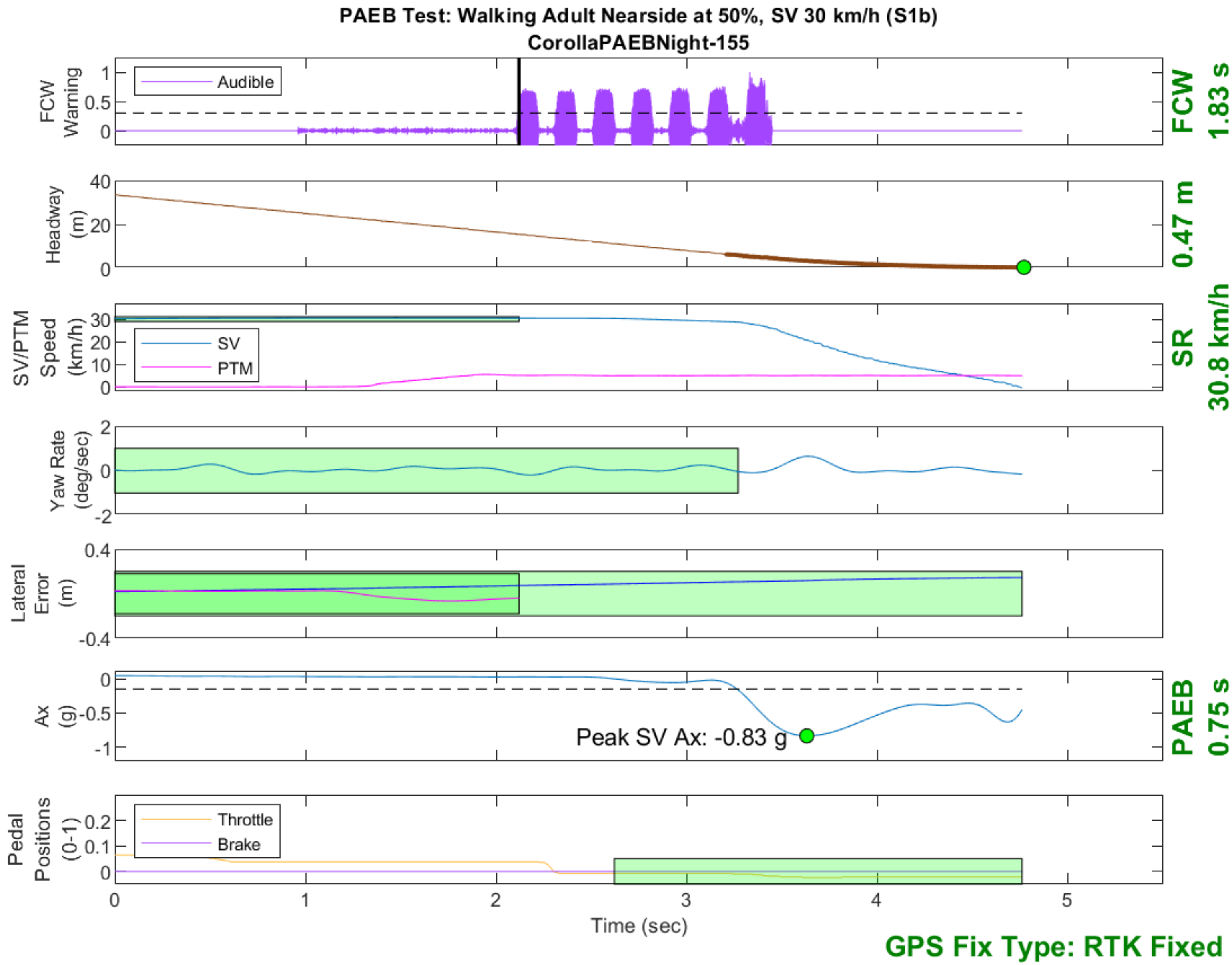


Figure D184. Time History for PAEB Run 155, S1b, Night, High Beam, 30 km/h

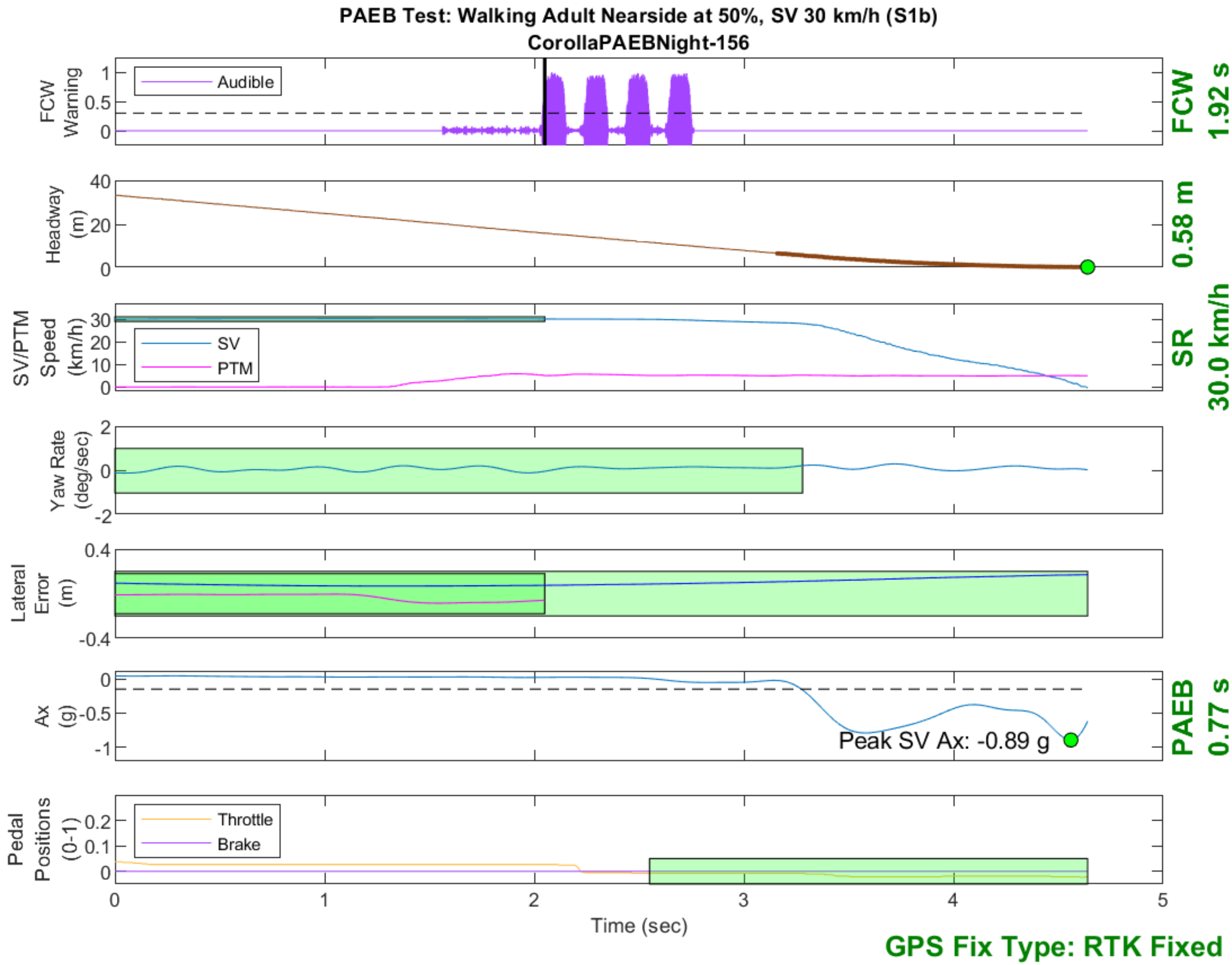


Figure D185. Time History for PAEB Run 156, S1b, Night, High Beam, 30 km/h

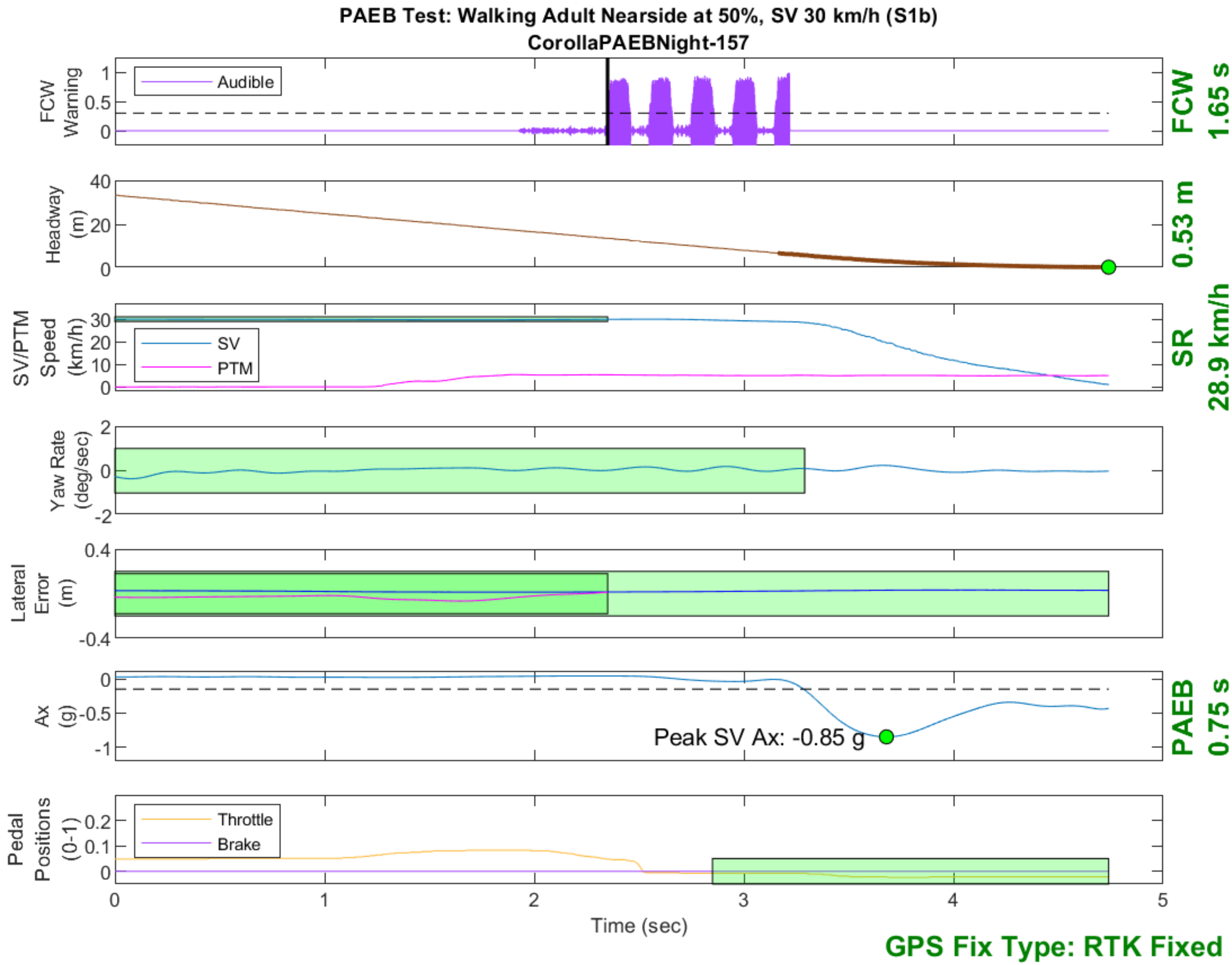


Figure D186. Time History for PAEB Run 157, S1b, Night, High Beam, 30 km/h

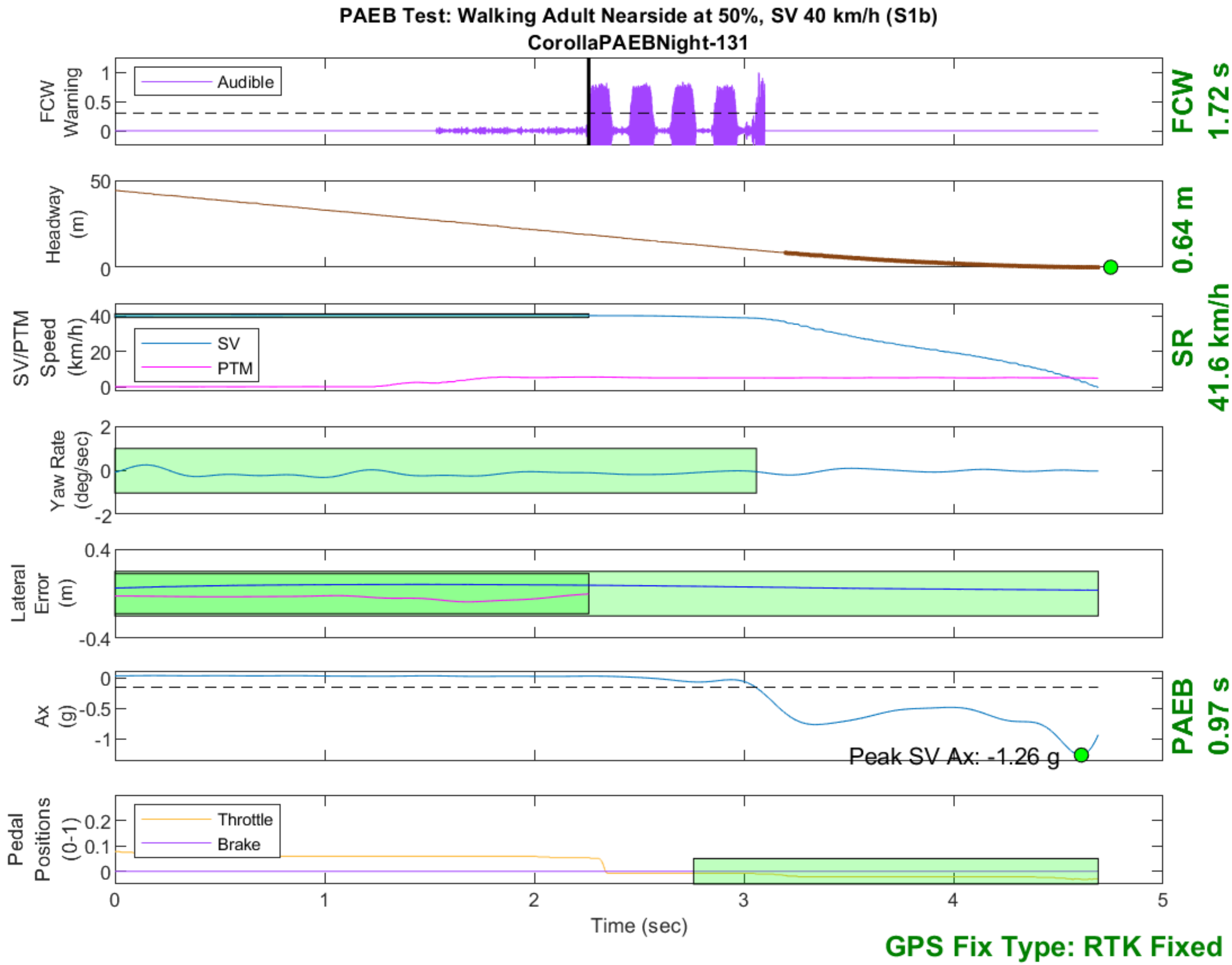


Figure D187. Time History for PAEB Run 131, S1b, Night, High Beam, 40 km/h

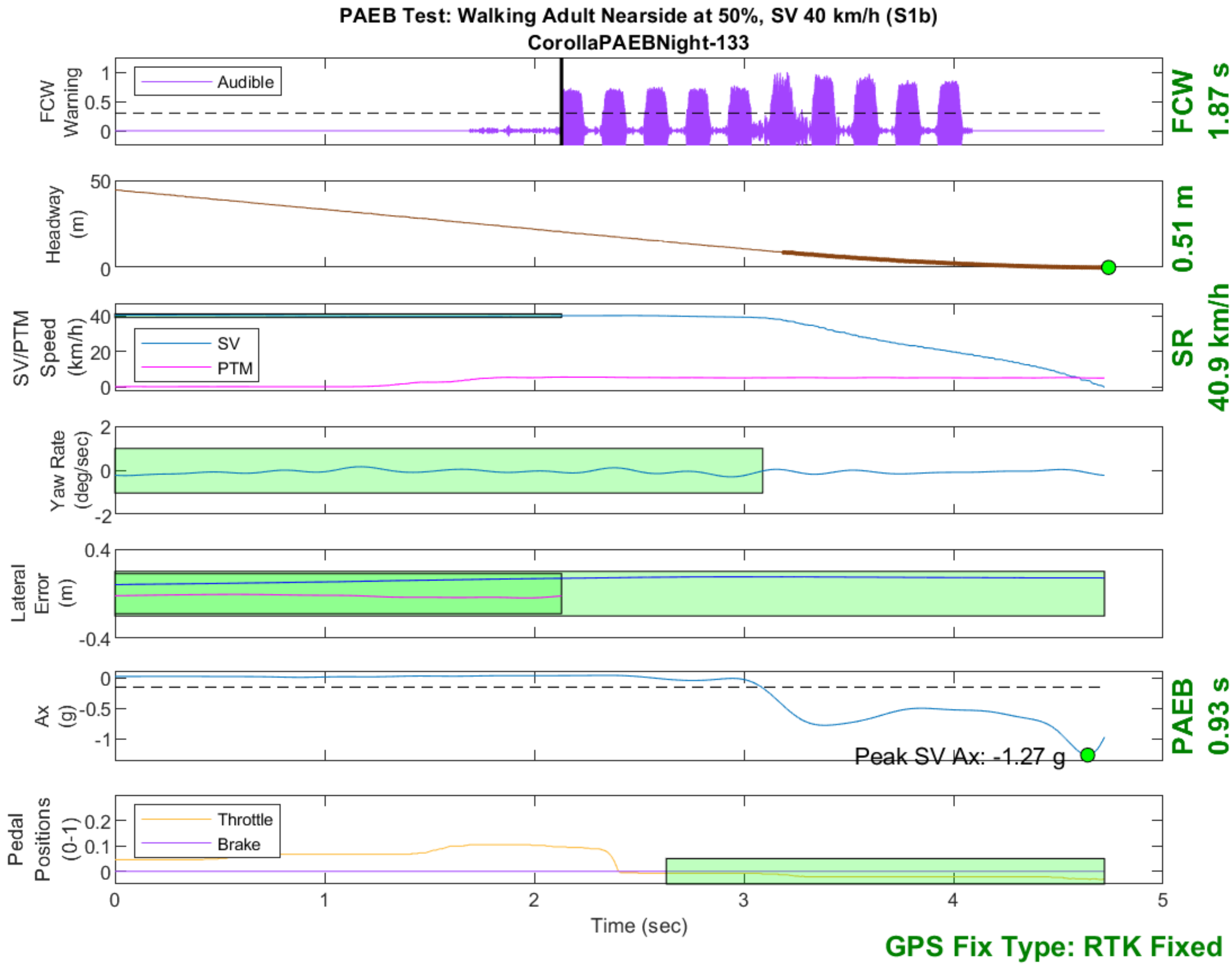


Figure D188. Time History for PAEB Run 133, S1b, Night, High Beam, 40 km/h

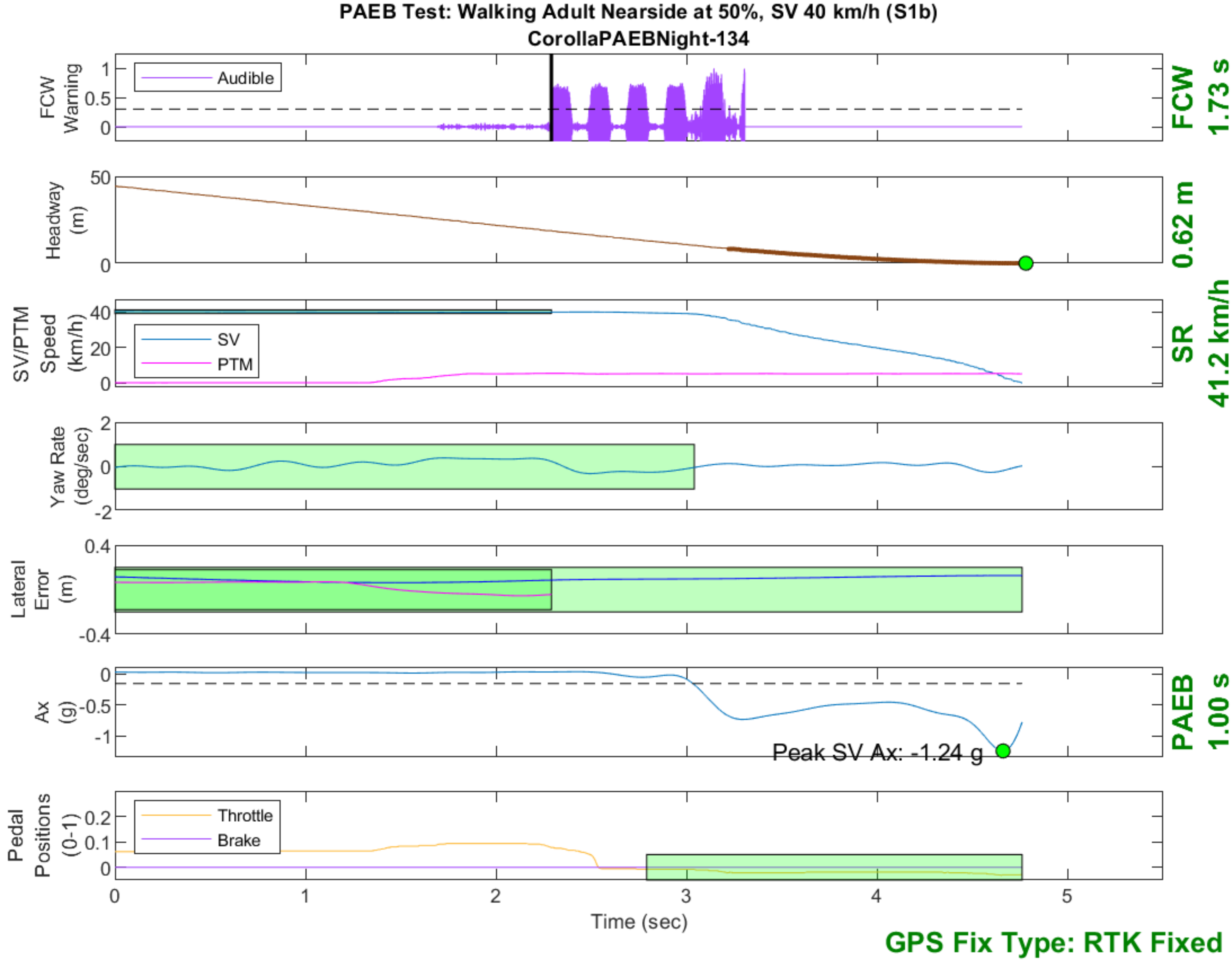


Figure D189. Time History for PAEB Run 134, S1b, Night, High Beam, 40 km/h

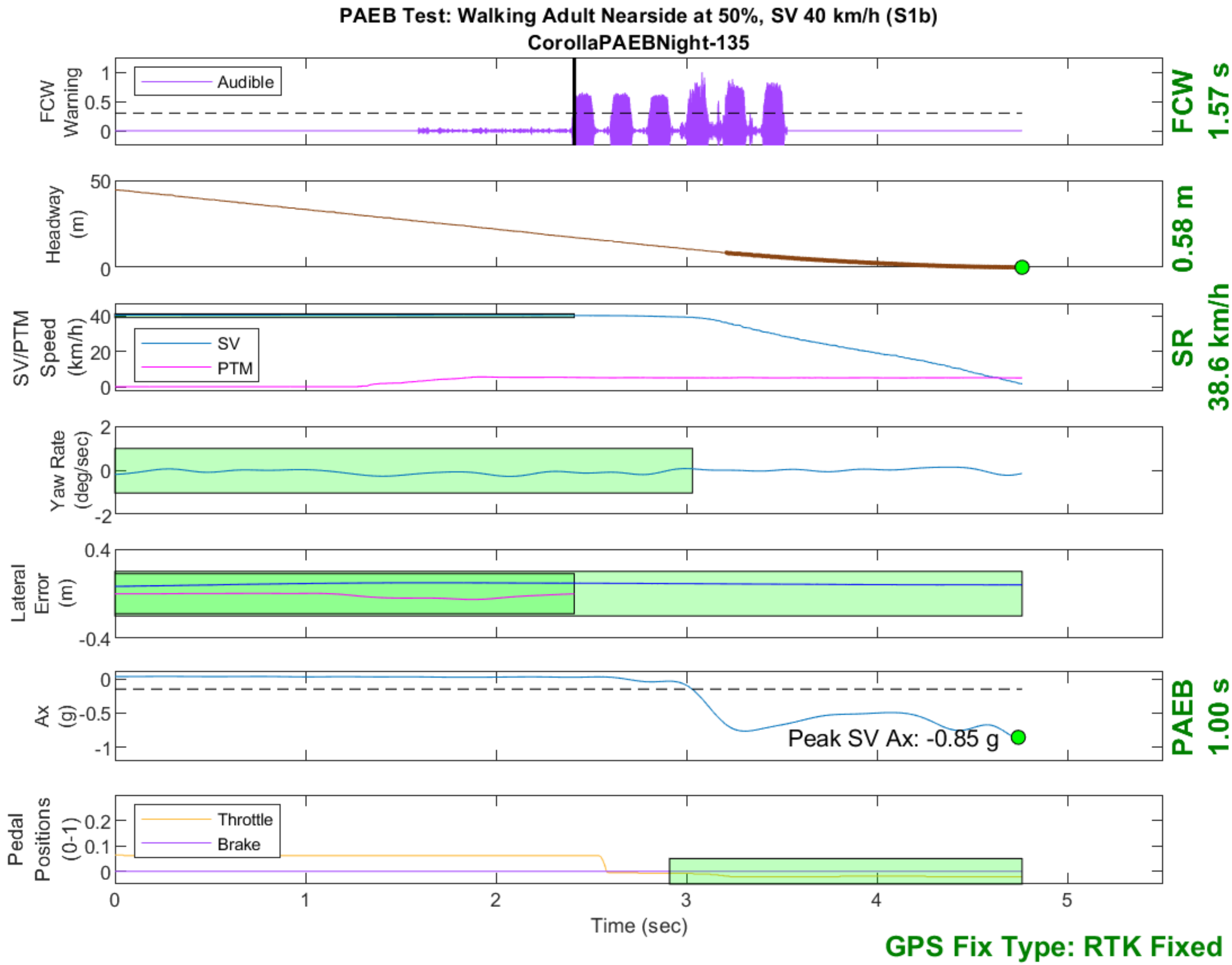


Figure D190. Time History for PAEB Run 135, S1b, Night, High Beam, 40 km/h

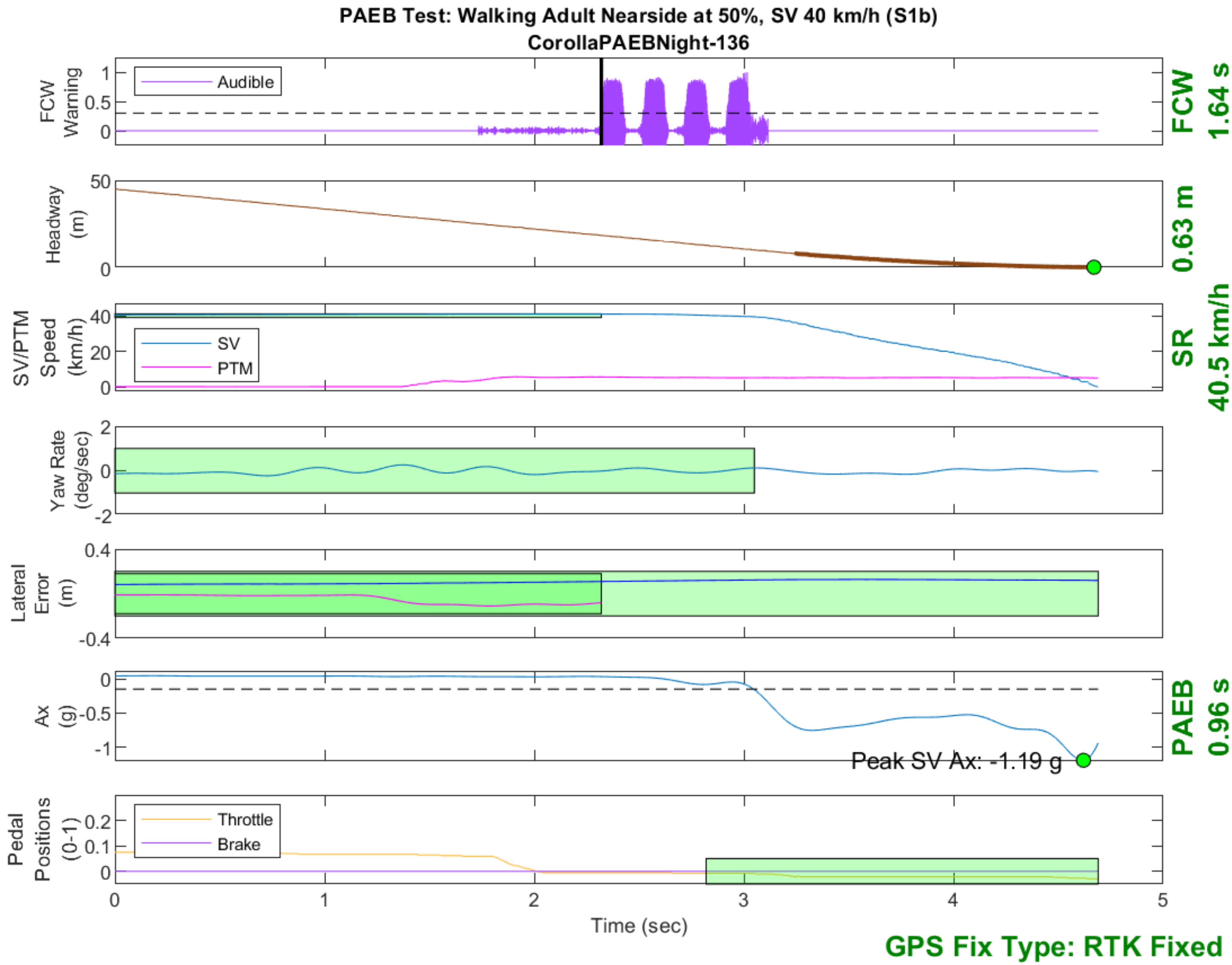


Figure D191. Time History for PAEB Run 136, S1b, Night, High Beam, 40 km/h

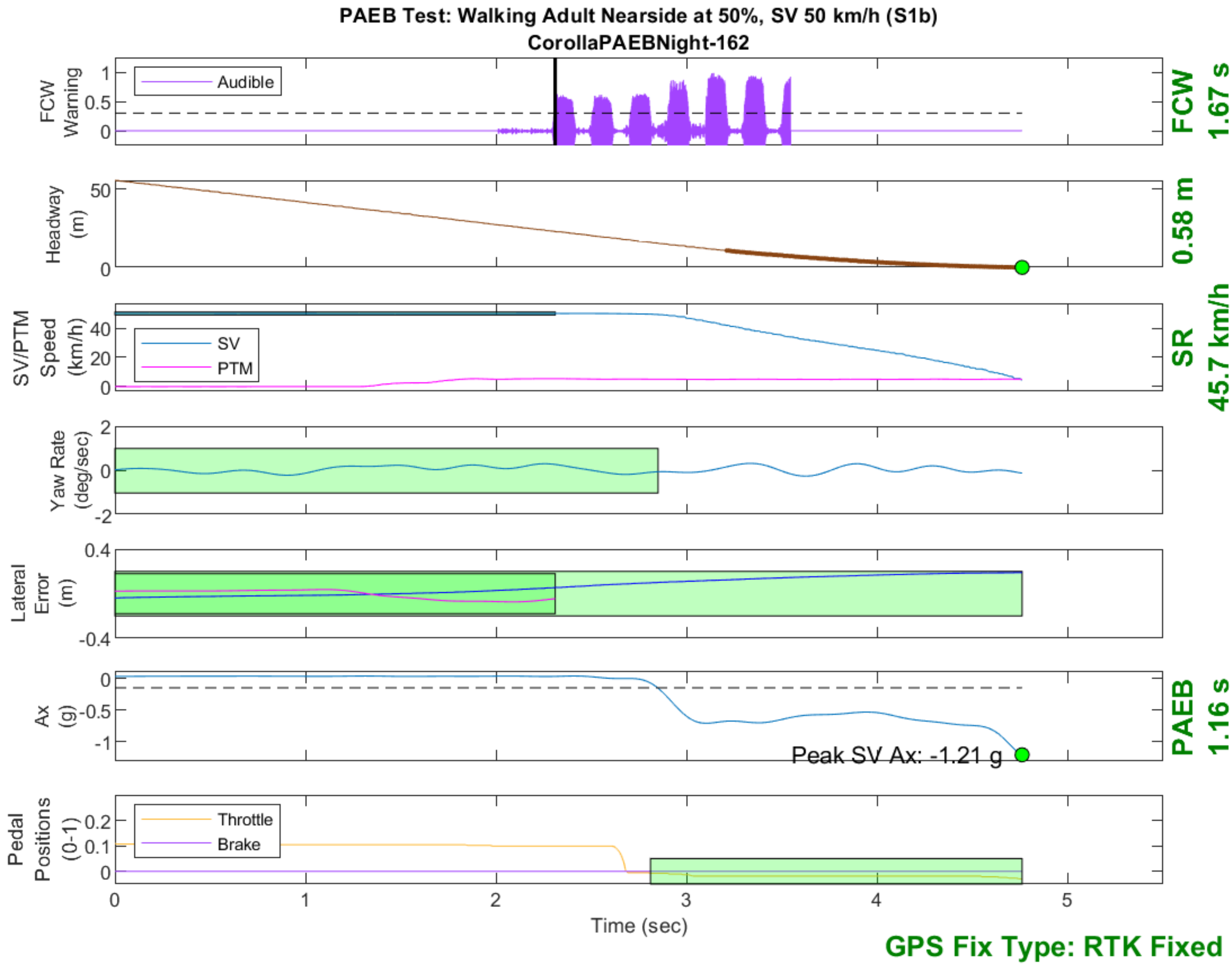


Figure D192. Time History for PAEB Run 162, S1b, Night, High Beam, 50 km/h

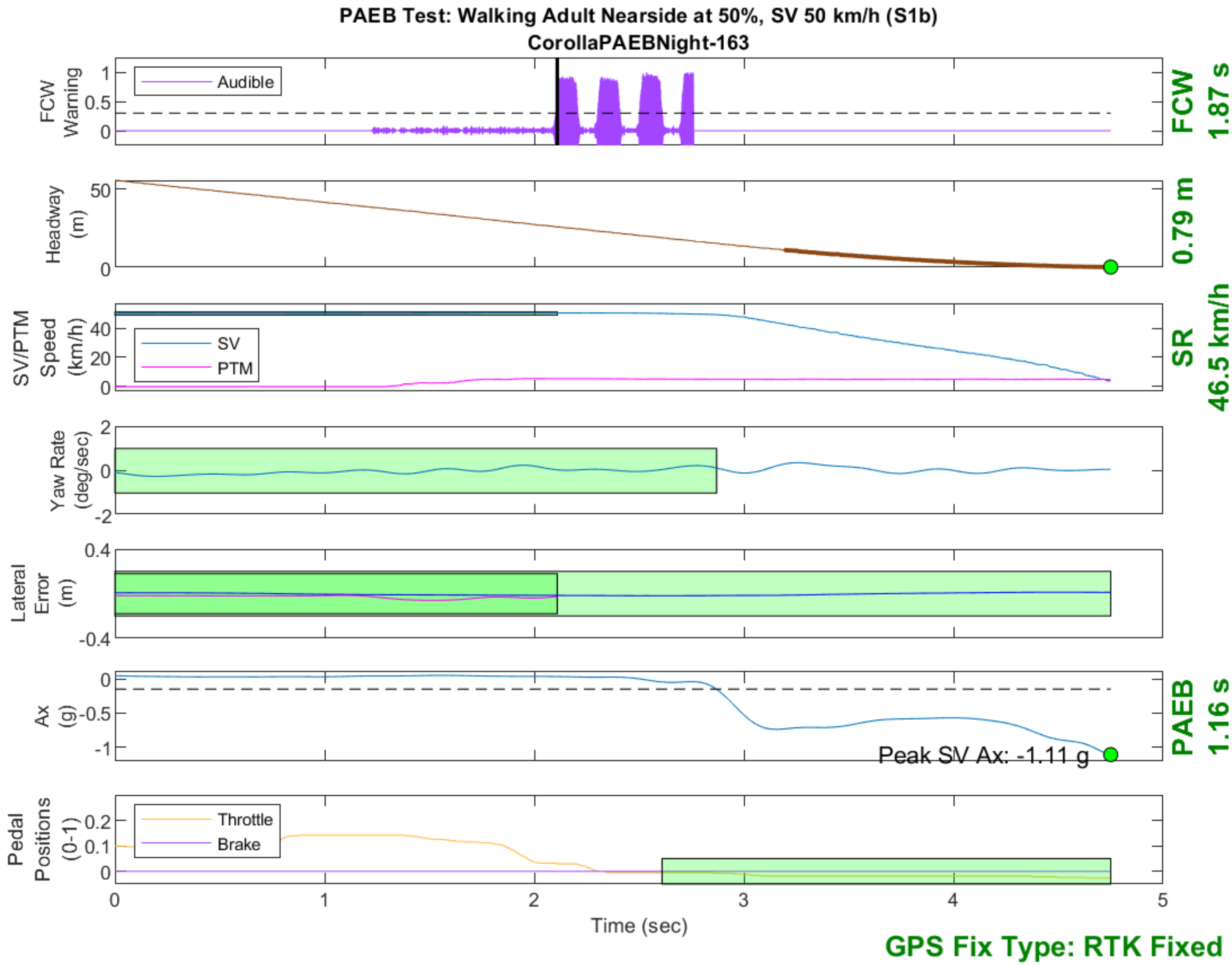


Figure D193. Time History for PAEB Run 163, S1b, Night, High Beam, 50 km/h

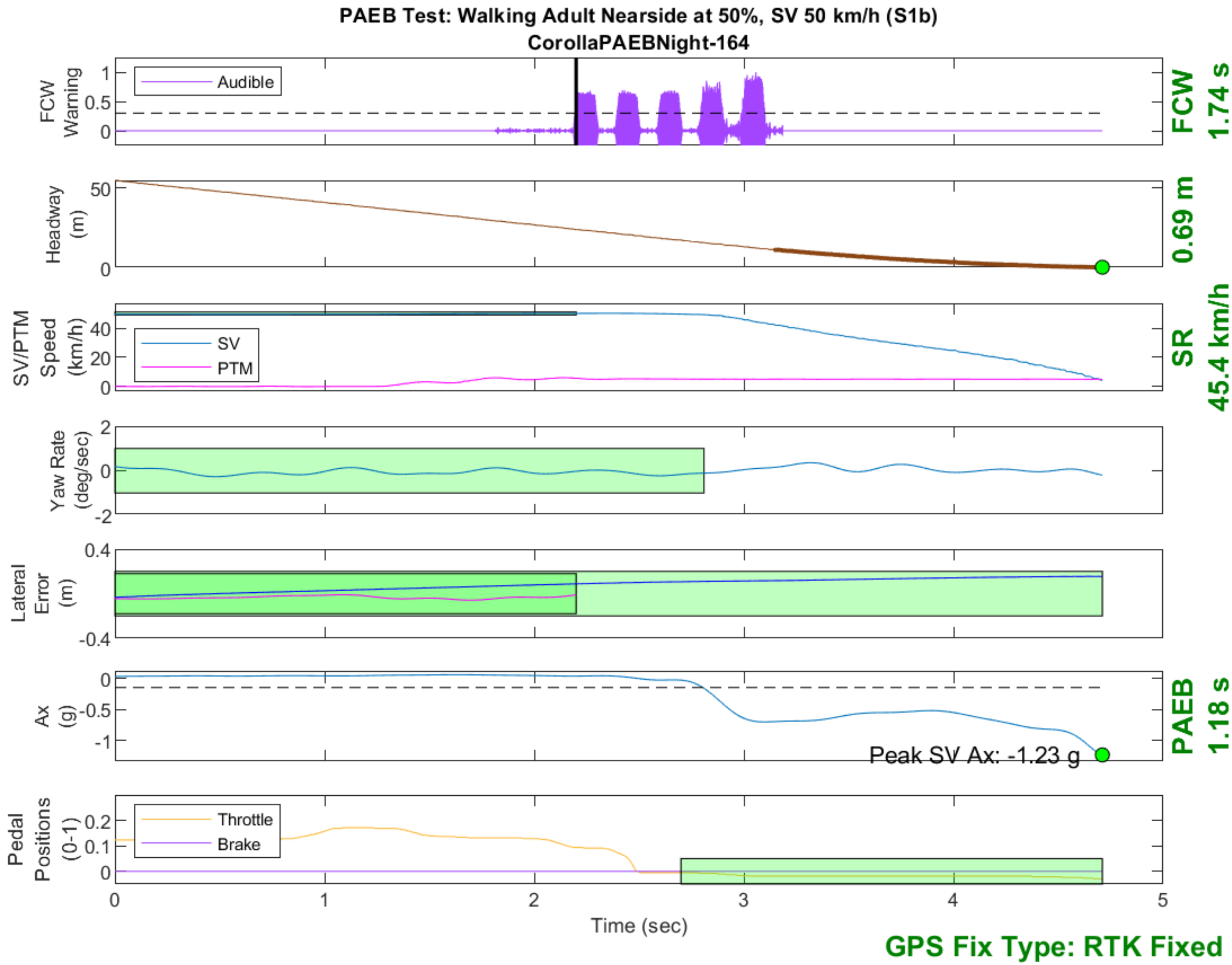


Figure D194. Time History for PAEB Run 164, S1b, Night, High Beam, 50 km/h

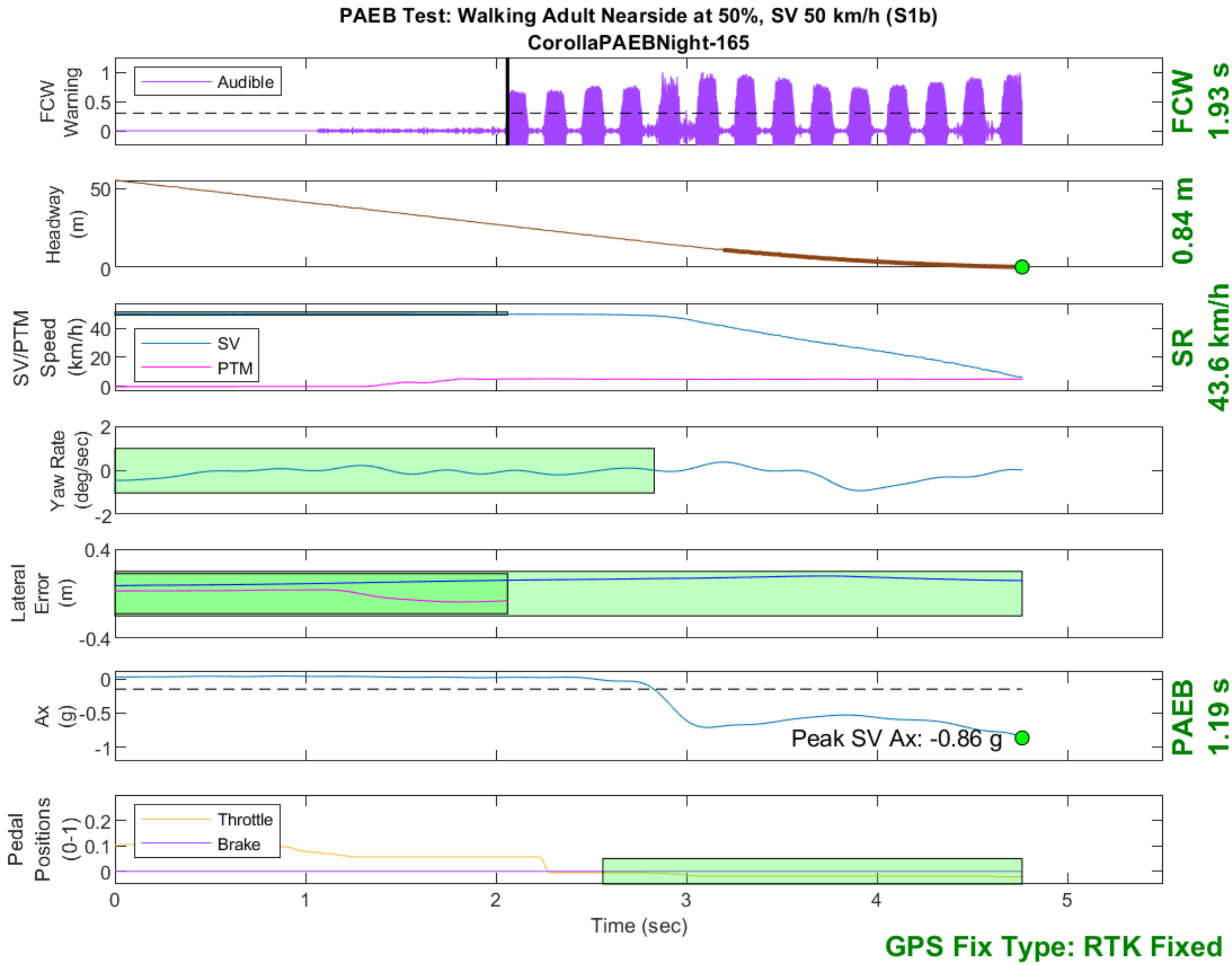


Figure D195. Time History for PAEB Run 165, S1b, Night, High Beam, 50 km/h

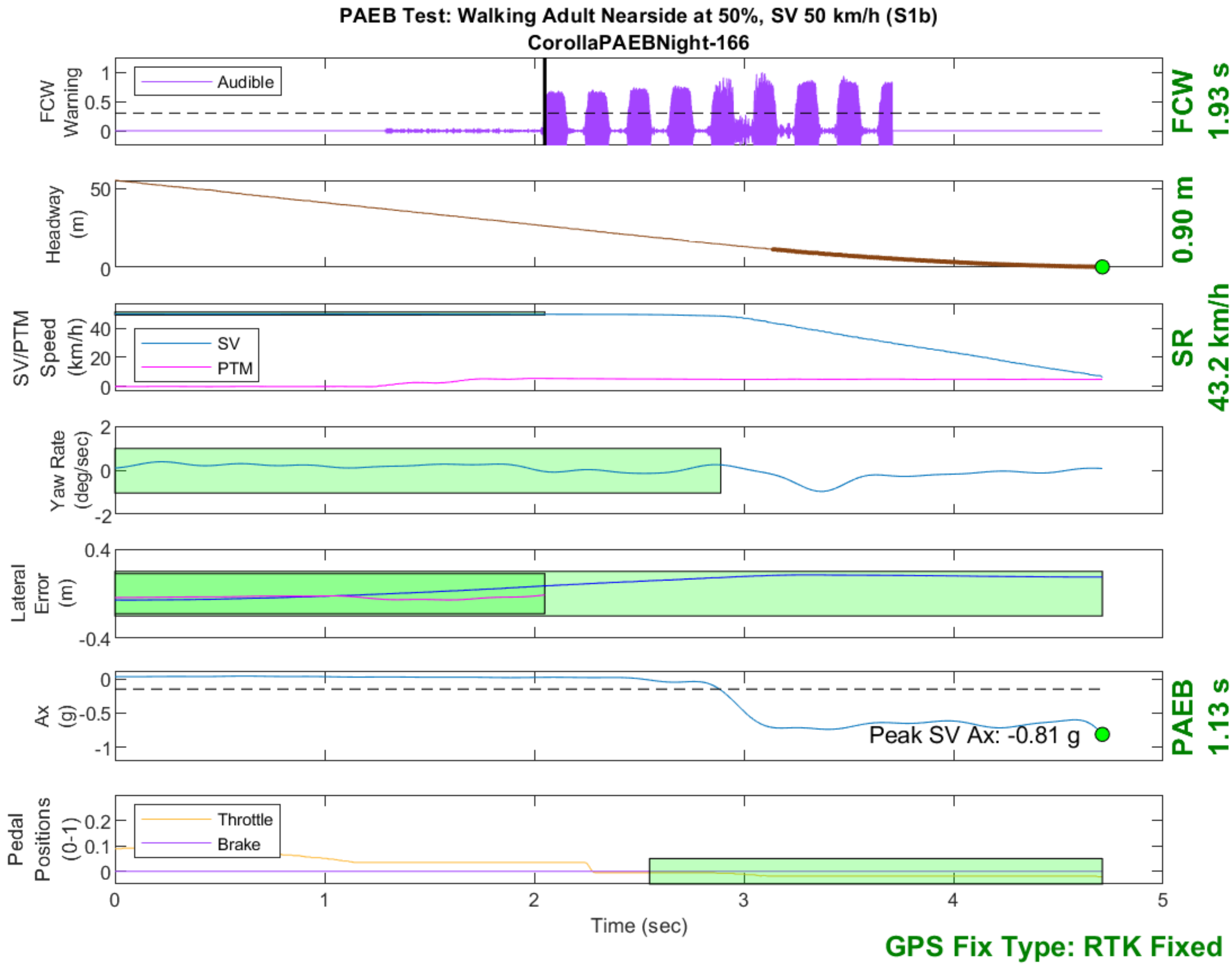


Figure D196. Time History for PAEB Run 166, S1b, Night, High Beam, 50 km/h

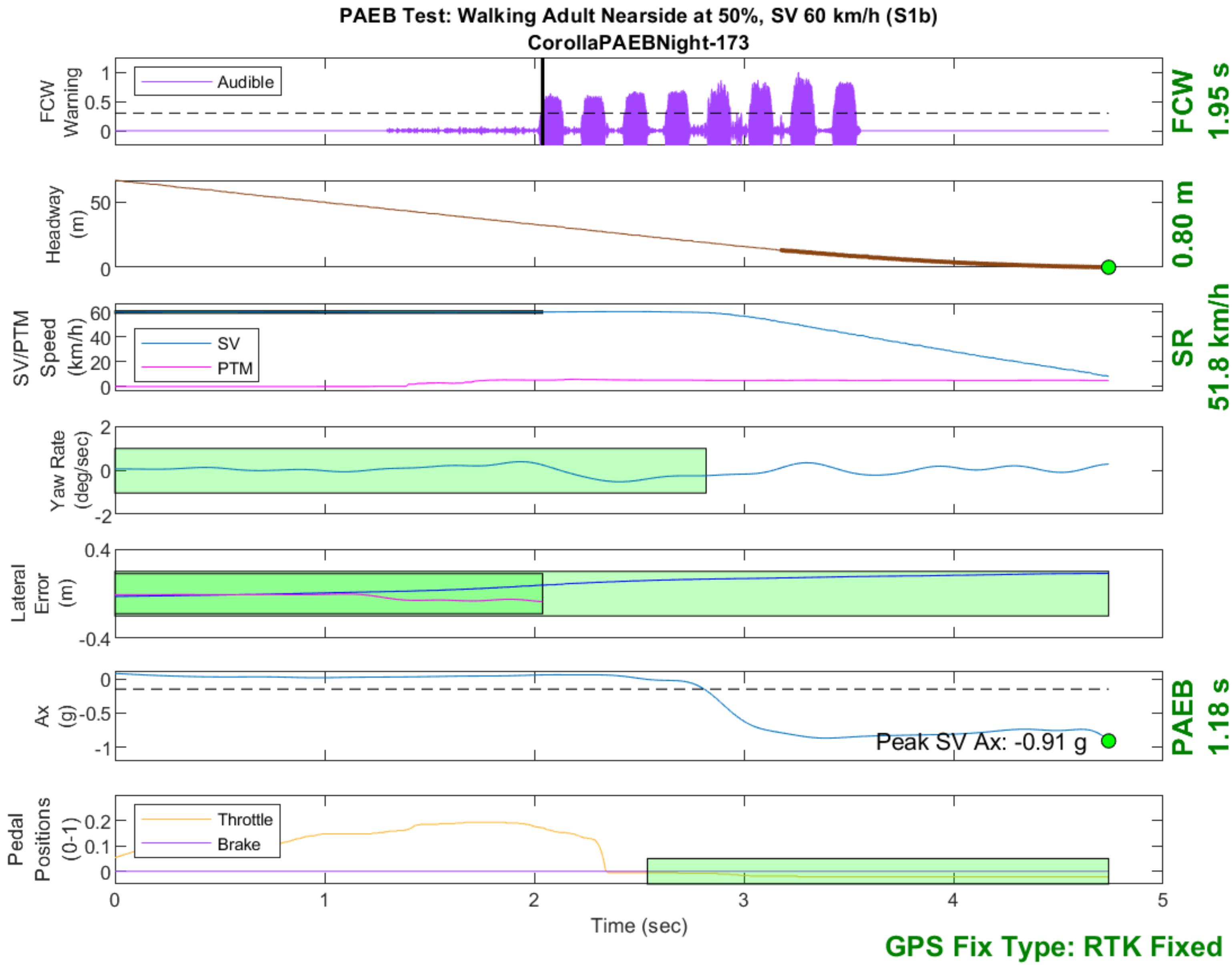


Figure D197. Time History for PAEB Run 173, S1b, Night, High Beam, 60 km/h

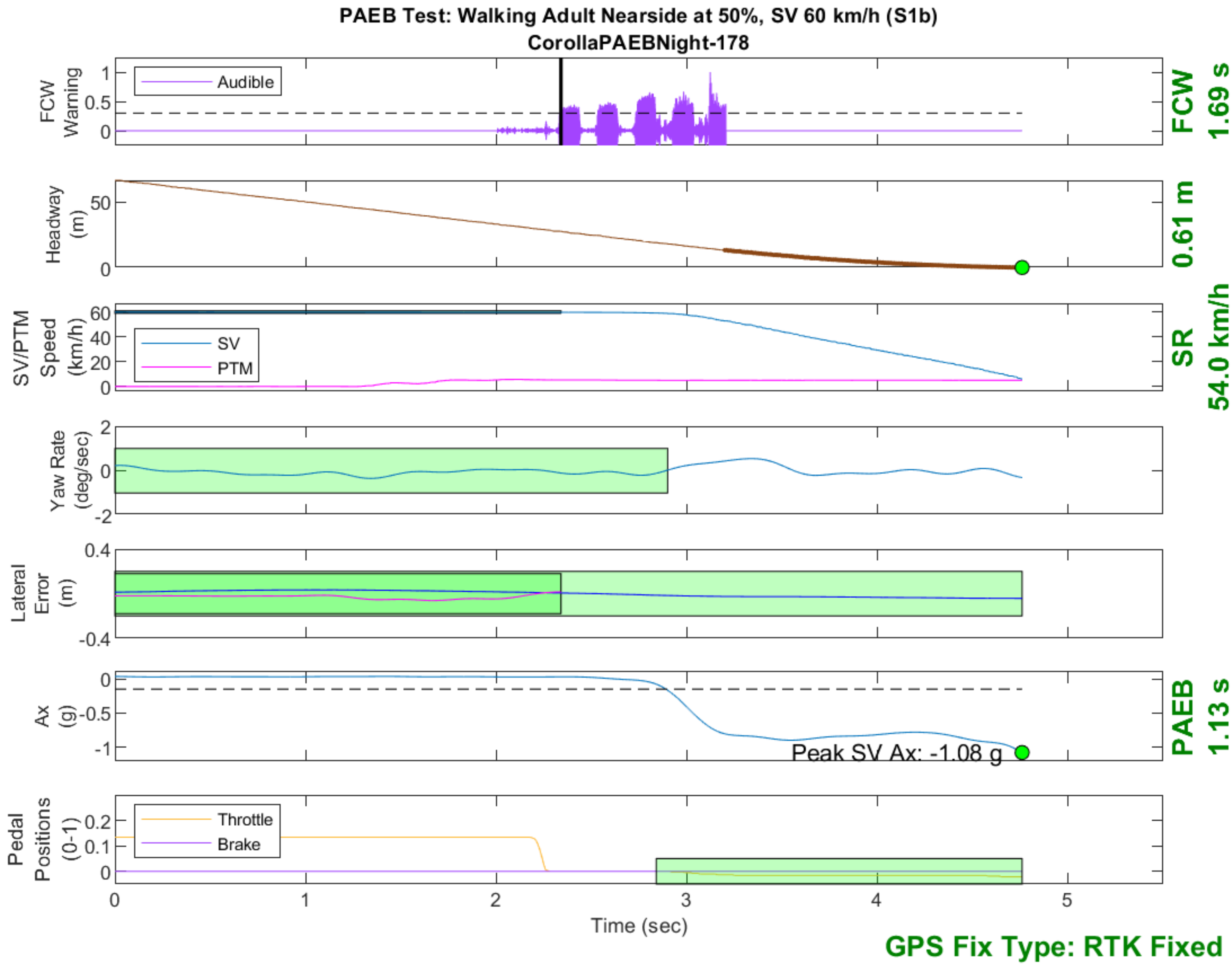


Figure D198. Time History for PAEB Run 178, S1b, Night, High Beam, 60 km/h

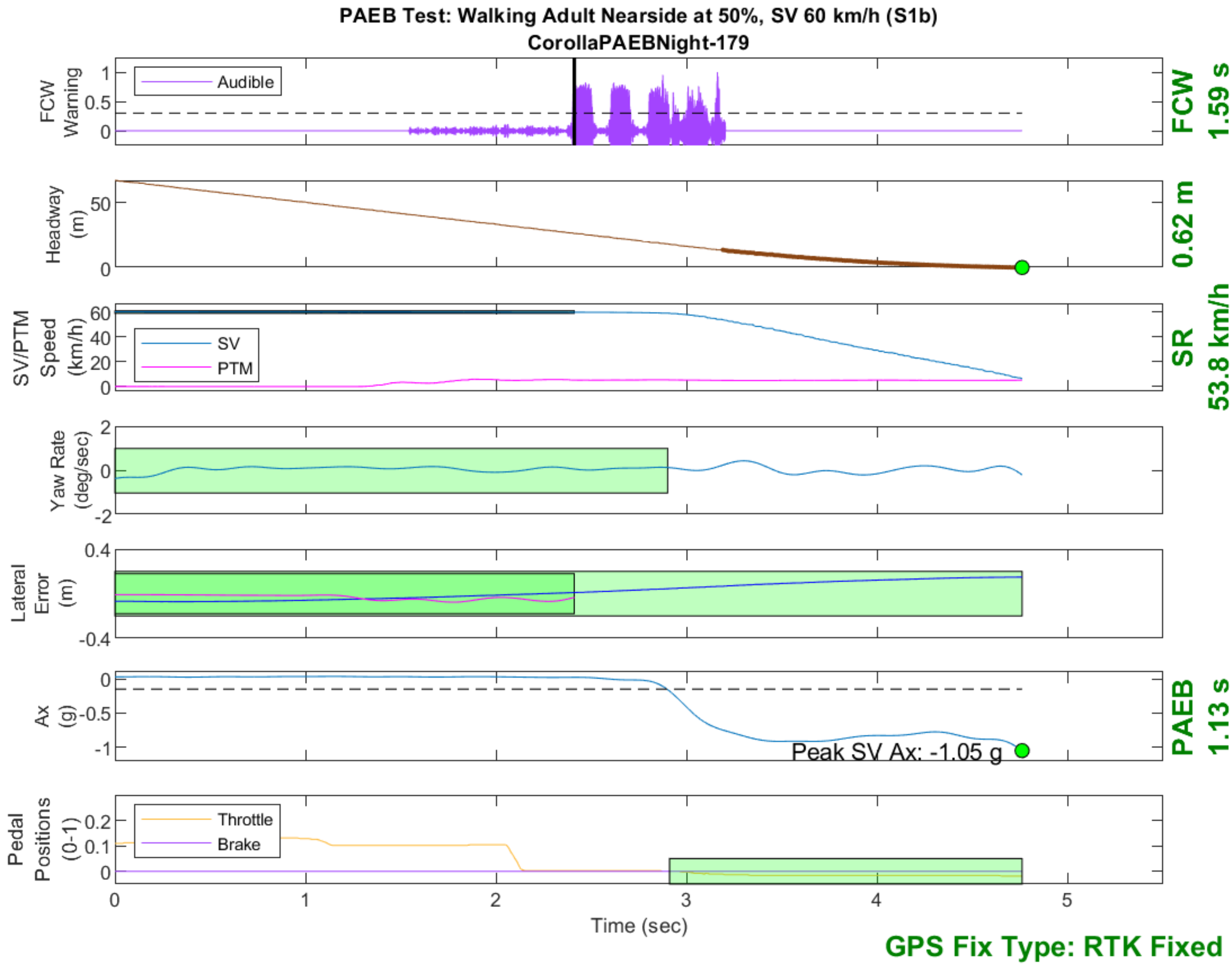


Figure D199. Time History for PAEB Run 179, S1b, Night, High Beam, 60 km/h

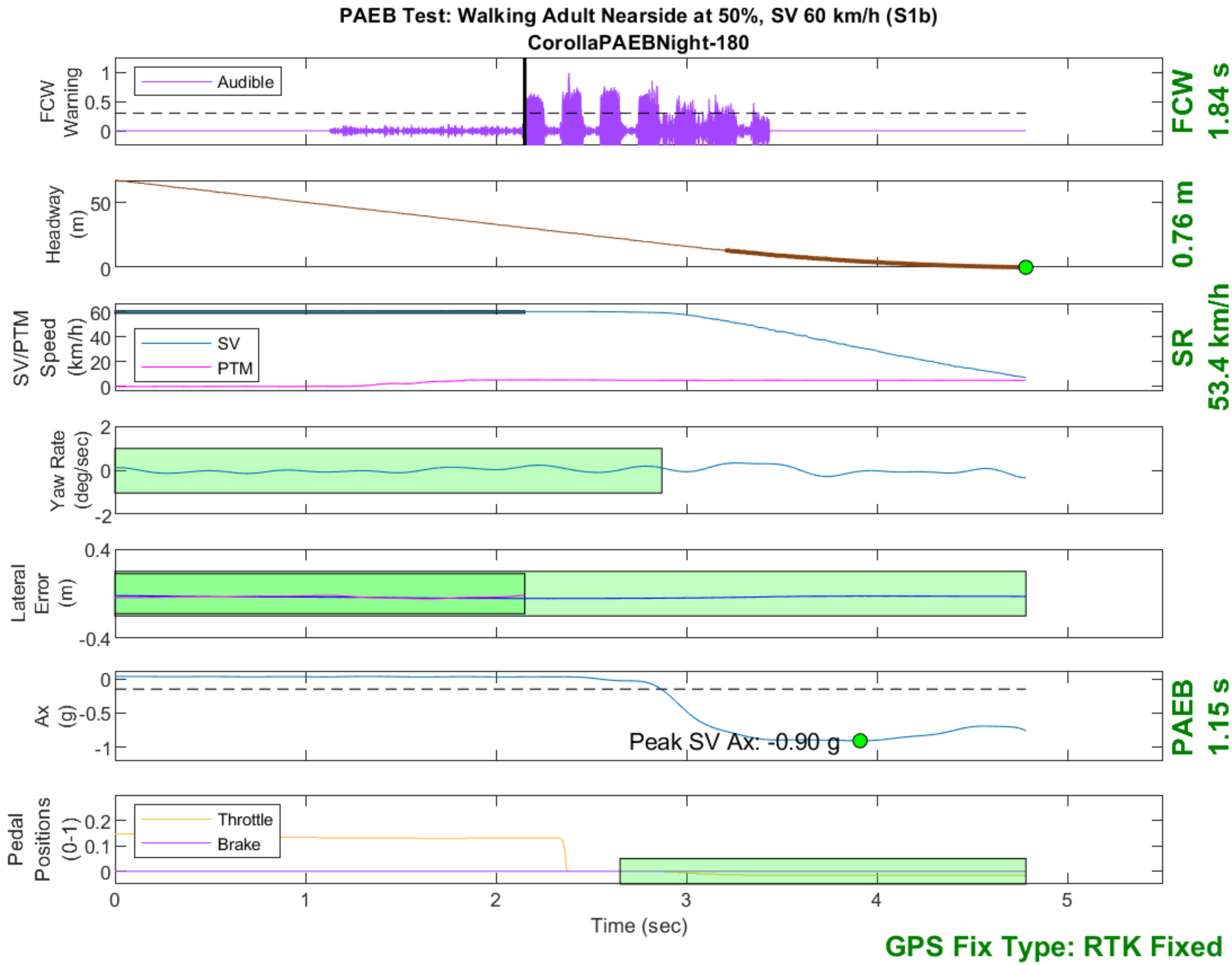


Figure D200. Time History for PAEB Run 180, S1b, Night, High Beam, 60 km/h

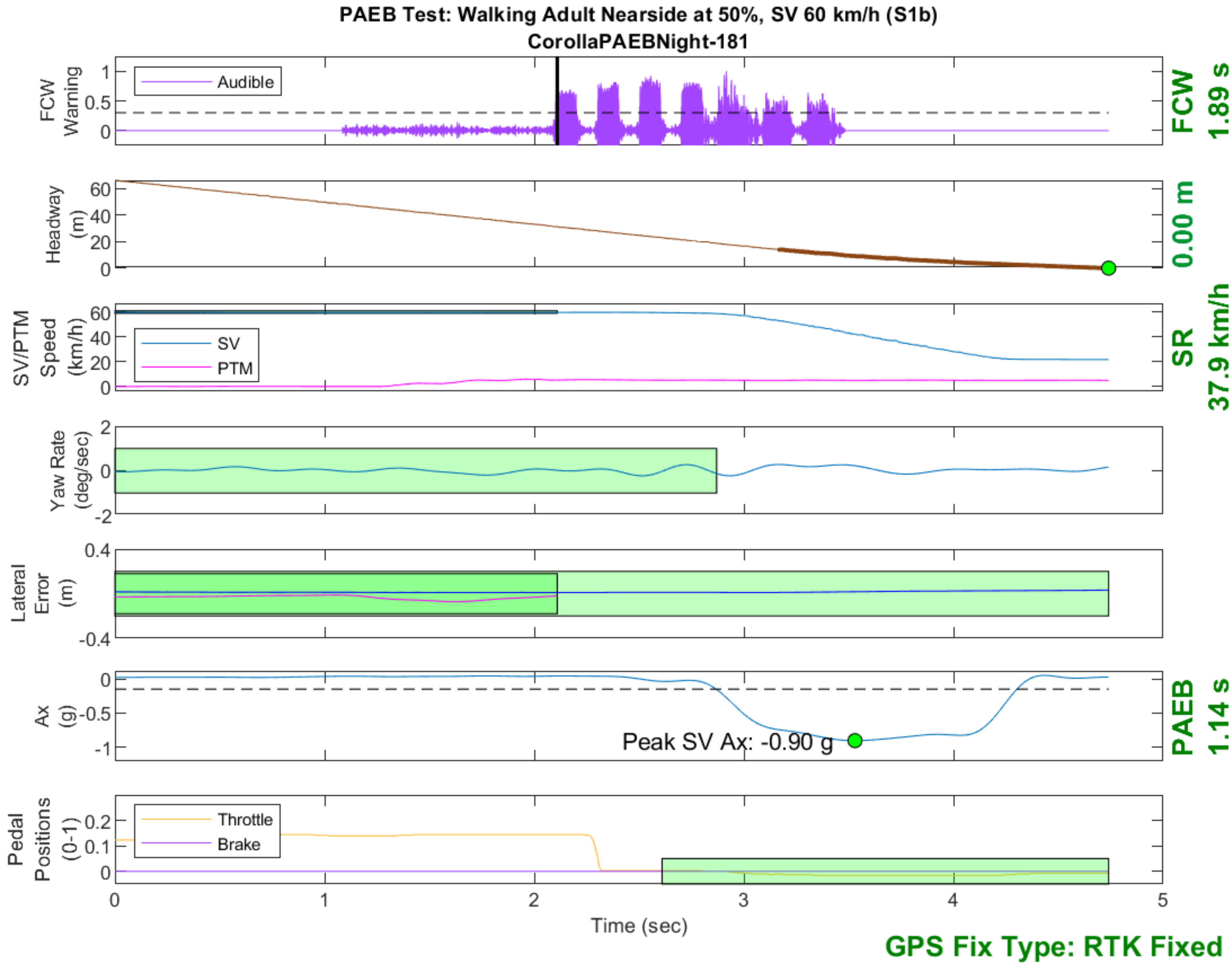


Figure D201. Time History for PAEB Run 181, S1b, Night, High Beam, 60 km/h

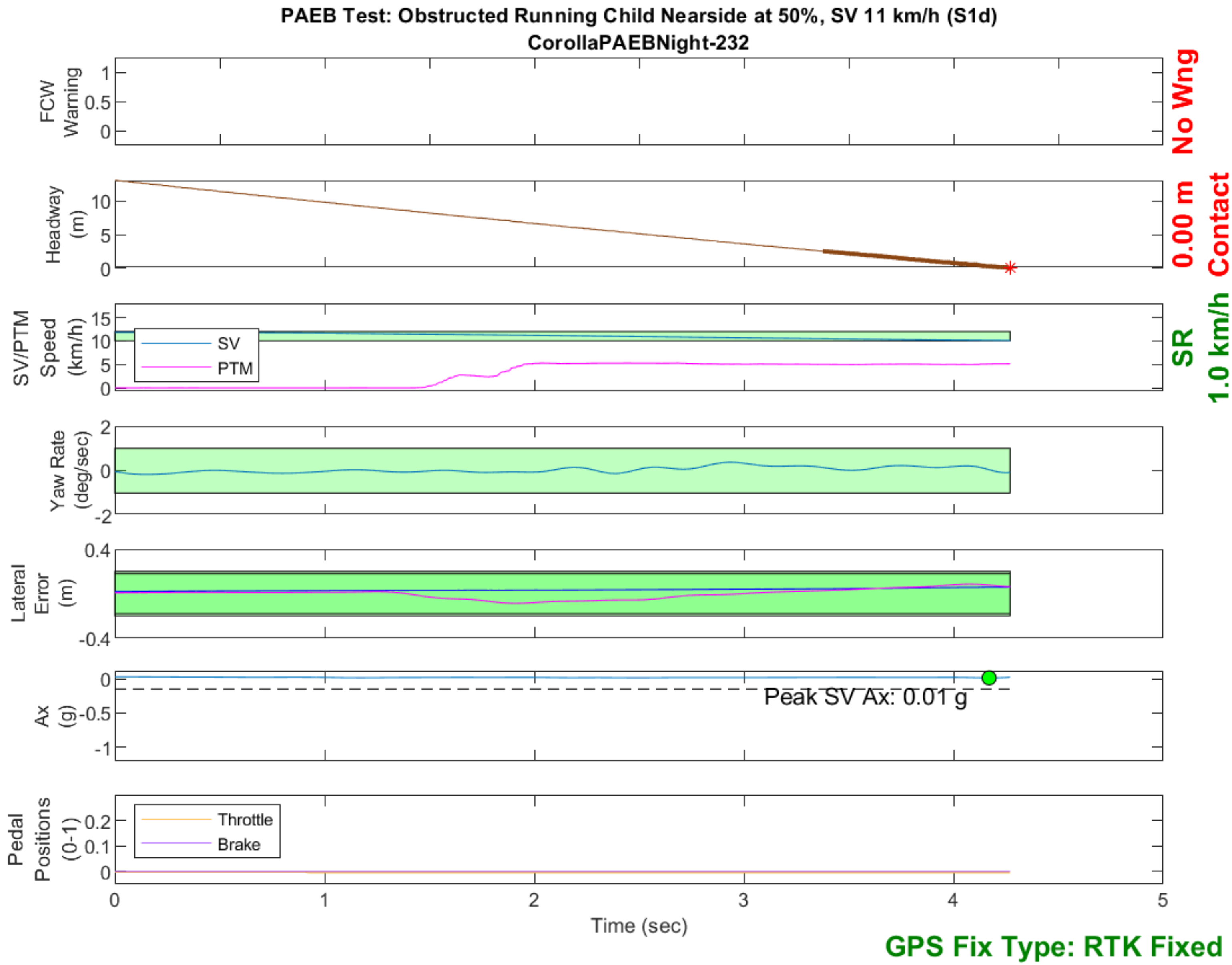


Figure D202. Time History for PAEB Run 232, S1d, Night, High Beam, 11 km/h

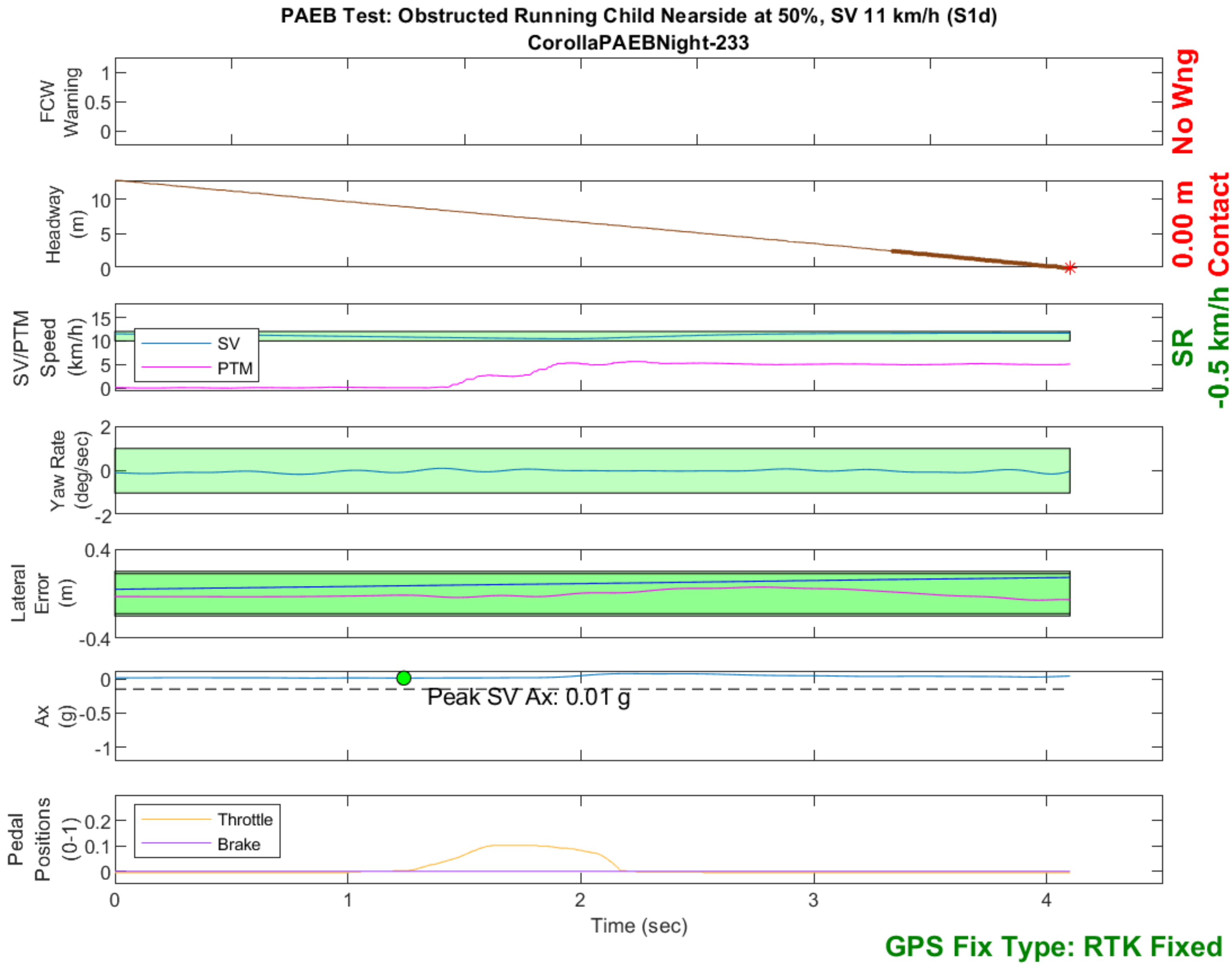


Figure D203. Time History for PAEB Run 233, S1d, Night, High Beam, 11 km/h

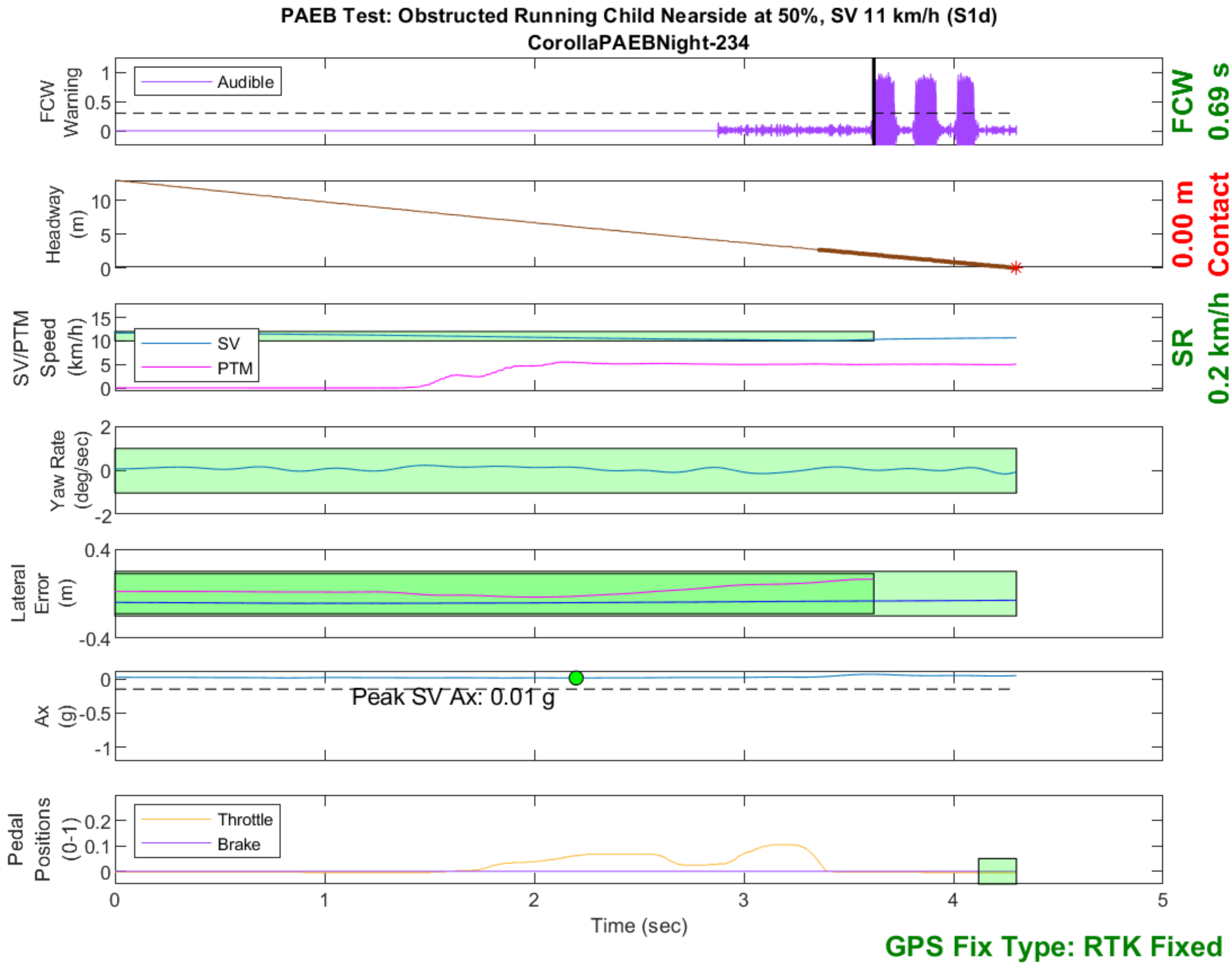


Figure D204. Time History for PAEB Run 234, S1d, Night, High Beam, 11 km/h

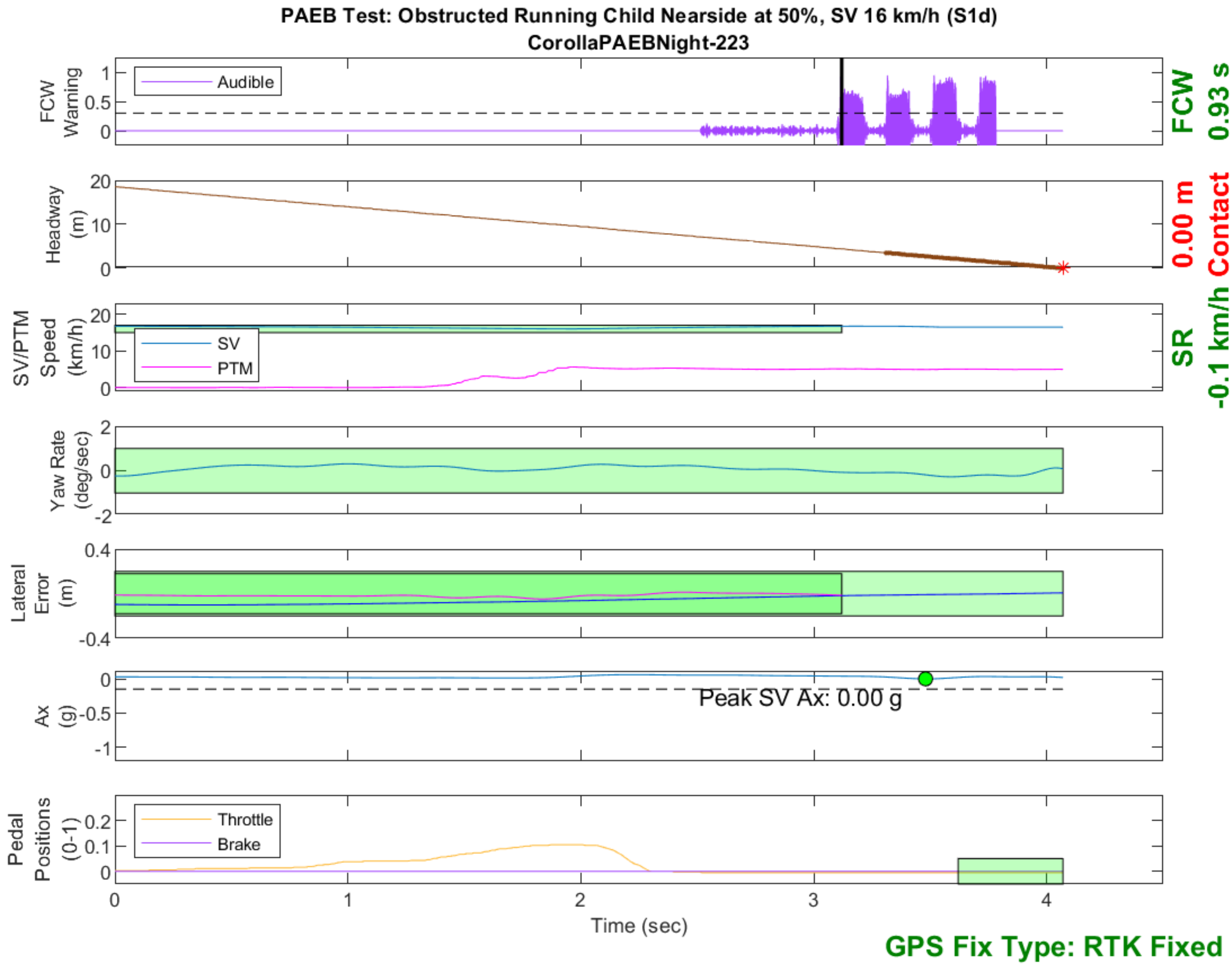


Figure D205. Time History for PAEB Run 223, S1d, Night, High Beam, 16 km/h

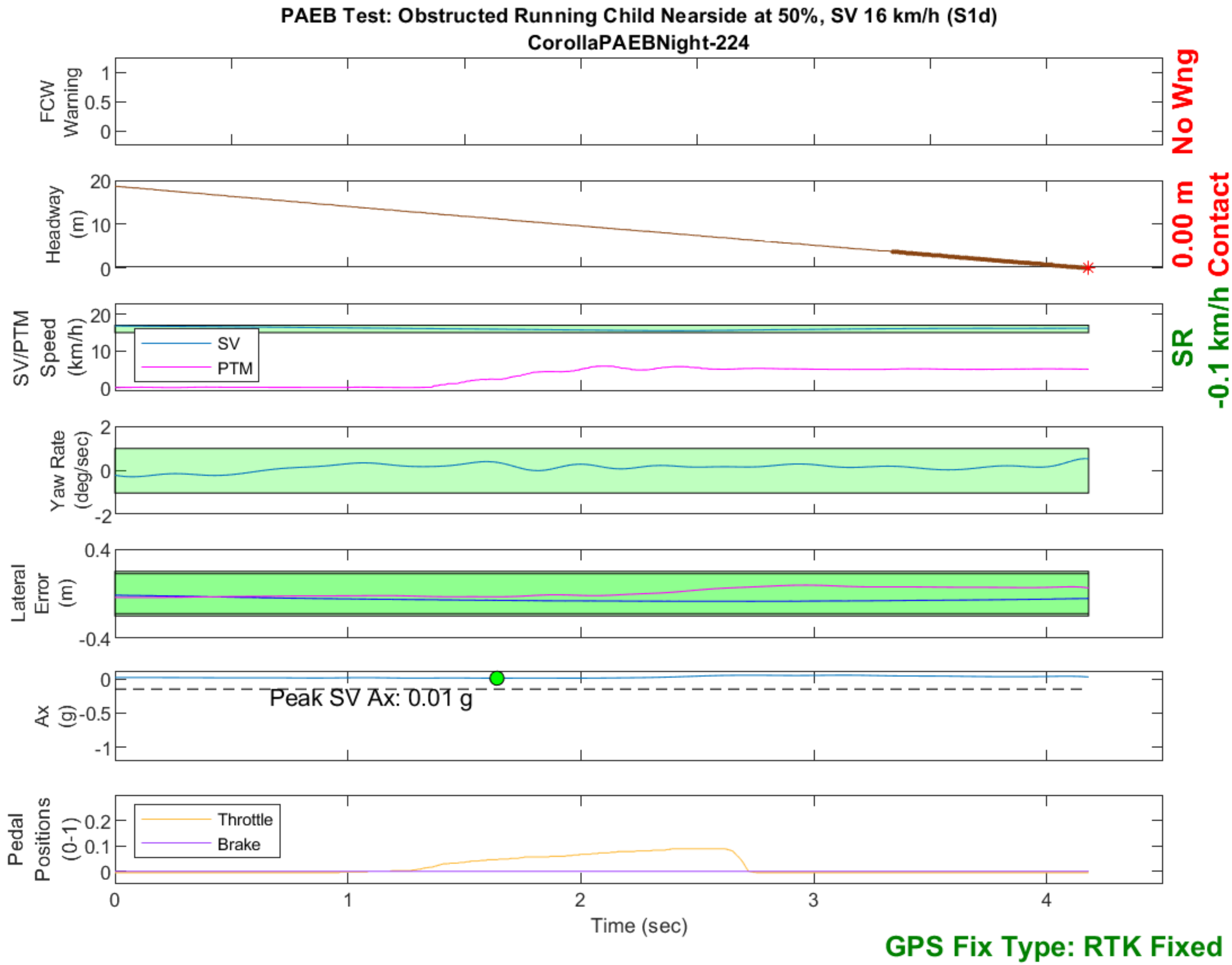


Figure D206. Time History for PAEB Run 224, S1d, Night, High Beam, 16 km/h

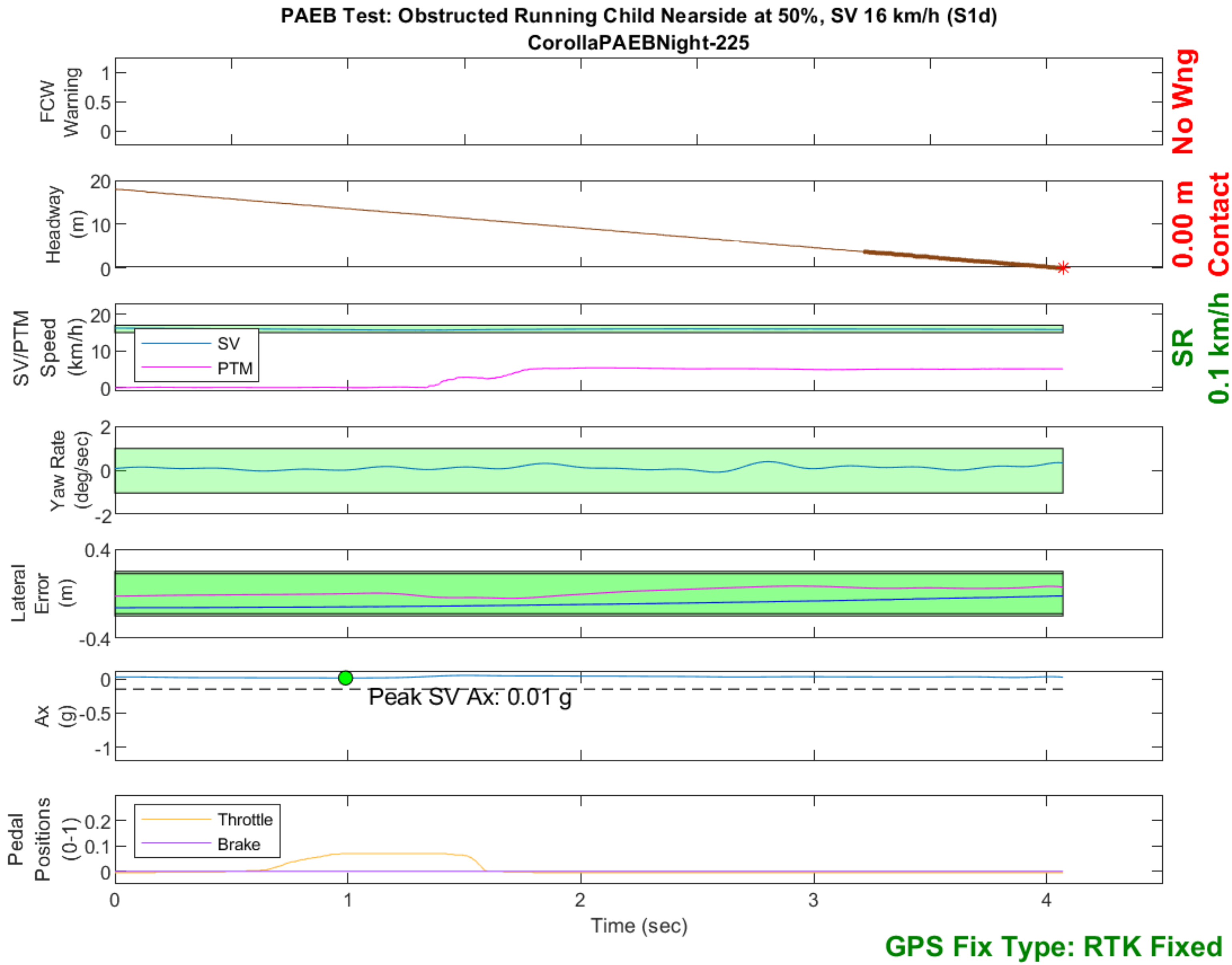


Figure D207. Time History for PAEB Run 225, S1d, Night, High Beam, 16 km/h

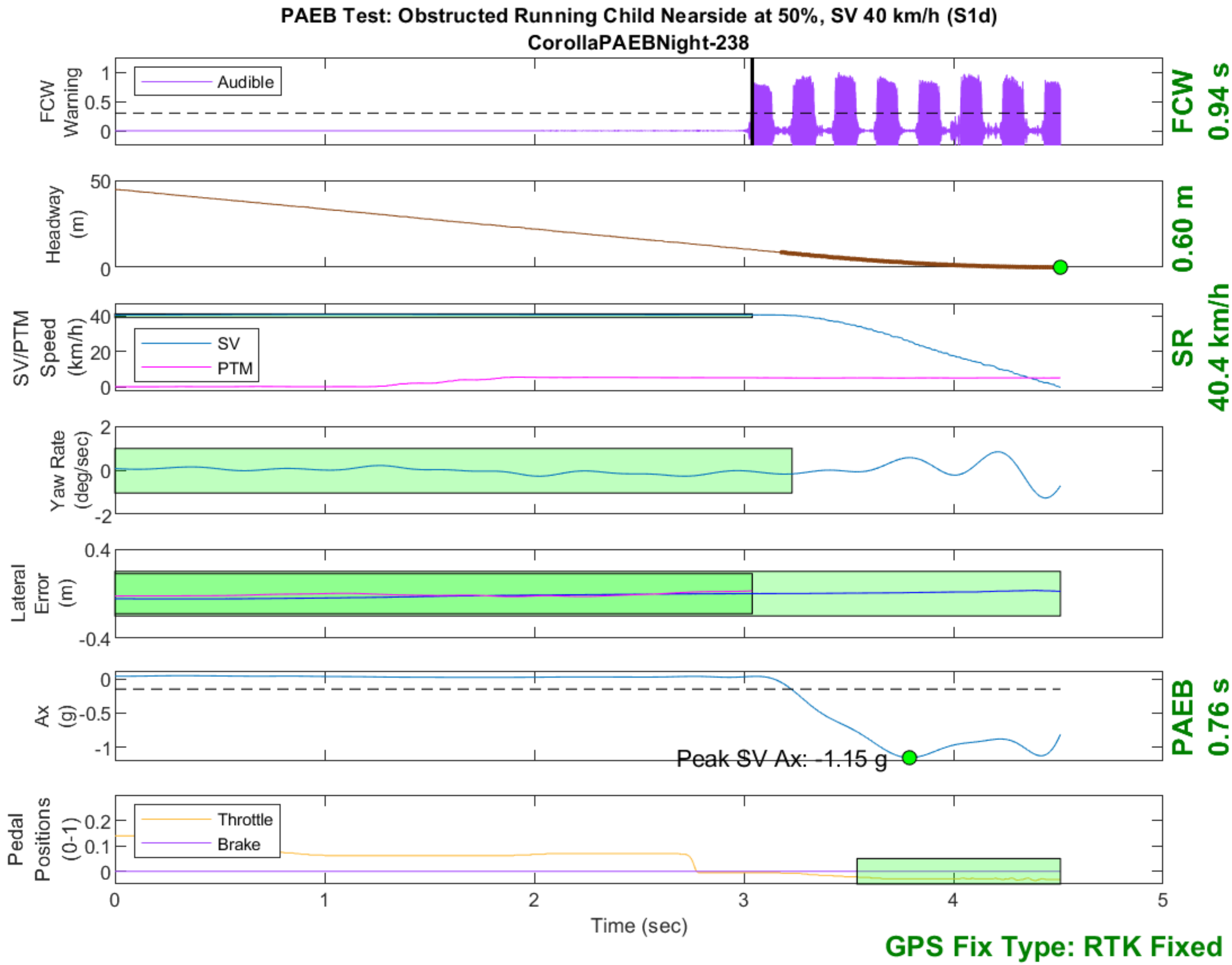


Figure D208. Time History for PAEB Run 238, S1d, Night, High Beam, 40 km/h

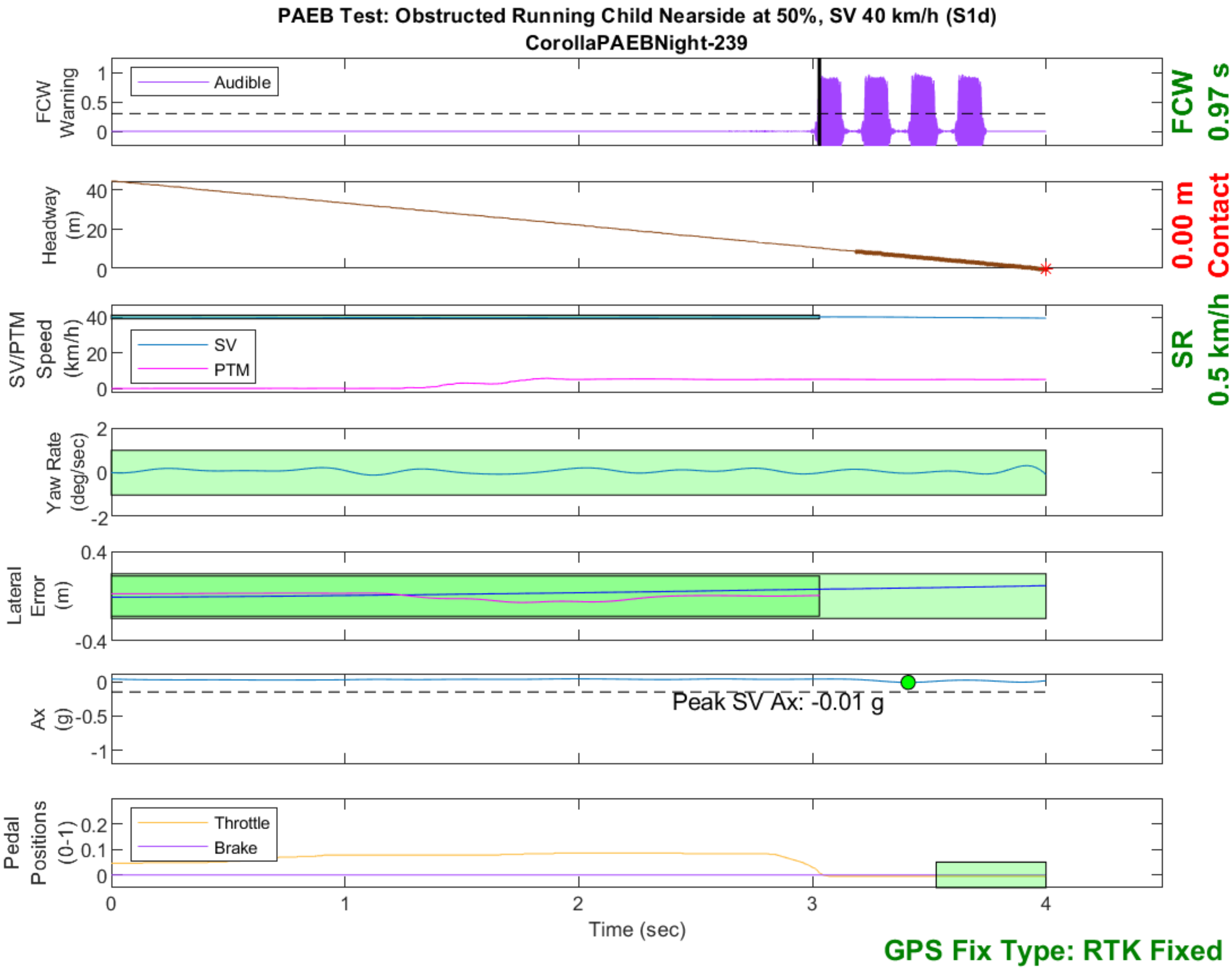


Figure D209. Time History for PAEB Run 239, S1d, Night, High Beam, 40 km/h

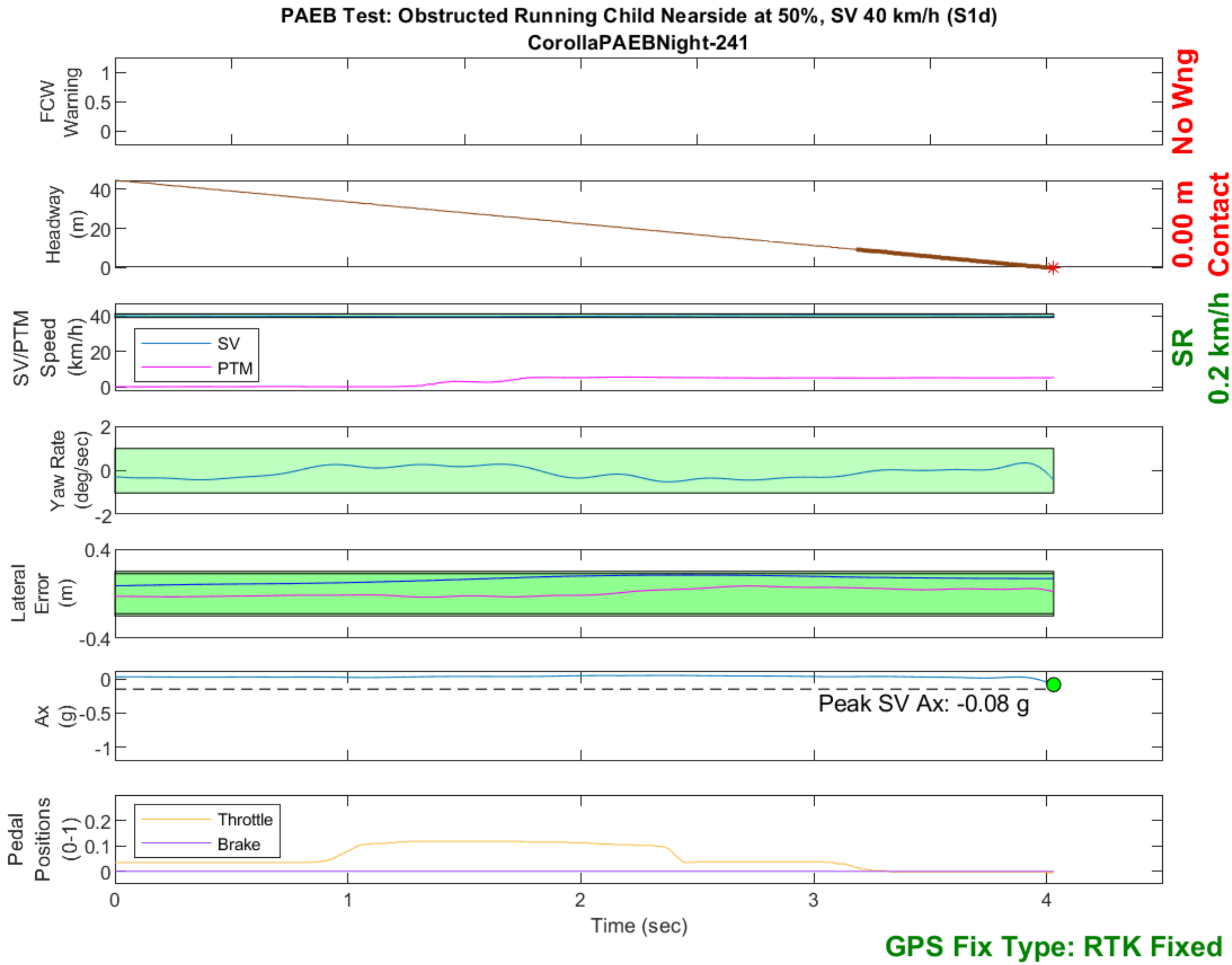


Figure D210. Time History for PAEB Run 241, S1d, Night, High Beam, 40 km/h

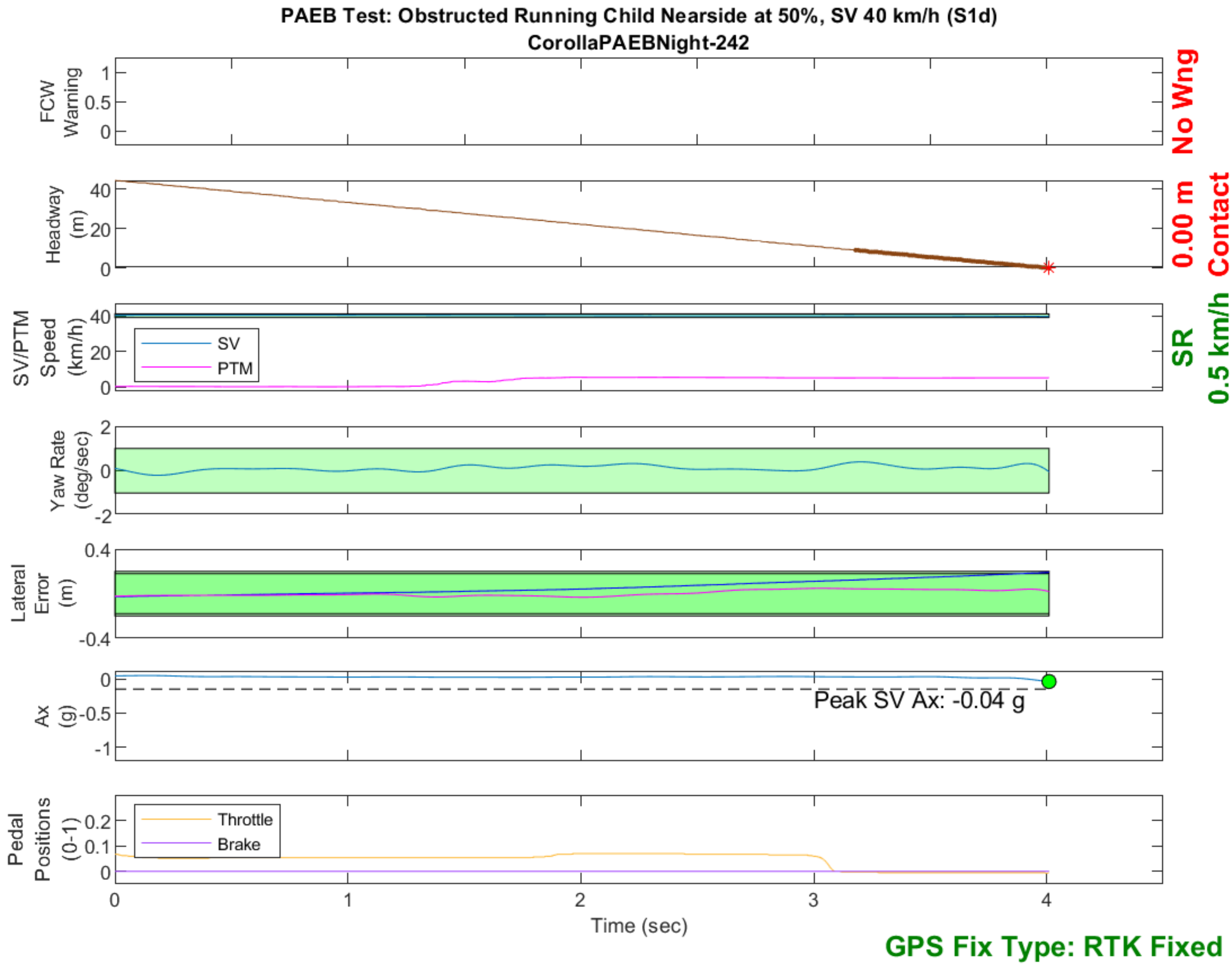


Figure D211. Time History for PAEB Run 242, S1d, Night, High Beam, 40 km/h

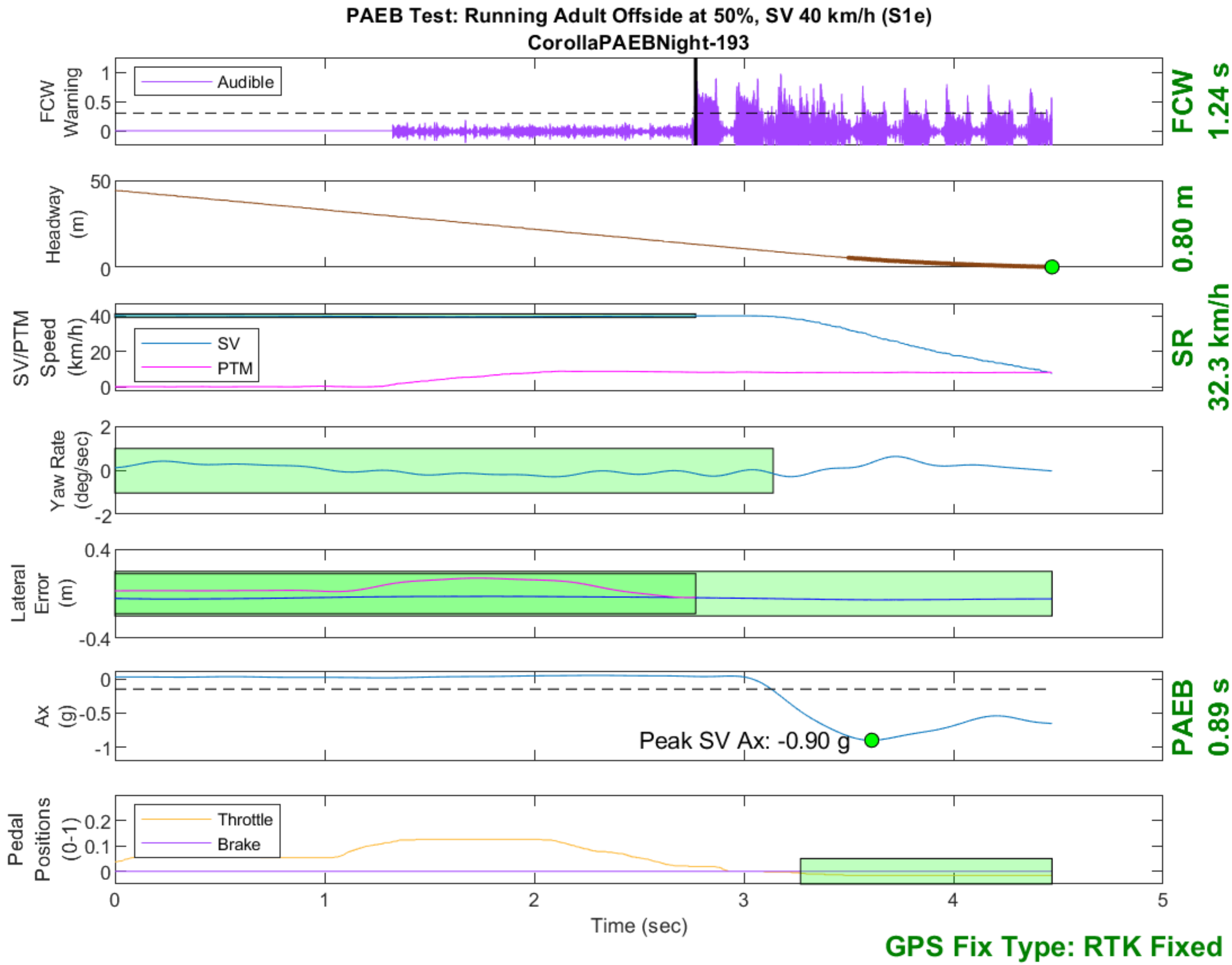


Figure D212. Time History for PAEB Run 193, S1e, Night, High Beam, 40 km/h

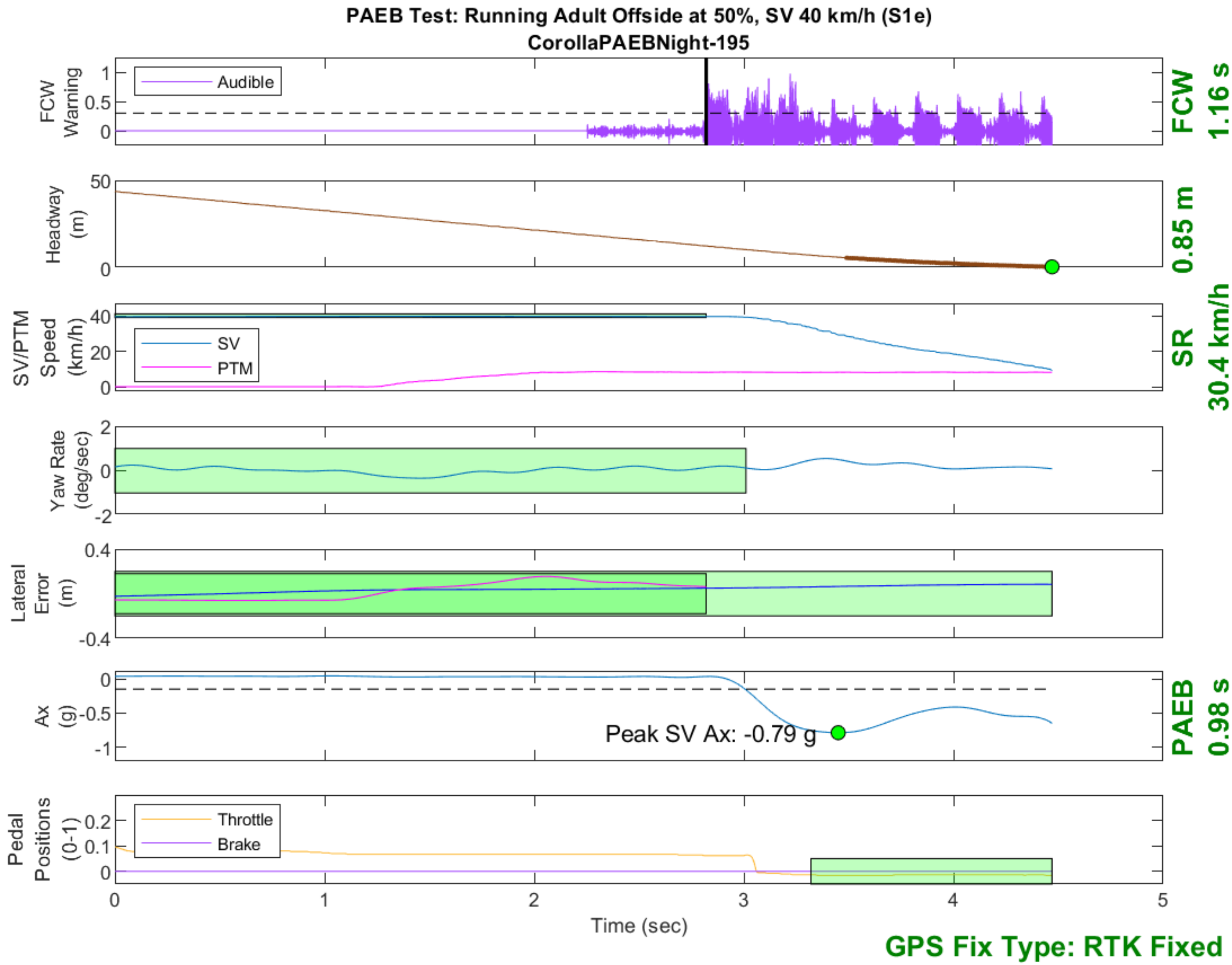


Figure D213. Time History for PAEB Run 195, S1e, Night, High Beam, 40 km/h

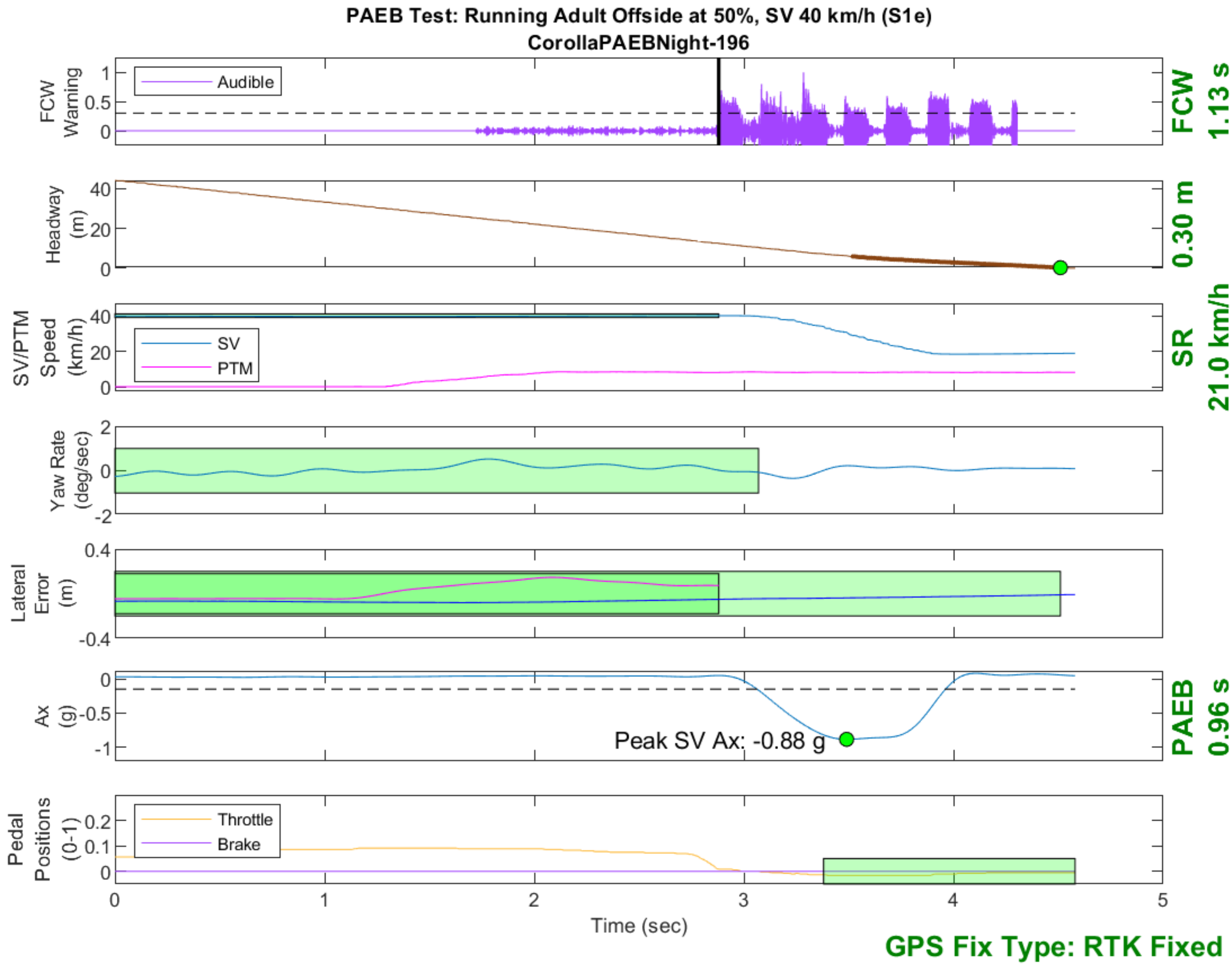


Figure D214. Time History for PAEB Run 196, S1e, Night, High Beam, 40 km/h

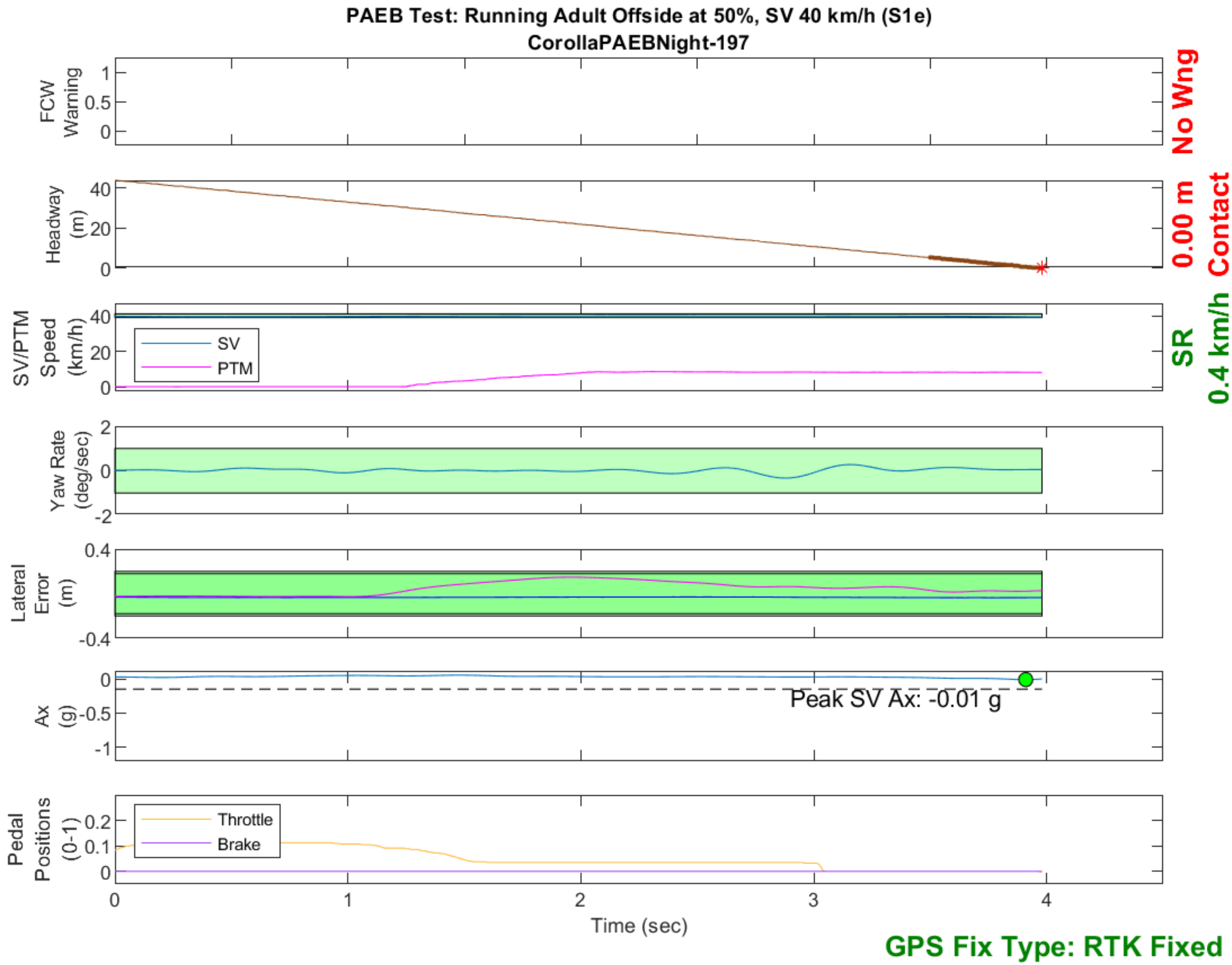


Figure D215. Time History for PAEB Run 197, S1e, Night, High Beam, 40 km/h

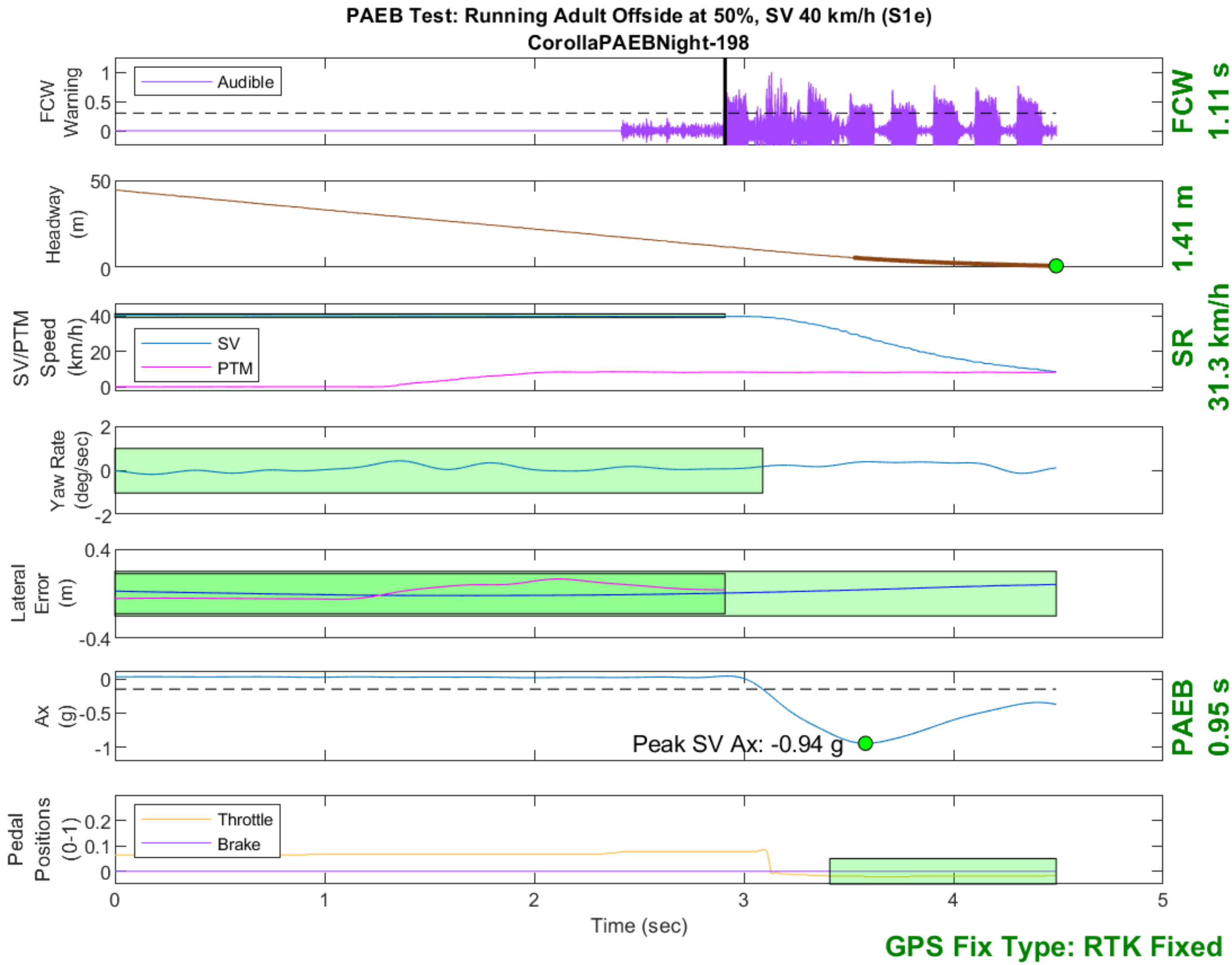


Figure D216. Time History for PAEB Run 198, S1e, Night, High Beam, 40 km/h

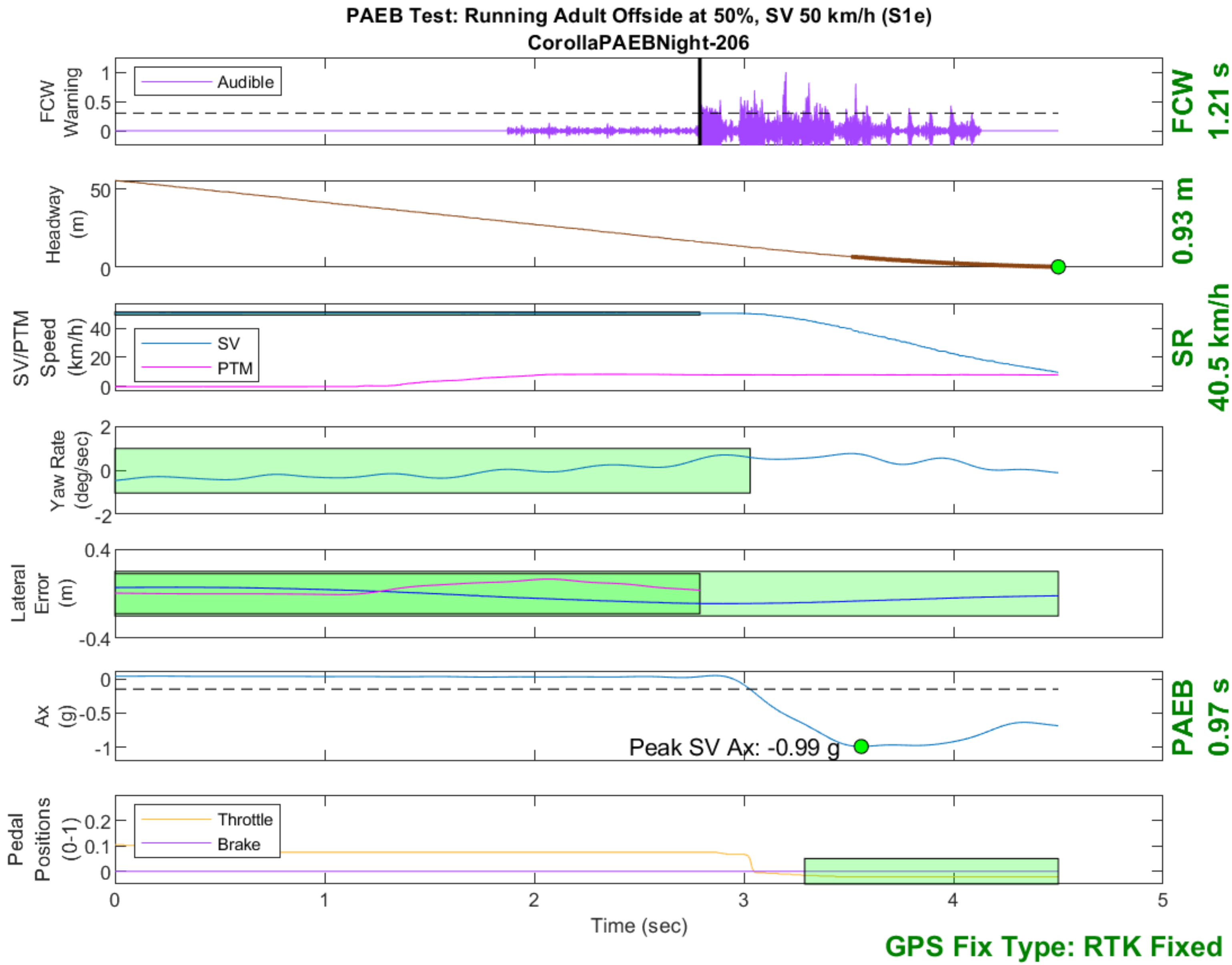


Figure D217. Time History for PAEB Run 206, S1e, Night, High Beam, 50 km/h

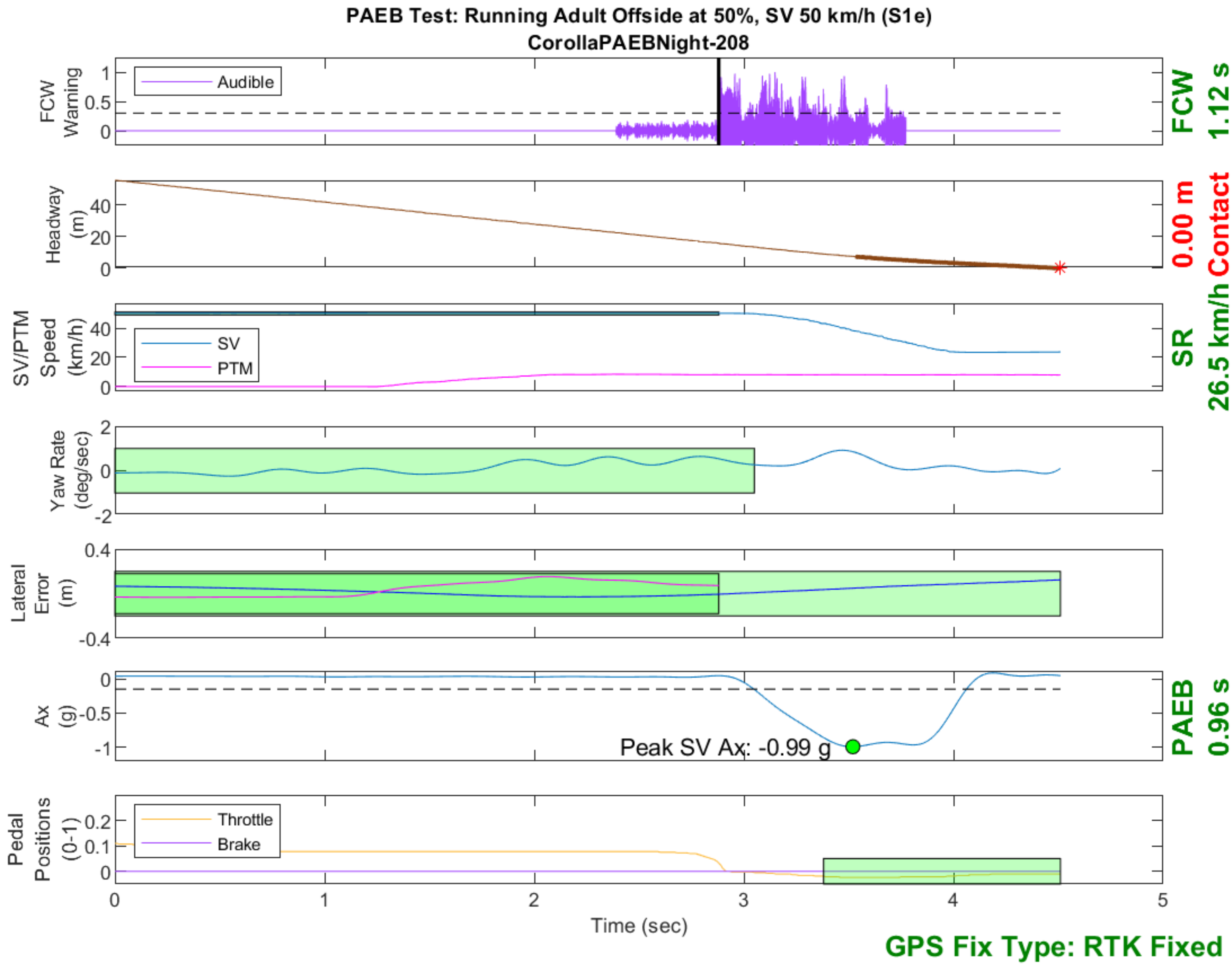


Figure D218. Time History for PAEB Run 208, S1e, Night, High Beam, 50 km/h

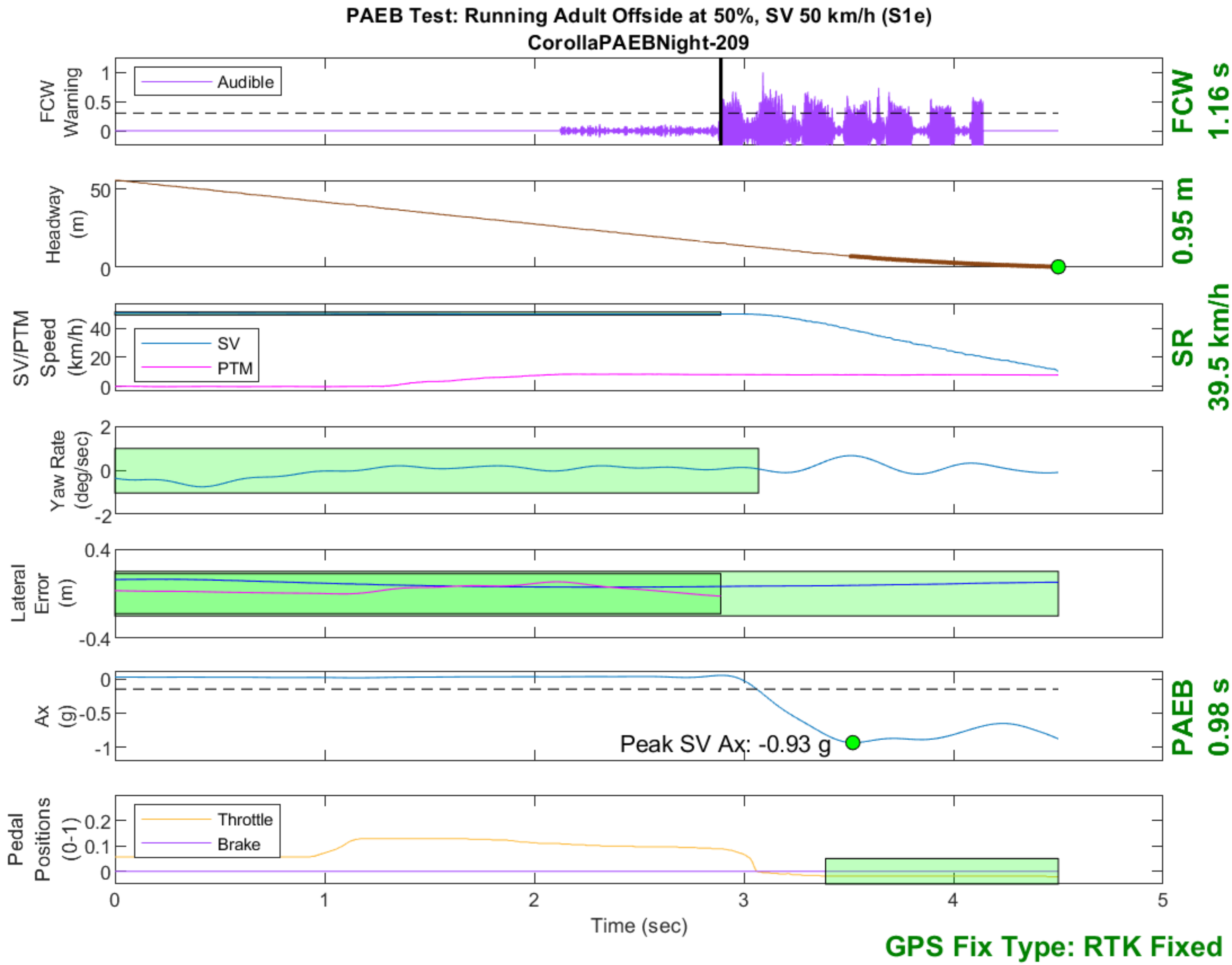


Figure D219. Time History for PAEB Run 209, S1e, Night, High Beam, 50 km/h

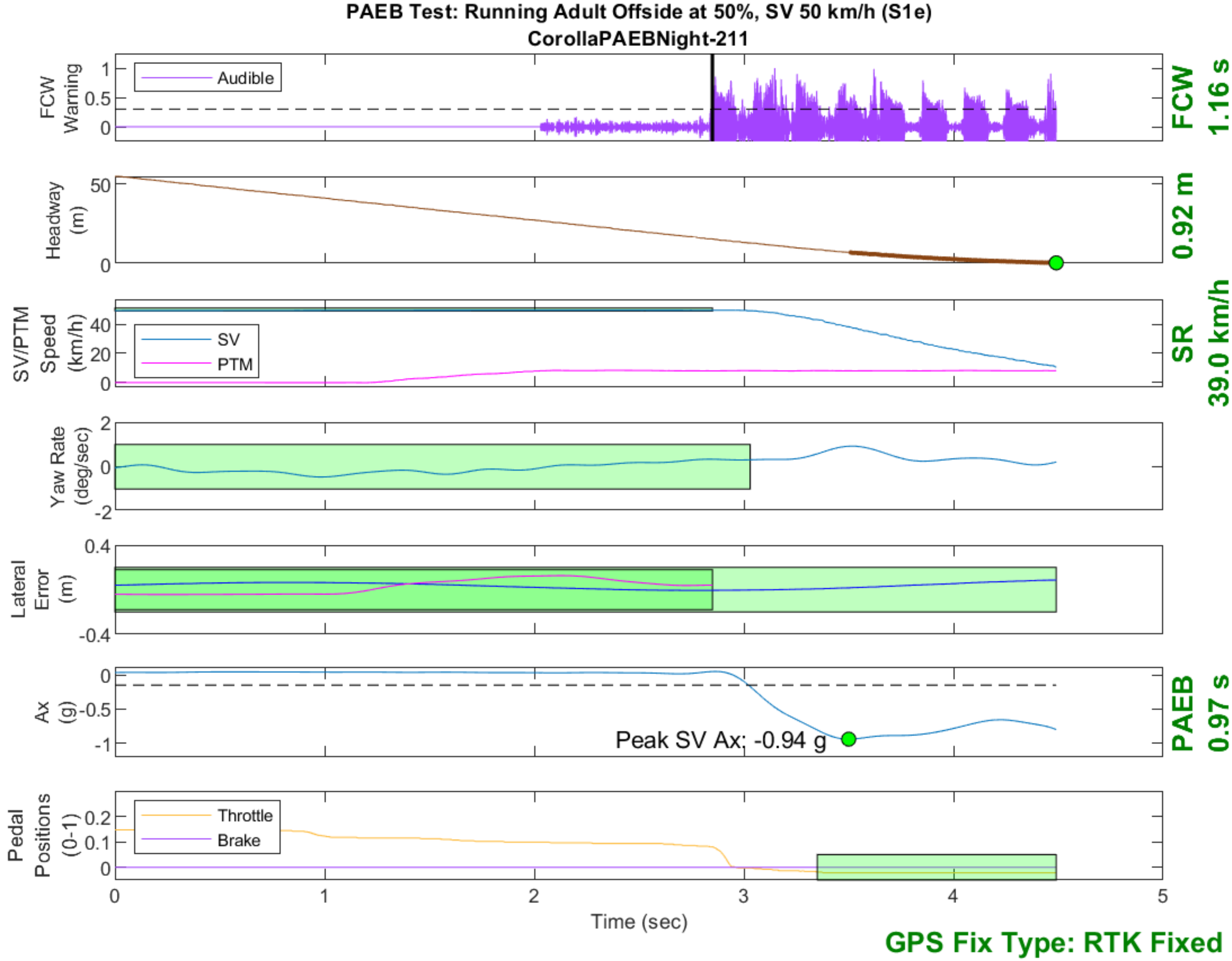


Figure D220. Time History for PAEB Run 211, S1e, Night, High Beam, 50 km/h

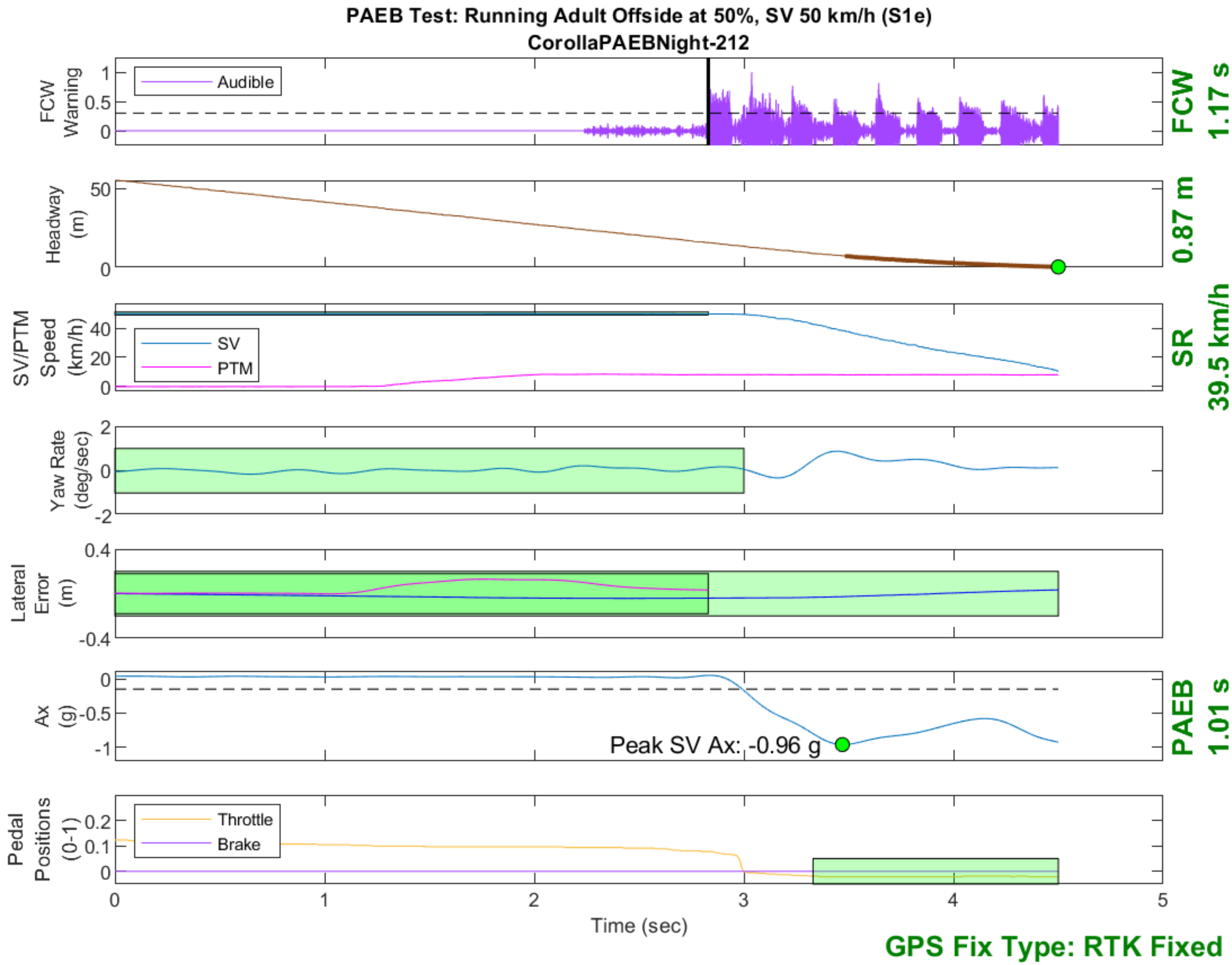


Figure D221. Time History for PAEB Run 212, S1e, Night, High Beam, 50 km/h

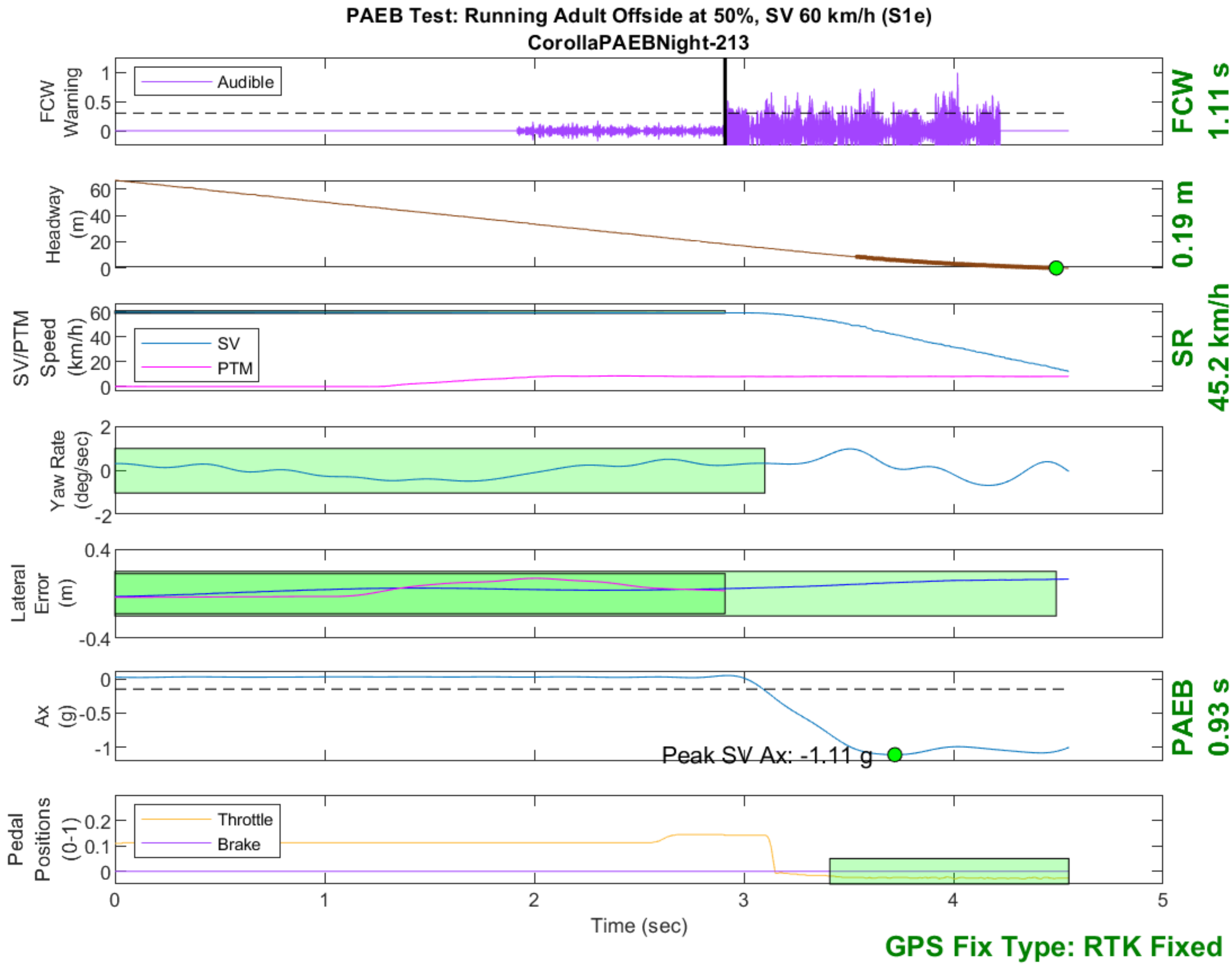


Figure D222. Time History for PAEB Run 213, S1e, Night, High Beam, 60 km/h

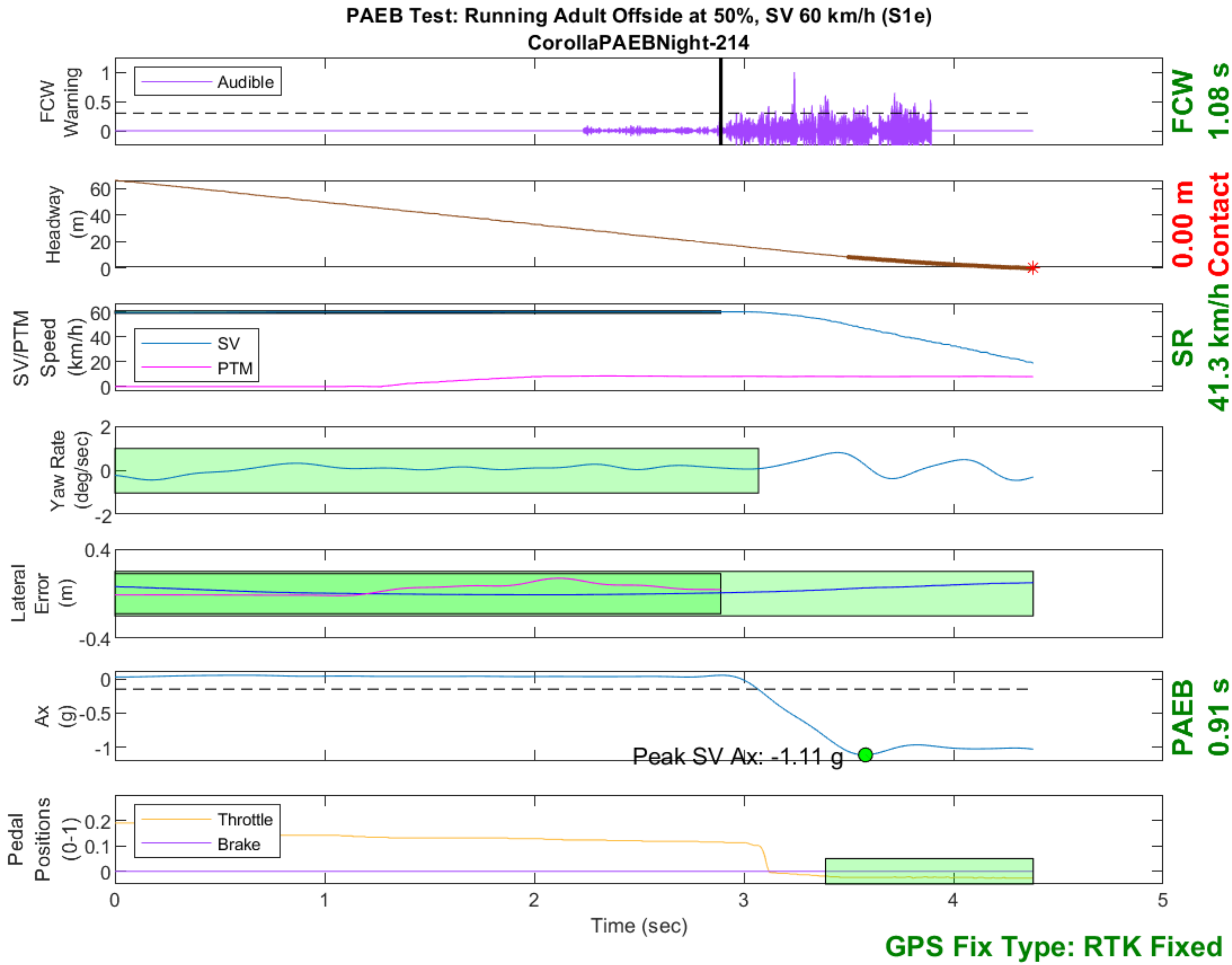


Figure D223. Time History for PAEB Run 214, S1e, Night, High Beam, 60 km/h

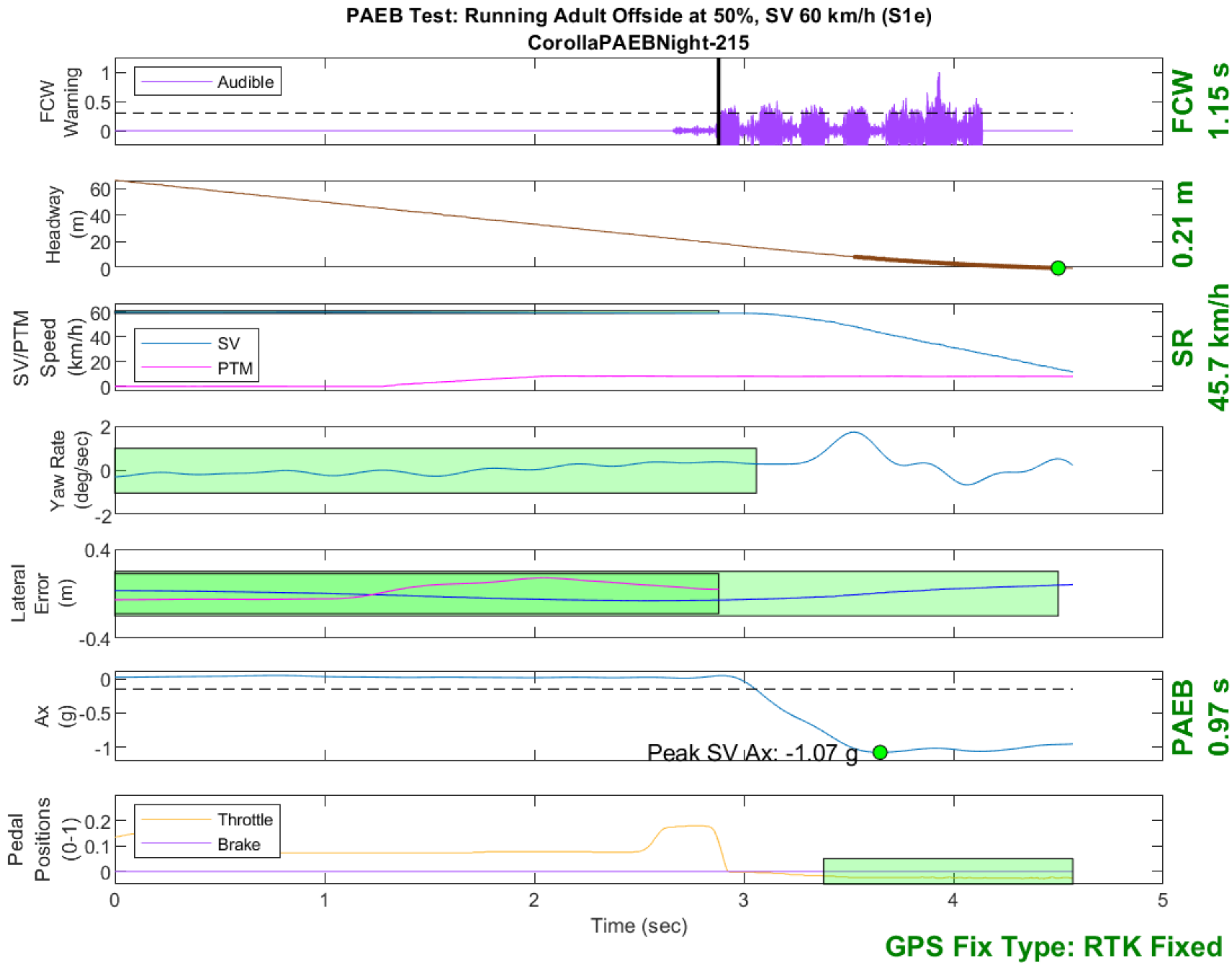


Figure D224. Time History for PAEB Run 215, S1e, Night, High Beam, 60 km/h

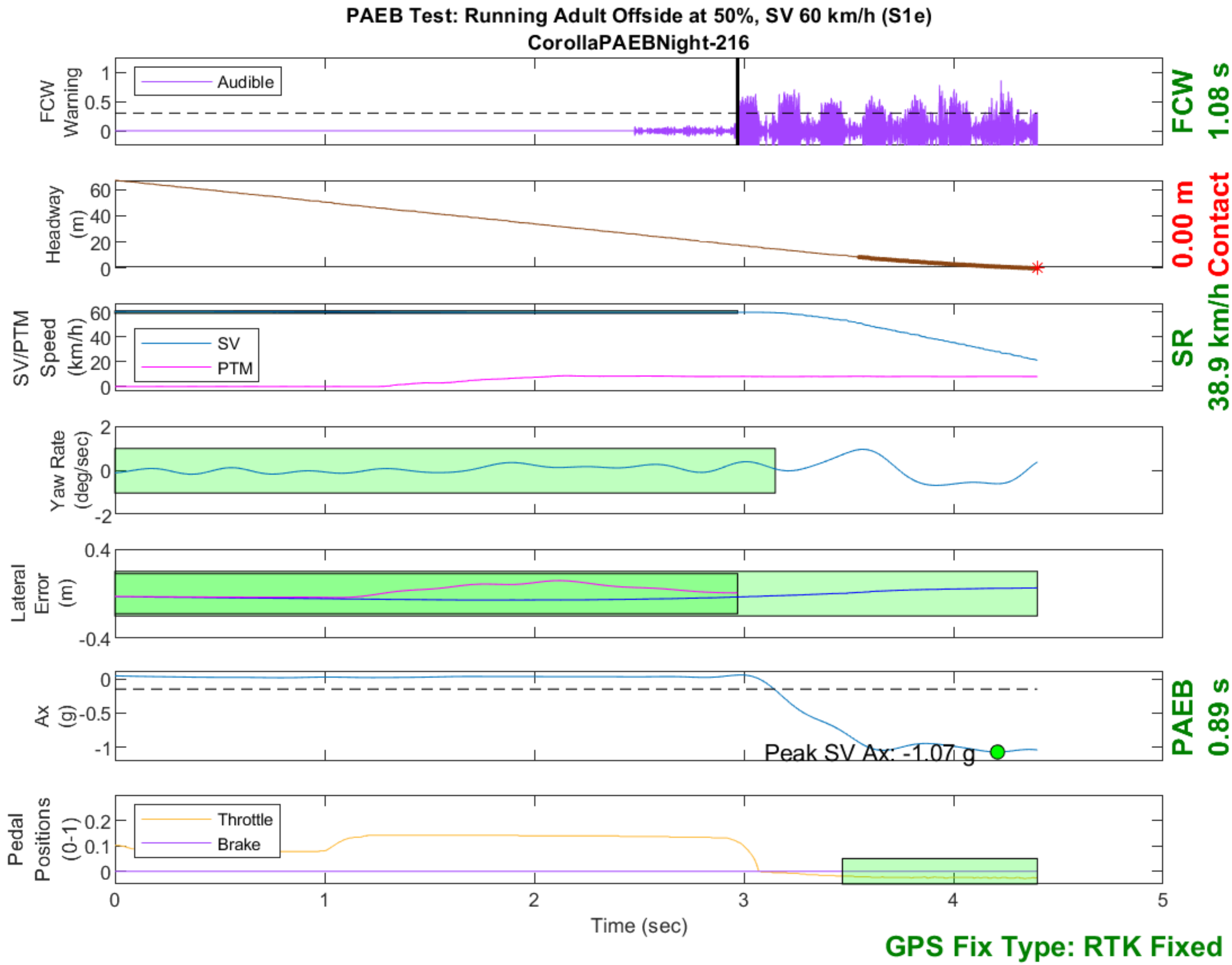


Figure D225. Time History for PAEB Run 216, S1e, Night, High Beam, 60 km/h

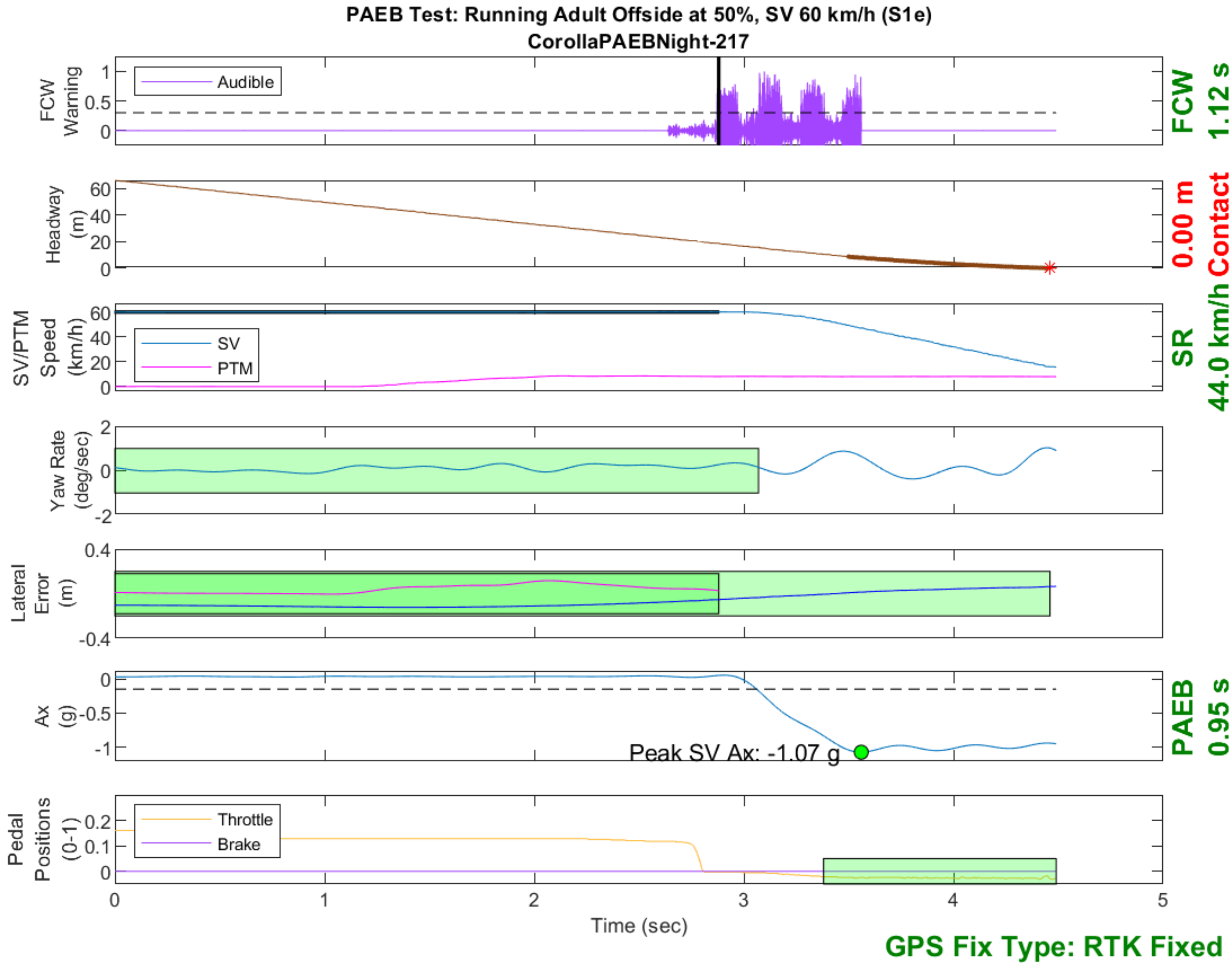


Figure D226. Time History for PAEB Run 217, S1e, Night, High Beam, 60 km/h

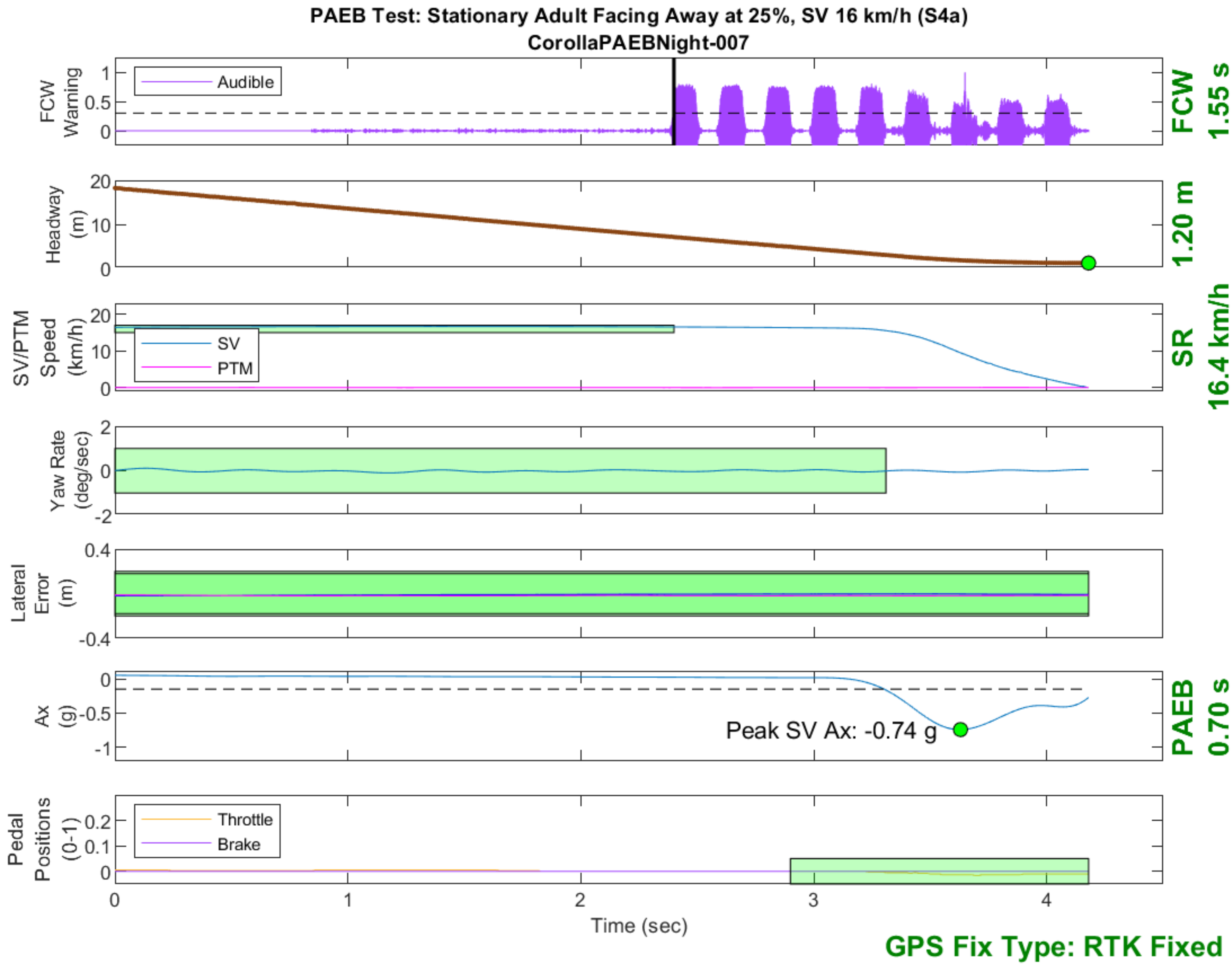


Figure D227. Time History for PAEB Run 7, S4a, Night, High Beam, 16 km/h

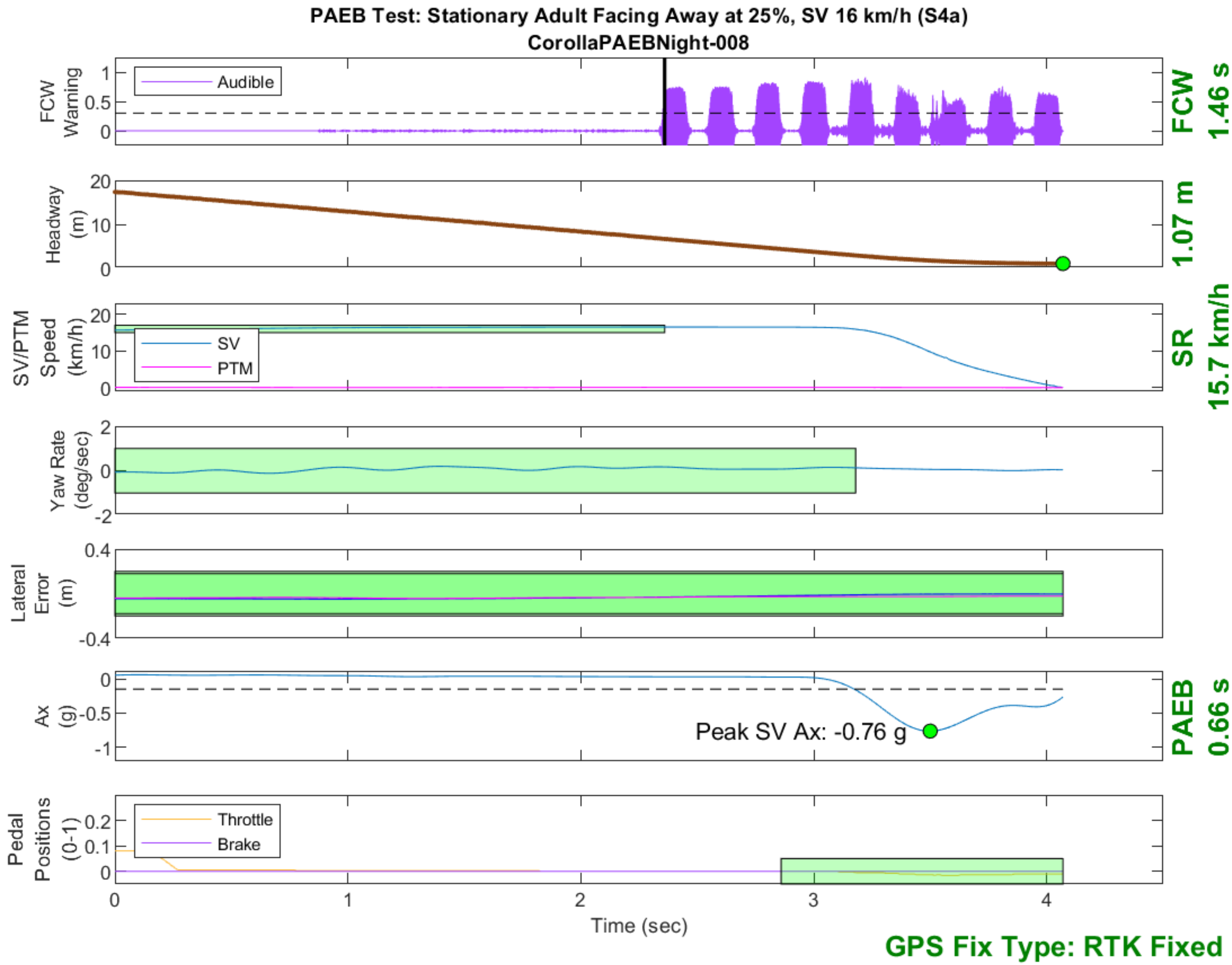


Figure D228. Time History for PAEB Run 8, S4a, Night, High Beam, 16 km/h

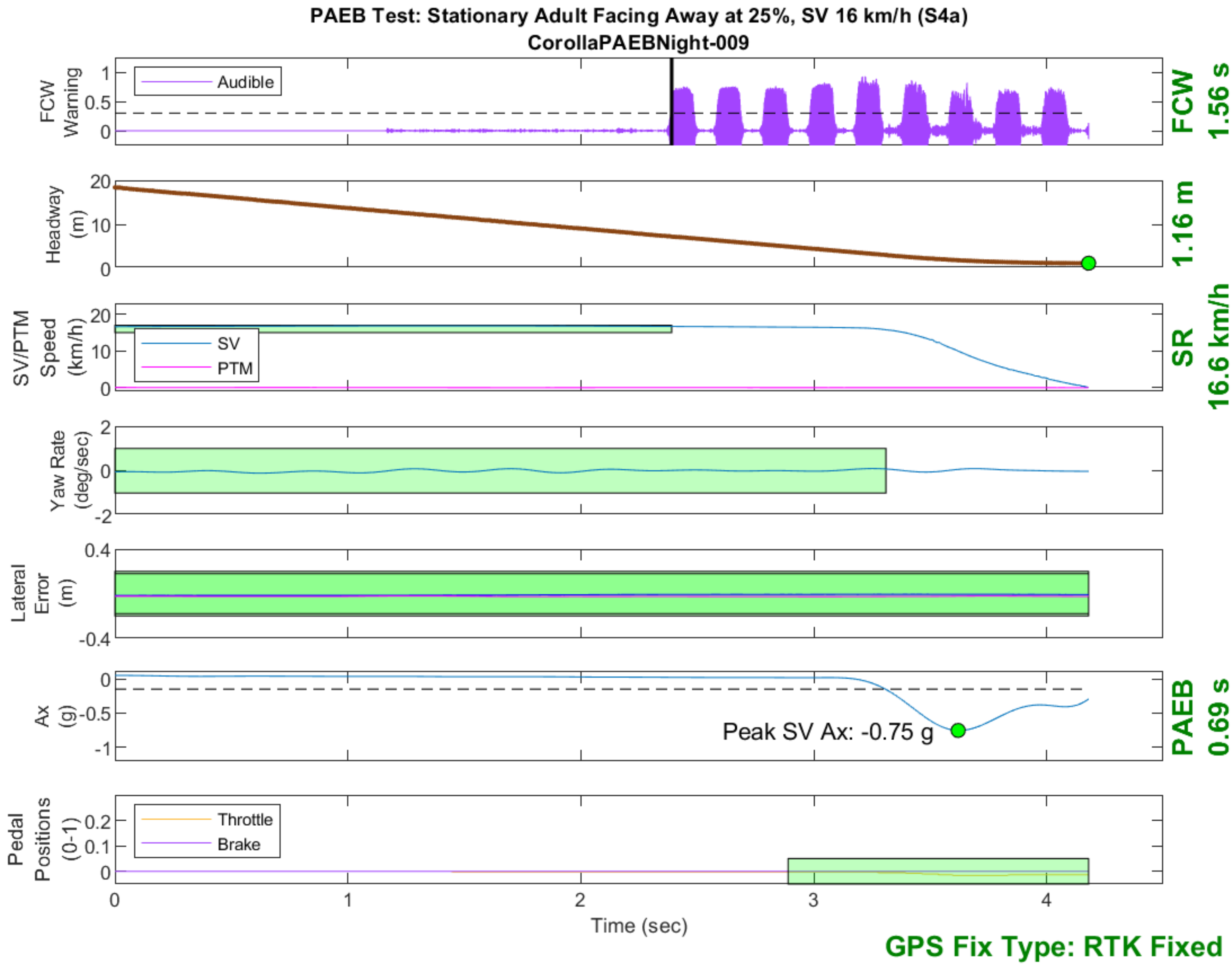


Figure D229. Time History for PAEB Run 9, S4a, Night, High Beam, 16 km/h

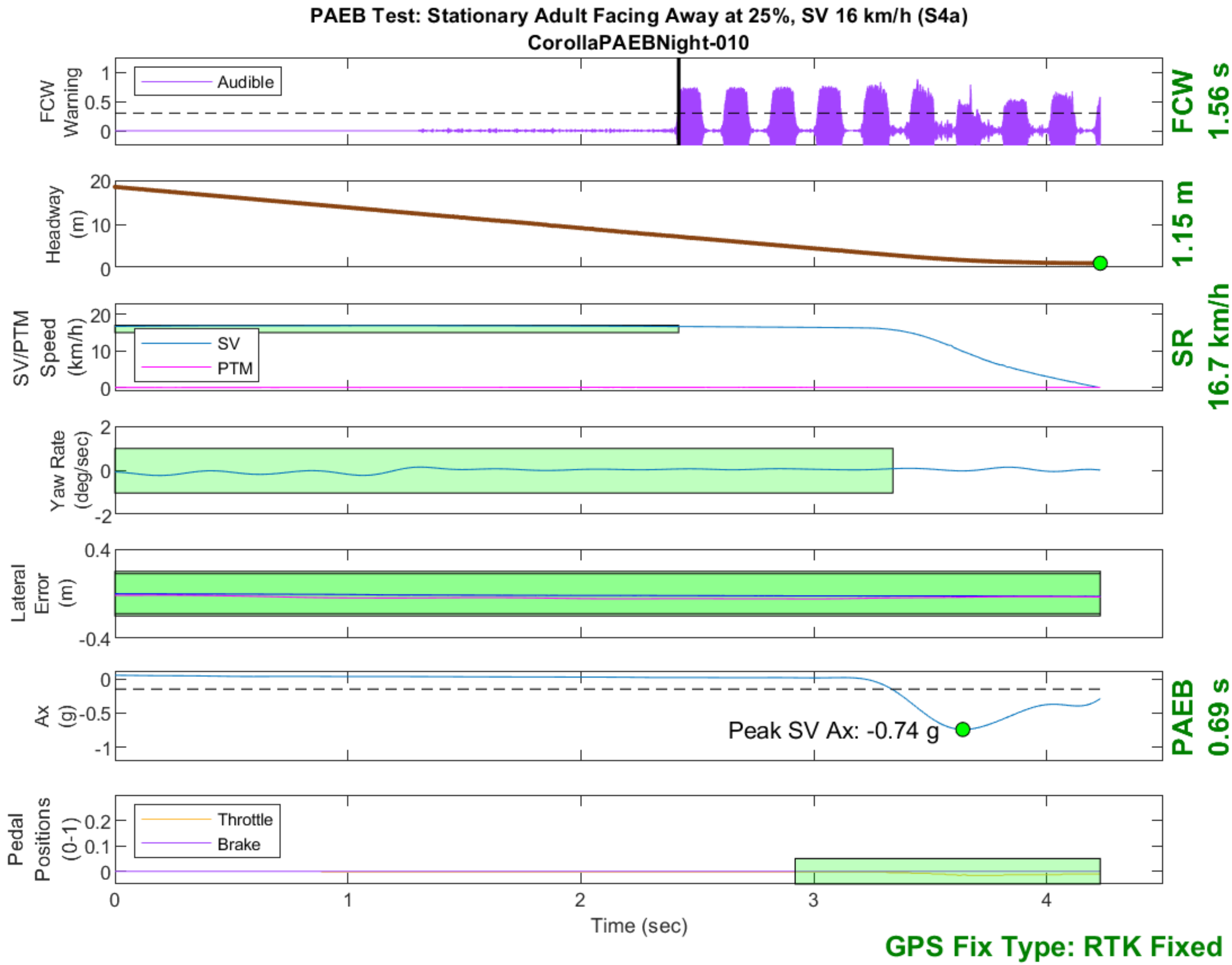


Figure D230. Time History for PAEB Run 10, S4a, Night, High Beam, 16 km/h

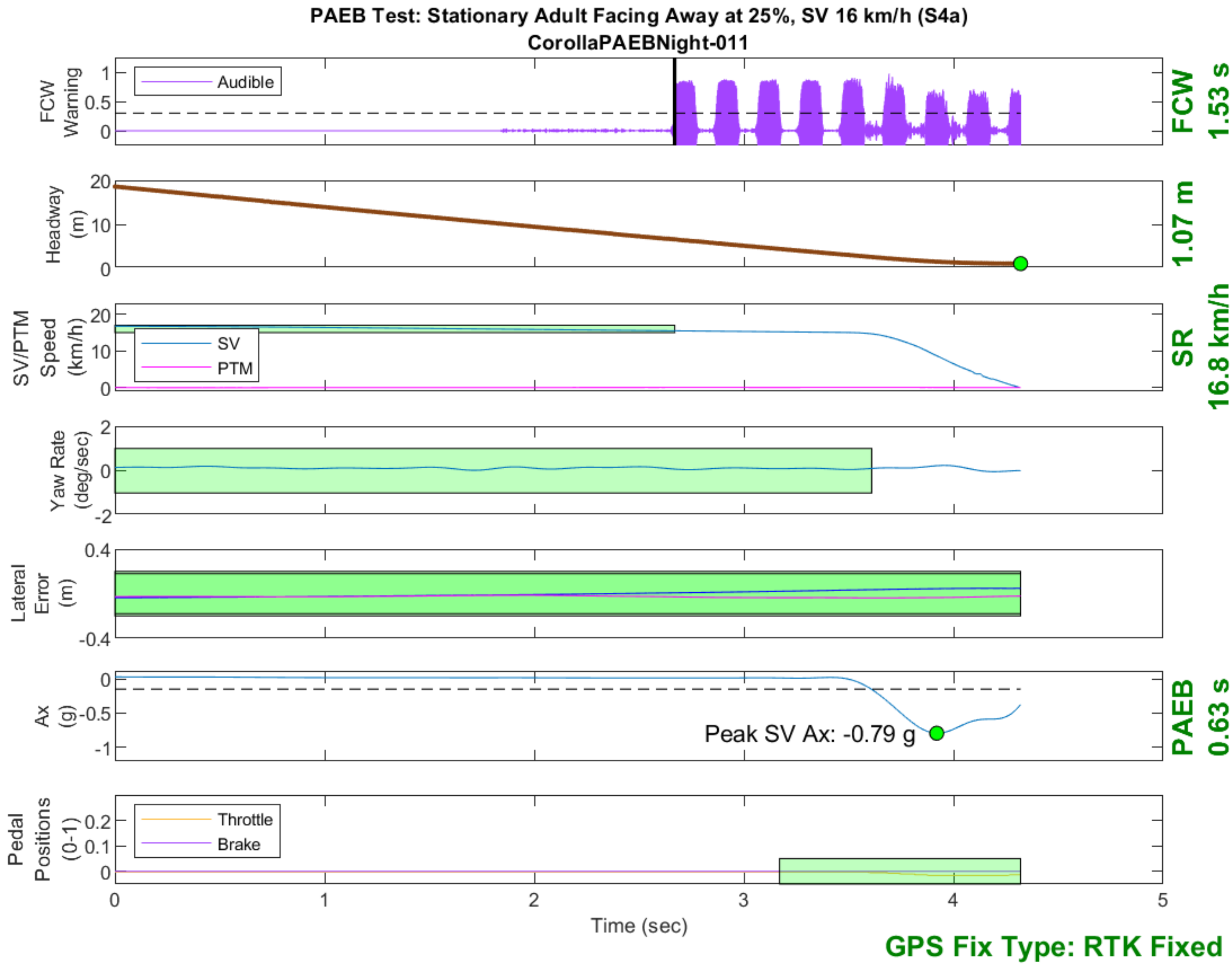


Figure D231. Time History for PAEB Run 11, S4a, Night, High Beam, 16 km/h

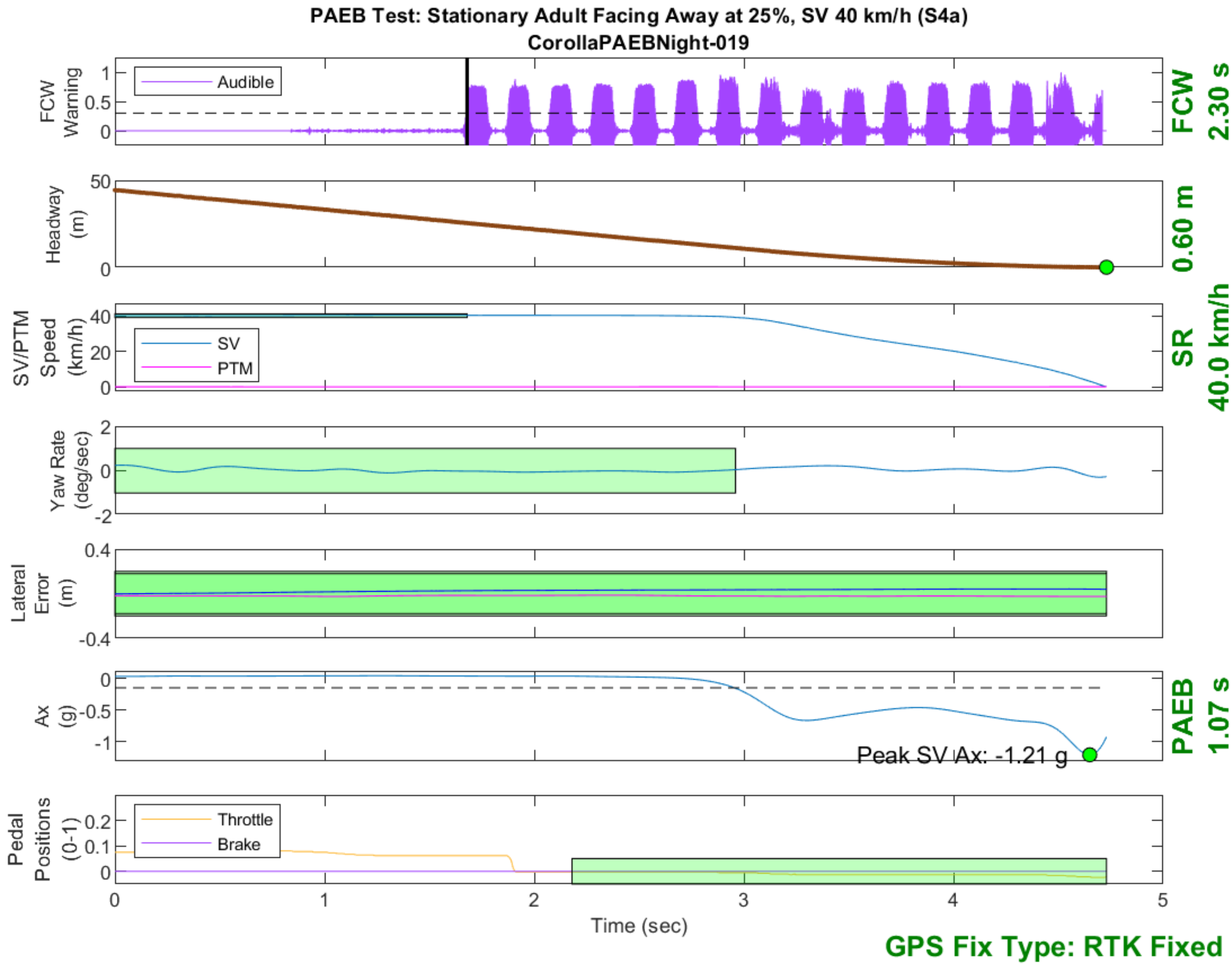


Figure D232. Time History for PAEB Run 19, S4a, Night, High Beam, 40 km/h

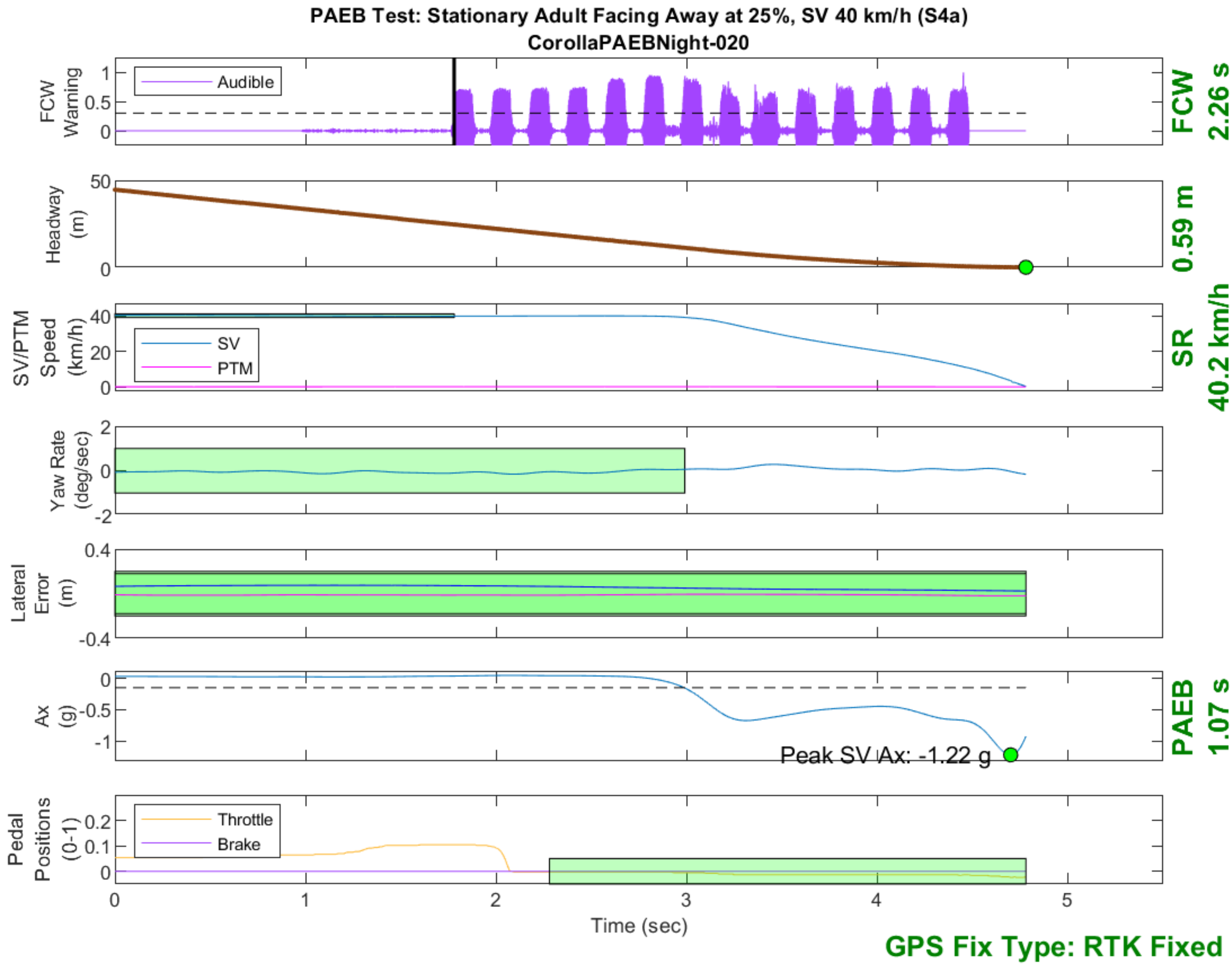


Figure D233. Time History for PAEB Run 20, S4a, Night, High Beam, 40 km/h

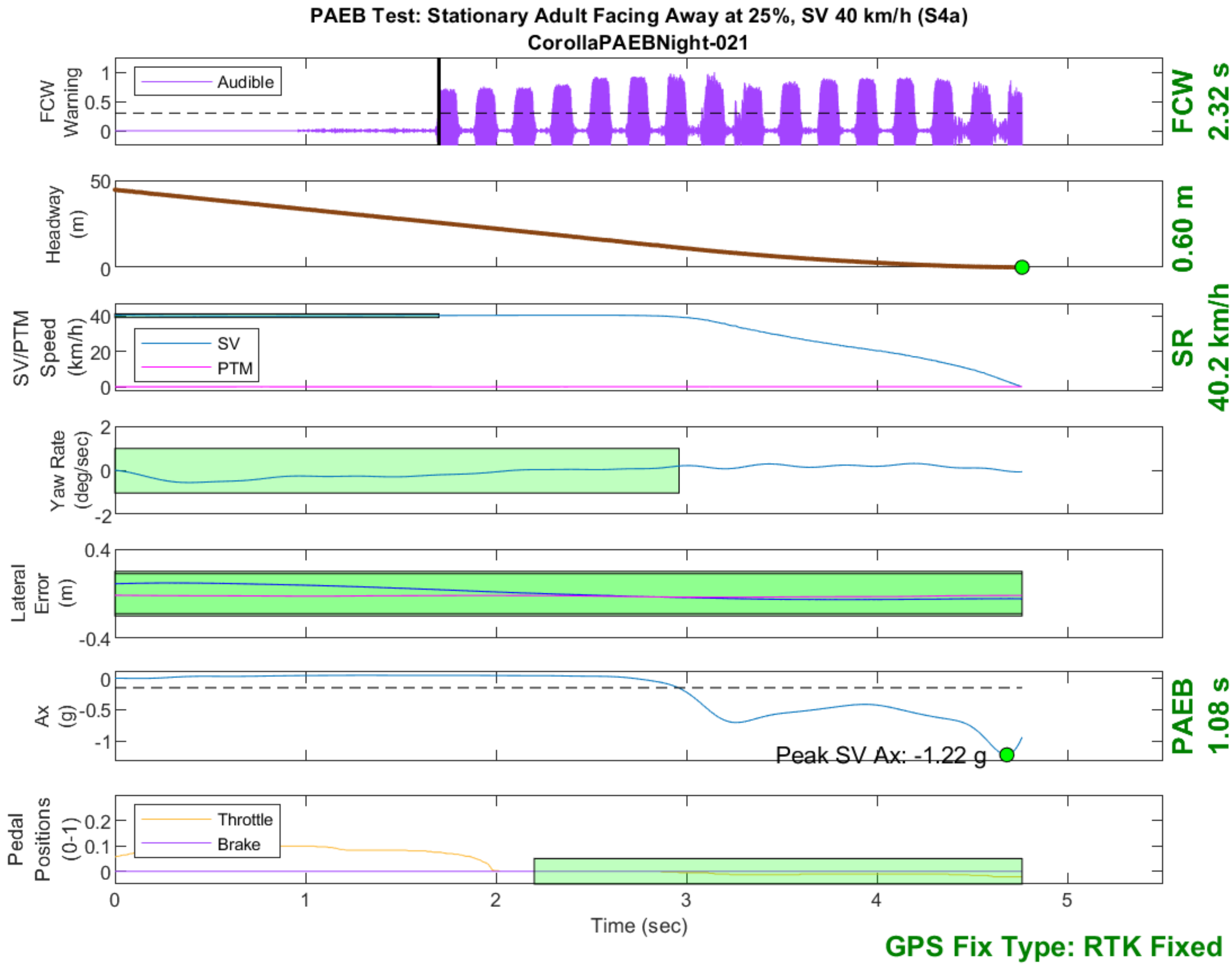


Figure D234. Time History for PAEB Run 21, S4a, Night, High Beam, 40 km/h

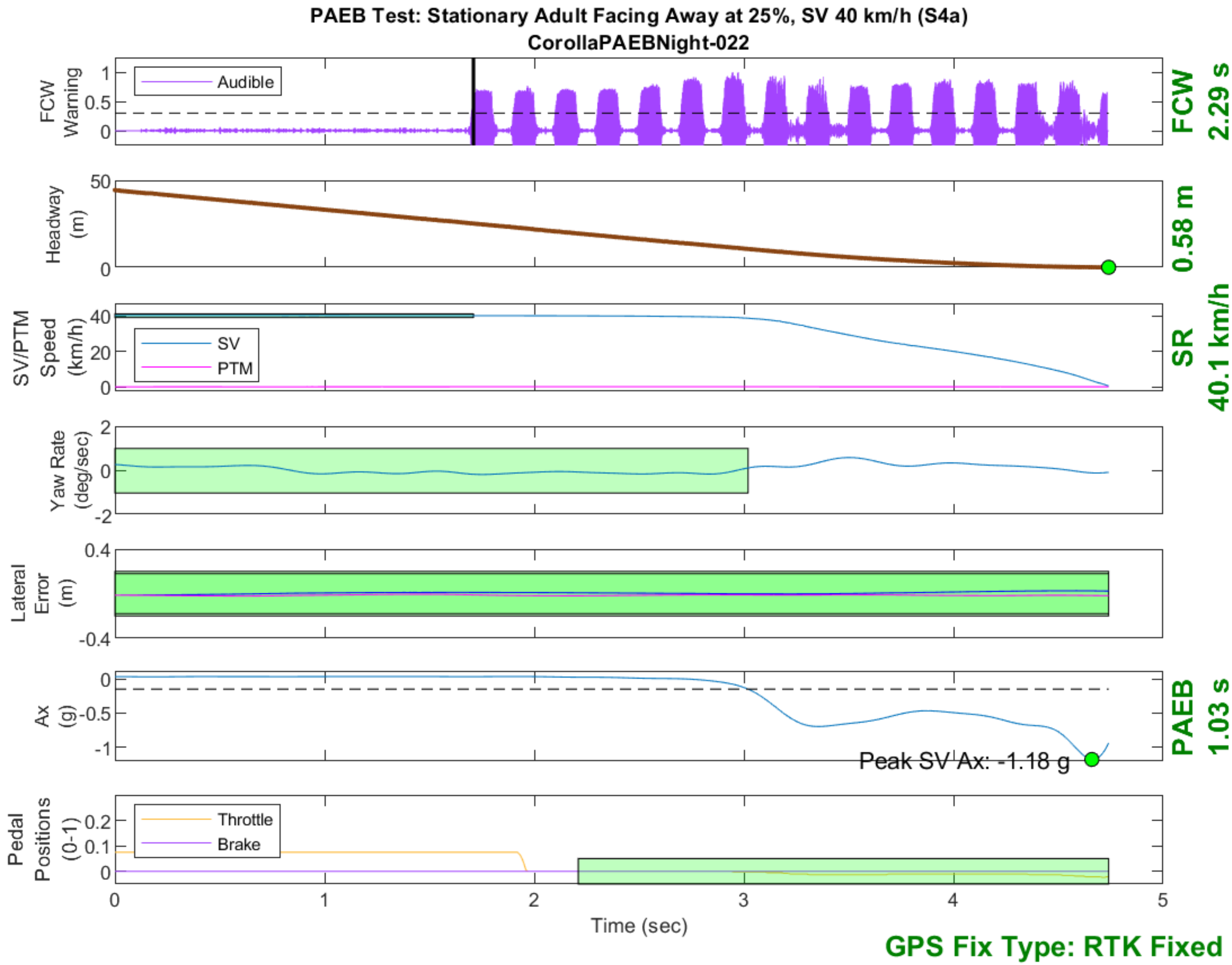


Figure D235. Time History for PAEB Run 22, S4a, Night, High Beam, 40 km/h

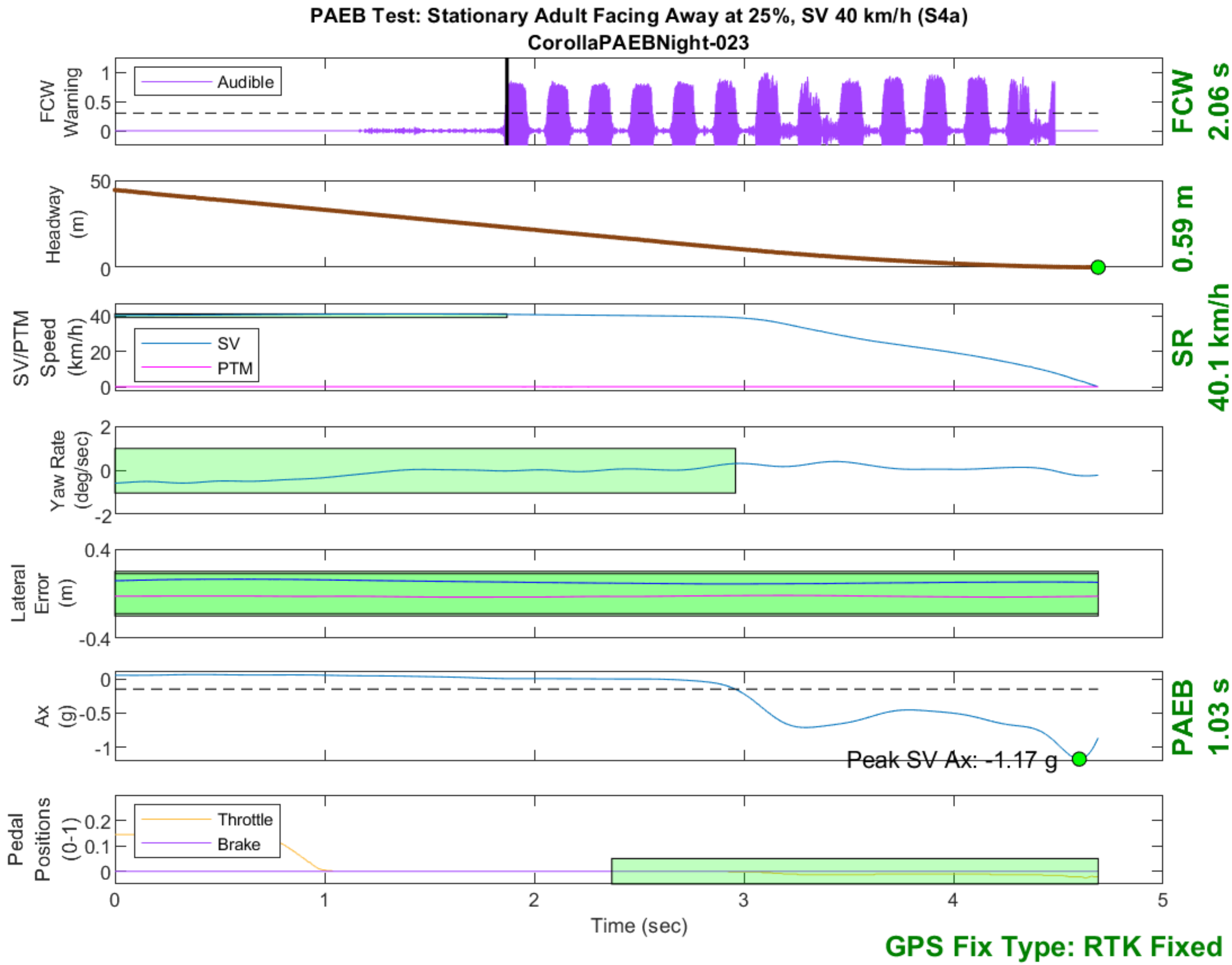


Figure D236. Time History for PAEB Run 23, S4a, Night, High Beam, 40 km/h

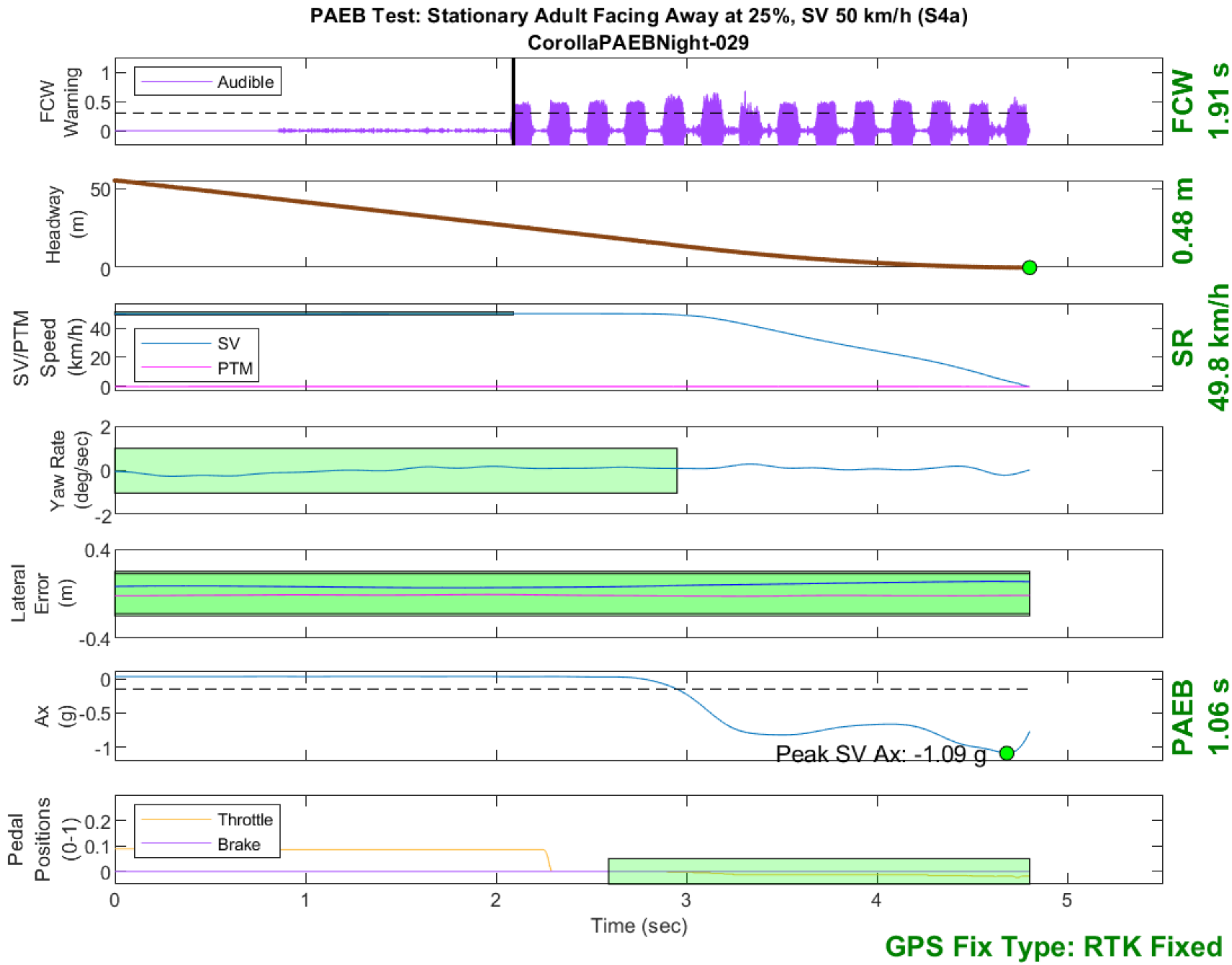


Figure D237. Time History for PAEB Run 29, S4a, Night, High Beam, 50 km/h

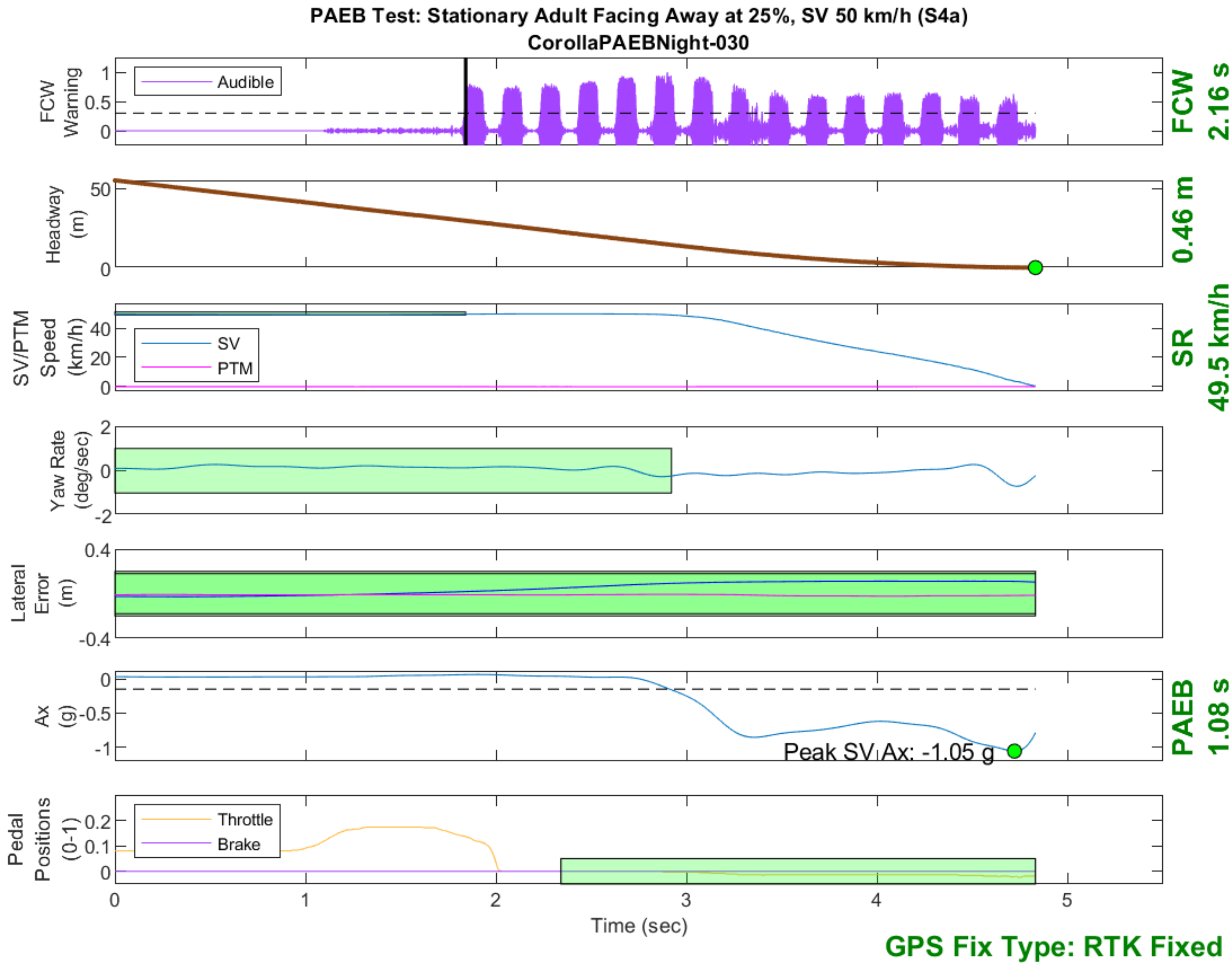


Figure D238. Time History for PAEB Run 30, S4a, Night, High Beam, 50 km/h

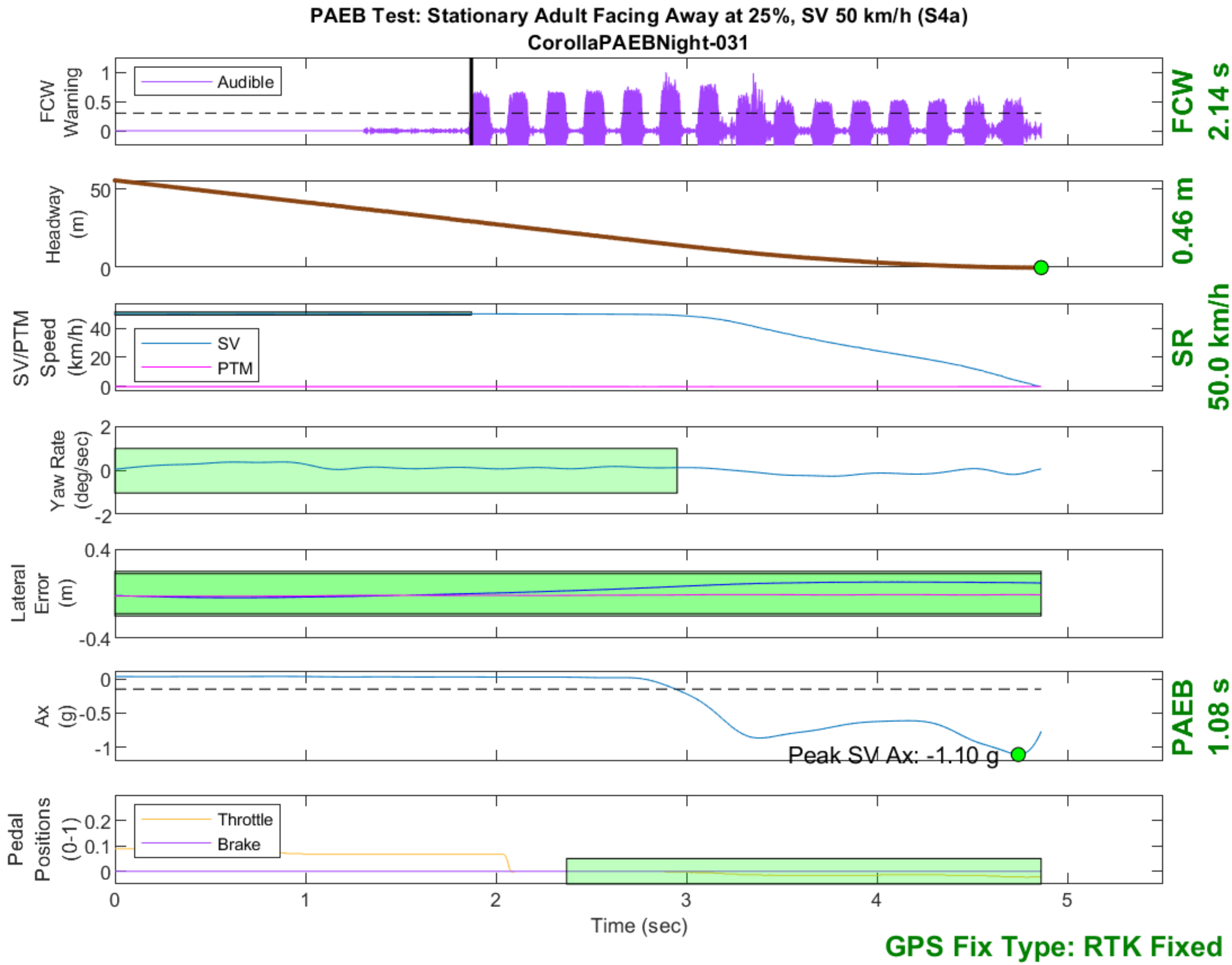


Figure D239. Time History for PAEB Run 31, S4a, Night, High Beam, 50 km/h

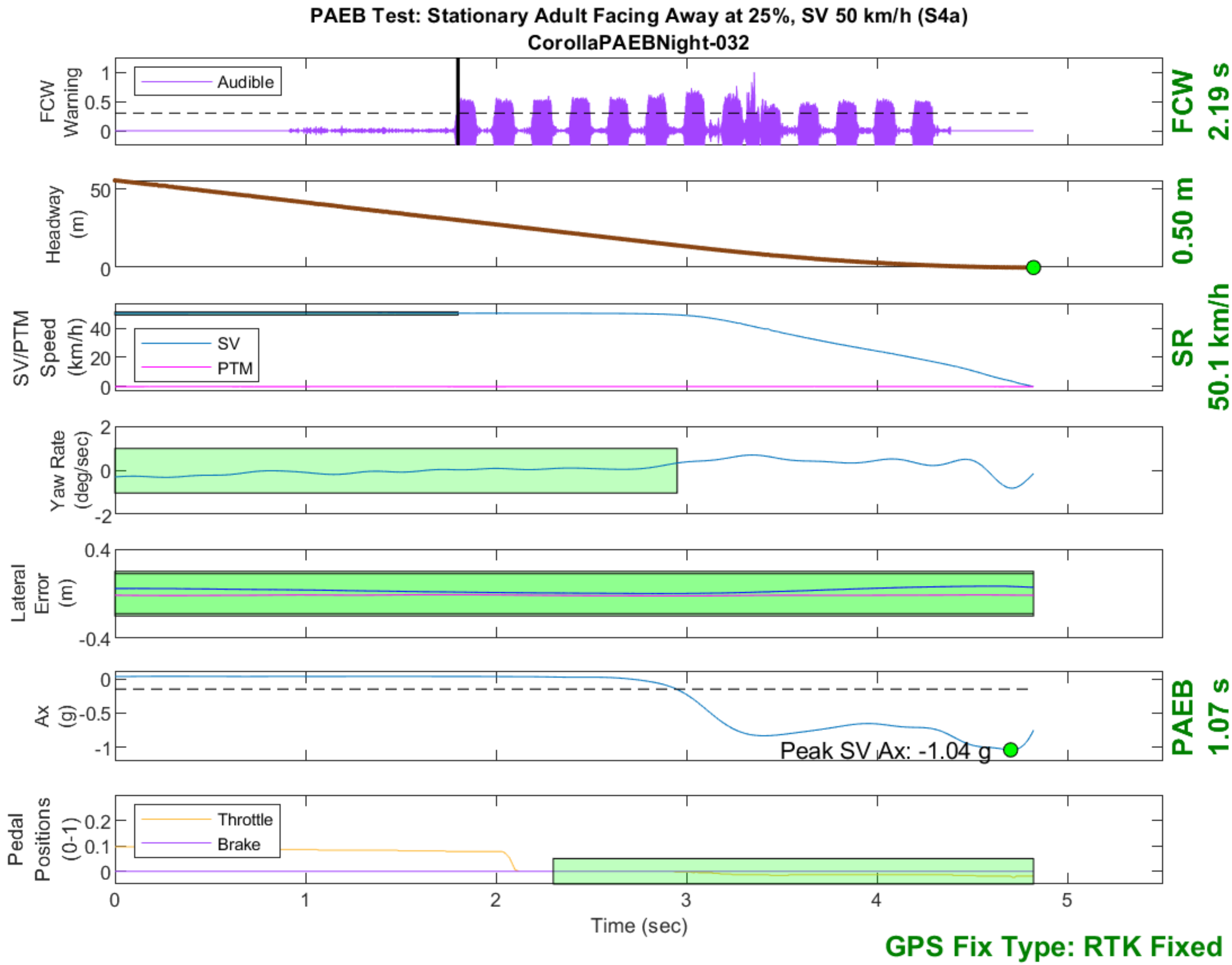


Figure D240. Time History for PAEB Run 32, S4a, Night, High Beam, 50 km/h

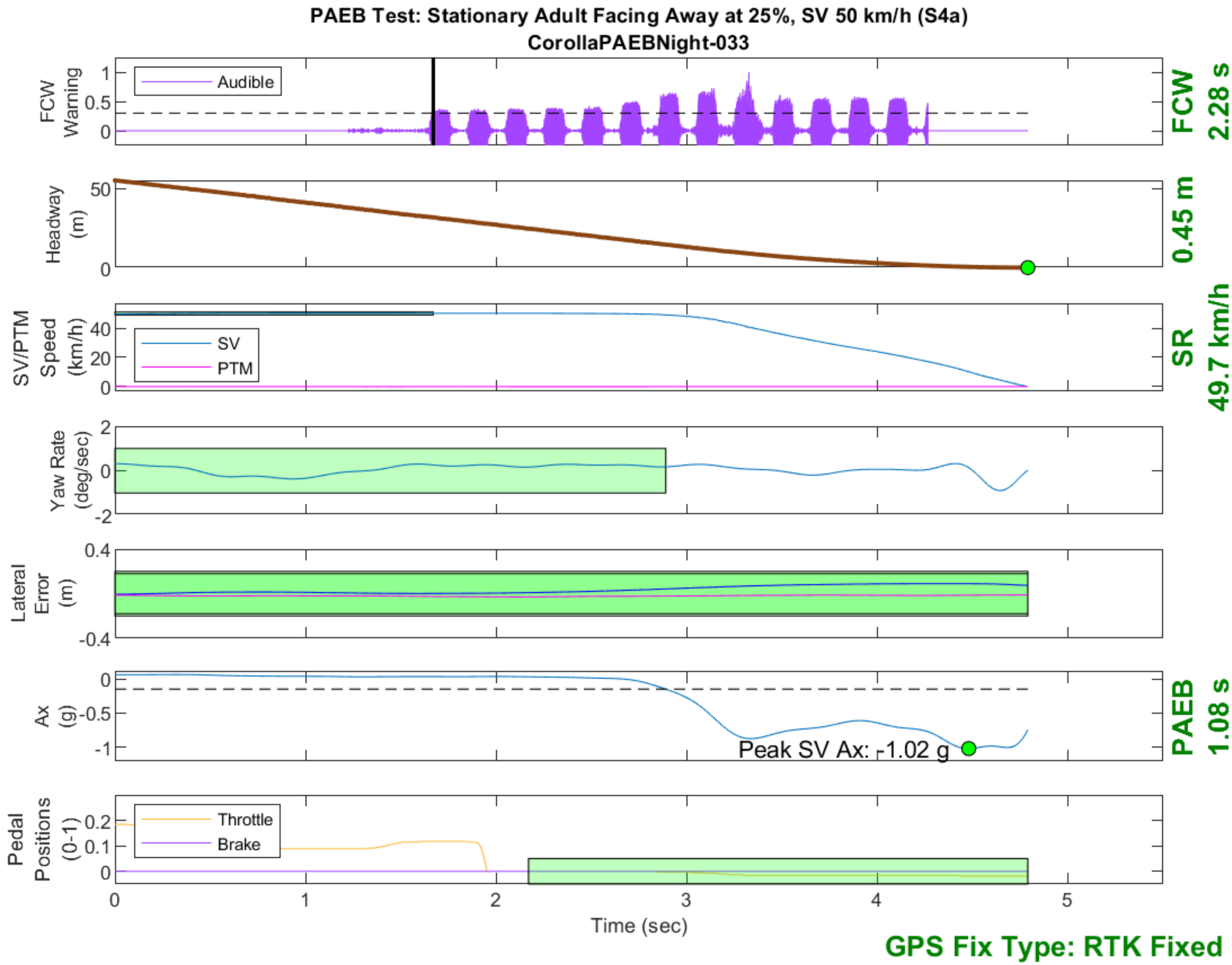


Figure D241. Time History for PAEB Run 33, S4a, Night, High Beam, 50 km/h

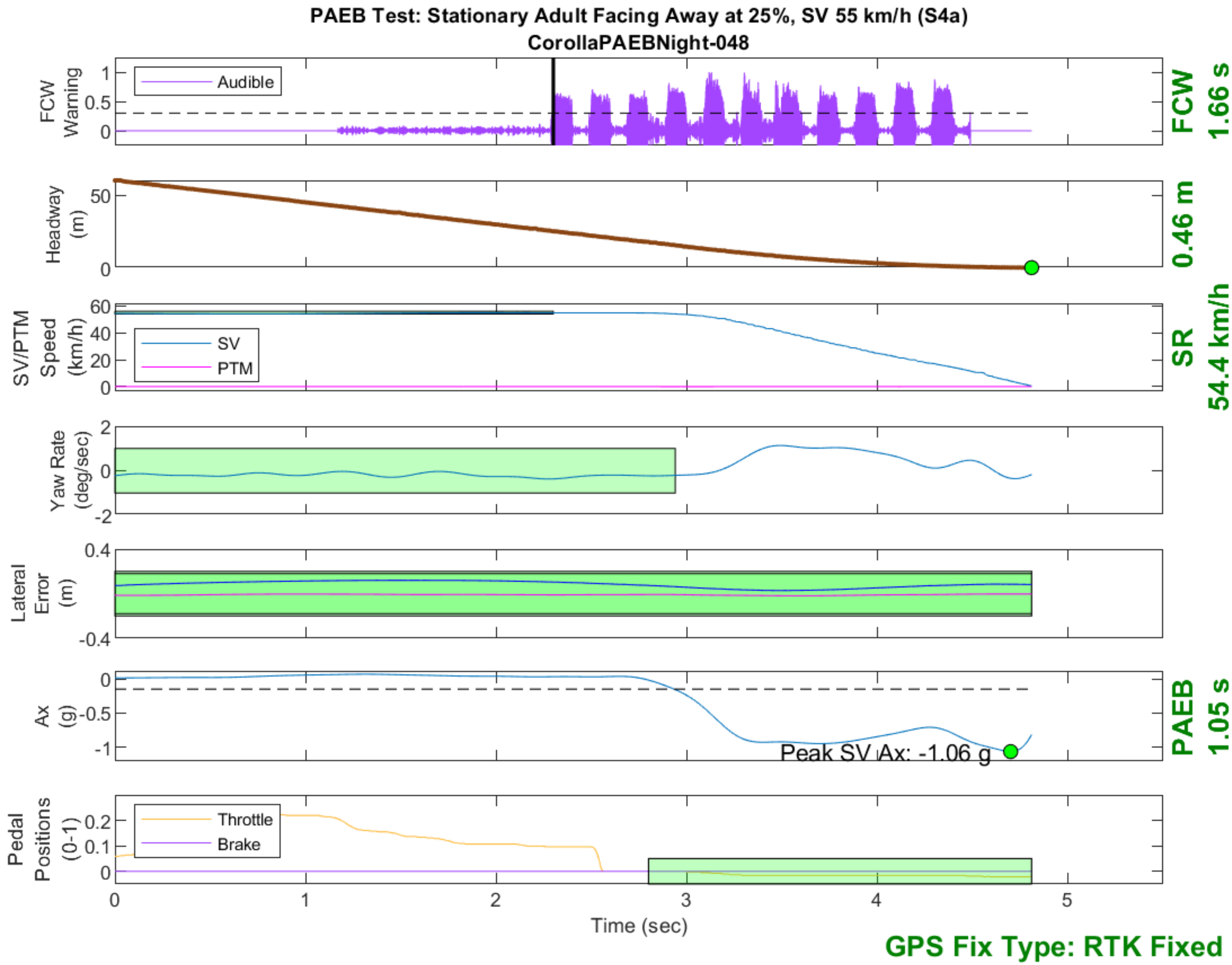


Figure D242. Time History for PAEB Run 48, S4a, Night, High Beam, 55 km/h

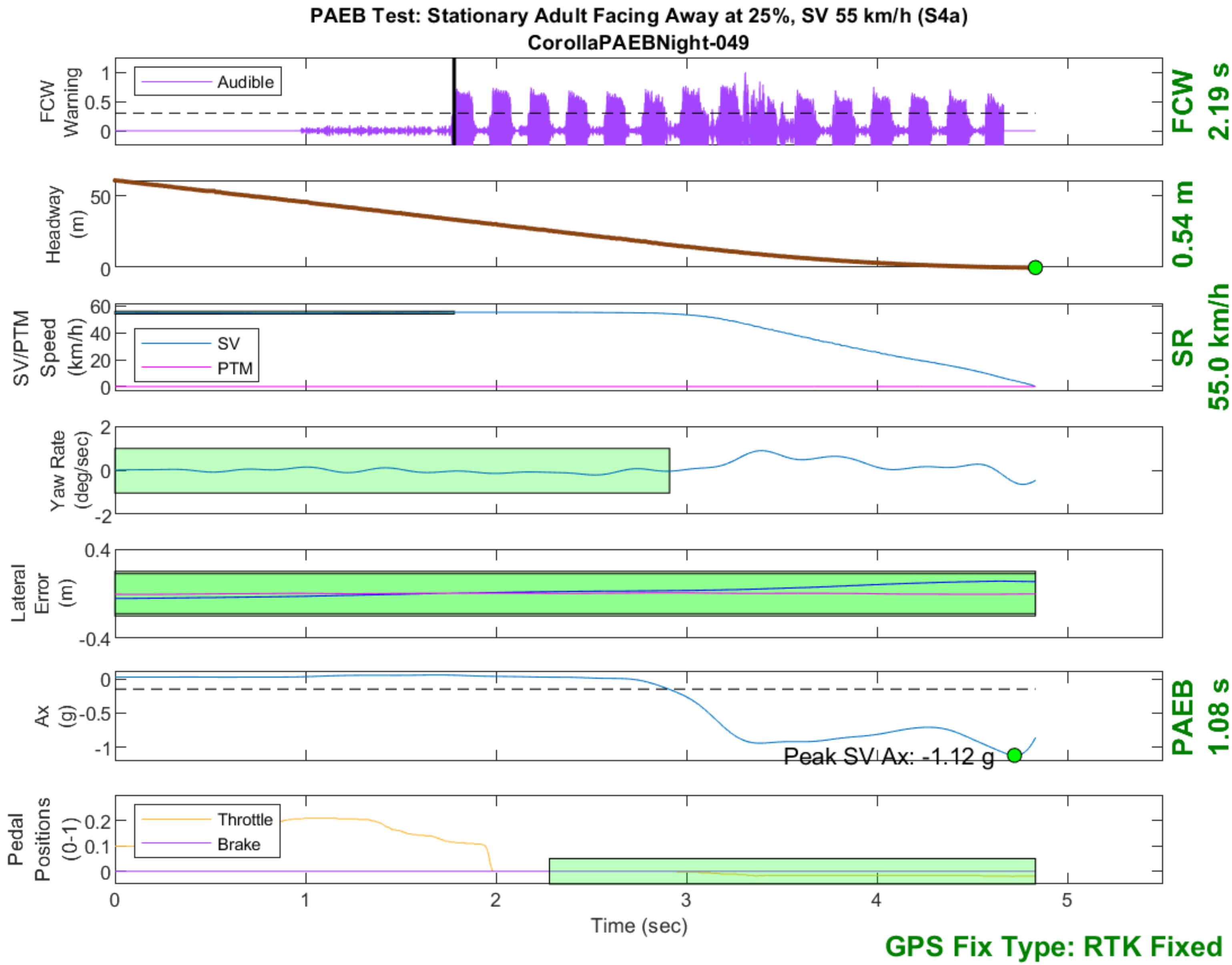


Figure D243. Time History for PAEB Run 49, S4a, Night, High Beam, 55 km/h

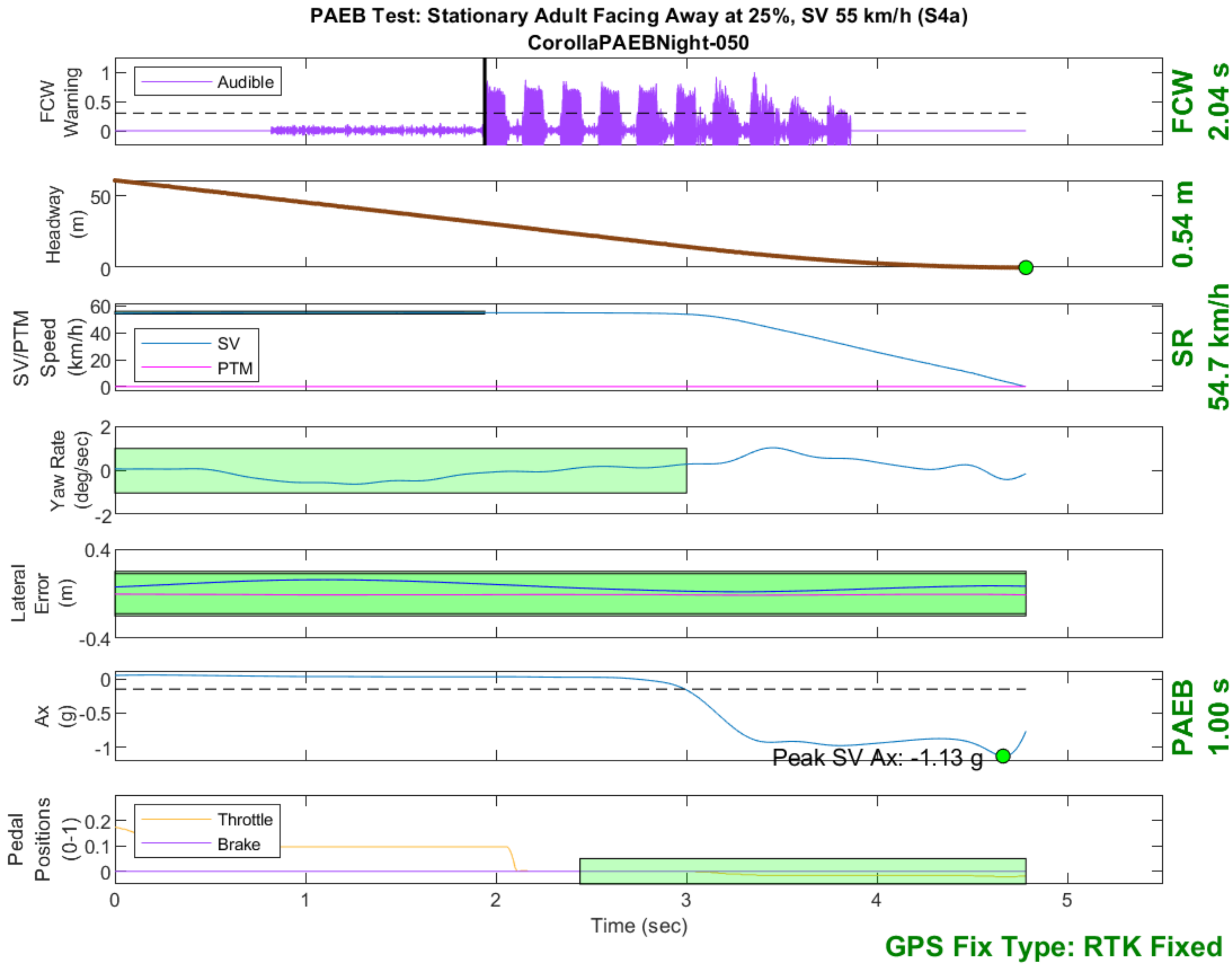


Figure D244. Time History for PAEB Run 50, S4a, Night, High Beam, 55 km/h

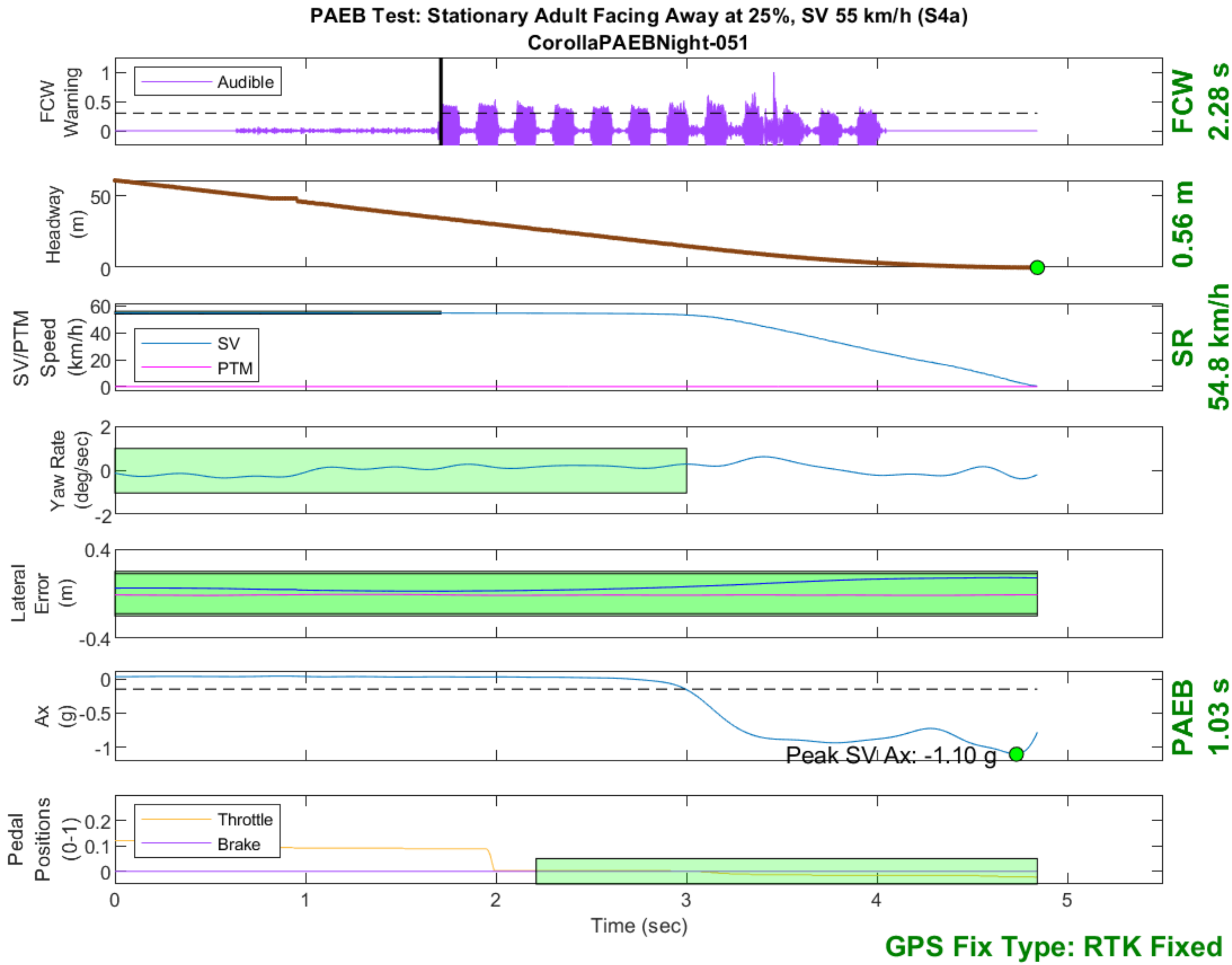


Figure D245. Time History for PAEB Run 51, S4a, Night, High Beam, 55 km/h

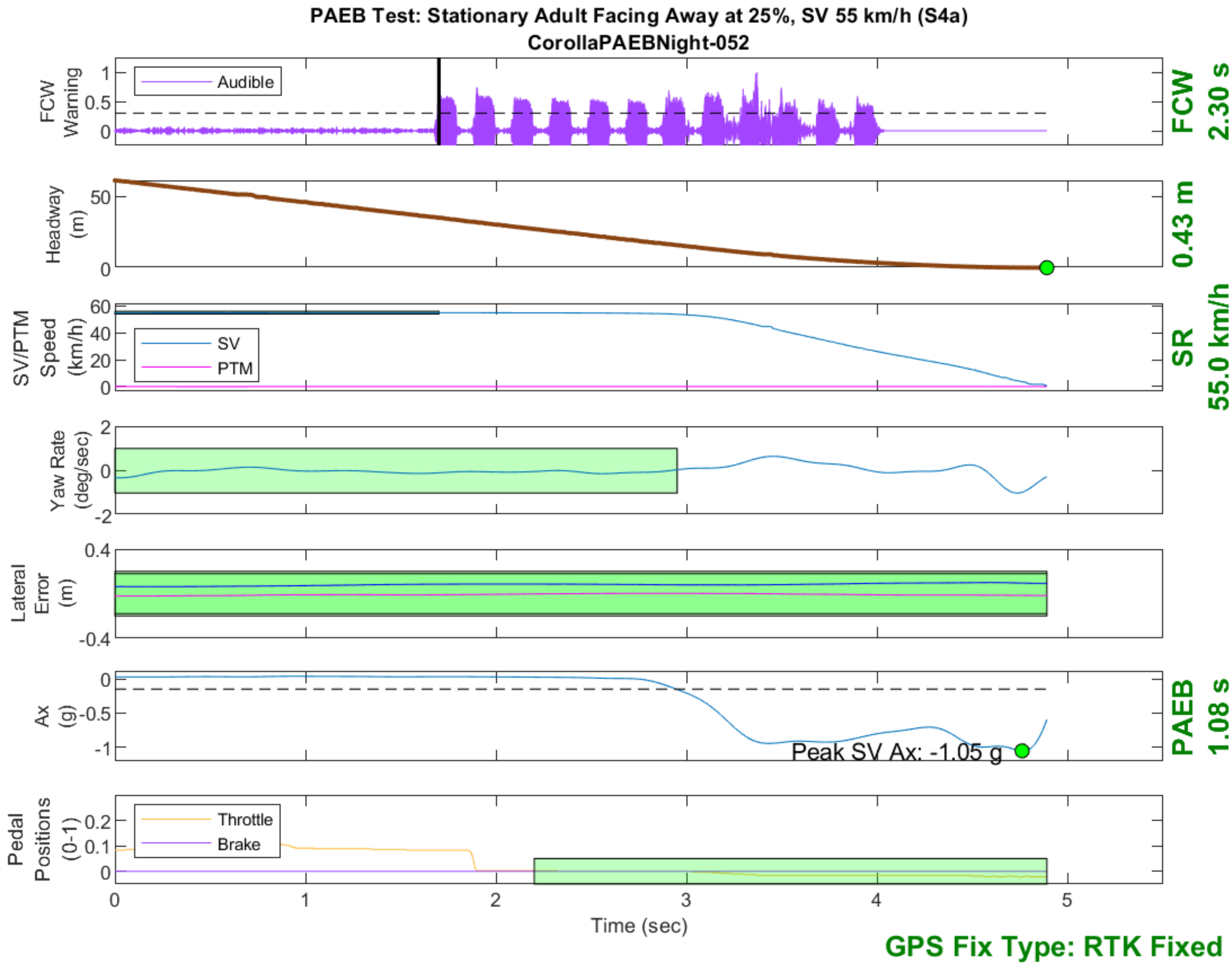


Figure D246. Time History for PAEB Run 52, S4a, Night, High Beam, 55 km/h

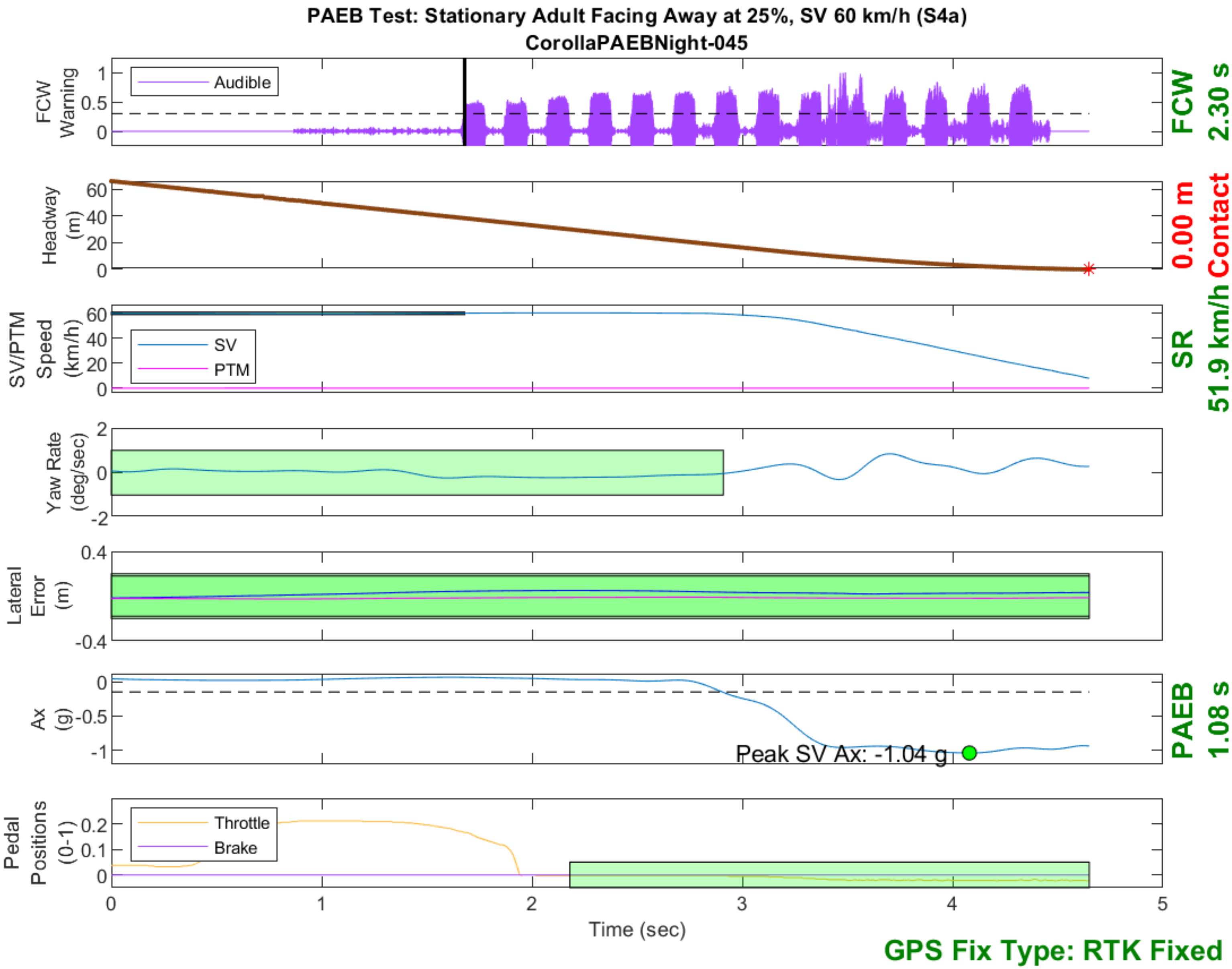


Figure D247. Time History for PAEB Run 45, S4a, Night, High Beam, 60 km/h

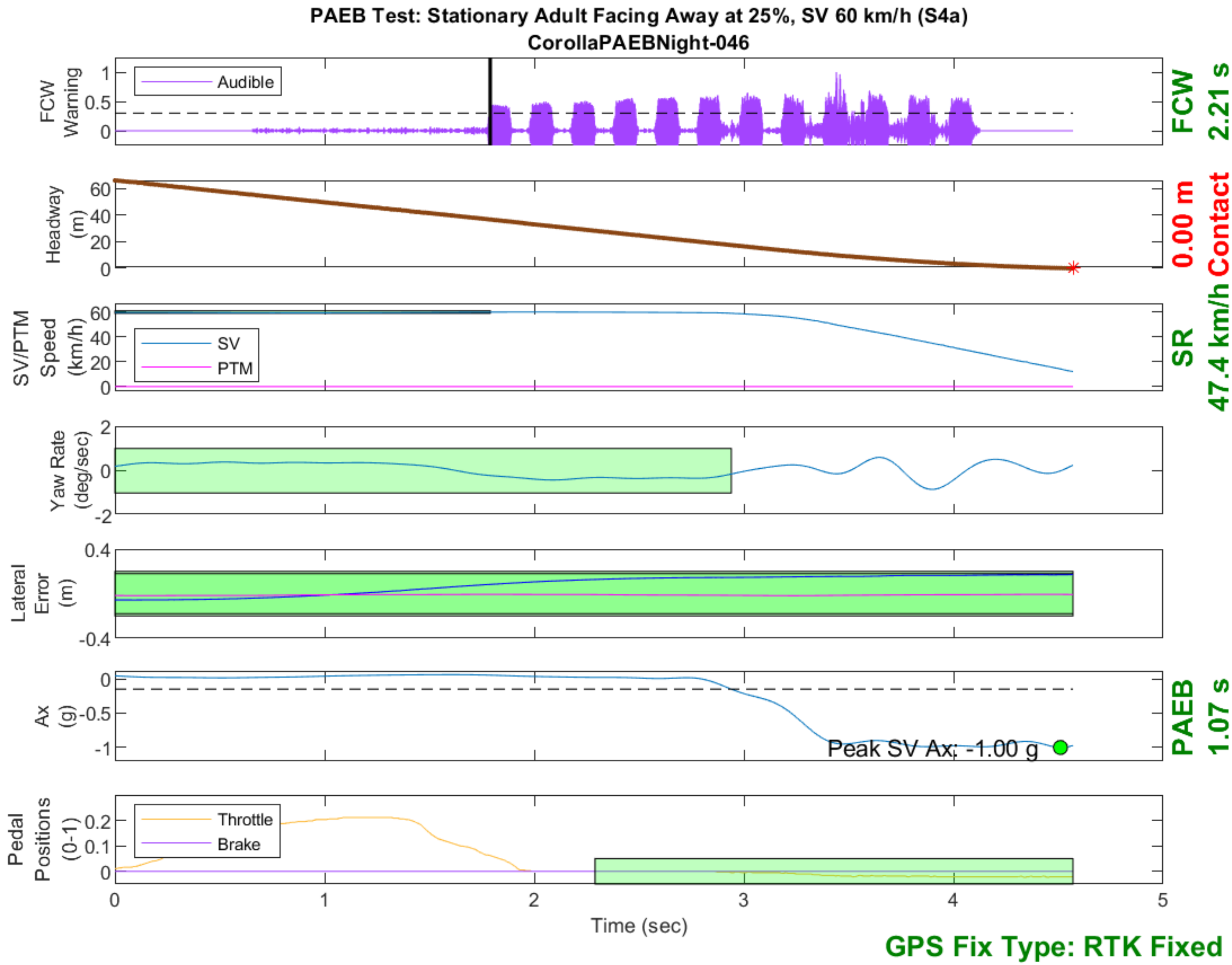


Figure D248. Time History for PAEB Run 46, S4a, Night, High Beam, 60 km/h

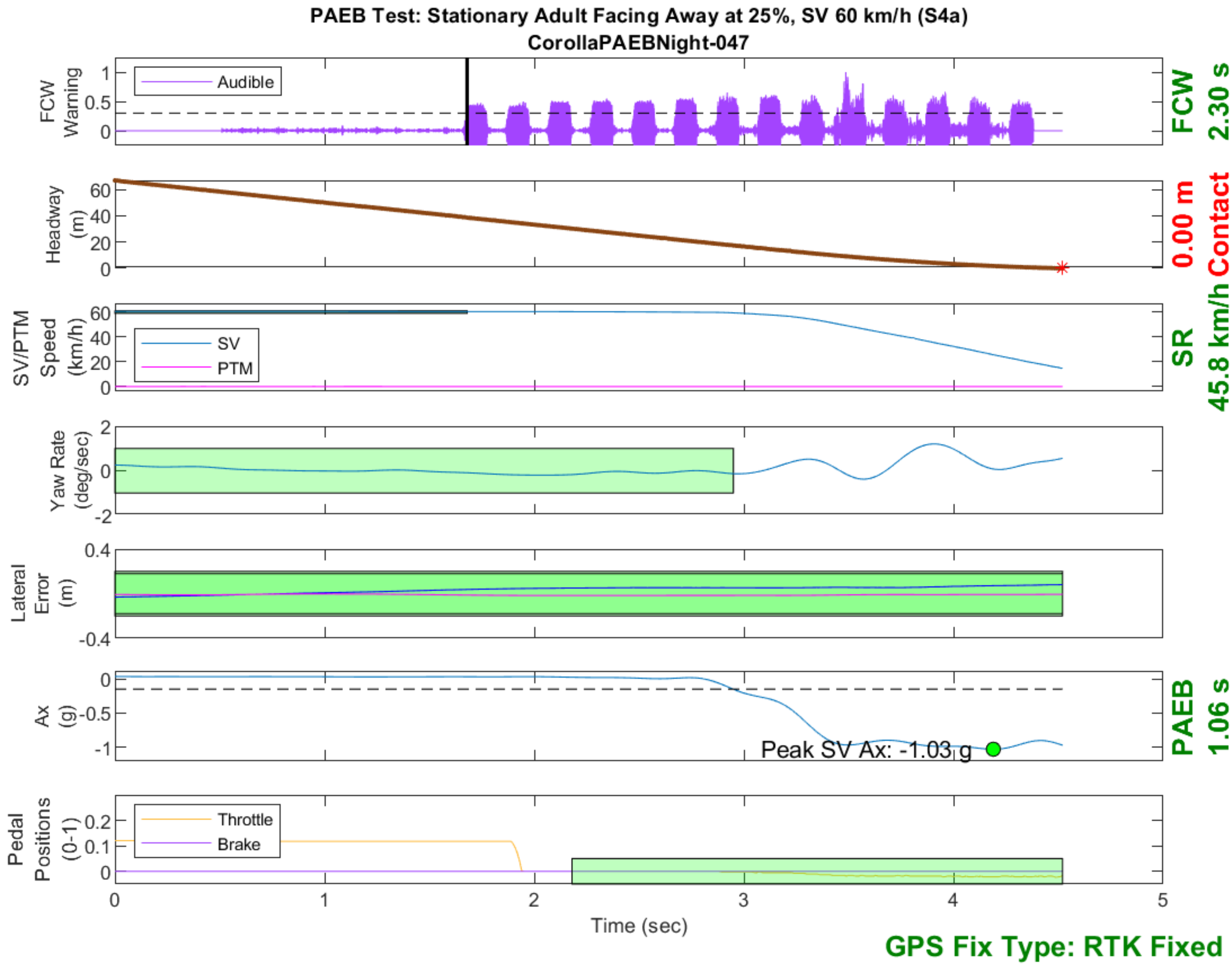


Figure D249. Time History for PAEB Run 47, S4a, Night, High Beam, 60 km/h

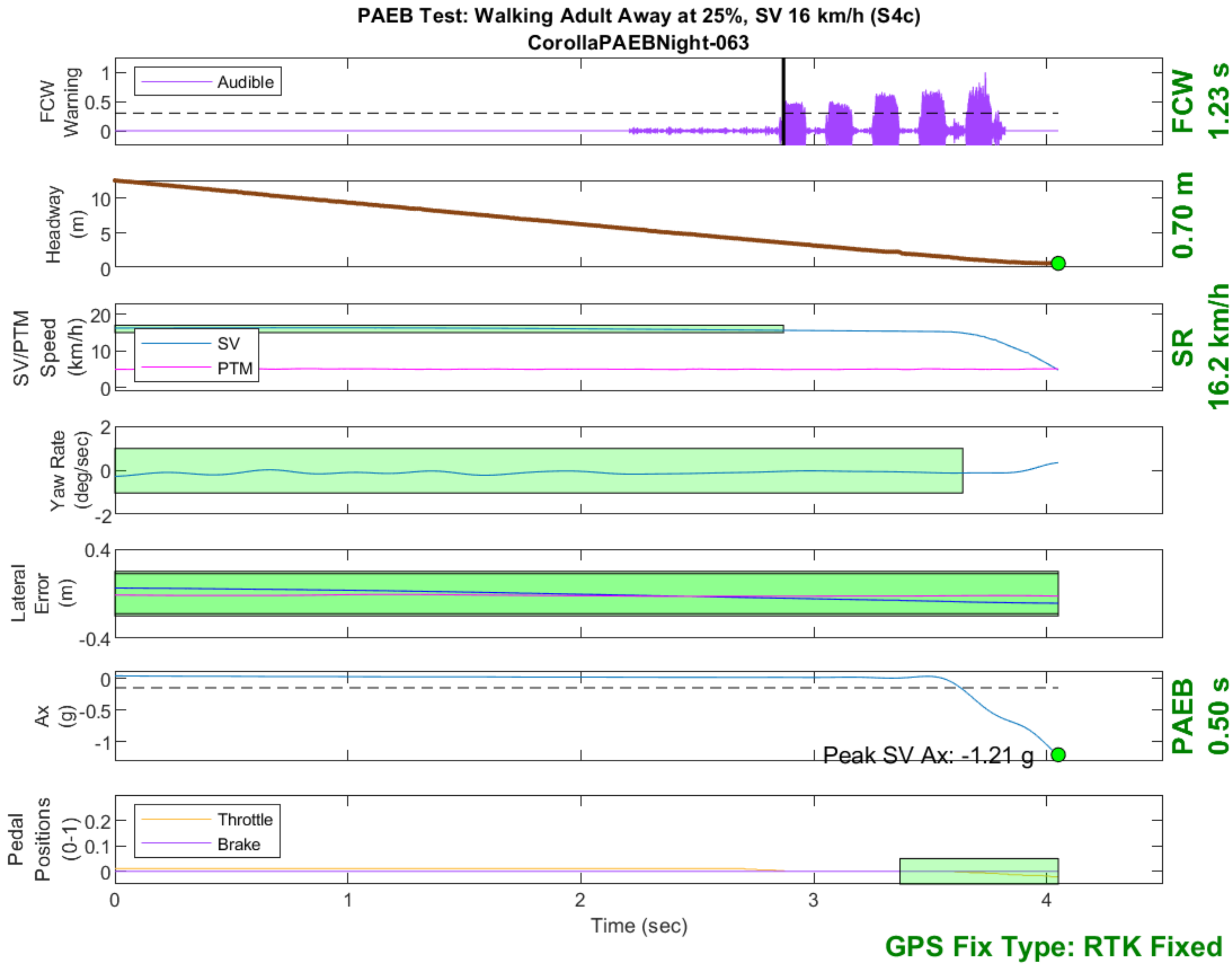


Figure D250. Time History for PAEB Run 63, S4c, Night, High Beam, 16 km/h

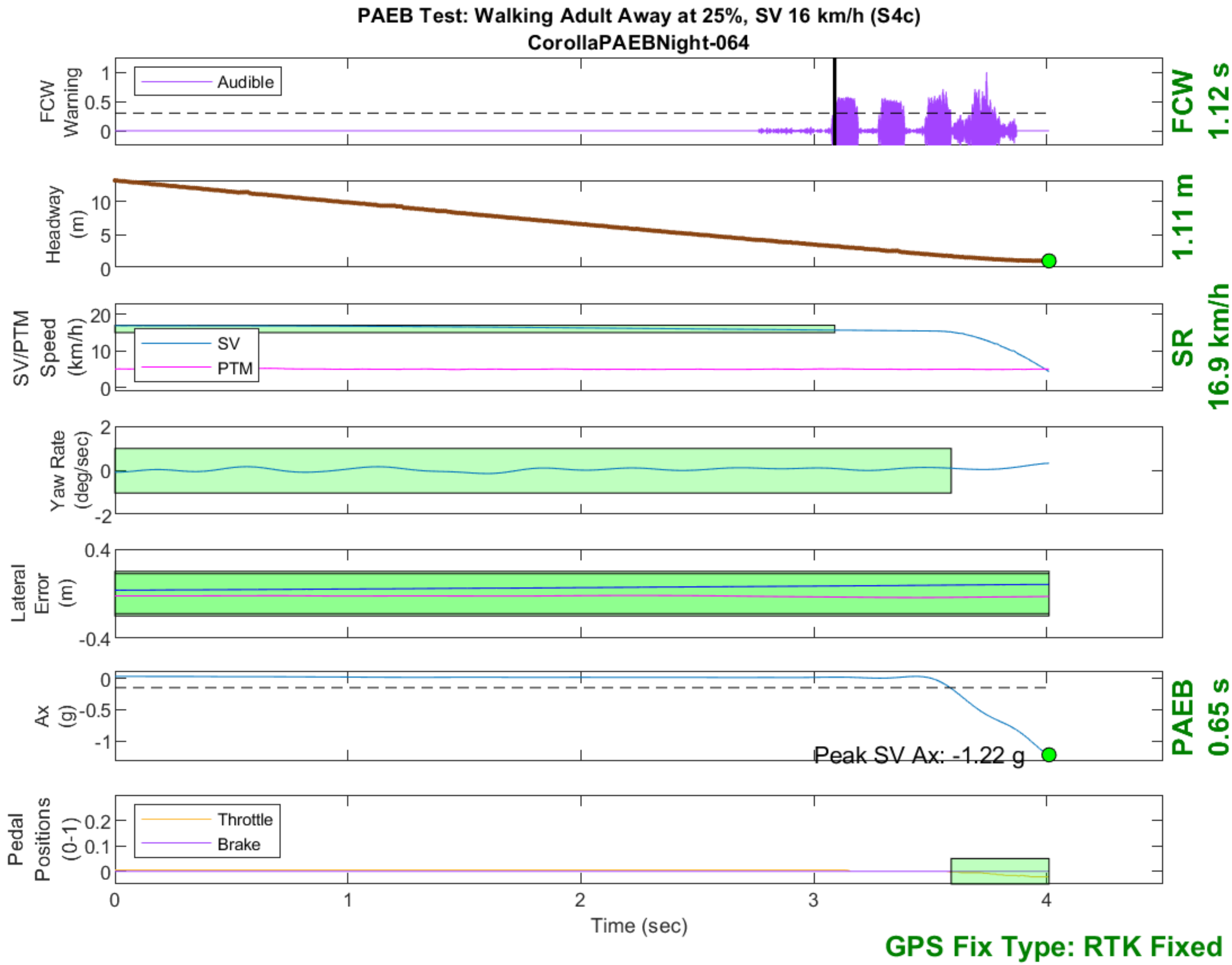


Figure D251. Time History for PAEB Run 64, S4c, Night, High Beam, 16 km/h

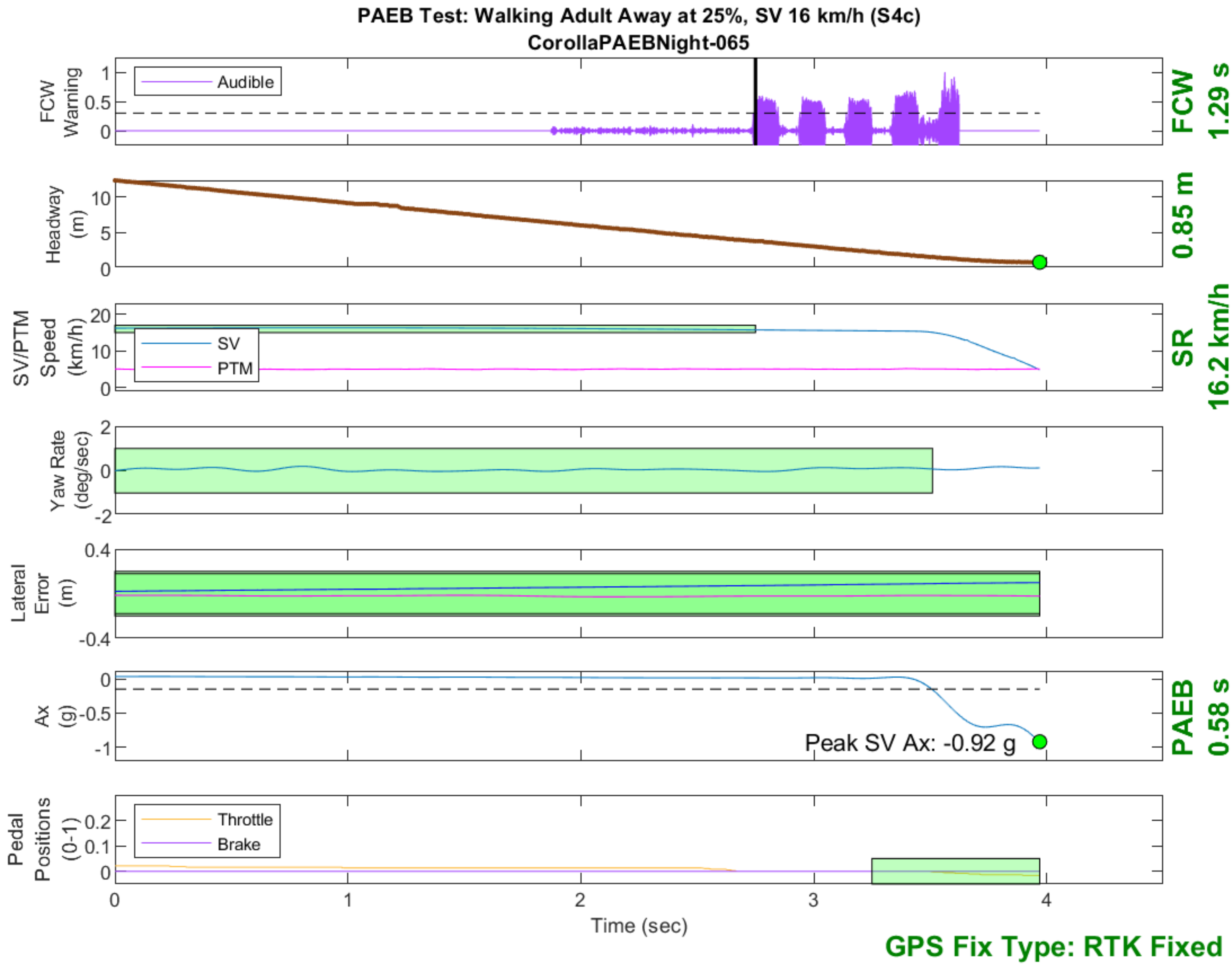


Figure D252. Time History for PAEB Run 65, S4c, Night, High Beam, 16 km/h

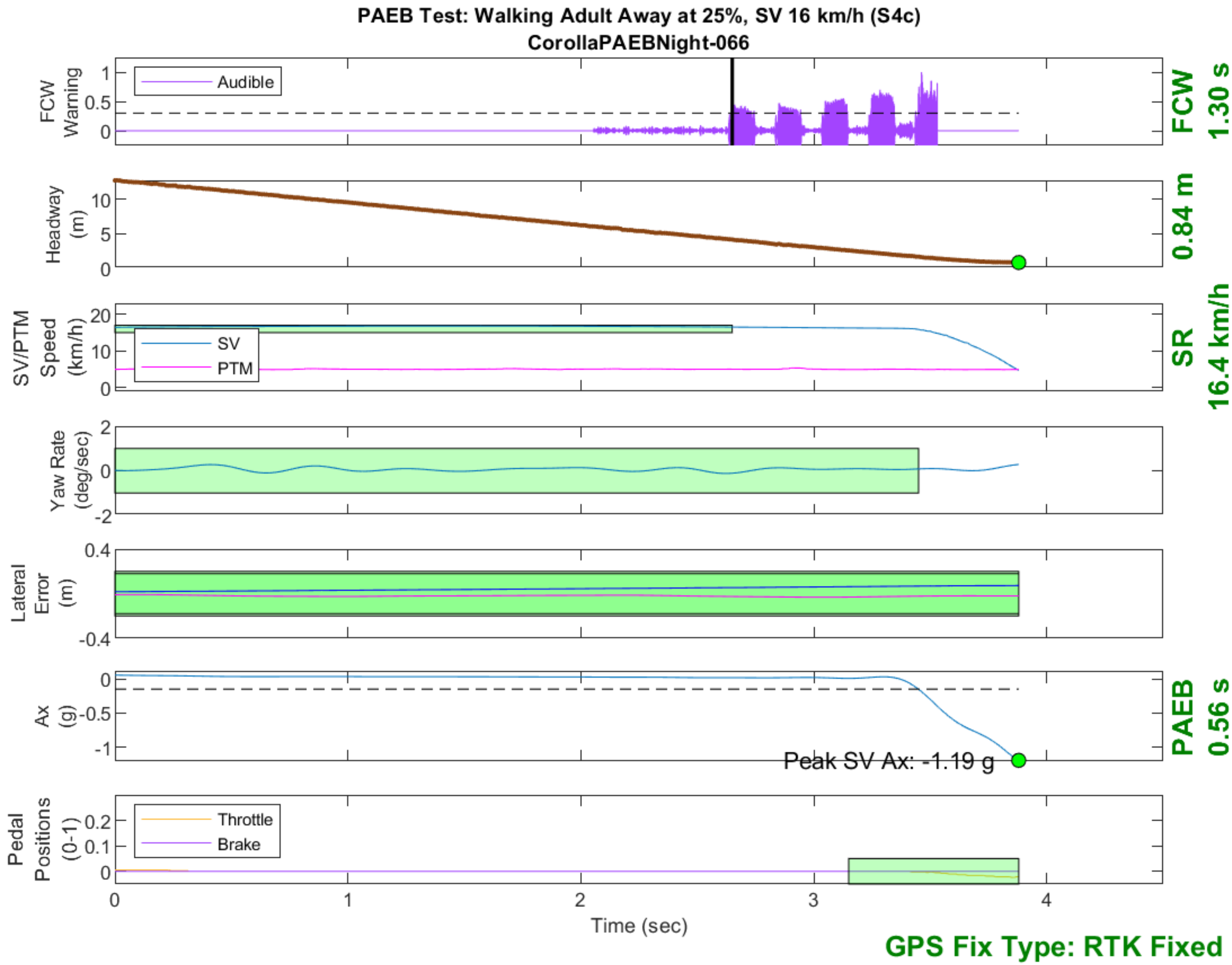


Figure D253. Time History for PAEB Run 66, S4c, Night, High Beam, 16 km/h

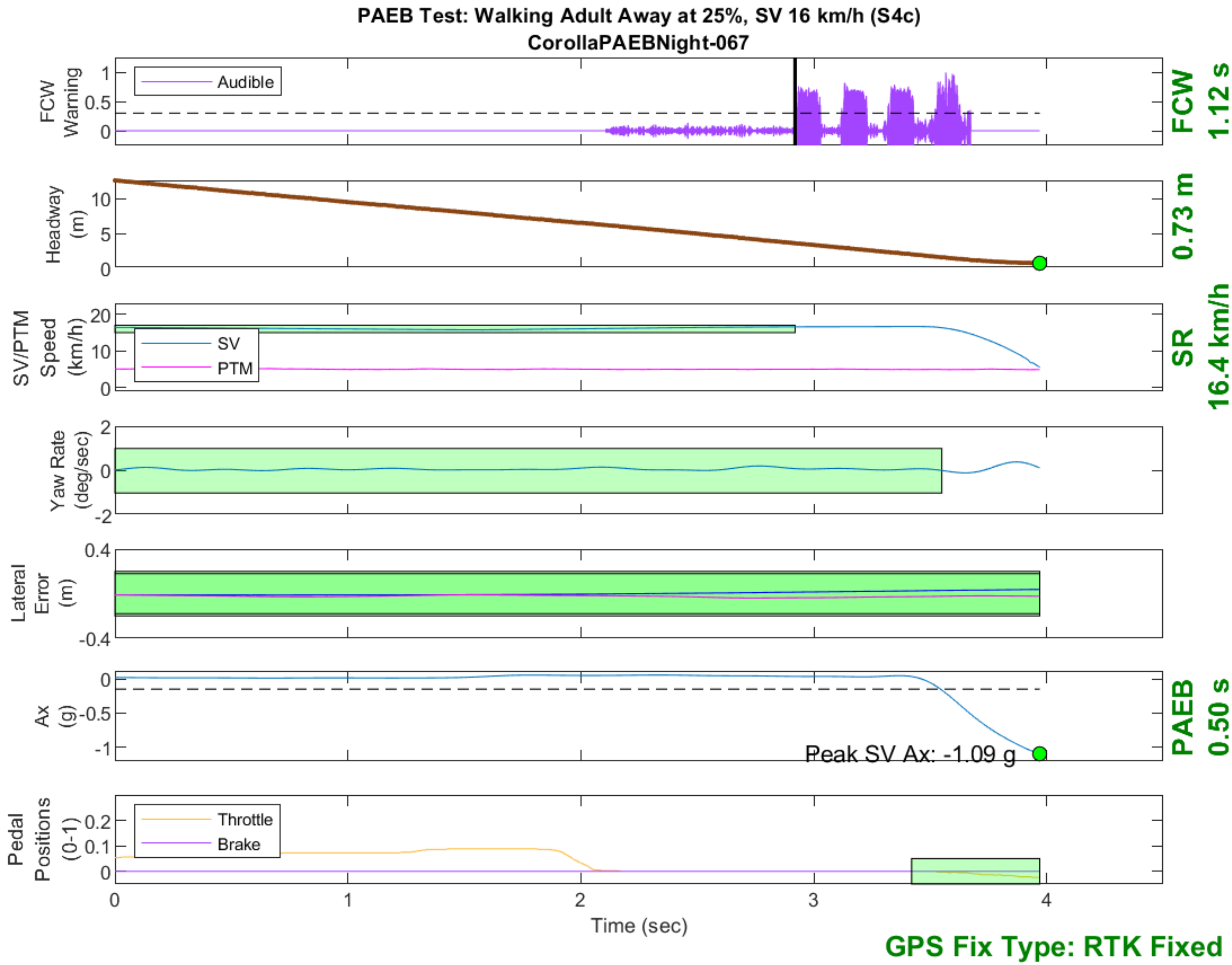


Figure D254. Time History for PAEB Run 67, S4c, Night, High Beam, 16 km/h

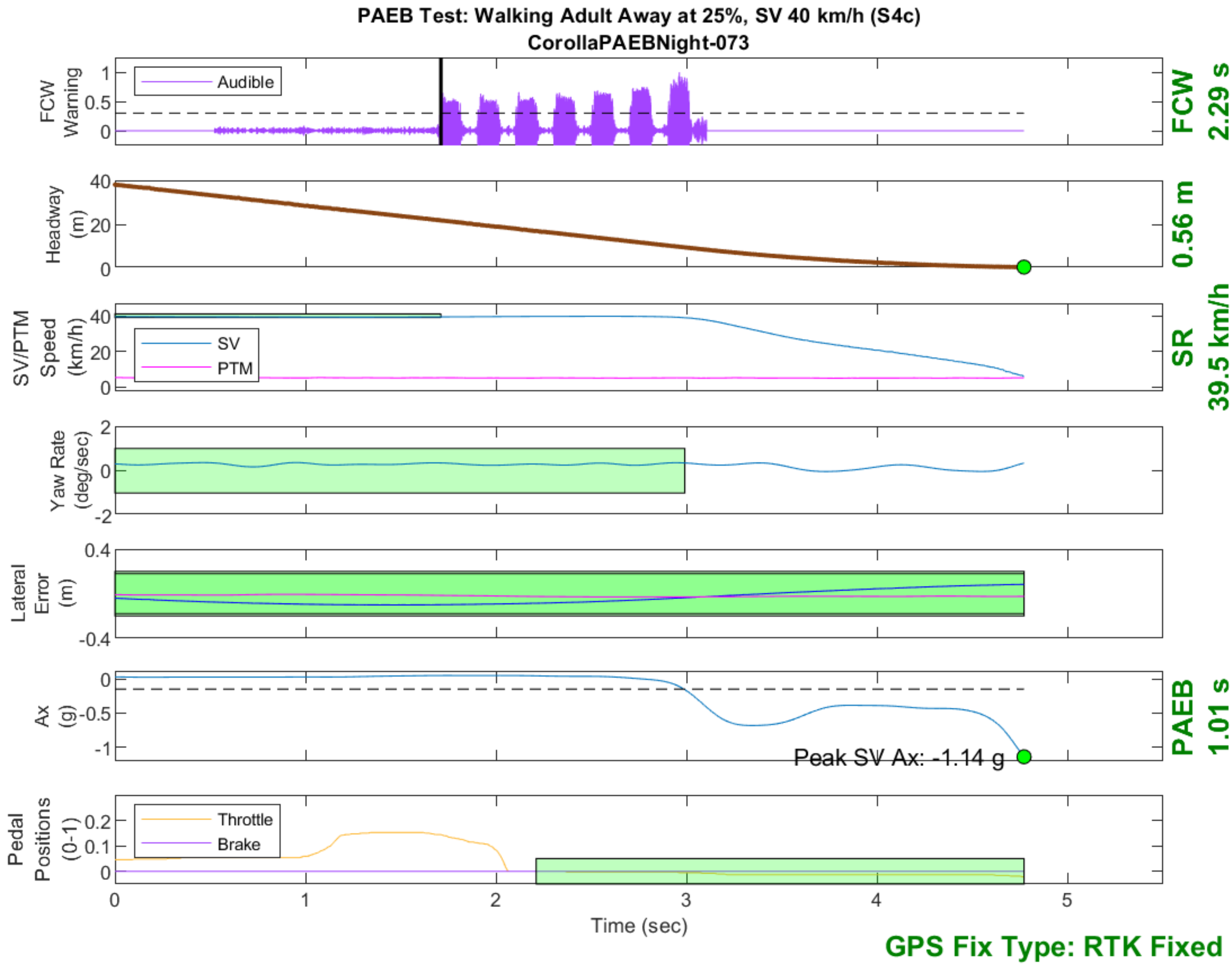


Figure D255. Time History for PAEB Run 73, S4c, Night, High Beam, 40 km/h

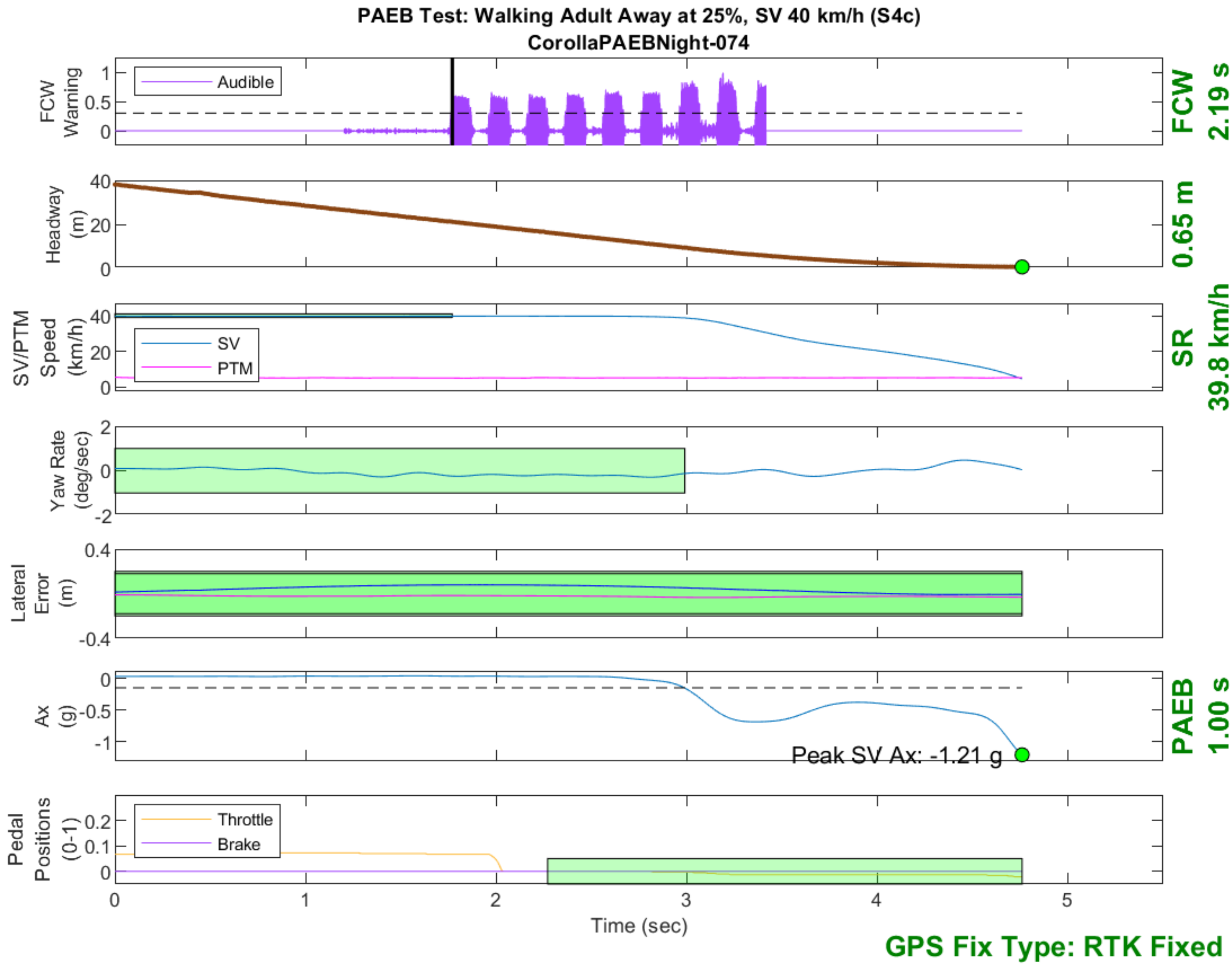


Figure D256. Time History for PAEB Run 74, S4c, Night, High Beam, 40 km/h

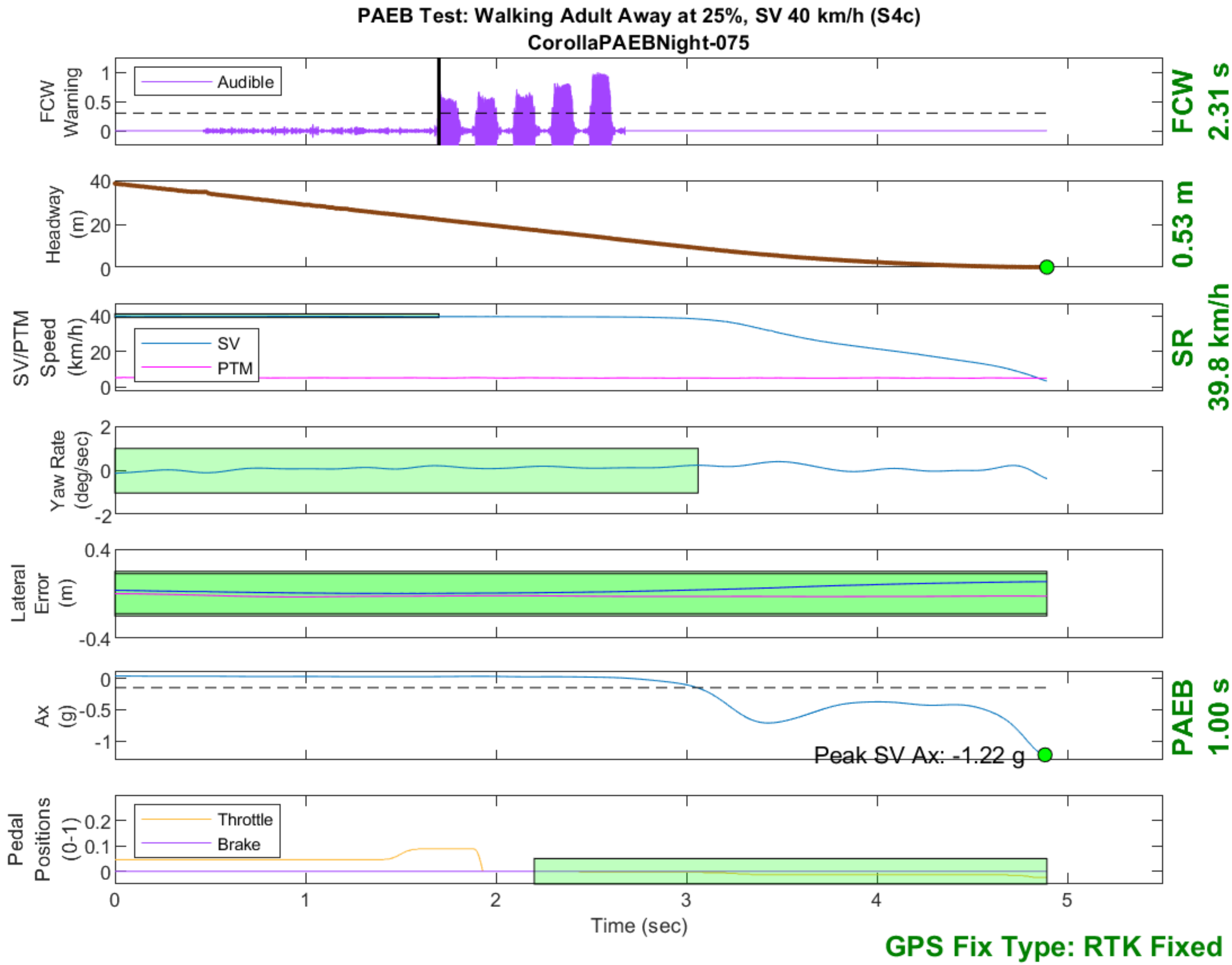


Figure D257. Time History for PAEB Run 75, S4c, Night, High Beam, 40 km/h

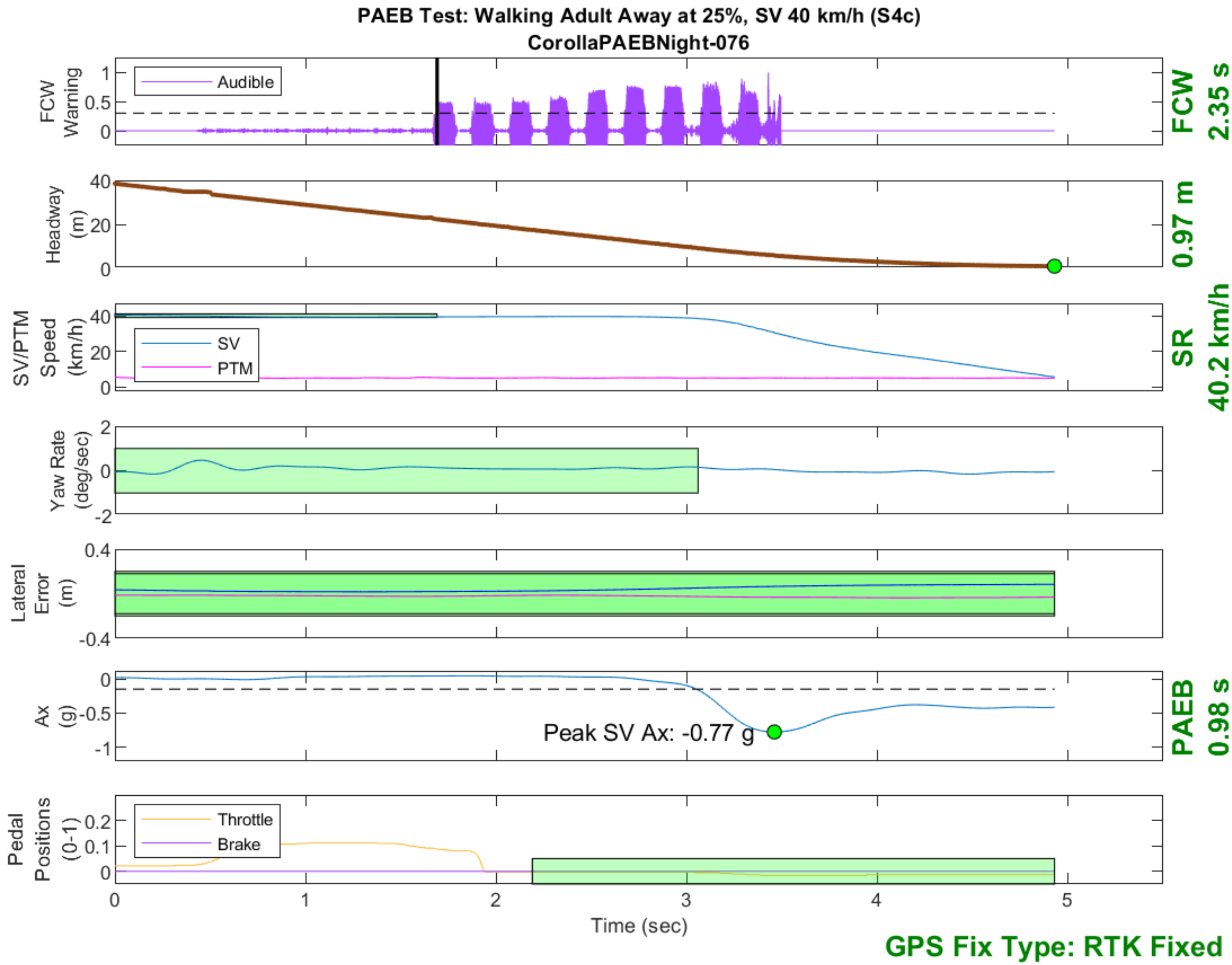


Figure D258. Time History for PAEB Run 76, S4c, Night, High Beam, 40 km/h

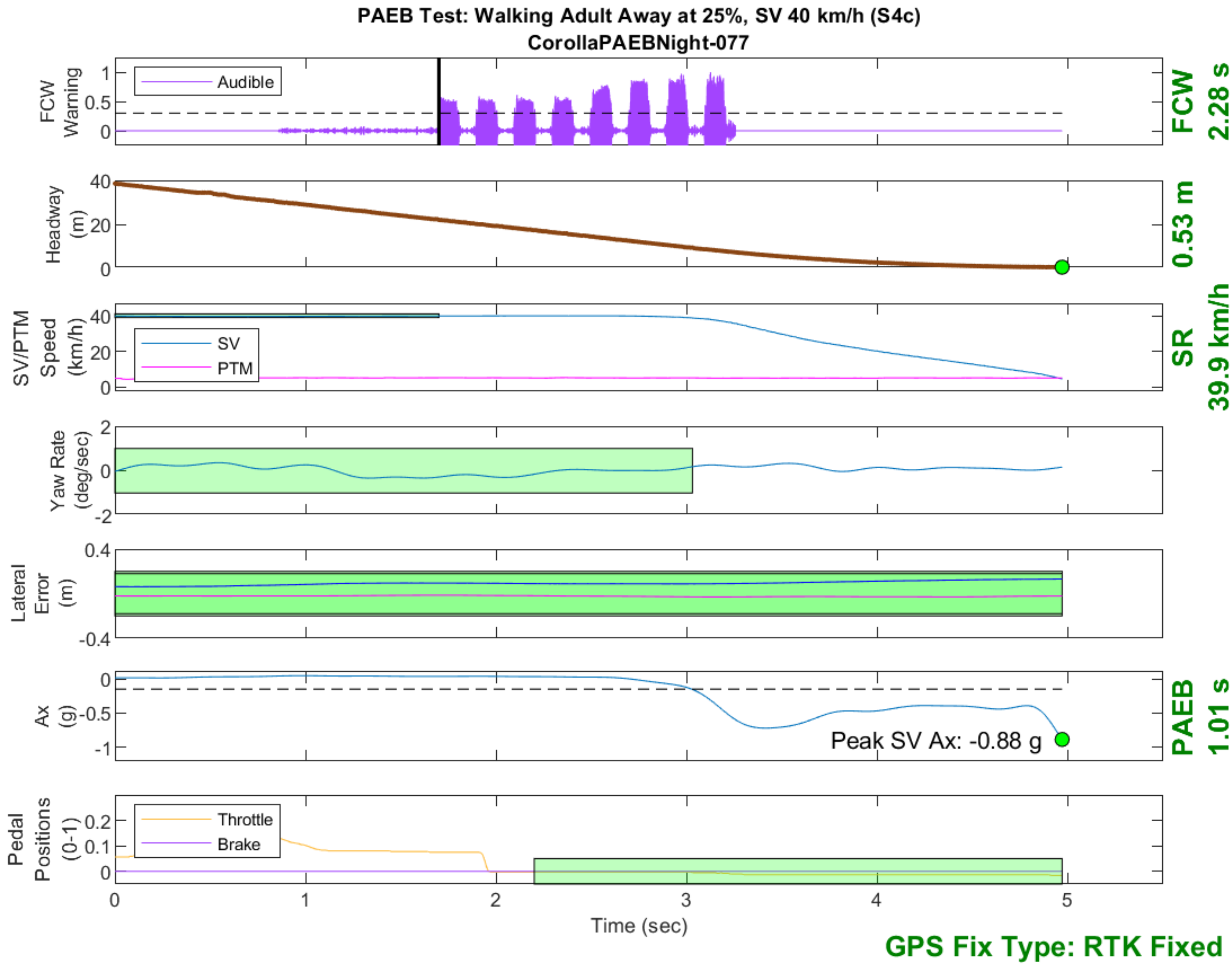


Figure D259. Time History for PAEB Run 77, S4c, Night, High Beam, 40 km/h

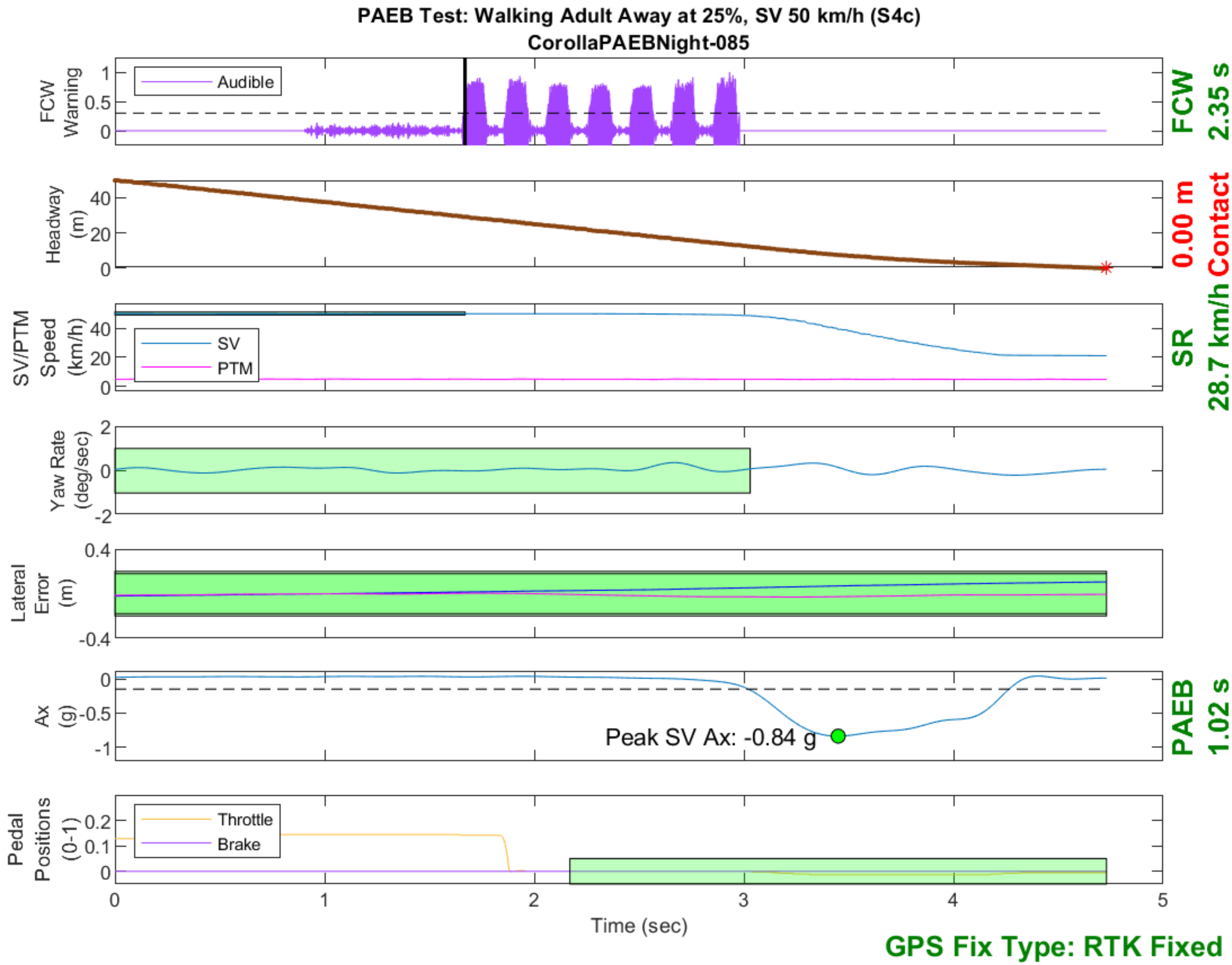


Figure D260. Time History for PAEB Run 85, S4c, Night, High Beam, 50 km/h

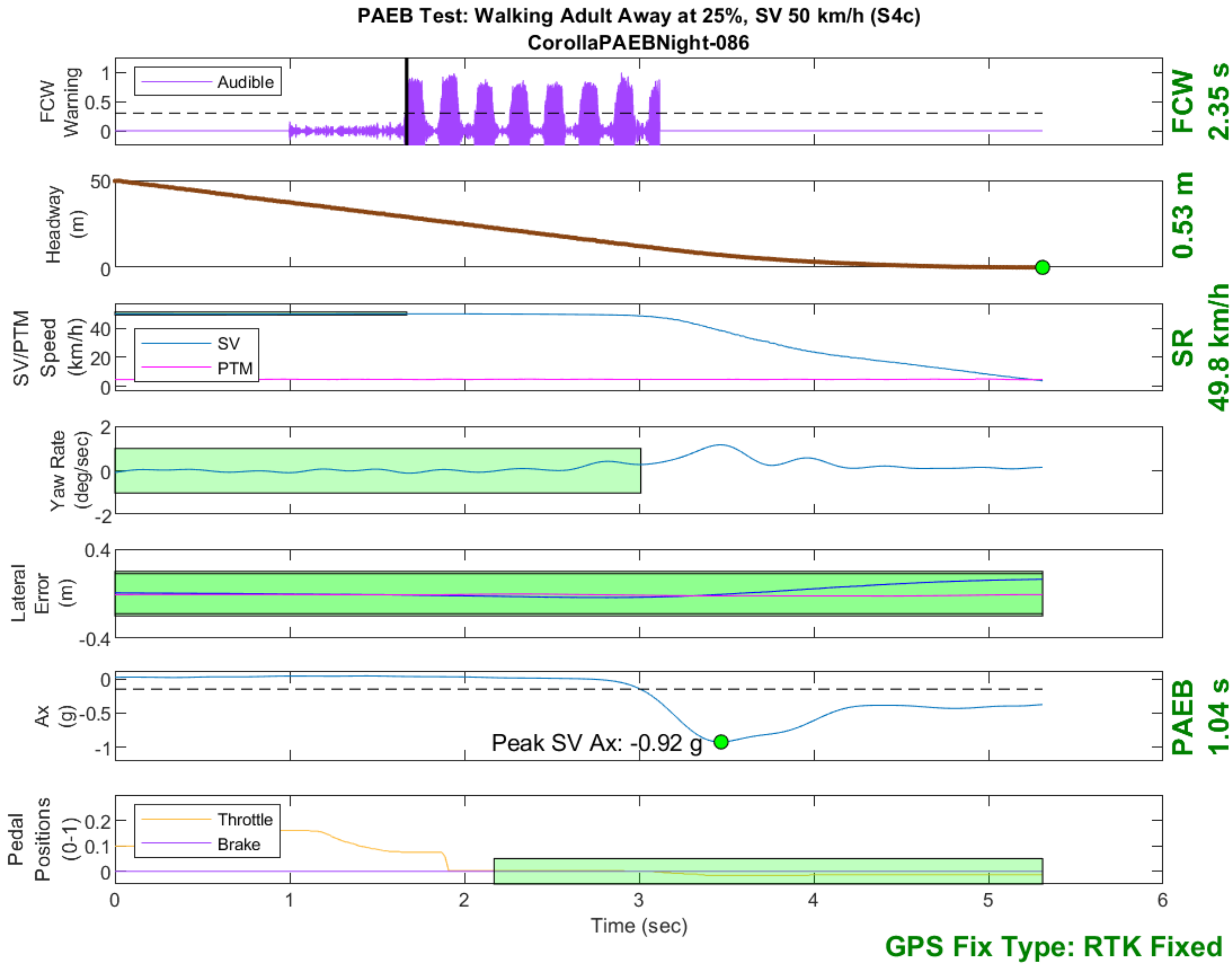


Figure D261. Time History for PAEB Run 86, S4c, Night, High Beam, 50 km/h

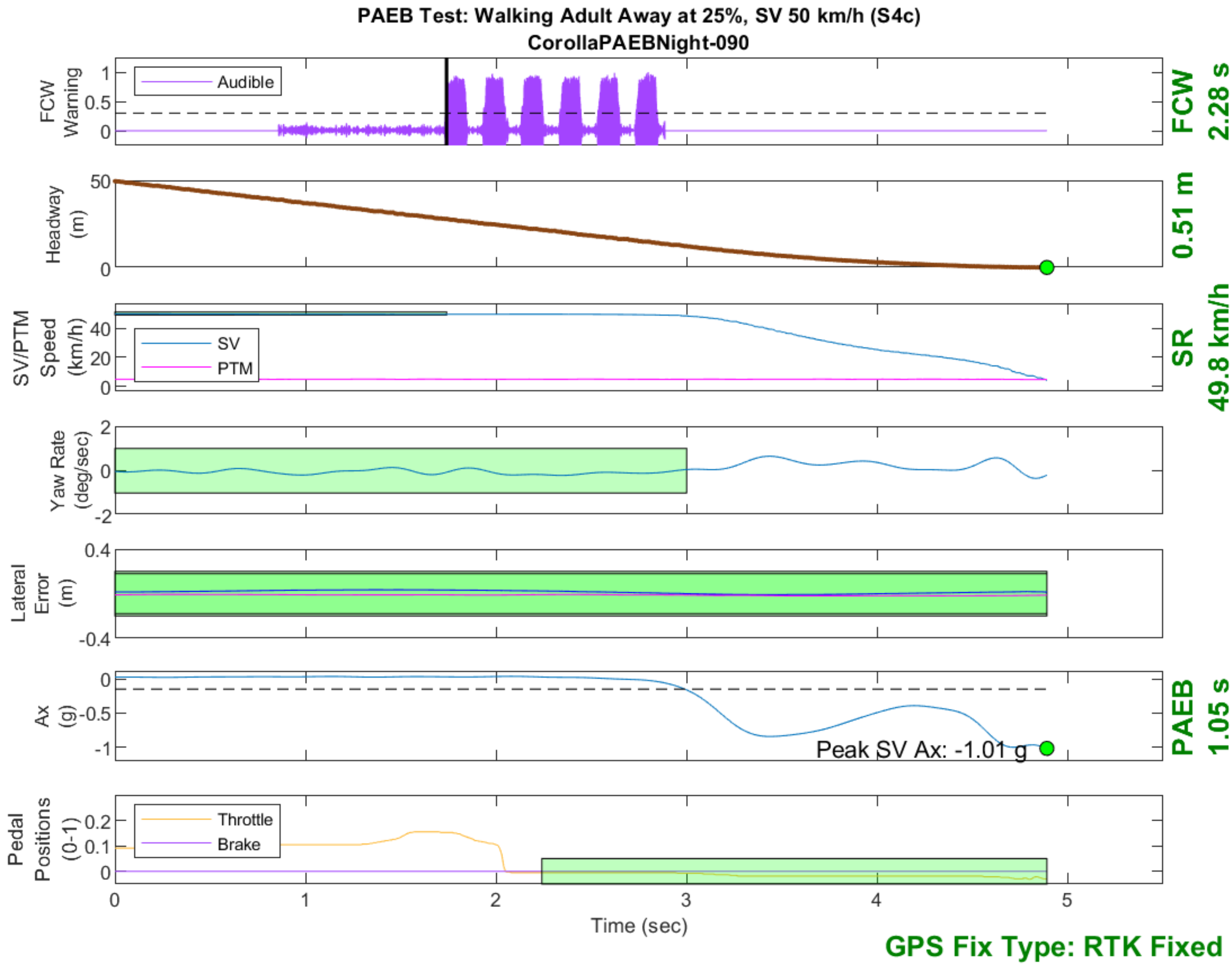


Figure D262. Time History for PAEB Run 90, S4c, Night, High Beam, 50 km/h

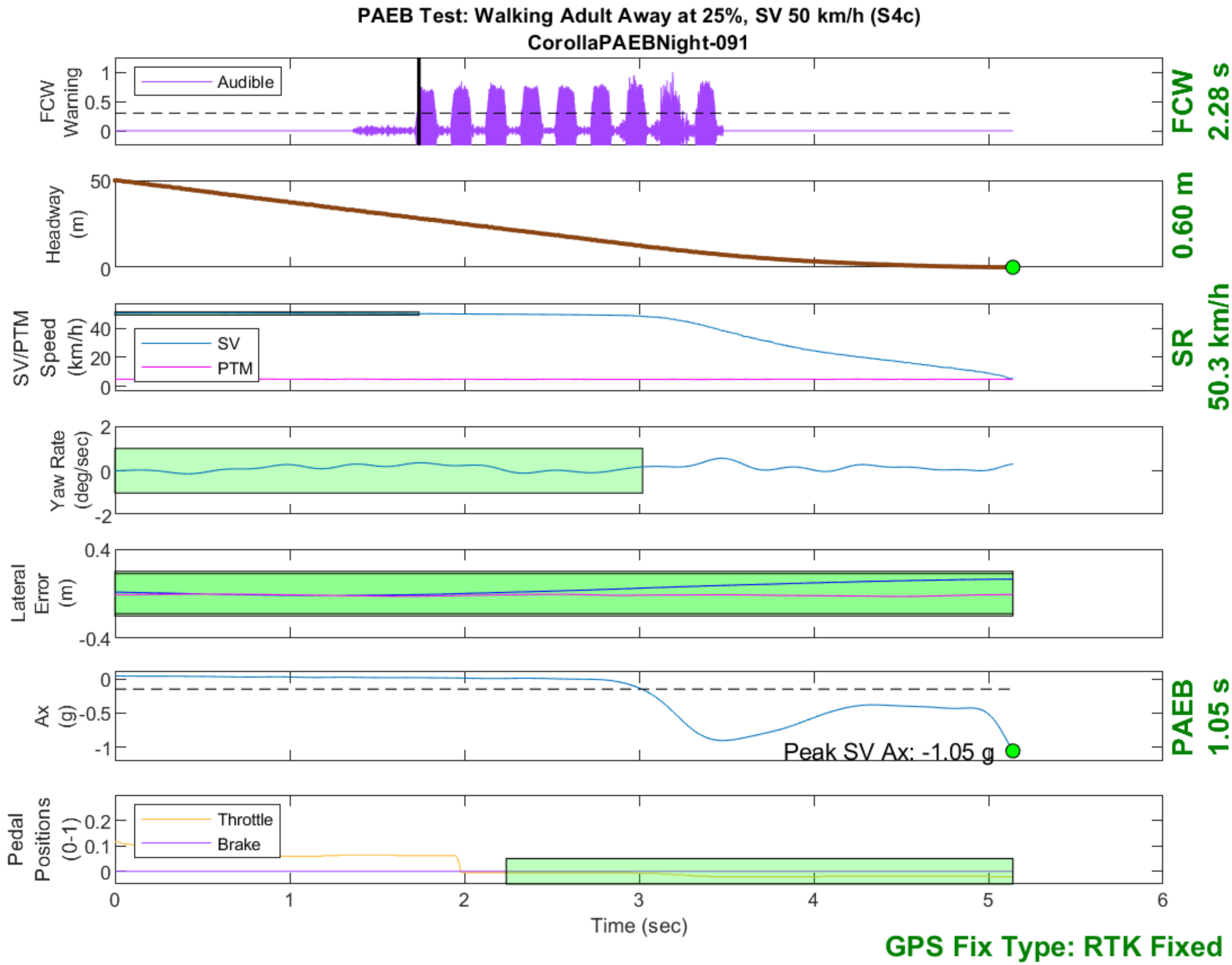


Figure D263. Time History for PAEB Run 91, S4c, Night, High Beam, 50 km/h

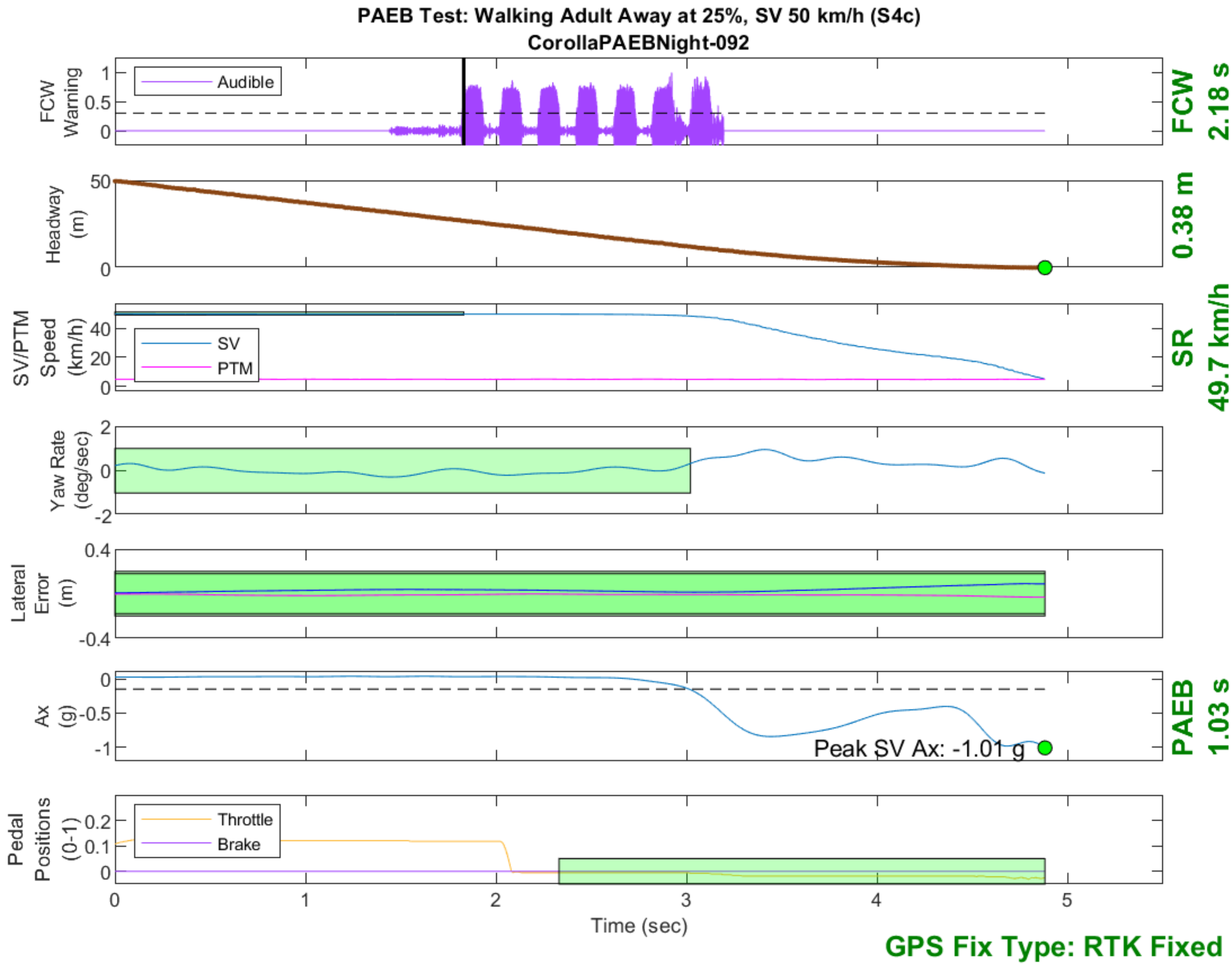


Figure D264. Time History for PAEB Run 92, S4c, Night, High Beam, 50 km/h

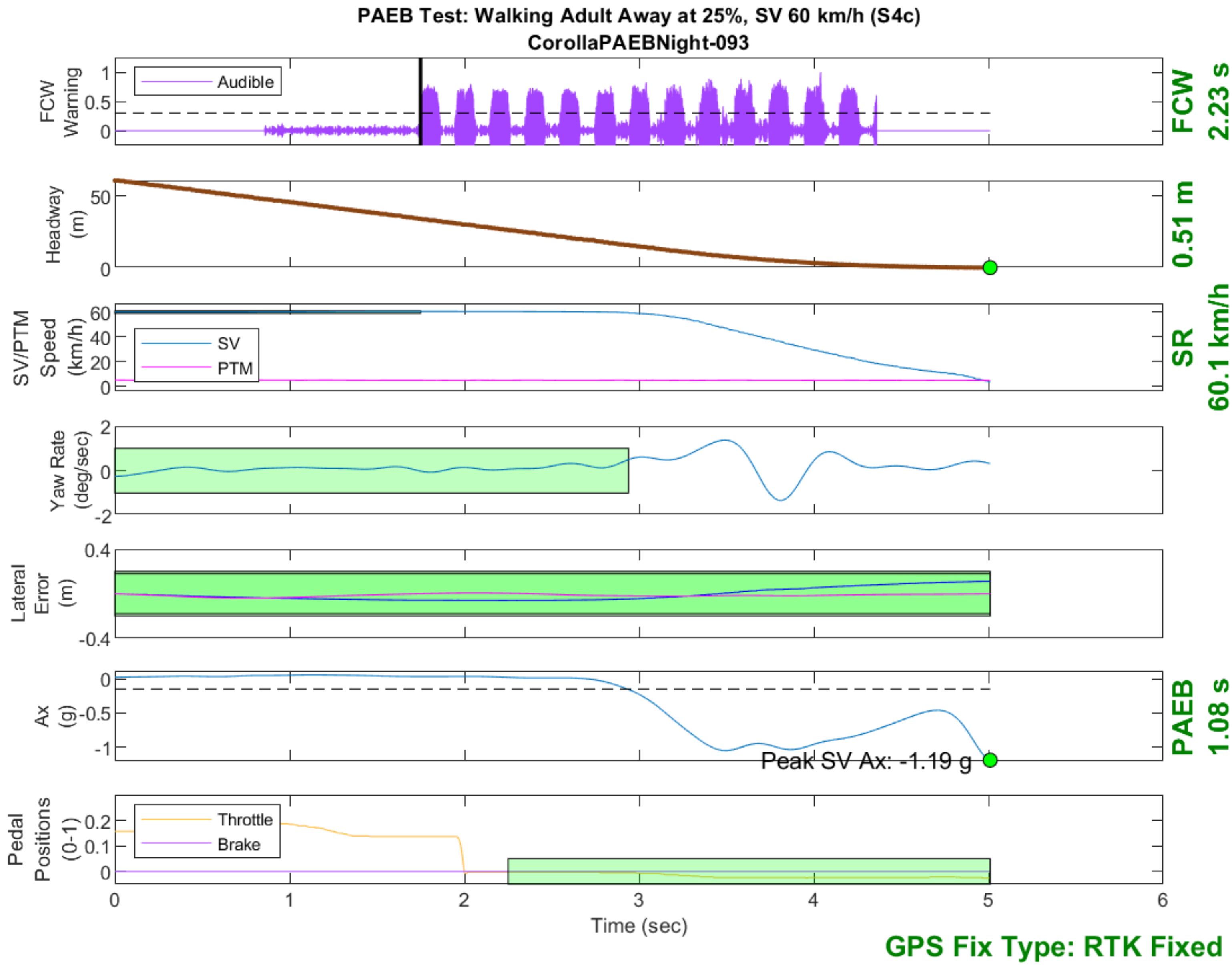


Figure D265. Time History for PAEB Run 93, S4c, Night, High Beam, 60 km/h

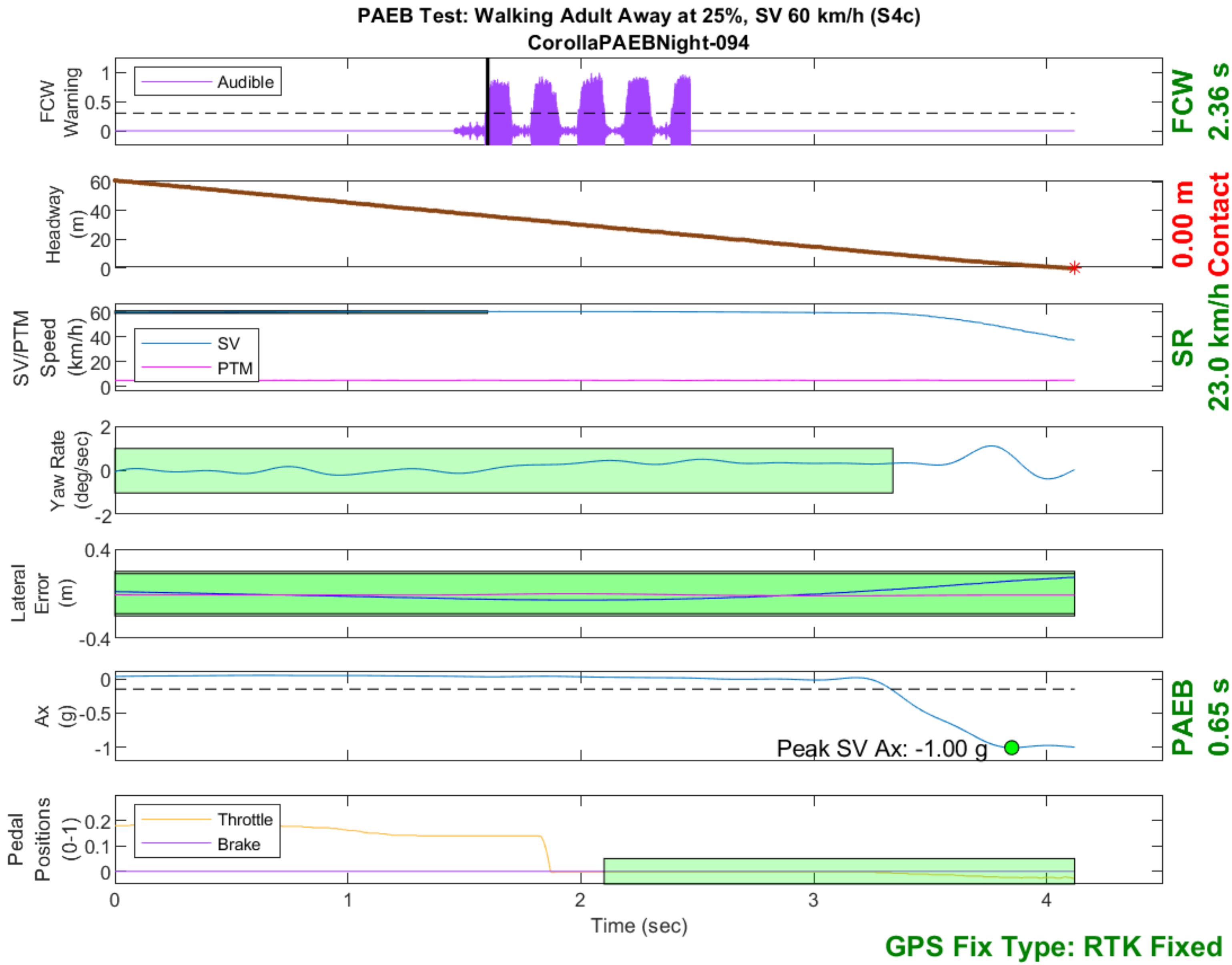


Figure D266. Time History for PAEB Run 94, S4c, Night, High Beam, 60 km/h

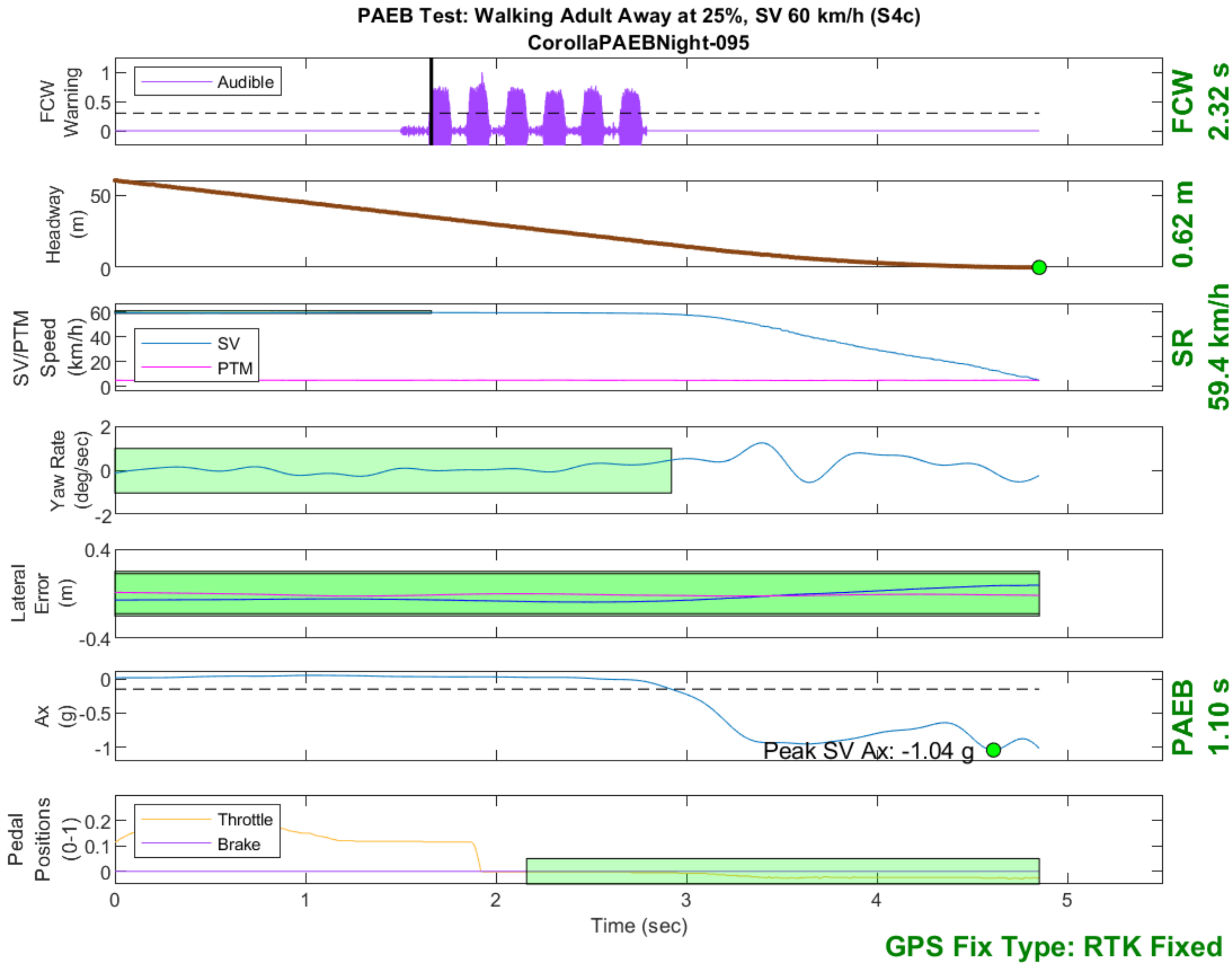


Figure D267. Time History for PAEB Run 95, S4c, Night, High Beam, 60 km/h

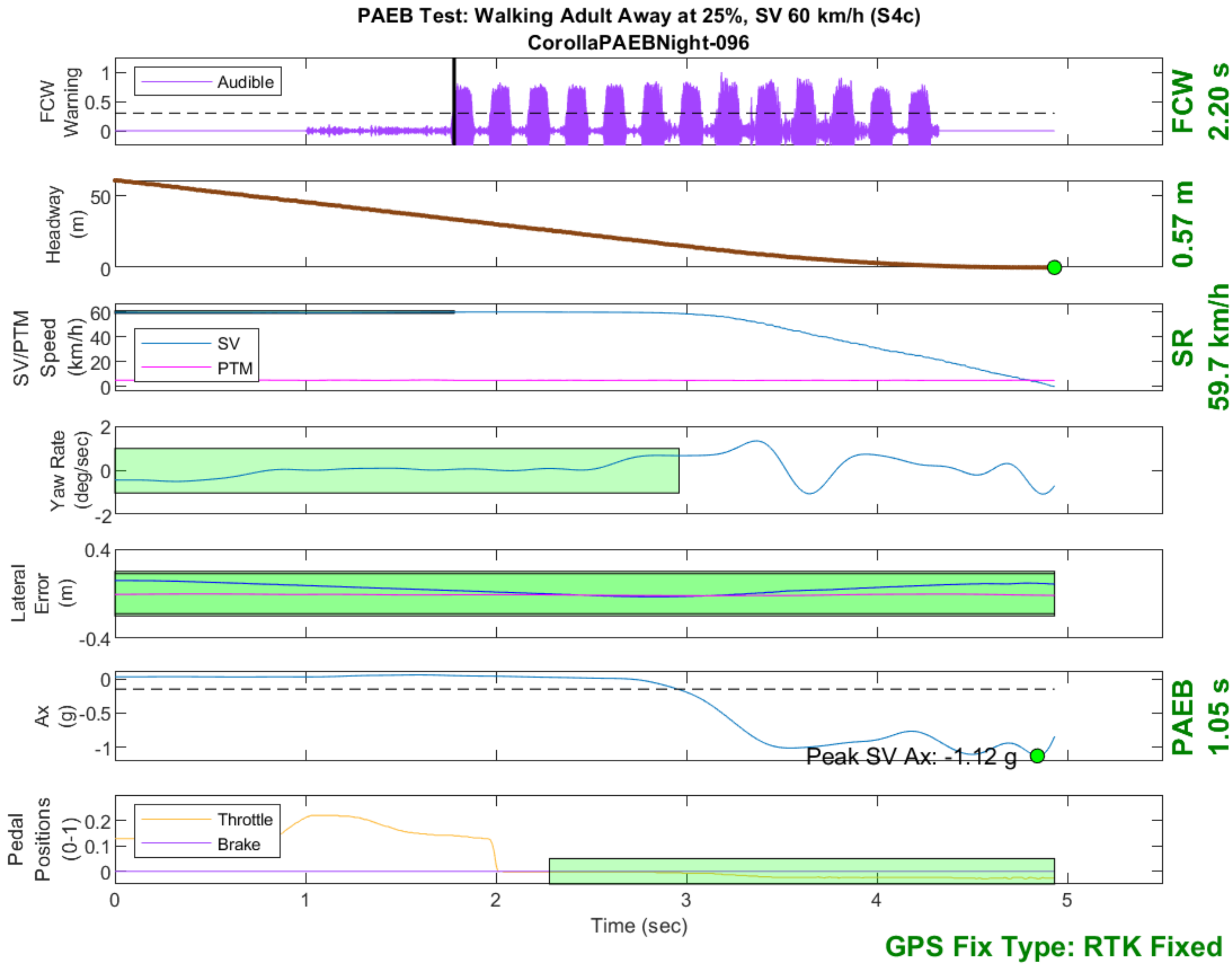


Figure D268. Time History for PAEB Run 96, S4c, Night, High Beam, 60 km/h

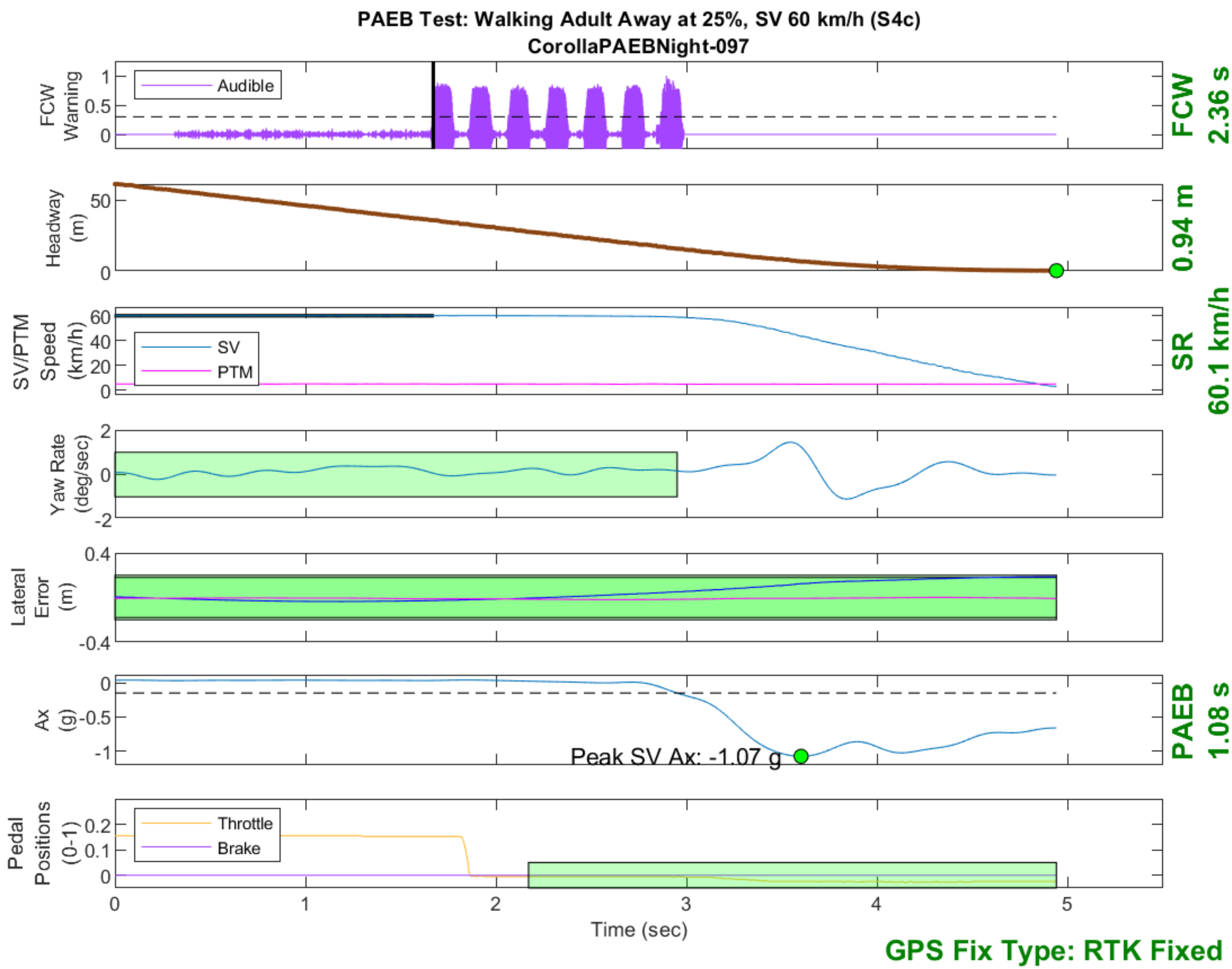


Figure D269. Time History for PAEB Run 97, S4c, Night, High Beam, 60 km/h

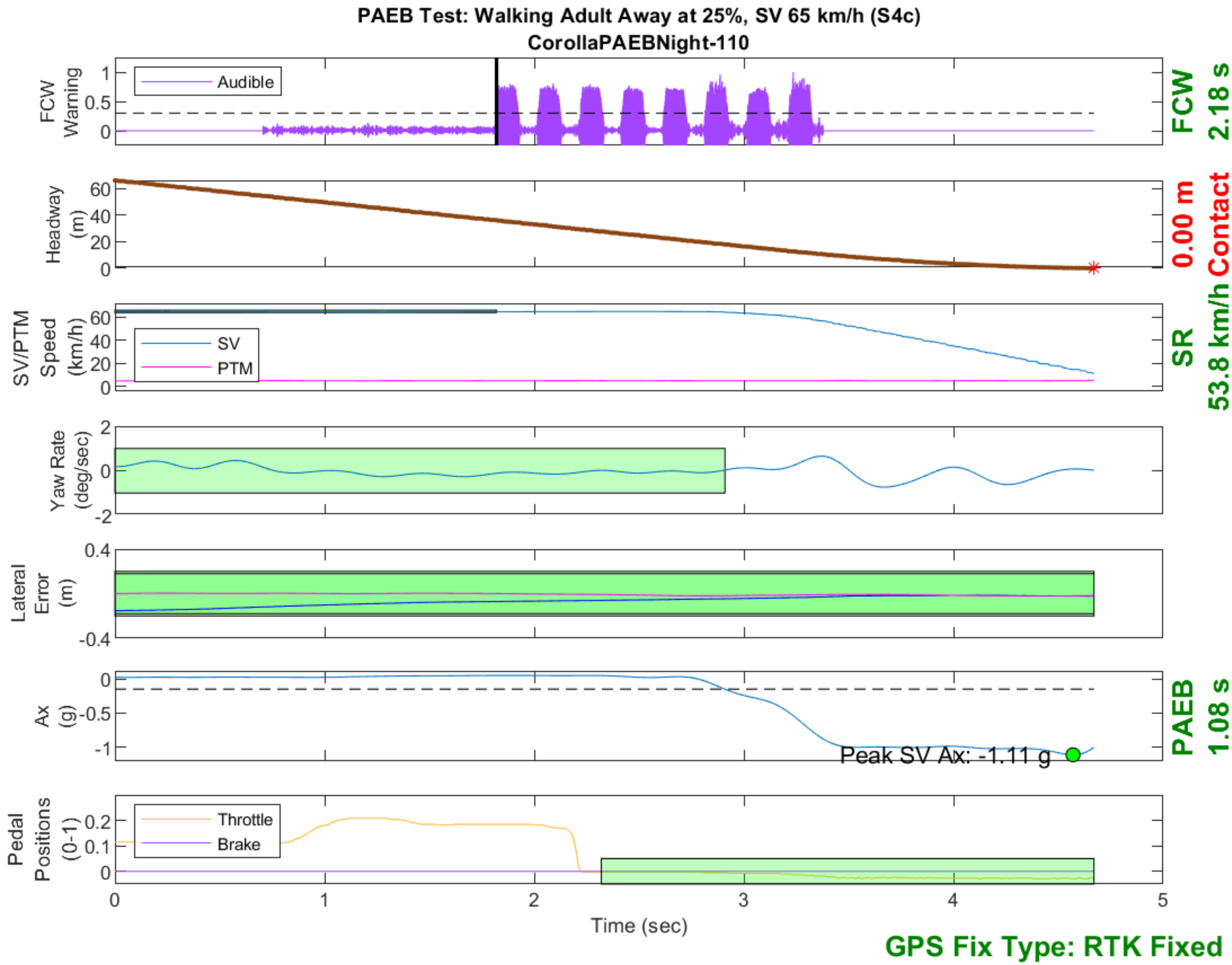


Figure D270. Time History for PAEB Run 110, S4c, Night, High Beam, 65 km/h

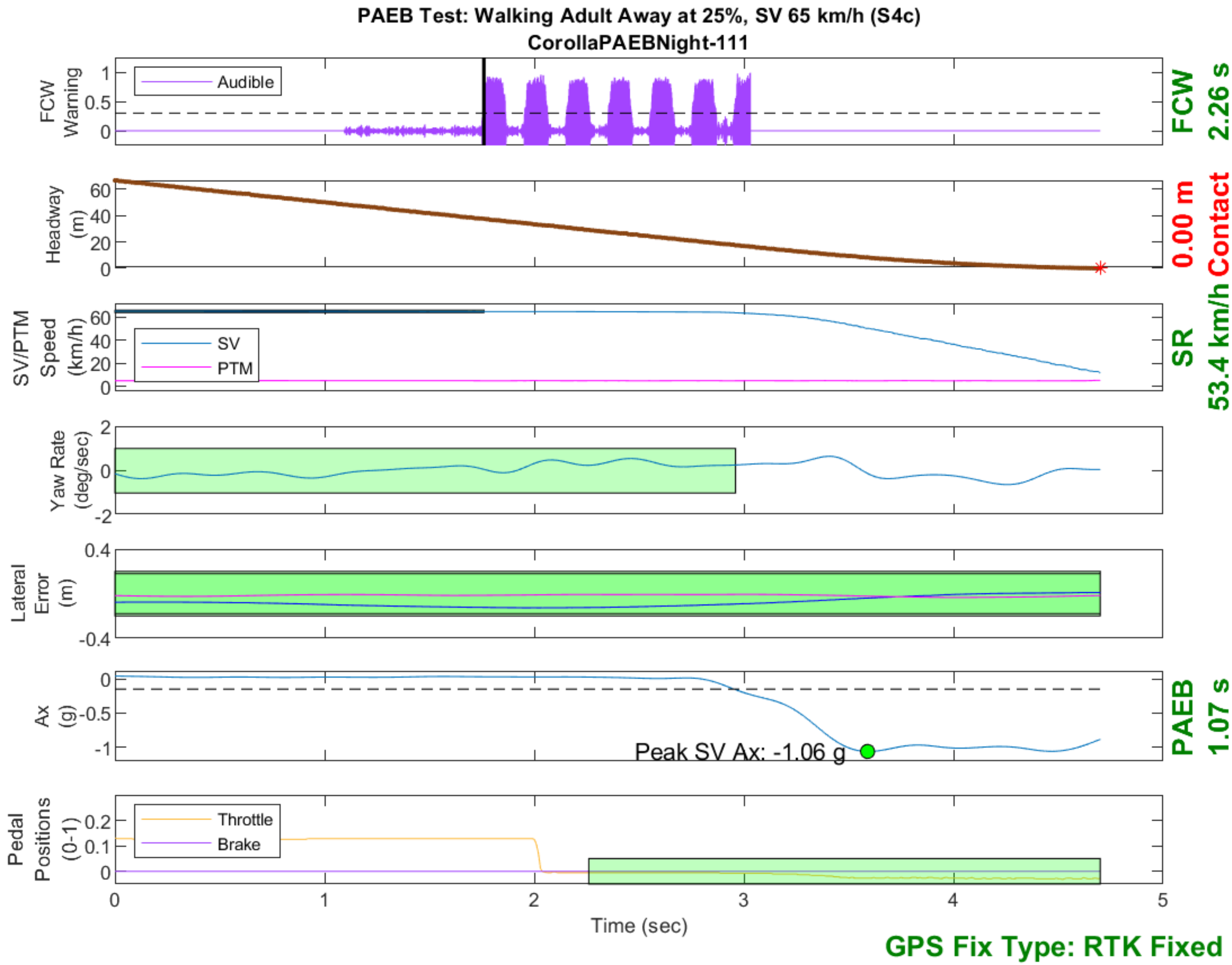


Figure D271. Time History for PAEB Run 111, S4c, Night, High Beam, 65 km/h

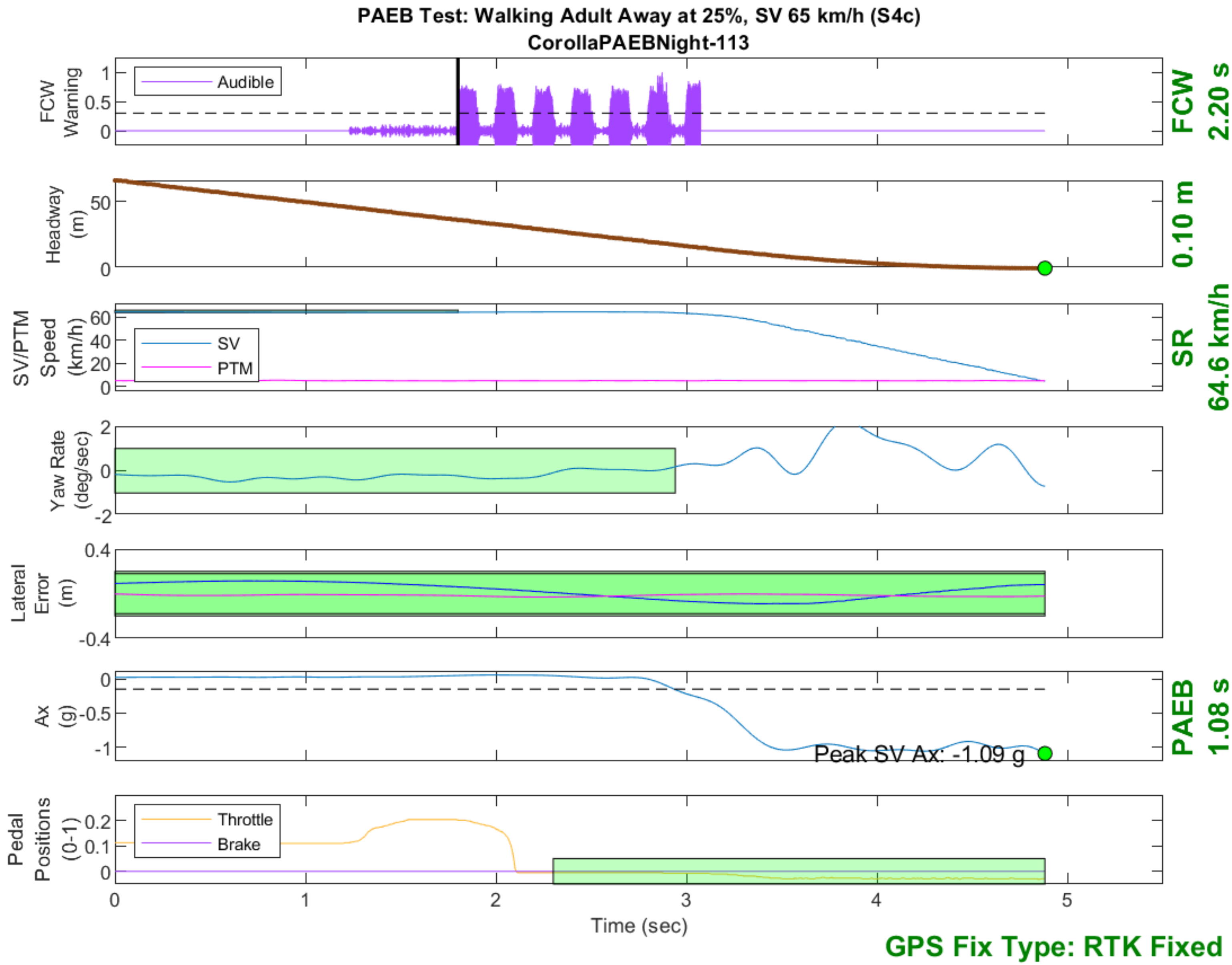


Figure D272. Time History for PAEB Run 113, S4c, Night, High Beam, 65 km/h

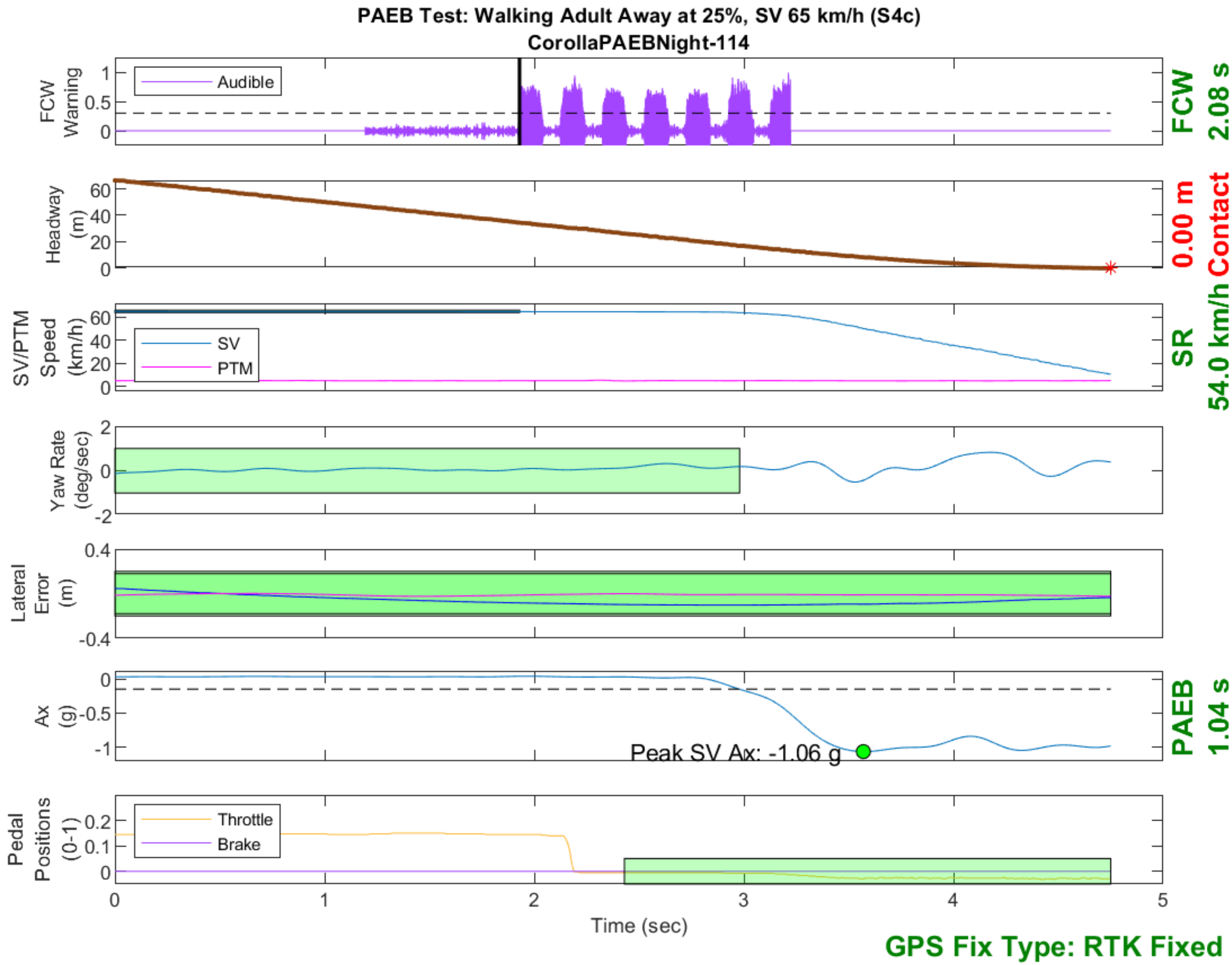


Figure D273. Time History for PAEB Run 114, S4c, Night, High Beam, 65 km/h

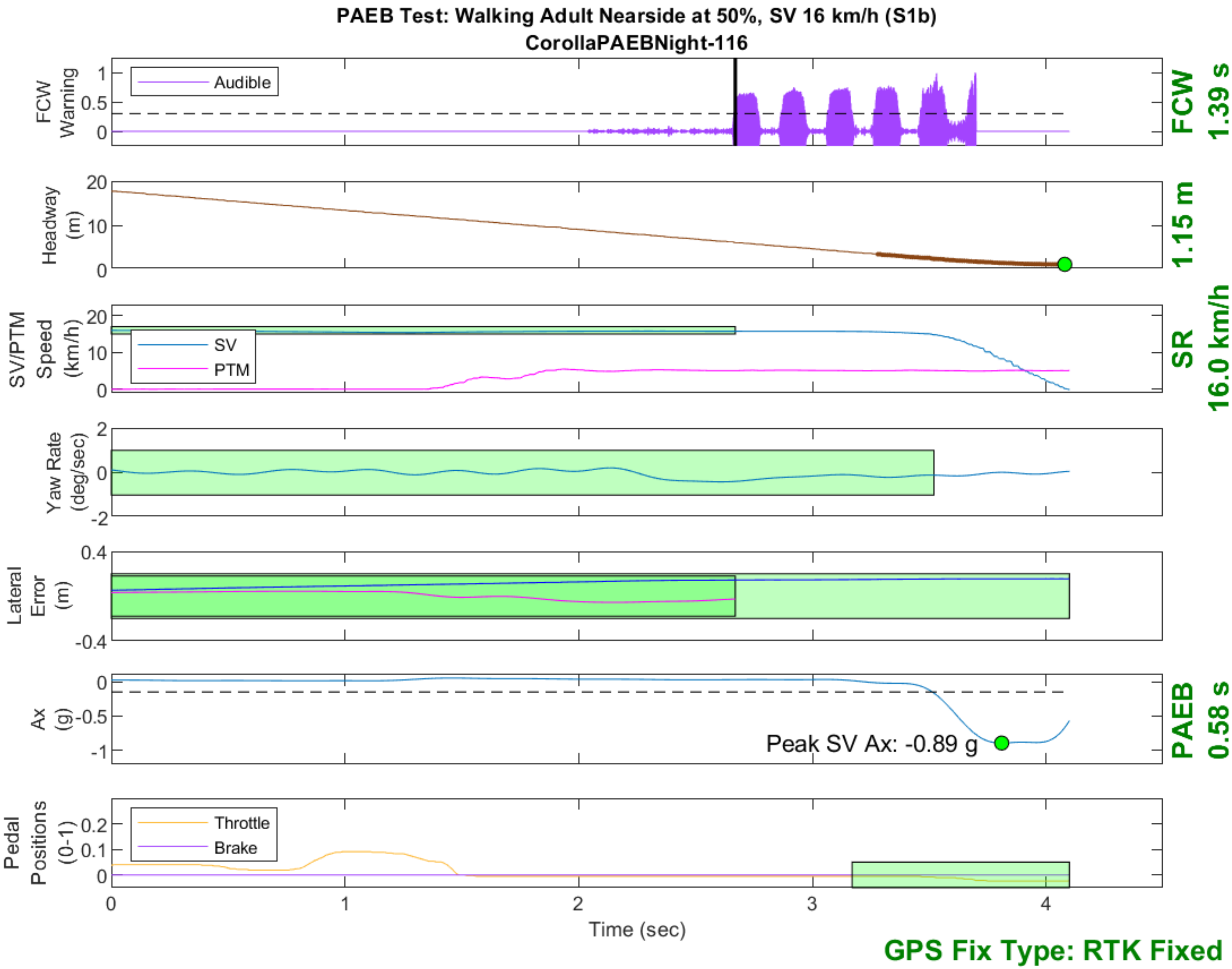


Figure D274. Time History for PAEB Run 116, S1b, Night, Low Beam, 16 km/h

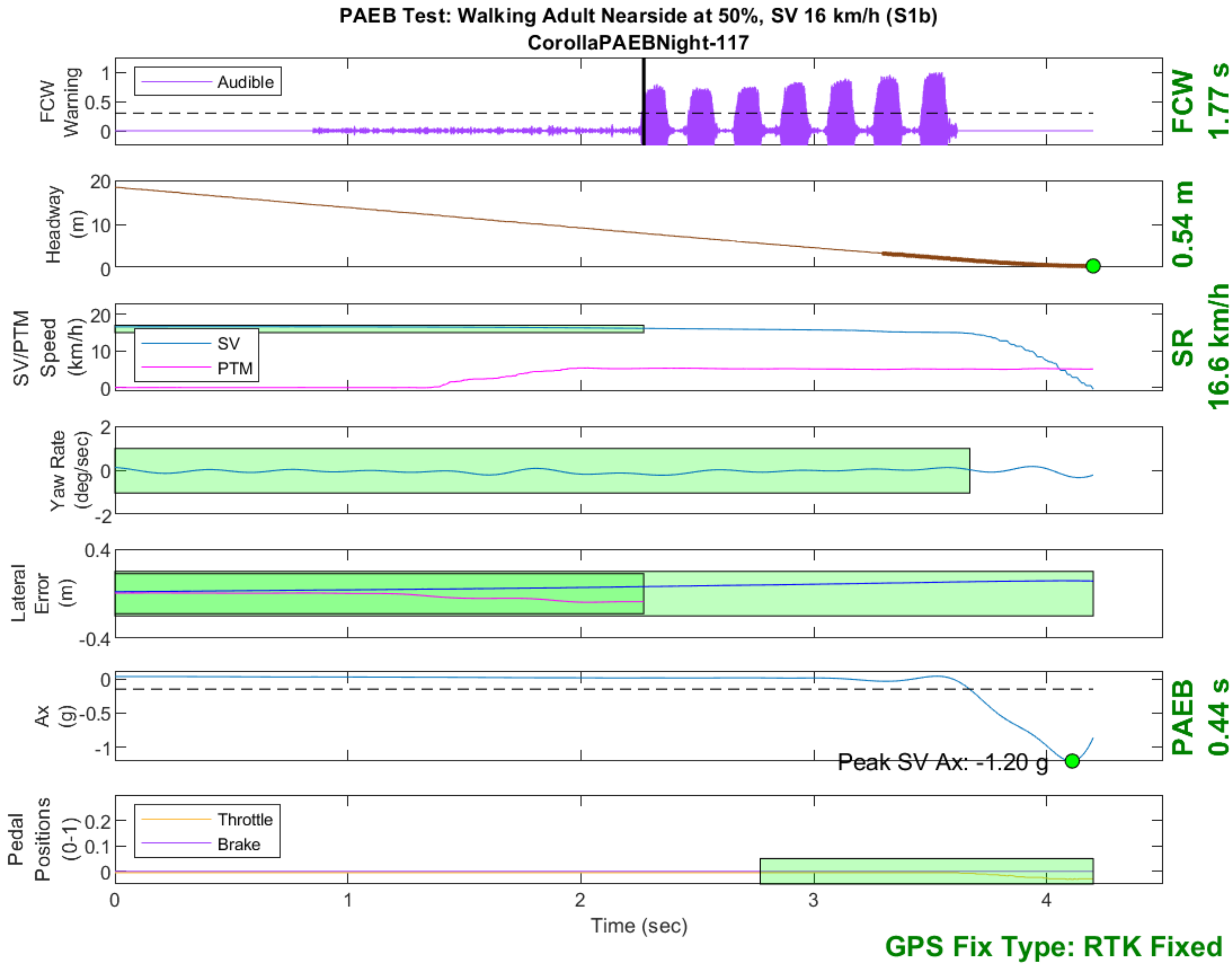


Figure D275. Time History for PAEB Run 117, S1b, Night, Low Beam, 16 km/h

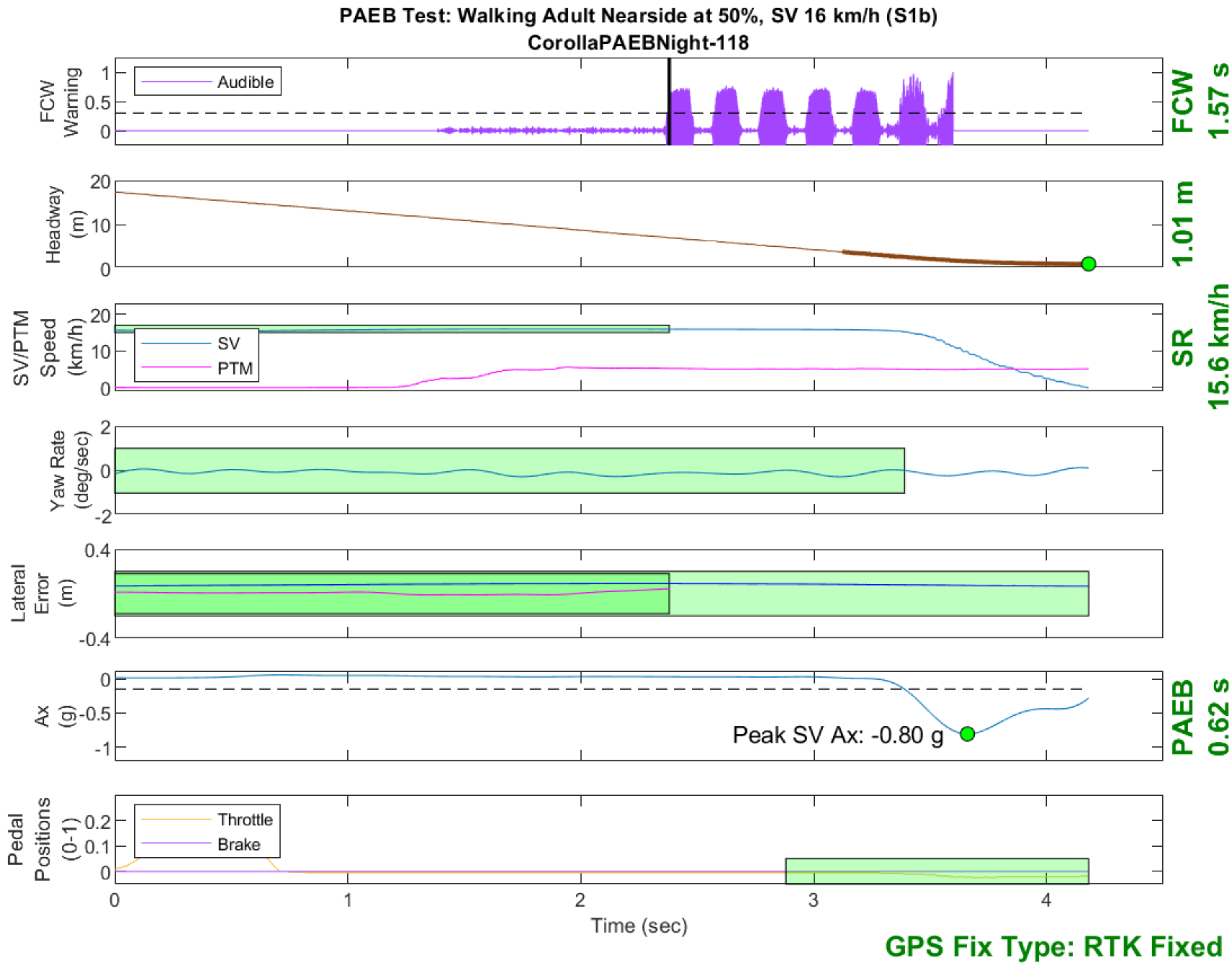


Figure D276. Time History for PAEB Run 118, S1b, Night, Low Beam, 16 km/h

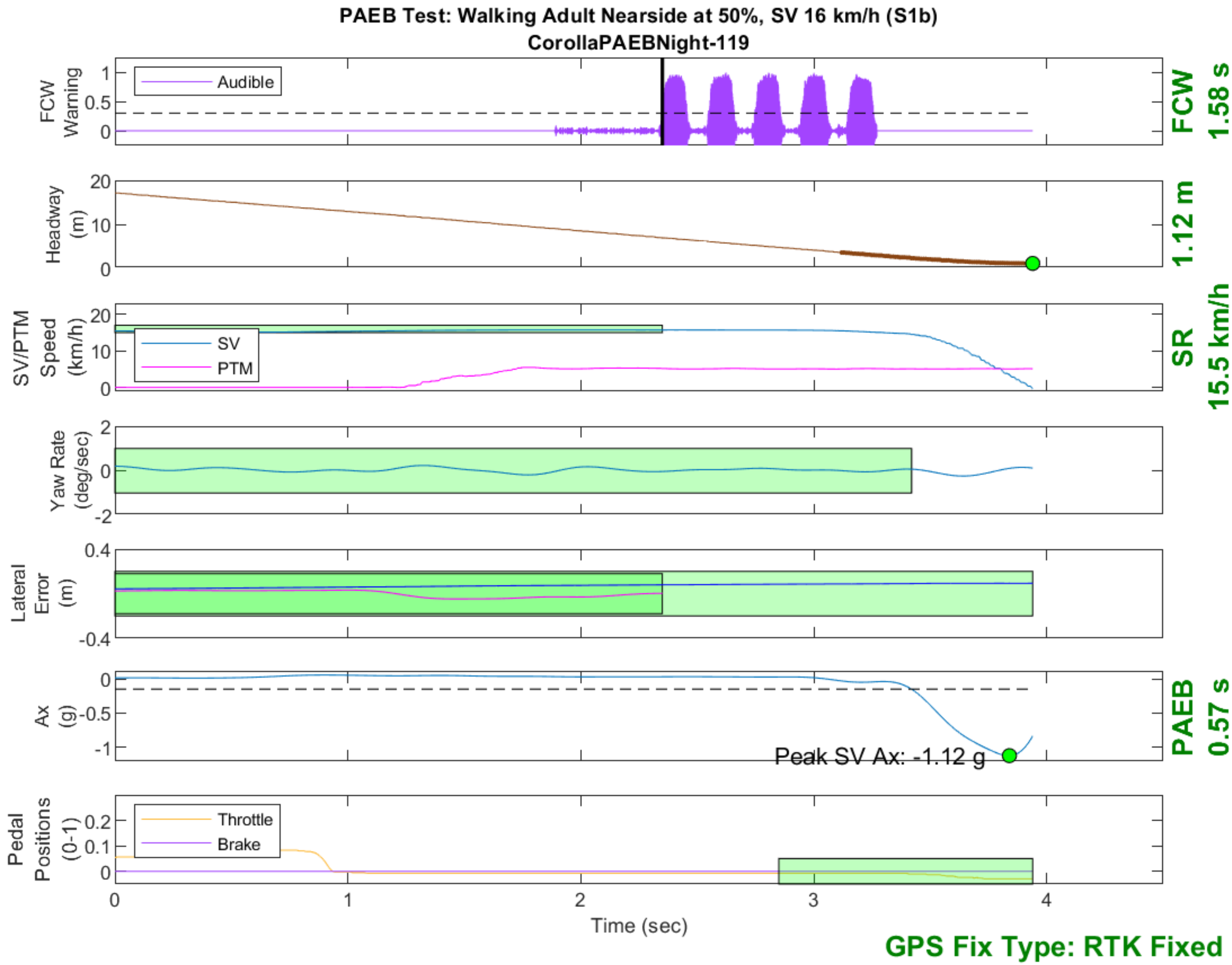


Figure D277. Time History for PAEB Run 119, S1b, Night, Low Beam, 16 km/h

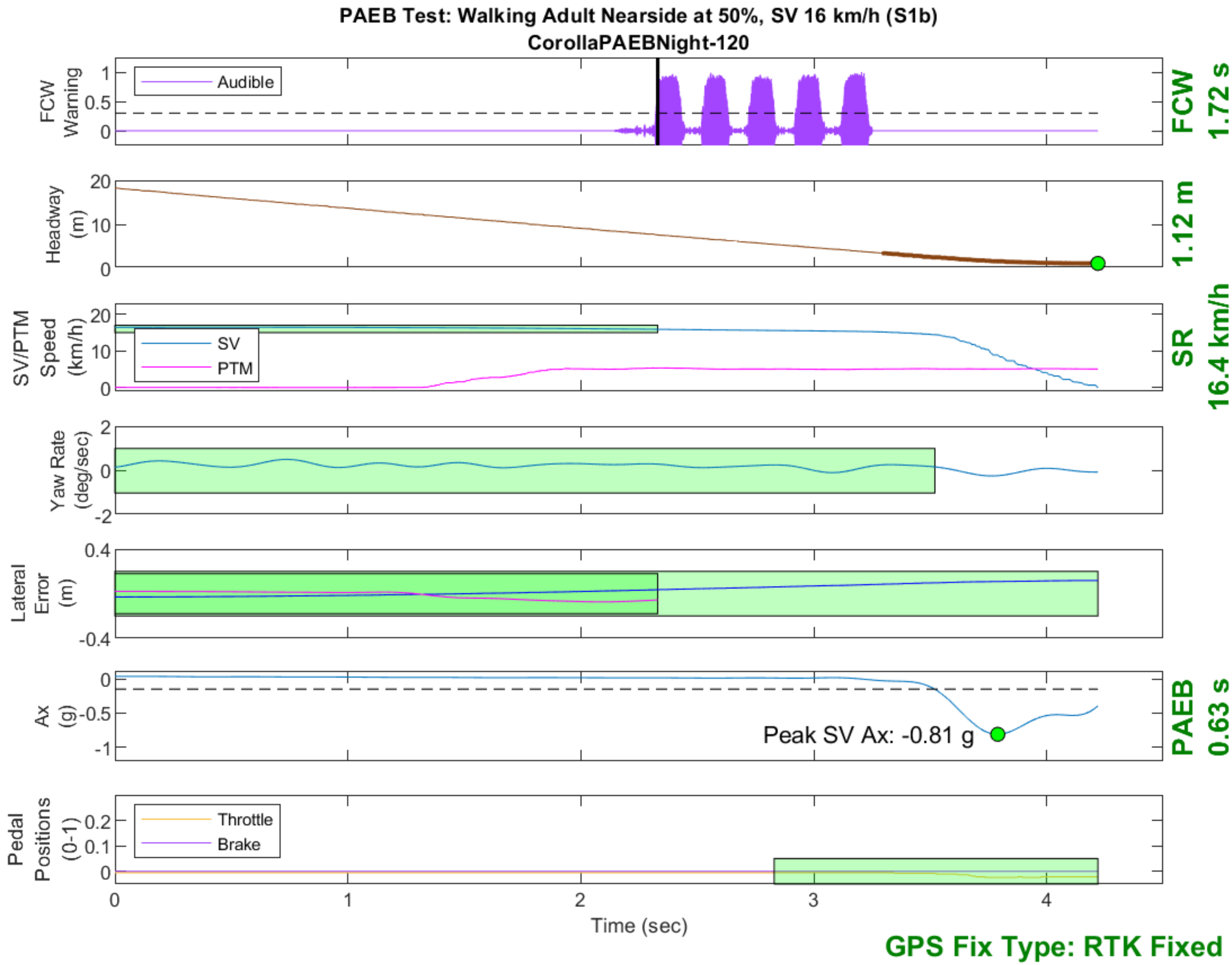


Figure D278. Time History for PAEB Run 120, S1b, Night, Low Beam, 16 km/h

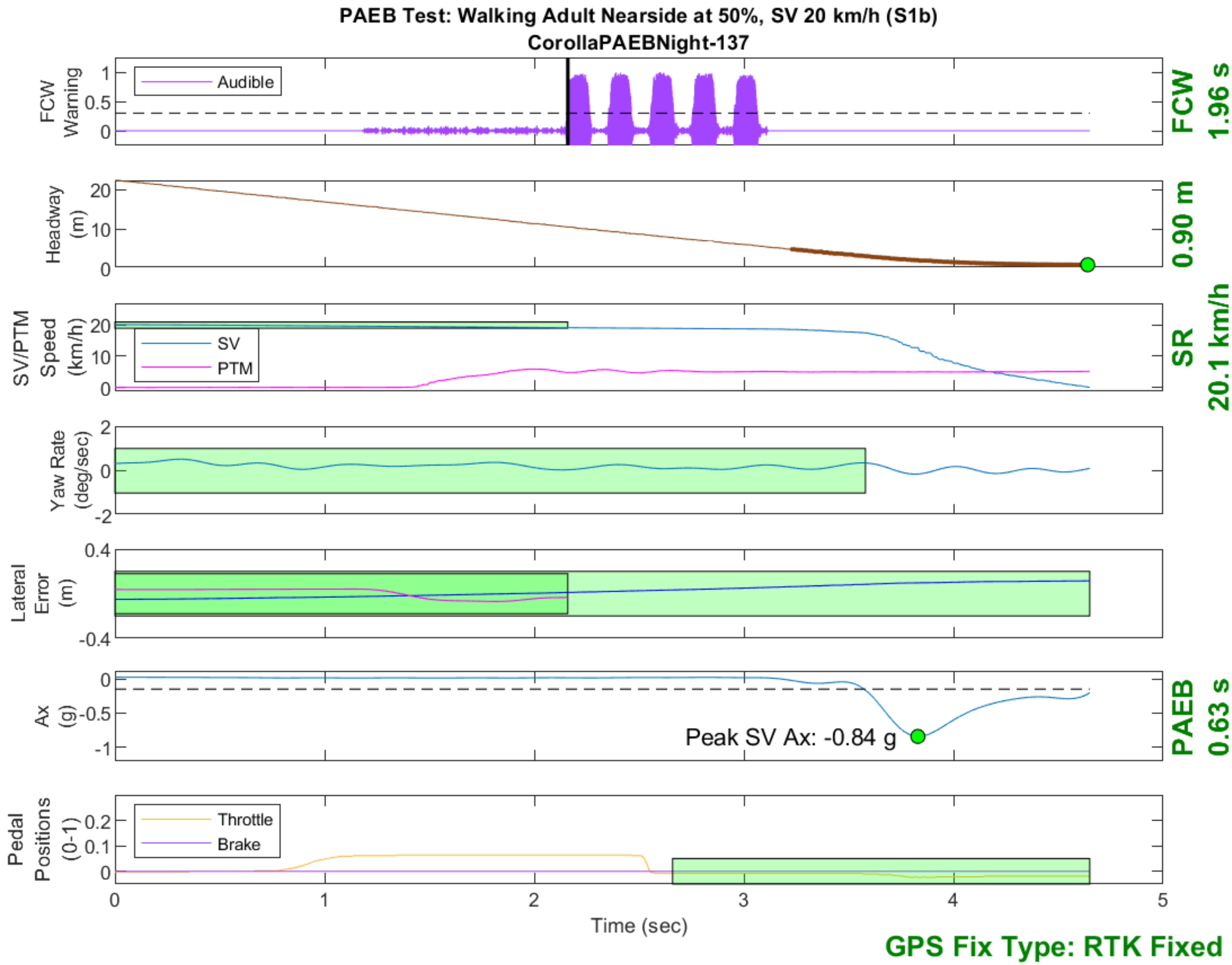


Figure D279. Time History for PAEB Run 137, S1b, Night, Low Beam, 20 km/h

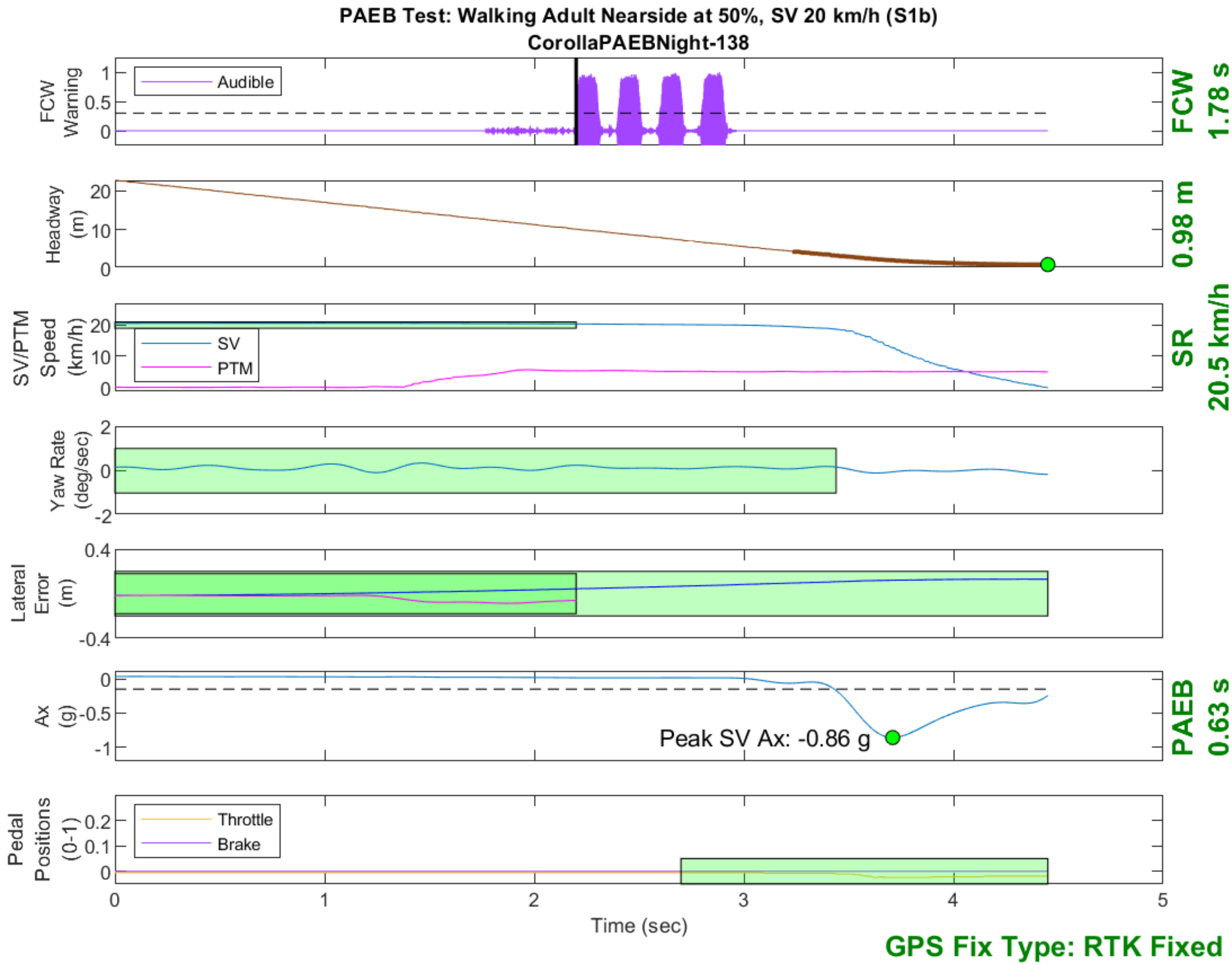


Figure D280. Time History for PAEB Run 138, S1b, Night, Low Beam, 20 km/h

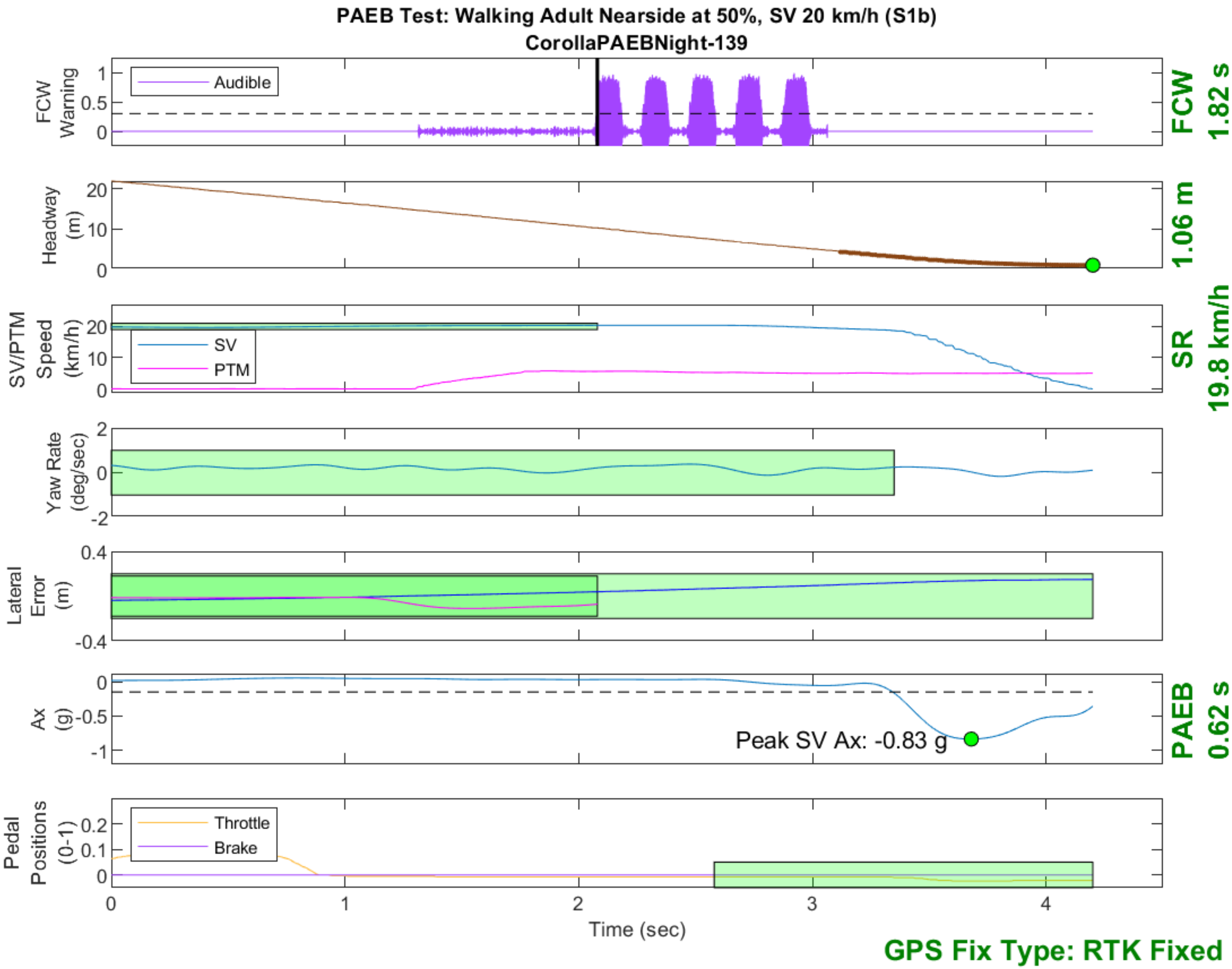


Figure D281. Time History for PAEB Run 139, S1b, Night, Low Beam, 20 km/h

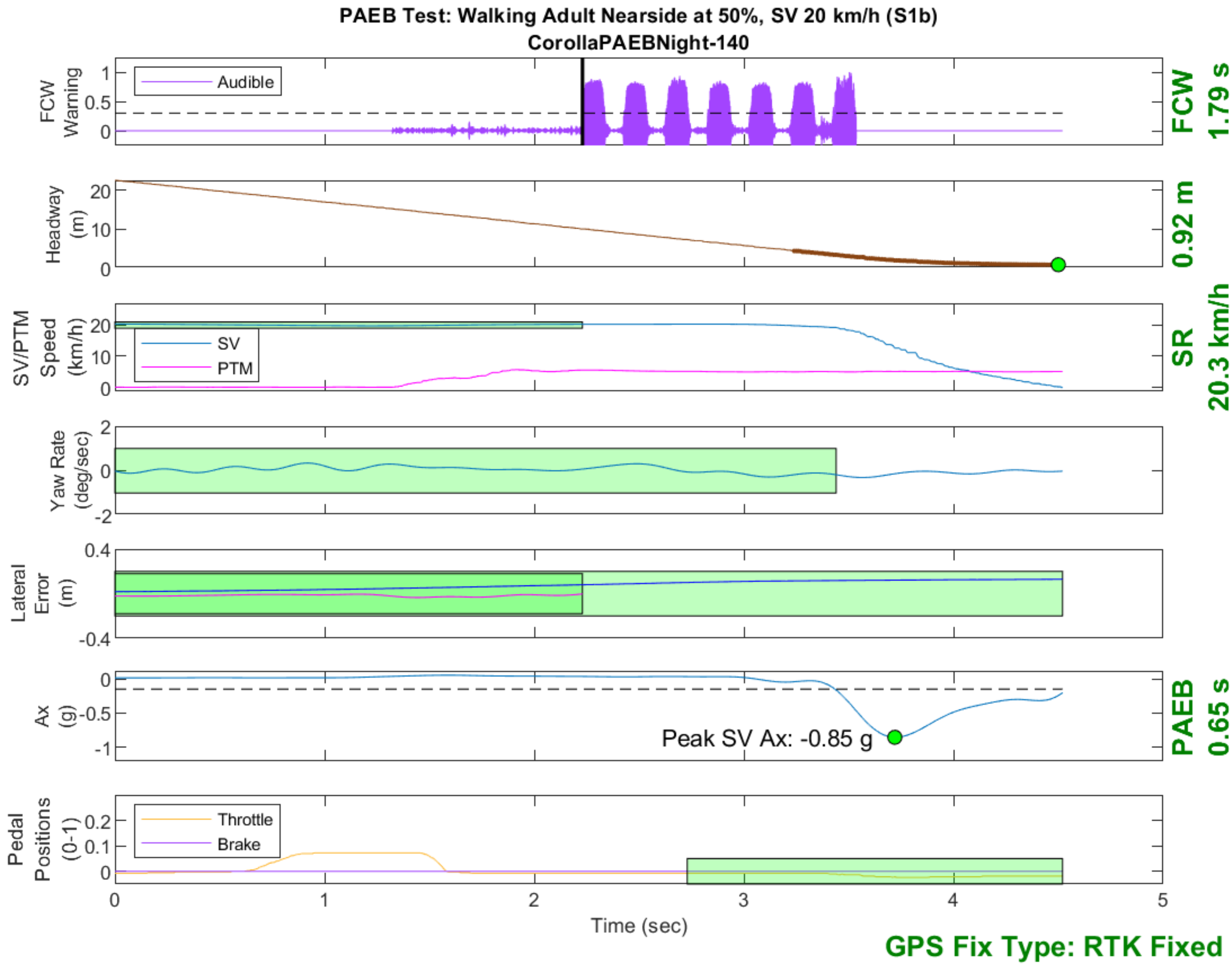


Figure D282. Time History for PAEB Run 140, S1b, Night, Low Beam, 20 km/h

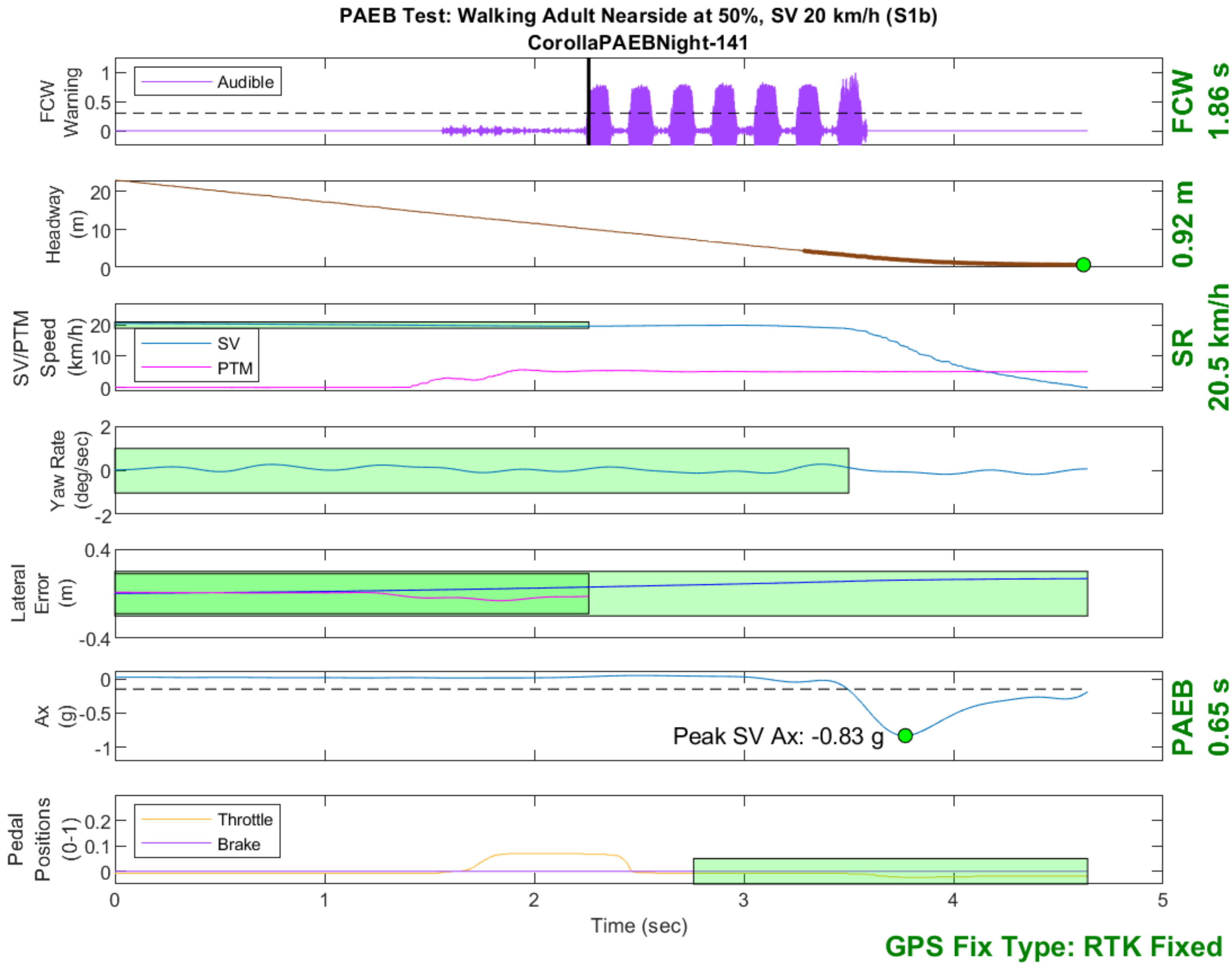


Figure D283. Time History for PAEB Run 141, S1b, Night, Low Beam, 20 km/h

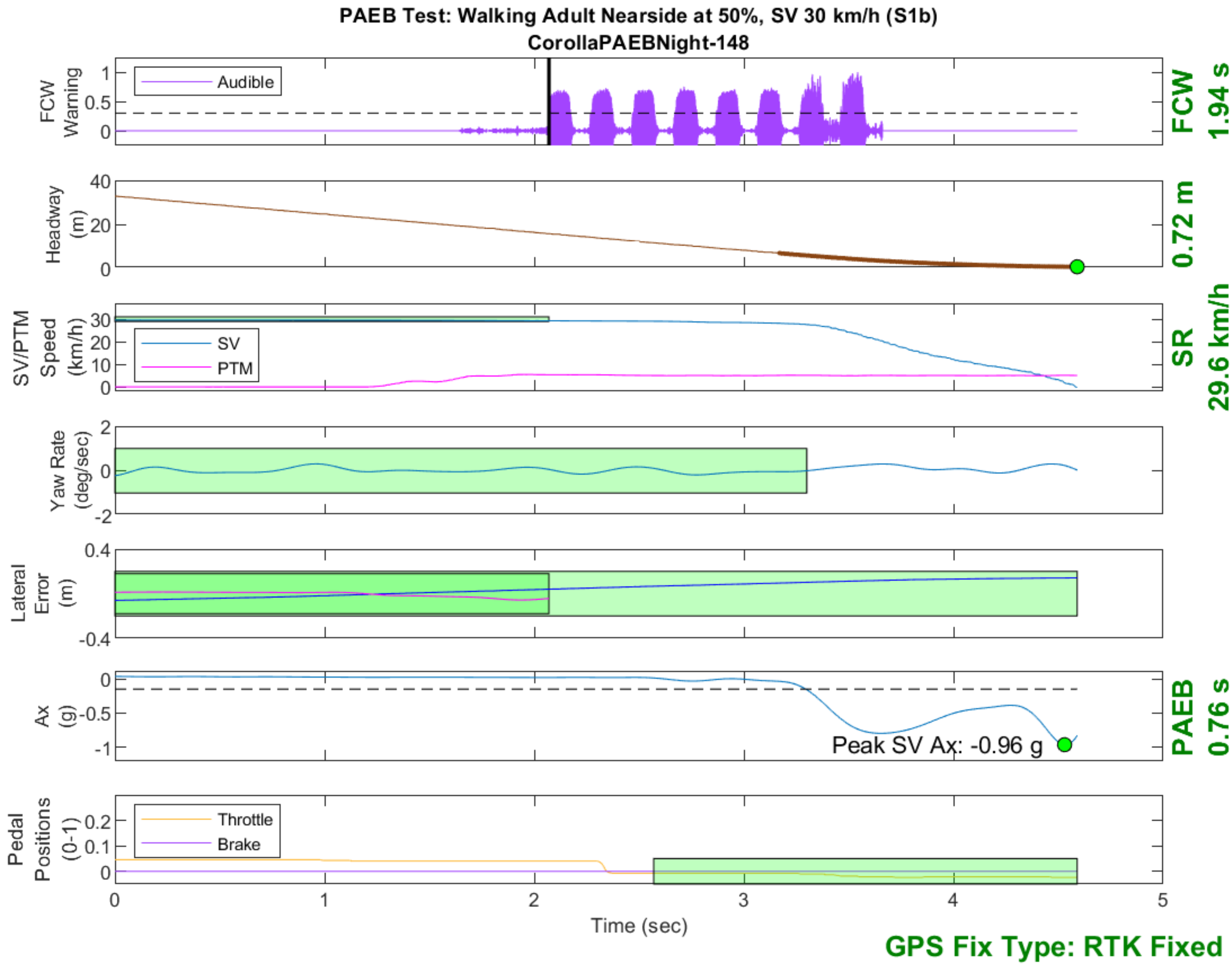


Figure D284. Time History for PAEB Run 148, S1b, Night, Low Beam, 30 km/h

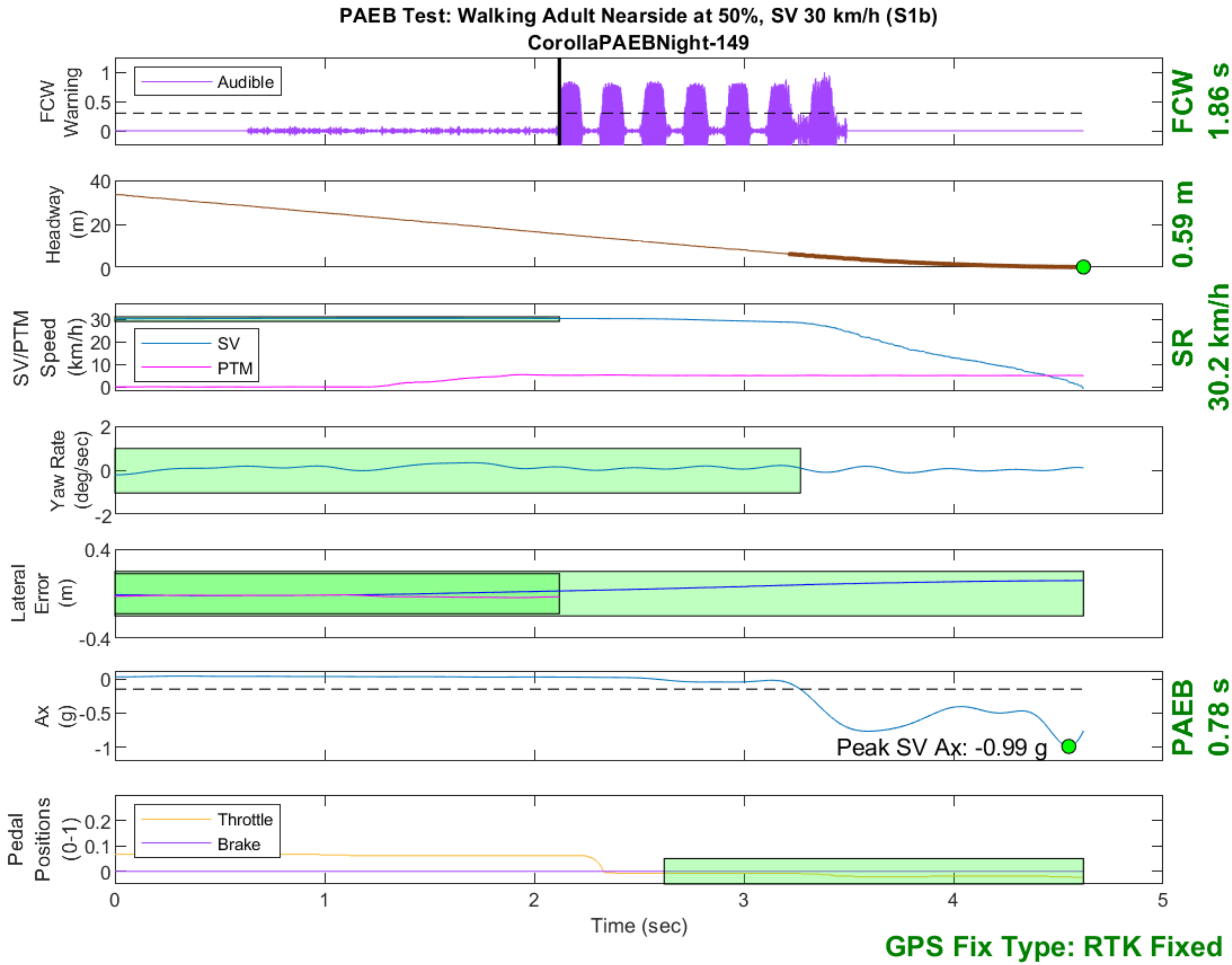


Figure D285. Time History for PAEB Run 149, S1b, Night, Low Beam, 30 km/h

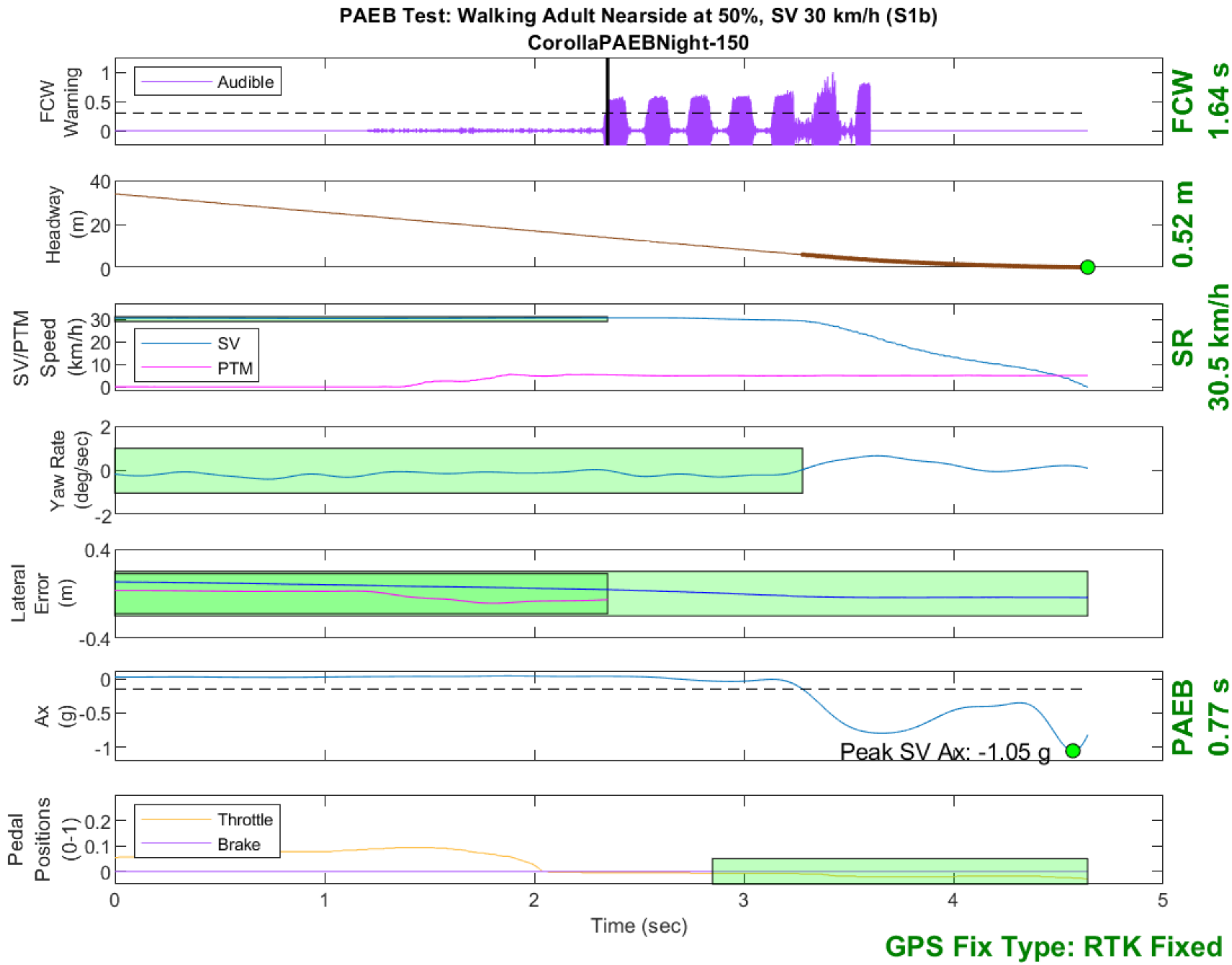


Figure D286. Time History for PAEB Run 150, S1b, Night, Low Beam, 30 km/h

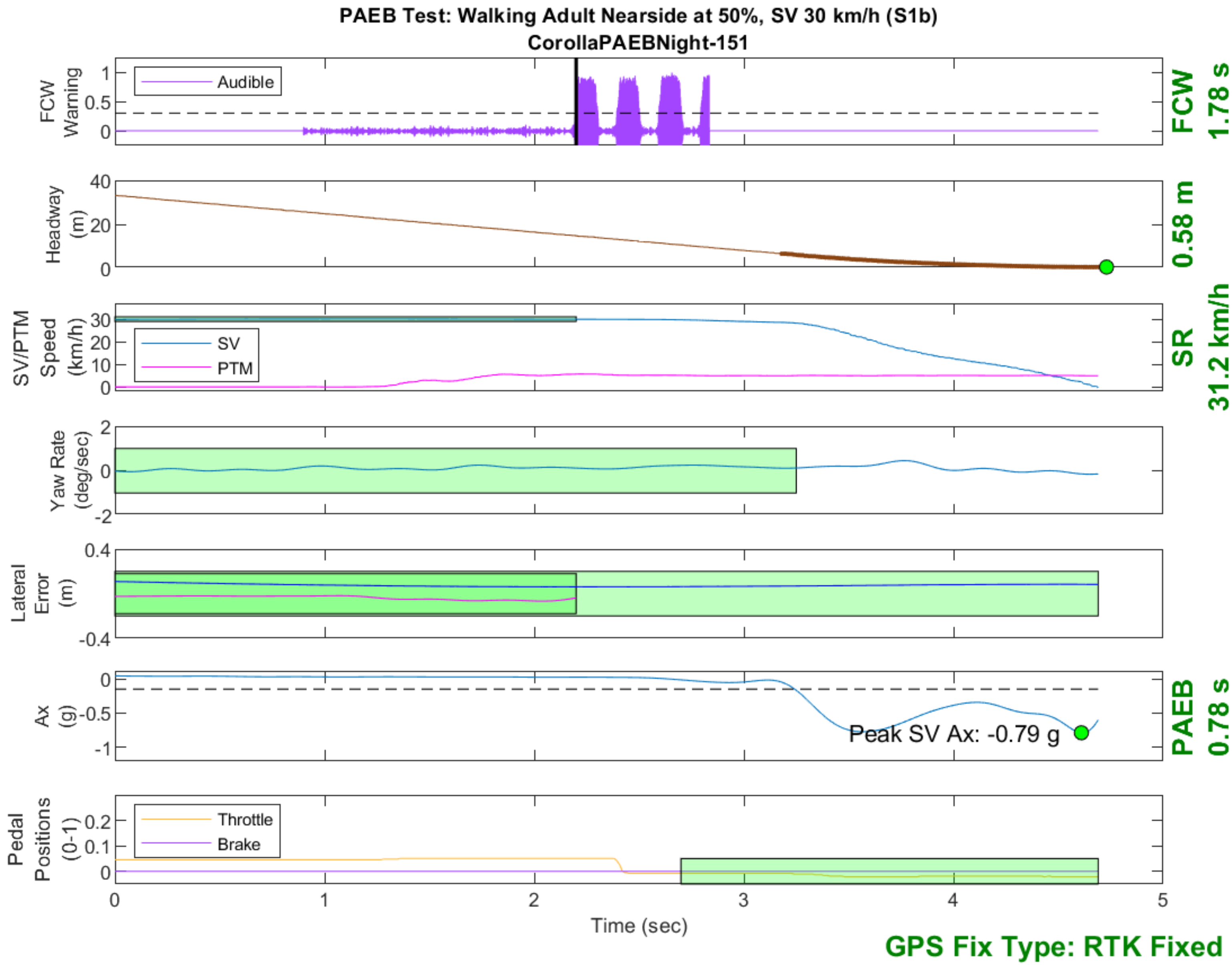


Figure D287. Time History for PAEB Run 151, S1b, Night, Low Beam, 30 km/h

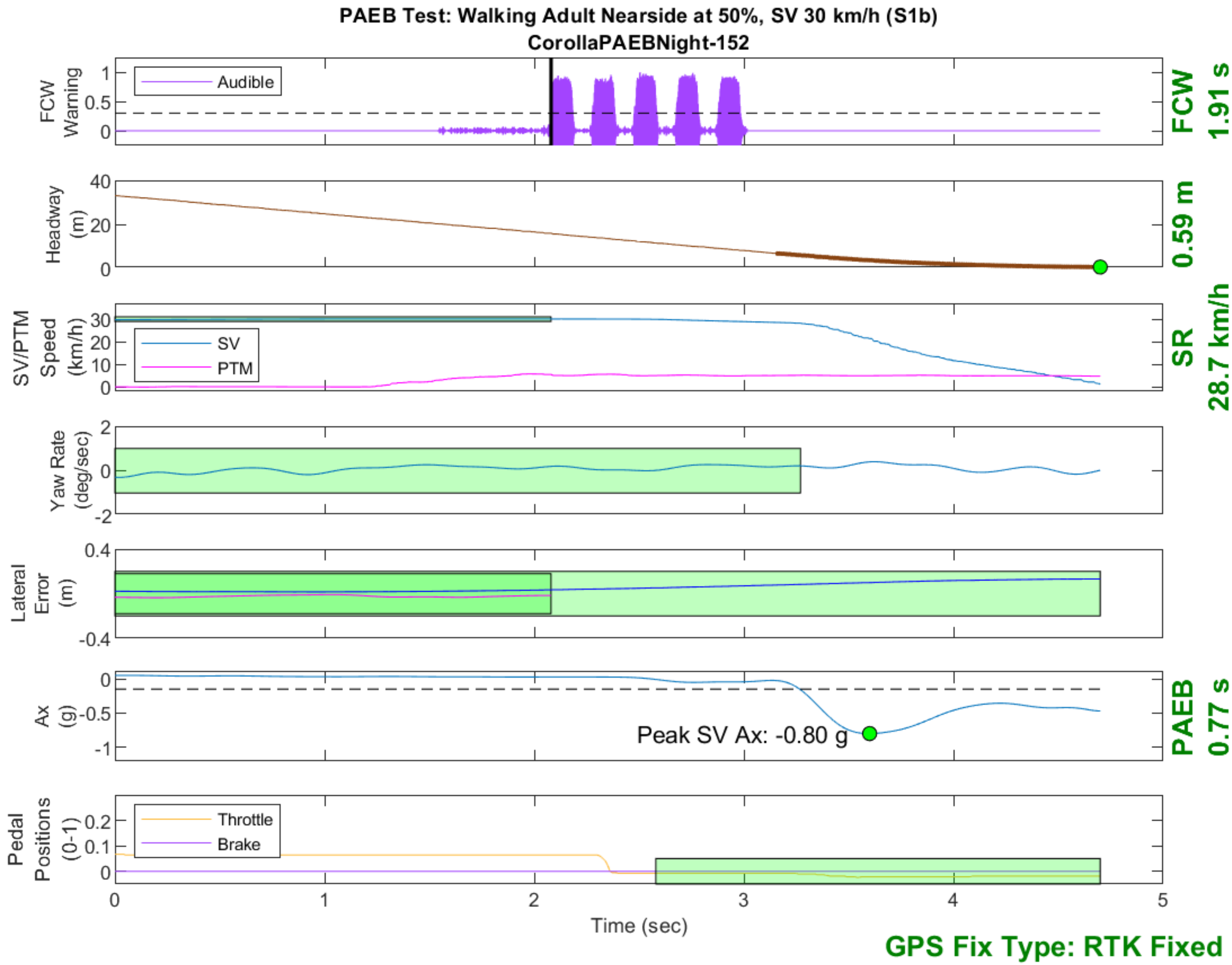


Figure D288. Time History for PAEB Run 152, S1b, Night, Low Beam, 30 km/h

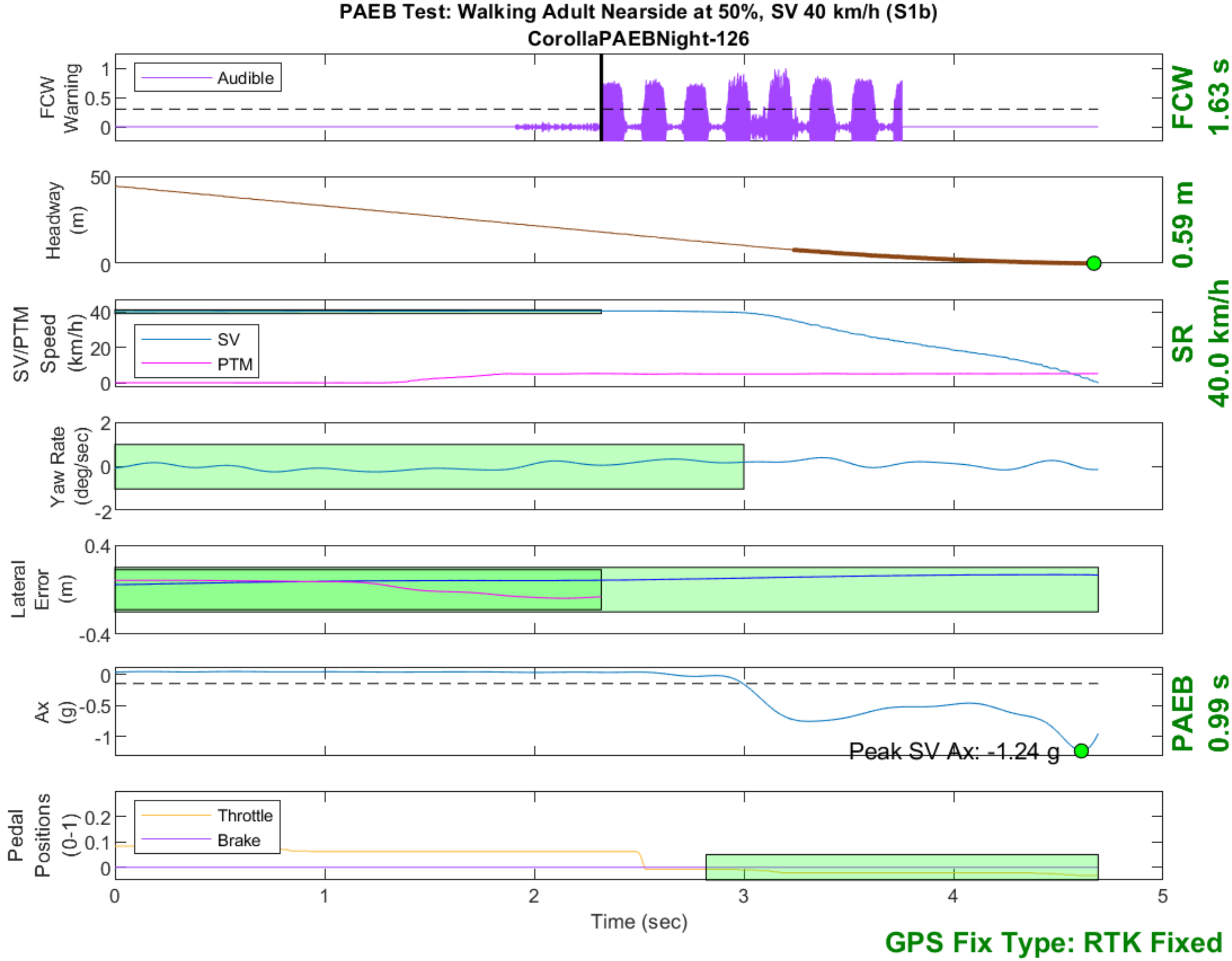


Figure D289. Time History for PAEB Run 126, S1b, Night, Low Beam, 40 km/h

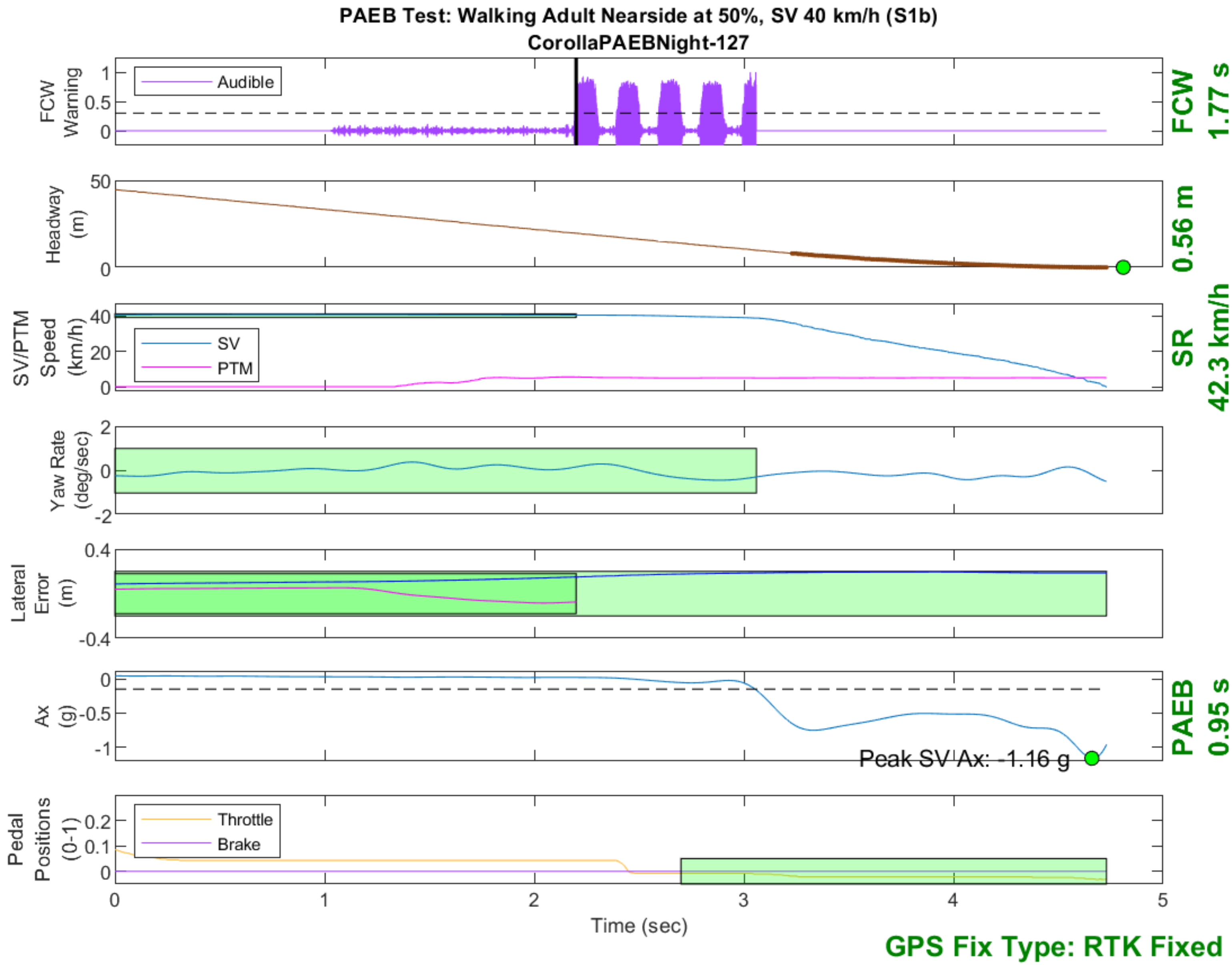


Figure D290. Time History for PAEB Run 127, S1b, Night, Low Beam, 40 km/h

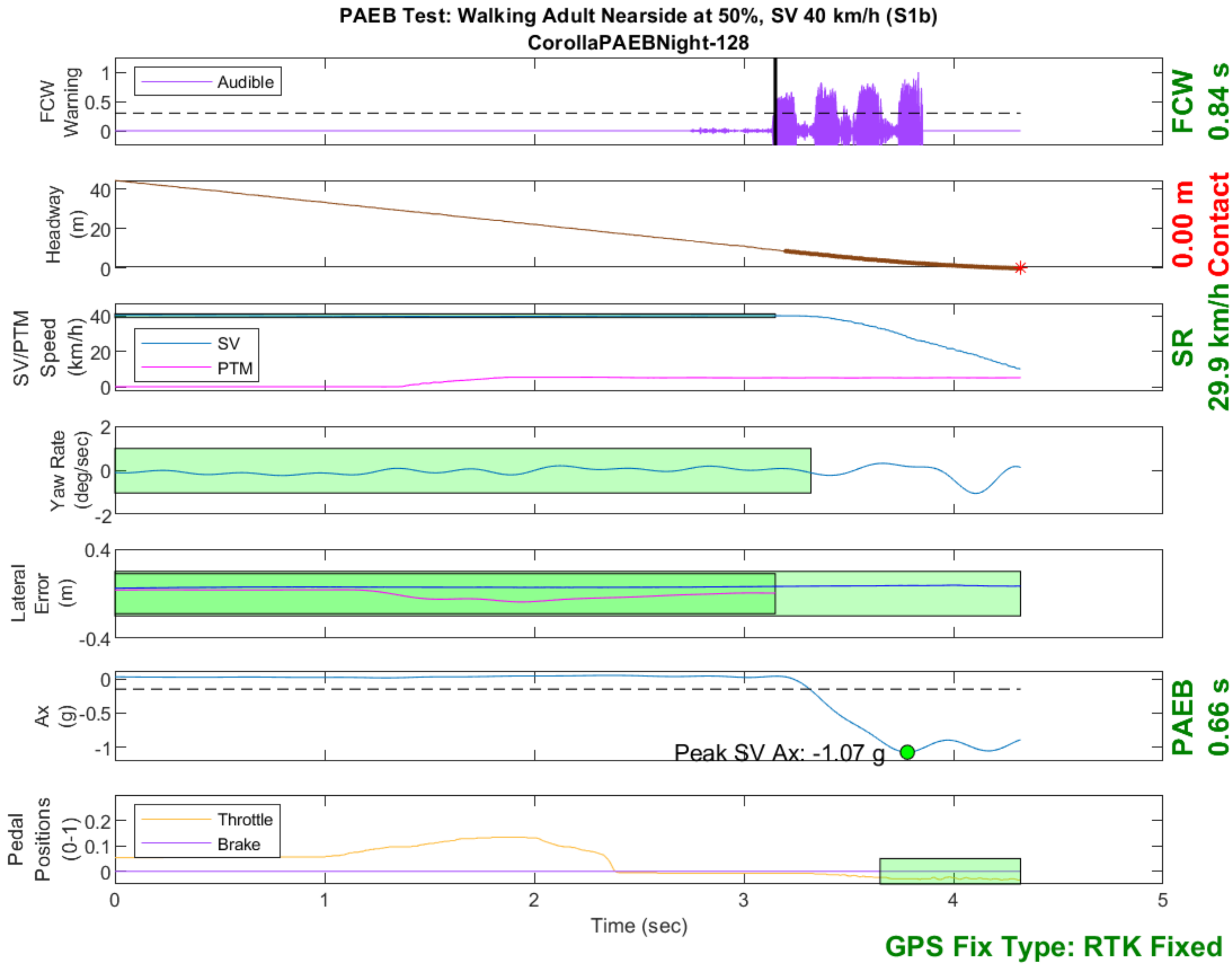


Figure D291. Time History for PAEB Run 128, S1b, Night, Low Beam, 40 km/h

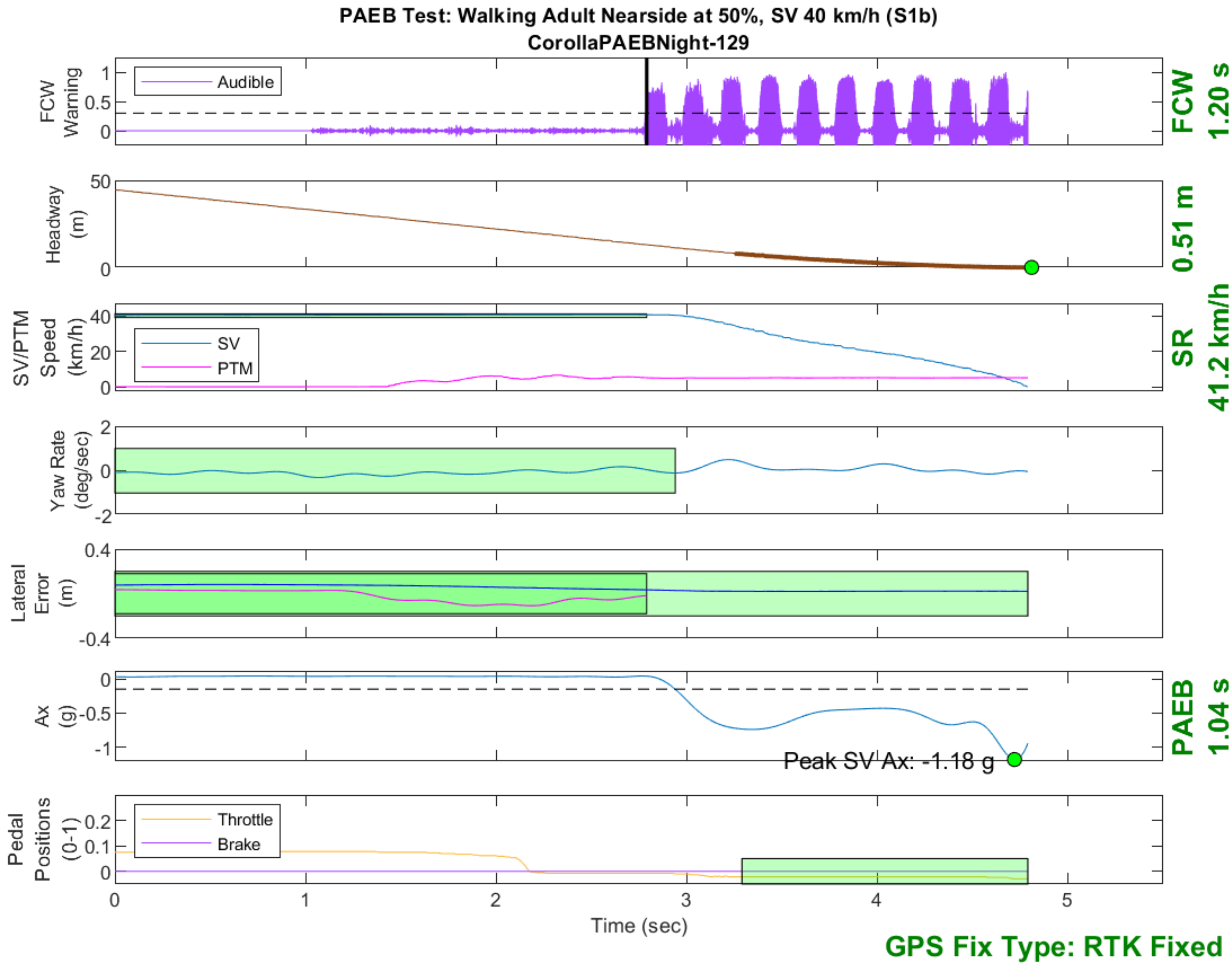


Figure D292. Time History for PAEB Run 129, S1b, Night, Low Beam, 40 km/h

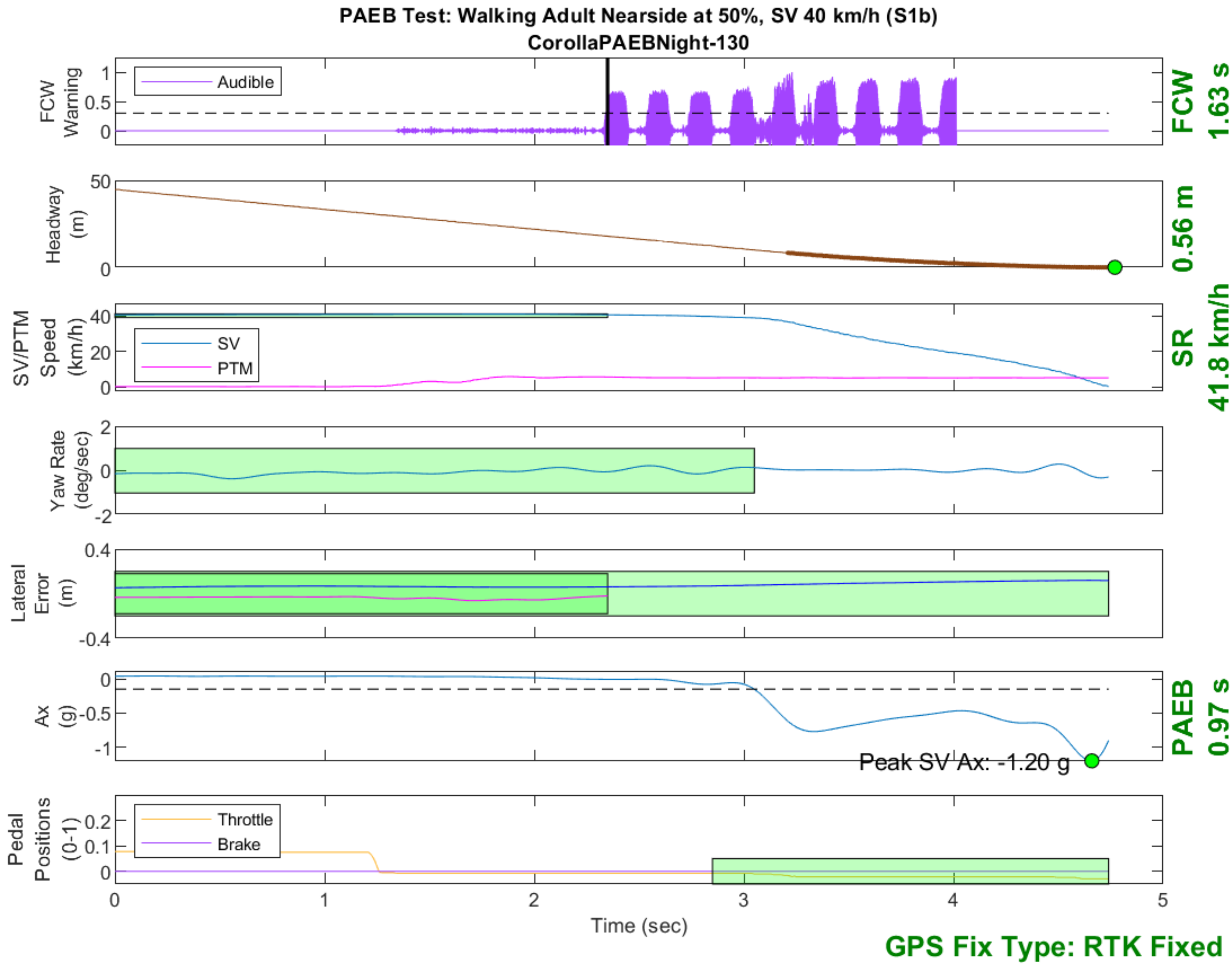


Figure D293. Time History for PAEB Run 130, S1b, Night, Low Beam, 40 km/h

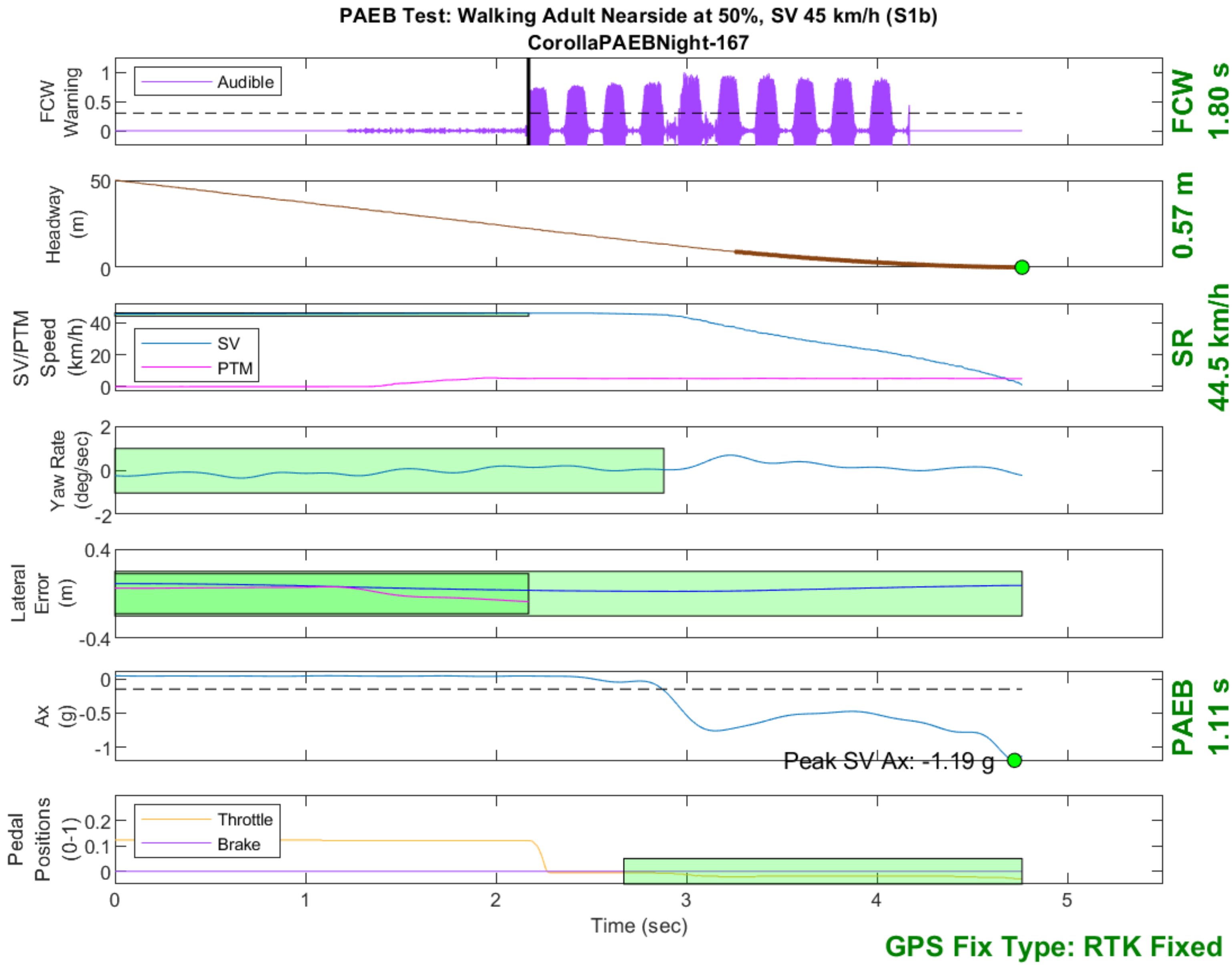


Figure D294. Time History for PAEB Run 167, S1b, Night, Low Beam, 45 km/h

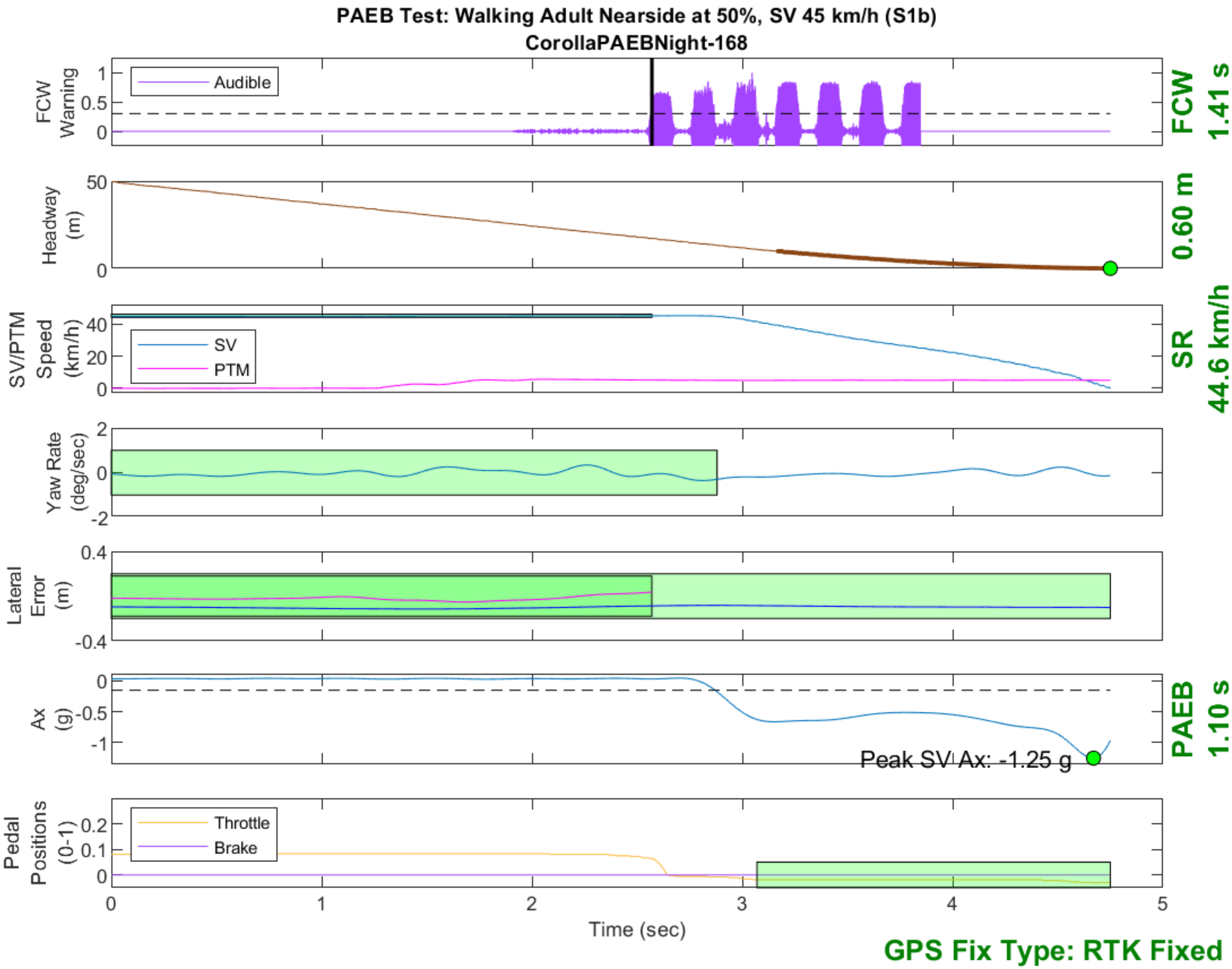


Figure D295. Time History for PAEB Run 168, S1b, Night, Low Beam, 45 km/h

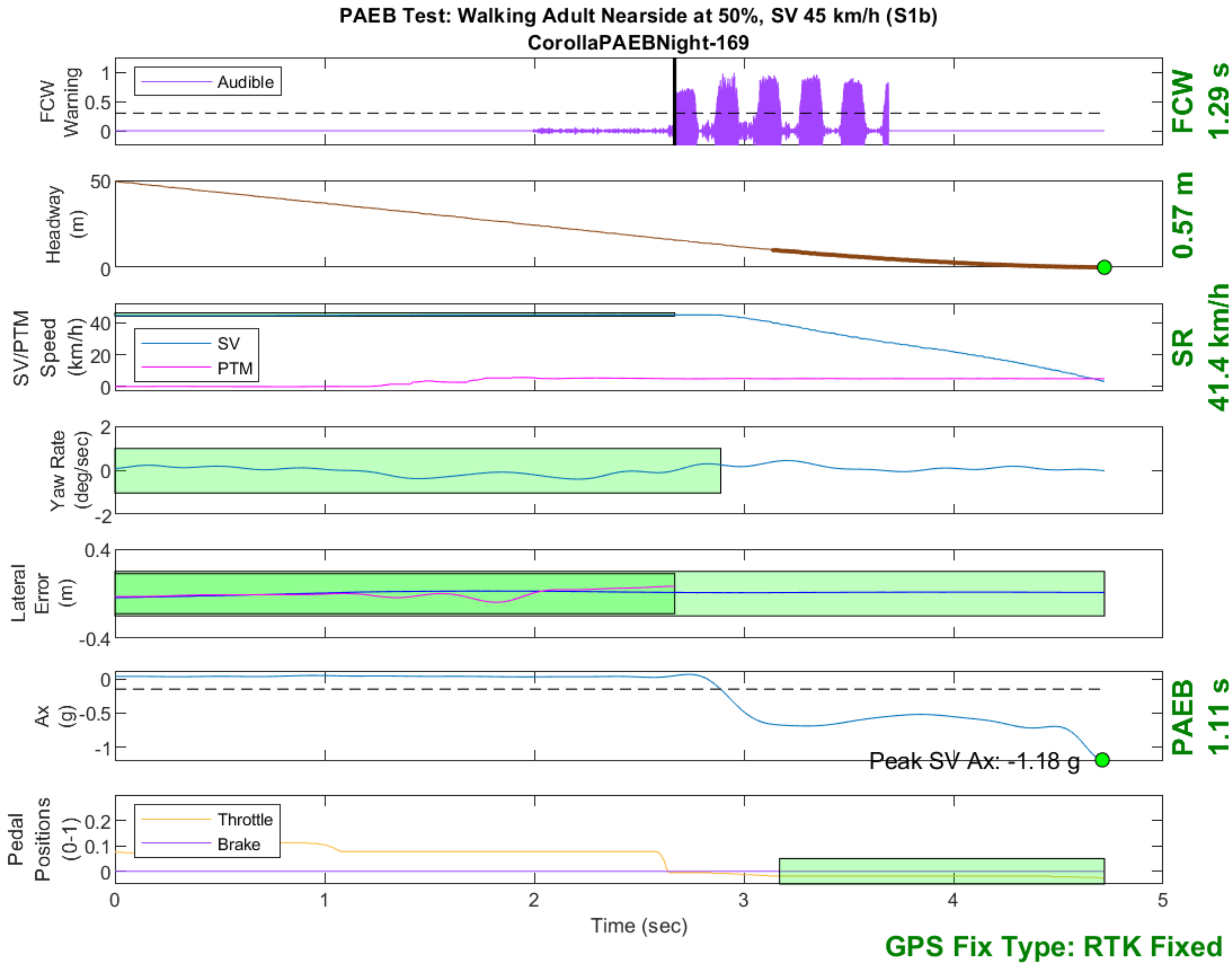


Figure D296. Time History for PAEB Run 169, S1b, Night, Low Beam, 45 km/h

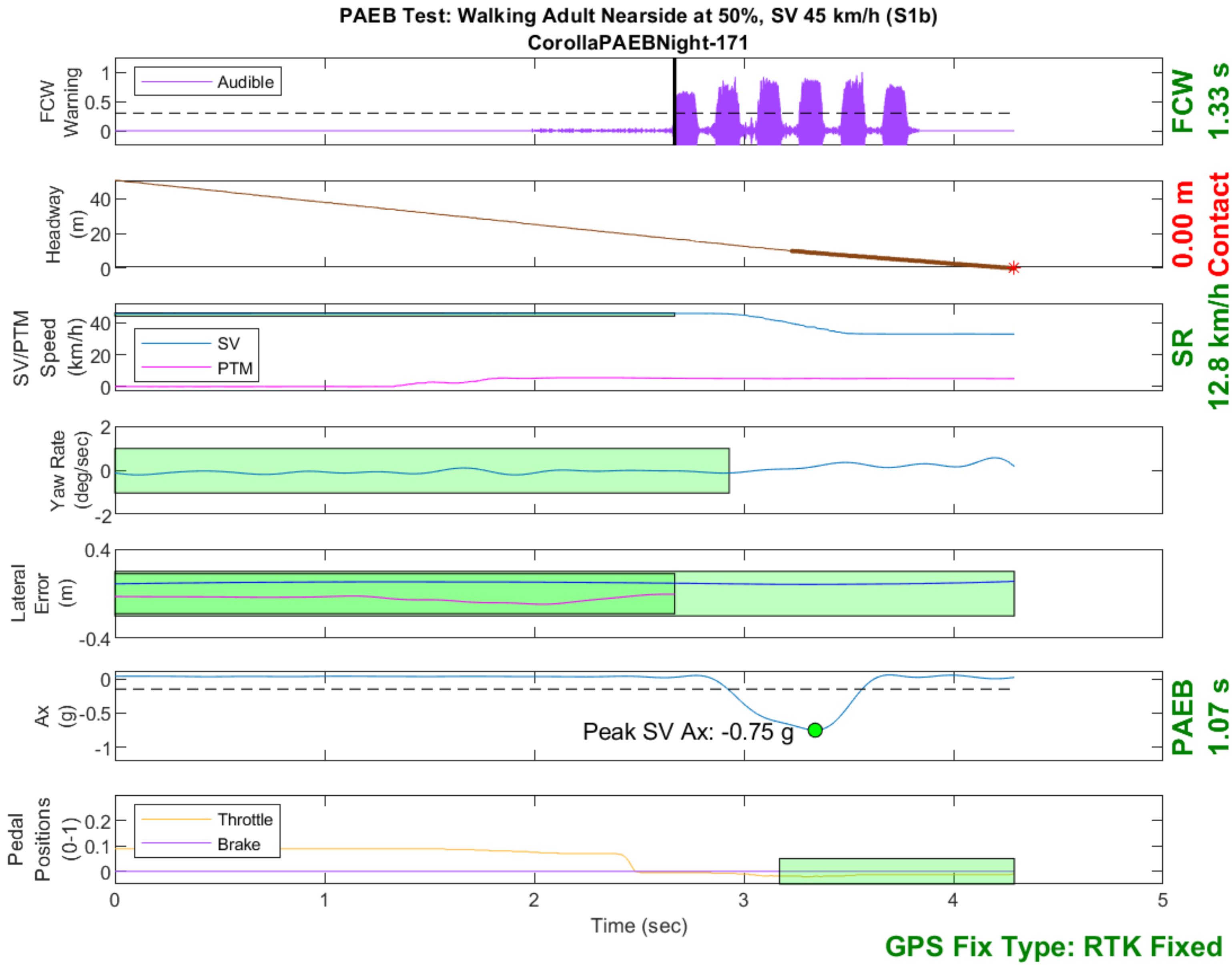


Figure D297. Time History for PAEB Run 171, S1b, Night, Low Beam, 45 km/h

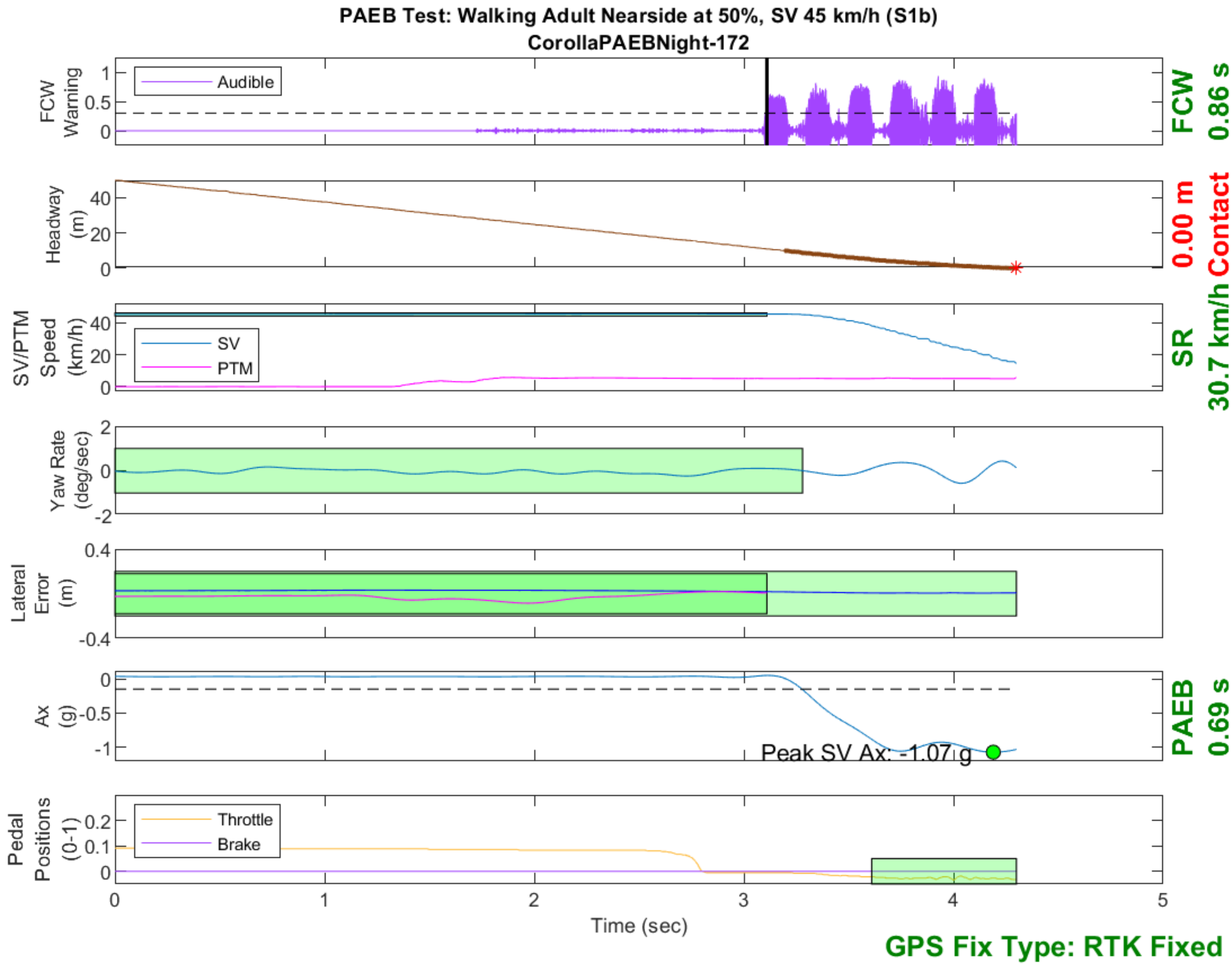


Figure D298. Time History for PAEB Run 172, S1b, Night, Low Beam, 45 km/h

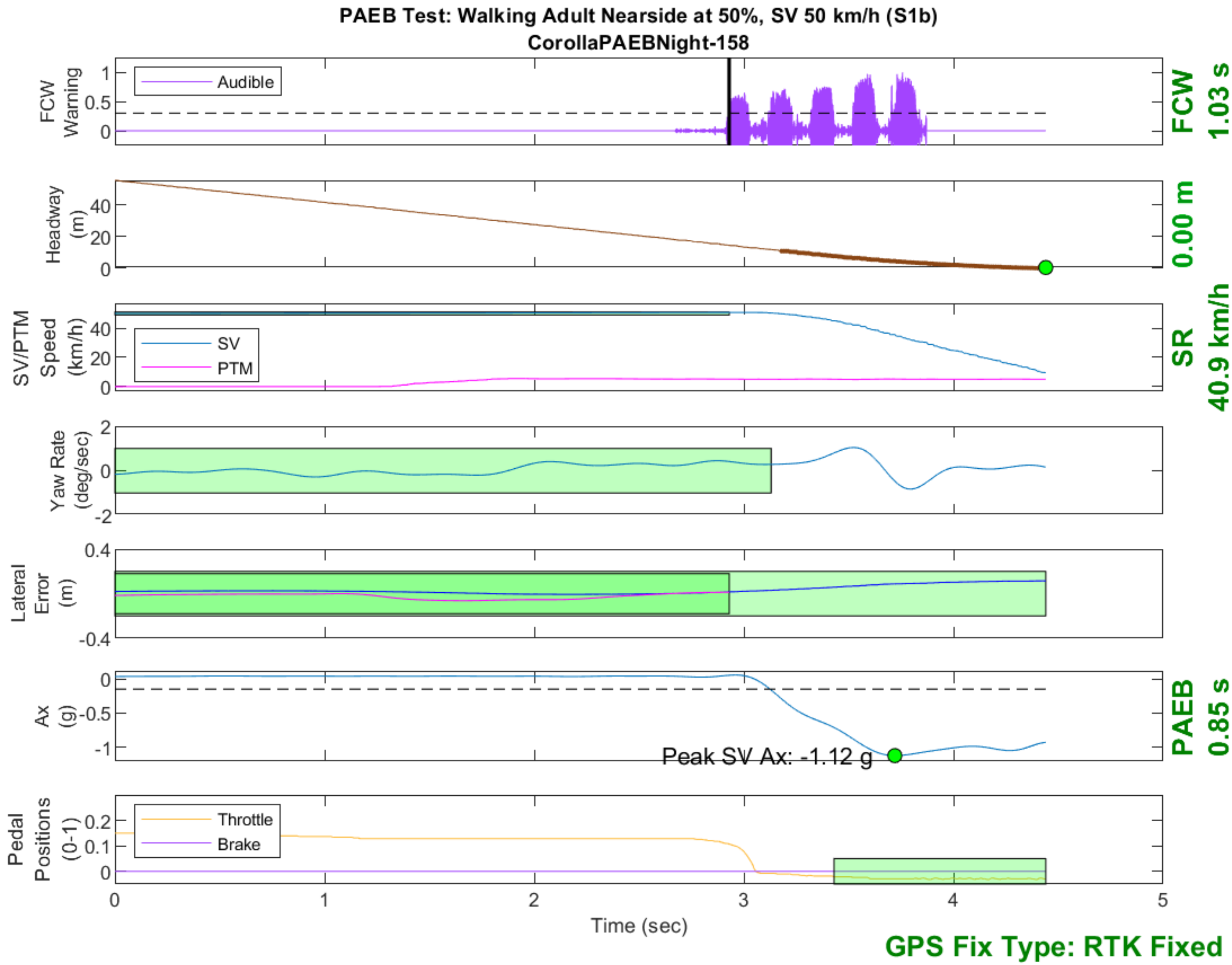


Figure D299. Time History for PAEB Run 158, S1b, Night, Low Beam, 50 km/h

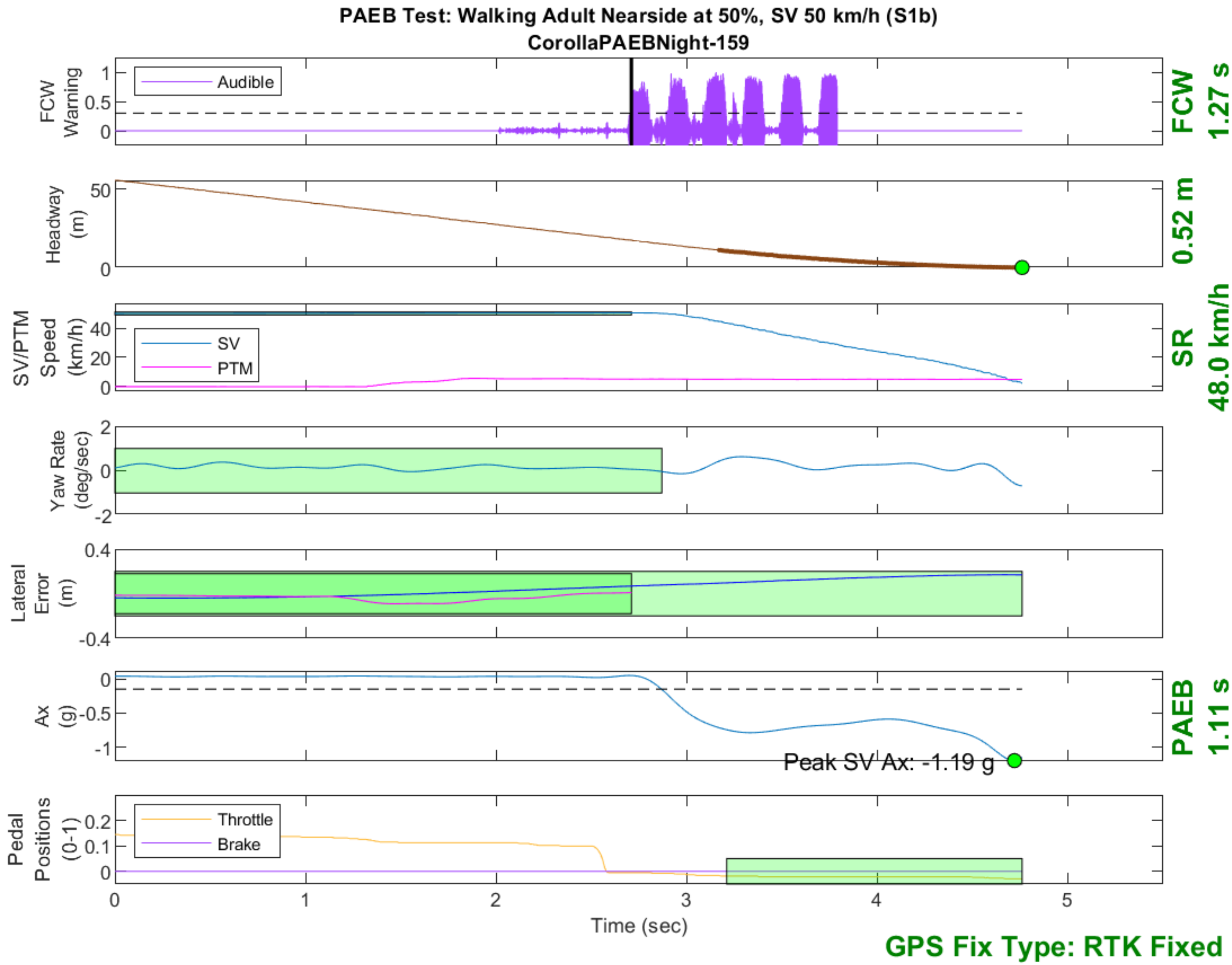


Figure D300. Time History for PAEB Run 159, S1b, Night, Low Beam, 50 km/h

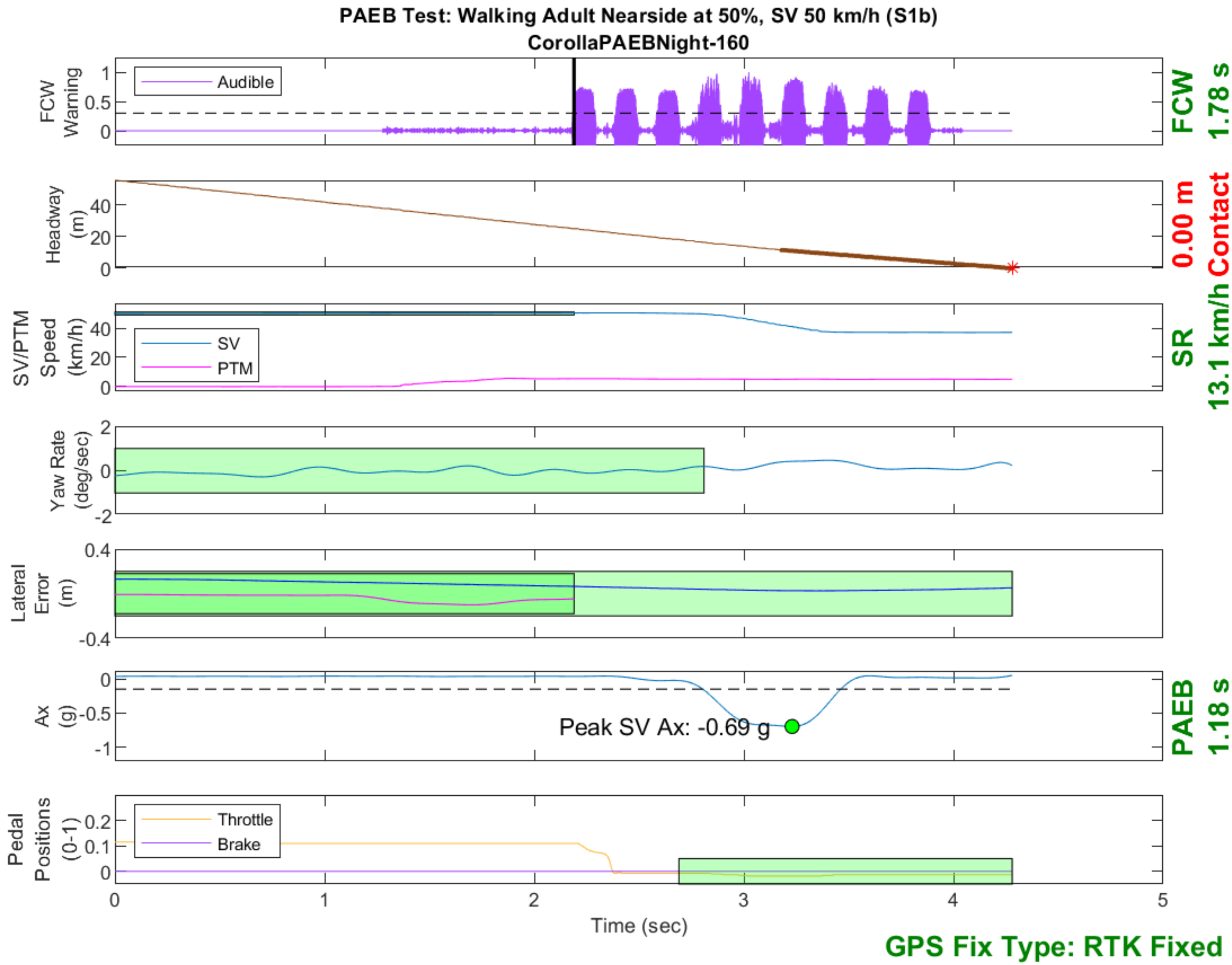


Figure D301. Time History for PAEB Run 160, S1b, Night, Low Beam, 50 km/h

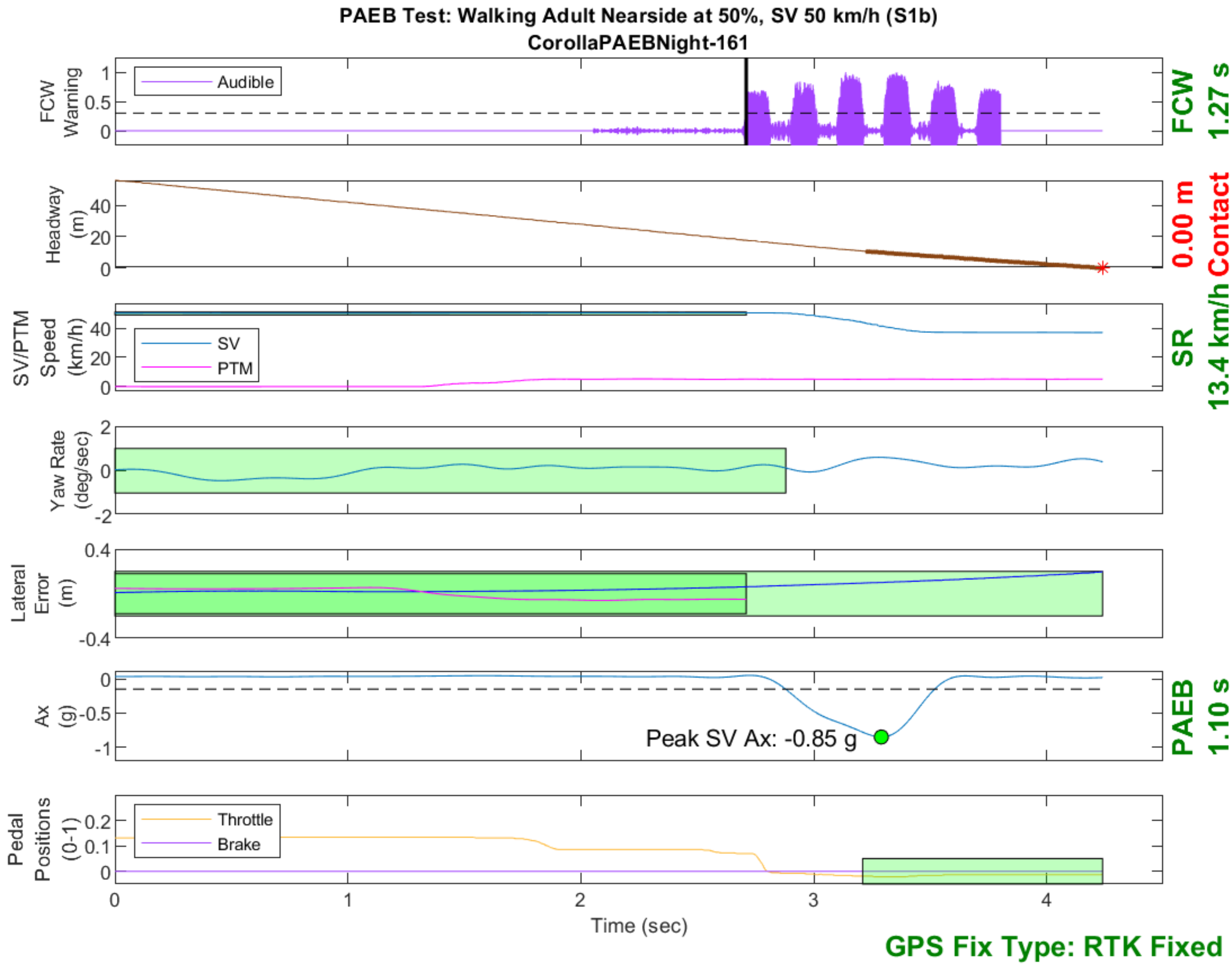


Figure D302. Time History for PAEB Run 161, S1b, Night, Low Beam, 50 km/h

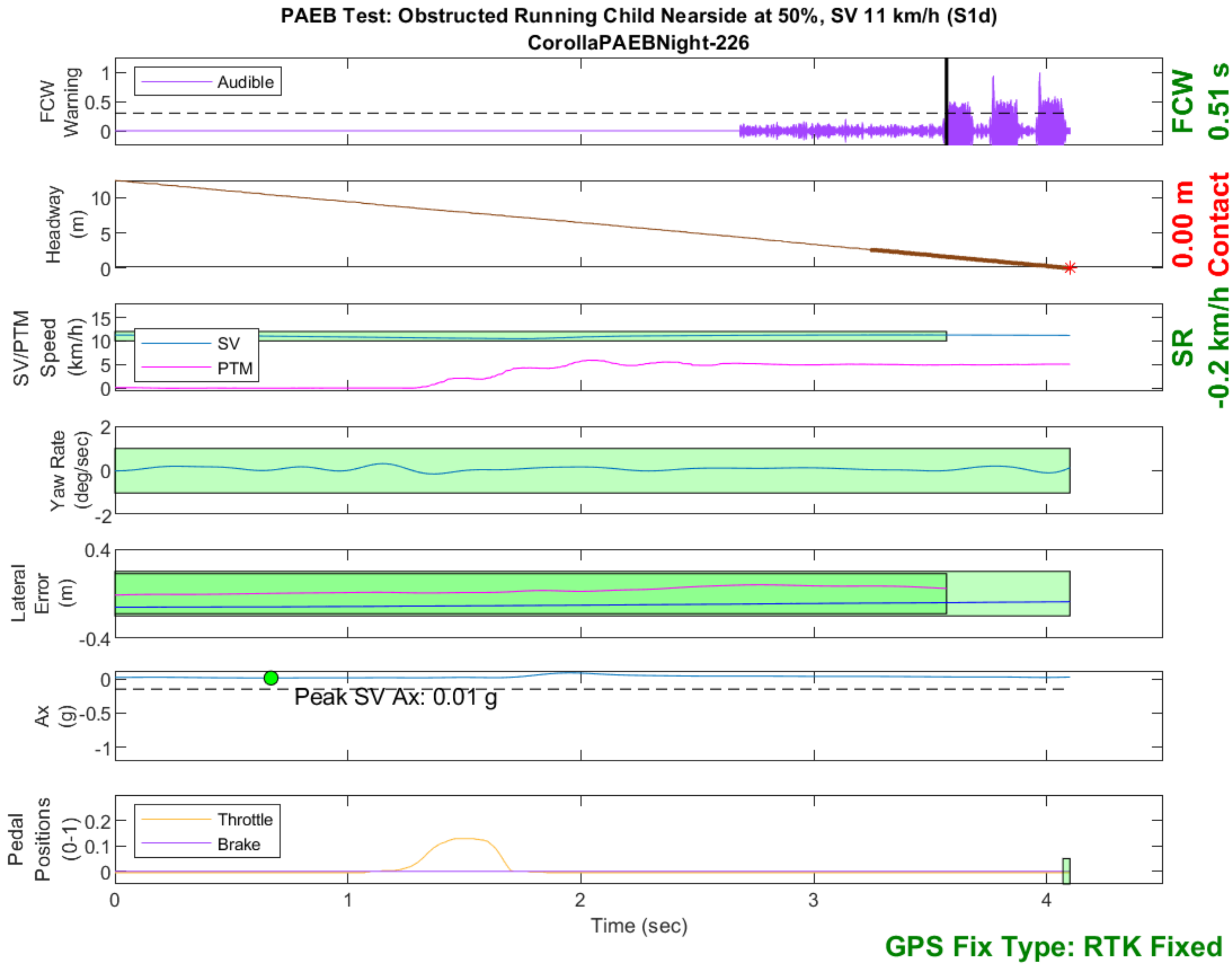


Figure D303. Time History for PAEB Run 226, S1d, Night, Low Beam, 11 km/h

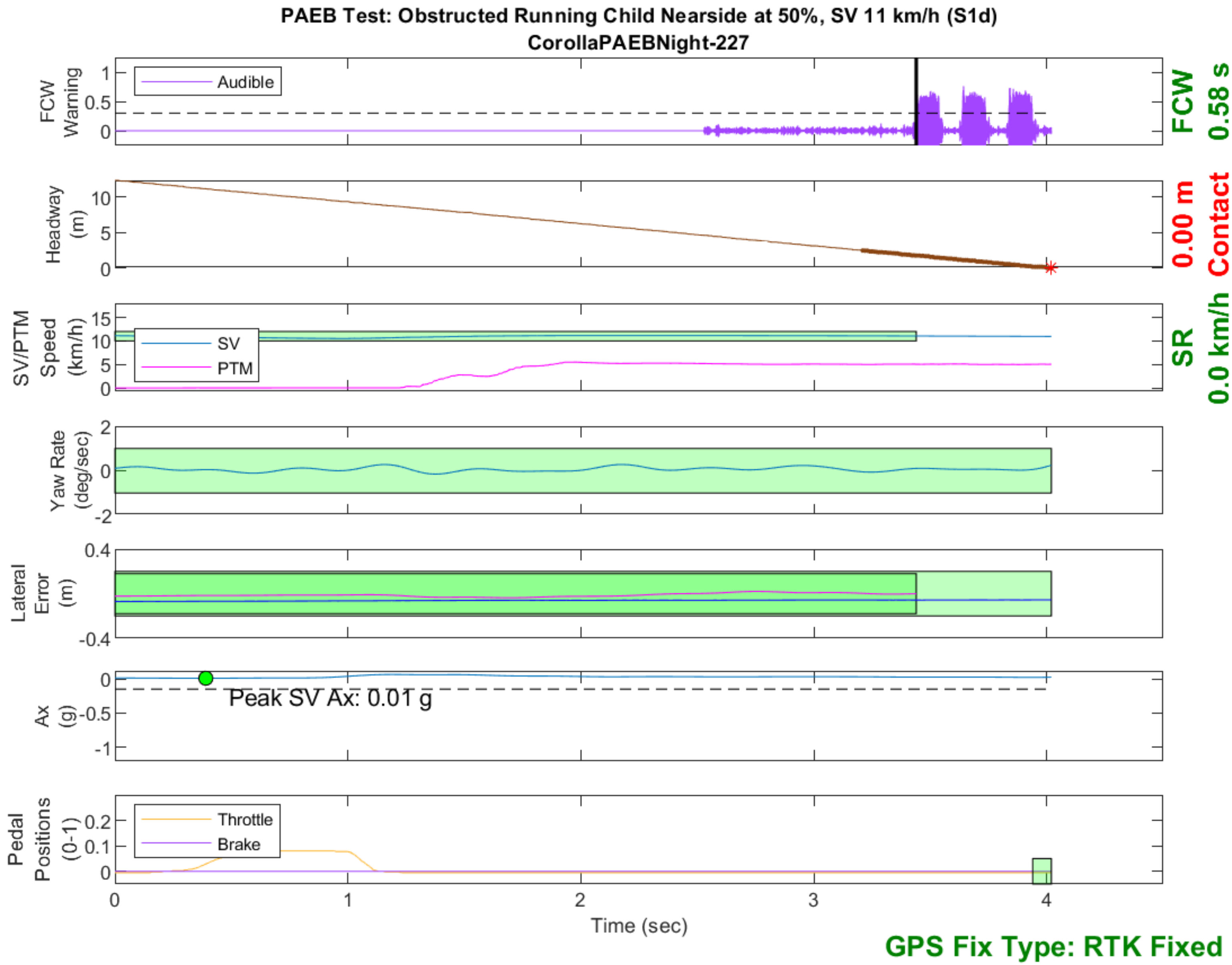


Figure D304. Time History for PAEB Run 227, S1d, Night, Low Beam, 11 km/h

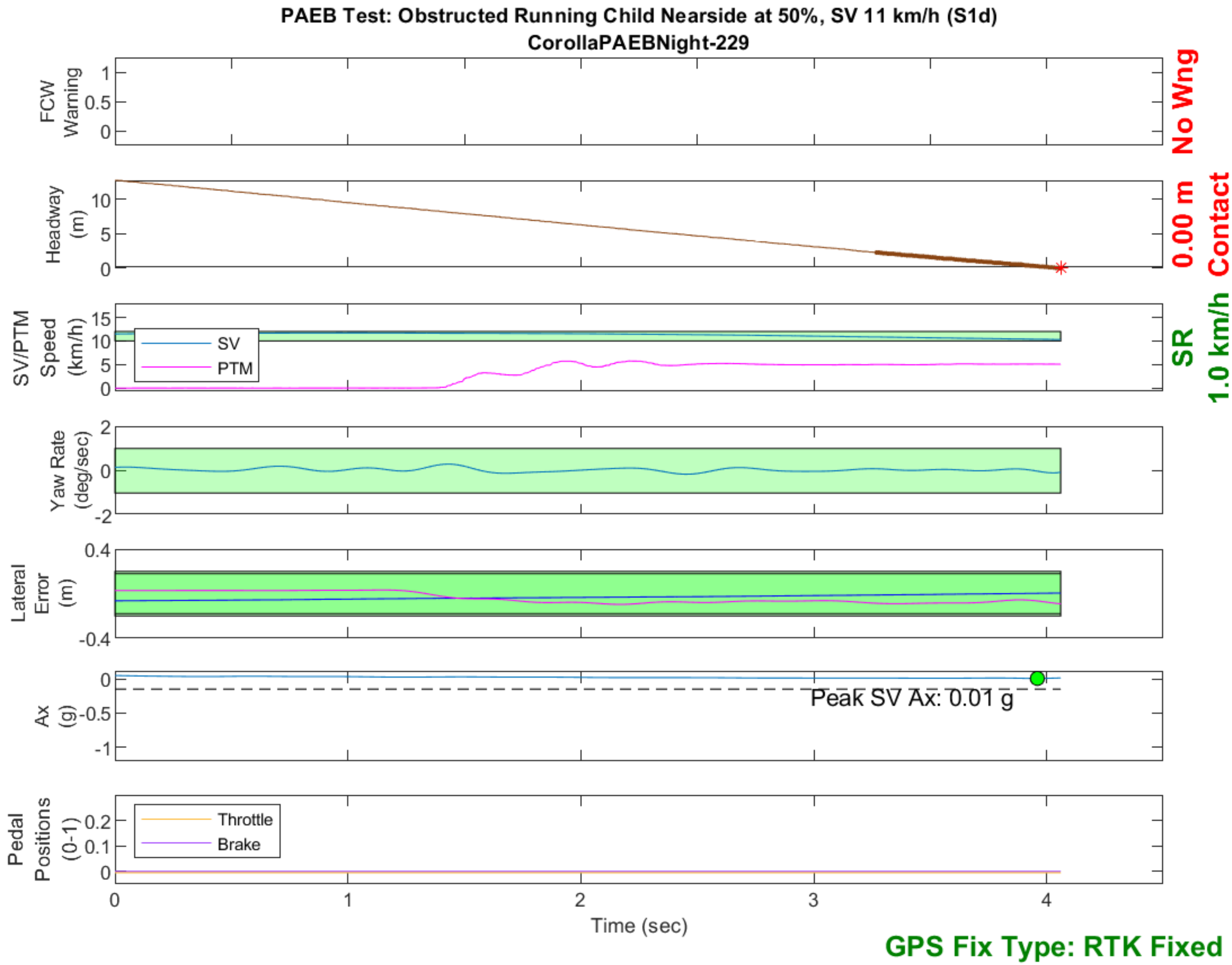


Figure D305. Time History for PAEB Run 229, S1d, Night, Low Beam, 11 km/h

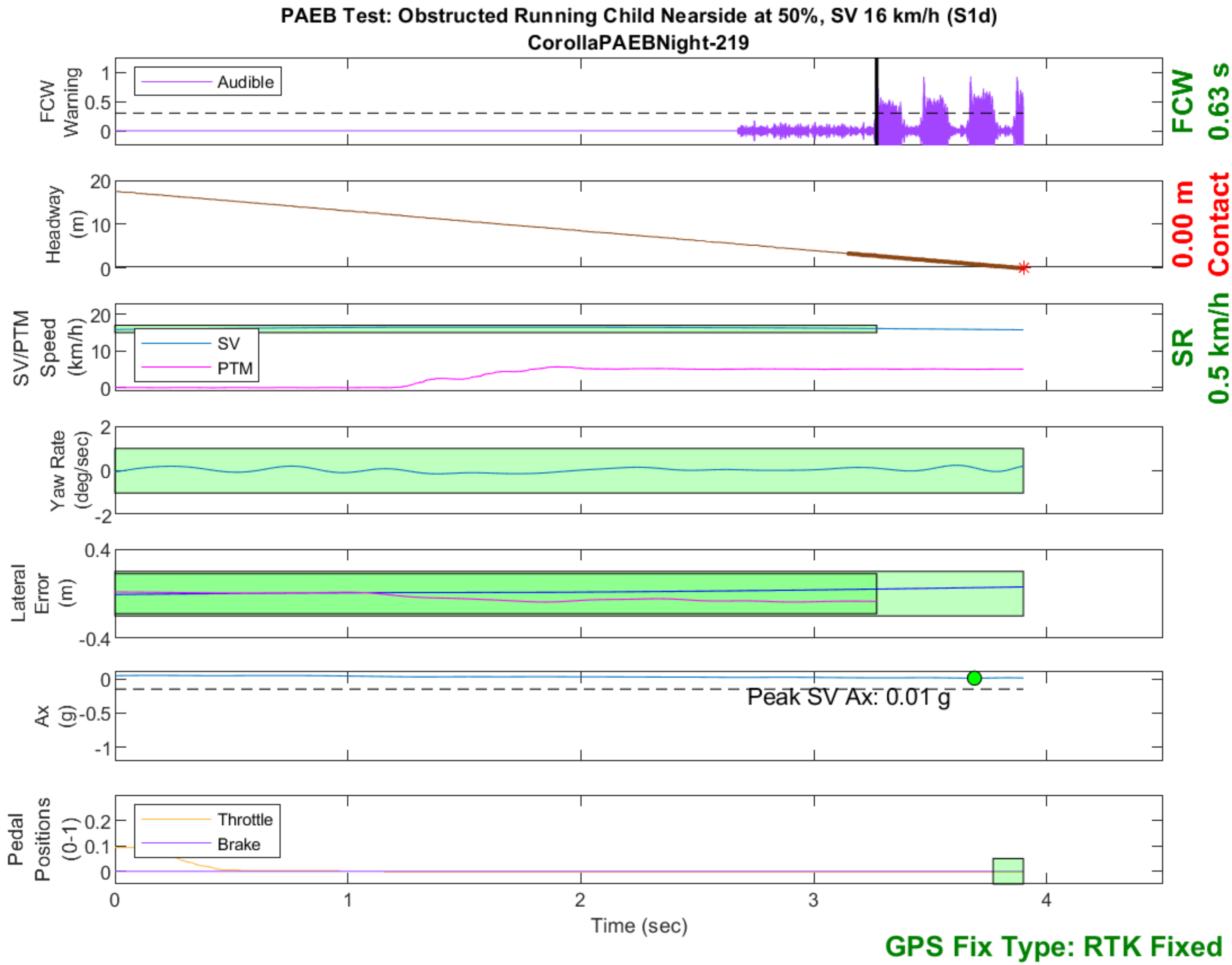


Figure D306. Time History for PAEB Run 219, S1d, Night, Low Beam, 16 km/h

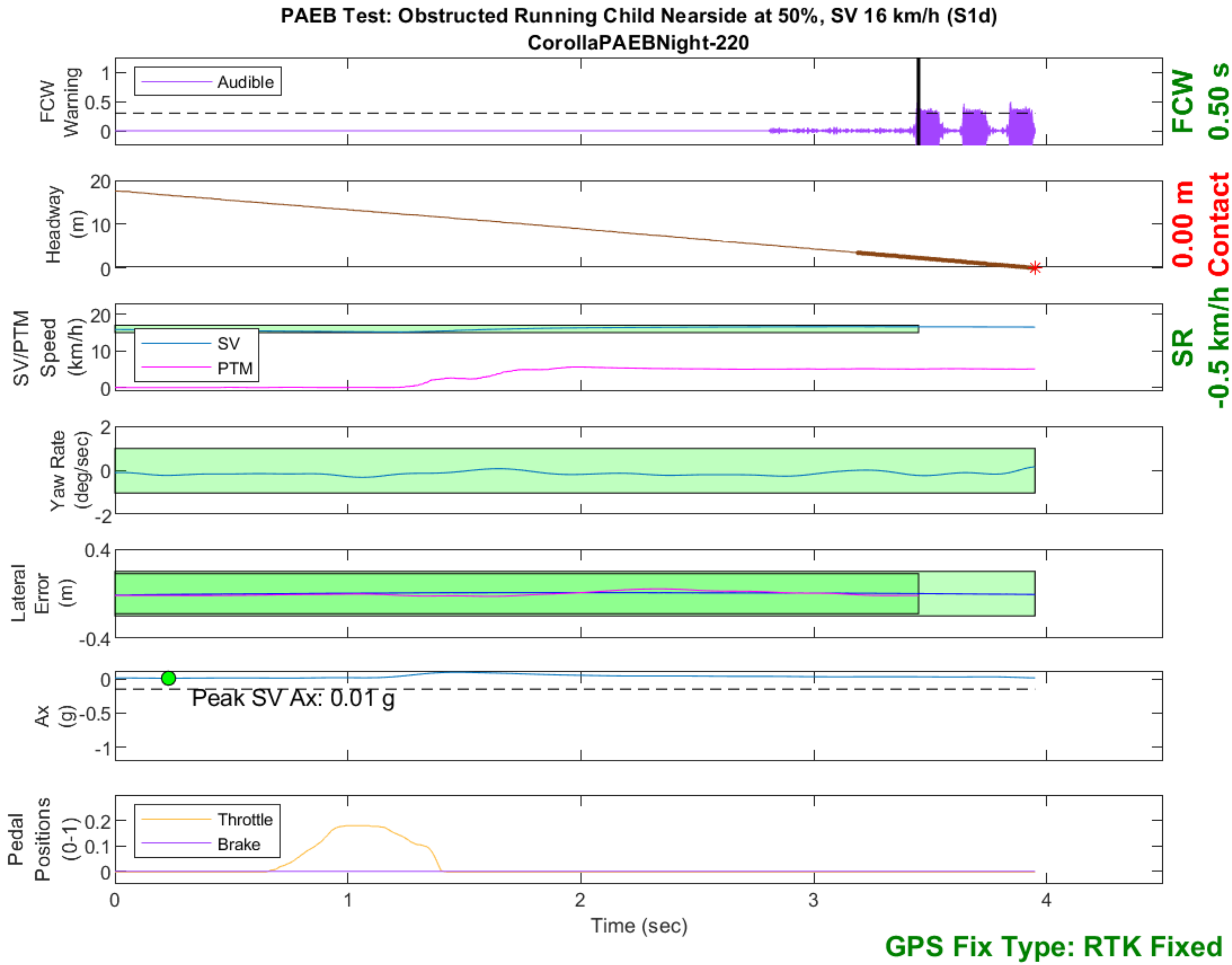


Figure D307. Time History for PAEB Run 220, S1d, Night, Low Beam, 16 km/h

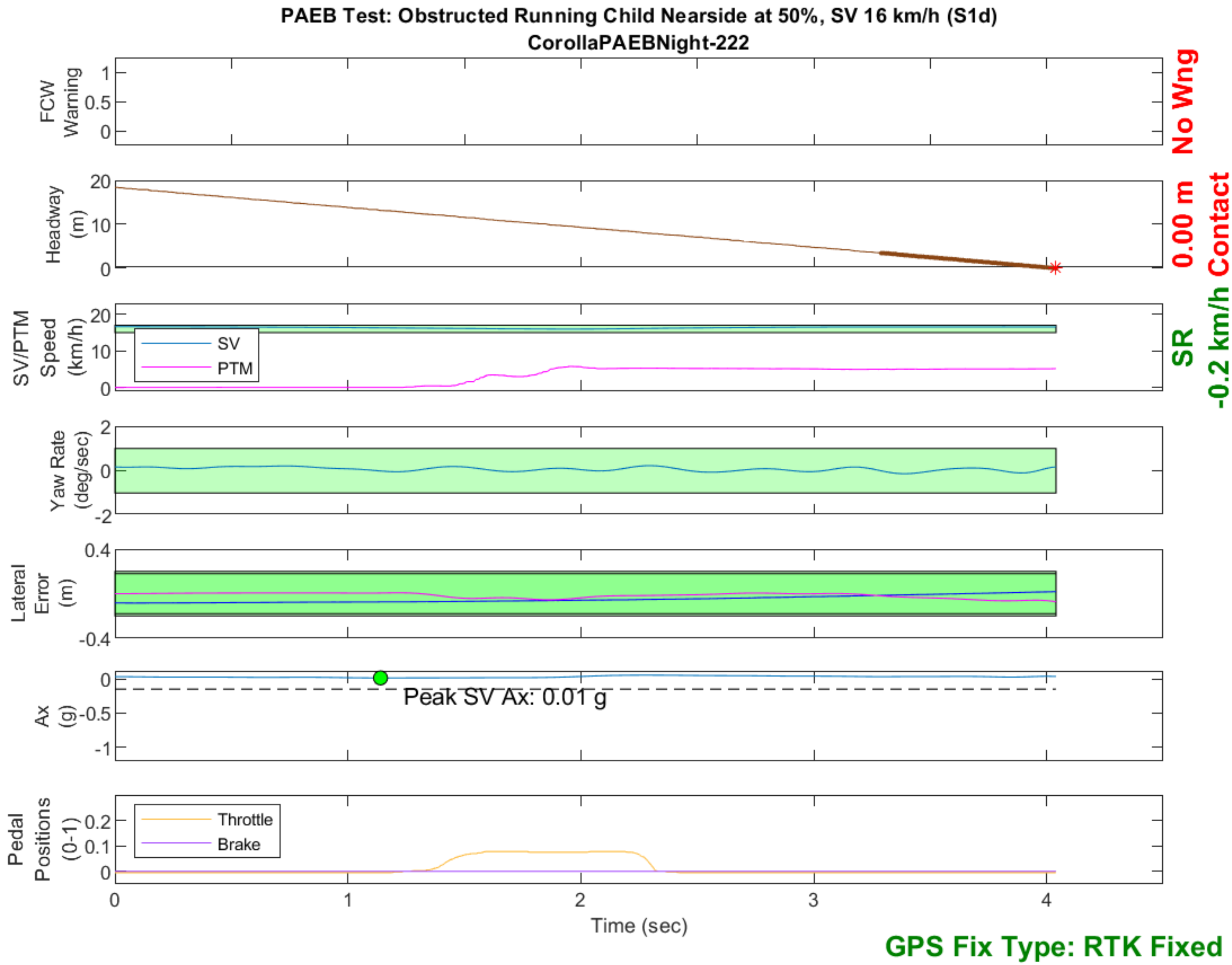


Figure D308. Time History for PAEB Run 222, S1d, Night, Low Beam, 16 km/h

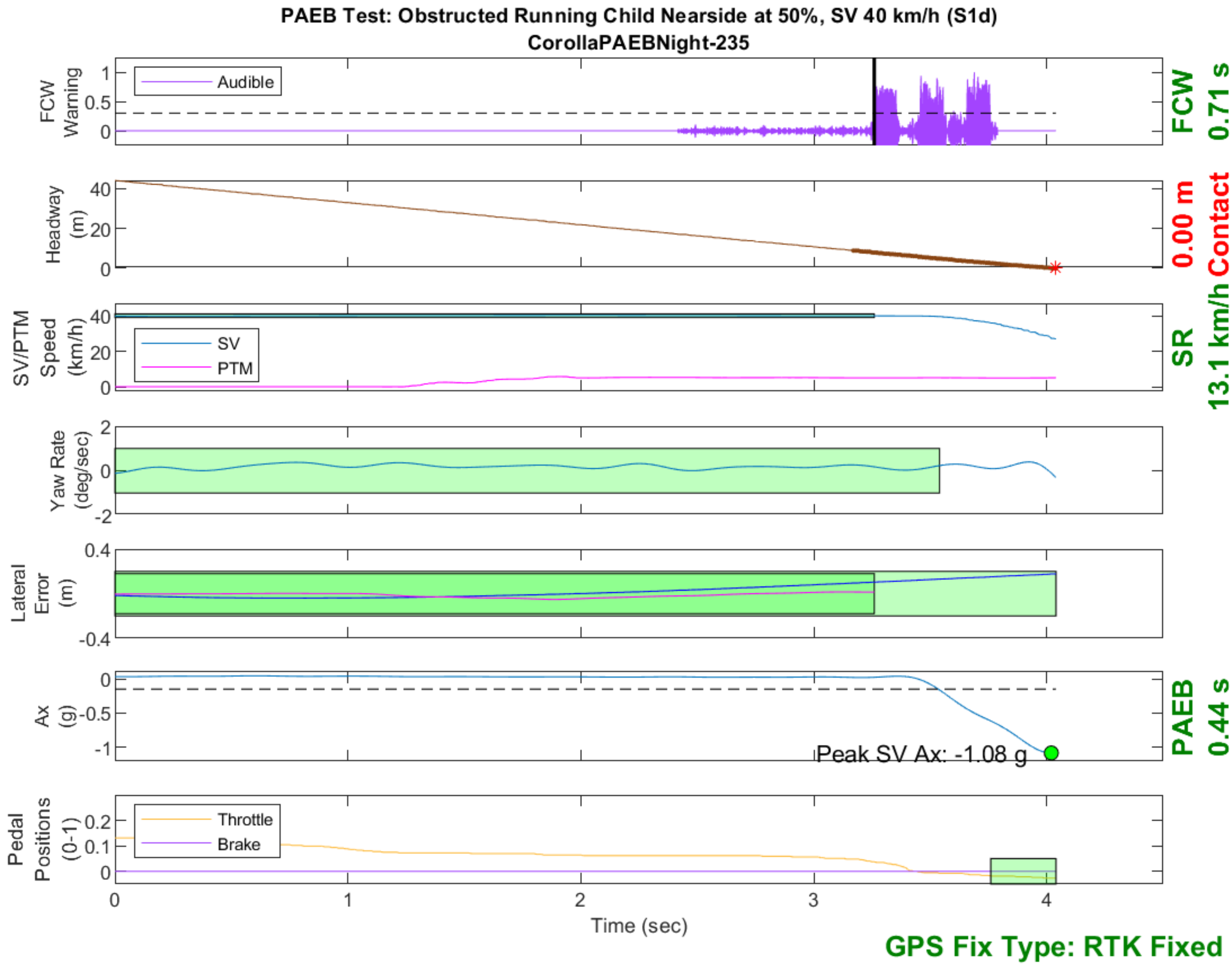


Figure D309. Time History for PAEB Run 235, S1d, Night, Low Beam, 40 km/h

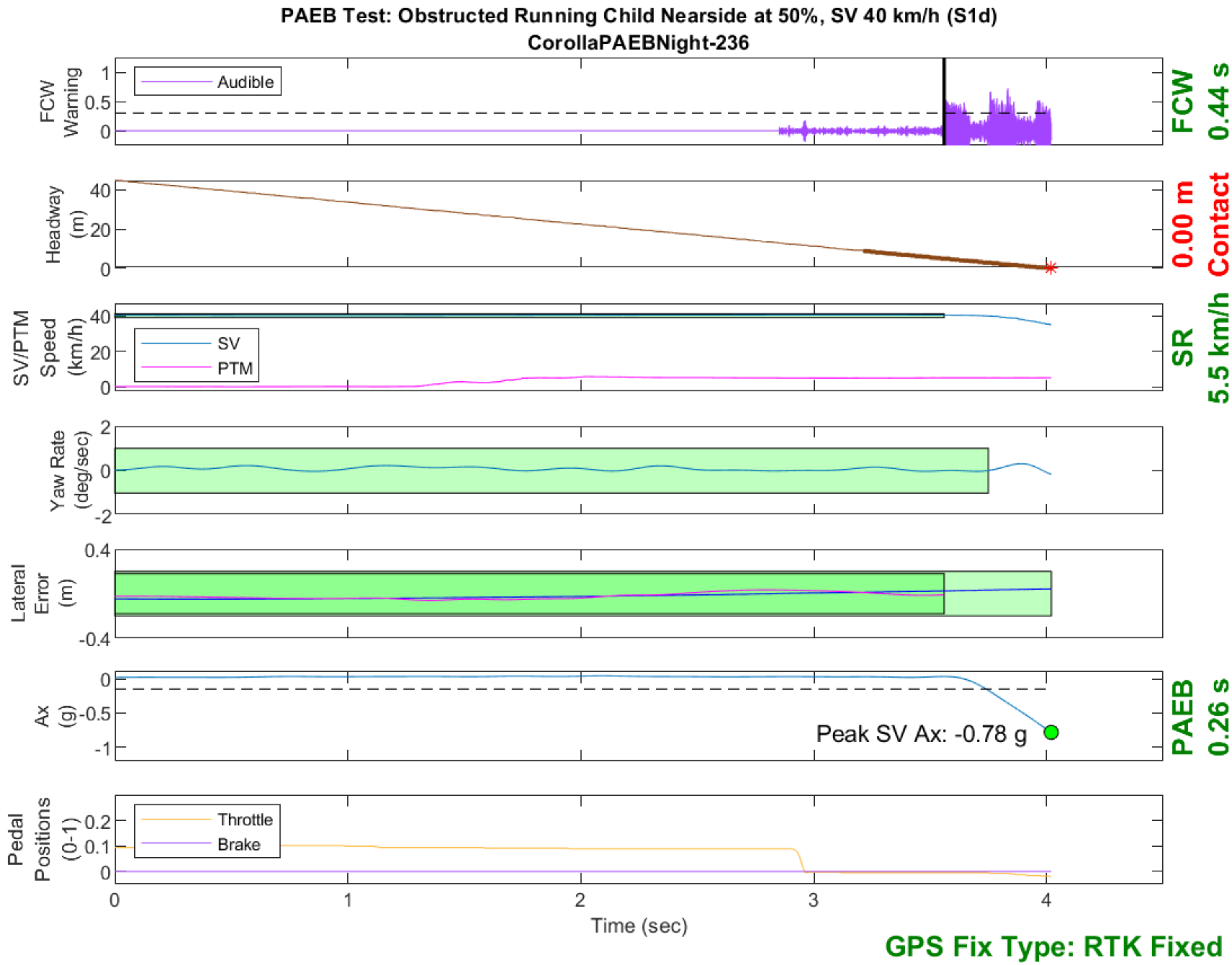


Figure D310. Time History for PAEB Run 236, S1d, Night, Low Beam, 40 km/h

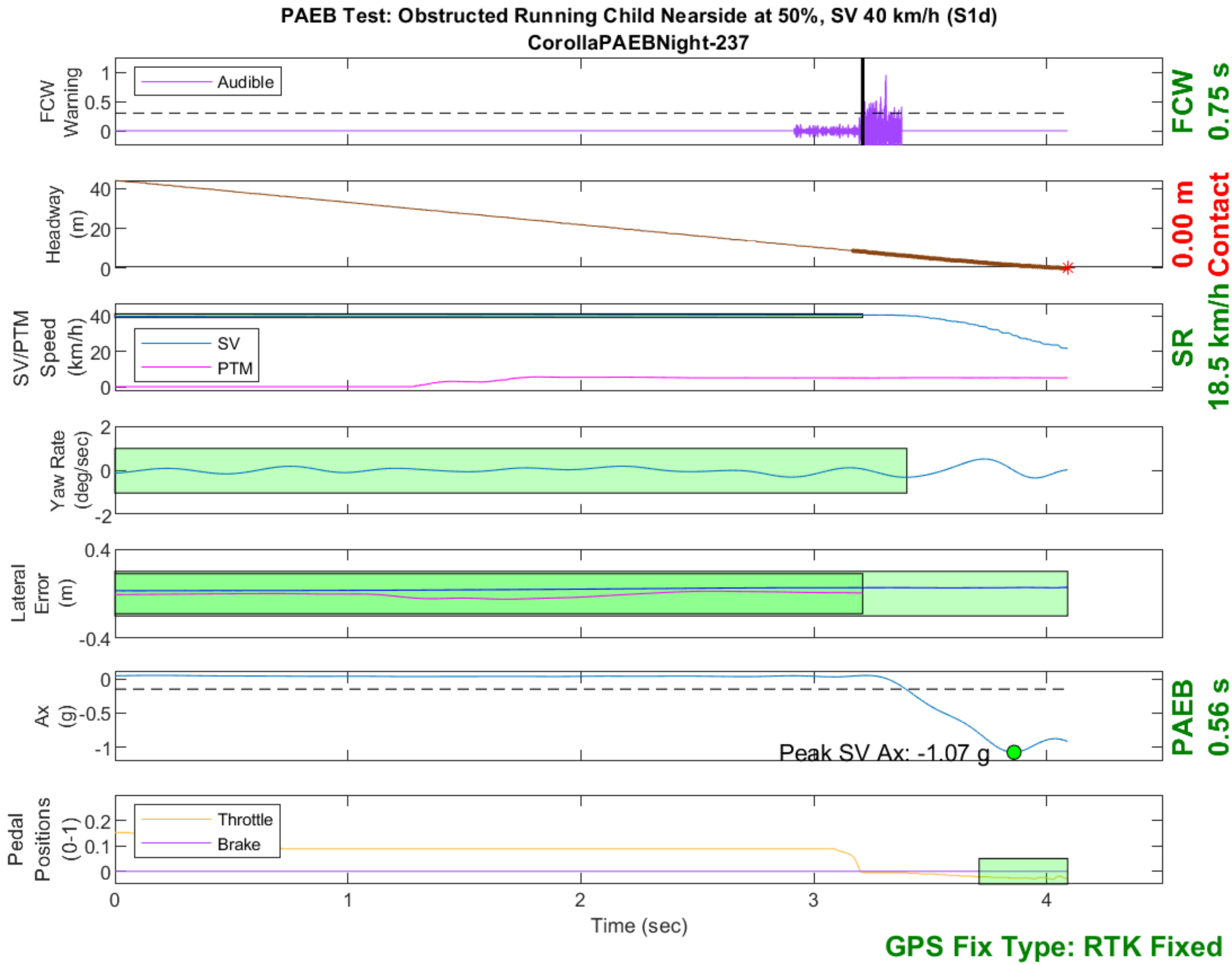


Figure D311. Time History for PAEB Run 237, S1d, Night, Low Beam, 40 km/h

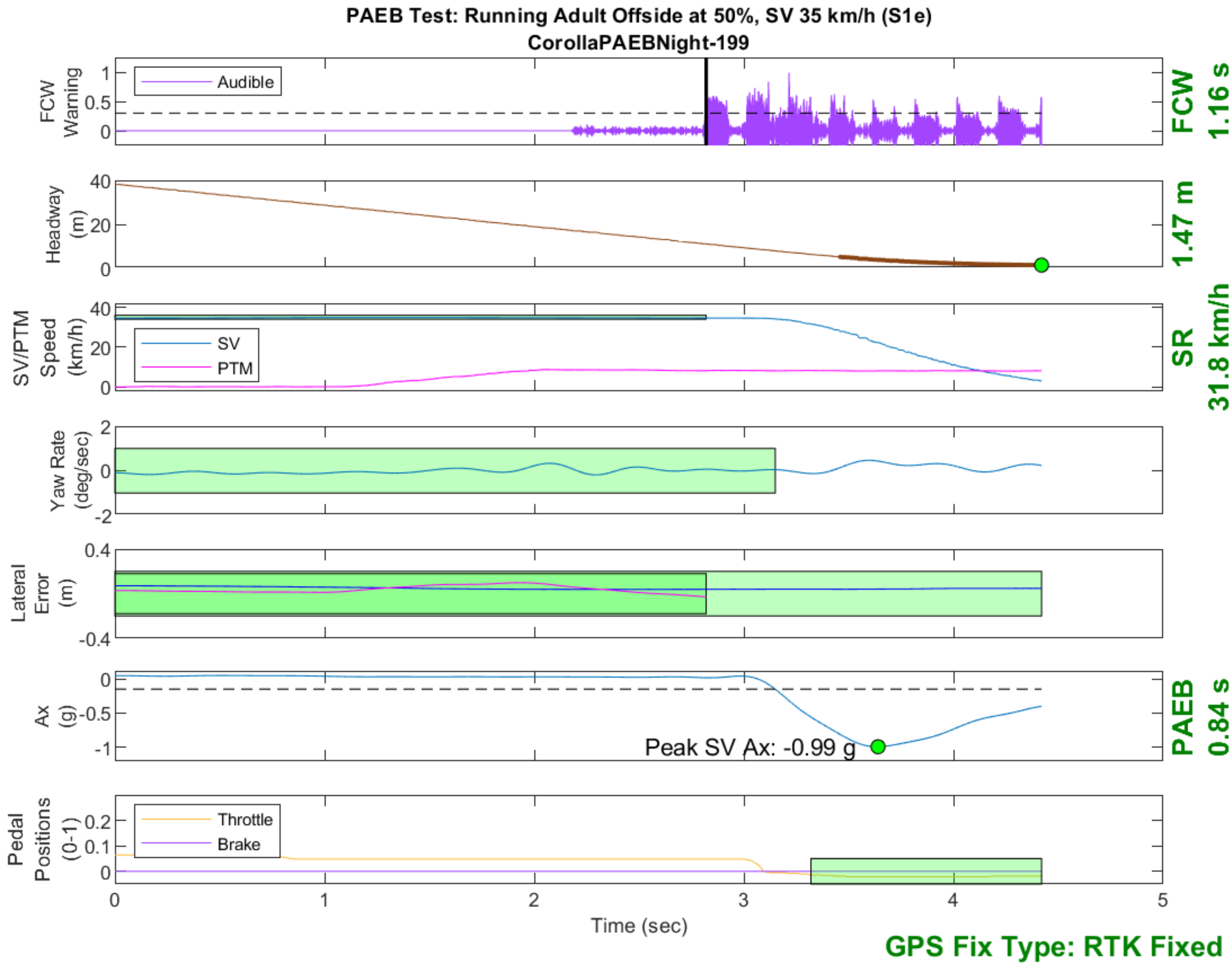


Figure D312. Time History for PAEB Run 199, S1e, Night, Low Beam, 35 km/h

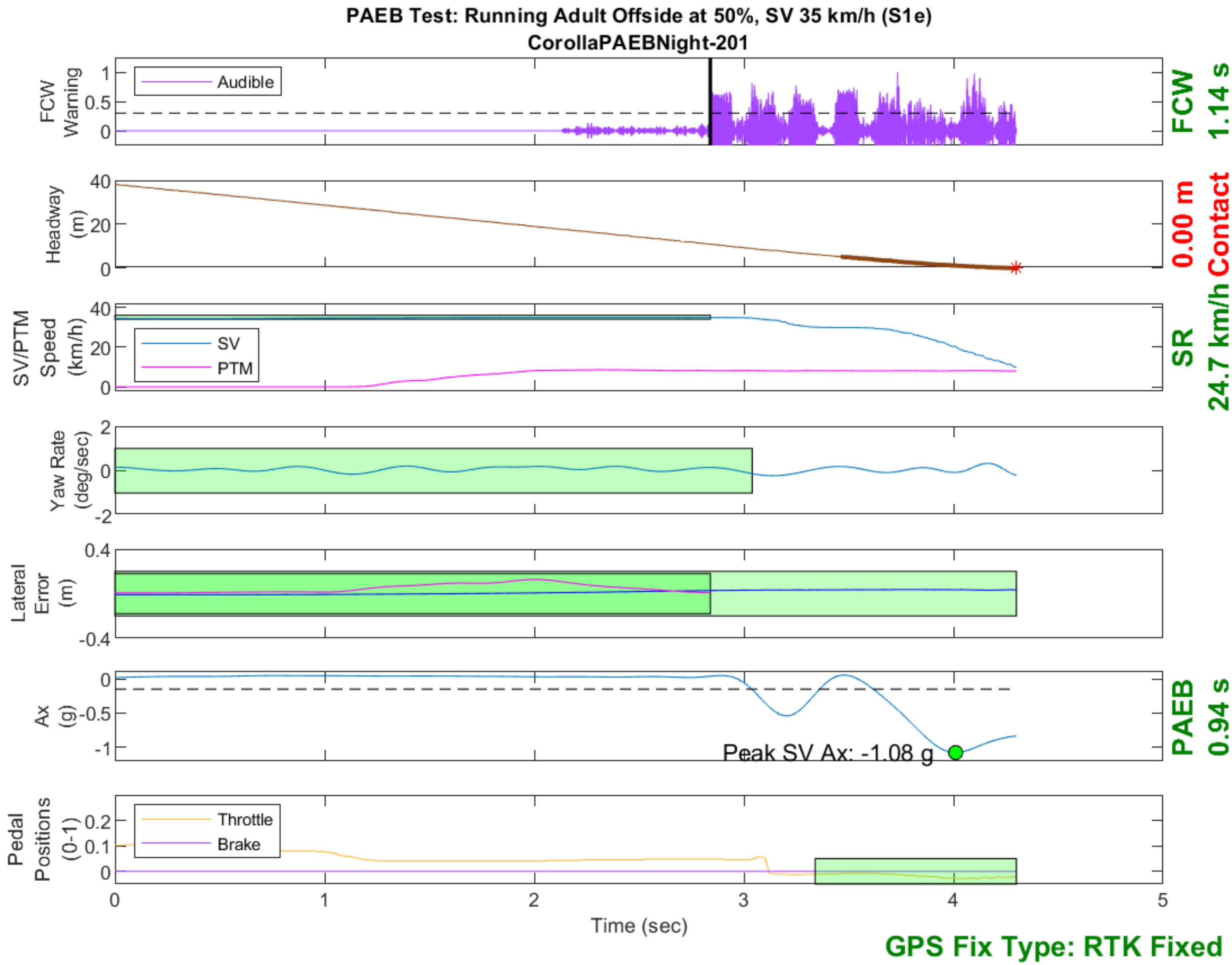


Figure D313. Time History for PAEB Run 201, S1e, Night, Low Beam, 35 km/h

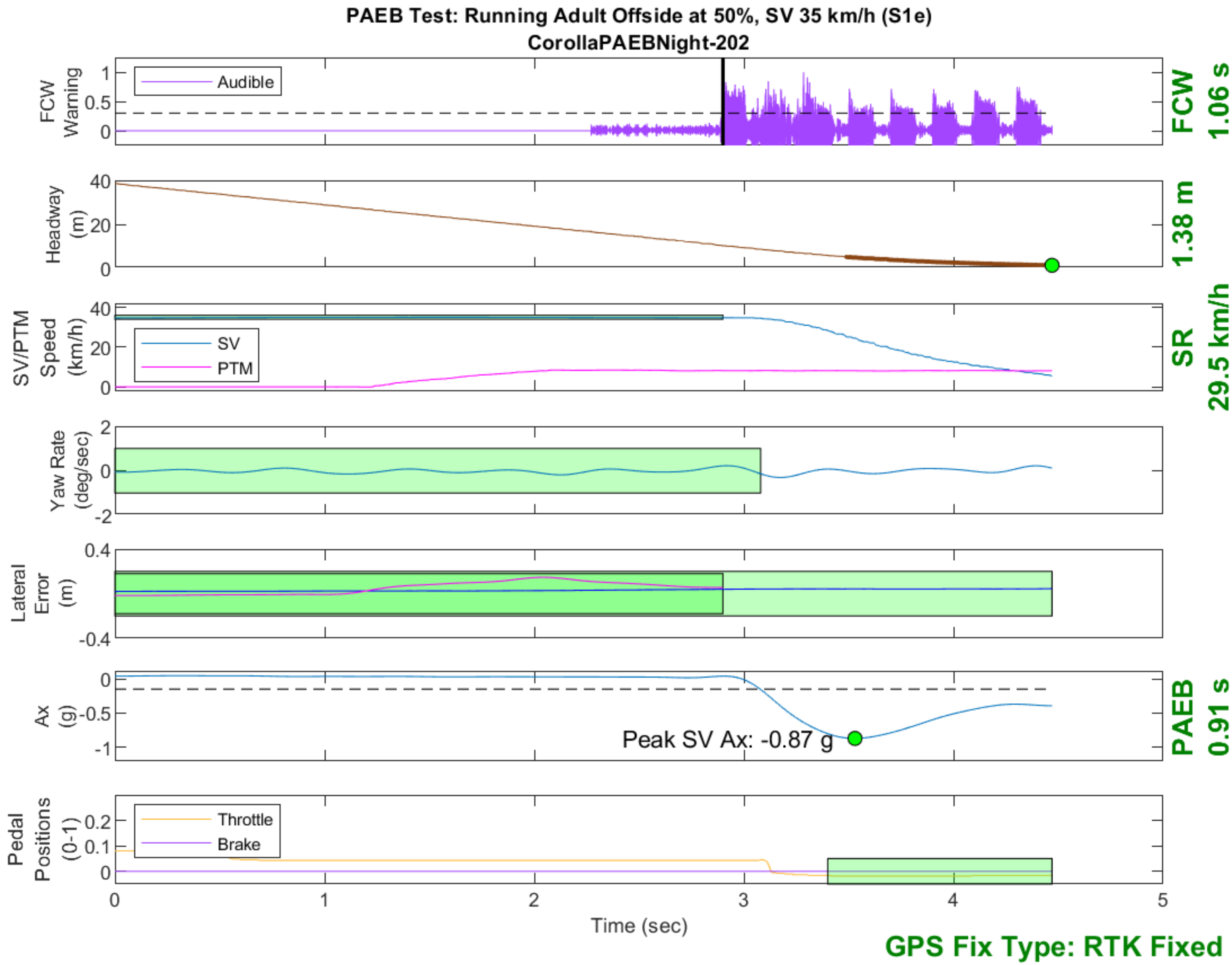


Figure D314. Time History for PAEB Run 202, S1e, Night, Low Beam, 35 km/h

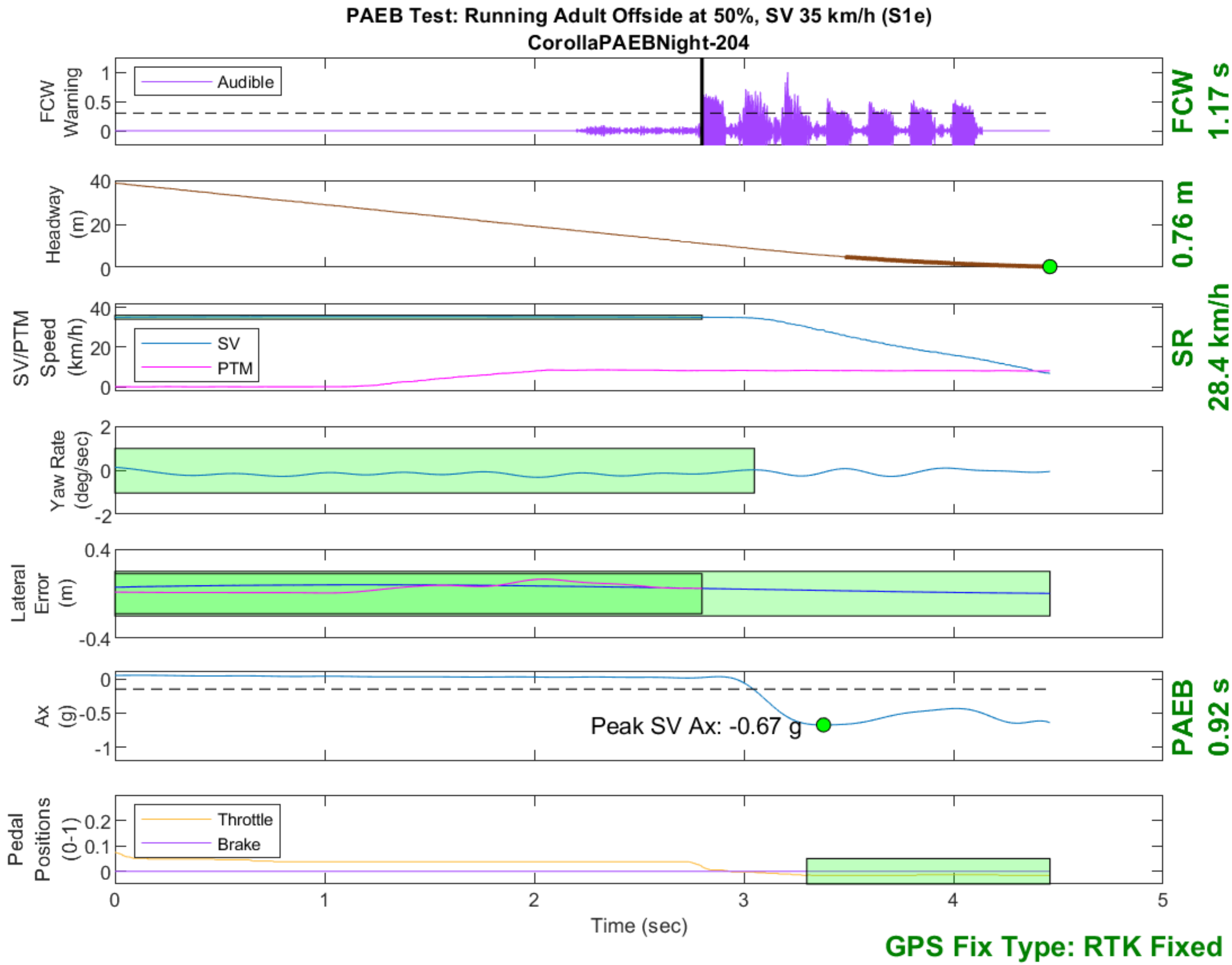


Figure D315. Time History for PAEB Run 204, S1e, Night, Low Beam, 35 km/h

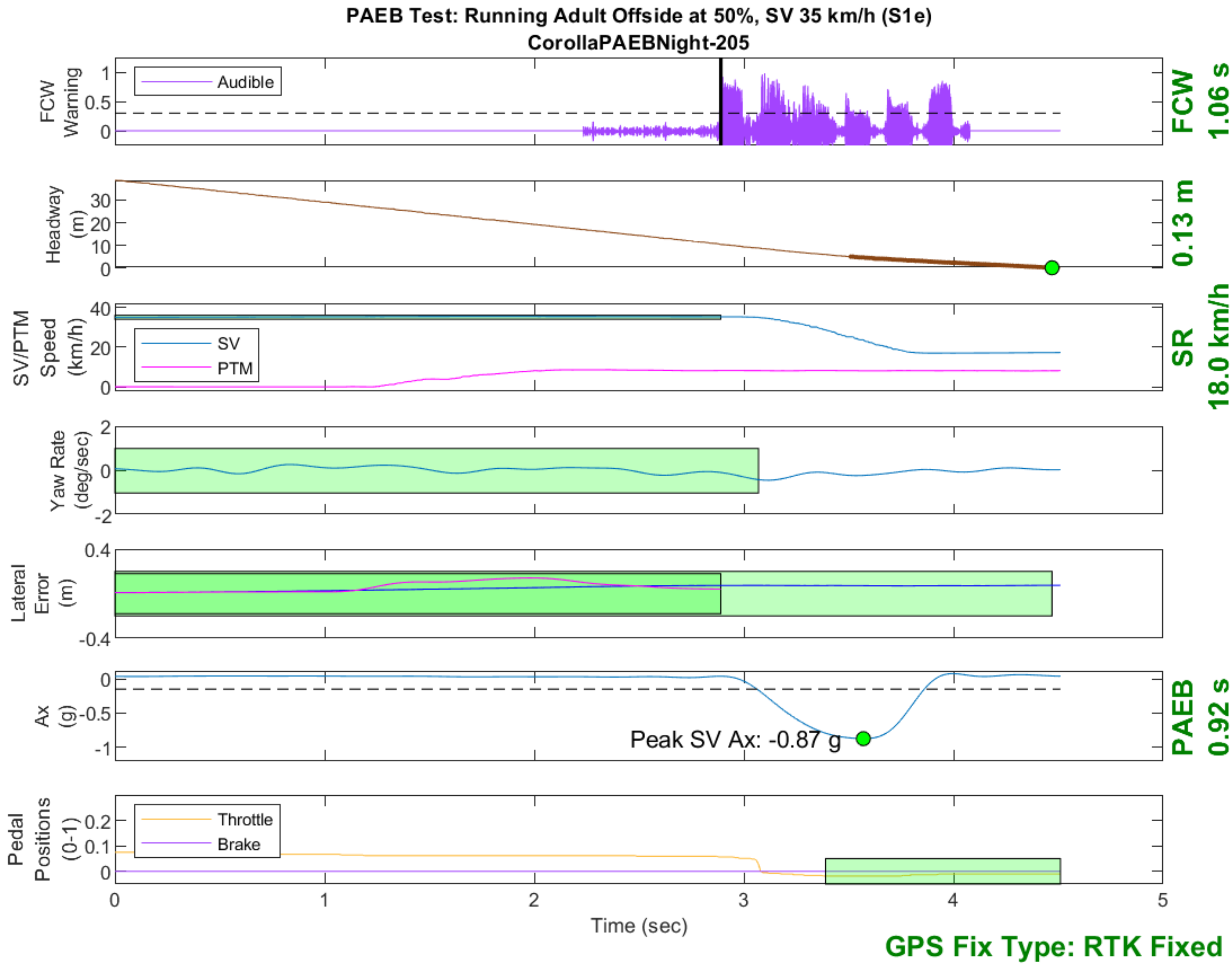


Figure D316. Time History for PAEB Run 205, S1e, Night, Low Beam, 35 km/h

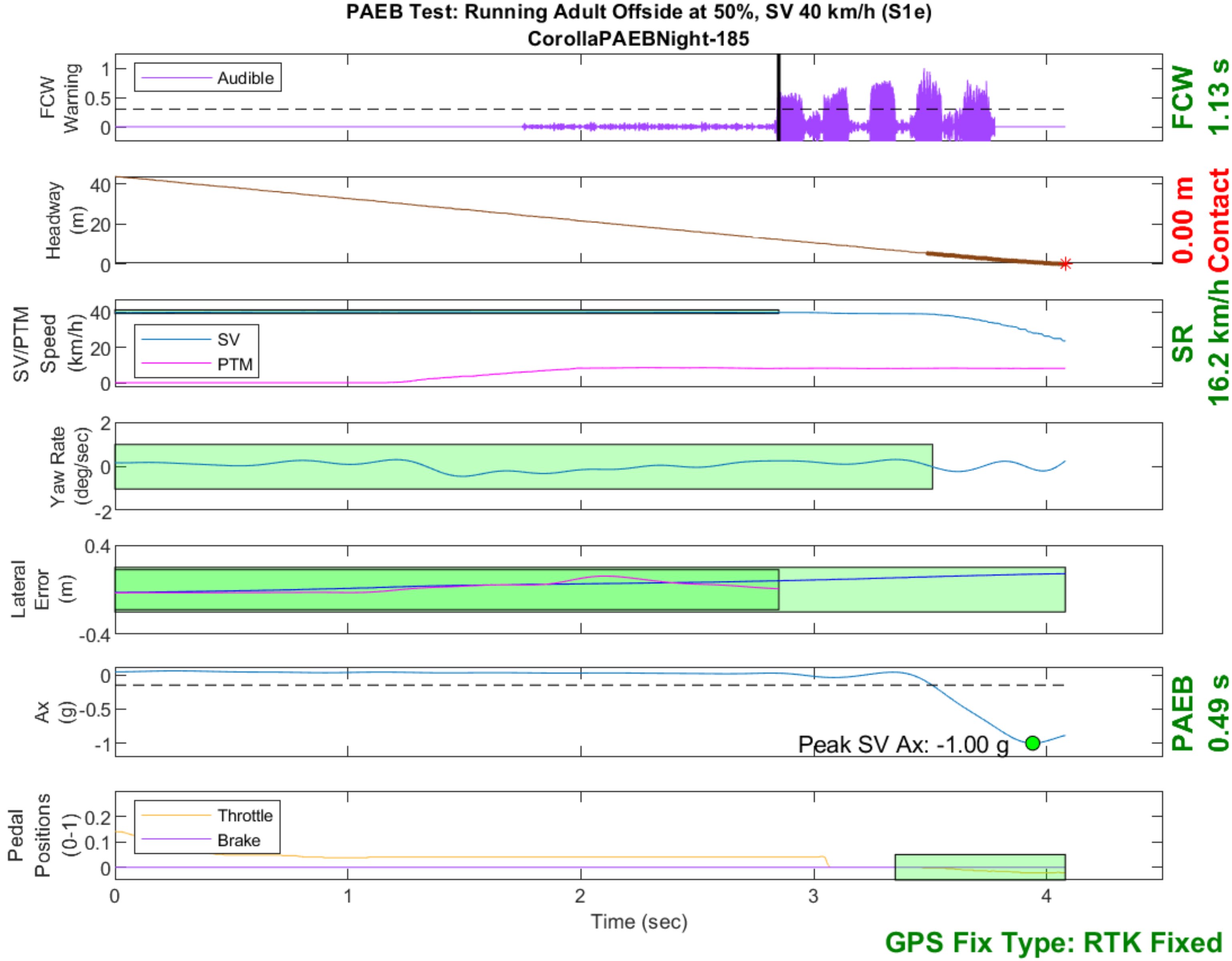


Figure D317. Time History for PAEB Run 185, S1e, Night, Low Beam, 40 km/h

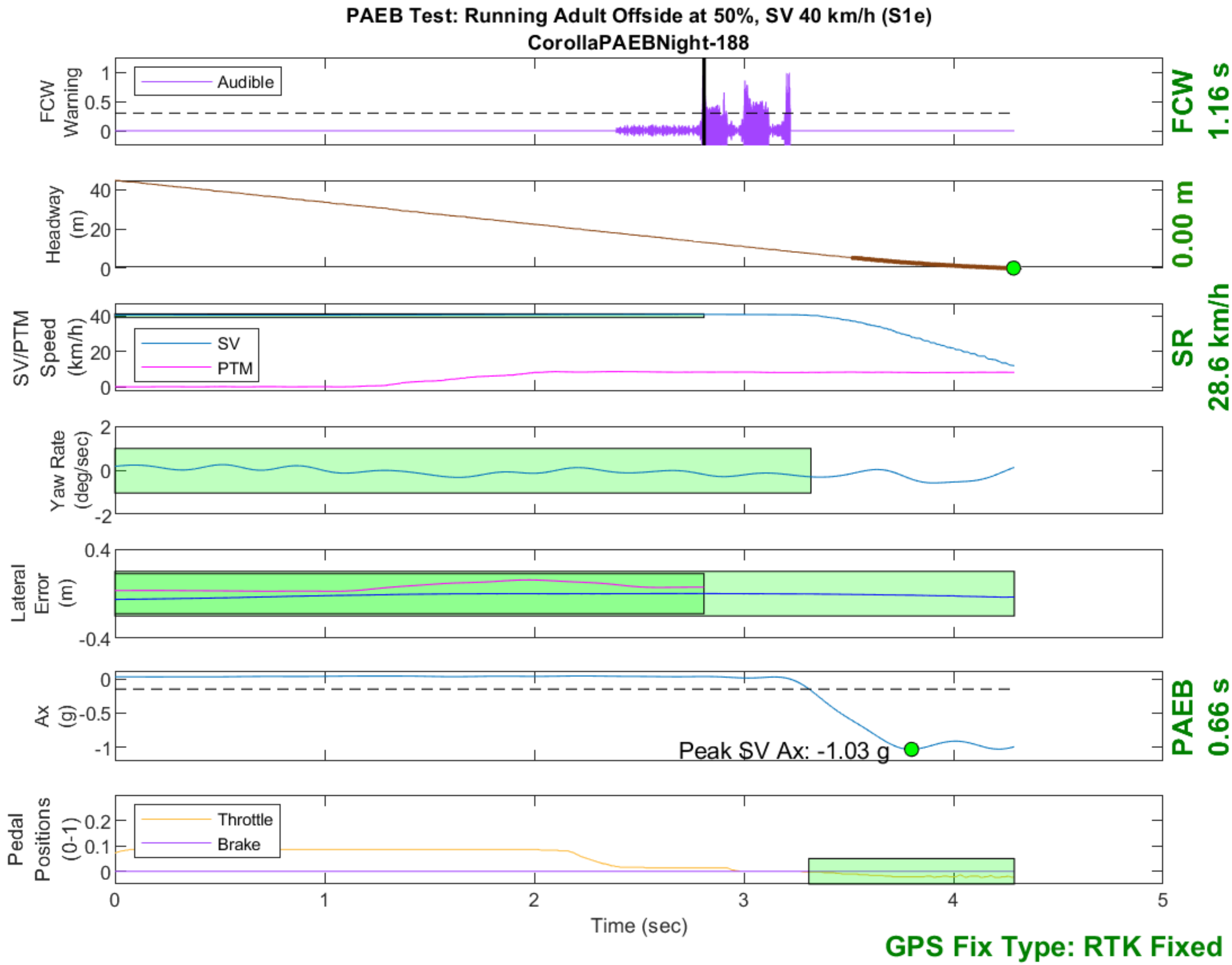


Figure D318. Time History for PAEB Run 188, S1e, Night, Low Beam, 40 km/h

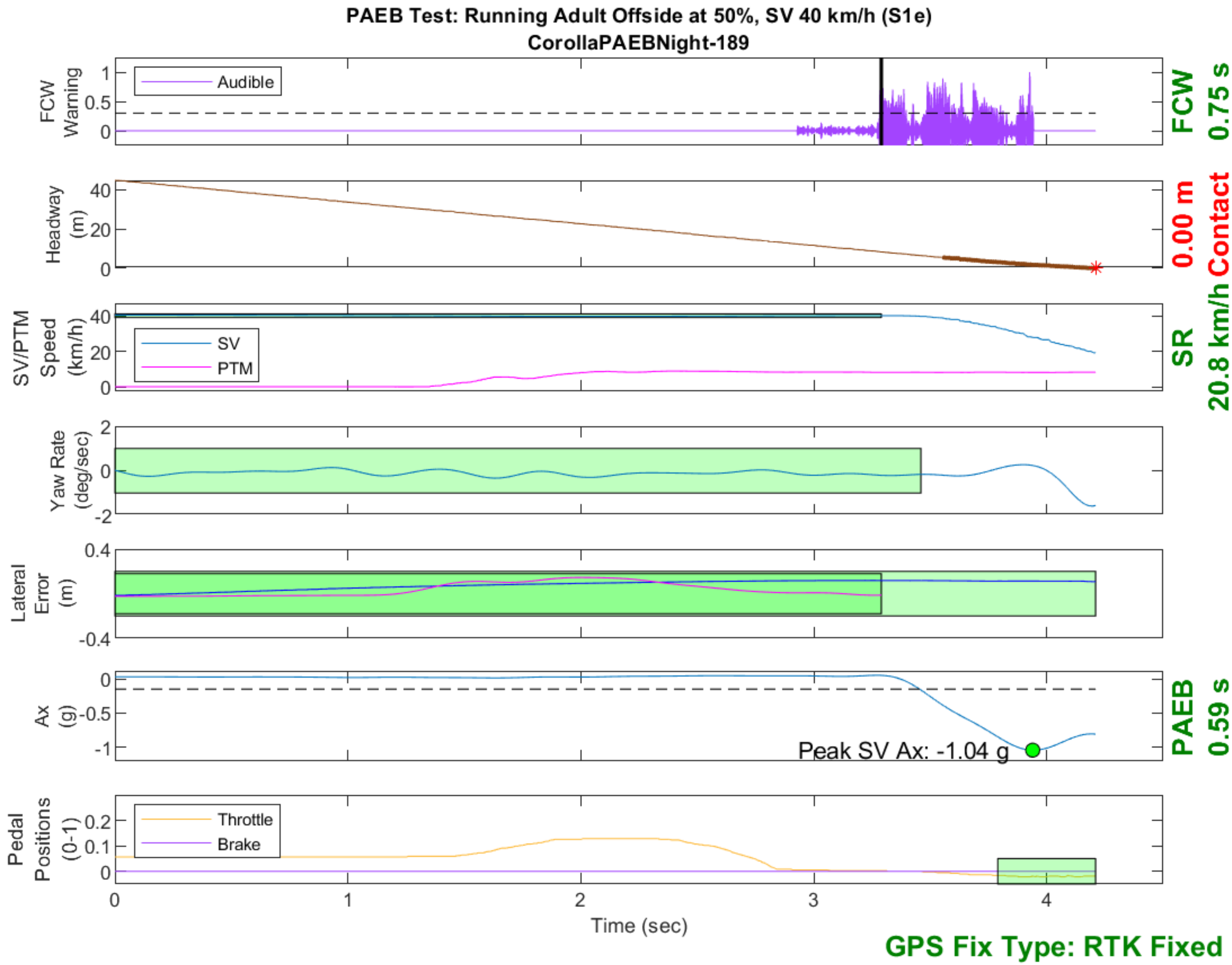


Figure D319. Time History for PAEB Run 189, S1e, Night, Low Beam, 40 km/h

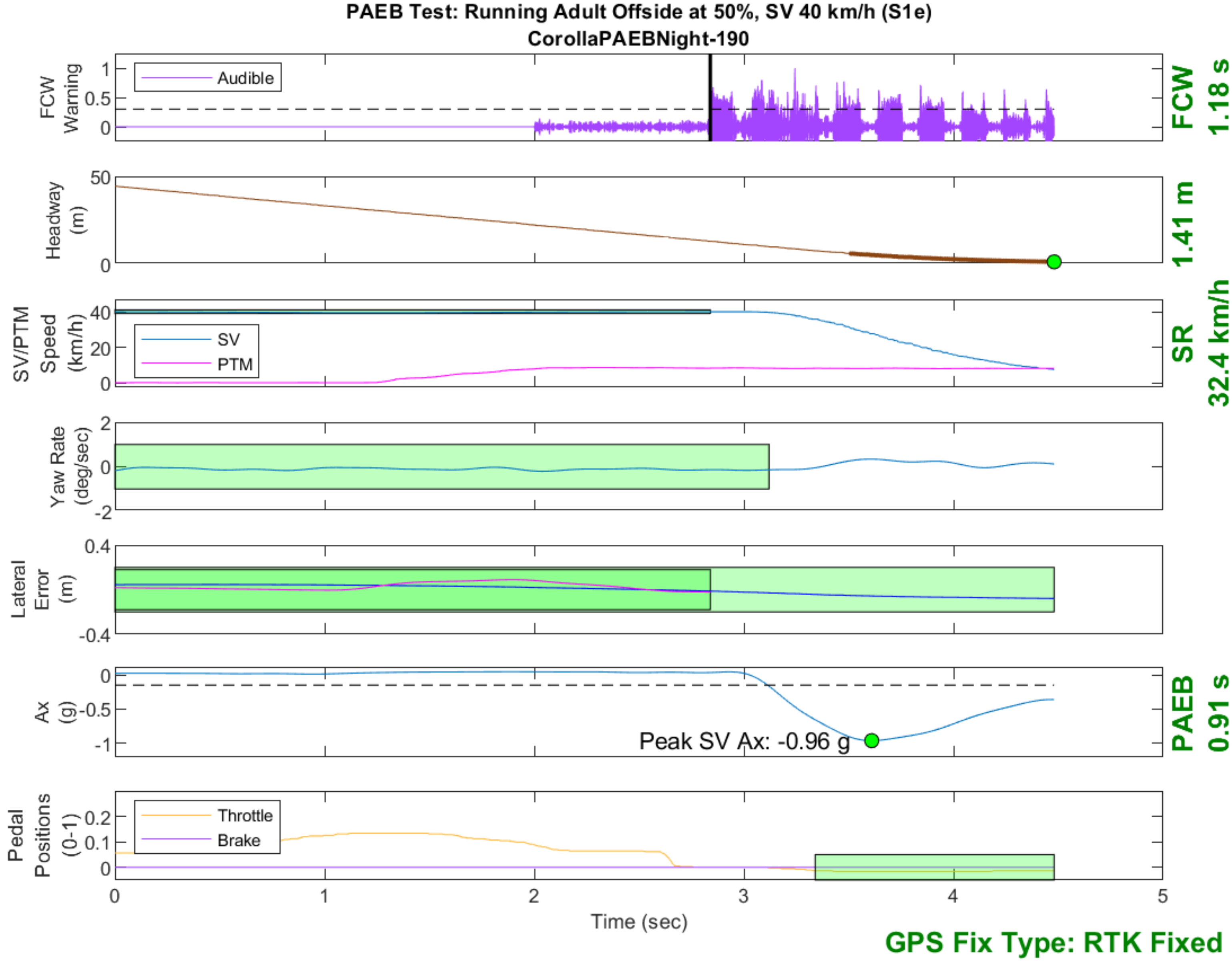


Figure D320. Time History for PAEB Run 190, S1e, Night, Low Beam, 40 km/h

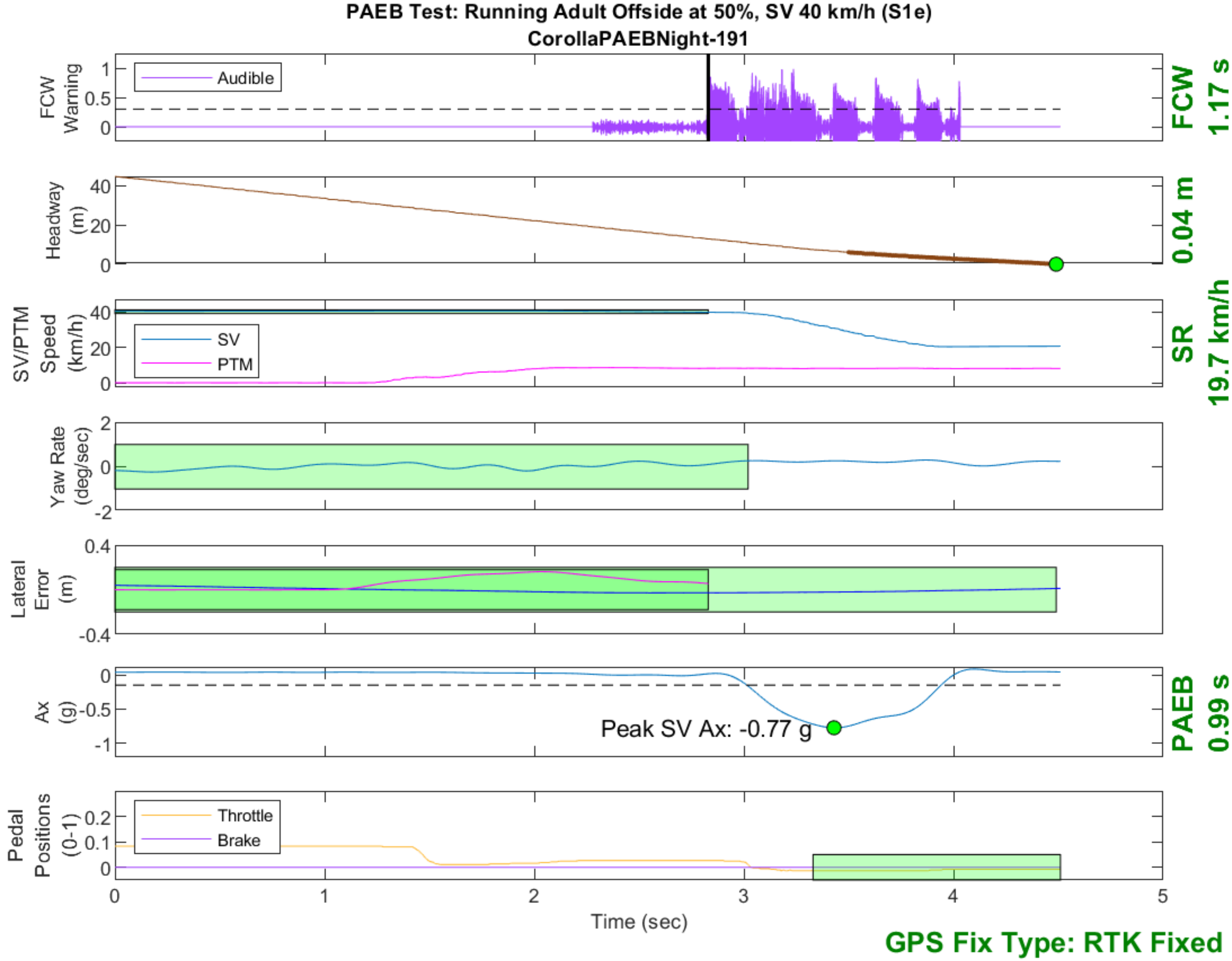


Figure D321. Time History for PAEB Run 191, S1e, Night, Low Beam, 40 km/h

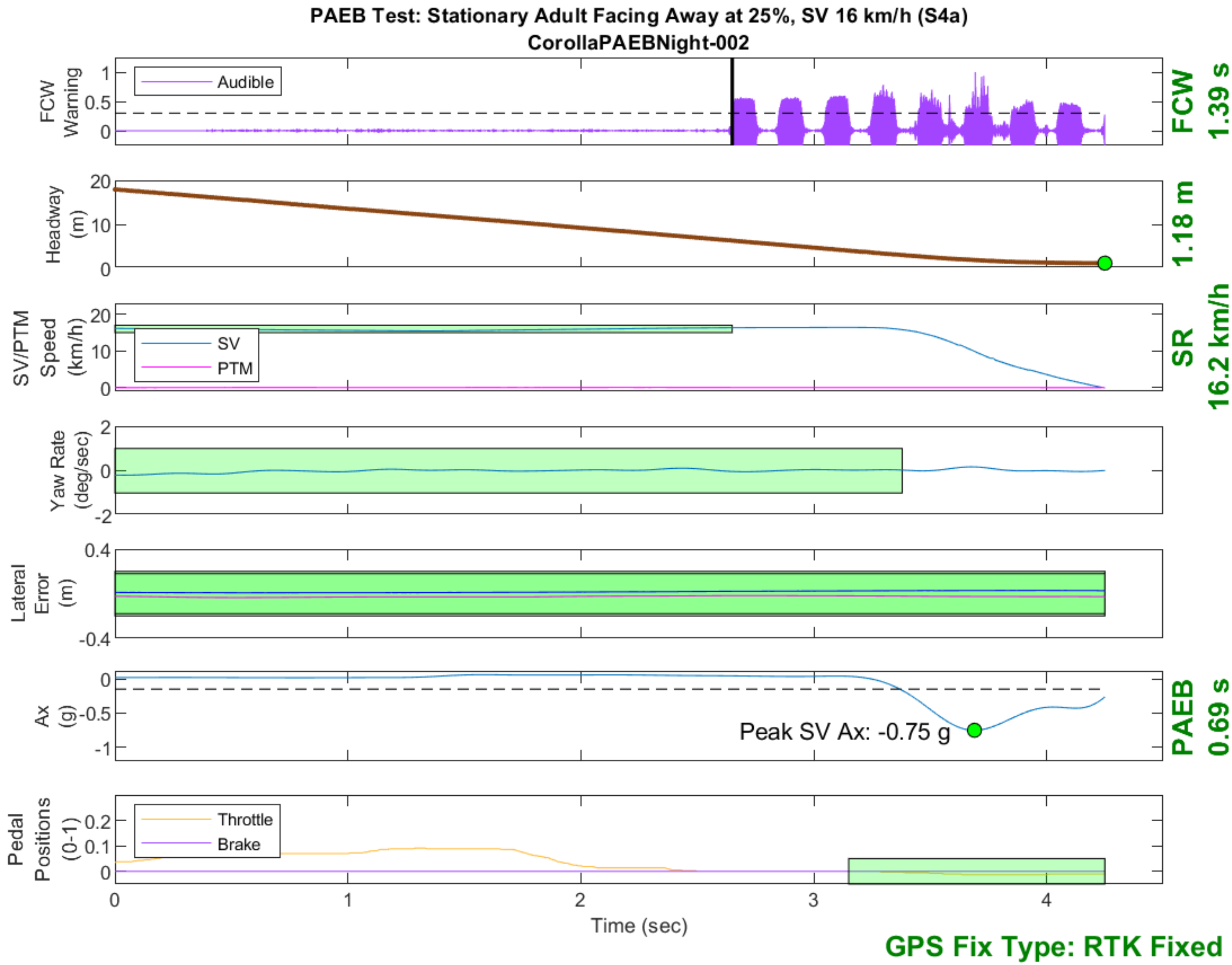


Figure D322. Time History for PAEB Run 2, S4a, Night, Low Beam, 16 km/h

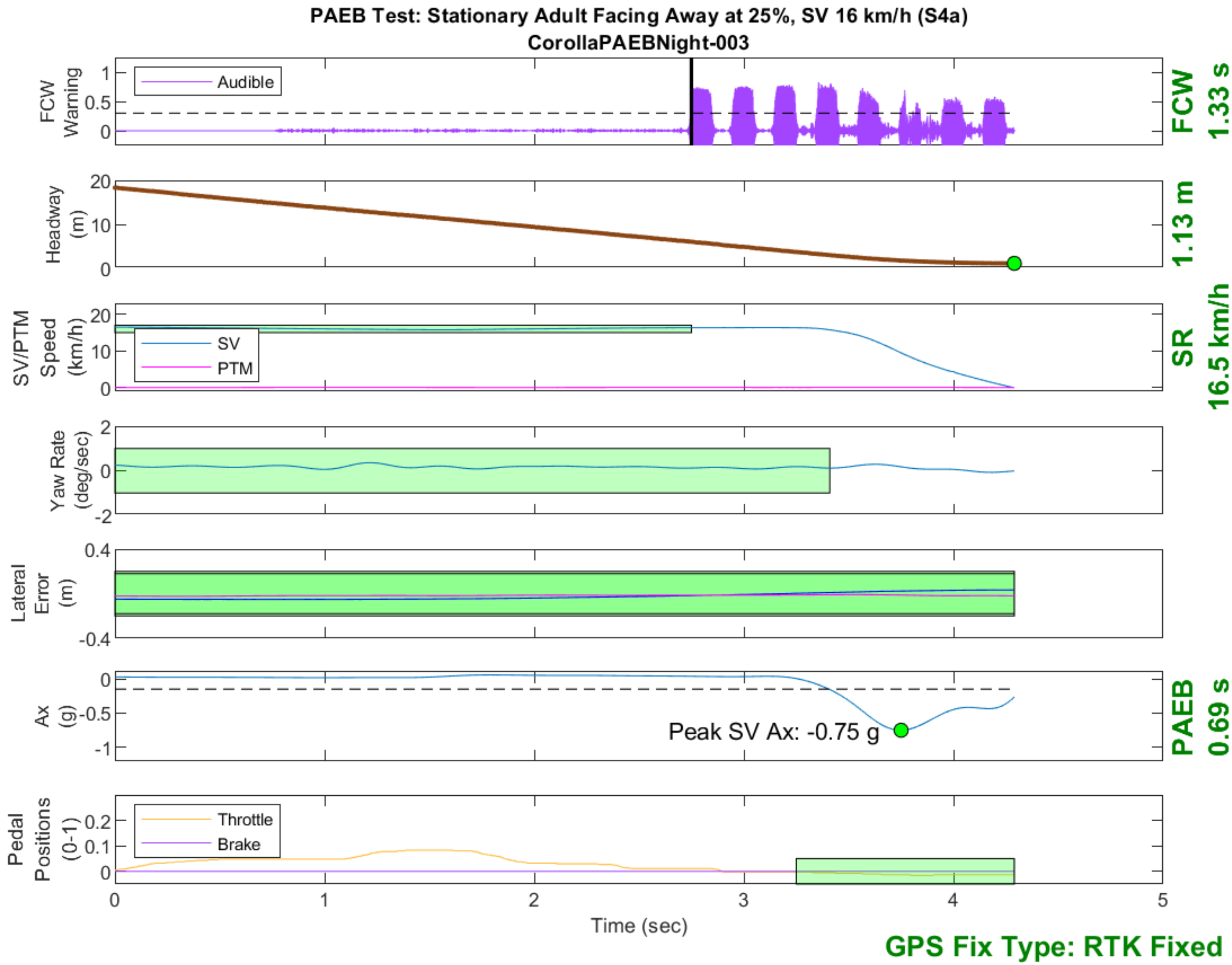


Figure D323. Time History for PAEB Run 3, S4a, Night, Low Beam, 16 km/h

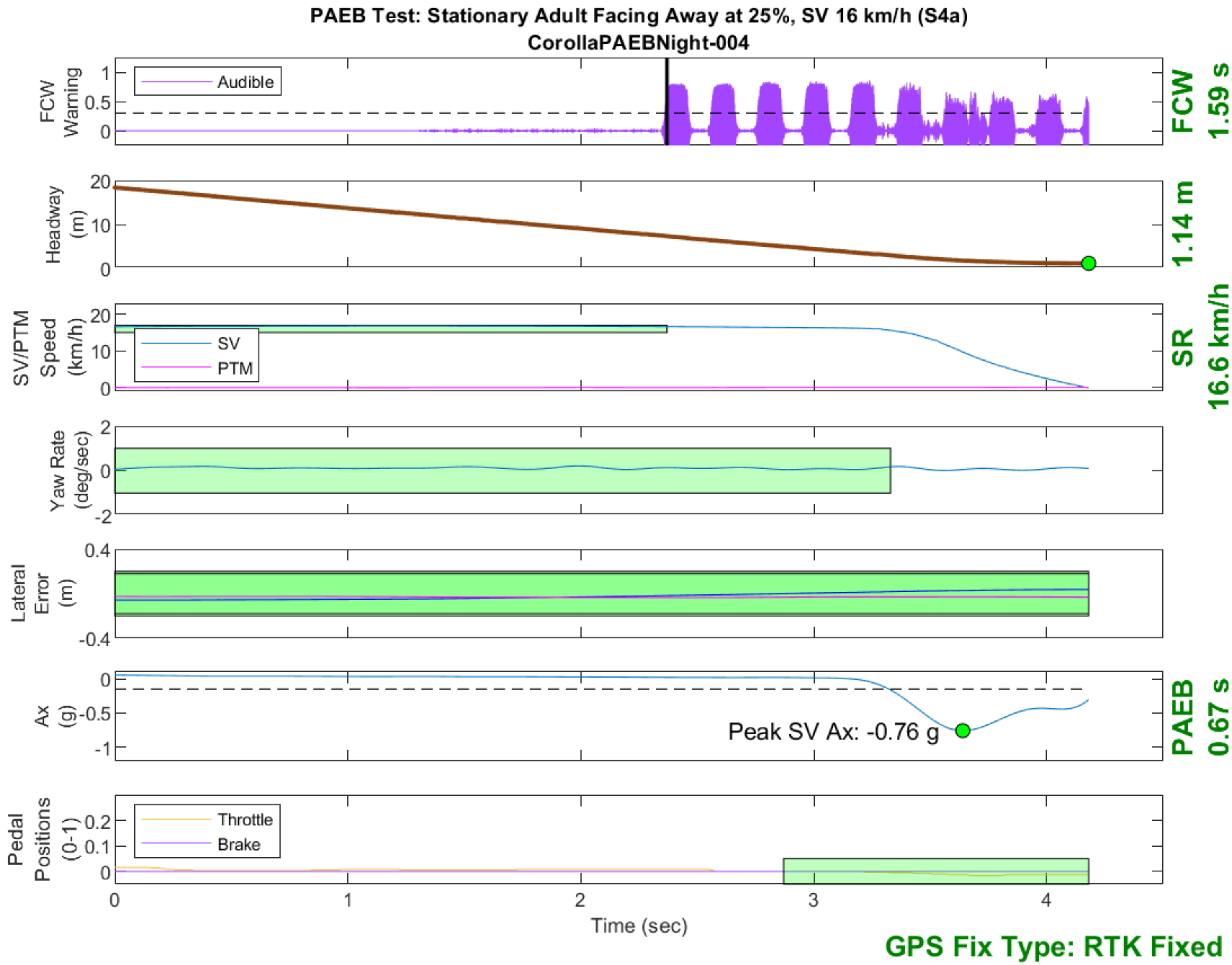


Figure D324. Time History for PAEB Run 4, S4a, Night, Low Beam, 16 km/h

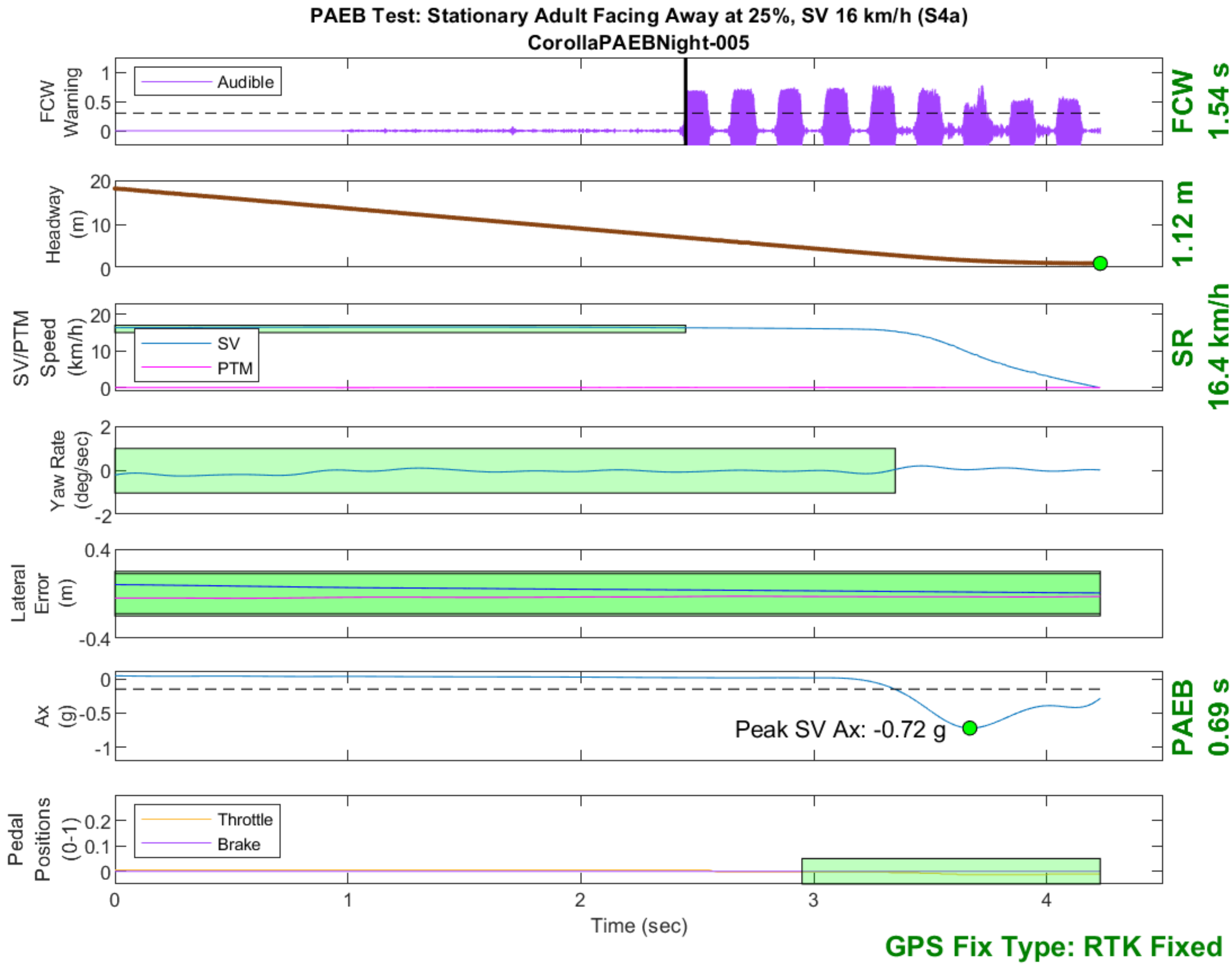


Figure D325. Time History for PAEB Run 5, S4a, Night, Low Beam, 16 km/h

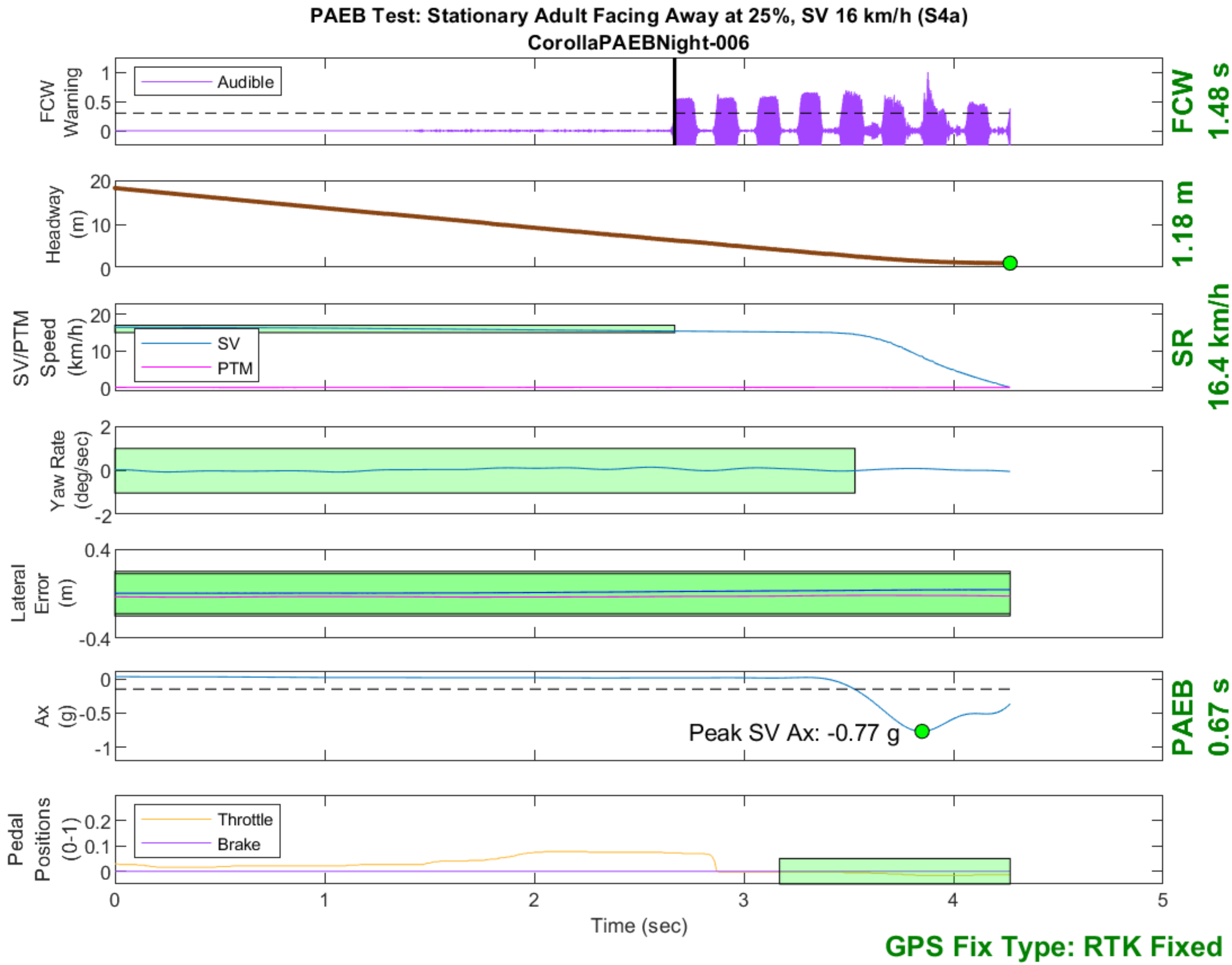


Figure D326. Time History for PAEB Run 6, S4a, Night, Low Beam, 16 km/h

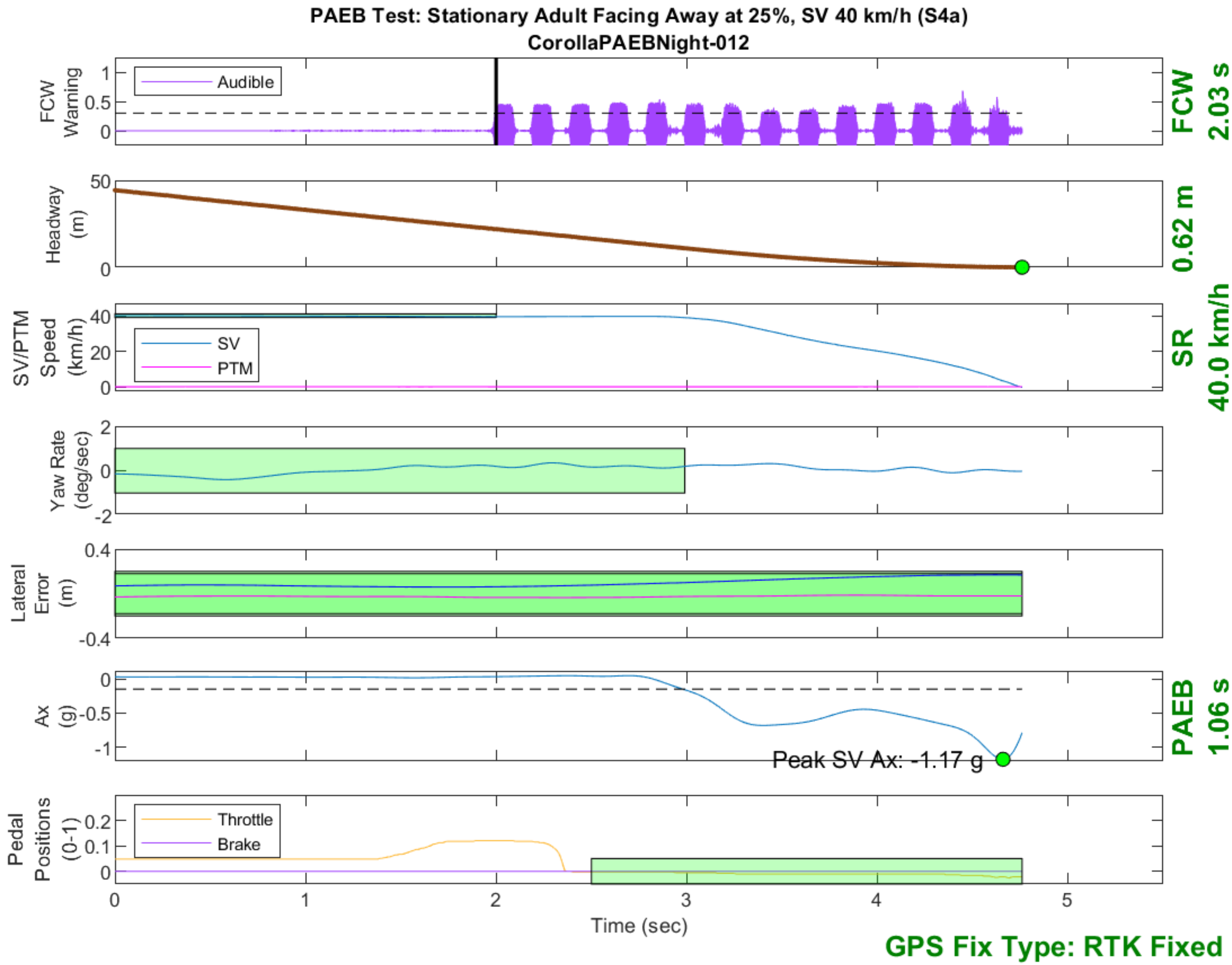


Figure D327. Time History for PAEB Run 12, S4a, Night, Low Beam, 40 km/h

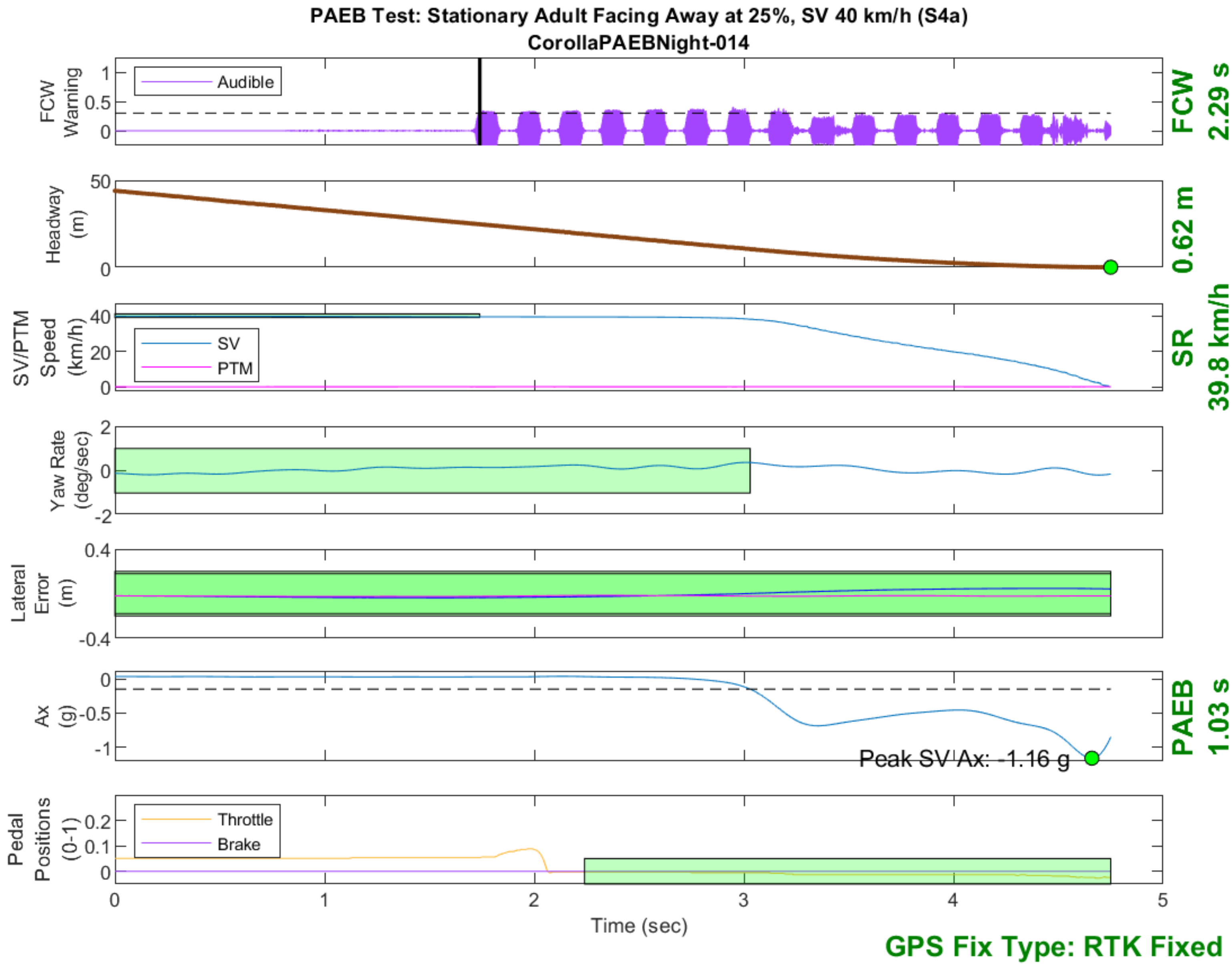


Figure D328. Time History for PAEB Run 14, S4a, Night, Low Beam, 40 km/h

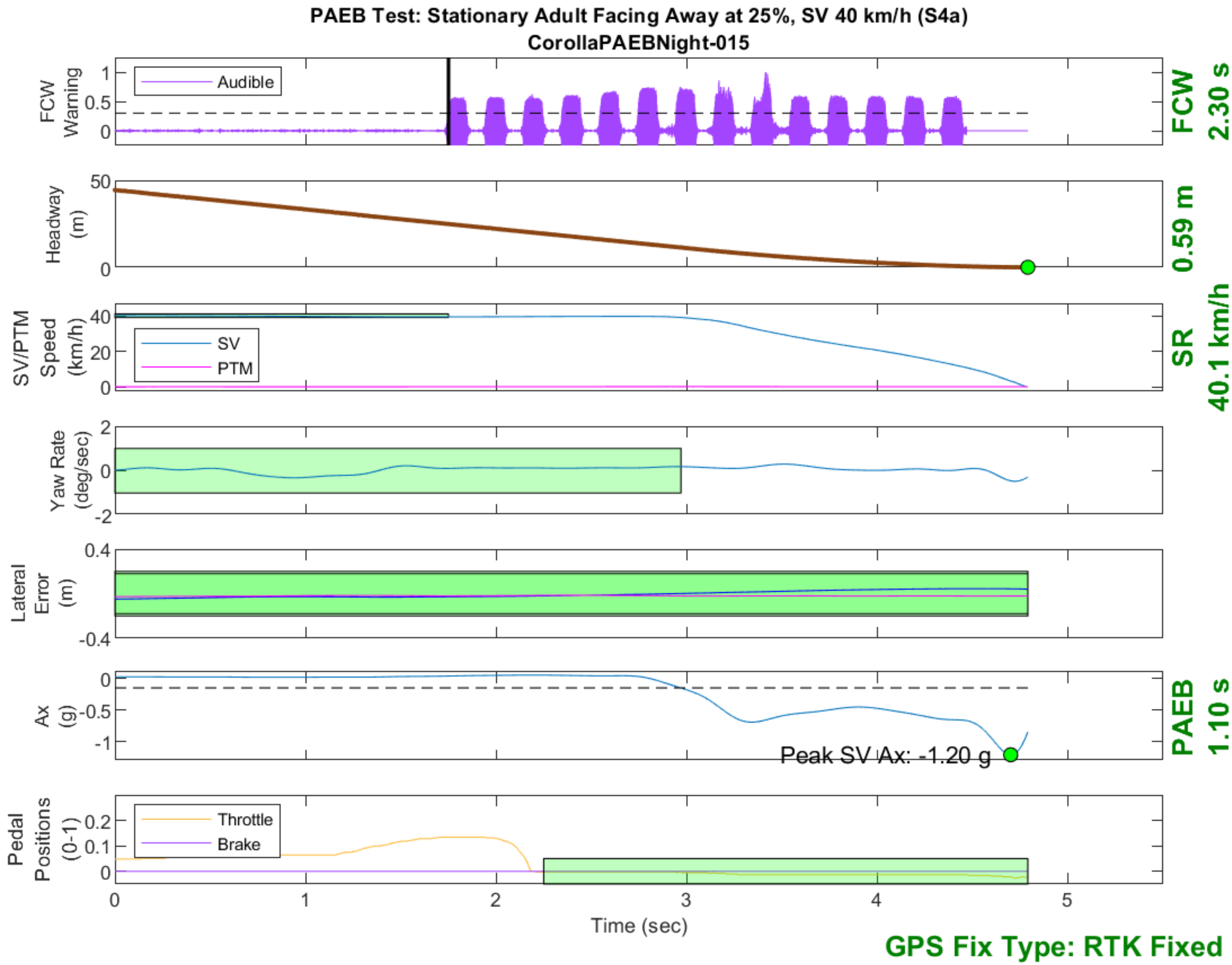


Figure D329. Time History for PAEB Run 15, S4a, Night, Low Beam, 40 km/h

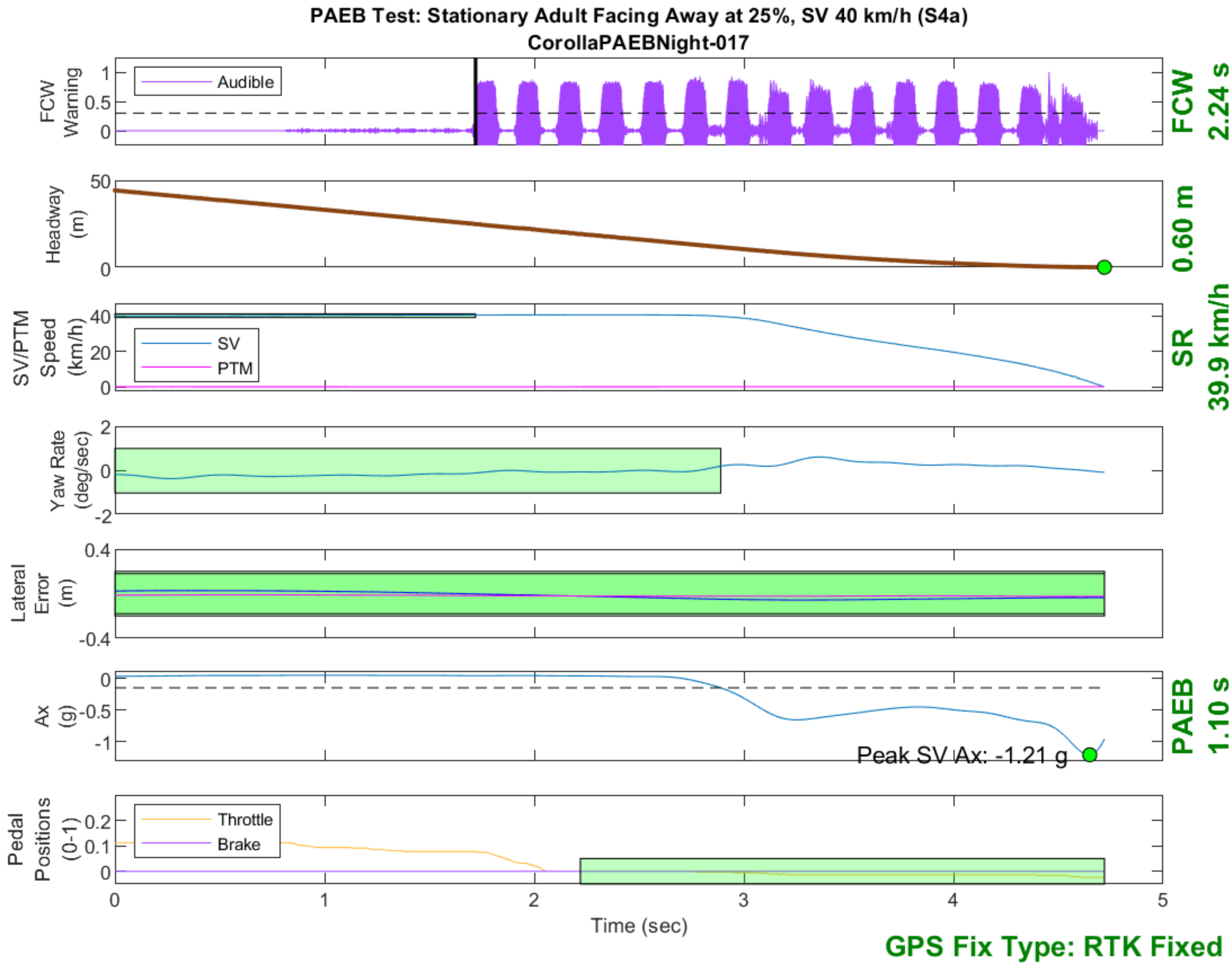


Figure D330. Time History for PAEB Run 17, S4a, Night, Low Beam, 40 km/h

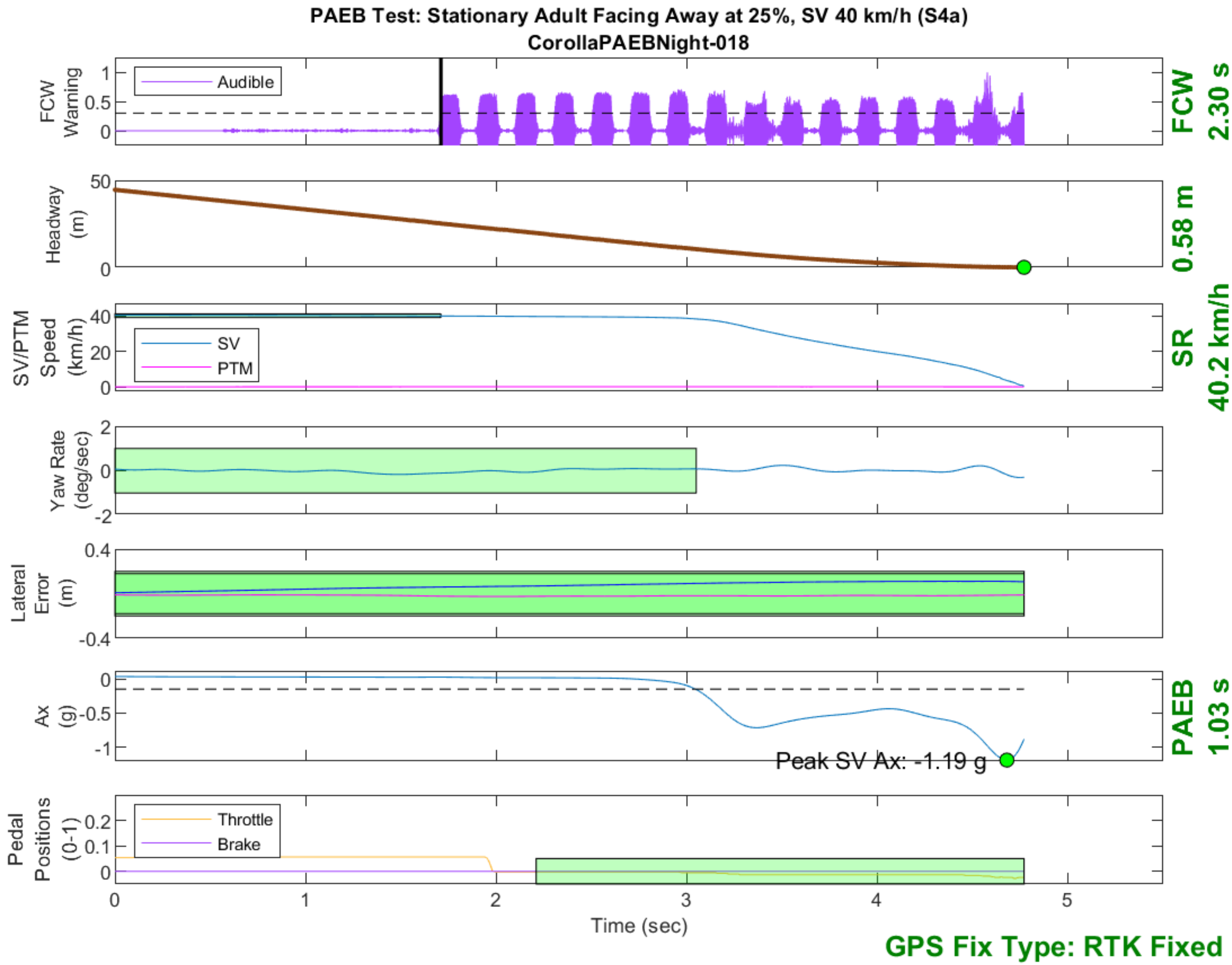


Figure D331. Time History for PAEB Run 18, S4a, Night, Low Beam, 40 km/h

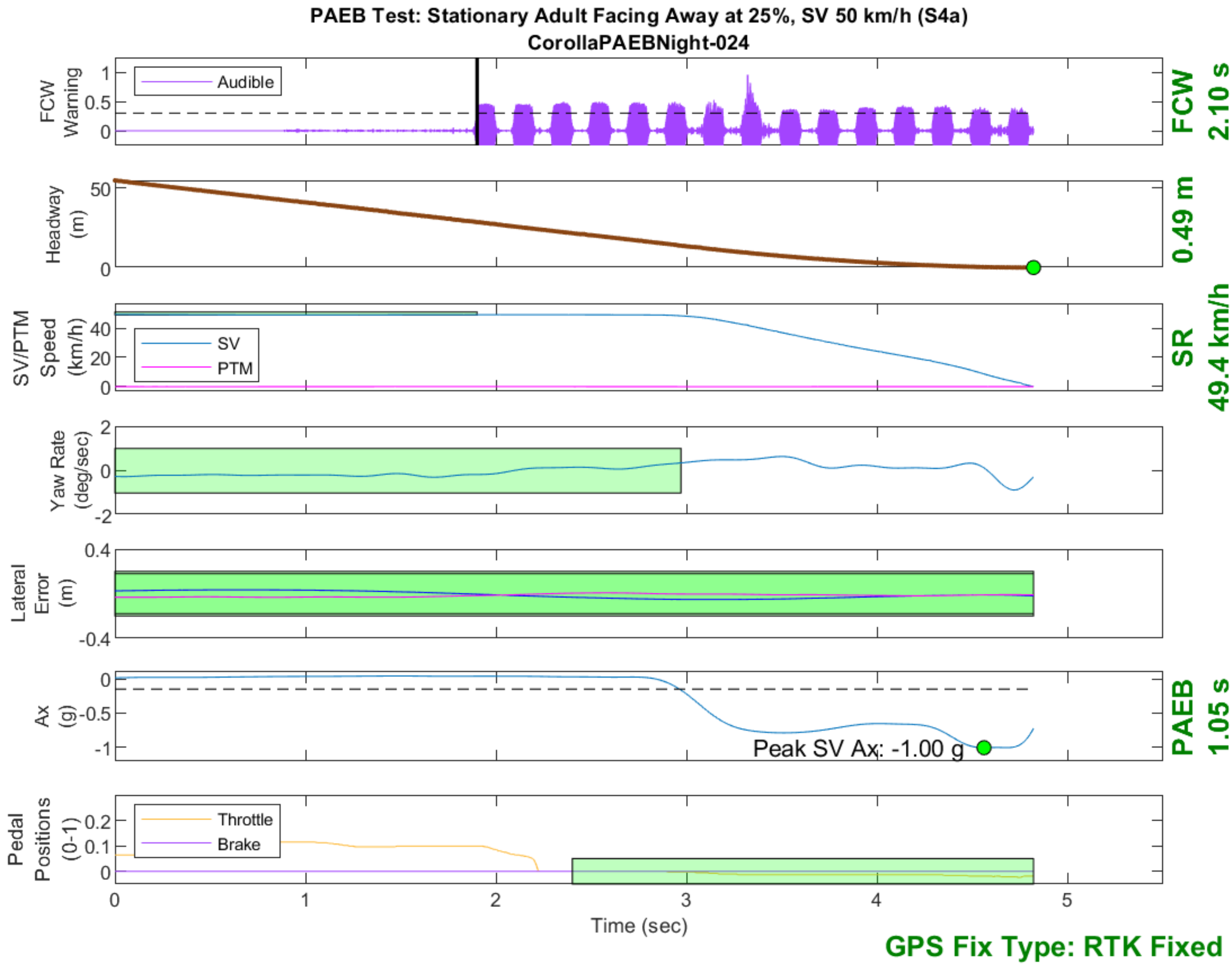


Figure D332. Time History for PAEB Run 24, S4a, Night, Low Beam, 50 km/h

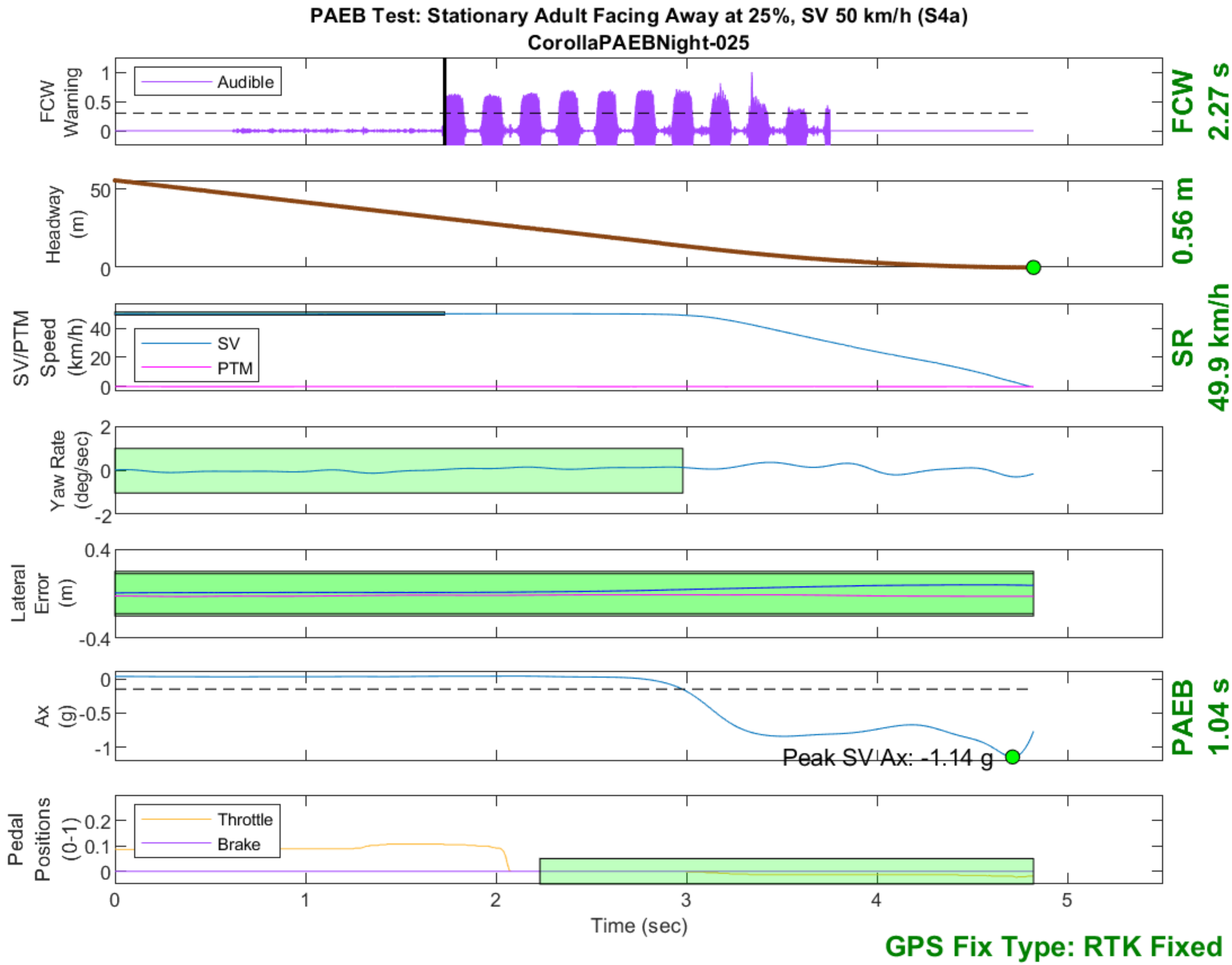


Figure D333. Time History for PAEB Run 25, S4a, Night, Low Beam, 50 km/h

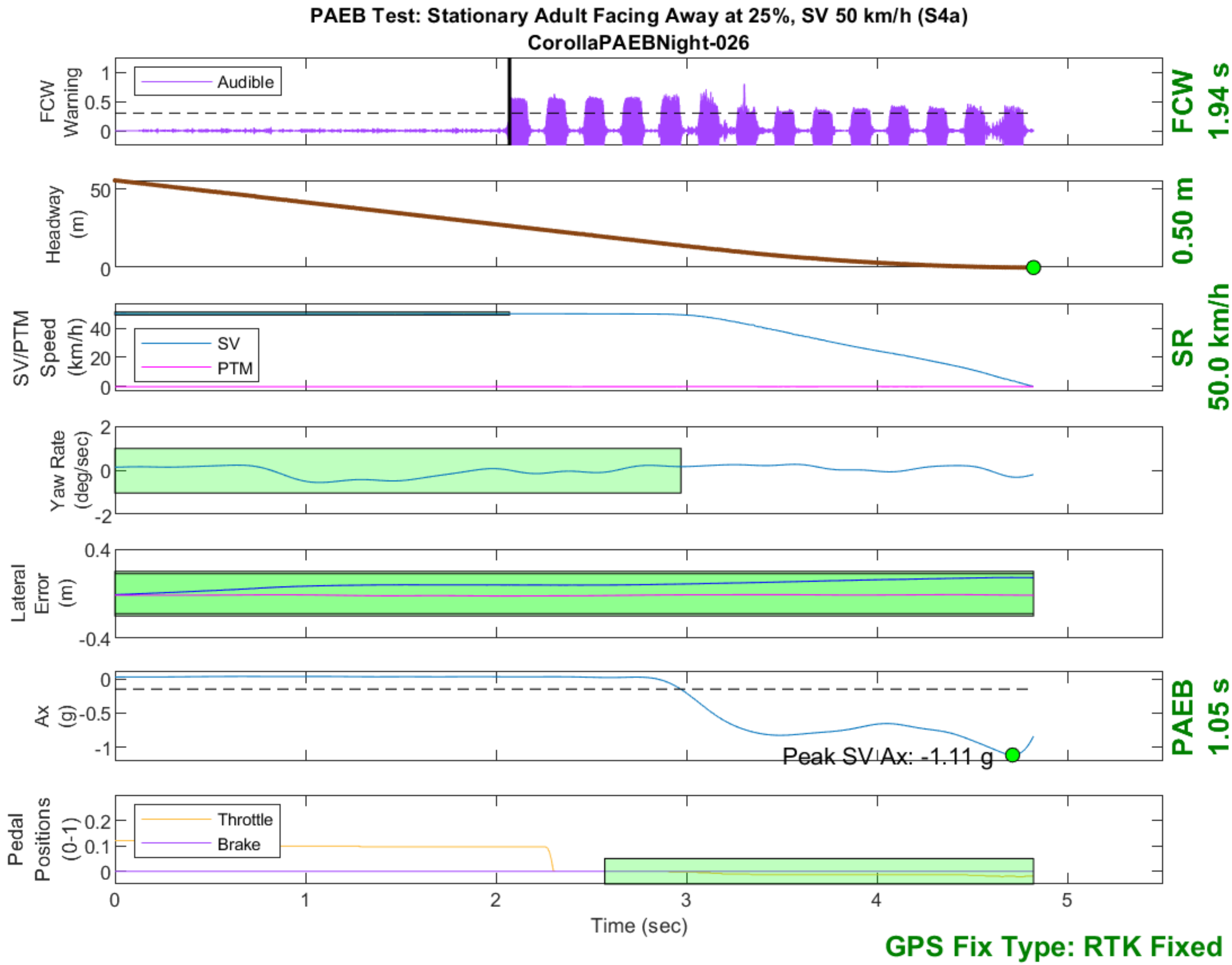


Figure D334. Time History for PAEB Run 26, S4a, Night, Low Beam, 50 km/h

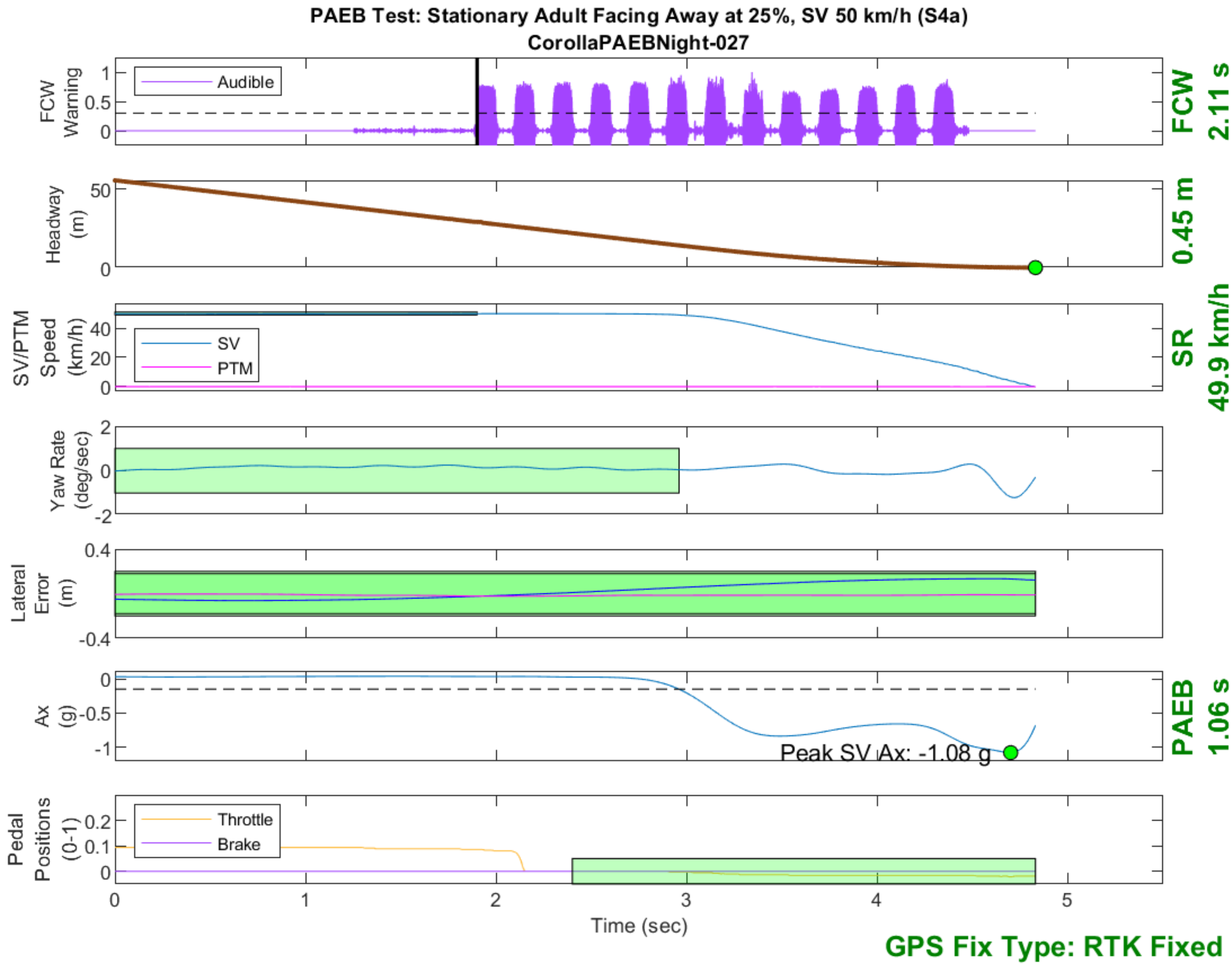


Figure D335. Time History for PAEB Run 27, S4a, Night, Low Beam, 50 km/h

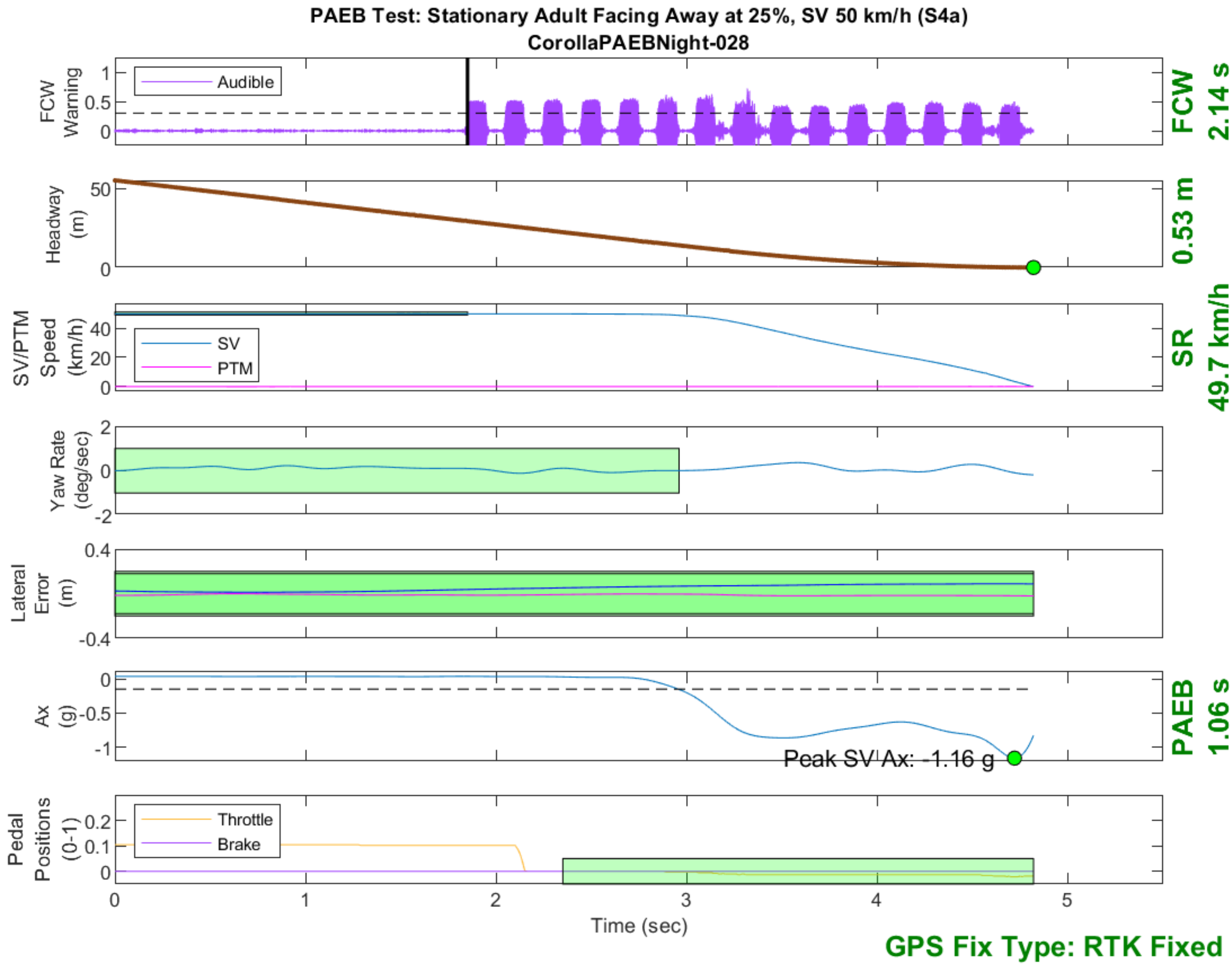


Figure D336. Time History for PAEB Run 28, S4a, Night, Low Beam, 50 km/h

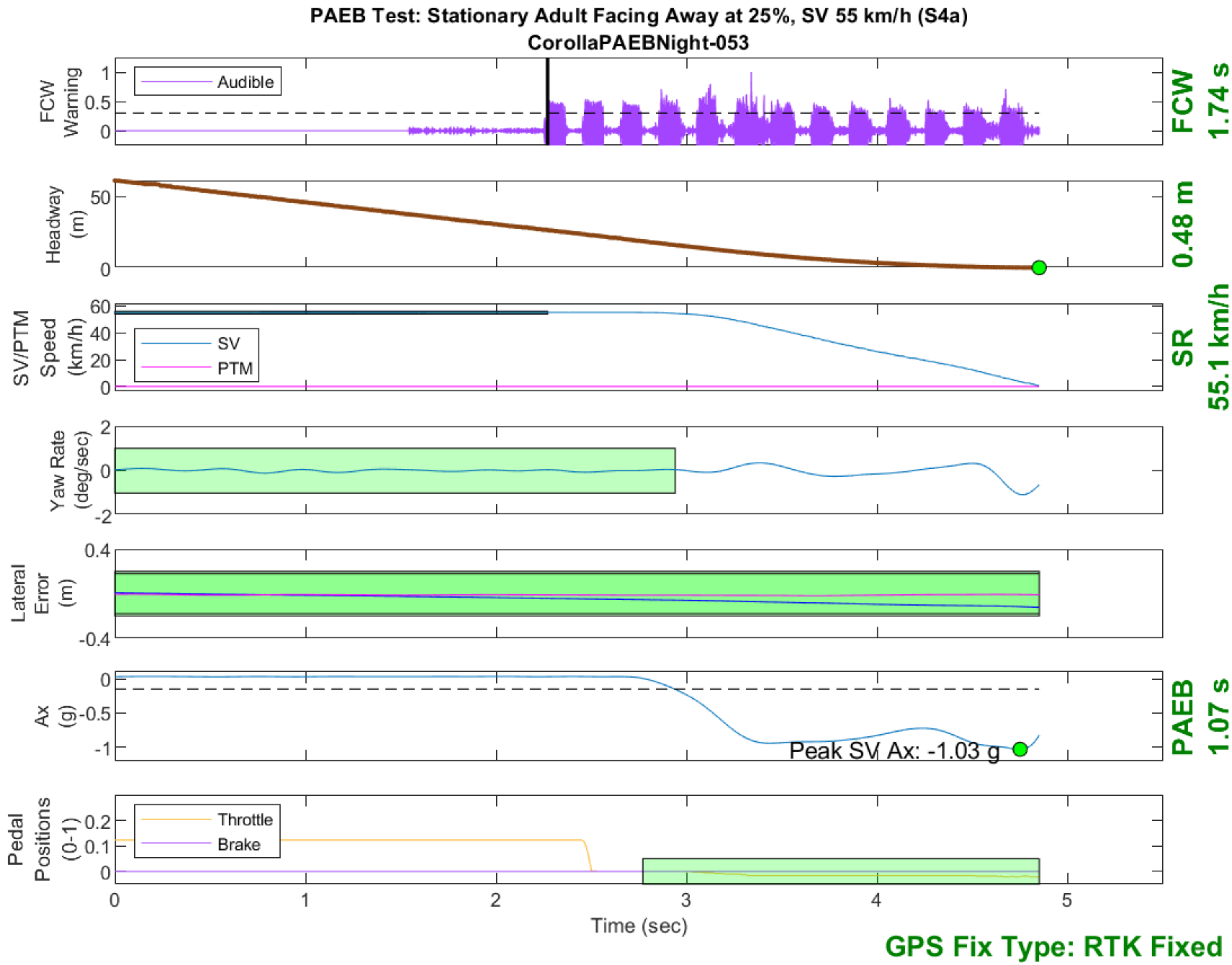


Figure D337. Time History for PAEB Run 53, S4a, Night, Low Beam, 55 km/h

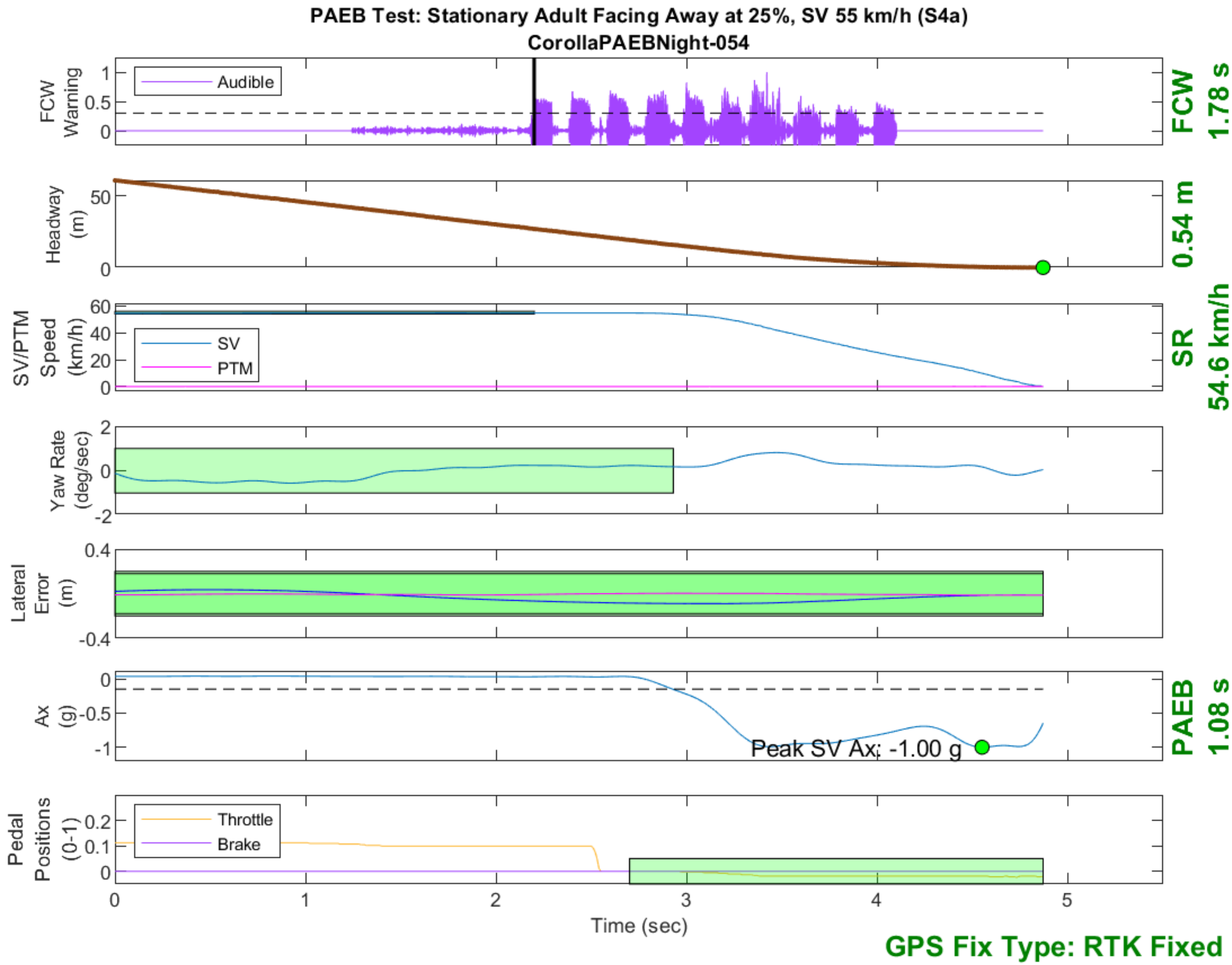


Figure D338. Time History for PAEB Run 54, S4a, Night, Low Beam, 55 km/h

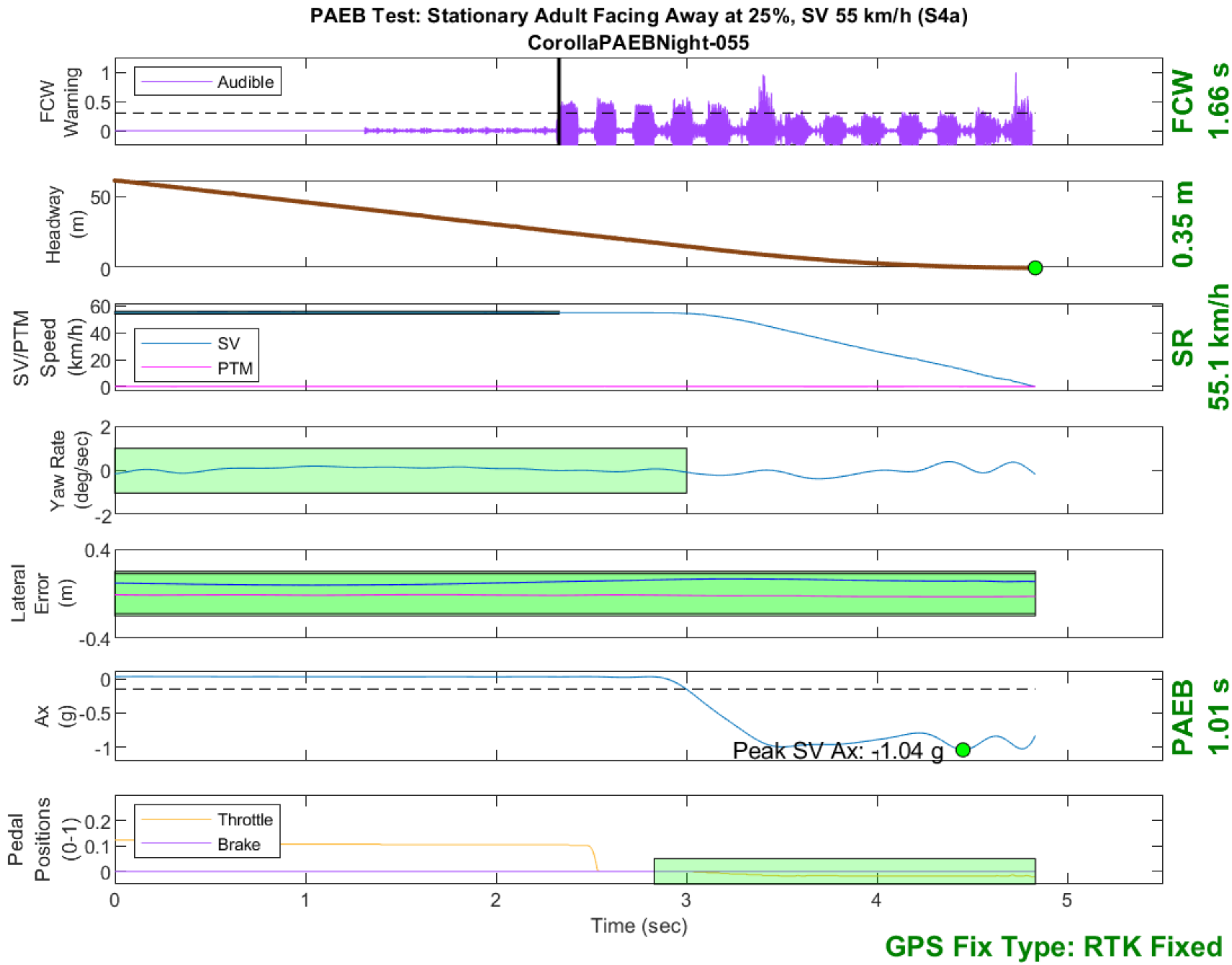


Figure D339. Time History for PAEB Run 55, S4a, Night, Low Beam, 55 km/h

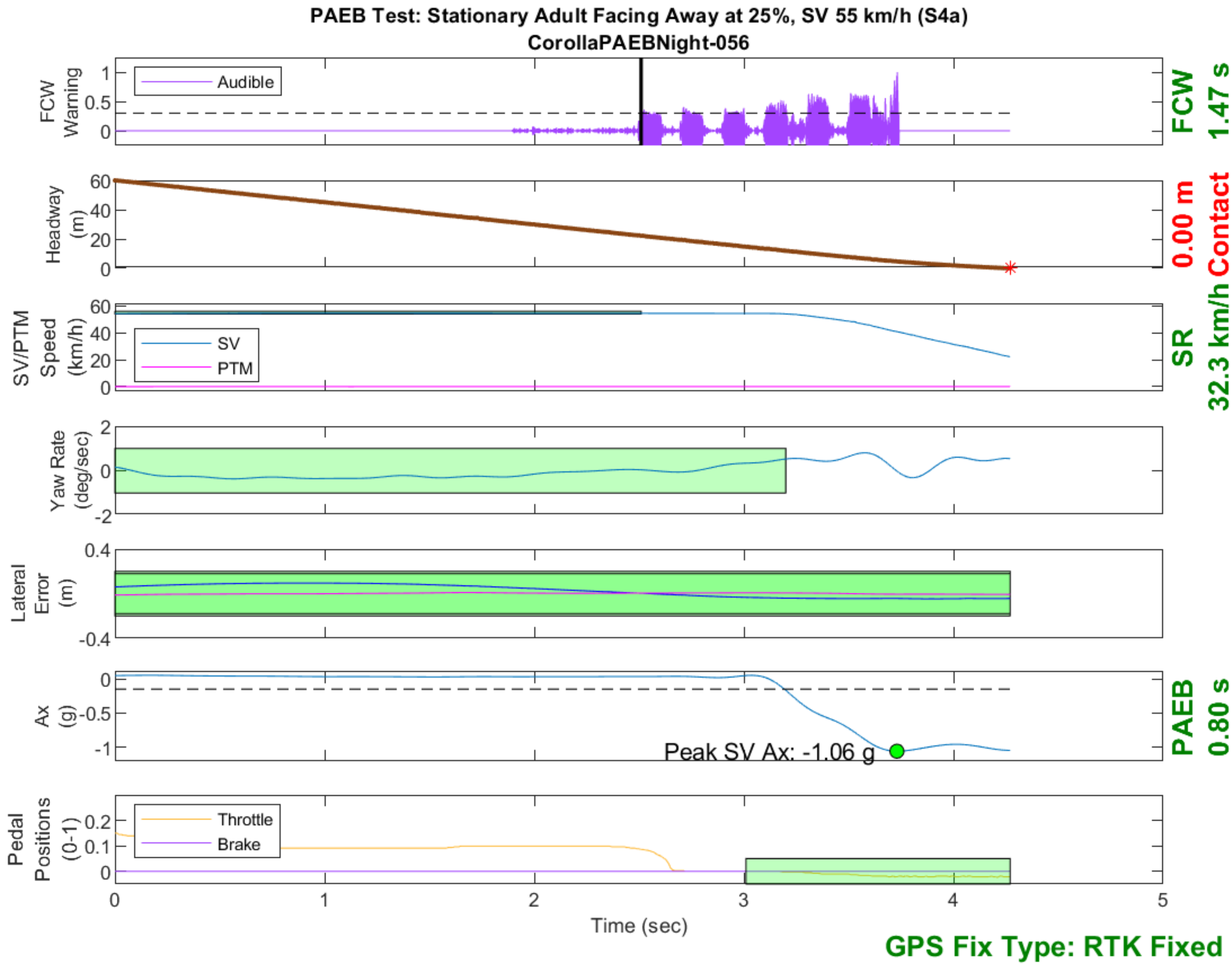


Figure D340. Time History for PAEB Run 56, S4a, Night, Low Beam, 55 km/h

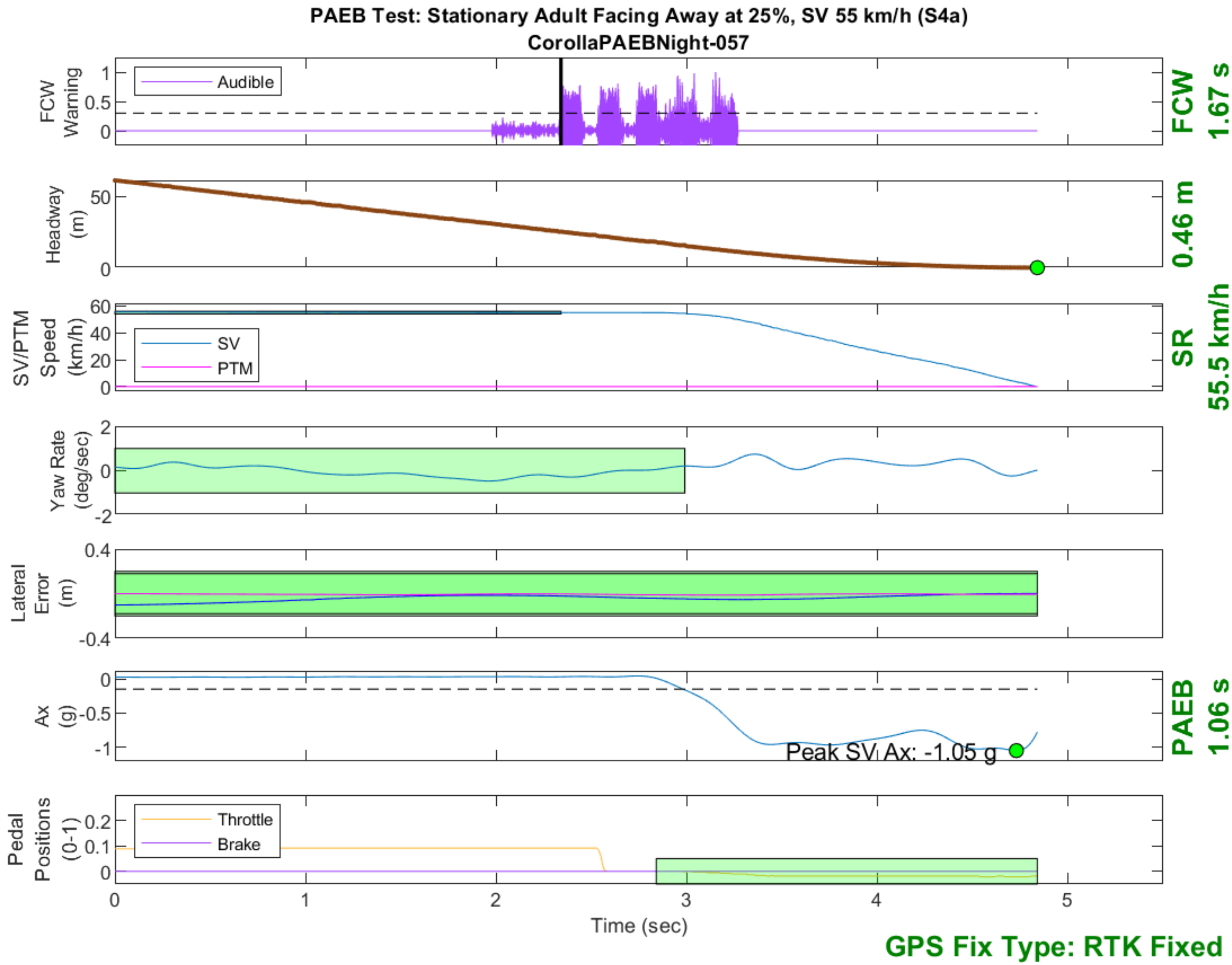


Figure D341. Time History for PAEB Run 57, S4a, Night, Low Beam, 55 km/h

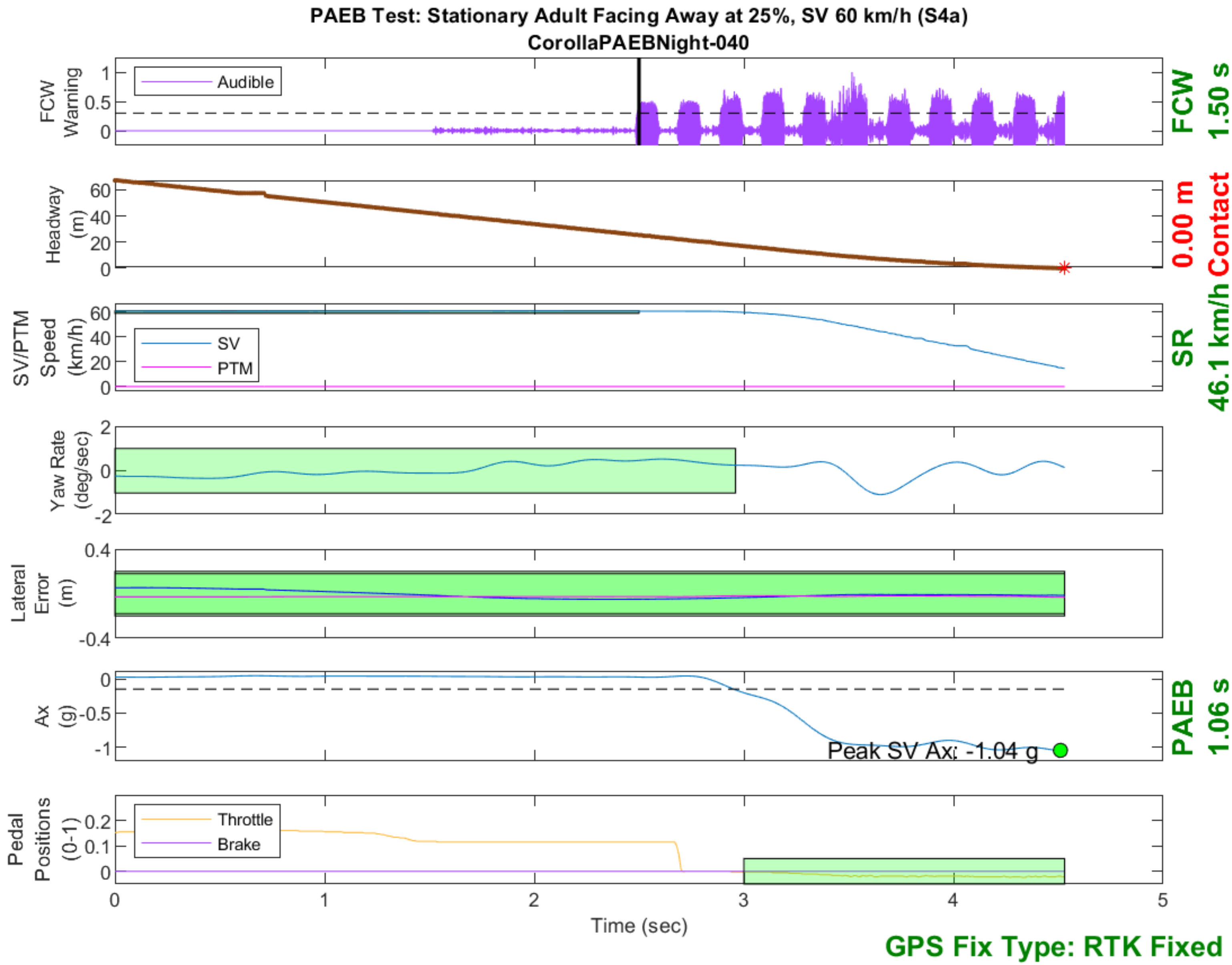


Figure D342. Time History for PAEB Run 40, S4a, Night, Low Beam, 60 km/h

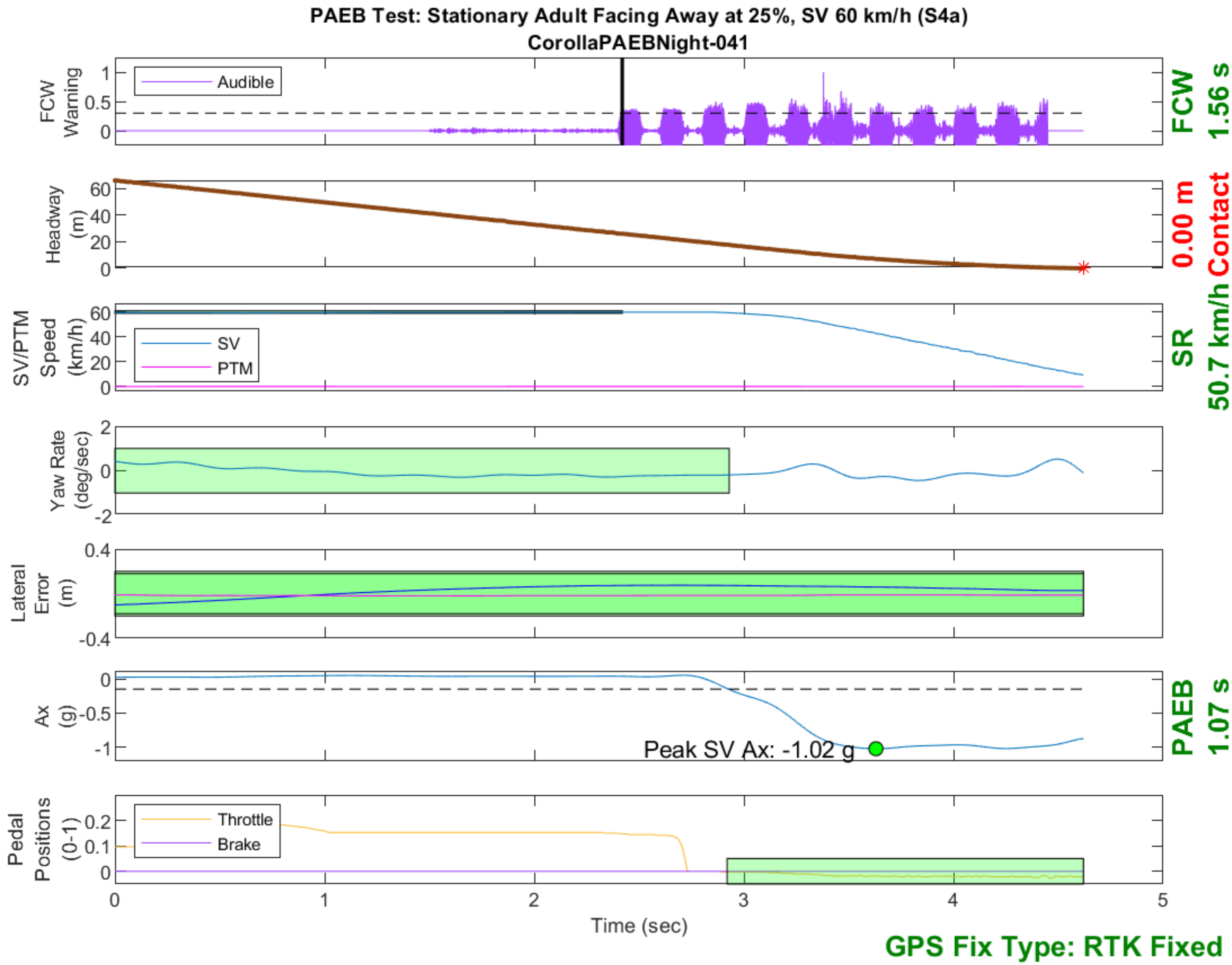


Figure D343. Time History for PAEB Run 41, S4a, Night, Low Beam, 60 km/h

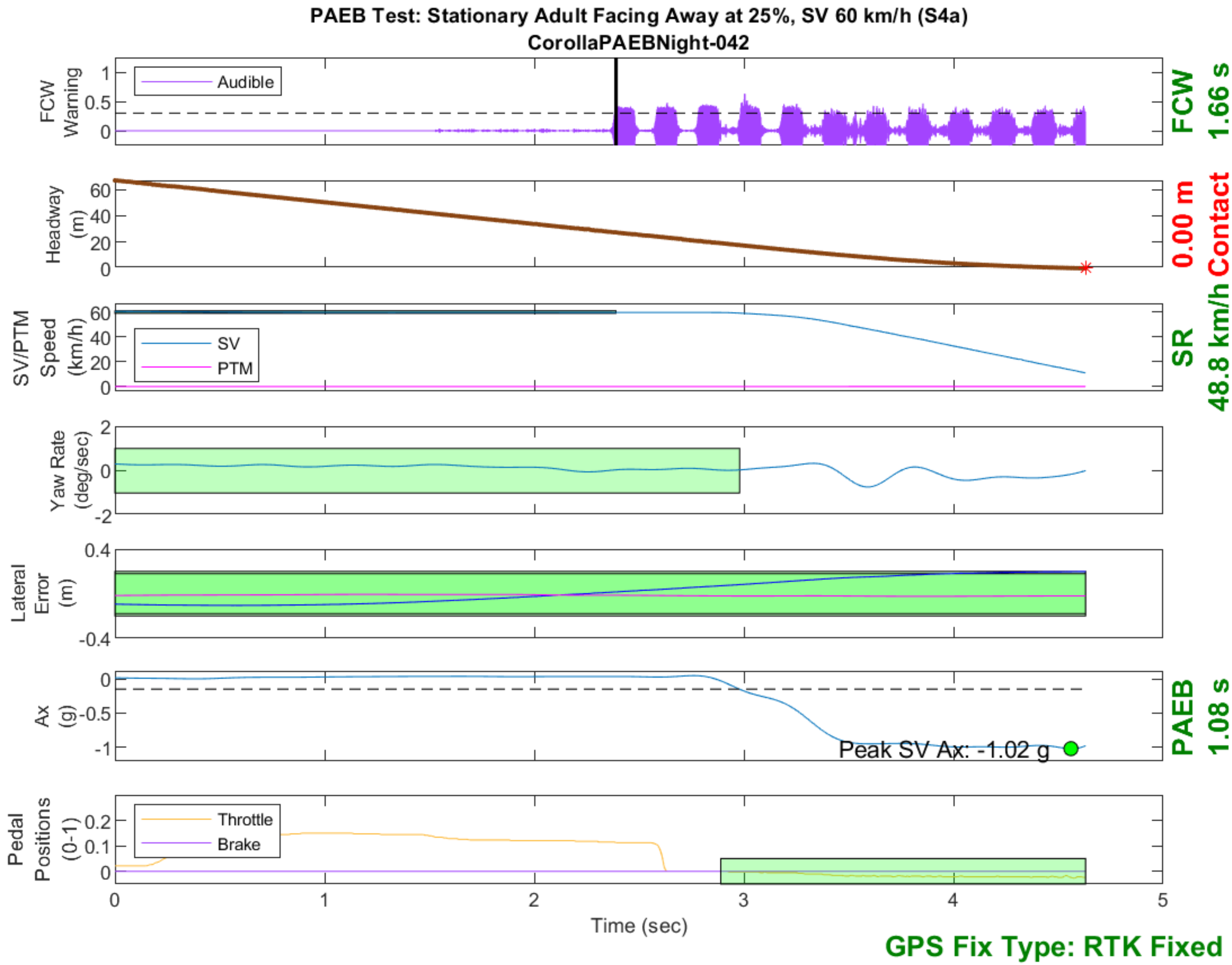


Figure D344. Time History for PAEB Run 42, S4a, Night, Low Beam, 60 km/h

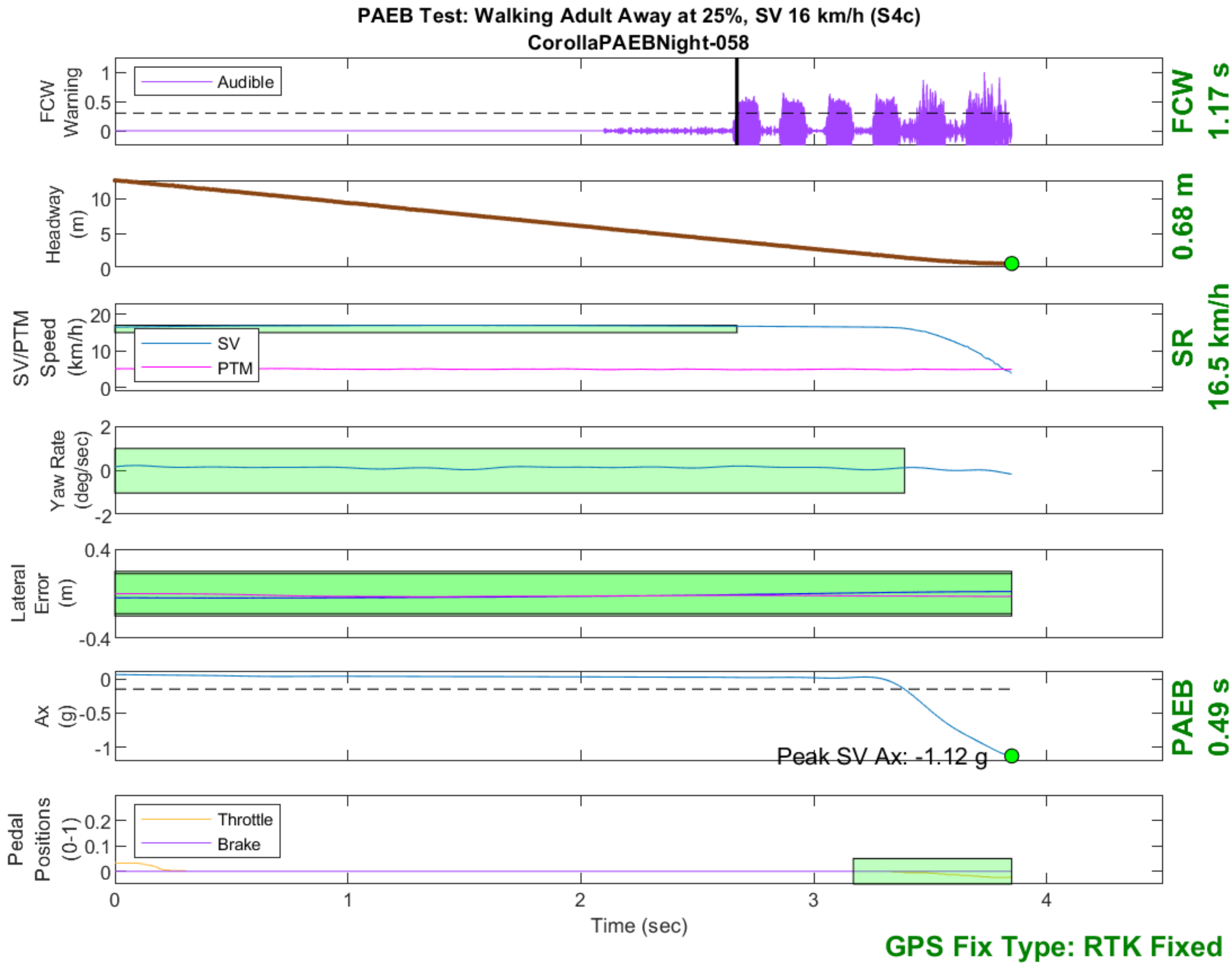


Figure D345. Time History for PAEB Run 58, S4c, Night, Low Beam, 16 km/h

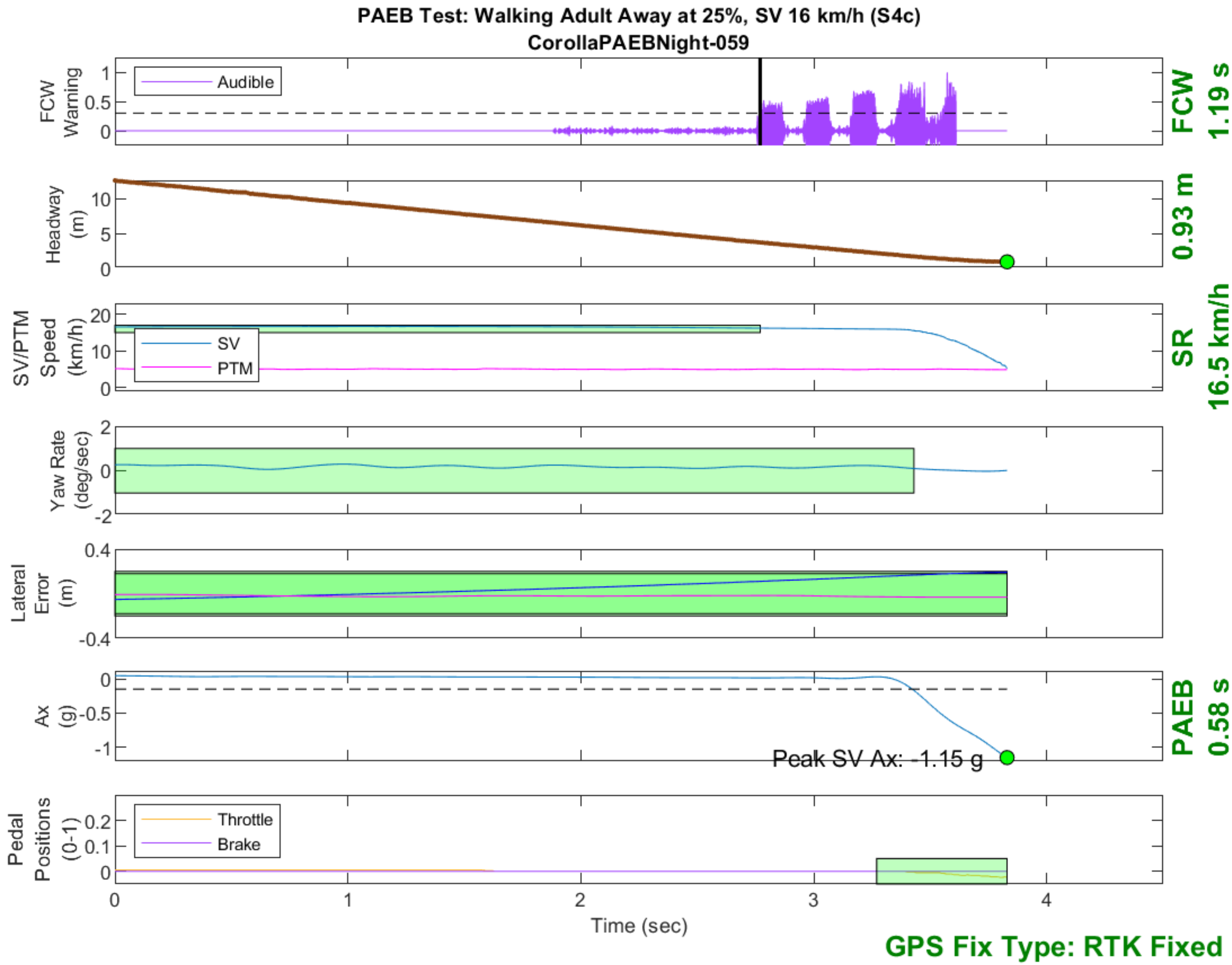


Figure D346. Time History for PAEB Run 59, S4c, Night, Low Beam, 16 km/h

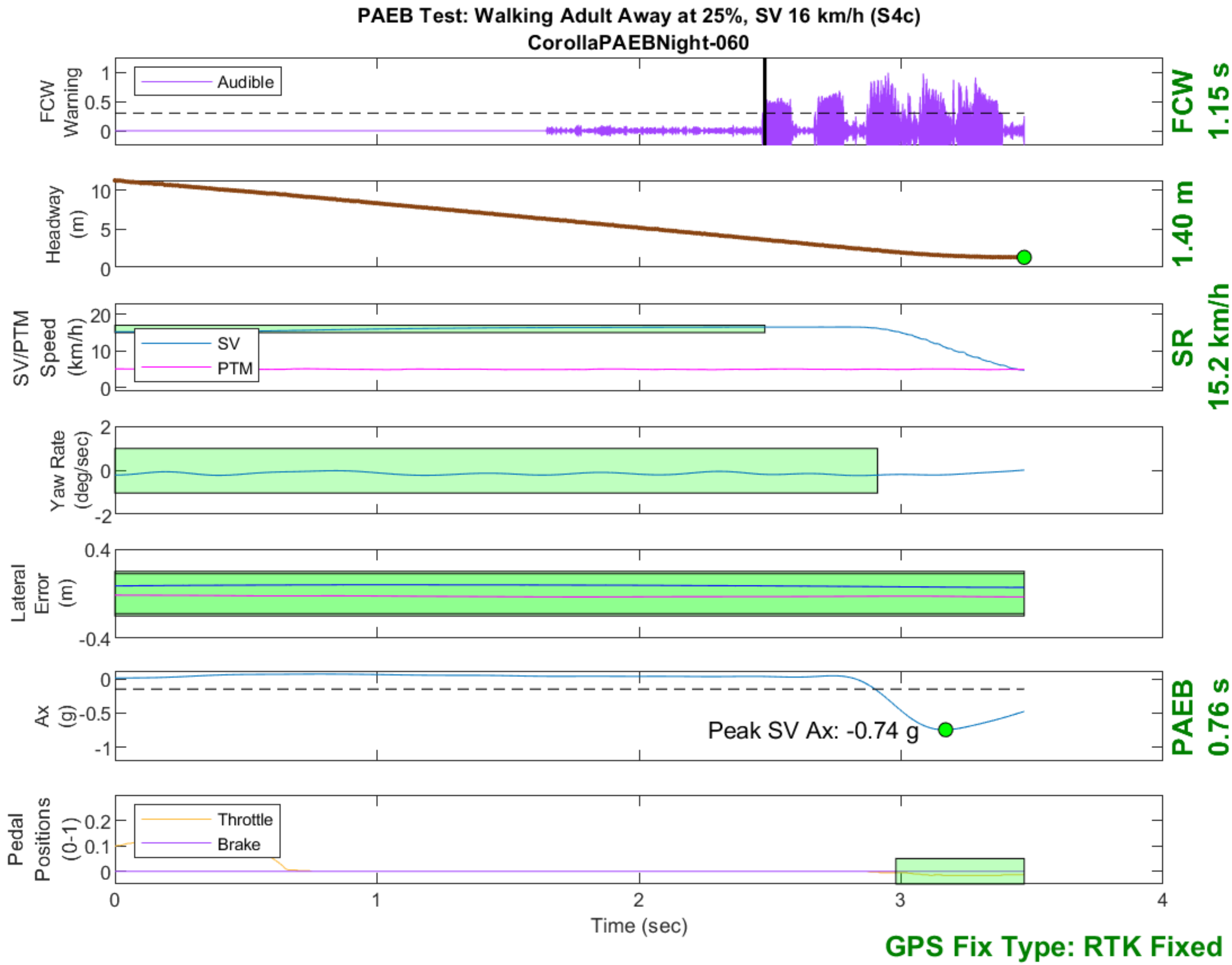


Figure D347. Time History for PAEB Run 60, S4c, Night, Low Beam, 16 km/h

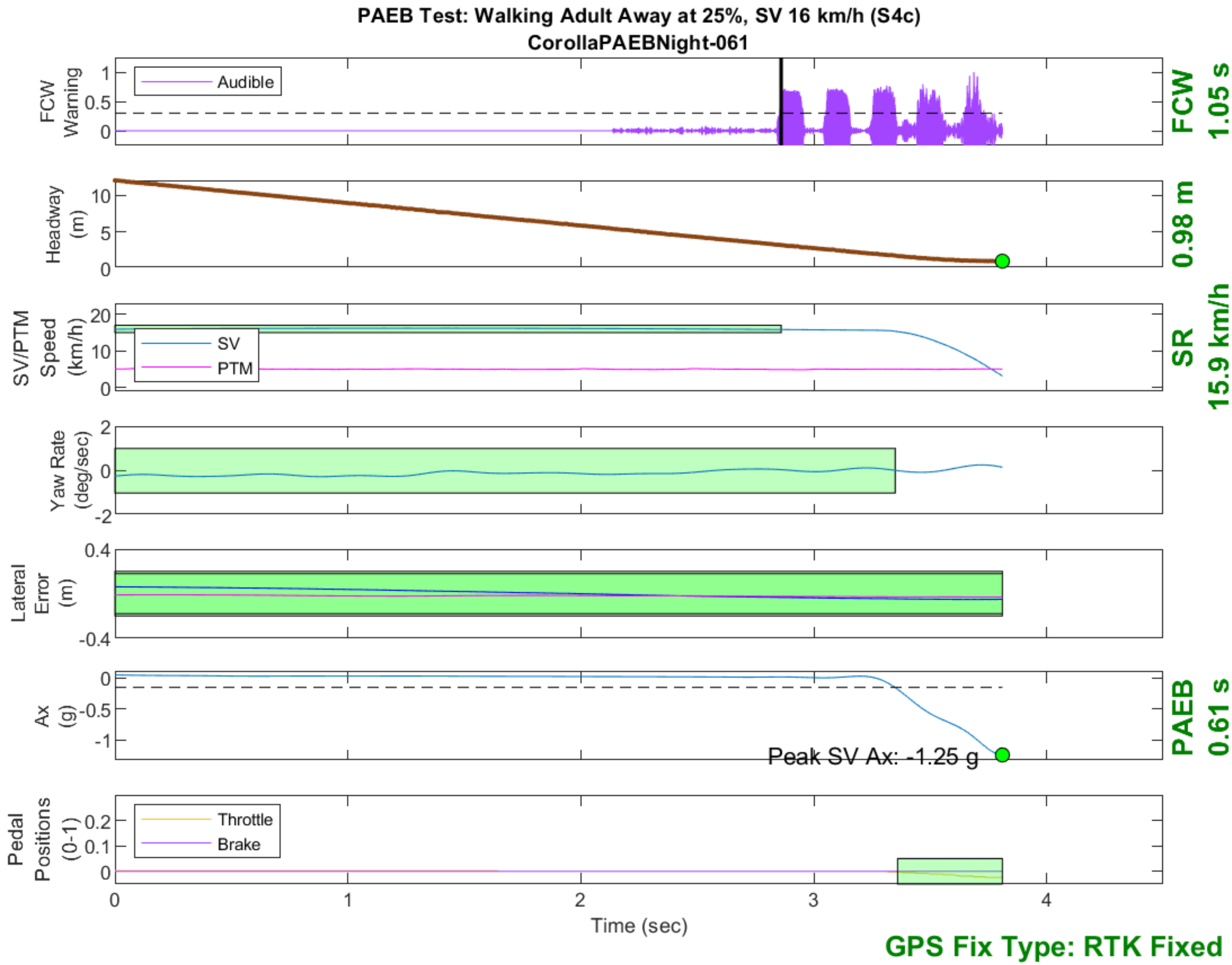


Figure D348. Time History for PAEB Run 61, S4c, Night, Low Beam, 16 km/h

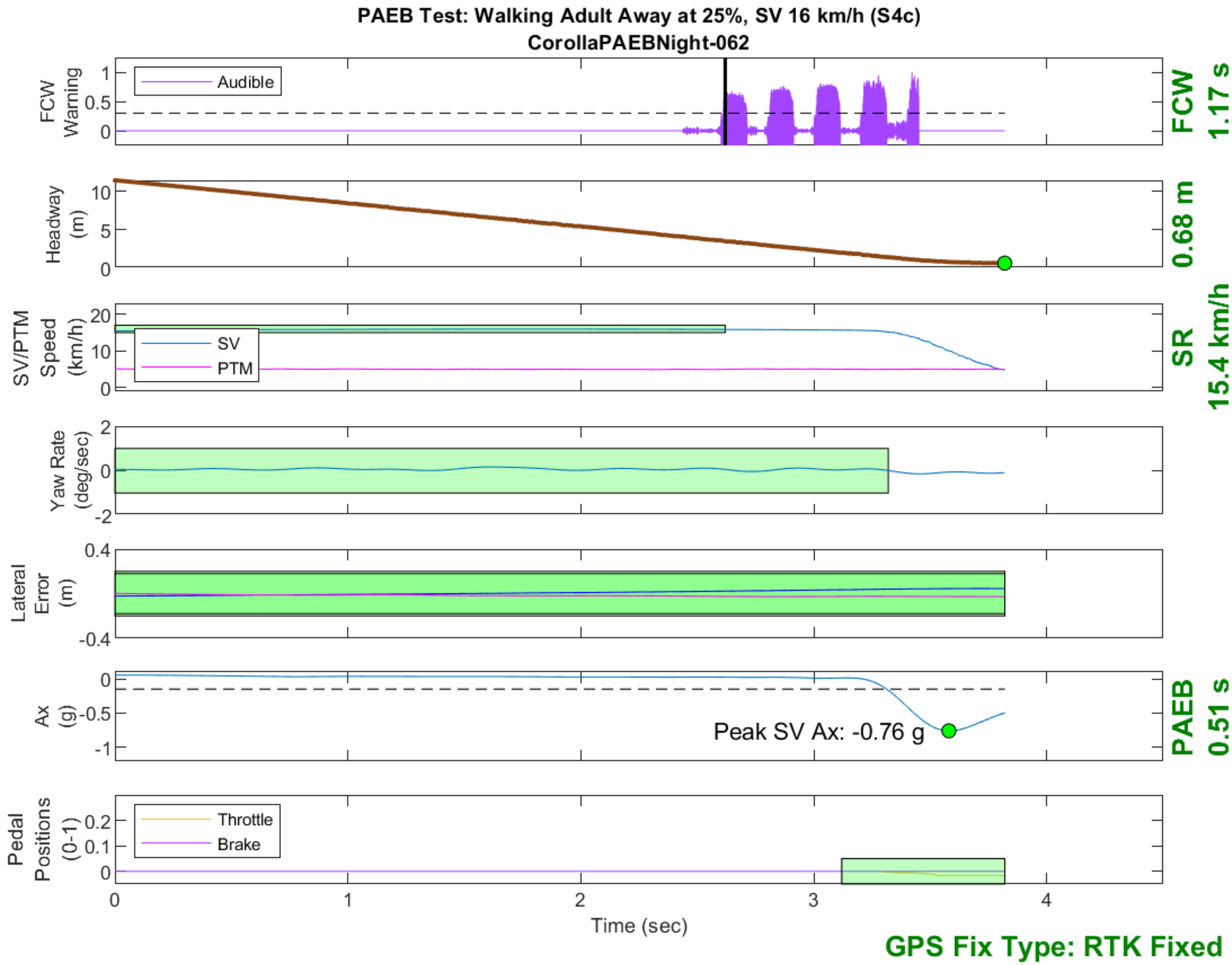


Figure D349. Time History for PAEB Run 62, S4c, Night, Low Beam, 16 km/h

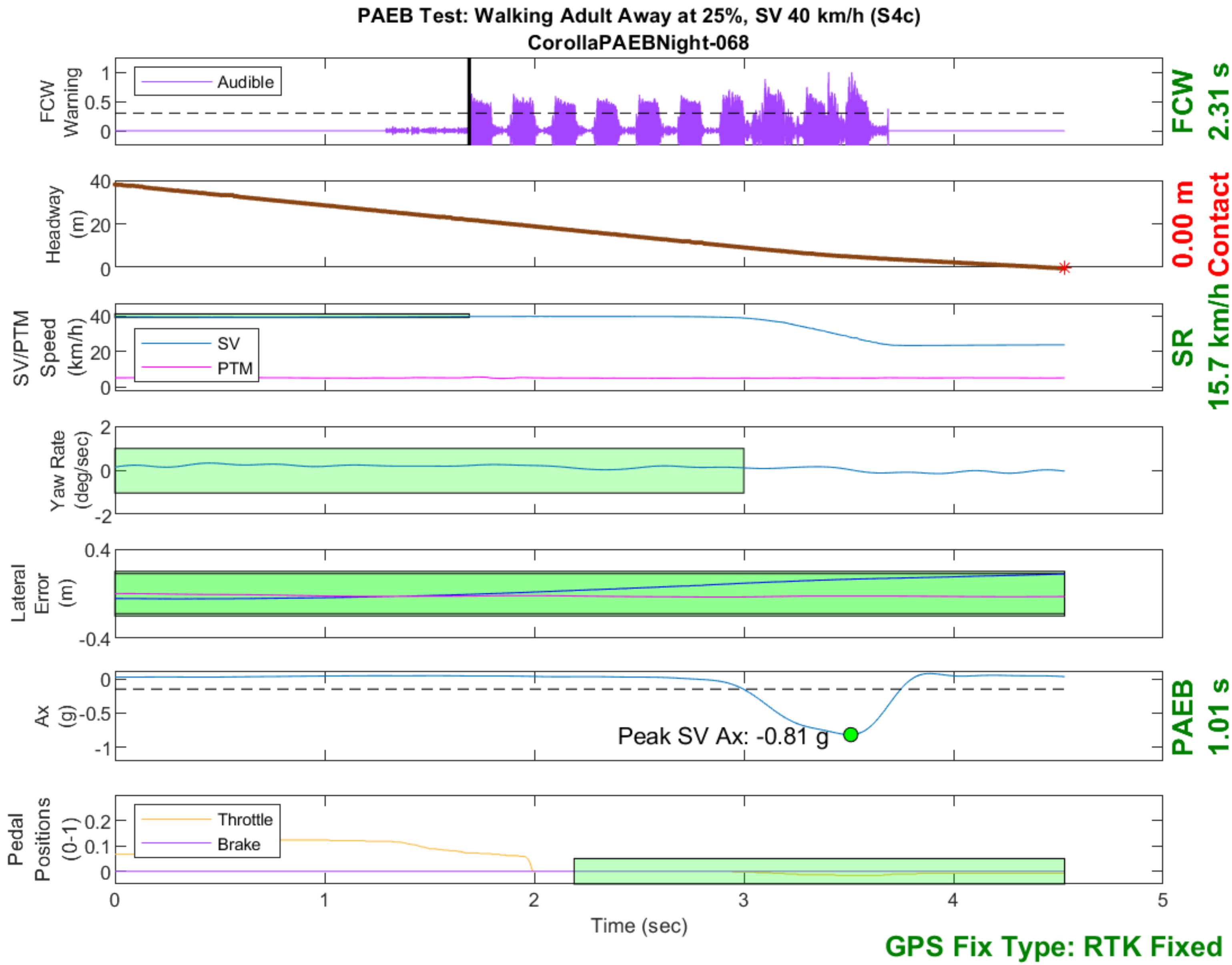


Figure D350. Time History for PAEB Run 68, S4c, Night, Low Beam, 40 km/h

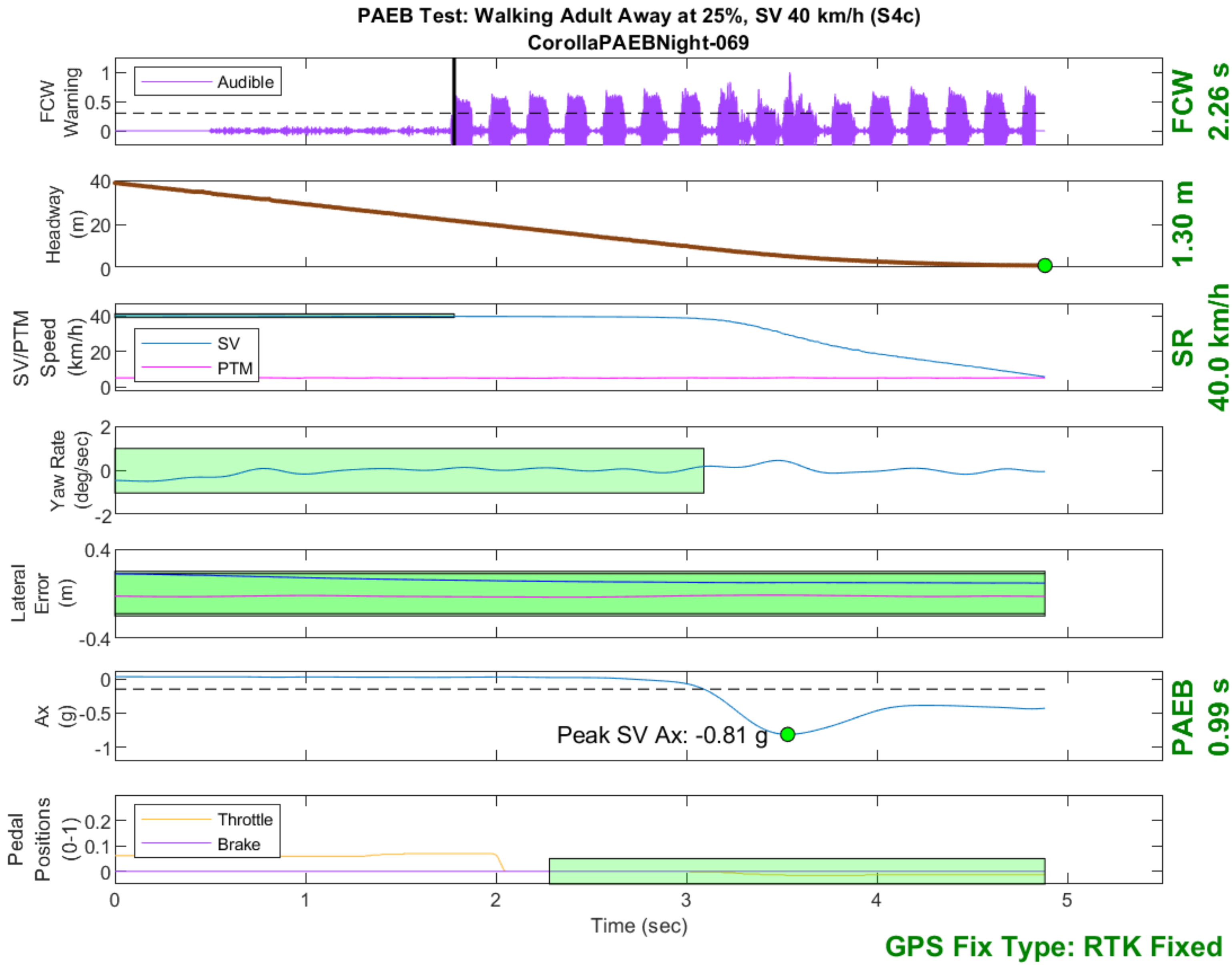


Figure D351. Time History for PAEB Run 69, S4c, Night, Low Beam, 40 km/h

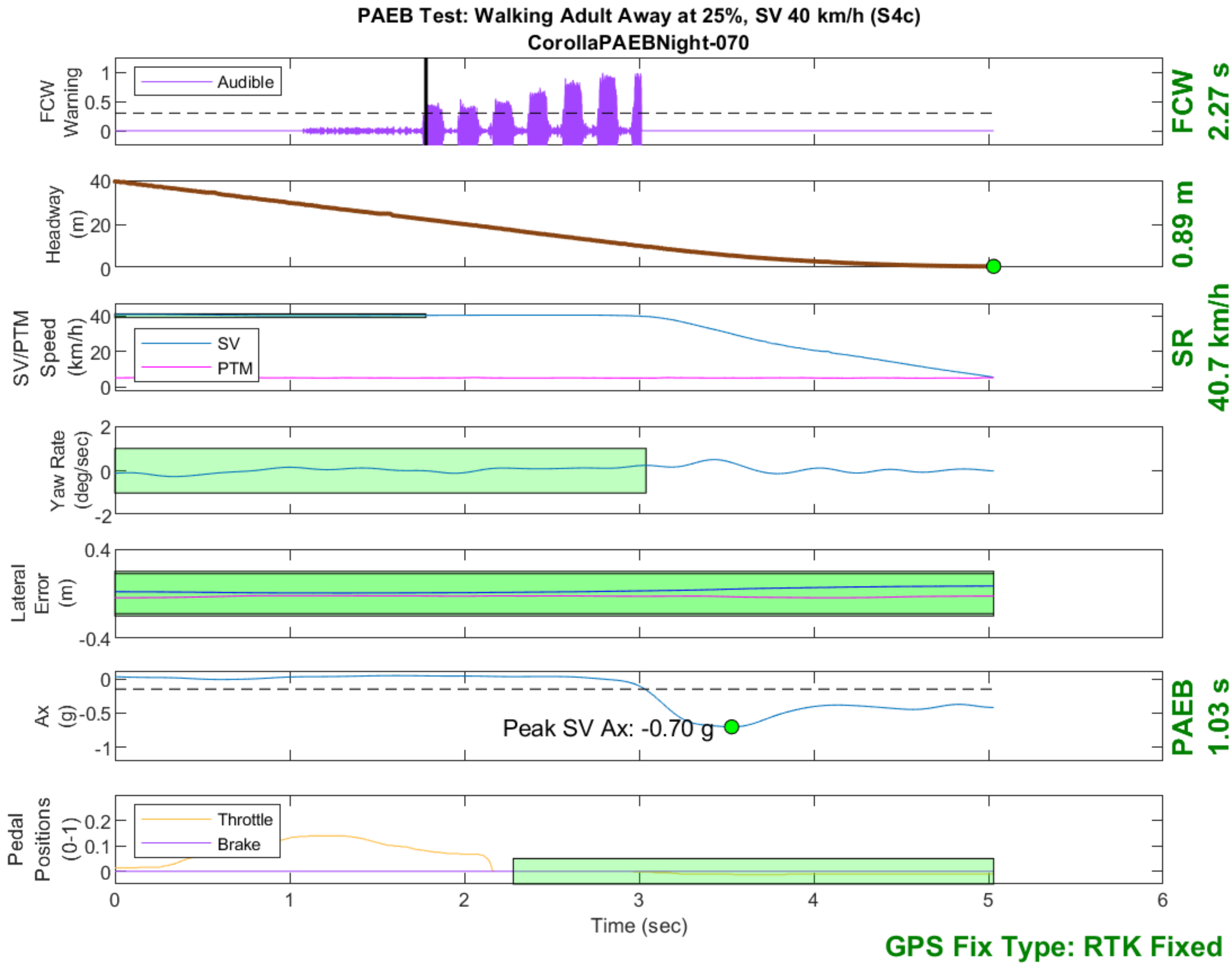


Figure D352. Time History for PAEB Run 70, S4c, Night, Low Beam, 40 km/h

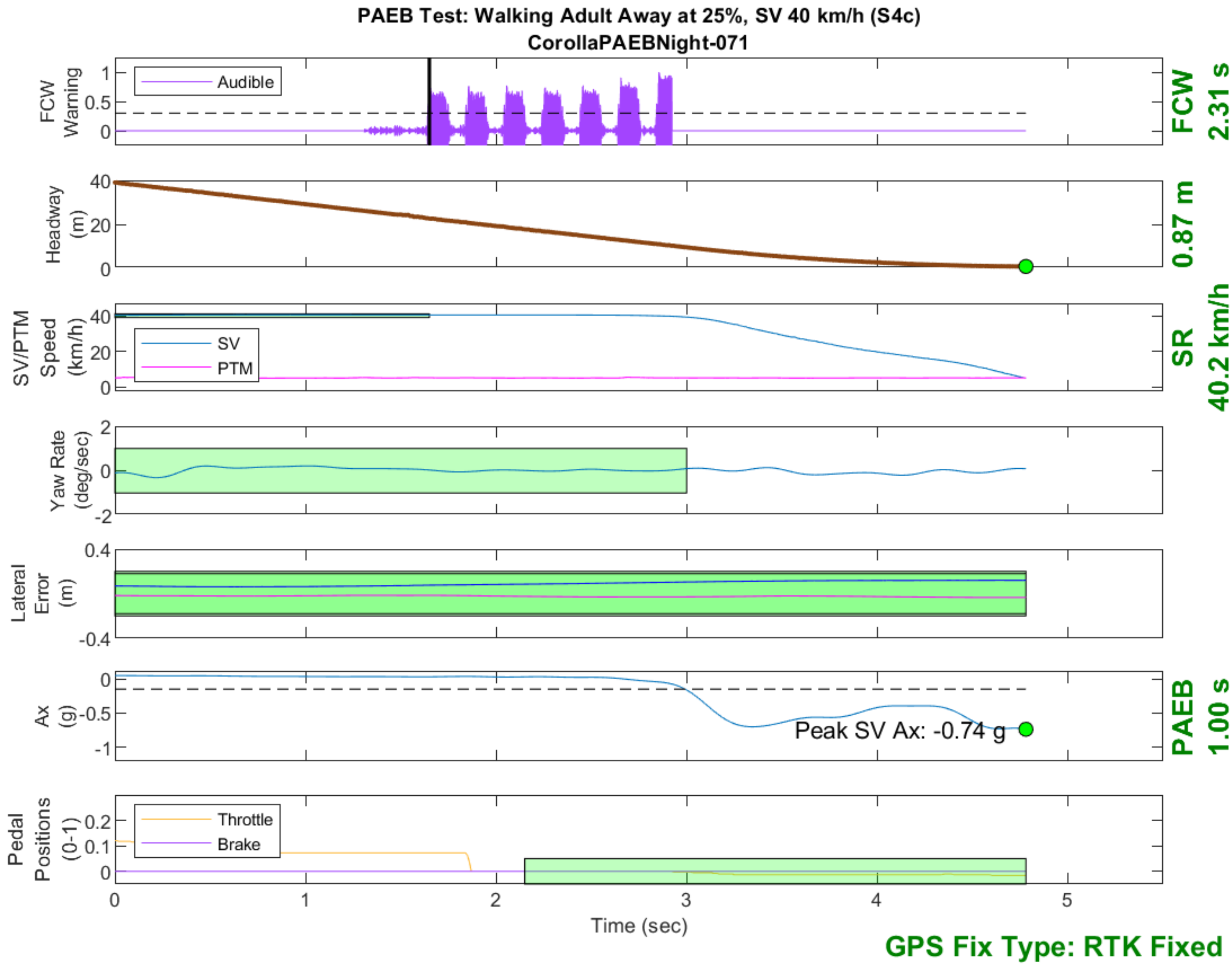


Figure D353. Time History for PAEB Run 71, S4c, Night, Low Beam, 40 km/h

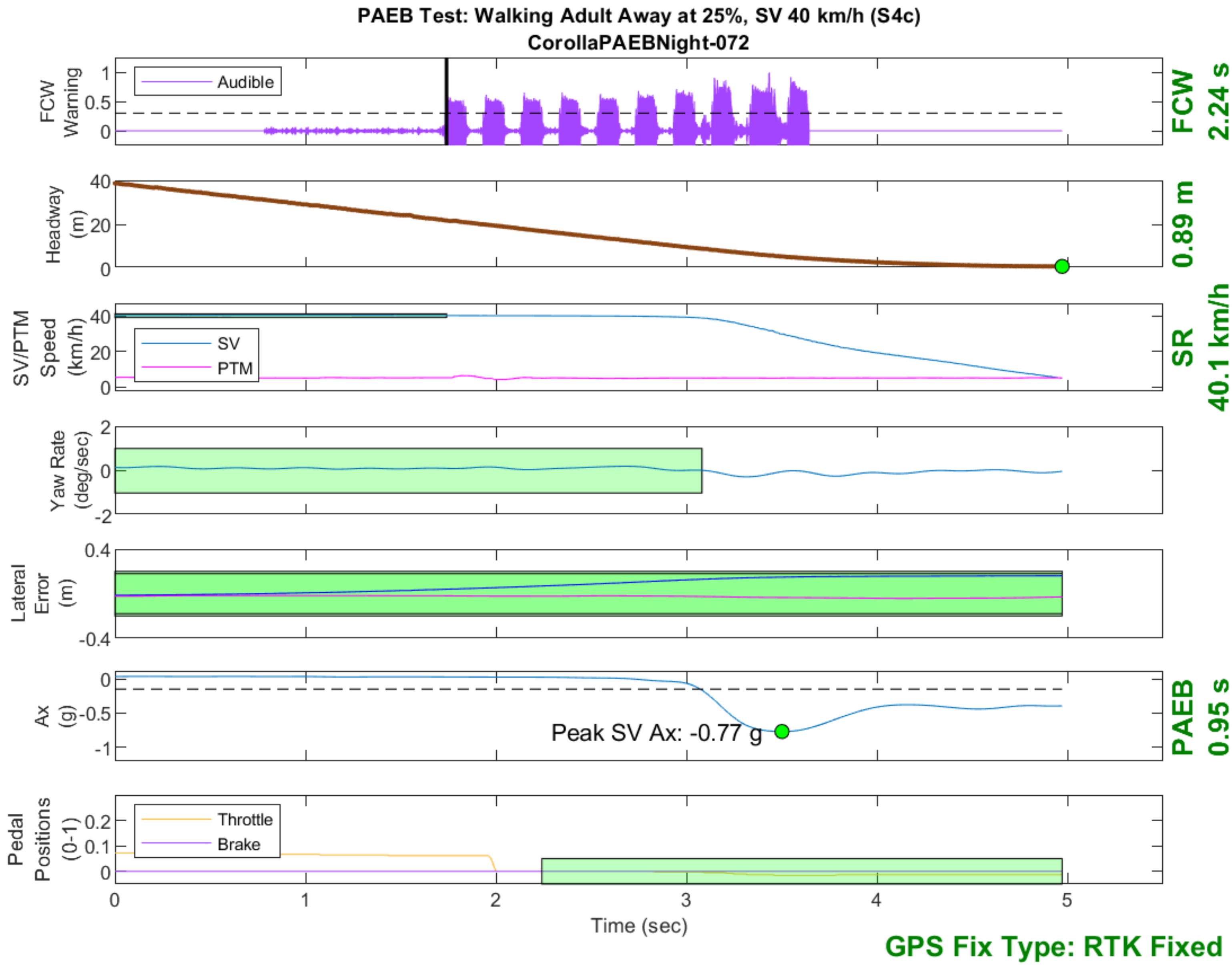


Figure D354. Time History for PAEB Run 72, S4c, Night, Low Beam, 40 km/h

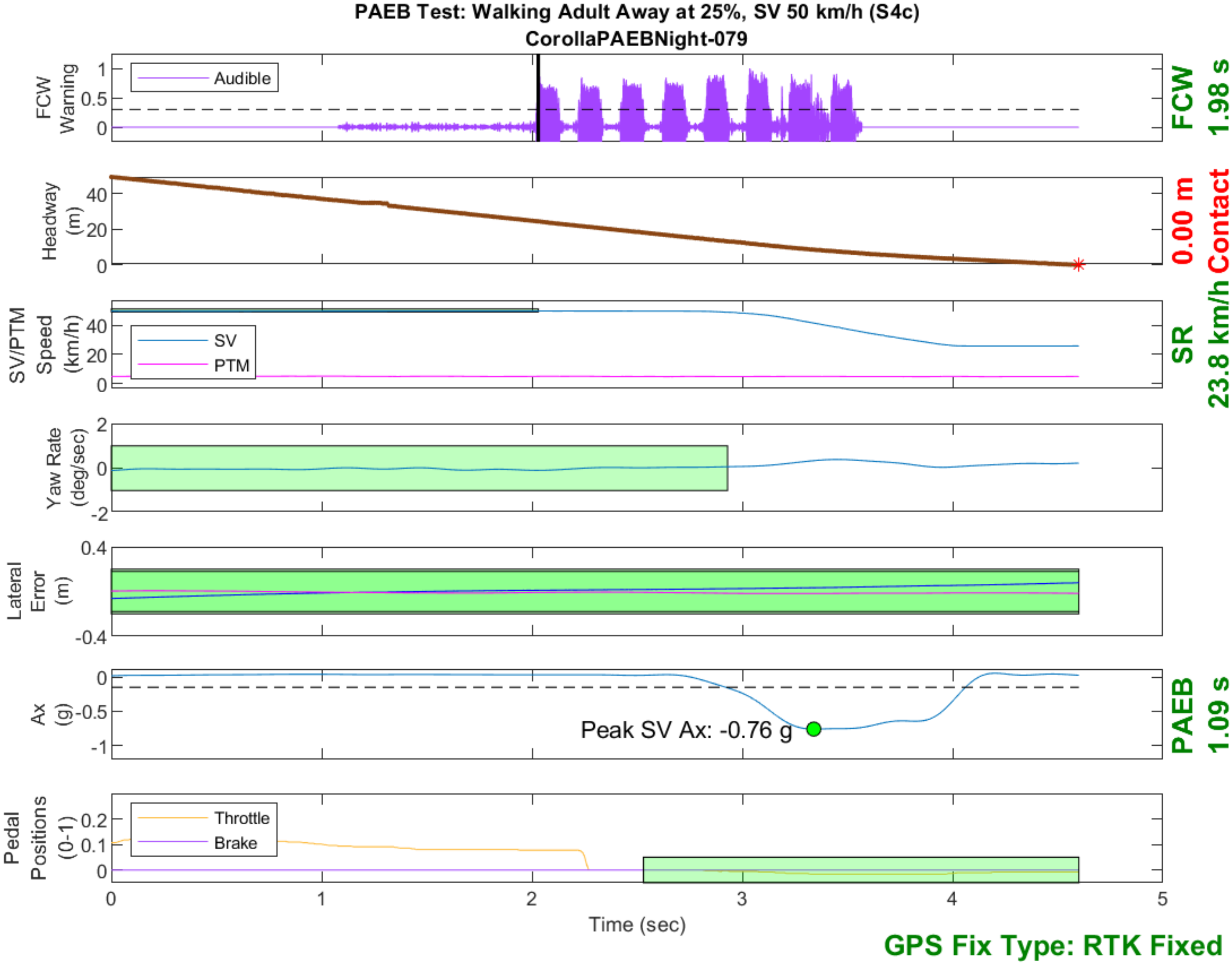


Figure D355. Time History for PAEB Run 79, S4c, Night, Low Beam, 50 km/h

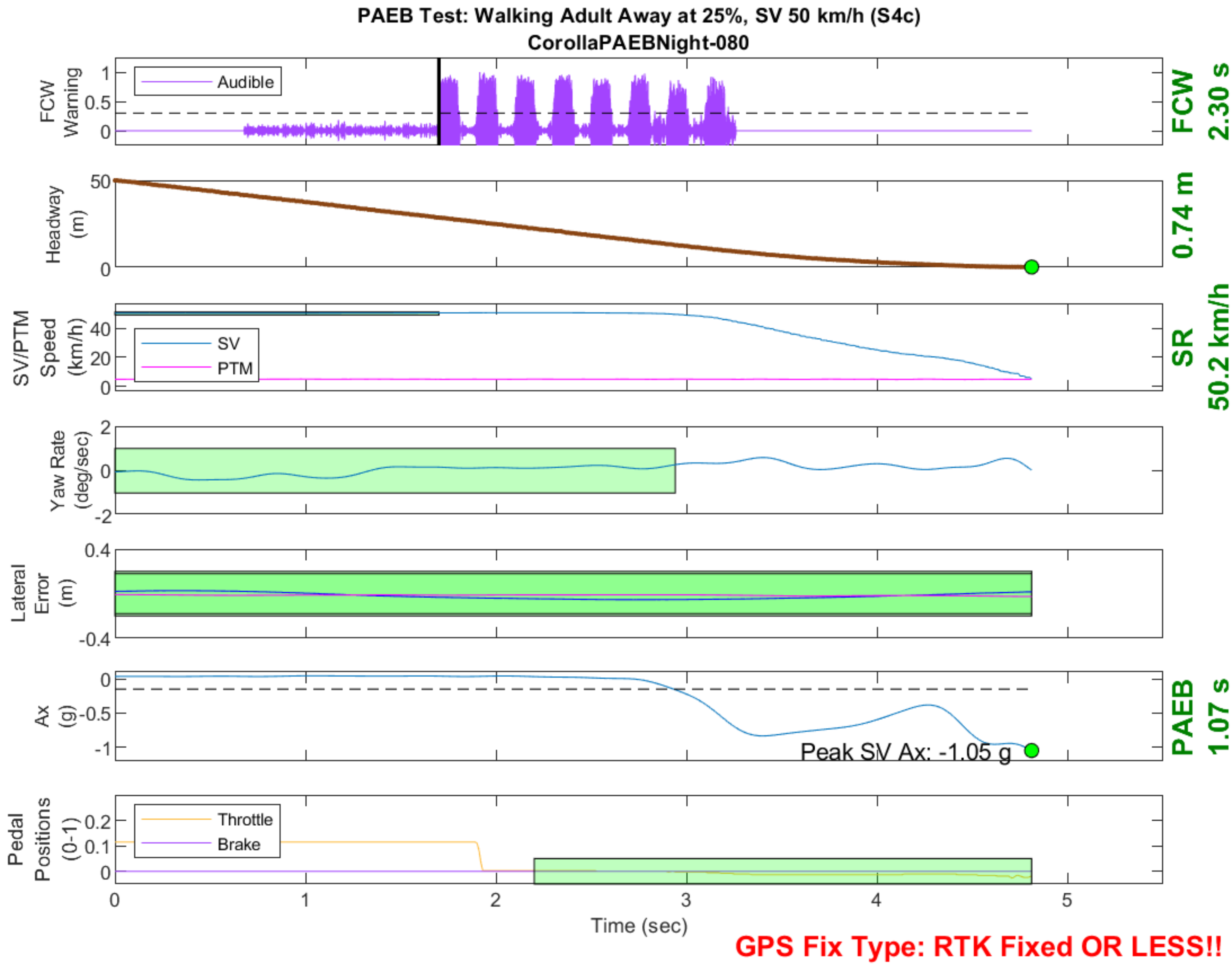


Figure D356. Time History for PAEB Run 80, S4c, Night, Low Beam, 50 km/h

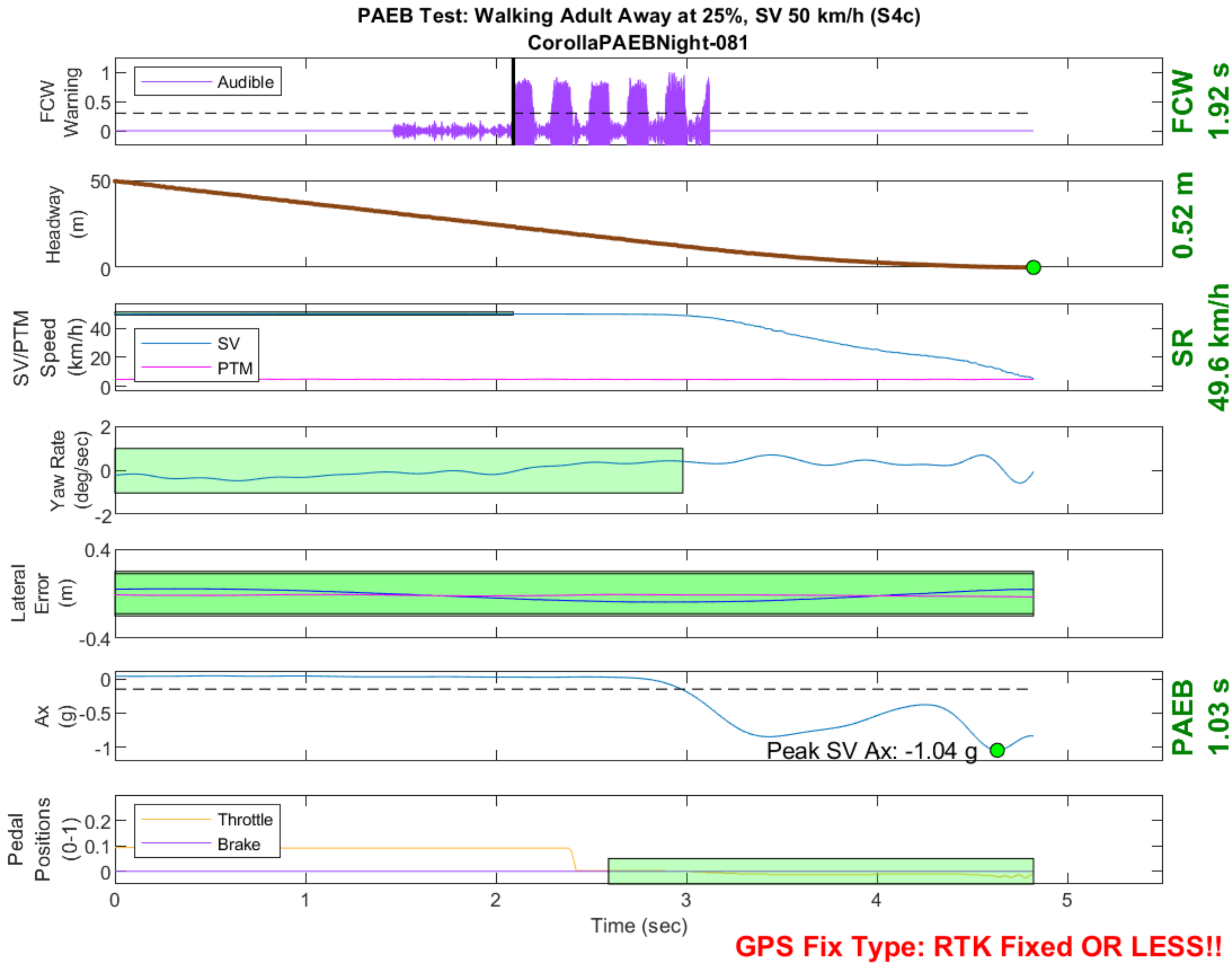


Figure D357. Time History for PAEB Run 81, S4c, Night, Low Beam, 50 km/h

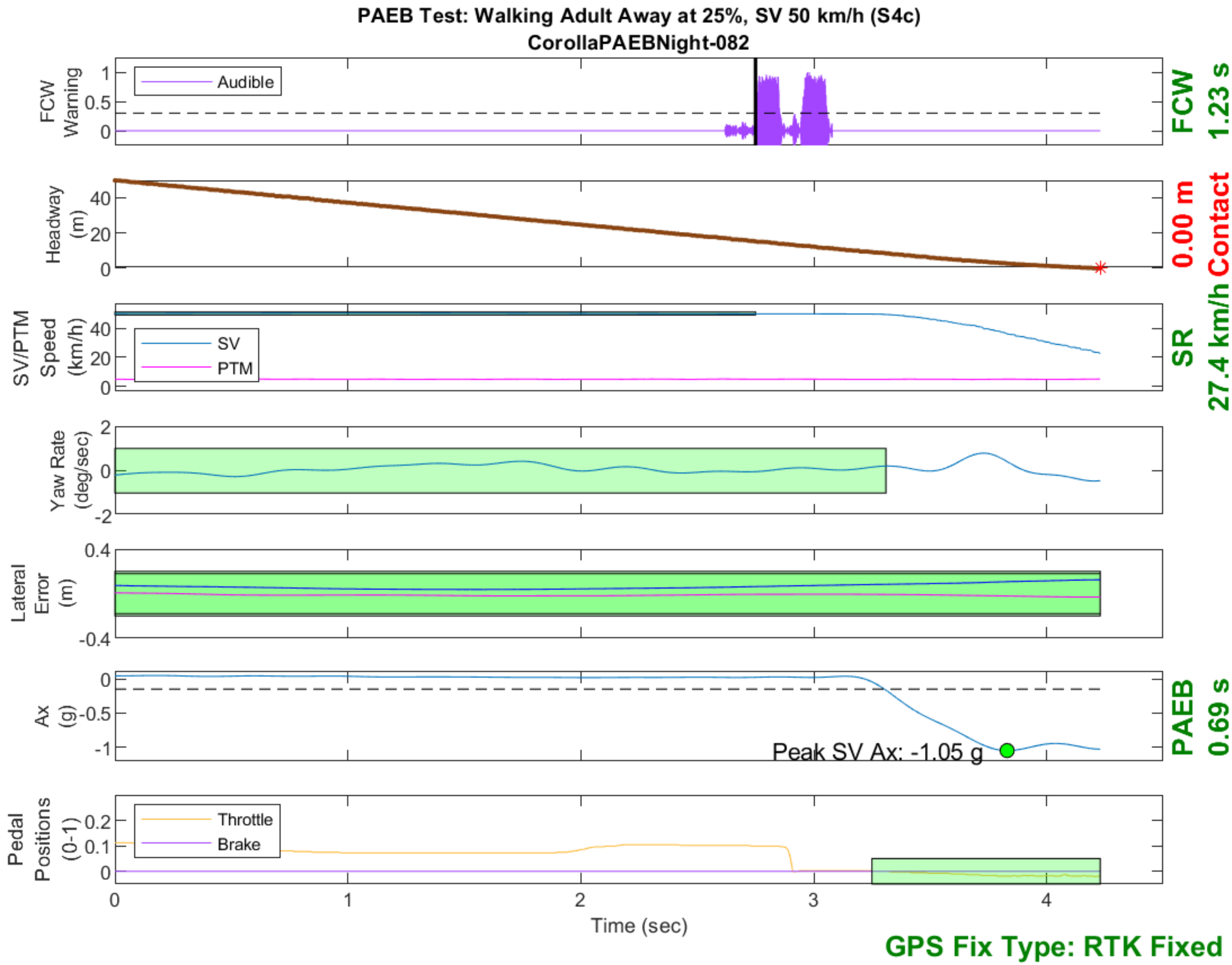


Figure D358. Time History for PAEB Run 82, S4c, Night, Low Beam, 50 km/h

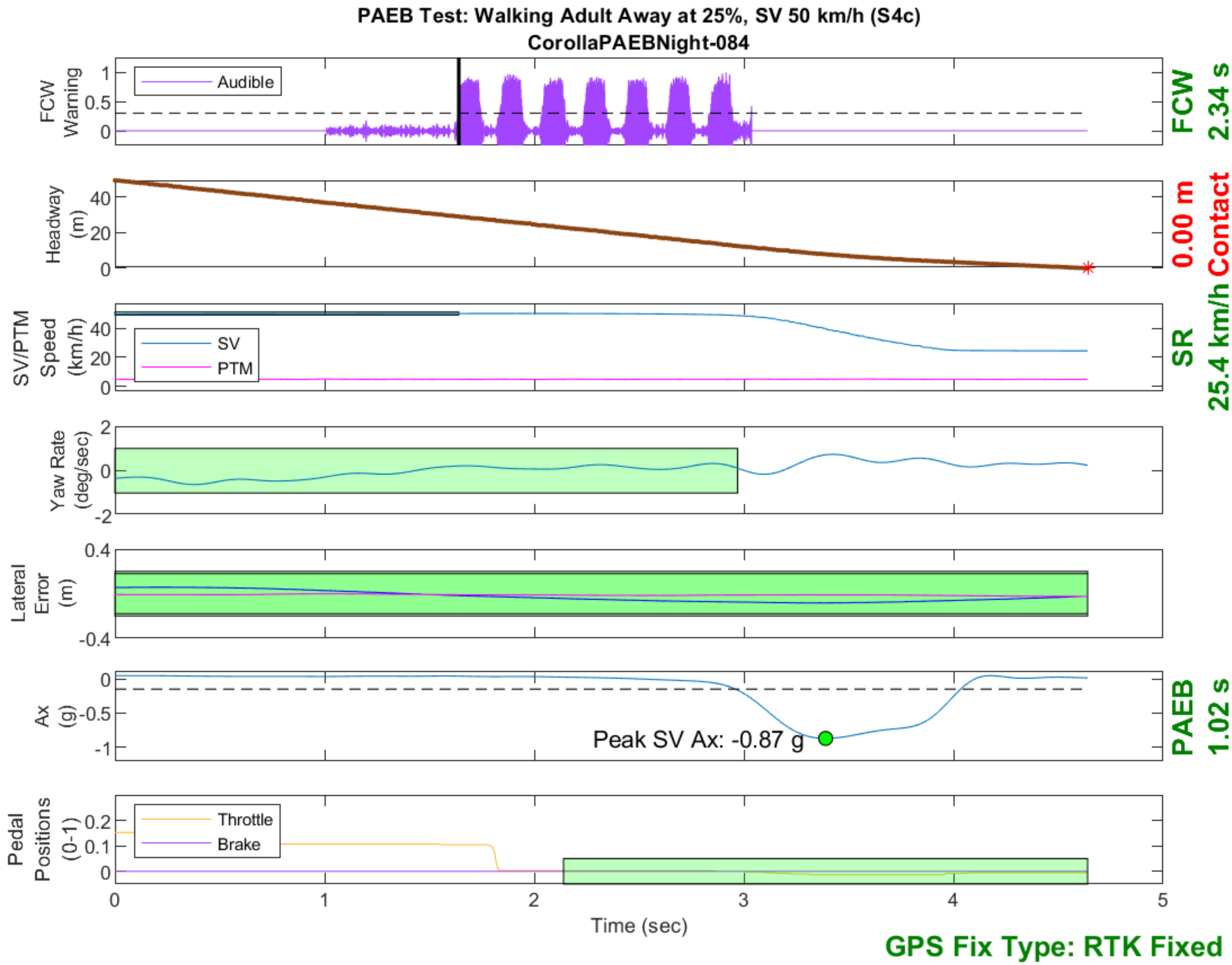


Figure D359. Time History for PAEB Run 84, S4c, Night, Low Beam, 50 km/h

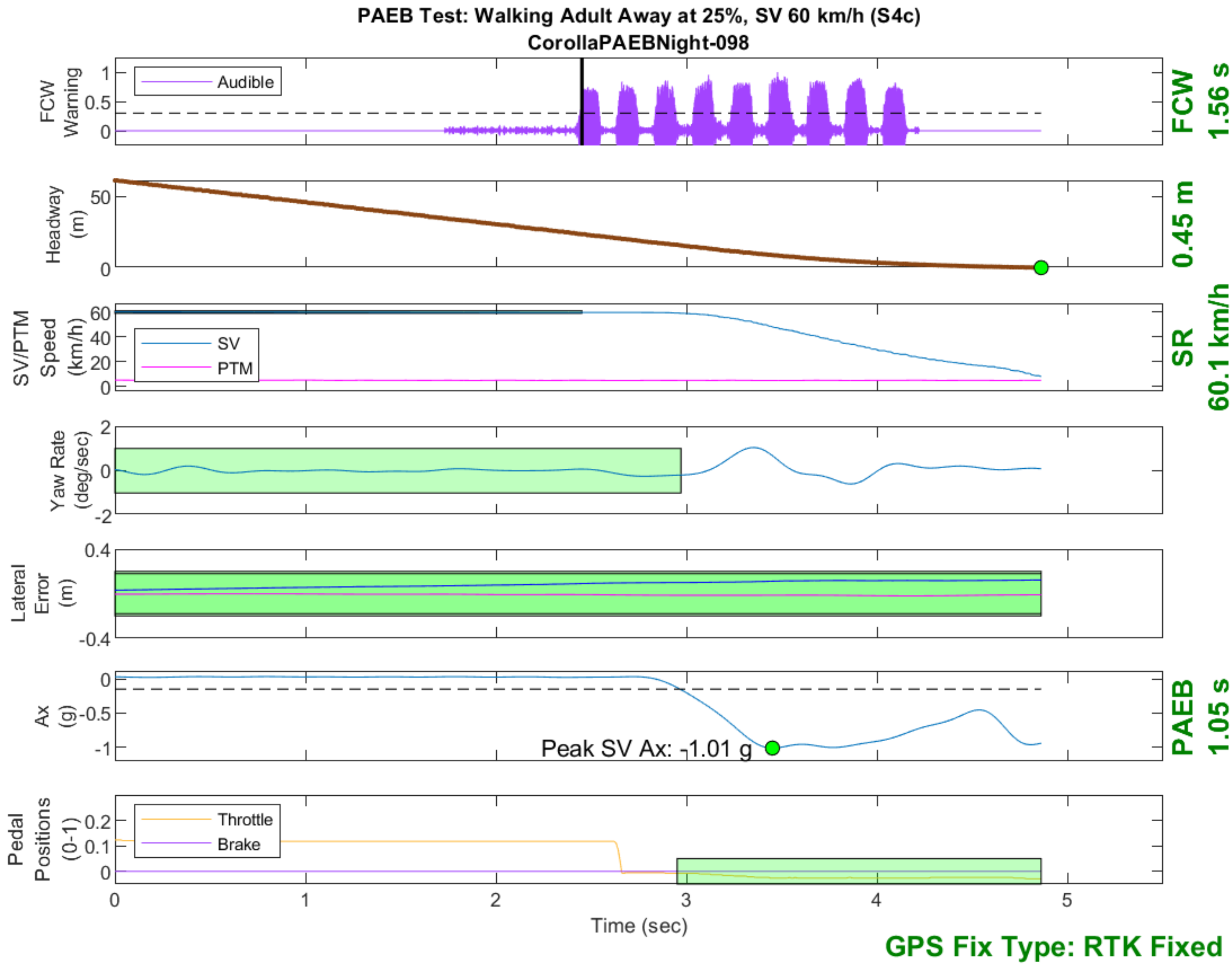


Figure D360. Time History for PAEB Run 98, S4c, Night, Low Beam, 60 km/h

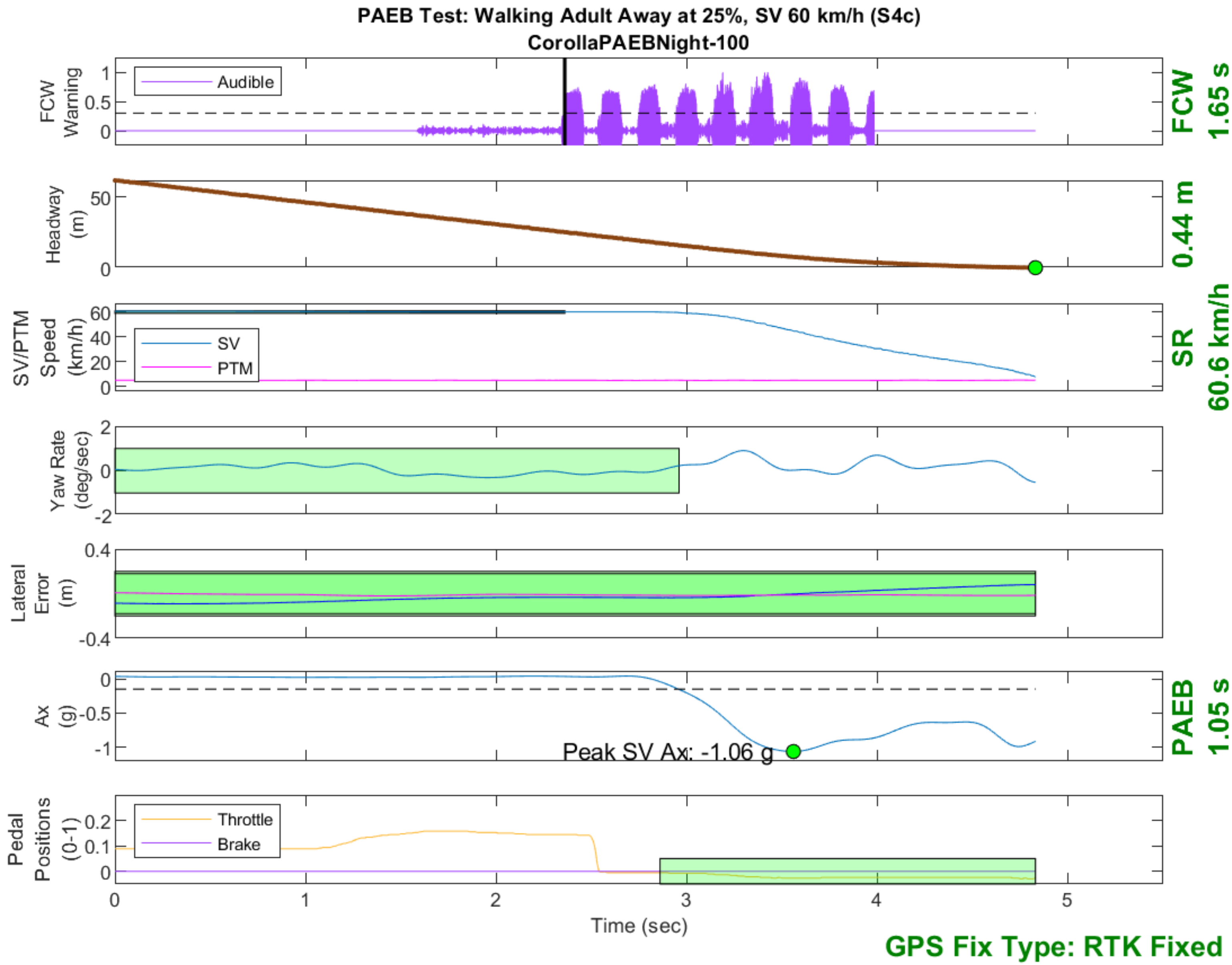


Figure D361. Time History for PAEB Run 100, S4c, Night, Low Beam, 60 km/h

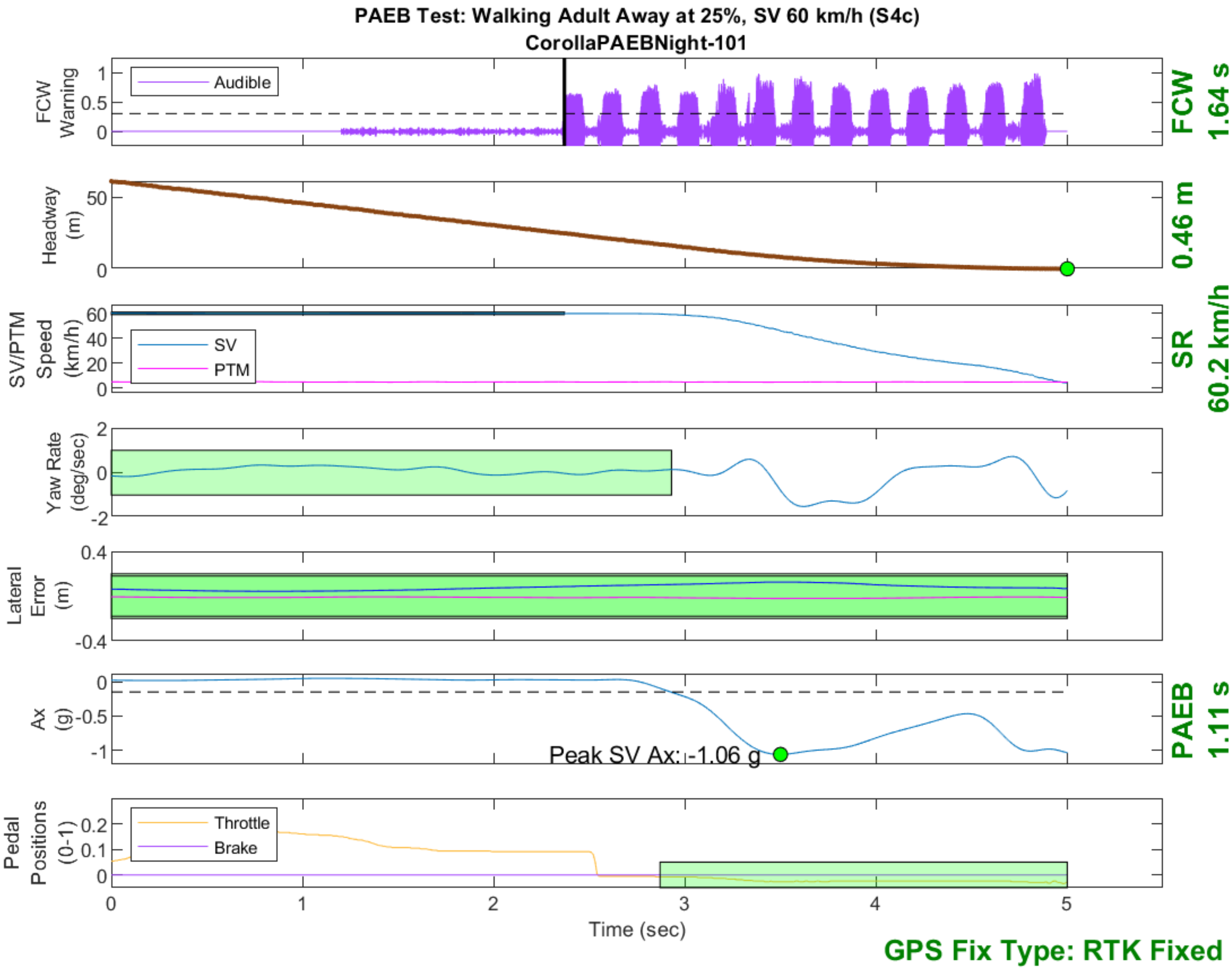


Figure D362. Time History for PAEB Run 101, S4c, Night, Low Beam, 60 km/h

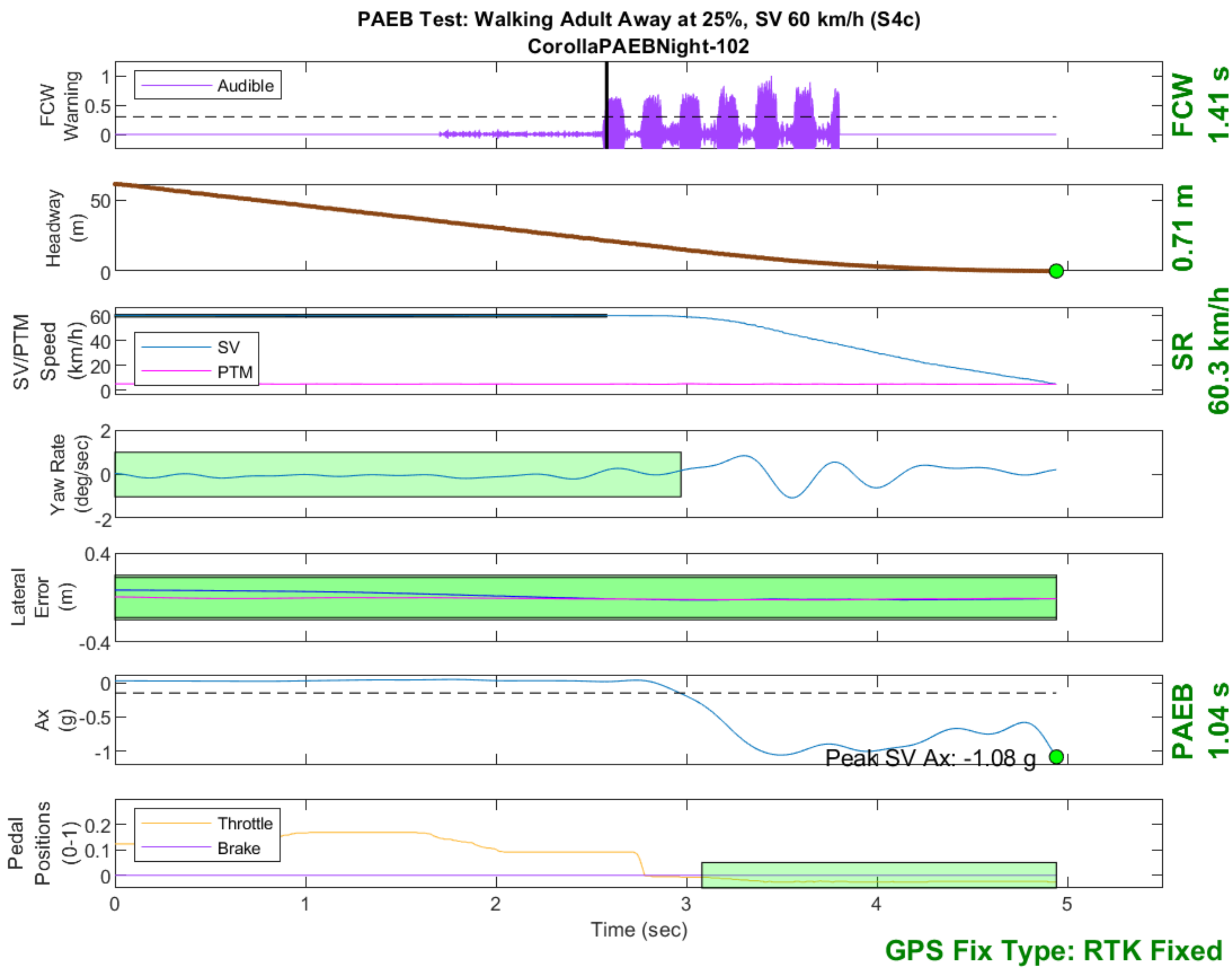


Figure D363. Time History for PAEB Run 102, S4c, Night, Low Beam, 60 km/h

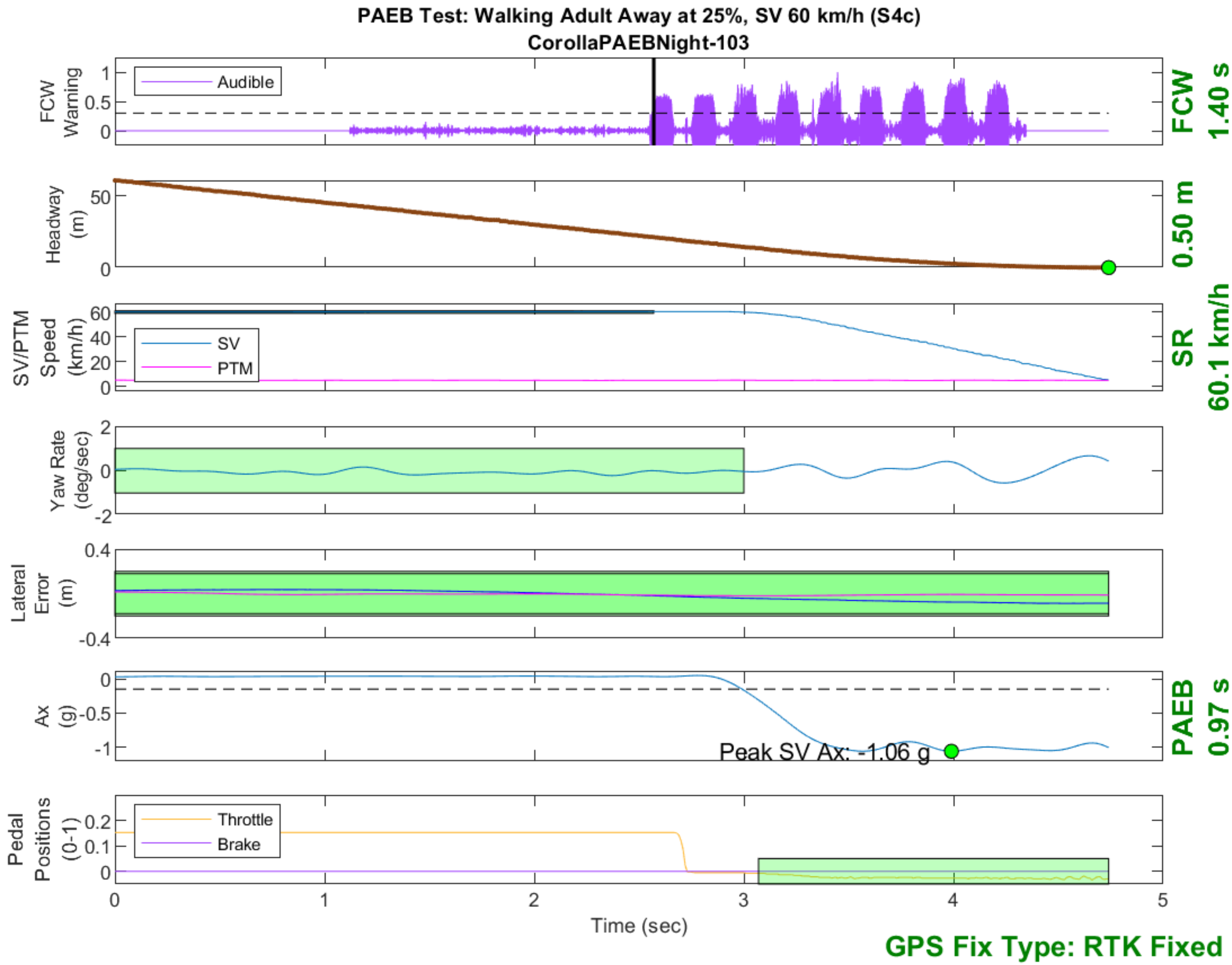


Figure D364. Time History for PAEB Run 103, S4c, Night, Low Beam, 60 km/h

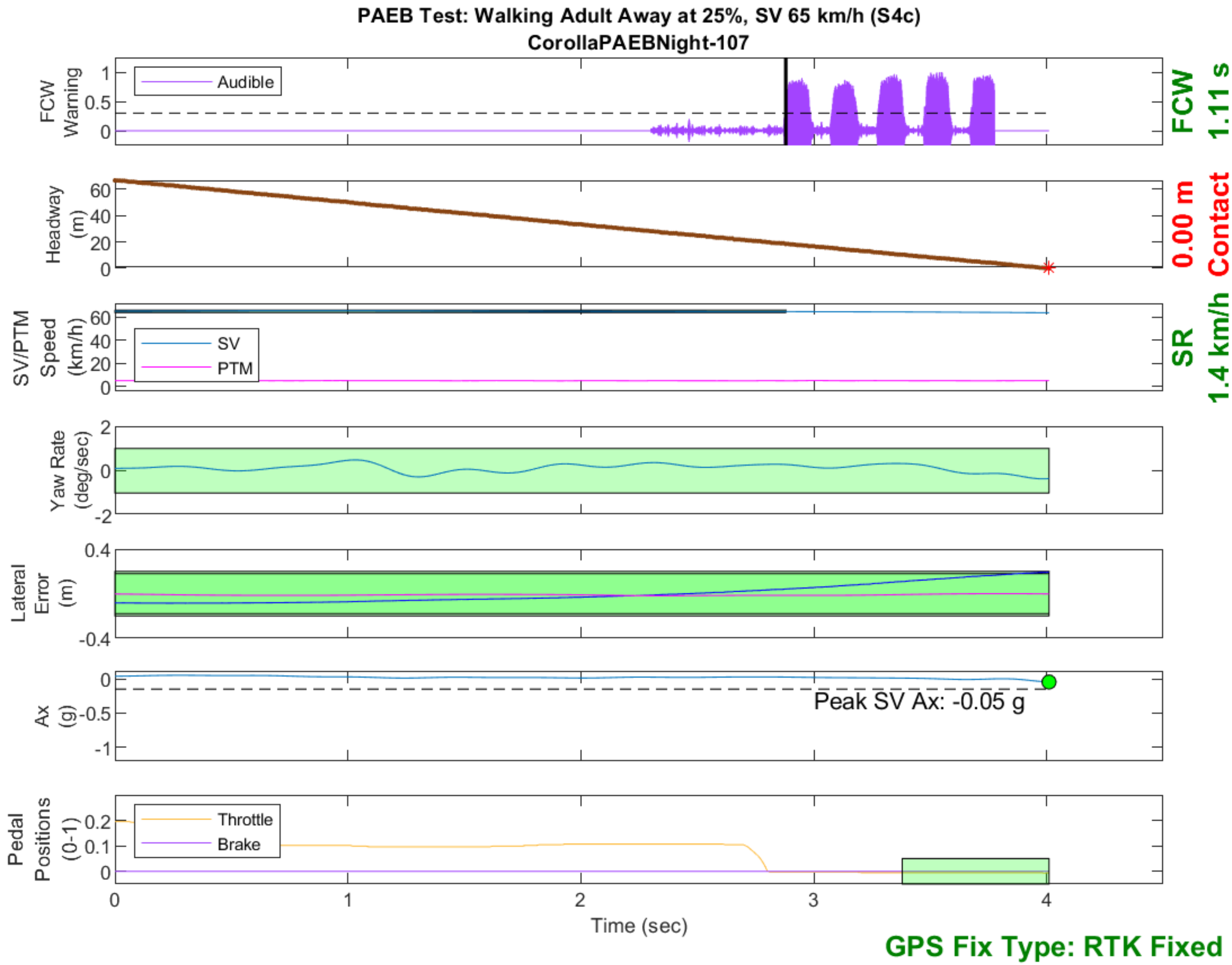


Figure D365. Time History for PAEB Run 107, S4c, Night, Low Beam, 65 km/h

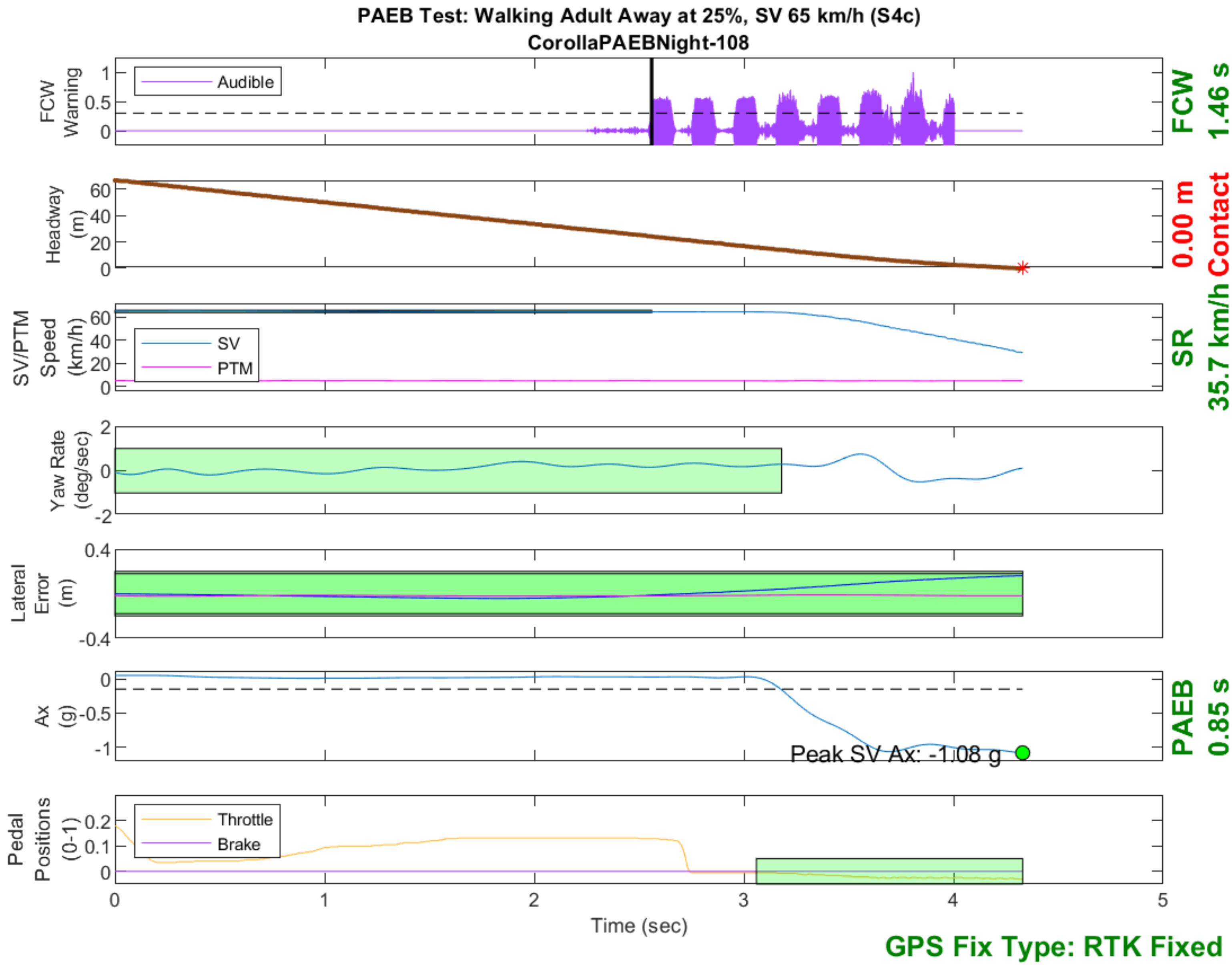


Figure D366. Time History for PAEB Run 108, S4c, Night, Low Beam, 65 km/h

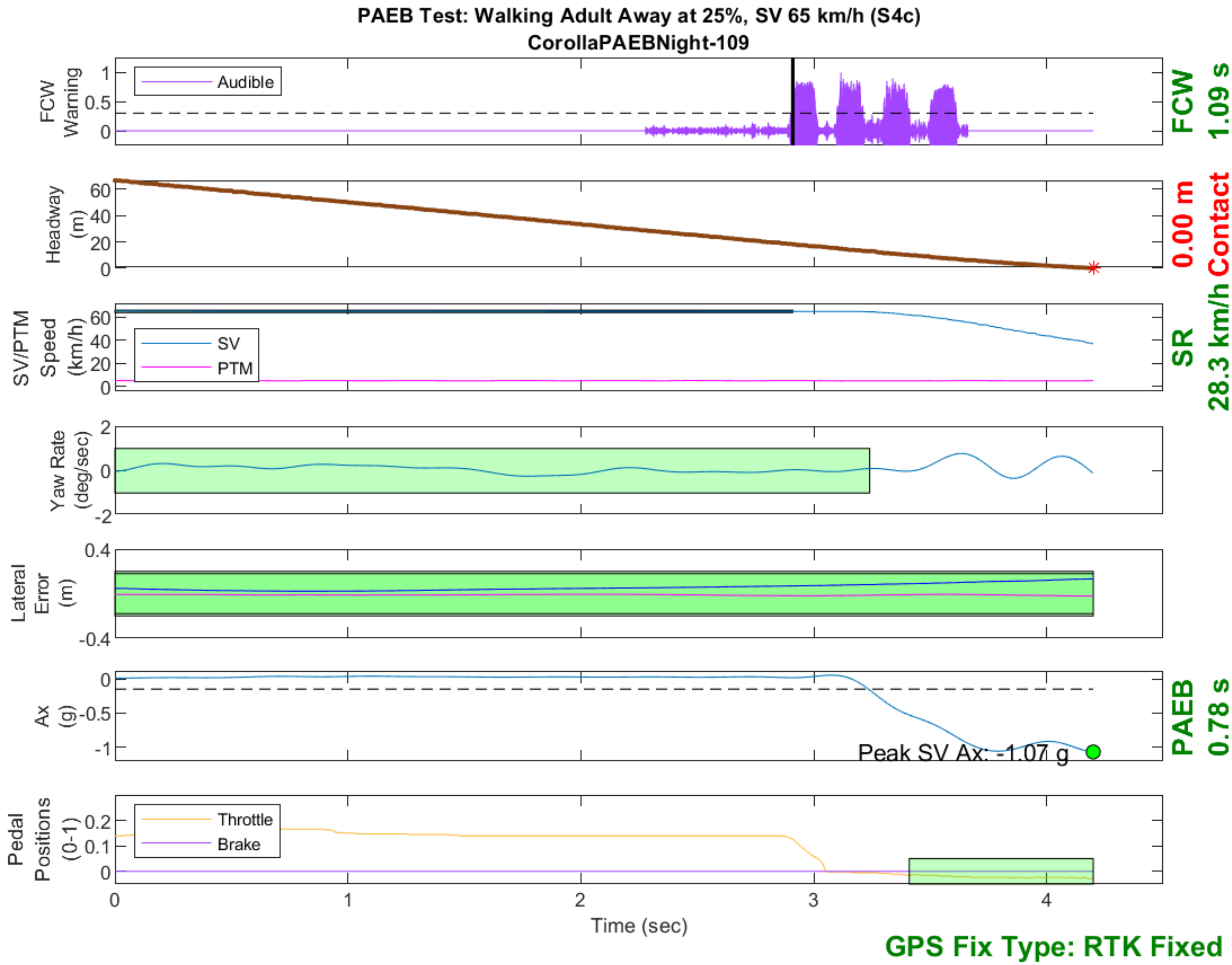


Figure D367. Time History for PAEB Run 109, S4c, Night, Low Beam, 65 km/h