PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM RESEARCH TEST
NCAP-DRI-PAEB-20-12

2020 Hyundai Palisade SEL FWD

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Final Report

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16. Abstract These research tests were conducted on the subject 2020 Hyundai Palisade SEL FWD 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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TABLE OF CONTENTS

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 Hyundai Palisade SEL FWD. 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

2020 Hyundai Palisade SEL FWD

VIN: *KM8R44HEXLU06xxxx*

Day Test Date: *8/25/2020*

Night Test Date: *8/24/2020*

System Setting: *Normal*

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	40	40	40
S1c	35		
S1d	35	16	16
S1e	45	40	35
S1f			
S1g			
S4a	35	35	16
S4b	50		
S4c	35	40	16

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

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

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
16	5	5	16.0						
40	5	3	29.7						

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	16.1	5	4	13.3	5	5	16.0
20	5	5	19.9	5	5	20.0	5	5	20.0
30	5	5	29.9	5	5	30.1	5	5	29.9
40	5	5	39.5	5	5	40.3	5	3	34.5
45	4	1	32.6	3	0	13.8	3	0	14.7
50	3	0	9.7	-	-	-	-	-	-

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	15.9						
35	5	5	35.1						
40	5	2	25.9						

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

2020 Hyundai Palisade SEL FWD

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	
16	5	4	14.4	5	3	10.1	5	5	16.1
20	5	5	20.0	3	0	3.1	3	0	4.7
30	5	5	29.9	-	-	-	-	-	-
35	5	5	34.6	-	-	-	-	-	-
40	4	1	23.4	3	0	0.5	3	0	1.3

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
35	-	-	-	-	-	-	4	2	27.4
40	5	4	36.0	5	3	29.1	3	1	27.0
45	5	5	40.8	3	0	31.6	-	-	-
50	5	2	35.5	-	-	-	-	-	-

S1f, S1g: Peak Deceleration Summary
(Day tests only)

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

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

Trial Number	S1f SV: 40 km/h PTM: 5 km/h	S1g SV: 40 km/h PTM: 5 km/h
	Peak Deceleration (g)	
1	0.74	0.00
2	0.58	0.01
3	0.63	0.01
4	0.22	0.01
7	0.26	0.01

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	16.1	5	5	16.0	5	5	15.5
35	5	4	35.3	5	3	21.1	3	0	6.1
40	5	2	17.9	2	0	0.4	1	0	-0.1

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
16	5	5	15.9						
40	5	4	34.2						
45	5	4	43.1						
50	3	3	50.0						

2020 Hyundai Palisade SEL FWD

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	16.3	5	4	13.7	5	5	16.2
35	5	5	35.0	-	-	-	5	2	14.5
40	3	0	0.5	5	3	24.0	3	0	0.2
45	-	-	-	4	1	11.3	-	-	-

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2020 Hyundai Palisade SEL FWD

TEST VEHICLE INFORMATION

VIN: *KM8R44HEXLU06xxxx*

Body Style: *SUV* Color: *Becketts Black*

Date Received: *8/10/2020* Odometer Reading: *4038 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Hyundai Motor Company*

Date of manufacture: *AUG/14/19*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *245/50R20*

Rear: *245/50R20*

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

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *Bridgestone Dueler H/P Sport AS*

Front tire size: *245/50R20 120V*

Rear tire size: *245/50/R20 120V*

Front tire DOT prefix: *DOT EJ KH CEC*

Rear tire DOT prefix: *DOT EJ KH CEC*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 5)

2020 Hyundai Palisade SEL FWD

DAYTIME TEST GENERAL INFORMATION

Test date: *8/25/2020*

AMBIENT CONDITIONS

Air temperature: *28.3 C (83 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*

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: *240 kPa (35 psi)*

NIGHTTIME TEST GENERAL INFORMATION

Test date: *8/24/2020*

AMBIENT CONDITIONS

Air temperature: *30.0 C (86 F)*

Wind speed: *2.1 m/s (4.6 mph)*

X Wind speed ≤ 10 m/s (22 mph)

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

X The tests were conducted between 1 hour after sunset and 1 hour before sunrise with good atmospheric visibility. There was no streetlighting.

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

OBSTRUCTION VEHICLES

Forward obstructing vehicle: *1999 Honda Accord*

Rear obstructing vehicle: *2012 Toyota Highlander*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 4 of 5)

2020 Hyundai Palisade SEL FWD

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: *240 kPa (35 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*567.0 kg (1250 lb)*	Right Front:	*601.9 kg (1327 lb)*
Left Rear:	*455.4 kg (1004 lb)*	Right Rear:	*430.5 kg (949 lb)*
		Total:	*2054.8 kg (4530 lb)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

2020 Hyundai Palisade SEL FWD

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

Forward Collision Avoidance Assist (FCA) w Pedestrian/Cyclist Detection

Type and location of sensors the system uses:

The system uses a fusion type which includes radar mounted in the front grille and mono camera mounted 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.

The driver can adjust the FCA via User Select Menu (USM) interface:

User Settings

- *Driver Assistance*
  - *Warning Timing*
    - *Normal*
    - *Later*
  - *Warning Volume*
    - *High*
    - *Medium*
    - *Low*
    - *Off*
- *Forward Safety*
  - *Active Assist*
  - *Warning Only*
  - *Off*

See Appendix A, Figures A14 – A16.

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

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

2020 Hyundai Palisade SEL FWD

How is the PAEB alert presented to the driver?

(Check all that apply)

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

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

The driver is alerted by a visual display (Figure A17), a repeated beep with a dominant frequency of 1506 Hz, and a steering wheel vibration.

Does the vehicle system require an initialization sequence/procedure?

- ___ Yes
- **X** No

If yes, please provide a full description.

The vehicle does not require an initialization sequence.

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

Minimum: *5 mph (8 km/h) (Per manufacturer supplied information)*

Maximum: *47 mph (80 km/h) (Per manufacturer supplied information)*

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

- ___ Yes
- **X** No

If yes, please provide a full description.

In general, the FCA does not deactivate due to repeated FCA activations or impacts. However, if the brake actuator or radar/camera sensors are damaged or have problems due to repeated activations or impacts, the FCA can deactivate. In this case, the system provides a diagnostic light to the driver.

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.

The driver can deactivate the FCA via User Select Menu (USM) interface:

User Settings

Driver Assistance

Forward Safety

Off

The FCA is reactivated on each ignition cycle.

See Appendix A, Figures A14 – A16.

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.

See pages 5-72 through 5-77 of the Owner's manual (shown in Appendix B, pages B-13 through B-18). See pages 5-76 through 5-77 of the Owner's Manual for limitations with specifically detecting pedestrians (shown in Appendix B, pages B-17 through B-18).

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Ten test scenarios were used, as follows:

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

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

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

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

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

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.

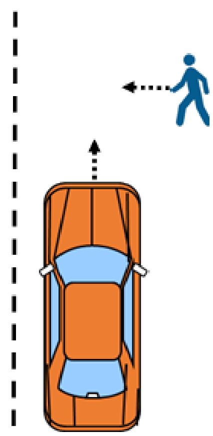


Figure 1. Scenarios S1a, b, c; Nearside Crossing Adult Pedestrian Walking 25/50/75% Overlap

- 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.

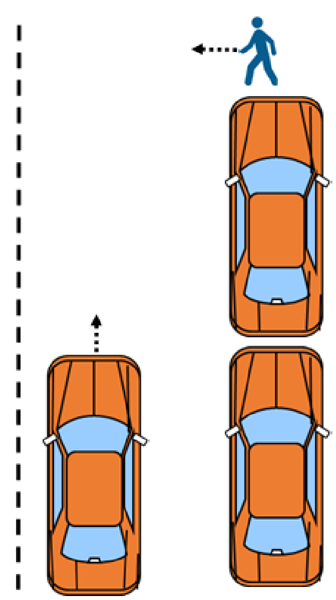


Figure 2. Scenario S1d; Nearside Obstructed Crossing Child Running, 50% Overlap

- 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.

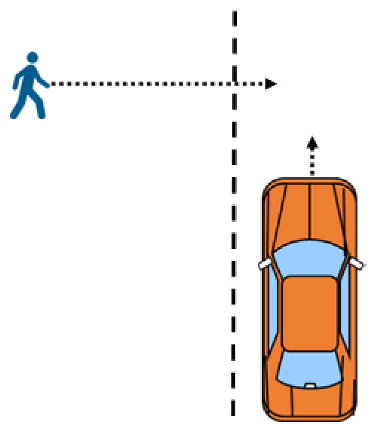


Figure 3. Scenario S1e; Offside Crossing Adult Running 50% Overlap

- 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.

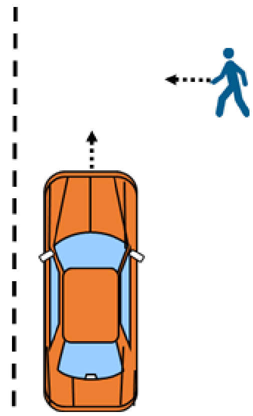


Figure 4. Scenario S1f; Nearside Crossing Adult Walking Stops Short

- 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.

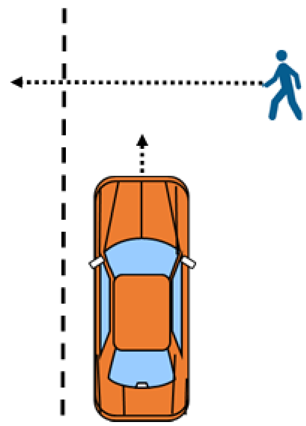


Figure 5. Scenario S1g; Nearside Crossing Adult Walking Clears Path

- 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. PEDESTRIAN TEST MANNEQUIN PLACEMENT AND MOVEMENT

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).

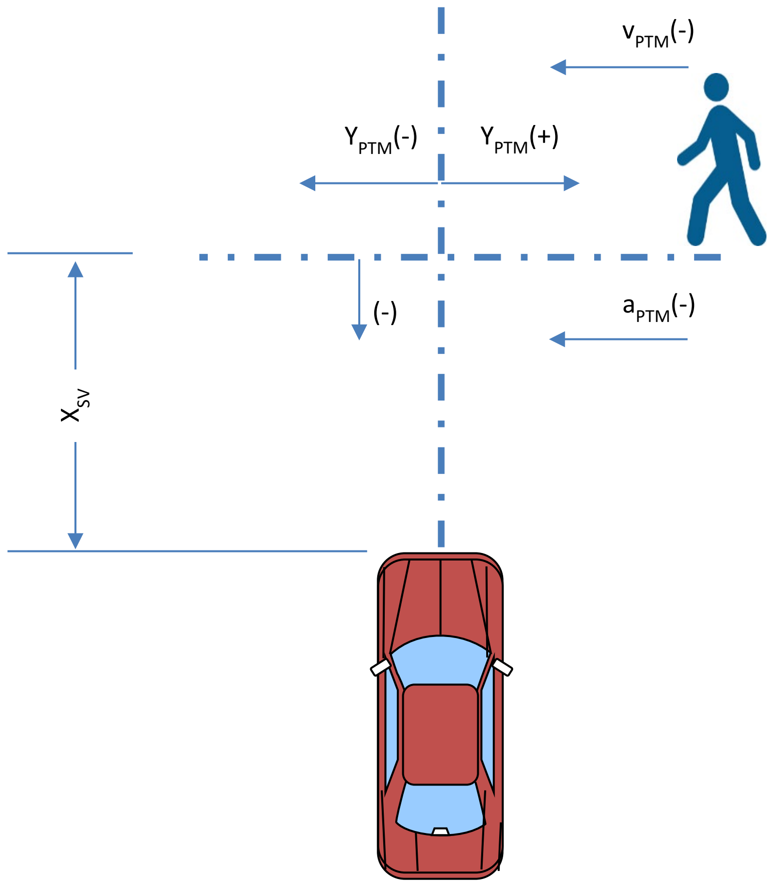


Figure 6. Coordinate System for Validation of Scenario 1

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.

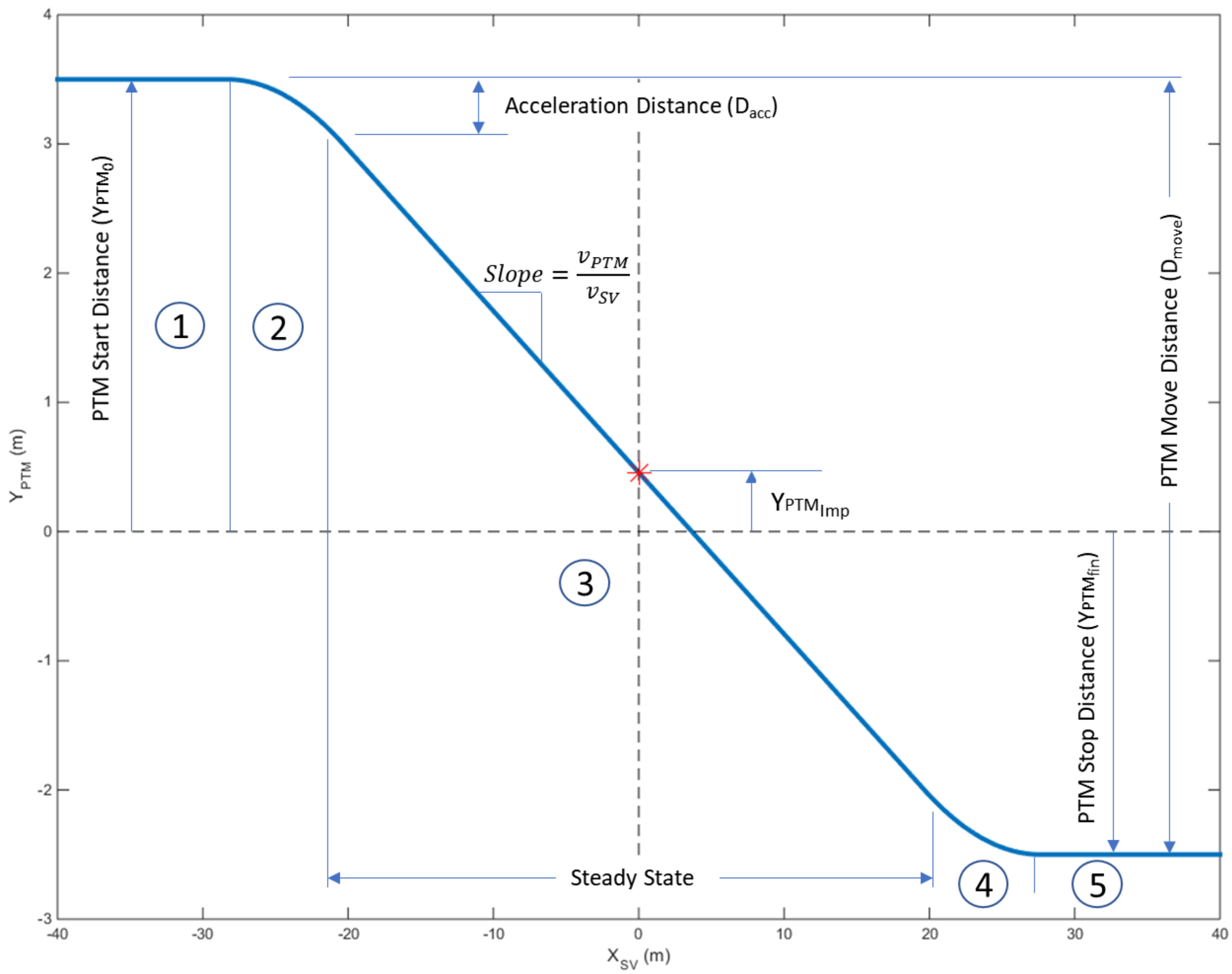


Figure 7. PTM Lateral Lane Position as a Function of SV Longitudinal Lane Position

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):

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

Domain 2 (Acceleration):

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

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 crosses the zero position.
    - The SV stopped (via PAEB).

d. End-of-Test Instructions

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

The test trial was then complete.

e. Number of Test Trial Repeats

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

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

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

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

g. Deceleration (S1f-g)

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

h. Pass/Fail Criteria

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

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

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

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

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

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

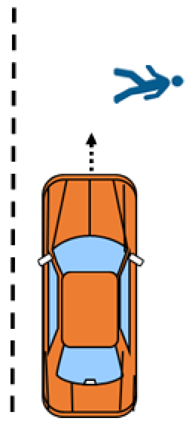


Figure 8. Scenario S4a; Nearside Standing Adult Facing Away From SV, 25% Overlap

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

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

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

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

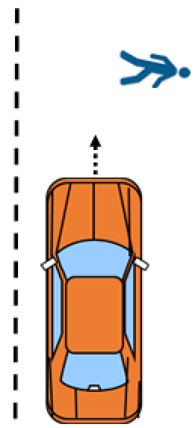


Figure 9. Scenario S4b; Nearside Standing Adult Facing Towards SV, 25% Overlap

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

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

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

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

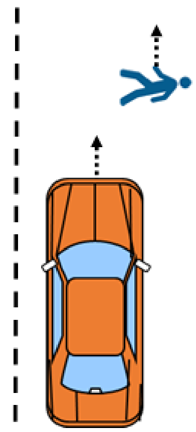


Figure 10. Scenario S4c; Nearside Walking Adult Away From SV, 25% Overlap

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

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

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. <u>SV ZERO POSITION</u>

- 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).
  - 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

[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.

any force to the brake pedal until the end of the test unless the PTM was contacted by the SV.

- The SV throttle was fully released within 500 ms after the SV PAEB warning event was presented (visual, haptic, or audible). If no SV warning event was presented by the SV PAEB system, the SV driver modulated the throttle to maintain constant speed until either the onset of PAEB or, if the SV's PAEB system did not activate, the end of the test occurred (i.e., contact with the PTM occurred).

c. Validity Period

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

d. End-of-Test Instructions

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

The test trial was then complete.

e. Number of Test Trial Repeats

Combinations of test speeds, and lighting conditions were tested as shown in Table 1. Five repeat trials were conducted for each test condition. As noted above, for all scenarios, 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.

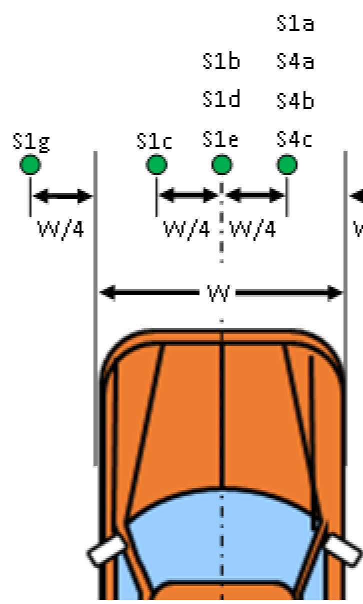


Figure 11. Offset Conditions

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 (600 ft)	
Lane Width *(Not standard lane width. Adapted to SV width. Lane width should be centered on SV path.)*	SV Width + 40 cm (16 in)	
Lane Length *(Based on 4.0 sec TTC and SV speed = 40 km/h (25 mph).)*	44 m (145 ft)	
Obstruction *(S1d only)*	PV1D1	1 m (3.2 ft)
	PV2D1	
	PVD1	

Drawing illustrates setup but is not to scale

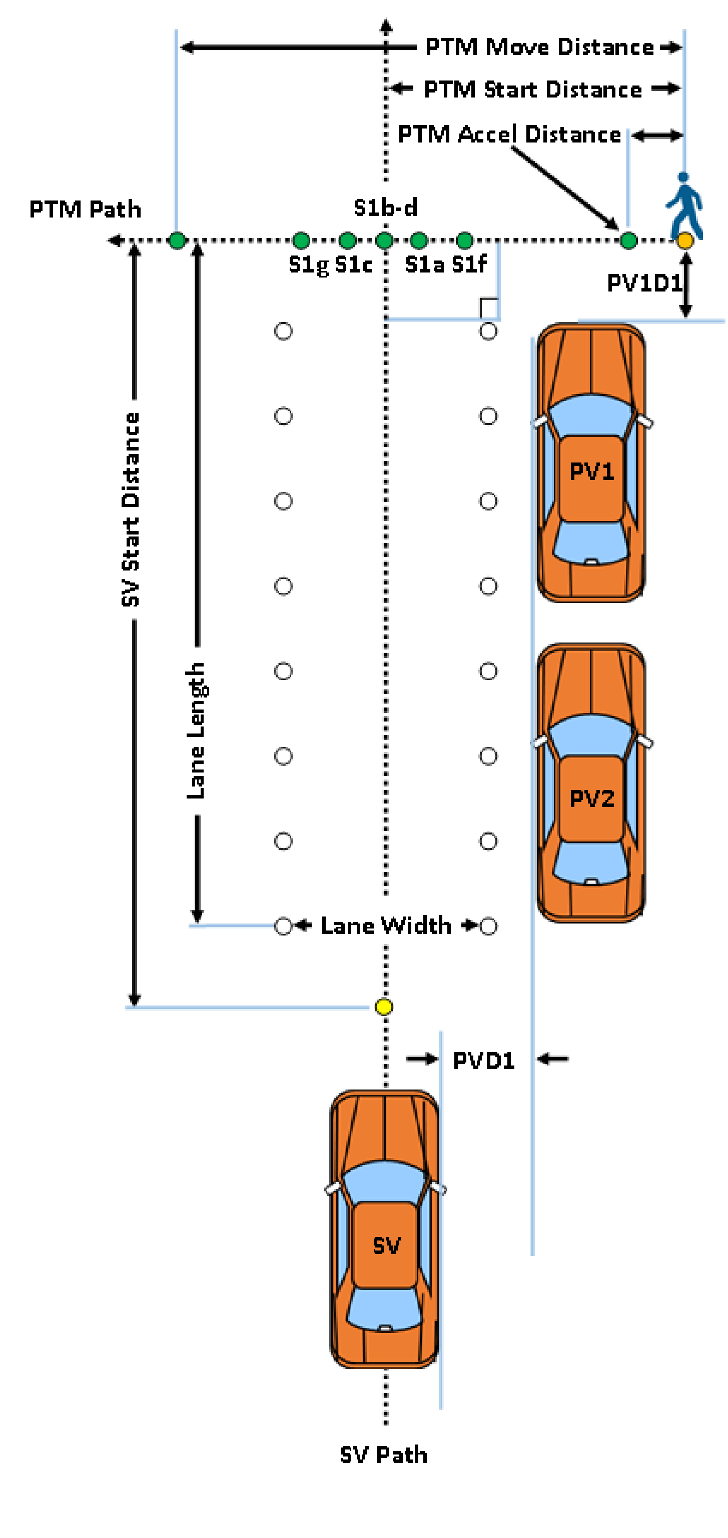


Table 4. Summary of S1e Scenario Setup

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

Drawing illustrates setup but is not to scale

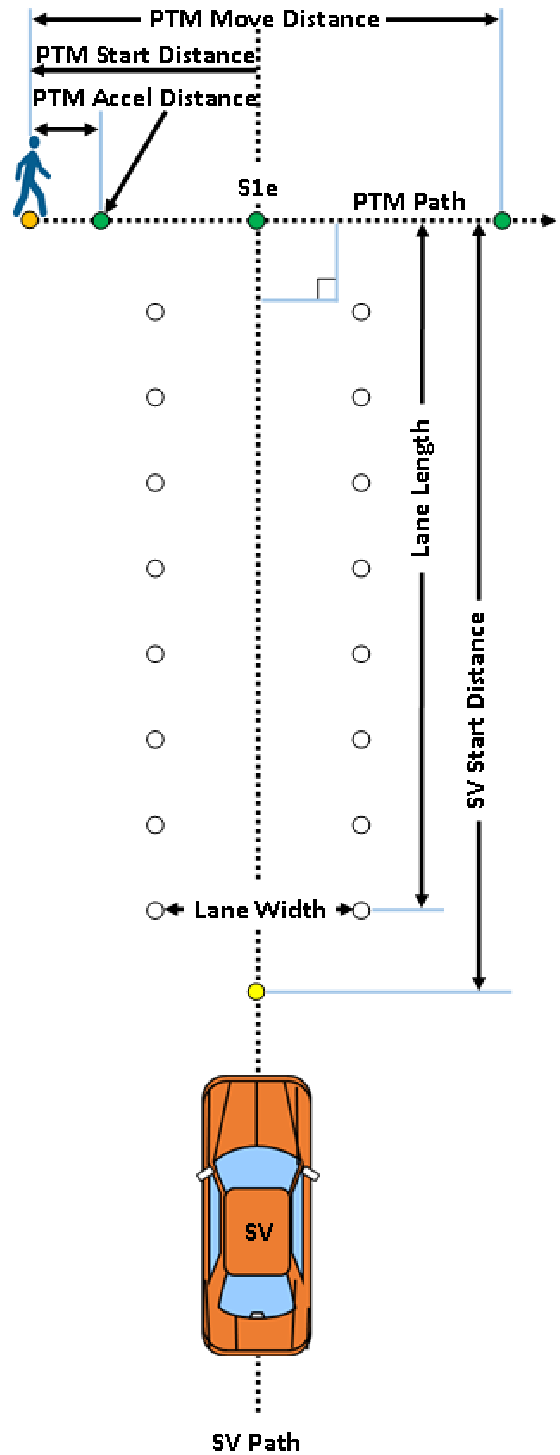


Table 5. Summary of S4a-b Scenarios Setup

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 (600 ft)	
Lane Width *(Not standard lane width. Adapted to SV width. Lane width should be centered on SV path.)*	SV Width + 40 cm (16 in)	
Lane Length *(Based on 4.0 sec TTC and SV speed = 40 km/h (25 mph).)*	44 m (145 ft)	

Drawing illustrates setup but is not to scale

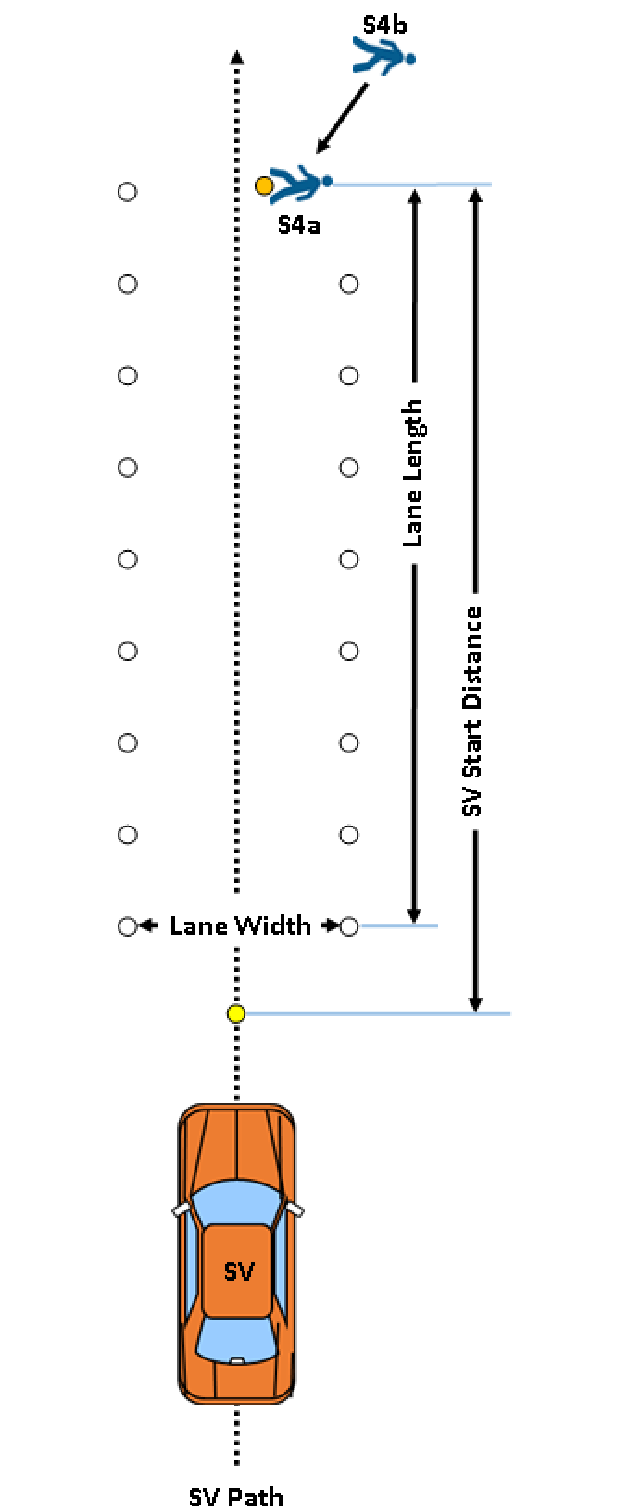
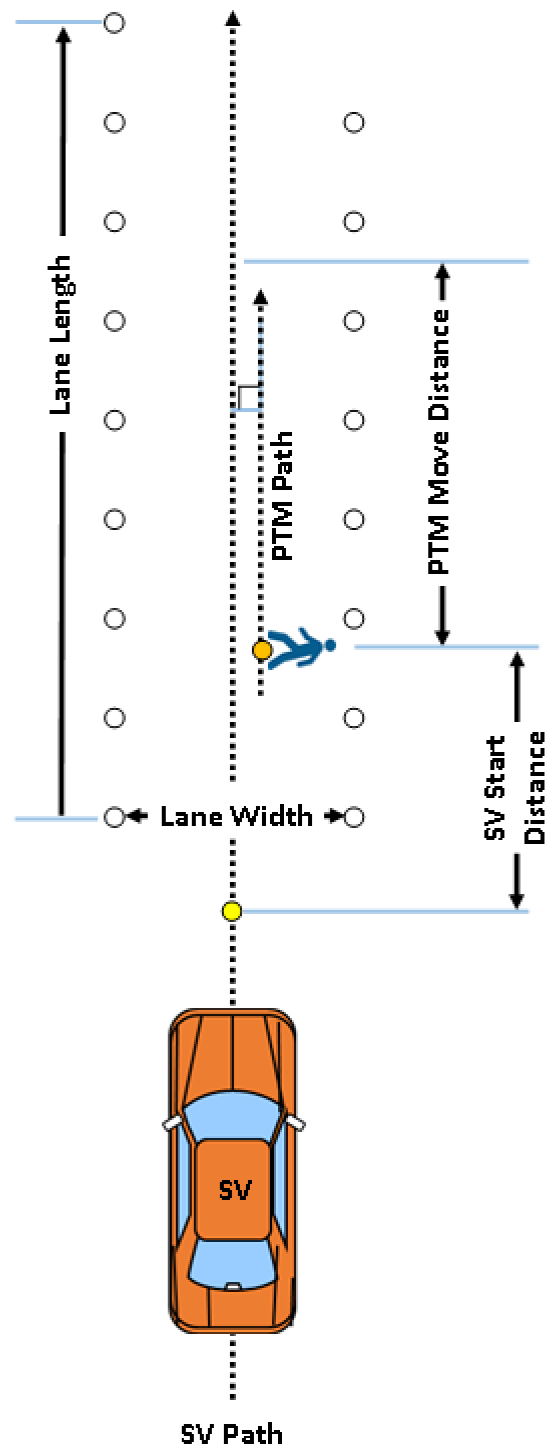


Table 6. Summary of S4c Scenario Setup

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

E. Pre-Test Brake Burnishing

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

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

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

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

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

F. Pedestrian Test Mannequin and Motion System

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

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

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

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

G. Instrumentation

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

Table 7. Test Instrumentation and Equipment

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: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 7/2/2020 Due: 7/2/2021
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)

<table>
<tr><th>Type</th><th>Output</th><th>Range</th><th>Accuracy, Other Primary Specs</th><th>Mfr, Model</th><th>Serial Number</th><th>Calibration Dates
Last
Due</th></tr>
<tr><td>Coordinate Measurement Machine</td><td>Inertial Sensing System Coordinates</td><td>0-8 ft
0-2.4 m</td><td>±.0020 in.
±.051 mm
(Single point articulation accuracy)</td><td>Faro Arm,
Fusion</td><td>UO8-05-08-06636</td><td>By: DRI
Date: 1/6/2020
Due: 1/6/2021</td></tr>
<tr><td>Microphone</td><td>Sound
(to measure time at alert)</td><td>Frequency Response:
80 Hz – 20 kHz</td><td>Signal-to-noise: 64 dB, 1 kHz at 1 Pa</td><td>Audio-Technica
AT899</td><td>NA</td><td>NA</td></tr>
<tr><td>Light Sensor</td><td>Light intensity
(to measure time at alert)</td><td>Spectral Bandwidth:
440-800 nm</td><td>Rise time < 10 msec</td><td>DRI designed and developed Light Sensor</td><td>NA</td><td>NA</td></tr>
<tr><td>Accelerometer</td><td>Acceleration
(to measure time at alert)</td><td>±5g</td><td>≤ 3% of full range</td><td>Silicon Designs, 2210-005</td><td>NA</td><td>NA</td></tr>
<tr><th>Type</th><th colspan="3">Description</th><th colspan="2">Mfr, Model</th><th>Serial Number</th></tr>
<tr><td rowspan="3">Data Acquisition System</td><td colspan="3" rowspan="3">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).</td><td colspan="2">dSPACE Micro-Autobox II 1401/1513</td><td></td></tr>
<tr><td colspan="2">Base Board</td><td>549068</td></tr>
<tr><td colspan="2">I/O Board</td><td>588523</td></tr>
</table>

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. 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.

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

Year: 2020
Make: Hyundai
Model: Palisade SEL FWD
VIN: KM8R44HEXLU06

Engine: V6 Cylinder Engine
Transmission: 8-Speed A/T
Exterior: Becketts Black (RB5)
Interior: Black

MECHANICAL

· 3.648 Axle Ratio
· GVWR: 5,732 lbs
· Front-Wheel Drive
· 54-Amp/Hr Maintenance-Free Battery w/Run Down Protection
· 180 Amp Alternator
· Towing Equipment -inc: Trailer Sway Control
· Trailer Wiring Harness
· Gas-Pressurized Shock Absorbers
· Front And Rear Anti-Roll Bars
· Electric Power-Assist Speed-Sensing Steering
· 18.8 Gal. Fuel Tank
· Single Stainless Steel Exhaust w/Chrome Tailpipe Finisher
· Strut Front Suspension w/Coil Springs
· Multi-Link Rear Suspension w/Coil Springs
· 4-Wheel Disc Brakes w/4-Wheel ABS, Front Vented Discs, Brake Assist, Hill Hold Control and Electric Parking Brake

EXTERIOR

· Wheels: 18" x 7.5J Machine Finish Alloy
· Tires: 245/60R18
· Steel Spare Wheel
· Compact Spare Tire Stored Underbody w/Crankdown
· Clearcoat Paint
· Body-Colored Front Bumper w/Black Rub Strip/Fascia Accent and Metal-Look Bumper Insert
· Body-Colored Rear Bumper w/Metal-Look Rub Strip/Fascia Accent and Black Bumper Insert
· Black Bodyside Cladding and Black Wheel Well Trim
· Chrome Side Windows Trim, Black Front Windshield Trim and Black Rear Window Trim
· Chrome Door Handles
· Body-Colored Power Heated Side Mirrors w/Manual Folding and Turn Signal Indicator
· Fixed Rear Window w/Fixed Interval Wiper and Defroster
· Deep Tinted Glass
· Variable Intermittent Wipers
· Fully Galvanized Steel Panels
· Lip Spoiler
· Metal-Look Grille
· Liftgate Rear Cargo Access
· Tailgate/Rear Door Lock Included w/Power Door Locks
· Roof Rack Rails Only
· Fully Automatic Projector Beam Halogen Daytime Running Auto High-Beam Headlamps w/Delay-Off

ENTERTAINMENT

· Radio: AM/FM/MP3 Display Audio -inc: 8" screen, Apple CarPlay & Android Auto, quiet mode, USB/Auxiliary input jacks, rearview monitor w/parking guidelines and Bluetooth hands-free w/wireless audio streaming
· Radio w/Seek-Scan, Clock, Speed Compensated Volume Control, Steering Wheel Controls, Voice Activation and Radio Data System
· 6 Speakers
· Automatic Equalizer
· Integrated Roof Antenna
· 1 LCD Monitor In The Front

INTERIOR

· Heated Front Bucket Seats -inc: 8-way power driver's seat w/2-way power lumbar support,
· Driver Seat
· 6-Way Passenger Seat -inc: Manual Recline, Height Adjustment and Fore/Aft Movement
· Bucket Folding Captain Front Facing Manual Reclining Fold Forward Seatback Rear Seat w/Manual Fore/Aft
· Front Center Armrest and Rear Seat Mounted Armrest
· Manual Tilt/Telescoping Steering Column
· Gauges -inc: Speedometer, Odometer, Engine Coolant Temp, Tachometer, Trip Odometer and Trip Computer
· Power Rear Windows and Fixed 3rd Row Windows
· Fixed 50-50 Split-Bench 3rd Row Seat Front, Manual Fold Into Floor, 2 Manual and Adjustable Head Restraints
· Leather Steering Wheel
· Front Cupholder
· Rear Cupholder
· Remote Keyless Entry w/Integrated Key Transmitter, Illuminated Entry, Illuminated Ignition Switch and Panic Button
· Remote Releases -Inc: Power Fuel
· Proximity Key For Doors And Push Button Start
· Valet Function
· HomeLink Garage Door Transmitter
· Cruise Control w/Steering Wheel Controls
· Distance Pacing w/Traffic Stop-Go
· Rear HVAC w/Separate Controls
· HVAC -inc: Underseat Ducts and Headliner/Pillar Ducts
· Dual Zone Front Automatic Air Conditioning
· Illuminated Locking Glove Box
· Driver Foot Rest
· Interior Trim -inc: Simulated Wood Instrument Panel Insert, Metal-Look Door Panel Insert and Metal-Look Interior Accents
· Full Cloth Headliner
· Cloth Door Trim Insert
· Stain Resistant Cloth Seat Trim
· Driver And Passenger Visor Vanity Mirrors w/Driver And Passenger Illumination, Driver And Passenger Auxiliary Mirror
· Day-Night Auto-Dimming Rearview Mirror
· Full Floor Console w/Covered Storage, Mini Overhead Console w/Storage, Conversation Mirror and 4 12V DC Power Outlets
· Front Map Lights
· Fade-To-Off Interior Lighting
· Full Carpet Floor Covering
· Carpet Floor Trim
· Cargo Area Concealed Storage
· Cargo Space Lights
· FOB Controls -inc: Cargo Access and Remote Engine Start
· Instrument Panel Bin, Driver / Passenger And Rear Door Bins
· Power 1st Row Windows w/Driver And Passenger 1-Touch Up/Down
· Delayed Accessory Power
· Power Door Locks w/Autolock Feature
· Systems Monitor
· Redundant Digital Speedometer
· Trip Computer
· Outside Temp Gauge
· Analog Display
· Manual w/Tilt Front Head Restraints and Manual Adjustable Rear Head Restraints
· 2 Seatback Storage Pockets
· Perimeter Alarm
· 4 12V DC Power Outlets
· Air Filtration

SAFETY

· Electronic Stability Control
· ABS And Driveline Traction Control
· Side Impact Beams
· Dual Stage Driver And Passenger Seat-Mounted Side Airbags
· Rear Park Assist Rear Parking Sensors
· Forward Collision-Avoidance Assist w/Pedestrian/Cyclist Detection
· Lane Keep Assist Lane Keeping Assist
· Lane Keep Assist Lane Departure Warning
· Blind-spot Collision-Avoidance Assist Blind Spot
· Tire Pressure Monitoring System Tire Specific Low Tire Pressure Warning
· Dual Stage Driver And Passenger Front Airbags
· Curtain 1st And 2nd Row Airbags
· Airbag Occupancy Sensor
· Driver Knee Airbag
· Blue Link
· Rear Child Safety Locks
· Outboard Front Lap And Shoulder Safety Belts -inc: Height Adjusters and Pretensioners

CITY MPG 19

Fuel Economy Information

HIGHWAY MPG 26

Actual mileage will vary with options, driving conditions, driving habits and vehicle's condition

New

MSRP	**$33,925.00**
INSTALLED OPTIONS	
Premium & Drive Guidance	$6,750
Becketts Black	$0
Black, Seat Trim	$0
Mudguards	$120
Cargo Tray	$150
Carpeted Floor Mats	$180
Cargo Net	$50
Original Shipping Charge	$1,140
RETAIL PRICE (ORIGINALLY NEW)	$42,315.00

Get more information on your smartphone:

Figure A5. Window Sticker (Monroney Label)

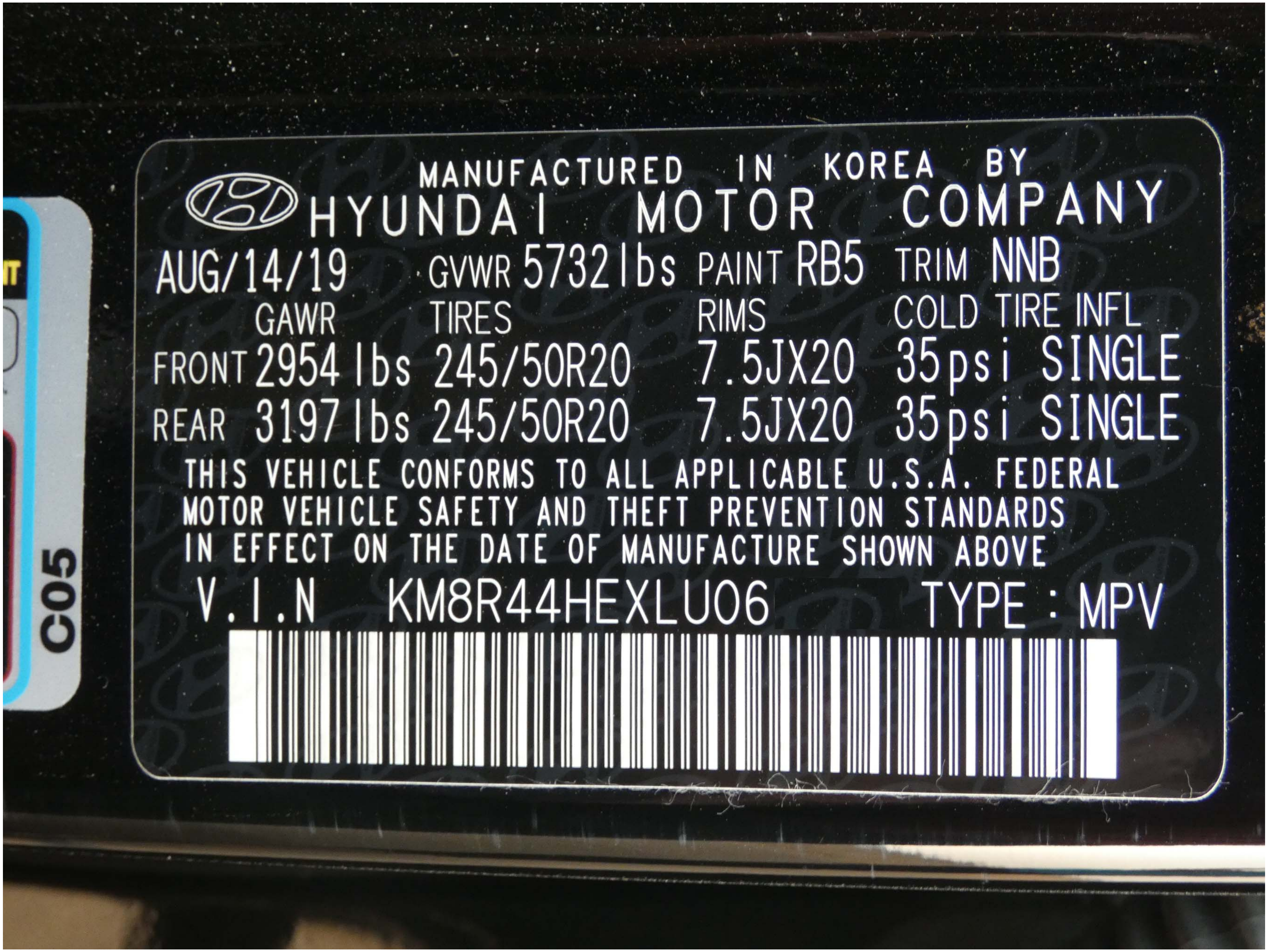


Figure A6. Vehicle Certification Label

Figure A7. Tire Placard

Figure A8. Adult and Child Pedestrian Surrogates and Motion Platform

Figure A9. Obstruction Vehicles

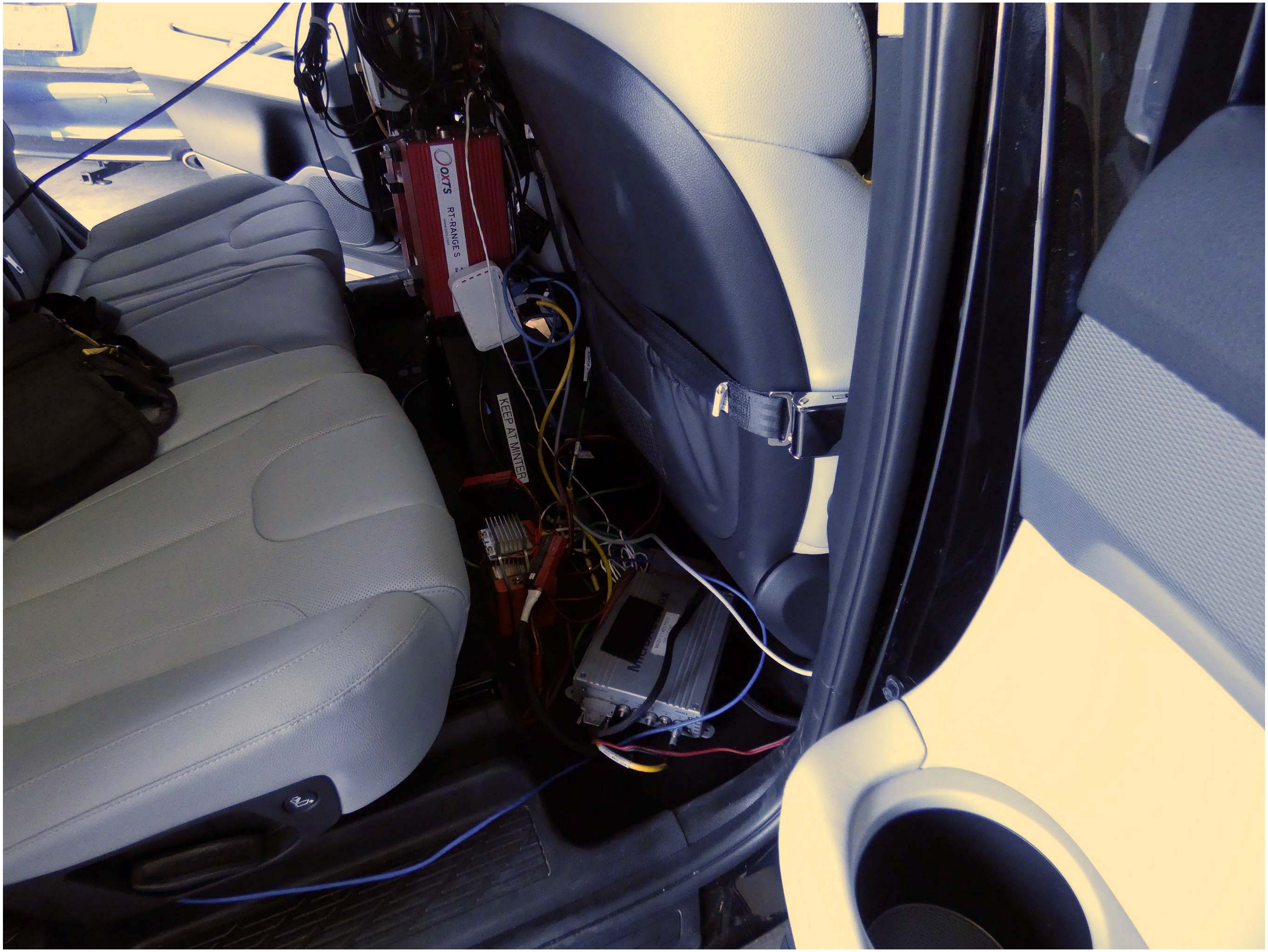


Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A11. Sensor for Detecting Auditory Alert

Figure A12. Sensor for Detecting Visual Alert

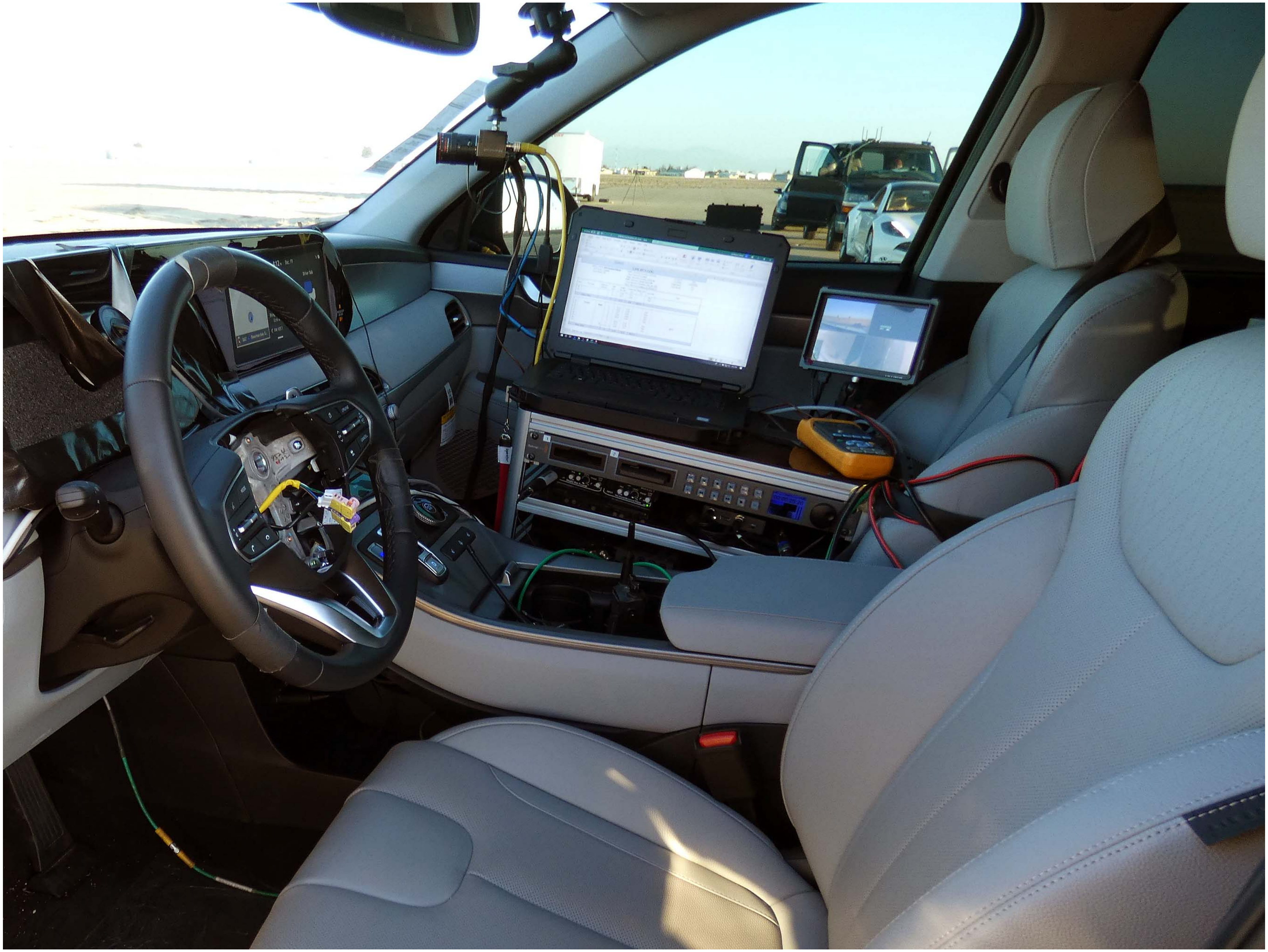


Figure A13. Computer Installed in Subject Vehicle

Figure A14. PAEB Setup Menus (page 1 of 2)

Figure A15. PAEB Setup Menus (page 2 of 2)

Figure A16. Controls for Changing Vehicle Parameters

Figure A17. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

Forward Collision-Avoidance Assist (FCA) System Warning Light

This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
  - It illuminates for approximately 3 seconds and then goes off.
- When there is a malfunction with the FCA.

If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Lane Keeping Assist (LKA) System Indicator Light

This indicator light illuminates:

- [Green] When the system operating conditions are satisfied.
- [White] The system operating conditions are not satisfied.
- [Yellow] When there is a malfunction with the lane keeping assist system.

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

For more details, refer to "Lane Keeping Assist (LKA) system" in chapter 5.

LED Headlight Warning Light (if equipped)

This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
- When there is a malfunction with the LED headlight.

  If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

This warning light blinks:

When there is a malfunction with a LED headlight related part.

If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

NOTICE

Continuous driving with the LED Headlight Warning Light on or blinking can reduce LED headlight life.

Check headlight (if equipped)

This warning message is displayed if the headlights are not operating properly. A headlight bulb may need to be replaced.

Information

Make sure to replace the burned out bulb with a new one of the same wattage rating.

Check turn signal (if equipped)

This warning message is displayed if the turn signal lamps are not operating properly. A lamp may need to be replaced.

Information

Make sure to replace the burned out bulb with a new one of the same wattage rating.

Check High Beam Assist (HBA) system (if equipped)

This warning message is displayed if there is a problem with the High Beam Assist (HBA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "High Beam Assist (HBA) system" in chapter 3.

Check headlight LED (if equipped)

This warning message is displayed if there is a problem with the LED headlight. Have the vehicle inspected by an authorized HYUNDAI dealer.

Check Forward Collision-Avoidance Assist system (if equipped)

This warning message is displayed if there is a problem with the Forward Collision-Avoidance Assist (FCA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Check Blind-Spot Collision Warning (BCW) system (if equipped)

This warning message is displayed if there is a problem with the Blind-Spot Collision Warning system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Blind-Spot Collision Warning (BCW)/ Blind-Spot Collision-Avoidance Assist (BCA)" or "Rear Cross-Traffic Collision Warning (RCCW)/ Rear Cross-Traffic Collision-Avoidance Assist (RCCA)" System in chapter 5.

FORWARD COLLISION-AVOIDANCE ASSIST (FCA) SYSTEM

The Forward Collision-Avoidance Assist (FCA) system is designed to help detect and monitor the vehicle ahead or help detect a pedestrian in the roadway through radar signals and camera recognition to warn the driver that a collision is imminent, and if necessary, apply emergency braking.

⚠ WARNING

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

- **This system is only a supplemental system and it is not intended to, nor does it replace the need for extreme care and attention of the driver. The sensing range and objects detectable by the sensors are limited. Pay attention to the road conditions at all times.**
- **Drive at posted speed limits and accordance to road conditions.**
- **Always drive cautiously to prevent unexpected and sudden situations from occurring. The Forward Collision-Avoidance system may not always stop the vehicle completely and is only intended to help mitigate a collision that is imminent.**

System Setting and Operation

System setting

OTMA058186

- Setting Forward Safety function

  The driver can activate the FCA by placing the ignition switch to the ON position and by selecting:

  'User Settings → Driver Assistance → Forward Safety'

  - If you select "Active Assist", the FCA system activates. The FCA produces warning messages and warning alarms in accordance with the collision risk levels. Braking assist will be applied in accordance with the collision risk.

- If you select 'Warning Only', the FCA system activates and produces only warning alarms in accordance with the collision risk levels. Braking assist will not be applied in this setting.
- If you select 'Off', the FCA system deactivates.

•  The warning light illuminates on the LCD display, when you cancel the FCA system. The driver can monitor the FCA ON/OFF status on the LCD display. Also, the warning light illuminates when the ESC (Electronic Stability Control) is turned off. If the warning light remains ON when the FCA is activated, have the system checked by an authorized HYUNDAI dealer.

OTMA058089

• Setting Warning Timing

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

Go to the 'User Settings → Driver Assistance → Warning Timing → Normal/Later'.

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

- Normal:

  When this option is selected, the initial Forward Collision Warning is activated sensitively. If you feel the warning activates too early, set the Forward Collision Warning to 'Later'.

  Even though, 'Normal' is selected if the front vehicle suddenly stops the initial warning activation time may not seem fast.

- Later:

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

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

Information

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

Prerequisite for activation

The FCA system is on and ready when 'Active Assist' or 'Warning Only' under Forward Safety is selected in the LCD display and when the following prerequisites are satisfied:

- ESC (Electronic Stability Control) is on.
- Vehicle speed is over 5 mph (8 km/h) (The FCA is only activated within a certain speed range.).
- The system detects a pedestrian or a vehicle in front, which may collide with your vehicle. However, FCA may not be activated or may only sound a warning alarm depending on the driving or vehicle conditions.

⚠ WARNING

- **To avoid driver distractions, do not attempt to set or cancel the FCA while driving the vehicle. Always completely stop the vehicle at a safe place before setting or canceling the system.**
- **FCA automatically activates upon placing the ignition switch to the ON position. The driver can deactivate FCA by canceling the system setting in the cluster LCD display.**
- **FCA automatically deactivates upon canceling ESC. When ESC is canceled, FCA cannot be activated in the cluster LCD display. In this situation, the FCA warning light will illuminate which is normal.**

FCA Warning Message and Brake Control

FCA produces warning messages, warning alarms, and emergency braking based on the level of risk of a frontal collision, such as when a vehicle ahead suddenly brakes, or when the system detects that a collision with a pedestrian is imminent.

Collision Warning (First and second warning)

OLX2059026N

- The warning message appears on the cluster LCD display with a warning chime.
- Your vehicle speed may decelerate moderately.
- If FCA detects a vehicle in front, the system operates when your vehicle speed is between 5 mph (8 km/h) and 100 mph (160km/h). Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If FCA detects a pedestrian in front, the system operates when your vehicle speed is between 5 mph (8 km/h) and 55 mph (90 km/h). Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If you select 'Warning only' for the system setting, the FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because the FCA system will not control the brake.

Emergency Braking (Third warning)

OLX2059027N

- The warning message appears on the cluster LCD display with a warning chime.
- Additionally, some vehicle system intervention occurs by the engine management system to help decelerate the vehicle.
- The brake control is maximized just before a collision, reducing impact when it strikes a forward vehicle.
- If FCA detects a vehicle in front, the system operates when your vehicle speed is above 5 mph (8 km/h) and 50 mph (80 km/h) or under. Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If FCA detects a pedestrian in front, the system operates when your vehicle speed is 5 mph (8 km/h) or above and under 45 mph (70 km/h). Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If you select 'Warning only' for the system setting, the FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because the FCA system do not control the brake.

Brake operation

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

⚠ CAUTION

- **The driver should always use extreme caution while operating the vehicle, whether or not there is a warning message or alarm from the FCA system.**
- **After the brake control is activated, the driver must immediately depress the brake pedal and check the surroundings. The brake activation by the system lasts for about 2 seconds.**
- **If any other warning sound such as seat belt warning chime is already generated, the Forward Collision-Avoidance Assist (FCA) system warning may not sound.**
- **Playing the vehicle audio system at high volume may prevent occupants from hearing the system warning sounds.**

⚠ WARNING

The FCA braking control cannot completely stop the vehicle nor avoid all collisions. The driver should hold the responsibility to safely drive and control the vehicle.

⚠ WARNING

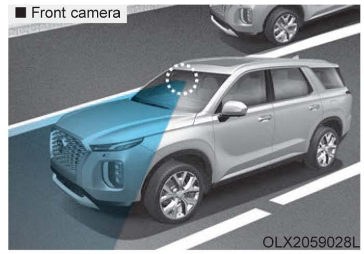
The FCA system logic operates within certain parameters, such as the distance from the vehicle, pedestrian ahead, the speed of the vehicle ahead, and the driver's vehicle speed. Certain conditions such as inclement weather and road conditions may affect the operation of the FCA system.

⚠ WARNING

Never deliberately drive dangerously to activate the system.

FCA Sensor (Front Radar/Front Camera)

OLX2059031N



OLX2059028L

In order for the FCA system to operate properly, always make sure the sensor cover or sensor is clean and free of dirt, snow, and debris.

Dirt, snow, or foreign substances on the sensor cover or sensor may adversely affect the sensing performance of the sensor.

NOTICE

- **Do not apply license plate frame or foreign objects such as a bumper sticker or a bumper guard near the sensor. Doing so may adversely affect the sensing performance of the radar.**
- **Always keep the sensor and cover clean and free of dirt and debris.**
- **Use only a soft cloth to wash the vehicle. Do not spray pressurized water directly on the sensor or sensor cover.**
- **Be careful not to apply unnecessary force on the sensor or sensor cover. If the sensor is forcibly moved out of proper alignment, the FCA system may not operate correctly. In this case, a warning message may not be displayed. Have the vehicle inspected by an authorized HYUNDAI dealer.**
- **If the front bumper becomes damaged in the area around the sensor, the FCA system may not operate properly. Have the vehicle inspected by an authorized HYUNDAI dealer.**
- **Use only genuine HYUNDAI parts to repair or replace a damaged sensor or sensor cover. Do not apply paint to the sensor cover.**

NOTICE

- **NEVER install any accessories or stickers on the front windshield, or tint the front windshield.**
- **NEVER place any reflective objects (i.e. white paper, mirror) over the crash pad. Any light reflection may prevent the system from functioning properly.**
- **Pay extreme caution to keep the camera dry.**
- **NEVER disassemble the camera assembly, or apply any impact on the camera assembly.**
- **If the sensor is forcibly moved out of proper alignment, the FCA system may not operate correctly. In this case, a warning message may not be displayed. Have the vehicle inspected by an authorized HYUNDAI dealer.**

i Information

Have the system checked by an authorized HYUNDAI dealer when:

- **The windshield glass is replaced.**
- **The radar sensor or cover gets damaged or replaced.**

Warning message and warning light

OIK057090L

Forward Collision-Avoidance Assist (FCA) system disabled.
Radar blocked

When the sensor cover is covered with dirt, snow, or debris, the FCA system operation may not be able to detect other vehicles. If this occurs, a warning message will appear on the LCD display.

The system will operate normally when such dirt, snow or debris is removed.

FCA may not properly operate in an area (e.g. open terrain) where any objects or vehicles are not detected after turning on the engine.

⚠ WARNING

The FCA system may not activate according to road conditions, inclement weather, driving conditions or traffic conditions.

System Malfunction

OIK057091L

Check Forward Collision-Avoidance Assist system

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

Both FCA warning light and warning message will disappear once the ESC warning light issue is resolved.

⚠ WARNING

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

Also due to sensing limitations, in certain situations, the front radar sensor or camera recognition system may not detect the vehicle, pedestrian ahead. The FCA system may not activate and the warning message may not be displayed.

- **If there is a malfunction with the FCA system, the Forward Collision avoidance assist system is not applied even though the braking system is operating normally.**
- **If the vehicle in front stops suddenly, you may have less control of the brake system. Therefore, always keep a safe distance between your vehicle and the vehicle in front of you.**
- **The FCA system may activate during braking and the vehicle may stop suddenly shifting loose objects toward the passengers. Always keep loose objects secured.**
- **The FCA system may not activate if the driver applies the brake pedal to avoid collision.**
- **The brake control may be insufficient, possibly causing a collision, if a vehicle in front abruptly stops. Always pay extreme caution.**
- **The FCA system may not activate according to the road conditions, inclement weather, driving conditions or traffic conditions.**
- **Occupants may get injured, if the vehicle abruptly stops by the activated FCA system. Pay extreme caution.**
- **The FCA system operates only to detect vehicles, pedestrian in front of the vehicle.**

⚠ WARNING

- **The FCA system operates only to help detect vehicles or pedestrians in front of the vehicle.**
- **The FCA system does not operate when the vehicle is in reverse.**
- **The FCA system is not designed to detect other objects on the road such as animals.**
- **The FCA system does not detect vehicles in the opposite lane.**
- **The FCA system does not detect cross traffic vehicles that are approaching.**
- **The FCA system cannot detect the cross traffic cyclist that are approaching.**
- **The FCA system cannot detect vehicles that are stopped vertically to your vehicle at a intersection or dead end street.**

In these cases, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce the driving speed in order to maintain a safe distance or to stop the vehicle.

Limitations of the System

The Forward Collision Avoidance Assist (FCA) system is designed to monitor the vehicle ahead or a pedestrian on the roadway through radar signals and camera recognition to warn the driver that a collision is imminent, and if necessary, apply emergency braking.

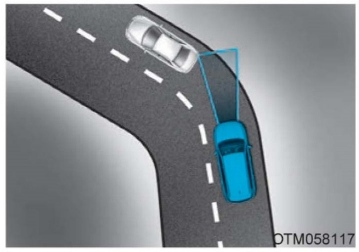
In certain situations, the radar sensor or the camera may not be able to detect the vehicle, pedestrian ahead. In these cases, the FCA system may not operate normally. The driver must pay careful attention in the following situations where the FCA operation may be limited.

Detecting vehicles

The sensor may be limited when:

- The system may not operate for 15 seconds after the engine is started or the camera is initialized
- The radar sensor or camera is covered with a foreign object or debris
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign matter (sticker, bug, etc.) on the glass
- Inclement weather such as heavy rain or snow obscures the field of view of the radar sensor or camera
- There is interference by electromagnetic waves
- There is severe irregular reflection from the radar sensor
- The radar/camera sensor recognition is limited
- The vehicle in front is too small to be detected (for example a motorcycle or a bicycle, etc.)
- The vehicle in front is an oversize vehicle or trailer that is too big to be detected by the camera recognition system (for example a tractor trailer, etc.)
- The camera's field of view is not well illuminated (either too dark or too much reflection or too much backlight that obscures the field of view)
- The vehicle in front does not have their rear lights properly turned ON or their rear lights are located unusually
- The outside brightness changes suddenly, for example when entering or exiting a tunnel
- Light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- The field of view in front is obstructed by sun glare
- The windshield glass is fogged up; a clear view of the road is obstructed
- The vehicle in front is driving erratically
- The vehicle is on unpaved or uneven rough surfaces, or road with sudden gradient changes
- The vehicle is driven near areas containing metal substances as a construction zone, railroad, etc.
- The vehicle drives inside a building, such as a basement parking lot
- The camera does not recognize the entire vehicle in front
- The camera is damaged
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel
- The shadow is on the road by a median strip, trees, etc.
- The vehicle drives through a tollgate.
- The rear part of the vehicle in front is not normally visible (the vehicle turns in other direction or the vehicle is overturned.)
- The adverse road conditions cause excessive vehicle vibrations while driving

- The sensor recognition changes suddenly when passing over a speed bump
- The vehicle in front is moving vertically to the driving direction
- The vehicle in front is stopped vertically
- The vehicle in front is driving towards your vehicle or reversing
- You are on a roundabout and the vehicle in front circles



OTM058117

- Driving on a curve

  The performance of the FCA system may be limited when driving on a curved road.

  In certain instances on a curved road, the FCA system may activate prematurely.

  Also, in certain instances the front radar sensor or camera recognition system may not detect the vehicle traveling on a curved road.

  In these cases, the driver must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

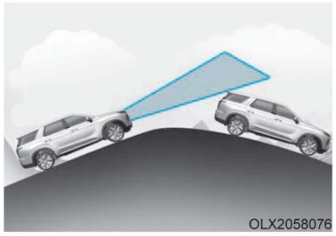
OTM058073

The FCA system may recognize a vehicle in the next lane when driving on a curved road.

In this case, the system may unnecessarily alarm the driver and apply the brake.

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

Also, when necessary depress the accelerator pedal to prevent the system from unnecessarily decelerating your vehicle.

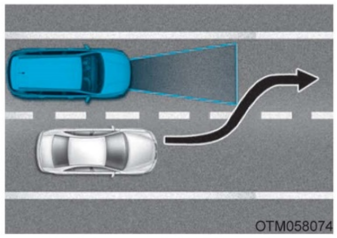

OLX2058076

- Driving on a slope

  The performance of the FCA decreases while driving upward or downward on a slope, not recognizing the vehicle in front in the same lane. It may unnecessarily produce the warning message and the warning alarm, or it may not produce the warning message and the warning alarm at all.

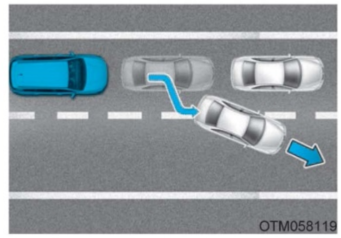
  When the FCA suddenly recognizes the vehicle in front while passing over a slope, you may experience sharp deceleration.

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


OTM058074

- Changing lanes

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


OTM058119

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


OLX2058077

- Detecting the vehicle in front of you

  If the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance, additional special attention is required. The FCA system may not be able to detect the cargo extending from the vehicle. In these instances, you must maintain a safe braking distance from the rearmost object, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

Detecting pedestrians

The sensor may be limited when:

- The pedestrian is not fully detected by the camera recognition system, for example, if the pedestrian is leaning over or is not fully walking upright
- The pedestrian is moving very quickly or appears abruptly in the camera detection area
- The pedestrian is wearing clothing that easily blends into the background, making it difficult to be detected by the camera recognition system
- The outside lighting is too bright (e.g. when driving in bright sunlight or in sun glare) or too dark (e.g. when driving on a dark rural road at night)
- It is difficult to detect and distinguish the pedestrian from other objects in the surroundings, for example, when there is a group of pedestrians or a large crowd
- There is an item similar to a person's body structure
- The pedestrian is small
- The pedestrian has impaired mobility
- The sensor recognition is limited
- The radar sensor or camera is covered with a foreign object or debris
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign matter (sticker, bug, etc.) on the glass
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel
- Inclement weather such as heavy rain or snow obscures the field of view of the radar sensor or camera
- Light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- The field of view in front is obstructed by sun glare
- The windshield glass is fogged up; a clear view of the road is obstructed

- The adverse road conditions cause excessive vehicle vibrations while driving
- The sensor recognition changes suddenly when passing over a speed bump
- You are on a roundabout
- When the pedestrian suddenly interrupts in front of the vehicle
- When there is any other electro-magnetic interference
- When the construction area, rail or other metal object is near the cyclist

⚠ WARNING

- **Do not use the Forward Collision Avoidance Assist (FCA) system when towing a vehicle. Application of the FCA system while towing may adversely affect the safety of your vehicle or the towing vehicle.**
- **Use extreme caution when the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance.**
- **The FCA system is designed to help detect and monitor the vehicle ahead to help detect a pedestrian in the roadway through radar signals and camera recognition. It is not designed to detect bicycles, motorcycles, or smaller wheeled objects such as luggage bags, shopping carts, or strollers.**
- **Never try to test the operation of the FCA system. Doing so may cause severe injury or death.**

Information

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

Information

This device complies with Part 15 of the FCC rules.

Operation is subject to the following two conditions:

1. **This device may not cause harmful interference.**
2. **This device must accept any interference received, including interference that may cause undesired operation.**

APPENDIX C

Run Log

Run Log for Daytime Tests

Subject Vehicle: *2020 Hyundai Palisade SEL FWD*

Test Date: *8/25/2020*

Adult Pedestrian Test Mannequin: *Articulated 4A Adult*

Test Driver: *N. Watanabe*

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
1	Static										
2	S1a	16	Day	Y	1.06	1.96	16.1	1.07	0.79	NC	Light sensor issue only audible
3				Y	1.16	2.02	16.2	1.05	0.85	NC	
4				Y	0.93	2.01	15.8	1.07	0.79	NC	
5				Y	1.14	2.23	16.3	1.07	0.84	NC	
6				Y	1.02	1.92	15.7	1.06	0.81	NC	
7	S1a	40	Day	Y	0.48	0.00	10.1	1.06	0.35	Contact	No video
8				Y	1.06	1.77	39.8	1.14	0.87	NC	
9				Y	1.26	2.39	39.7	1.14	0.99	NC	
10				Y	1.08	2.02	40.3	1.13	0.90	NC	
11				Y	0.65	0.00	18.7	1.04	0.52	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
12	Static										
13	S1b	16	Day	Y	1.58	2.22	15.9	1.12	0.89	NC	
14				Y	1.35	2.07	16.2	1.10	0.81	NC	
15				Y	1.43	1.98	16.1	1.10	0.78	NC	
16				Y	1.35	1.97	16.1	1.12	0.78	NC	
17				Y	1.38	2.15	16.0	1.18	0.85	NC	
23	S1b	20	Day	Y	1.42	2.43	19.7	1.05	0.84	NC	
24				Y	1.52	2.48	20.0	1.04	0.85	NC	
25				Y	1.51	2.56	20.0	1.05	0.86	NC	
26				Y	1.40	2.46	19.8	1.03	0.85	NC	
27				Y	1.41	2.51	19.9	1.03	0.88	NC	
28	S1b	30	Day	Y	1.51	3.25	30.0	1.13	1.01	NC	
29				Y	1.42	3.33	30.0	1.08	0.99	NC	
30				Y	1.40	3.04	30.0	1.06	1.00	NC	
31				Y	1.35	3.33	29.8	1.14	1.01	NC	
32				Y	1.52	3.55	29.9	1.06	1.07	NC	
18	S1b	40	Day	Y	0.81	0.00	37.8	1.07	0.69	NC	
19				Y	0.99	2.15	40.3	1.13	0.87	NC	
20				Y	1.16	2.91	40.1	1.02	0.99	NC	
21				Y	1.24	1.98	39.5	1.15	1.03	NC	
22				Y	1.29	1.41	39.6	1.09	0.94	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
36	S1b	45	Day	Y	0.86	0.00	33.6	1.06	0.73	Contact	
37				Y	0.81	0.00	28.3	1.08	0.66	Contact	
38				Y	1.17	0.57	44.7	1.08	0.88	NC	
39				Y	0.71	0.00	23.8	1.04	0.61	Contact	
33	S1b	50	Day	Y	0.59	0.00	15.3	1.03	0.47	Contact	
34				Y	0.58	0.00	13.3	1.04	0.45	Contact	
35				Y	0.43	0.00	0.5	0.10		Contact	No AEB
40	Static										
41	S1c	16	Day	Y	1.31	1.66	15.7	1.01	0.72	NC	
42				Y	1.50	2.07	15.8	1.08	0.83	NC	
43				Y	1.47	1.91	15.8	1.10	0.78	NC	
44				Y	1.74	1.94	16.1	1.10	0.82	NC	
45				Y	1.53	2.07	16.1	1.11	0.83	NC	
51	S1c	35	Day	Y	1.29	3.19	34.7	1.13	0.99	NC	
52				Y	1.65	3.32	35.1	1.15	1.05	NC	
53				N							PTM lateral error
54				Y	1.60	2.96	34.8	1.16	1.06	NC	
55				Y	1.54	2.80	35.4	1.15	1.05	NC	
56				Y	1.59	2.84	35.3	1.08	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
46	S1c	40	Day	Y	0.73	0.00	26.2	1.01	0.62	Contact	
47				Y	1.32	2.28	39.8	1.13	1.02	NC	
48				Y	1.60	0.00	14.5	0.64	0.90	Contact	
49				Y	1.35	2.27	39.8	1.15	0.98	NC	
50				Y	0.64	0.00	9.1	1.01	0.31	Contact	
150	S1d	16	Day	Y	0.85	1.83	15.5	1.16	0.71	NC	
151				Y	0.46	0.25	16.2	1.07	0.36	NC	
152				Y	0.41	0.00	8.6	1.08	0.26	Contact	
153				Y	0.69	1.08	15.8	1.11	0.55	NC	
154				Y	1.05	1.48	16.1	1.06	0.70	NC	
159	S1d	20	Day	Y	1.04	2.25	20.3	1.05	0.80	NC	
160				Y	0.92	2.12	19.8	1.02	0.78	NC	
161				Y	1.05	2.01	20.0	1.05	0.75	NC	
162				Y	0.83	1.89	19.9	1.04	0.72	NC	
163				Y	1.04	2.27	20.1	1.04	0.81	NC	
164	S1d	30	Day	Y	0.95	2.28	30.2	1.02	0.81	NC	
165				Y	0.98	2.52	29.7	1.10	0.82	NC	
166				Y	0.95	2.24	29.7	1.06	0.81	NC	
167				Y	0.93	1.99	29.5	1.10	0.77	NC	
168				Y	0.99	2.63	30.3	1.07	0.87	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
169	S1d	35	Day	Y	0.86	0.11	34.3	1.19	0.63	NC	
170				Y	0.86	1.46	34.8	1.21	0.74	NC	
171				Y	0.84	0.85	34.9	1.19	0.70	NC	
172				Y	0.98	1.14	34.0	1.12	0.75	NC	
173				Y	0.99	2.63	34.8	1.17	0.87	NC	
174	Static										
155	S1d	40	Day	Y	0.69	0.00	22.2	1.03	0.55	Contact	
156				Y	0.66	0.00	18.9	1.02	0.51	Contact	
157				Y	0.85	0.41	40.2	1.07	0.73	NC	
158				Y	0.56	0.00	12.4	1.01	0.38	Contact	
130	Static										
131	S1e	40	Day	N							PTM lateral error
132				Y	0.89	0.79	39.4	1.04	0.76	NC	
133				Y	1.04	1.95	41.2	1.04	0.88	NC	
134				Y	0.97	1.32	40.5	1.06	0.81	NC	
135				Y	0.71	0.00	22.7	1.05	0.58	Contact	
136				Y	0.99	0.89	36.4	1.05	0.79	NC	
137	S1e	45	Day	Y	1.05	0.89	40.1	1.06	0.84	NC	
138				Y	0.98	0.84	42.9	1.08	0.81	NC	
139				Y	0.96	0.52	40.0	1.11	0.78	NC	
140				Y	1.00	0.80	40.8	1.10	0.81	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
141	S1e	45	Day	Y	0.88	0.00	40.1	1.13	0.74	NC	PTM leg fell off near end of brake event
142	S1e	50	Day	Y	0.77	0.00	25.9	1.12	0.64	Contact	
143				Y	0.94	-0.13	42.0	1.10	0.80	NC	
144				Y	1.03	0.68	41.6	1.10	0.85	NC	
145				Y	0.85	0.00	36.1	1.11	0.73	Contact	
146				N							PTM lateral error
147				Y	0.83	0.00	31.9	1.10	0.71	Contact	
148	Static										
149	Static										
57	Static										
58	S1f	40	Day	Y	0.82	0.00	14.2	0.74	0.71	N/A	
59				Y	0.98	0.00	10.4	0.58	0.84	N/A	
60				Y	1.34	0.00	13.2	0.63	1.03	N/A	
61				Y	1.21	0.00	5.0	0.22	0.88	N/A	
62				Y	0.78	0.00	4.2	0.26	0.63	N/A	
63	S1g	40	Day	N							PTM lateral error
64				N							PTM lateral error
65				N							SV lateral
66				N							PTM lateral error

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
67	S1g	40	Day	Y		0.00	0.3	0.00		N/A	No warning
68				N							SV lateral
69				Y	0.79	0.00	0.1	0.01		N/A	
70				Y		0.00	0.3	0.01		N/A	No warning
71				Y	1.31	0.00	0.8	0.01		N/A	
72				Y		0.00	0.0	0.01		N/A	No warning
73	Static		Day								
74	S4a	16	Day	Y	1.58	2.38	16.1	1.15	0.90	NC	
75				Y	1.64	2.48	16.4	1.11	0.94	NC	
76				Y	0.87	1.83	15.8	1.05	0.73	NC	
77				Y	1.59	2.59	16.0	1.13	0.94	NC	
78				Y	1.61	2.44	16.1	1.10	0.90	NC	
85	S4a	35	Day	Y	1.66	2.86	35.5	1.06	1.09	NC	No warning, no AEB
86				Y	1.59	3.27	35.3	1.14	1.06	NC	SV speed
87				Y	1.58	3.06	35.1	1.06	1.08	NC	No warning, no AEB
88				Y	1.66	3.01	35.3	1.11	1.07	NC	
89				Y	1.41	2.96	35.1	1.11	1.05	NC	
79	S4a	40	Day	Y		0.00	0.4	0.01		Contact	No warning, no AEB
80				N							SV speed
81				Y		0.00	0.4	0.06		Contact	No warning, no AEB
82				Y	1.37	2.89	39.3	1.04	1.01	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
83	S4a	40	Day	Y	1.68	2.34	40.8	1.05	1.07	NC	
84				Y	1.51	0.00	8.5	0.25	1.04	Contact	
90	Static										
91	S4b	16	Day	Y	1.60	2.26	16.0	1.06	0.89	NC	
92				N							Throttle release
93				Y	1.66	1.65	15.8	1.01	0.75	NC	
94				Y	1.51	2.99	16.6	0.76	1.07	NC	
95				Y	1.64	2.18	15.8	1.06	0.86	NC	
96				Y	1.50	2.37	15.3	1.00	0.91	NC	
97	S4b	40	Day	Y	1.59	0.00	9.8	0.23	1.13	Contact	
98											Static run
99				N							PTM facing wrong direction
100				Y	1.52	2.42	39.7	1.17	1.04	NC	
101				Y	1.53	2.22	40.3	1.05	0.97	NC	
102				Y	1.62	2.85	40.8	1.16	0.97	NC	
103				Y	1.45	2.81	40.2	1.06	1.00	NC	
104	S4b	45	Day	Y	0.87	0.00	35.8	1.08	0.73	Contact	Not a test condition
105				N							SV lateral error
106				Y	1.55	2.50	45.0	1.12	1.13	NC	Not a test condition
107				Y	1.47	2.48	45.3	1.11	1.08	NC	Not a test condition

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
108	S4b	45	Day	Y	1.47	2.46	44.4	1.12	1.01	NC	Not a test condition
109				Y	1.57	2.36	45.0	1.13	1.06	NC	Not a test condition
110	S4b	50	Day	Y	1.54	1.89	49.8	1.11	0.96	NC	Not a test condition
111				Y	1.43	2.60	50.1	1.13	1.07	NC	Not a test condition
112				Y	1.54	2.37	50.0	1.13	1.07	NC	Not a test condition
113	Static		Day								
114	S4c	16	Day	Y	1.47	0.98	16.2	1.09	0.57	NC	
115				Y	1.63	2.71	16.4	1.13	1.13	NC	
116				Y	1.69	1.55	16.2	1.13	0.83	NC	
117				Y	1.55	2.12	16.6	1.12	0.95	NC	
118				Y	1.67	1.30	16.3	1.17	0.75	NC	
122	S4c	35	Day	Y	1.57	3.39	34.5	1.06	1.04	NC	
123				N							GPS Antenna fell off
124				Y	1.59	3.99	35.2	1.09	1.11	NC	
125				Y	1.53	3.88	35.2	1.05	1.05	NC	
126				Y	1.56	3.02	34.6	1.05	1.08	NC	
127				N							SV yaw
128				Y	1.63	3.22	35.6	1.05	1.06	NC	
129	Static		Day								
119	S4c	40	Day	Y		0.00	0.5	0.01		Contact	No warning, No AEB
120				Y		0.00	-0.1	0.04		Contact	No warning, No AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
121	S4c	40	Day	Y	1.06	0.00	1.2	0.04		Contact	No warning, No AEB

Run Log for Nighttime Tests

Subject Vehicle: *2020 Hyundai Palisade SEL FWD*　　Test Date: *8/24/2020*

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
72	S1b	16	High	Y	1.10	1.61	15.8	1.12	0.70	NC	
73				Y	1.08	0.00	2.0	0.06		Contact	No AEB
74				Y	1.25	1.32	16.3	1.16	0.63	NC	
75				Y	1.05	1.42	16.1	1.13	0.65	NC	
76				N							PTM lateral error
77				Y	1.21	1.49	16.1	1.17	0.67	NC	
83	S1b	20	High	Y	1.21	1.75	20.0	1.08	0.73	NC	
84				Y	1.20	1.81	20.1	1.10	0.73	NC	
85				N							PTM lateral error
86				Y	1.26	1.68	19.6	1.09	0.70	NC	
87				Y	1.22	1.44	19.7	1.11	0.64	NC	
88				Y	1.20	1.58	20.4	1.12	0.68	NC	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
94	S1b	30	High	Y	1.18	1.74	30.3	1.14	0.77	NC	
95				Y	1.08	1.71	30.0	1.14	0.75	NC	
96				Y	1.29	2.22	29.9	1.14	0.85	NC	
97				Y	1.18	1.88	30.2	1.12	0.81	NC	
98				Y	1.23	1.99	29.9	1.15	0.82	NC	
104	S1b	40	High	Y	0.91	0.12	39.6	1.17	0.71	NC	
105				Y	1.04	1.13	40.4	1.11	0.80	NC	
106				N							SV yaw
107				Y	1.08	0.84	40.2	1.16	0.78	NC	
108				Y	1.16	1.14	40.4	1.12	0.79	NC	
109				Y	0.92	0.82	40.7	1.12	0.74	NC	
113	S1b	45	High	Y	0.77	0.00	21.3	1.03	0.55	Contact	
114				Y	0.56	0.00	13.6	1.03	0.42	Contact	
115				N							PTM leg not moving. Data dropouts
116				Y	0.66	0.00	6.4	0.43	0.49	Contact	
117	Static		High								
118	Static										

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
147	S1d	16	High	Y	0.58	0.61	16.0	1.09	0.44	NC	
148				Y	0.46	0.02	16.3	1.05	0.33	NC	
149				Y	0.27	0.00	1.8	0.51	0.08	Contact	
150				Y	0.17	0.00	0.3	0.14		Contact	No AEB
151				Y	0.47	0.23	16.0	1.02	0.36	NC	
155	S1d	20	High	Y		0.00	0.0	0.00		Contact	No warning, No AEB
156				Y	0.16	0.00	0.9	0.28	0.03	Contact	
157				Y	0.39	0.00	8.4	1.03	0.27	Contact	
161	S1d	40	High	Y		0.00	0.5	0.00		Contact	No warning, no AEB
162				Y		0.00	0.6	0.02		Contact	No warning, no AEB
163				Y		0.00	0.3	0.02		Contact	No warning, no AEB
164	Static		High								
125	S1e	40	High	Y	0.38	0.00	6.8	0.87	0.22	Contact	
126				Y	0.63	0.00	18.8	1.04	0.50	Contact	
127				Y	1.02	0.73	39.5	1.17	0.75	NC	
128				Y	0.81	0.03	39.8	1.10	0.68	NC	
129				Y	0.94	0.49	40.5	1.15	0.77	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	S1e	45	High	Y	0.94	0.00	35.1	1.13	0.72	Contact	
131				Y	0.82	0.00	28.6	1.06	0.65	Contact	
132				N							PTM lateral error
133				Y	0.86	0.00	31.2	1.06	0.69	Contact	
7	S4a	16	High	Y	1.43	1.67	15.8	1.07	0.73	NC	
8				Y	1.38	1.72	15.9	1.10	0.77	NC	
9				Y	1.50	1.88	16.1	1.09	0.77	NC	
10				Y	1.34	1.76	15.5	1.08	0.74	NC	
11				Y	1.35	1.71	16.8	1.10	0.73	NC	
22	S4a	35	High	Y	1.26	1.59	34.9	1.04	0.77	NC	
23				N							SV lateral error
24				Y		0.00	0.2	0.01		Contact	No warning, no AEB
25				Y		0.00	0.4	0.06		Contact	No warning, no AEB
62				Y	1.32	2.13	35.0	1.13	0.94	NC	
63				Y	1.41	1.92	35.0	1.07	0.84	NC	
64	Static										
12	S4a	40	High	N							SV speed
13				Y		0.00	0.5	0.03		Contact	No warning, no AEB
14				Y		0.00	0.2	0.00		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
31	S4c	16	High	Y	1.43	0.69	16.7	1.11	0.49	NC	
32				Y	0.88	0.86	15.3	1.11	0.55	NC	
33				Y	1.26	1.33	16.9	1.08	0.71	NC	
34				Y	1.31	0.00	3.7	0.48	0.09	Contact	
35				Y	1.34	1.81	16.1	1.10	0.85	NC	
40	S4c	40	High	N							SV lateral error
41				N							SV lateral error, SV speed
42				N							SV speed
43				Y	1.49	3.48	39.7	1.15	0.96	NC	
44				Y		0.00	0.8	0.02		Contact	No warning, no AEB
45				N							SV speed
46				Y	1.61	3.53	40.0	1.13	1.01	NC	
47				Y	1.60	3.48	39.7	1.19	1.02	NC	
48				Y		0.00	0.0	0.02		Contact	No warning, no AEB
49	S4c	45	High	Y		0.00	0.6	0.03		Contact	No warning, no AEB
50				Y		0.00	-0.2	0.00		Contact	No warning, no AEB
51				Y	0.81	0.11	44.8	1.14	0.65	NC	
52				N							Leg not working
53				Y	0.91	0.00	0.0	0.01		Contact	No AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
65	Static										
66	S1b	16	Low	Y	1.17	1.25	16.0	1.09	0.64	NC	
67				Y	1.21	1.39	15.9	1.12	0.67	NC	
68				Y	1.15	1.48	16.2	1.08	0.68	NC	
69				Y	1.27	1.52	15.7	1.14	0.71	NC	
70				N							PTM error
71				Y	1.22	1.45	16.3	1.13	0.65	NC	
78	S1b	20	Low	Y	1.24	2.08	19.9	1.12	0.79	NC	
79				Y	1.21	1.68	19.6	1.12	0.67	NC	
80				Y	1.05	1.92	20.2	1.13	0.75	NC	
81				Y	1.18	2.13	20.0	1.09	0.77	NC	
82				Y	1.25	1.71	20.3	1.10	0.71	NC	
89	S1b	30	Low	Y	1.05	0.95	30.2	1.14	0.66	NC	
90				Y	1.21	1.86	29.6	1.14	0.77	NC	
91				Y	1.23	1.83	30.1	1.14	0.77	NC	
92				Y	1.15	1.61	29.9	1.08	0.85	NC	
93				Y	1.32	2.07	29.9	1.19	0.82	NC	
99	S1b	40	Low	Y	1.13	1.30	40.4	1.19	0.81	NC	
100				Y	1.16	1.51	40.5	1.16	0.84	NC	
101				Y	1.14	1.59	40.5	1.16	0.84	NC	
102				Y	0.70	0.00	25.2	1.08	0.59	Contact	
103				Y	0.72	0.00	26.1	1.04	0.60	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
110	S1b	45	Low	Y	0.88	0.00	24.9	1.06	0.60	Contact	
111				Y	0.51	0.00	11.7	1.07	0.36	Contact	
112				Y	0.42	0.00	7.4	1.01	0.26	Contact	
141	S1d	16	Low	Y	0.47	0.25	15.8	1.12	0.37	NC	
142				Y	0.52	0.41	16.2	1.10	0.41	NC	
143				N							PTM lateral error
144				Y	0.41	0.05	16.3	1.09	0.32	NC	
145				Y	0.49	0.21	16.0	1.01	0.36	NC	
146				Y	0.55	0.52	16.0	1.10	0.43	NC	
152	S1d	20	Low	Y	0.23	0.00	1.5	0.49	0.08	Contact	
153				Y	0.18	0.00	1.1	0.41	0.07	Contact	
154				Y	0.45	0.00	11.4	1.03	0.31	Contact	
	S1d	40	Low	Y	0.29	0.00	3.4	0.68	0.16	Contact	
159				Y		0.00	0.2	0.03		Contact	No warning, no AEB
160				Y	0.04	0.00	-0.2	0.02		Contact	No AEB
134	S1e	35	Low	Y	0.95	0.96	34.9	1.15	0.72	NC	
135				N							PTM lateral error
136				Y	0.61	0.00	17.1	1.05	0.45	Contact	
137				Y	0.70	0.00	23.7	1.05	0.52	Contact	
138				Y	0.95	0.19	33.9	1.03	0.65	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
139	Static										
140	Static										
119	Static										
120	S1e	40	Low	N							PTM cleared before zero headway
121				Y	0.61	0.00	17.1	1.07	0.48	Contact	
122				Y	0.96	0.49	40.5	1.12	0.73	NC	
123				N							PTM lateral error
124				Y	0.73	0.00	23.5	1.09	0.56	Contact	
1	Static										
2	S4a	16	Low	Y	1.40	1.91	15.4	1.19	0.77	NC	
3				Y	1.35	2.02	15.3	1.14	0.84	NC	
4				Y	1.45	1.90	15.9	1.15	0.79	NC	
5				Y	1.40	1.66	15.3	1.13	0.74	NC	
6				Y	1.46	1.97	15.4	1.10	0.82	NC	
19	S4a	35	Low	Y		0.00	0.5	0.02		Contact	No warning, no AEB
20				Y		0.00	-0.4	0.01		Contact	No warning, no AEB
21				Y	0.62	0.00	18.2	1.05	0.47	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
15	S4a	40	Low	N							SV speed
16				N							SV lateral error
17				Y		0.00	-0.1	0.06		Contact	No warning, no AEB
18				N							SV speed
26	S4c	16	Low	Y	1.25	0.19	16.3	1.09	0.30	NC	
27				Y	1.67	1.63	16.5	1.09	0.91	NC	
28				Y	1.40	2.06	15.9	1.13	0.97	NC	
29				Y	1.51	0.86	16.1	1.11	0.56	NC	
30				Y	1.59	1.74	16.3	1.11	0.87	NC	
54	S4c	35	Low	N							Lat error
55				N							Lat error
56				Y		0.00	0.3	0.04		Contact	No warning, no AEB
57	Static										
58	S4c	35	Low	Y	0.87	1.64	35.3	1.07	0.73	NC	
59				Y	1.09	2.88	35.4	1.06	0.90	NC	
60				Y		0.00	0.8	0.05		Contact	No warning, no AEB
61				Y		0.00	0.6	0.01		Contact	No warning, no AEB, alert occurred after impact

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
36	S4c	40	Low	Y		0.00	0.2	0.05		Contact	No warning, no AEB
37				Y		0.00	0.1	0.03		Contact	No warning, no AEB, warning occurred after contact
38				N							SV lateral error
39				Y		0.00	0.2	0.00		Contact	No warning, no AEB

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.

  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.

  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 tolerance for SV speed is ±1.0 km/h (required until the FCW alert is given). Note that there is no tolerance for PTM speed because PTM motion validity is a function of SV longitudinal position.

- 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 -0.15 g, which is used as the threshold to indicate PAEB braking. When the SV's Ax crosses this threshold, this indicates the moment of first PAEB system 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 an audible FCW alert is provided.

Envelopes and Thresholds

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

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

Color Codes

Color codes have been adopted to easily identify which data correspond to which vehicle, as well as to indicate the types of envelopes and thresholds used in the plots.

Color codes can be broken into four categories:

1. Time-varying data color codes:

   - Blue = SV data
   - Magenta = PTM data
   - Brown = Relative data between SV and PTM (i.e., headway distance)

2. Validation envelope and threshold color codes:

   - Green envelope = time varying data must be within the envelope at all times in order to be valid
   - Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds

3. Individual data point color codes:

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

4. Text color codes:

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

Other Notations

- Contact – Indicates that contact was made between the SV and PTM.
- ENV – Indicates that the value for that variable was outside of its specified validity envelope.
- NG – Indicates that the value for that variable was outside of bounds and therefore “No Good”.
- No Wng – No warning was detected.
- PTM – Indicates that the value for the Pedestrian Test Mannequin was out of bounds.
- SV – Indicates that the value for the Subject Vehicle was out of bounds.
- SR – Shows the speed reduction value.
- Thr – Indicates that the requirements for the throttle were not met.

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

Examples of time history plots for each test type (including passing, failing and invalid runs) are shown in Figures D1 through Figure D5. Figures D1 and D2 show typical passing and failing runs. Figures D3 through D5 show examples of invalid runs. Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure D6.

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

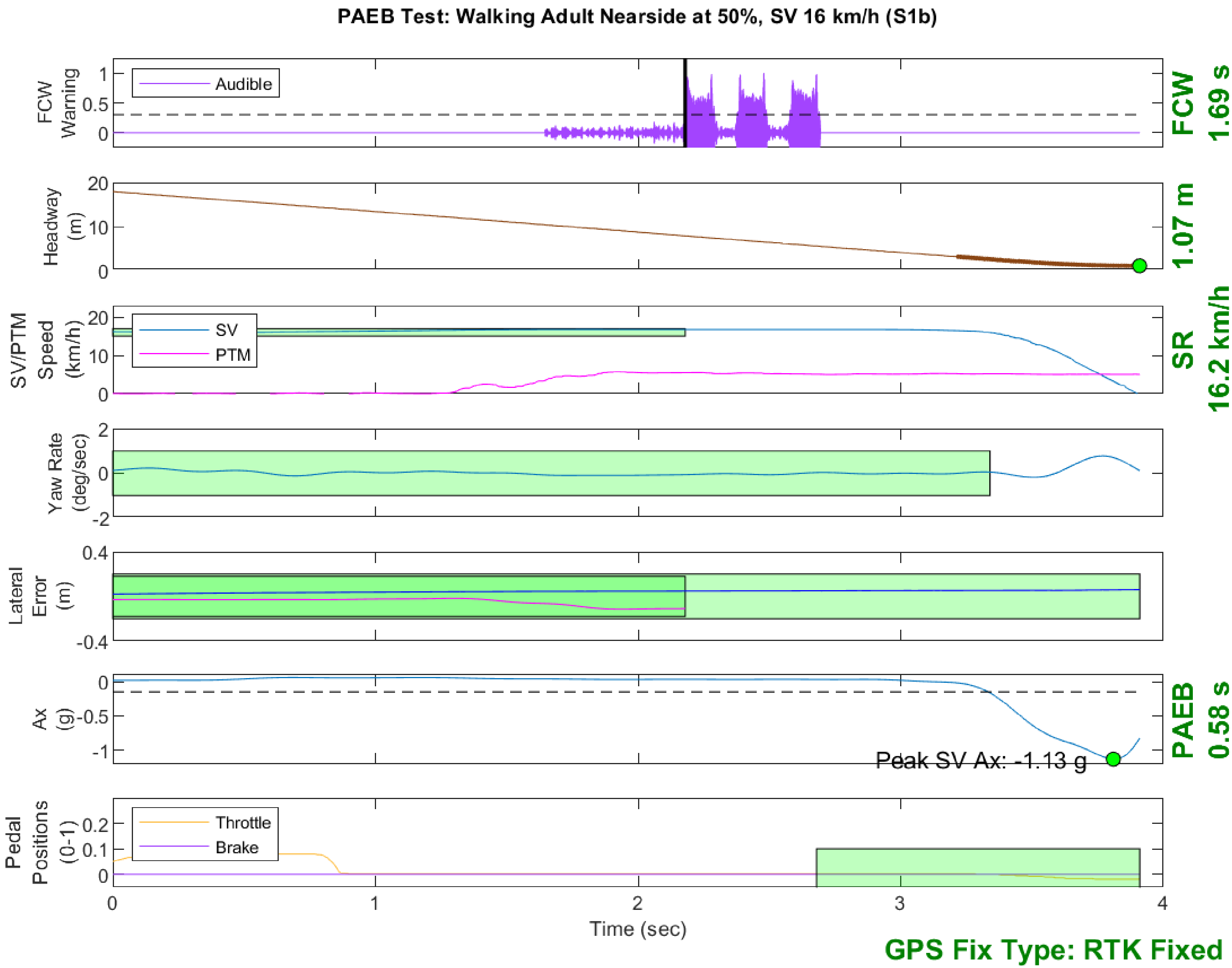


Figure D1. Example Time History for a Passing Run

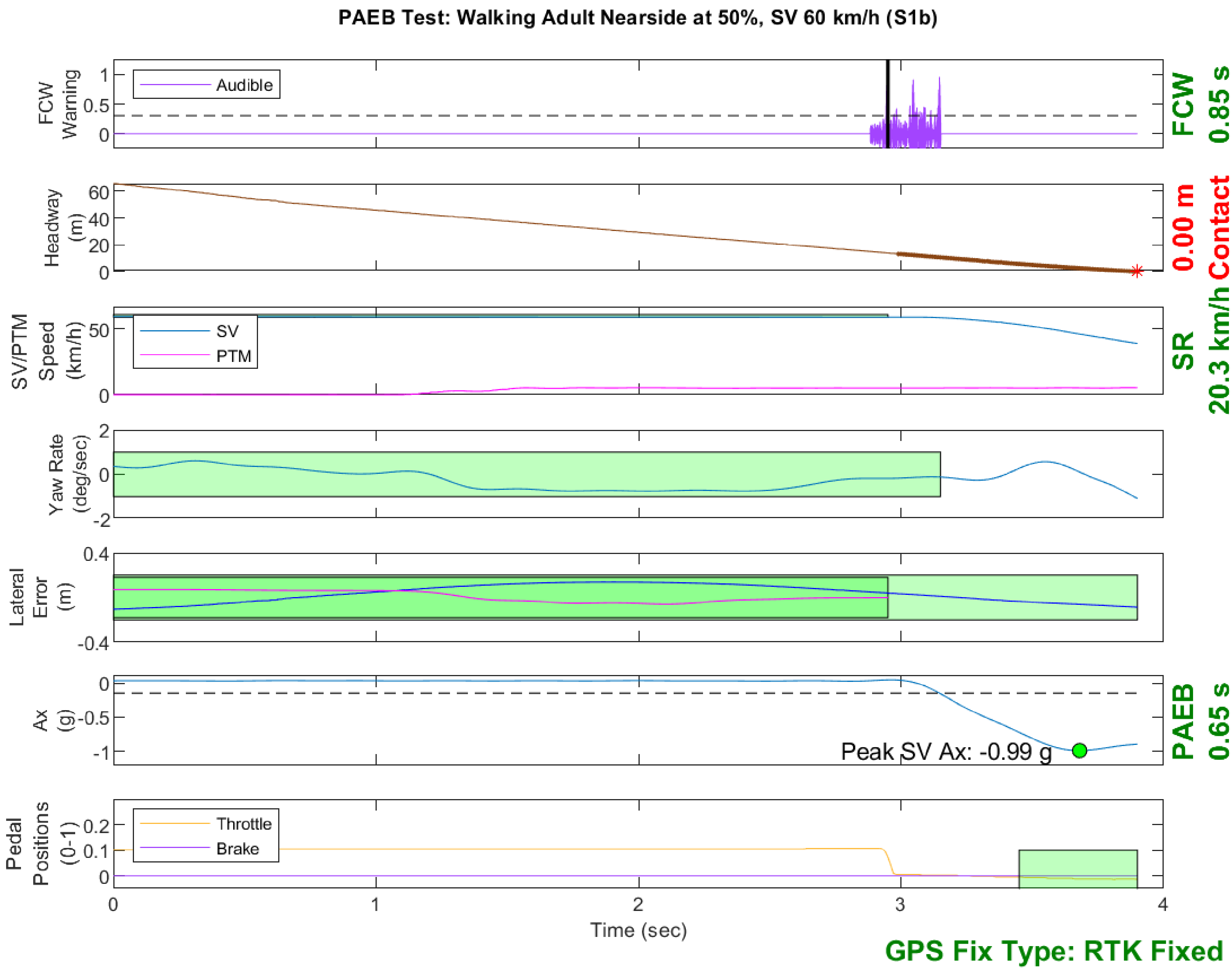


Figure D2. Example Time History for a Failed Run

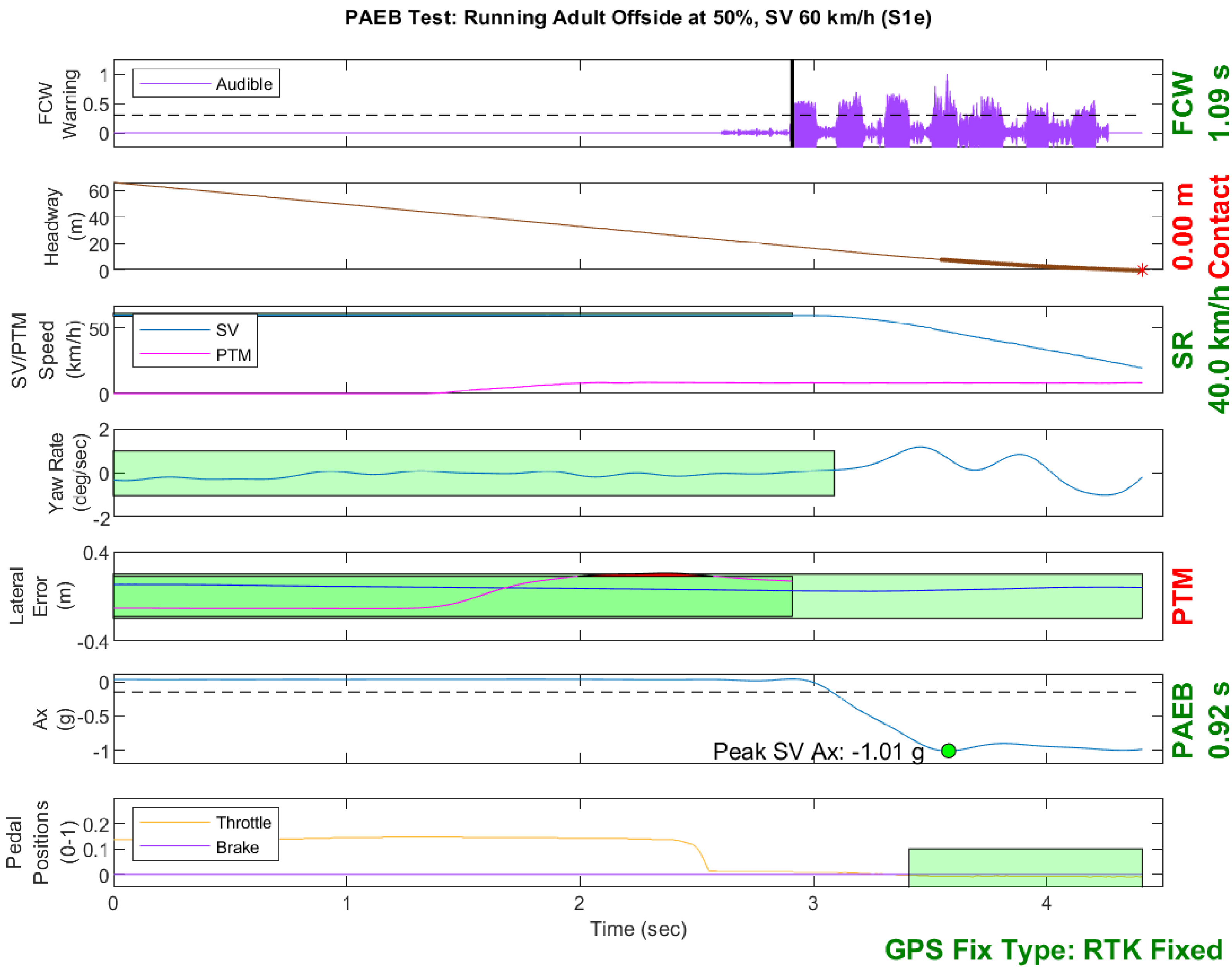


Figure D3. Example Time History for an Invalid Run Due to PTM Lateral Error

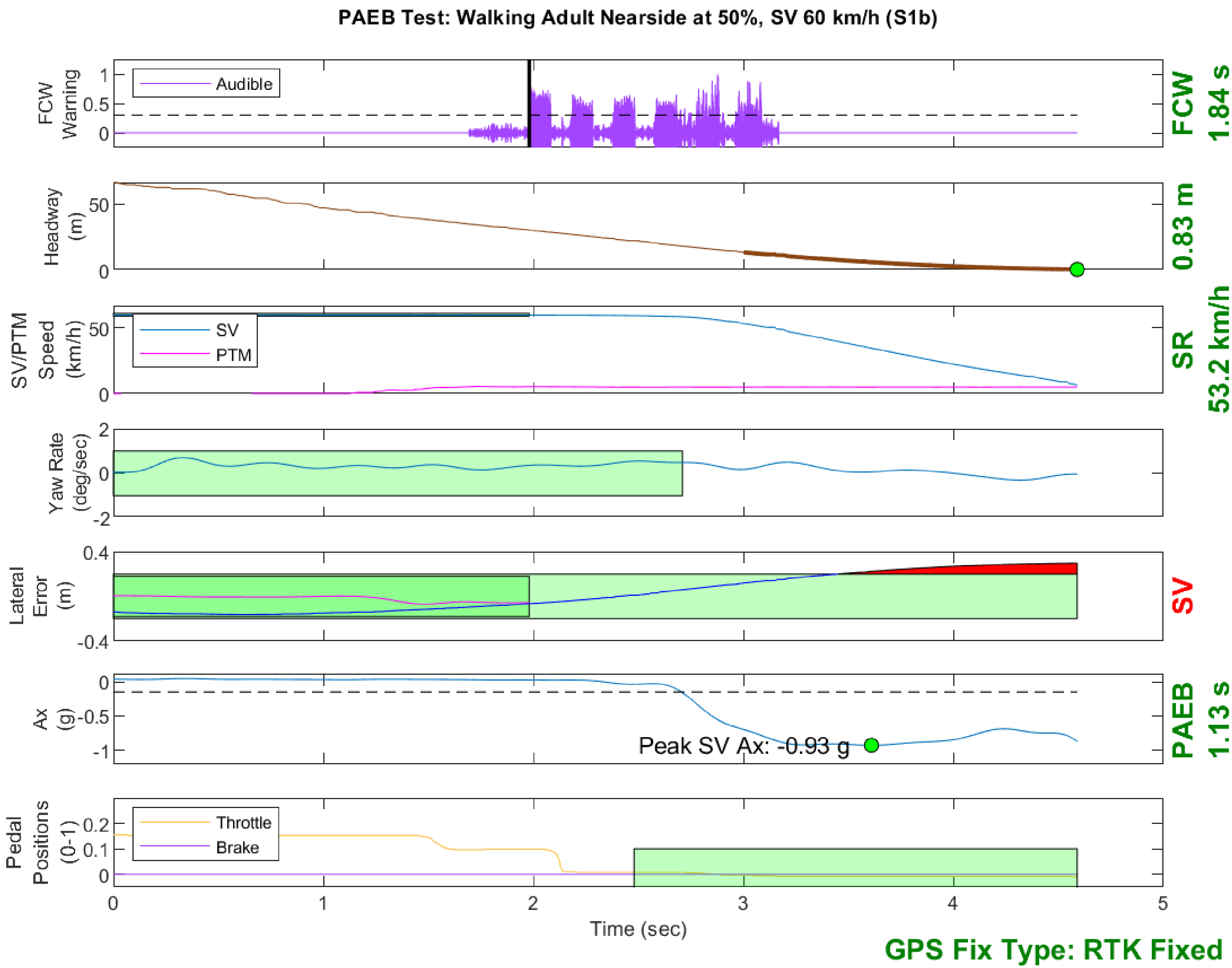


Figure D4. Example Time History for an Invalid Run Due to SV Lateral Error

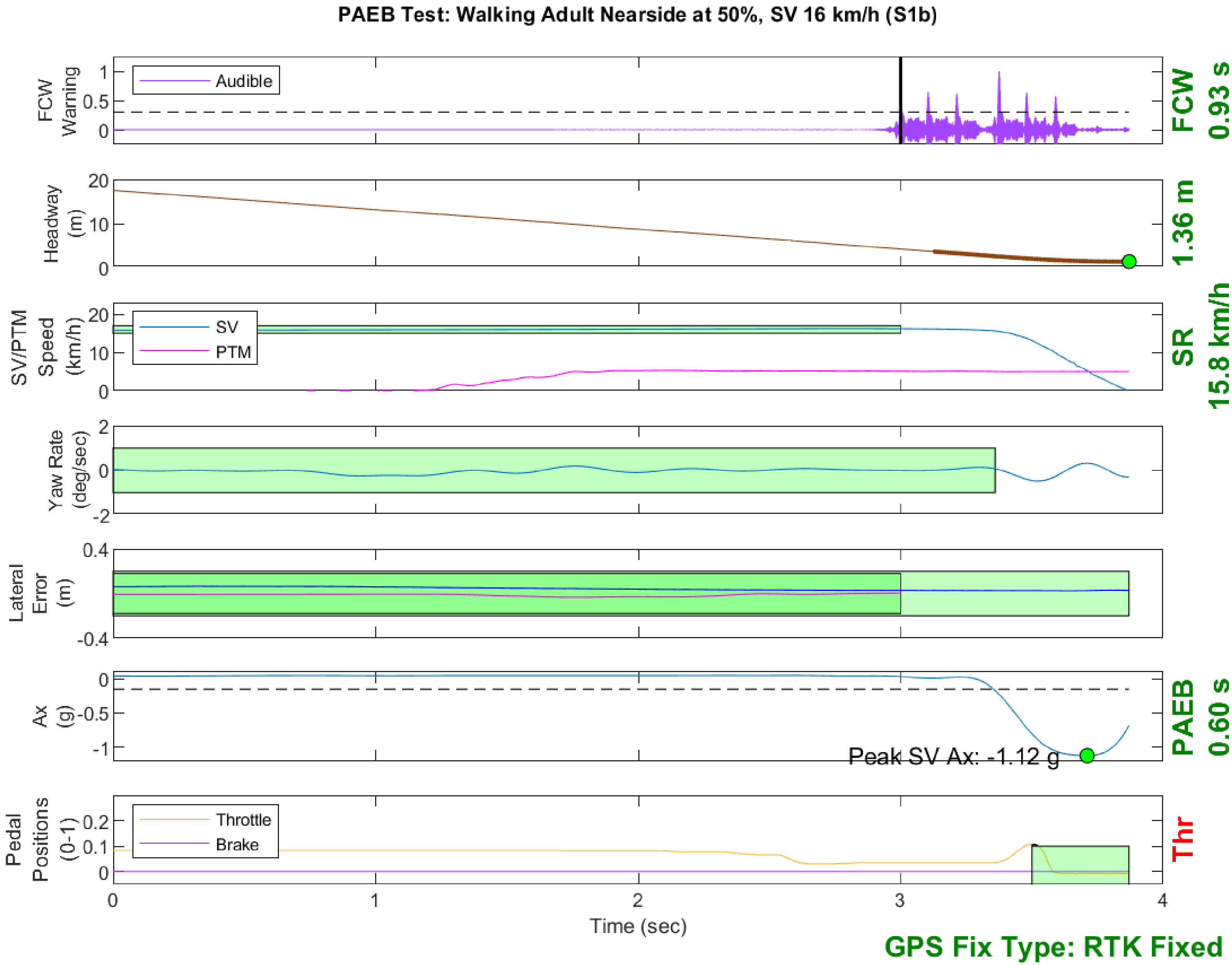


Figure D5. Example Time History for an Invalid Run Due to Throttle Error

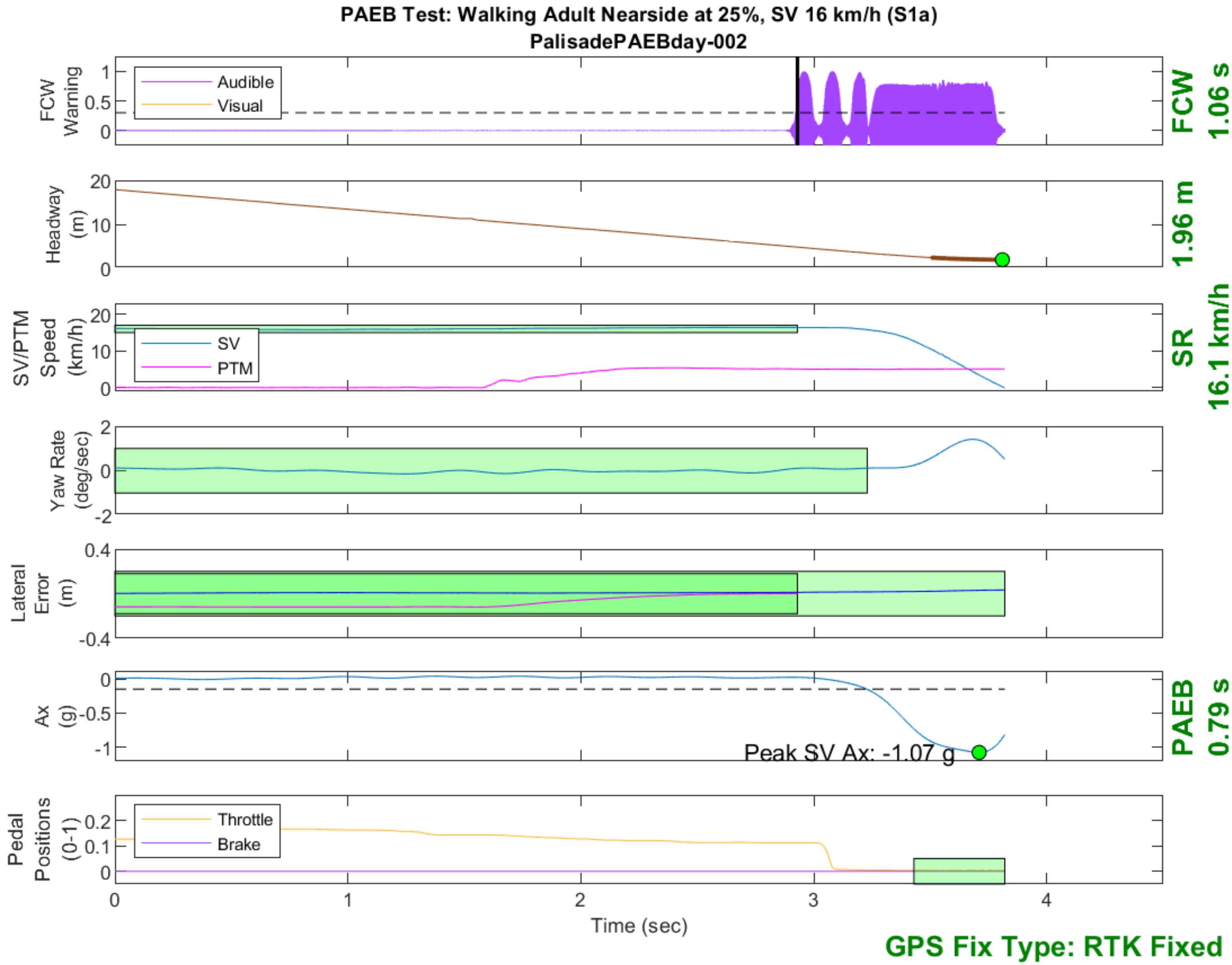


Figure D6. Time History for PAEB Run 2, S1a, Daytime, 16 km/h

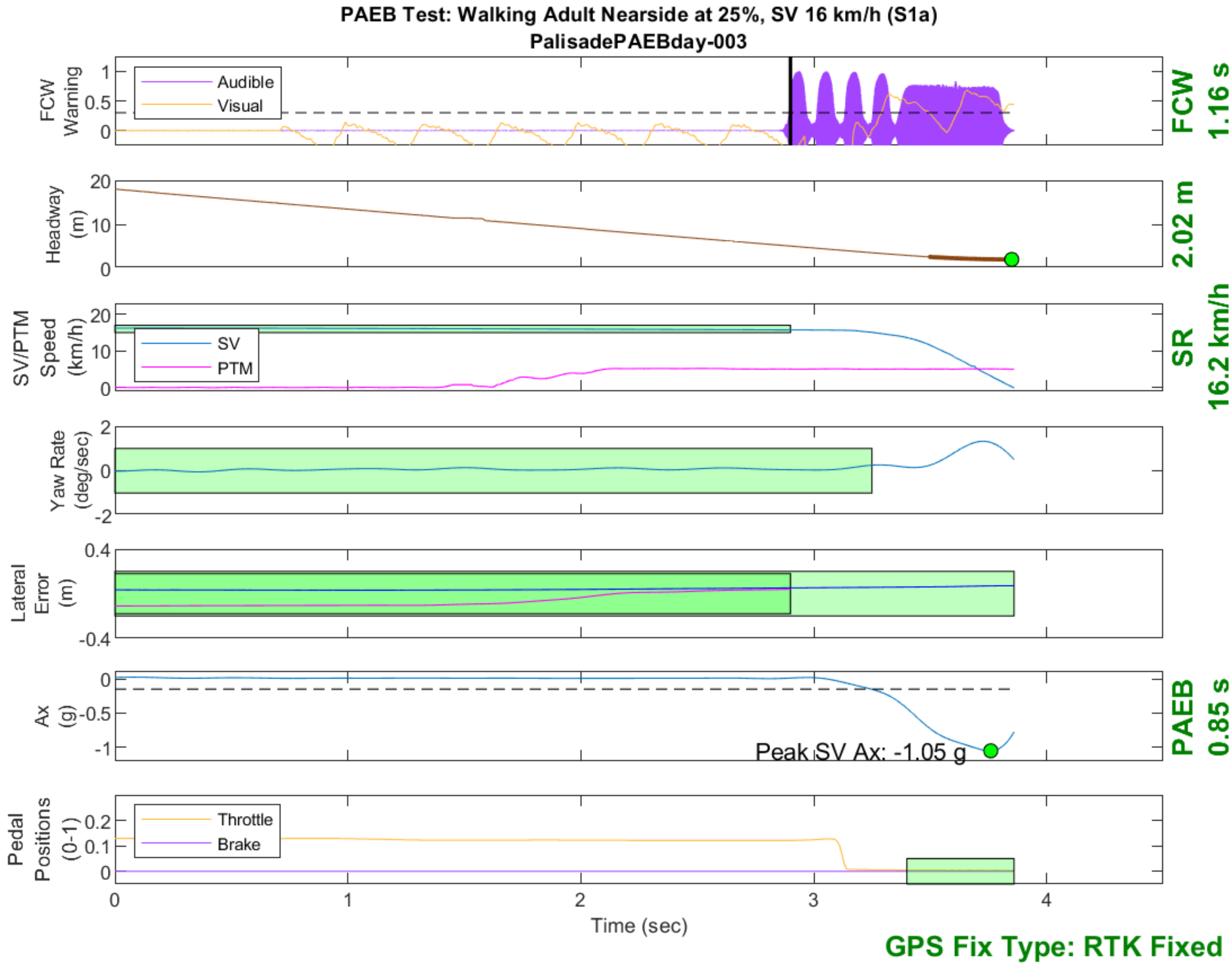


Figure D7. Time History for PAEB Run 3, S1a, Daytime, 16 km/h

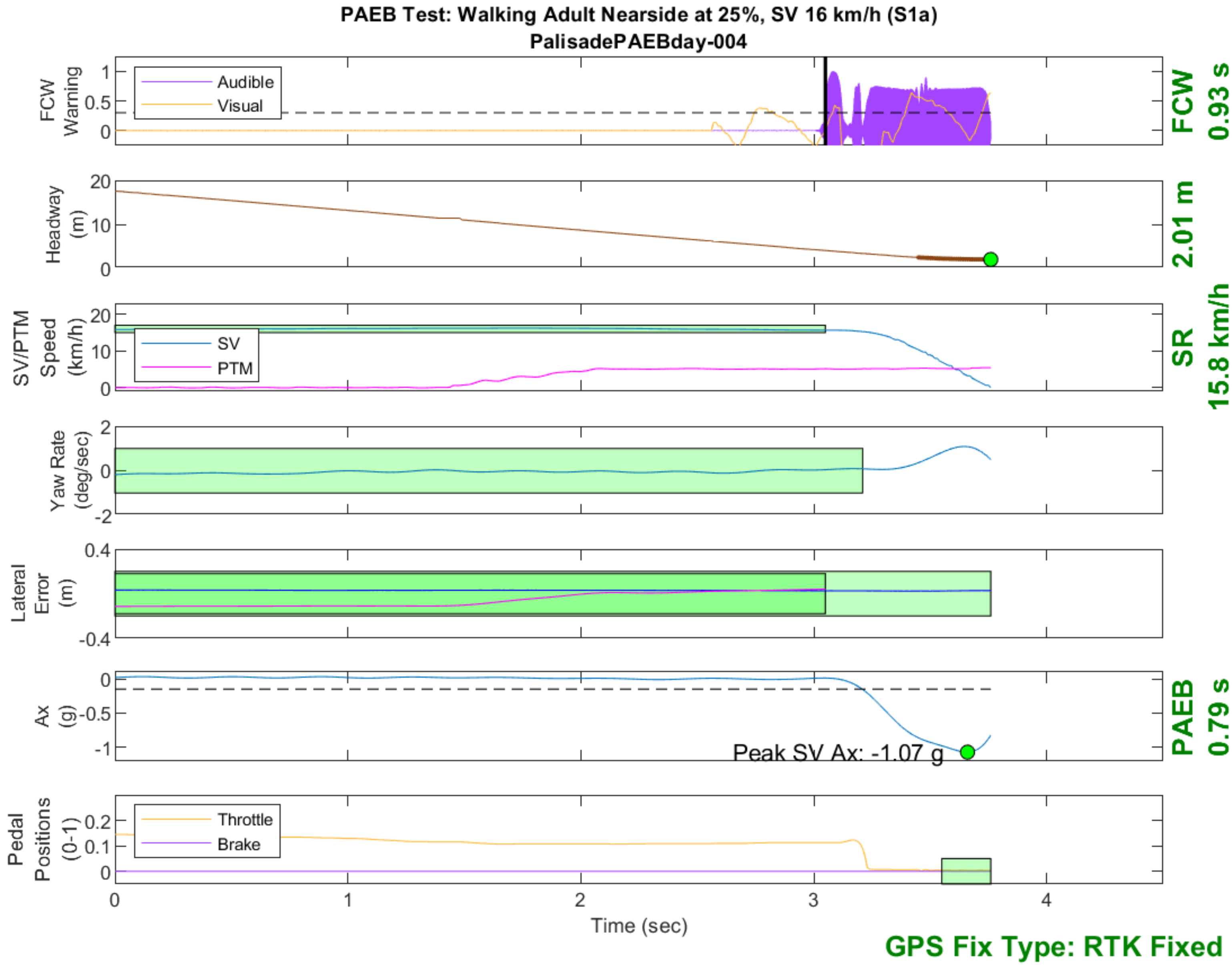


Figure D8. Time History for PAEB Run 4, S1a, Daytime, 16 km/h

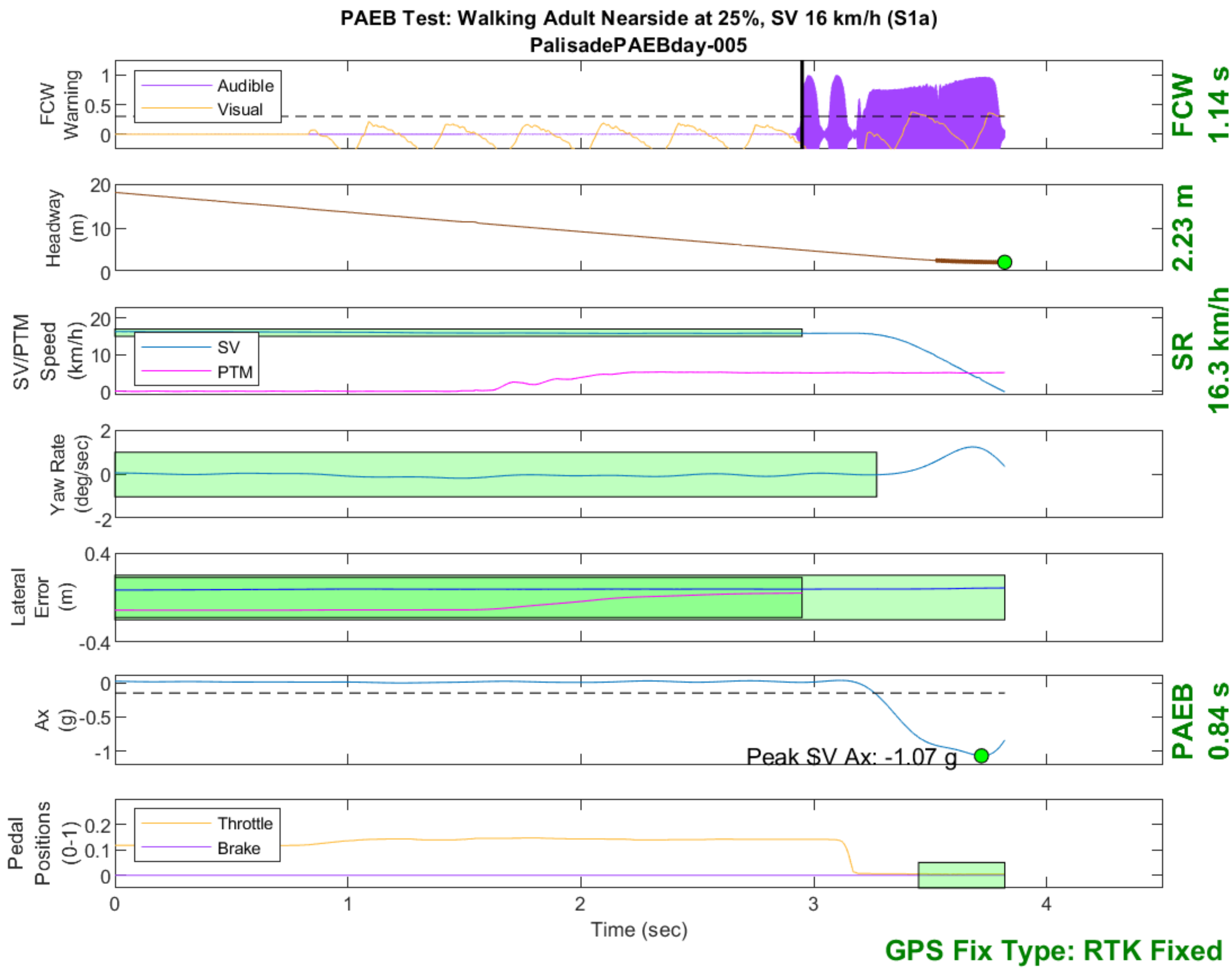


Figure D9. Time History for PAEB Run 5, S1a, Daytime, 16 km/h

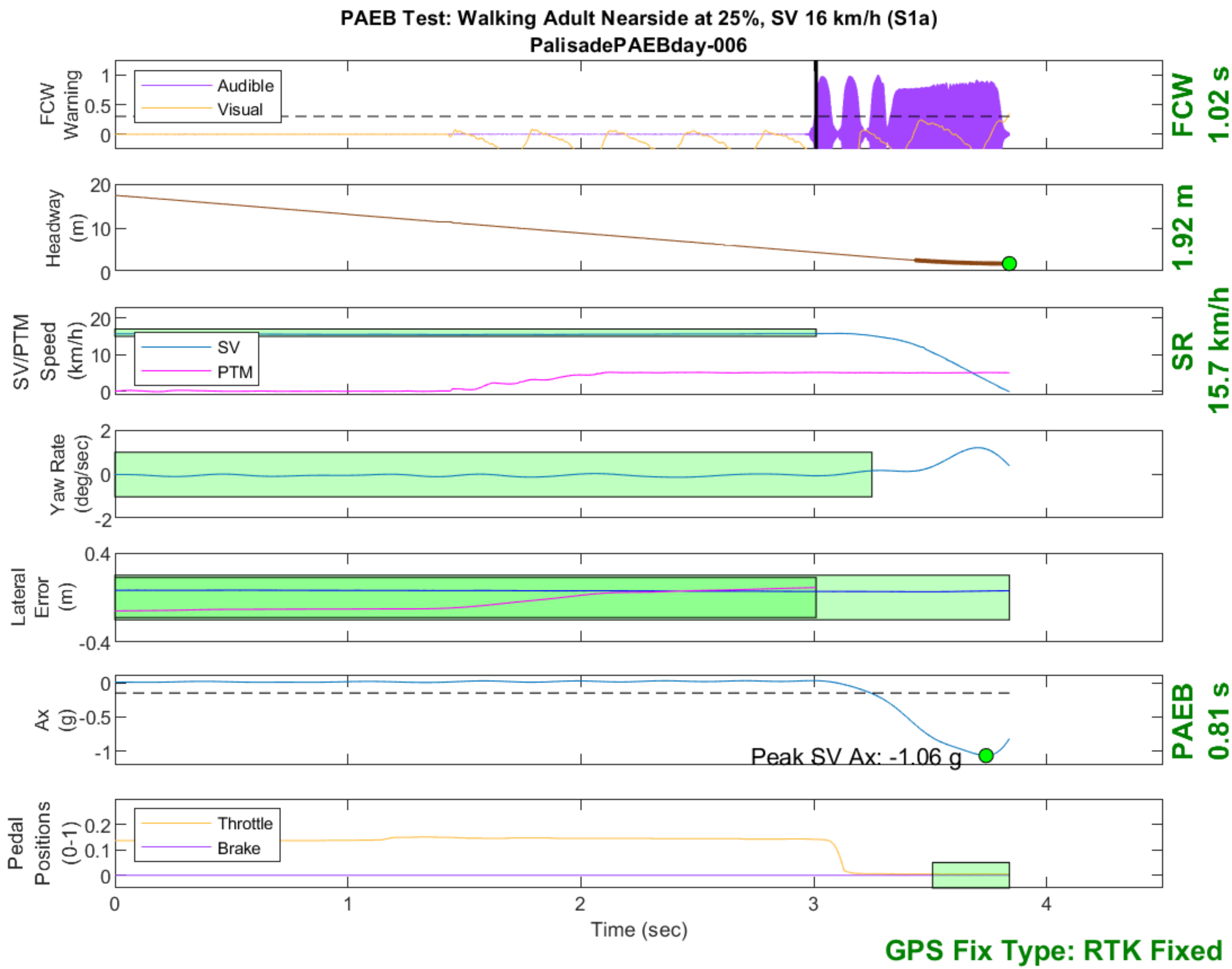


Figure D10. Time History for PAEB Run 6, S1a, Daytime, 16 km/h

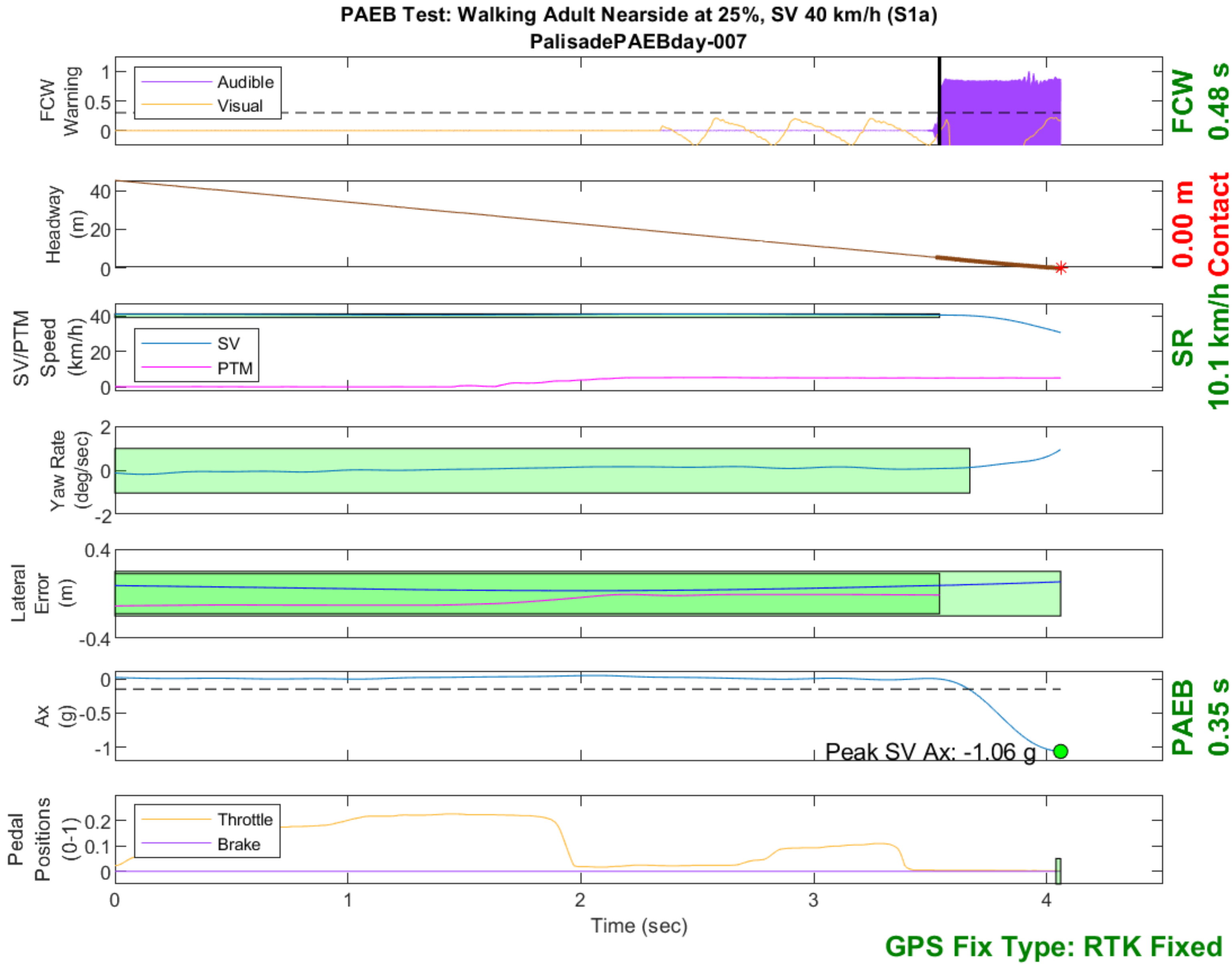


Figure D11. Time History for PAEB Run 7, S1a, Daytime, 40 km/h

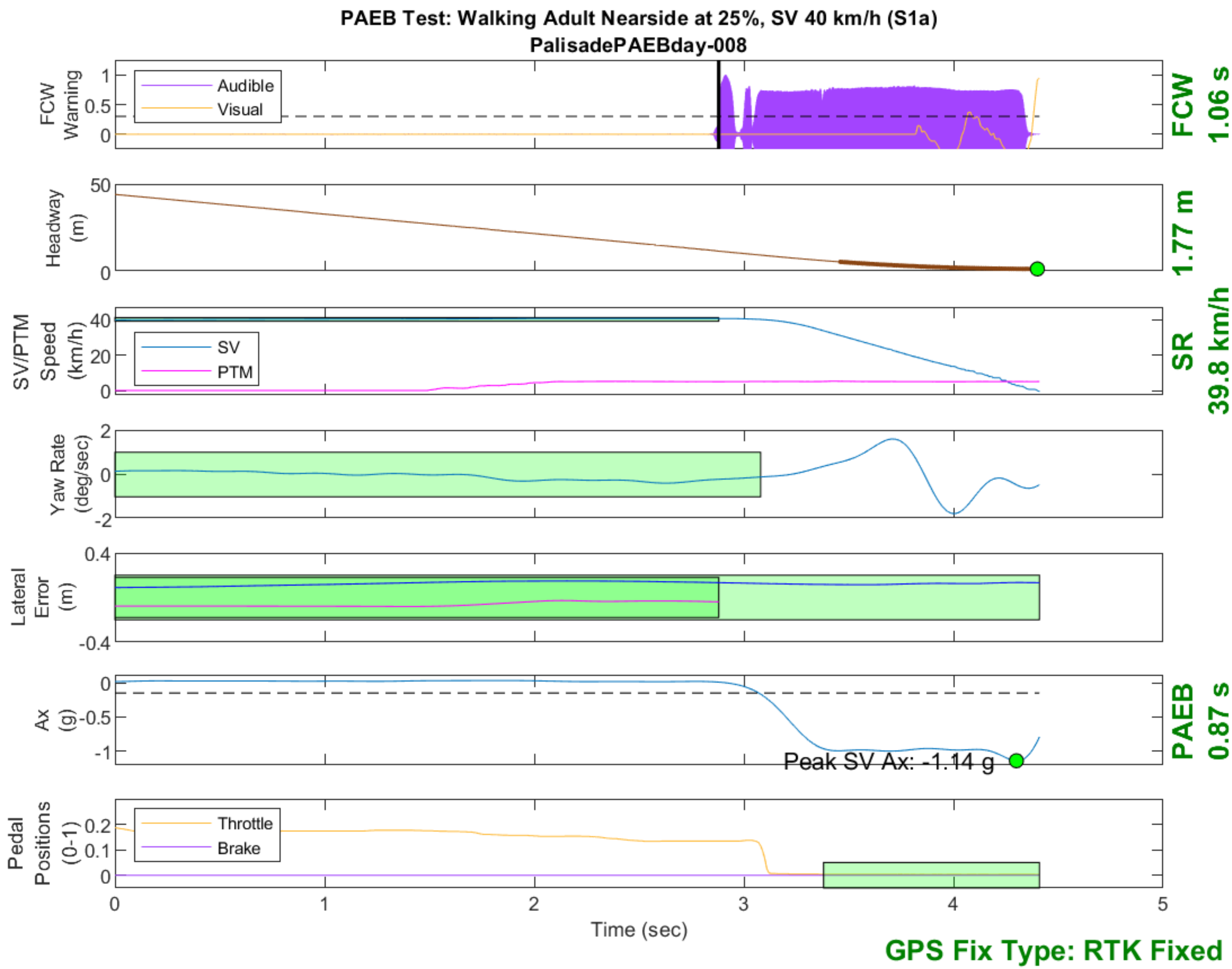


Figure D12. Time History for PAEB Run 8, S1a, Daytime, 40 km/h

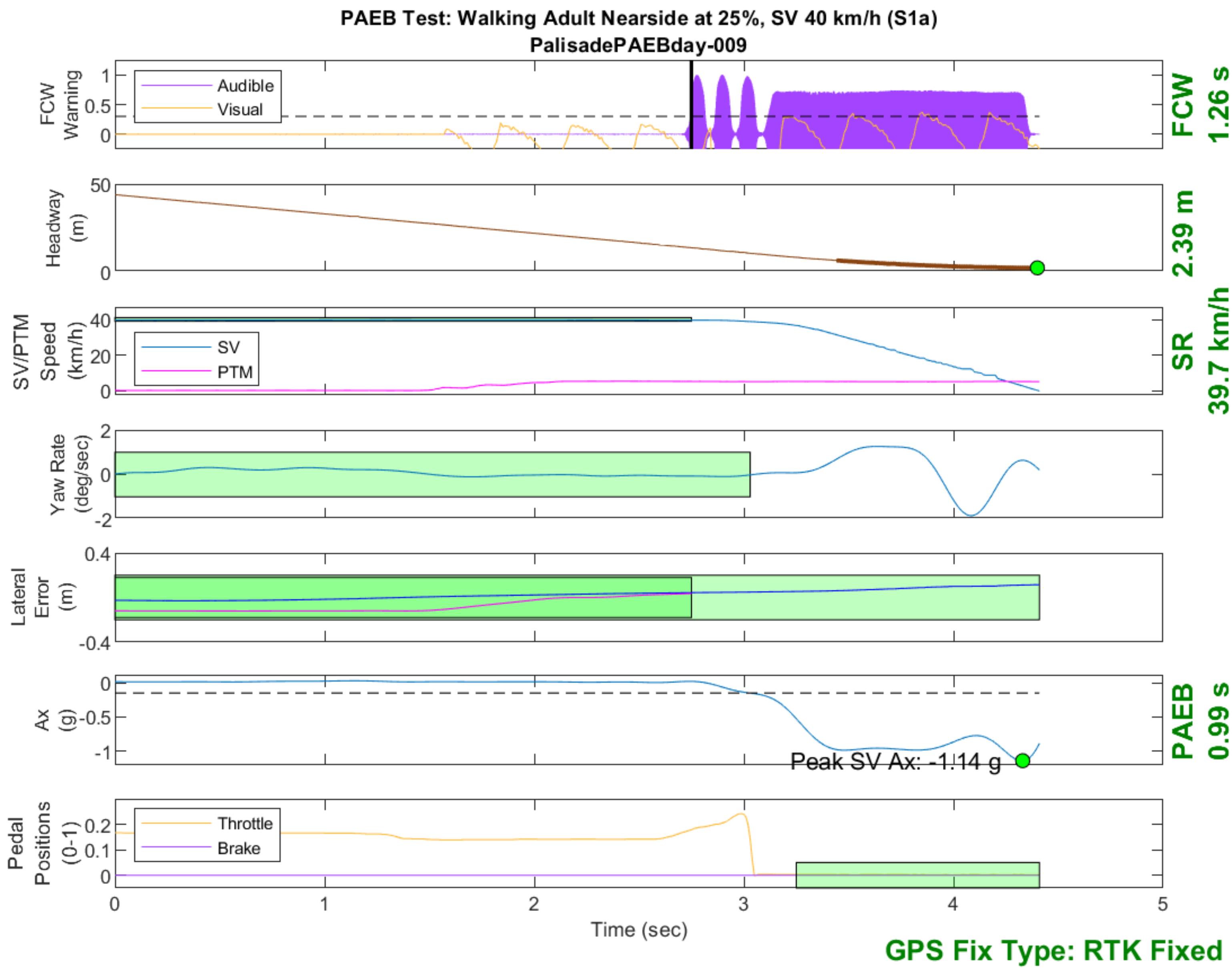


Figure D13. Time History for PAEB Run 9, S1a, Daytime, 40 km/h

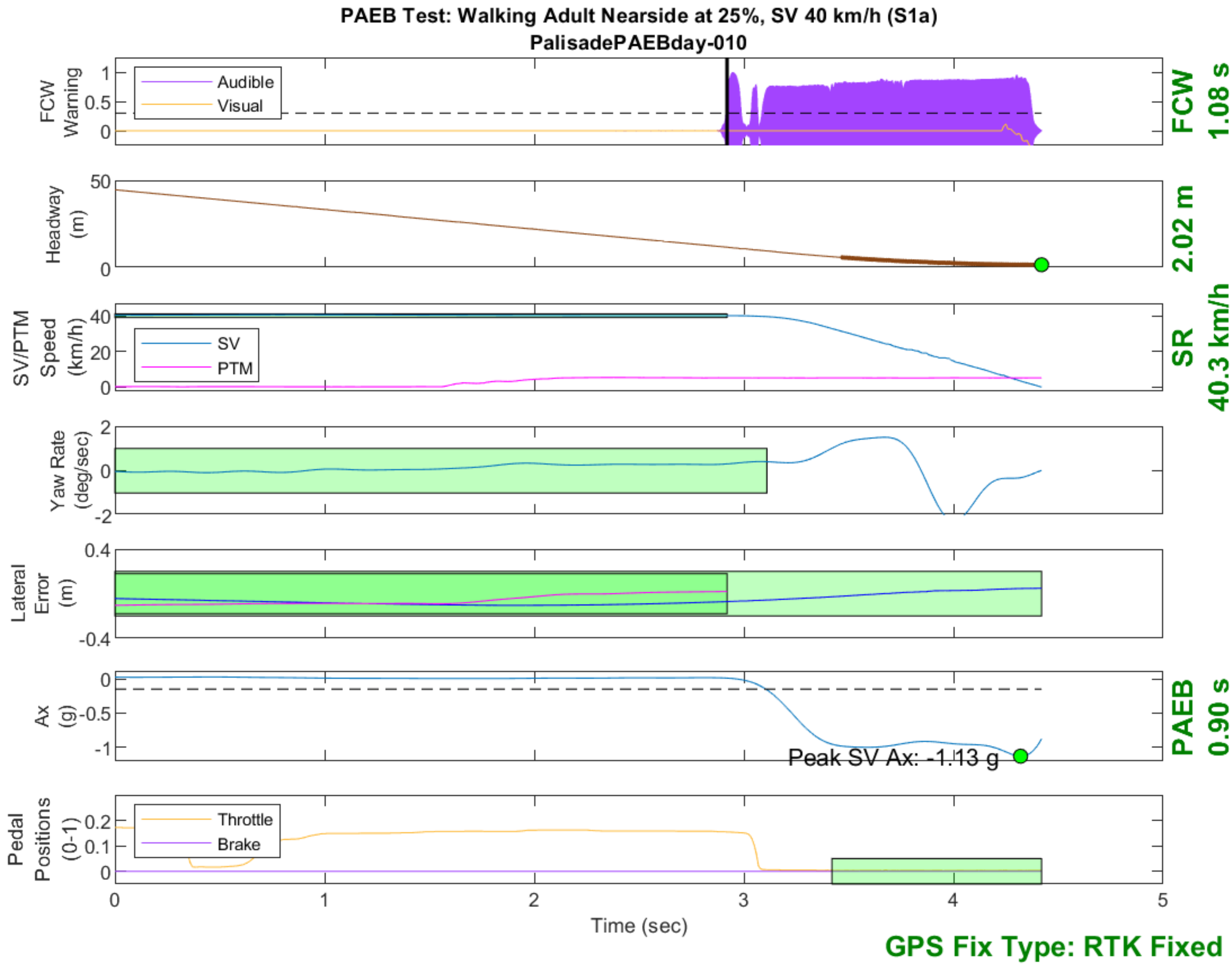


Figure D14. Time History for PAEB Run 10, S1a, Daytime, 40 km/h

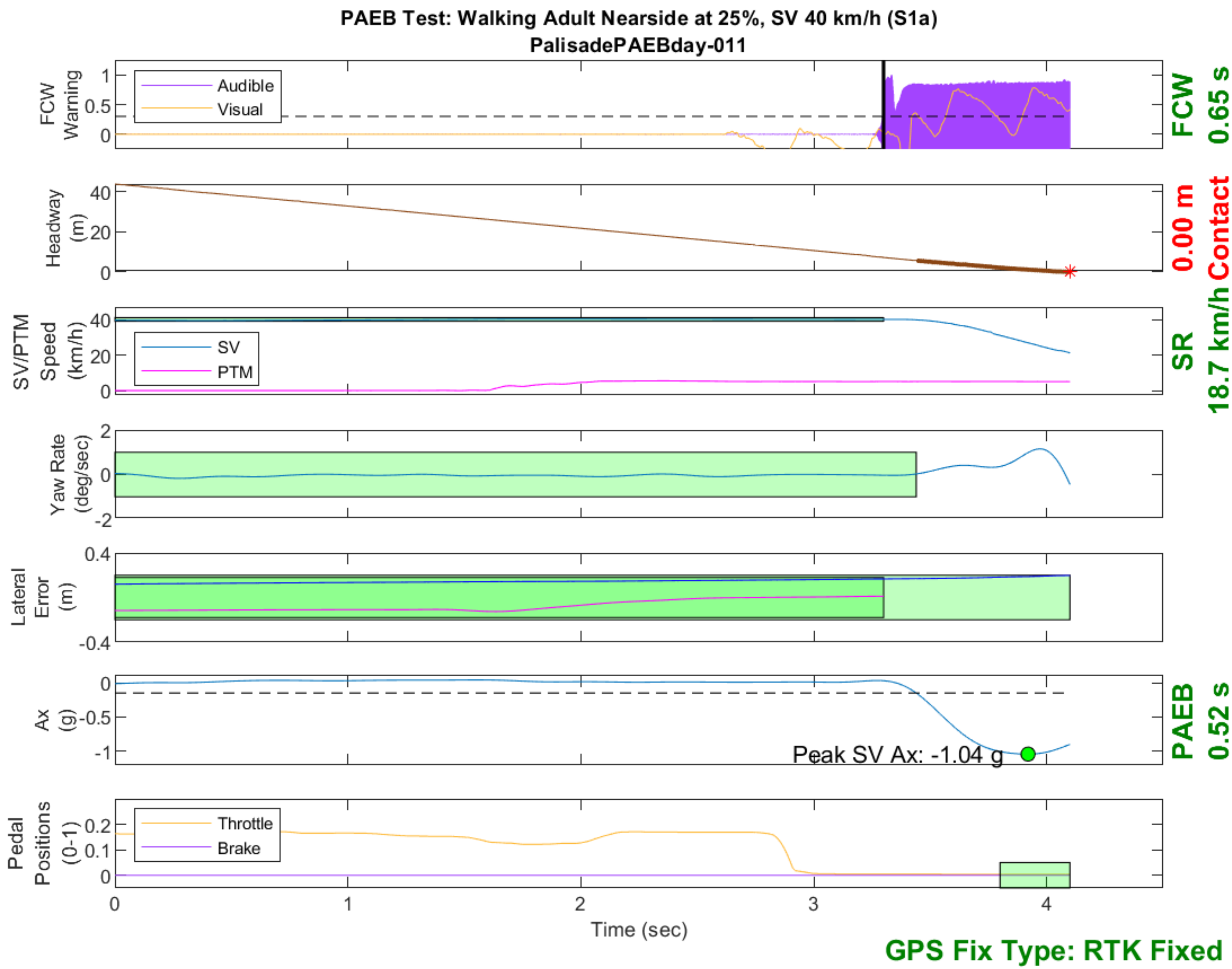


Figure D15. Time History for PAEB Run 11, S1a, Daytime, 40 km/h

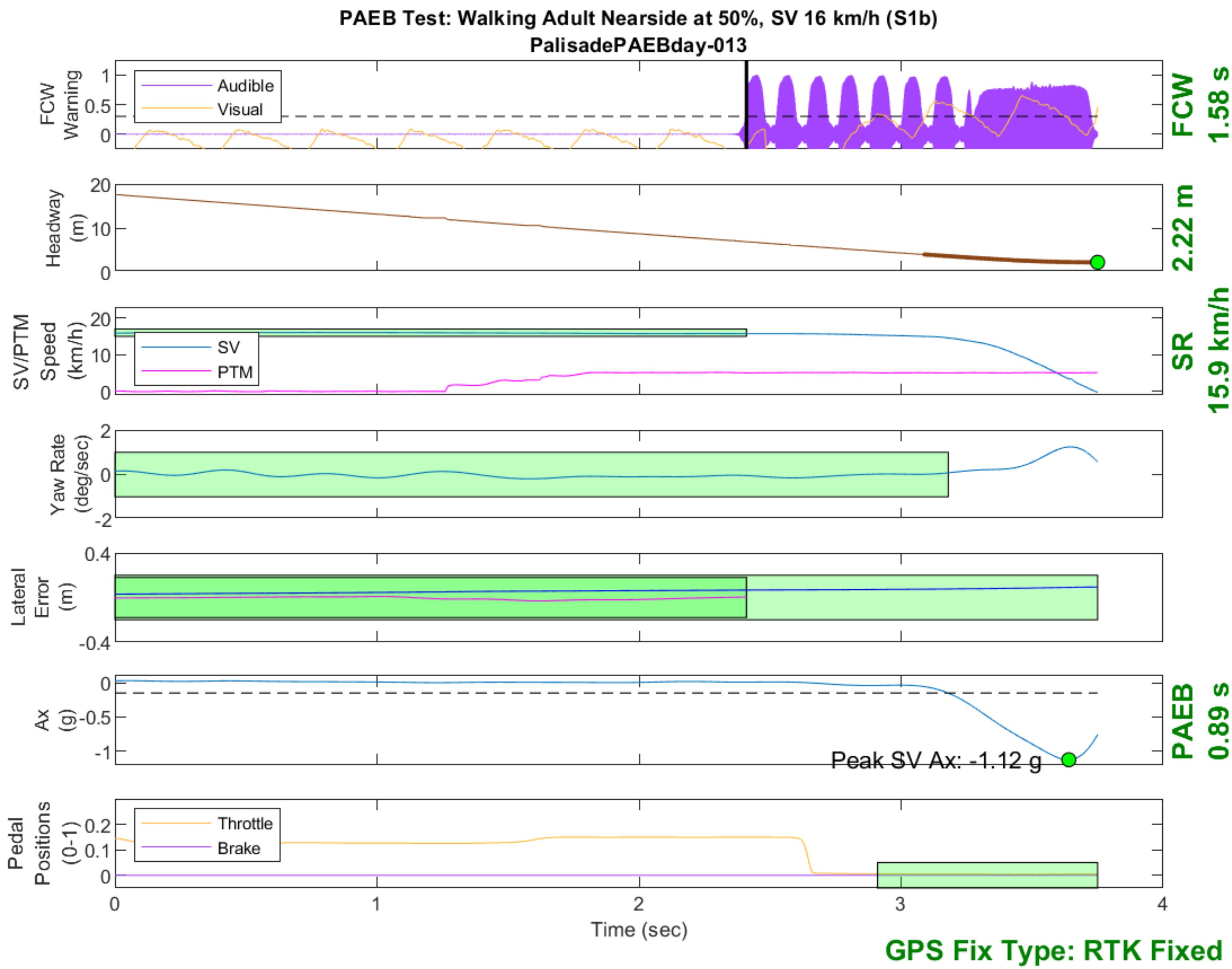


Figure D16. Time History for PAEB Run 13, S1b, Daytime, 16 km/h

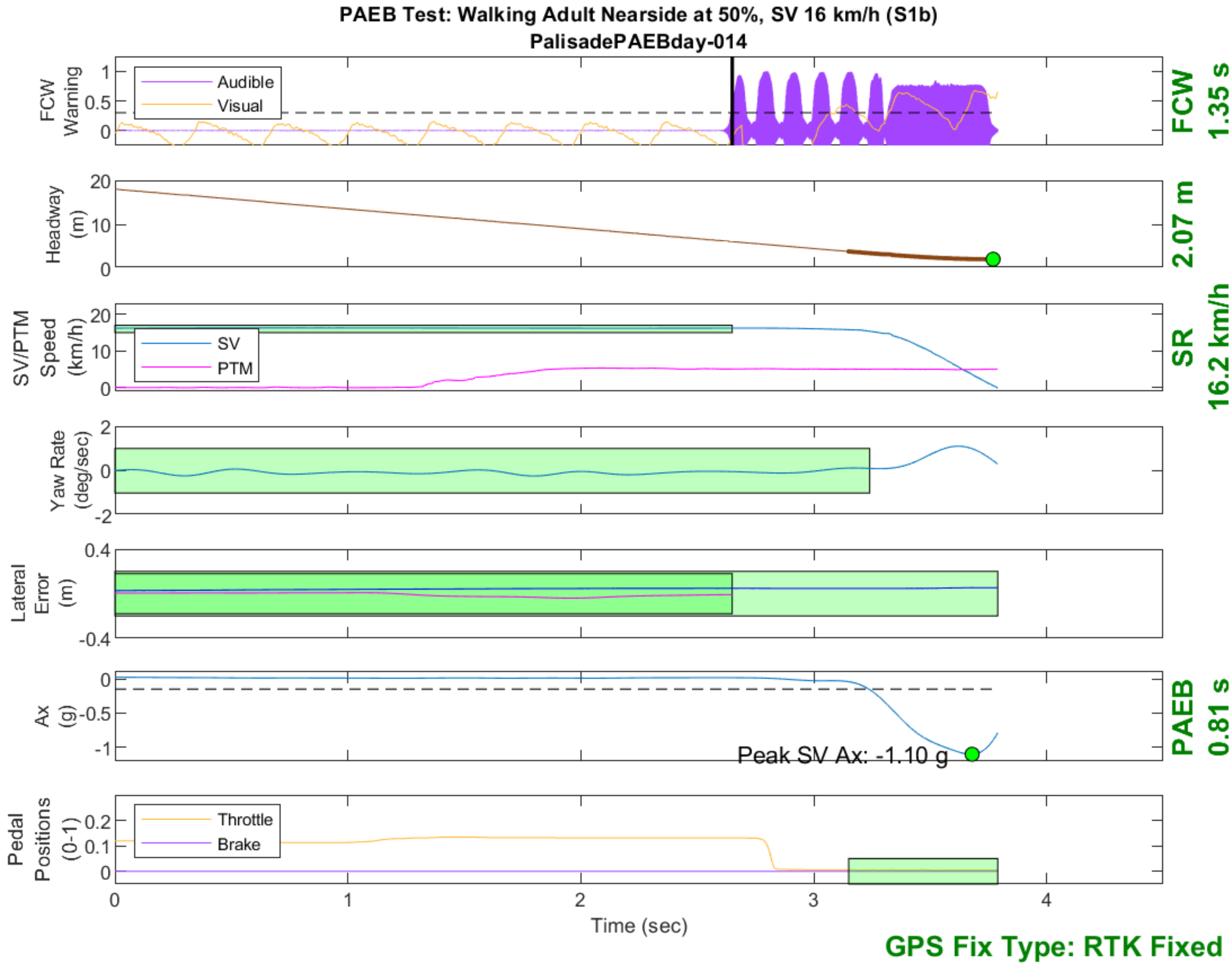


Figure D17. Time History for PAEB Run 14, S1b, Daytime, 16 km/h

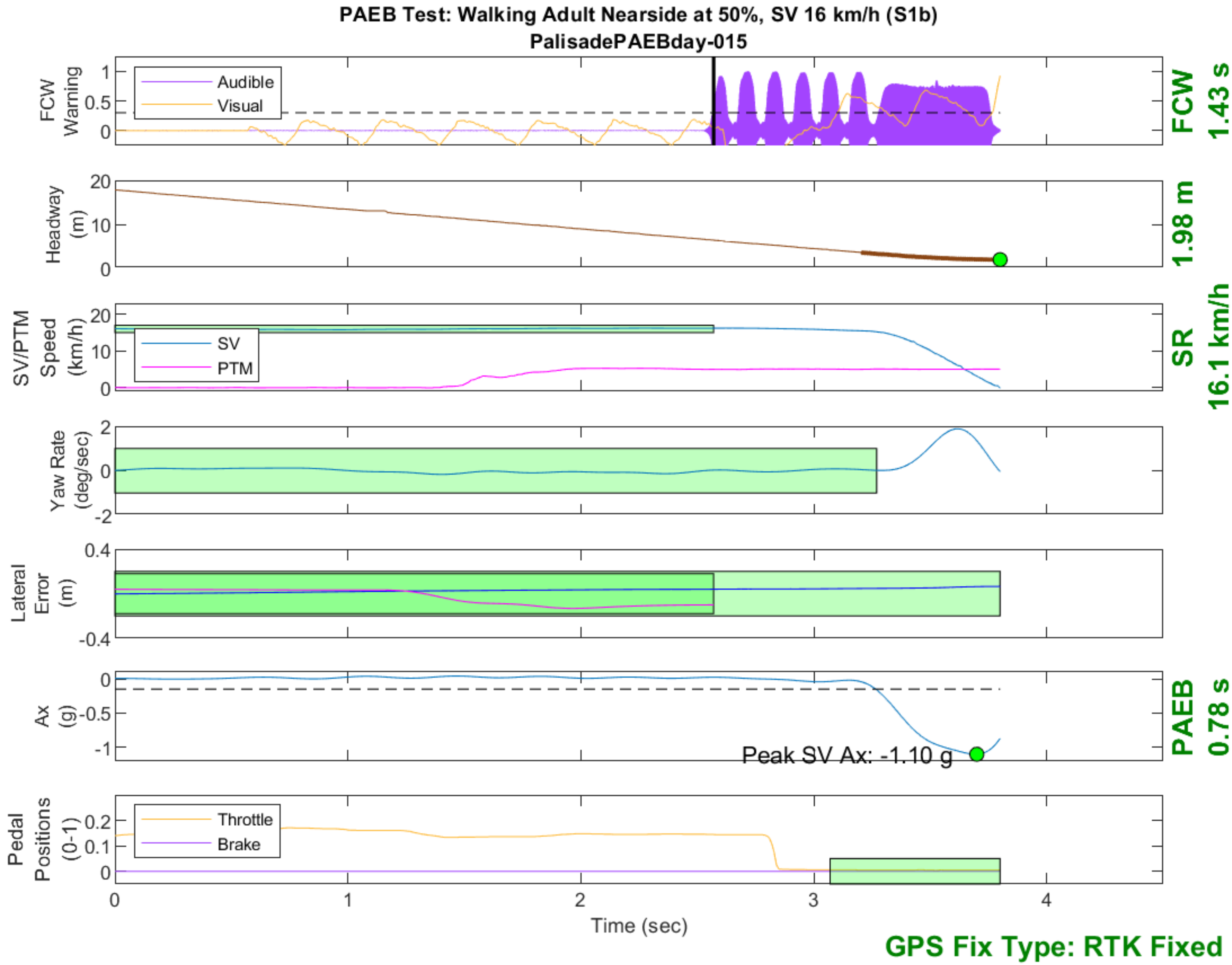


Figure D18. Time History for PAEB Run 15, S1b, Daytime, 16 km/h

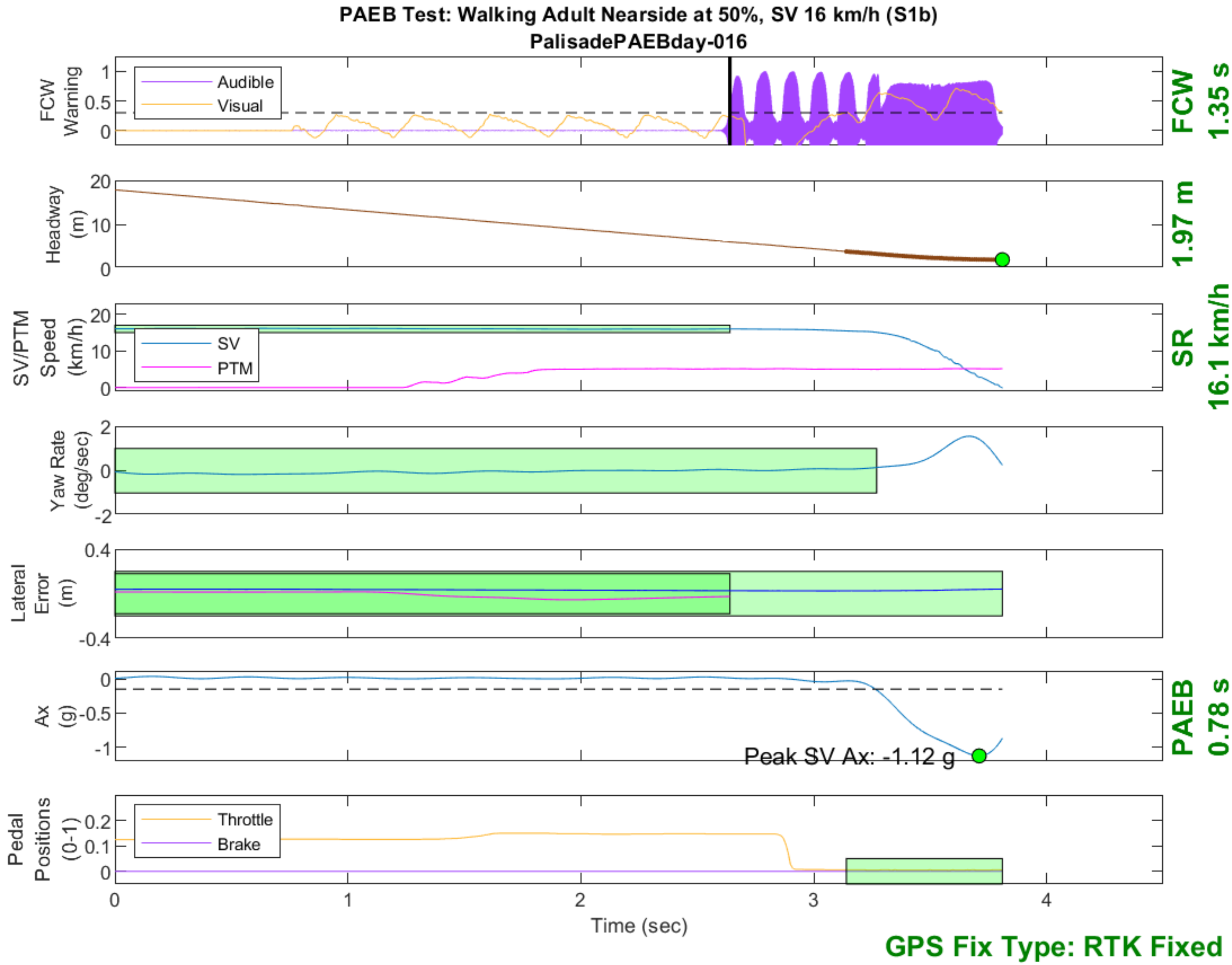


Figure D19. Time History for PAEB Run 16, S1b, Daytime, 16 km/h

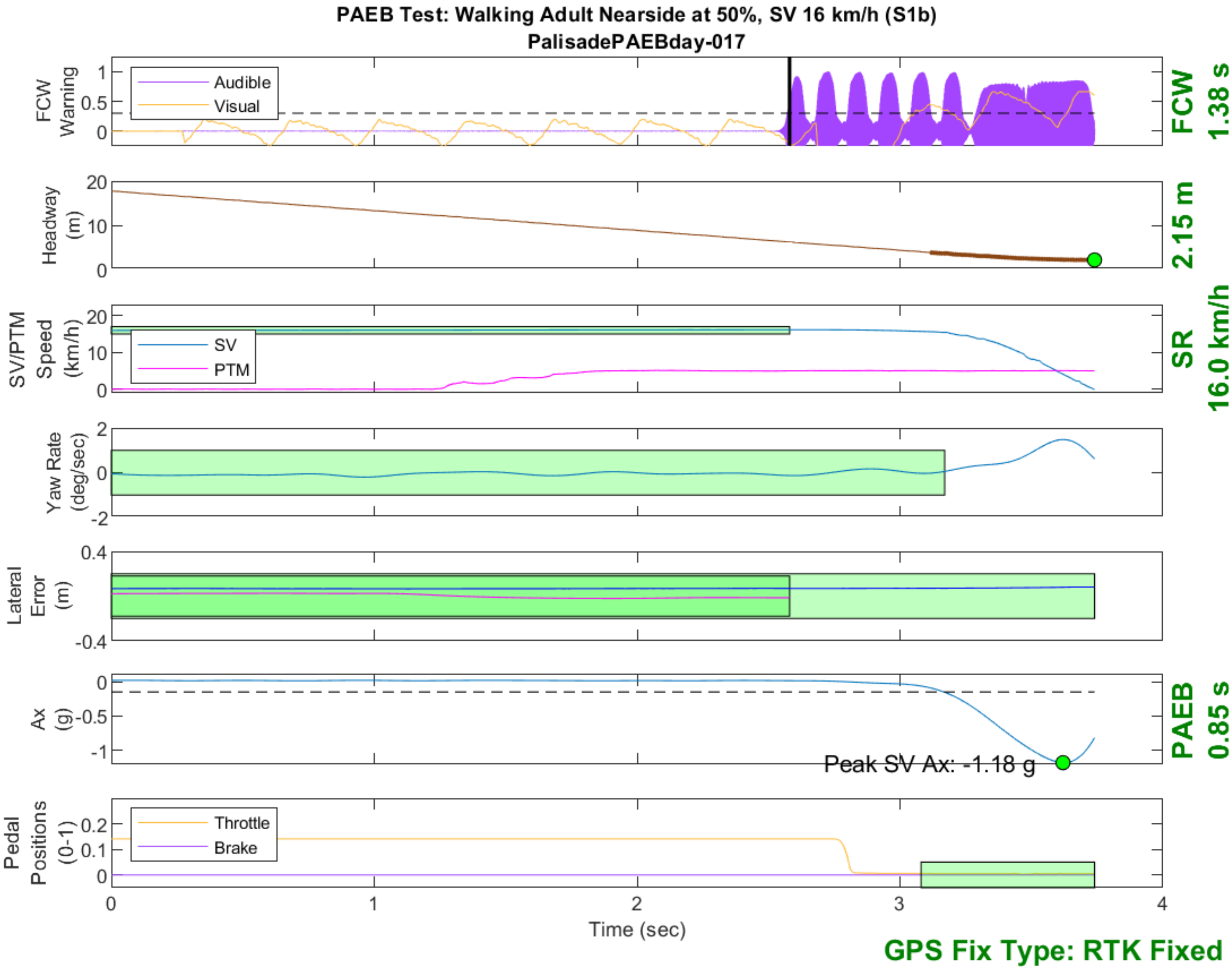


Figure D20. Time History for PAEB Run 17, S1b, Daytime, 16 km/h

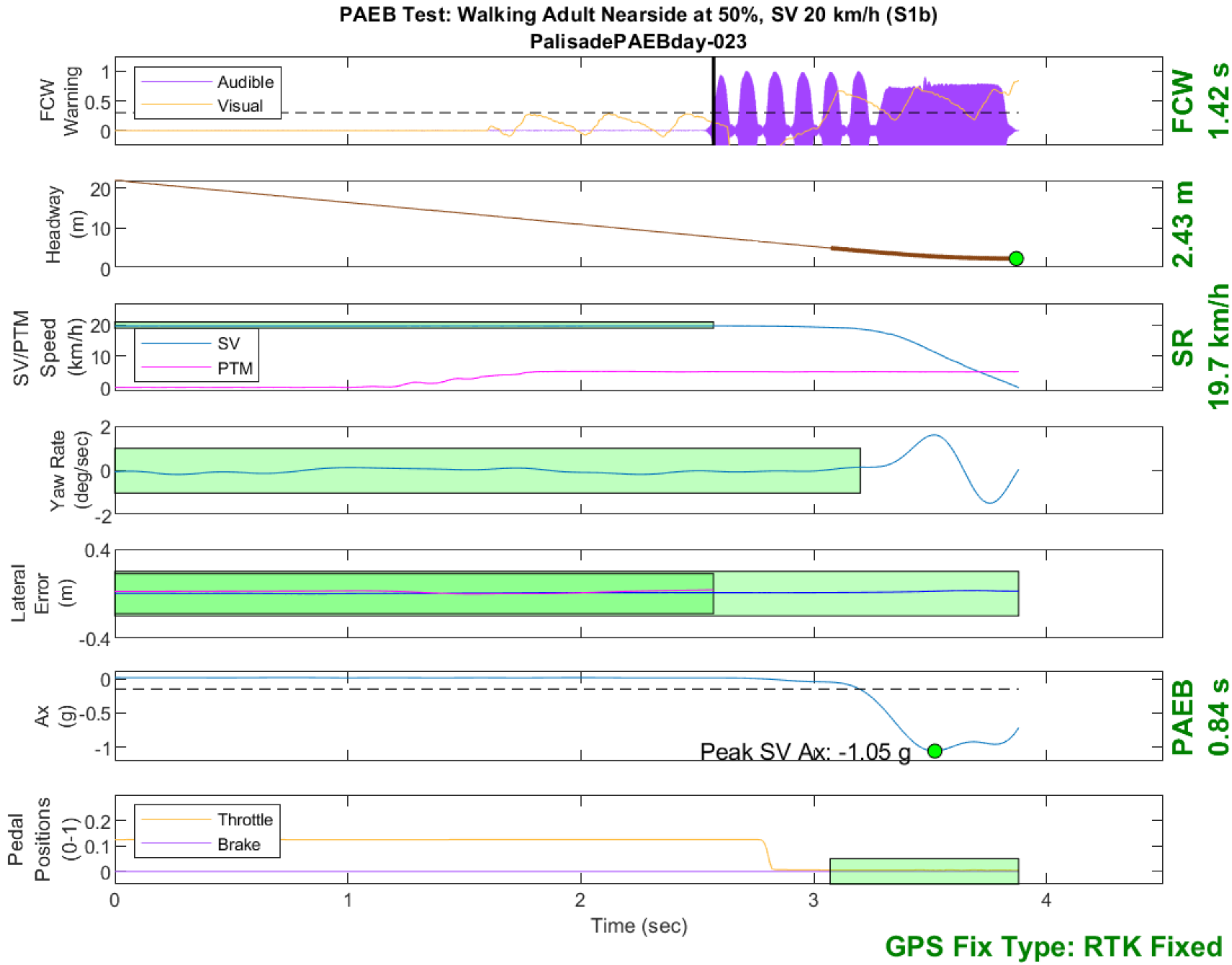


Figure D21. Time History for PAEB Run 23, S1b, Daytime, 20 km/h

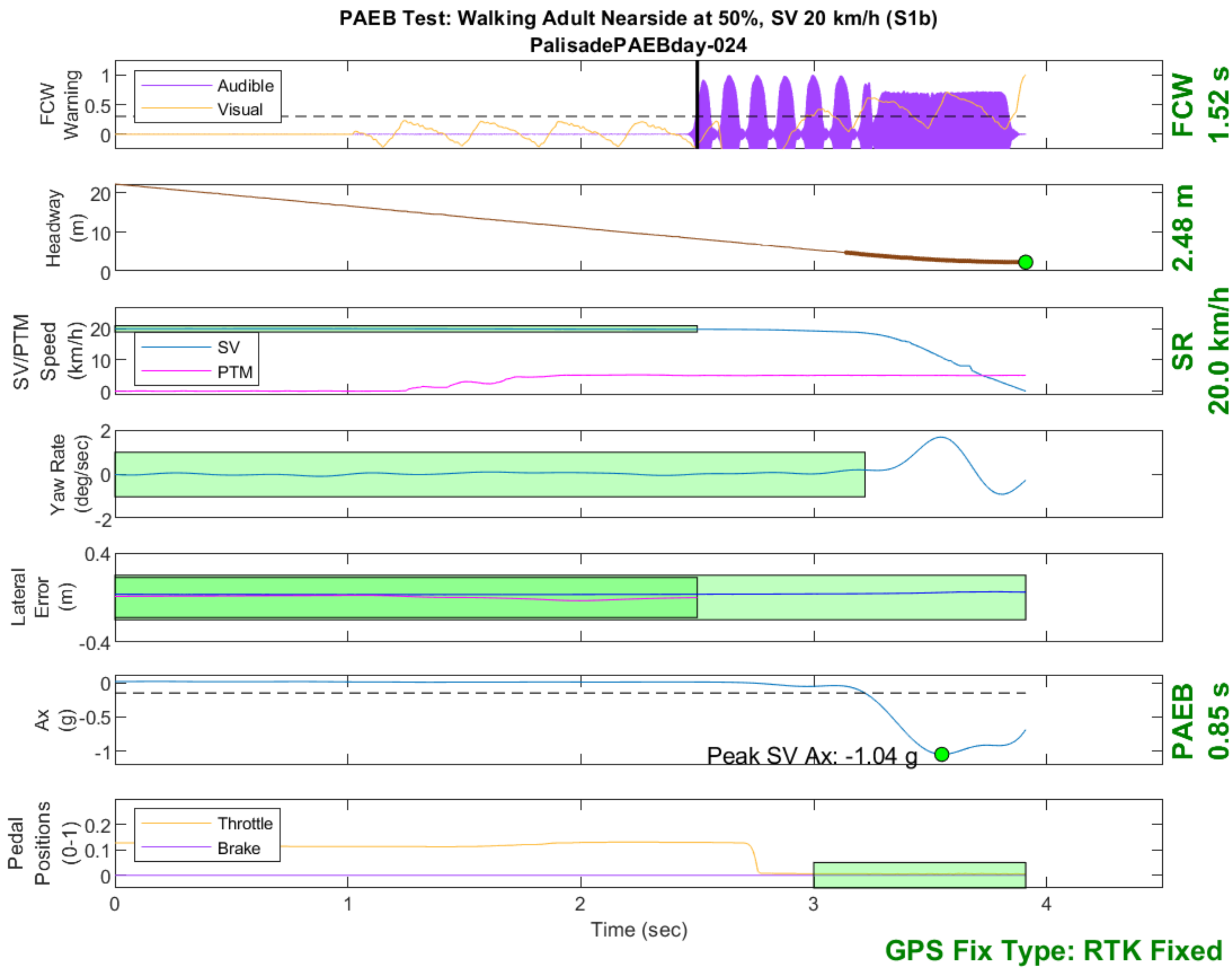


Figure D22. Time History for PAEB Run 24, S1b, Daytime, 20 km/h

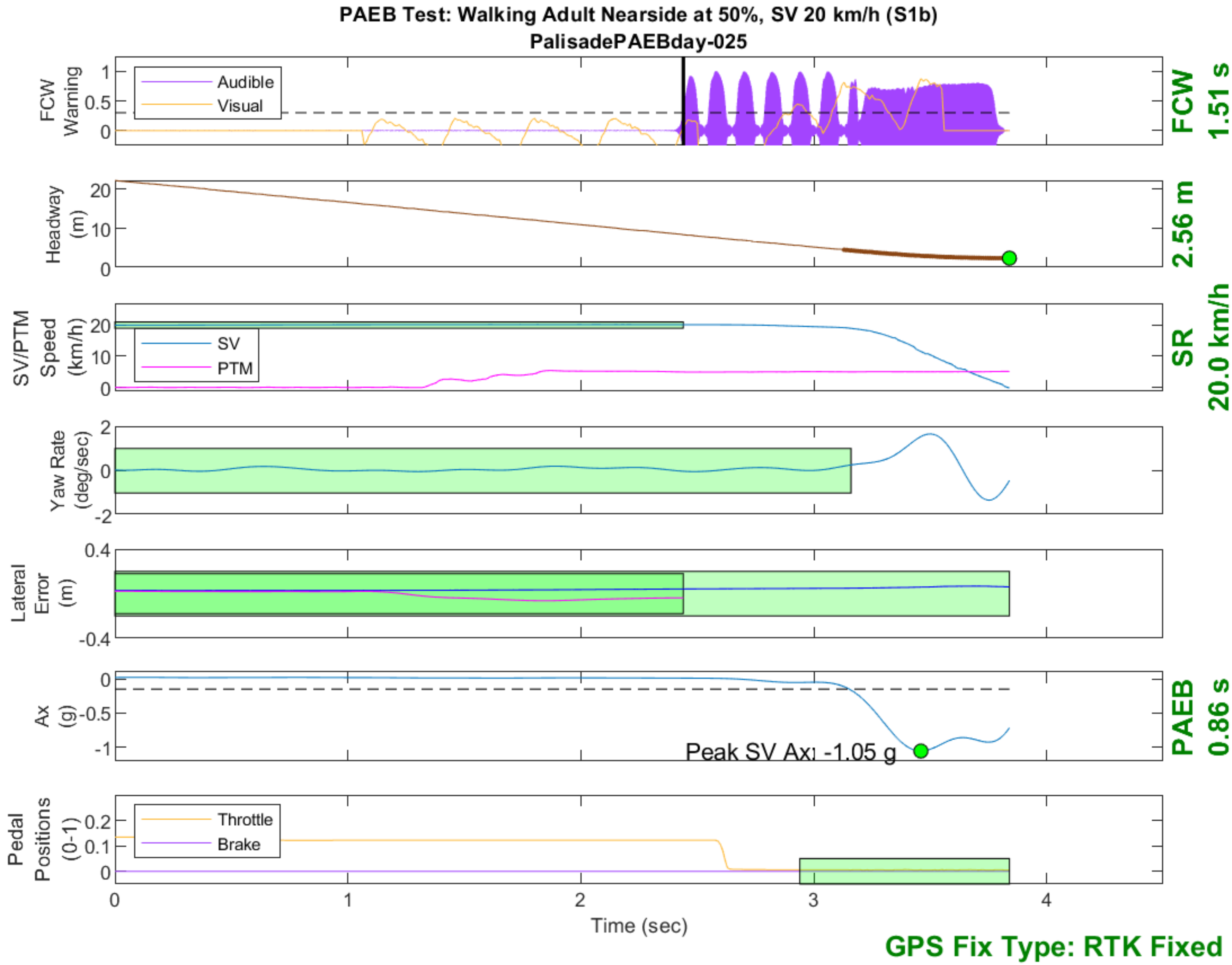


Figure D23. Time History for PAEB Run 25, S1b, Daytime, 20 km/h

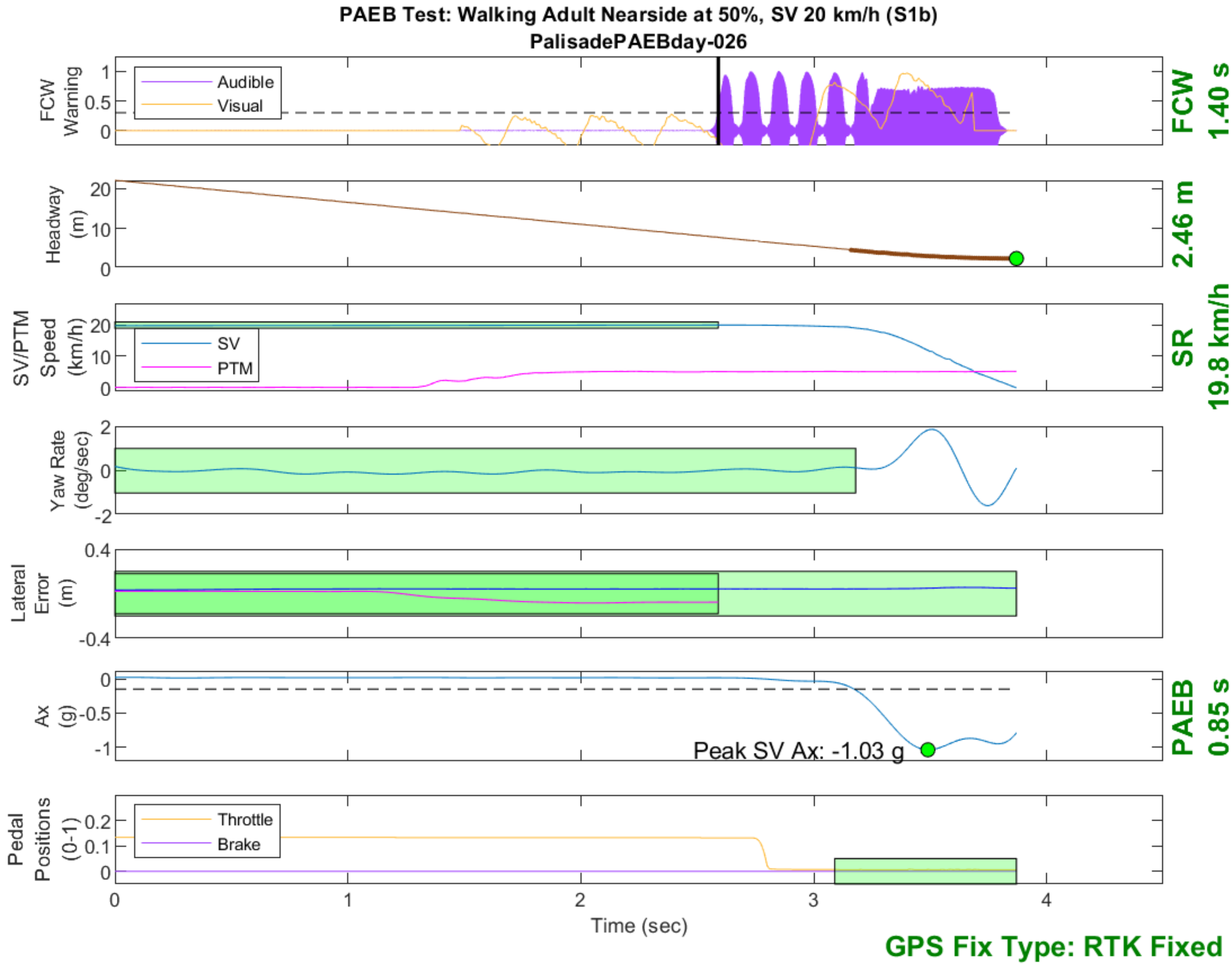


Figure D24. Time History for PAEB Run 26, S1b, Daytime, 20 km/h

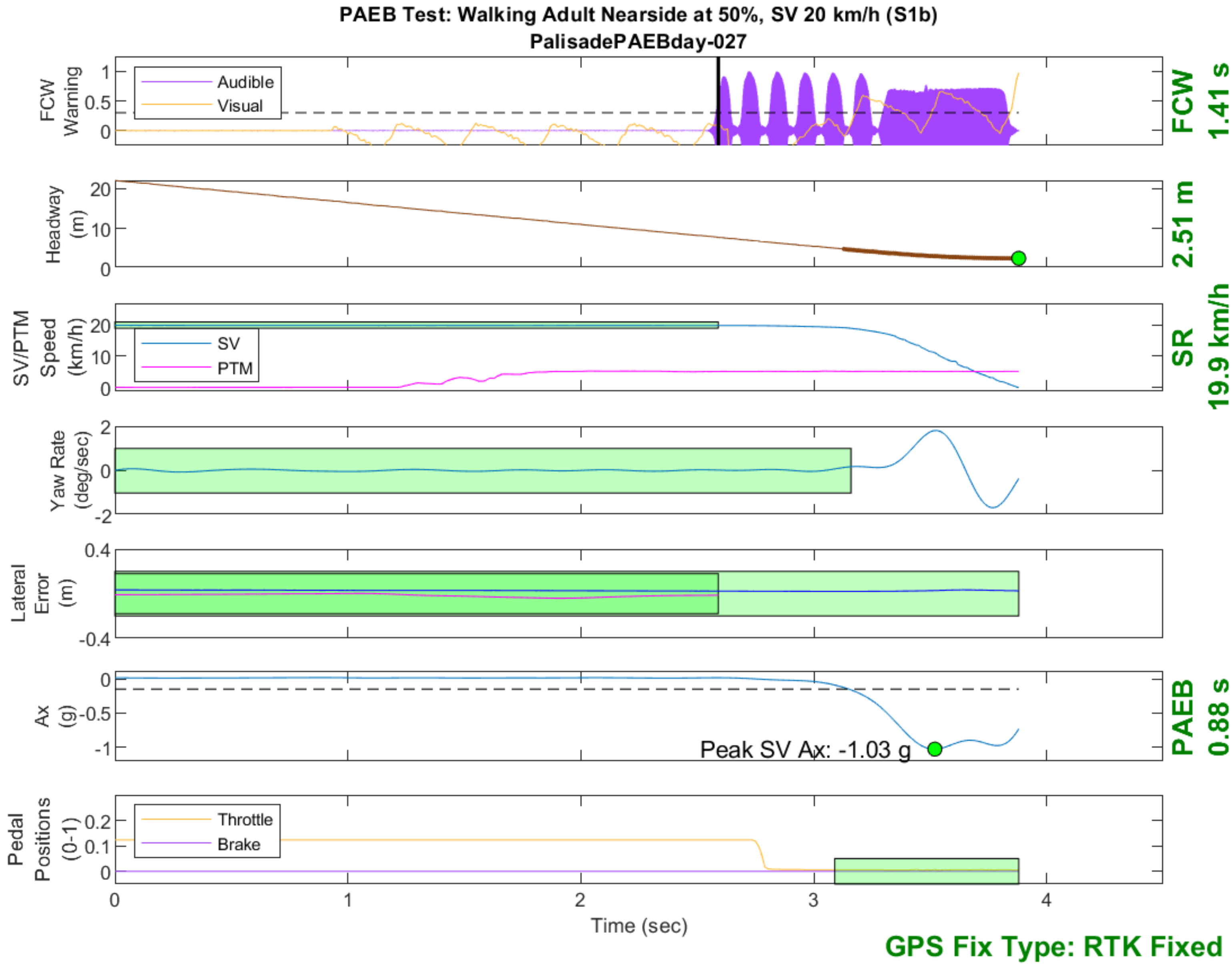


Figure D25. Time History for PAEB Run 27, S1b, Daytime, 20 km/h

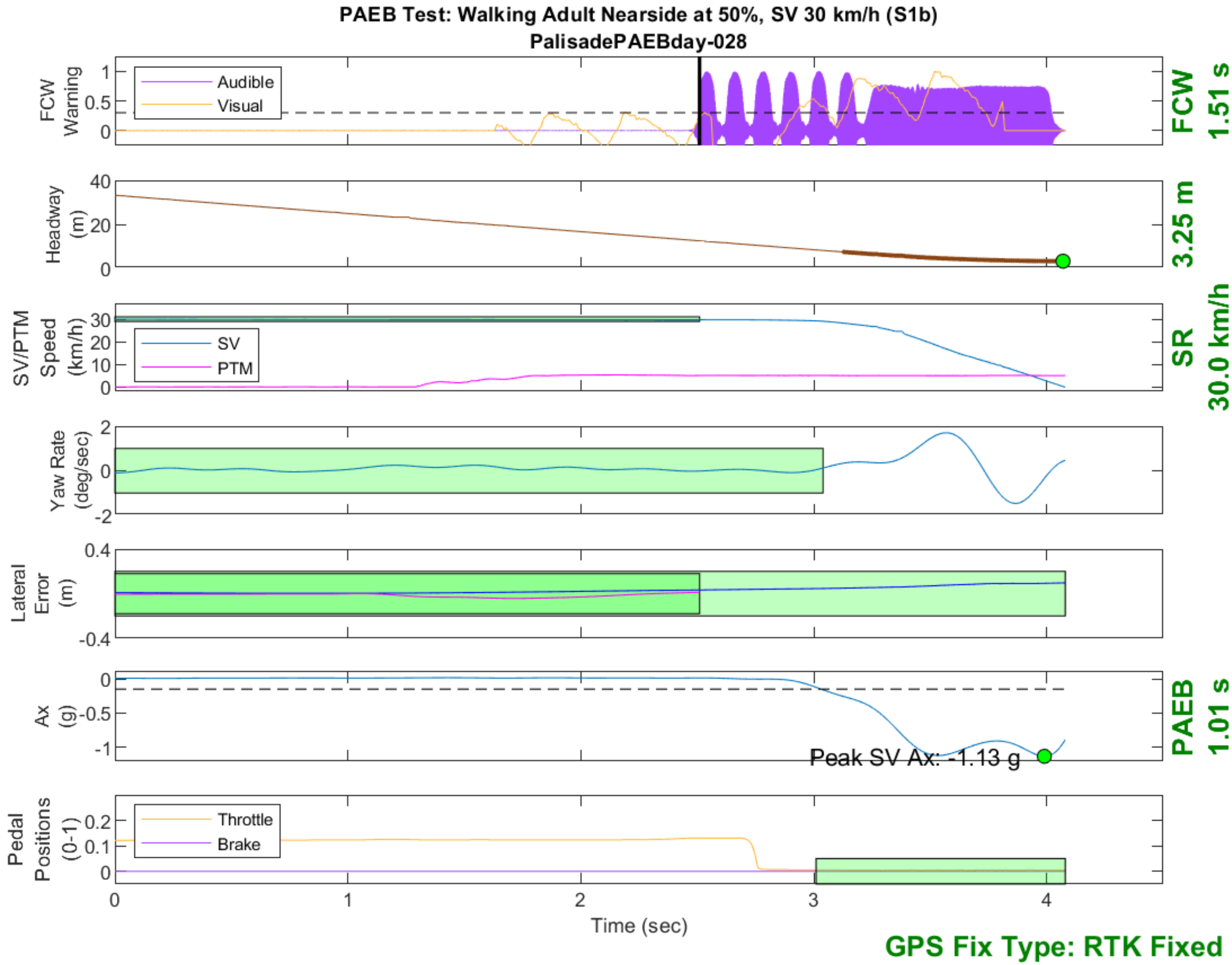


Figure D26. Time History for PAEB Run 28, S1b, Daytime, 30 km/h

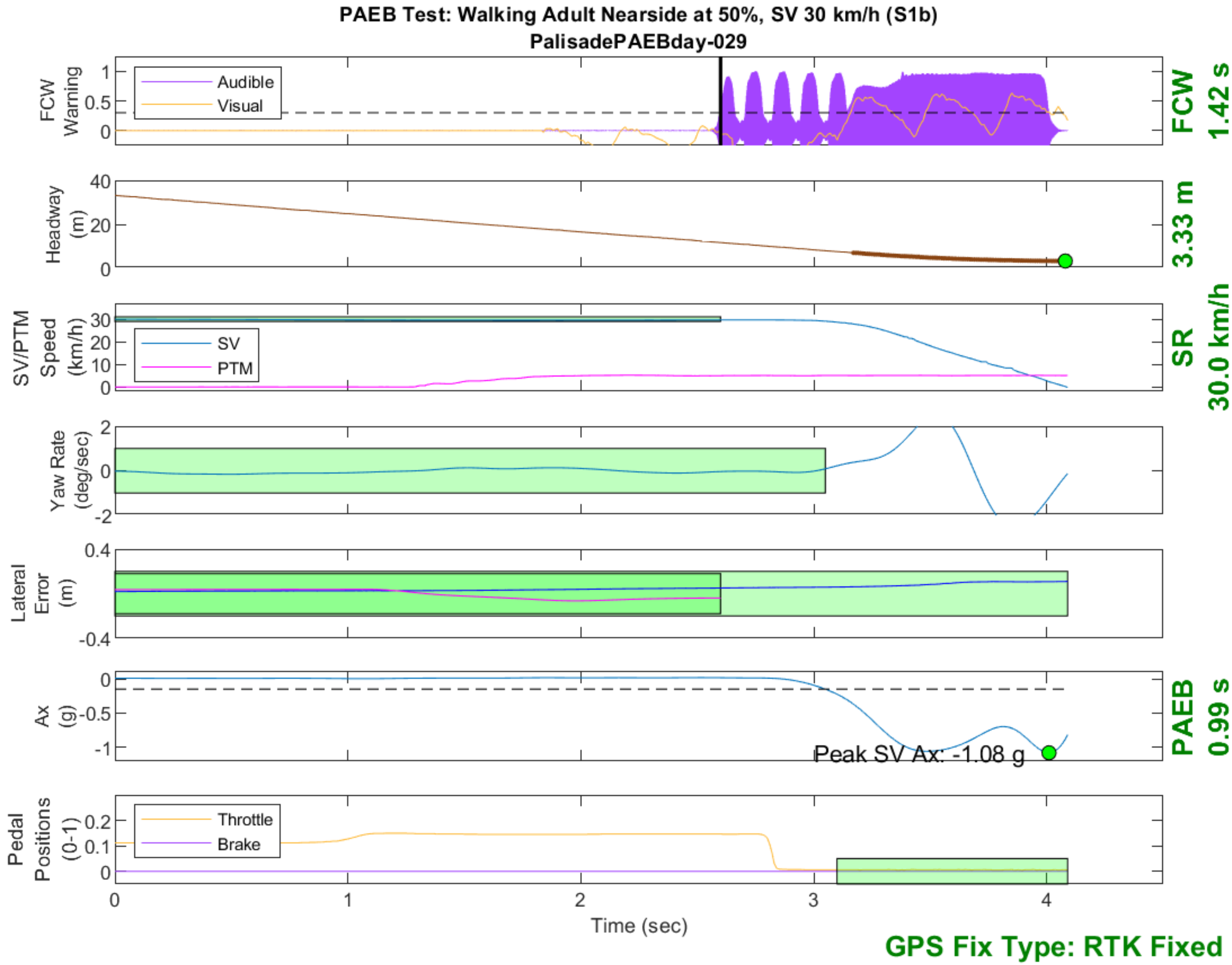


Figure D27. Time History for PAEB Run 29, S1b, Daytime, 30 km/h

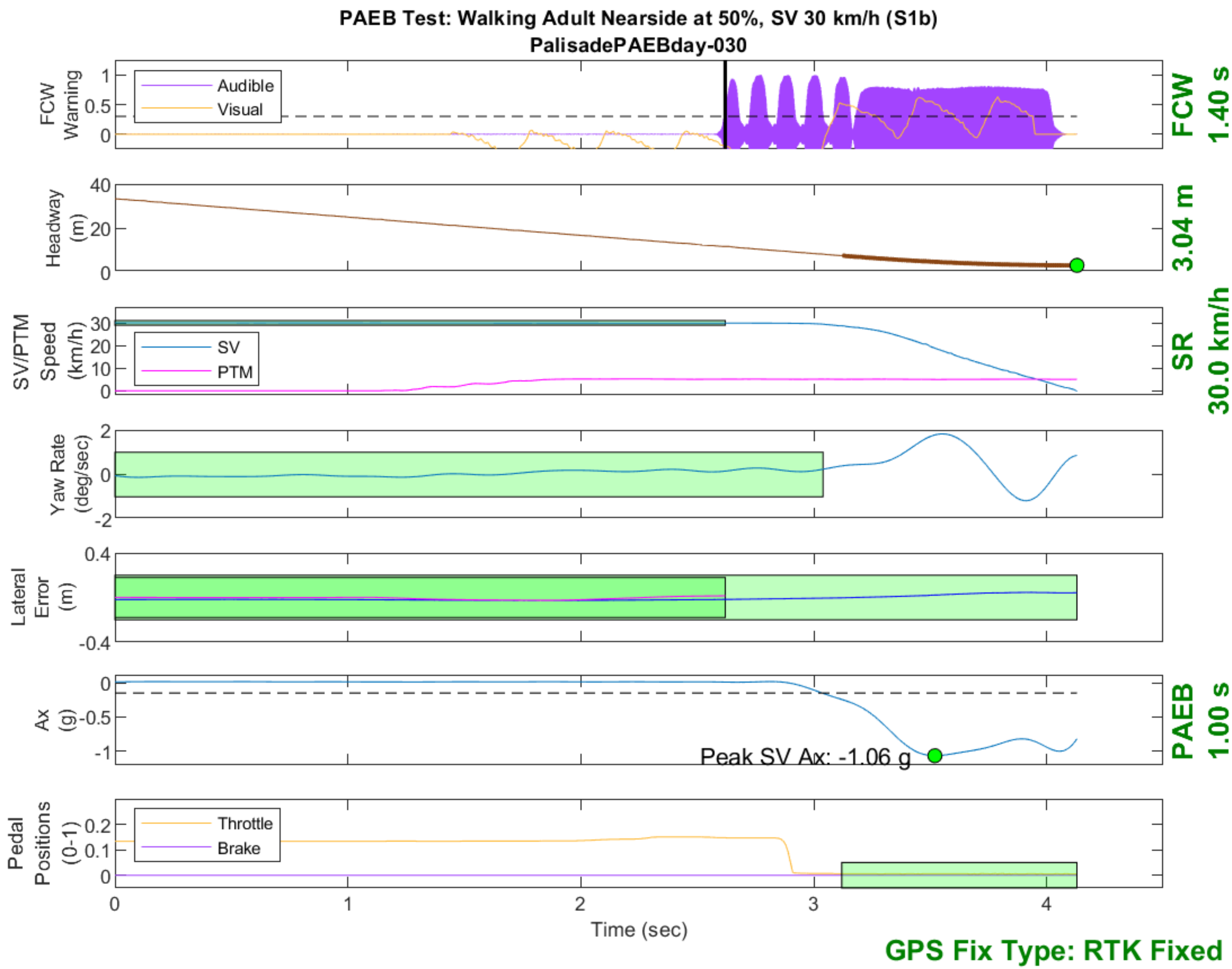


Figure D28. Time History for PAEB Run 30, S1b, Daytime, 30 km/h

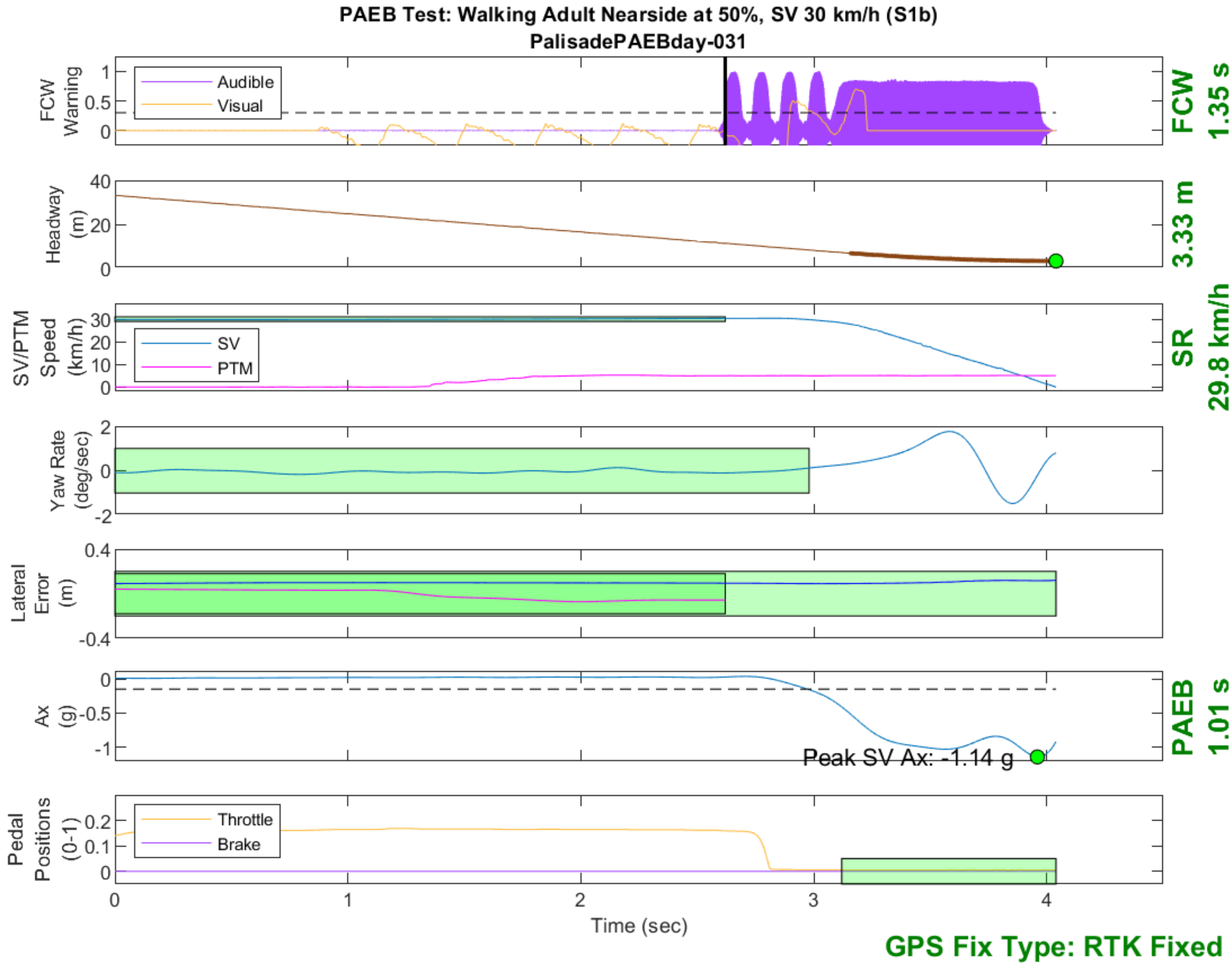


Figure D29. Time History for PAEB Run 31, S1b, Daytime, 30 km/h

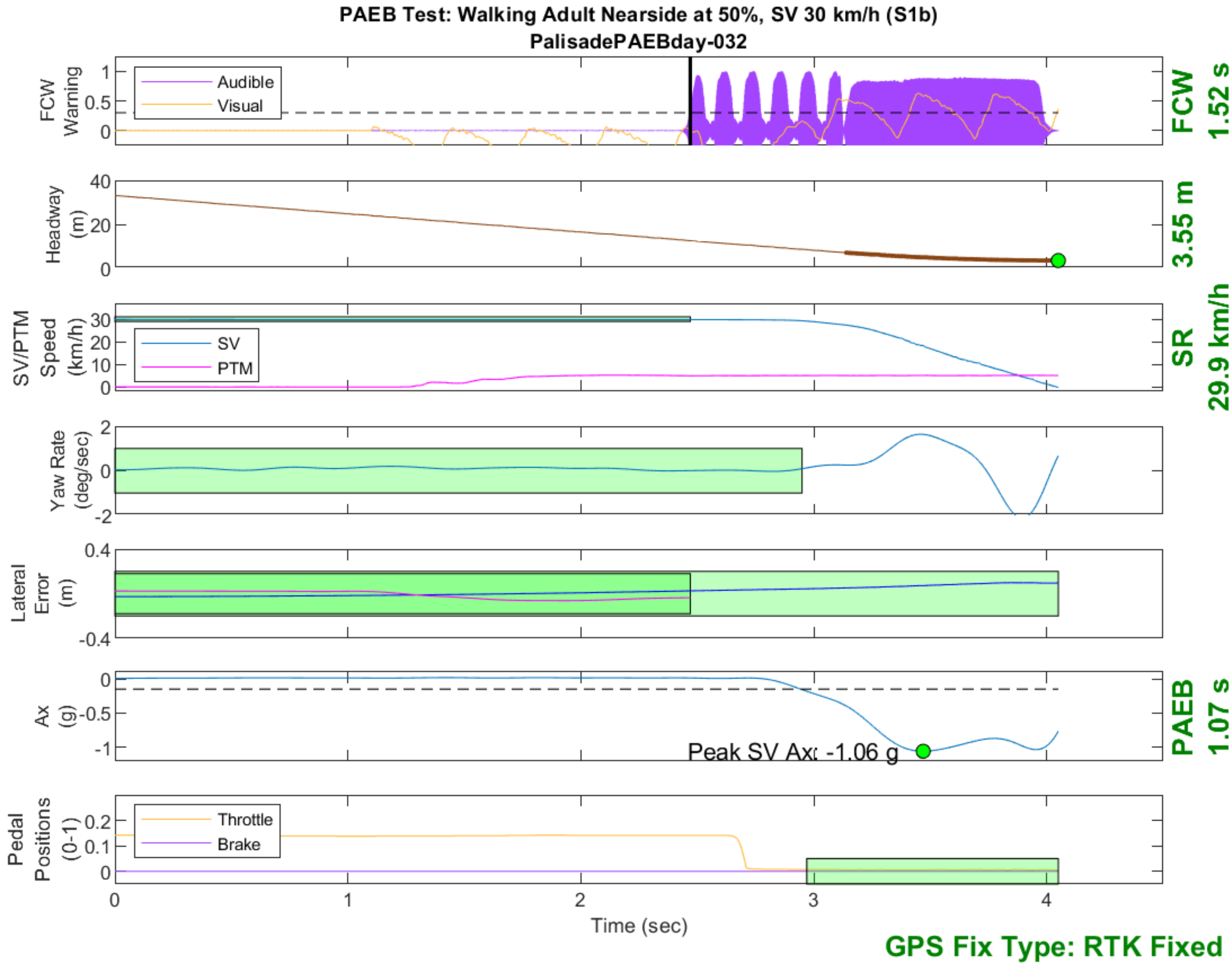


Figure D30. Time History for PAEB Run 32, S1b, Daytime, 30 km/h

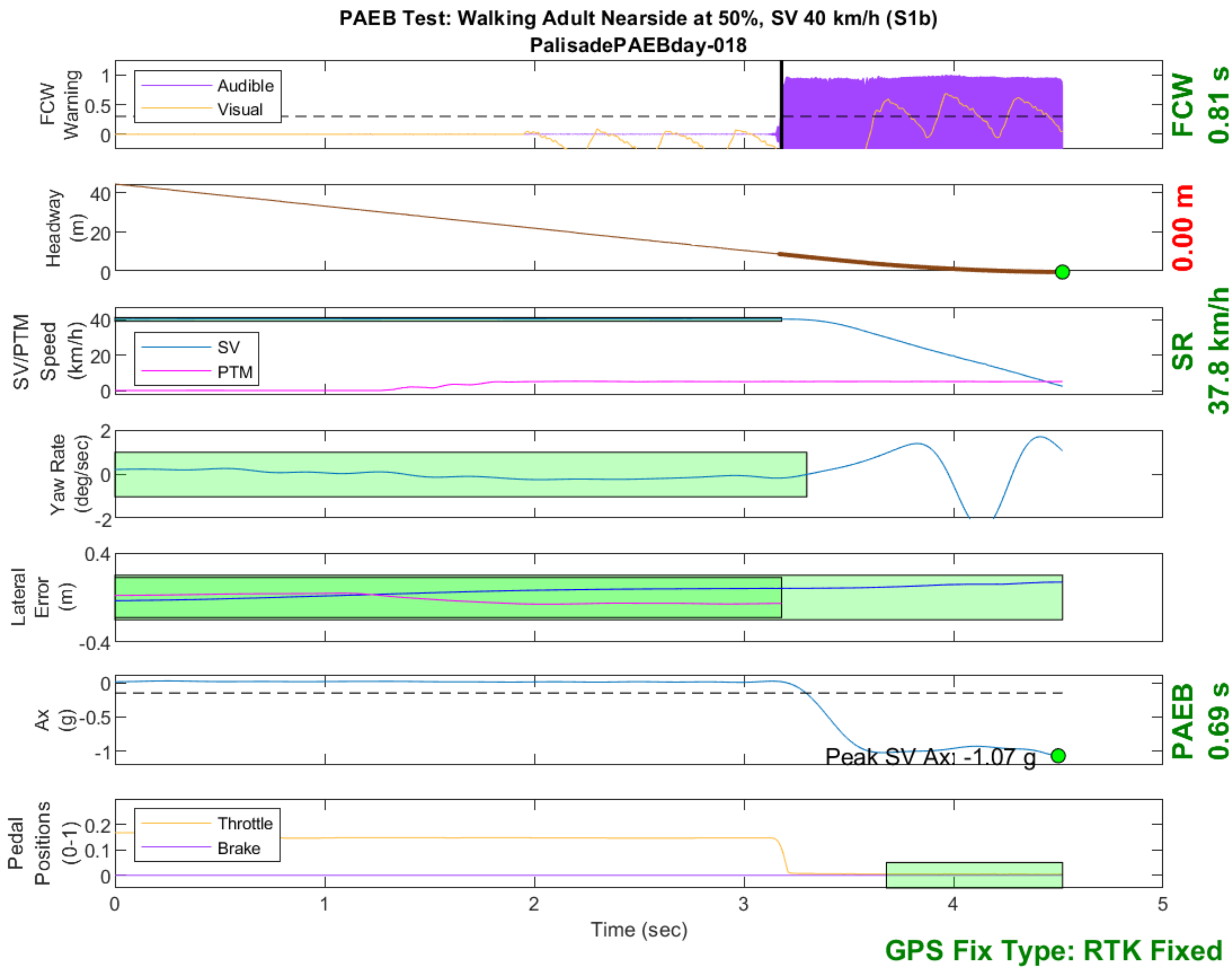


Figure D31. Time History for PAEB Run 18, S1b, Daytime, 40 km/h

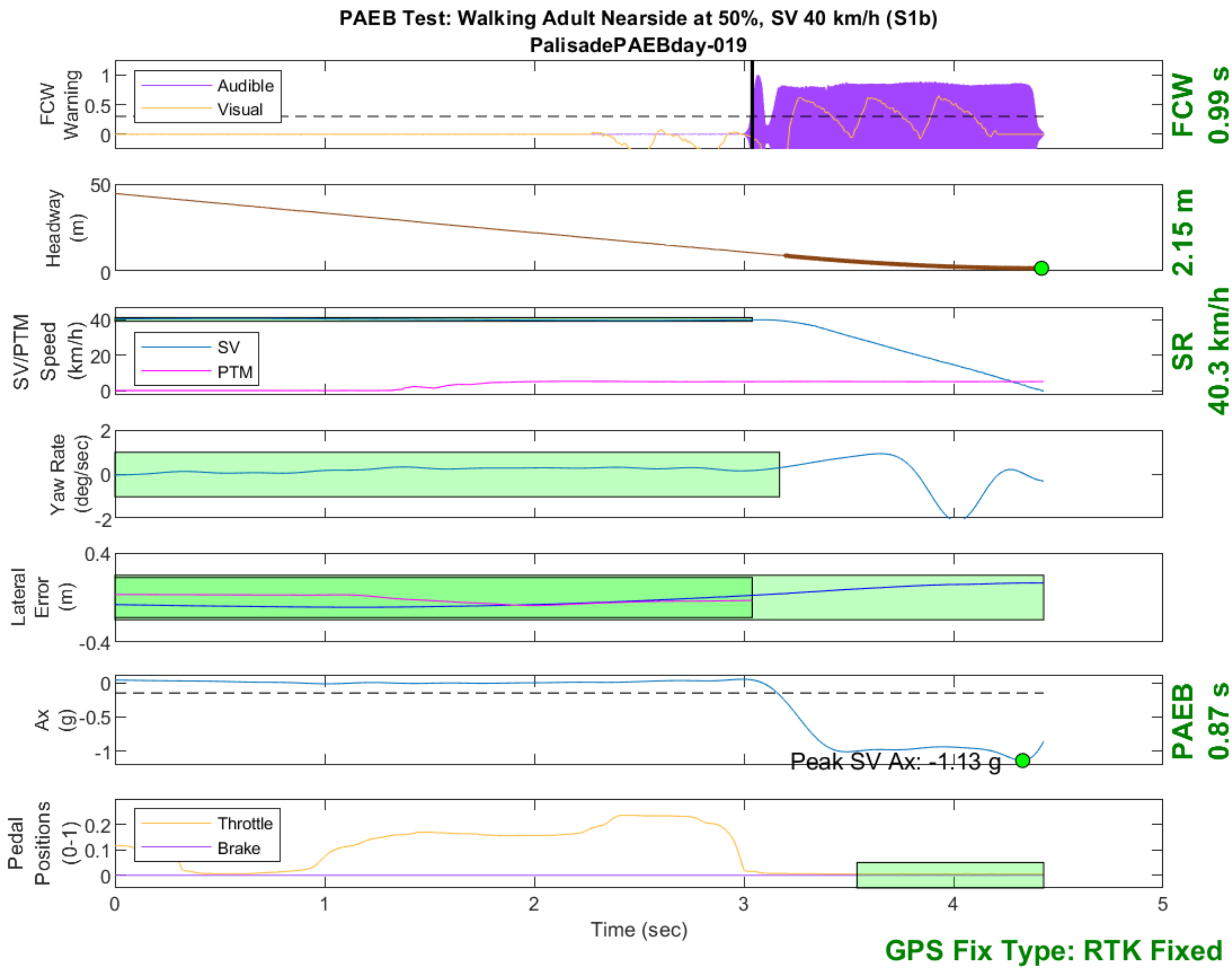


Figure D32. Time History for PAEB Run 19, S1b, Daytime, 40 km/h

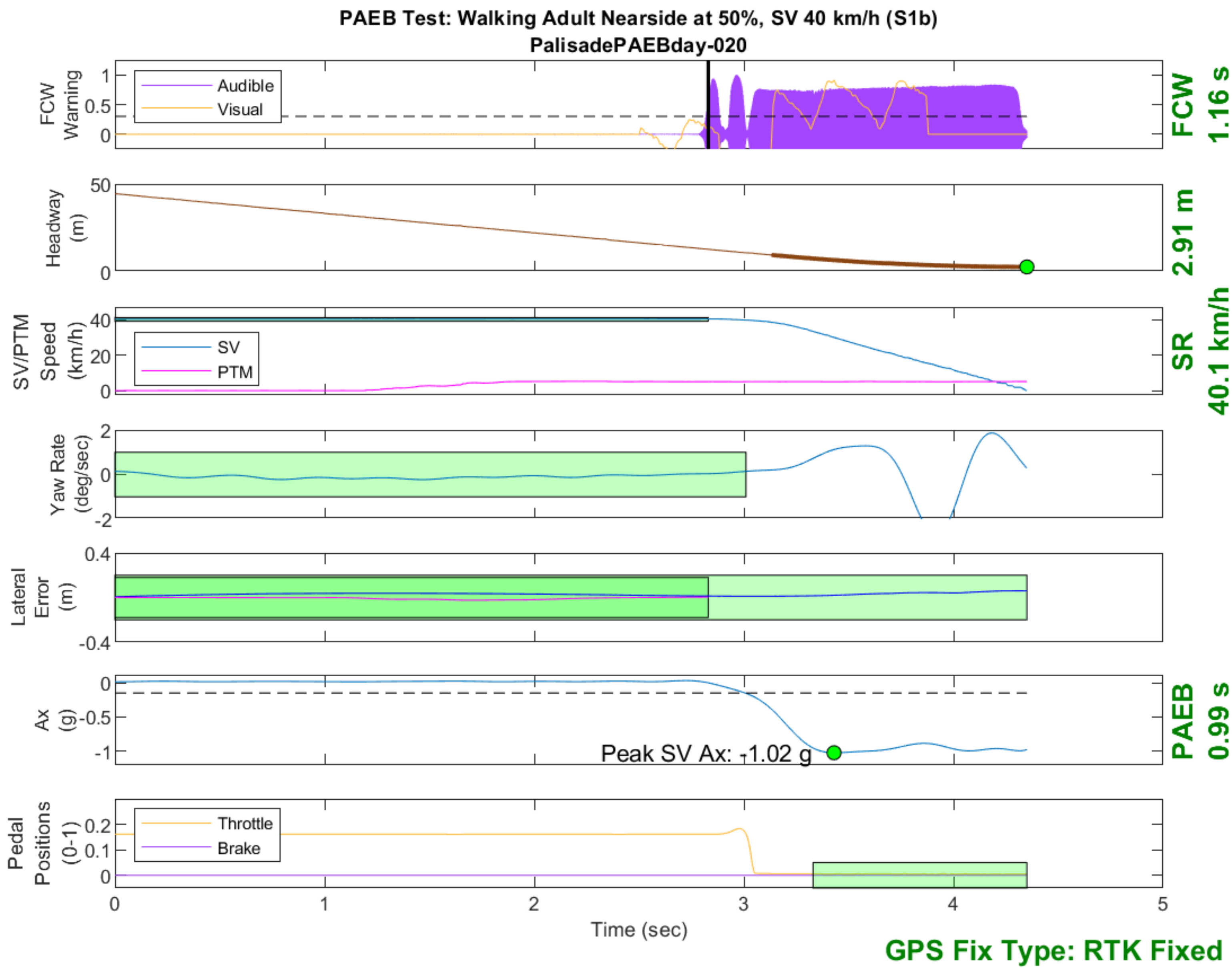


Figure D33. Time History for PAEB Run 20, S1b, Daytime, 40 km/h

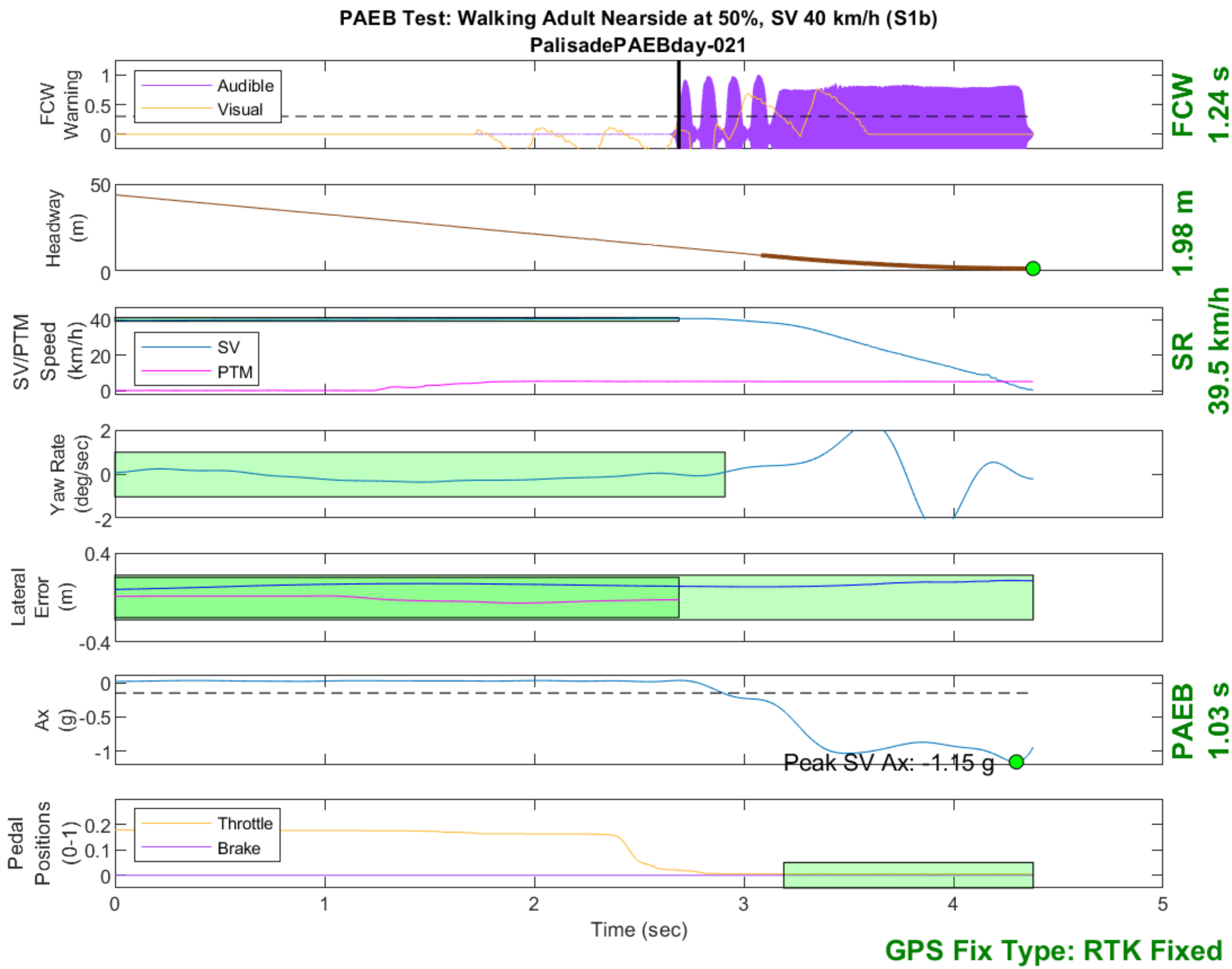


Figure D34. Time History for PAEB Run 21, S1b, Daytime, 40 km/h

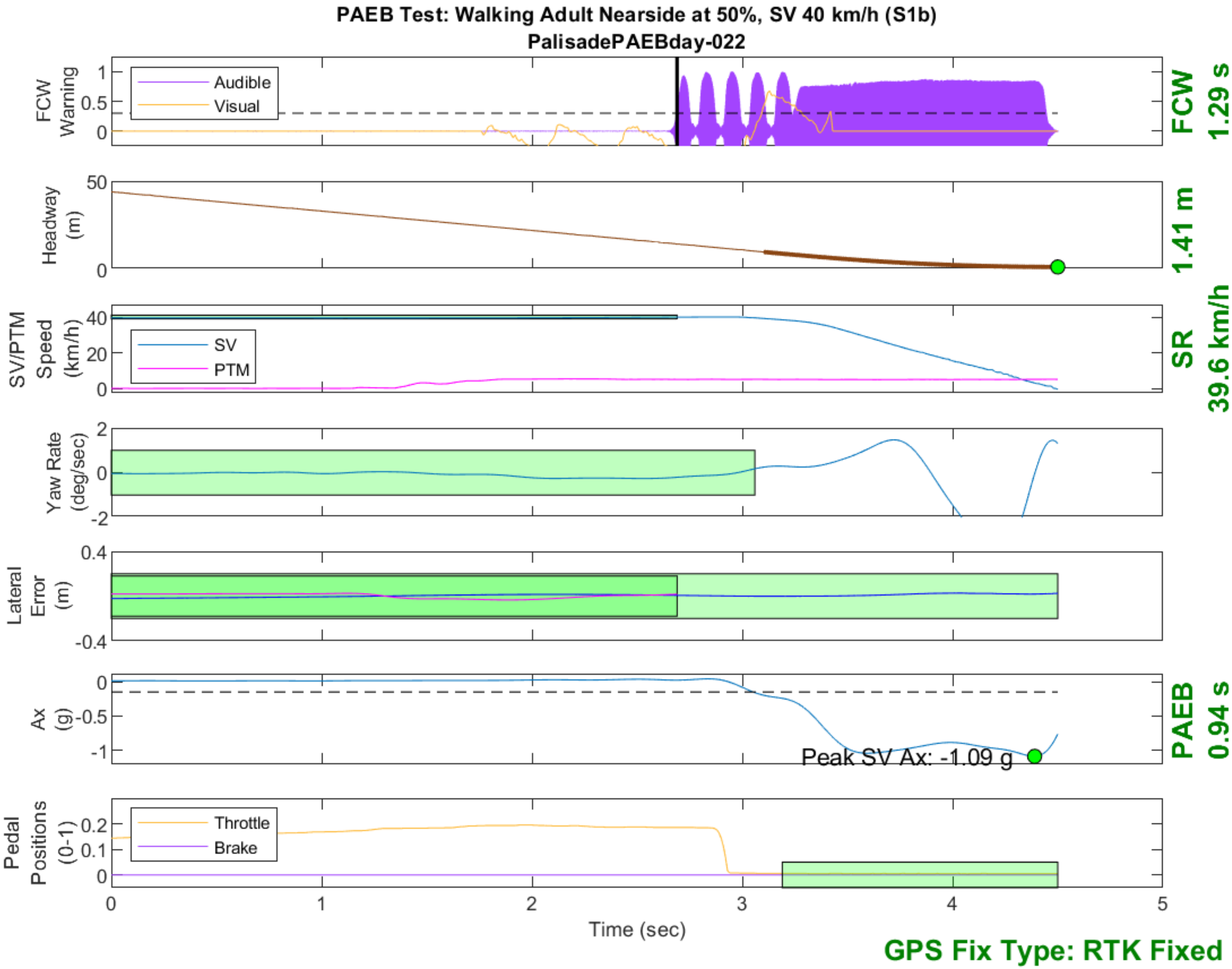


Figure D35. Time History for PAEB Run 22, S1b, Daytime, 40 km/h

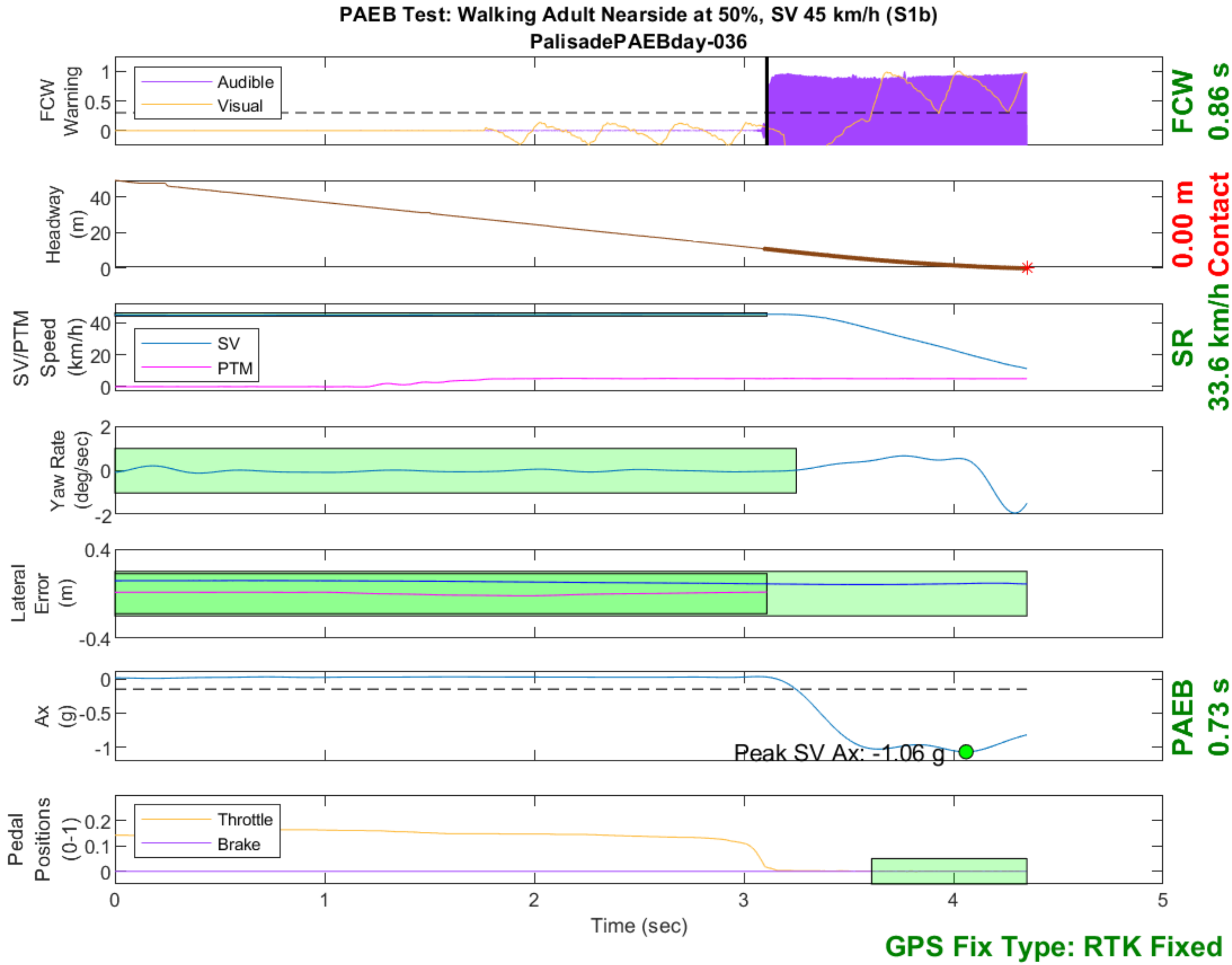


Figure D36. Time History for PAEB Run 36, S1b, Daytime, 45 km/h

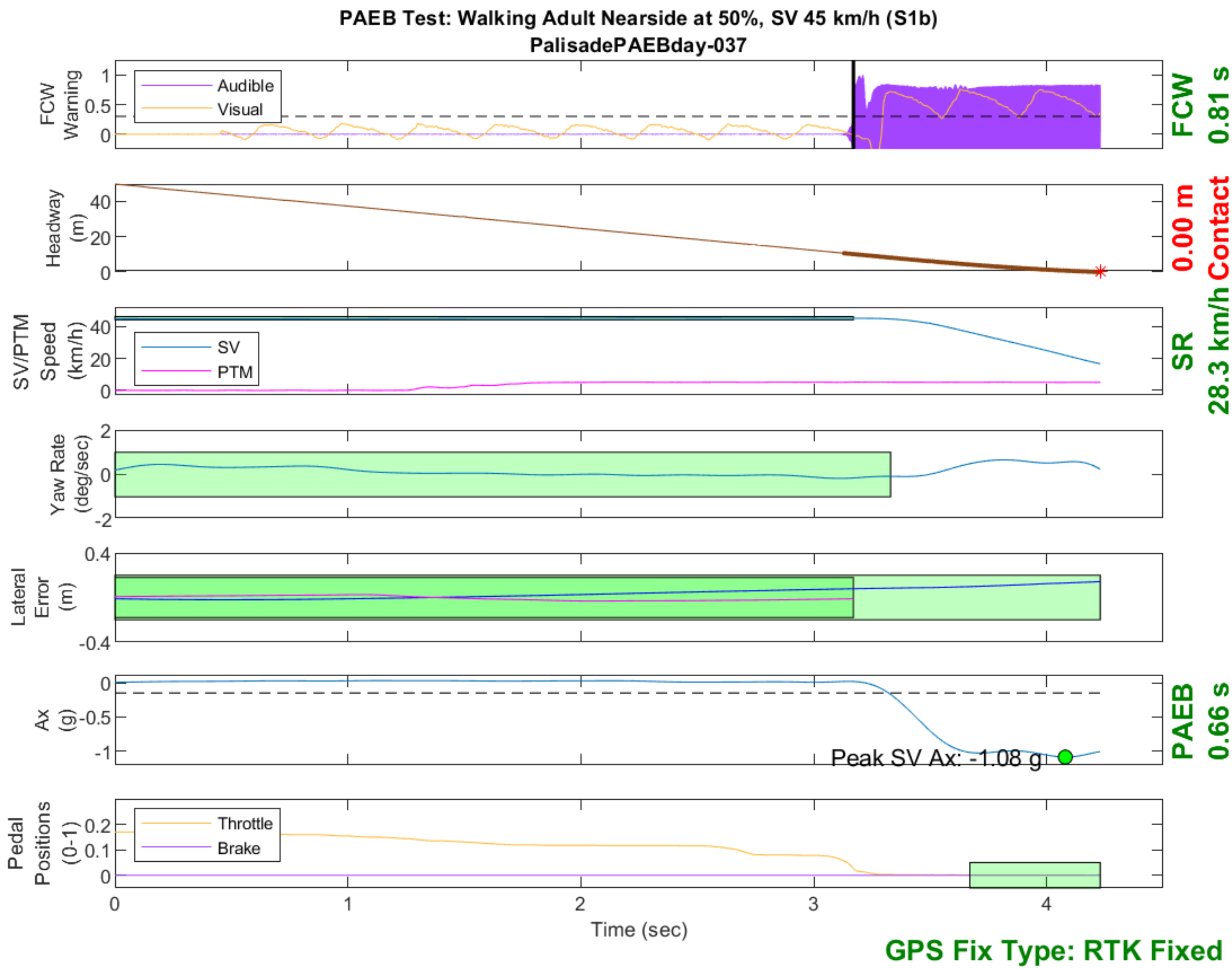


Figure D37. Time History for PAEB Run 37, S1b, Daytime, 45 km/h

Figure D38. Time History for PAEB Run 38, S1b, Daytime, 45 km/h

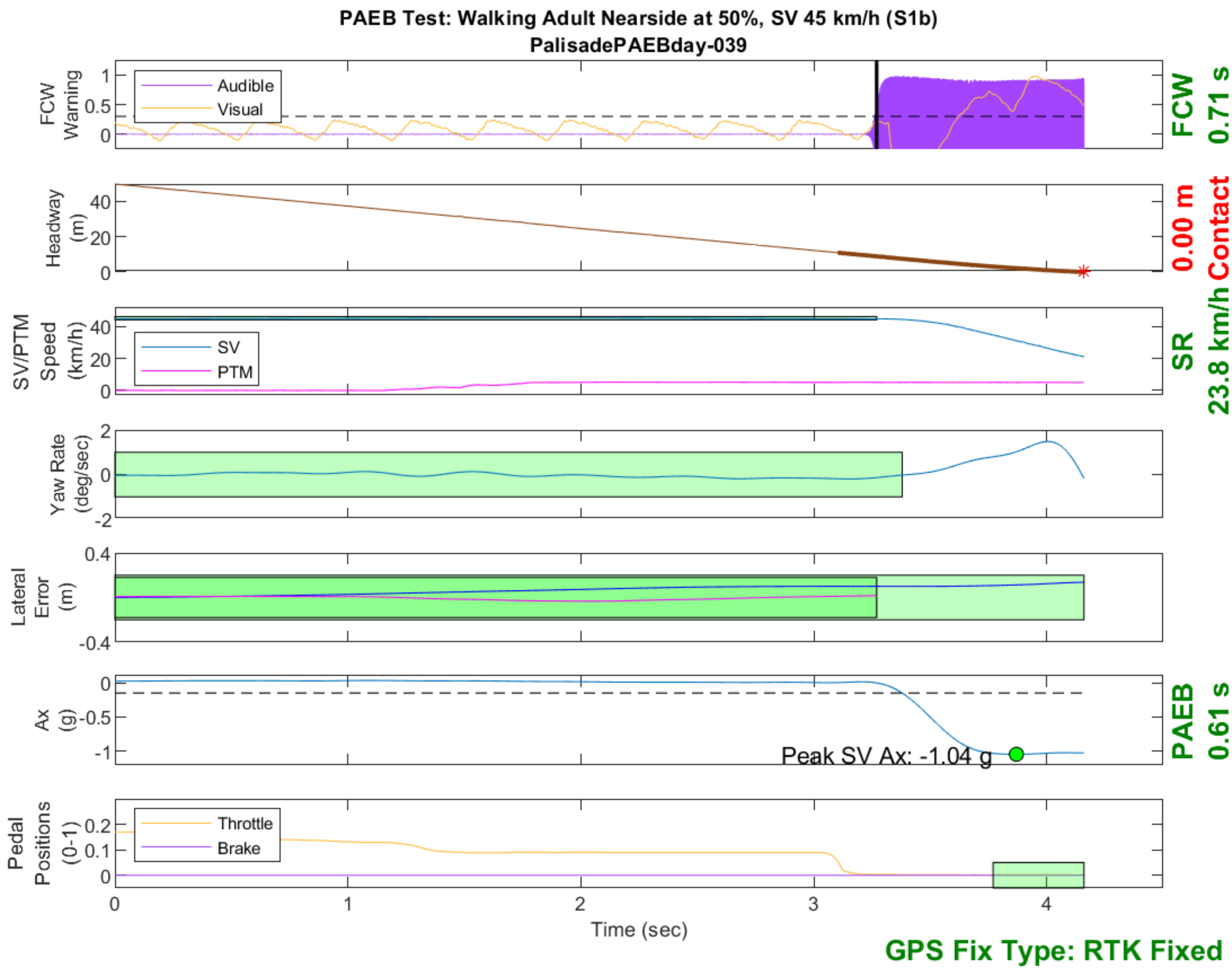


Figure D39. Time History for PAEB Run 39, S1b, Daytime, 45 km/h

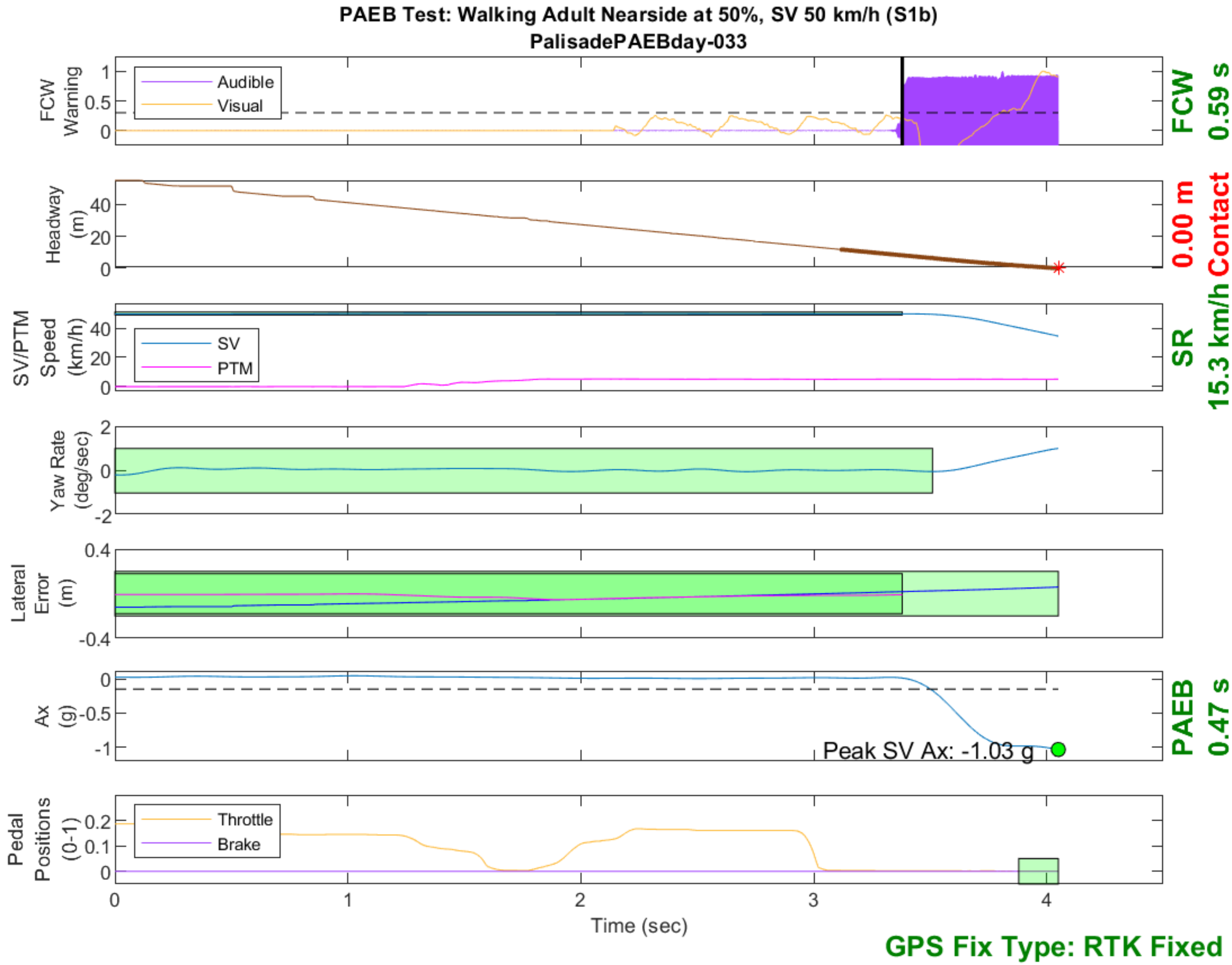


Figure D40. Time History for PAEB Run 33, S1b, Daytime, 50 km/h

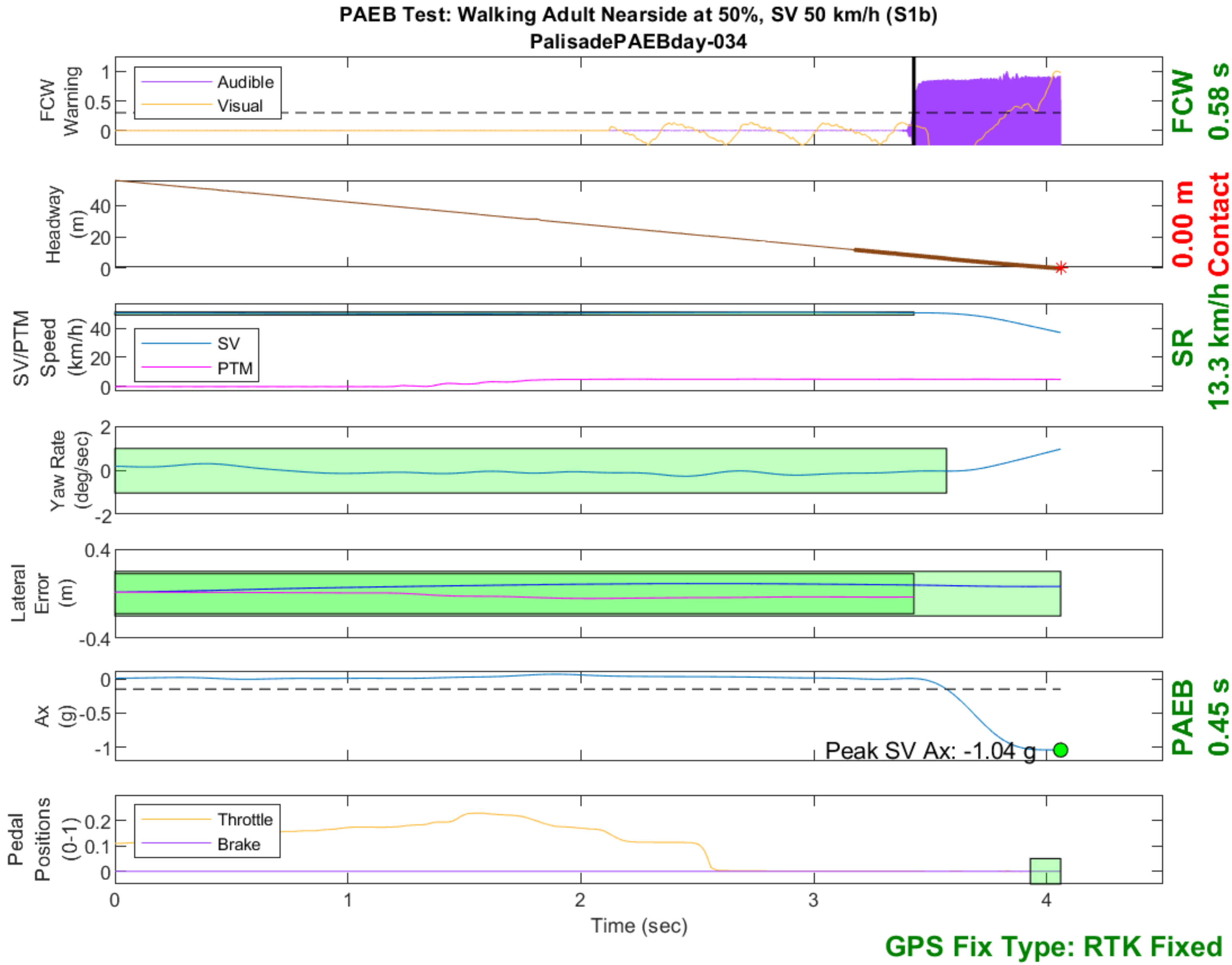


Figure D41. Time History for PAEB Run 34, S1b, Daytime, 50 km/h

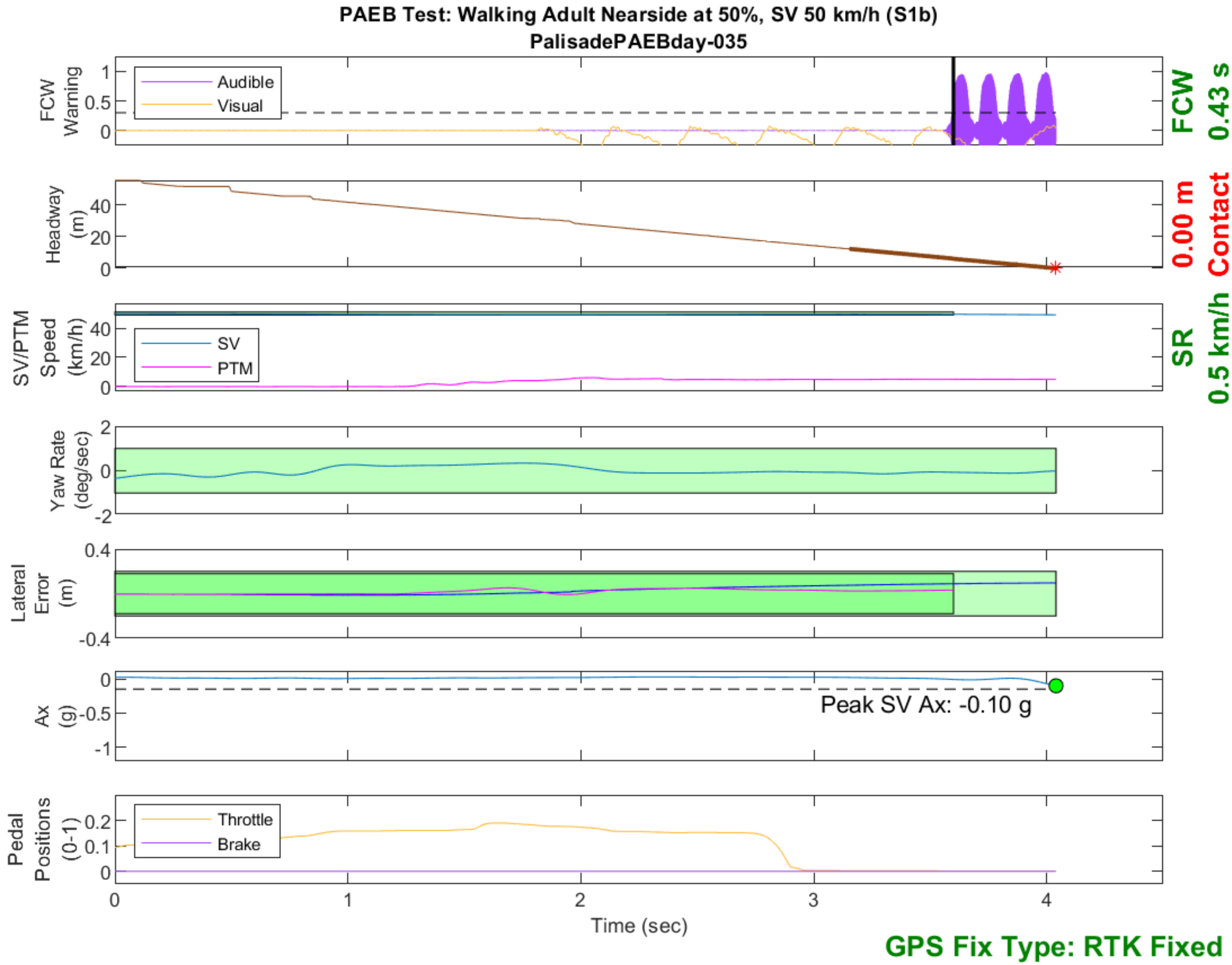


Figure D42. Time History for PAEB Run 35, S1b, Daytime, 50 km/h

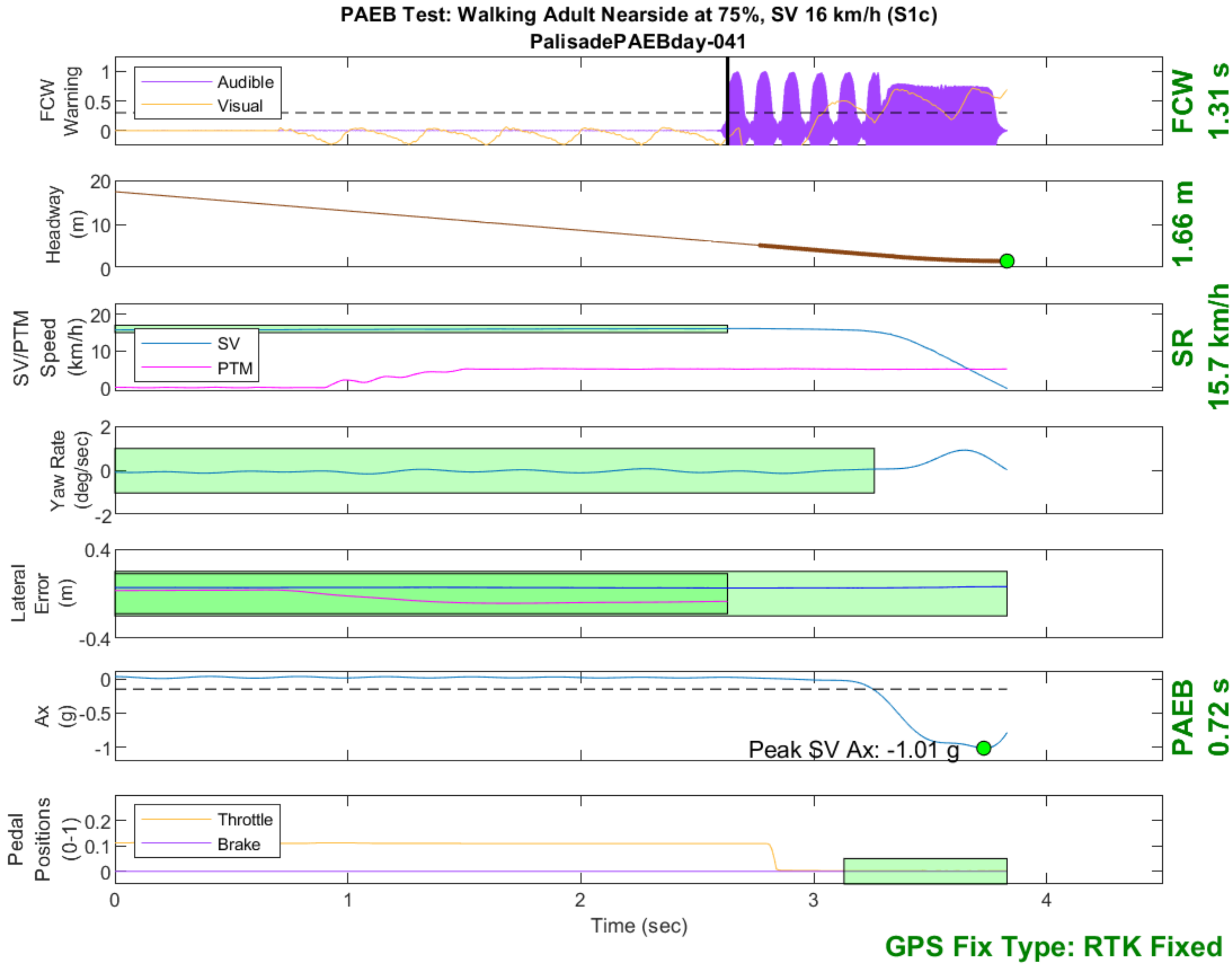


Figure D43. Time History for PAEB Run 41, S1c, Daytime, 16 km/h

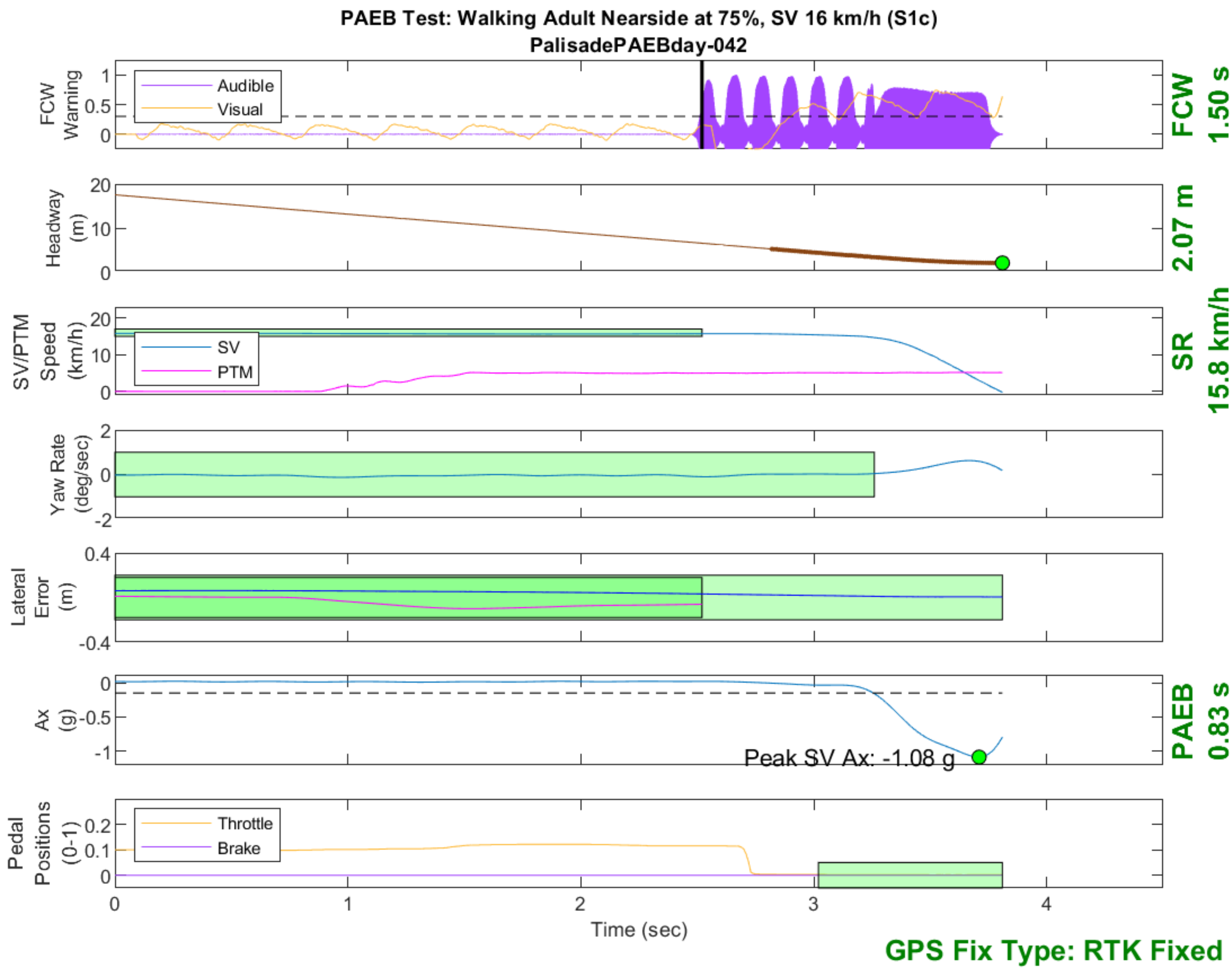


Figure D44. Time History for PAEB Run 42, S1c, Daytime, 16 km/h

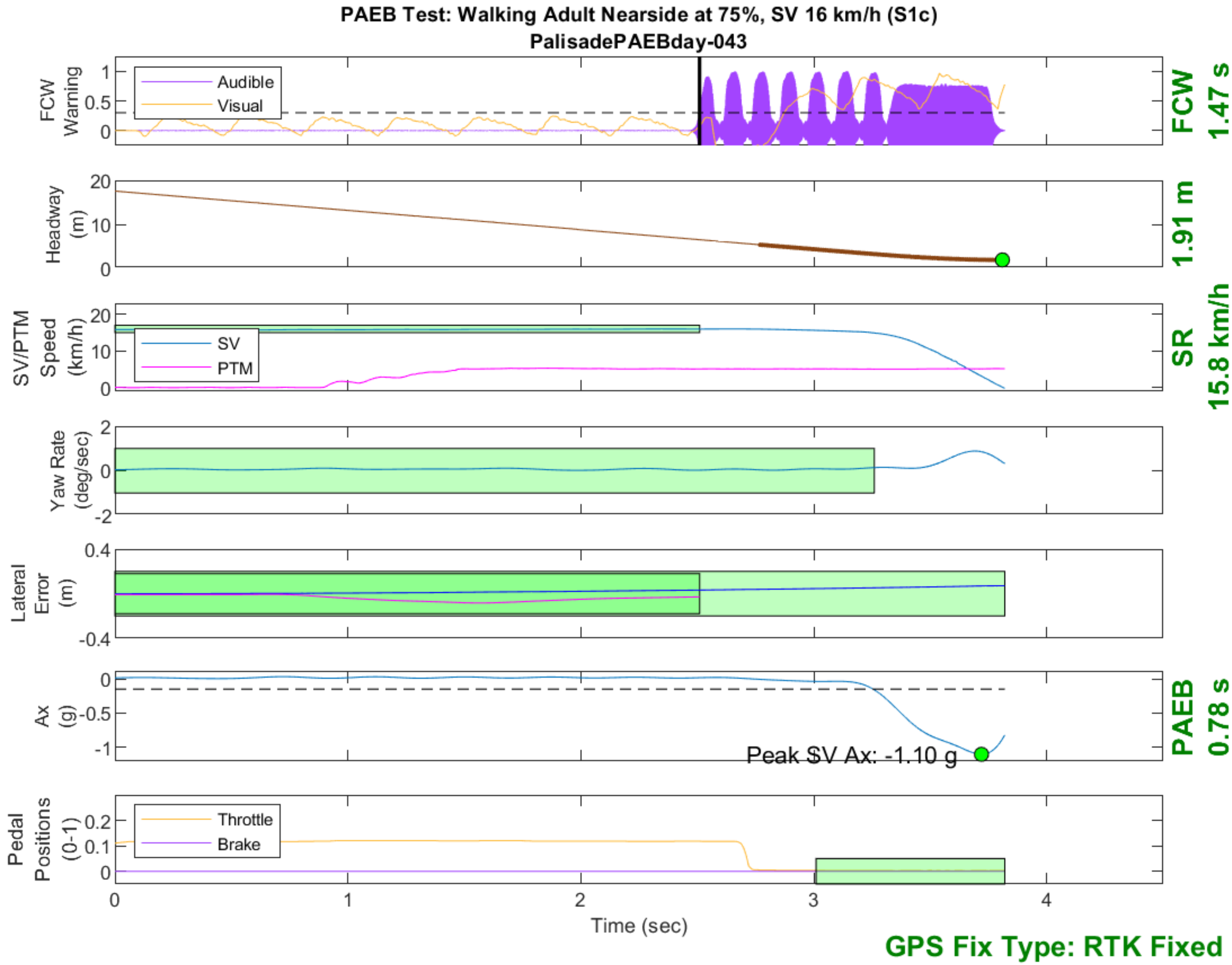


Figure D45. Time History for PAEB Run 43, S1c, Daytime, 16 km/h

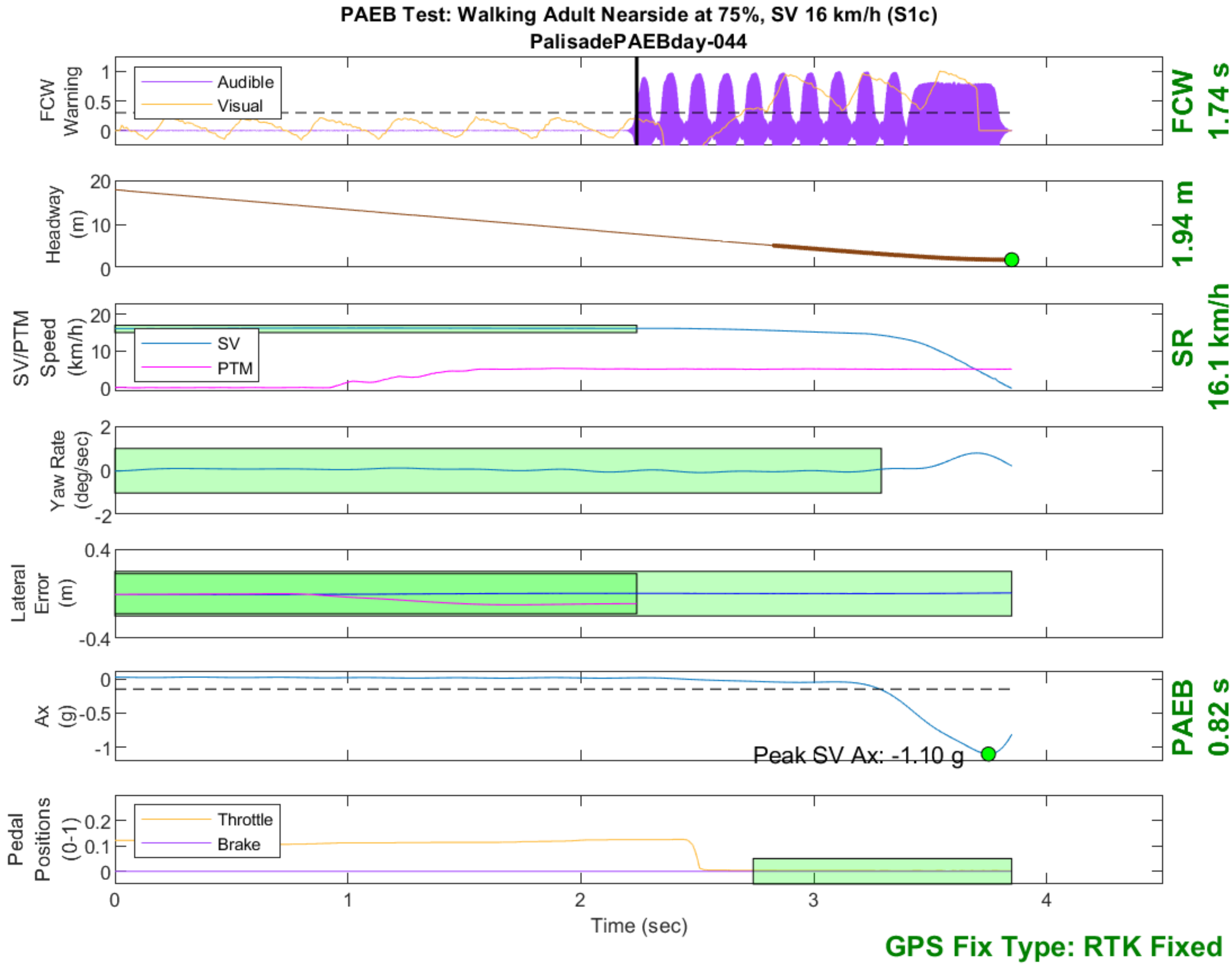


Figure D46. Time History for PAEB Run 44, S1c, Daytime, 16 km/h

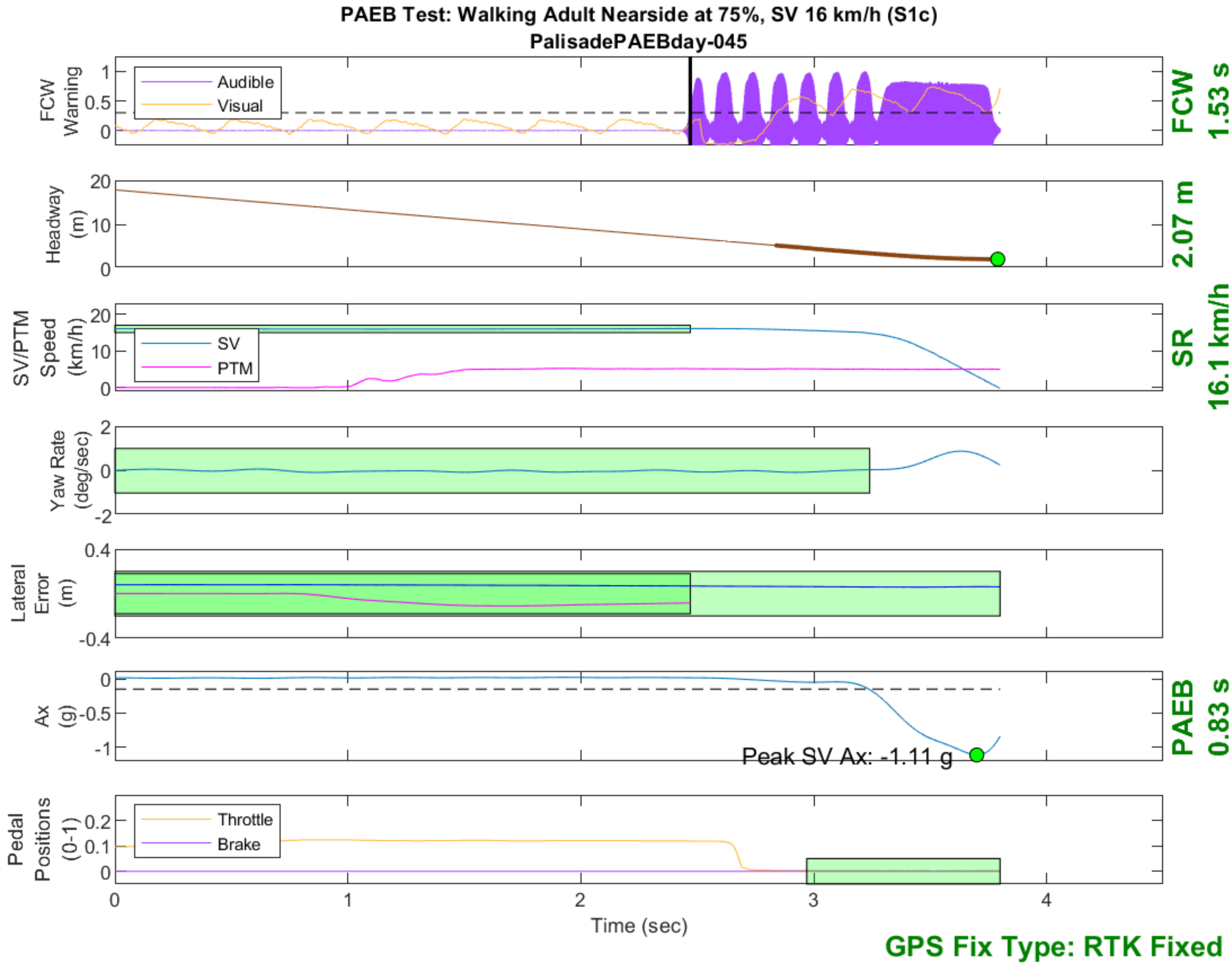


Figure D47. Time History for PAEB Run 45, S1c, Daytime, 16 km/h

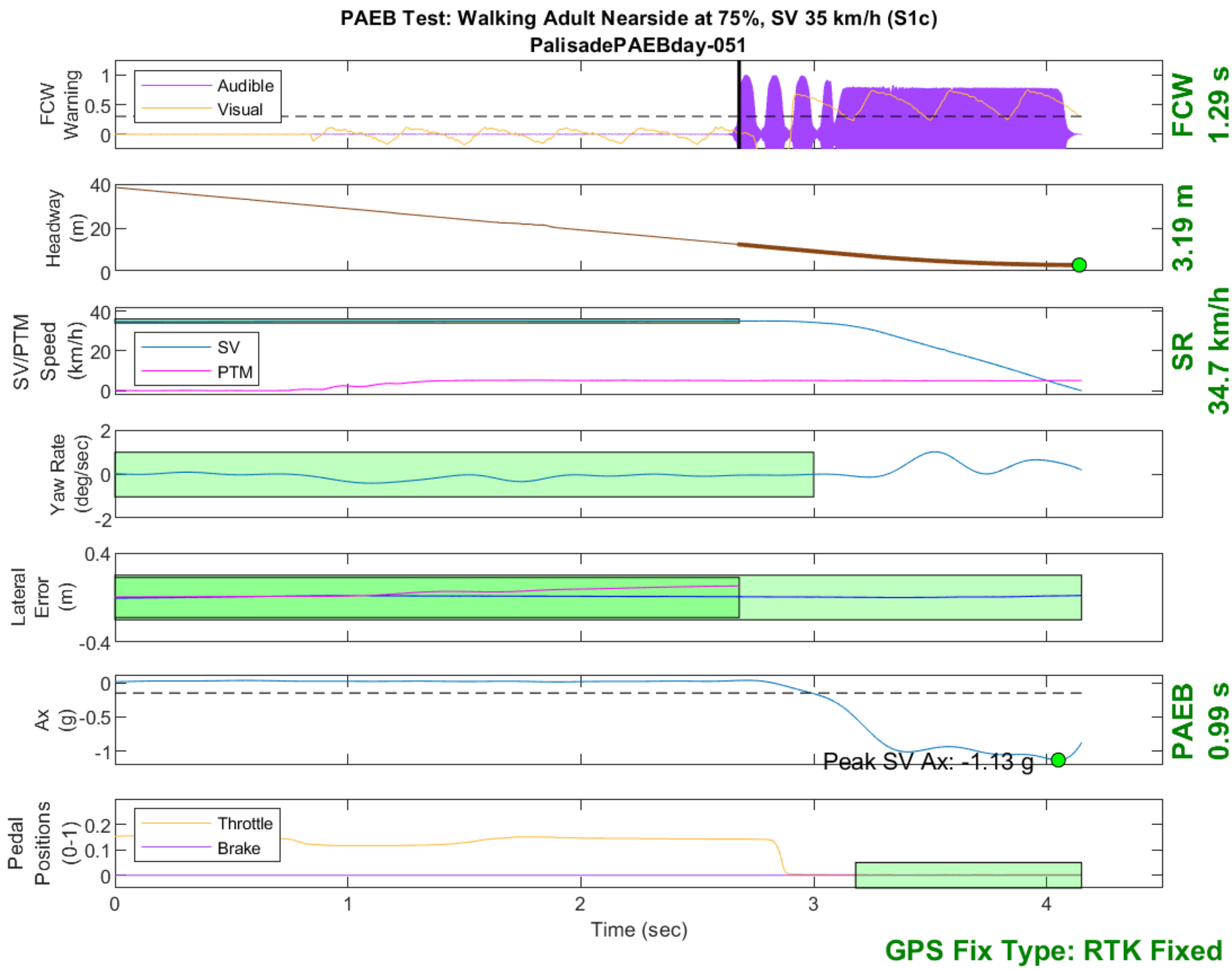


Figure D48. Time History for PAEB Run 51, S1c, Daytime, 35 km/h

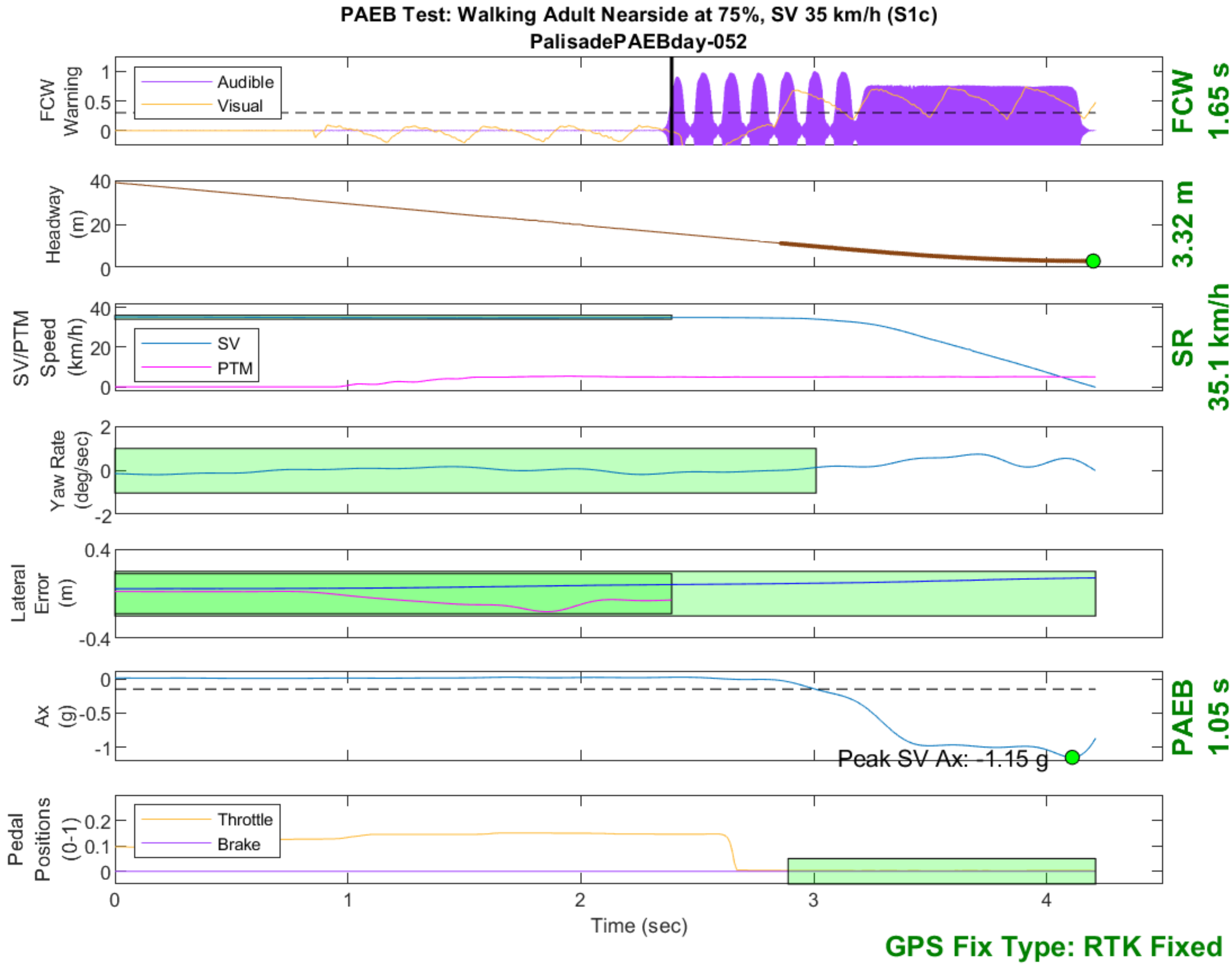


Figure D49. Time History for PAEB Run 52, S1c, Daytime, 35 km/h

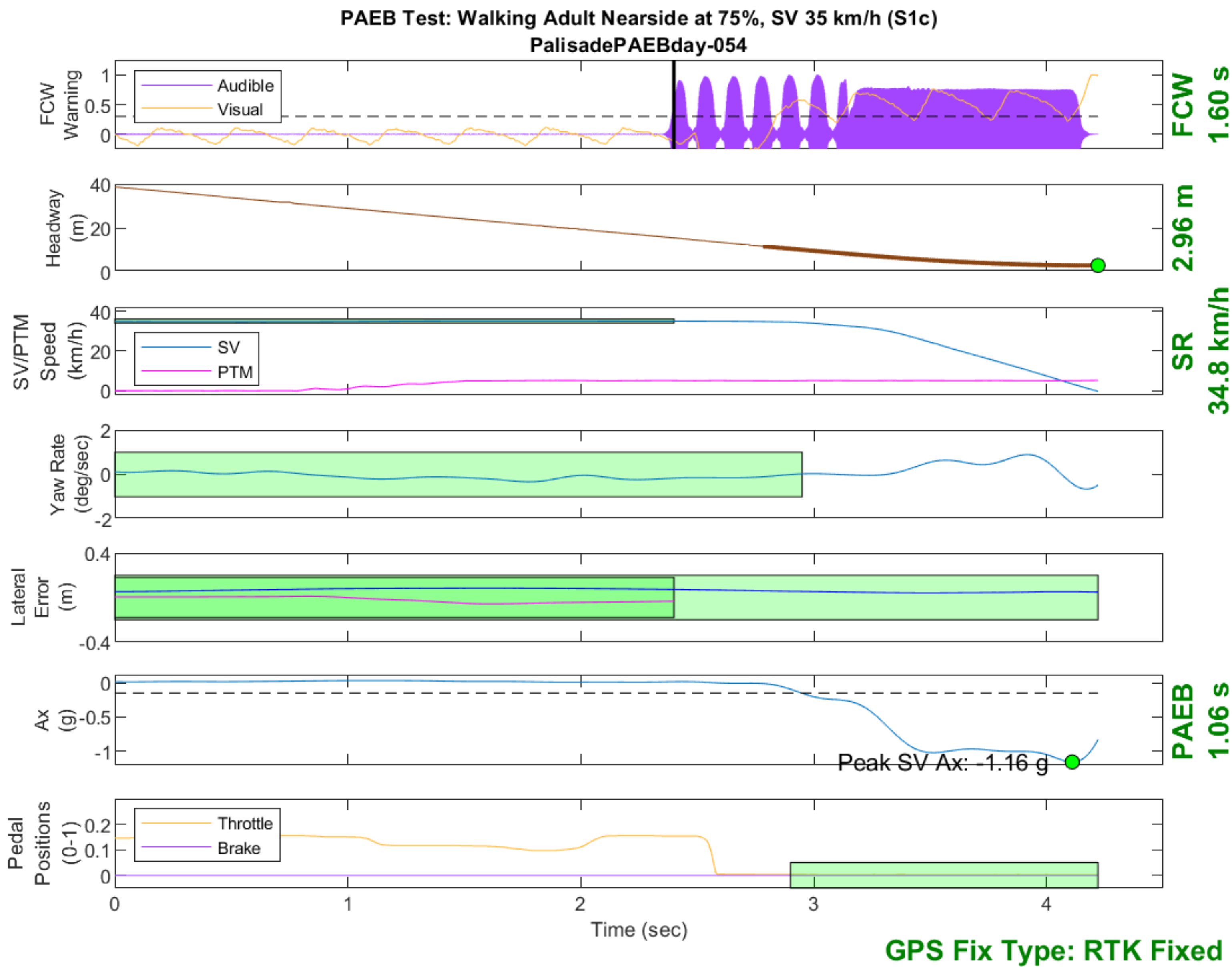


Figure D50. Time History for PAEB Run 54, S1c, Daytime, 35 km/h

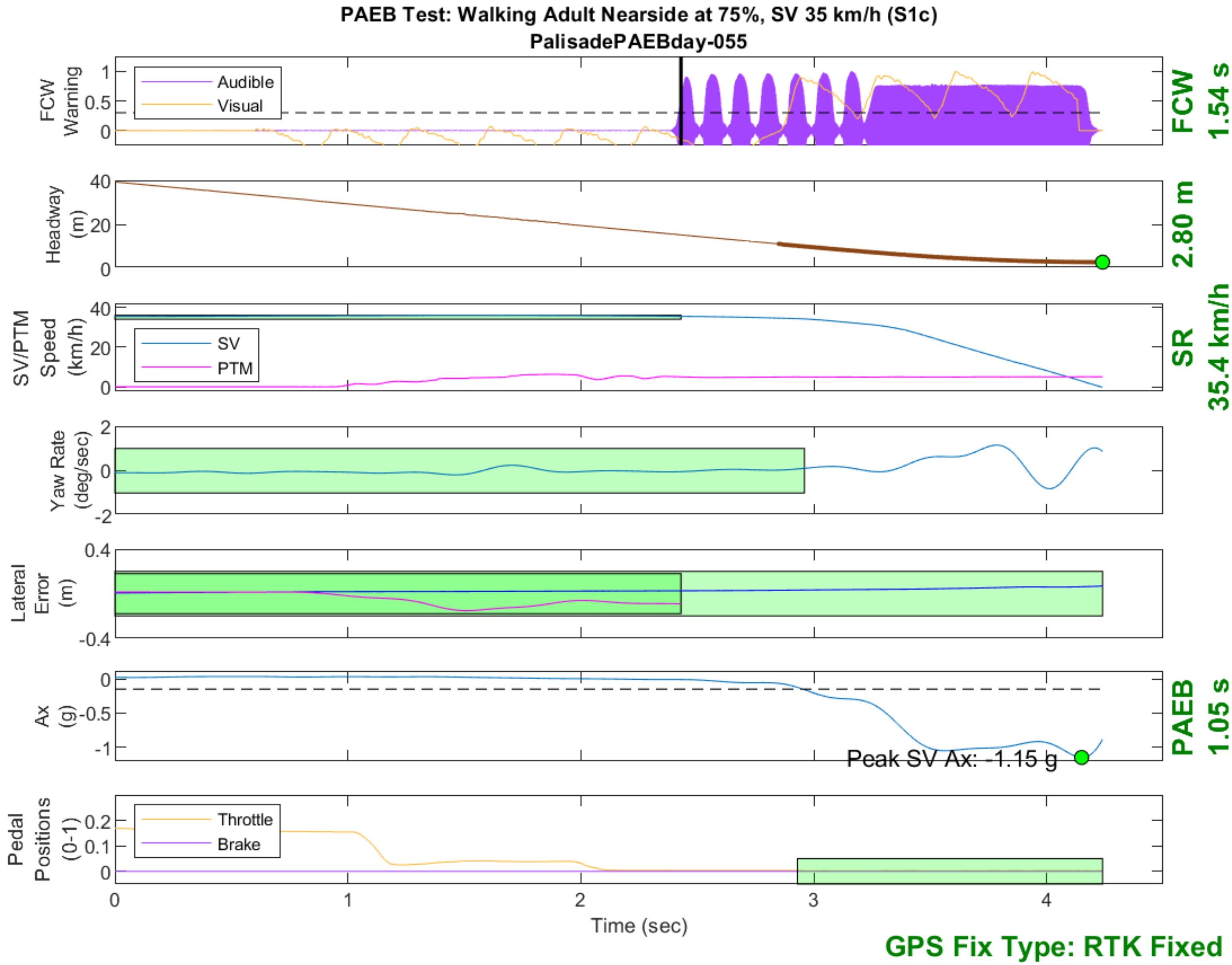


Figure D51. Time History for PAEB Run 55, S1c, Daytime, 35 km/h

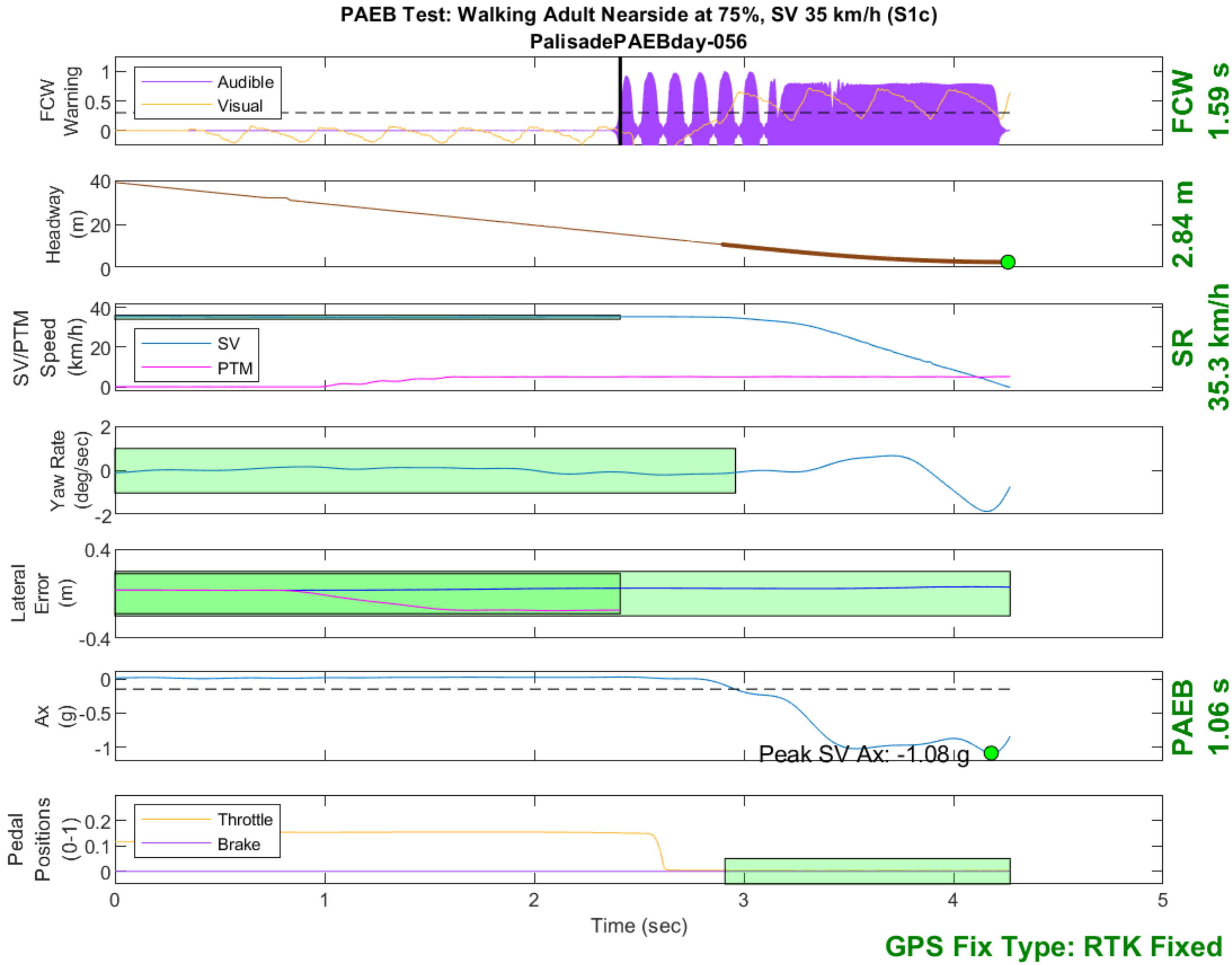


Figure D52. Time History for PAEB Run 56, S1c, Daytime, 35 km/h

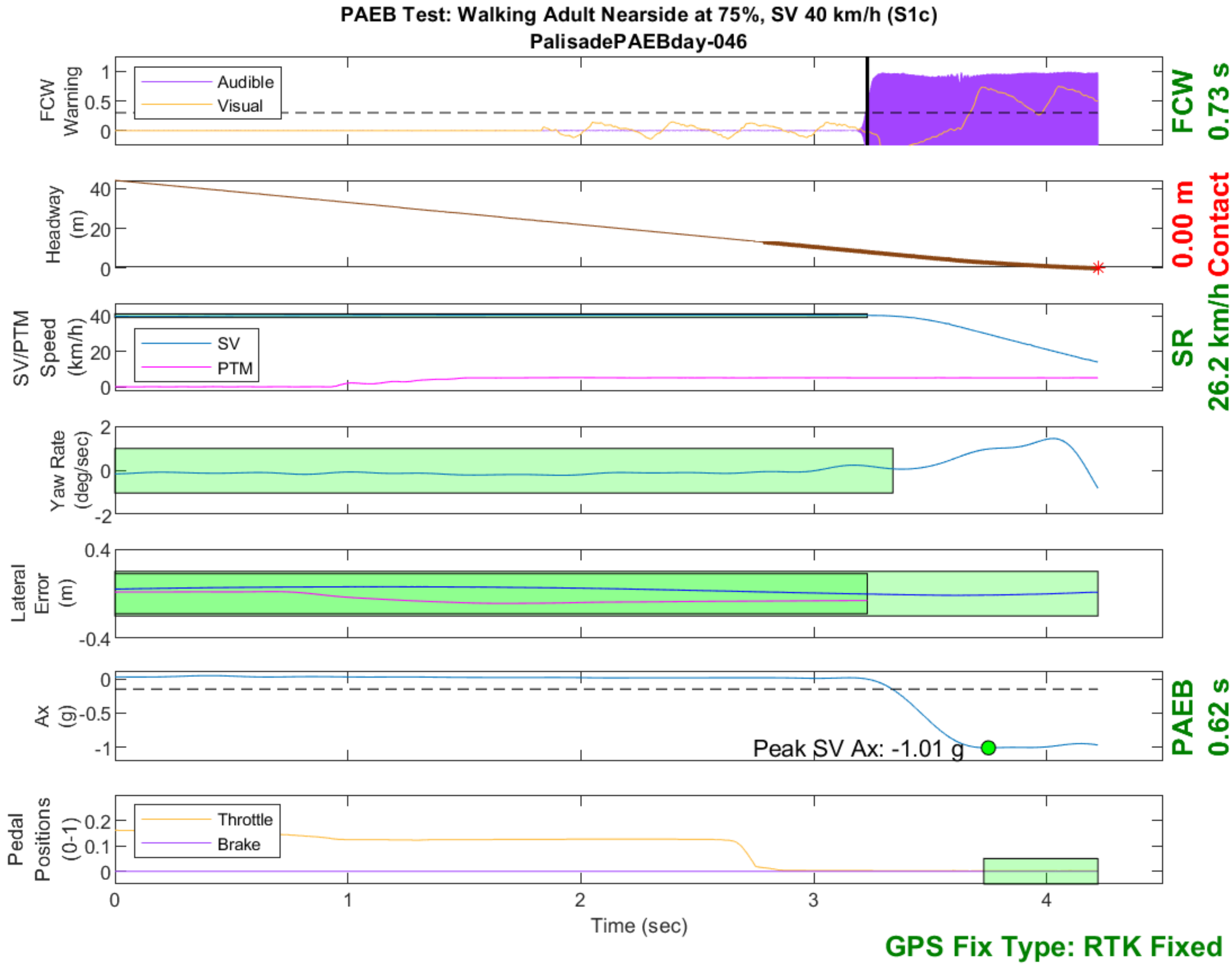


Figure D53. Time History for PAEB Run 46, S1c, Daytime, 40 km/h

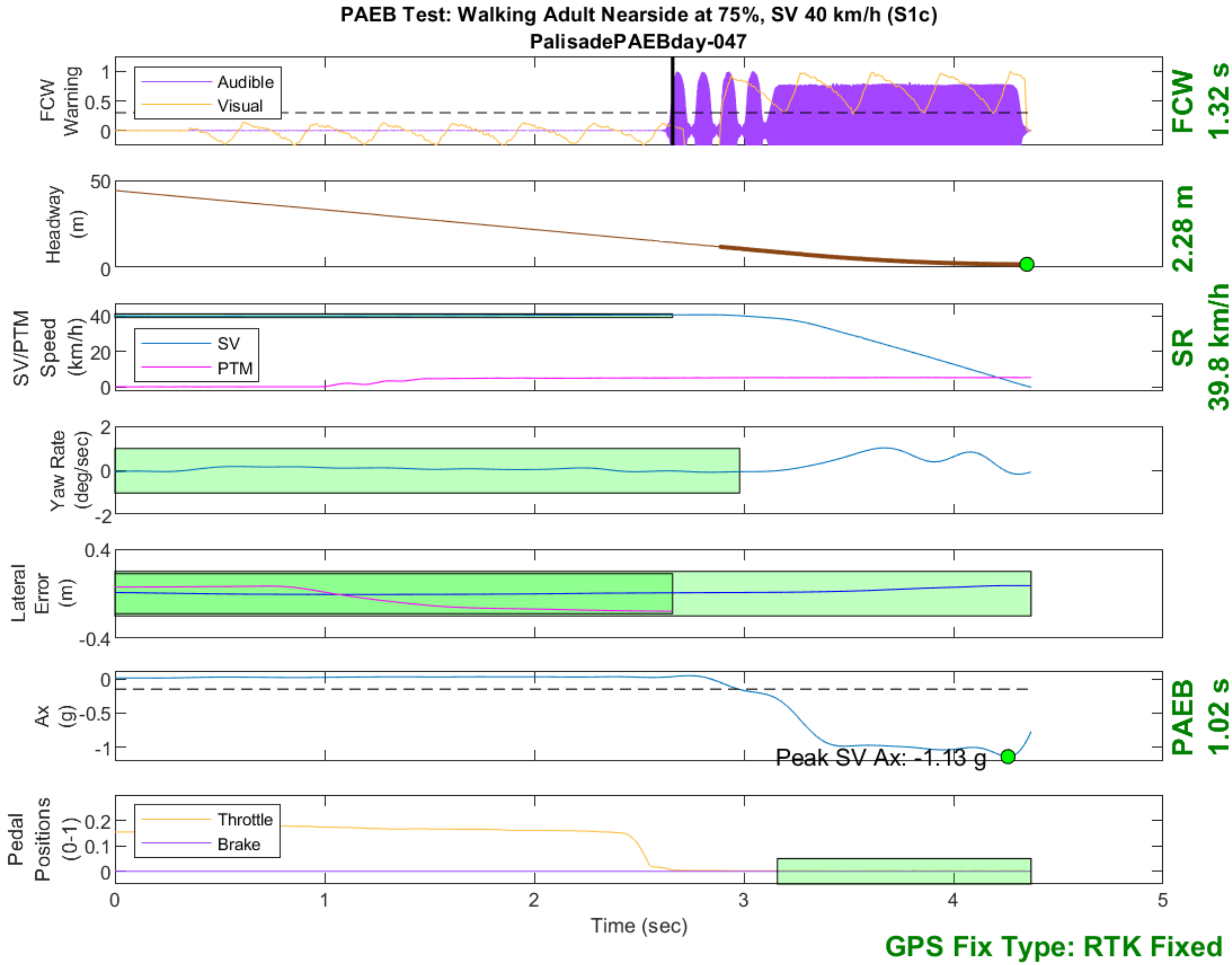


Figure D54. Time History for PAEB Run 47, S1c, Daytime, 40 km/h

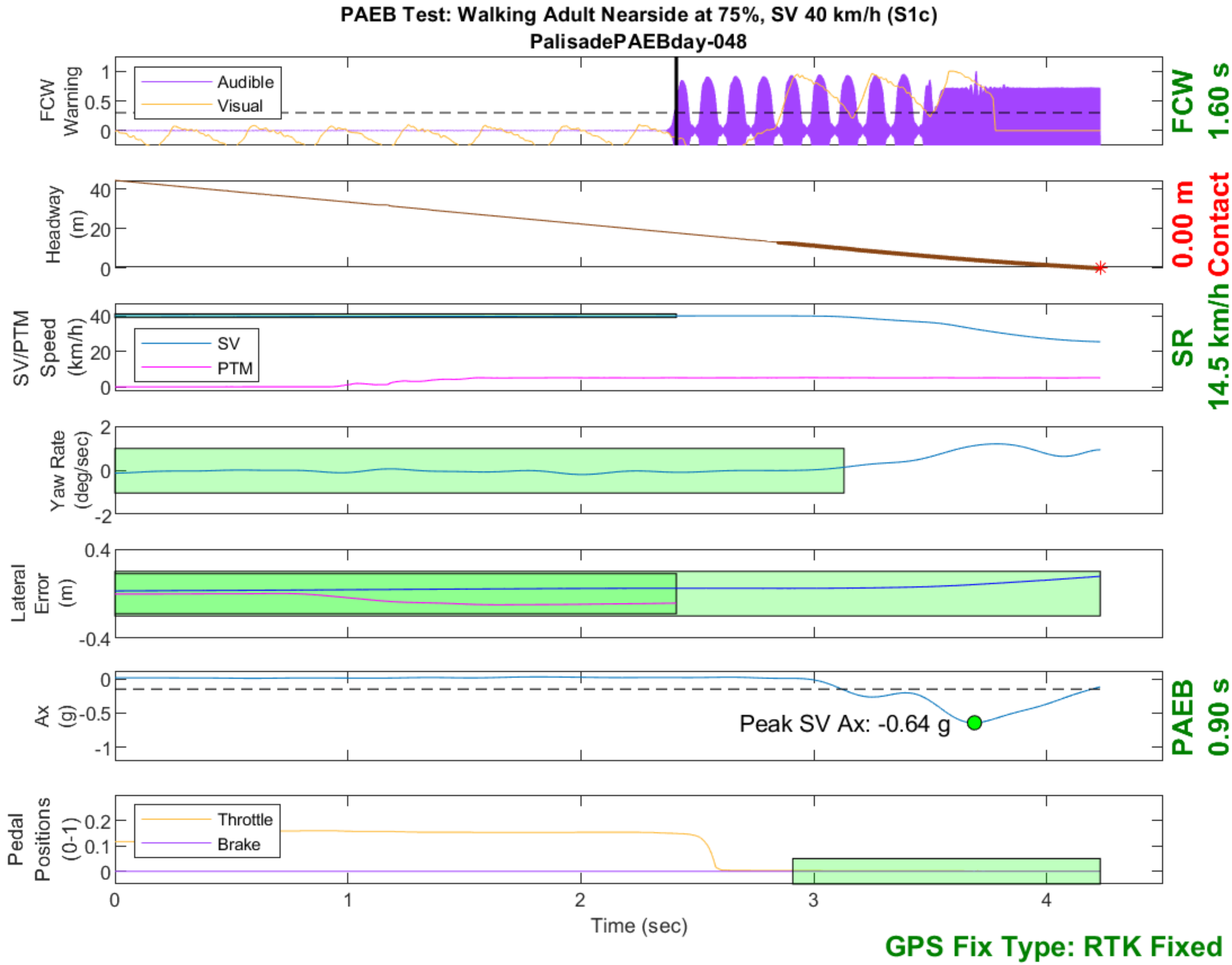


Figure D55. Time History for PAEB Run 48, S1c, Daytime, 40 km/h

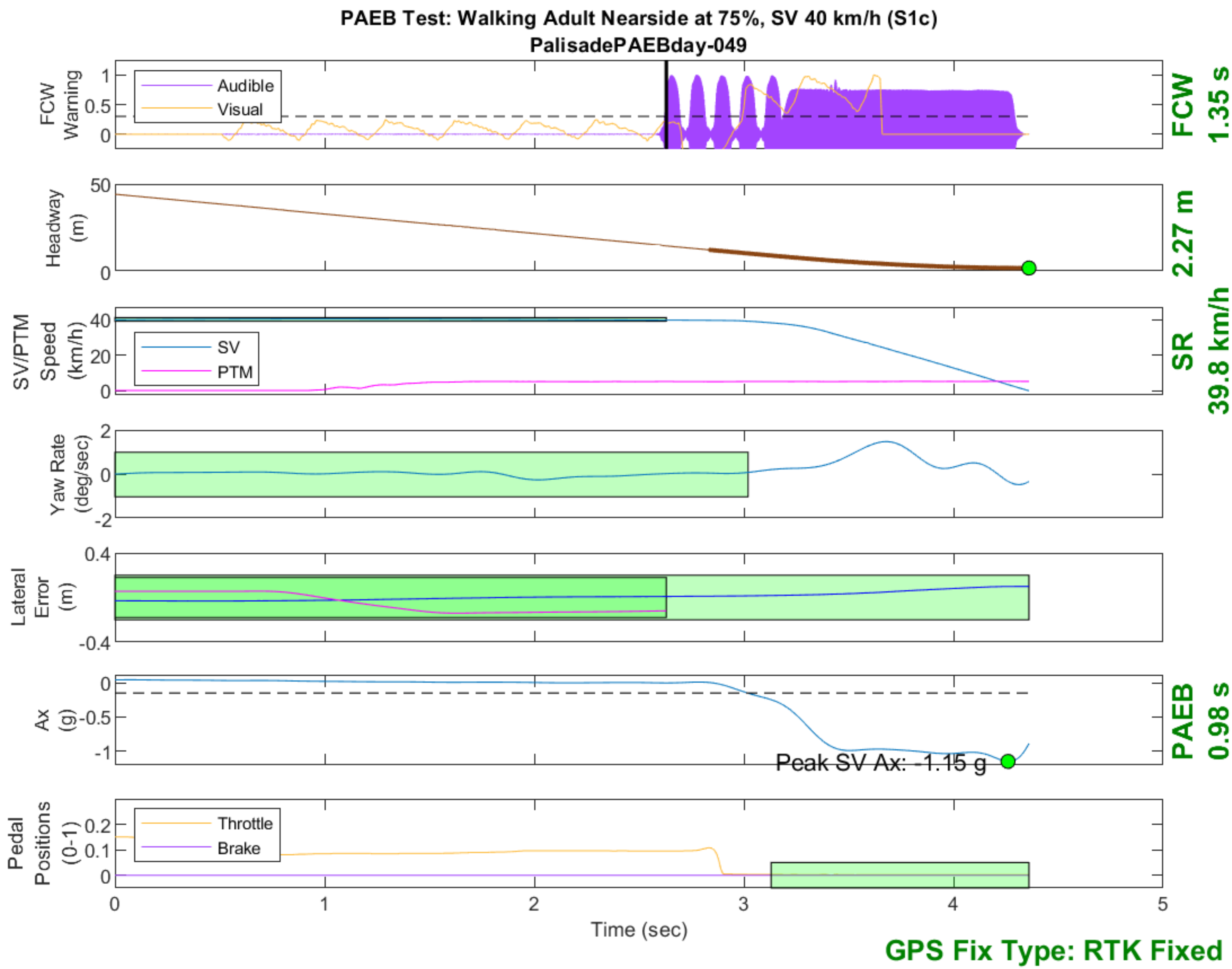


Figure D56. Time History for PAEB Run 49, S1c, Daytime, 40 km/h

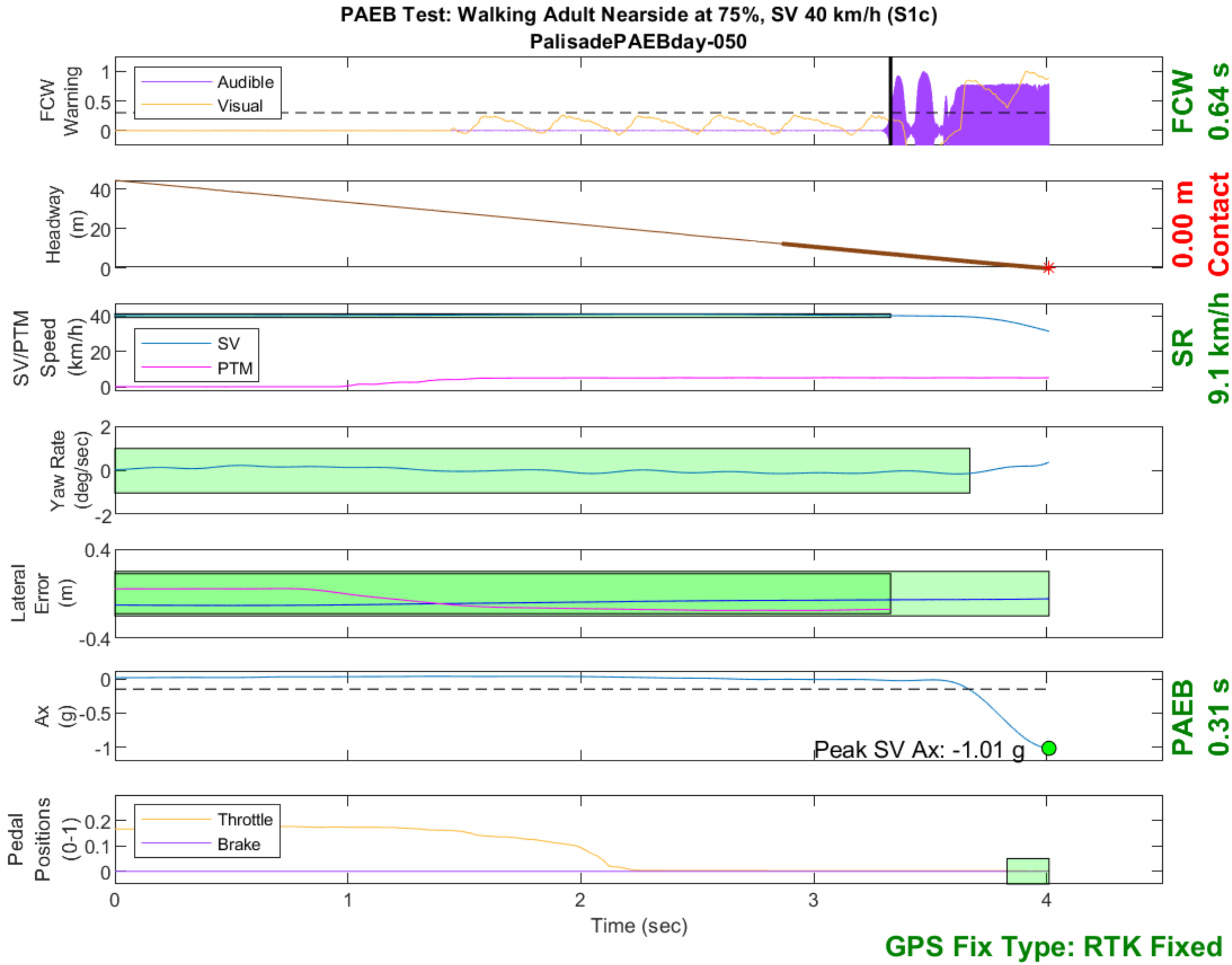


Figure D57. Time History for PAEB Run 50, S1c, Daytime, 40 km/h

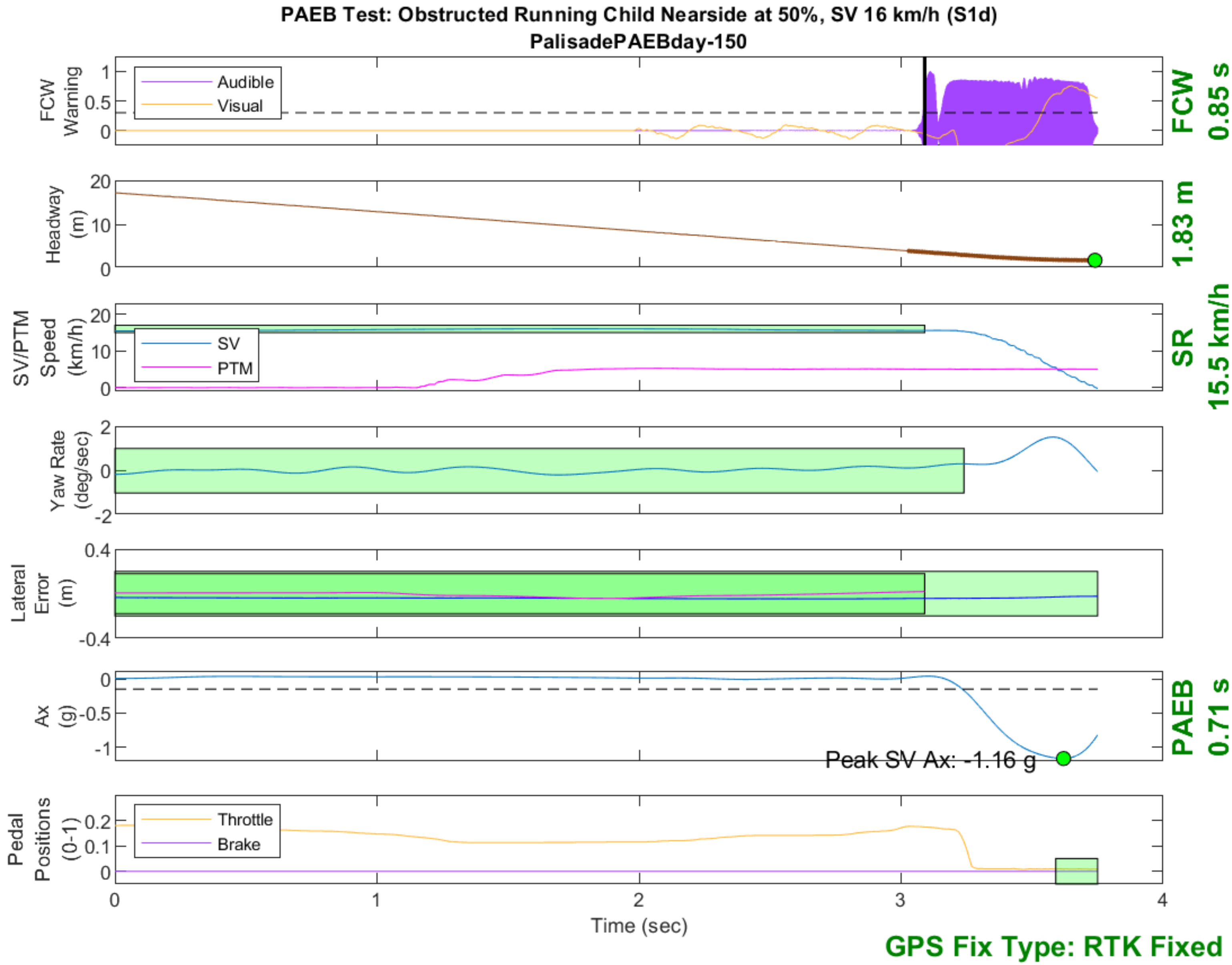


Figure D58. Time History for PAEB Run 150, S1d, Daytime, 16 km/h

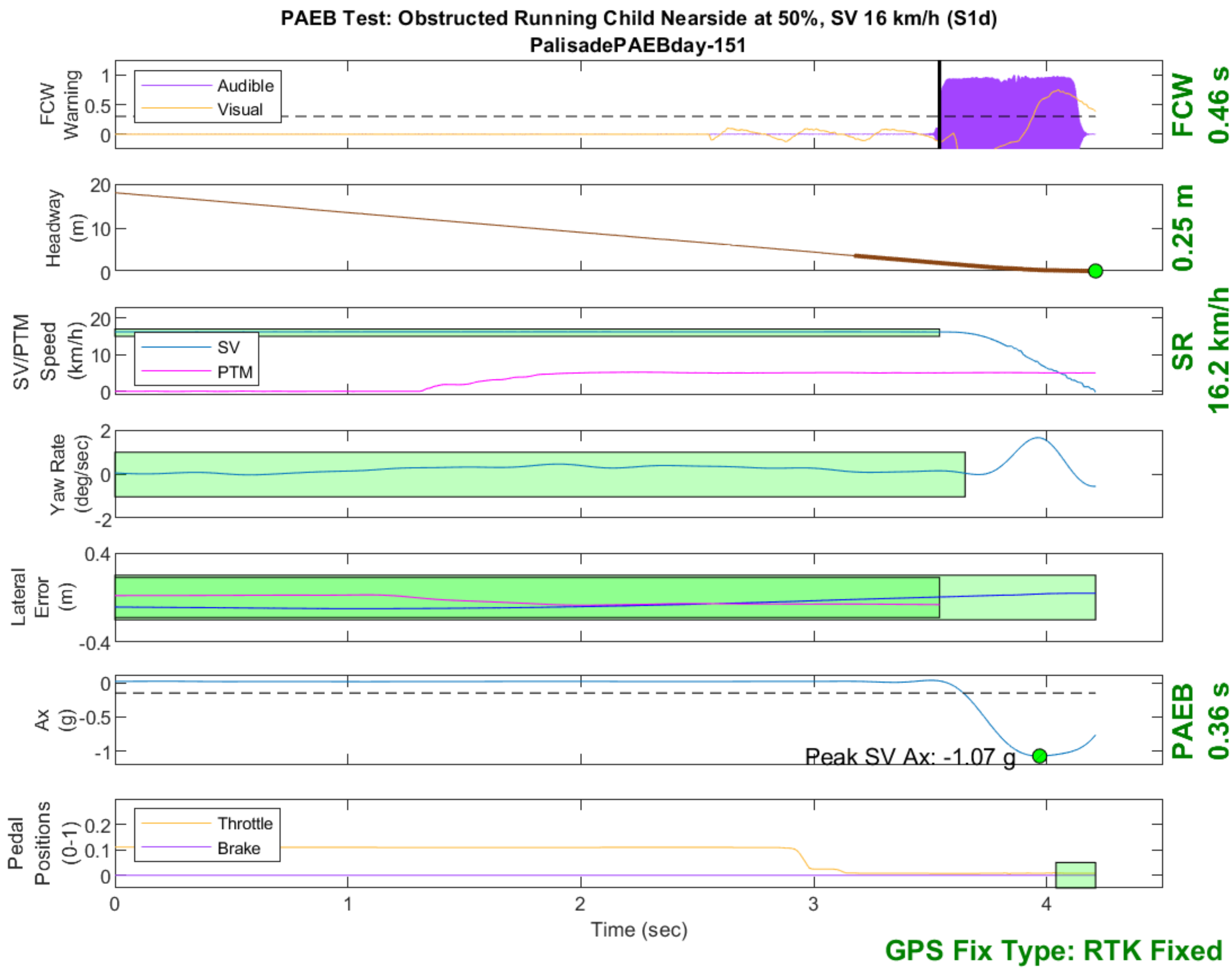


Figure D59. Time History for PAEB Run 151, S1d, Daytime, 16 km/h

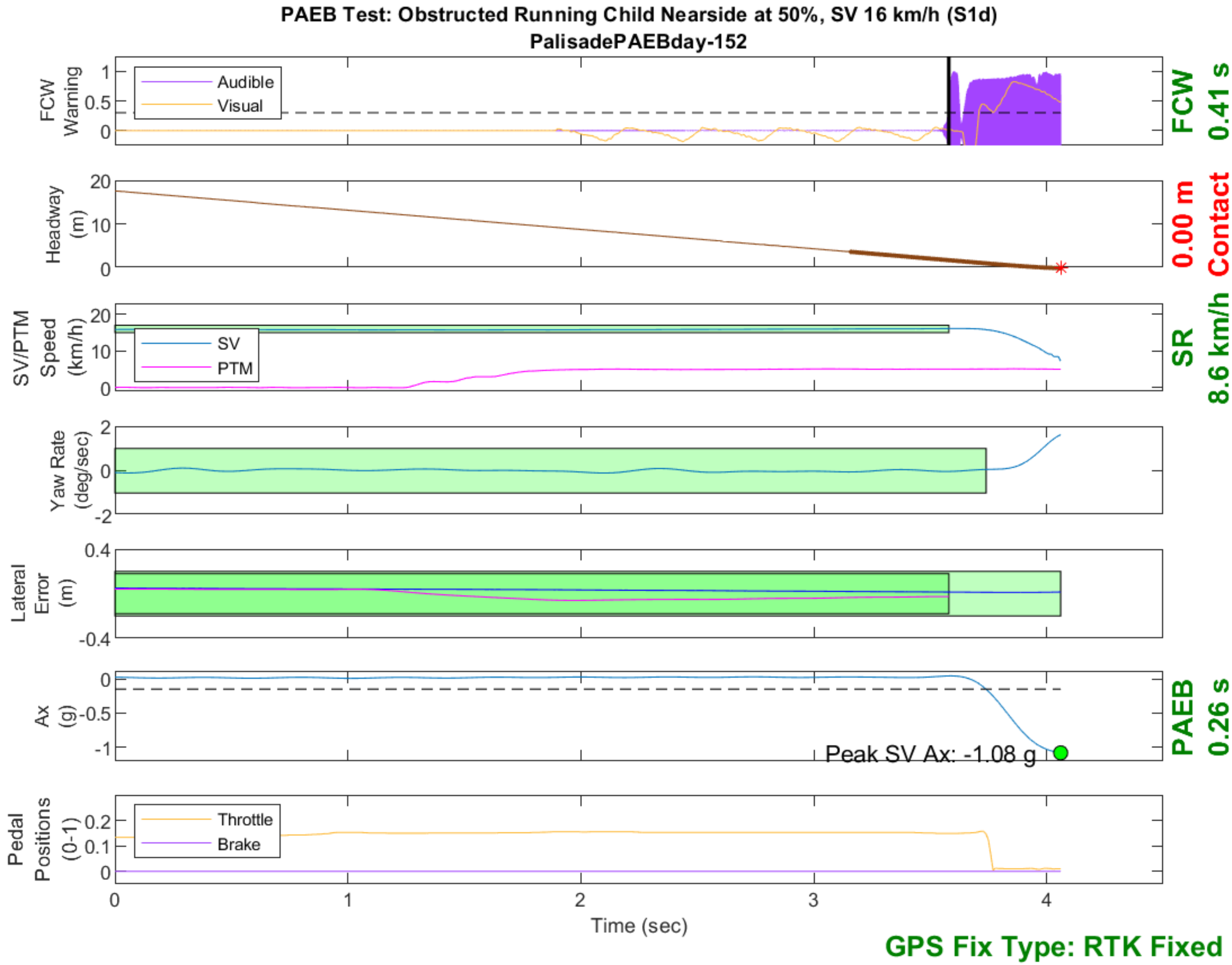


Figure D60. Time History for PAEB Run 152, S1d, Daytime, 16 km/h

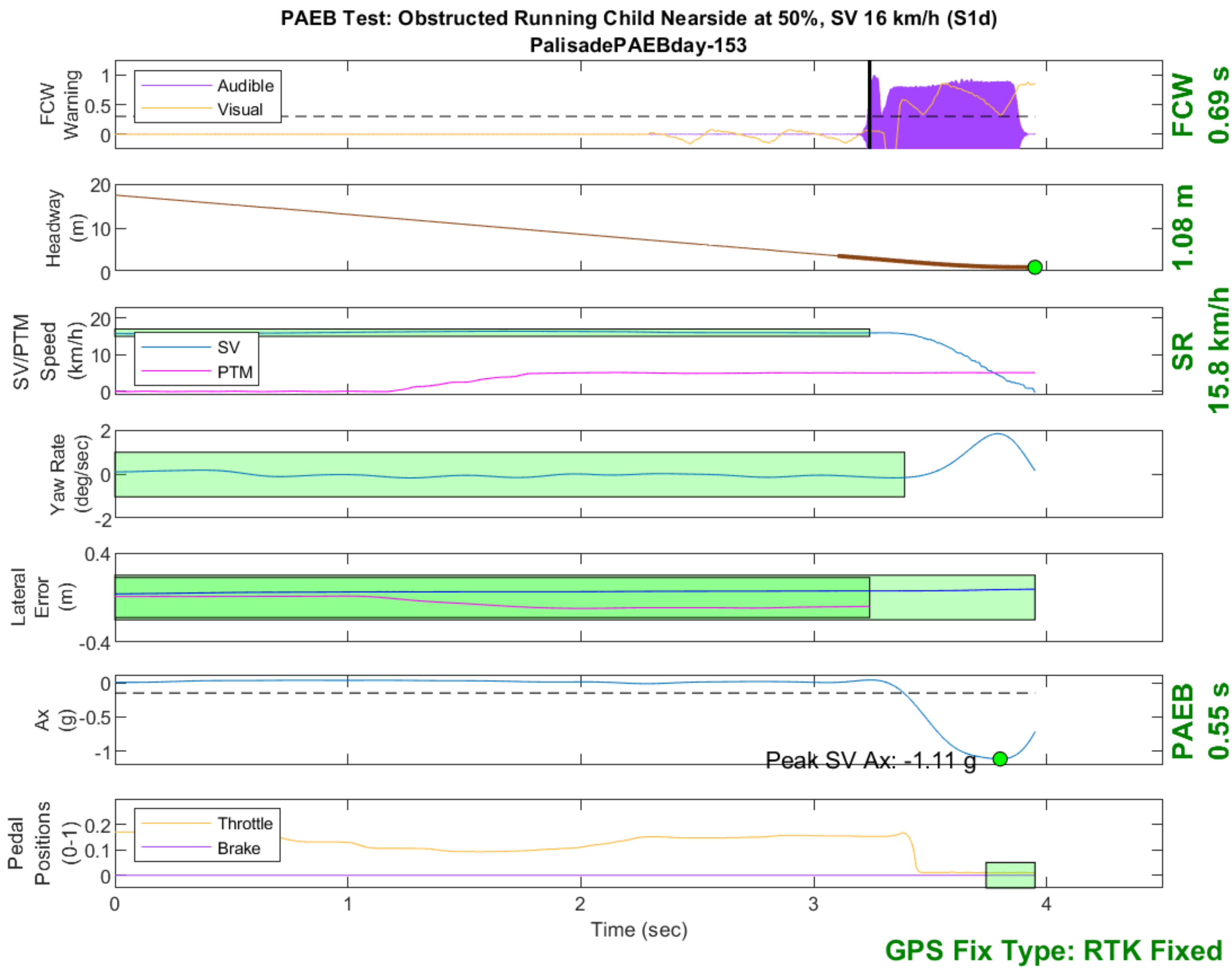


Figure D61. Time History for PAEB Run 153, S1d, Daytime, 16 km/h

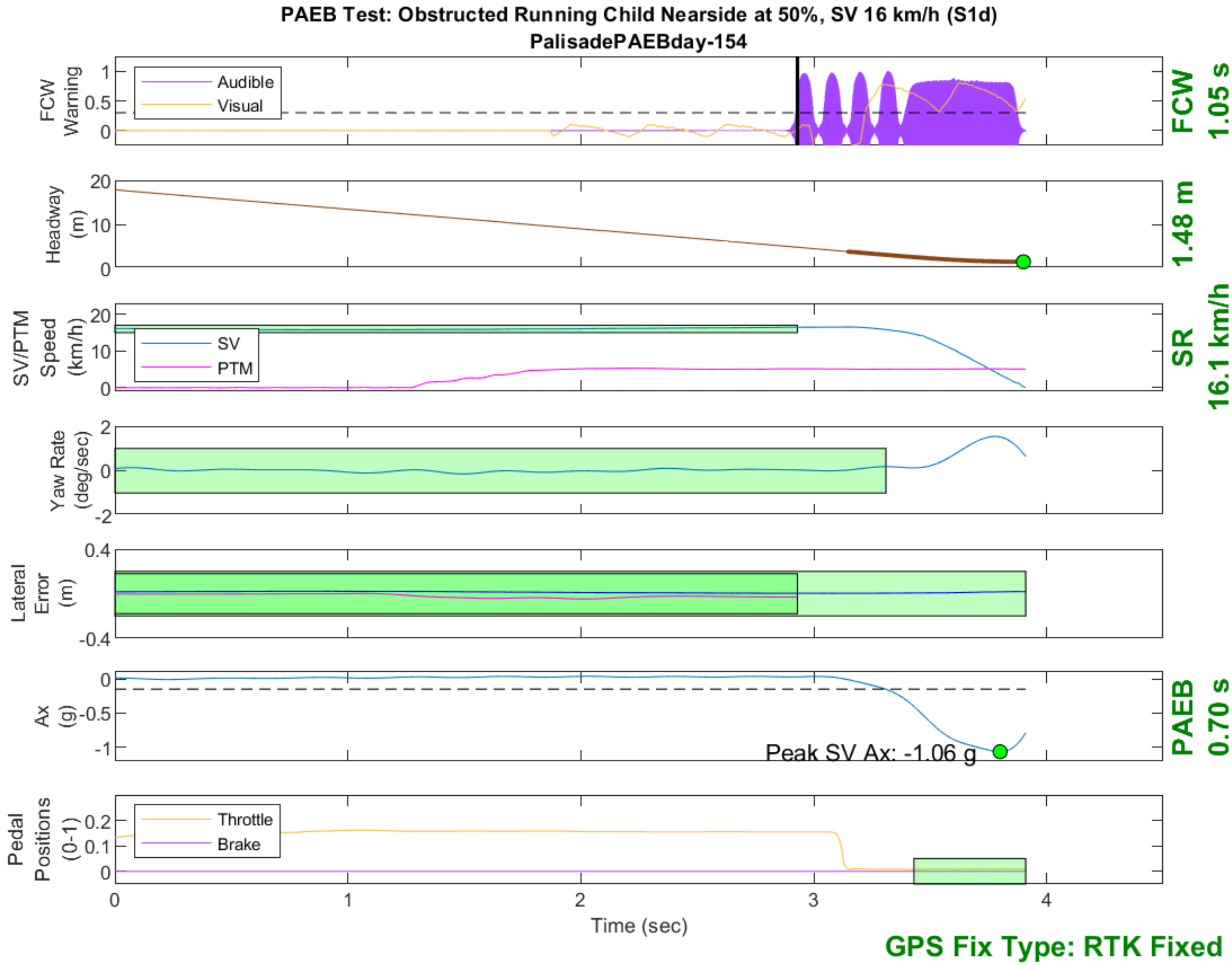


Figure D62. Time History for PAEB Run 154, S1d, Daytime, 16 km/h

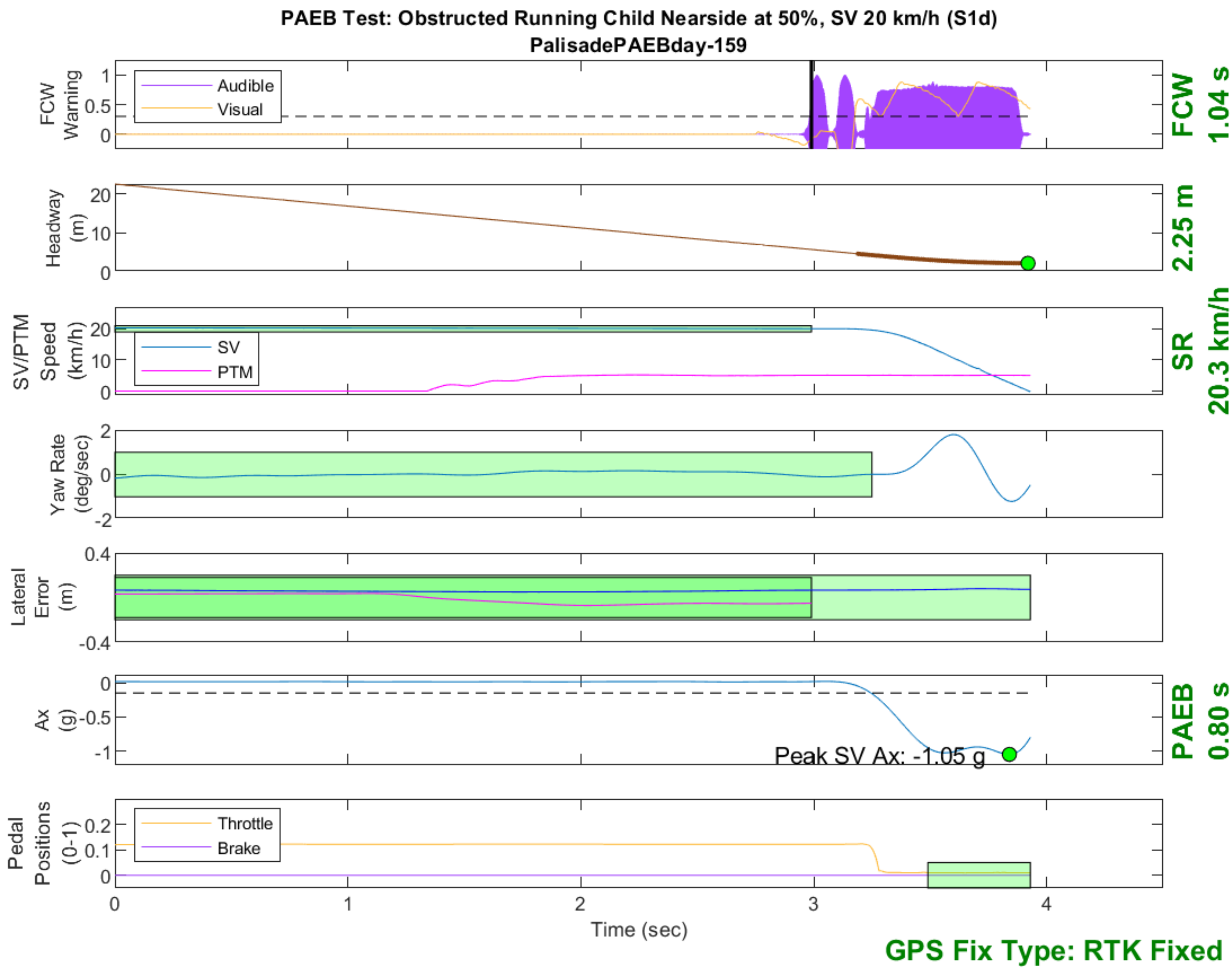


Figure D63. Time History for PAEB Run 159, S1d, Daytime, 20 km/h

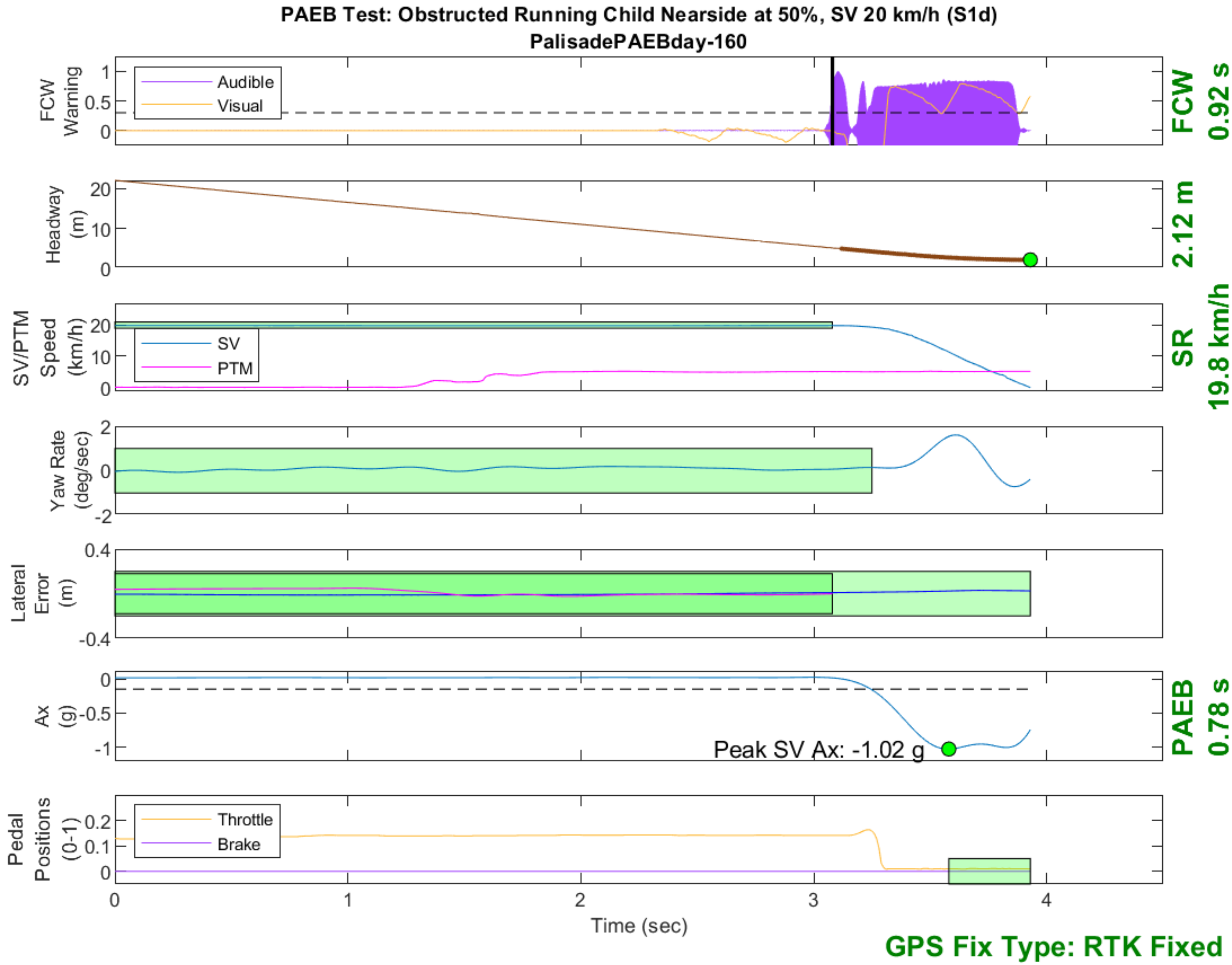


Figure D64. Time History for PAEB Run 160, S1d, Daytime, 20 km/h

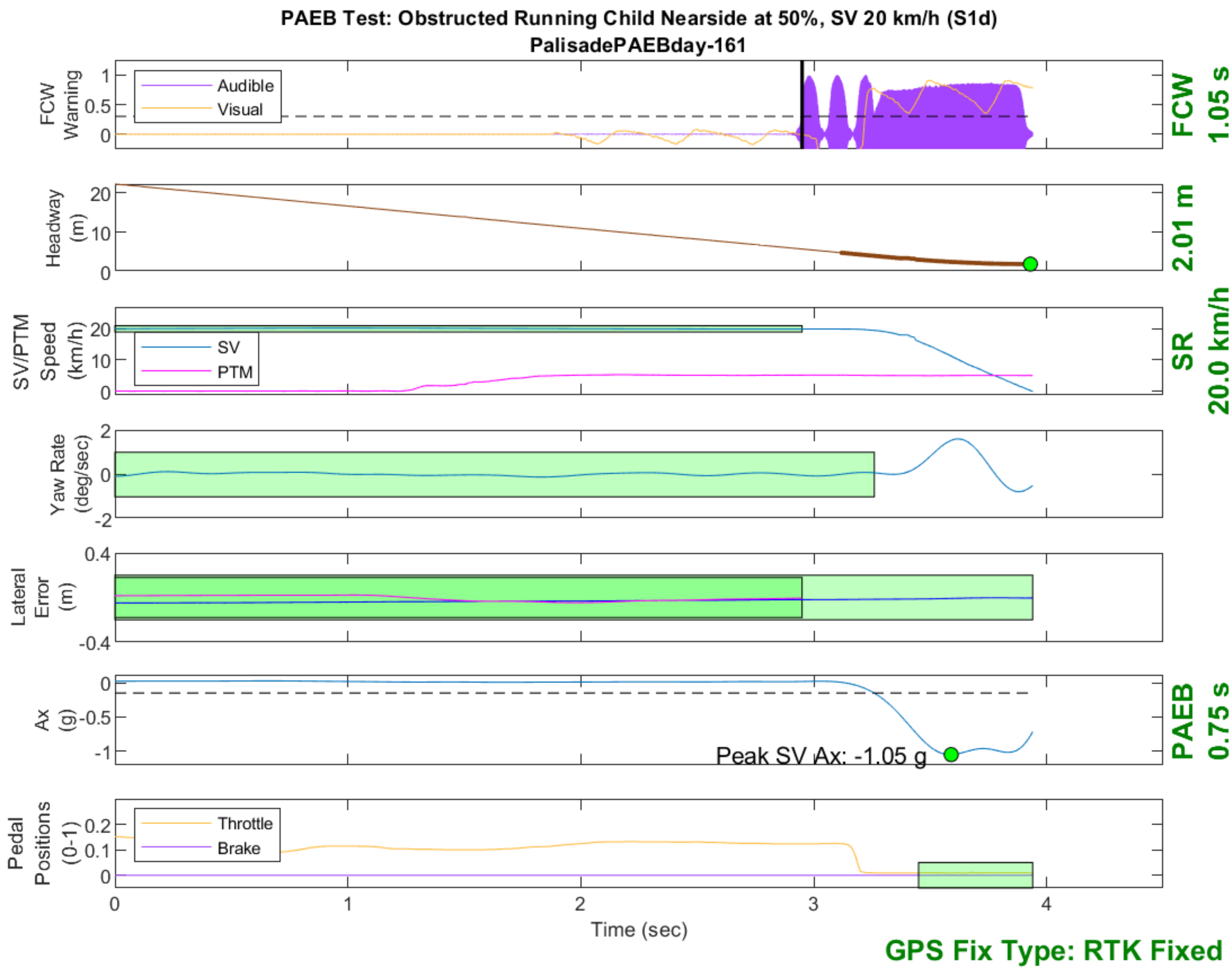


Figure D65. Time History for PAEB Run 161, S1d, Daytime, 20 km/h

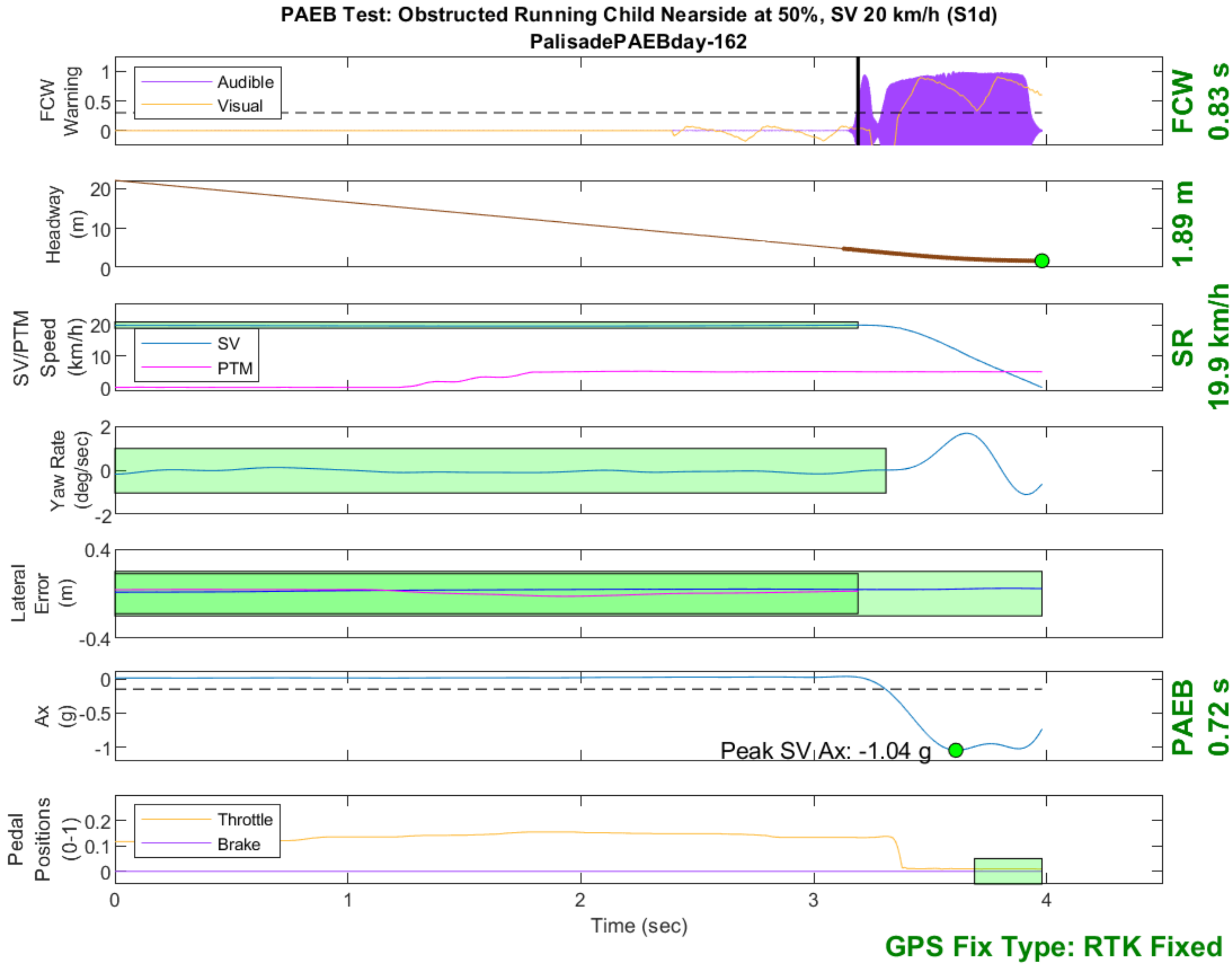


Figure D66. Time History for PAEB Run 162, S1d, Daytime, 20 km/h

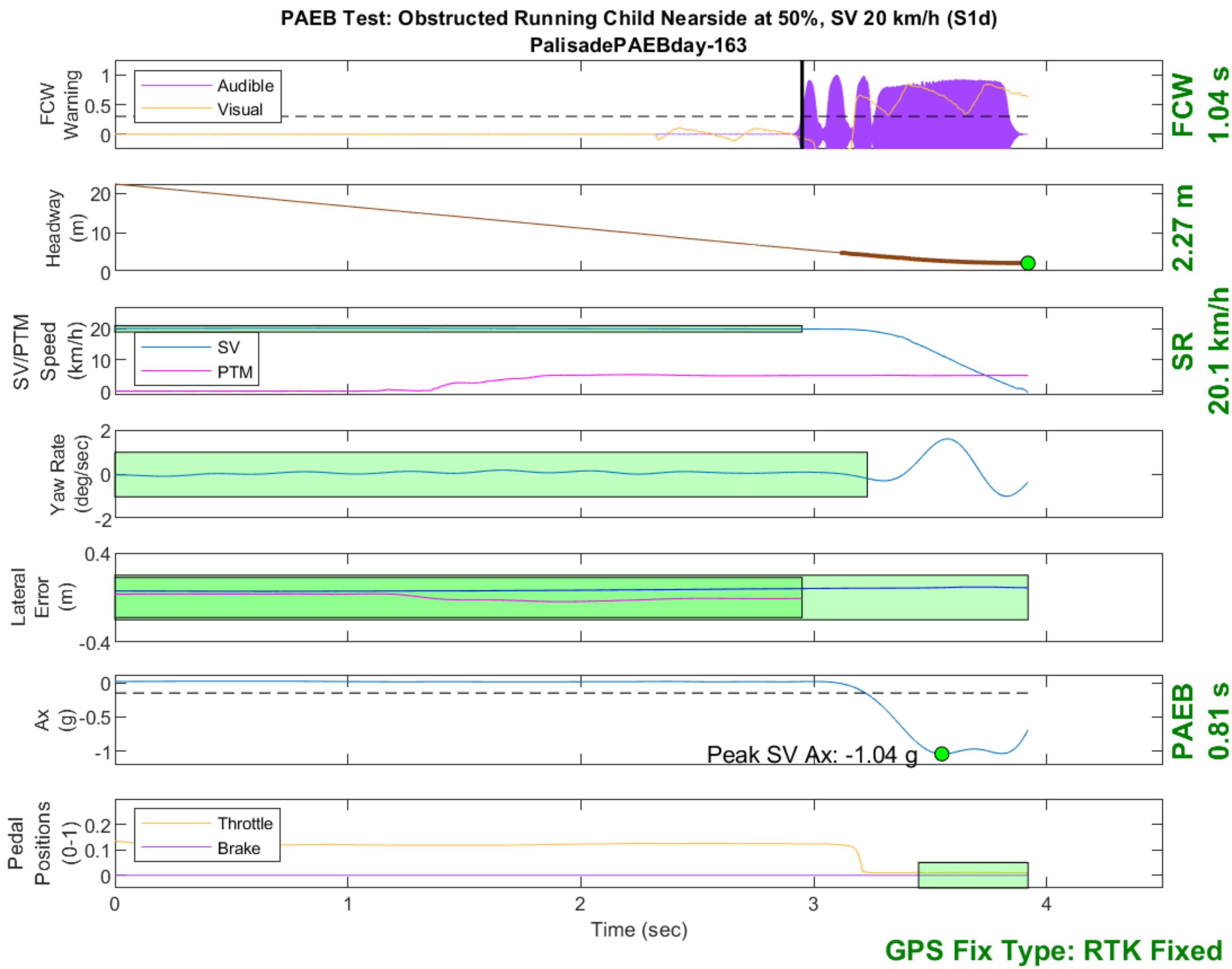


Figure D67. Time History for PAEB Run 163, S1d, Daytime, 20 km/h

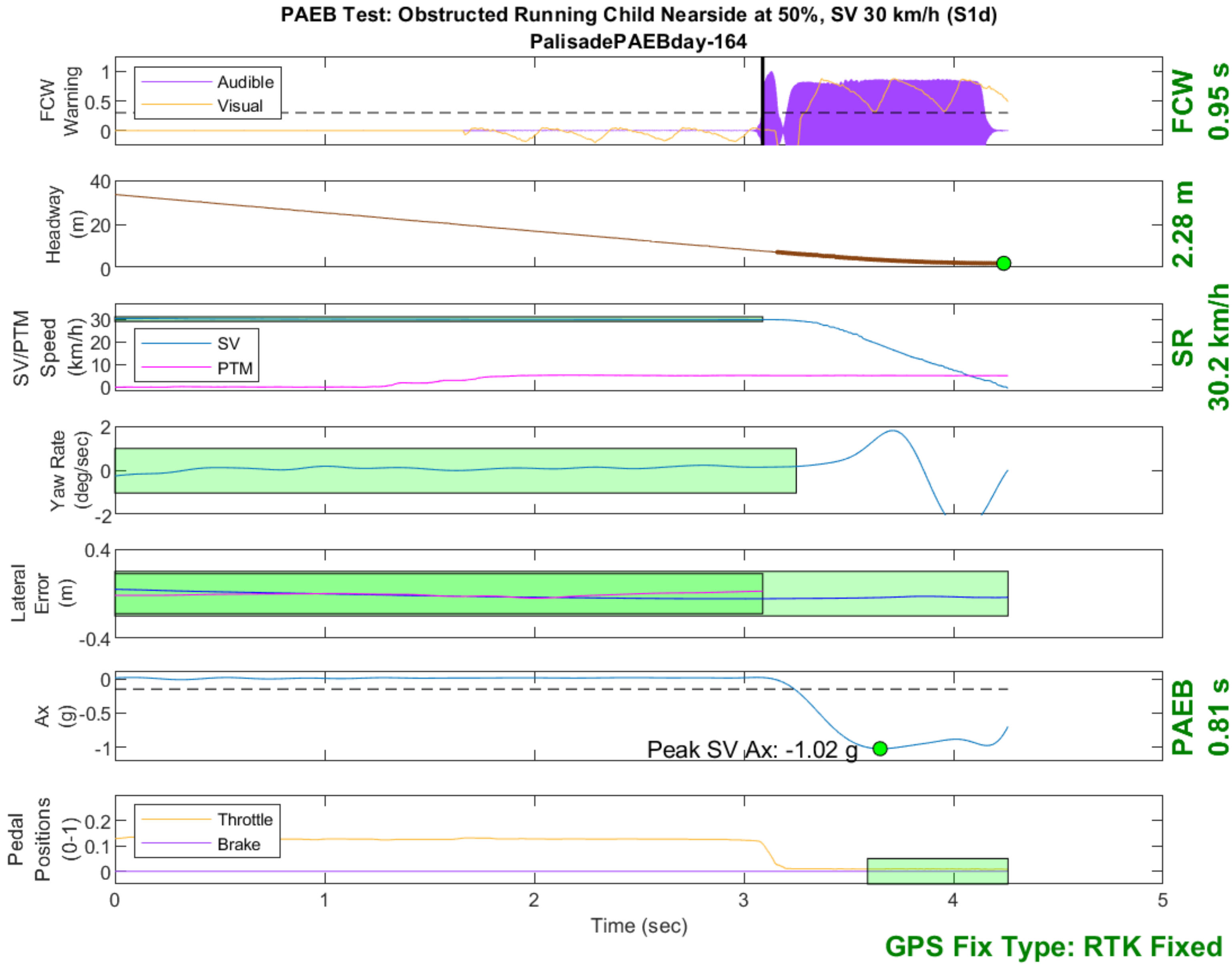


Figure D68. Time History for PAEB Run 164, S1d, Daytime, 30 km/h

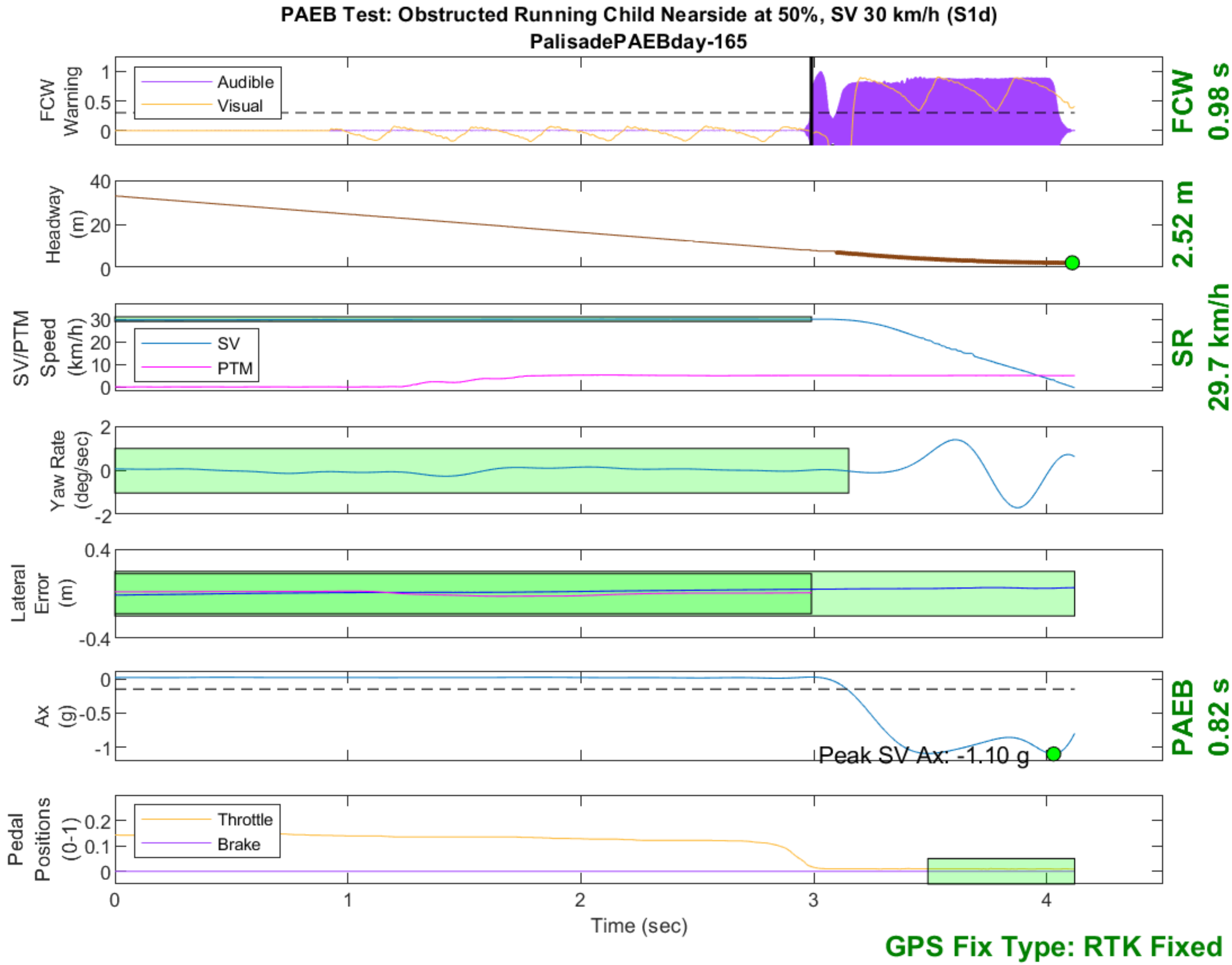


Figure D69. Time History for PAEB Run 165, S1d, Daytime, 30 km/h

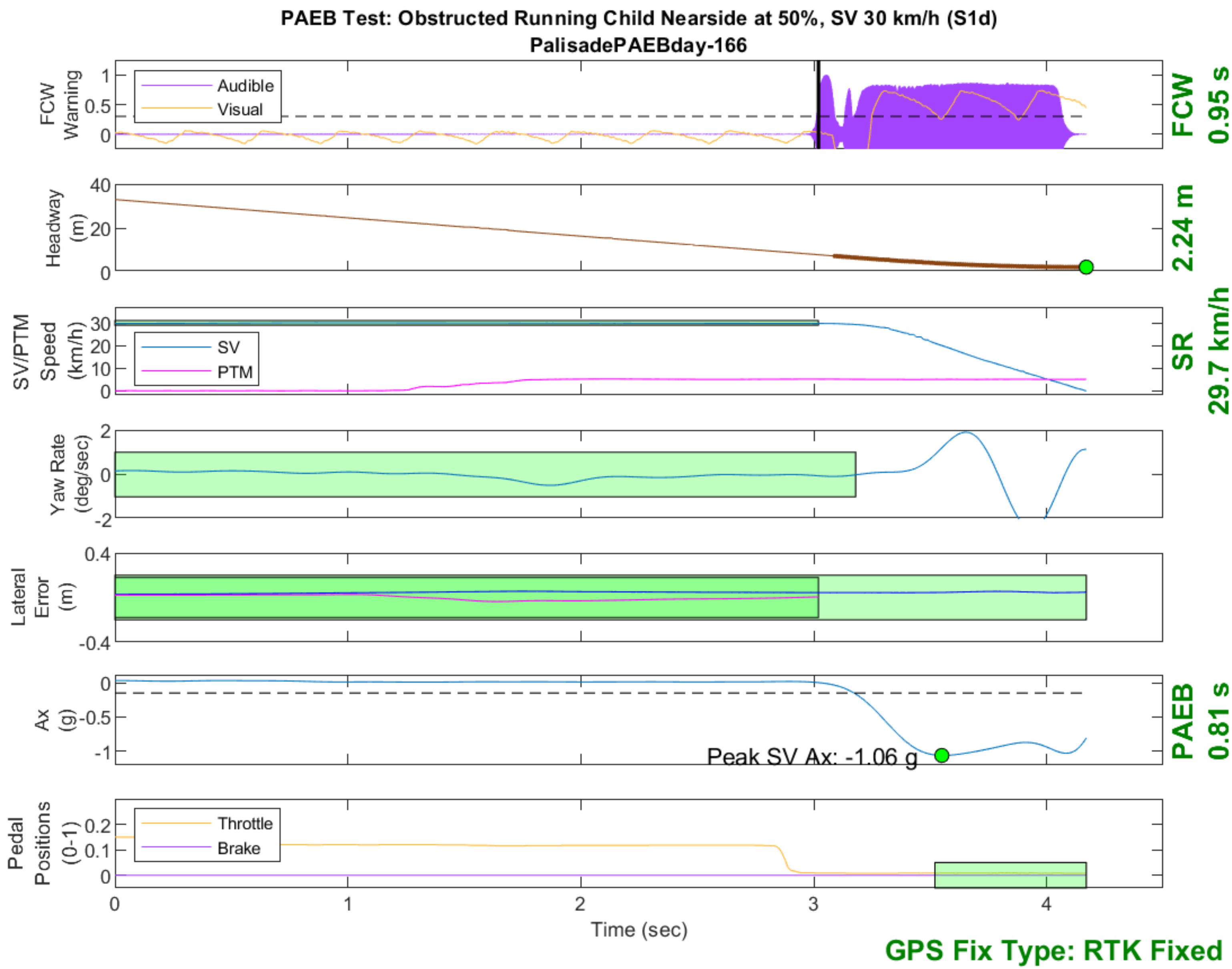


Figure D70. Time History for PAEB Run 166, S1d, Daytime, 30 km/h

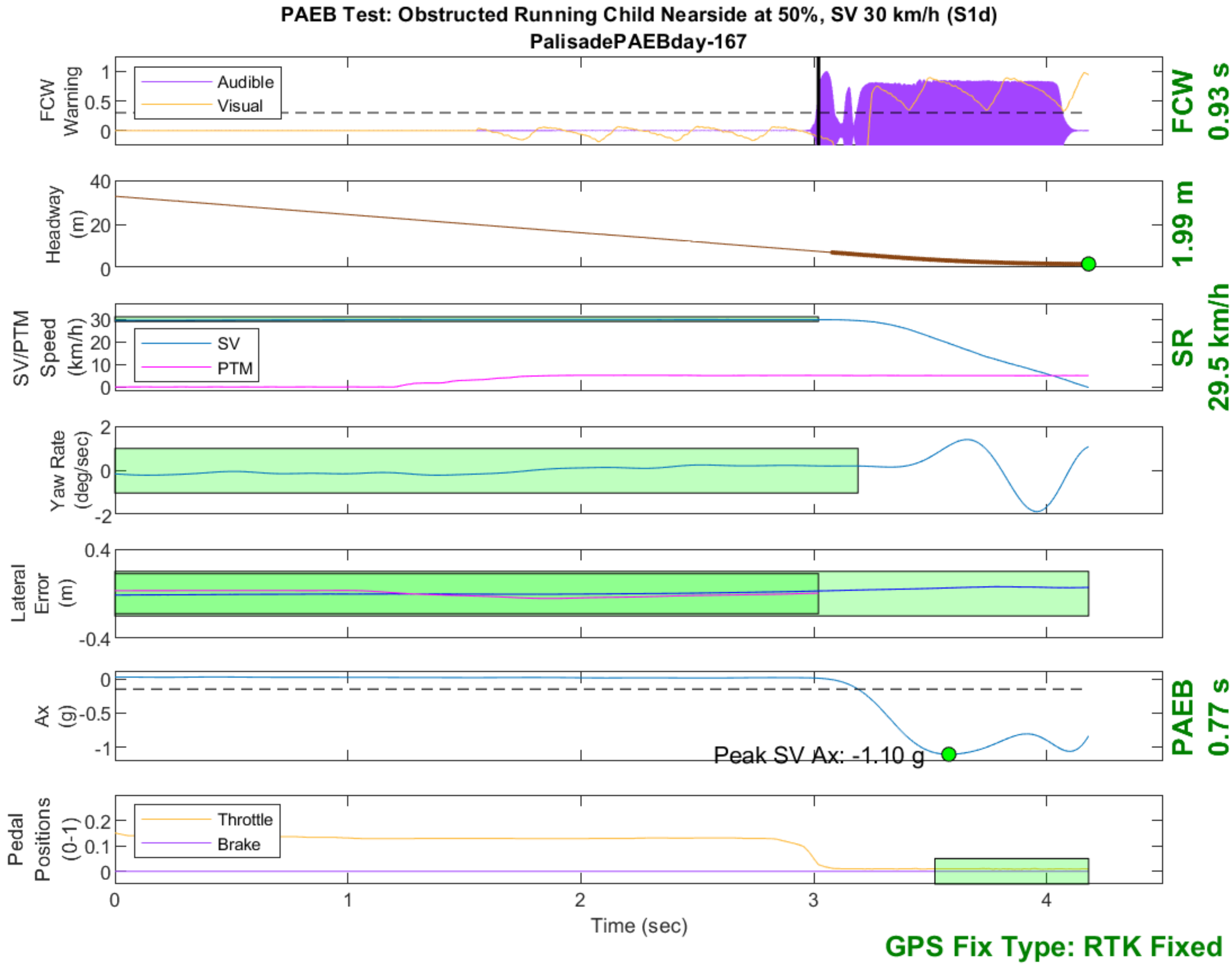


Figure D71. Time History for PAEB Run 167, S1d, Daytime, 30 km/h

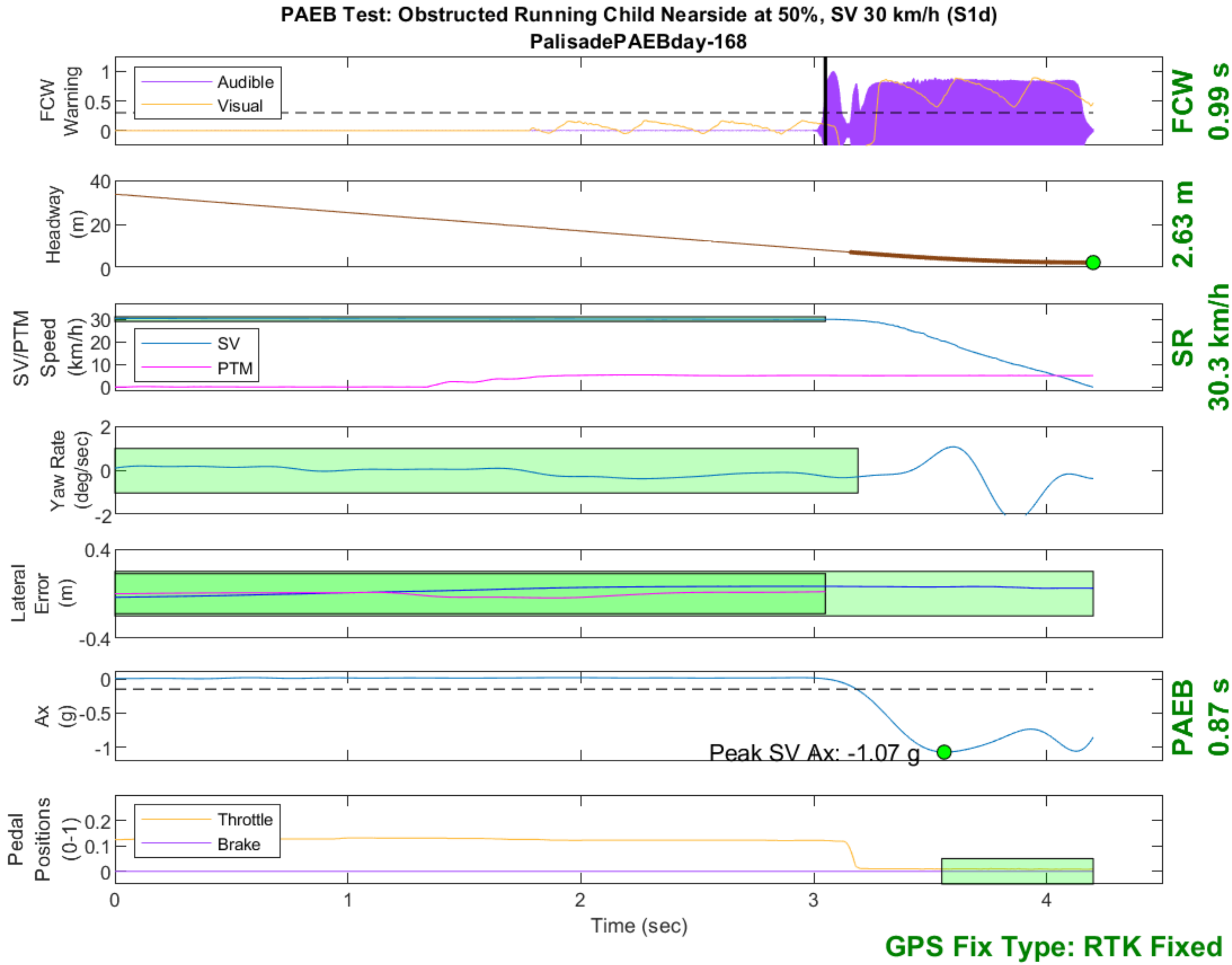


Figure D72. Time History for PAEB Run 168, S1d, Daytime, 30 km/h

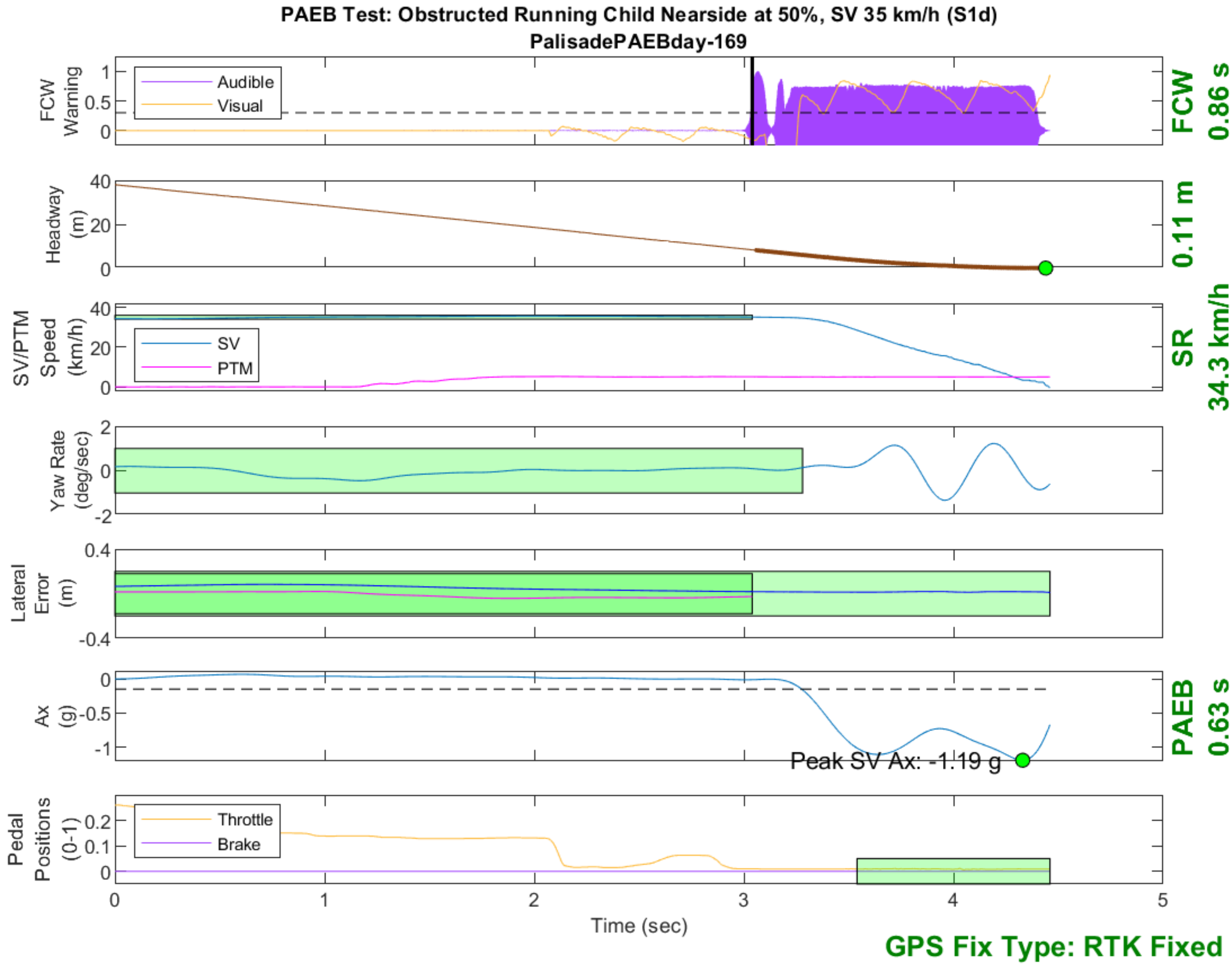


Figure D73. Time History for PAEB Run 169, S1d, Daytime, 35 km/h

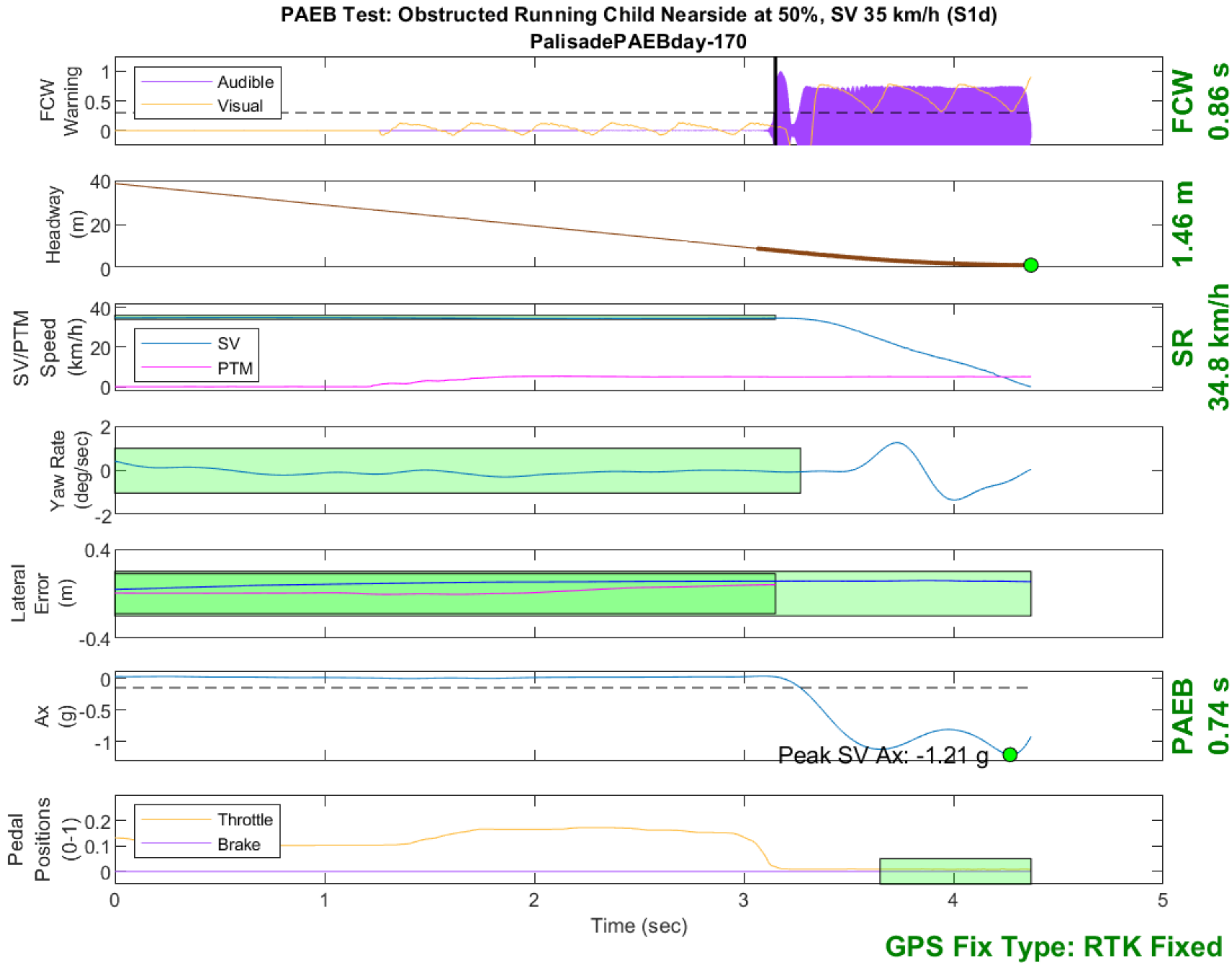


Figure D74. Time History for PAEB Run 170, S1d, Daytime, 35 km/h

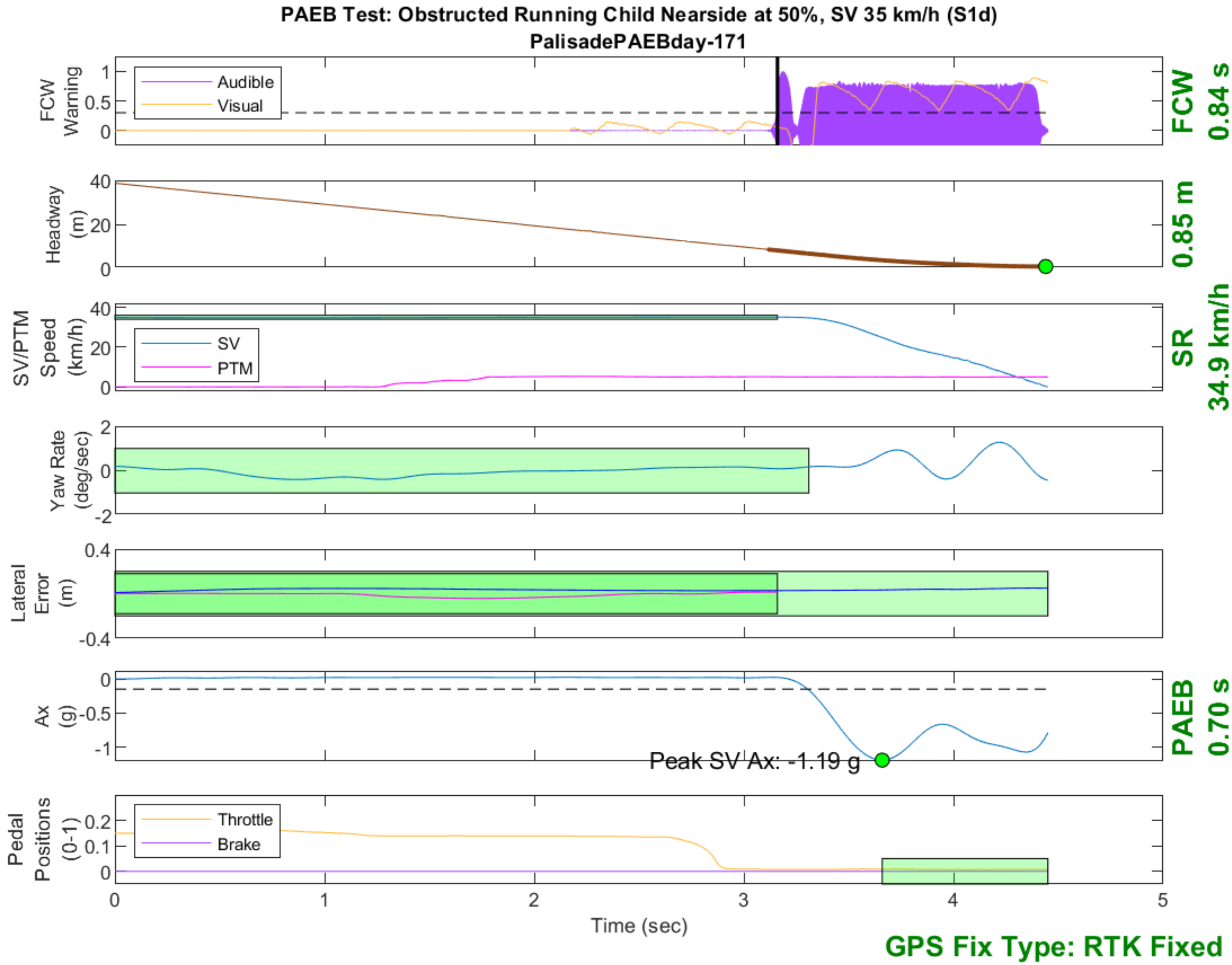


Figure D75. Time History for PAEB Run 171, S1d, Daytime, 35 km/h

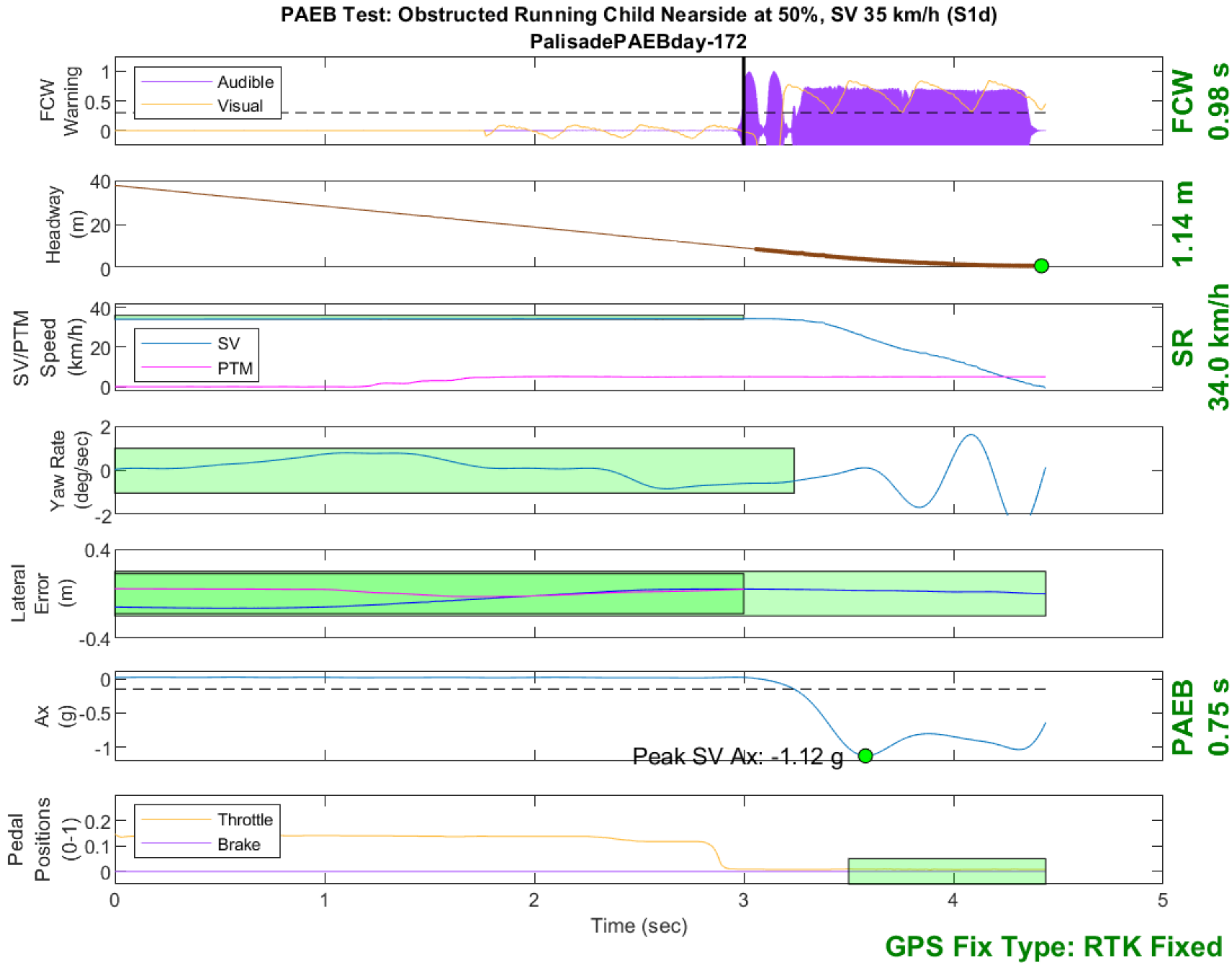


Figure D76. Time History for PAEB Run 172, S1d, Daytime, 35 km/h

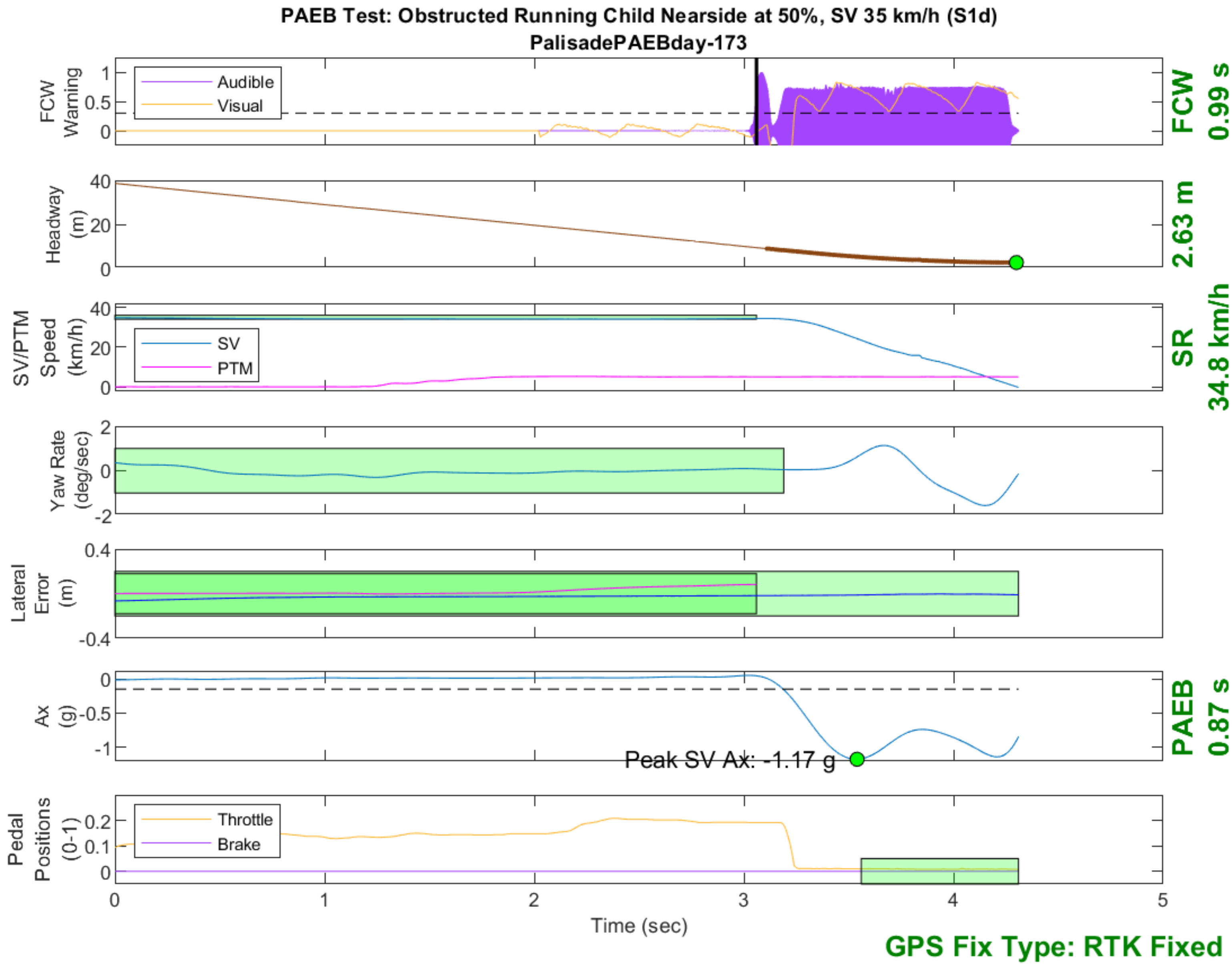


Figure D77. Time History for PAEB Run 173, S1d, Daytime, 35 km/h

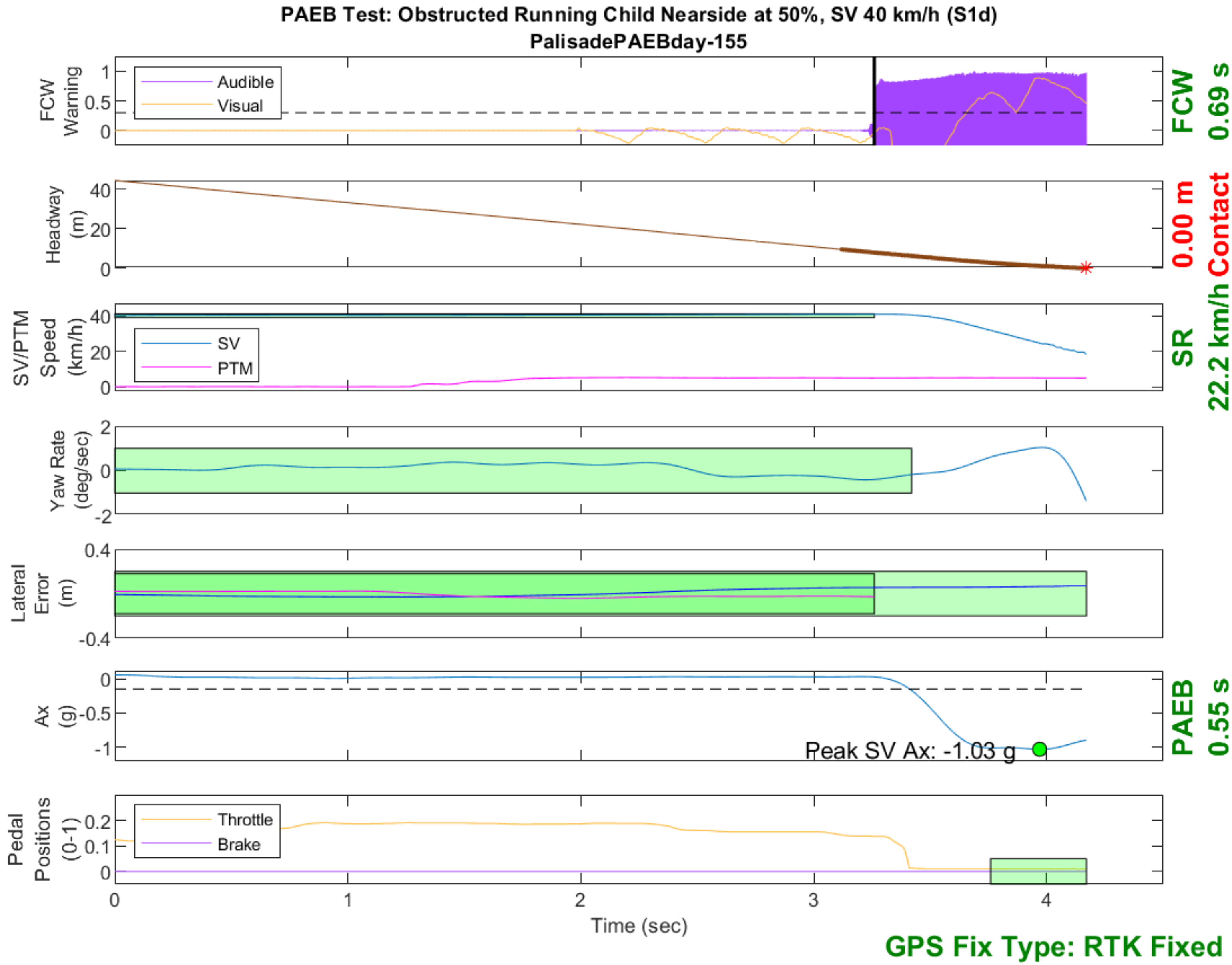


Figure D78. Time History for PAEB Run 155, S1d, Daytime, 40 km/h

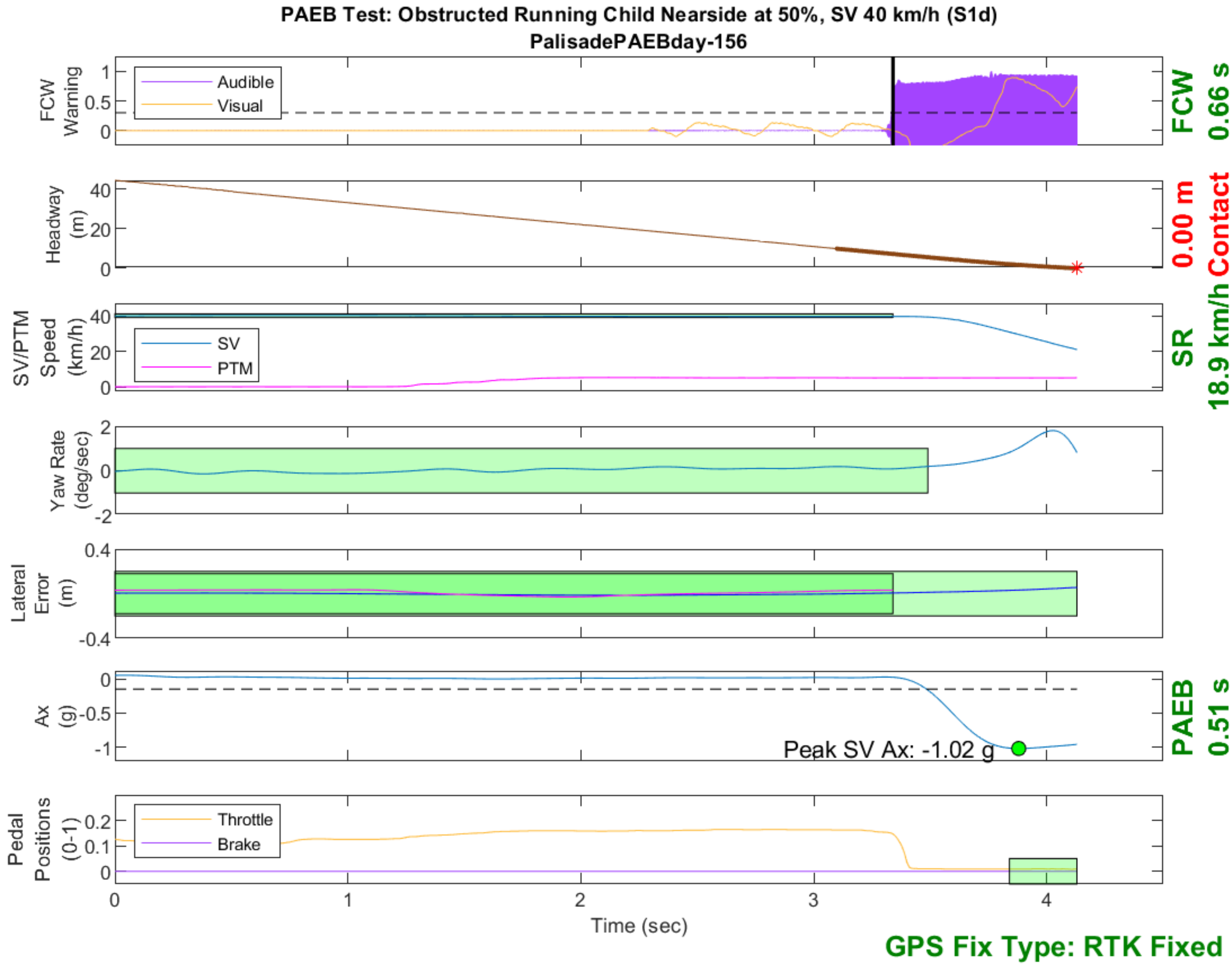


Figure D79. Time History for PAEB Run 156, S1d, Daytime, 40 km/h

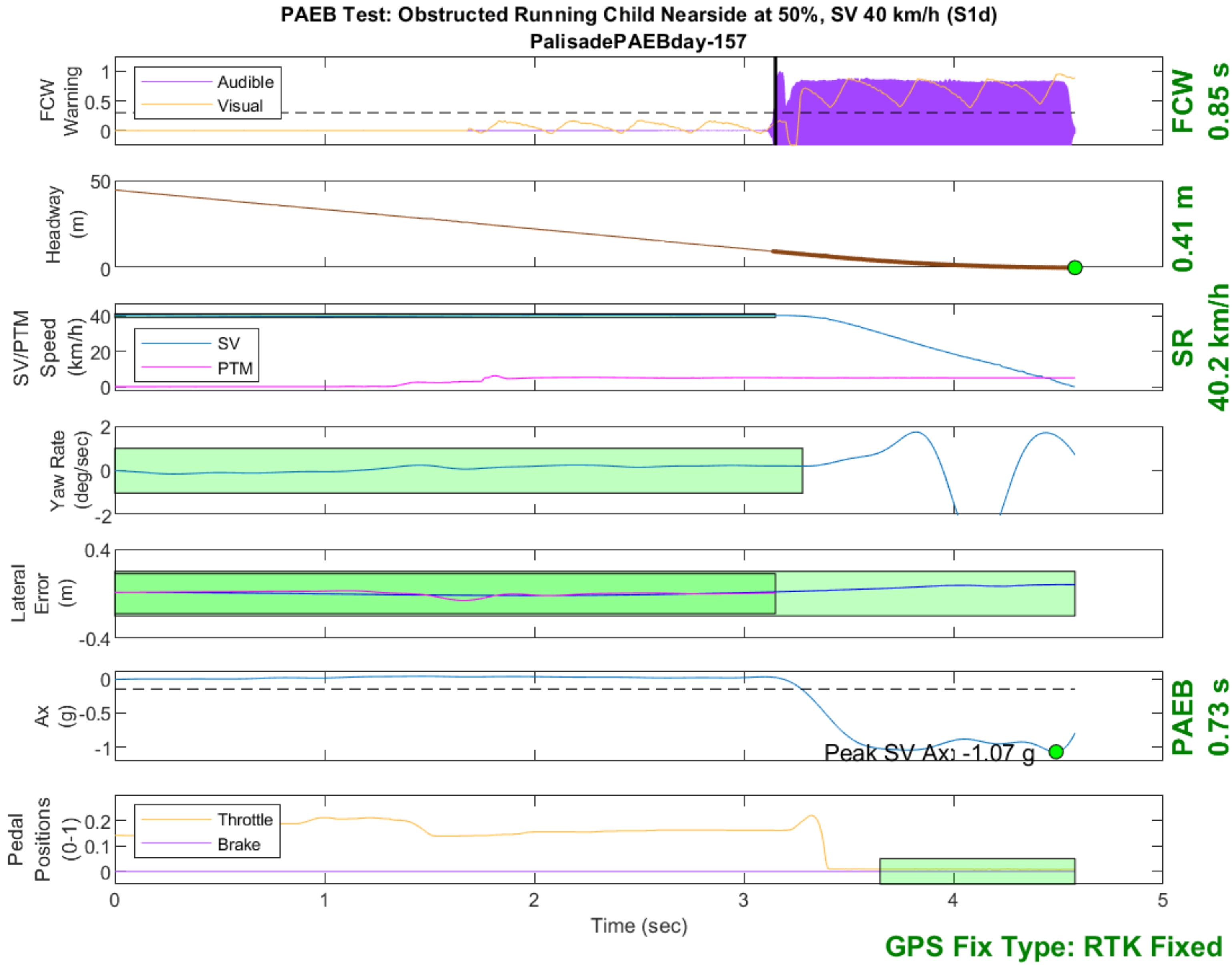


Figure D80. Time History for PAEB Run 157, S1d, Daytime, 40 km/h

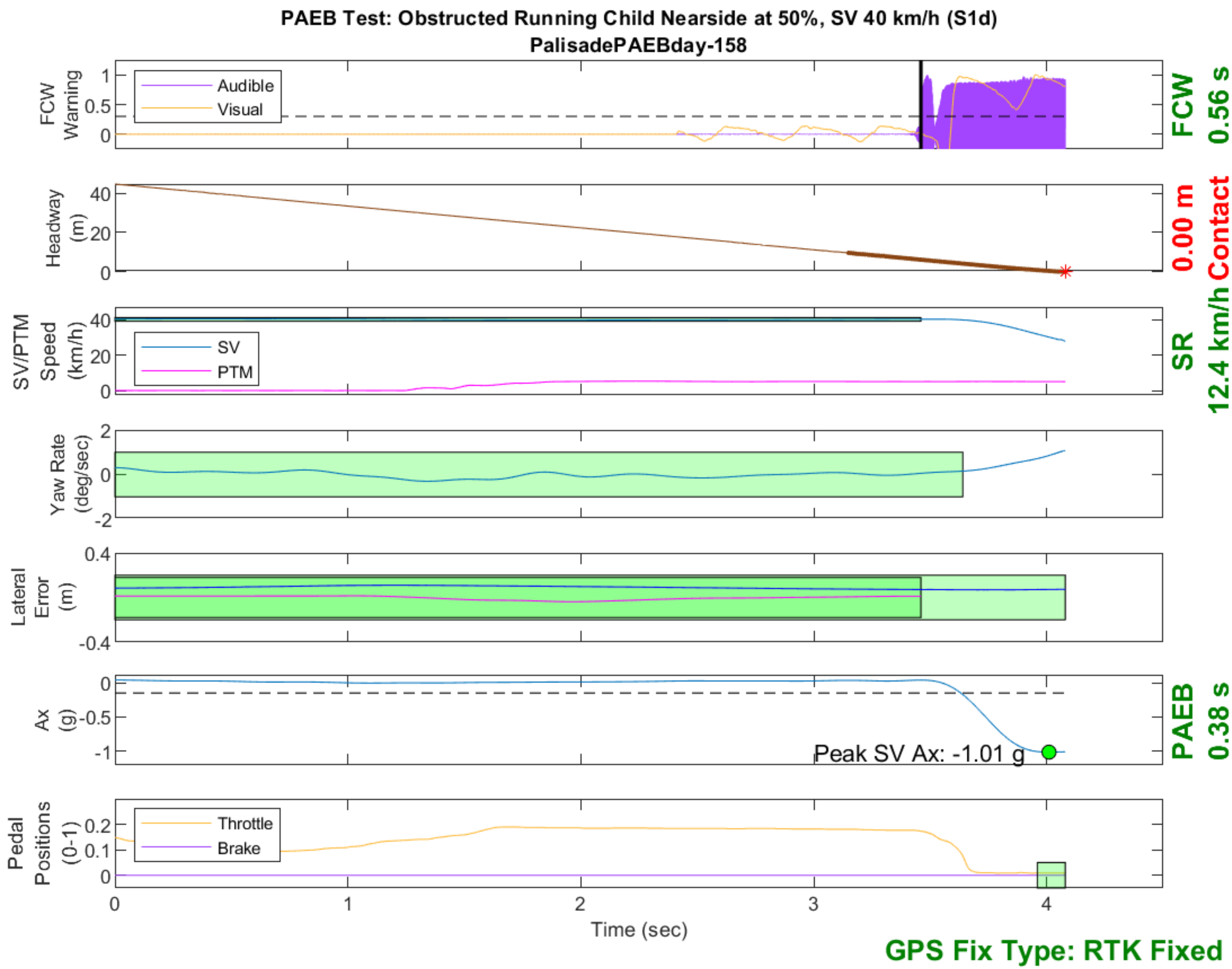


Figure D81. Time History for PAEB Run 158, S1d, Daytime, 40 km/h

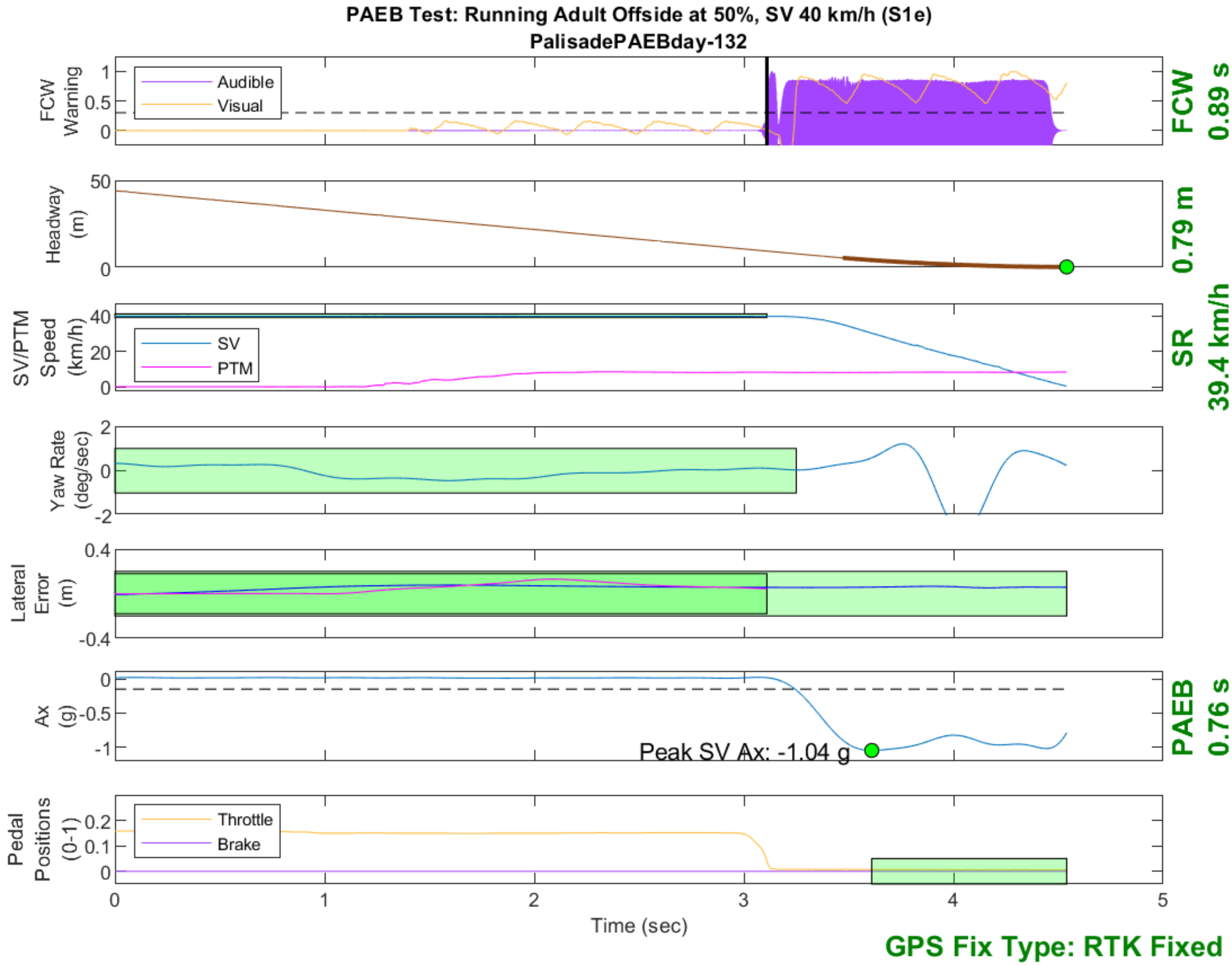


Figure D82. Time History for PAEB Run 132, S1e, Daytime, 40 km/h

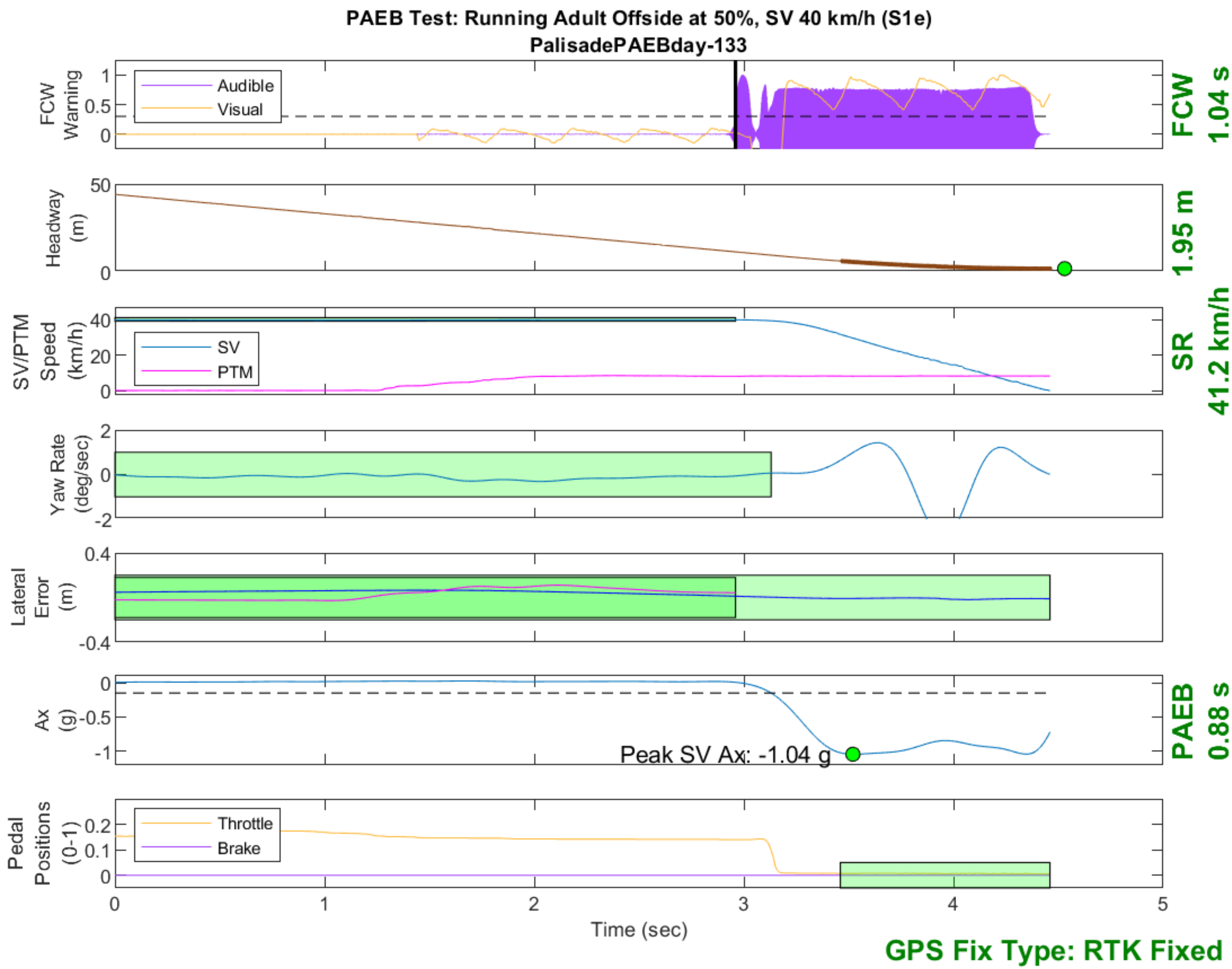


Figure D83. Time History for PAEB Run 133, S1e, Daytime, 40 km/h

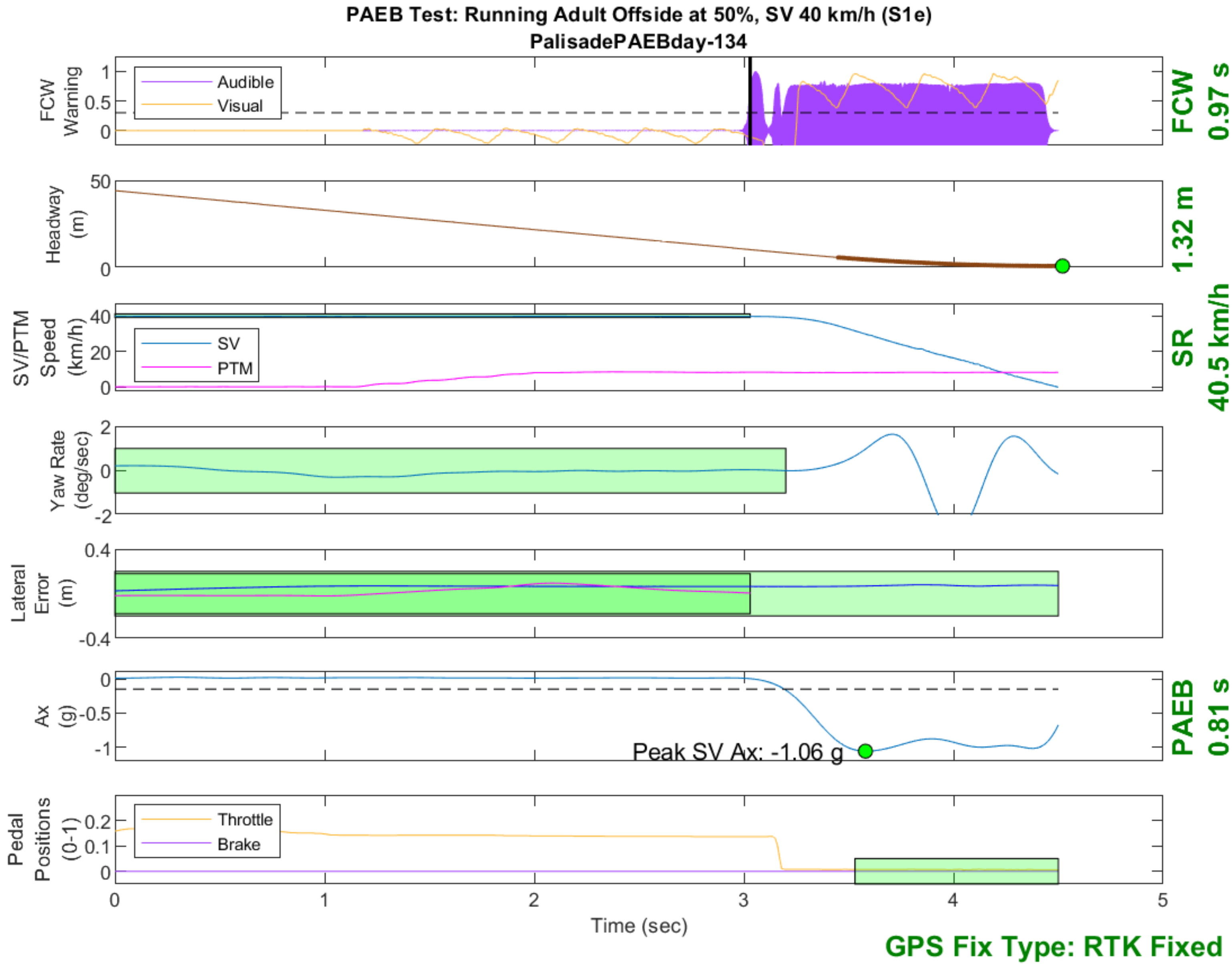


Figure D84. Time History for PAEB Run 134, S1e, Daytime, 40 km/h

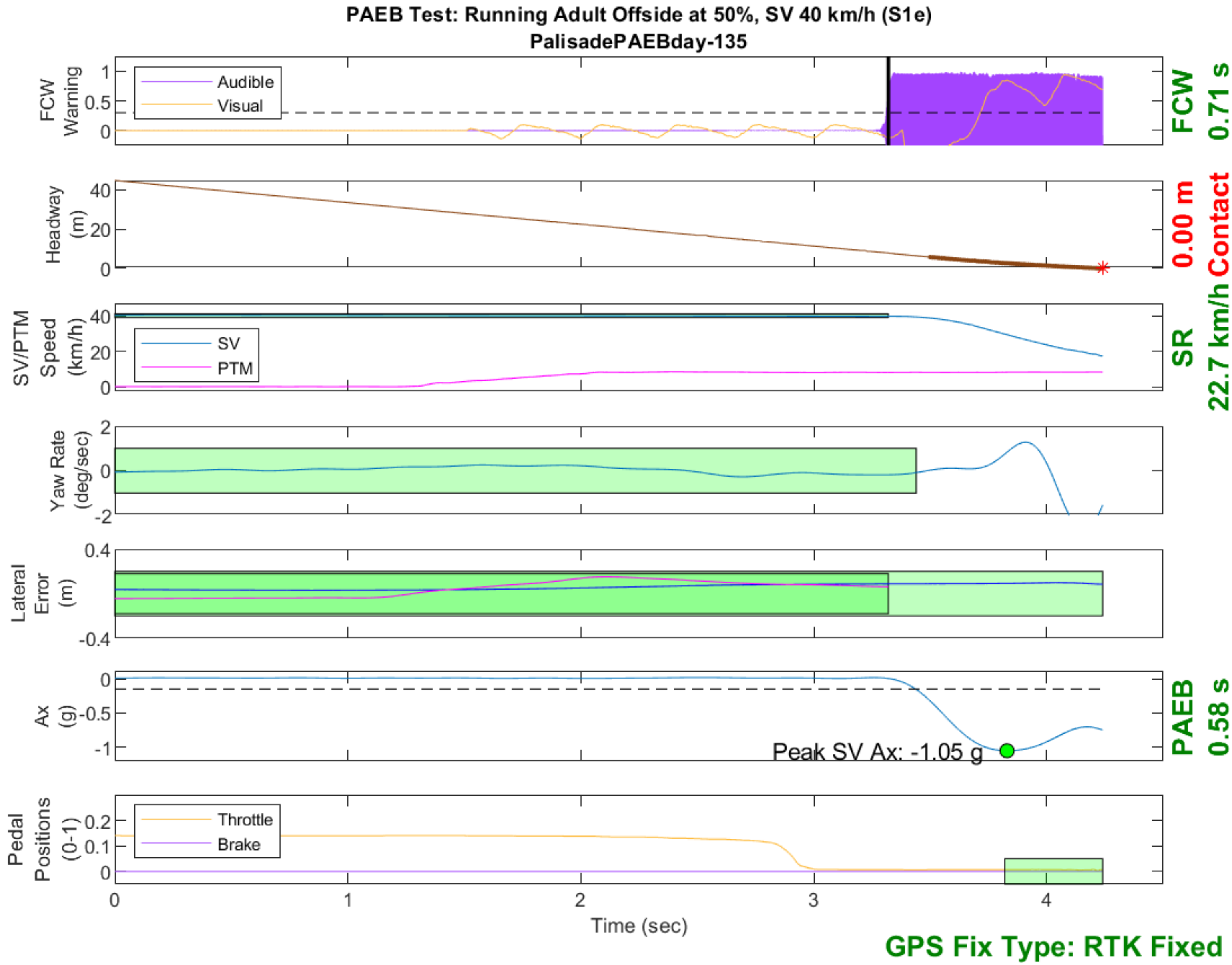


Figure D85. Time History for PAEB Run 135, S1e, Daytime, 40 km/h

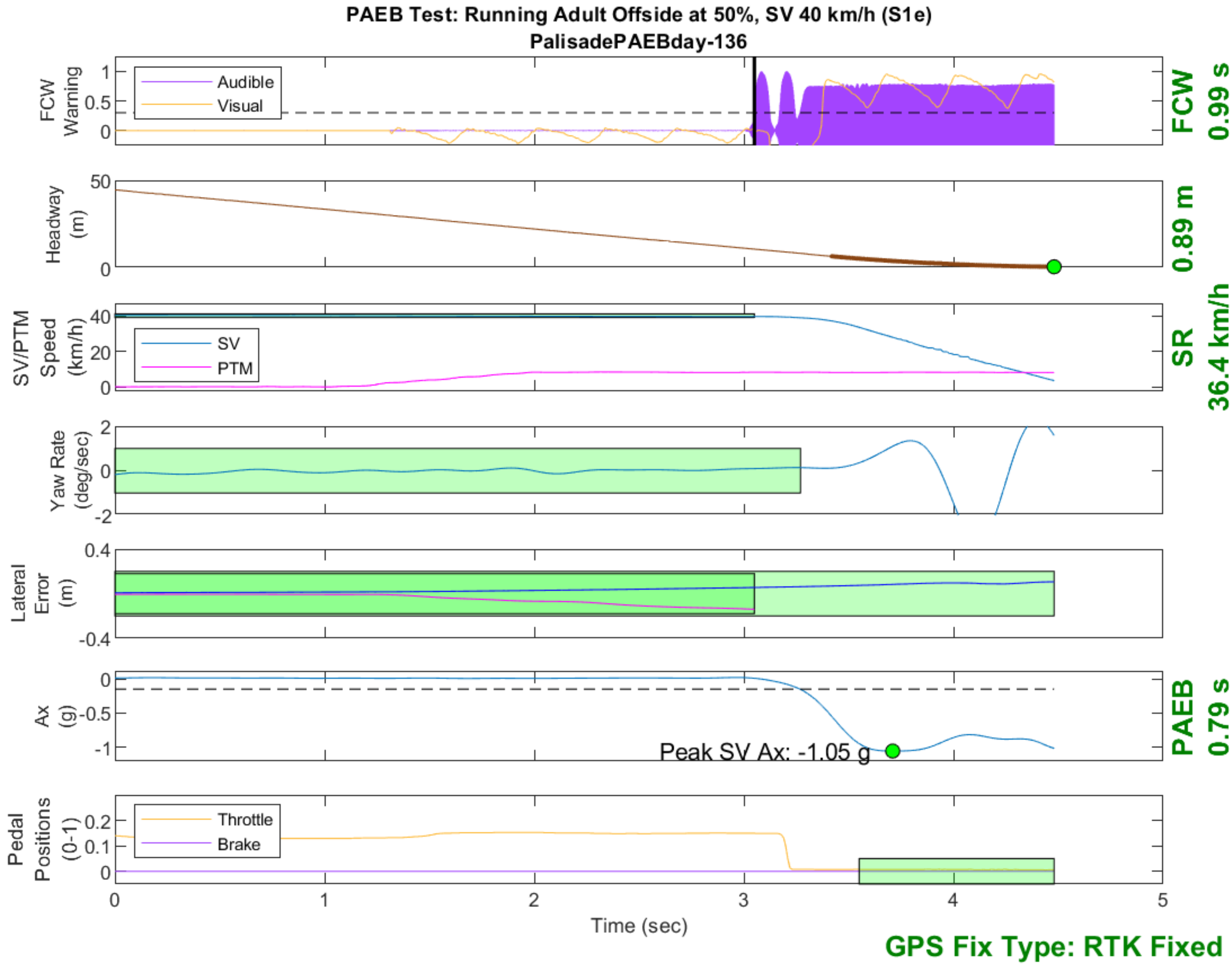


Figure D86. Time History for PAEB Run 136, S1e, Daytime, 40 km/h

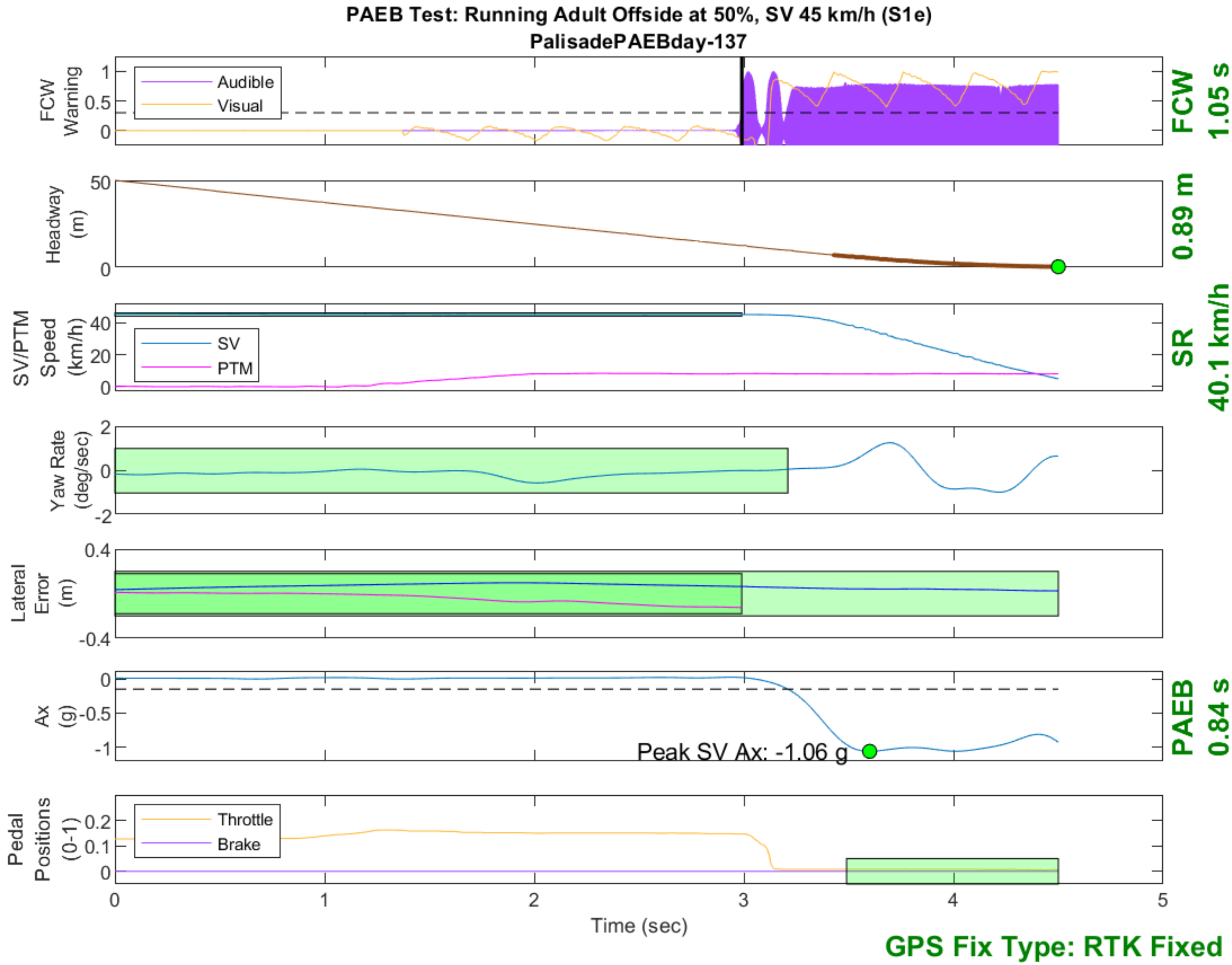


Figure D87. Time History for PAEB Run 137, S1e, Daytime, 45 km/h

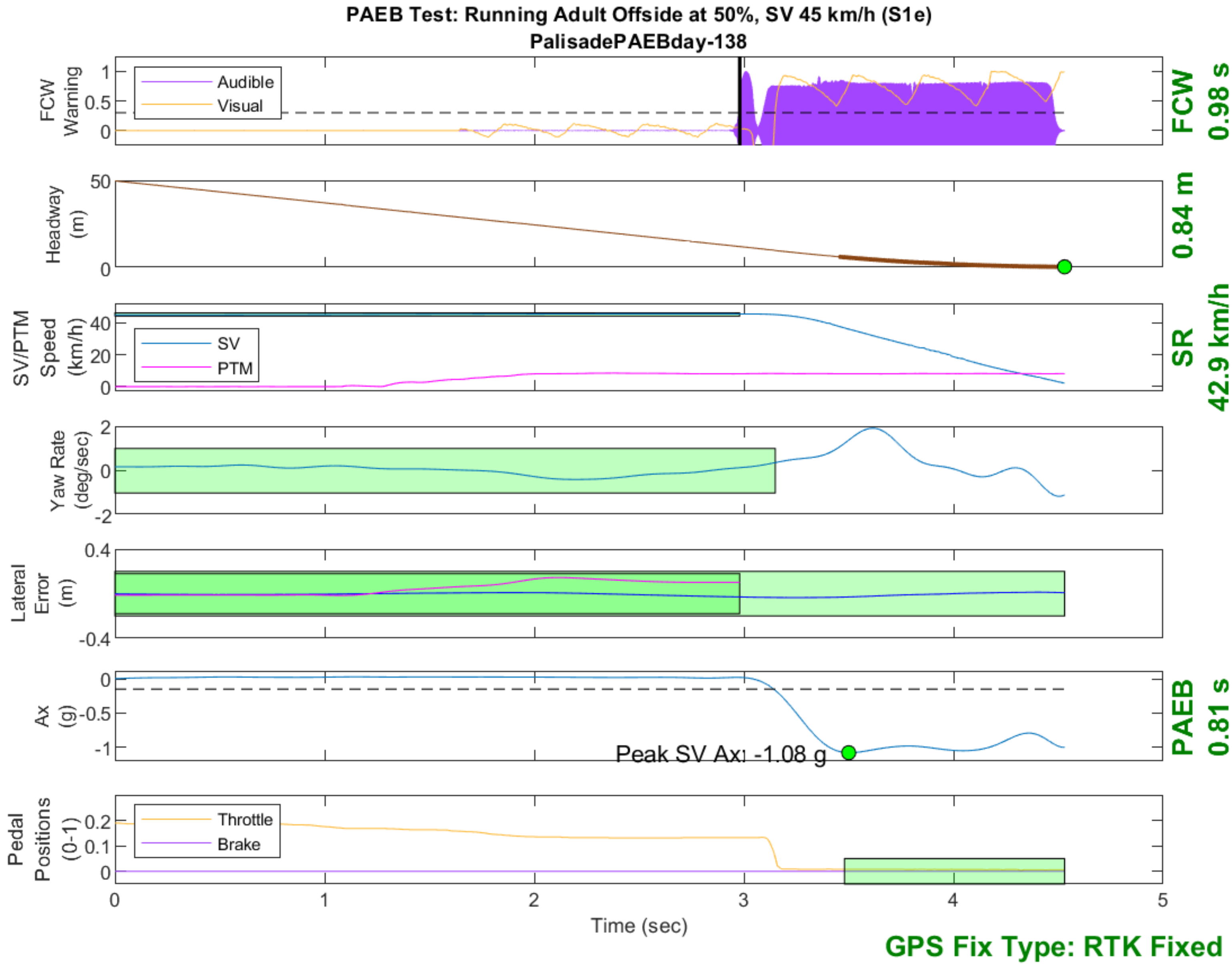


Figure D88. Time History for PAEB Run 138, S1e, Daytime, 45 km/h

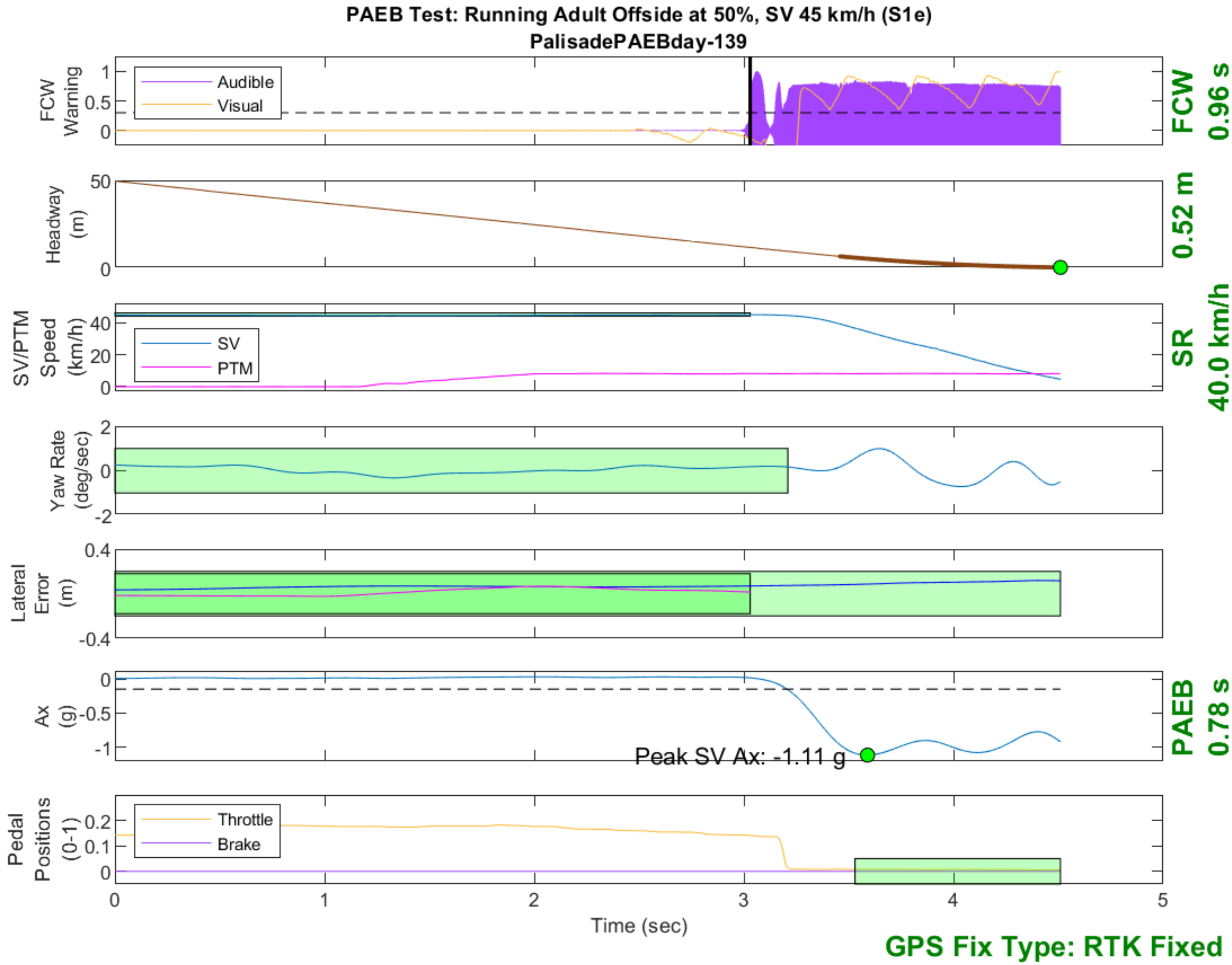


Figure D89. Time History for PAEB Run 139, S1e, Daytime, 45 km/h

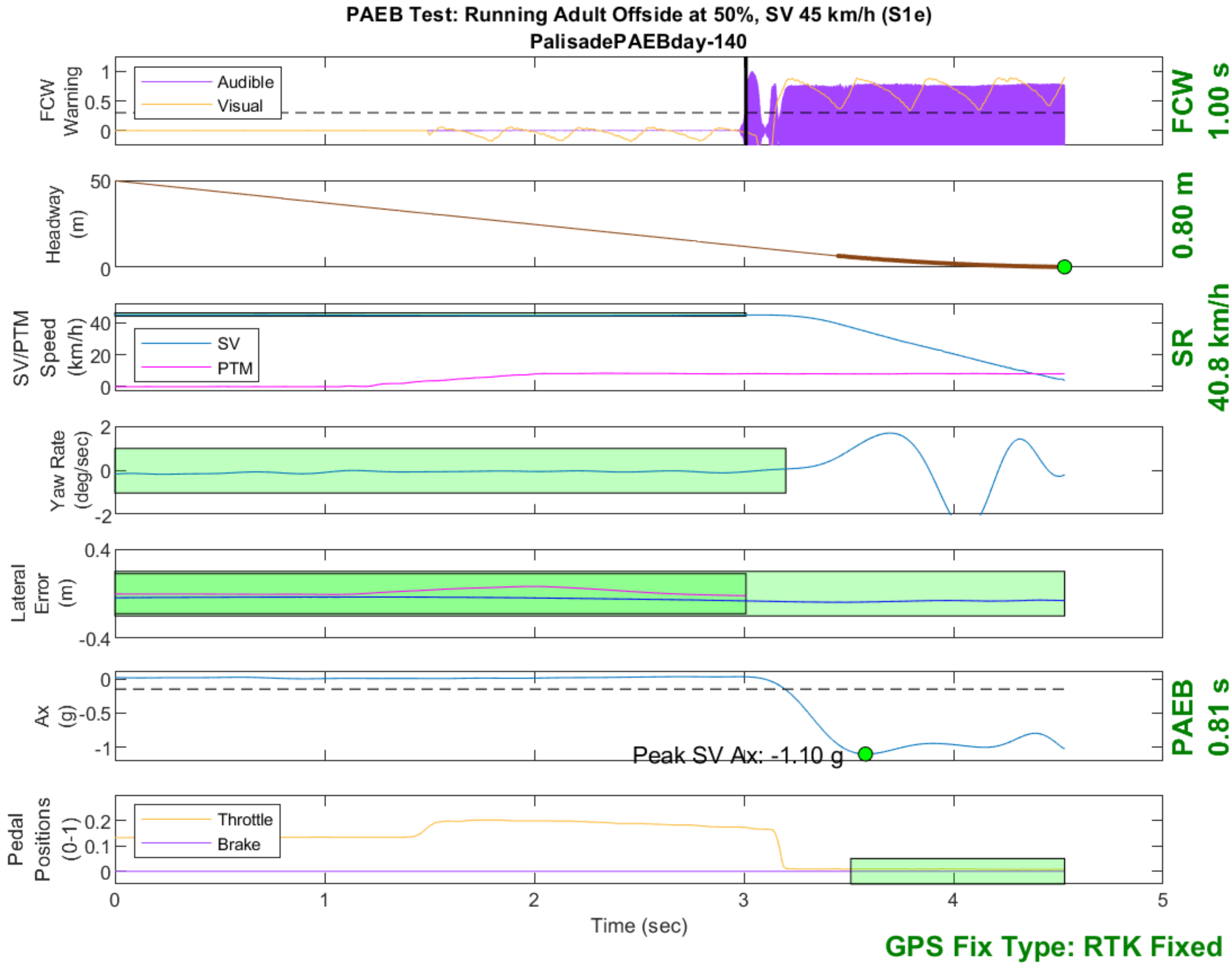


Figure D90. Time History for PAEB Run 140, S1e, Daytime, 45 km/h

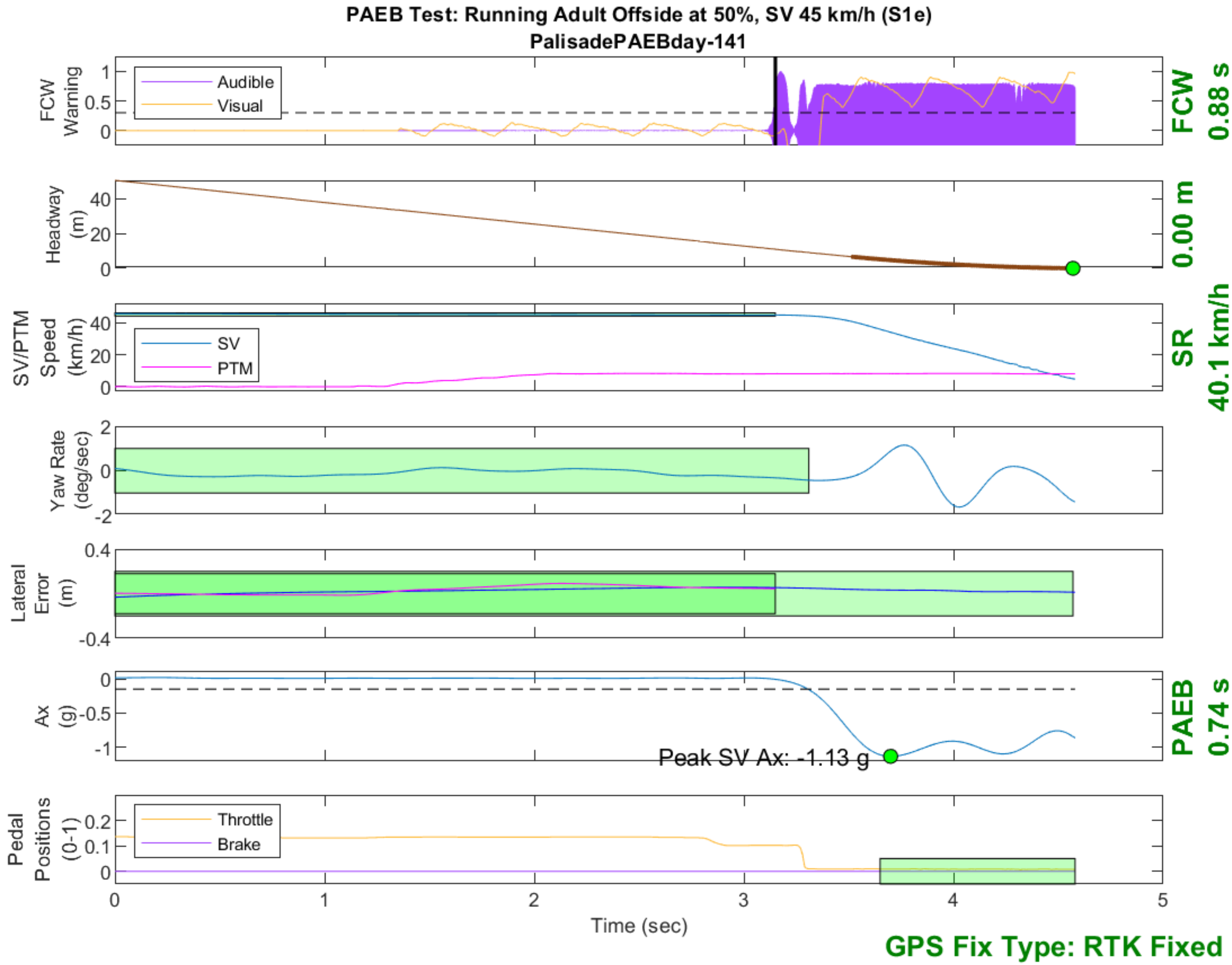


Figure D91. Time History for PAEB Run 141, S1e, Daytime, 45 km/h

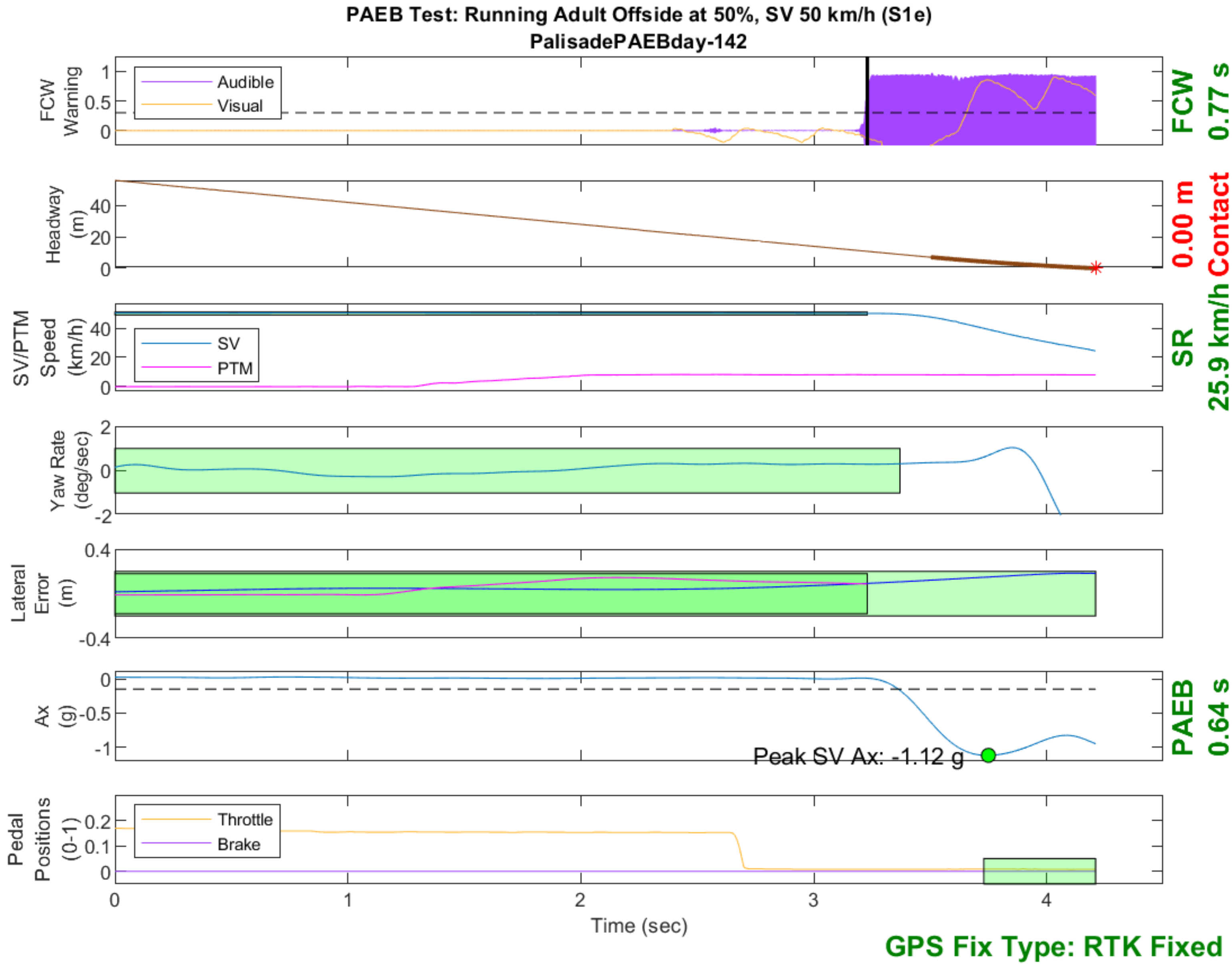


Figure D92. Time History for PAEB Run 142, S1e, Daytime, 50 km/h

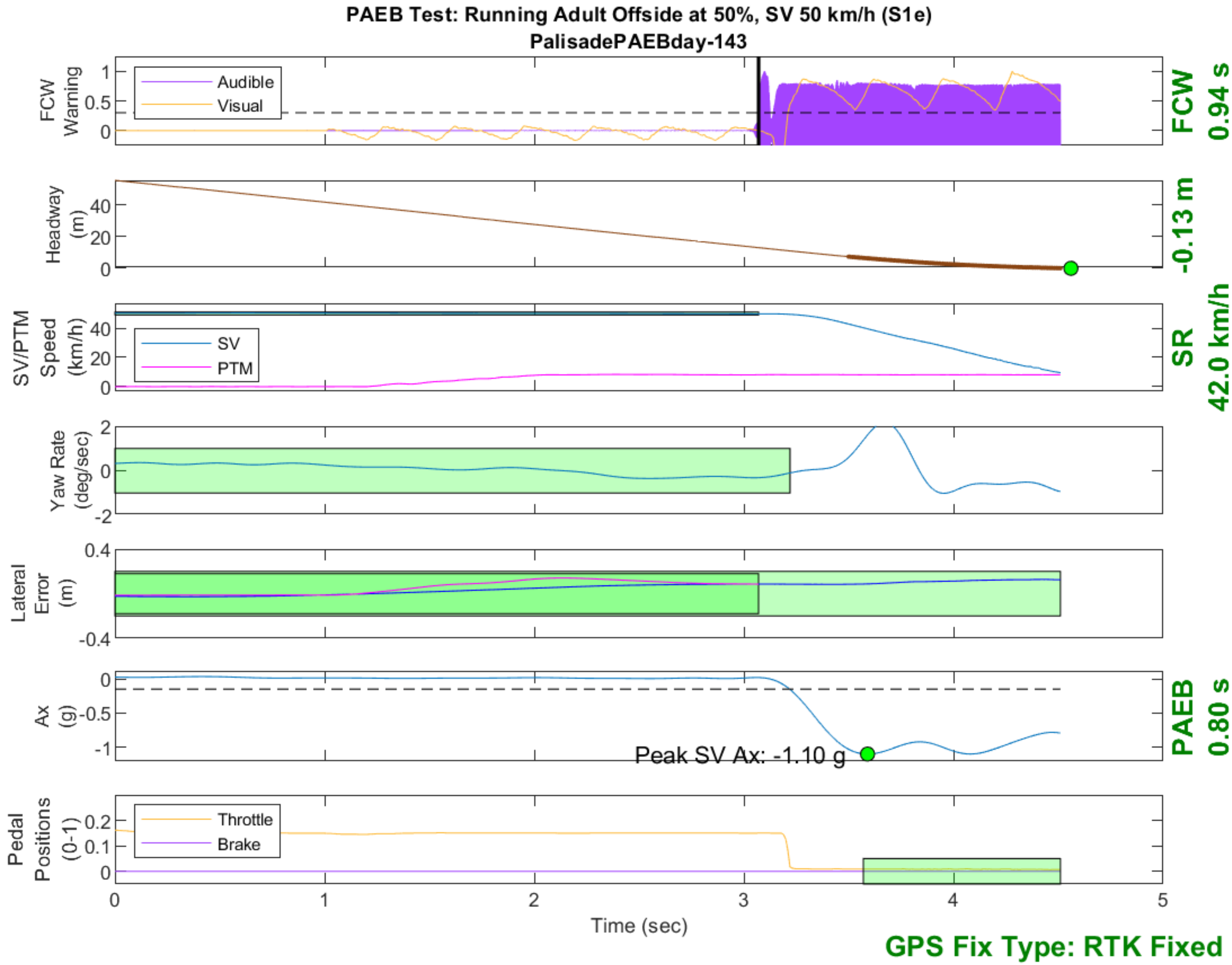


Figure D93. Time History for PAEB Run 143, S1e, Daytime, 50 km/h

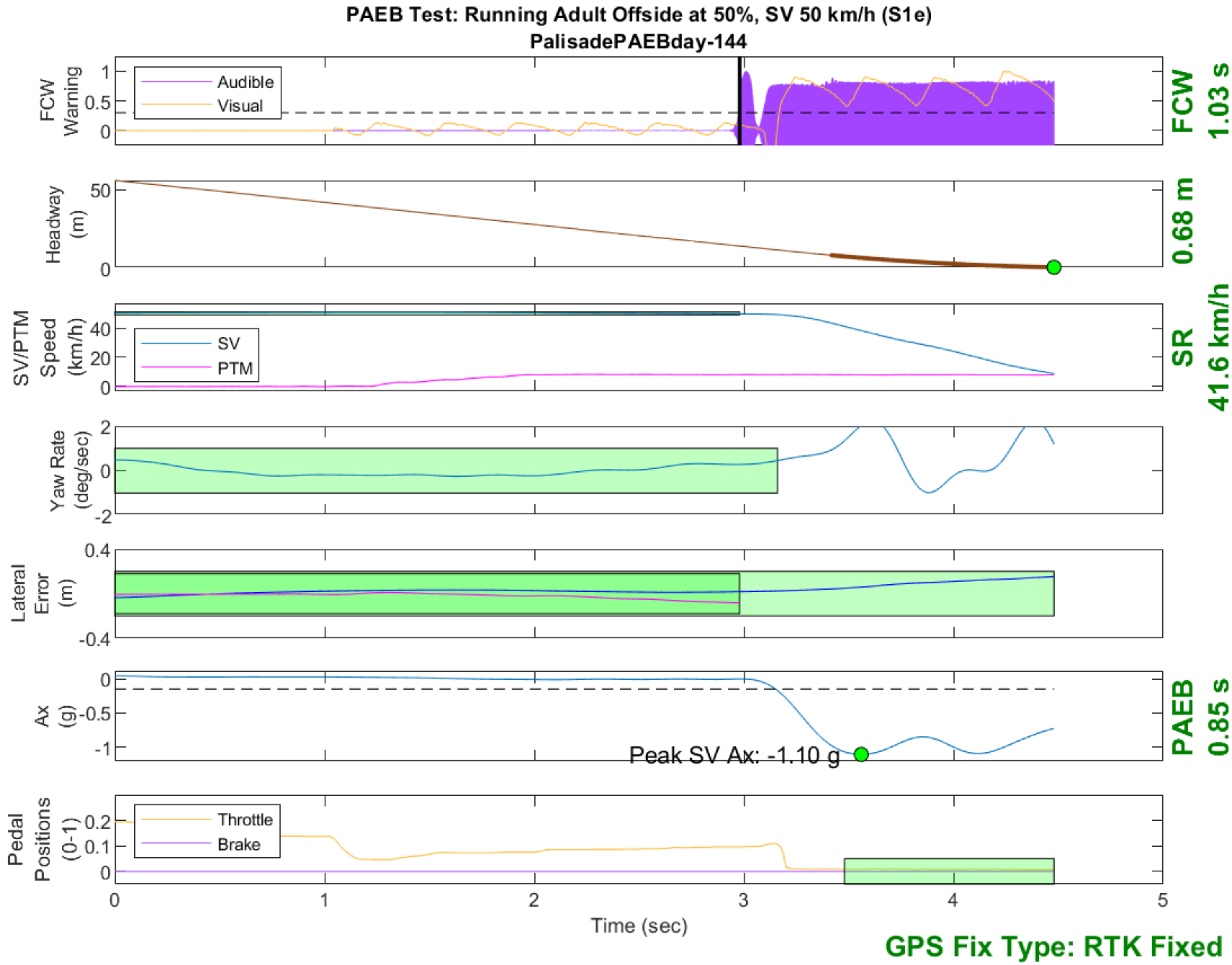


Figure D94. Time History for PAEB Run 144, S1e, Daytime, 50 km/h

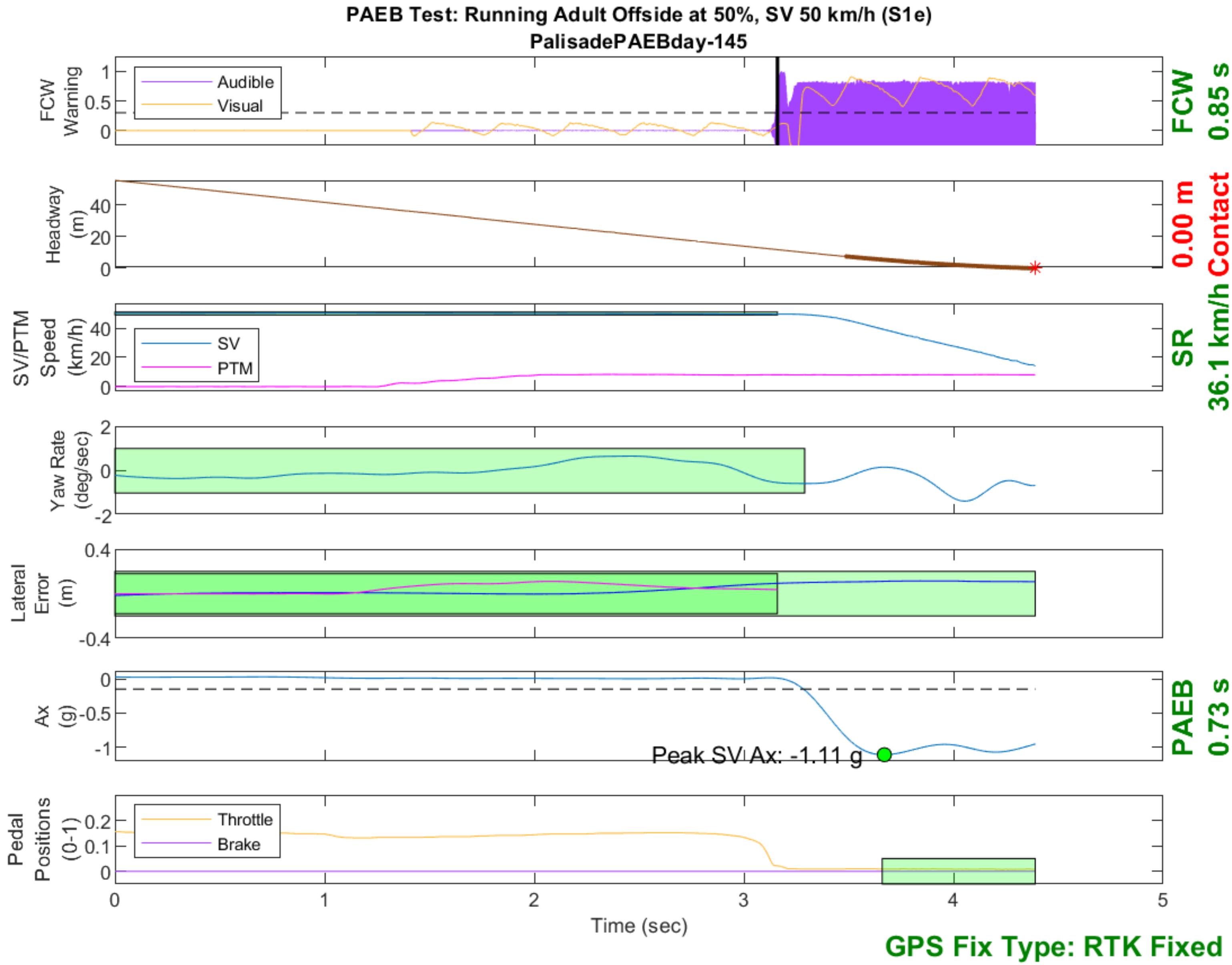


Figure D95. Time History for PAEB Run 145, S1e, Daytime, 50 km/h

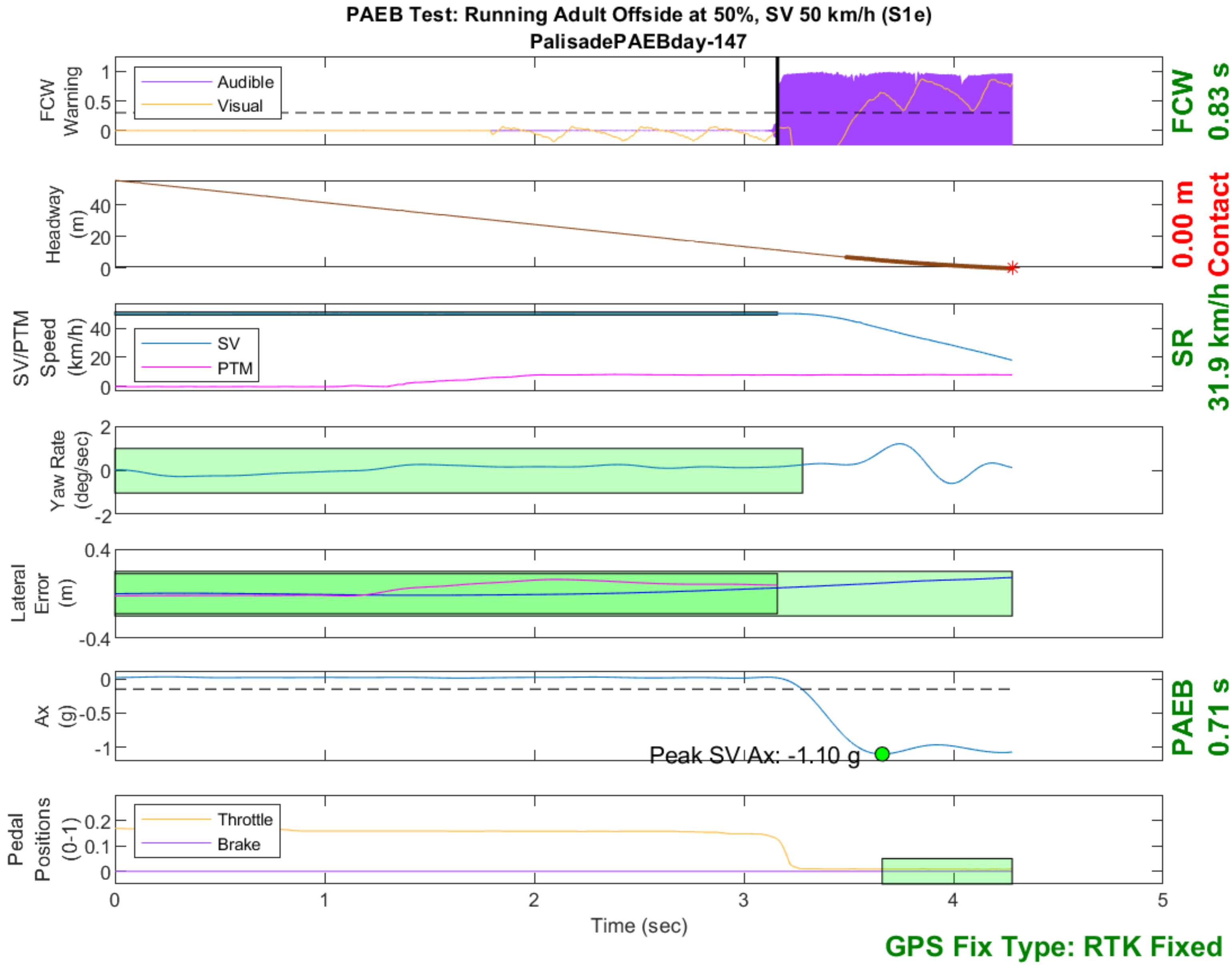


Figure D96. Time History for PAEB Run 147, S1e, Daytime, 50 km/h

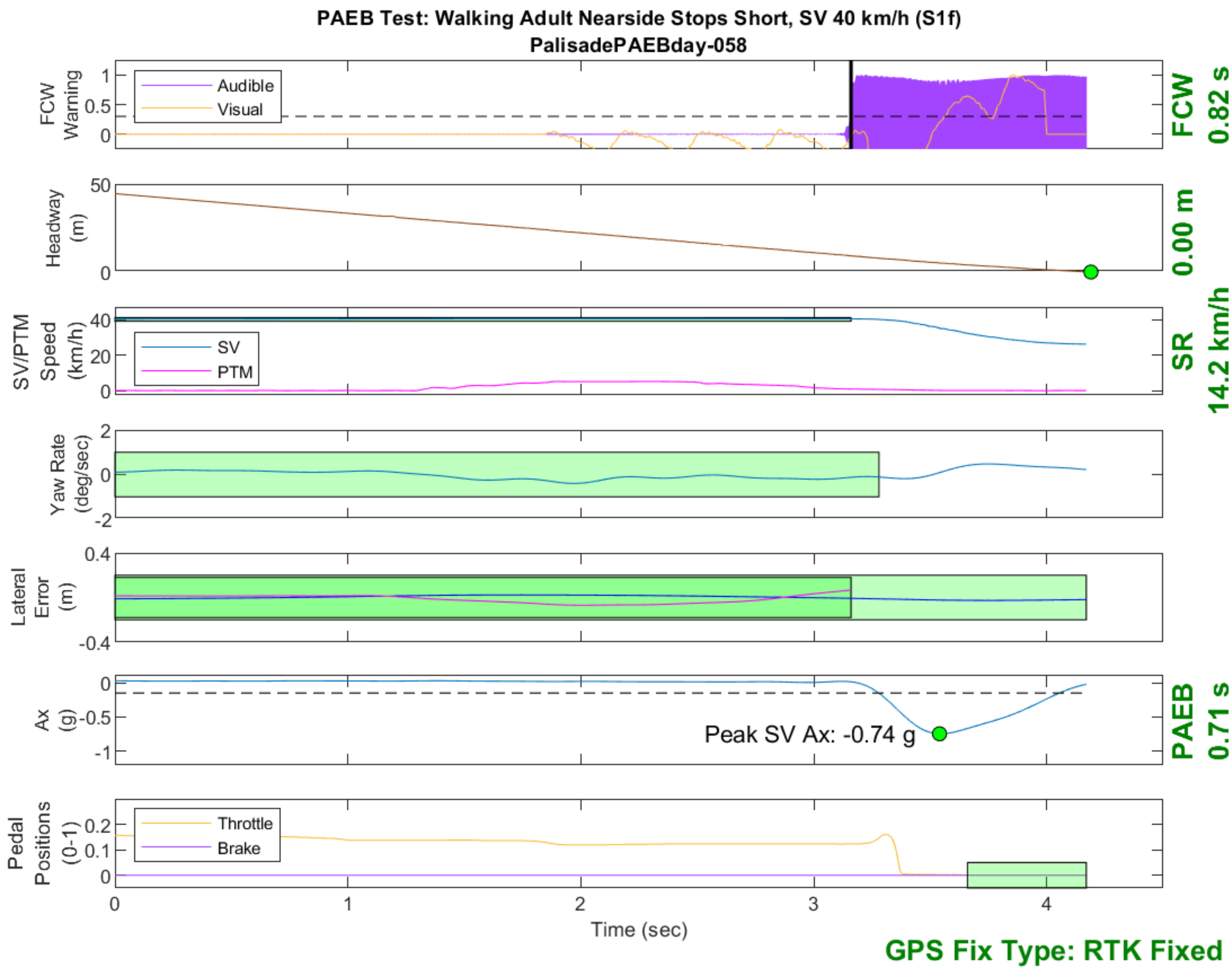


Figure D97. Time History for PAEB Run 58, S1f, Daytime, 40 km/h

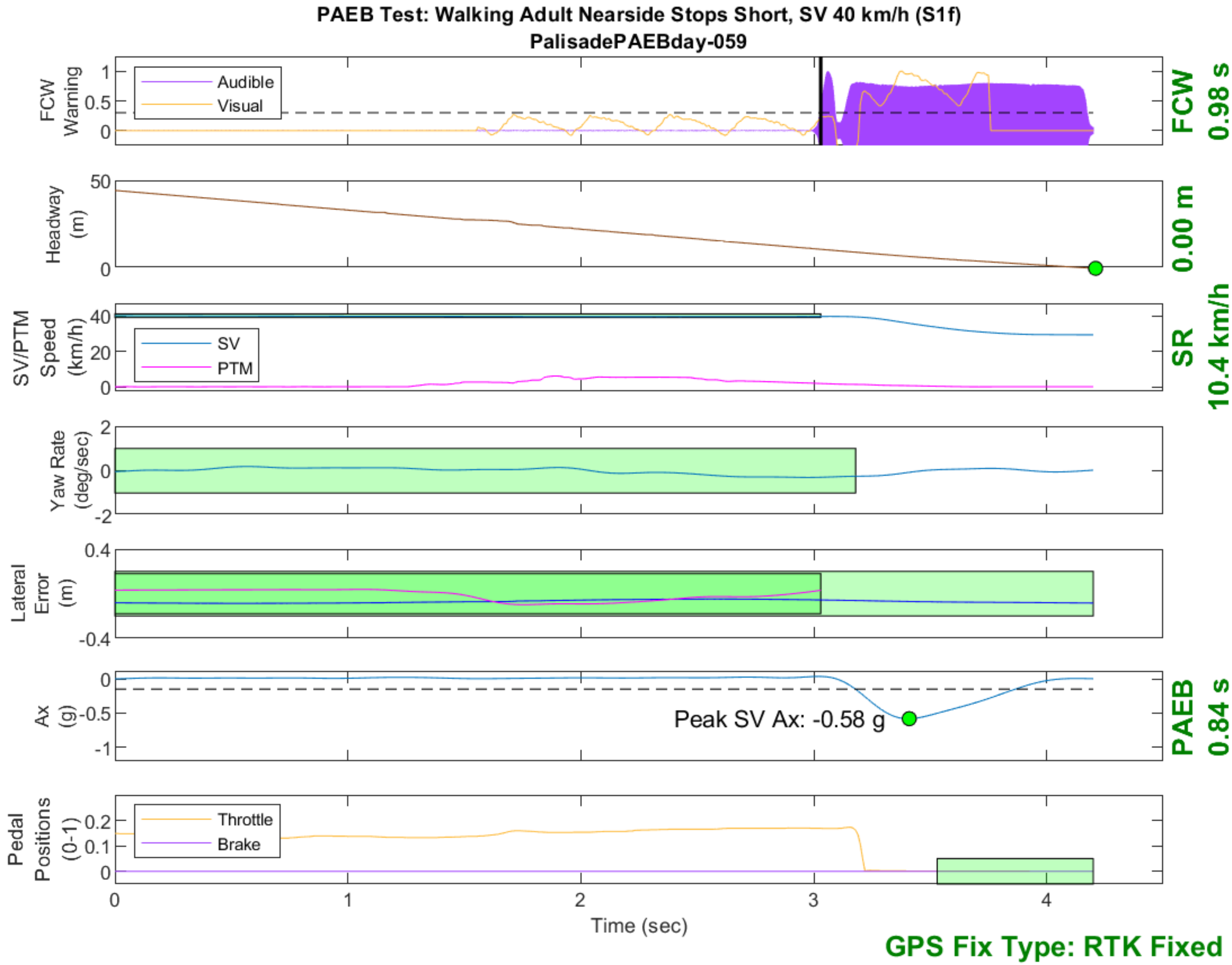


Figure D98. Time History for PAEB Run 59, S1f, Daytime, 40 km/h

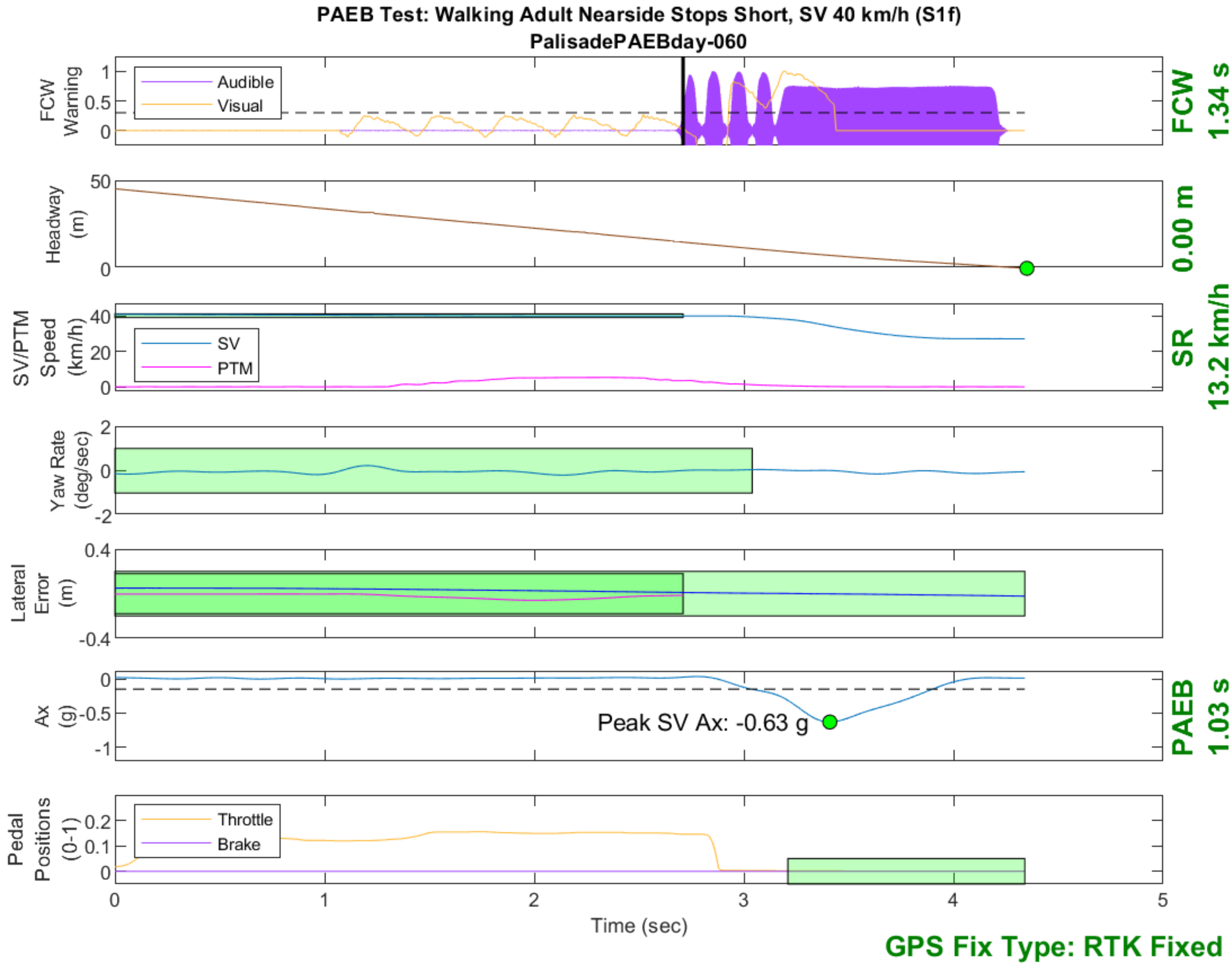


Figure D99. Time History for PAEB Run 60, S1f, Daytime, 40 km/h

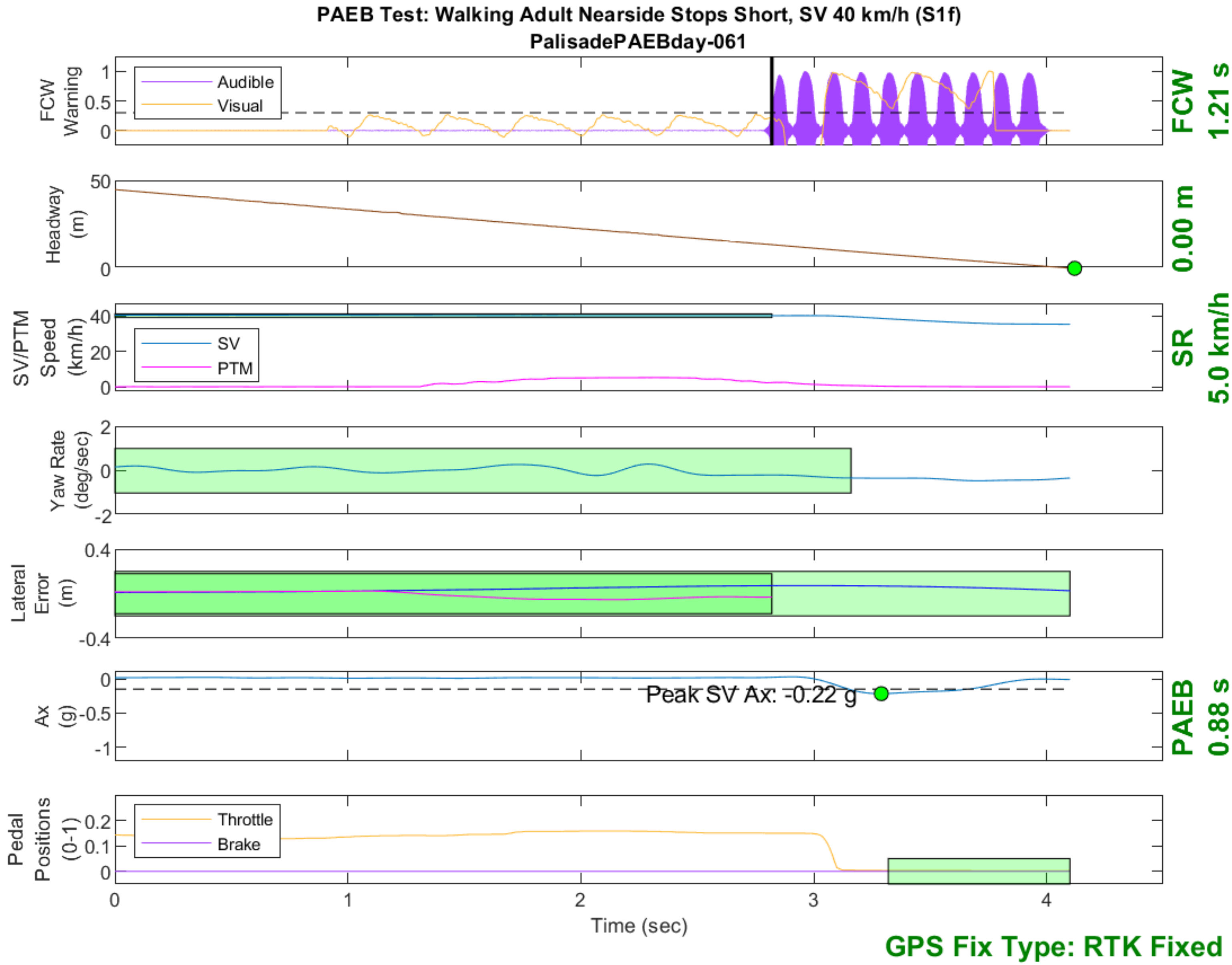


Figure D100. Time History for PAEB Run 61, S1f, Daytime, 40 km/h

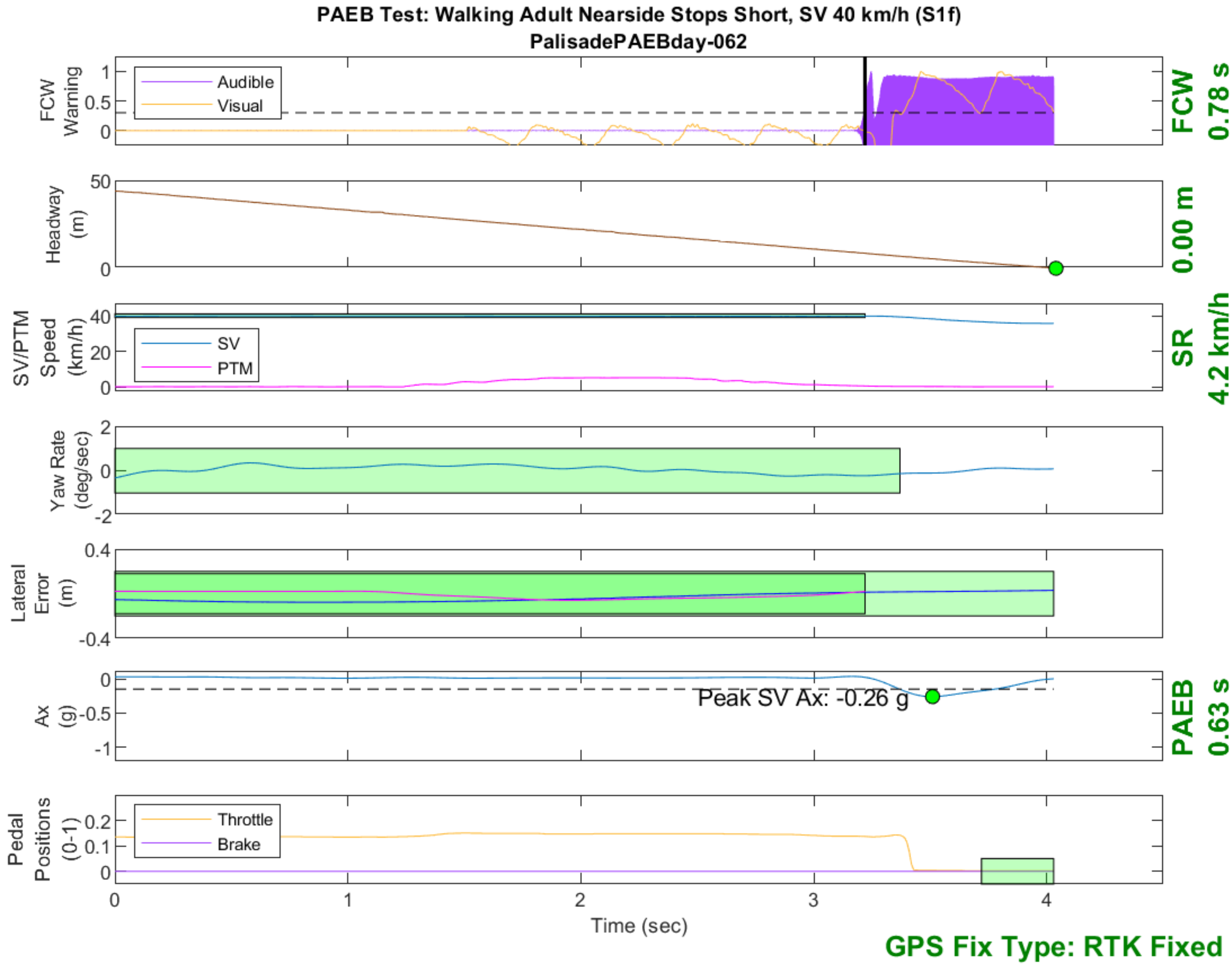


Figure D101. Time History for PAEB Run 62, S1f, Daytime, 40 km/h

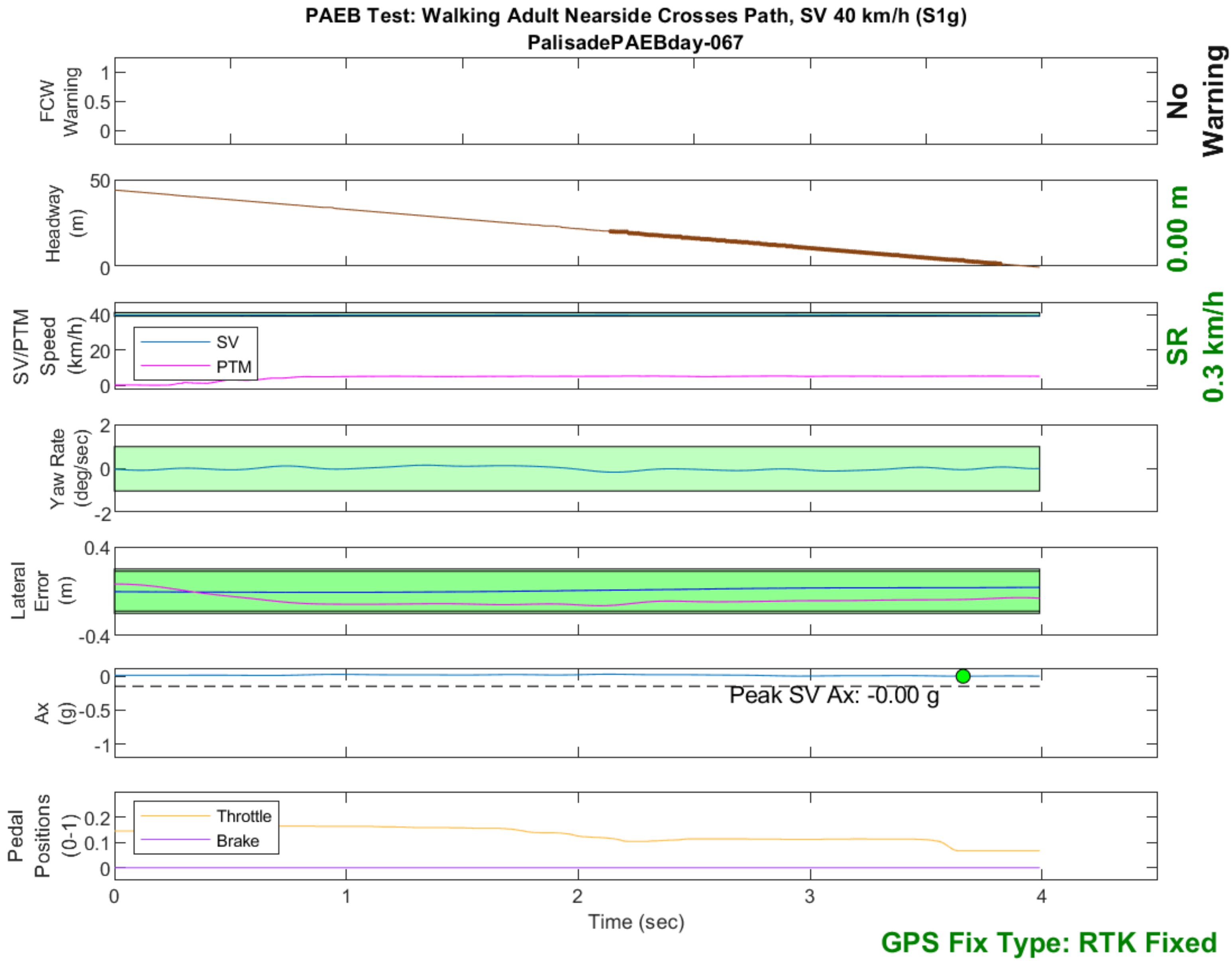


Figure D102. Time History for PAEB Run 67, S1g, Daytime, 40 km/h

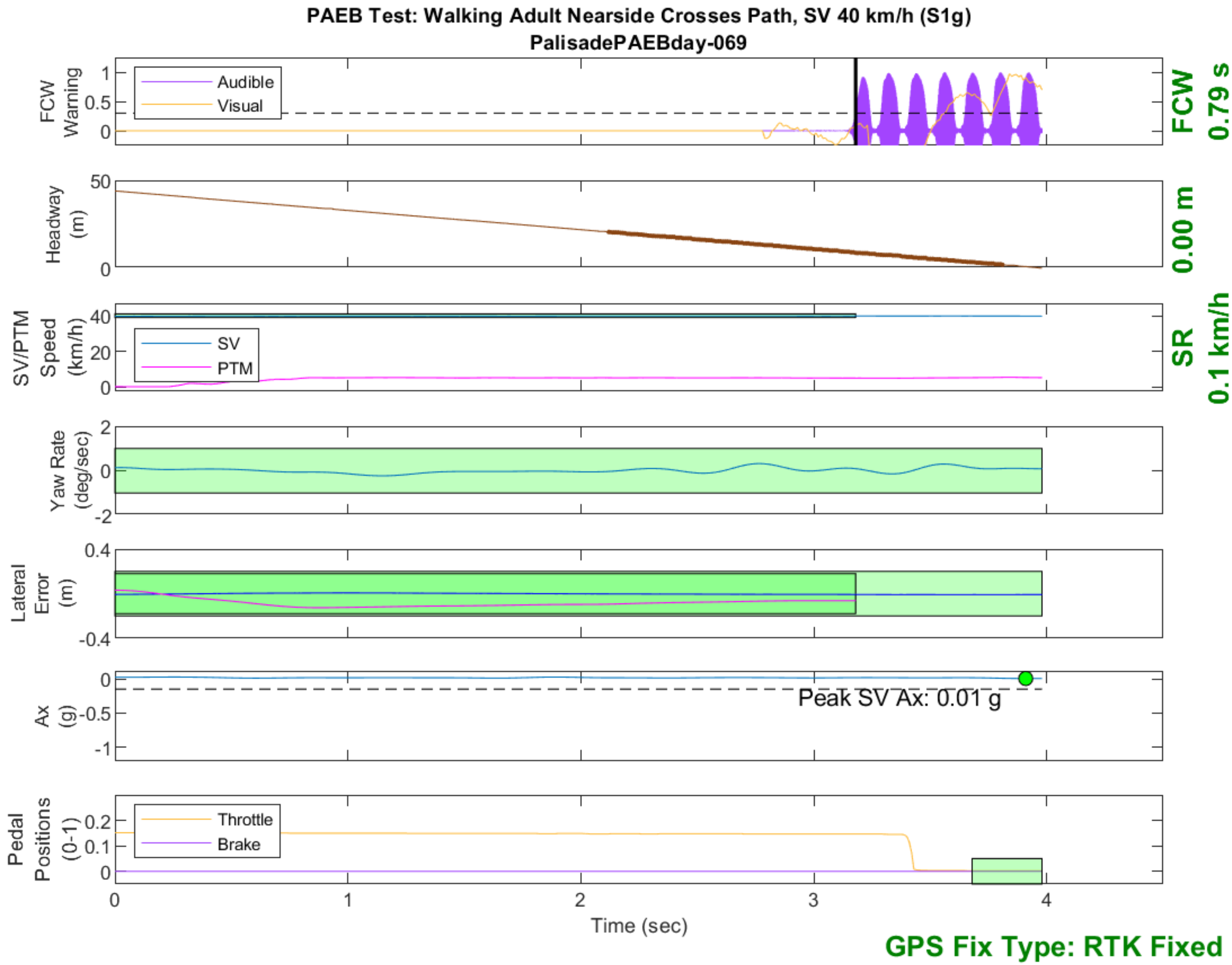


Figure D103. Time History for PAEB Run 69, S1g, Daytime, 40 km/h

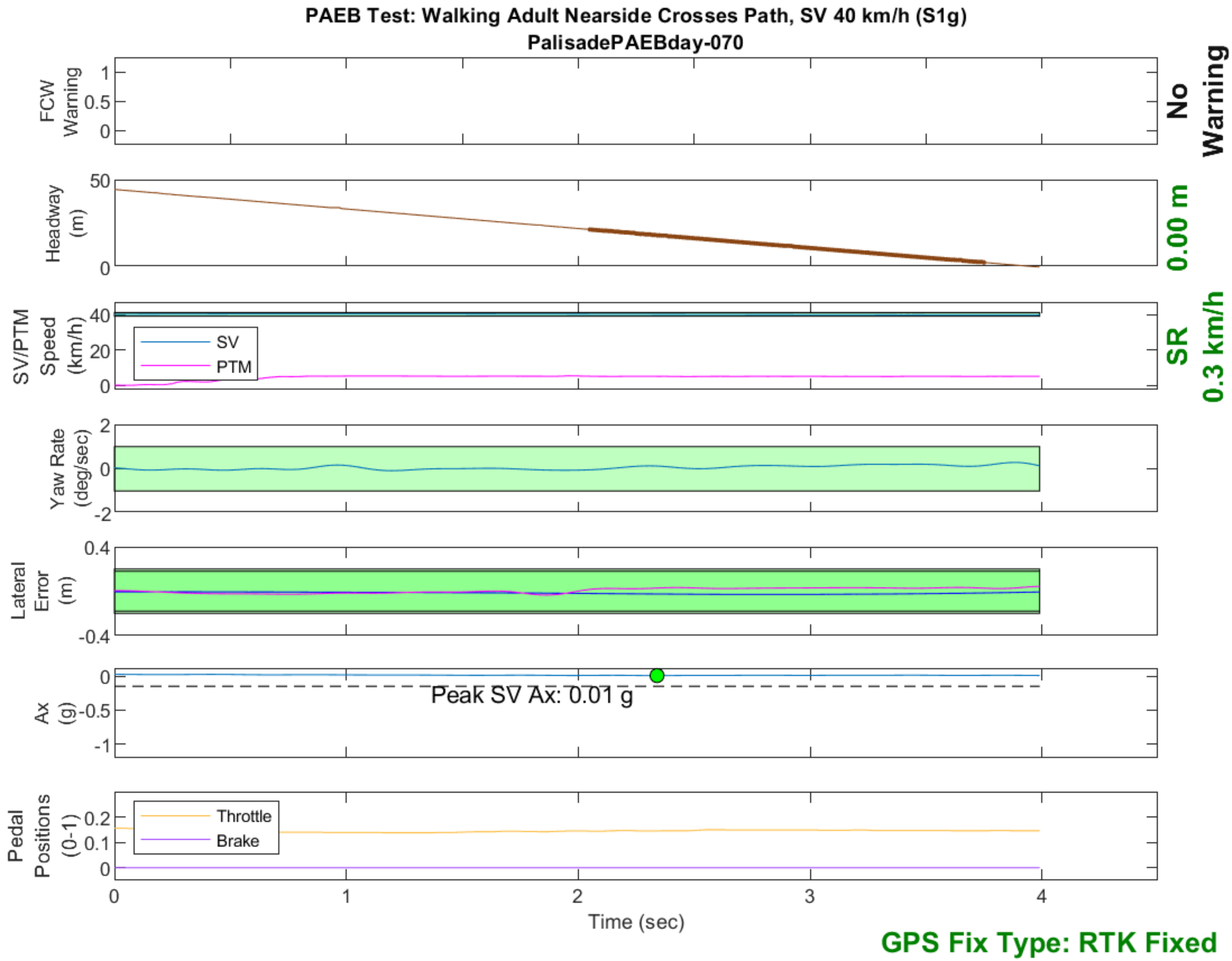


Figure D104. Time History for PAEB Run 70, S1g, Daytime, 40 km/h

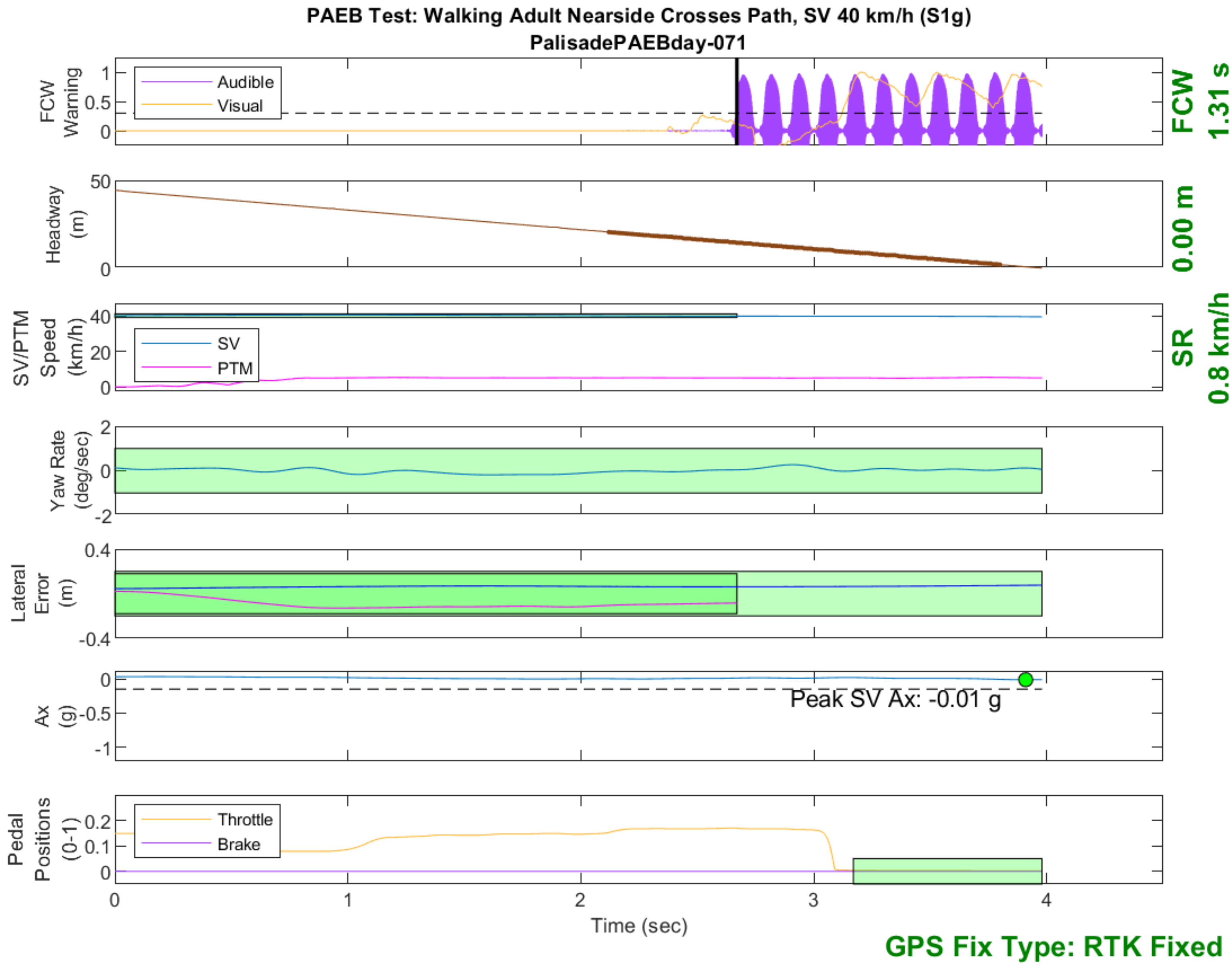


Figure D105. Time History for PAEB Run 71, S1g, Daytime, 40 km/h

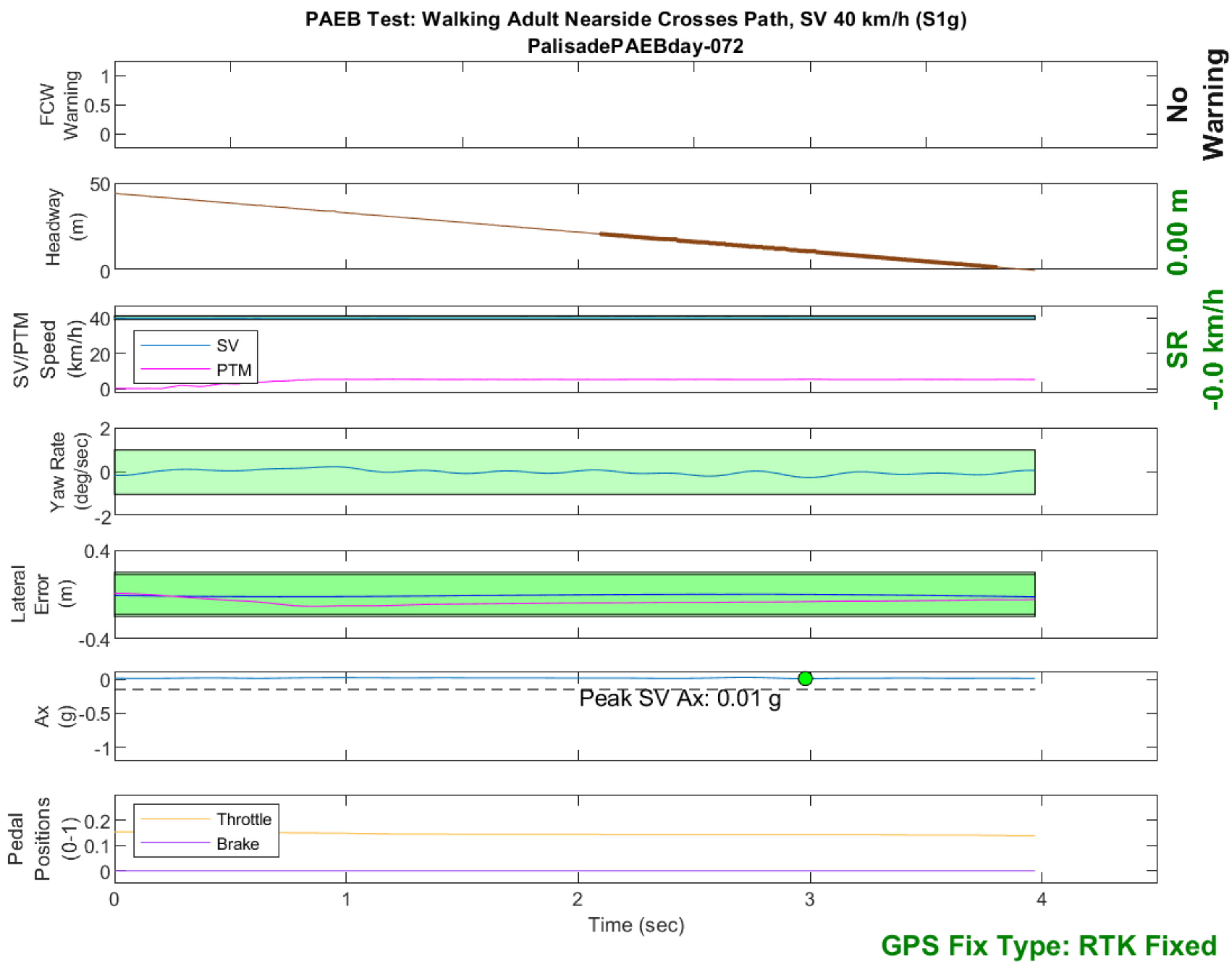


Figure D106. Time History for PAEB Run 72, S1g, Daytime, 40 km/h

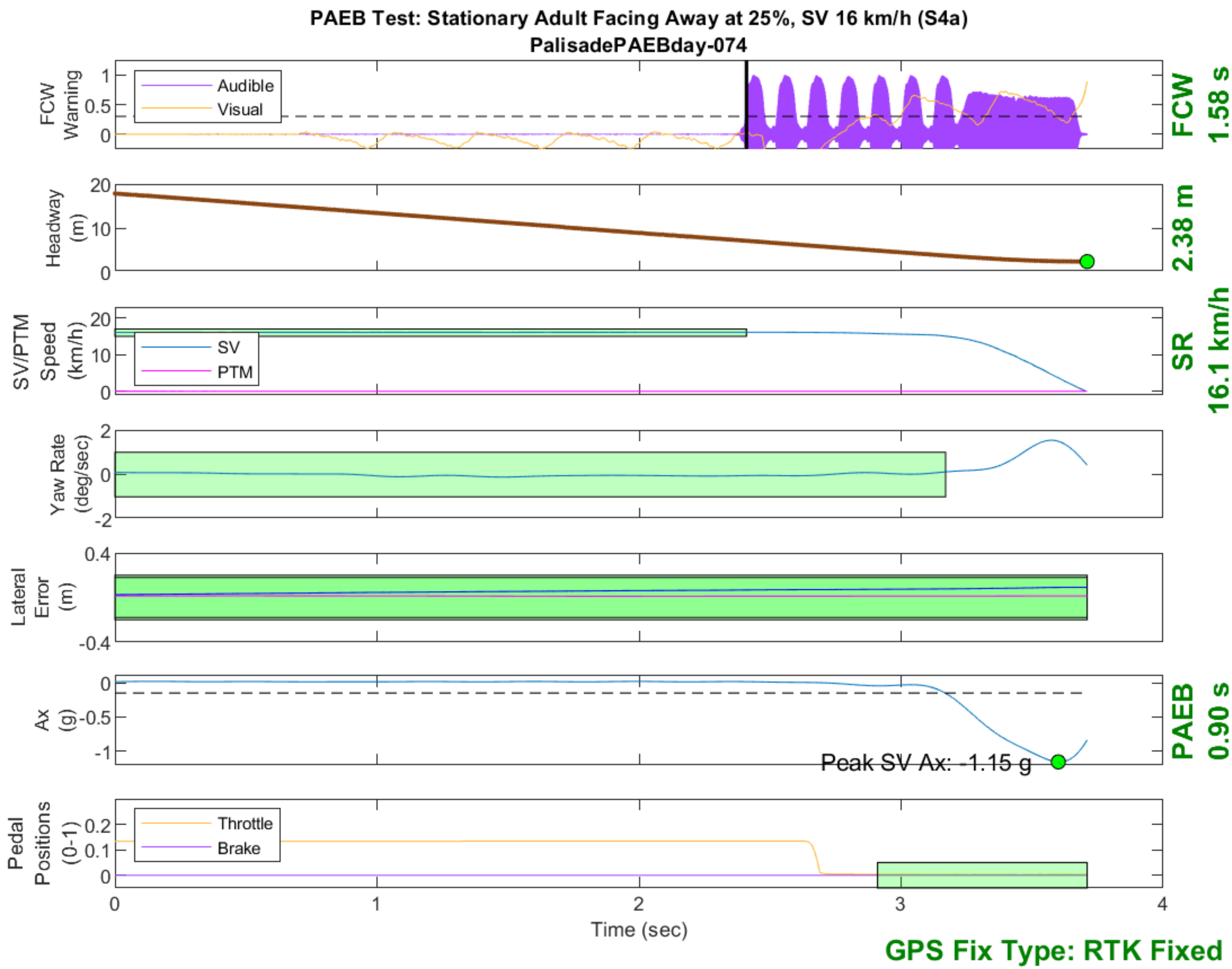


Figure D107. Time History for PAEB Run 74, S4a, Daytime, 16 km/h

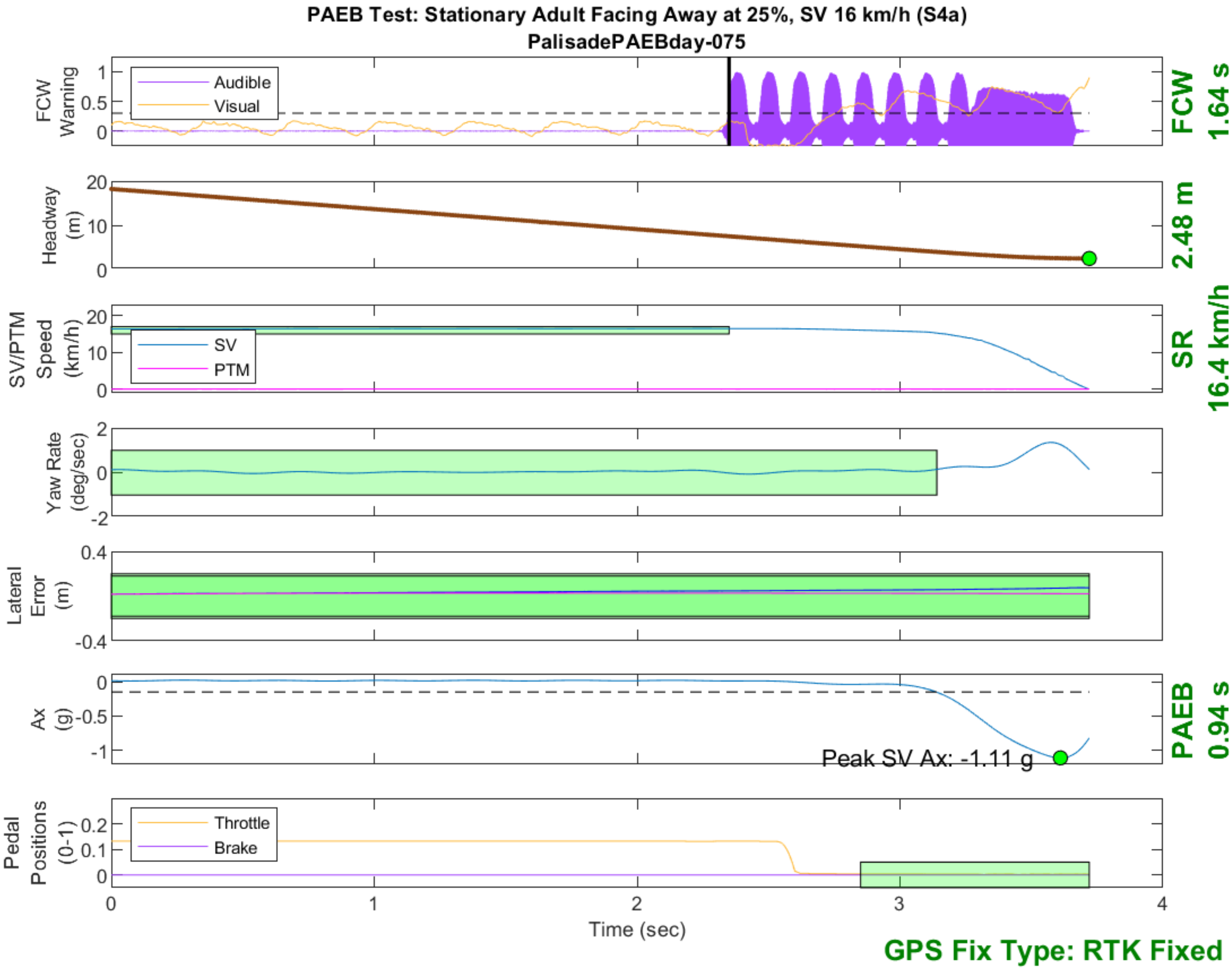


Figure D108. Time History for PAEB Run 75, S4a, Daytime, 16 km/h

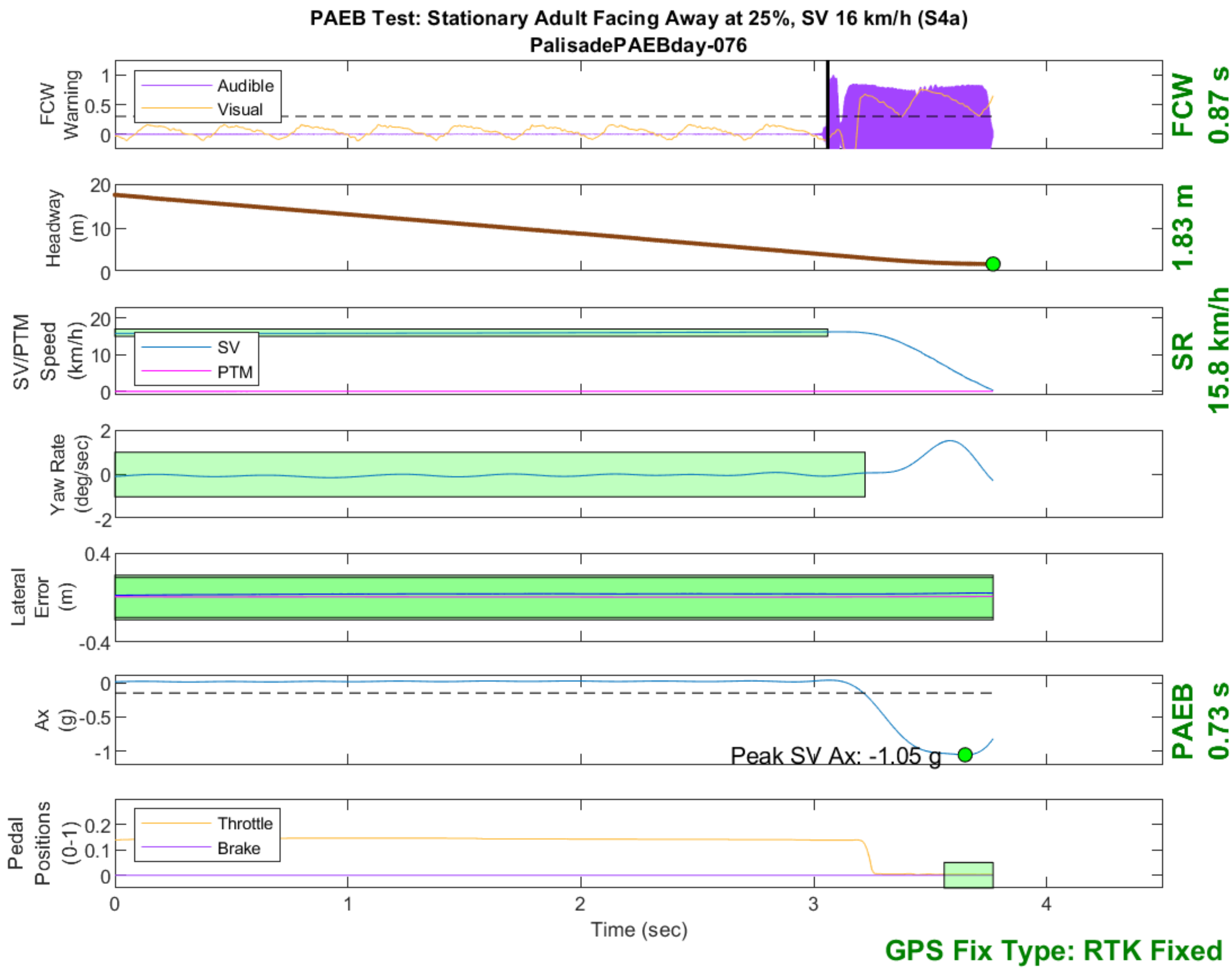


Figure D109. Time History for PAEB Run 76, S4a, Daytime, 16 km/h

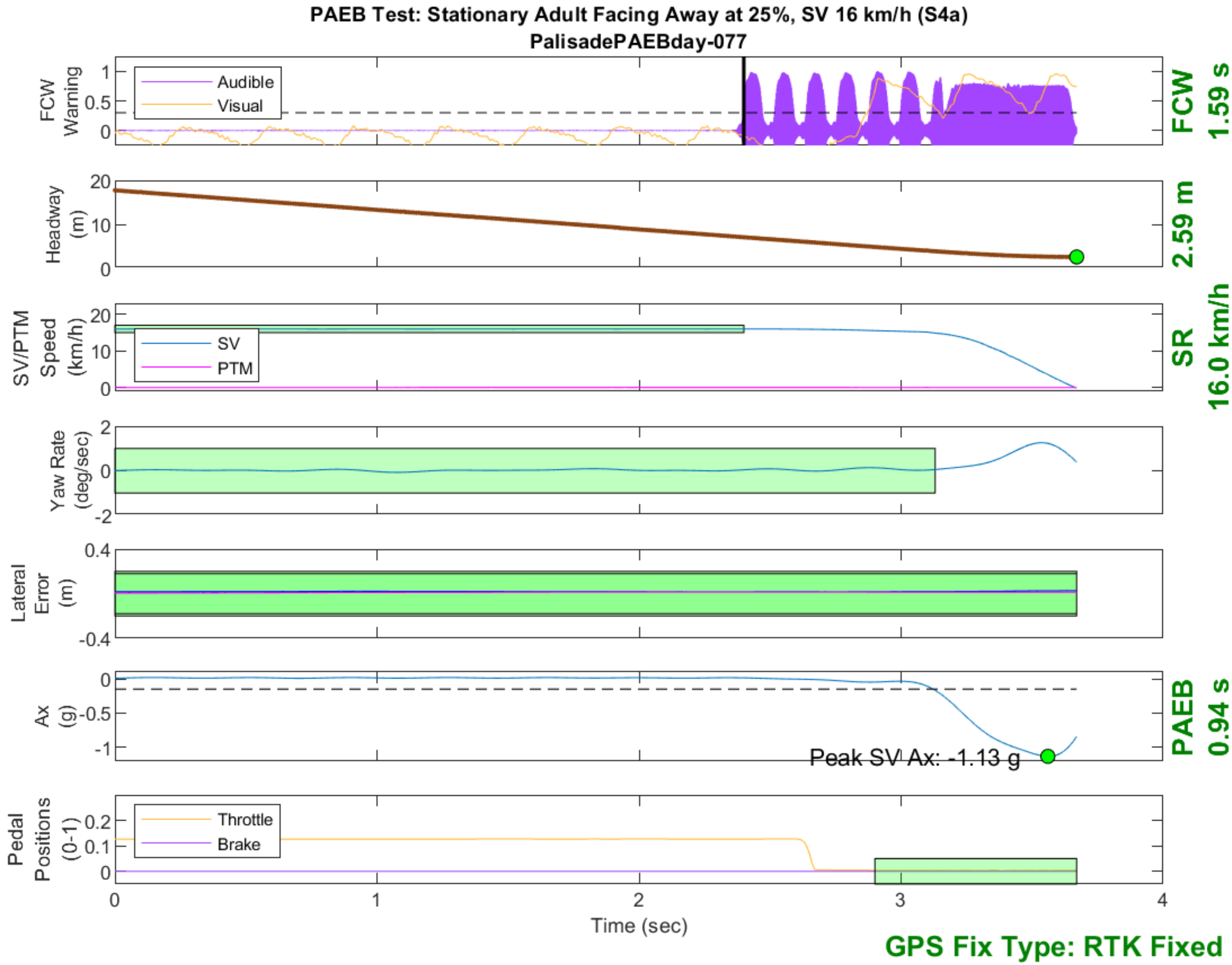


Figure D110. Time History for PAEB Run 77, S4a, Daytime, 16 km/h

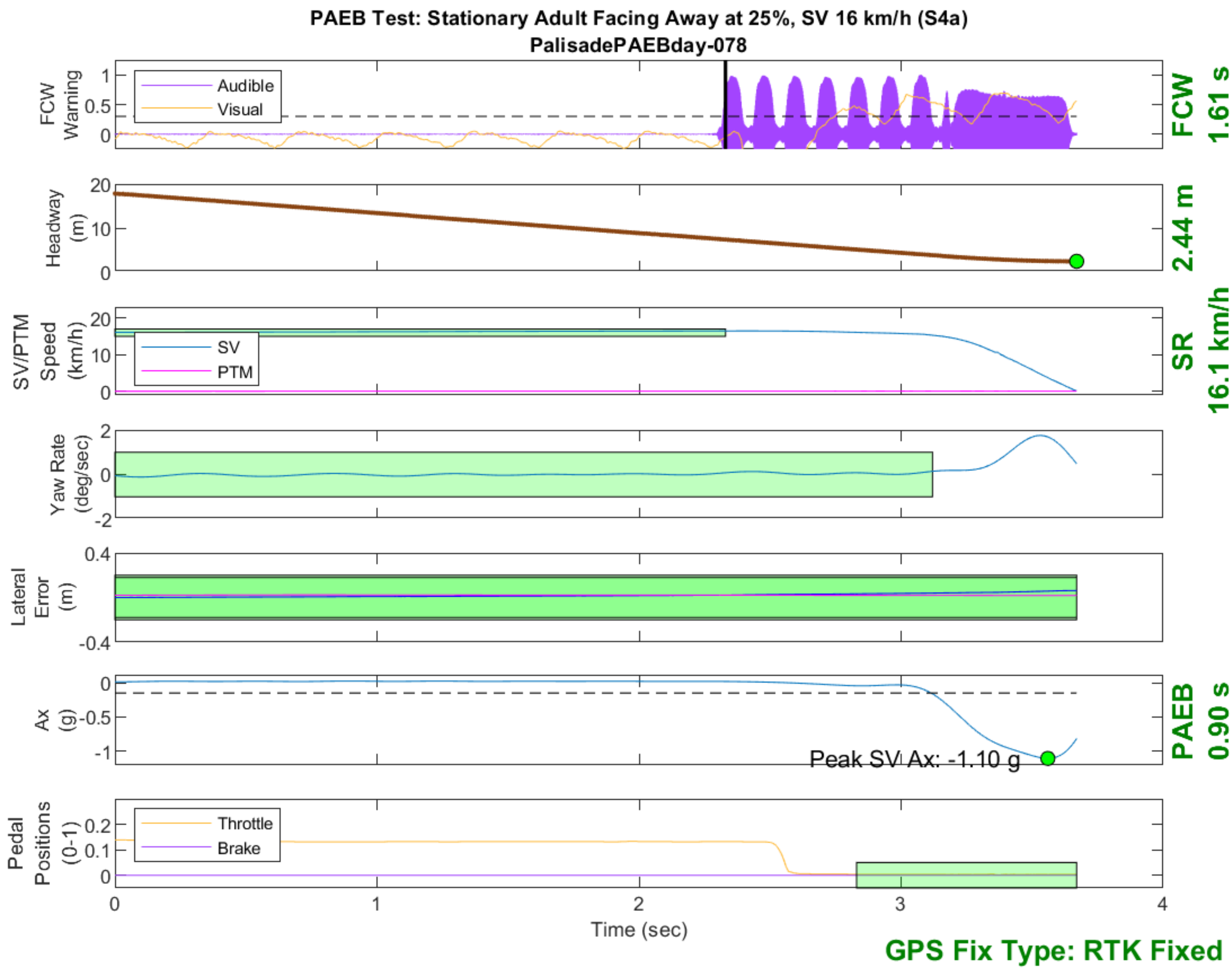


Figure D111. Time History for PAEB Run 78, S4a, Daytime, 16 km/h

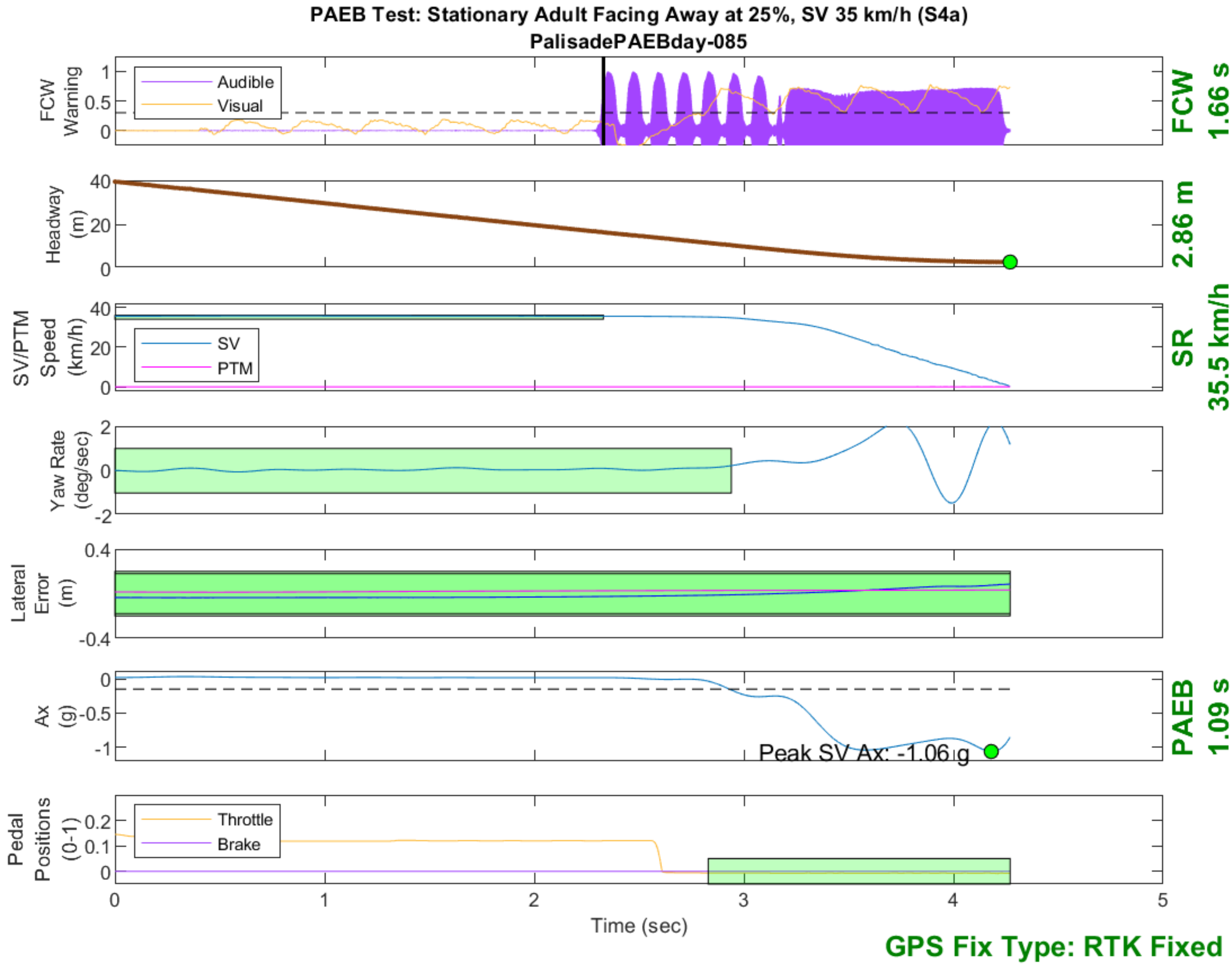


Figure D112. Time History for PAEB Run 85, S4a, Daytime, 35 km/h

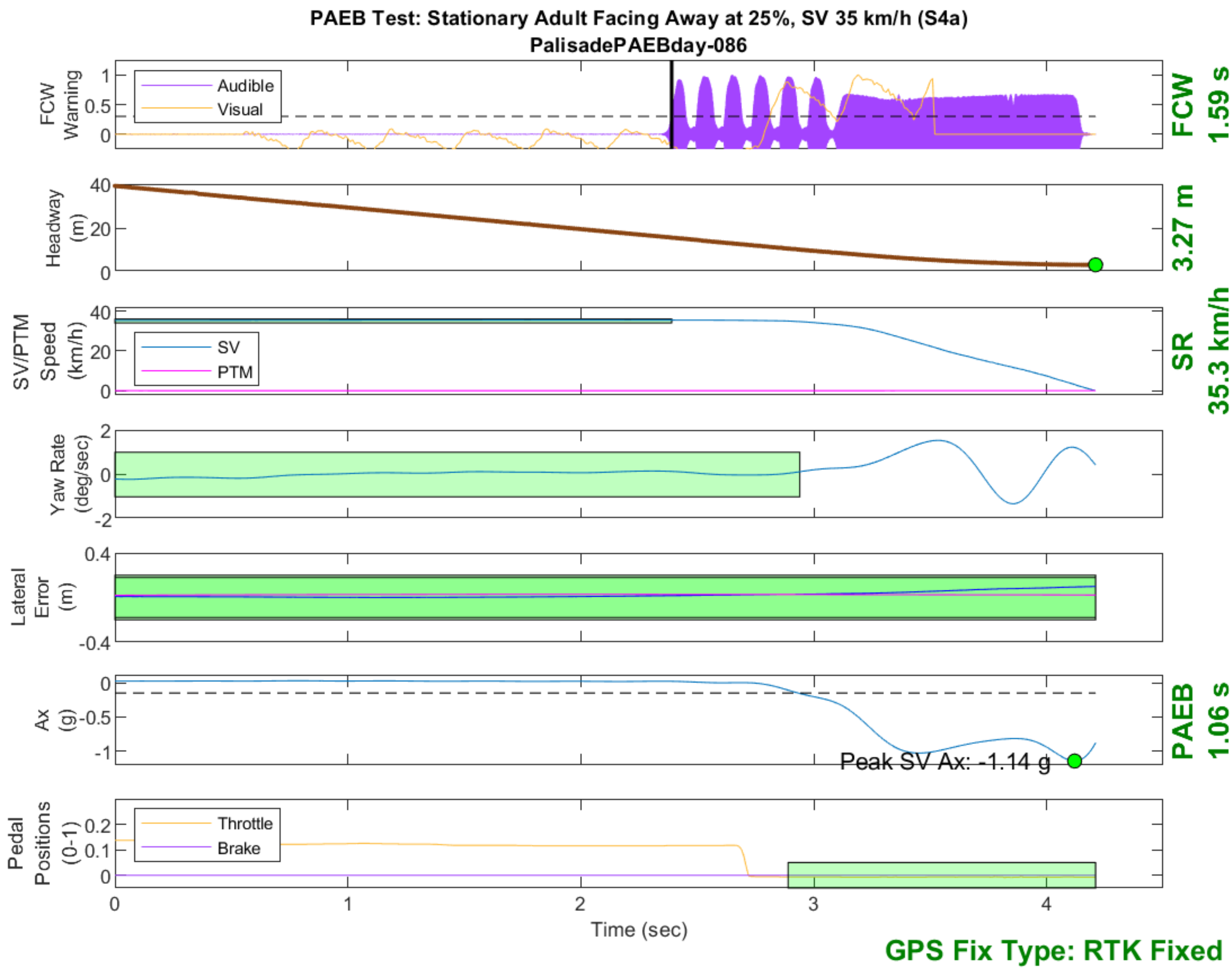


Figure D113. Time History for PAEB Run 86, S4a, Daytime, 35 km/h

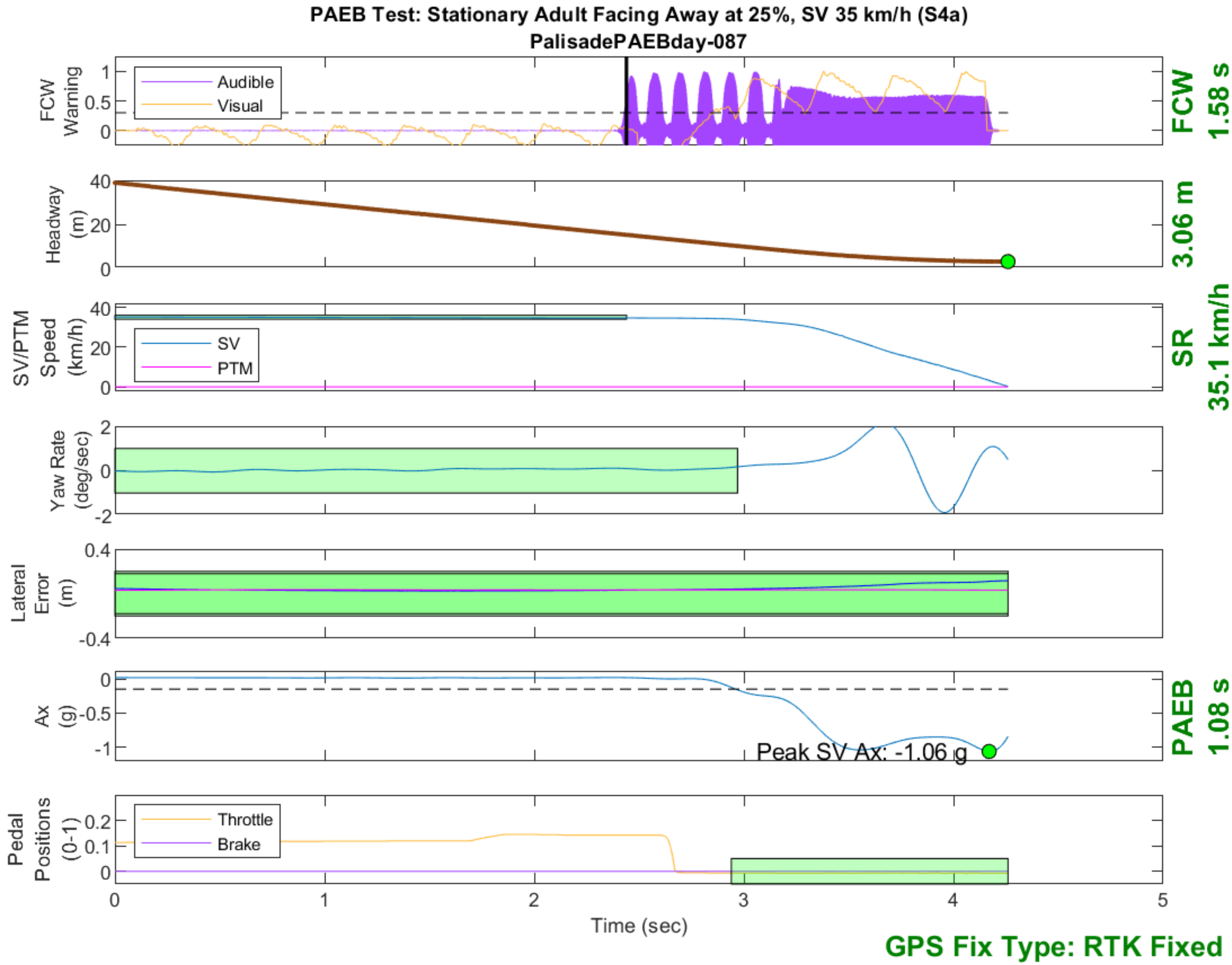


Figure D114. Time History for PAEB Run 87, S4a, Daytime, 35 km/h

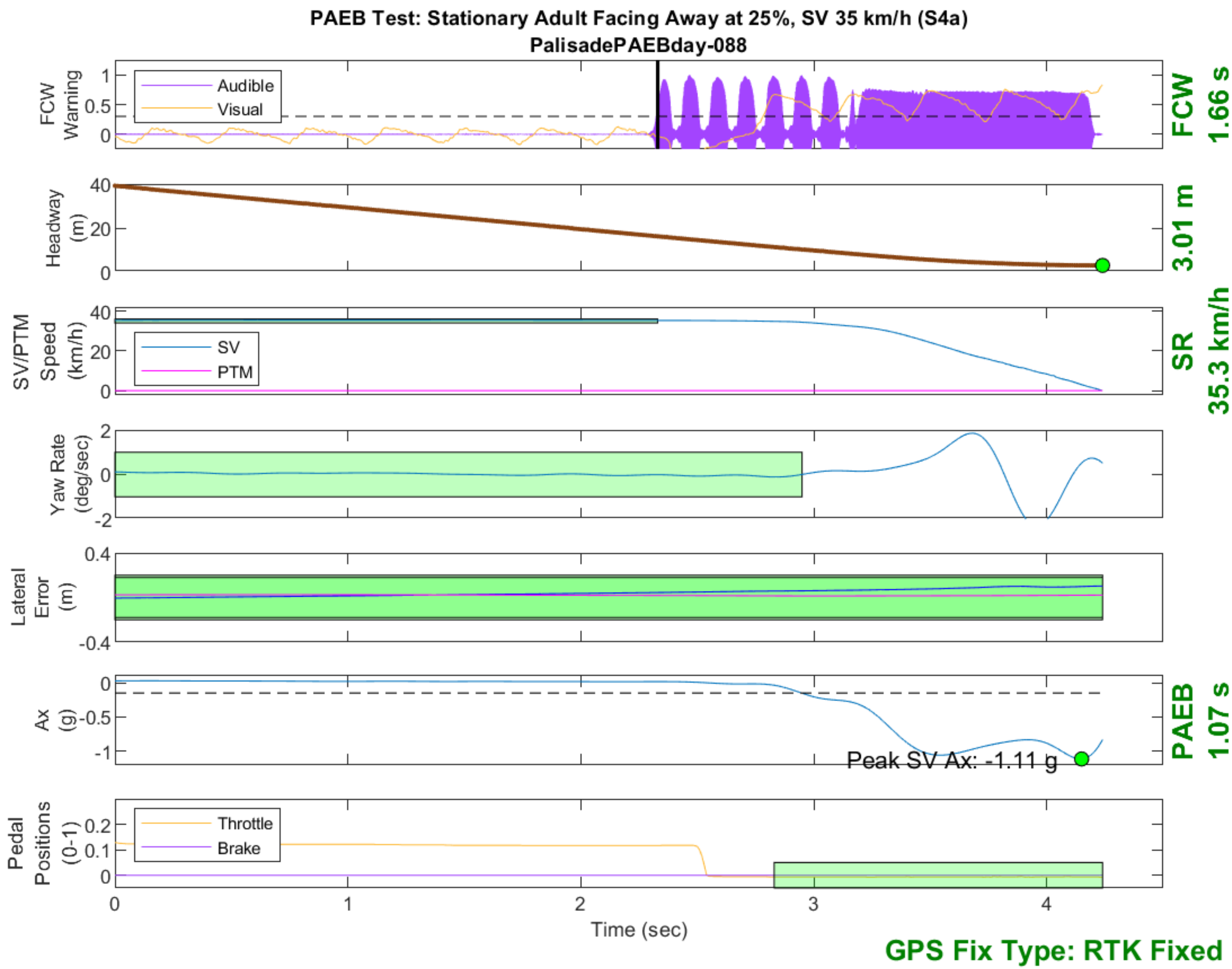


Figure D115. Time History for PAEB Run 88, S4a, Daytime, 35 km/h

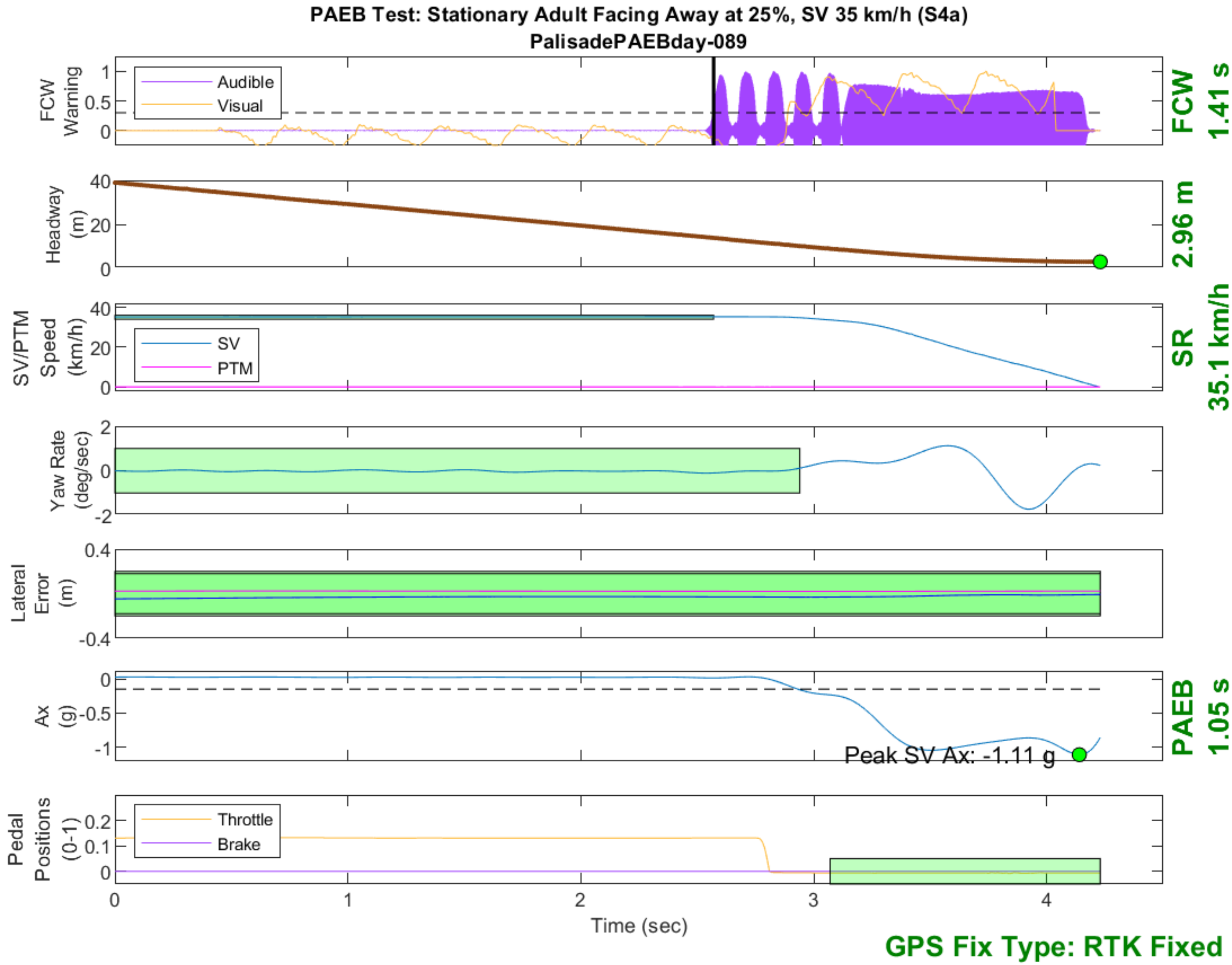


Figure D116. Time History for PAEB Run 89, S4a, Daytime, 35 km/h

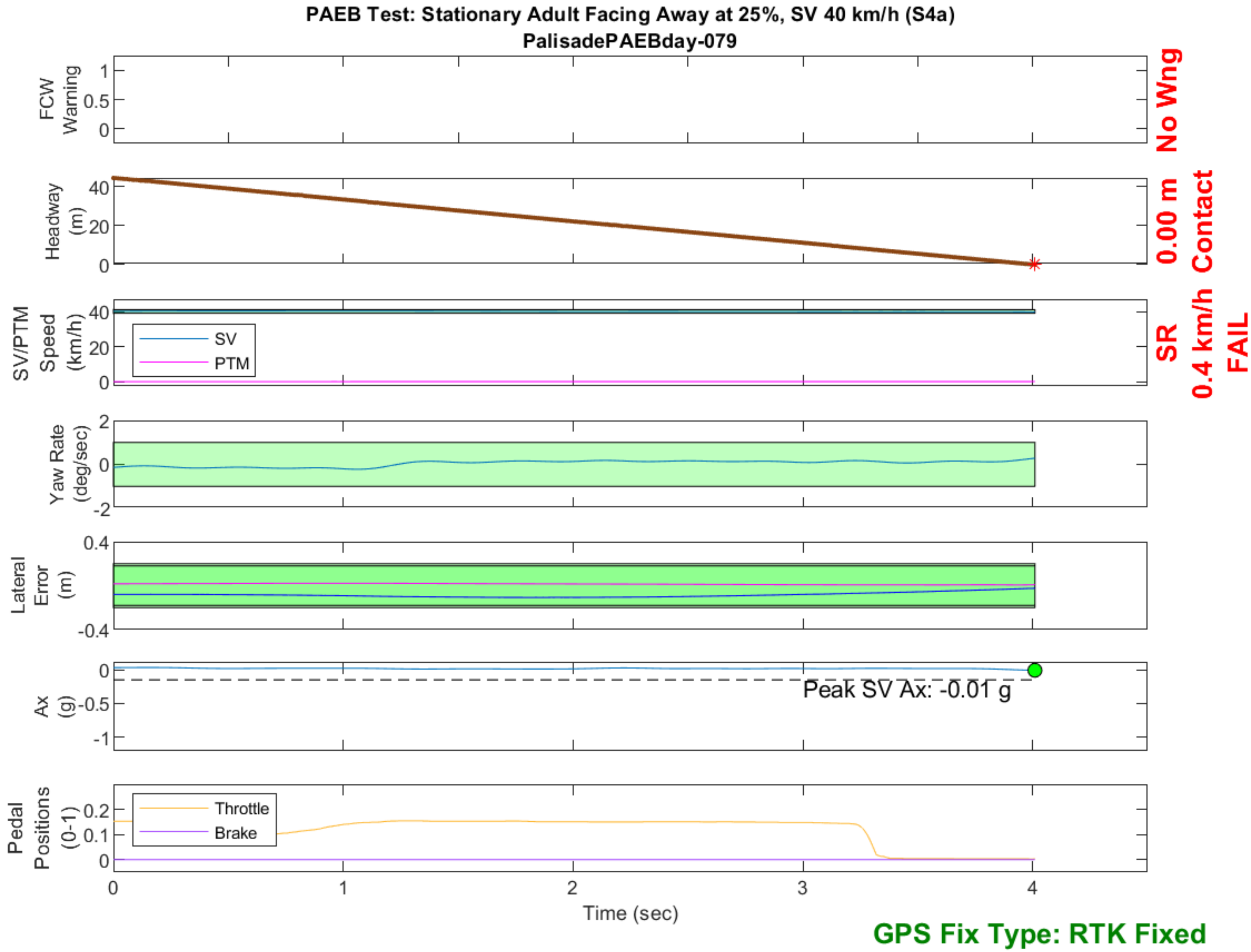


Figure D117. Time History for PAEB Run 79, S4a, Daytime, 40 km/h

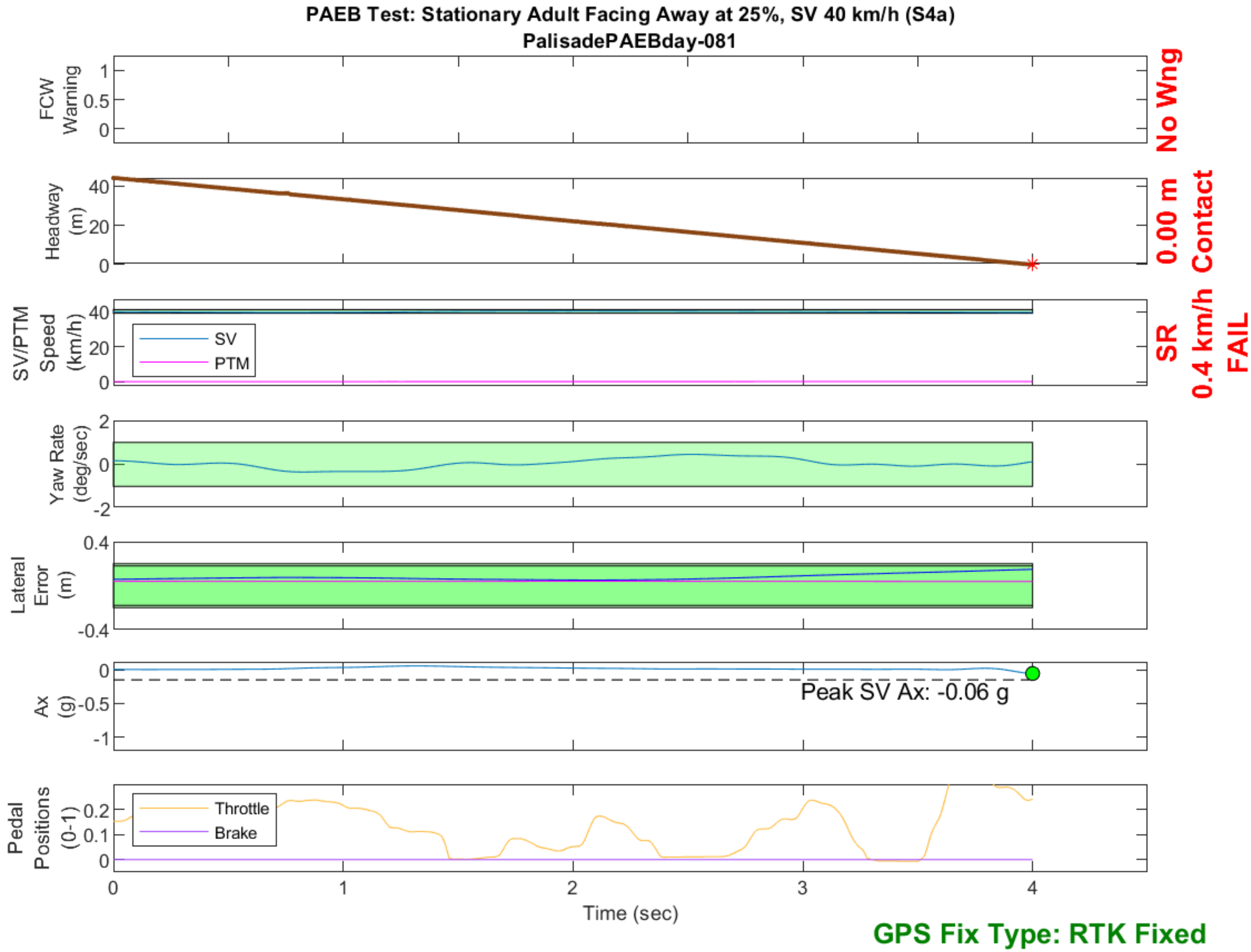


Figure D118. Time History for PAEB Run 81, S4a, Daytime, 40 km/h

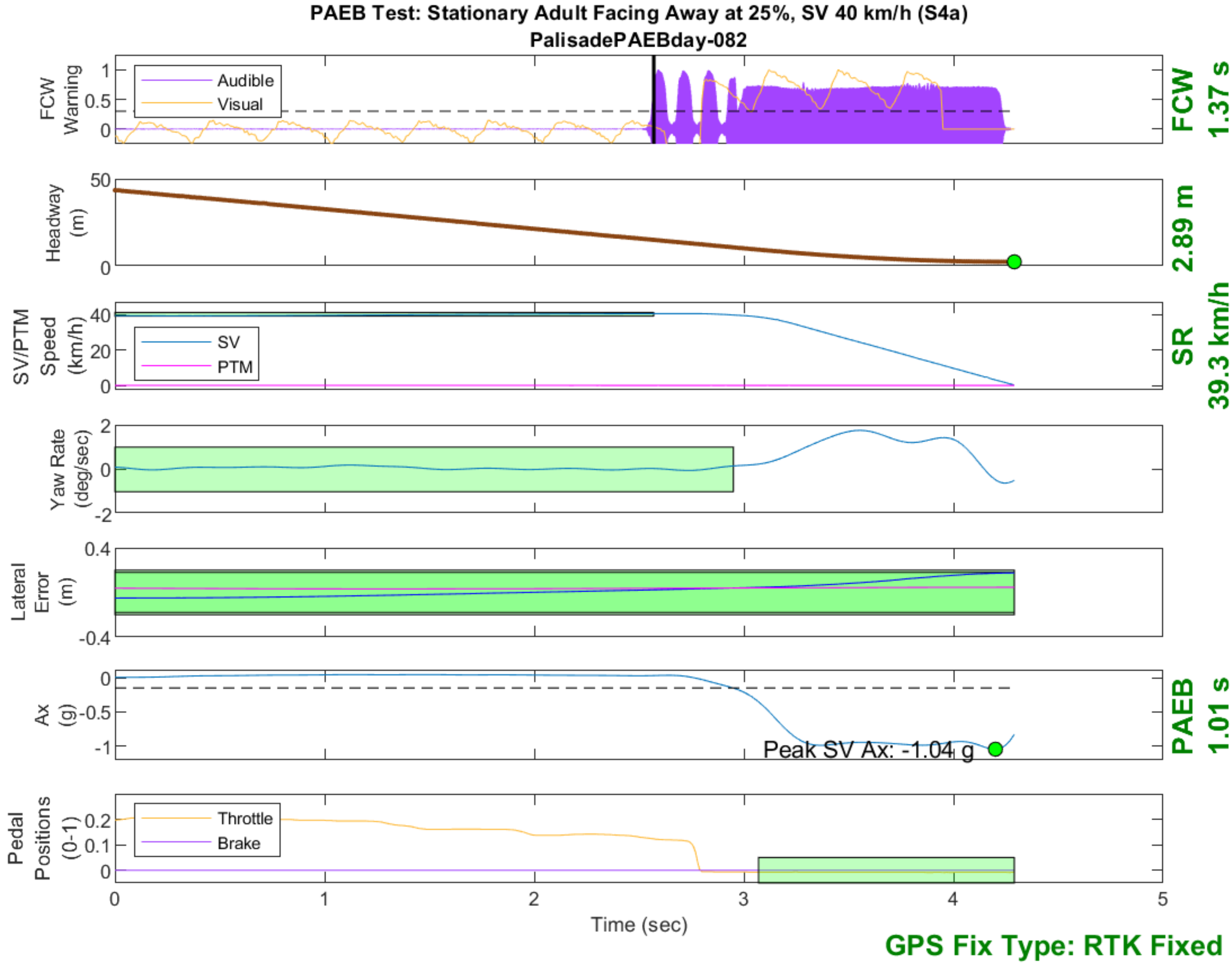


Figure D119. Time History for PAEB Run 82, S4a, Daytime, 40 km/h

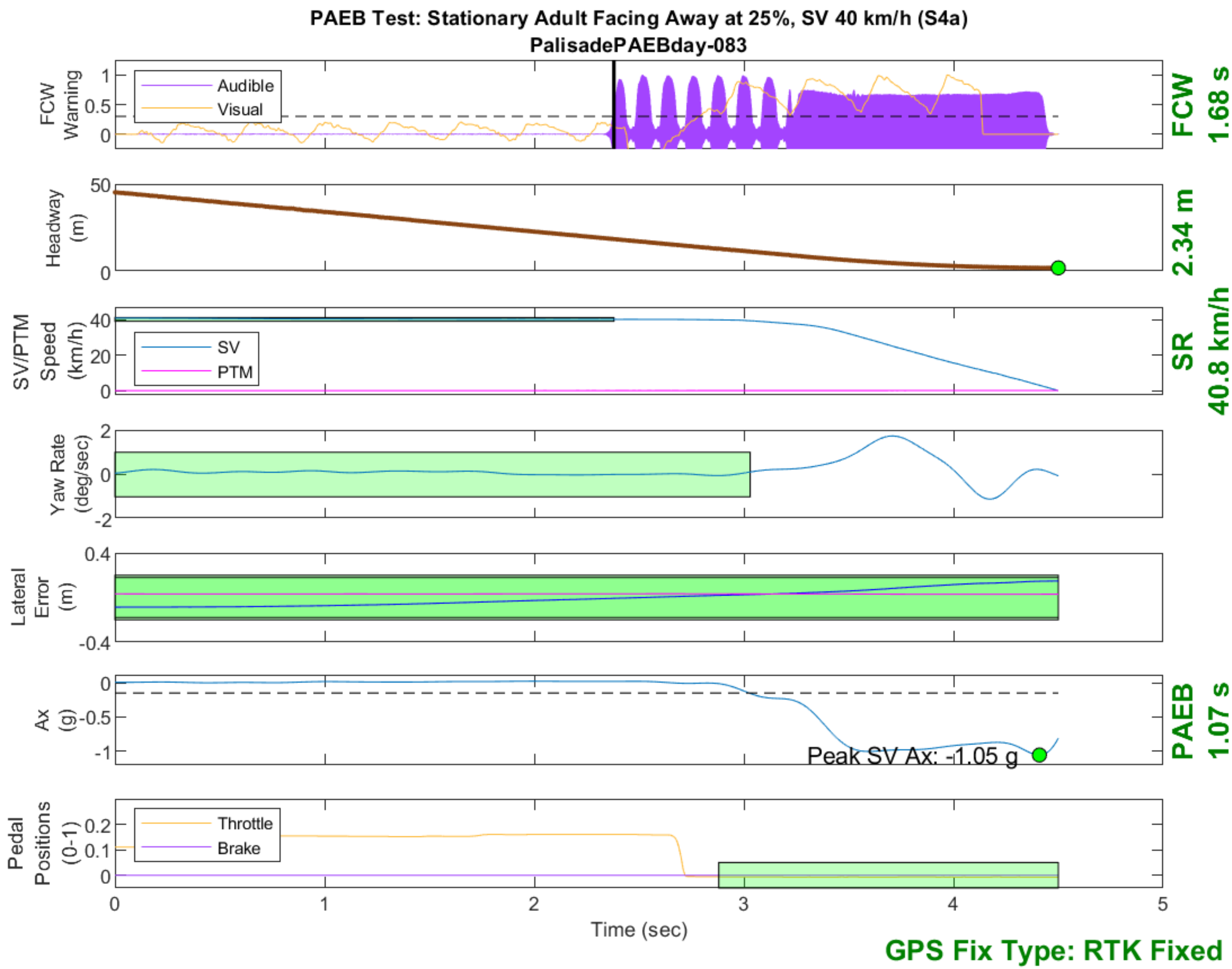


Figure D120. Time History for PAEB Run 83, S4a, Daytime, 40 km/h

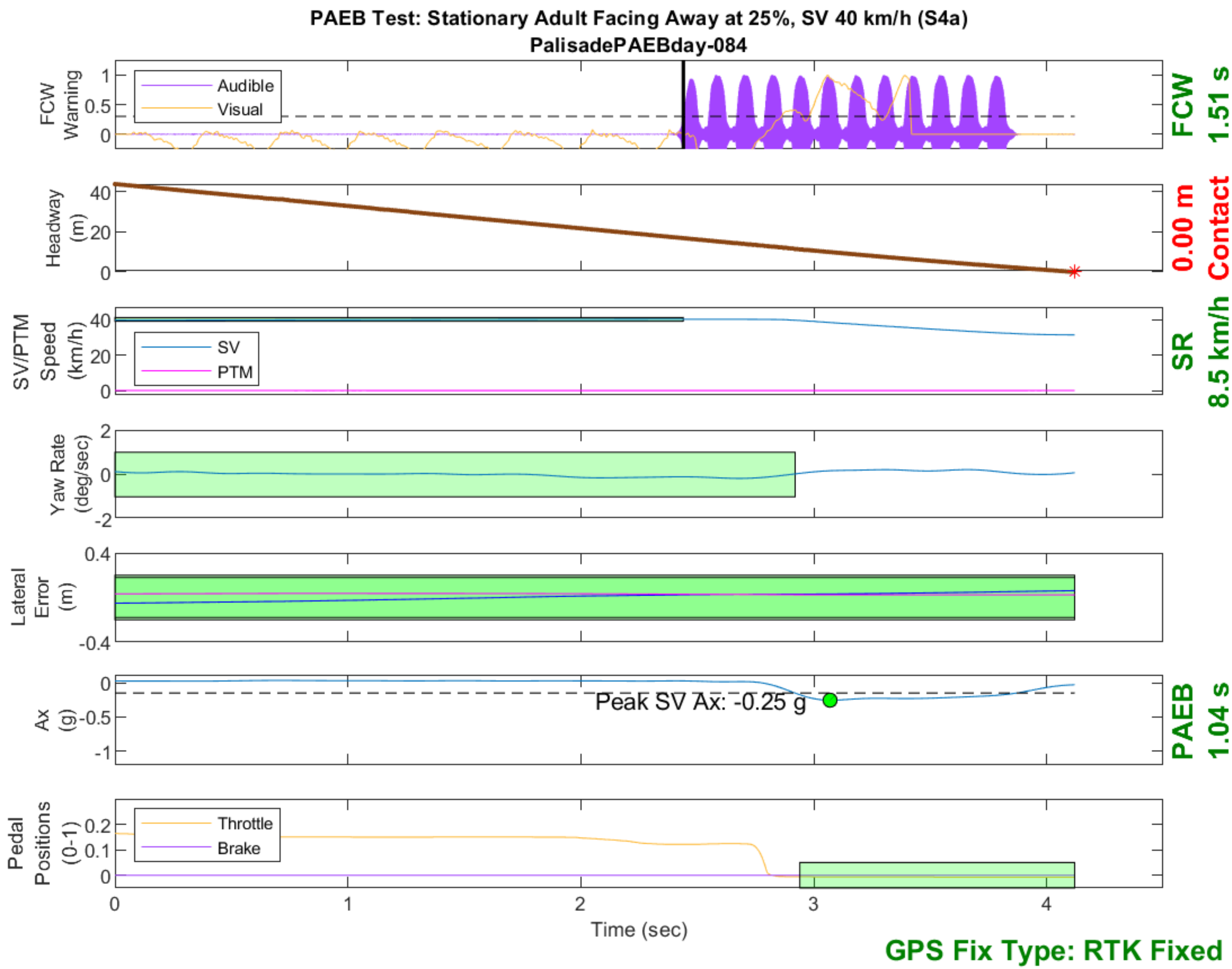


Figure D121. Time History for PAEB Run 84, S4a, Daytime, 40 km/h

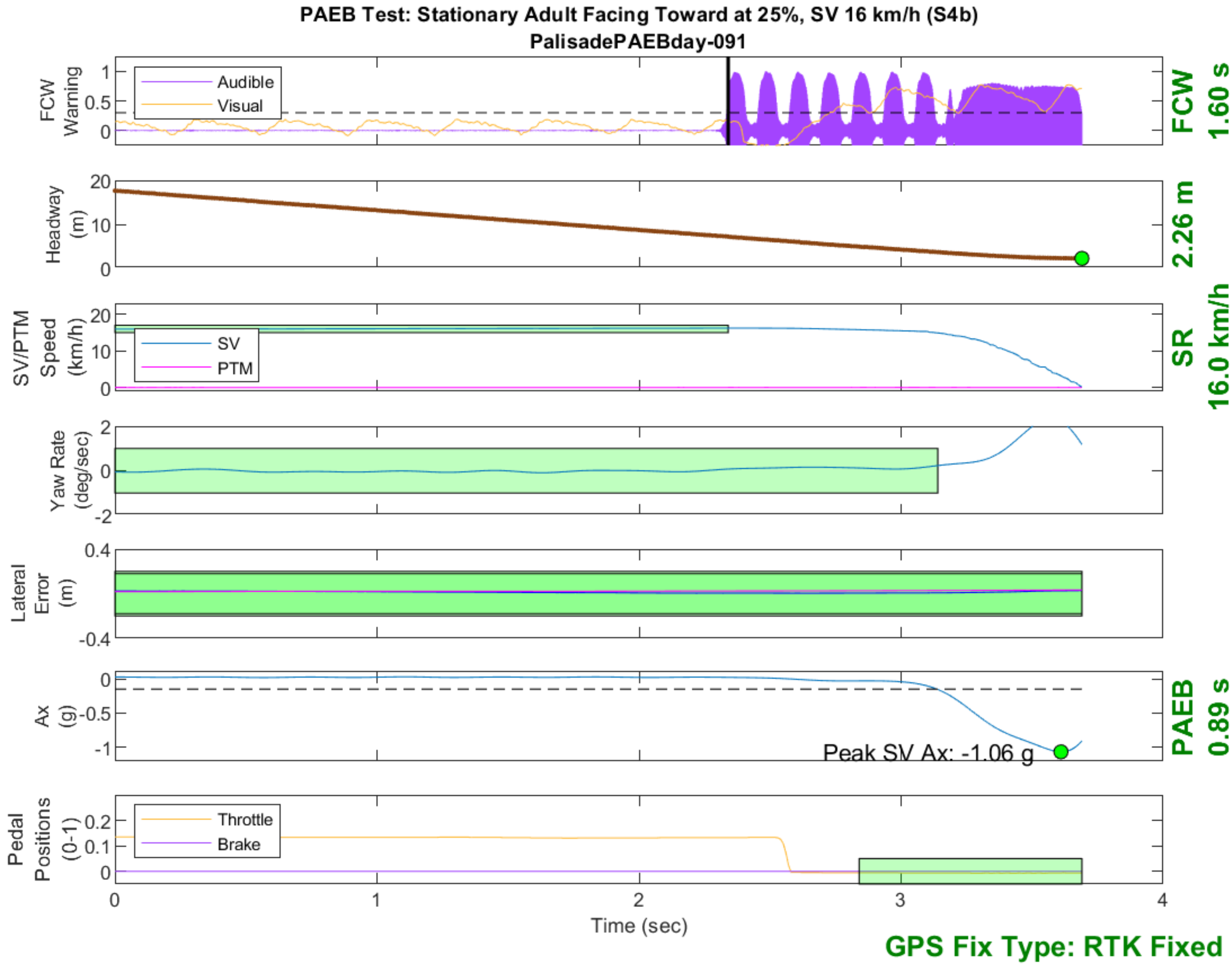


Figure D122. Time History for PAEB Run 91, S4b, Daytime, 16 km/h

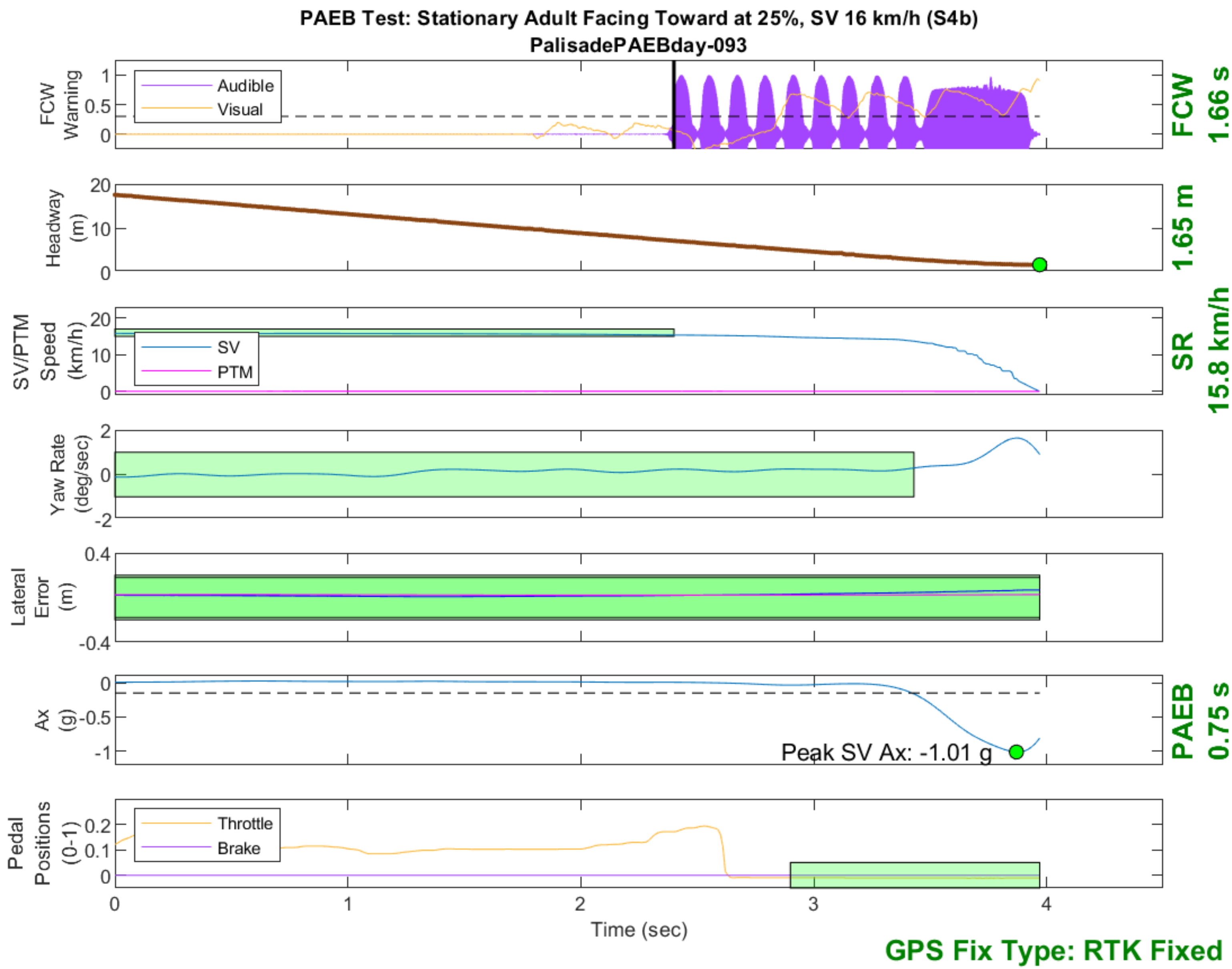


Figure D123. Time History for PAEB Run 93, S4b, Daytime, 16 km/h

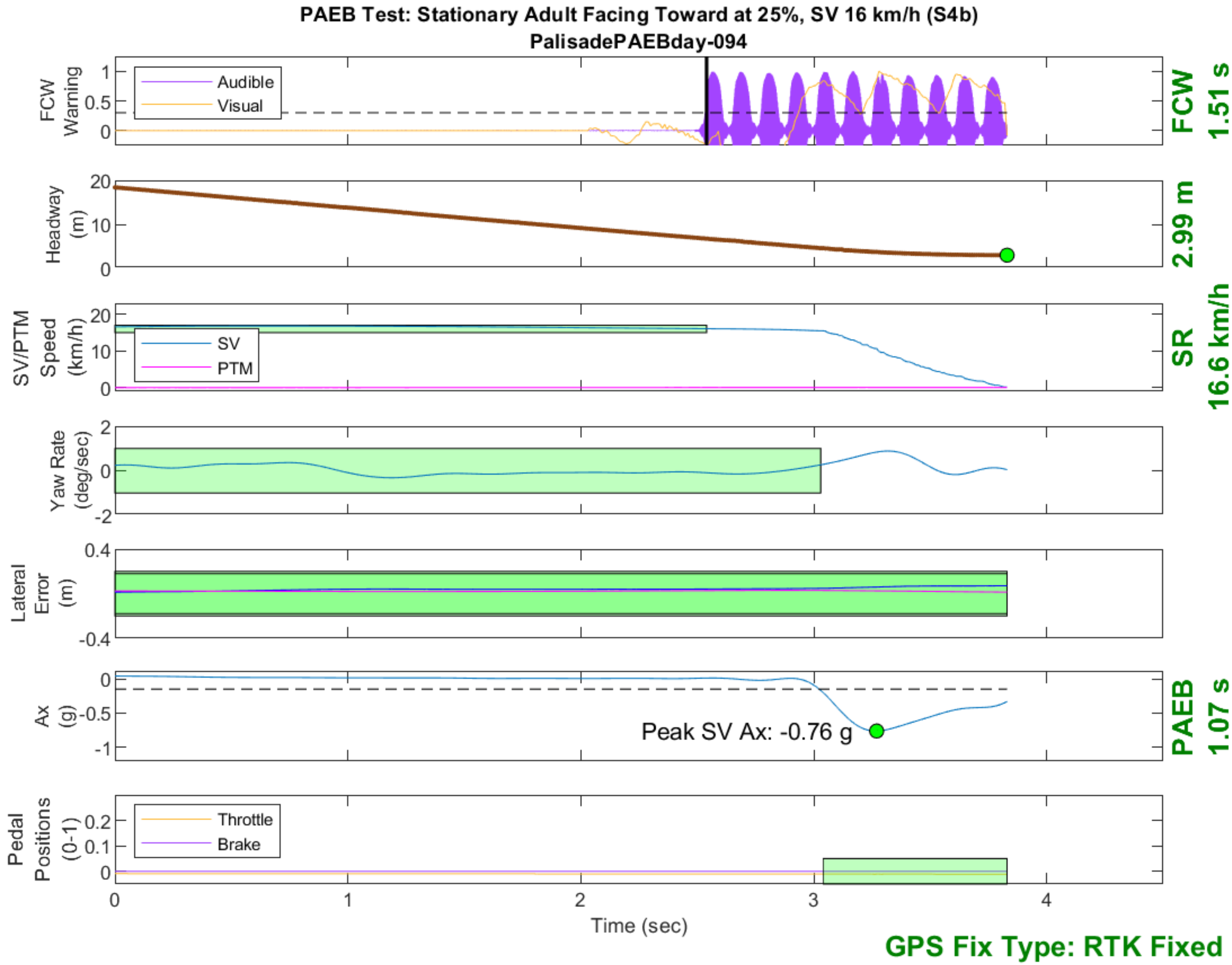


Figure D124. Time History for PAEB Run 94, S4b, Daytime, 16 km/h

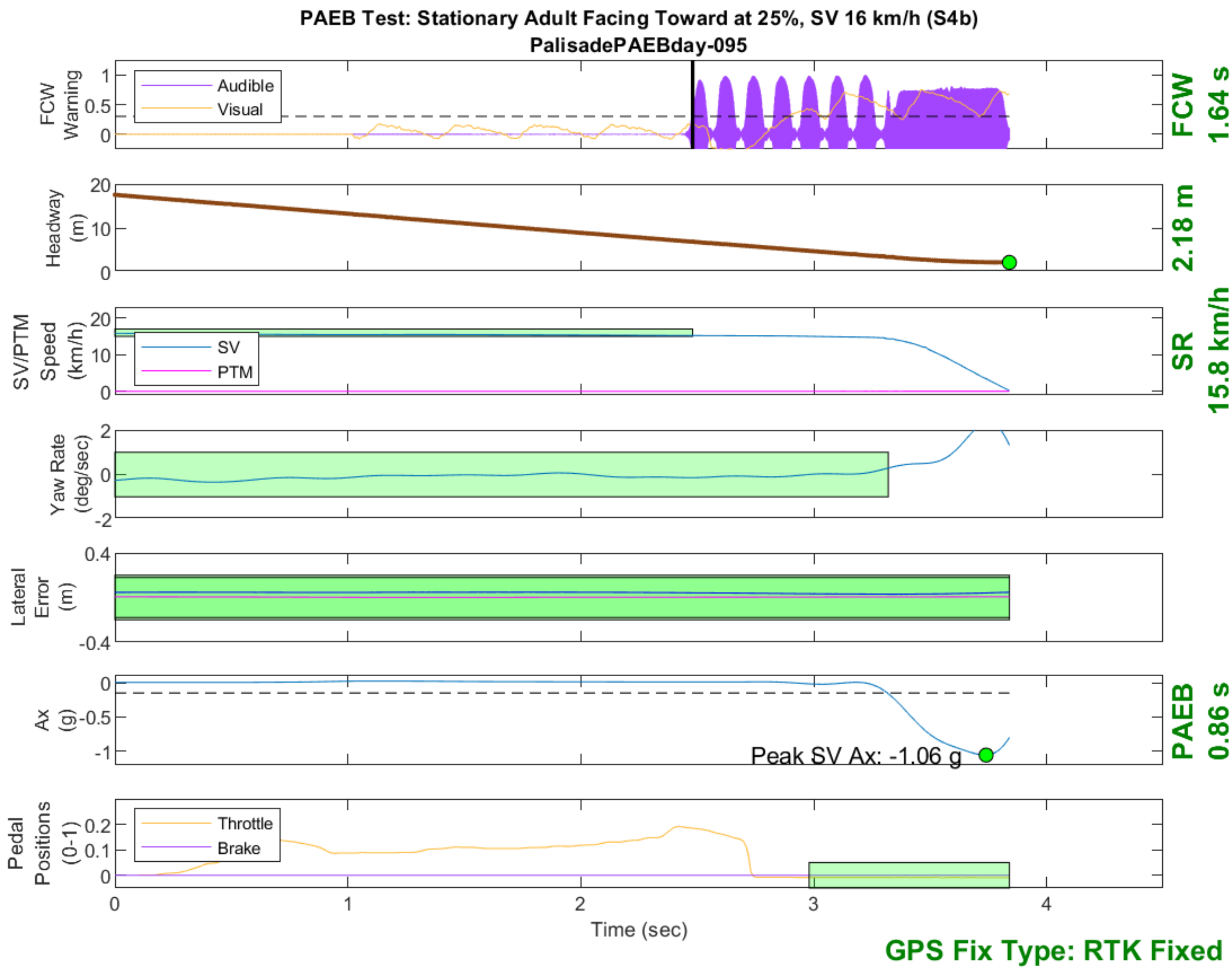


Figure D125. Time History for PAEB Run 95, S4b, Daytime, 16 km/h

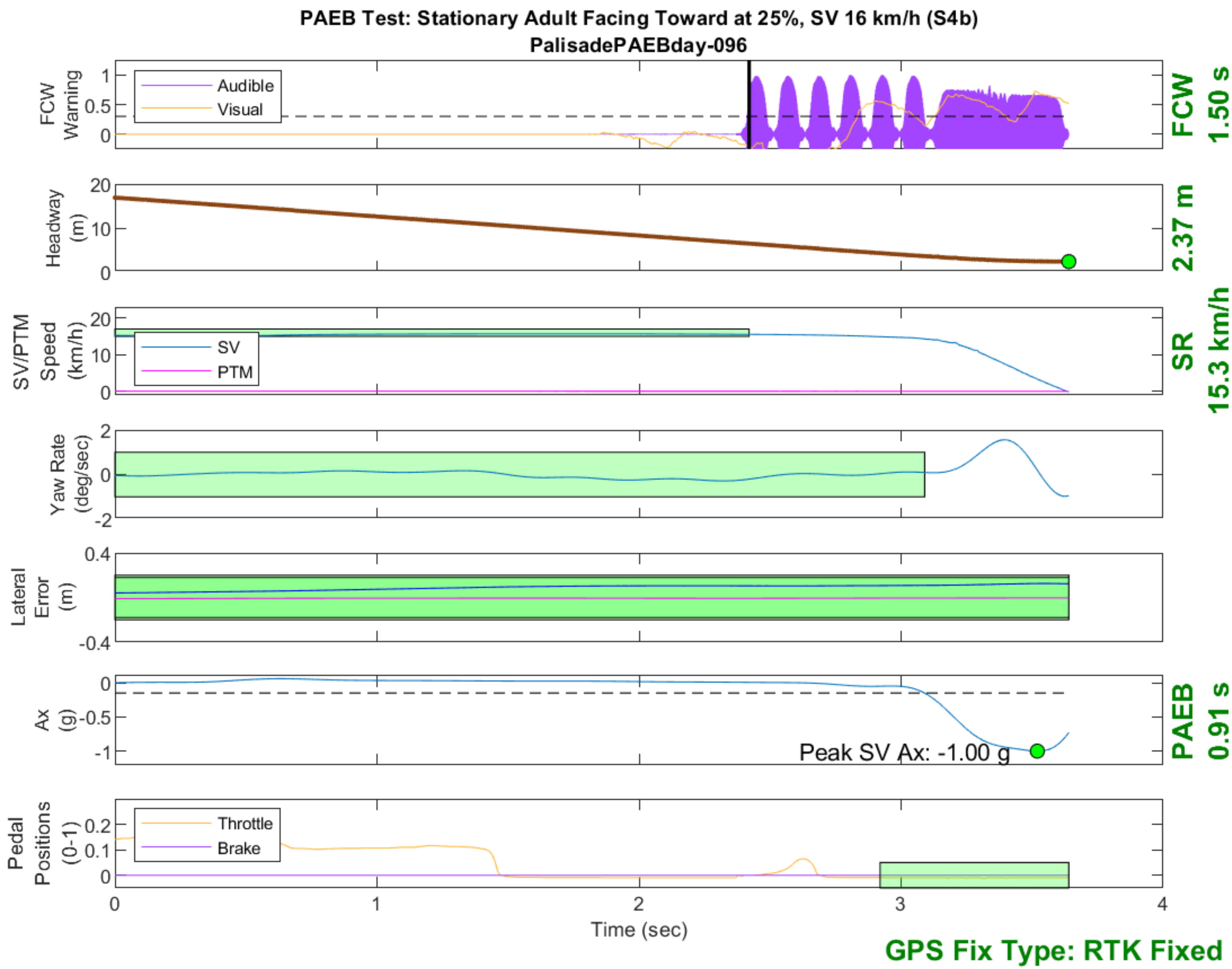


Figure D126. Time History for PAEB Run 96, S4b, Daytime, 16 km/h

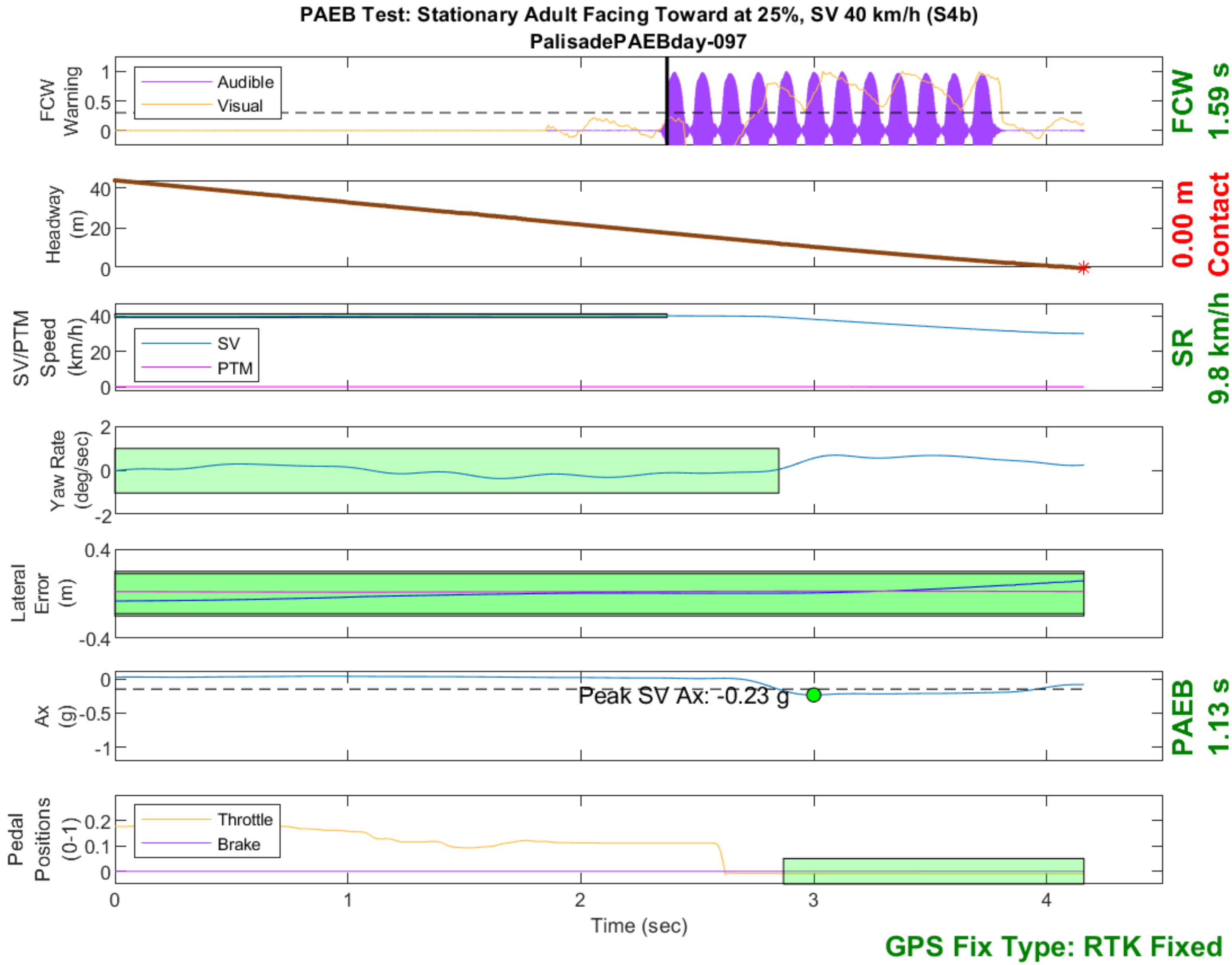


Figure D127. Time History for PAEB Run 97, S4b, Daytime, 40 km/h

Figure D128. Time History for PAEB Run 100, S4b, Daytime, 40 km/h

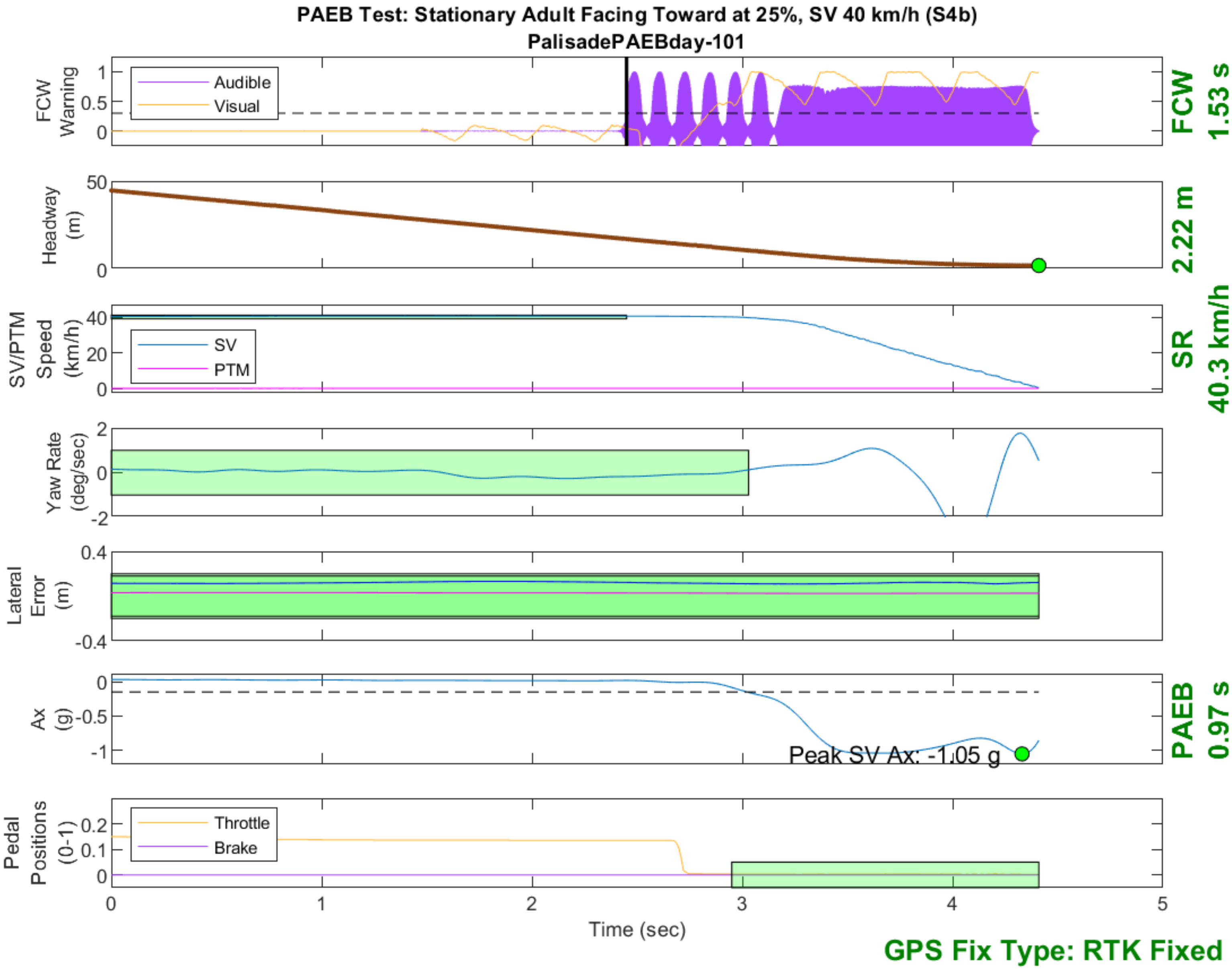


Figure D129. Time History for PAEB Run 101, S4b, Daytime, 40 km/h

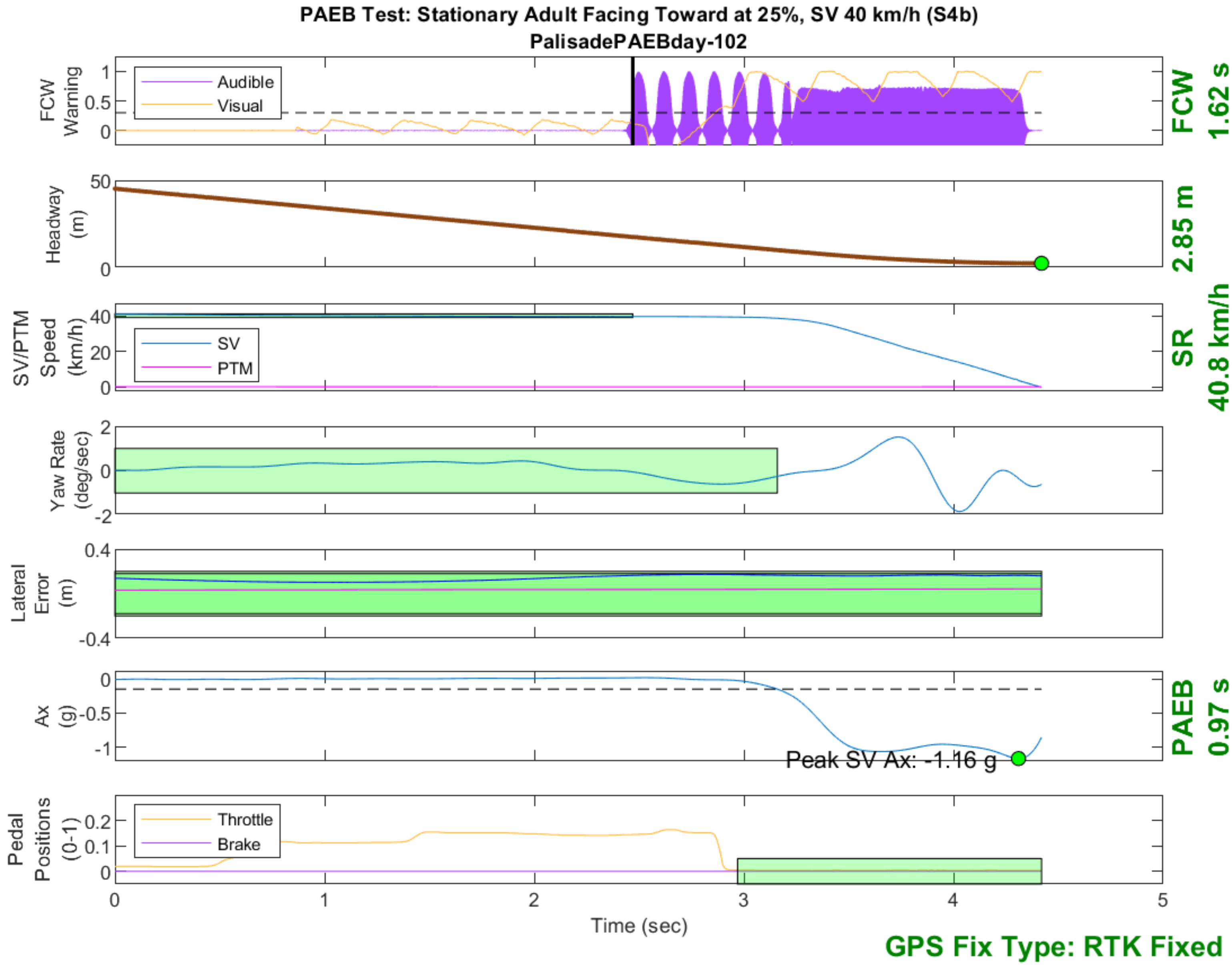


Figure D130. Time History for PAEB Run 102, S4b, Daytime, 40 km/h

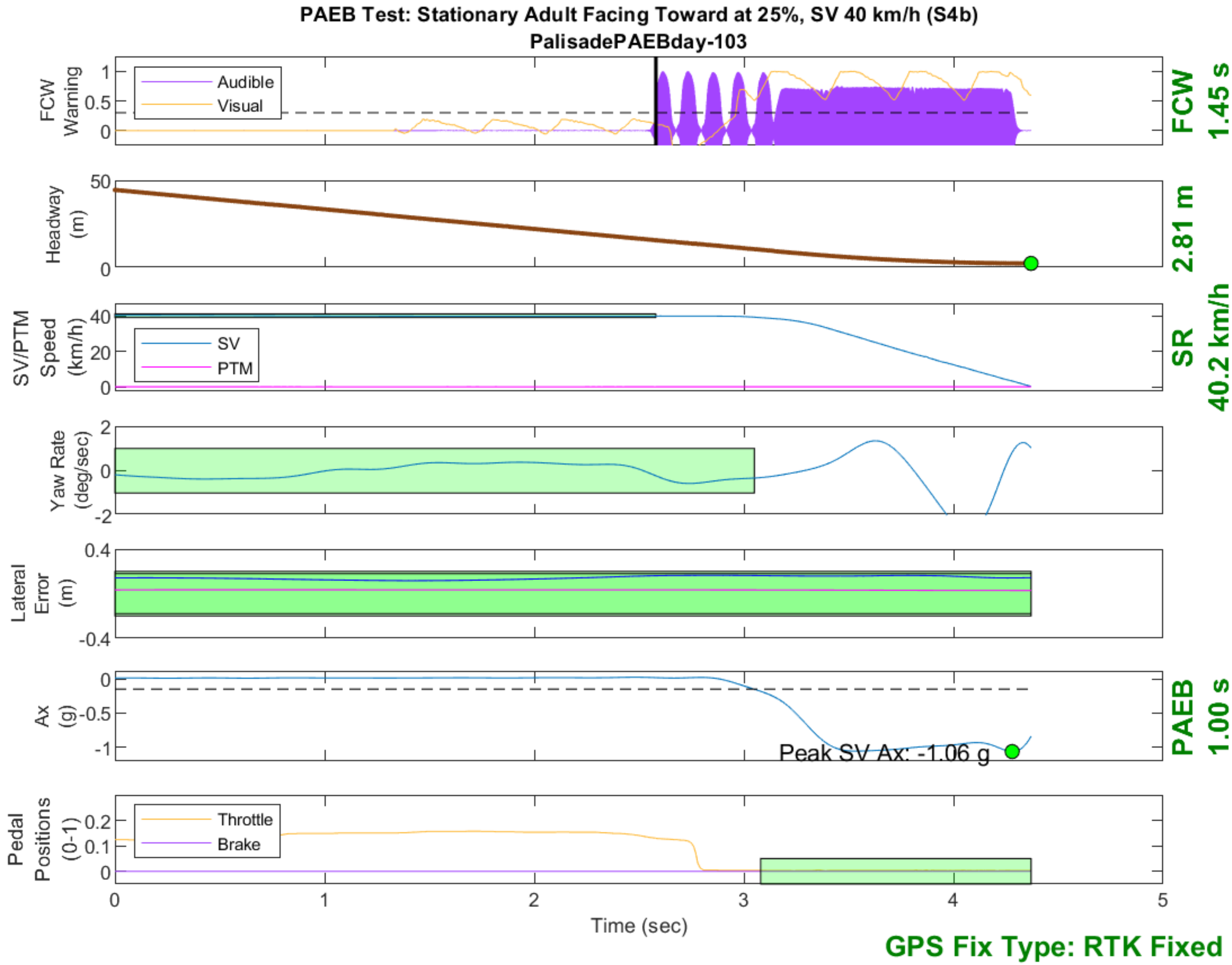


Figure D131. Time History for PAEB Run 103, S4b, Daytime, 40 km/h

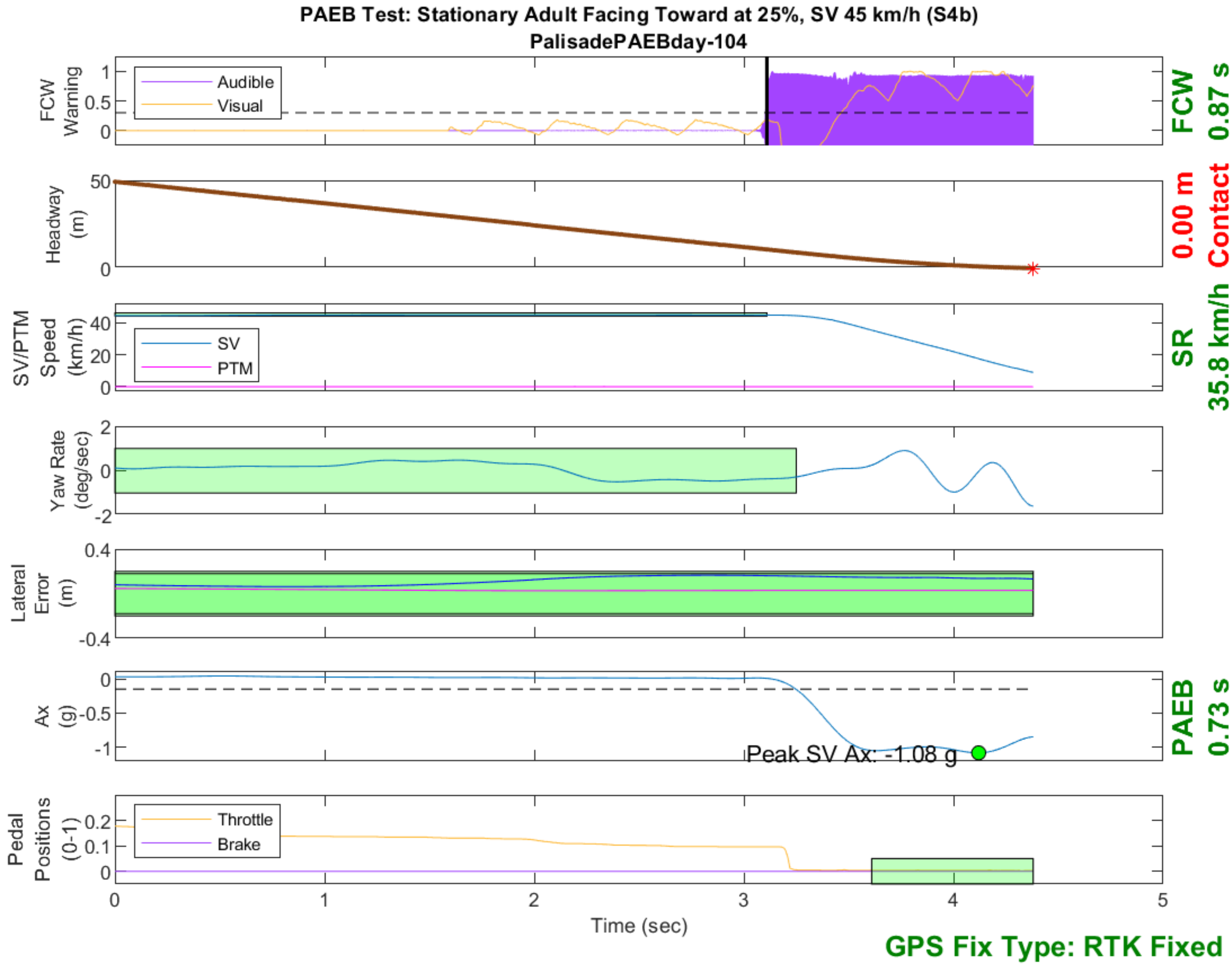


Figure D132. Time History for PAEB Run 104, S4b, Daytime, 45 km/h

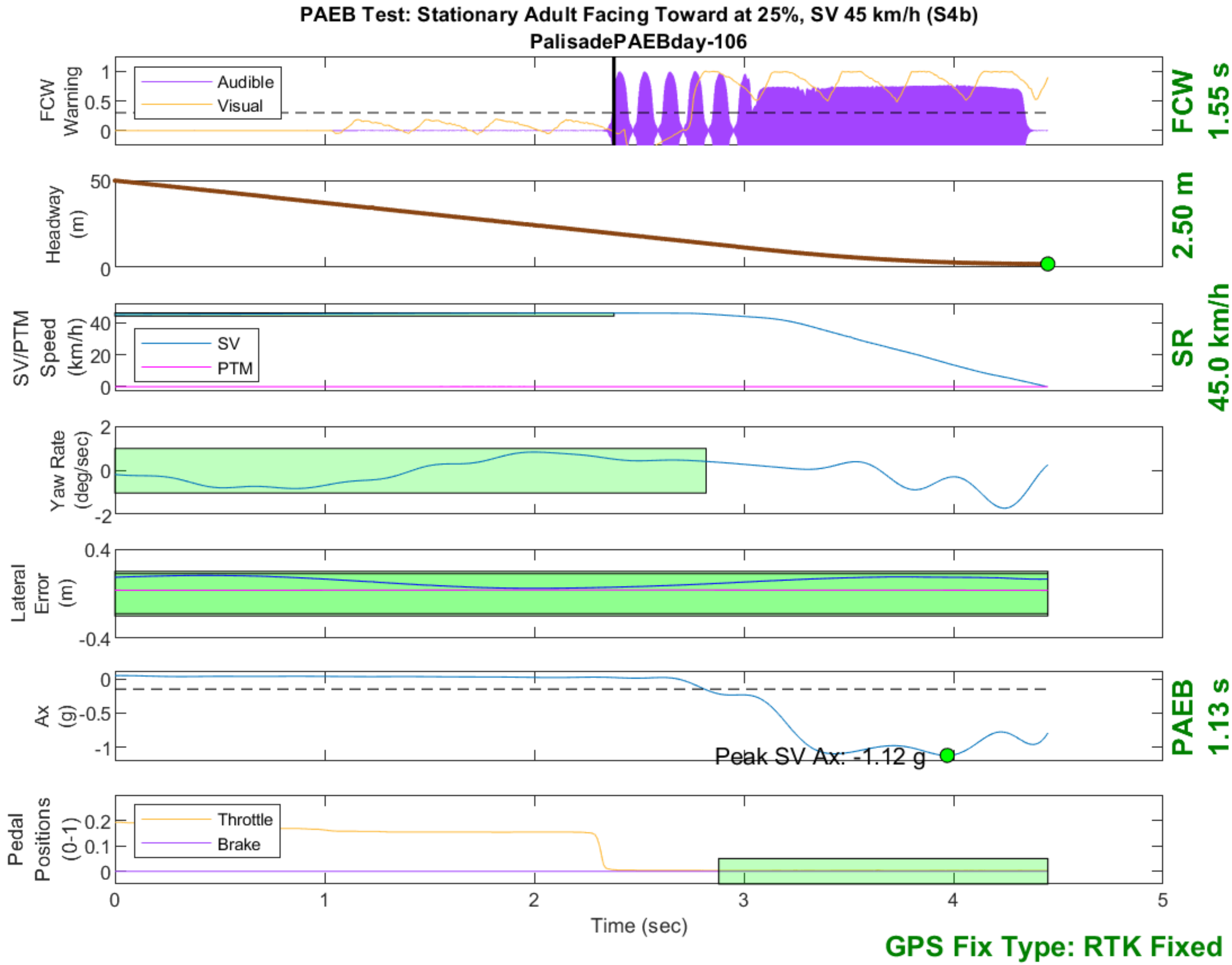


Figure D133. Time History for PAEB Run 106, S4b, Daytime, 45 km/h

Figure D134. Time History for PAEB Run 107, S4b, Daytime, 45 km/h

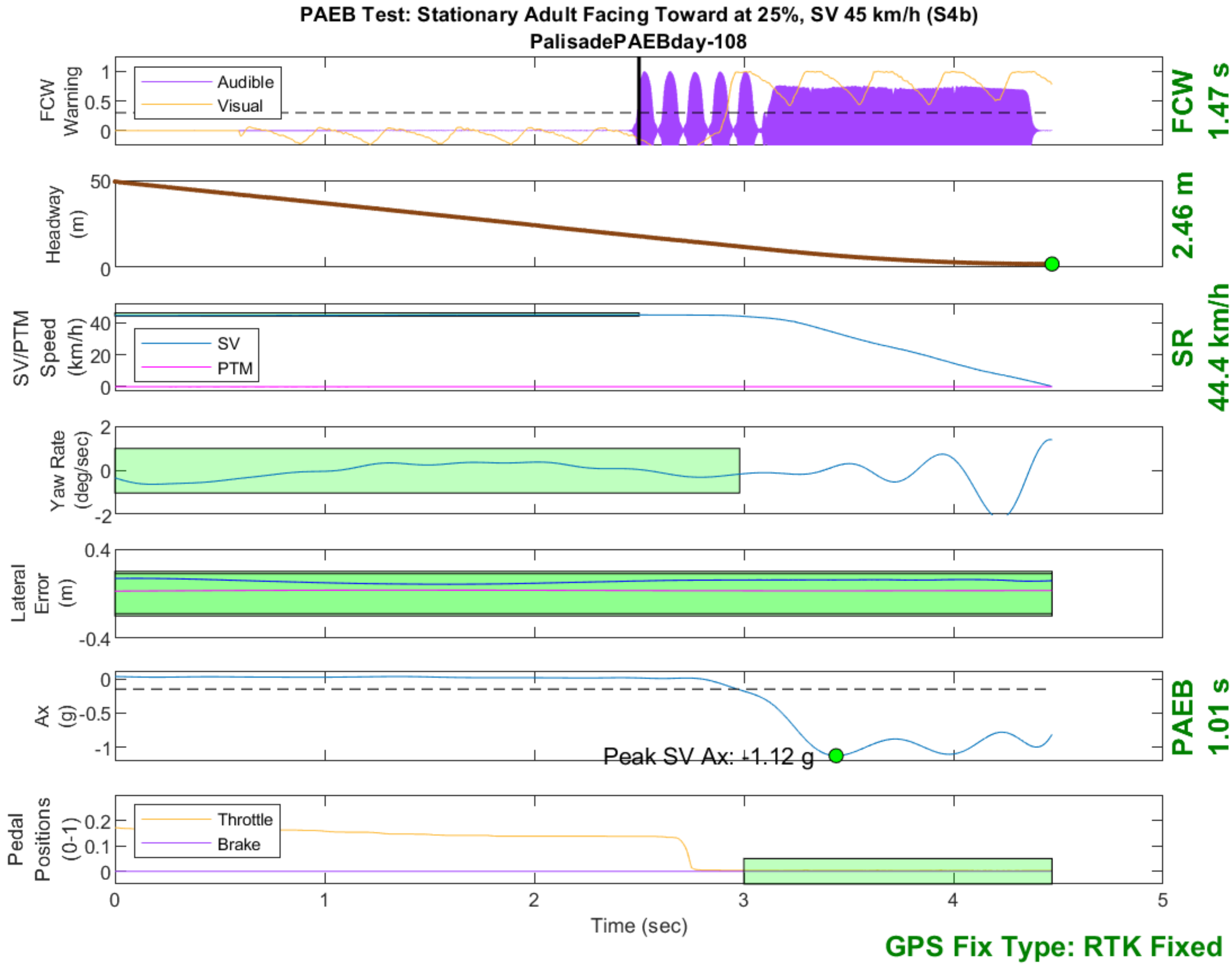


Figure D135. Time History for PAEB Run 108, S4b, Daytime, 45 km/h

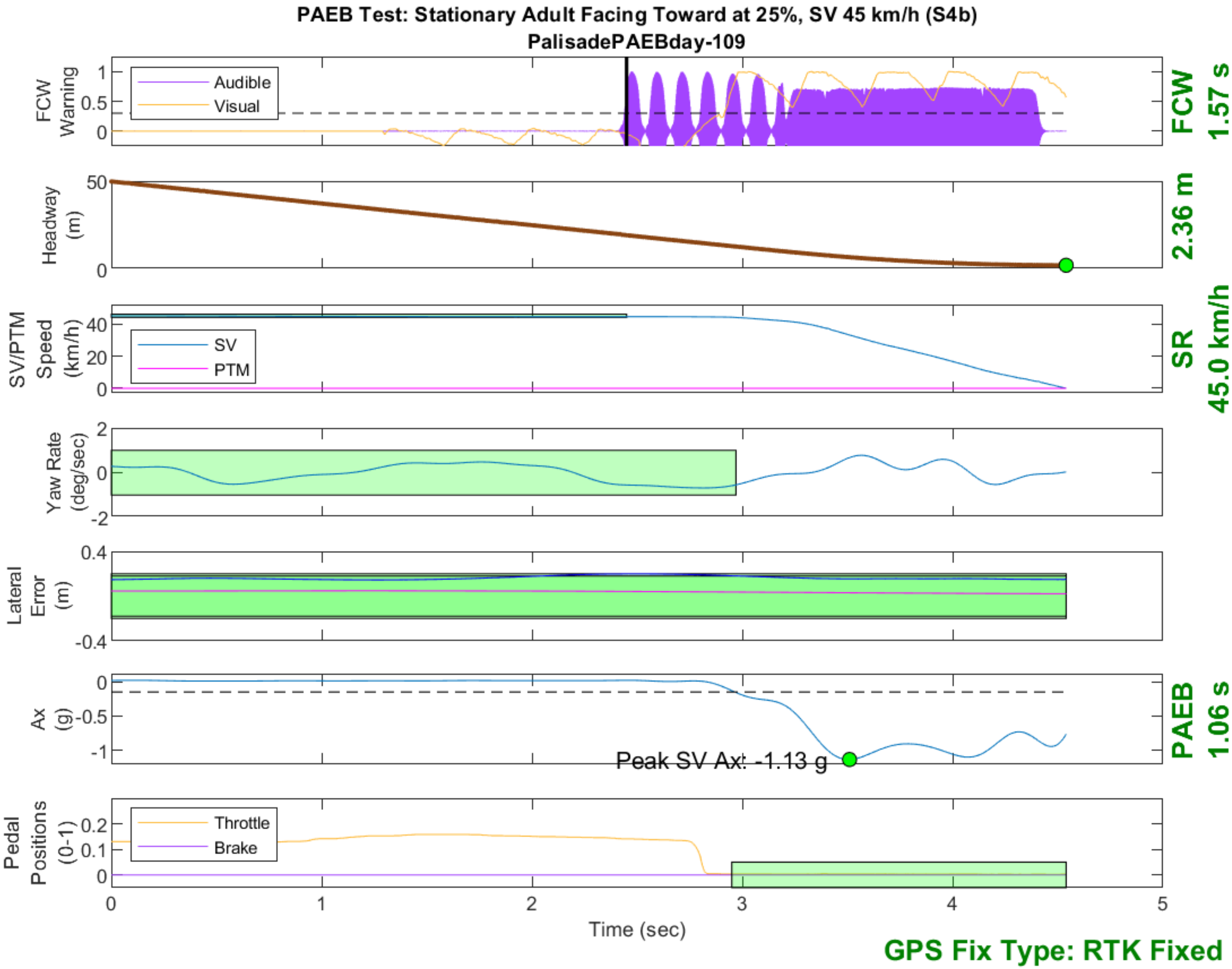


Figure D136. Time History for PAEB Run 109, S4b, Daytime, 45 km/h

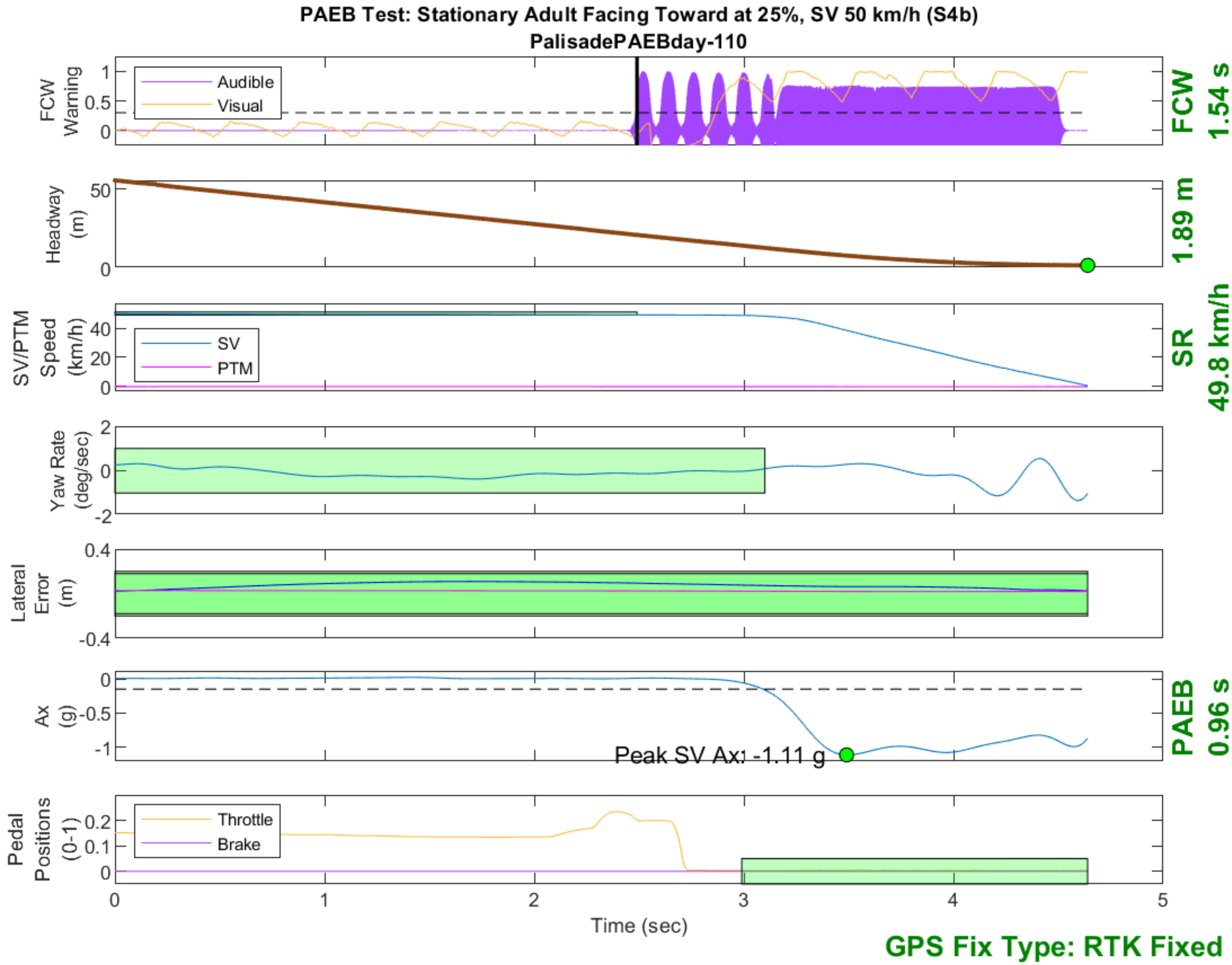


Figure D137. Time History for PAEB Run 110, S4b, Daytime, 50 km/h

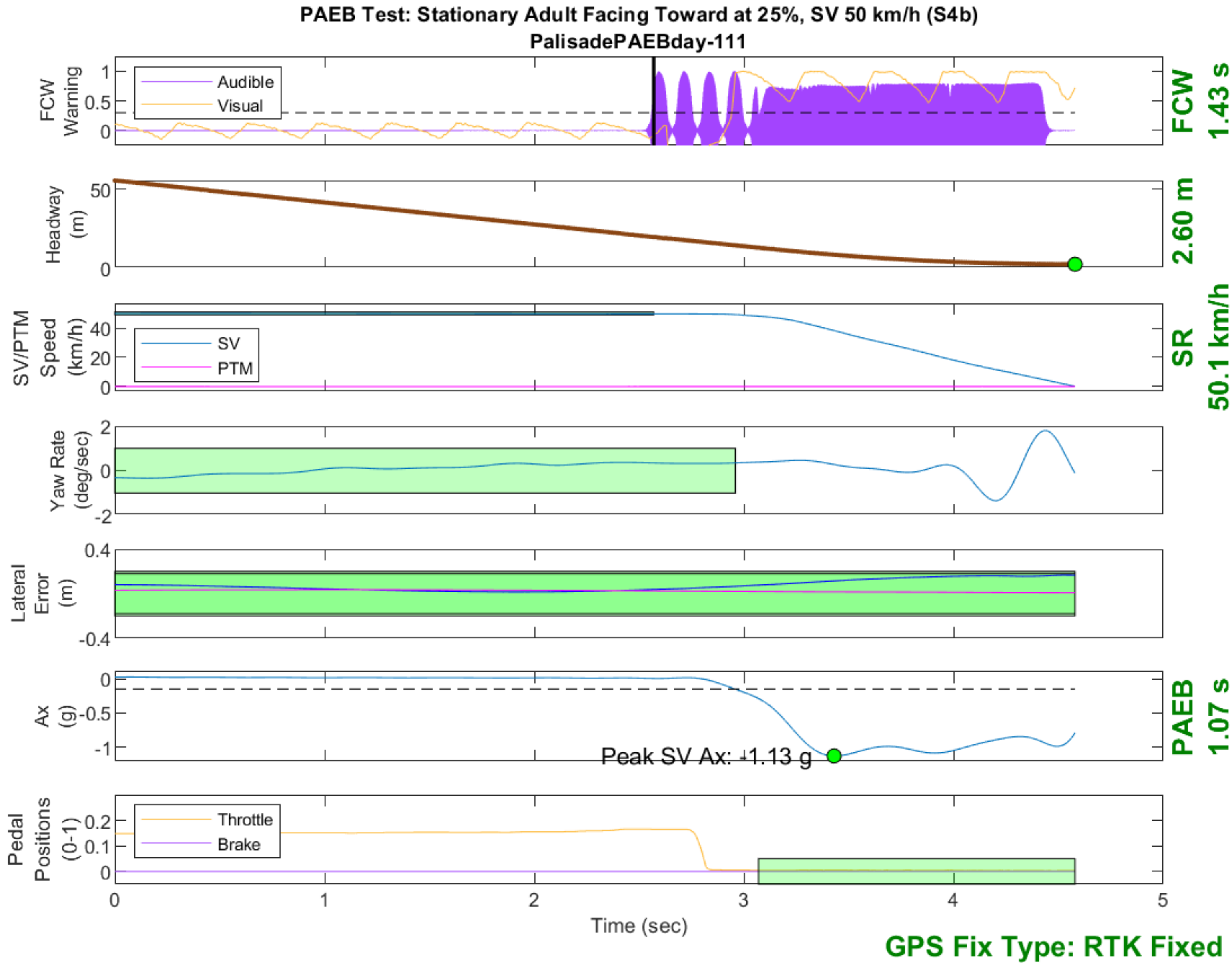


Figure D138. Time History for PAEB Run 111, S4b, Daytime, 50 km/h

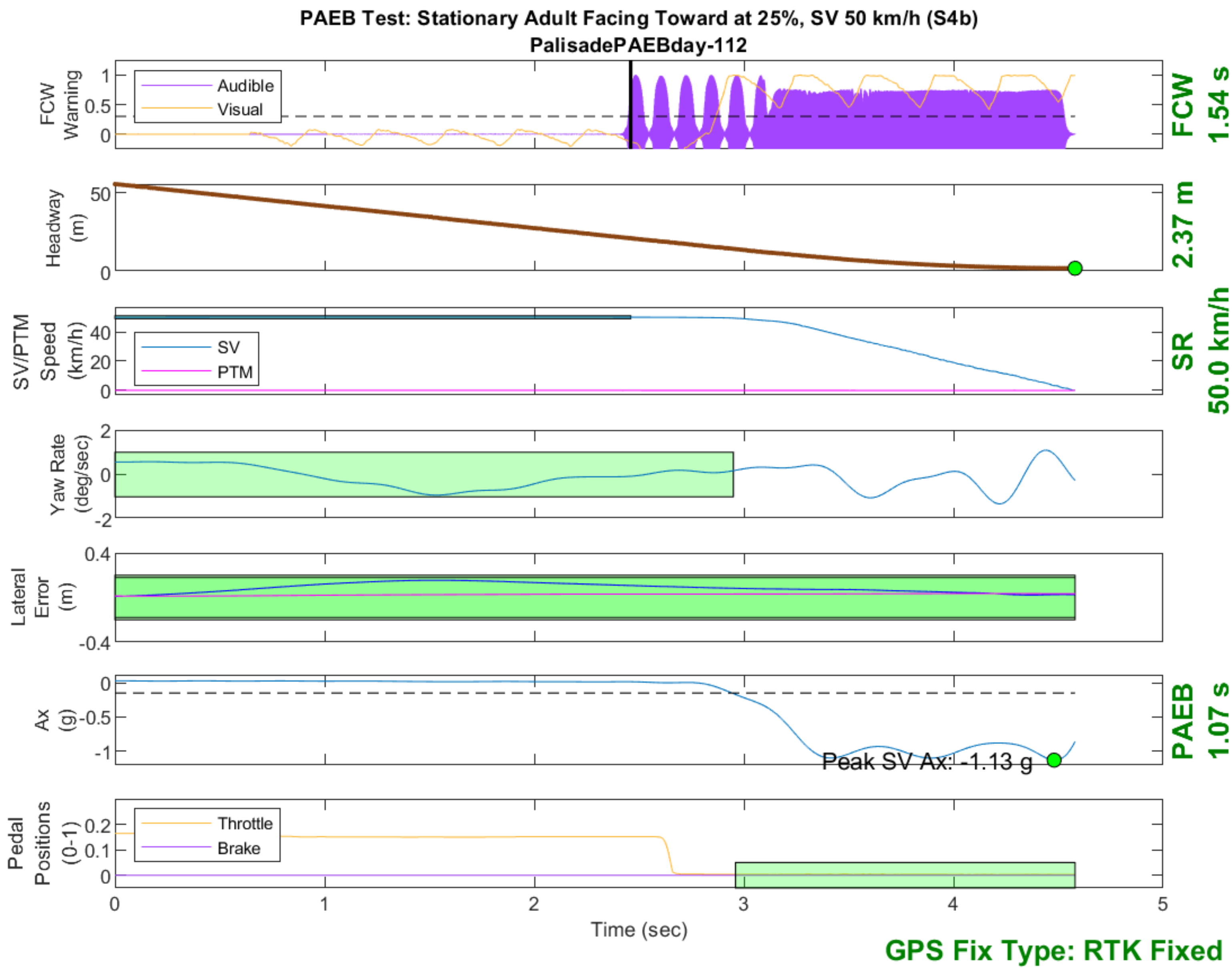


Figure D139. Time History for PAEB Run 112, S4b, Daytime, 50 km/h

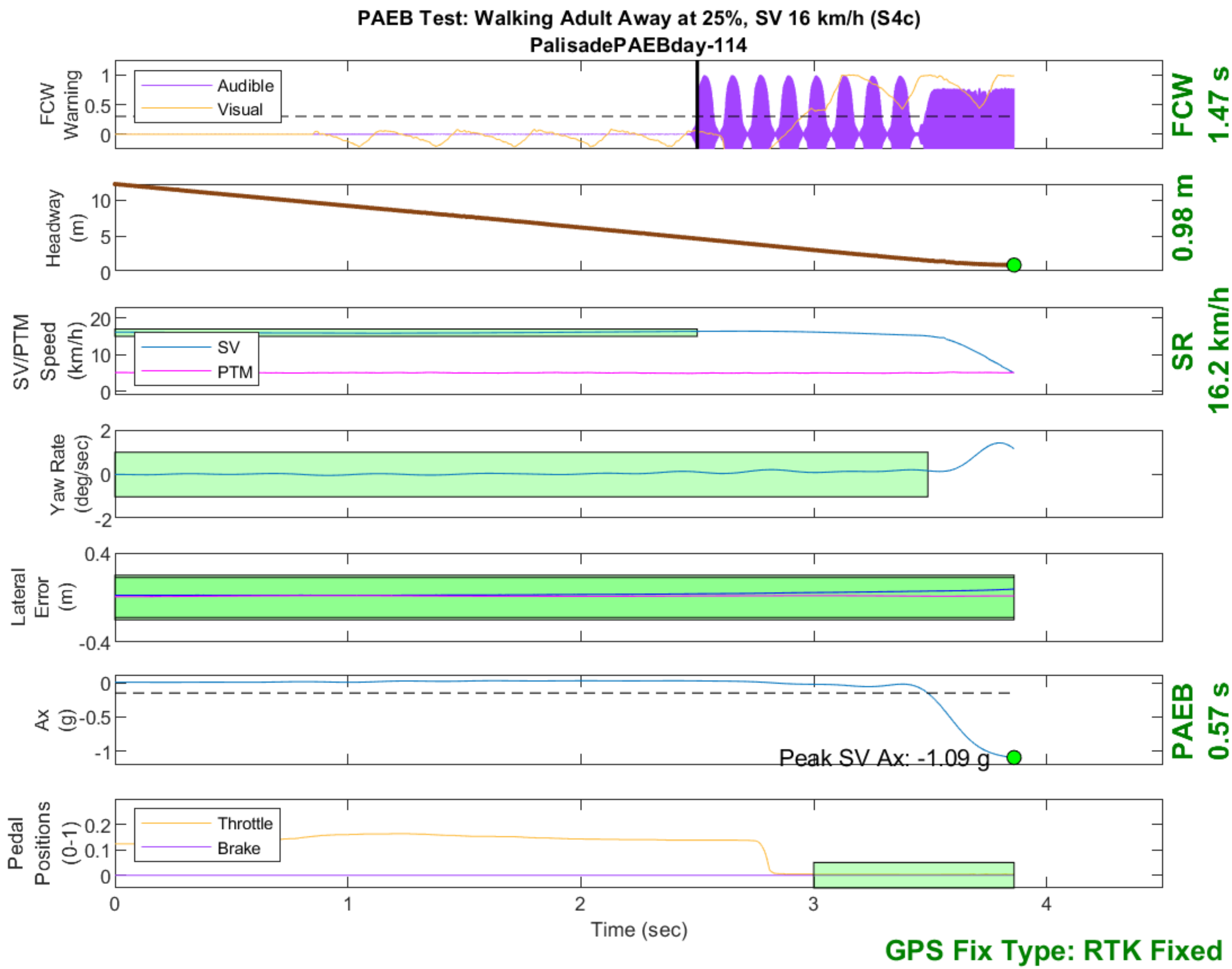


Figure D140. Time History for PAEB Run 114, S4c, Daytime, 16 km/h

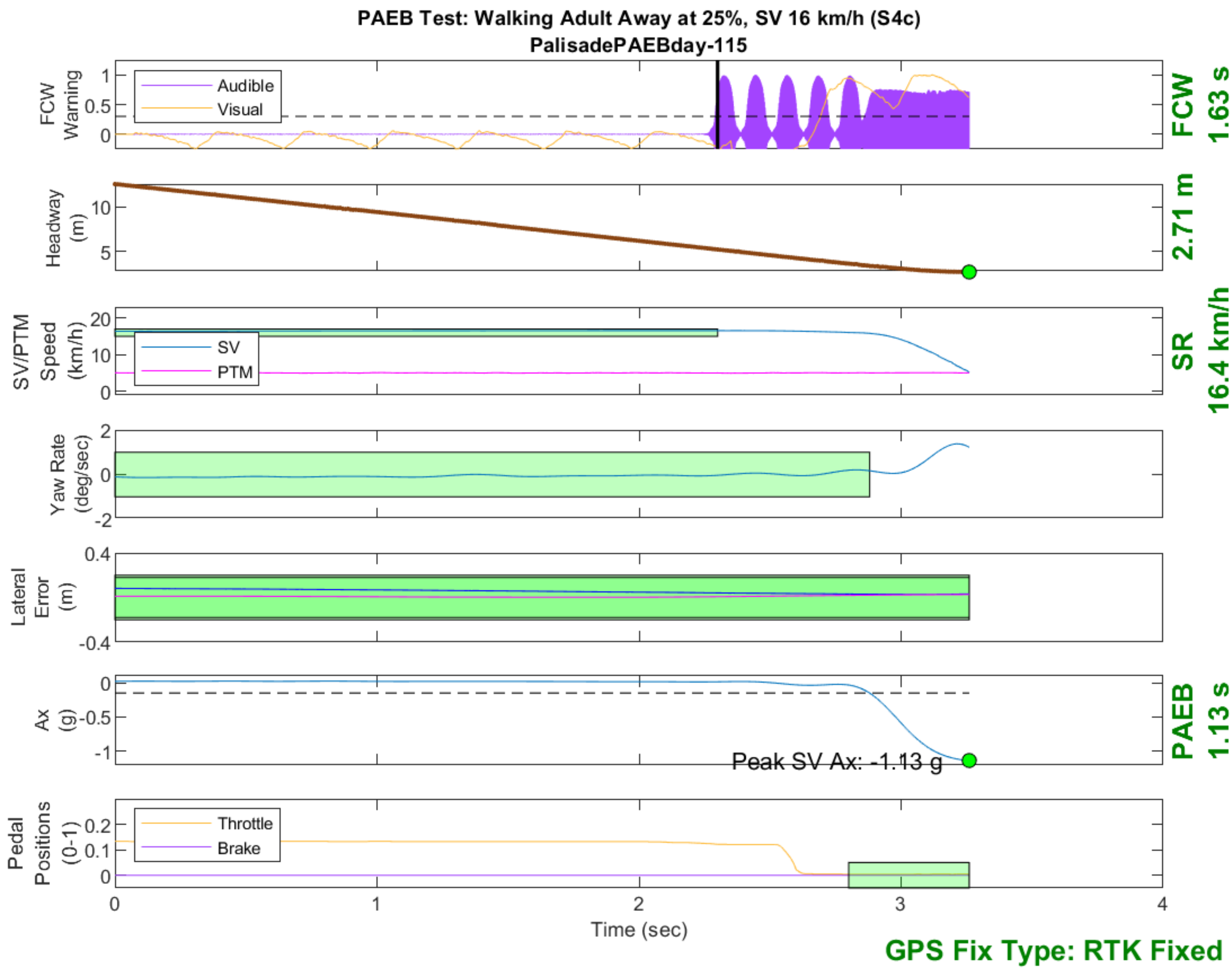


Figure D141. Time History for PAEB Run 115, S4c, Daytime, 16 km/h

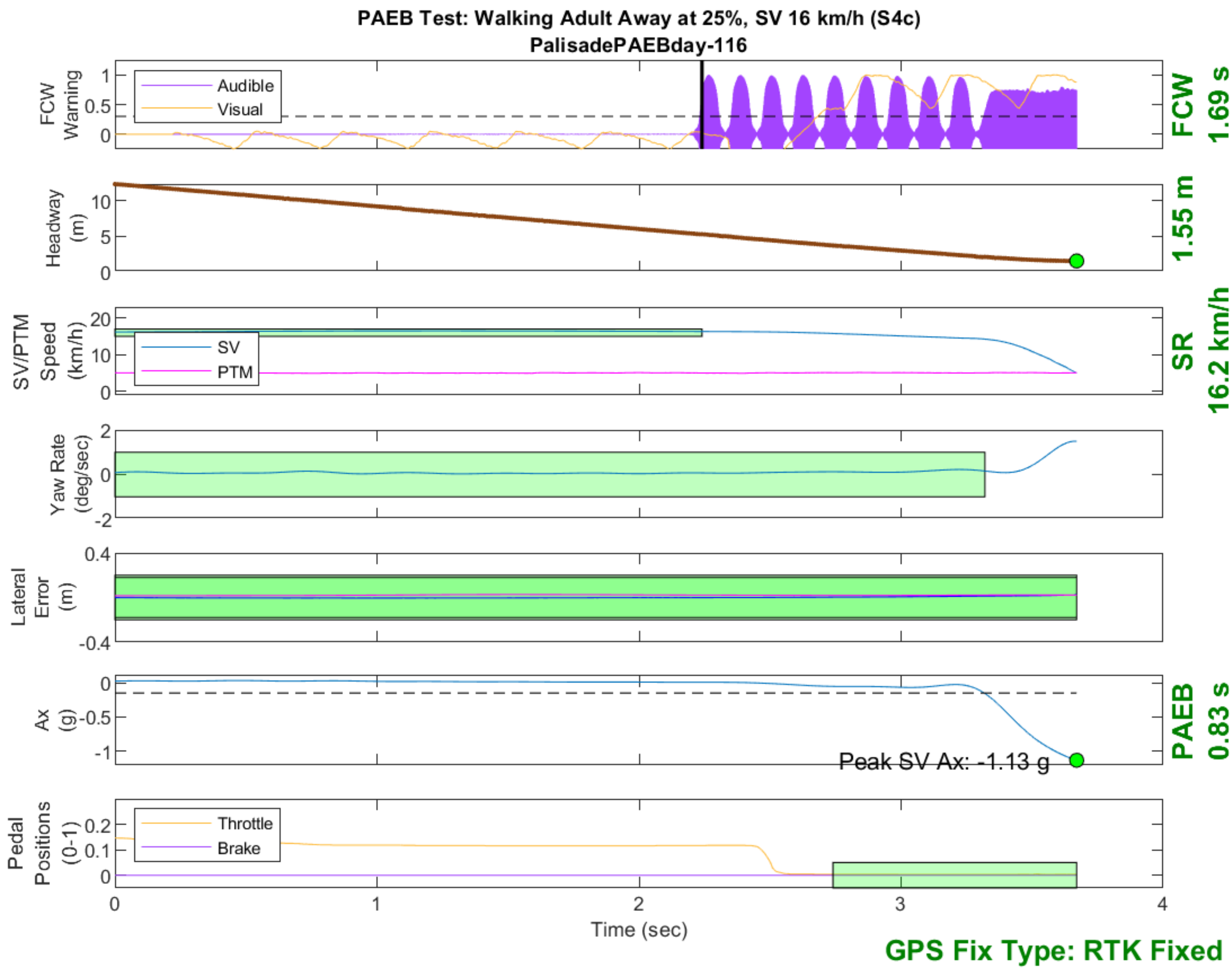


Figure D142. Time History for PAEB Run 116, S4c, Daytime, 16 km/h

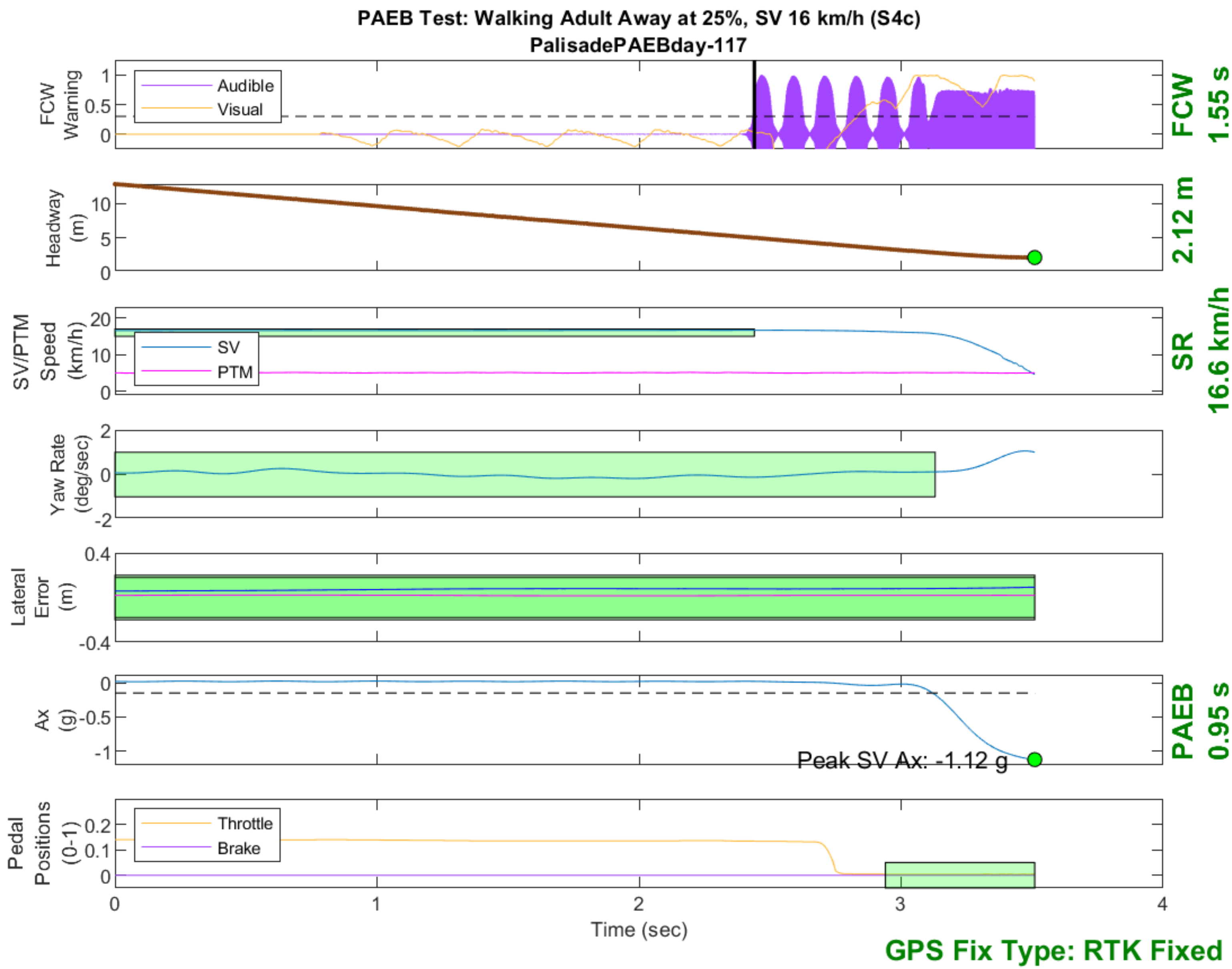


Figure D143. Time History for PAEB Run 117, S4c, Daytime, 16 km/h

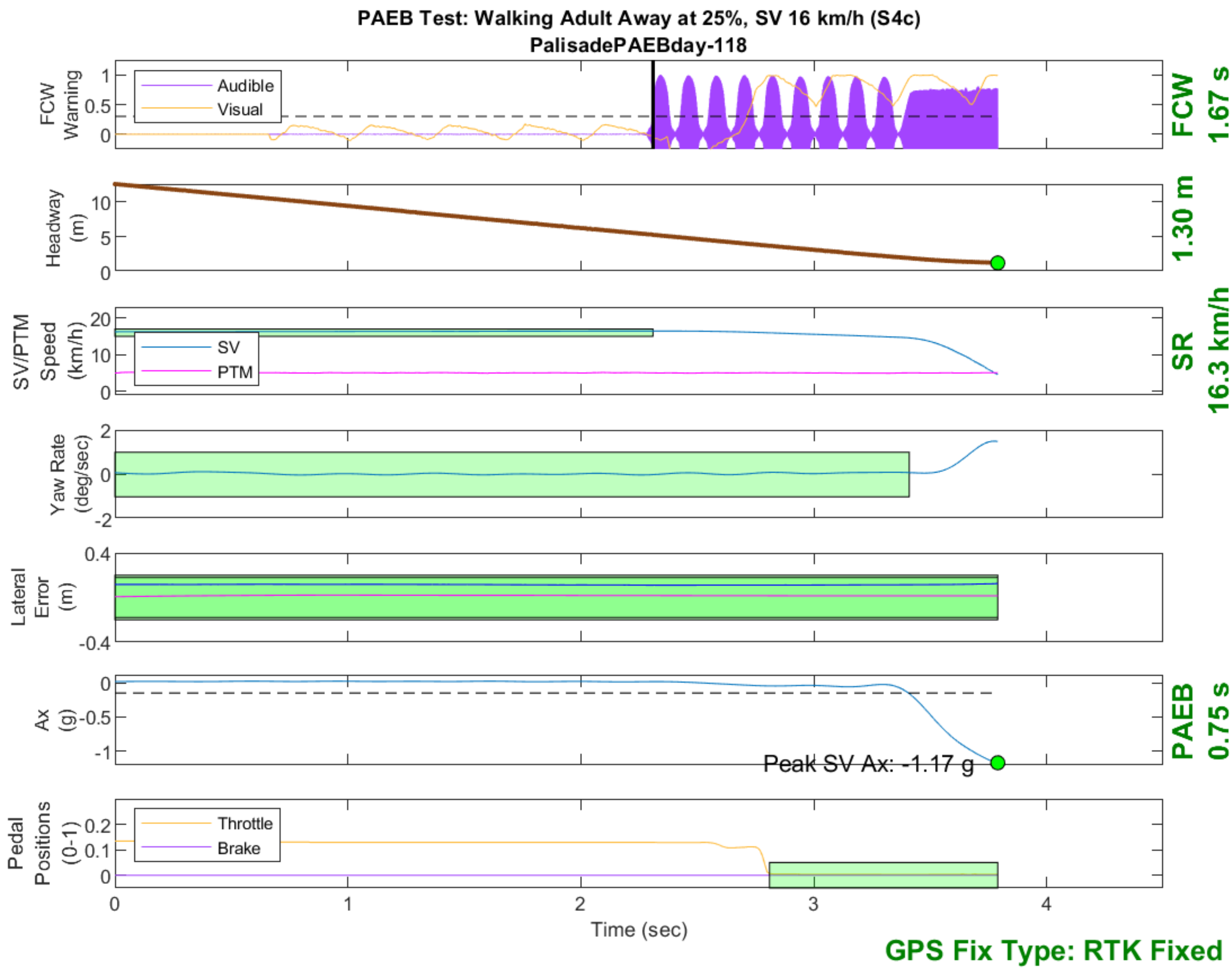


Figure D144. Time History for PAEB Run 118, S4c, Daytime, 16 km/h

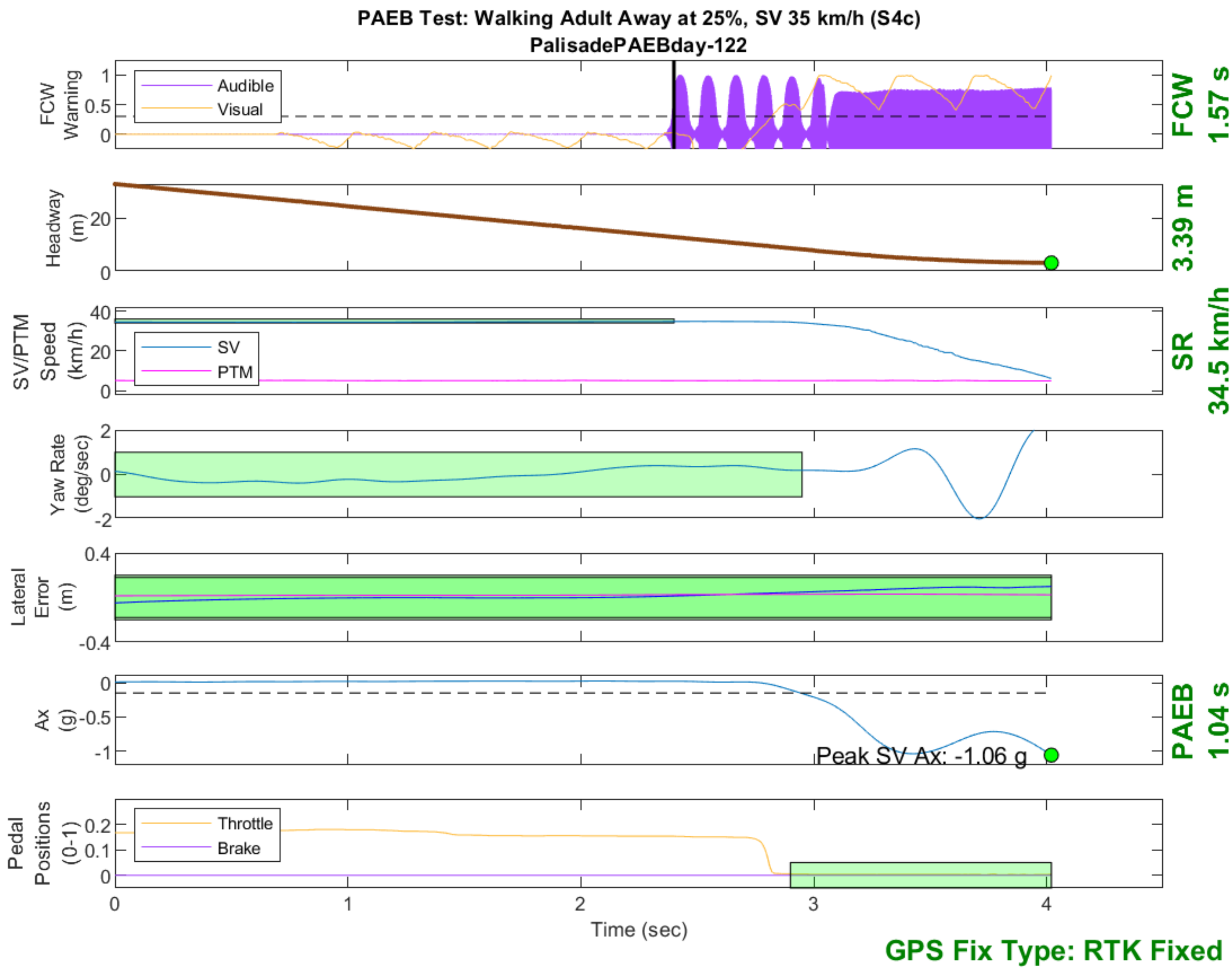


Figure D145. Time History for PAEB Run 122, S4c, Daytime, 35 km/h

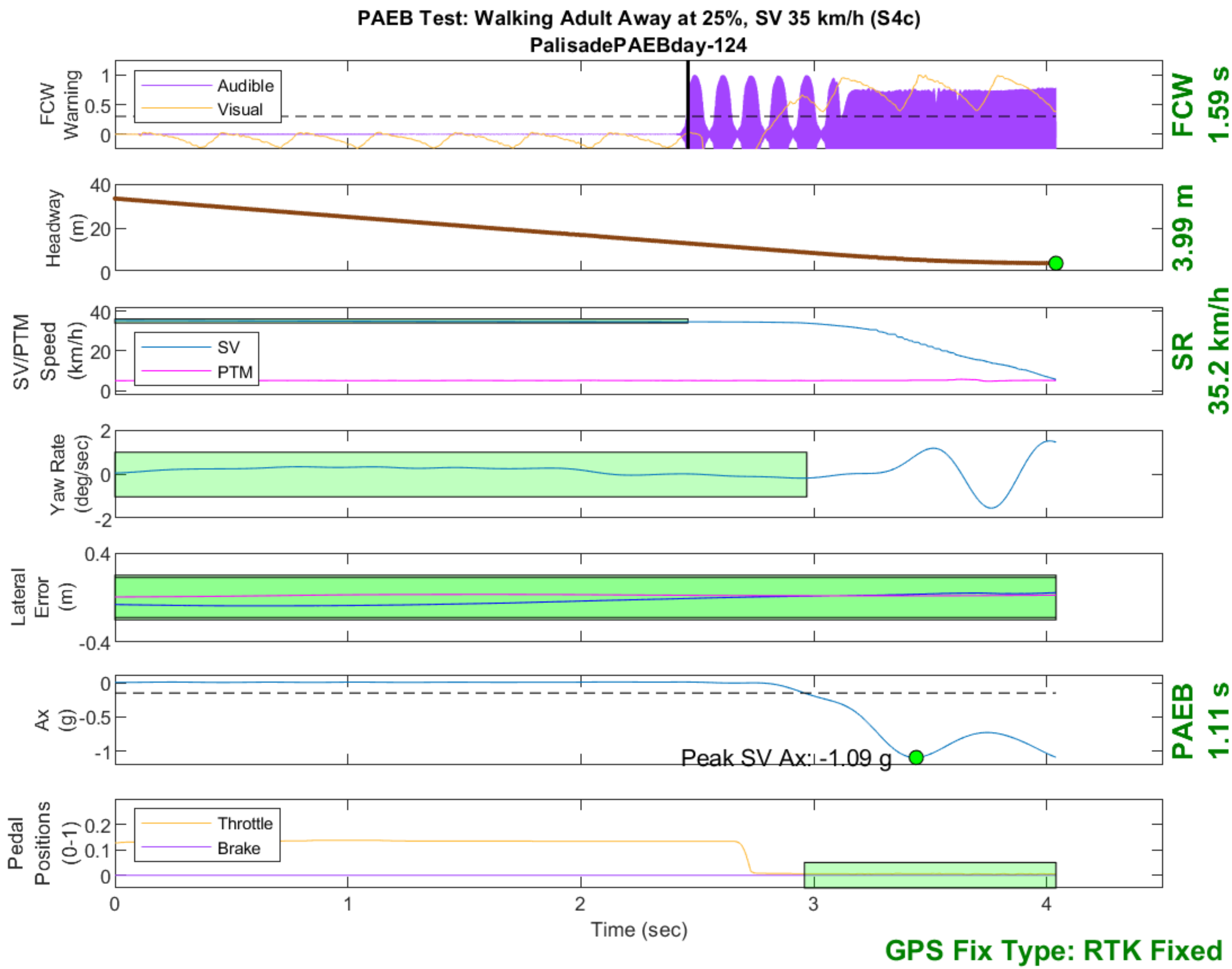


Figure D146. Time History for PAEB Run 124, S4c, Daytime, 35 km/h

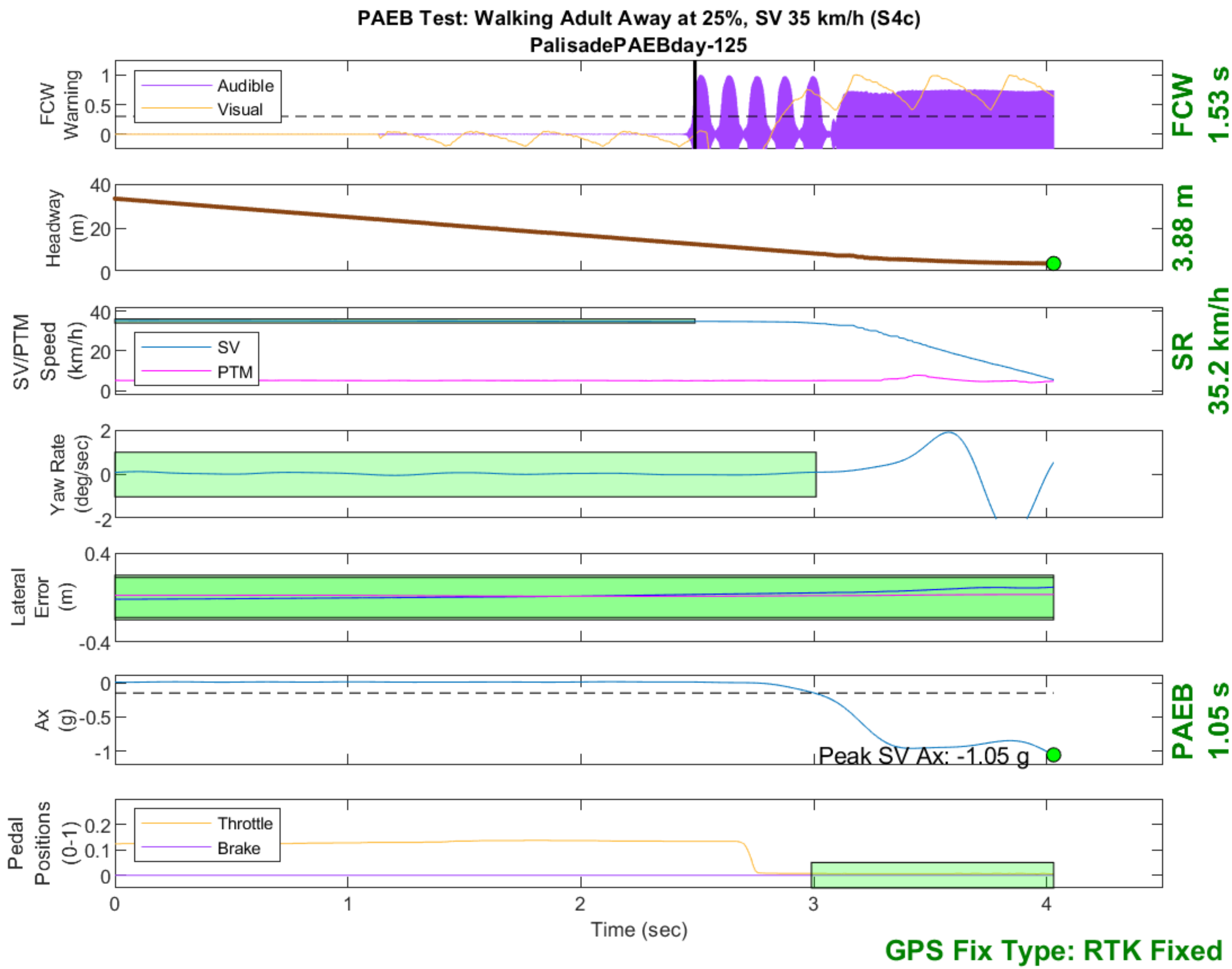


Figure D147. Time History for PAEB Run 125, S4c, Daytime, 35 km/h

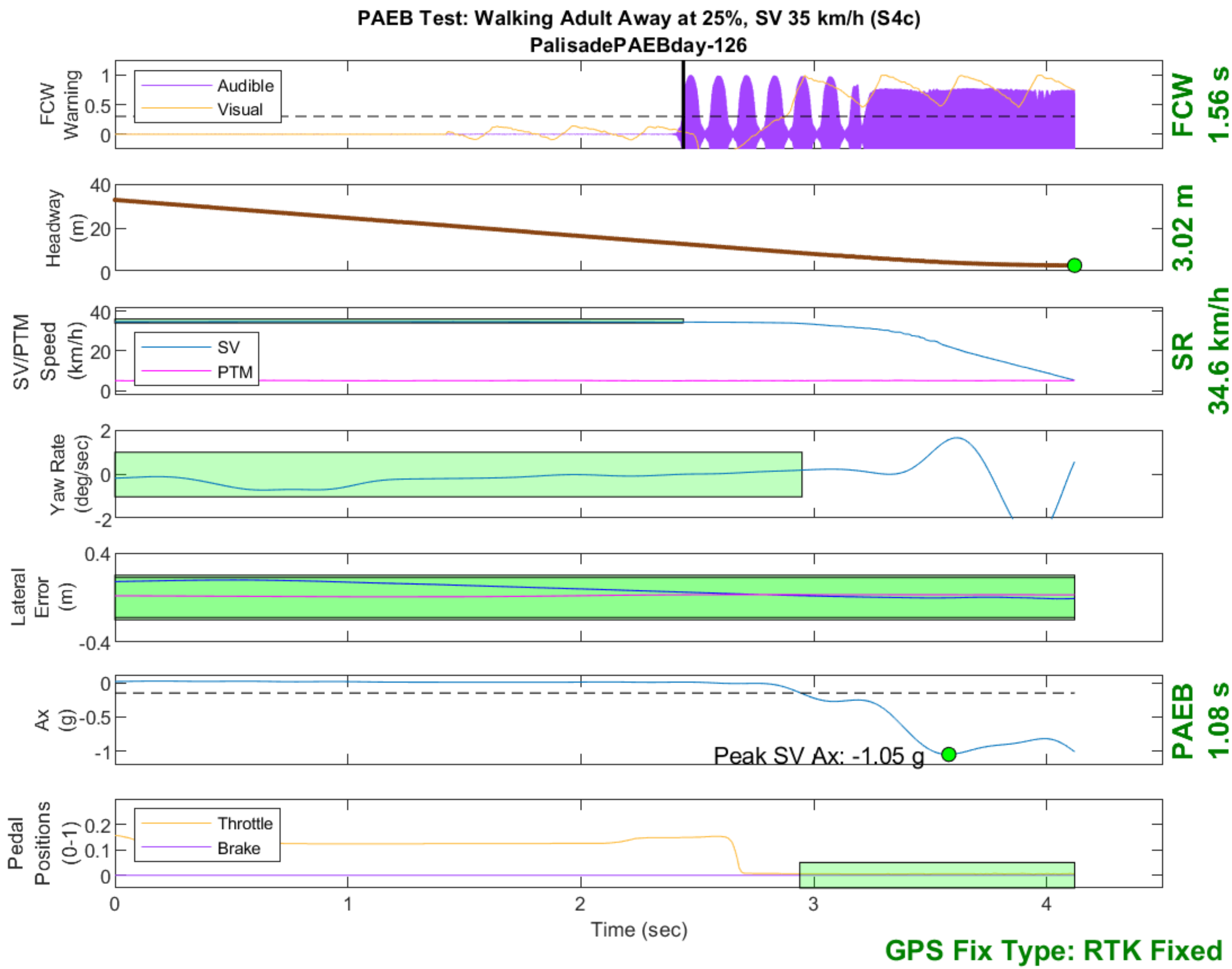


Figure D148. Time History for PAEB Run 126, S4c, Daytime, 35 km/h

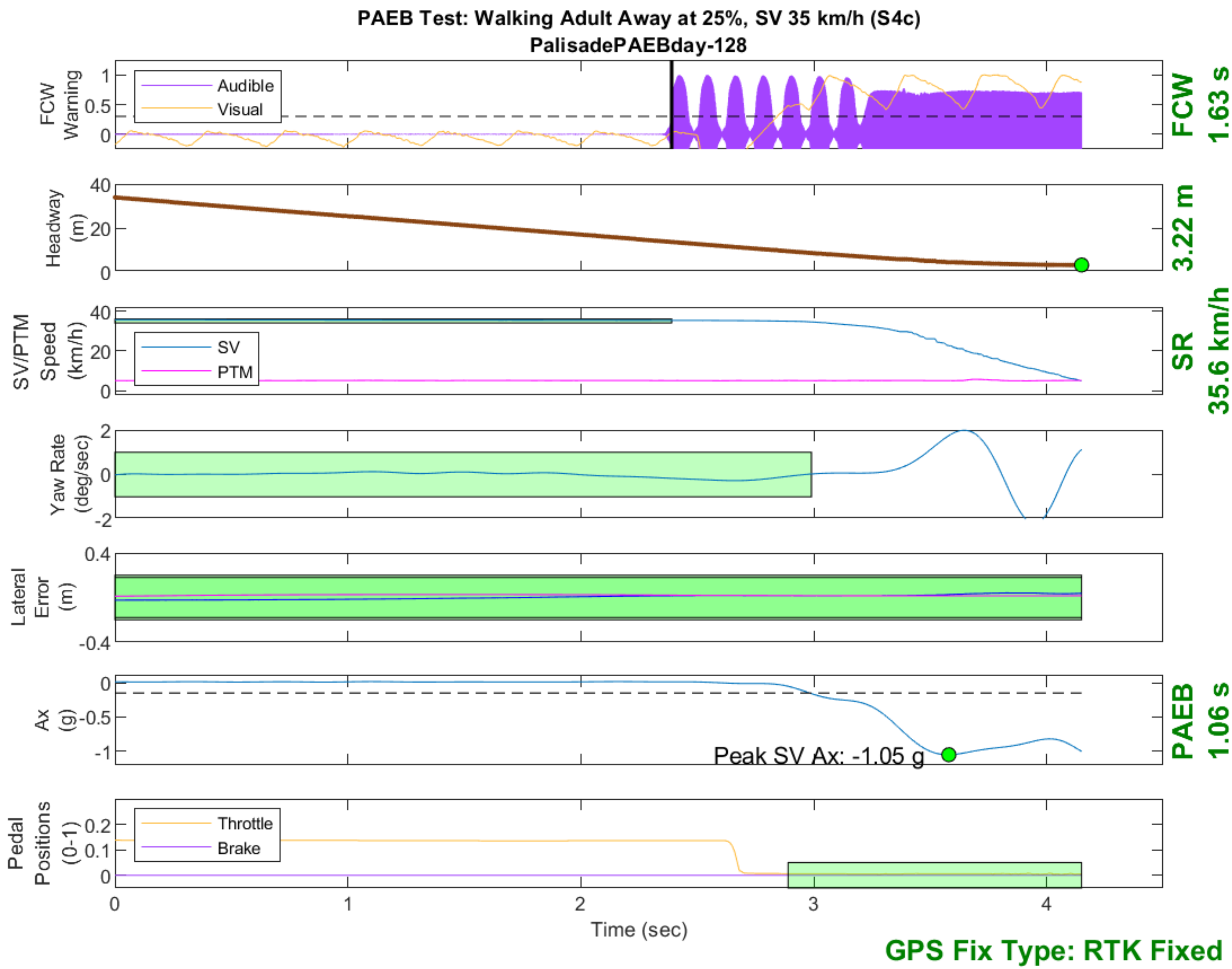


Figure D149. Time History for PAEB Run 128, S4c, Daytime, 35 km/h

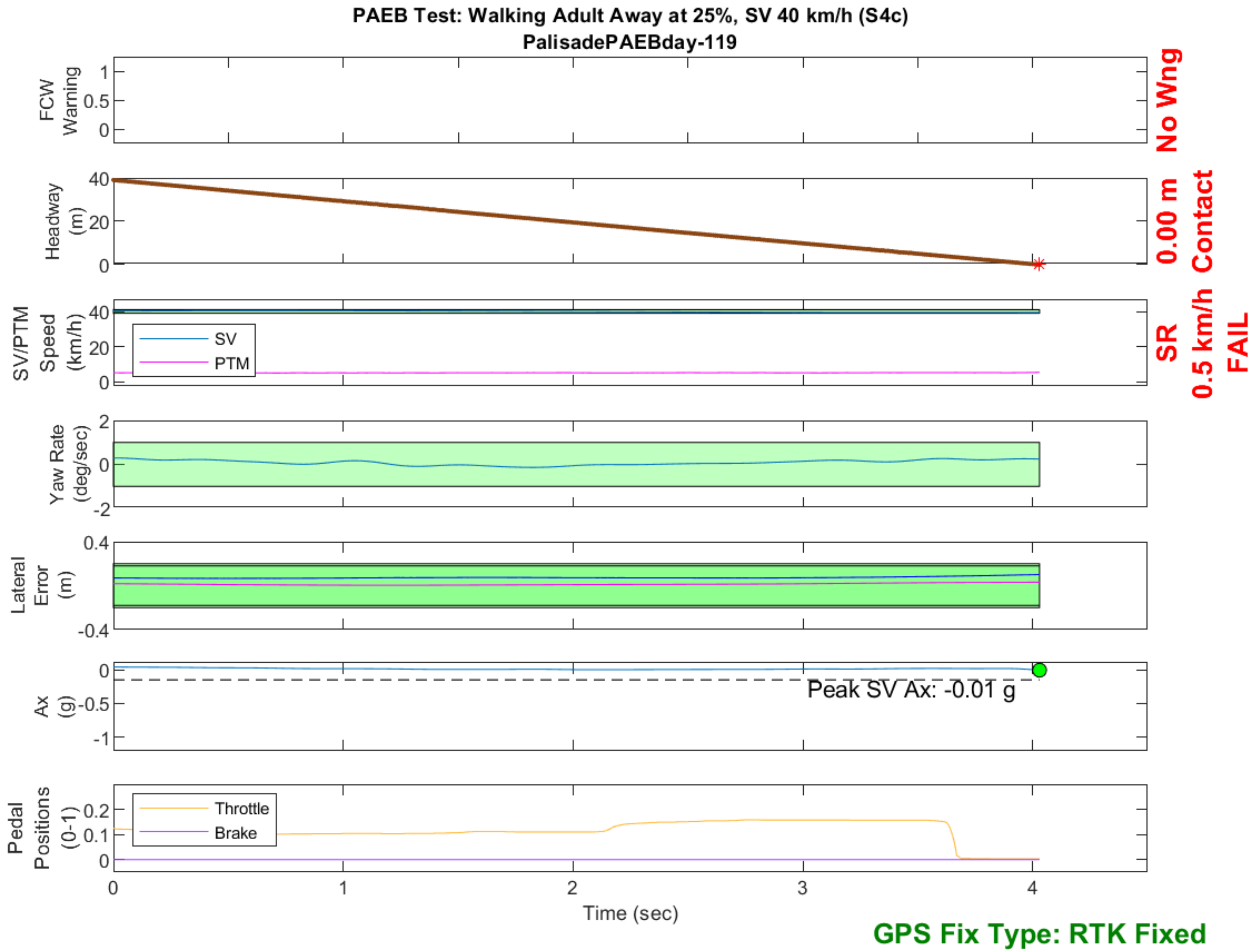


Figure D150. Time History for PAEB Run 119, S4c, Daytime, 40 km/h

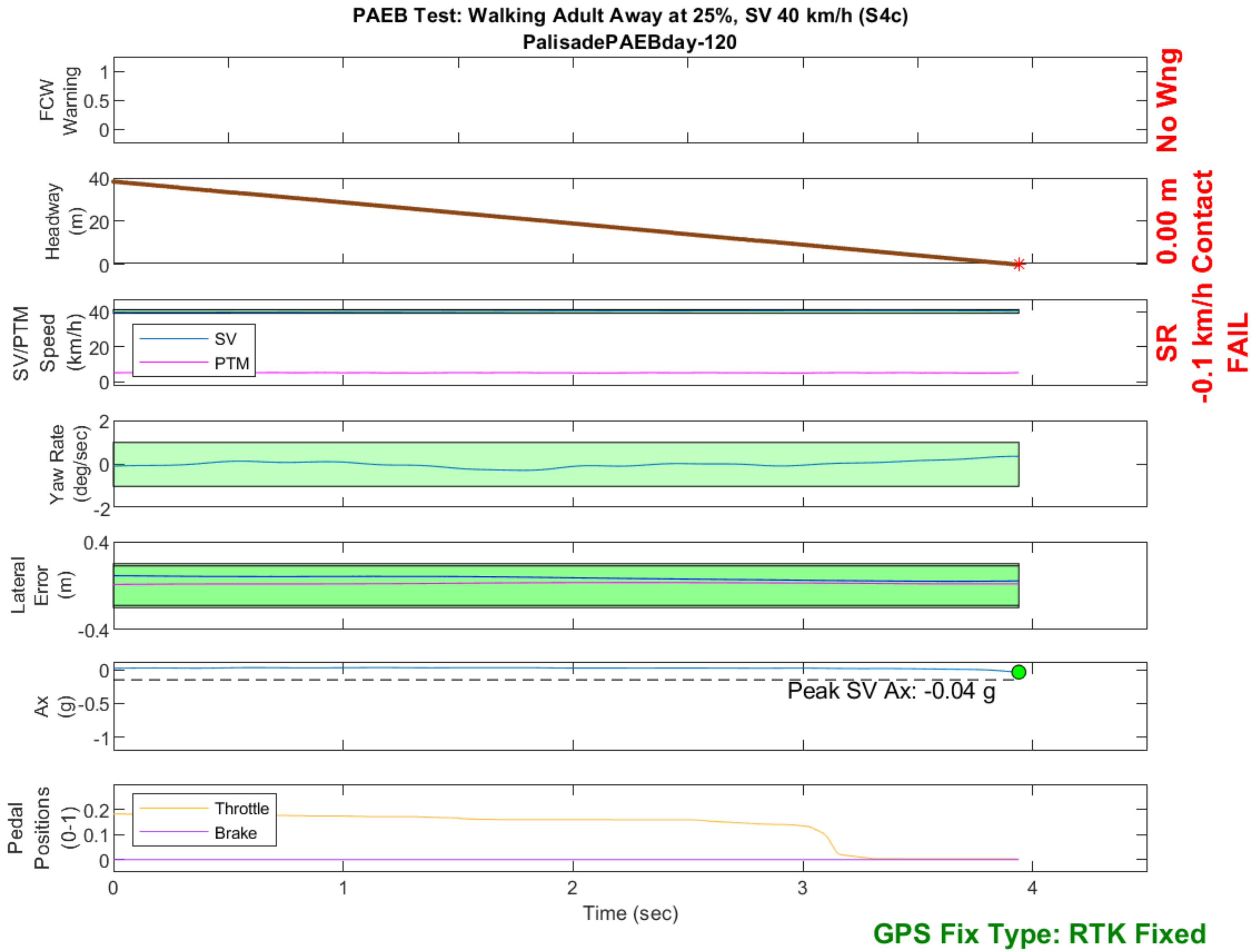


Figure D151. Time History for PAEB Run 120, S4c, Daytime, 40 km/h

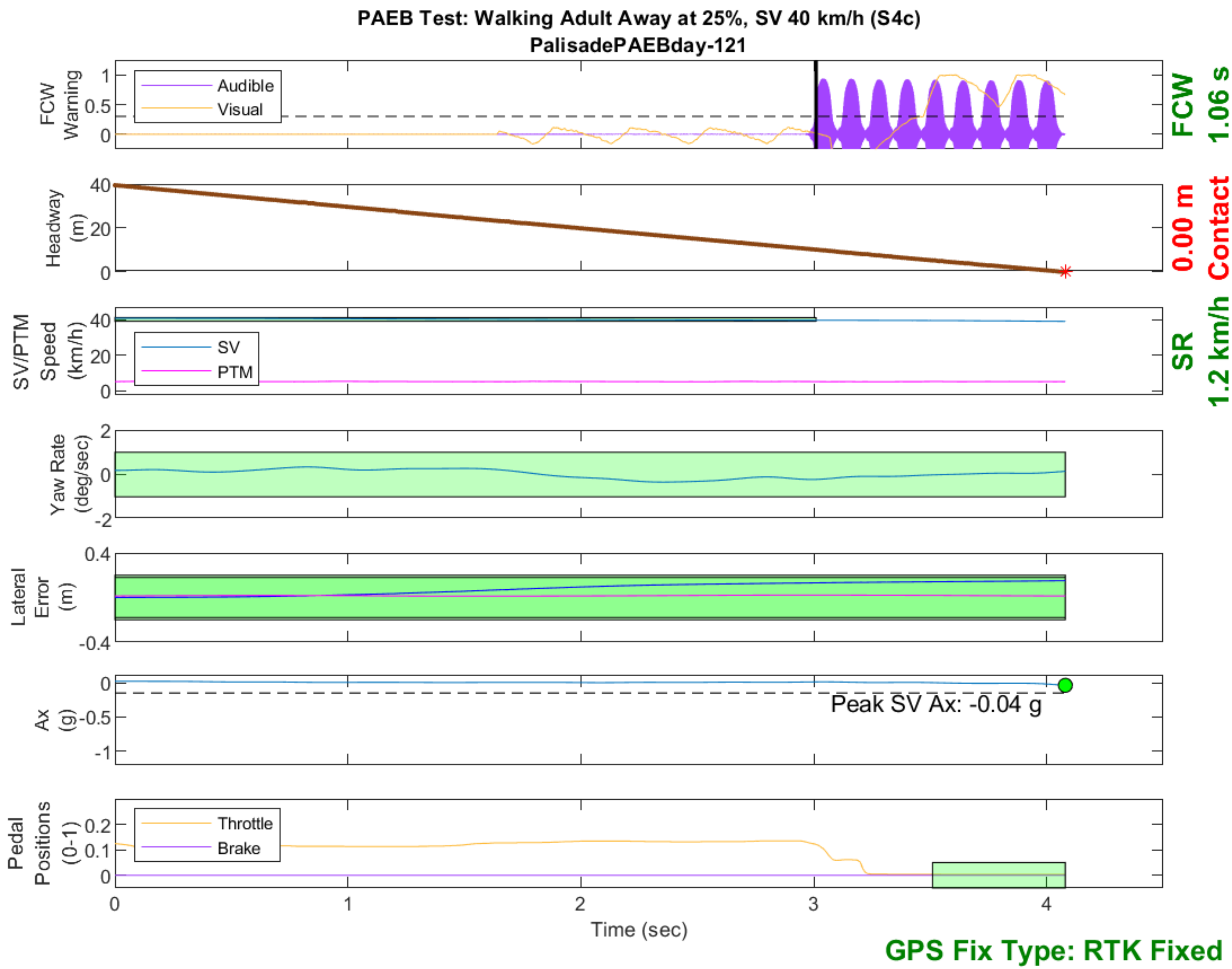


Figure D152. Time History for PAEB Run 121, S4c, Daytime, 40 km/h

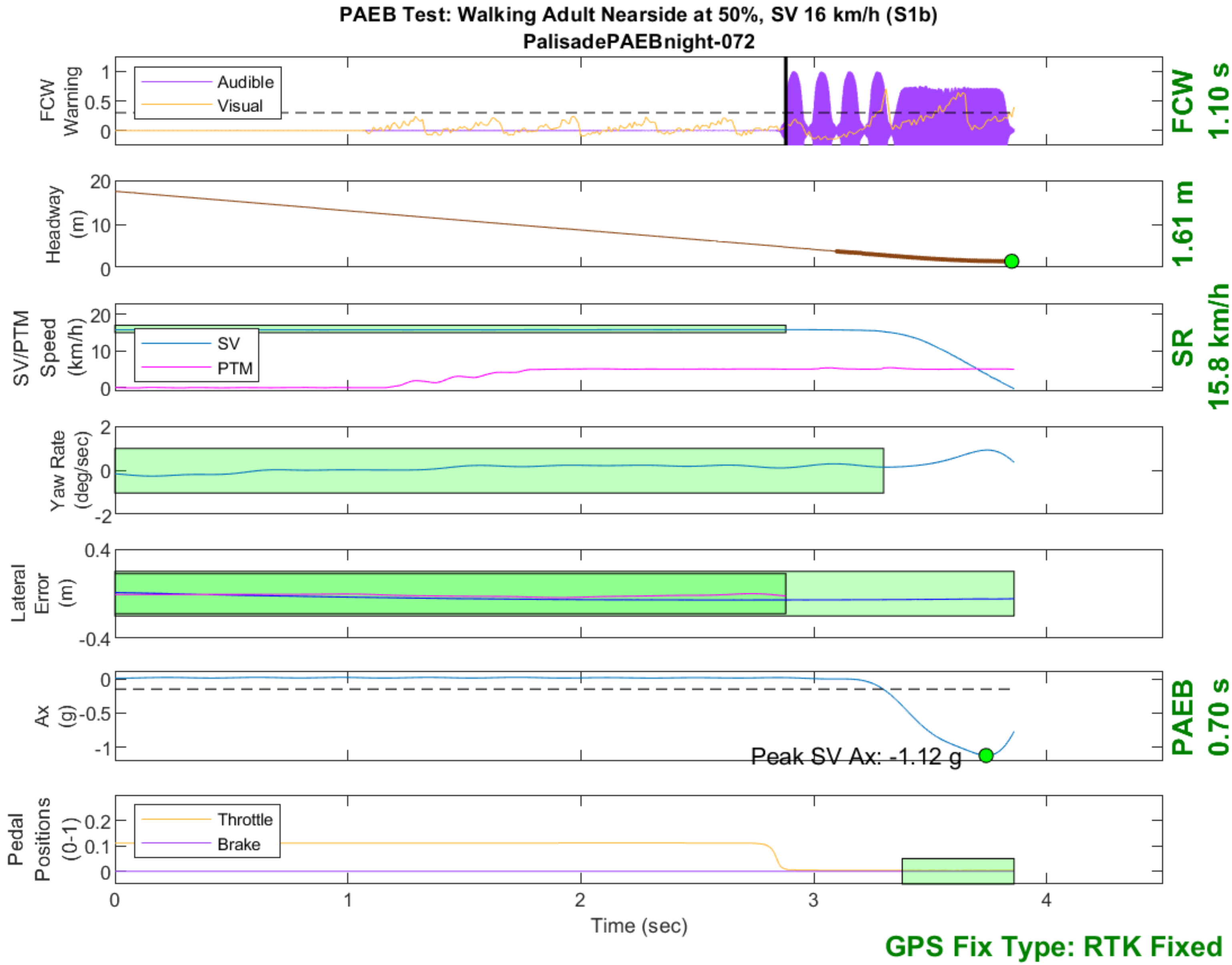


Figure D153. Time History for PAEB Run 72, S1b, Night, High Beam, 16 km/h

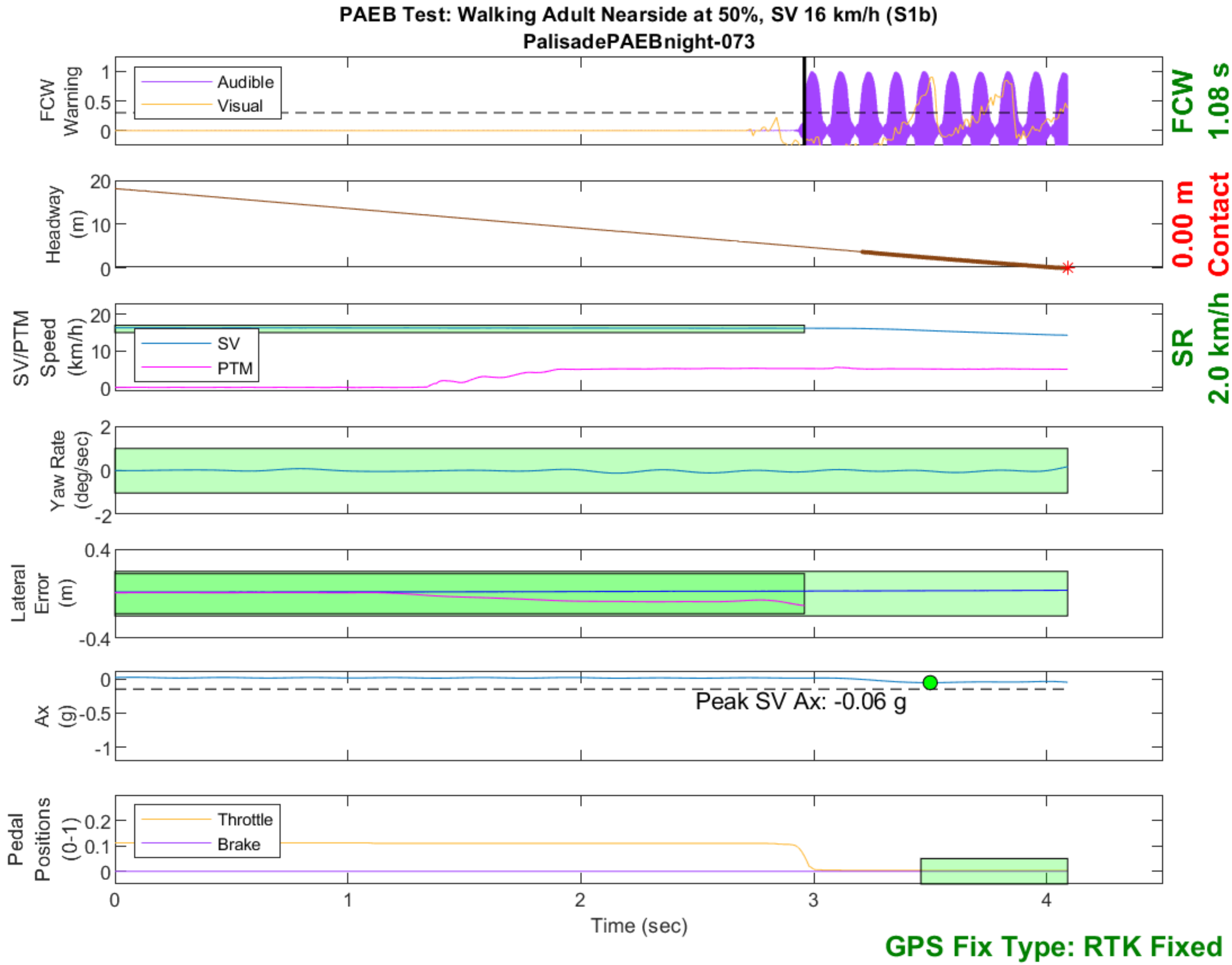


Figure D154. Time History for PAEB Run 73, S1b, Night, High Beam, 16 km/h

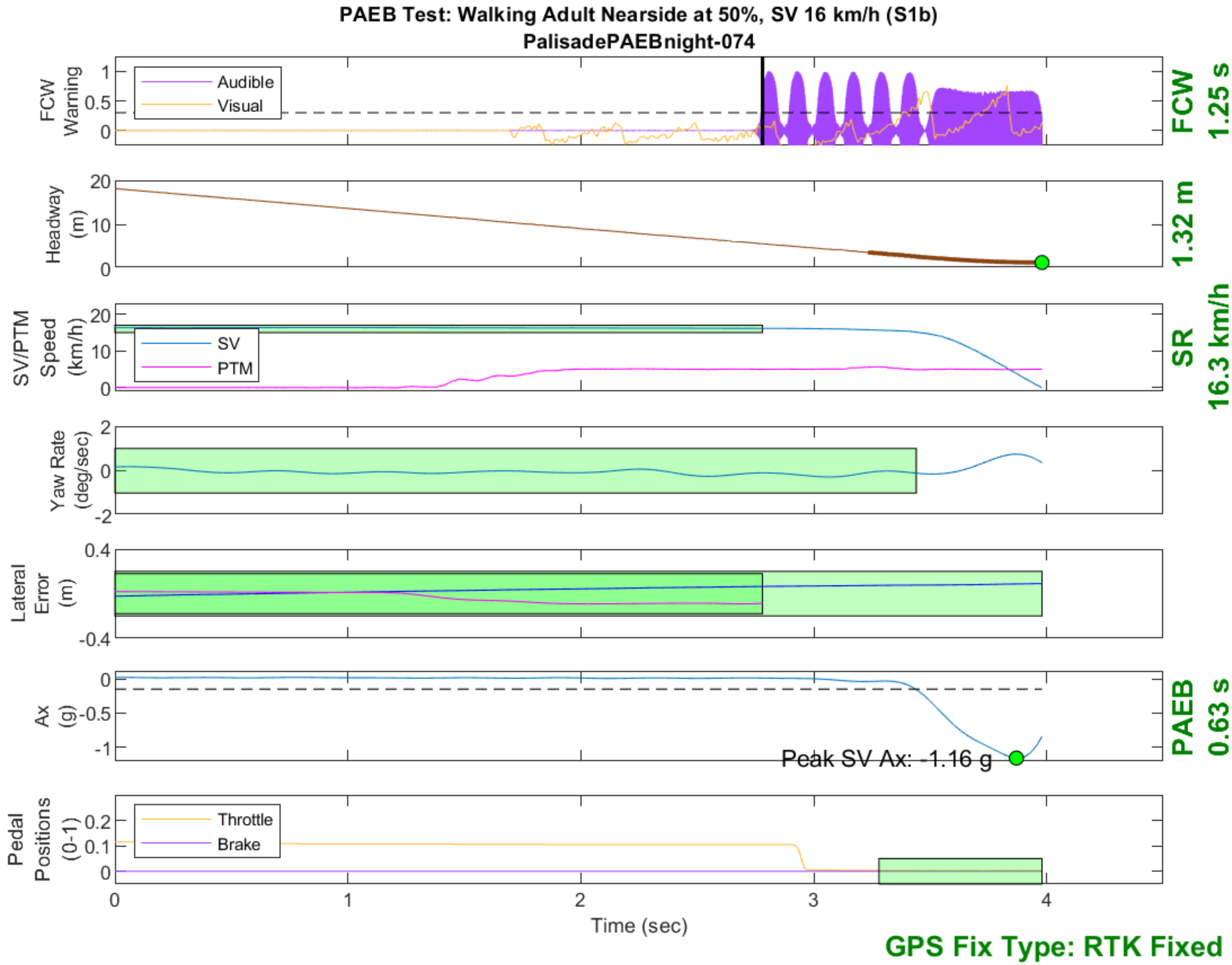


Figure D155. Time History for PAEB Run 74, S1b, Night, High Beam, 16 km/h

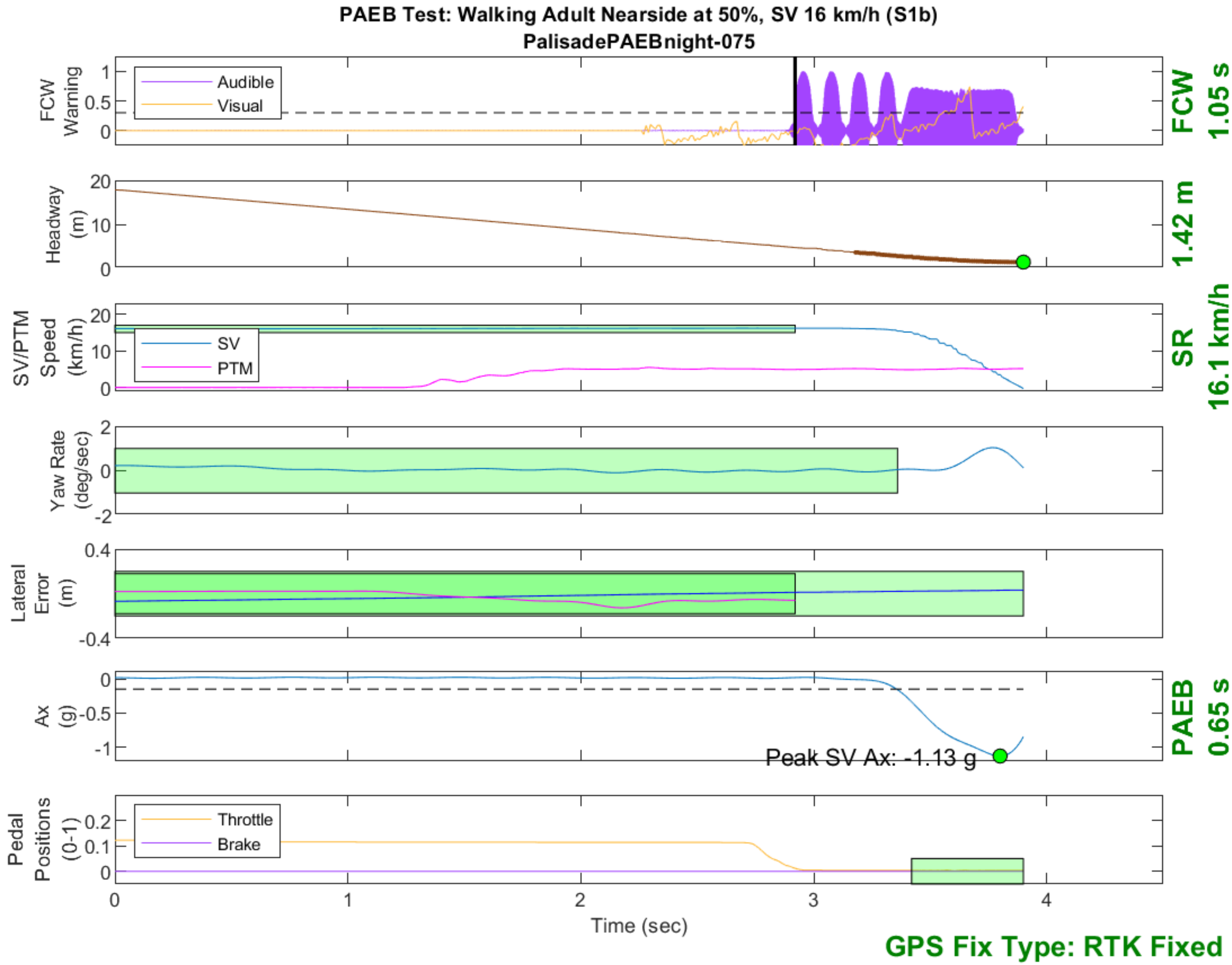


Figure D156. Time History for PAEB Run 75, S1b, Night, High Beam, 16 km/h

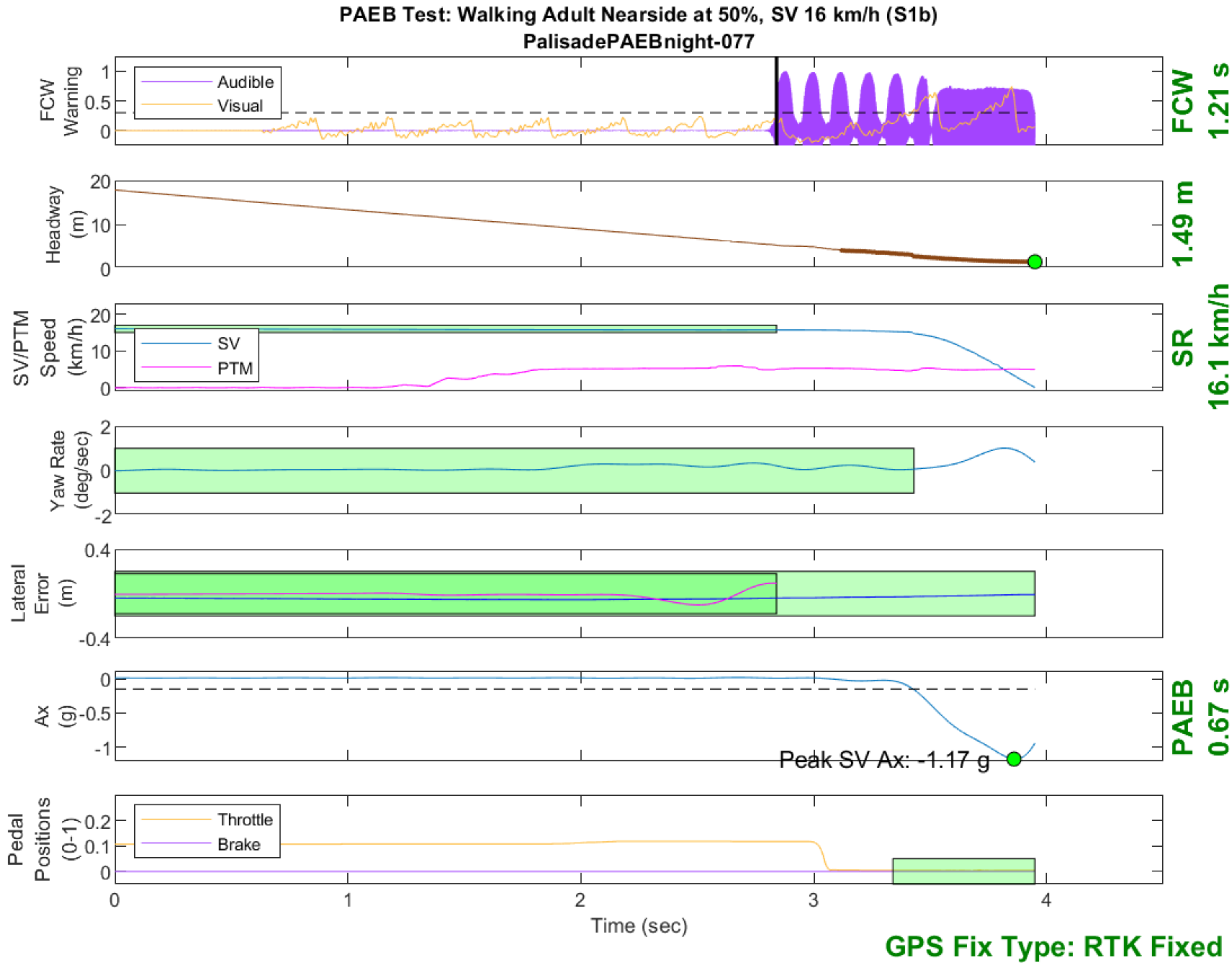


Figure D157. Time History for PAEB Run 77, S1b, Night, High Beam, 16 km/h

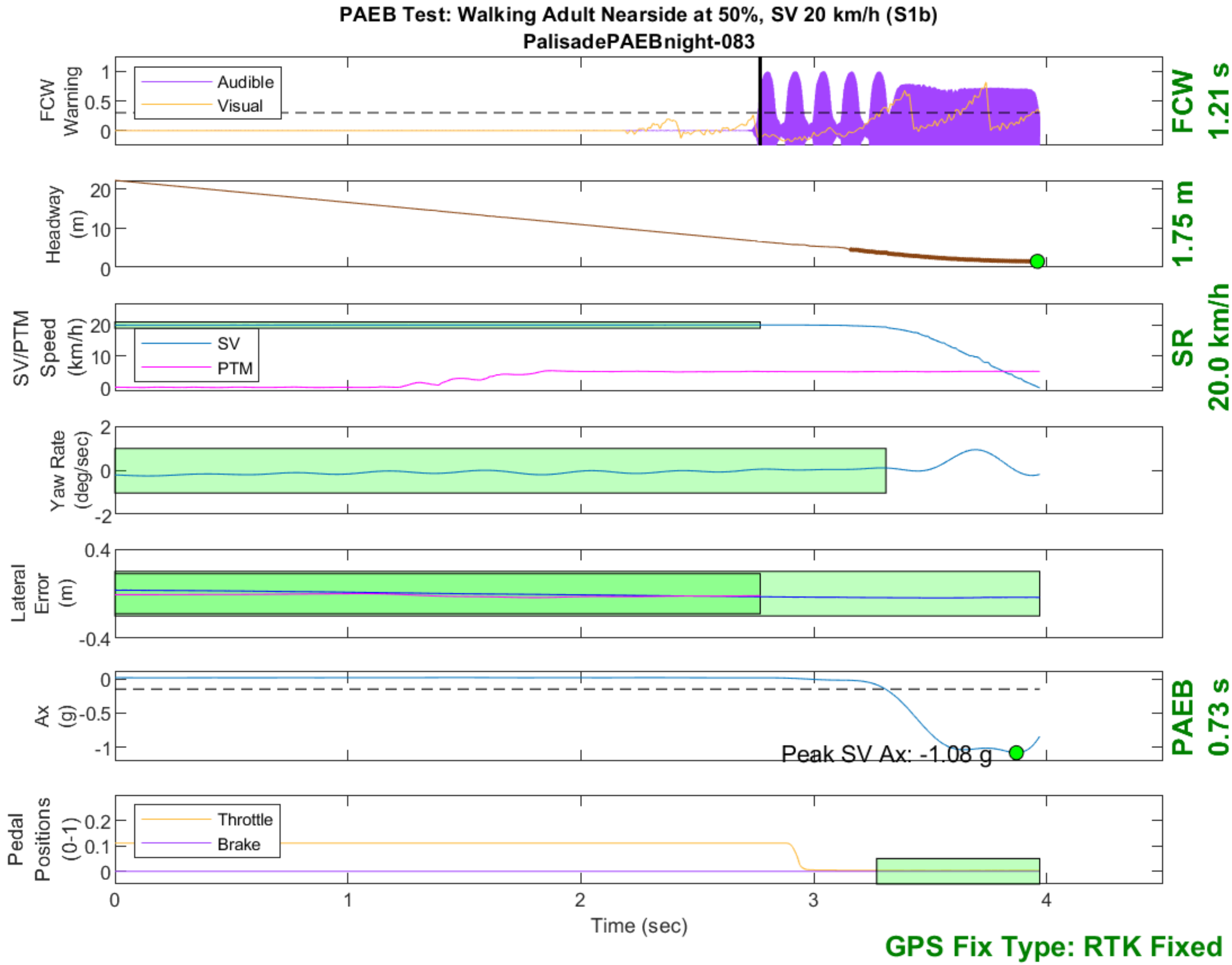


Figure D158. Time History for PAEB Run 83, S1b, Night, High Beam, 20 km/h

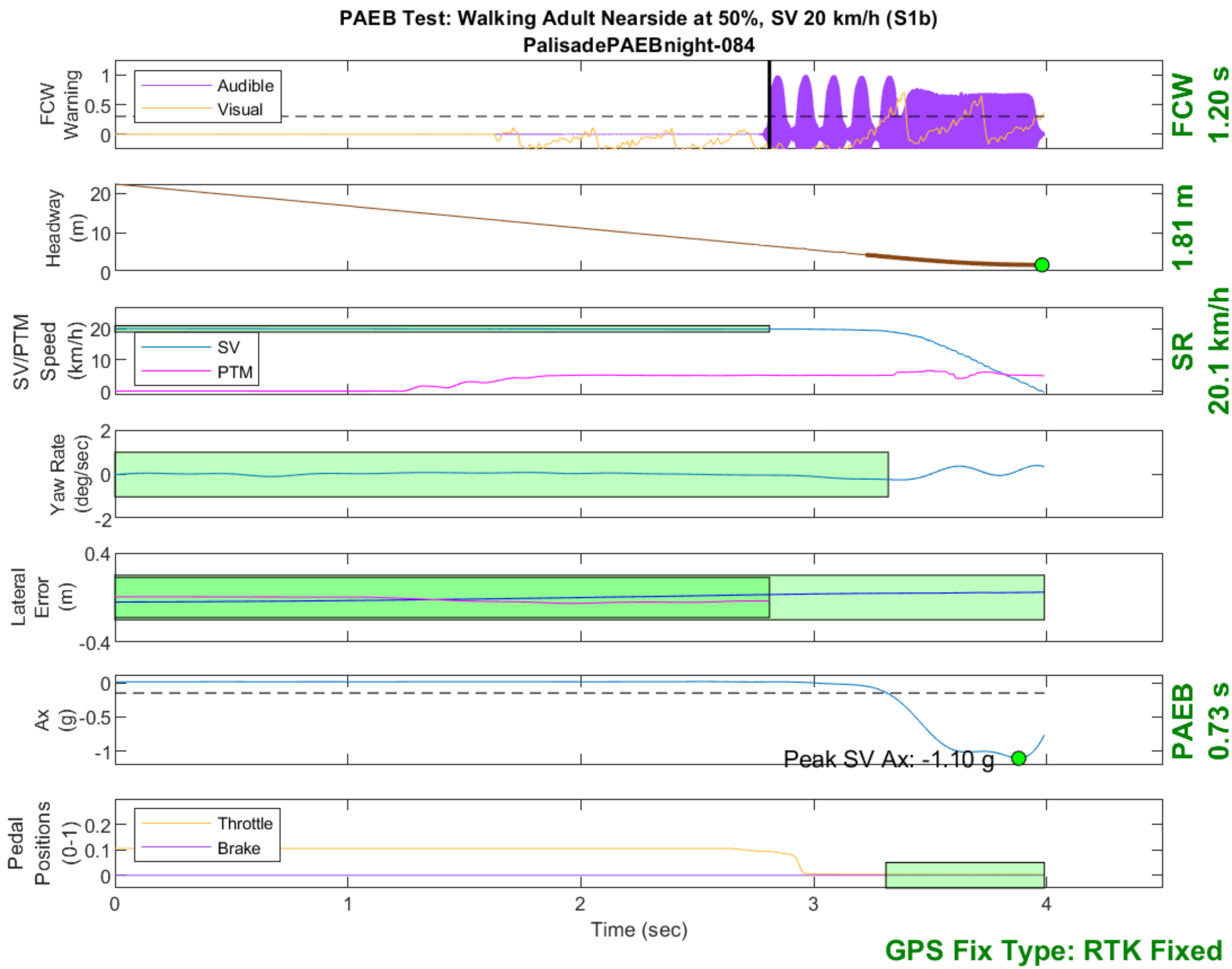


Figure D159. Time History for PAEB Run 84, S1b, Night, High Beam, 20 km/h

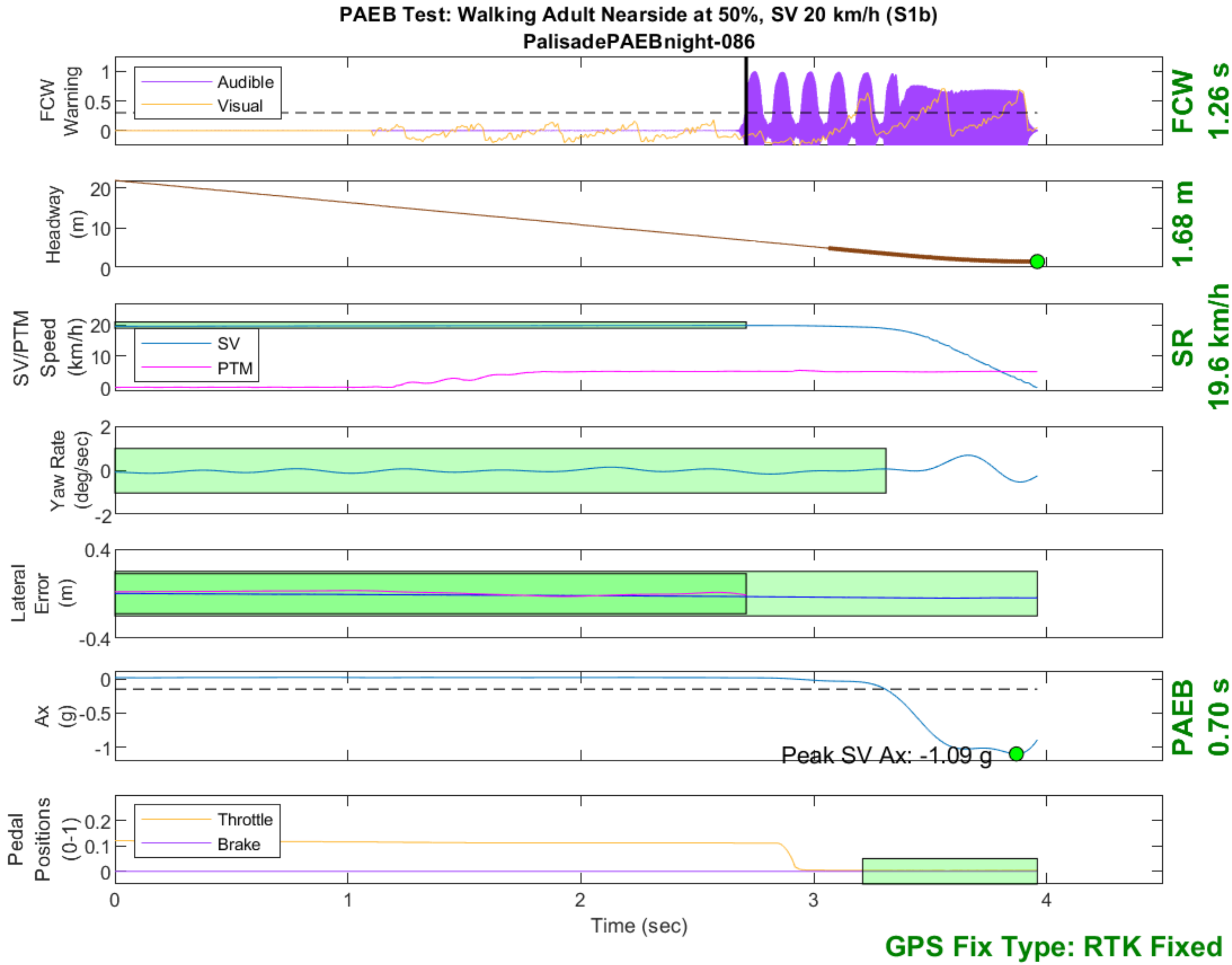


Figure D160. Time History for PAEB Run 86, S1b, Night, High Beam, 20 km/h

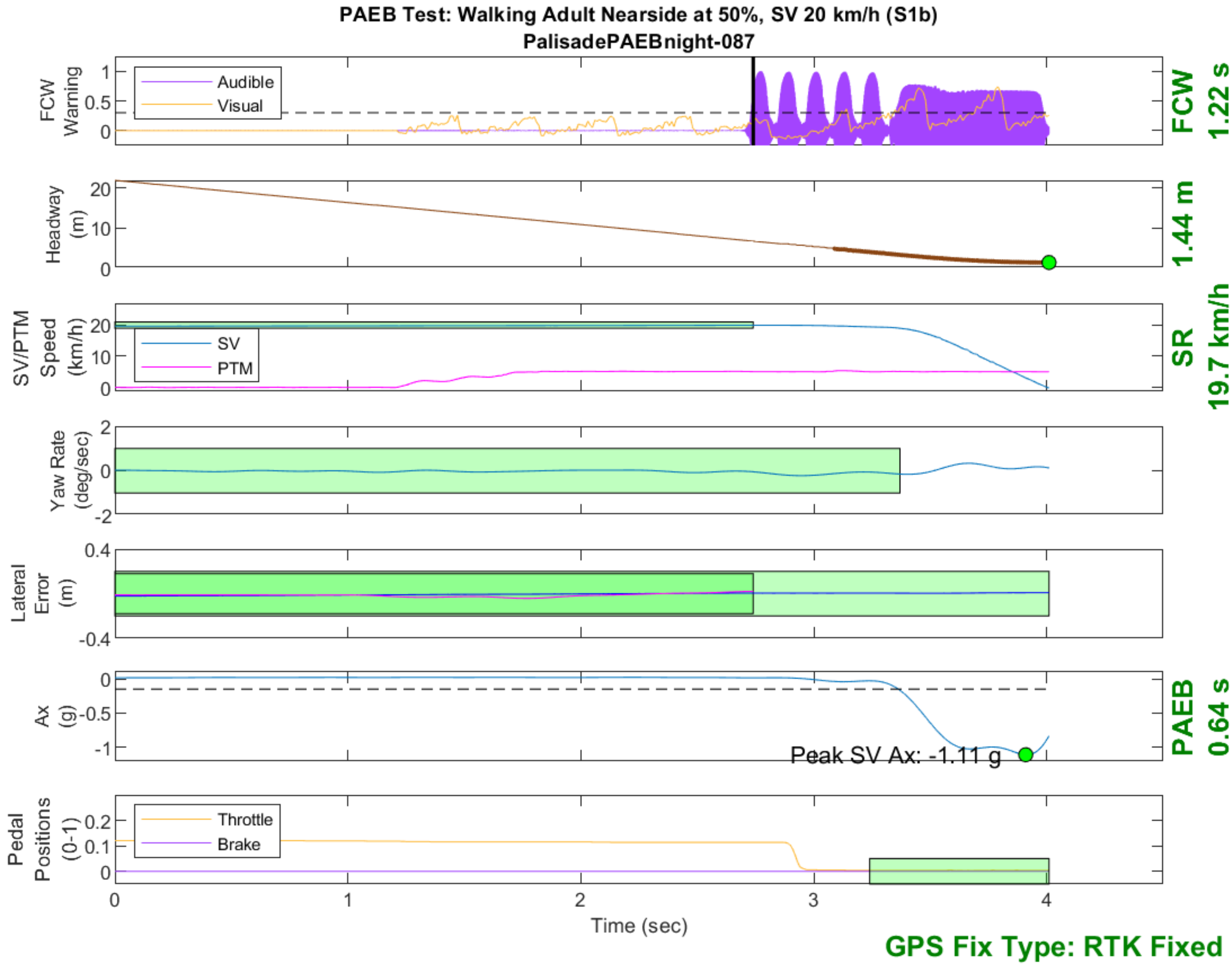


Figure D161. Time History for PAEB Run 87, S1b, Night, High Beam, 20 km/h

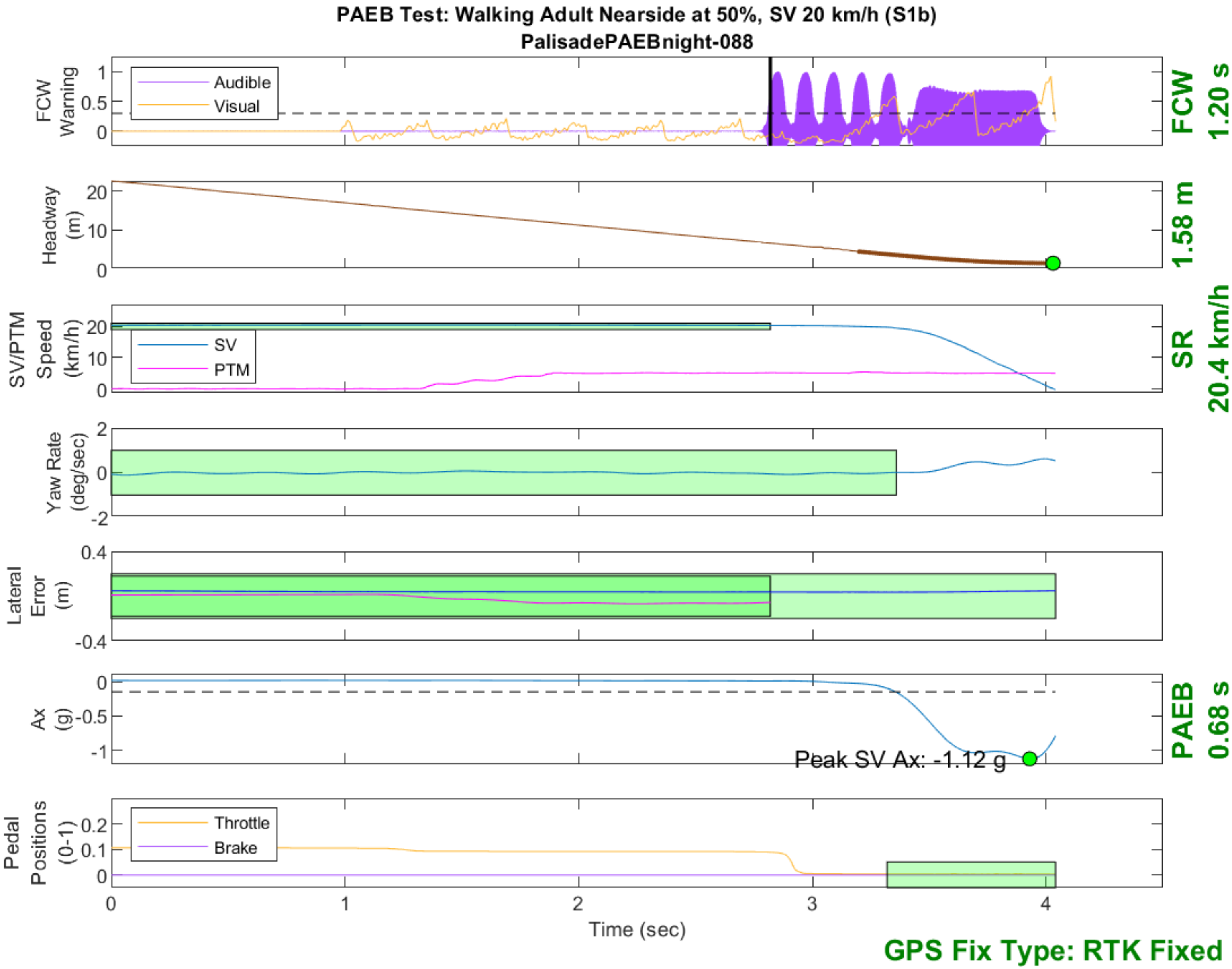


Figure D162. Time History for PAEB Run 88, S1b, Night, High Beam, 20 km/h

Figure D163. Time History for PAEB Run 94, S1b, Night, High Beam, 30 km/h

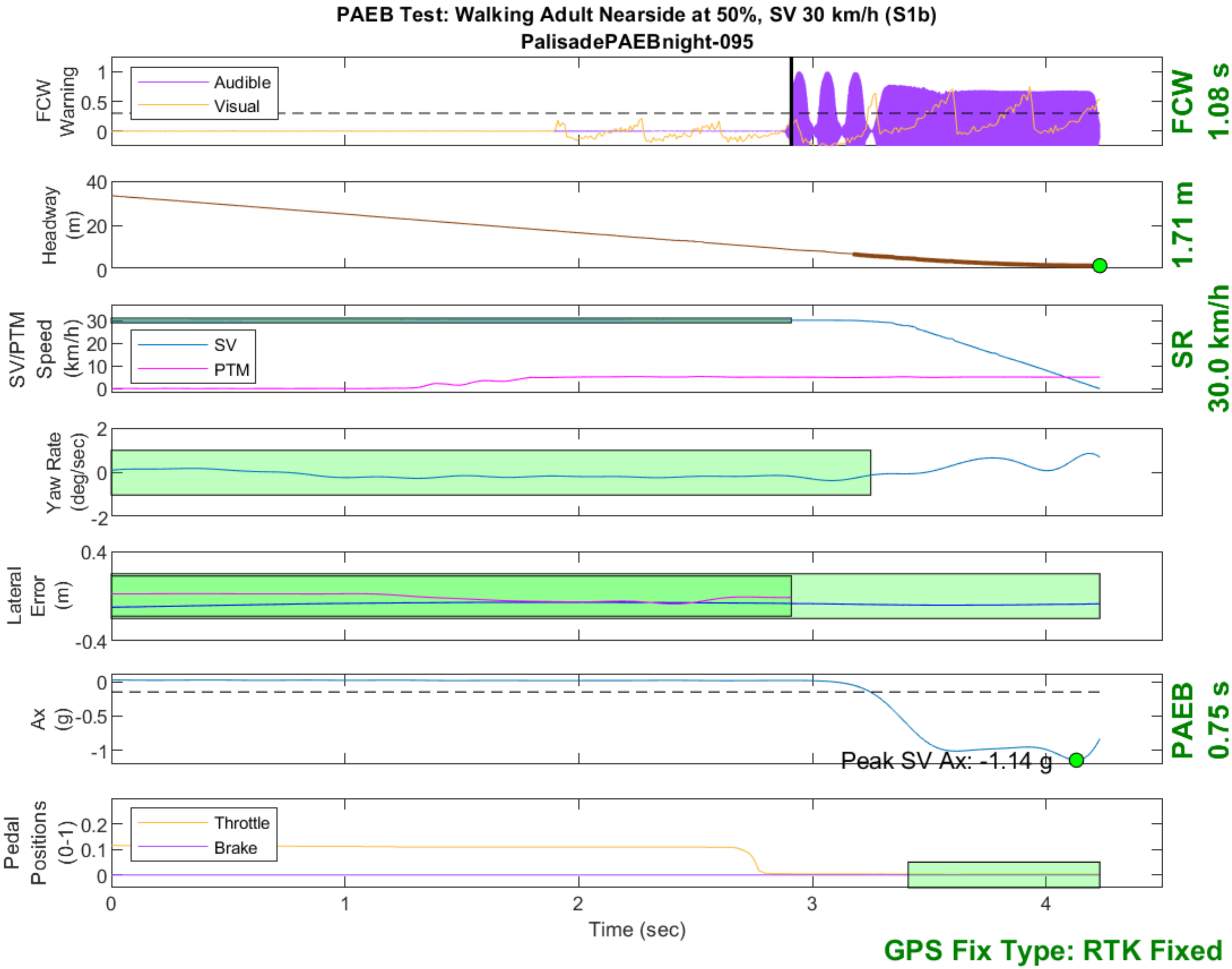


Figure D164. Time History for PAEB Run 95, S1b, Night, High Beam, 30 km/h

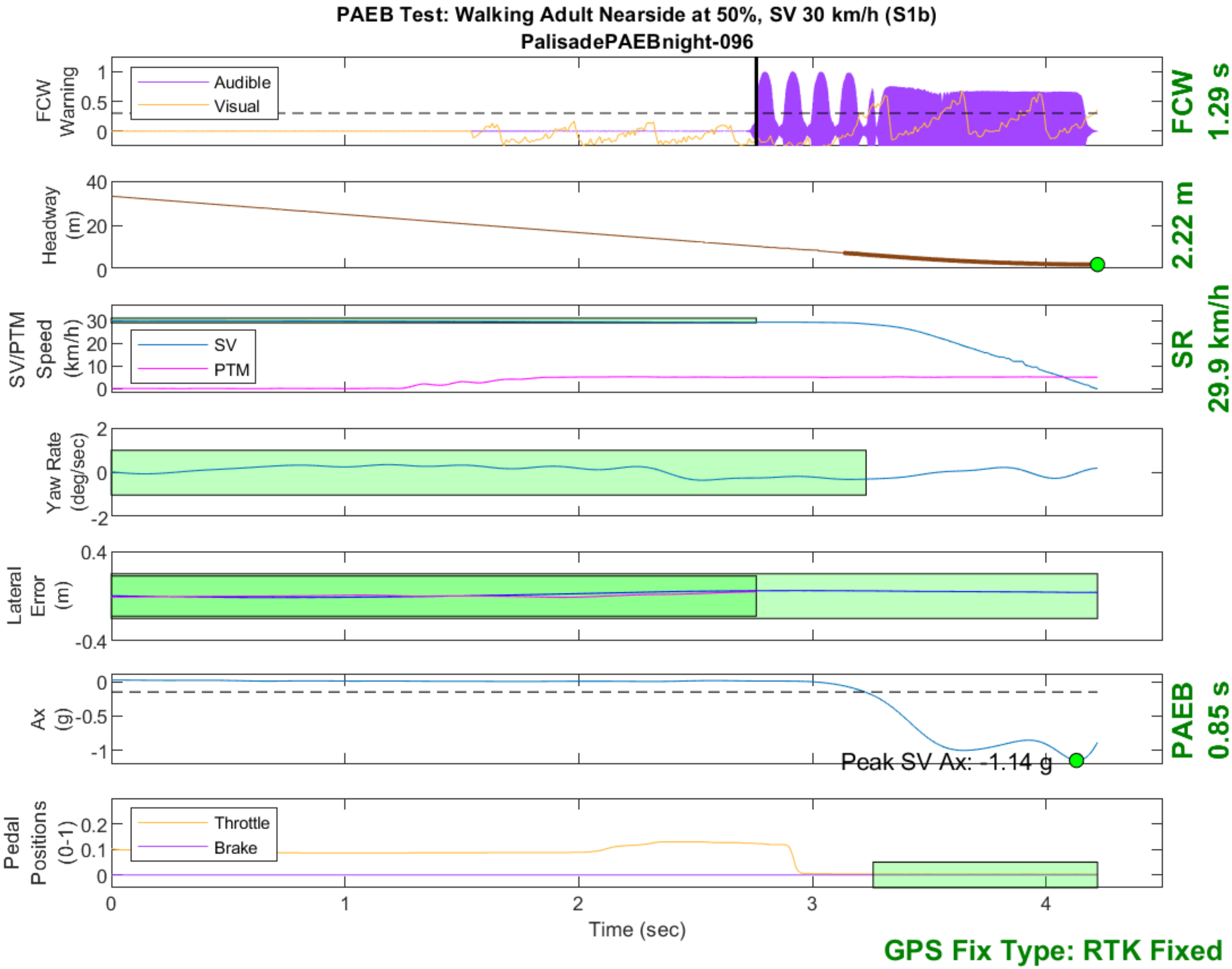


Figure D165. Time History for PAEB Run 96, S1b, Night, High Beam, 30 km/h

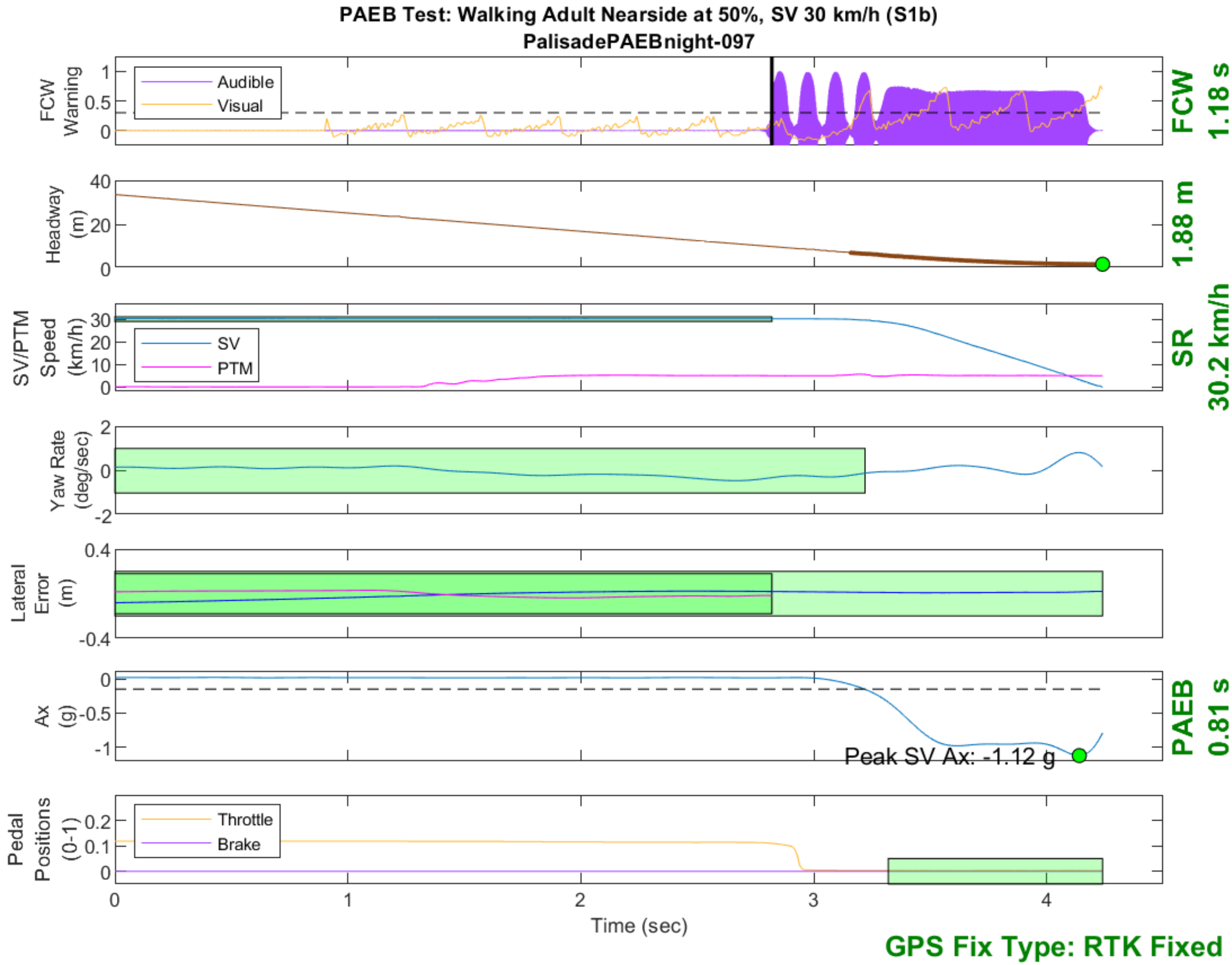


Figure D166. Time History for PAEB Run 97, S1b, Night, High Beam, 30 km/h

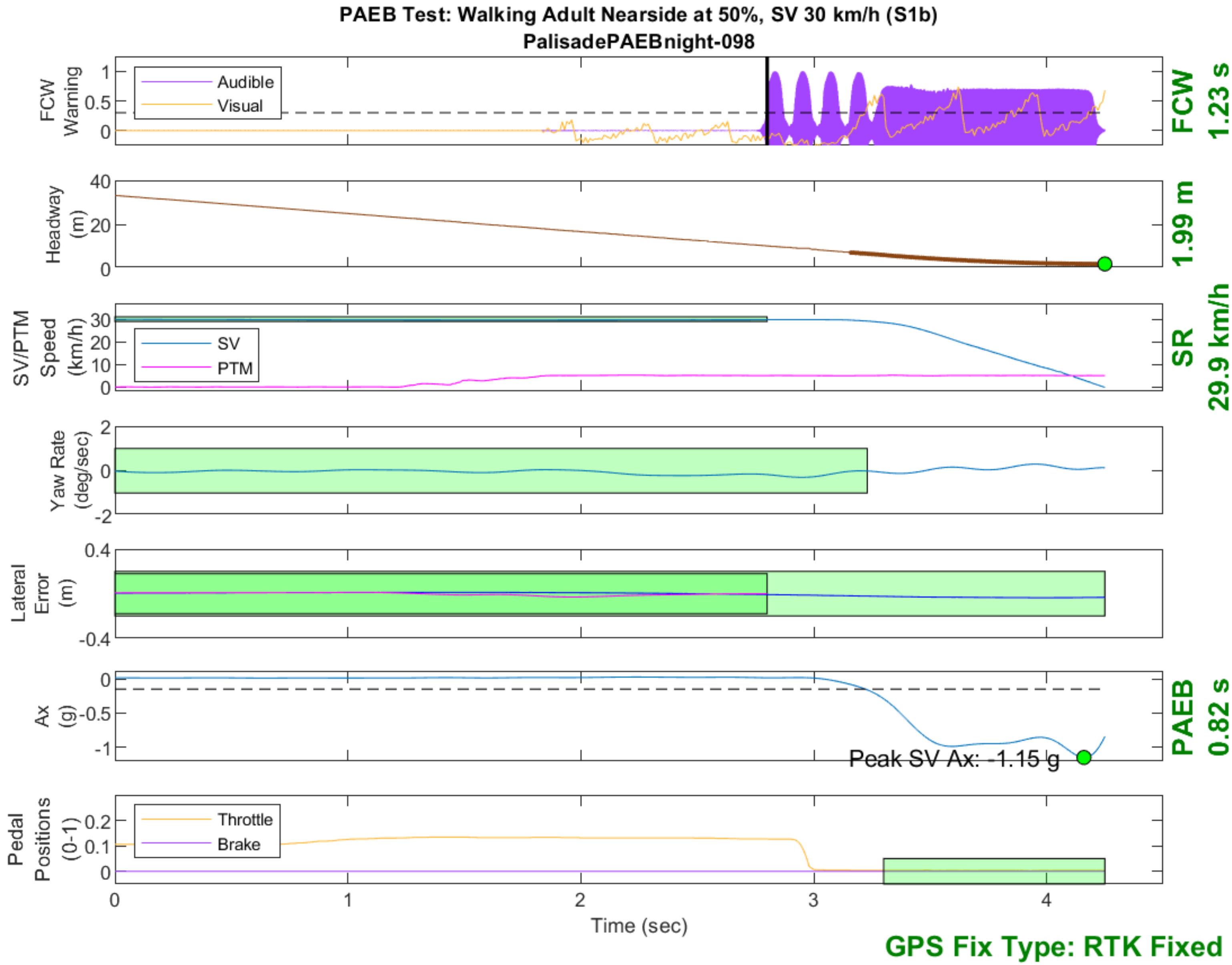


Figure D167. Time History for PAEB Run 98, S1b, Night, High Beam, 30 km/h

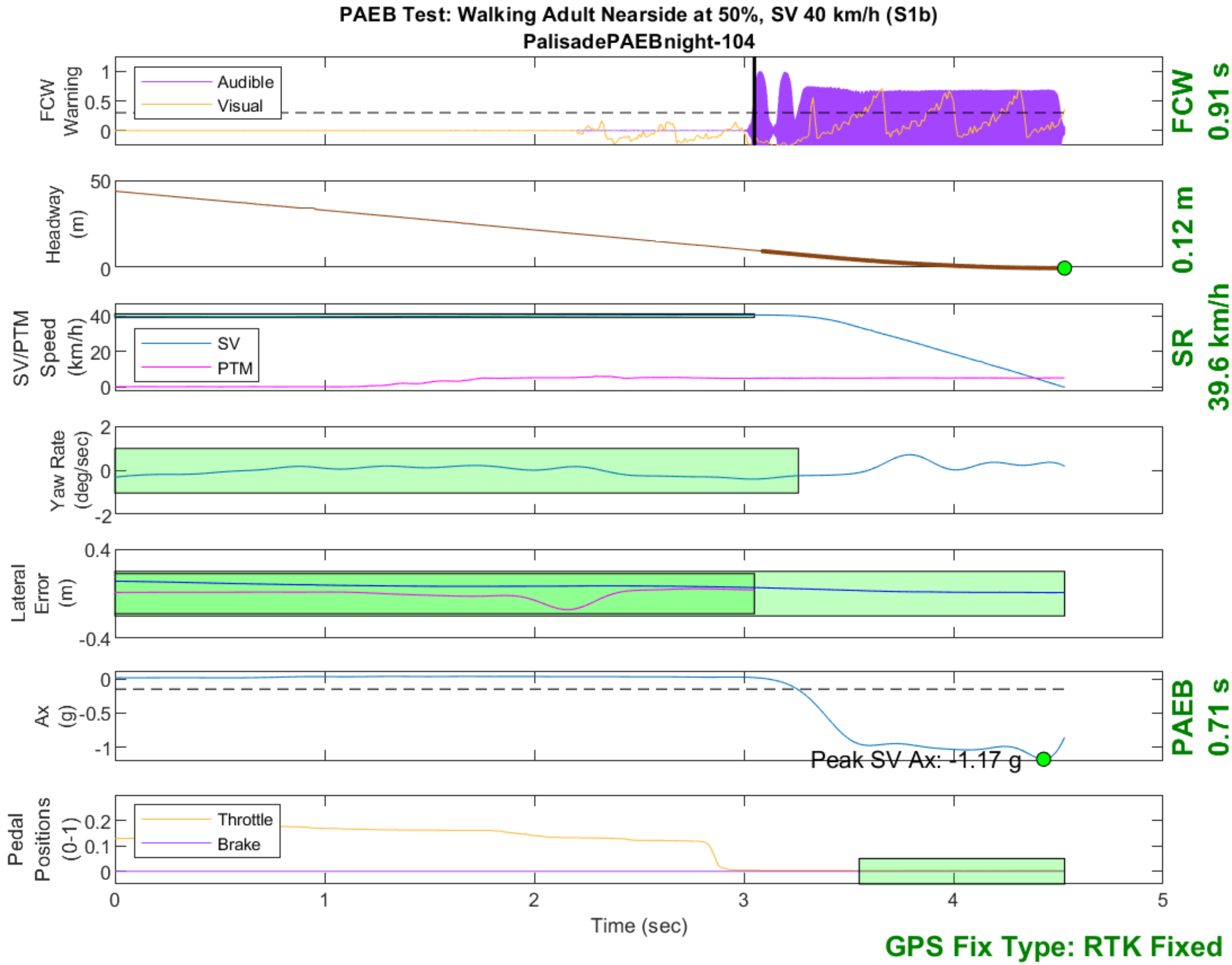


Figure D168. Time History for PAEB Run 104, S1b, Night, High Beam, 40 km/h

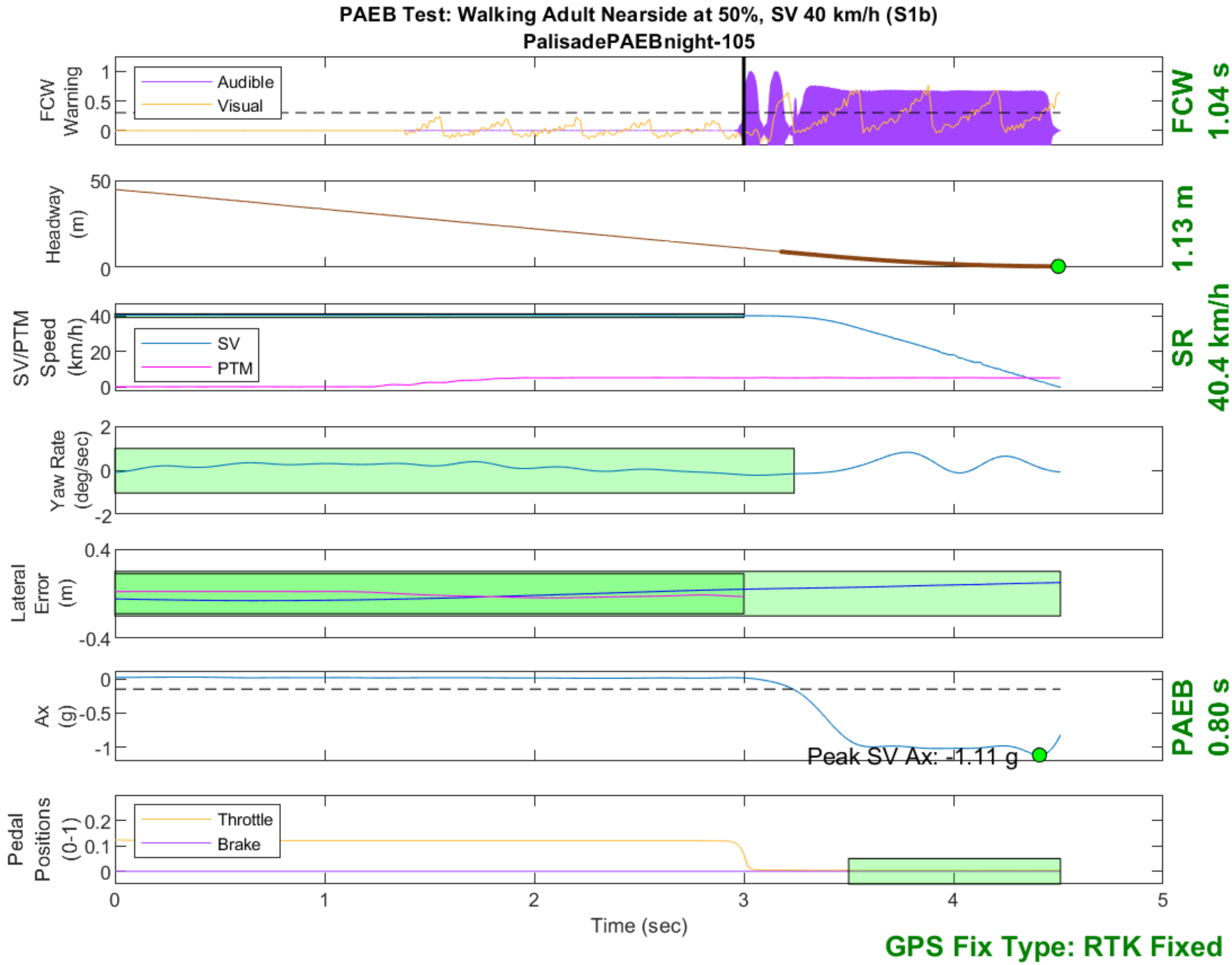


Figure D169. Time History for PAEB Run 105, S1b, Night, High Beam, 40 km/h

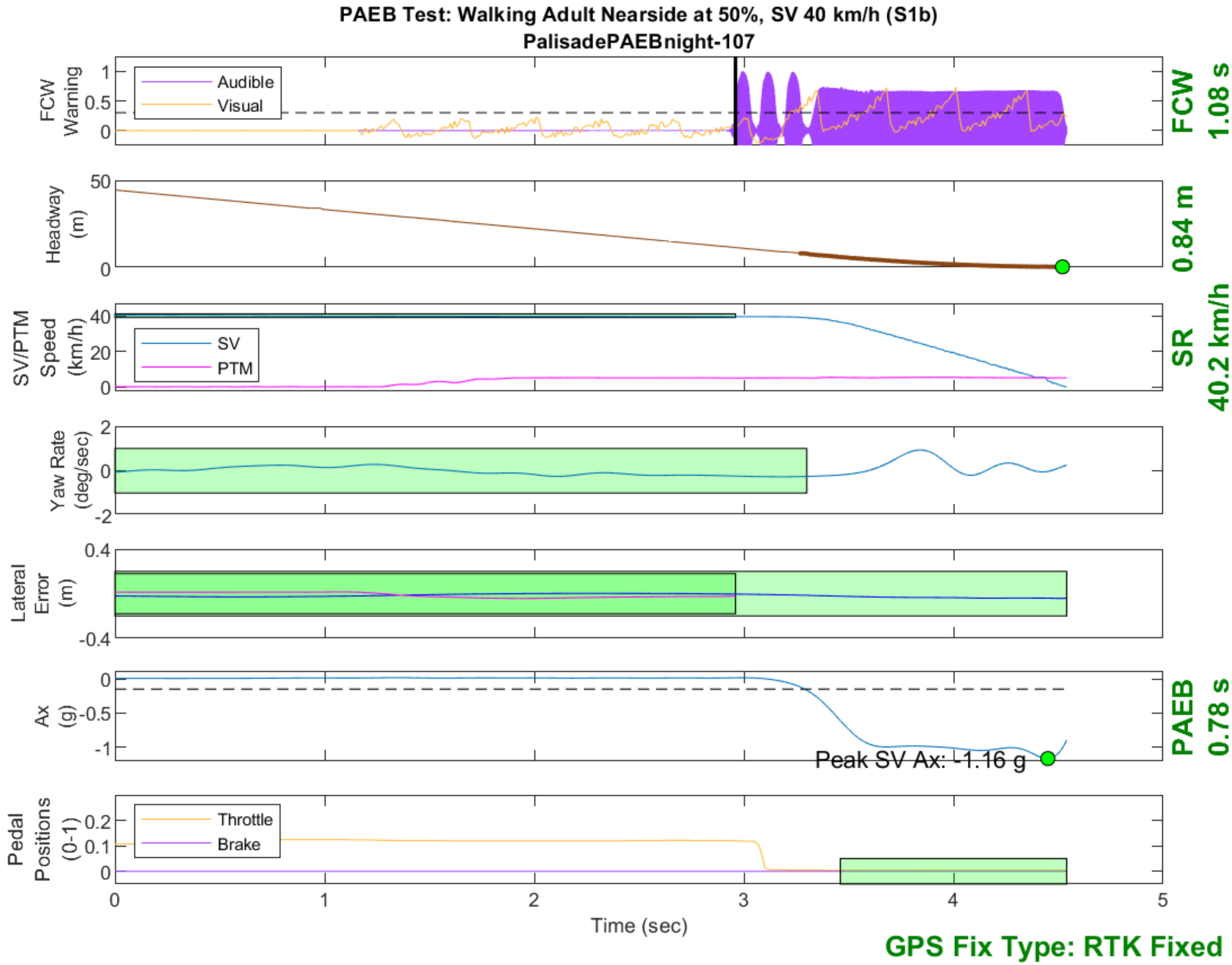


Figure D170. Time History for PAEB Run 107, S1b, Night, High Beam, 40 km/h

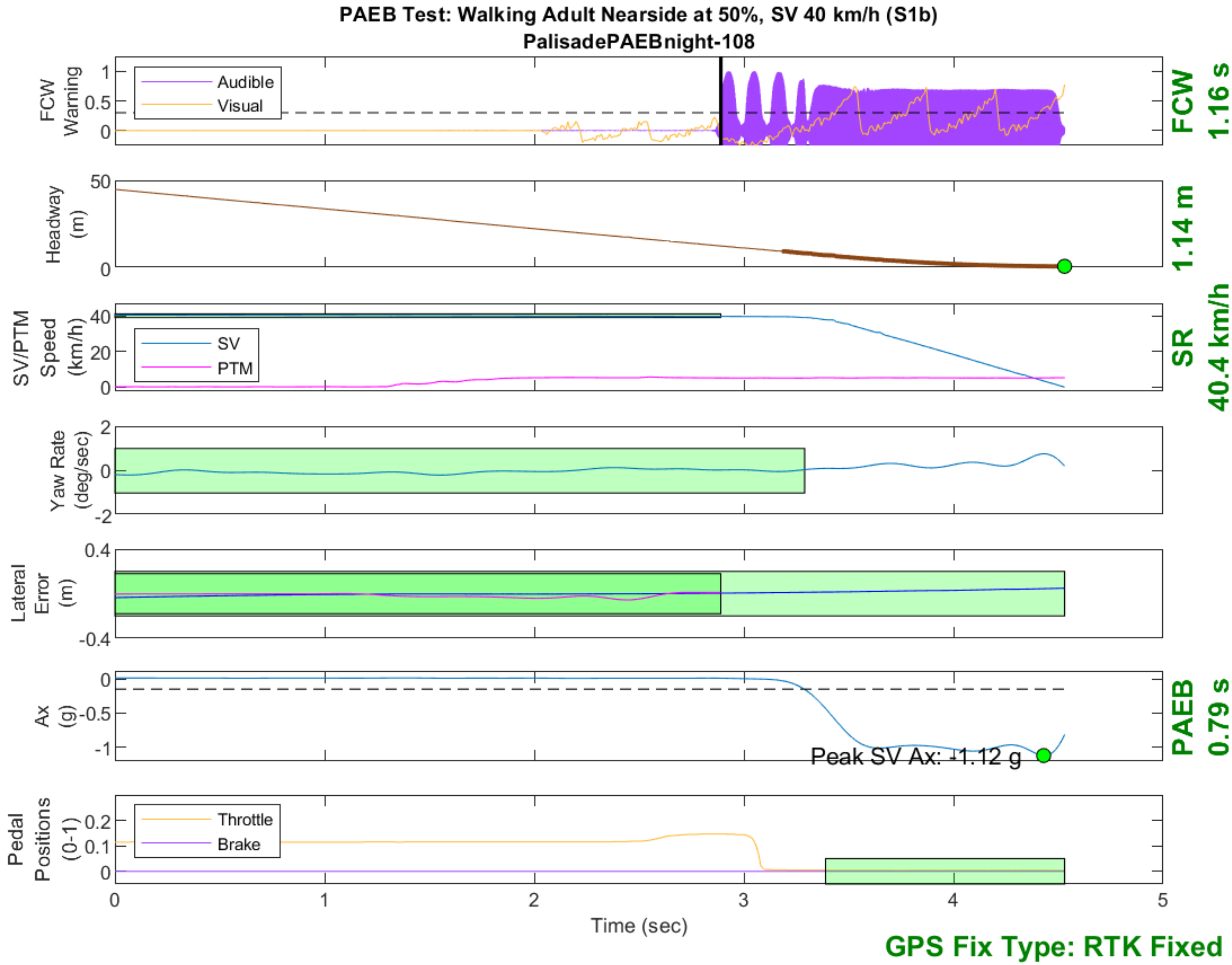


Figure D171. Time History for PAEB Run 108, S1b, Night, High Beam, 40 km/h

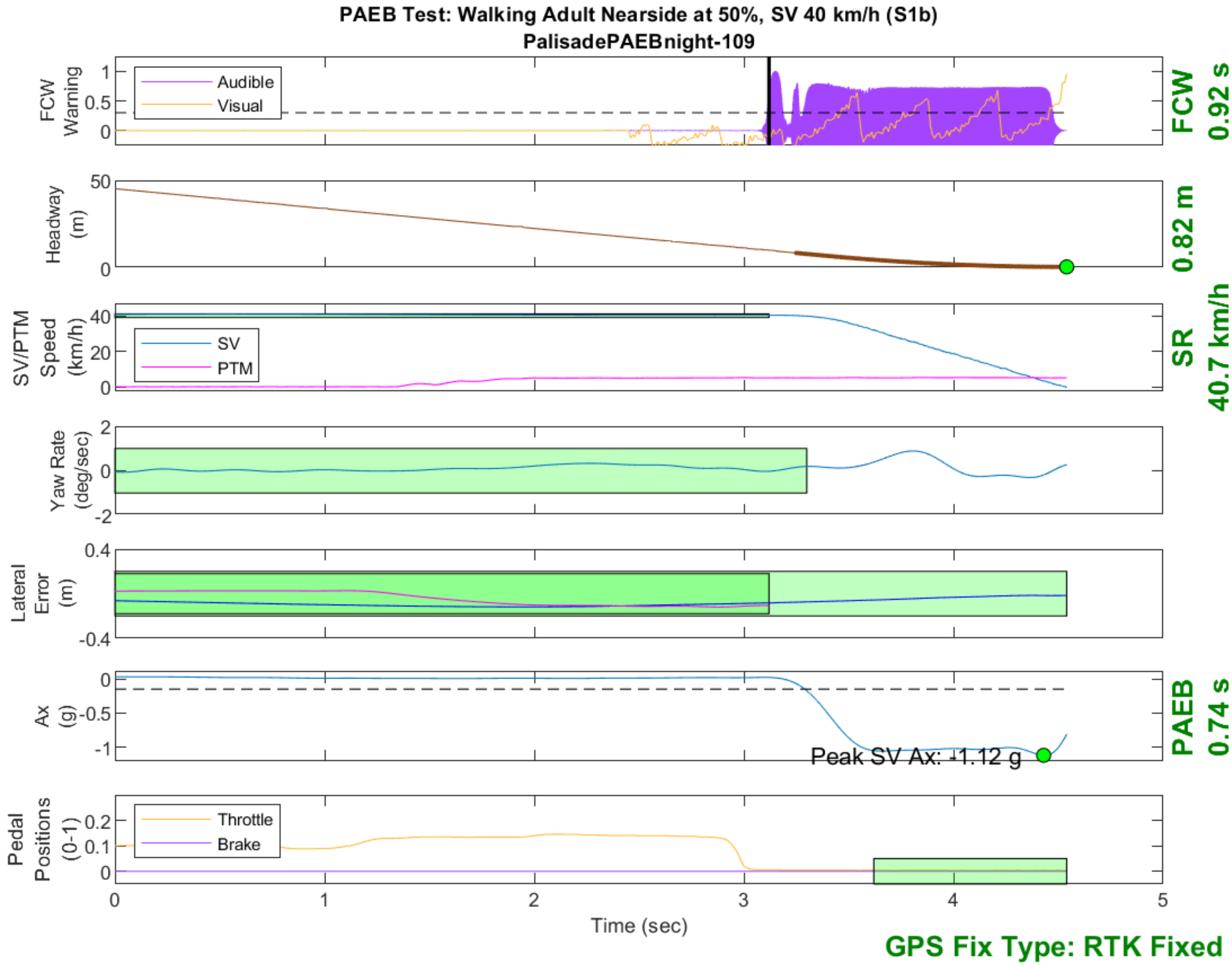


Figure D172. Time History for PAEB Run 109, S1b, Night, High Beam, 40 km/h

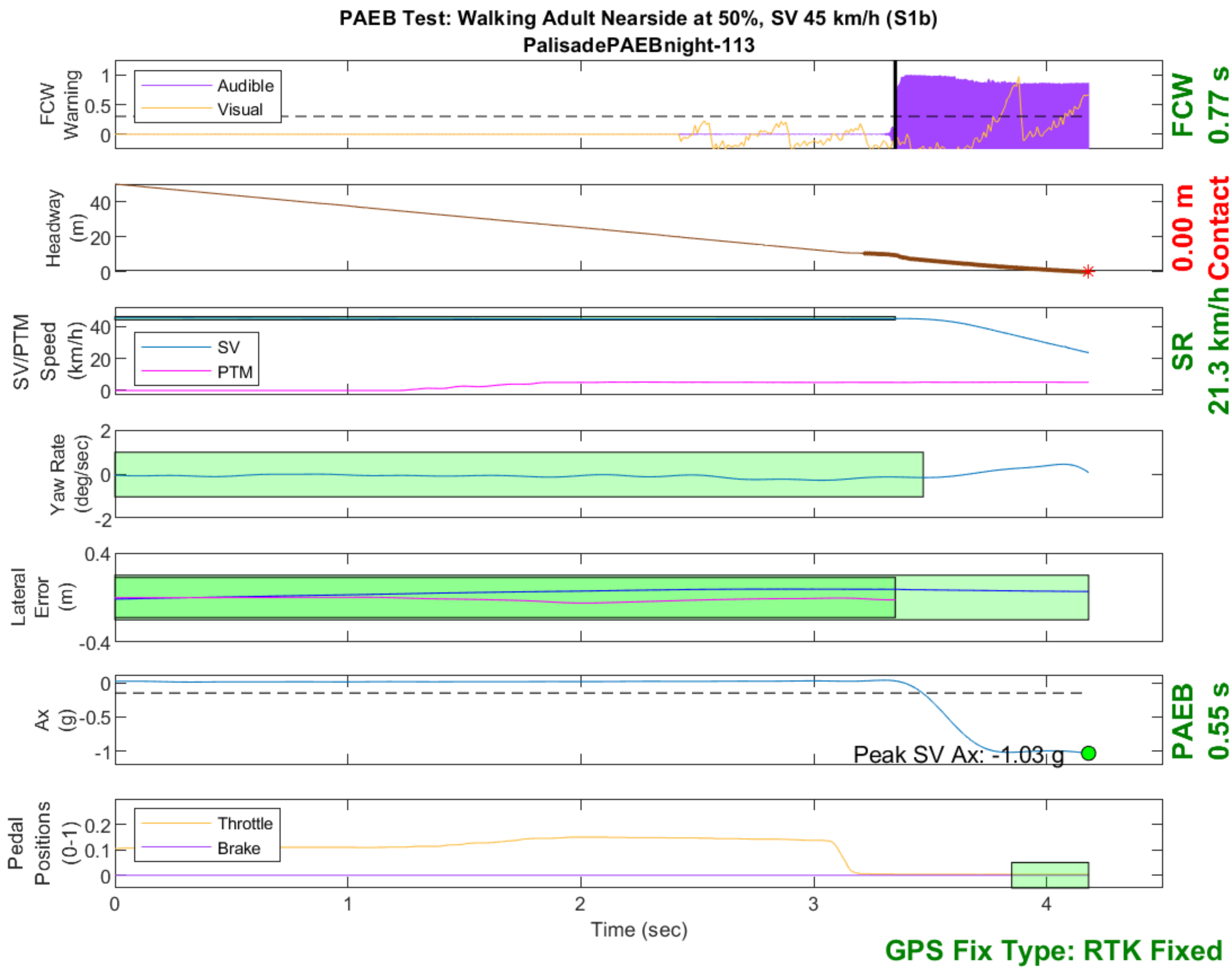


Figure D173. Time History for PAEB Run 113, S1b, Night, High Beam, 45 km/h

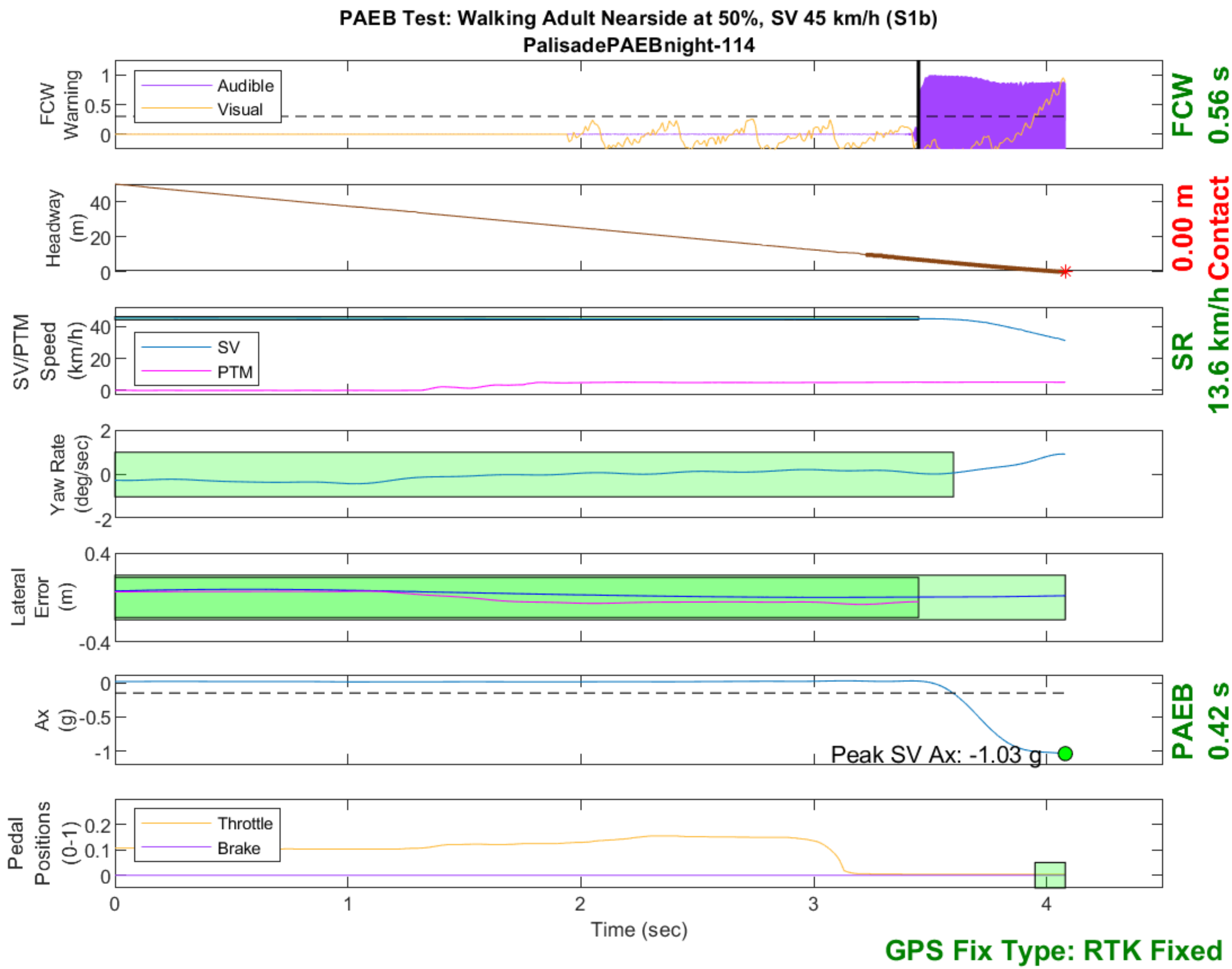


Figure D174. Time History for PAEB Run 114, S1b, Night, High Beam, 45 km/h

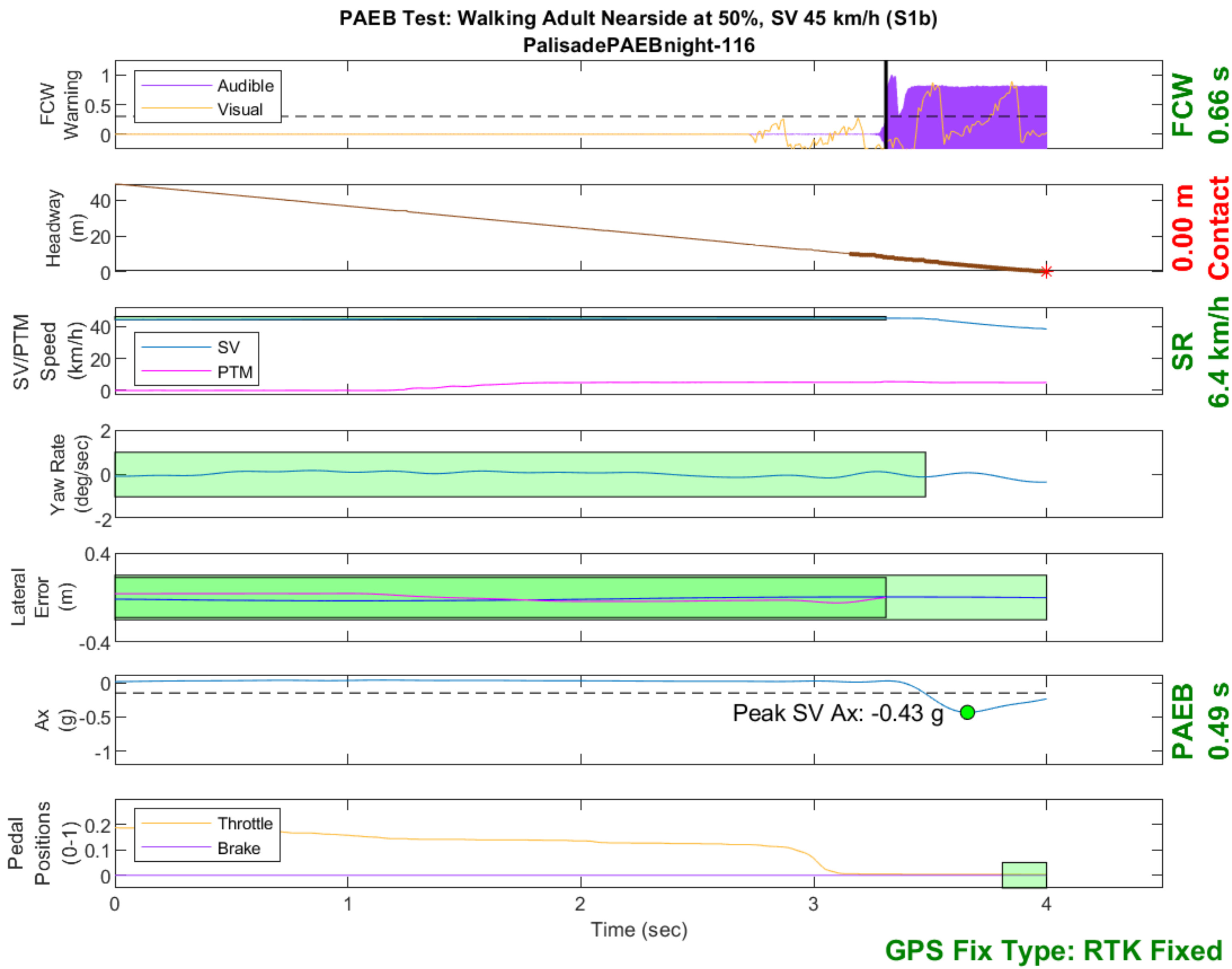


Figure D175. Time History for PAEB Run 116, S1b, Night, High Beam, 45 km/h

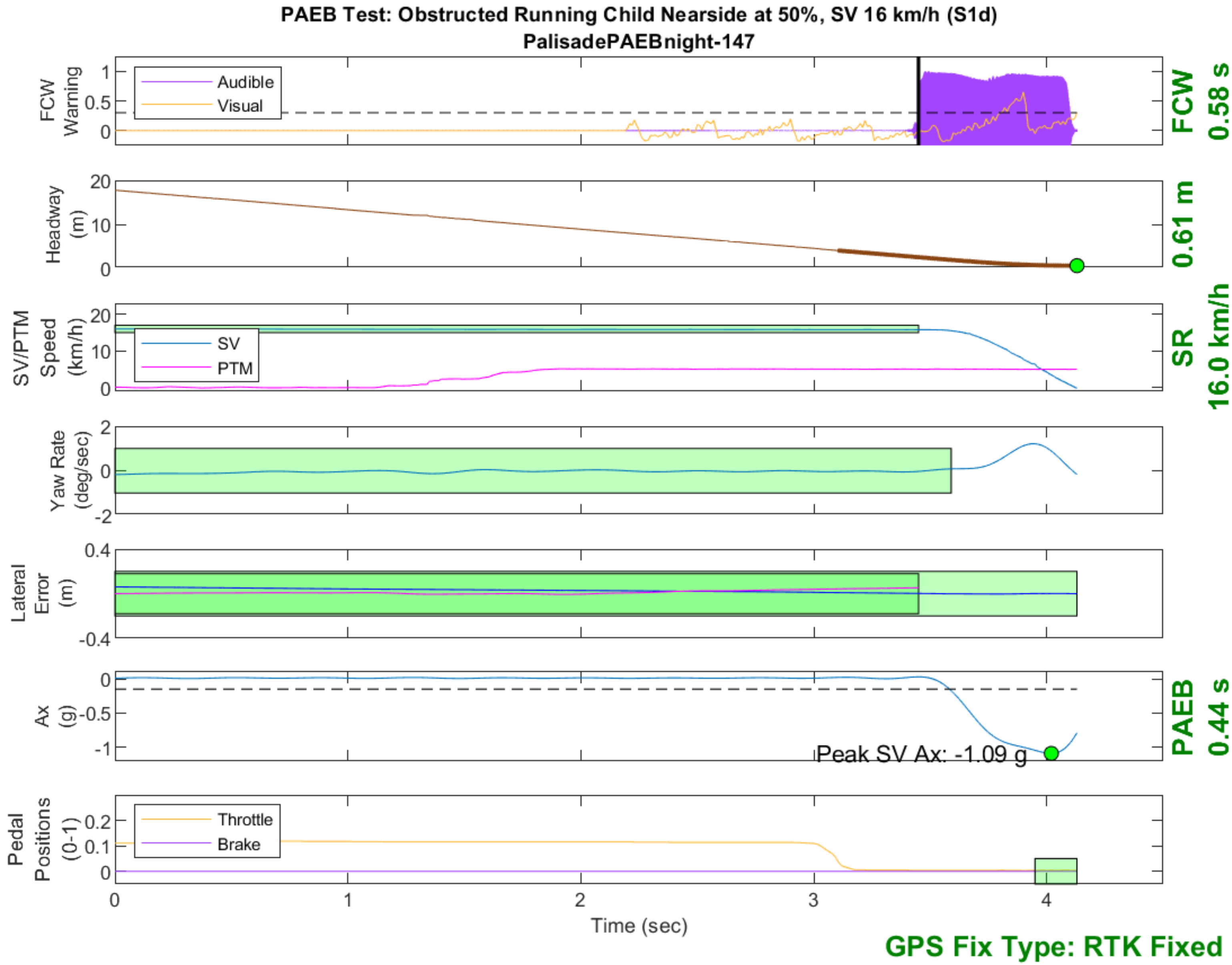


Figure D176. Time History for PAEB Run 147, S1d, Night, High Beam, 16 km/h

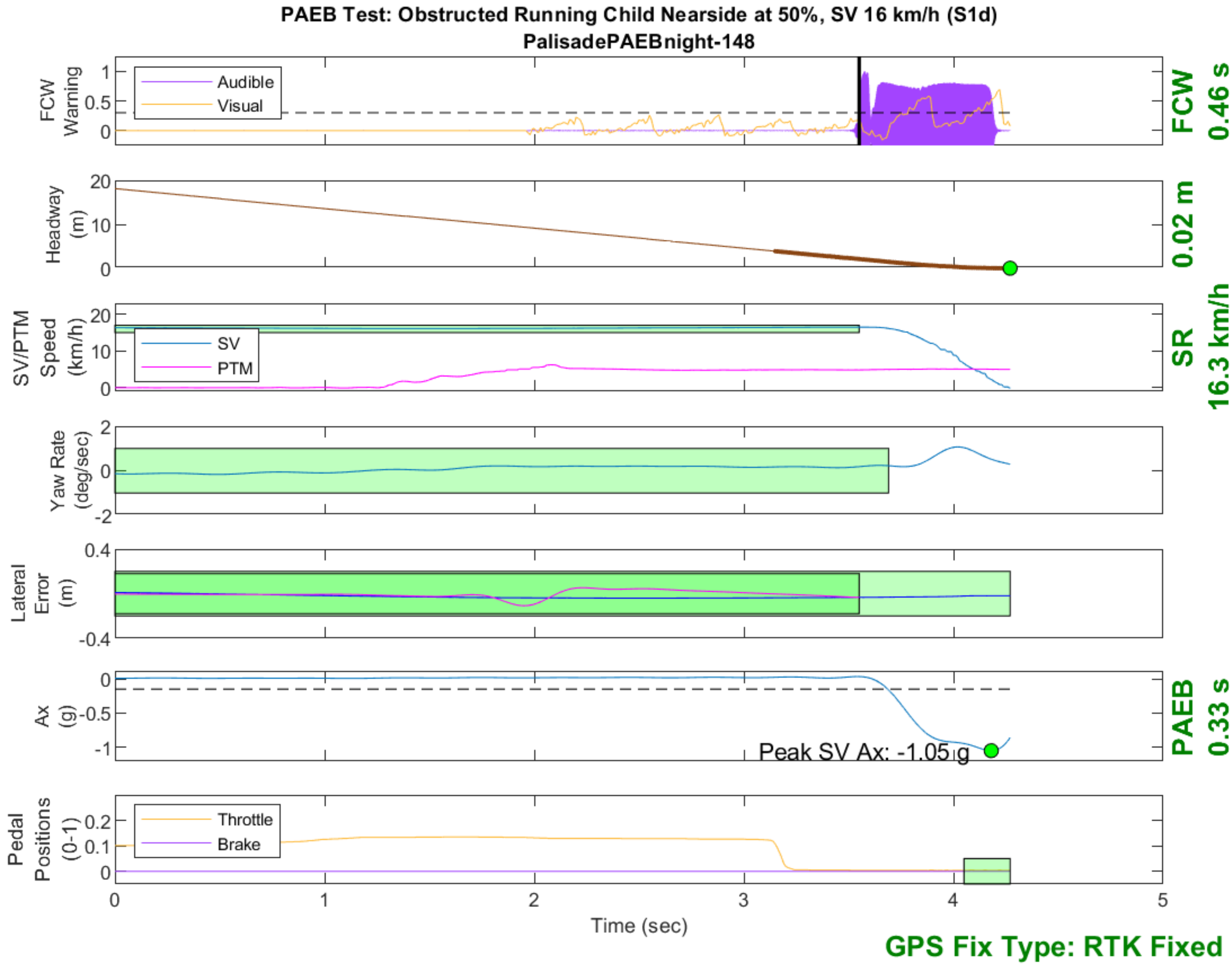


Figure D177. Time History for PAEB Run 148, S1d, Night, High Beam, 16 km/h

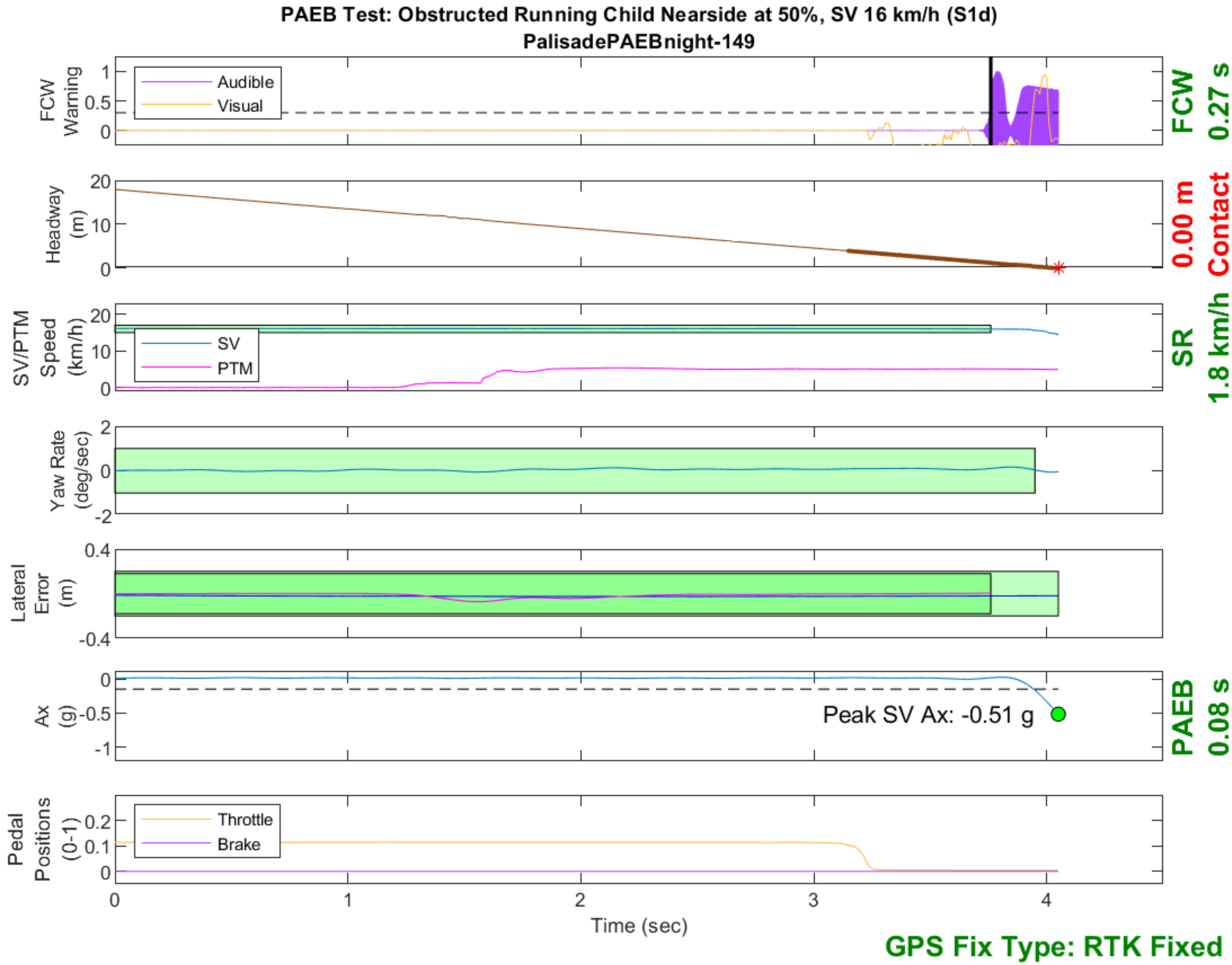


Figure D178. Time History for PAEB Run 149, S1d, Night, High Beam, 16 km/h

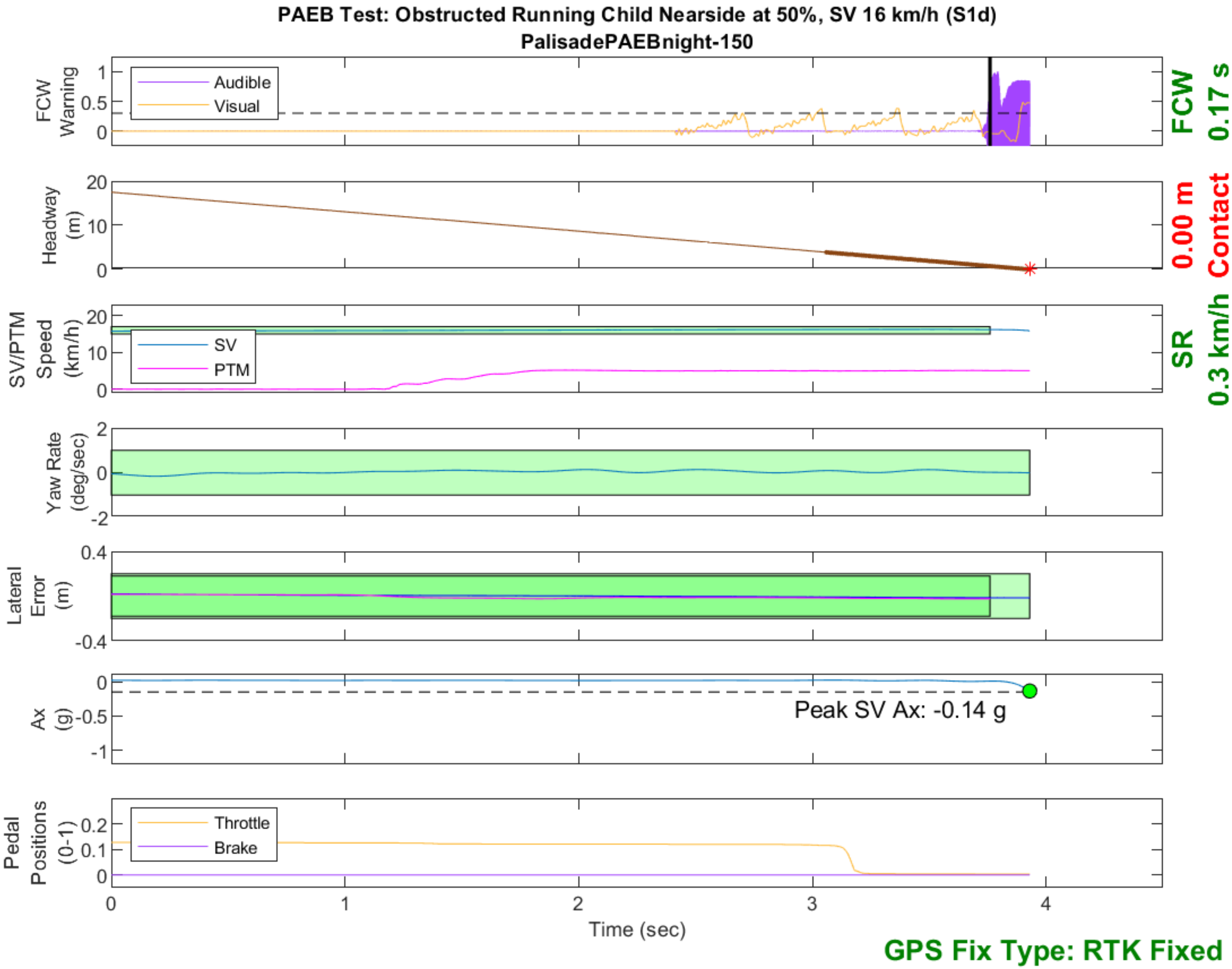


Figure D179. Time History for PAEB Run 150, S1d, Night, High Beam, 16 km/h

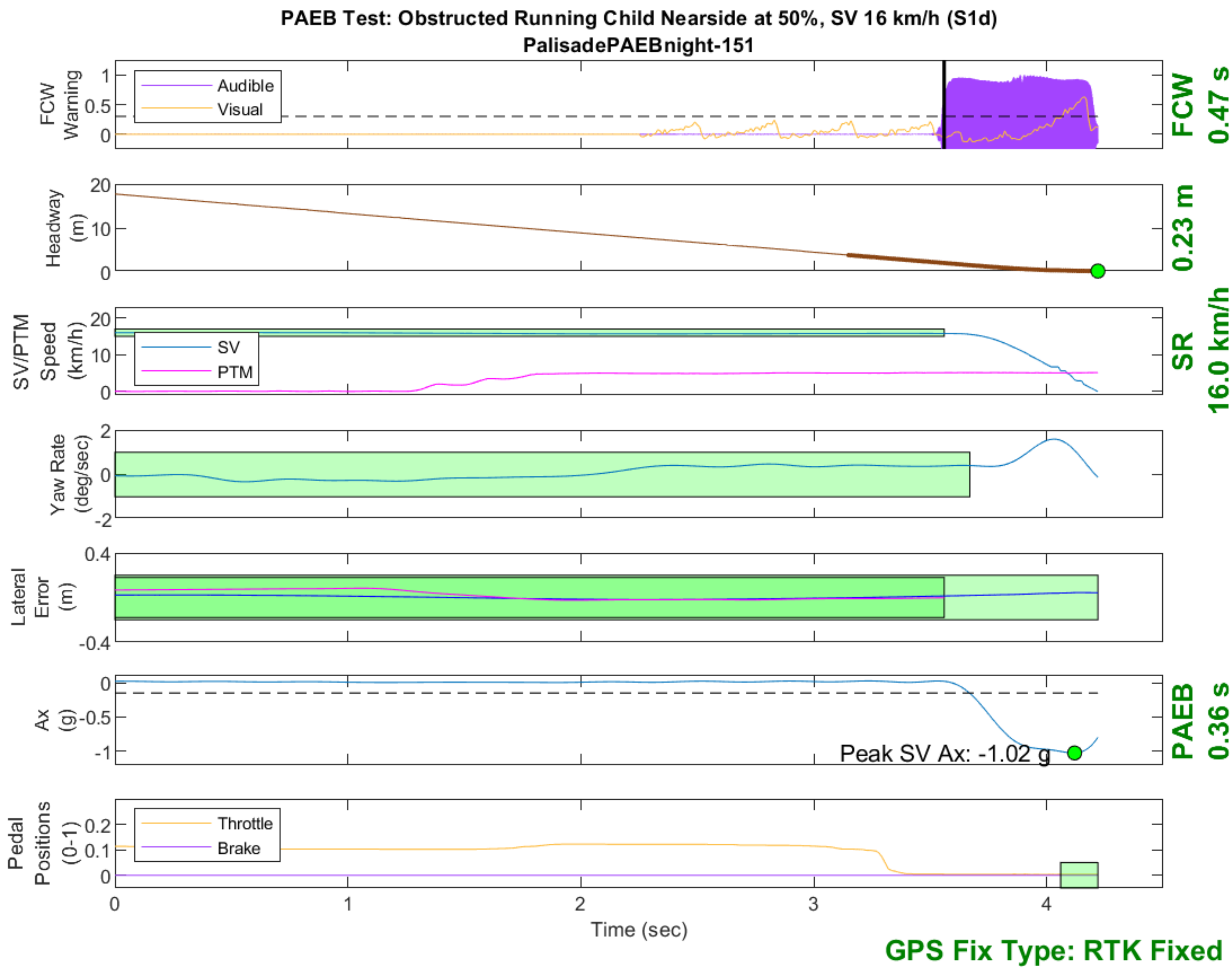


Figure D180. Time History for PAEB Run 151, S1d, Night, High Beam, 16 km/h

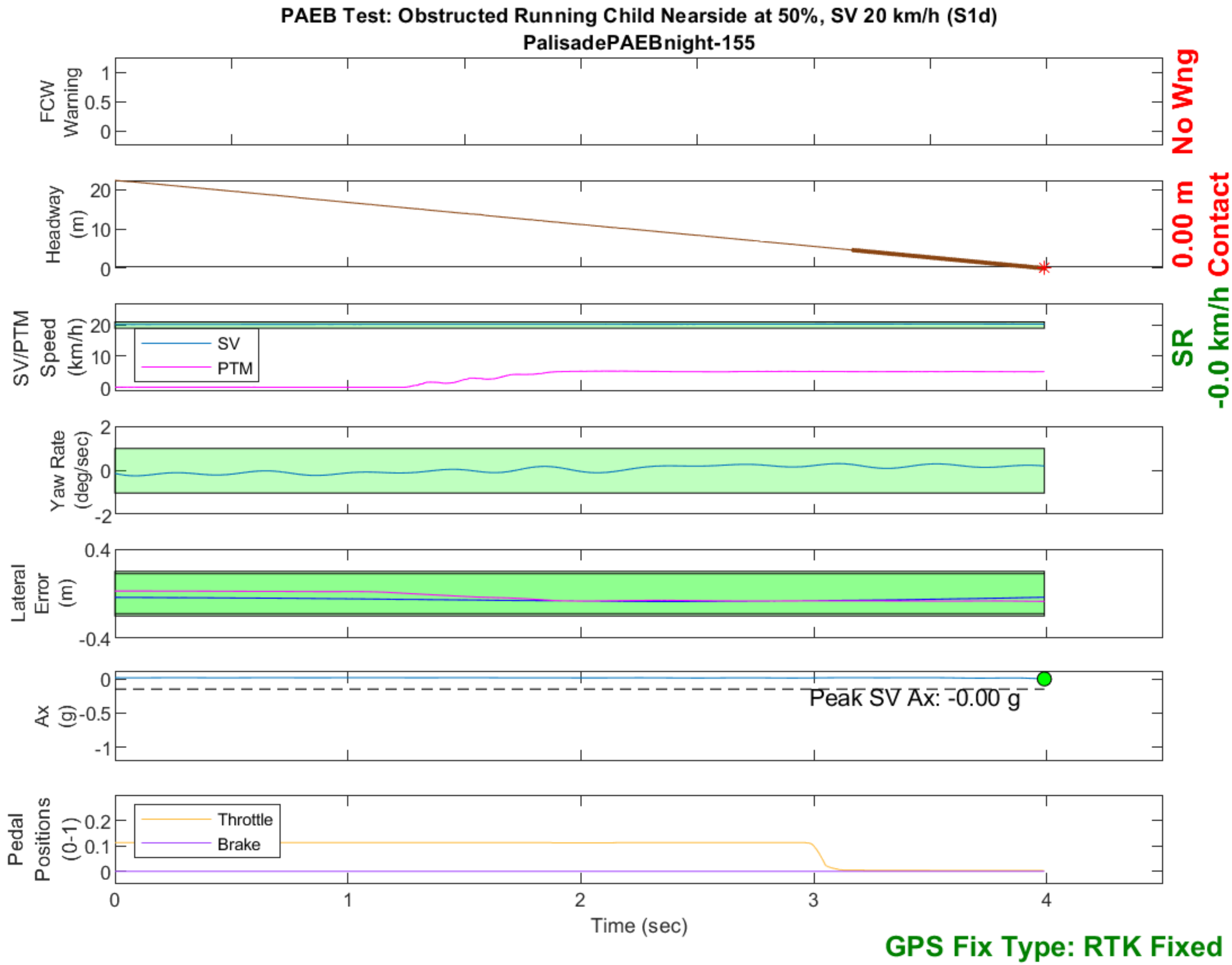


Figure D181. Time History for PAEB Run 155, S1d, Night, High Beam, 20 km/h

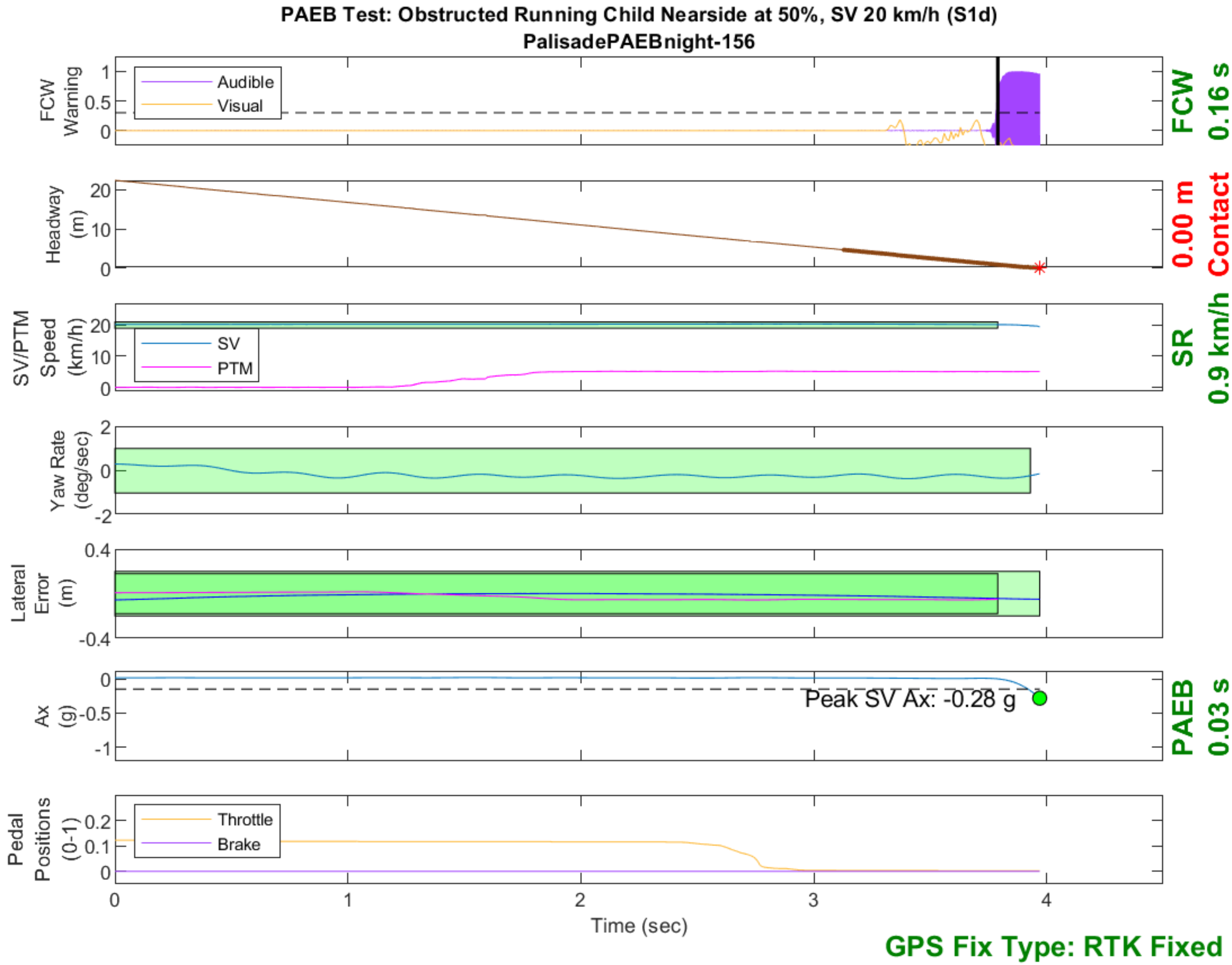


Figure D182. Time History for PAEB Run 156, S1d, Night, High Beam, 20 km/h

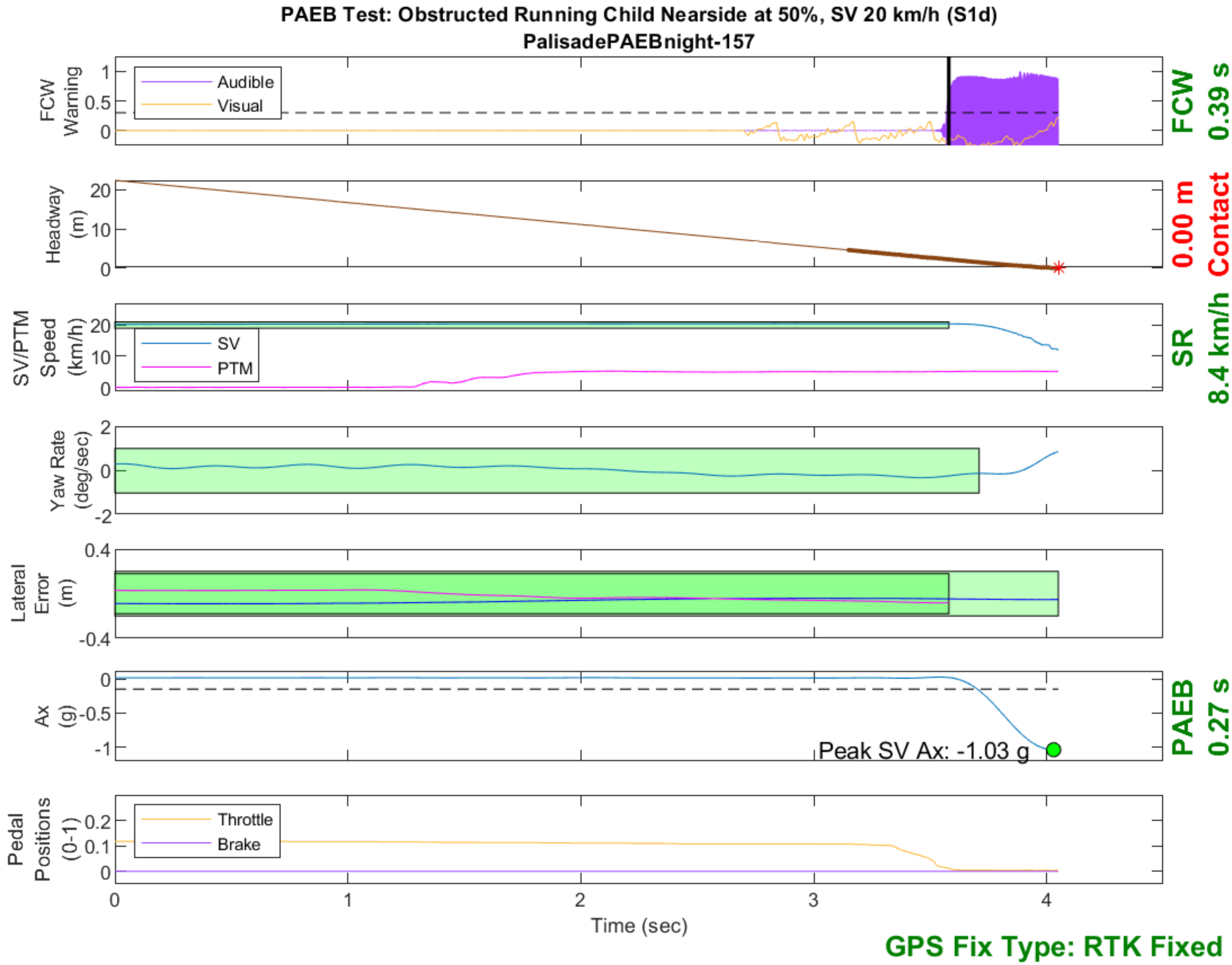


Figure D183. Time History for PAEB Run 157, S1d, Night, High Beam, 20 km/h

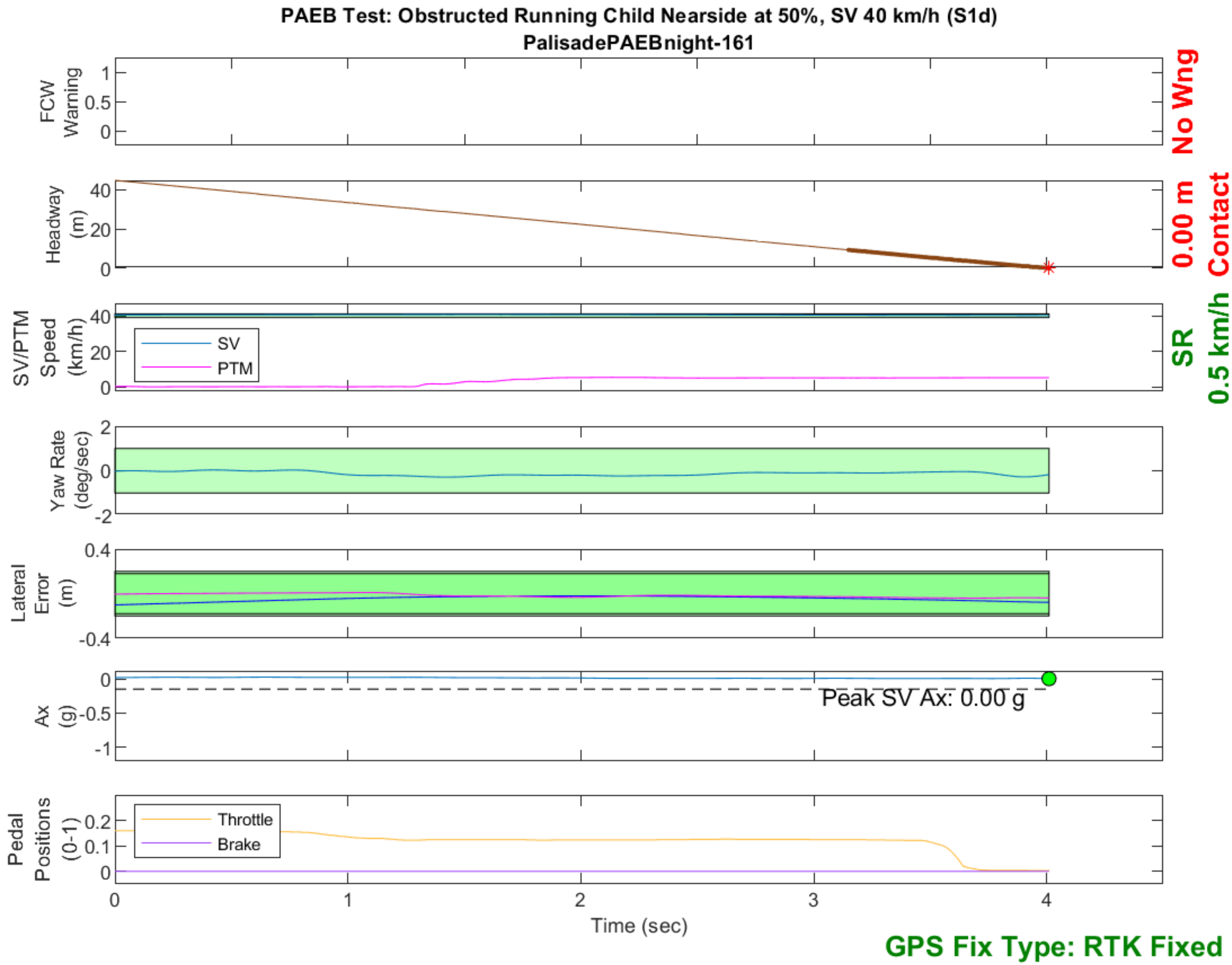


Figure D184. Time History for PAEB Run 161, S1d, Night, High Beam, 40 km/h

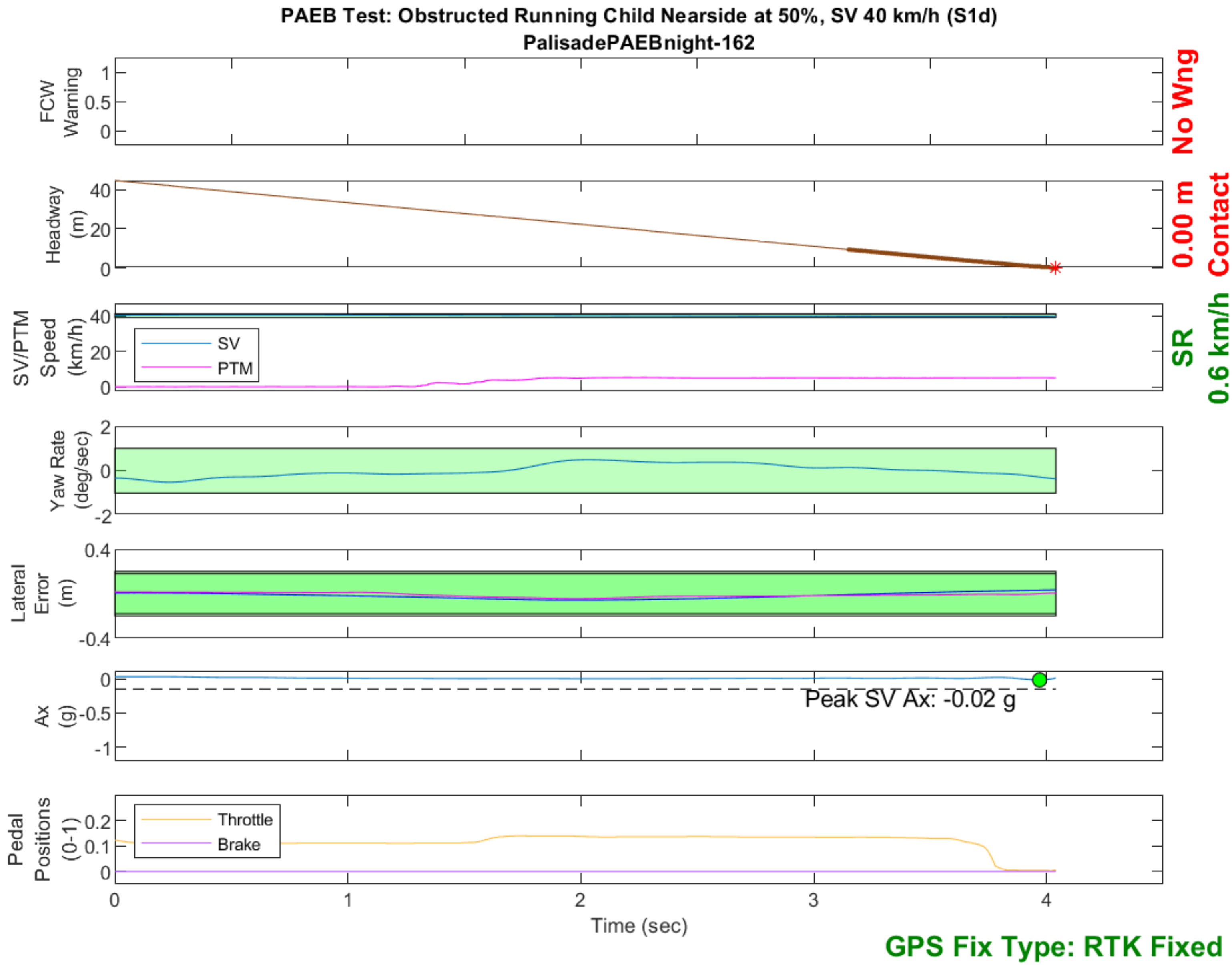


Figure D185. Time History for PAEB Run 162, S1d, Night, High Beam, 40 km/h

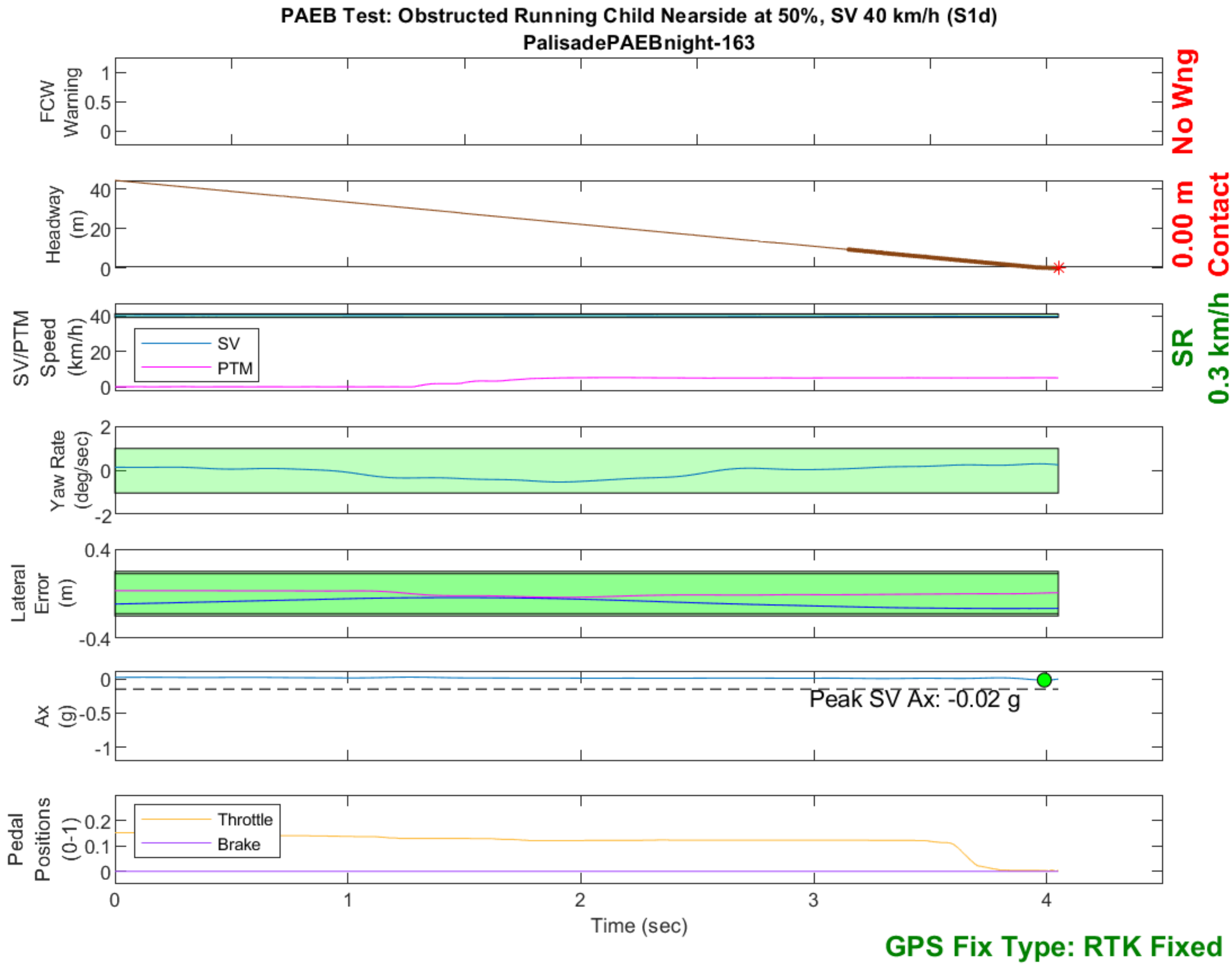


Figure D186. Time History for PAEB Run 163, S1d, Night, High Beam, 40 km/h

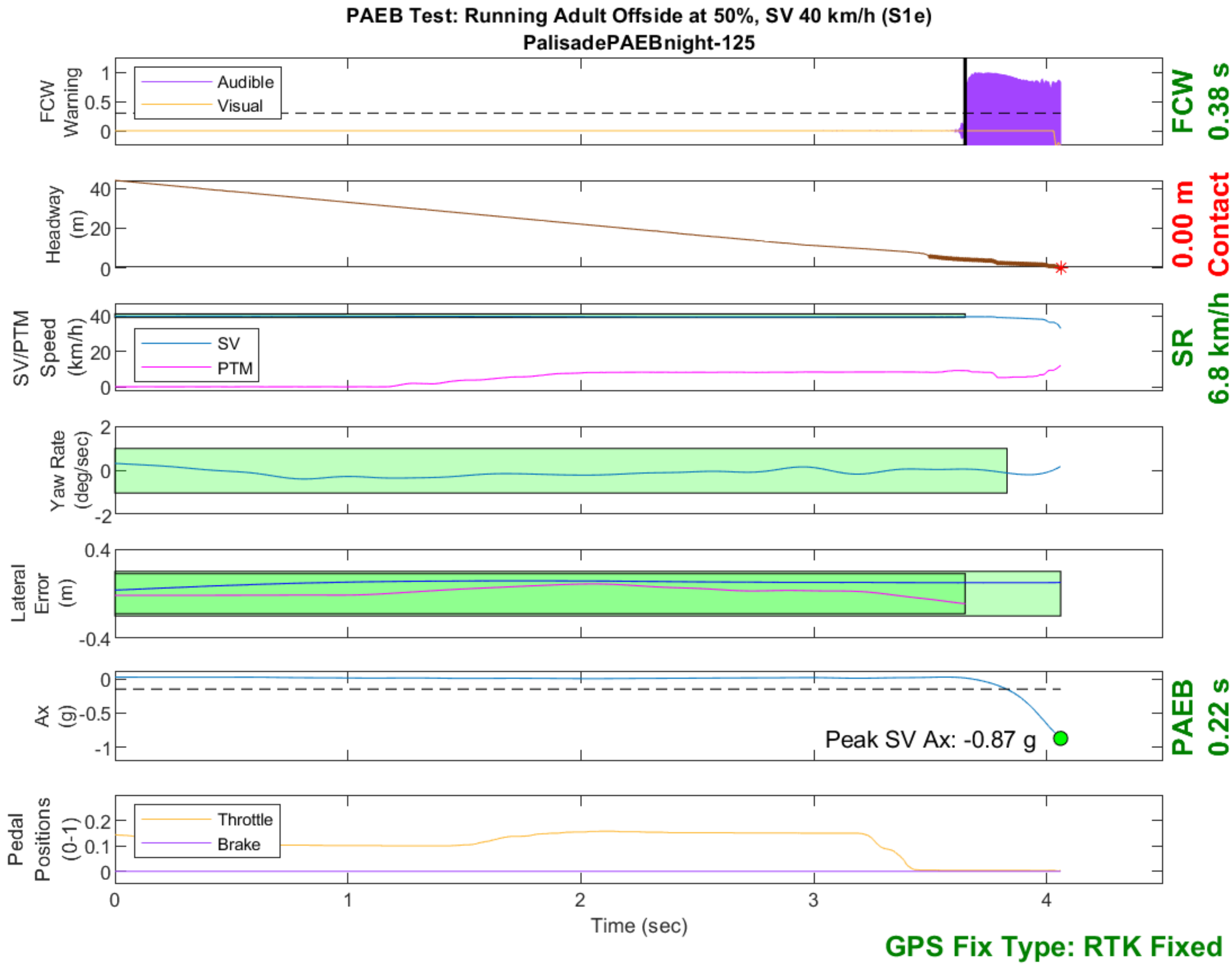


Figure D187. Time History for PAEB Run 125, S1e, Night, High Beam, 40 km/h

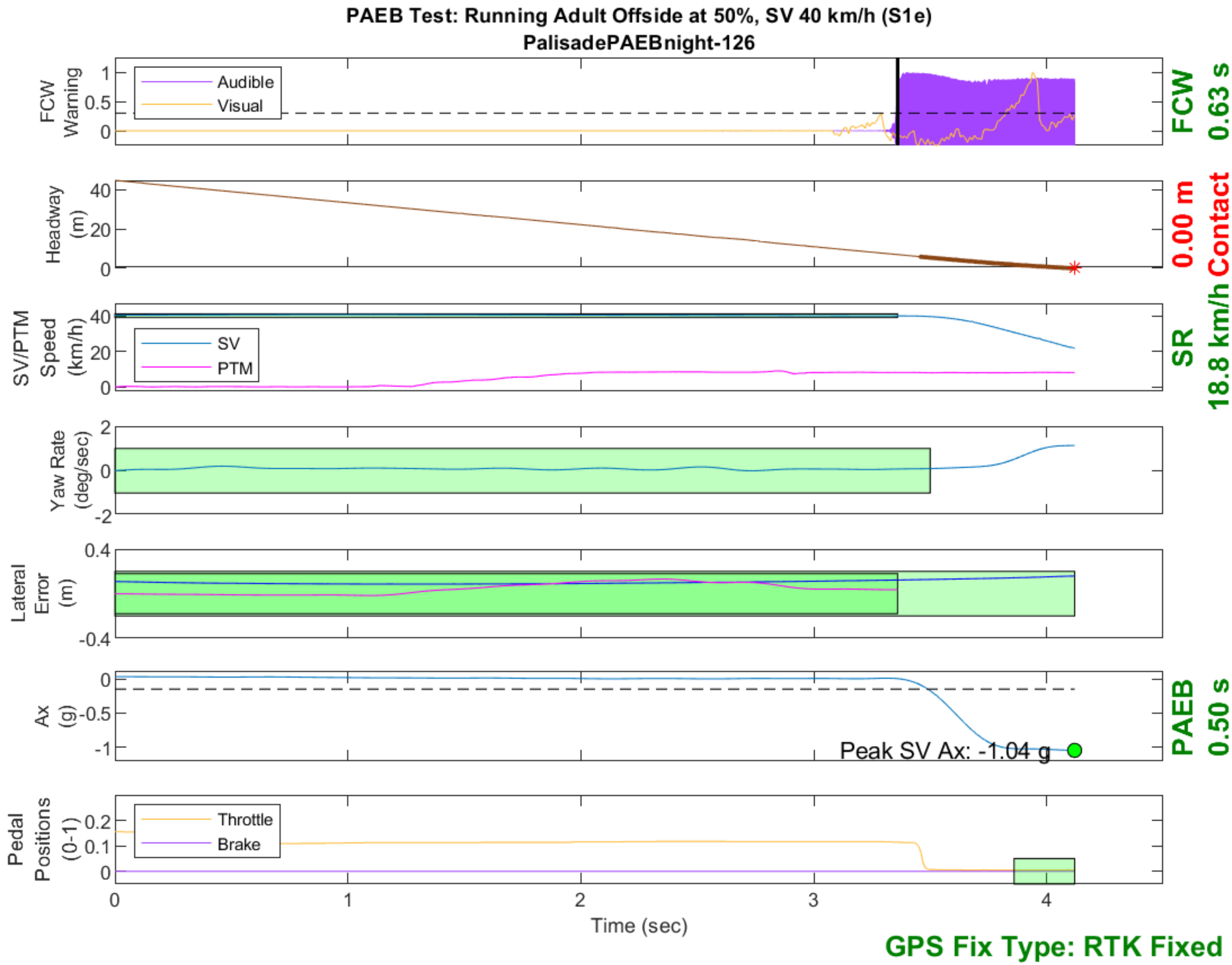


Figure D188. Time History for PAEB Run 126, S1e, Night, High Beam, 40 km/h

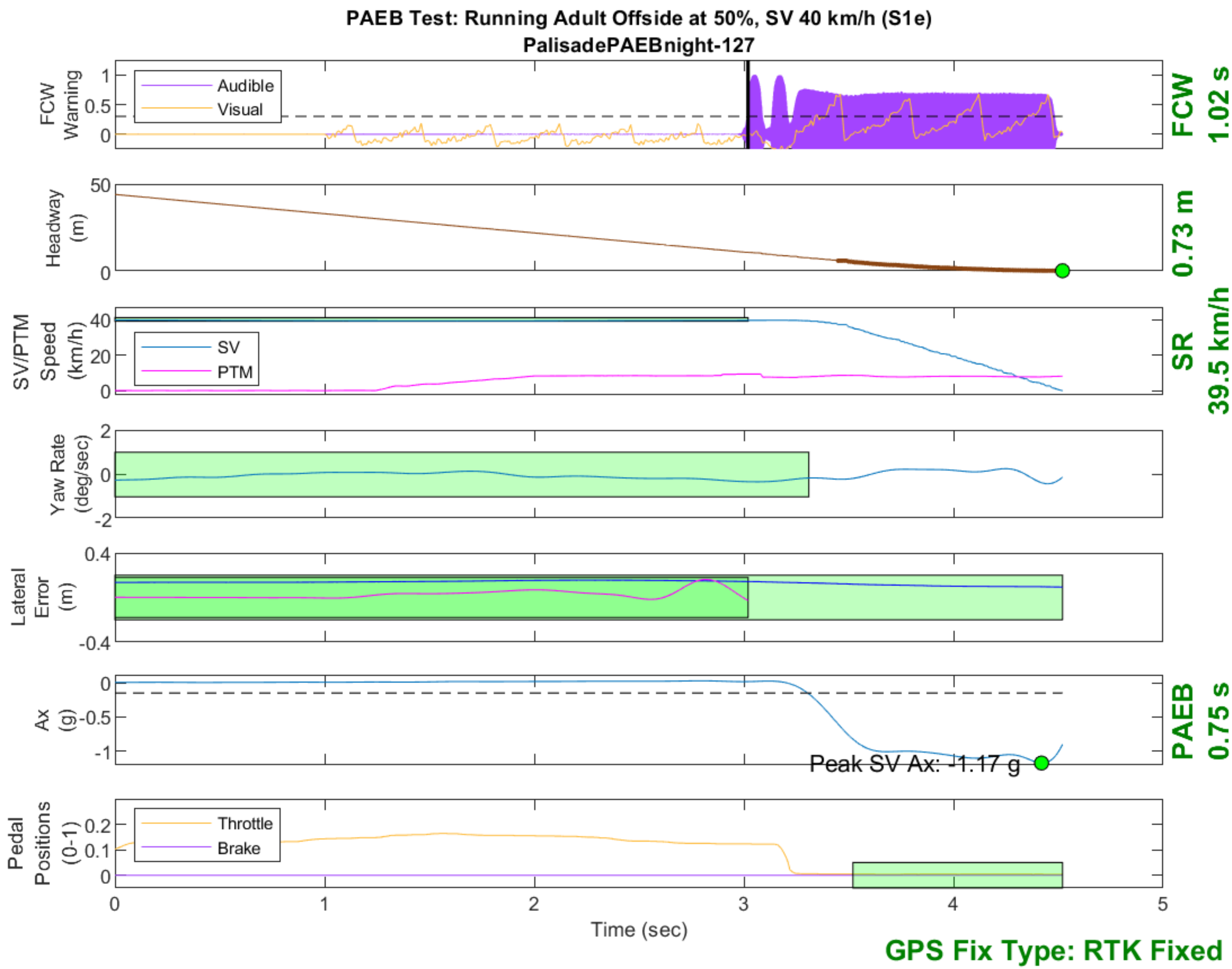


Figure D189. Time History for PAEB Run 127, S1e, Night, High Beam, 40 km/h

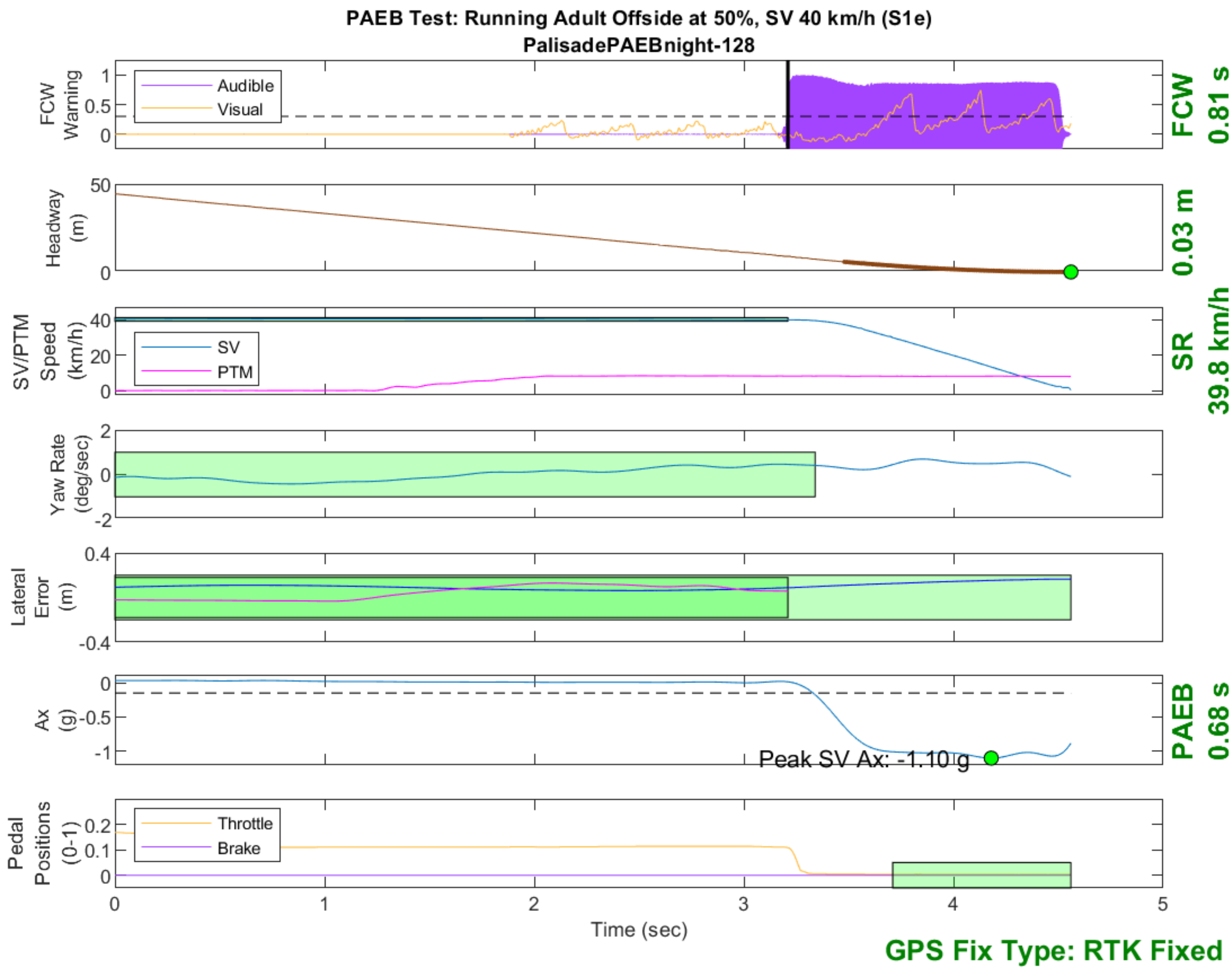


Figure D190. Time History for PAEB Run 128, S1e, Night, High Beam, 40 km/h

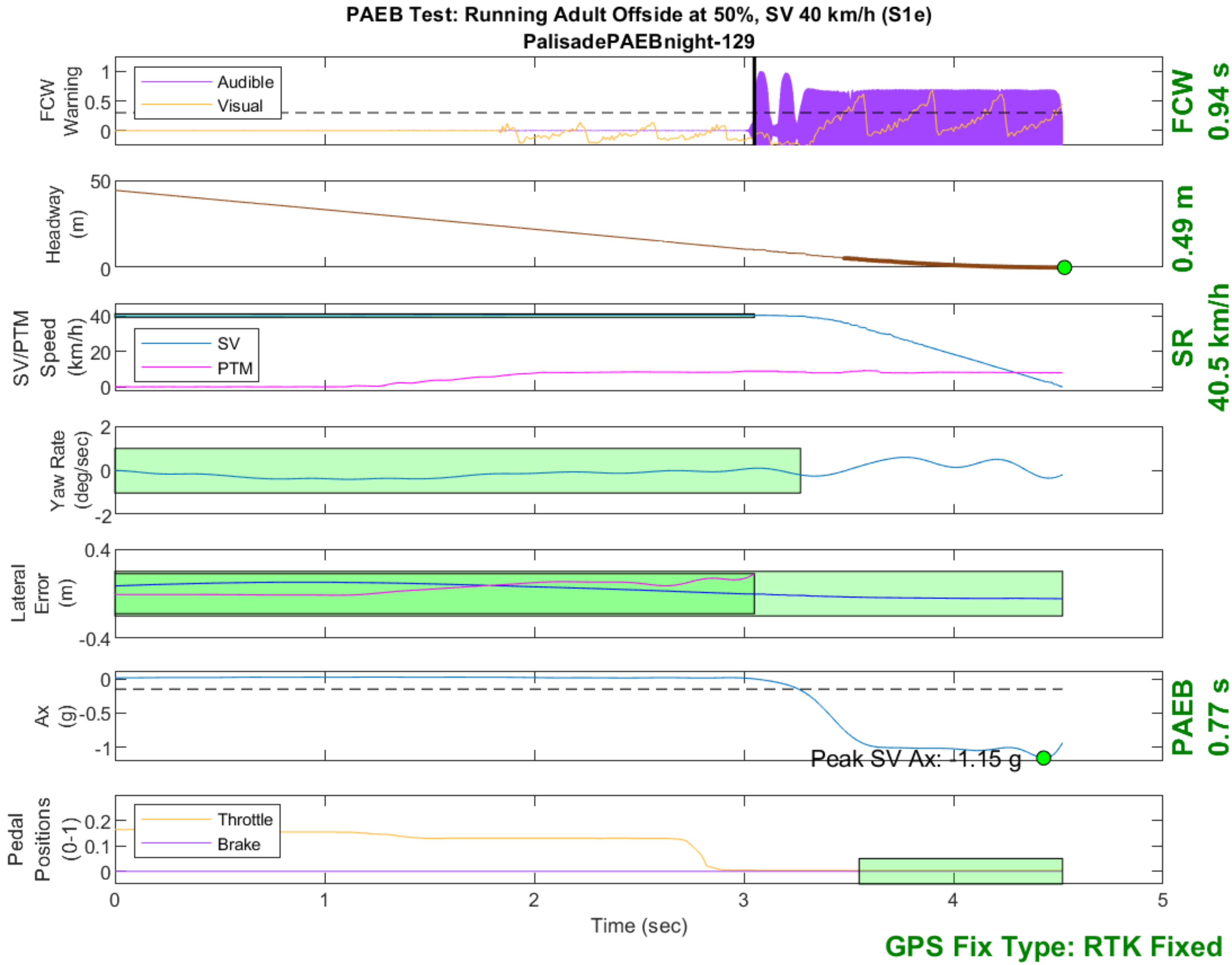


Figure D191. Time History for PAEB Run 129, S1e, Night, High Beam, 40 km/h

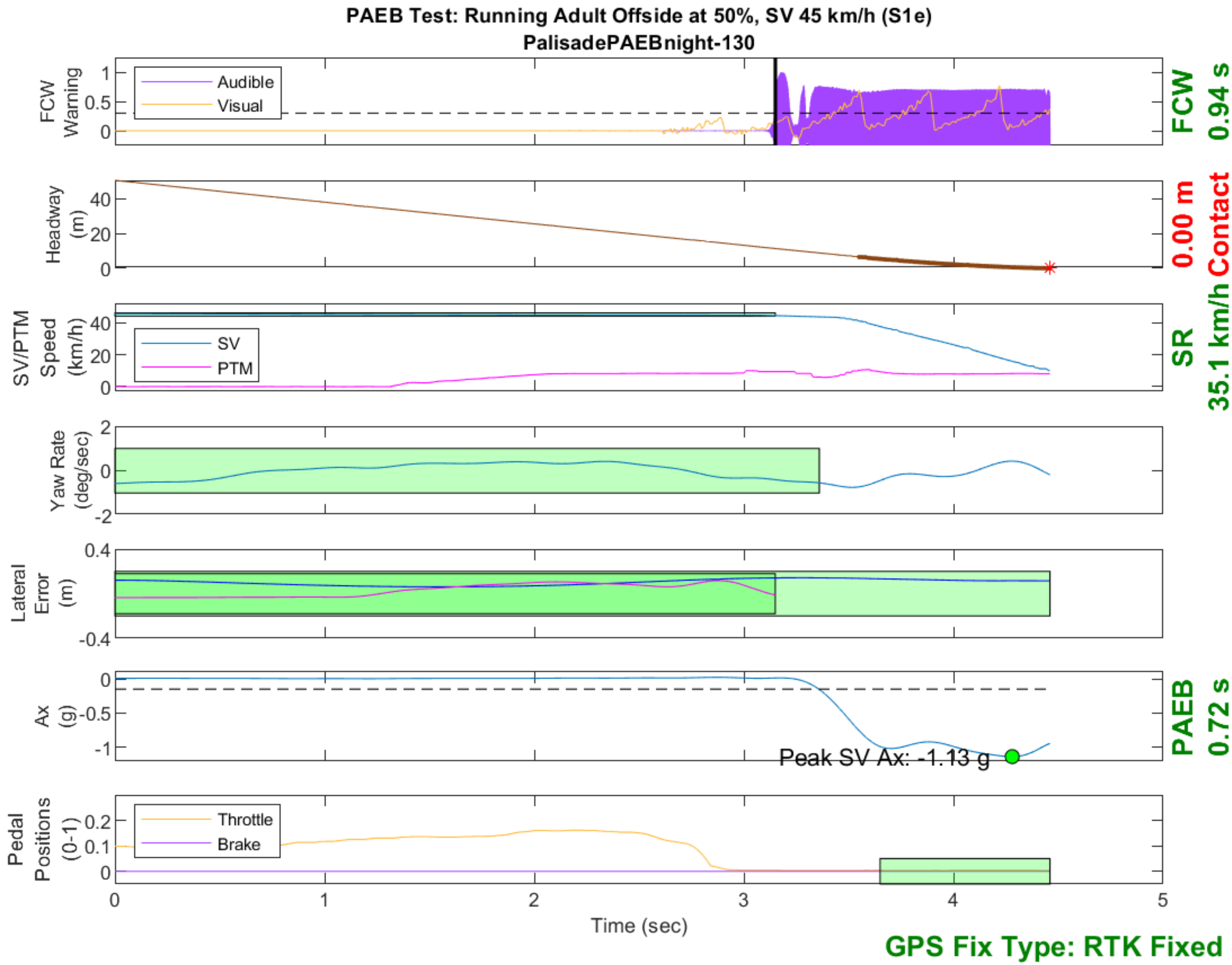


Figure D192. Time History for PAEB Run 130, S1e, Night, High Beam, 45 km/h

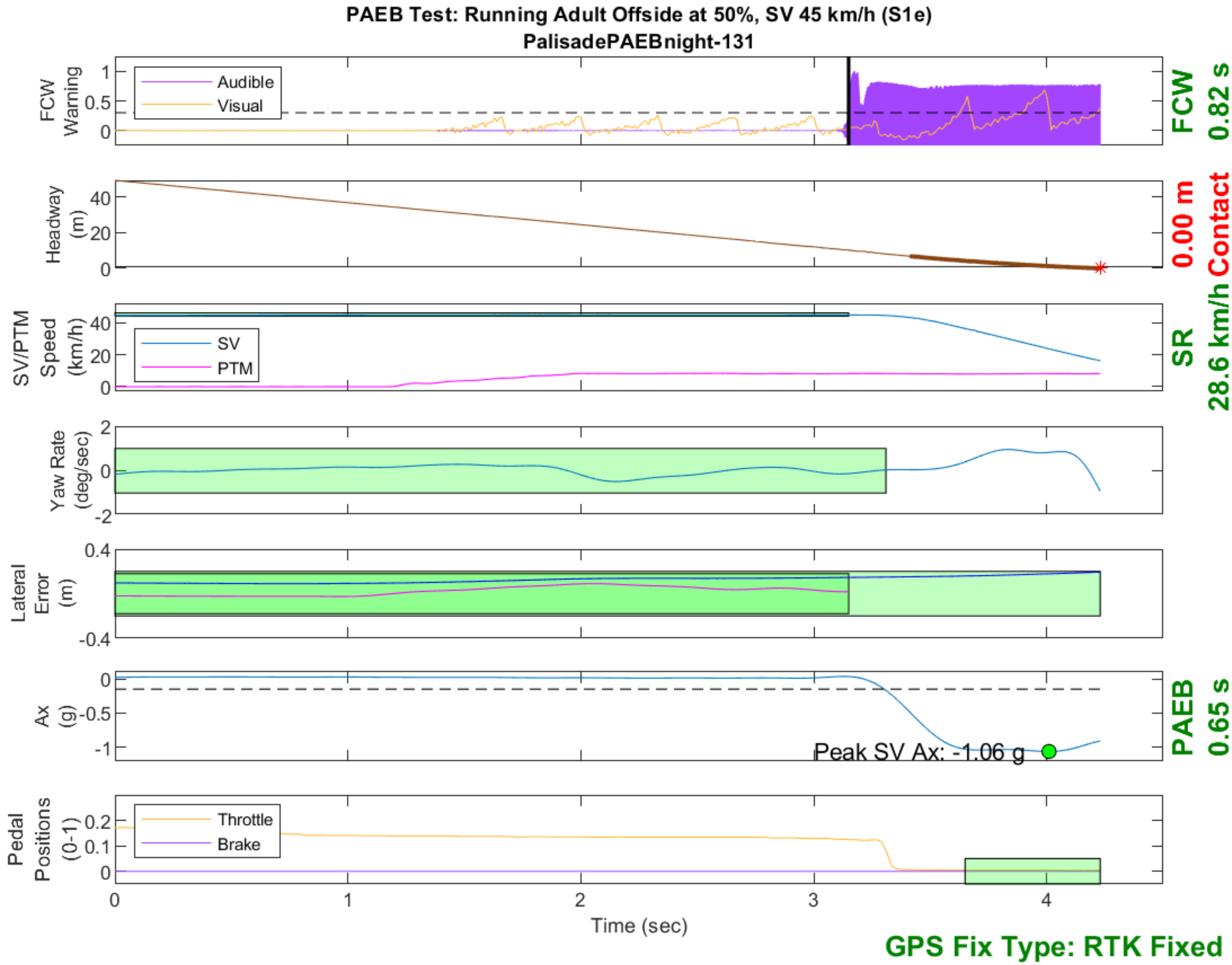


Figure D193. Time History for PAEB Run 131, S1e, Night, High Beam, 45 km/h

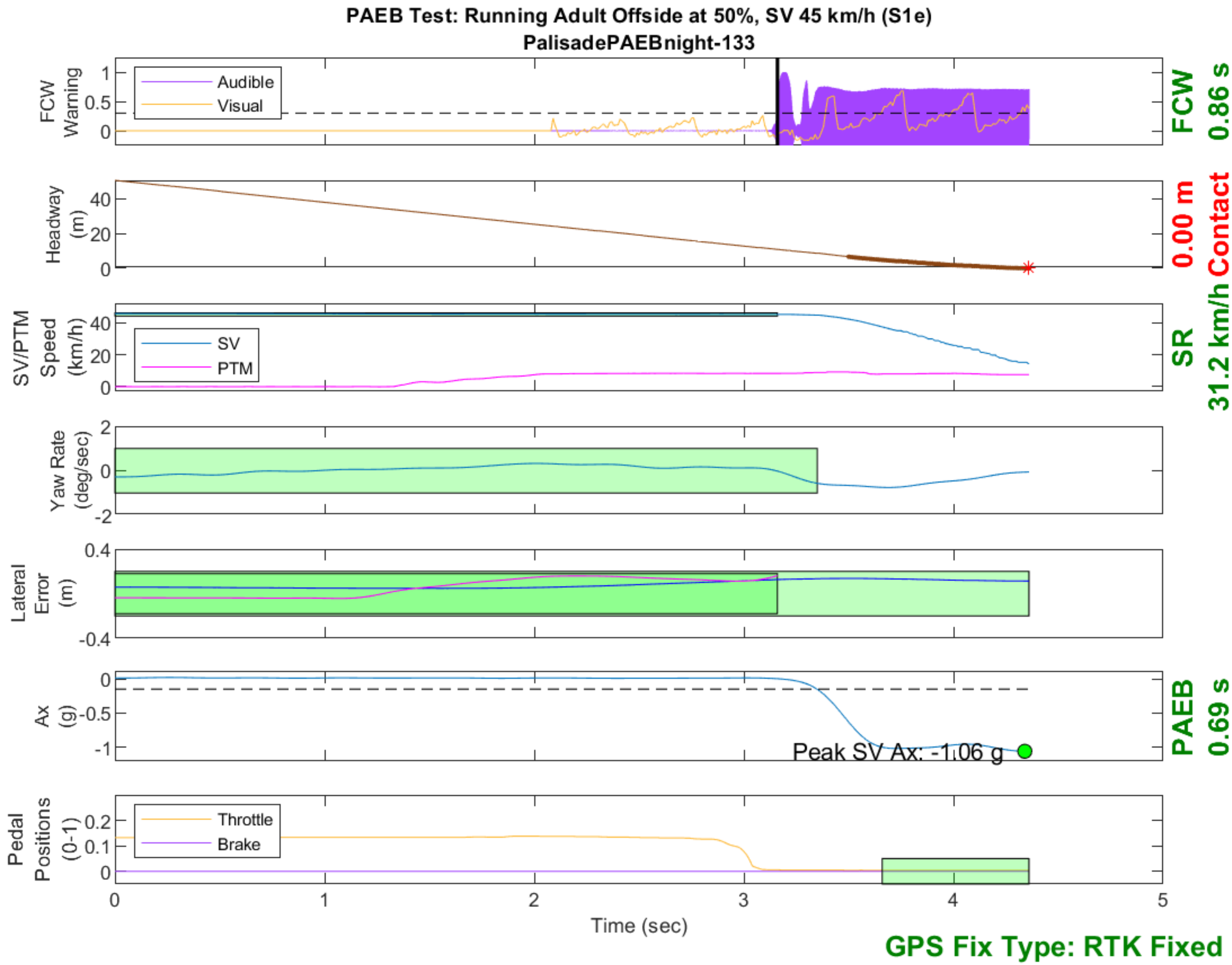


Figure D194. Time History for PAEB Run 133, S1e, Night, High Beam, 45 km/h

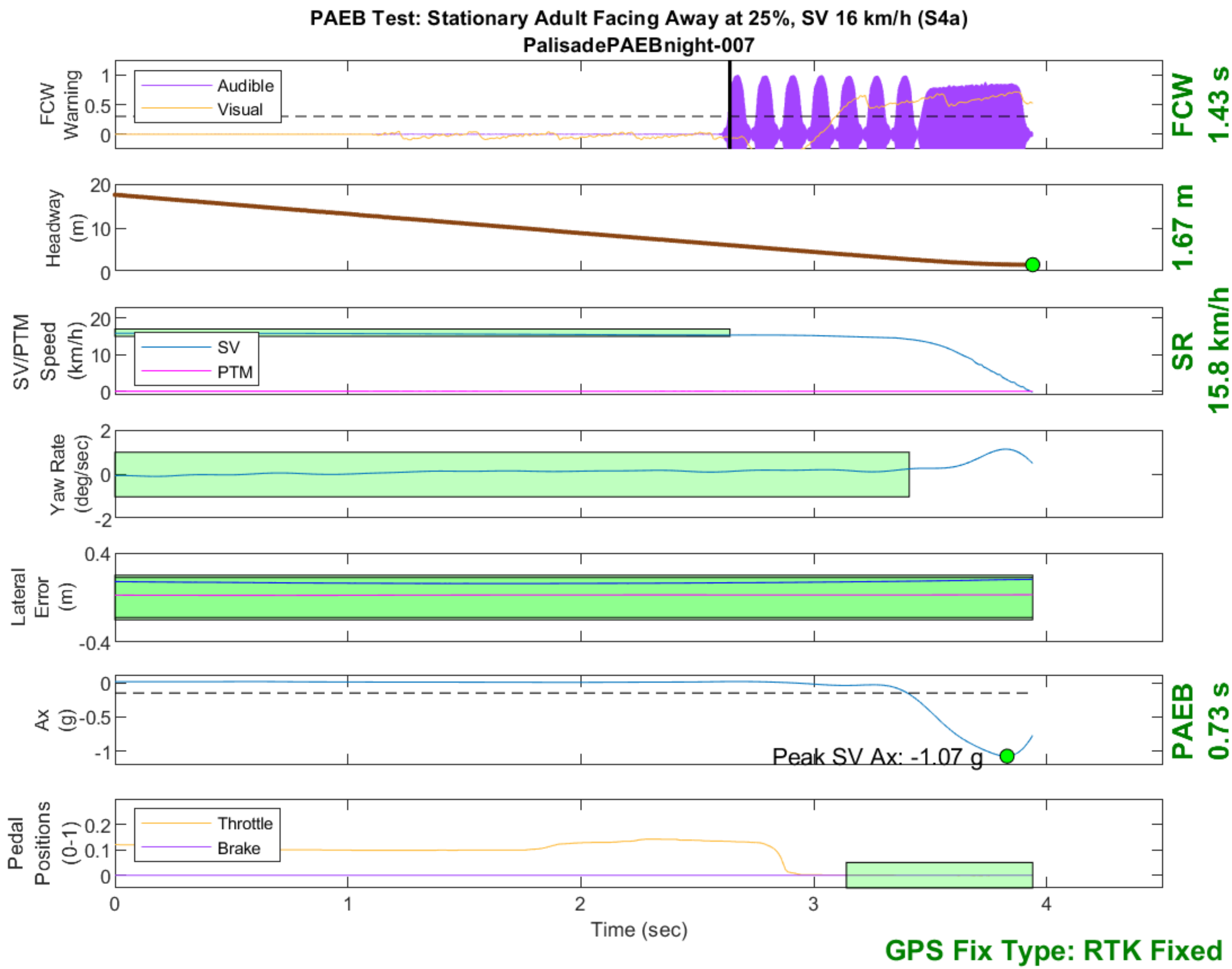


Figure D195. Time History for PAEB Run 7, S4a, Night, High Beam, 16 km/h

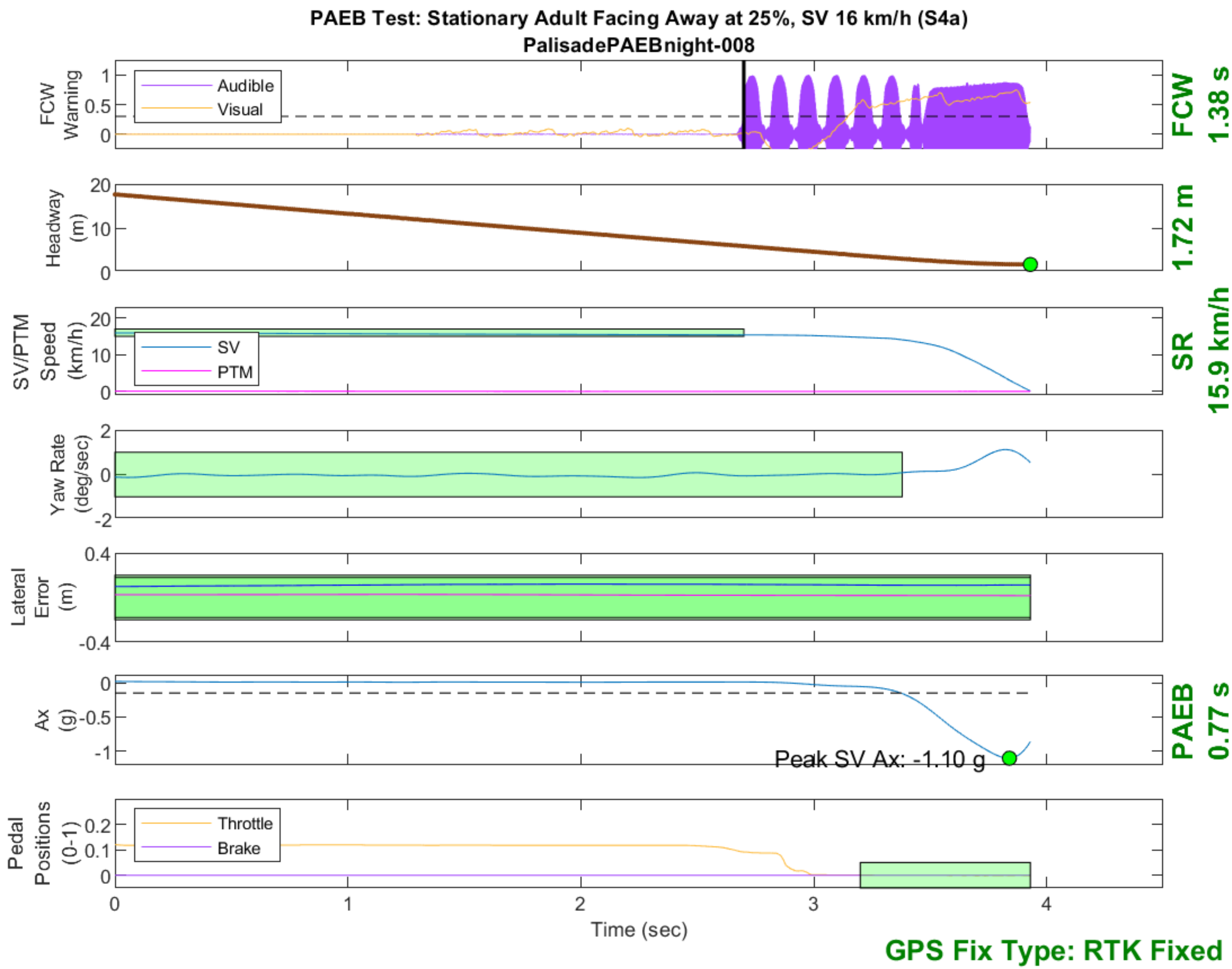


Figure D196. Time History for PAEB Run 8, S4a, Night, High Beam, 16 km/h

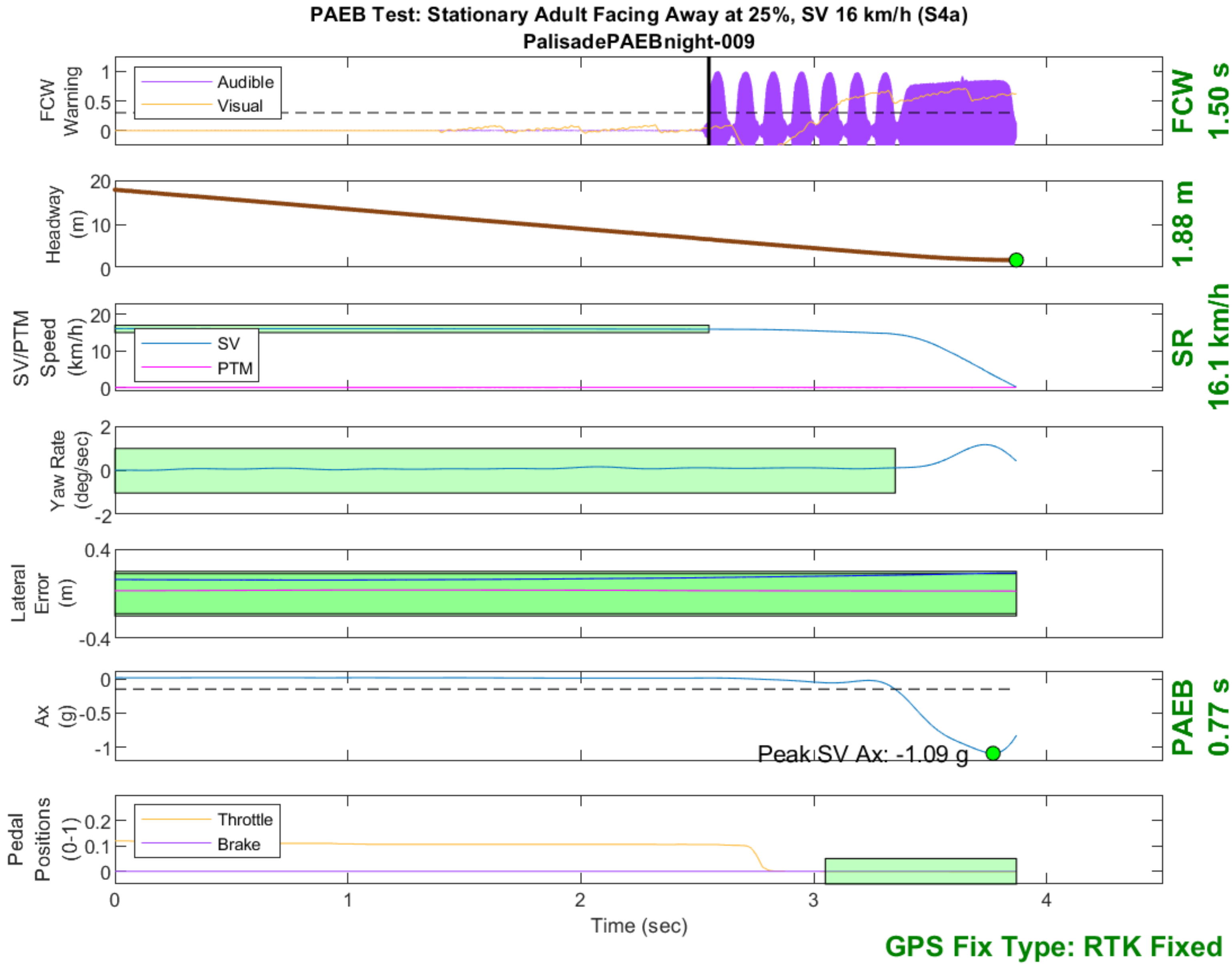


Figure D197. Time History for PAEB Run 9, S4a, Night, High Beam, 16 km/h

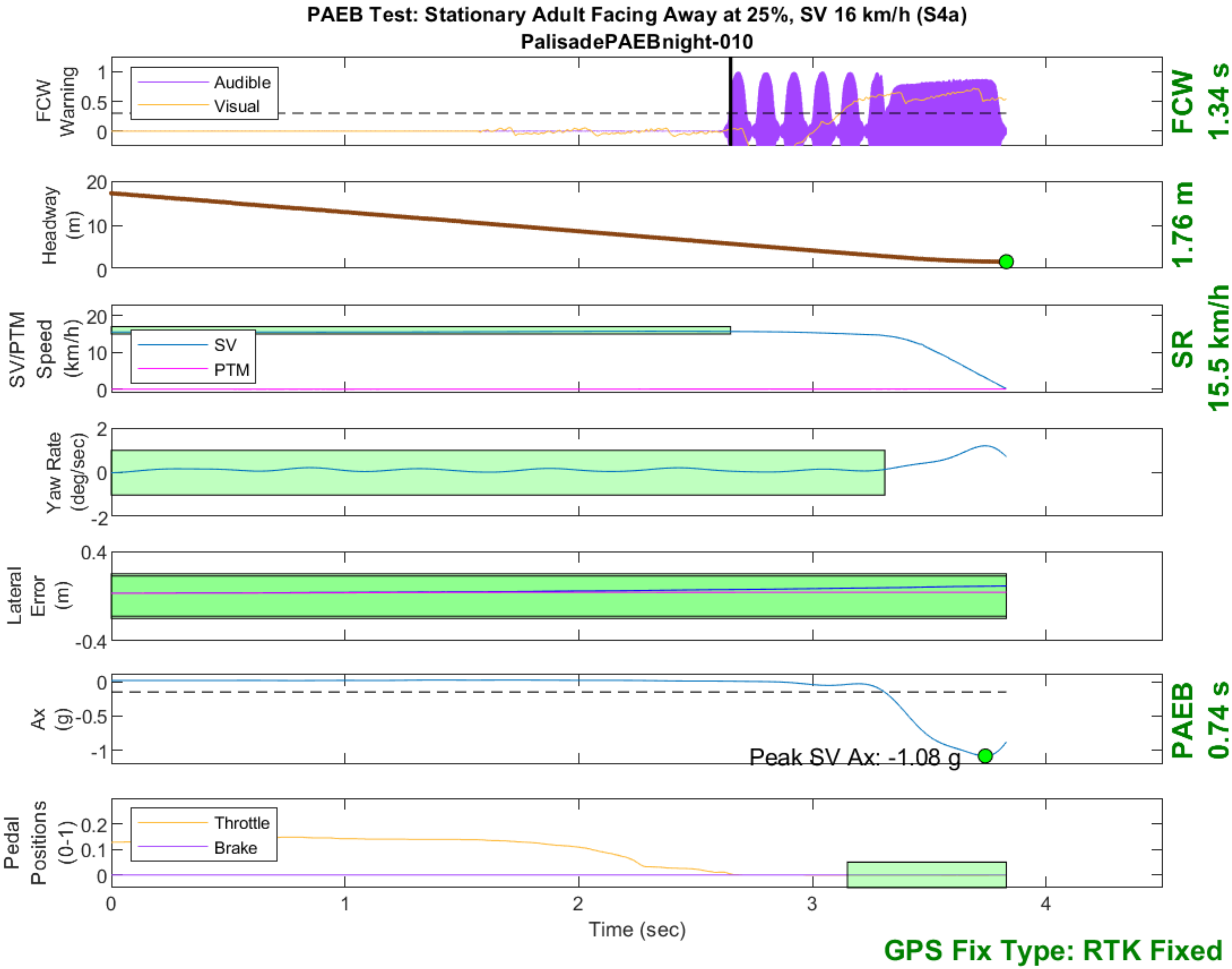


Figure D198. Time History for PAEB Run 10, S4a, Night, High Beam, 16 km/h

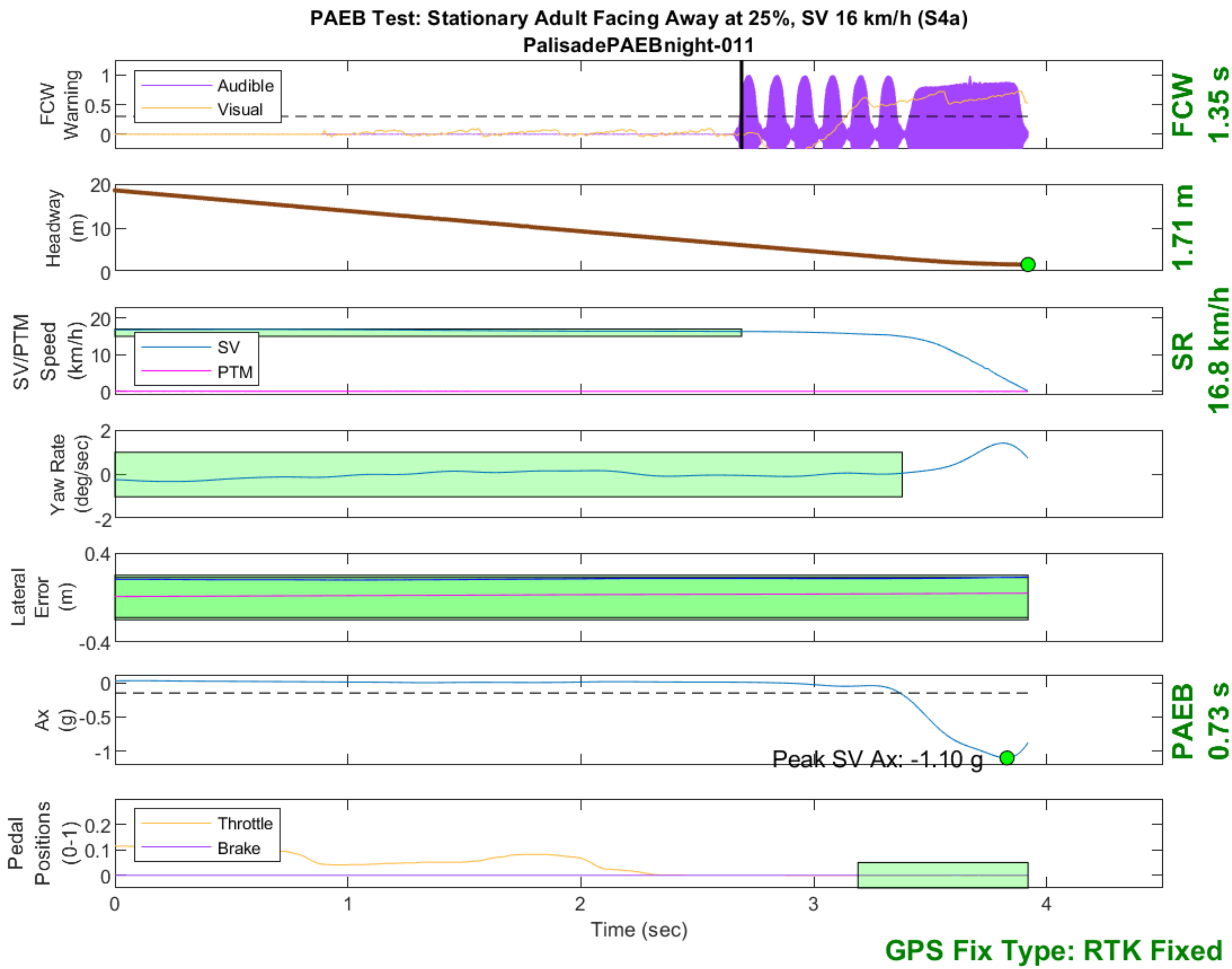


Figure D199. Time History for PAEB Run 11, S4a, Night, High Beam, 16 km/h

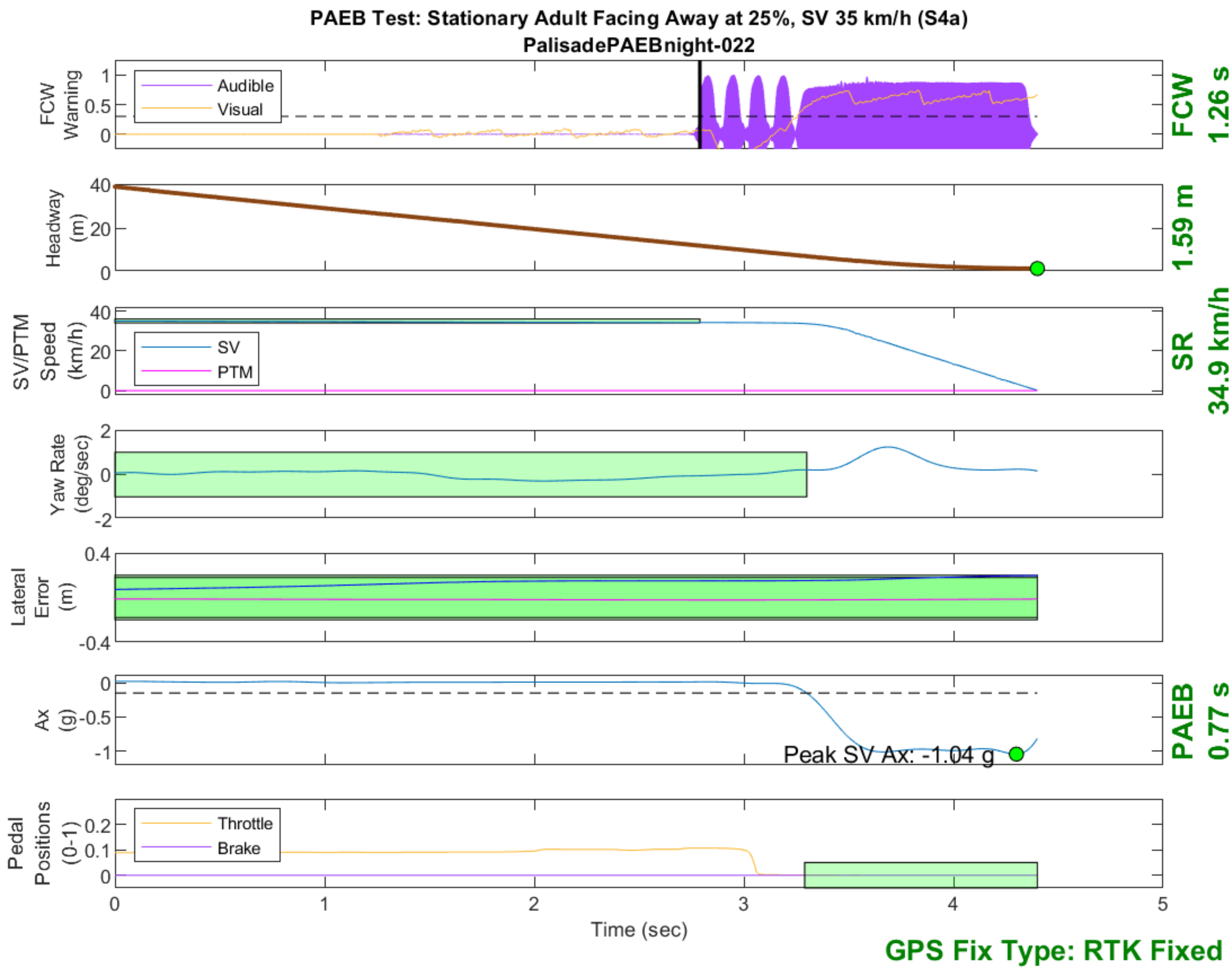


Figure D200. Time History for PAEB Run 22, S4a, Night, High Beam, 35 km/h

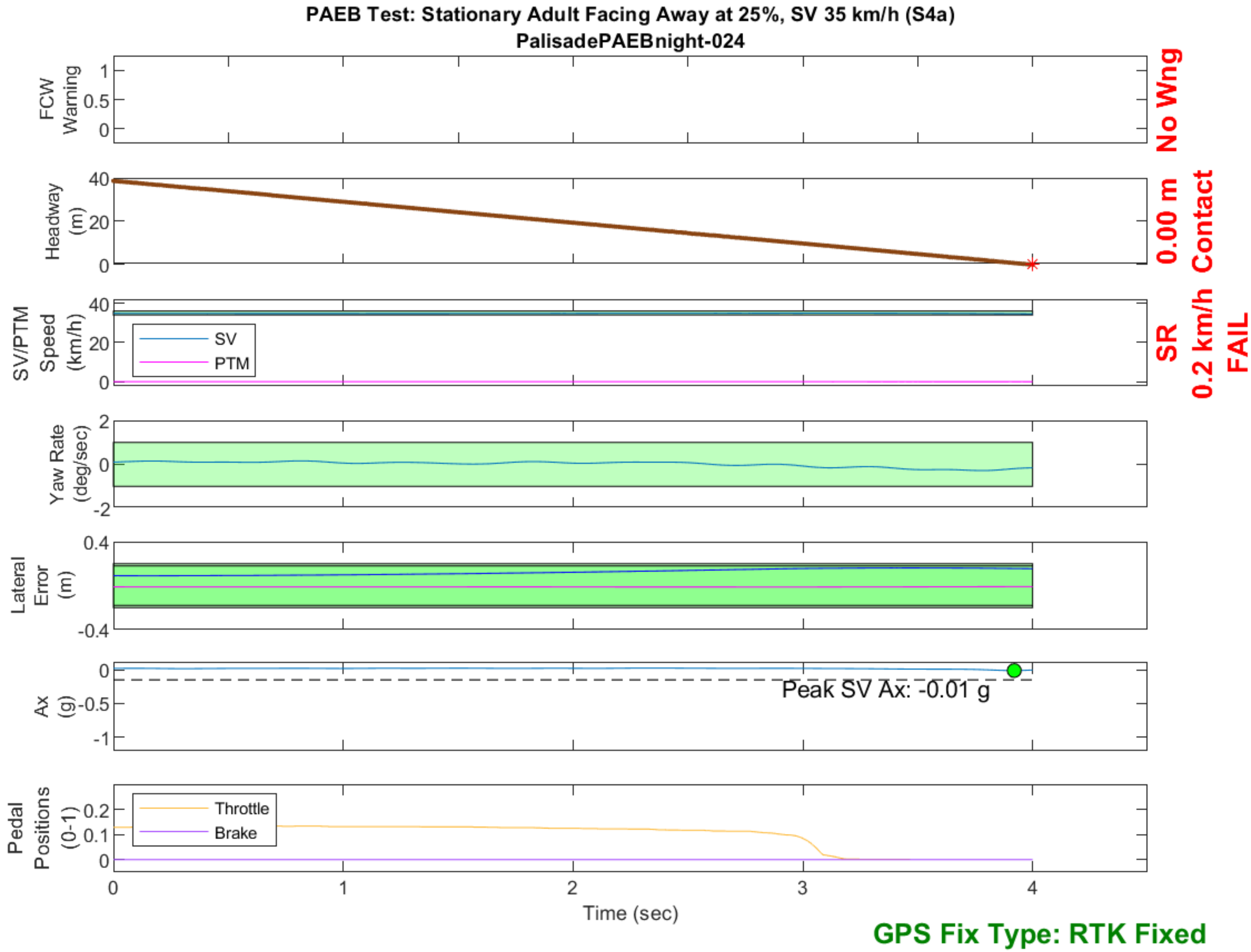


Figure D201. Time History for PAEB Run 24, S4a, Night, High Beam, 35 km/h

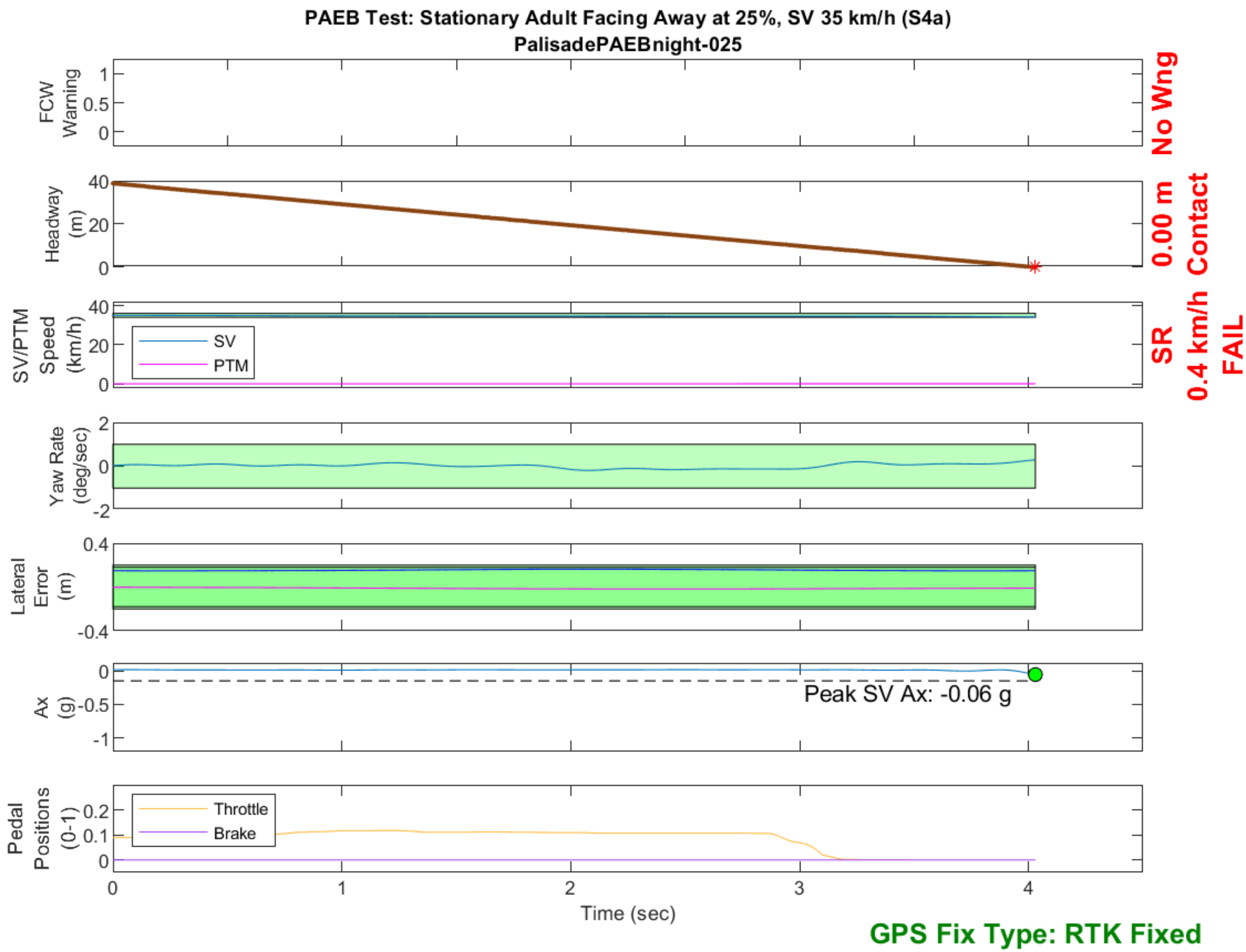


Figure D202. Time History for PAEB Run 25, S4a, Night, High Beam, 35 km/h

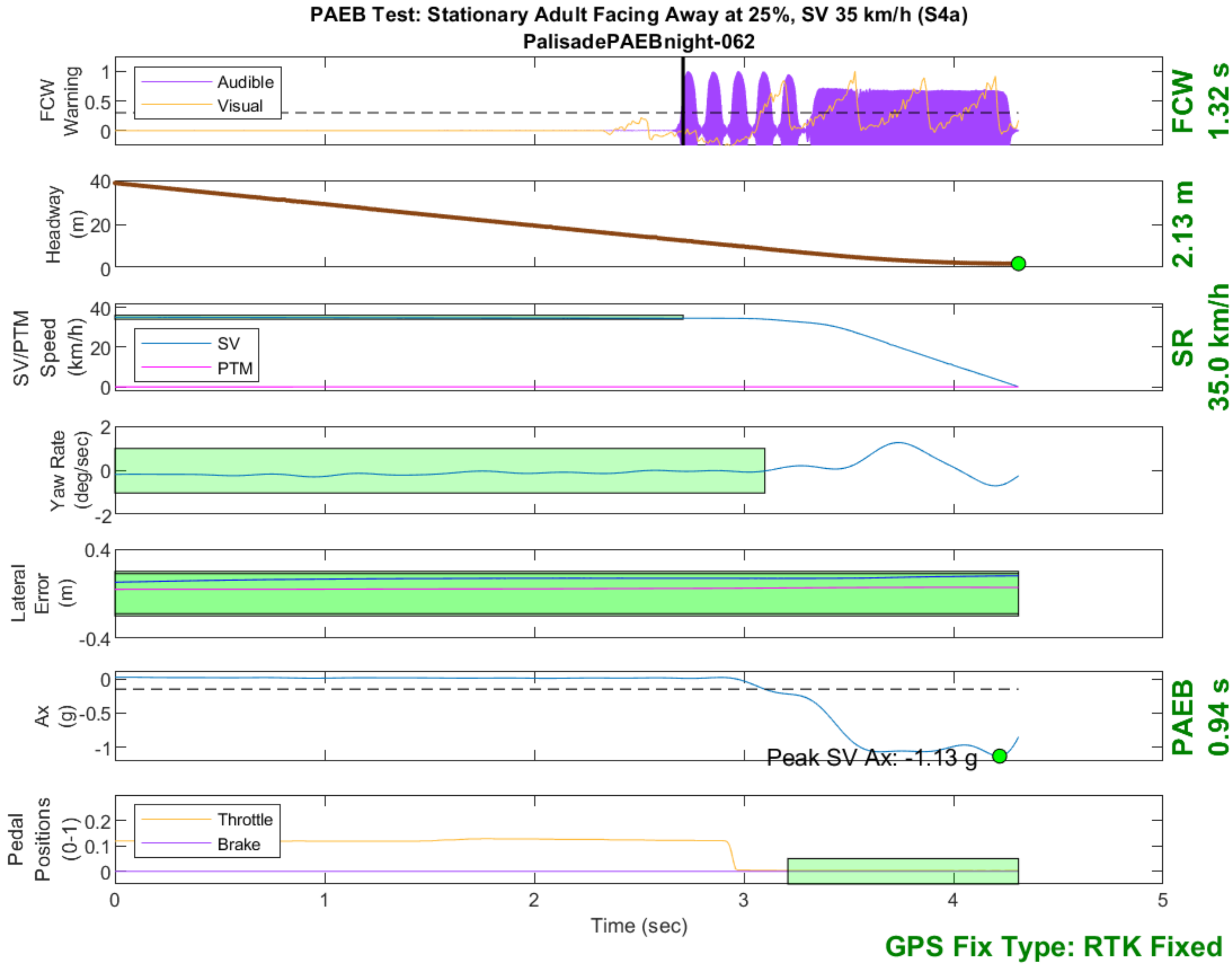


Figure D203. Time History for PAEB Run 62, S4a, Night, High Beam, 35 km/h

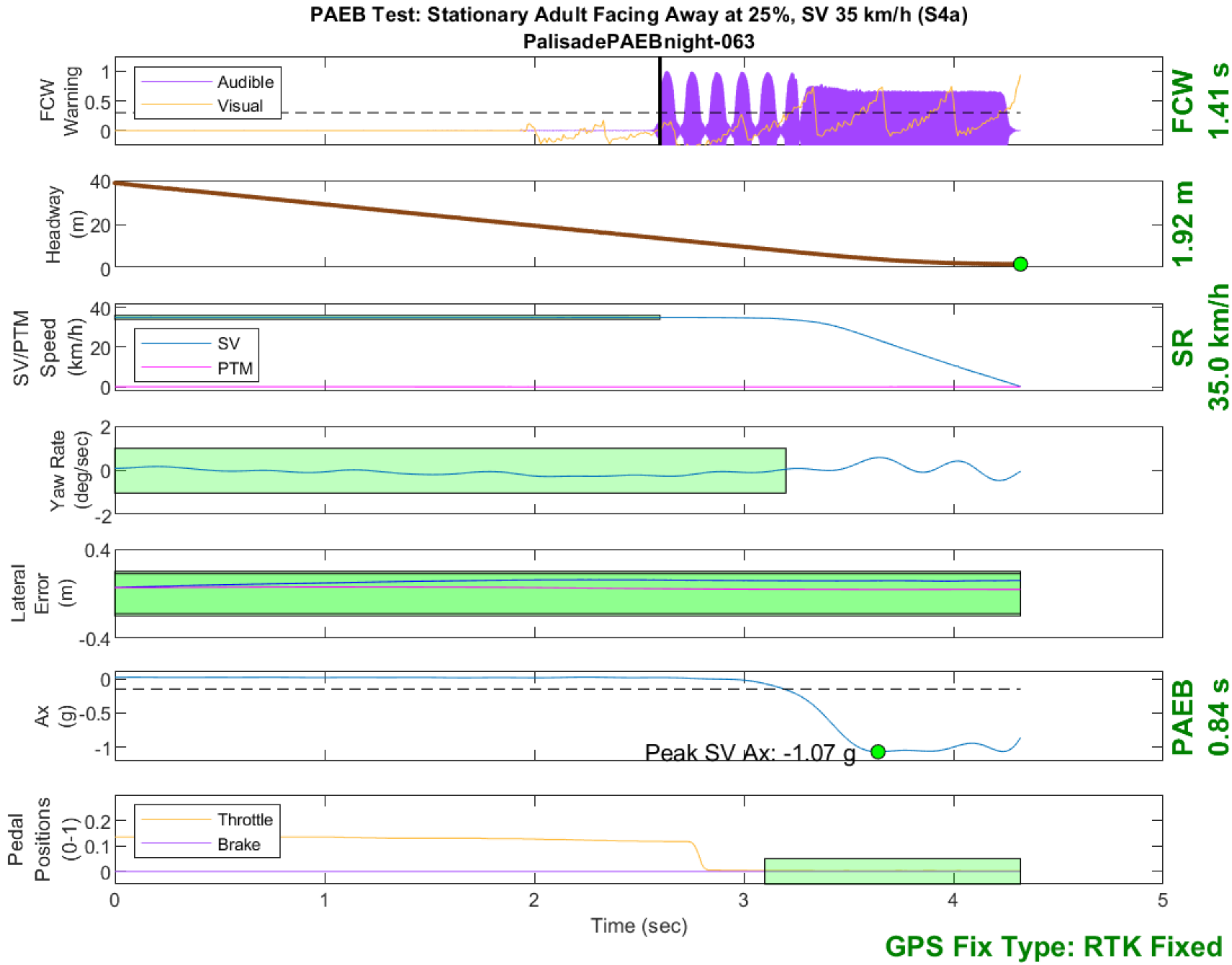


Figure D204. Time History for PAEB Run 63, S4a, Night, High Beam, 35 km/h

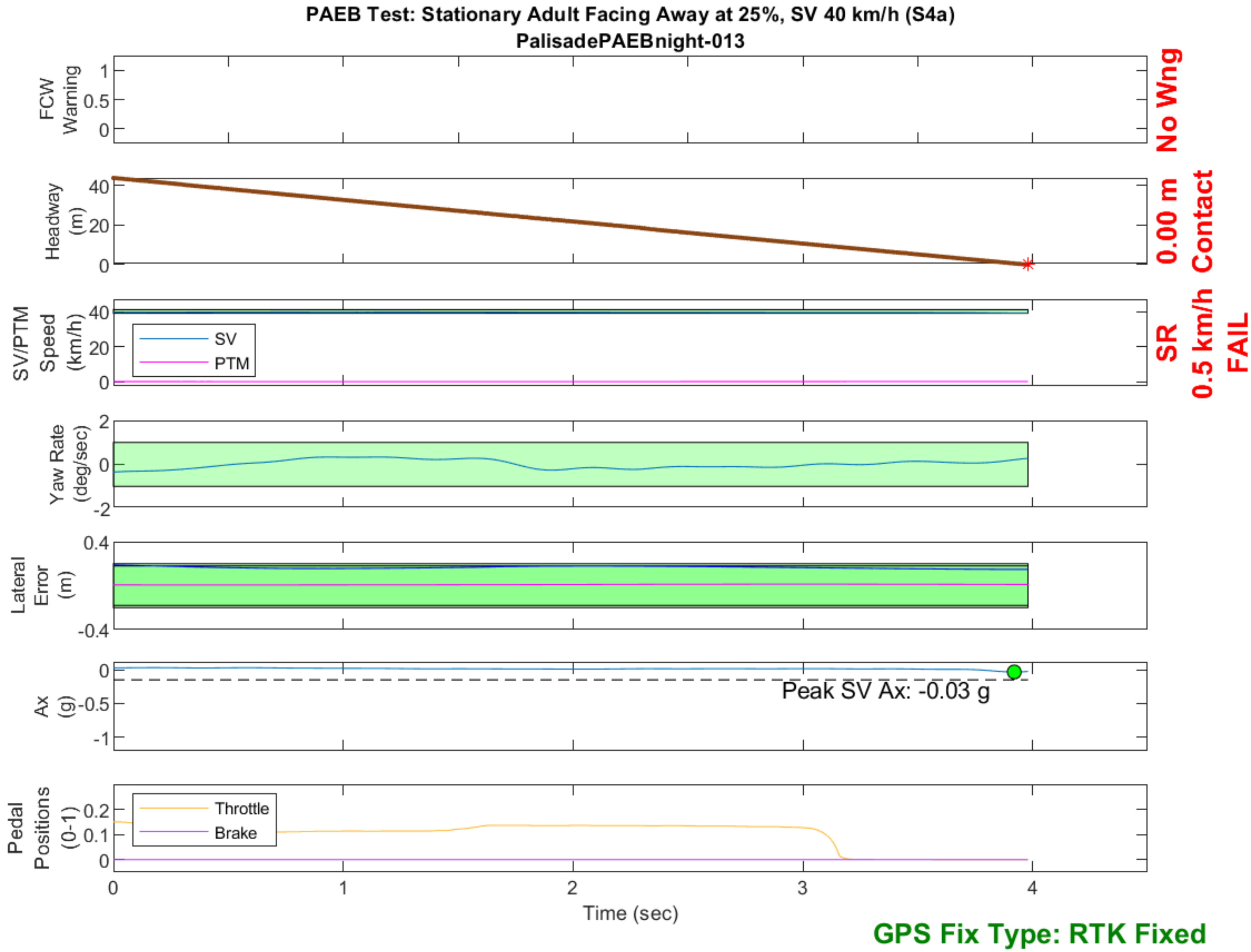


Figure D205. Time History for PAEB Run 13, S4a, Night, High Beam, 40 km/h

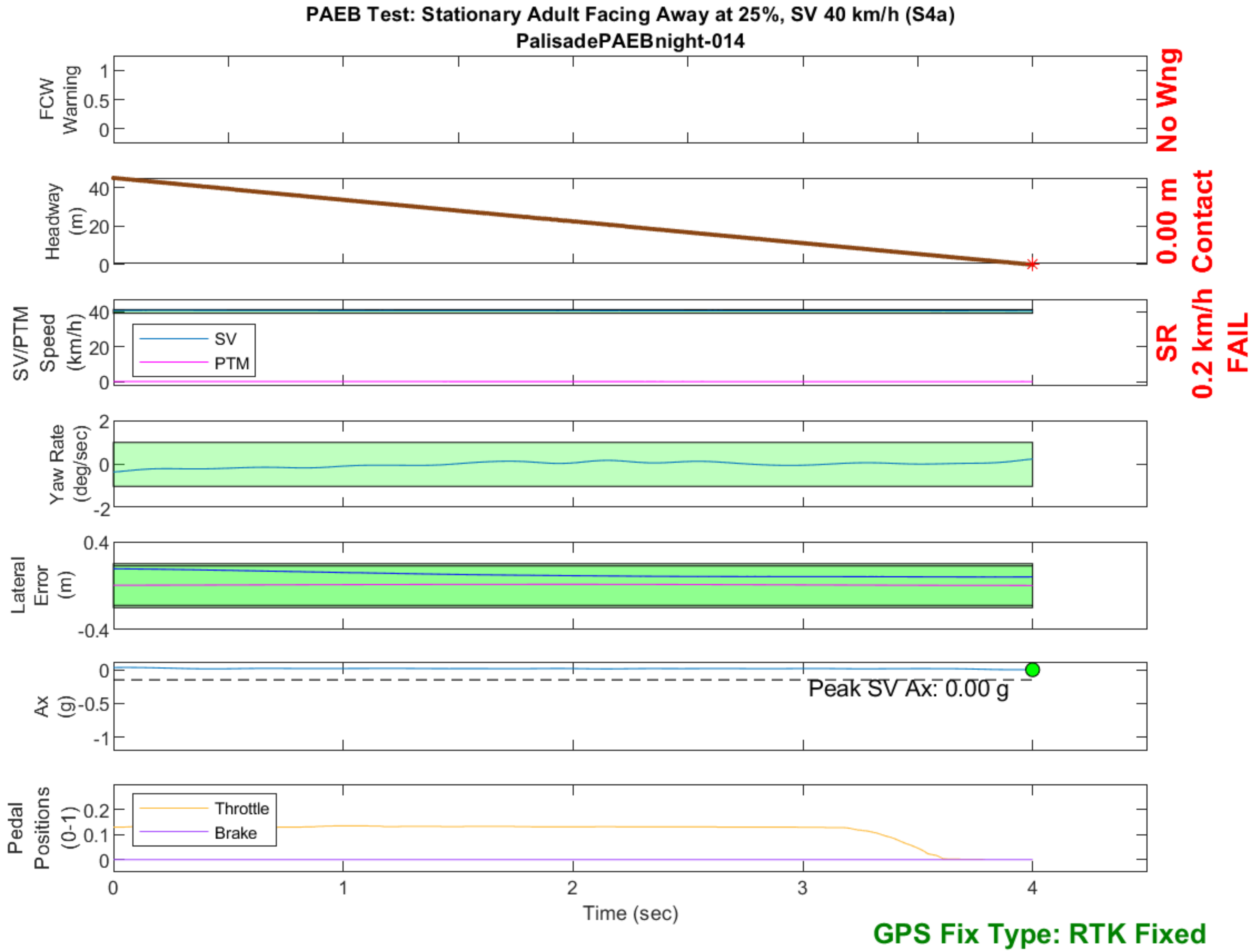


Figure D206. Time History for PAEB Run 14, S4a, Night, High Beam, 40 km/h

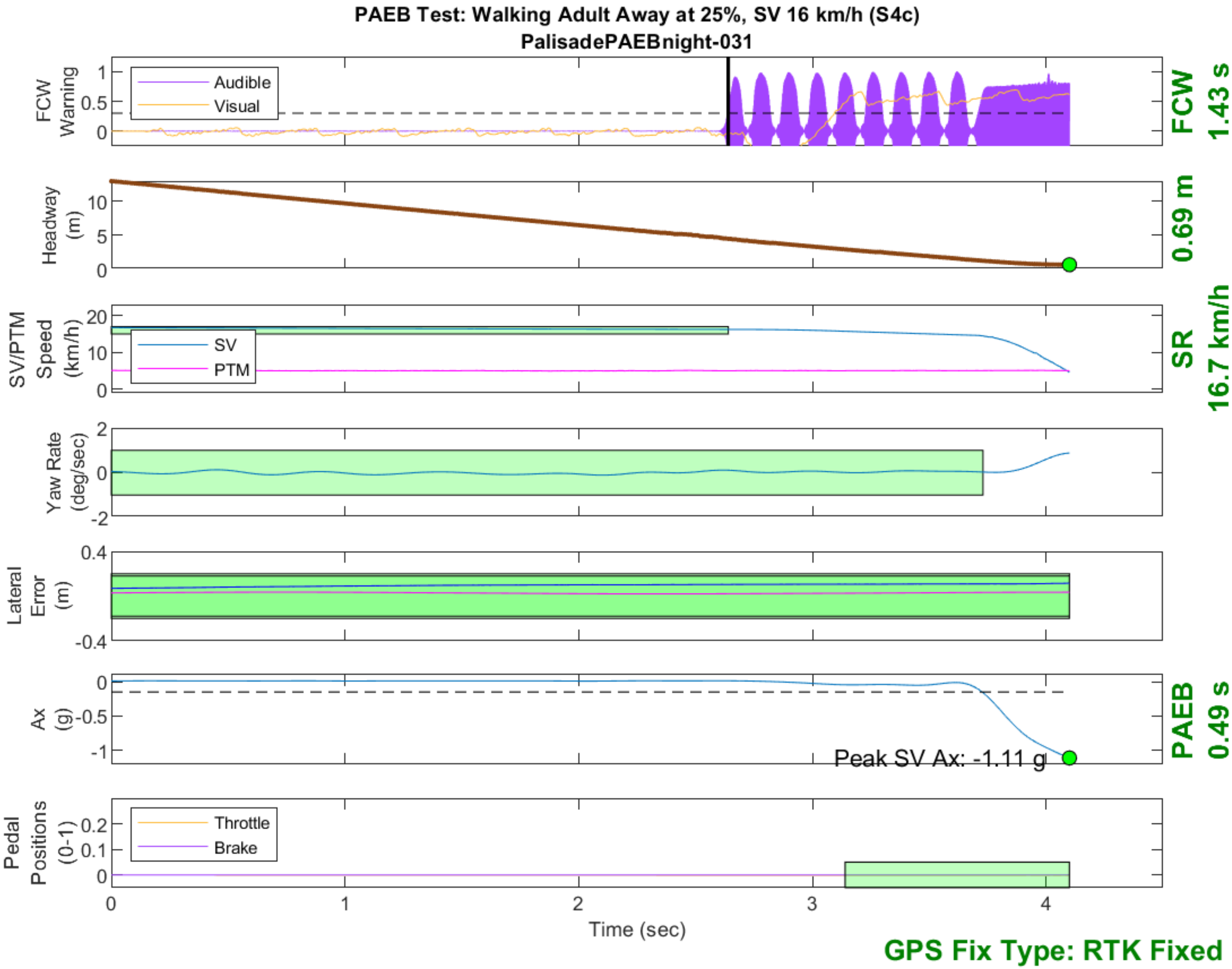


Figure D207. Time History for PAEB Run 31, S4c, Night, High Beam, 16 km/h

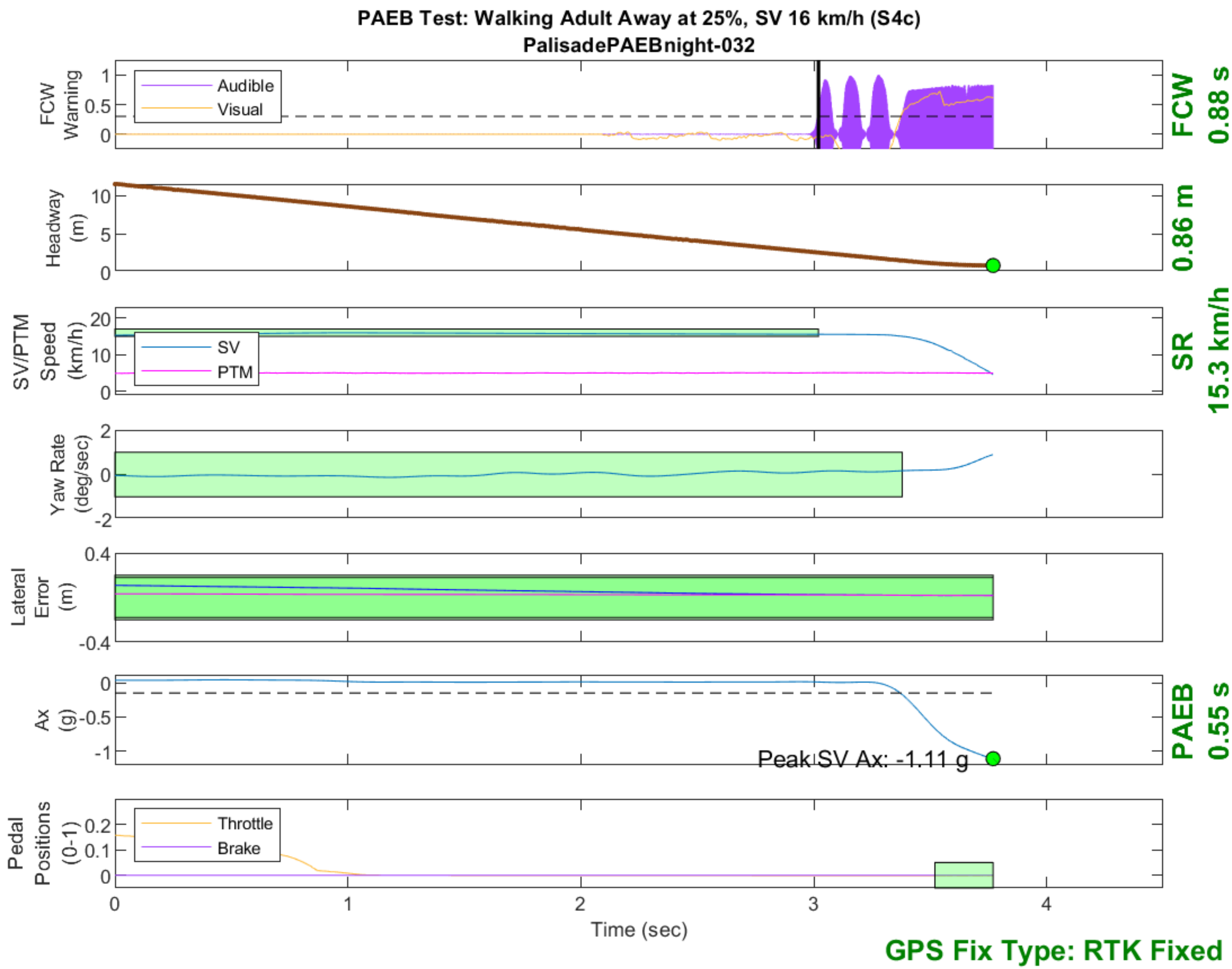


Figure D208. Time History for PAEB Run 32, S4c, Night, High Beam, 16 km/h

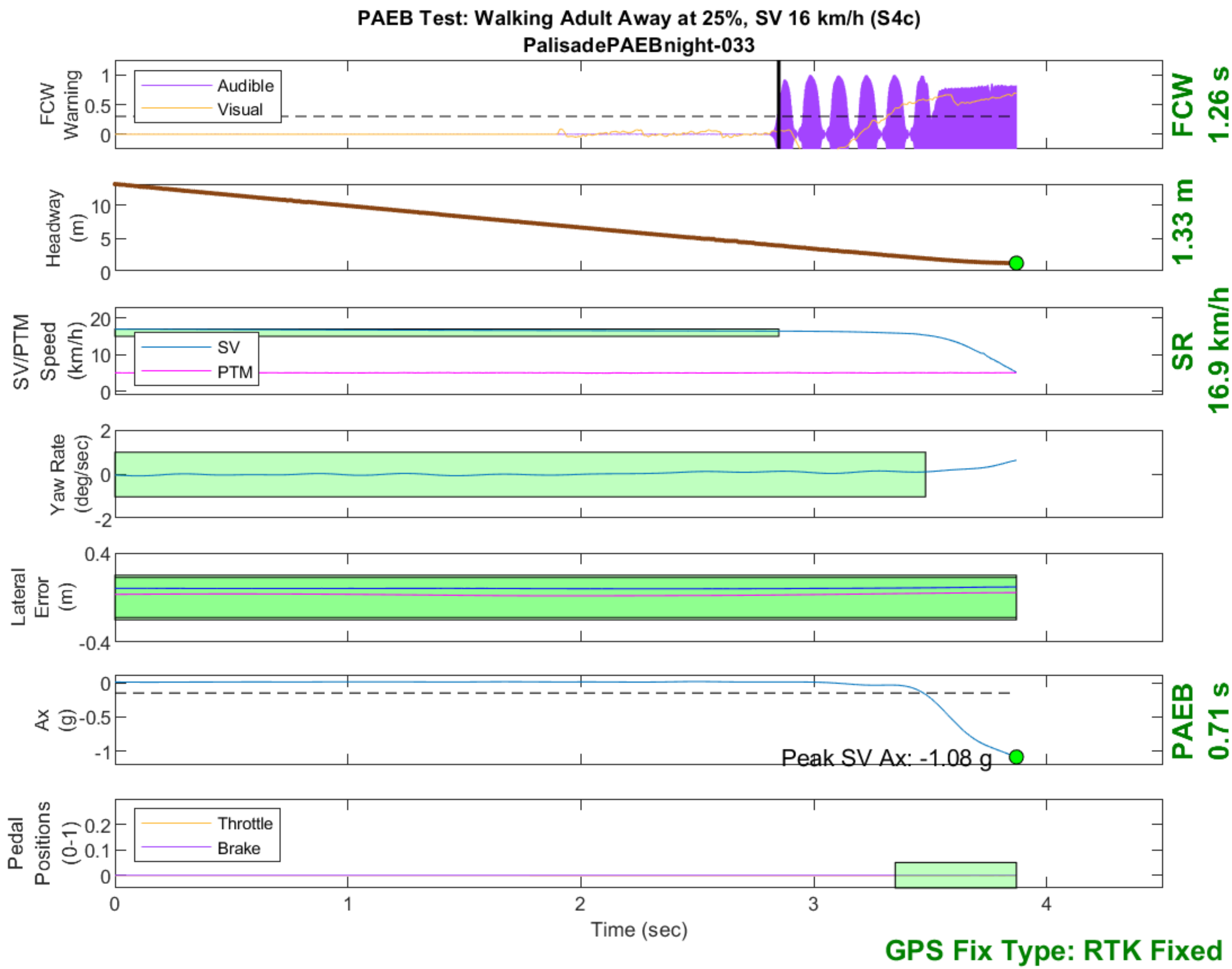


Figure D209. Time History for PAEB Run 33, S4c, Night, High Beam, 16 km/h

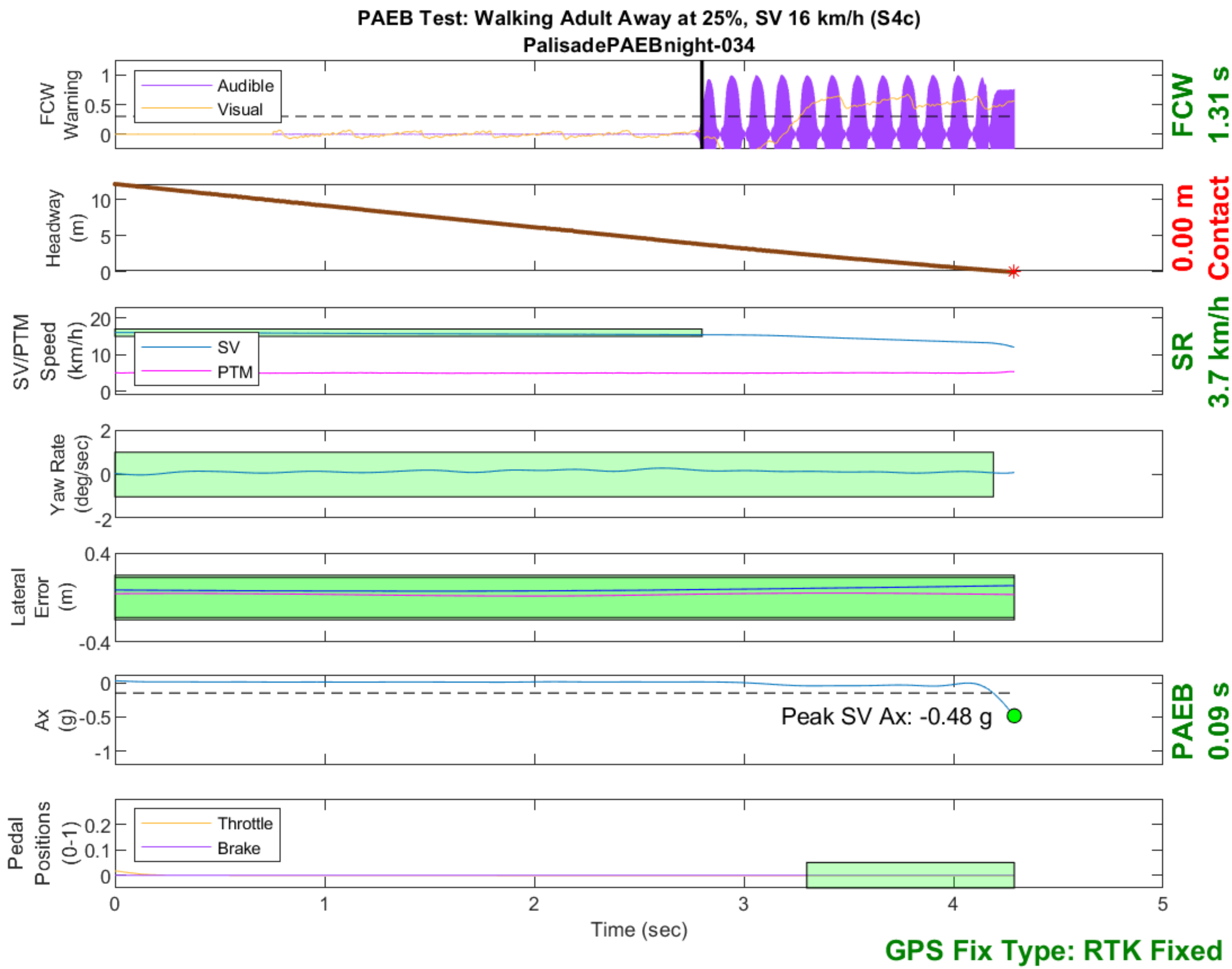


Figure D210. Time History for PAEB Run 34, S4c, Night, High Beam, 16 km/h

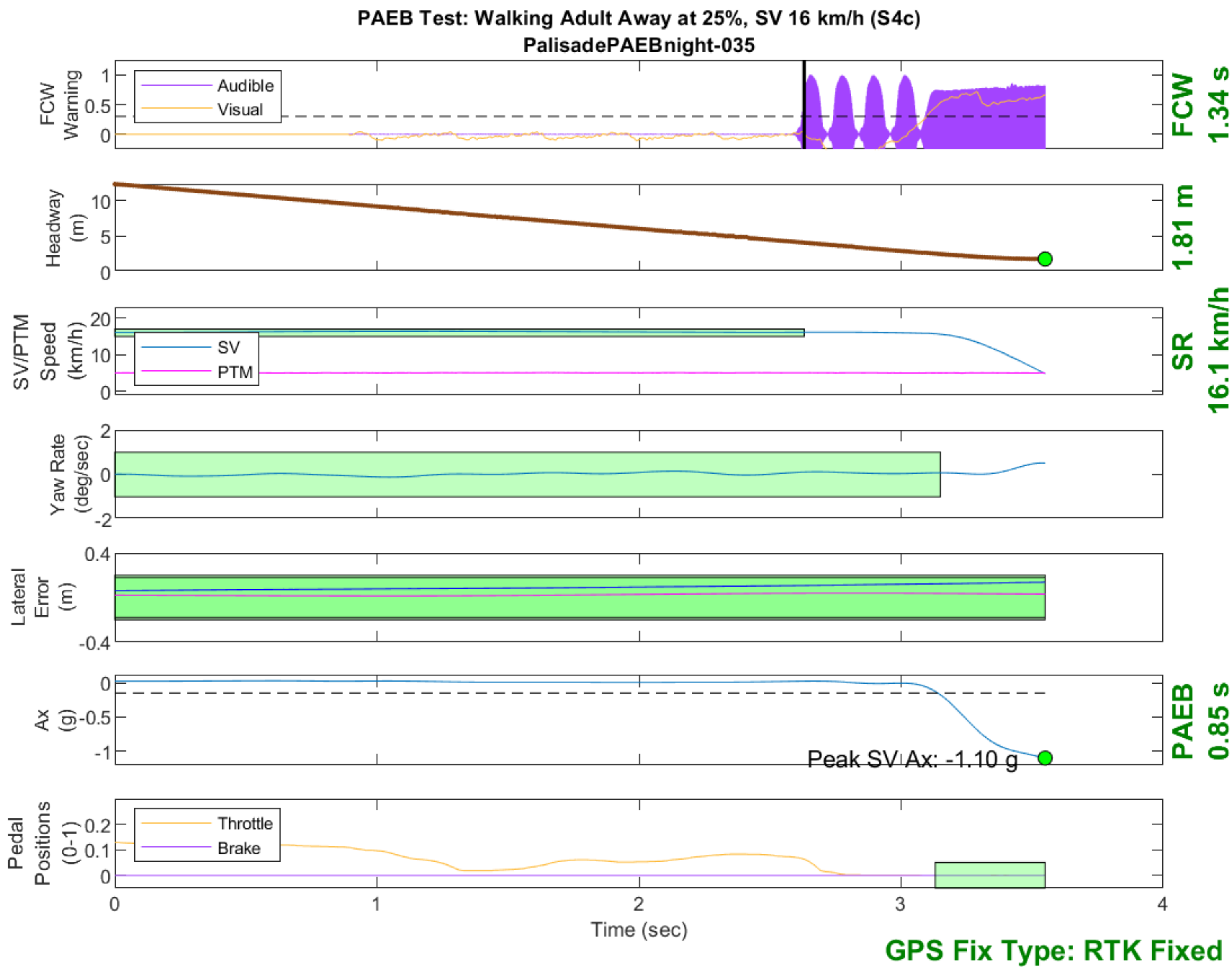


Figure D211. Time History for PAEB Run 35, S4c, Night, High Beam, 16 km/h

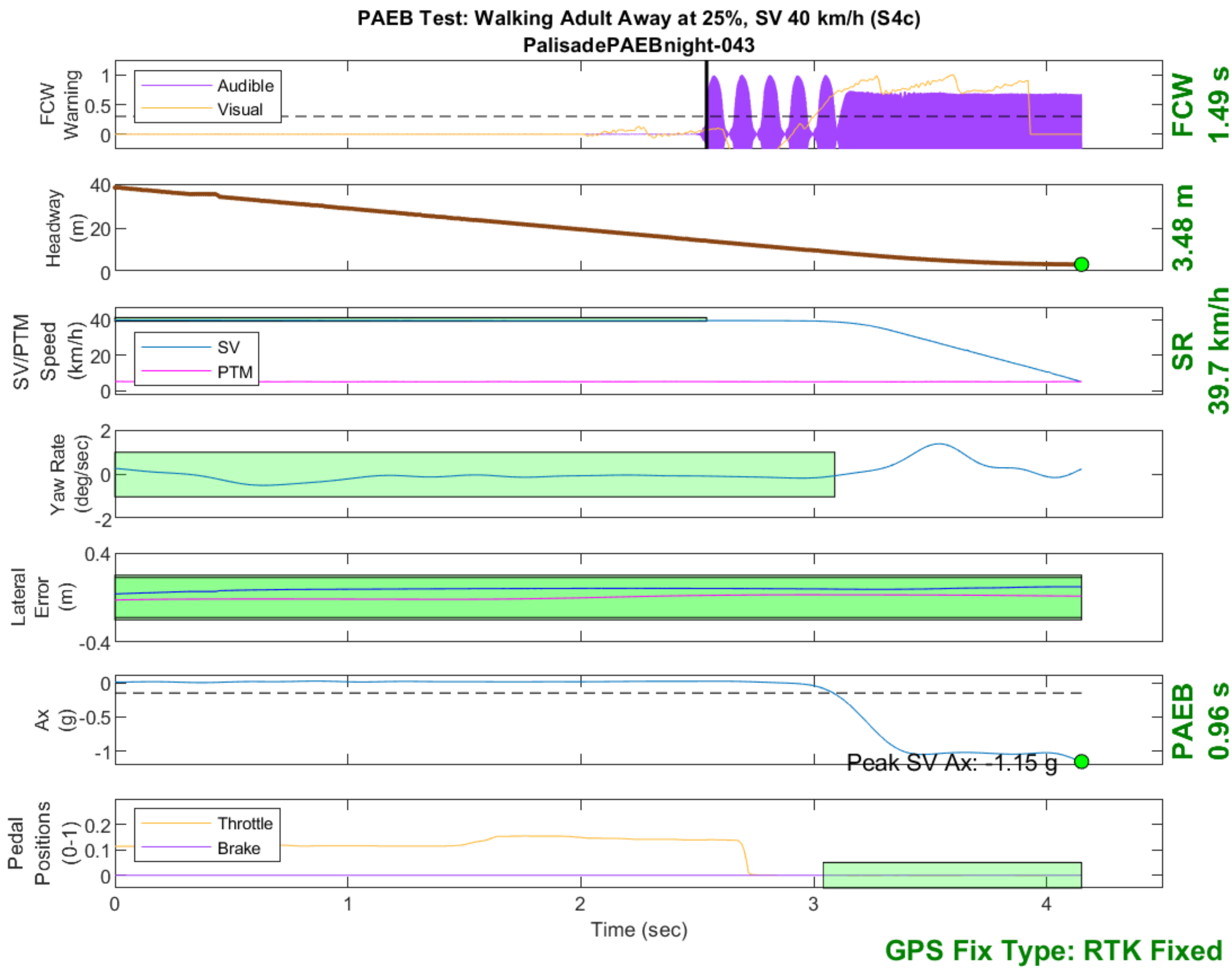


Figure D212. Time History for PAEB Run 43, S4c, Night, High Beam, 40 km/h

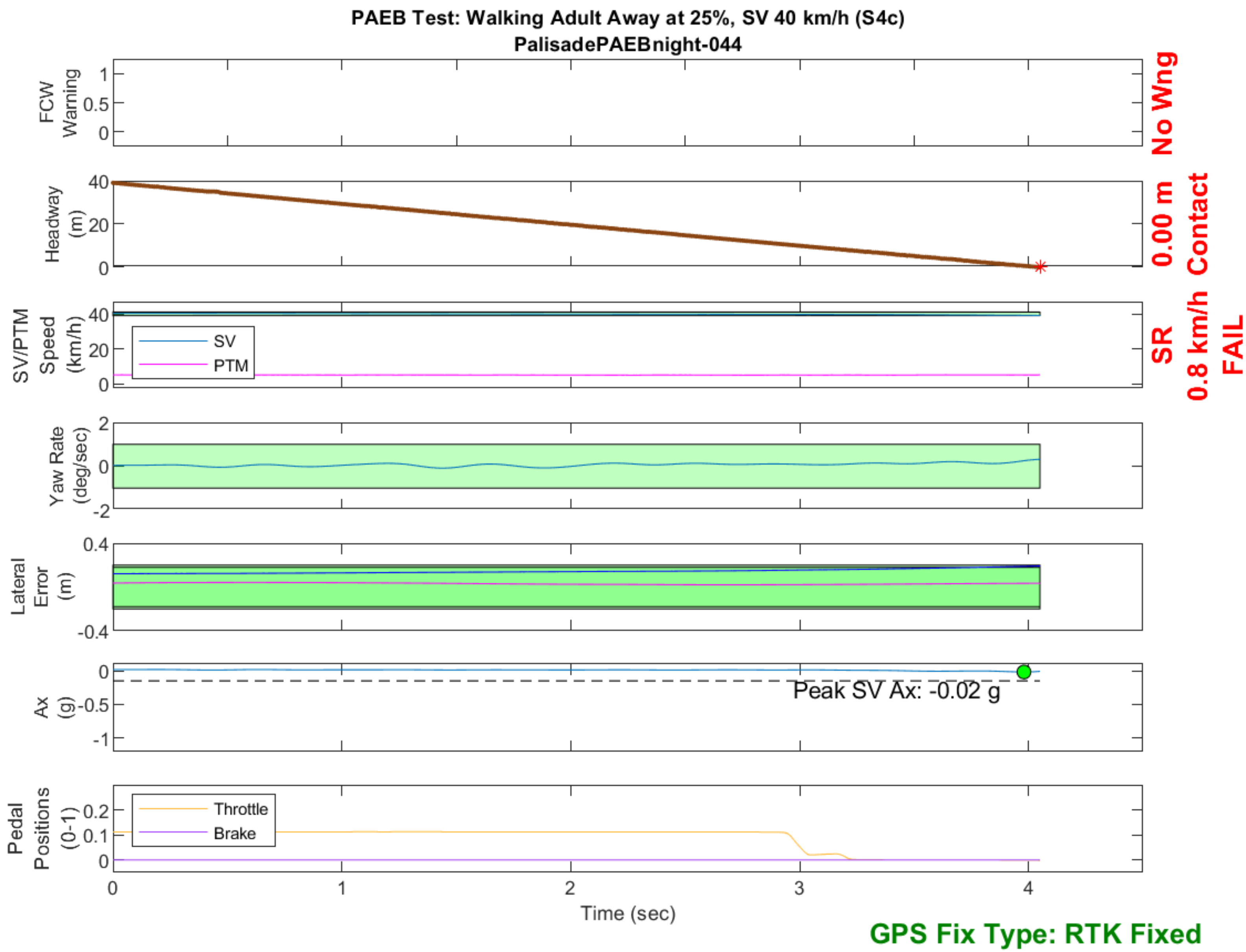


Figure D213. Time History for PAEB Run 44, S4c, Night, High Beam, 40 km/h

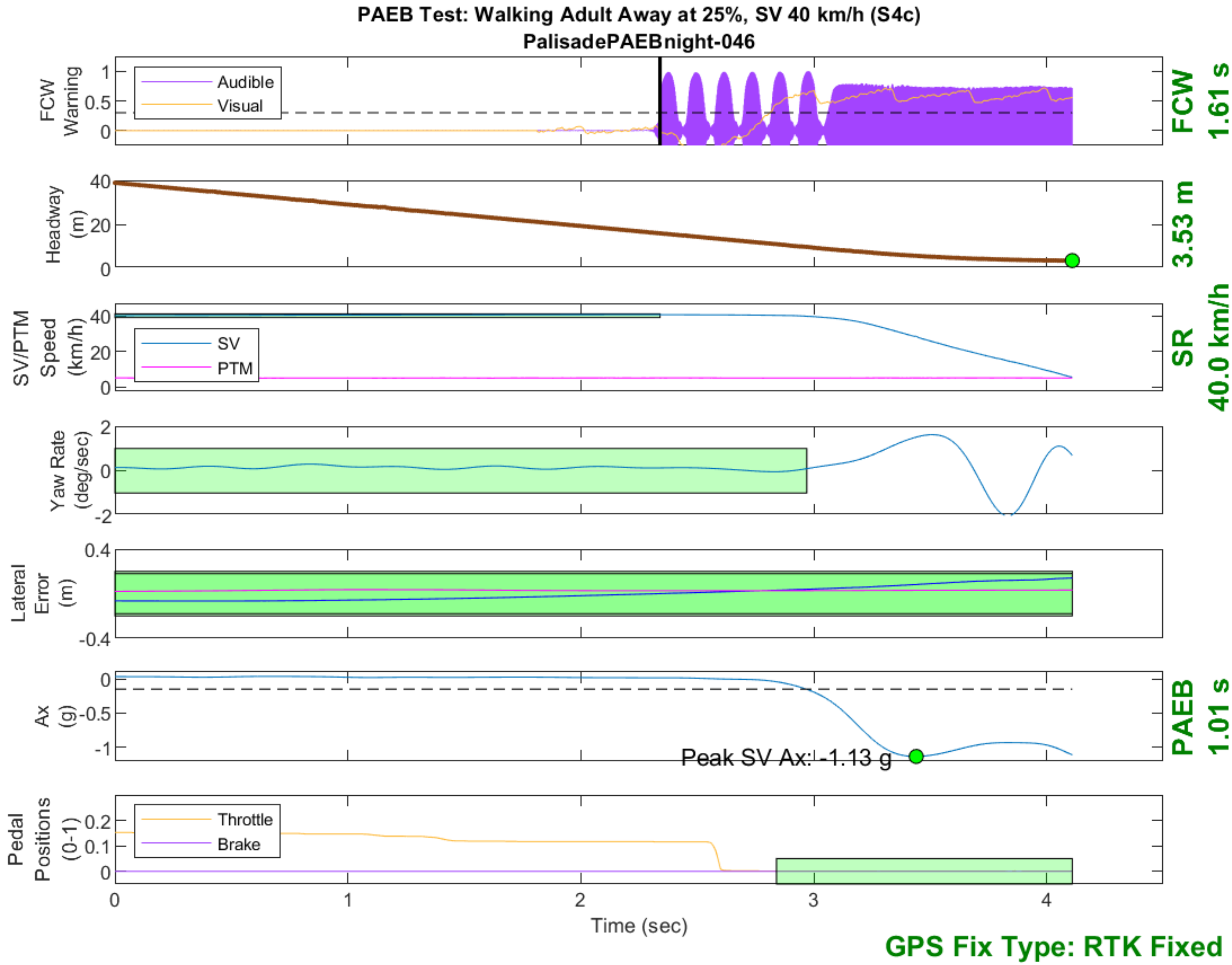


Figure D214. Time History for PAEB Run 46, S4c, Night, High Beam, 40 km/h

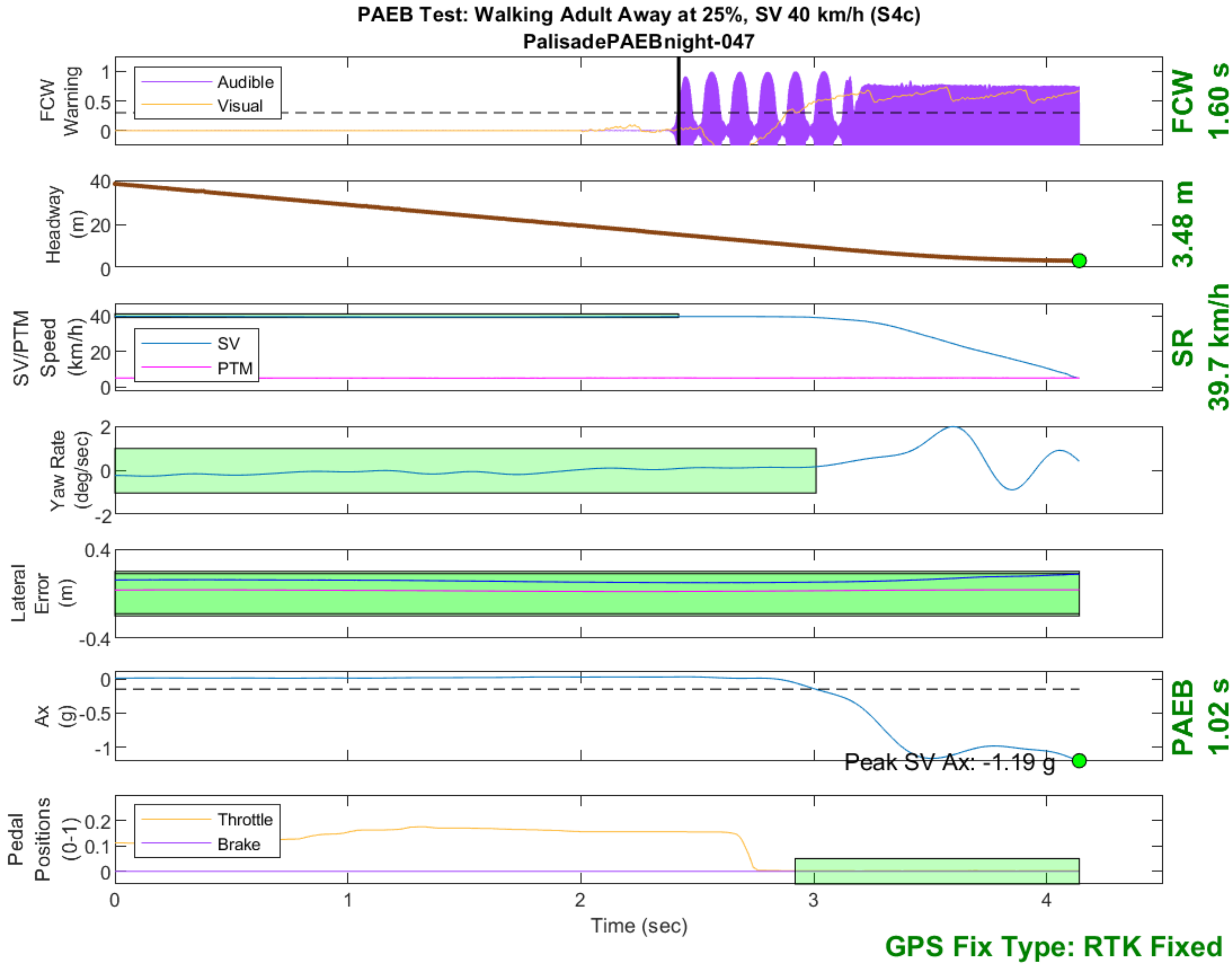


Figure D215. Time History for PAEB Run 47, S4c, Night, High Beam, 40 km/h

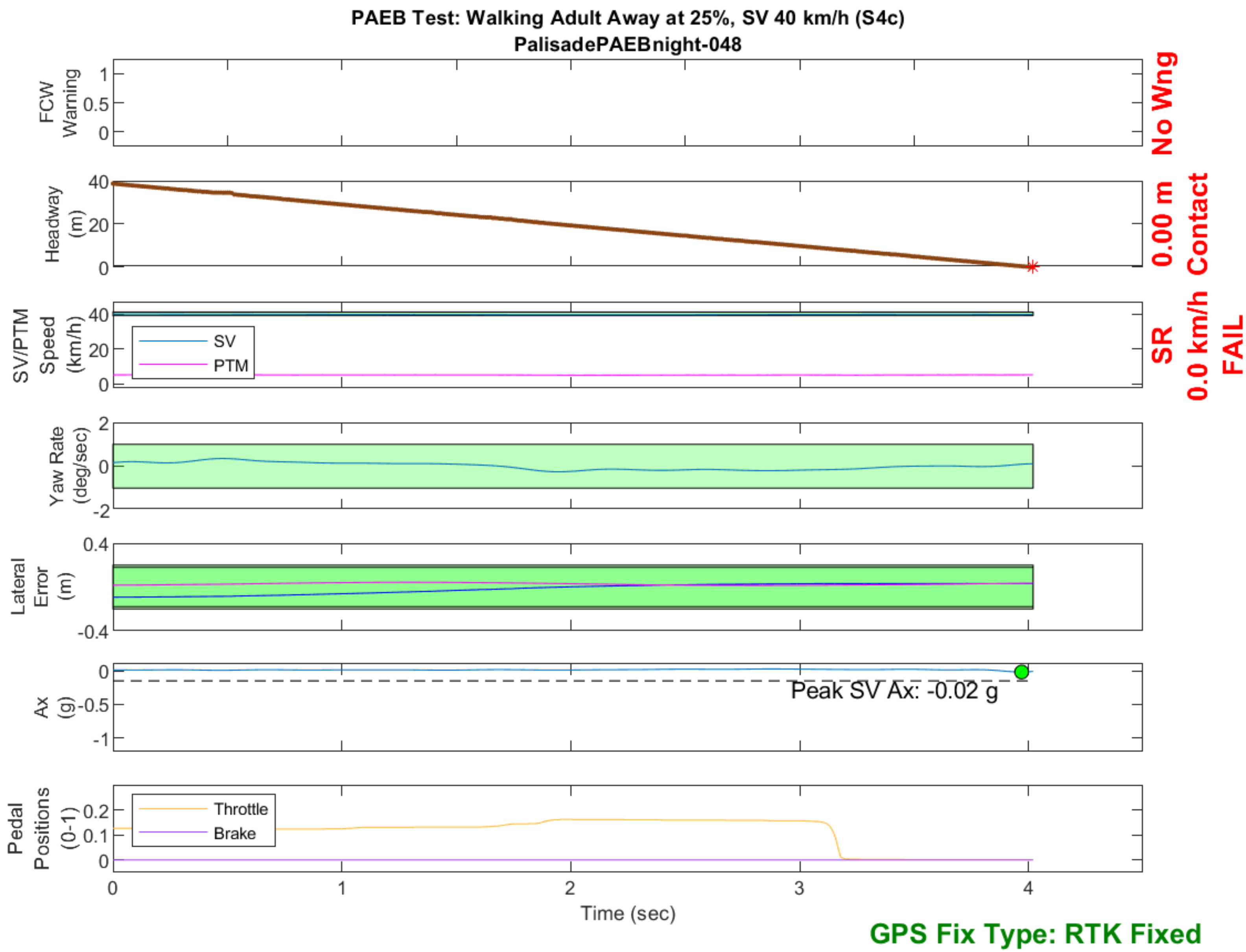


Figure D216. Time History for PAEB Run 48, S4c, Night, High Beam, 40 km/h

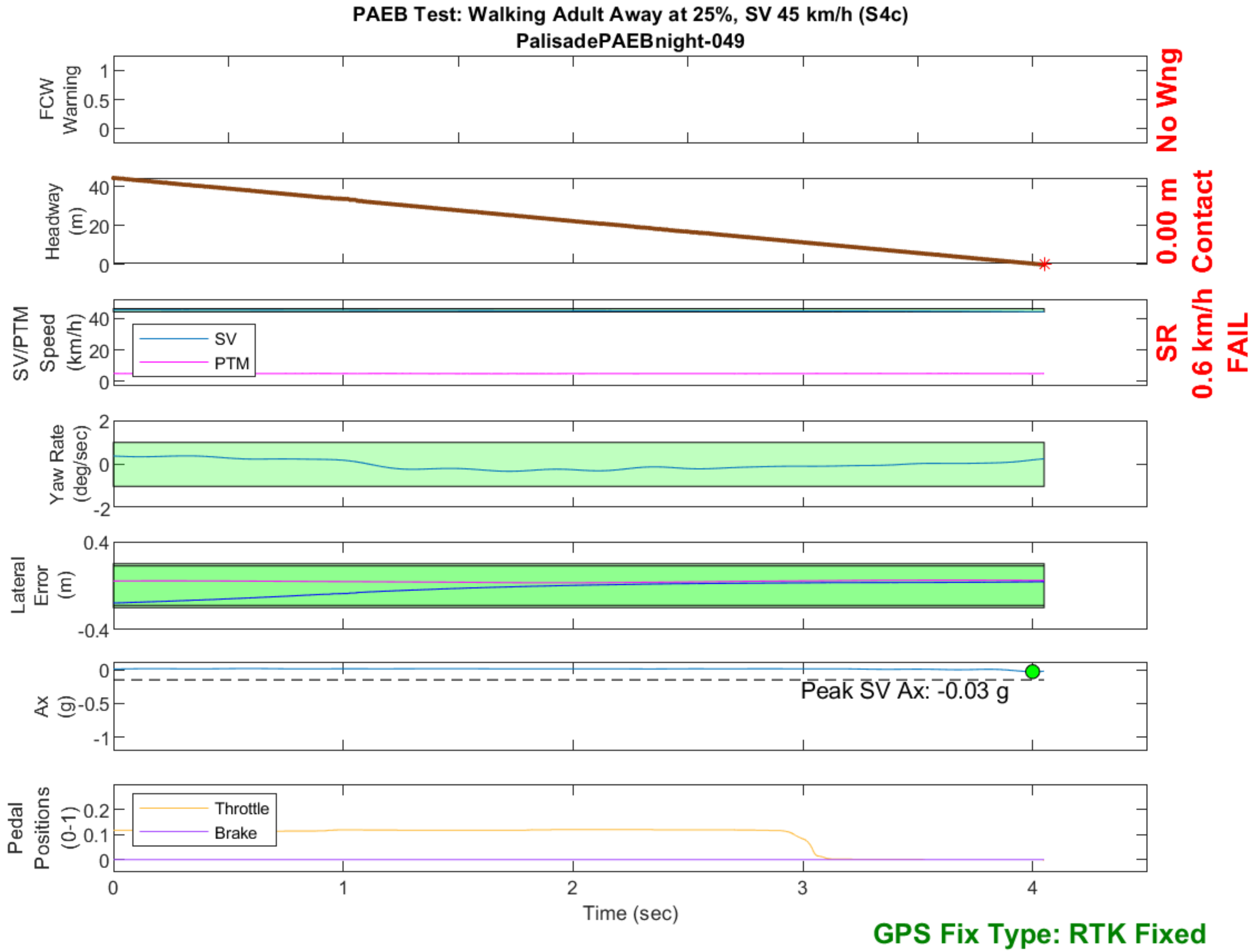


Figure D217. Time History for PAEB Run 49, S4c, Night, High Beam, 45 km/h

Figure D218. Time History for PAEB Run 50, S4c, Night, High Beam, 45 km/h

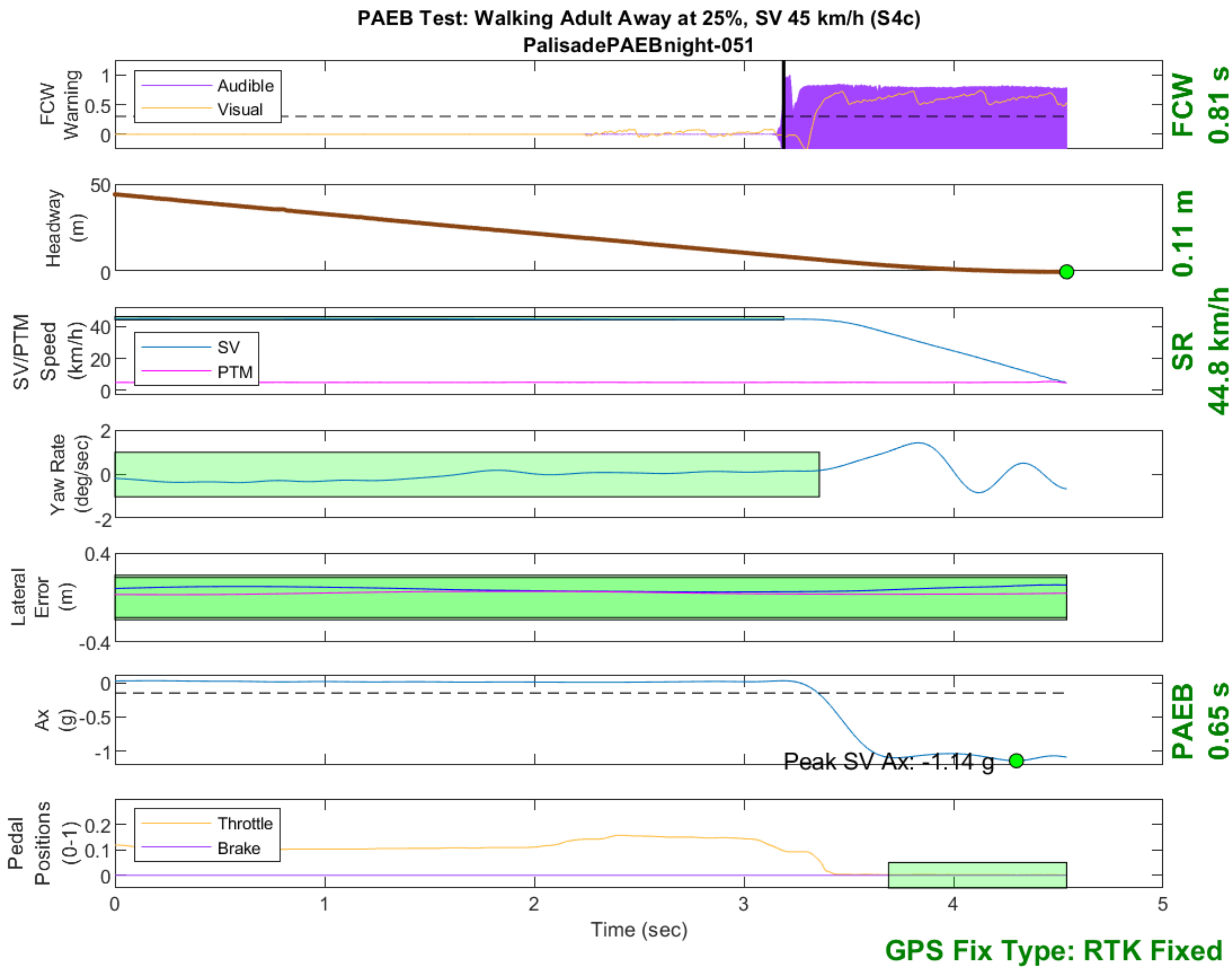


Figure D219. Time History for PAEB Run 51, S4c, Night, High Beam, 45 km/h

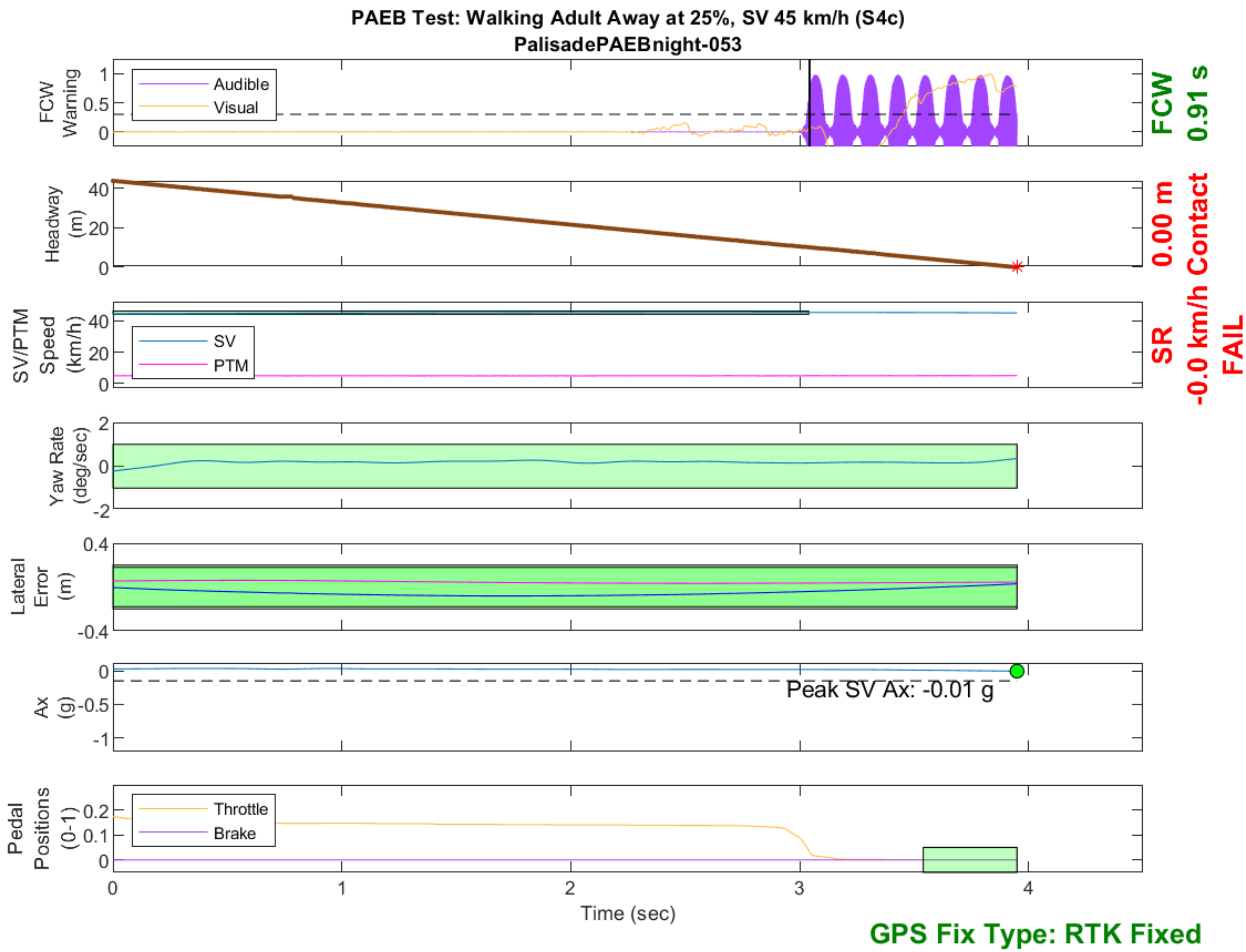


Figure D220. Time History for PAEB Run 53, S4c, Night, High Beam, 45 km/h

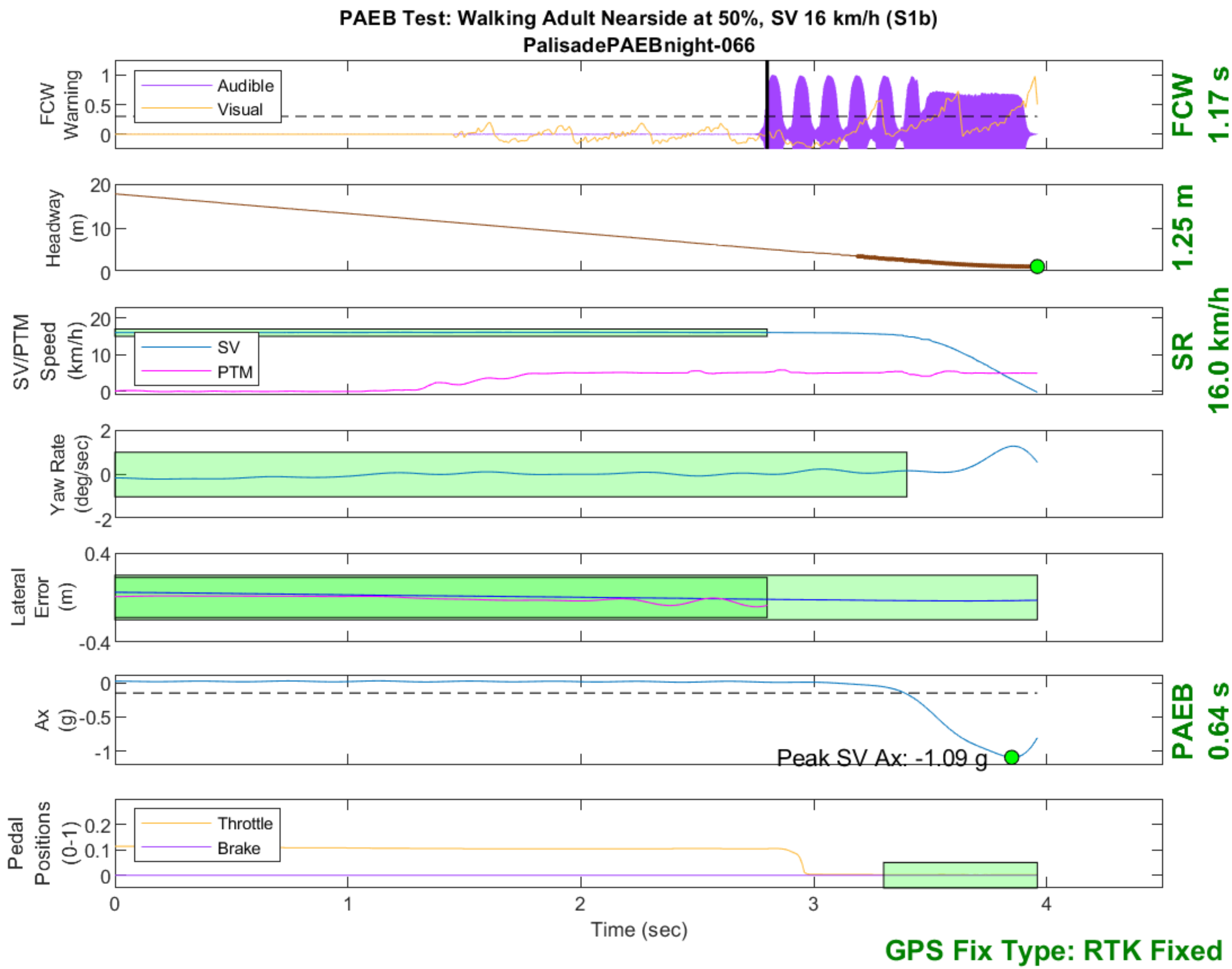


Figure D221. Time History for PAEB Run 66, S1b, Night, Low Beam, 16 km/h

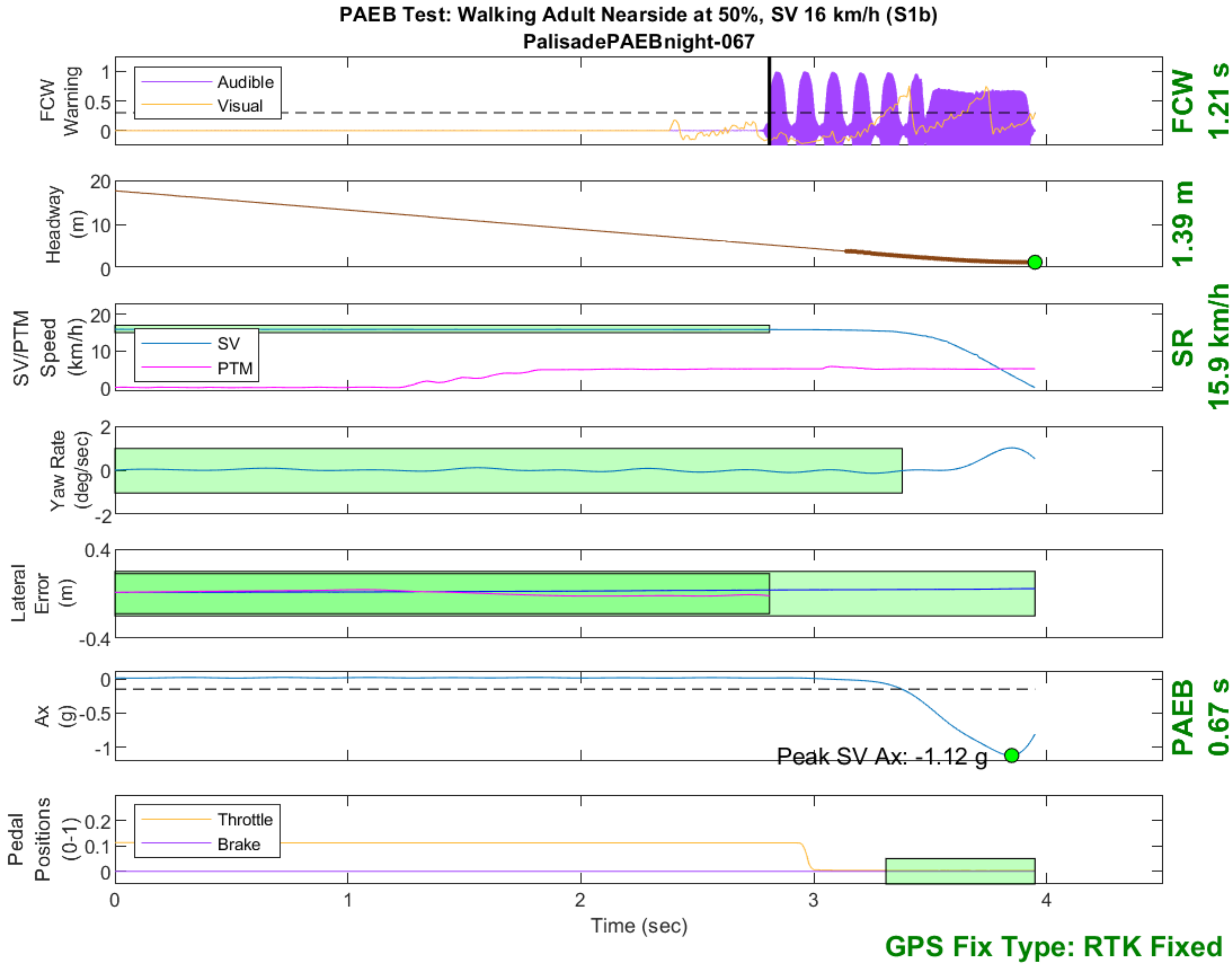


Figure D222. Time History for PAEB Run 67, S1b, Night, Low Beam, 16 km/h

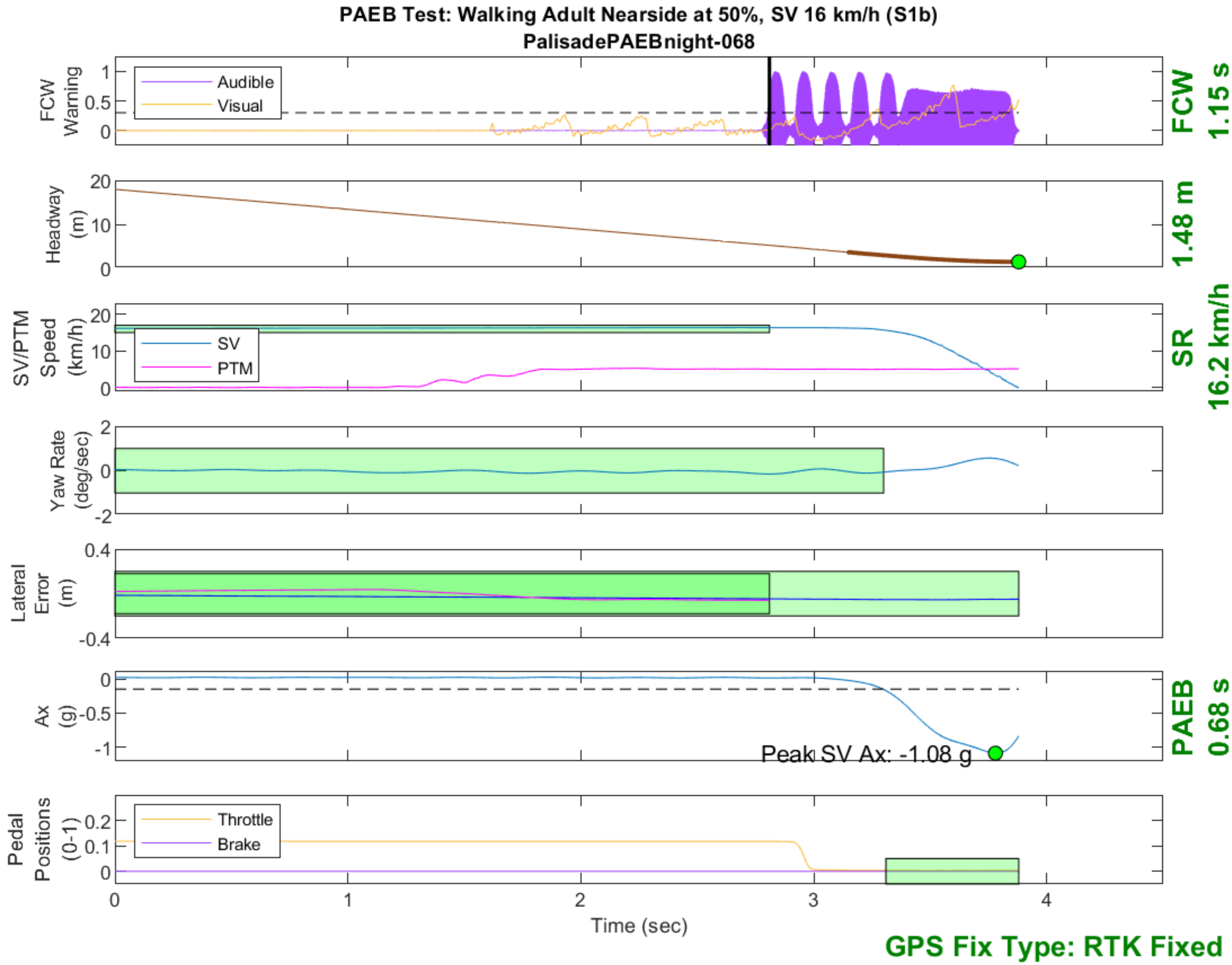


Figure D223. Time History for PAEB Run 68, S1b, Night, Low Beam, 16 km/h

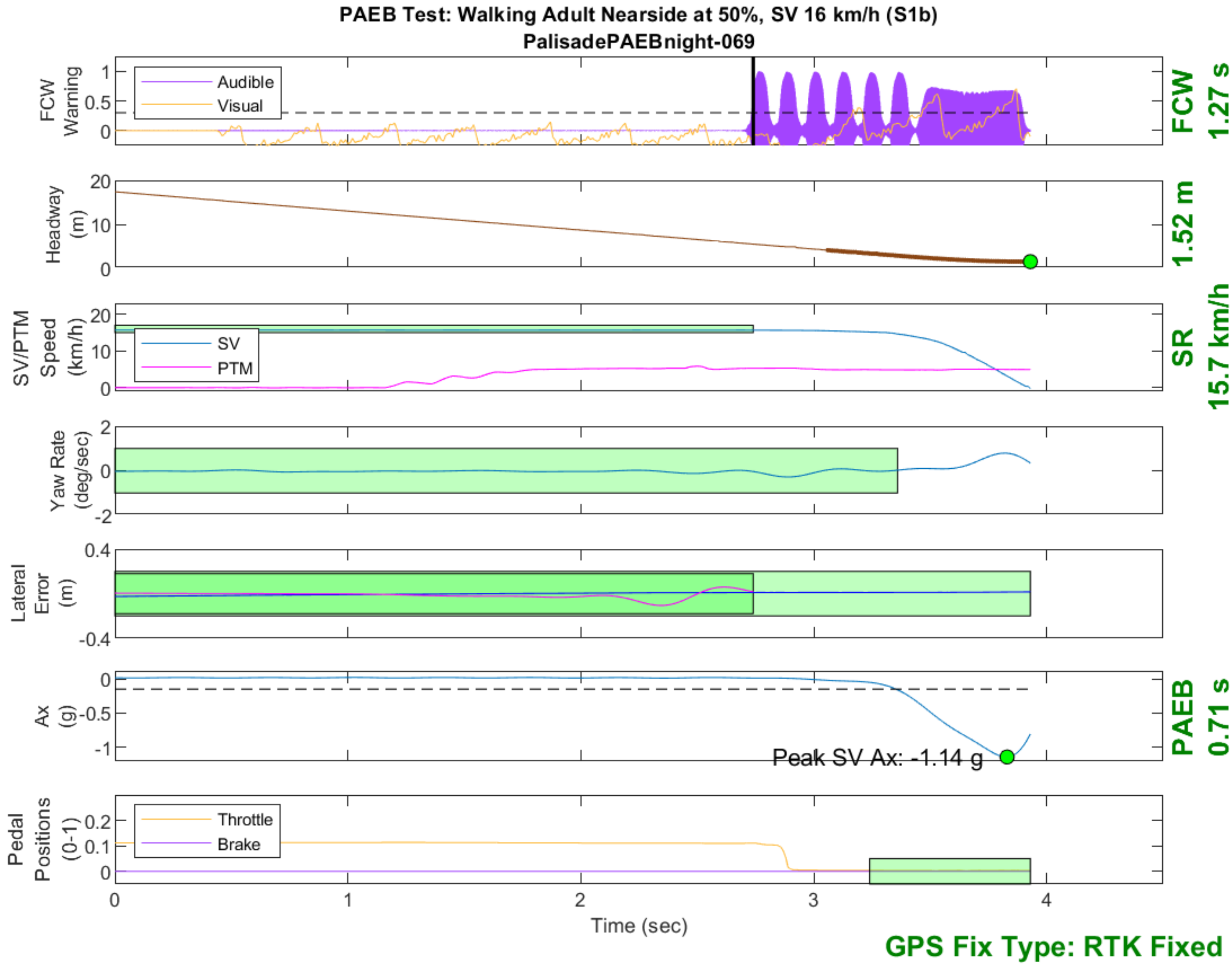


Figure D224. Time History for PAEB Run 69, S1b, Night, Low Beam, 16 km/h

Figure D225. Time History for PAEB Run 71, S1b, Night, Low Beam, 16 km/h

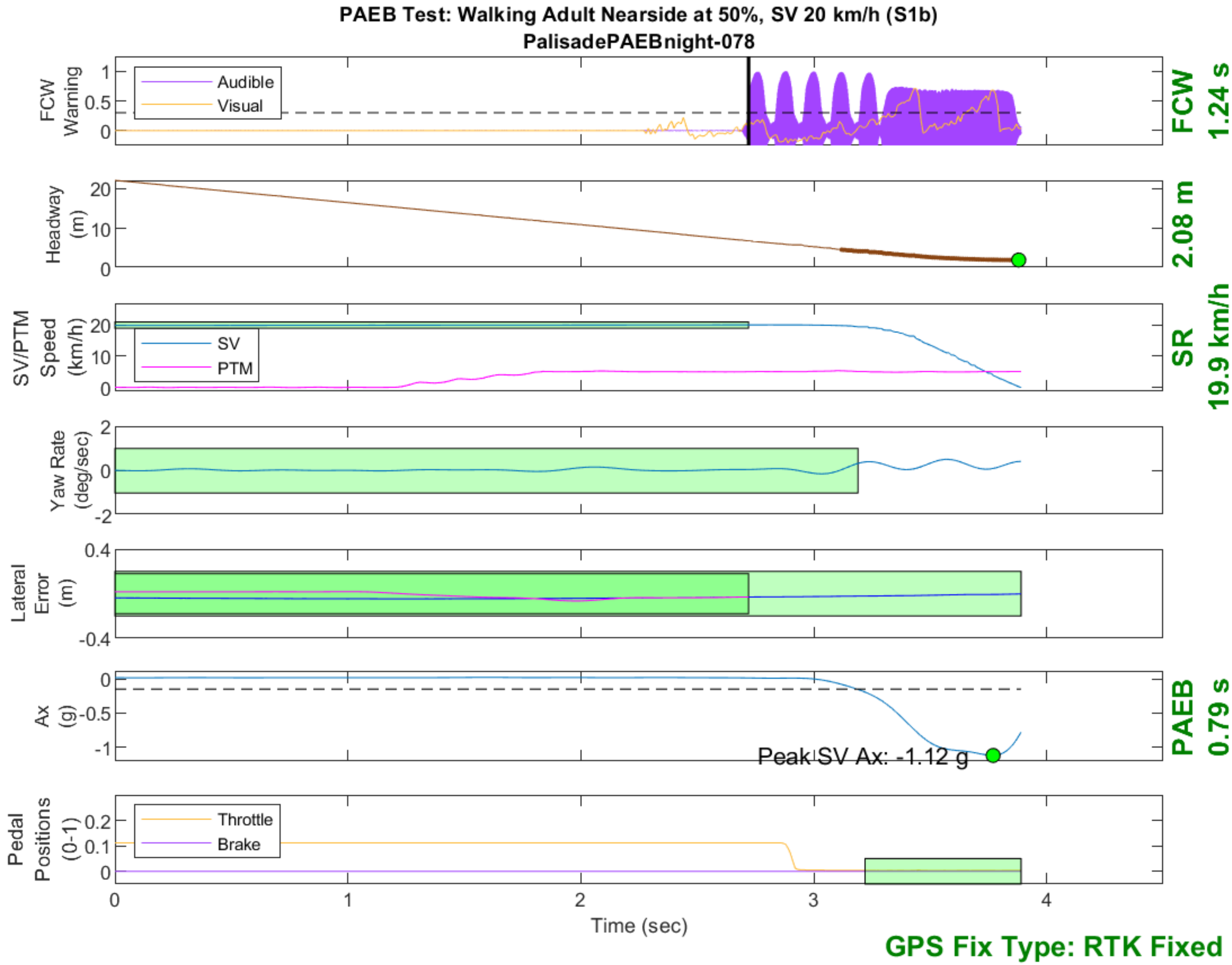


Figure D226. Time History for PAEB Run 78, S1b, Night, Low Beam, 20 km/h

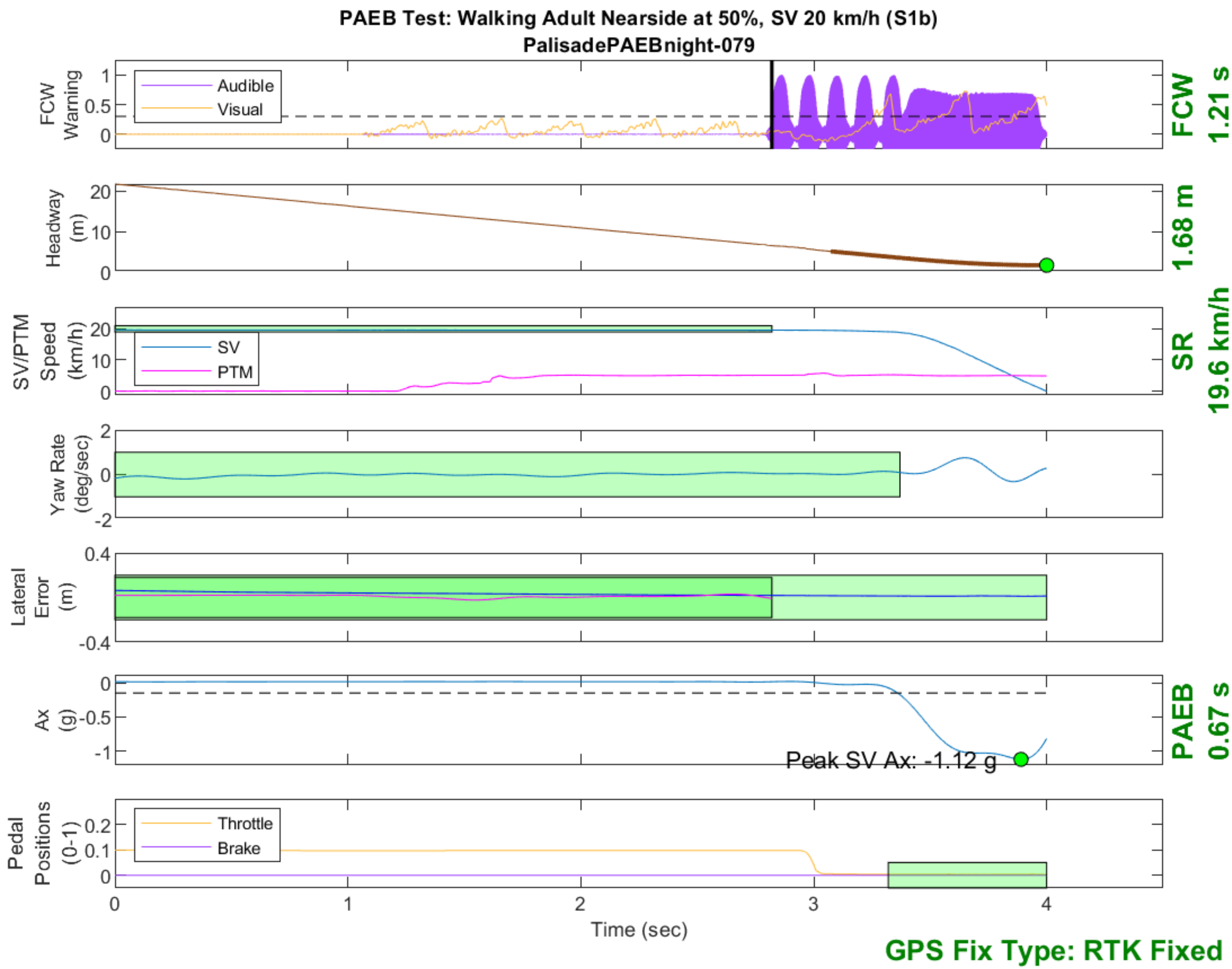


Figure D227. Time History for PAEB Run 79, S1b, Night, Low Beam, 20 km/h

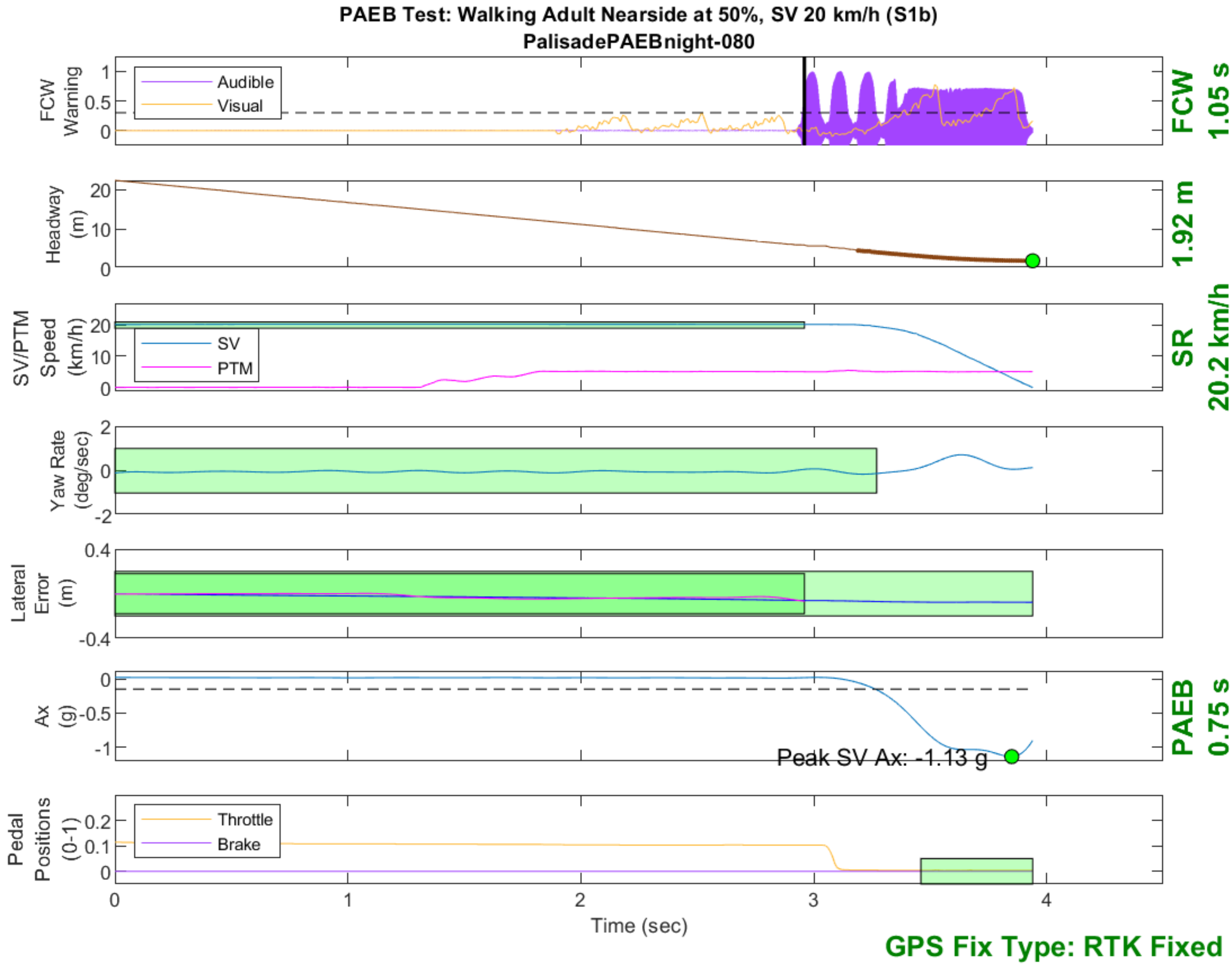


Figure D228. Time History for PAEB Run 80, S1b, Night, Low Beam, 20 km/h

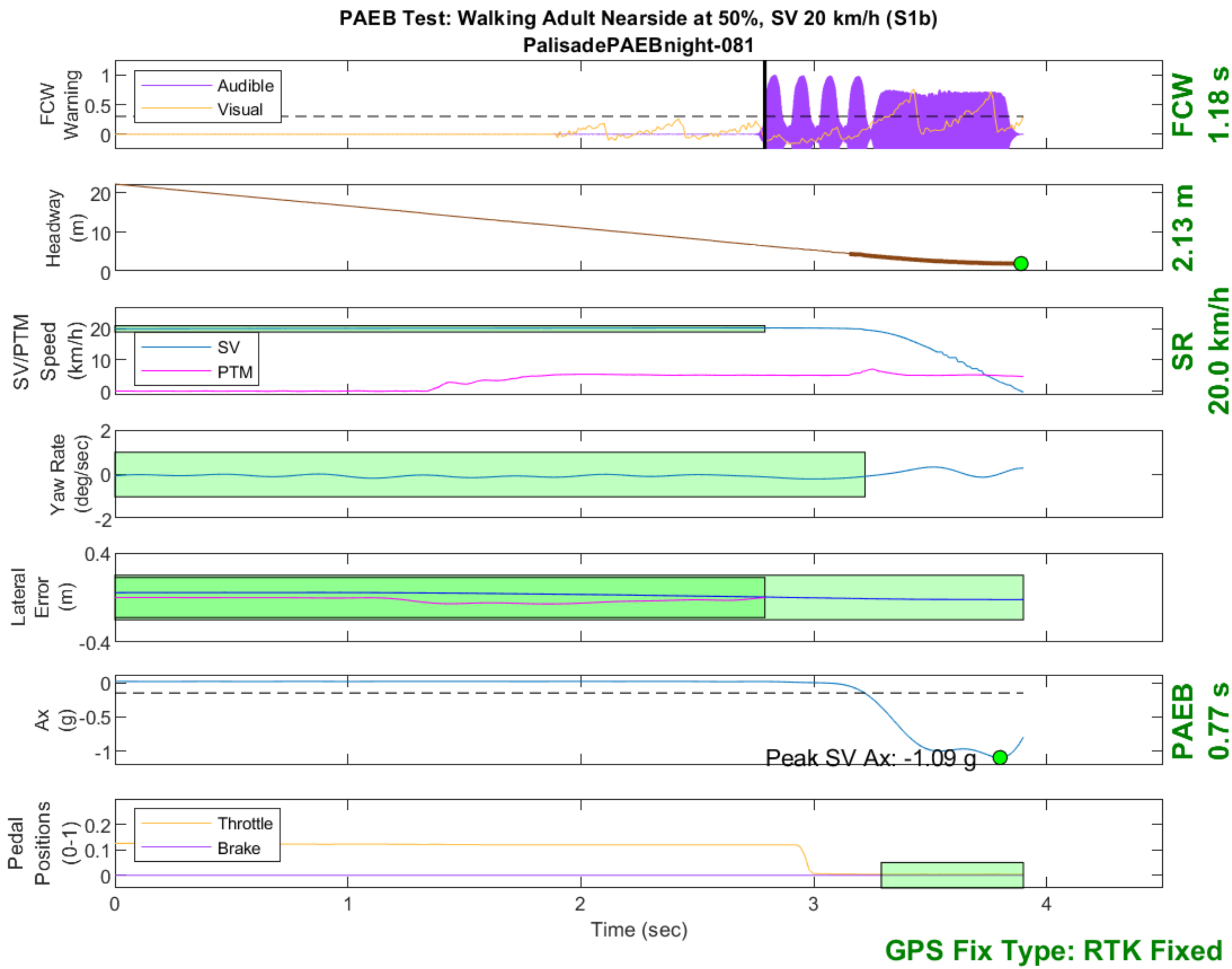


Figure D229. Time History for PAEB Run 81, S1b, Night, Low Beam, 20 km/h

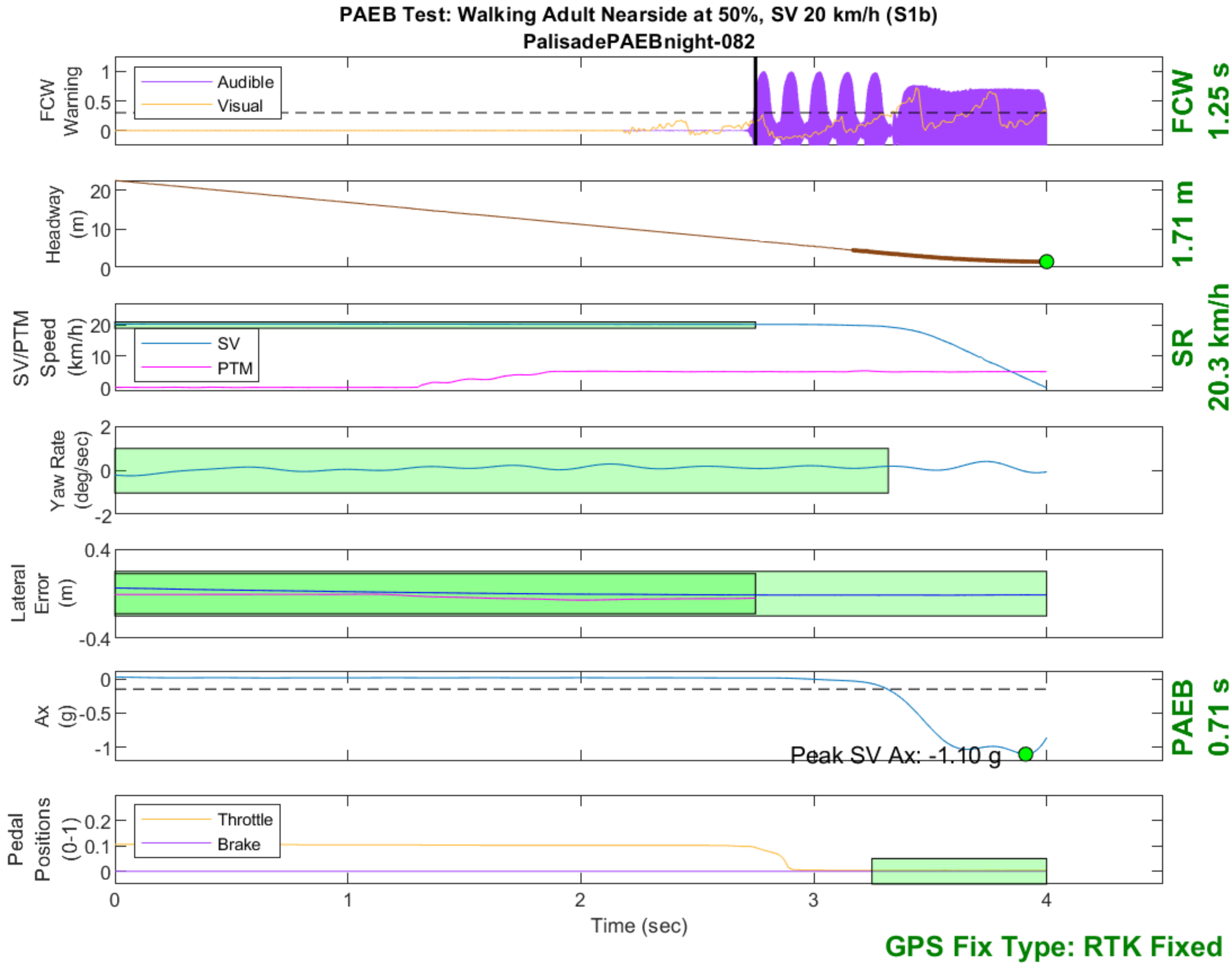


Figure D230. Time History for PAEB Run 82, S1b, Night, Low Beam, 20 km/h

Figure D231. Time History for PAEB Run 89, S1b, Night, Low Beam, 30 km/h

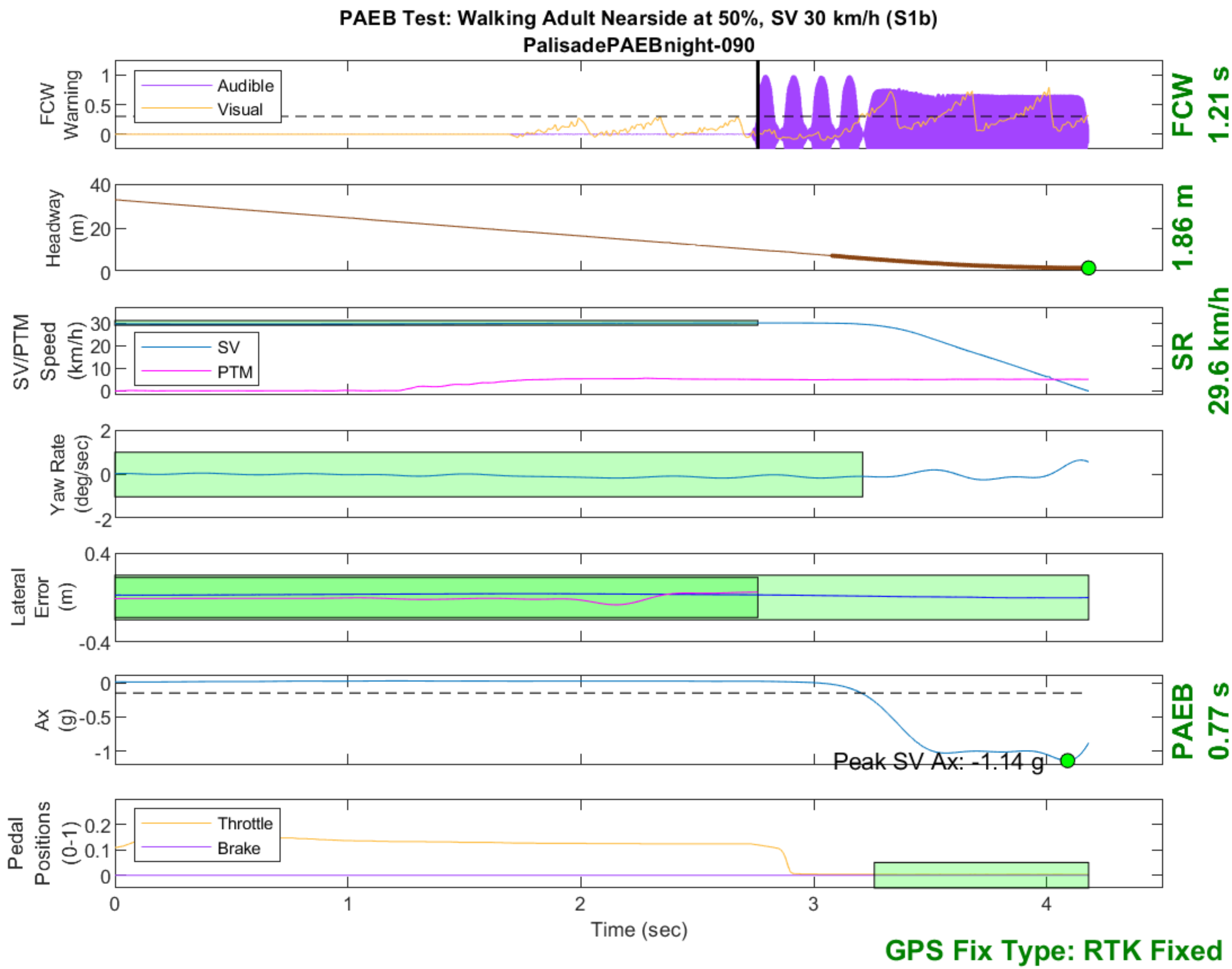


Figure D232. Time History for PAEB Run 90, S1b, Night, Low Beam, 30 km/h

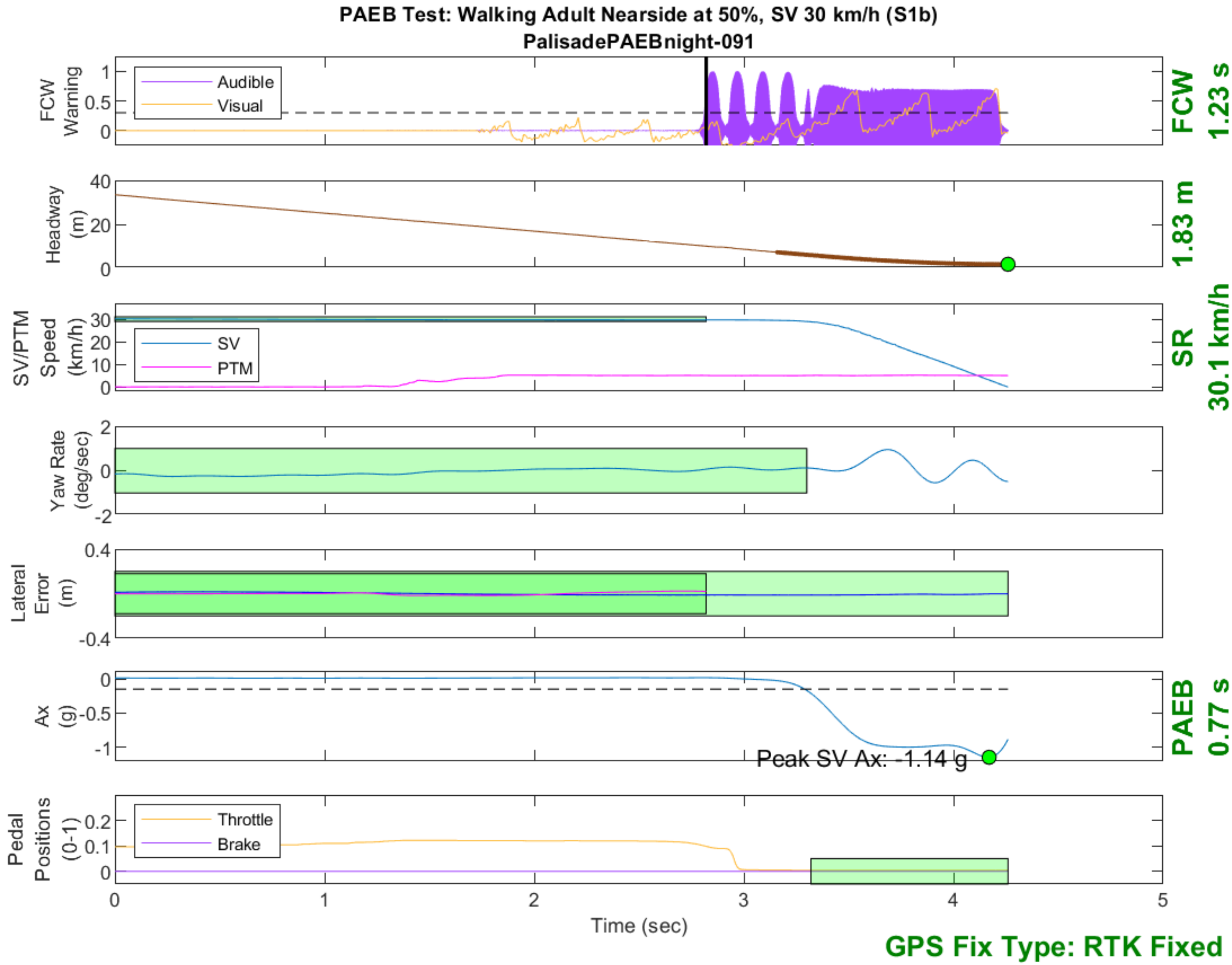


Figure D233. Time History for PAEB Run 91, S1b, Night, Low Beam, 30 km/h

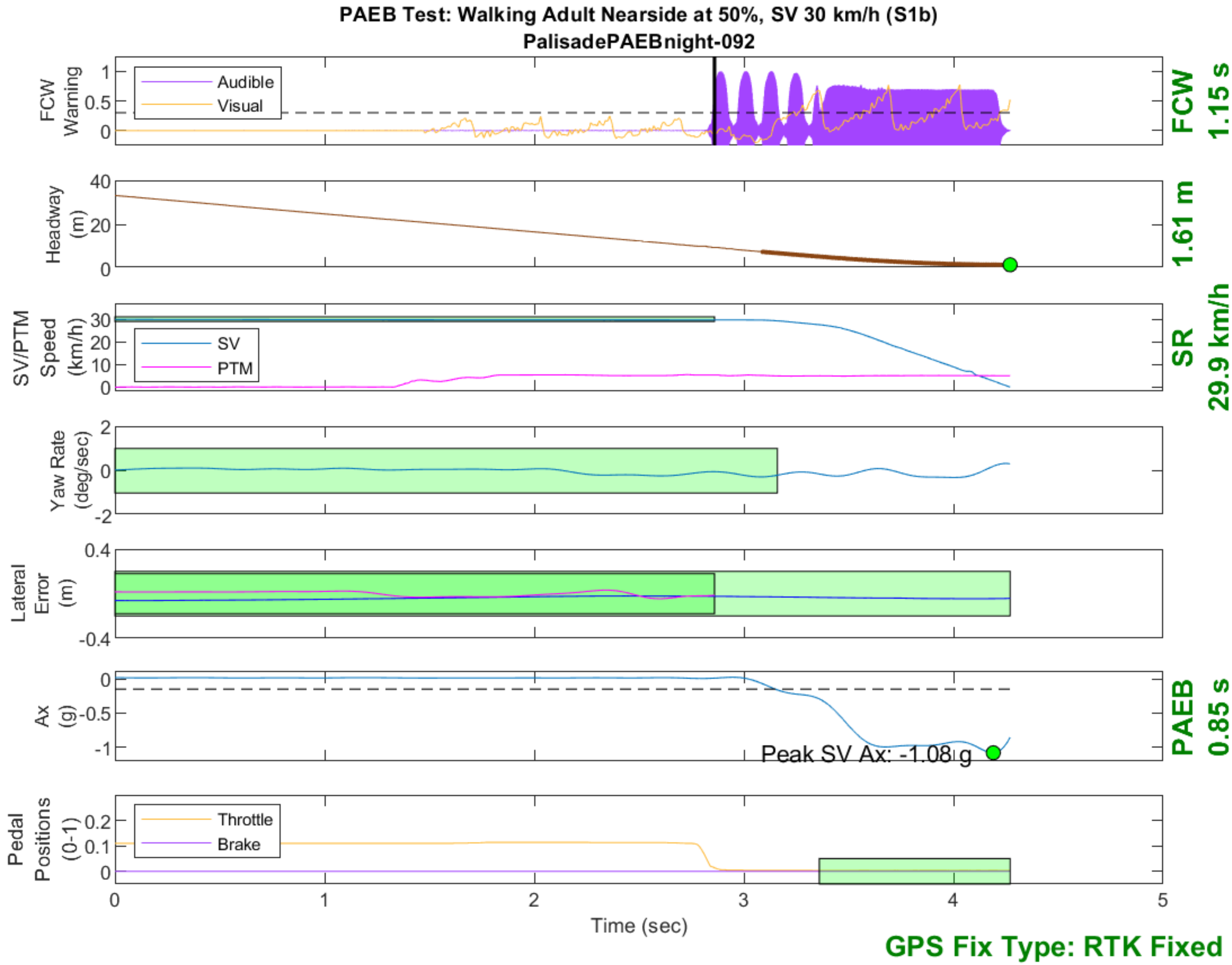


Figure D234. Time History for PAEB Run 92, S1b, Night, Low Beam, 30 km/h

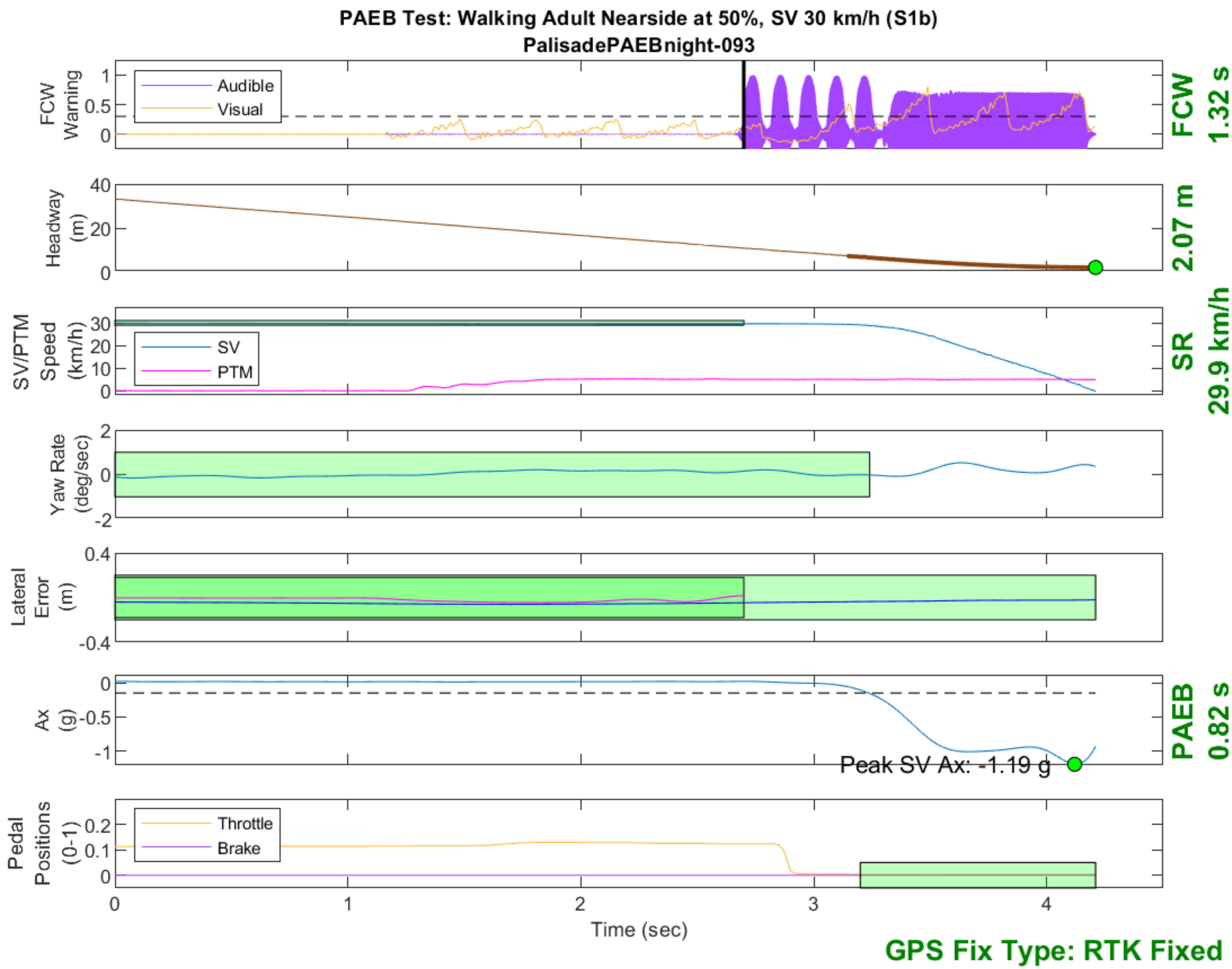


Figure D235. Time History for PAEB Run 93, S1b, Night, Low Beam, 30 km/h

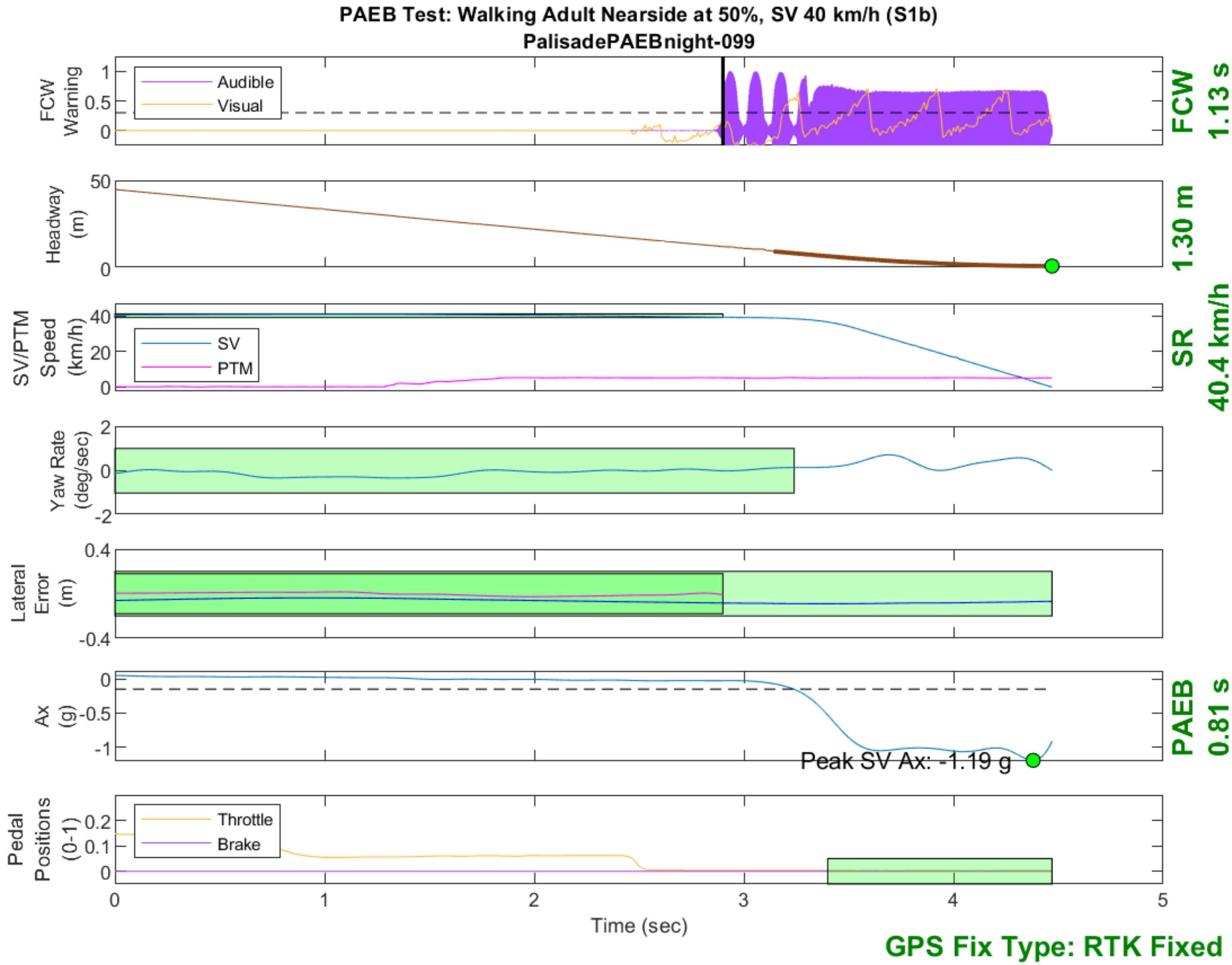


Figure D236. Time History for PAEB Run 99, S1b, Night, Low Beam, 40 km/h

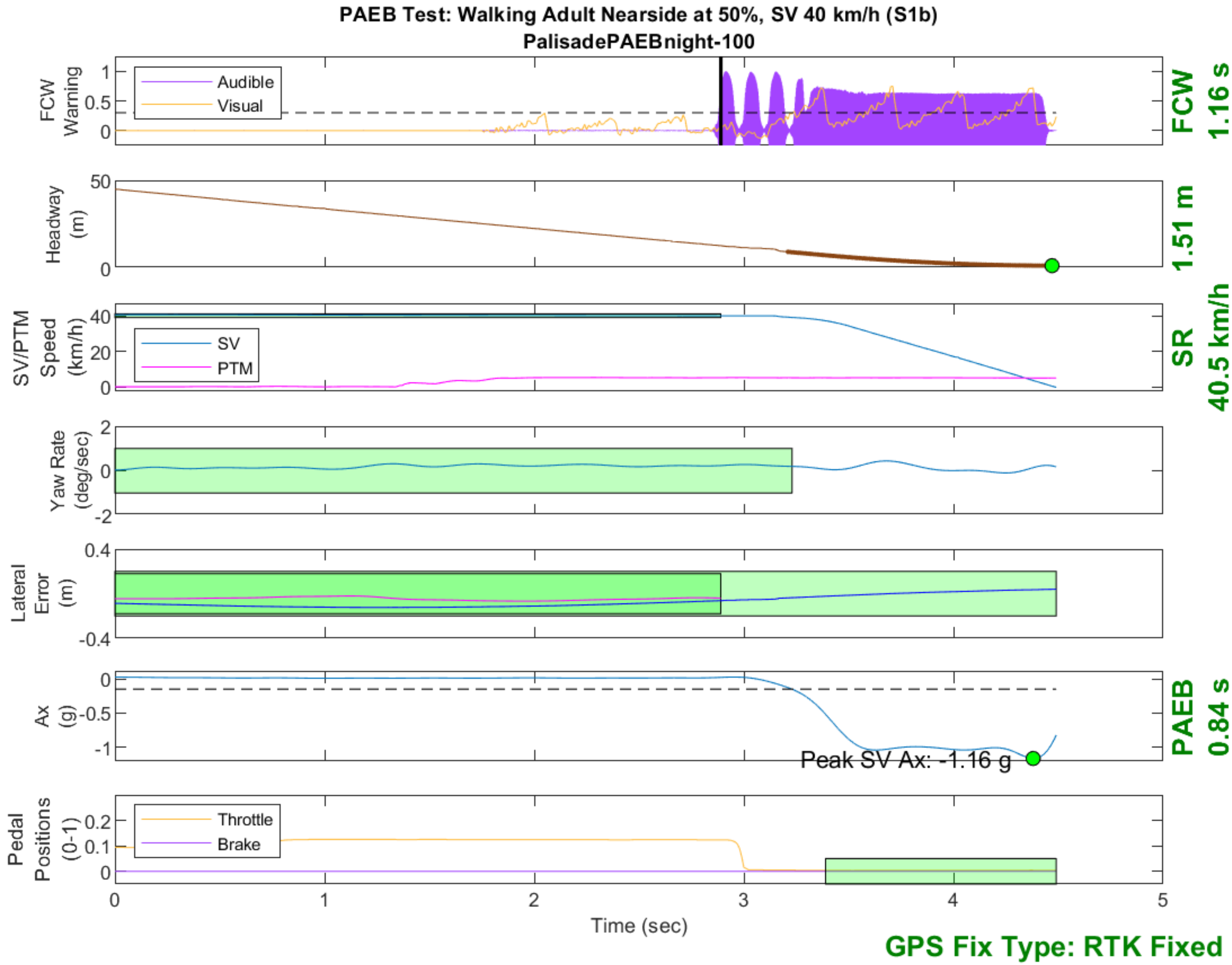


Figure D237. Time History for PAEB Run 100, S1b, Night, Low Beam, 40 km/h

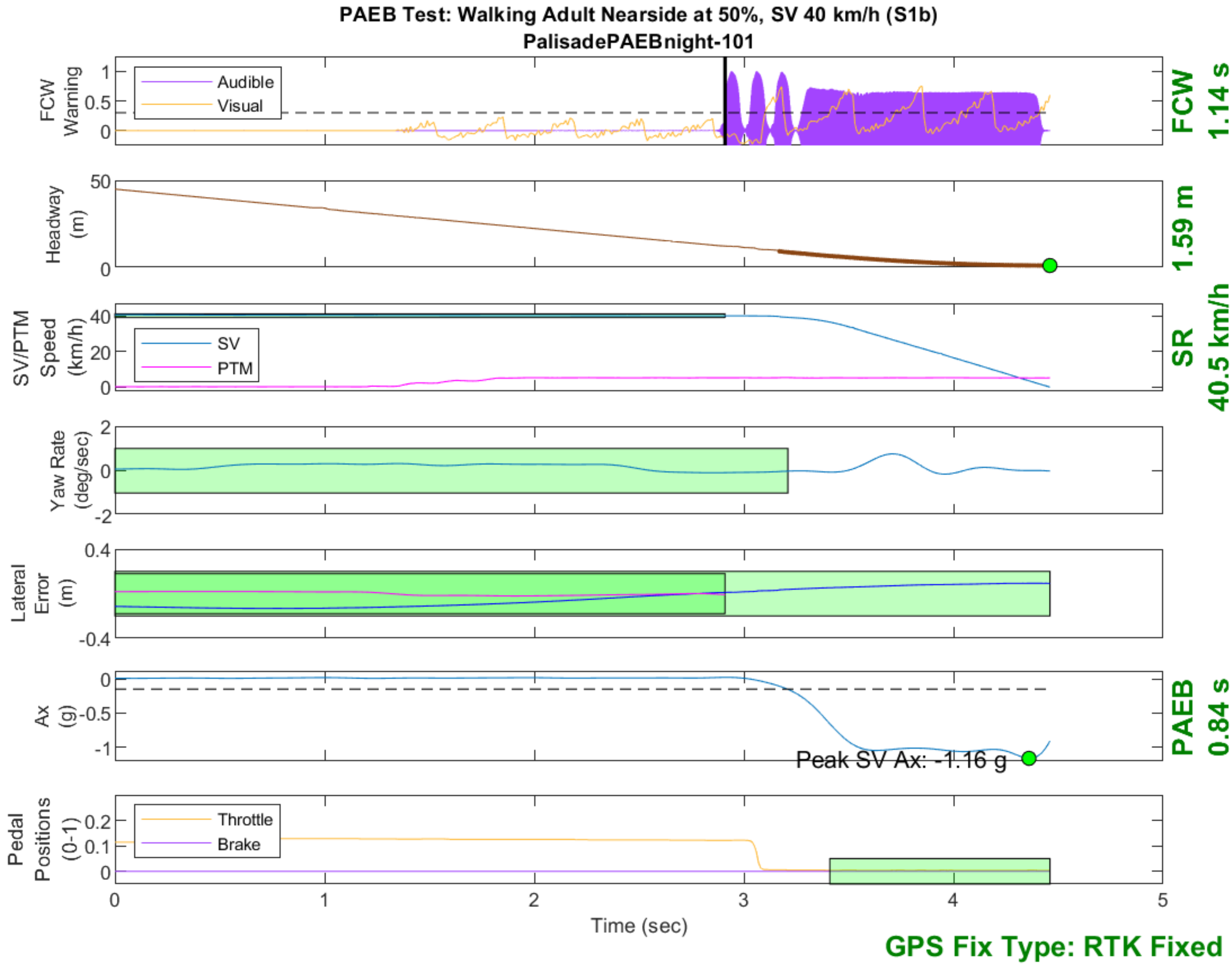


Figure D238. Time History for PAEB Run 101, S1b, Night, Low Beam, 40 km/h

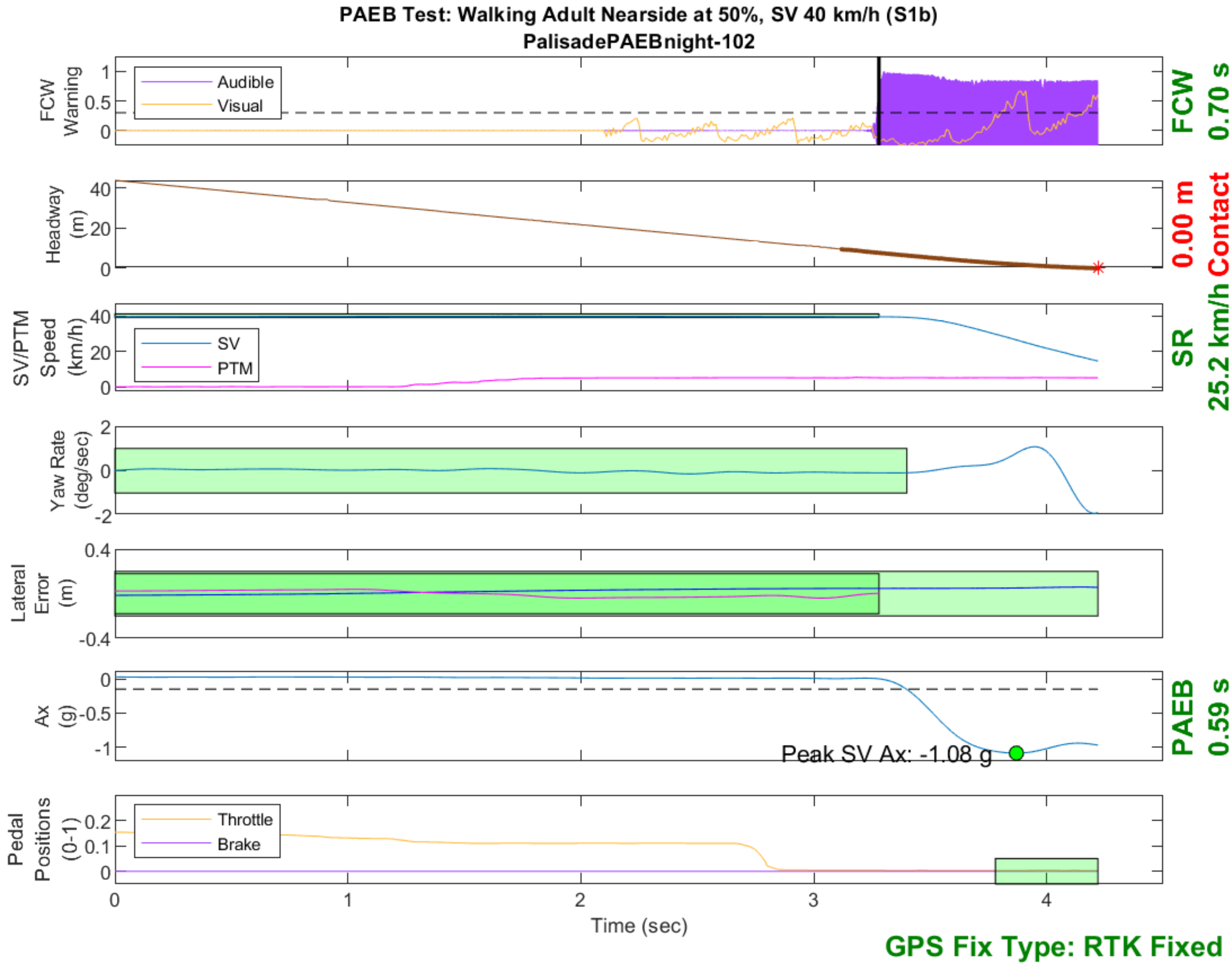


Figure D239. Time History for PAEB Run 102, S1b, Night, Low Beam, 40 km/h

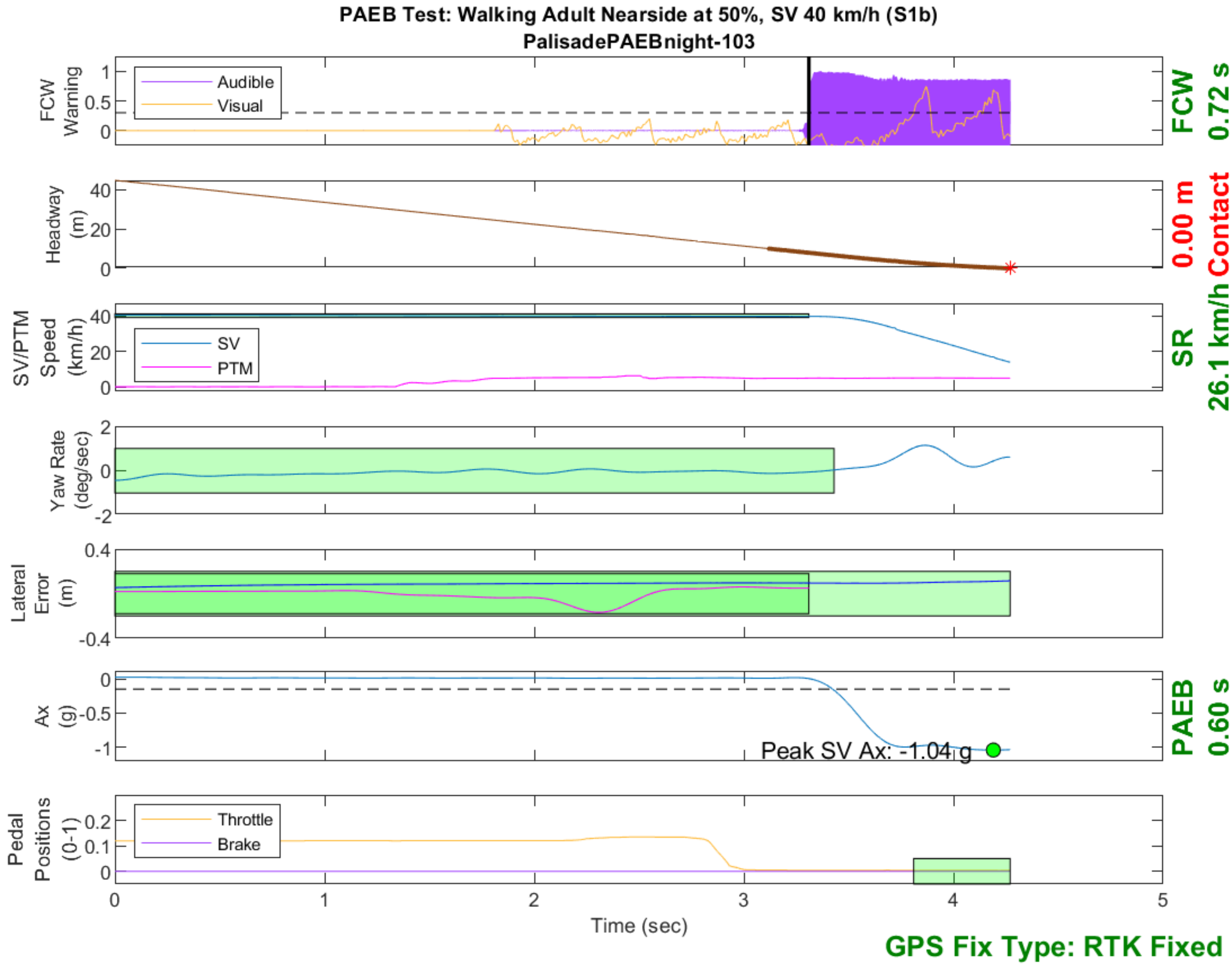


Figure D240. Time History for PAEB Run 103, S1b, Night, Low Beam, 40 km/h

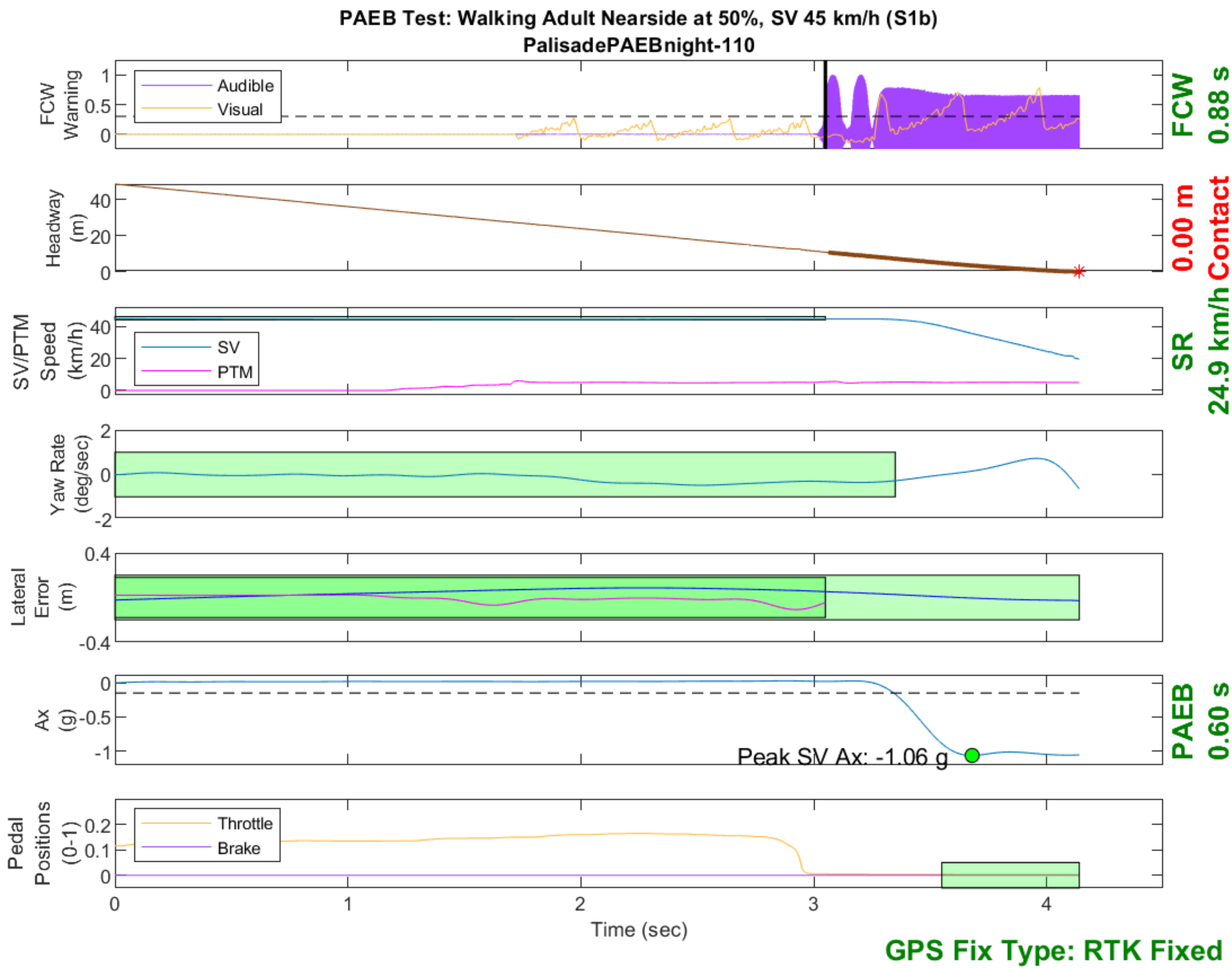


Figure D241. Time History for PAEB Run 110, S1b, Night, Low Beam, 45 km/h

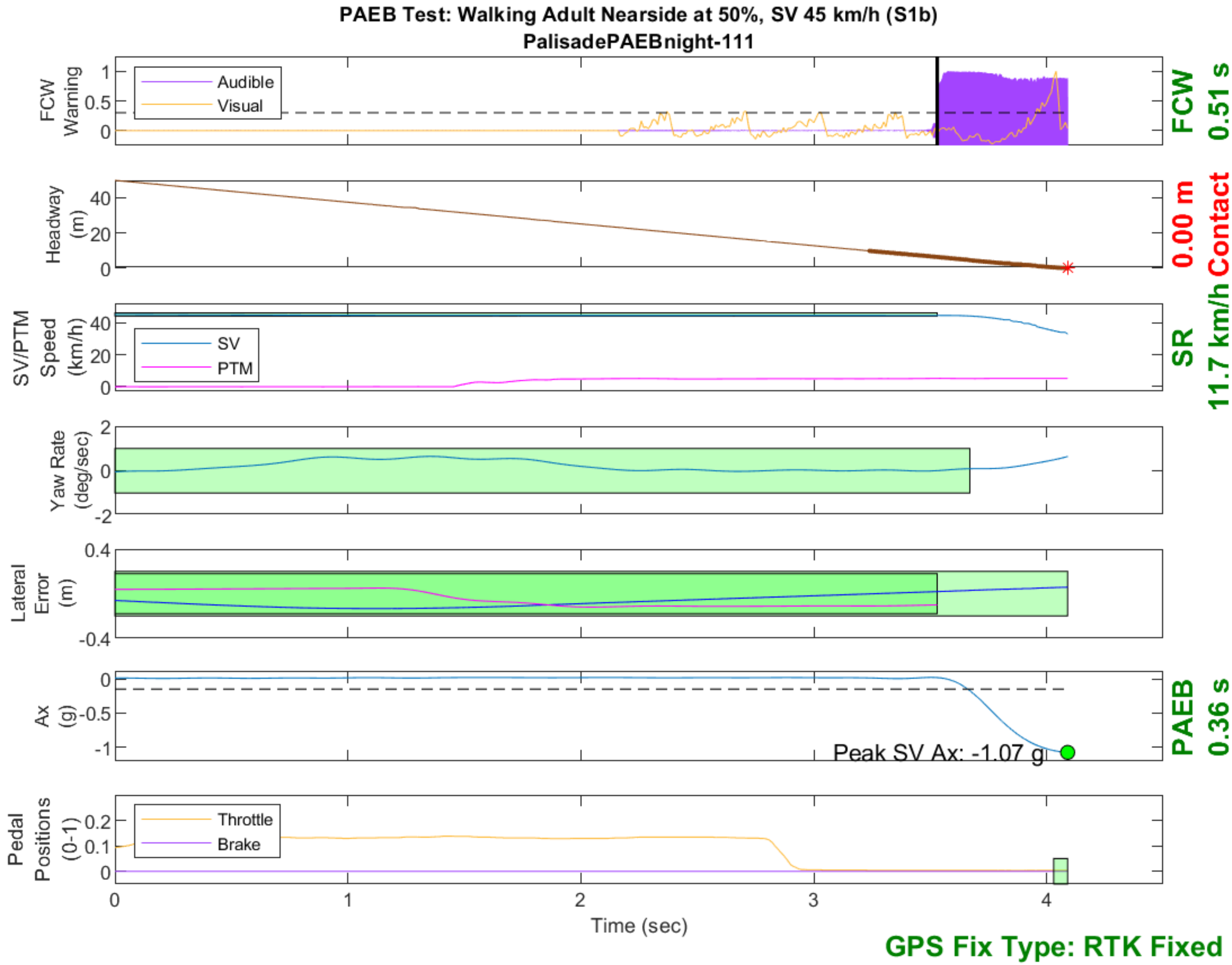


Figure D242. Time History for PAEB Run 111, S1b, Night, Low Beam, 45 km/h

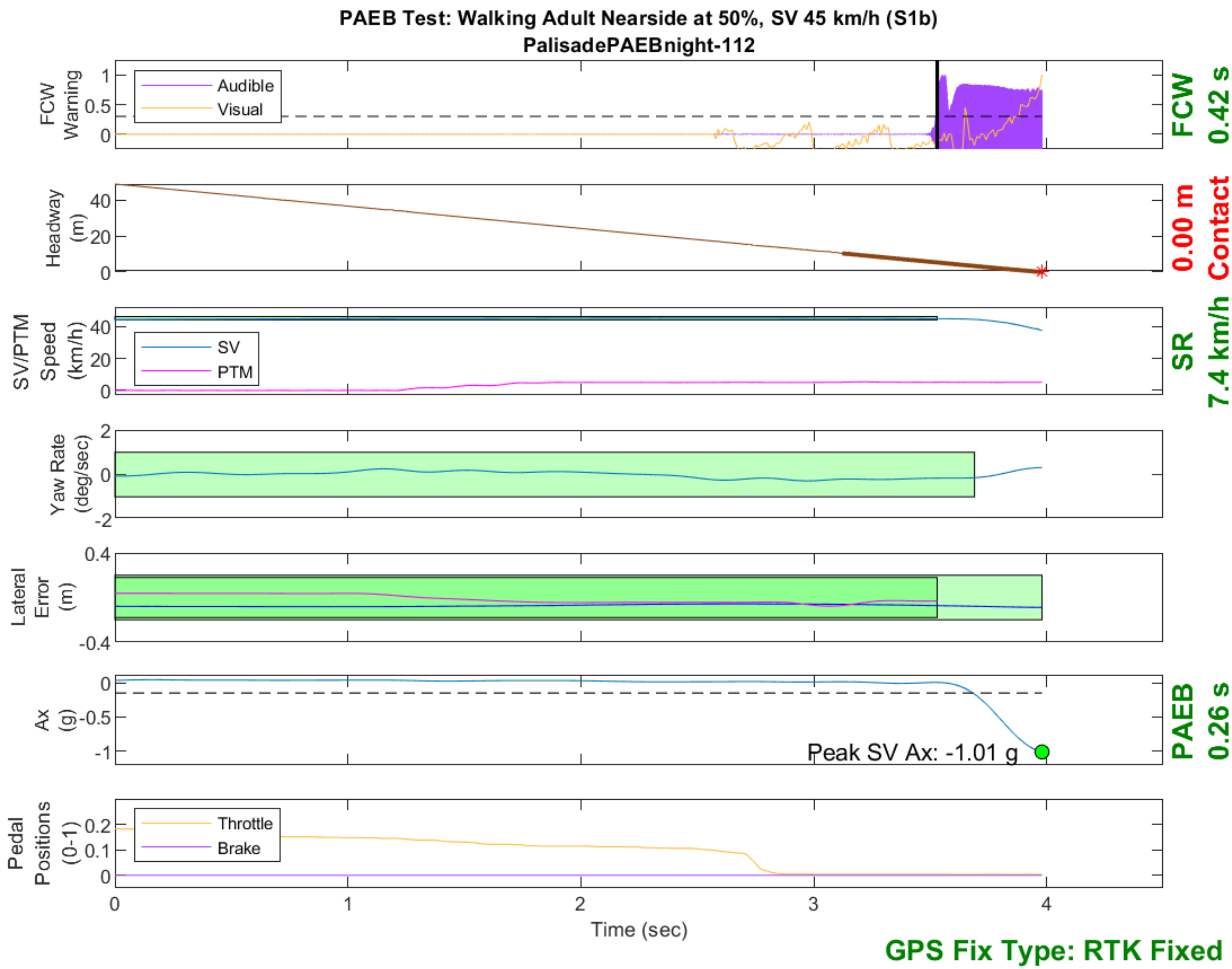


Figure D243. Time History for PAEB Run 112, S1b, Night, Low Beam, 45 km/h

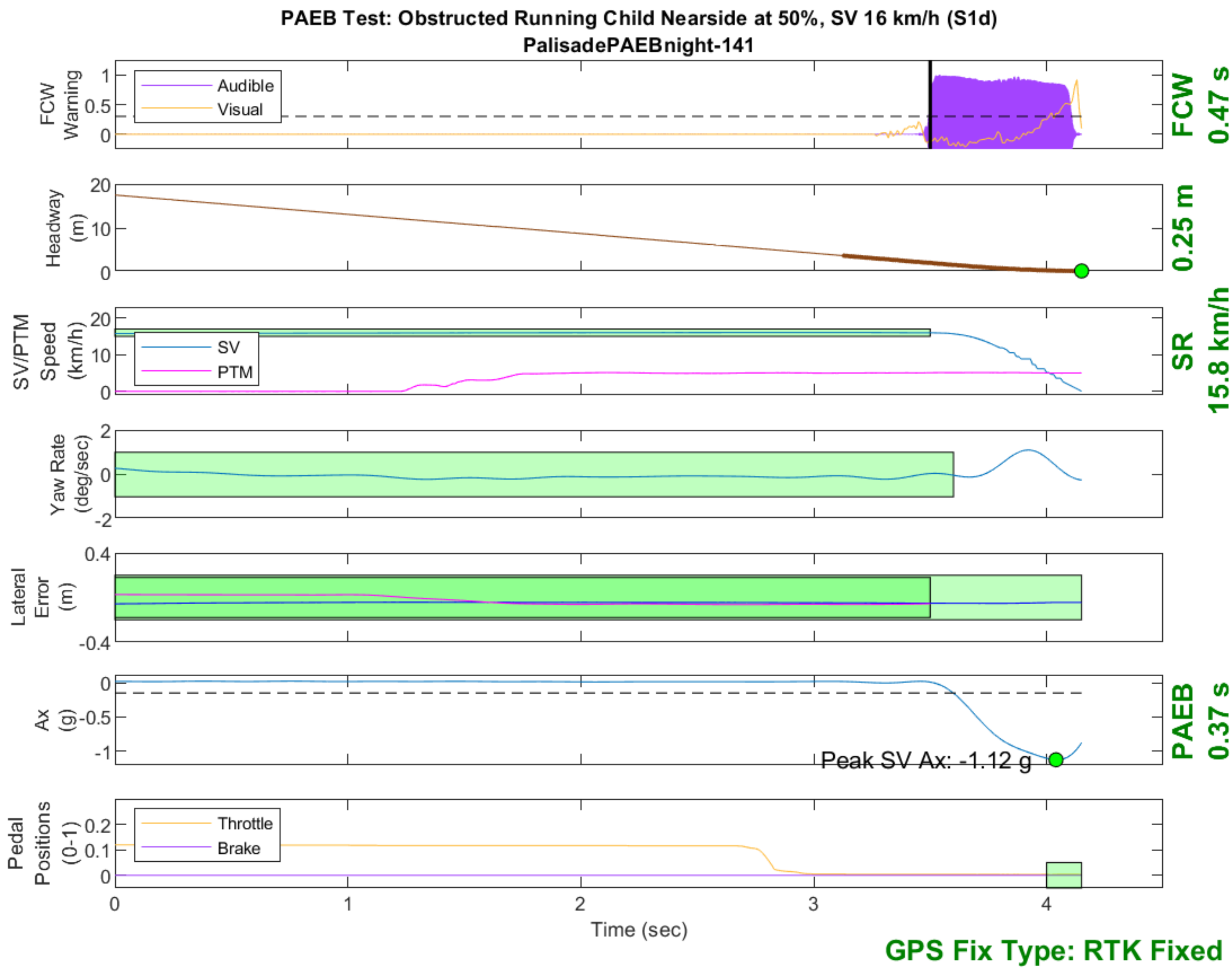


Figure D244. Time History for PAEB Run 141, S1d, Night, Low Beam, 16 km/h

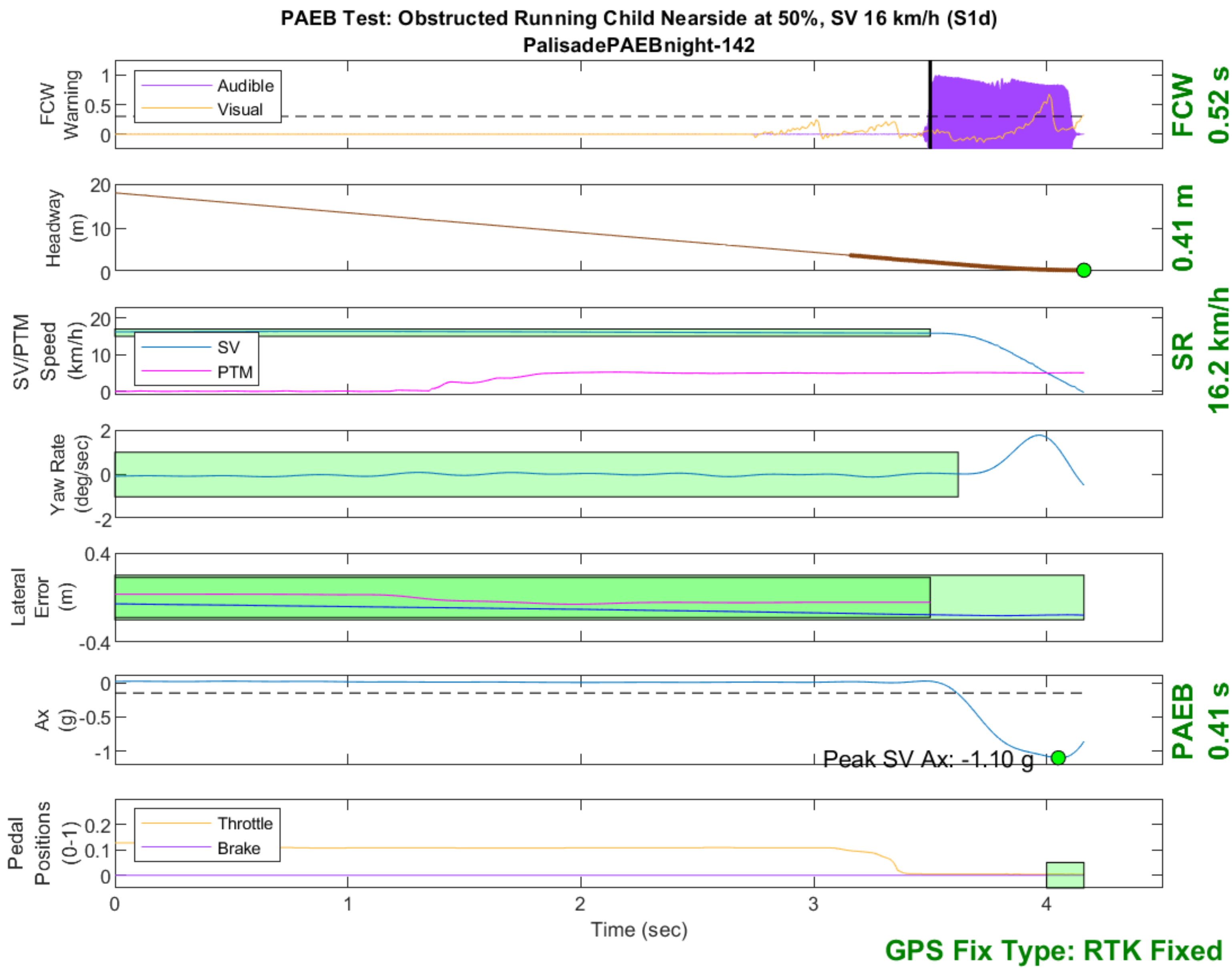


Figure D245. Time History for PAEB Run 142, S1d, Night, Low Beam, 16 km/h

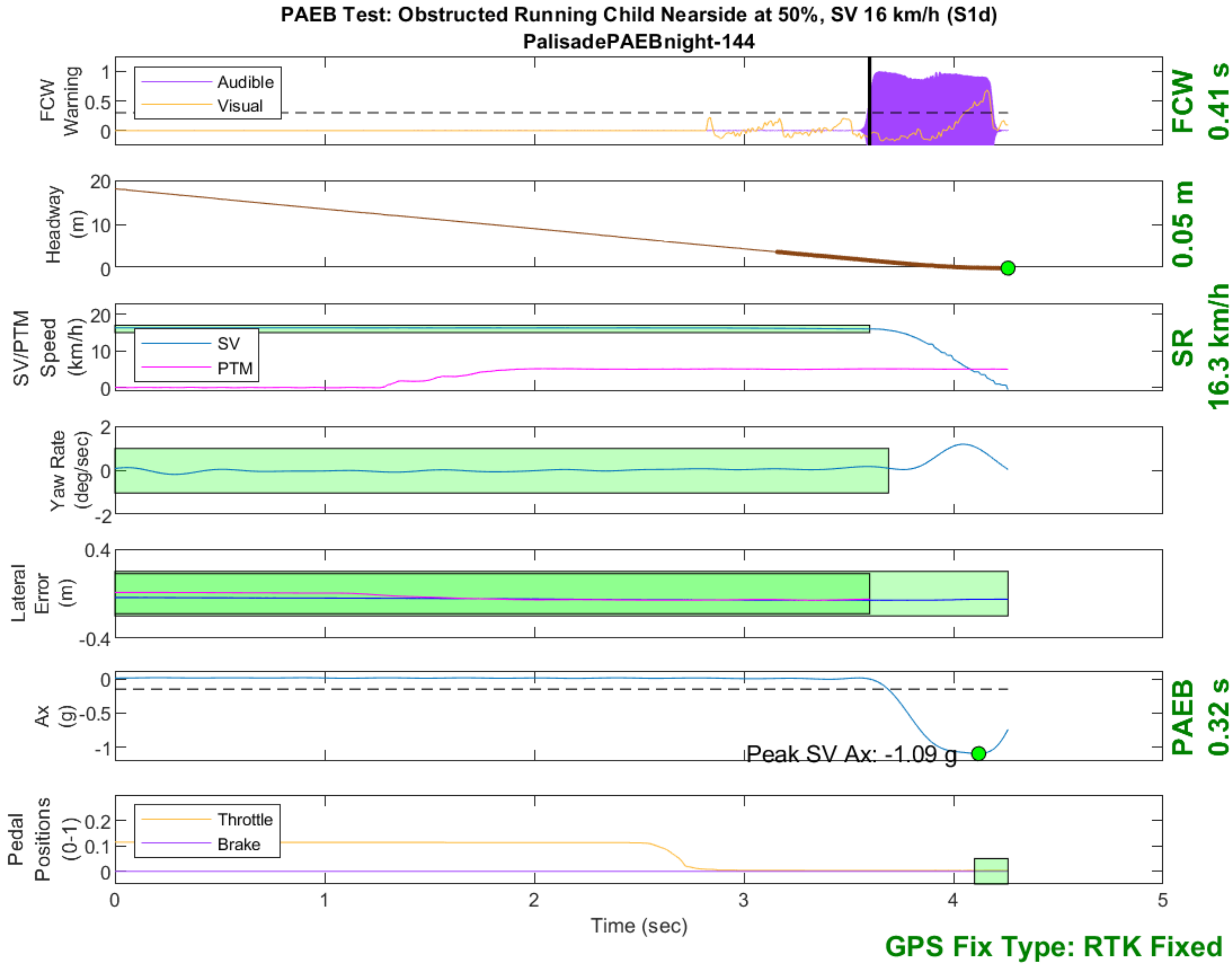


Figure D246. Time History for PAEB Run 144, S1d, Night, Low Beam, 16 km/h

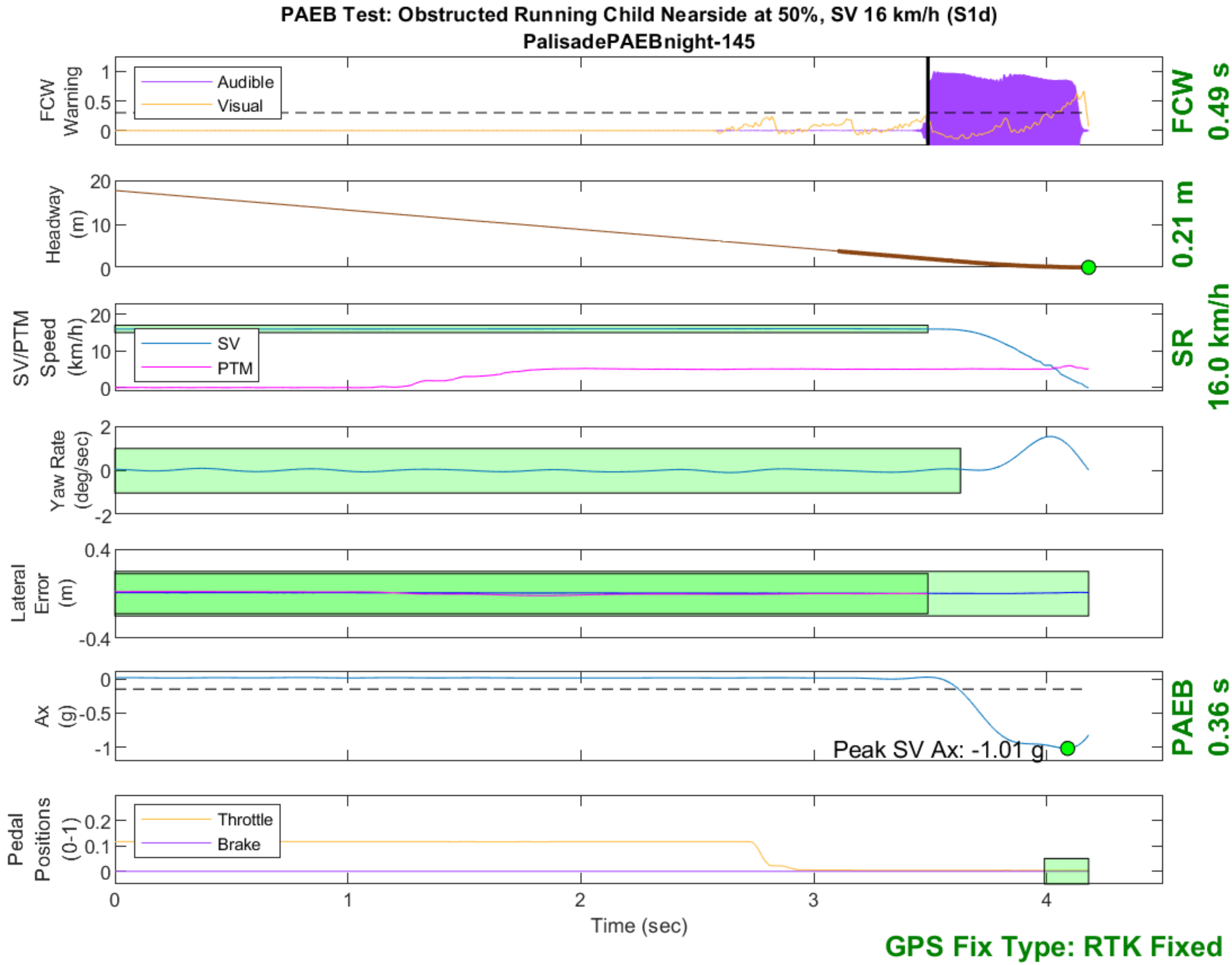


Figure D247. Time History for PAEB Run 145, S1d, Night, Low Beam, 16 km/h

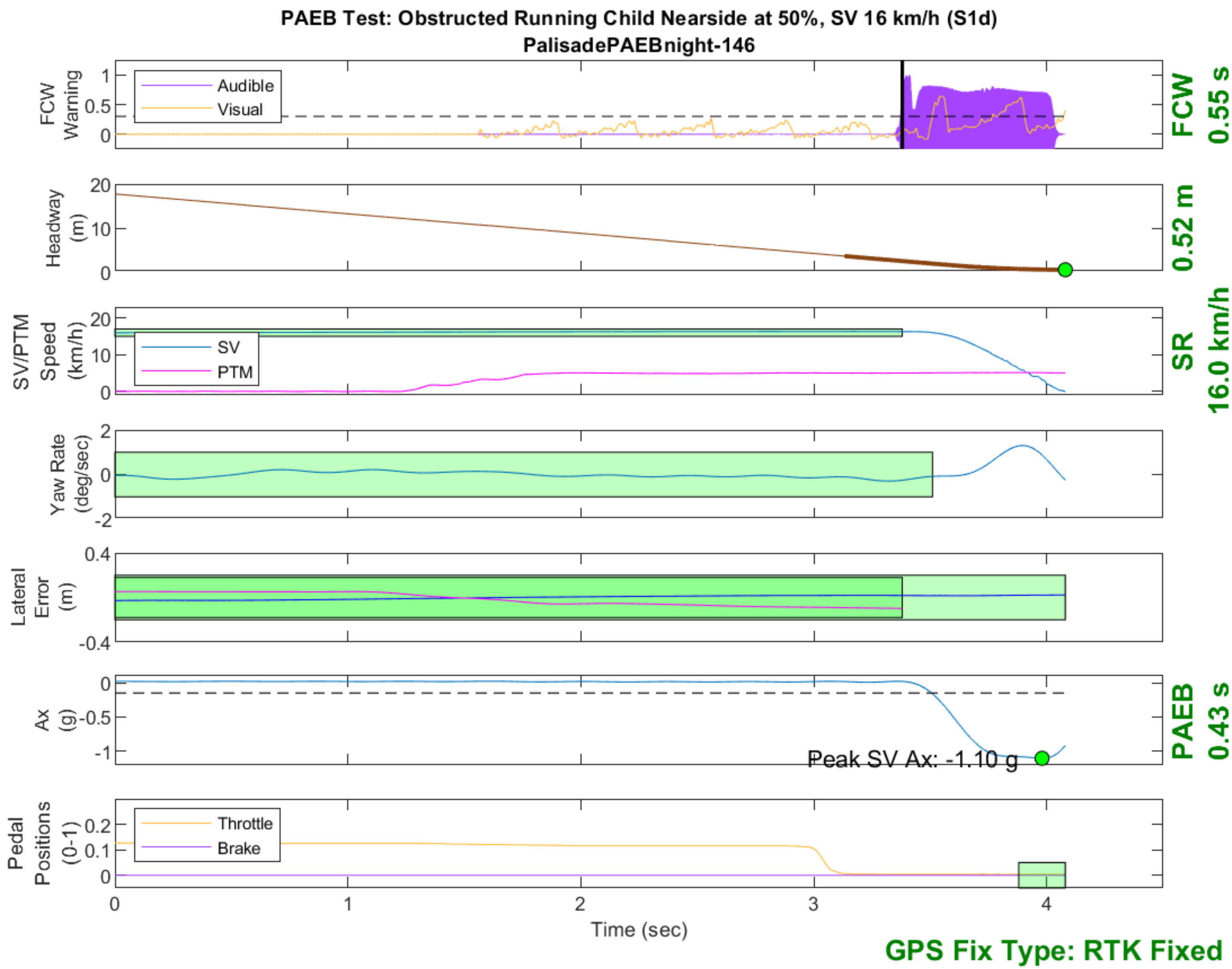


Figure D248. Time History for PAEB Run 146, S1d, Night, Low Beam, 16 km/h

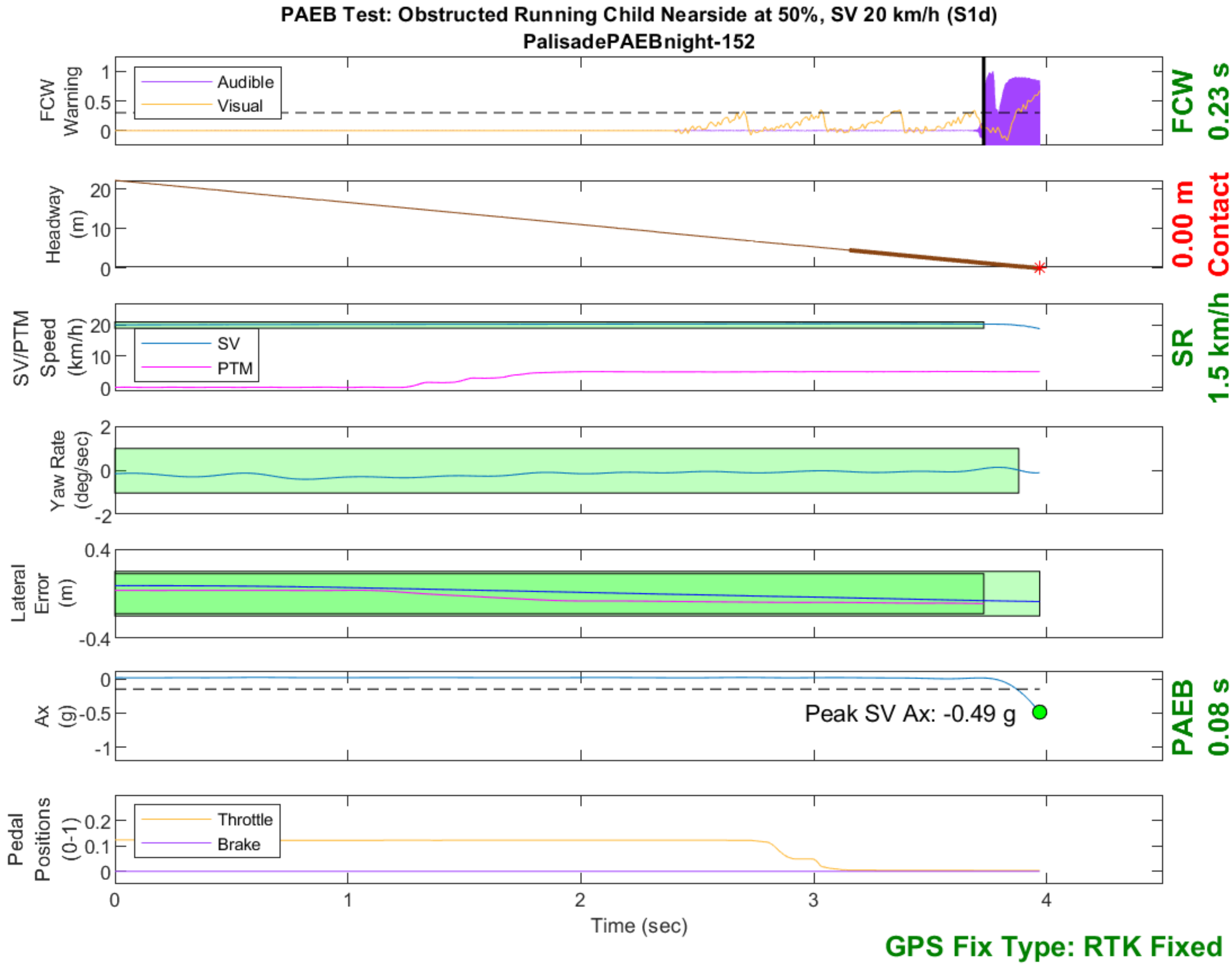


Figure D249. Time History for PAEB Run 152, S1d, Night, Low Beam, 20 km/h

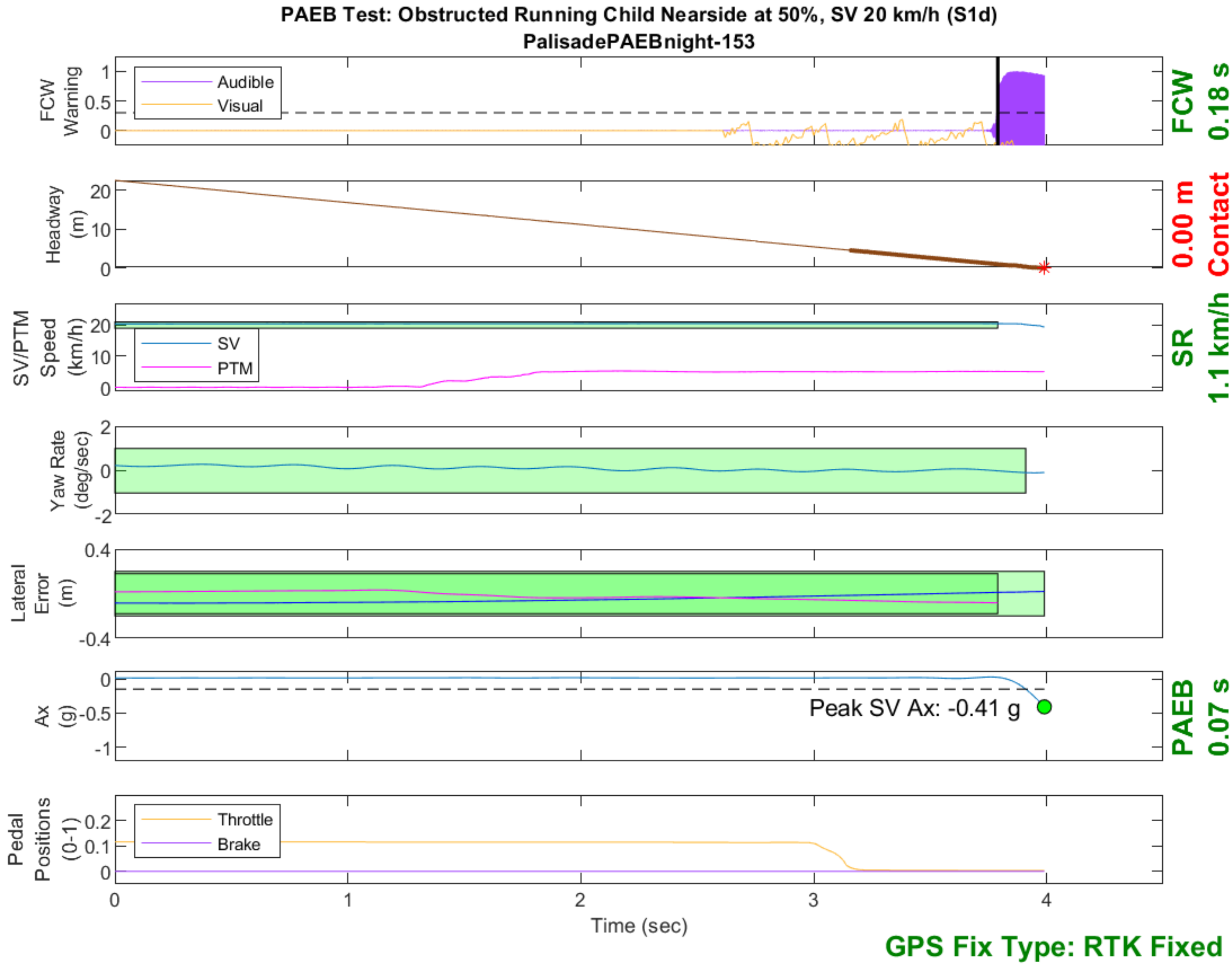


Figure D250. Time History for PAEB Run 153, S1d, Night, Low Beam, 20 km/h

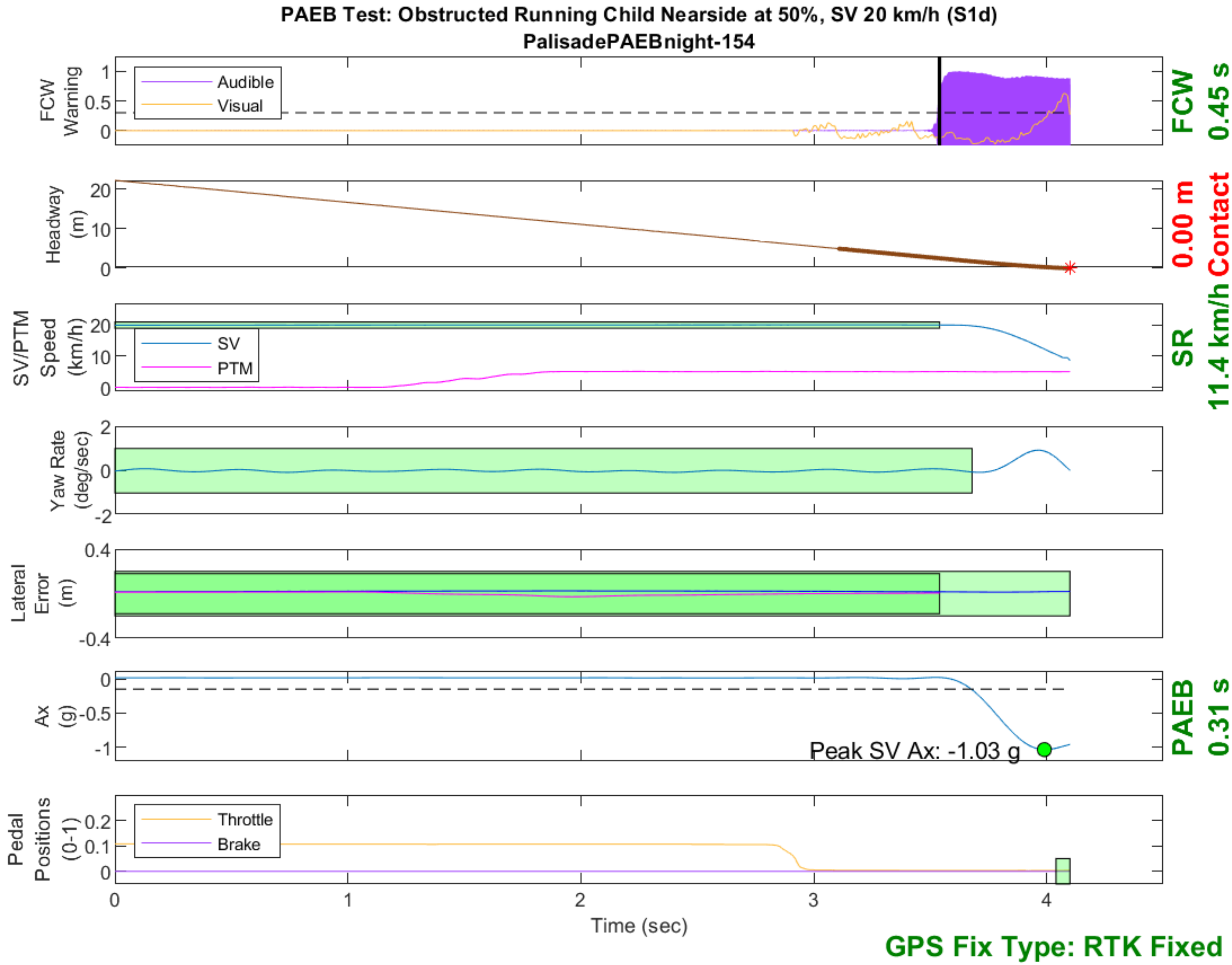


Figure D251. Time History for PAEB Run 154, S1d, Night, Low Beam, 20 km/h

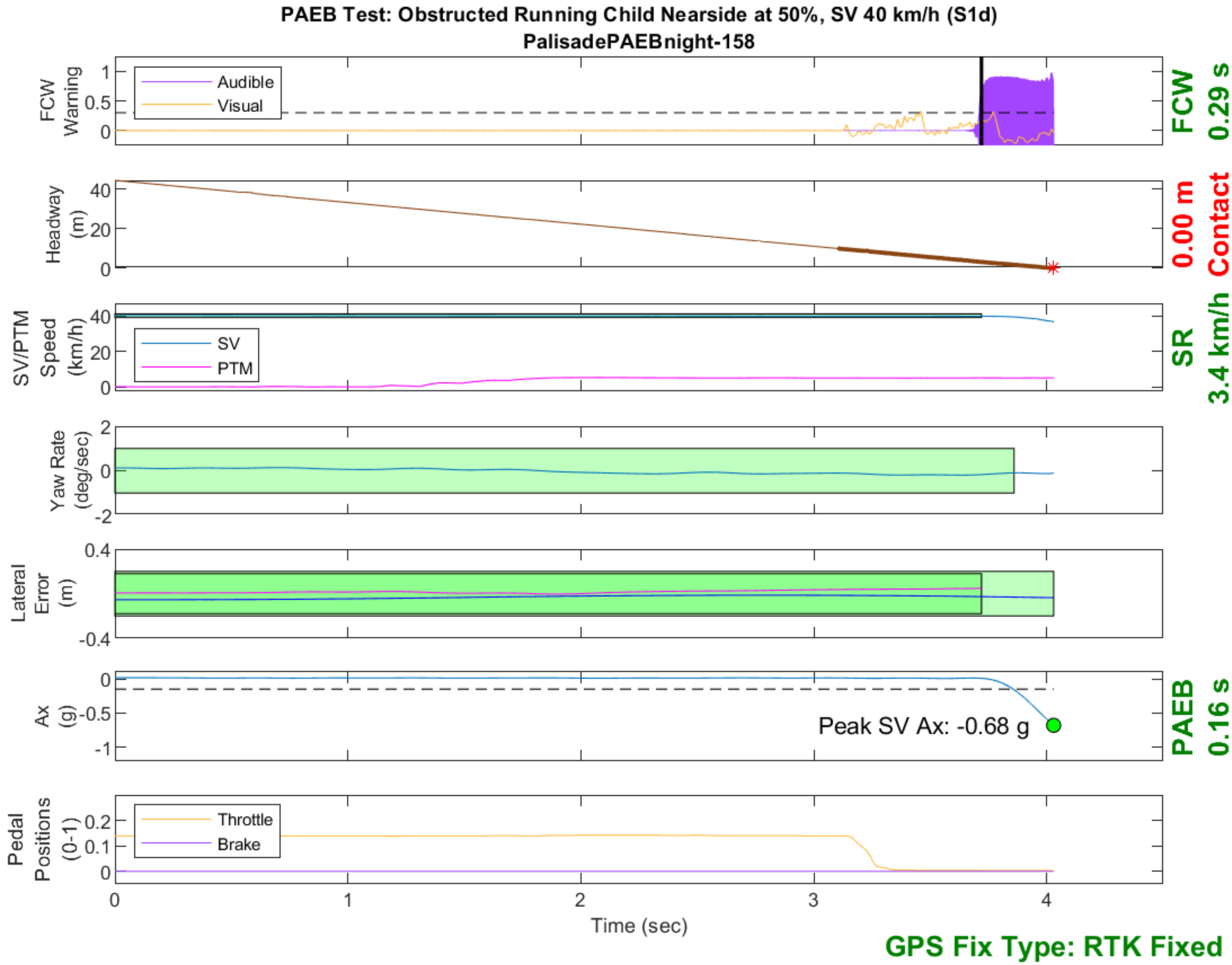


Figure D252. Time History for PAEB Run 158, S1d, Night, Low Beam, 40 km/h

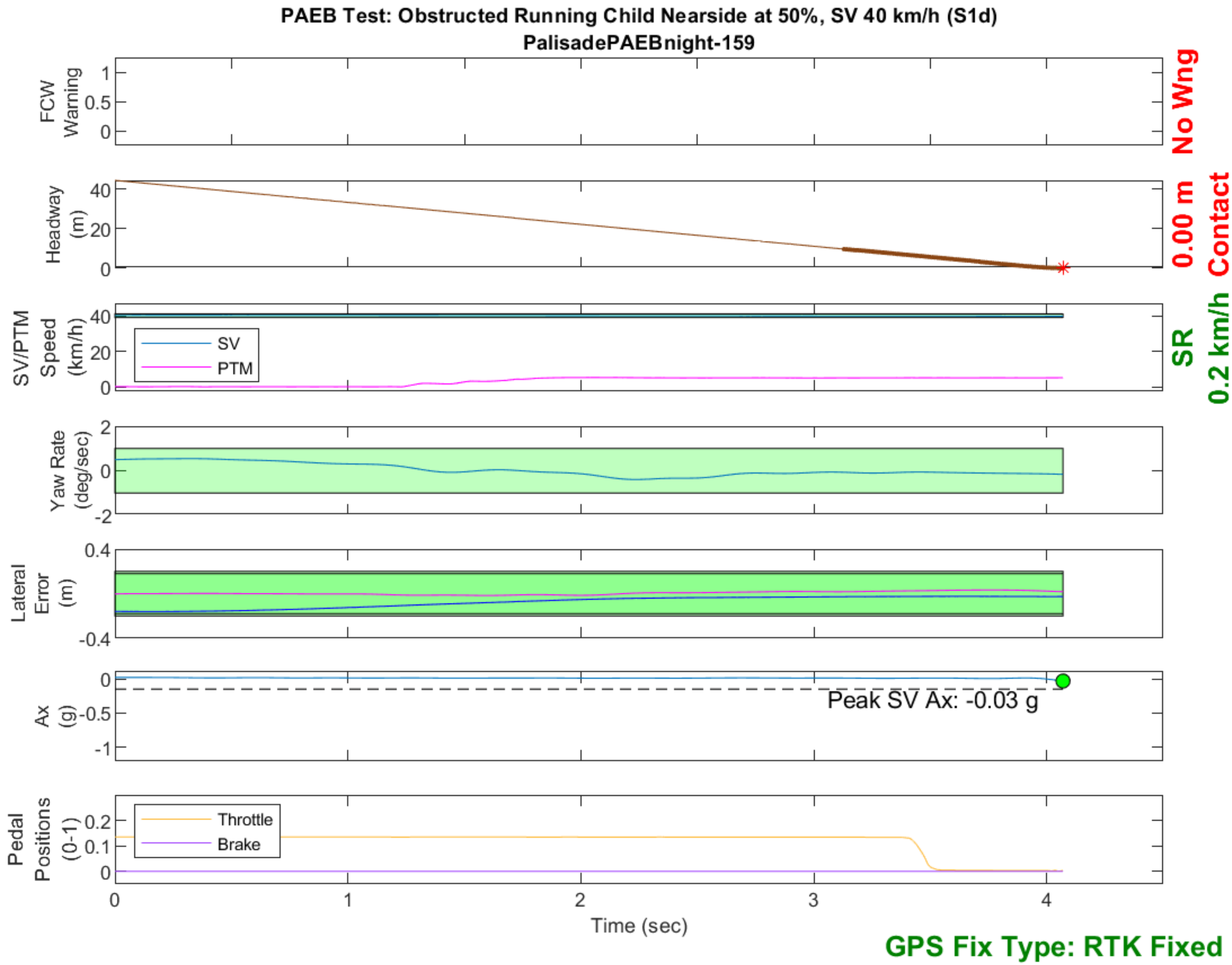


Figure D253. Time History for PAEB Run 159, S1d, Night, Low Beam, 40 km/h

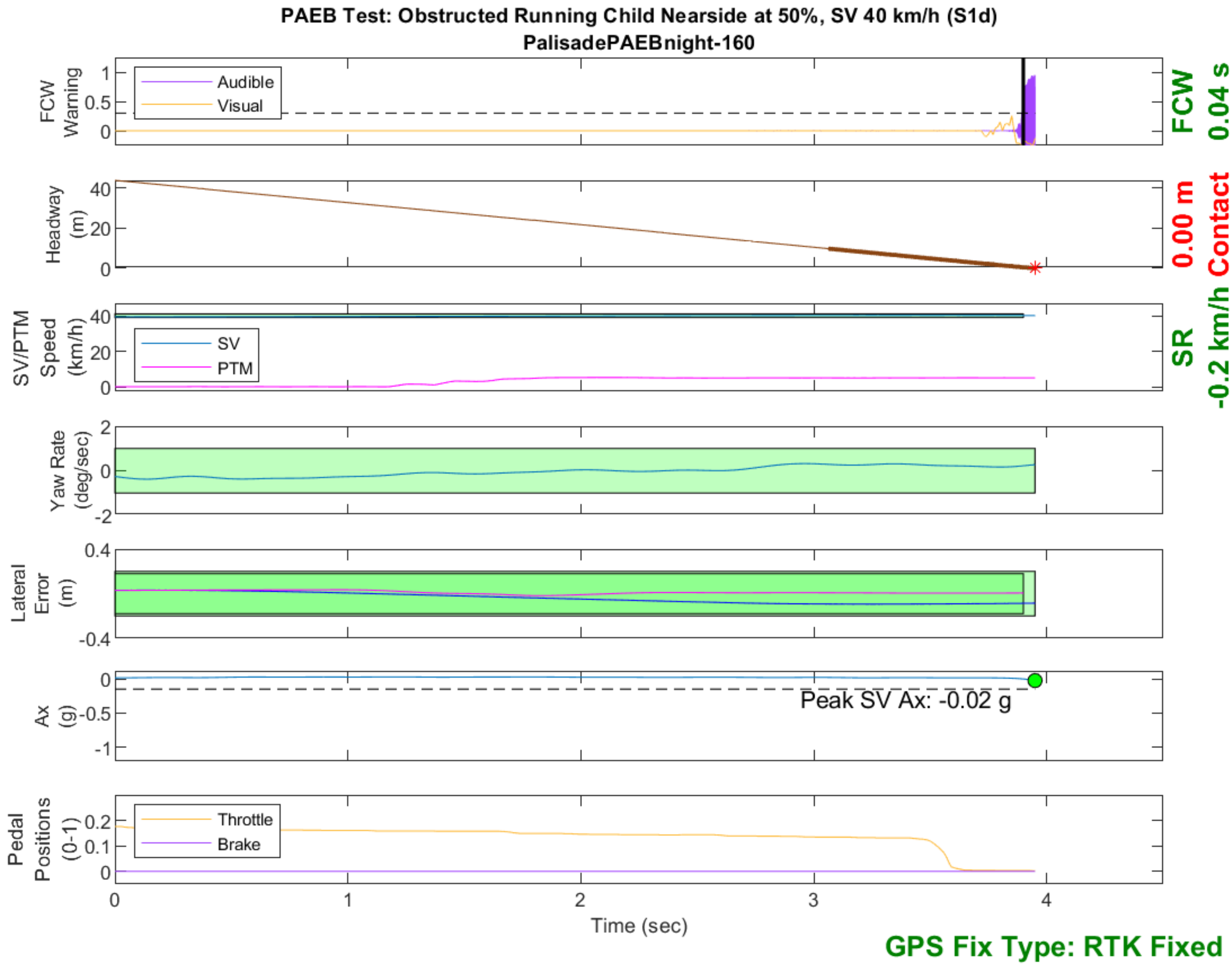


Figure D254. Time History for PAEB Run 160, S1d, Night, Low Beam, 40 km/h

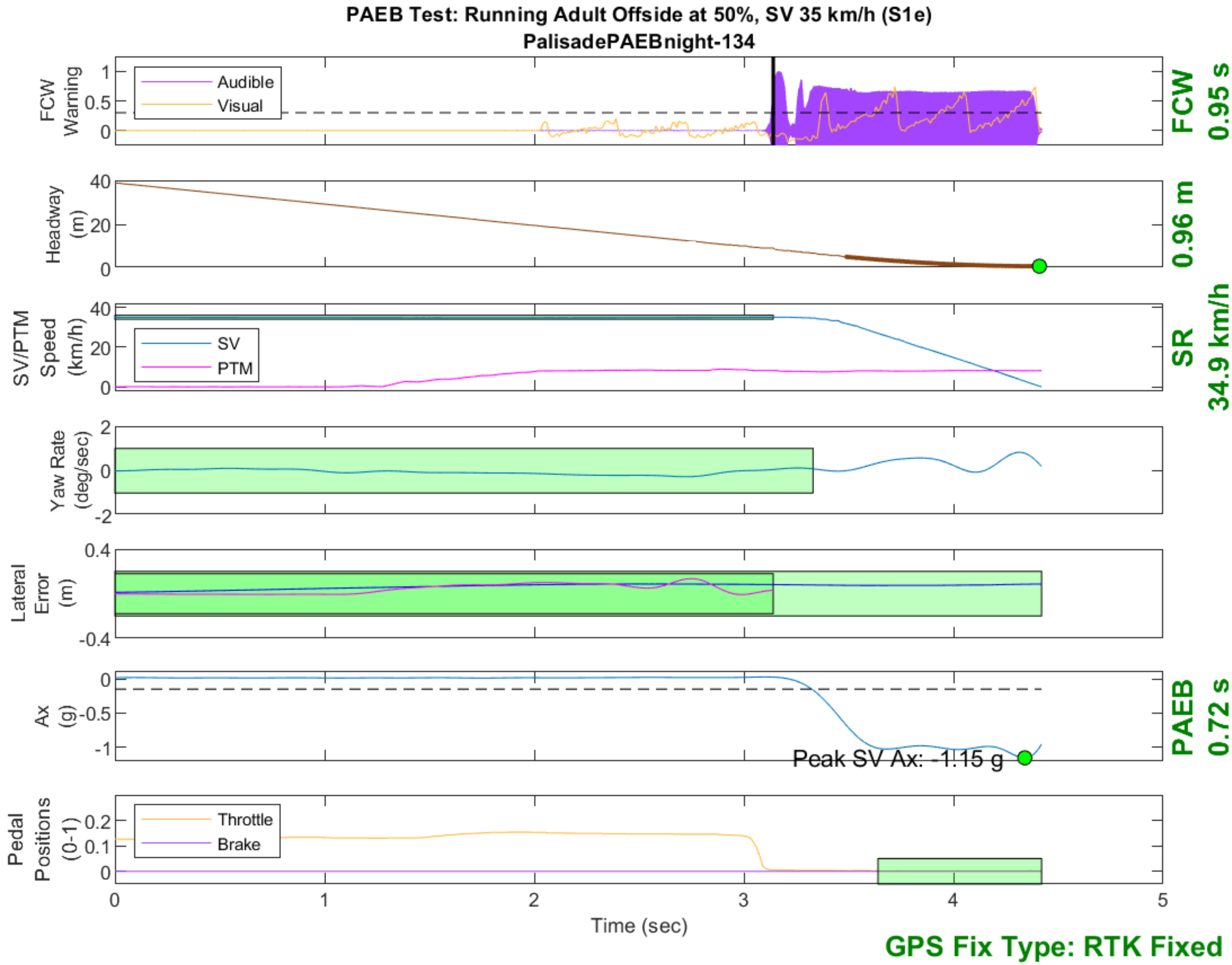


Figure D255. Time History for PAEB Run 134, S1e, Night, Low Beam, 35 km/h

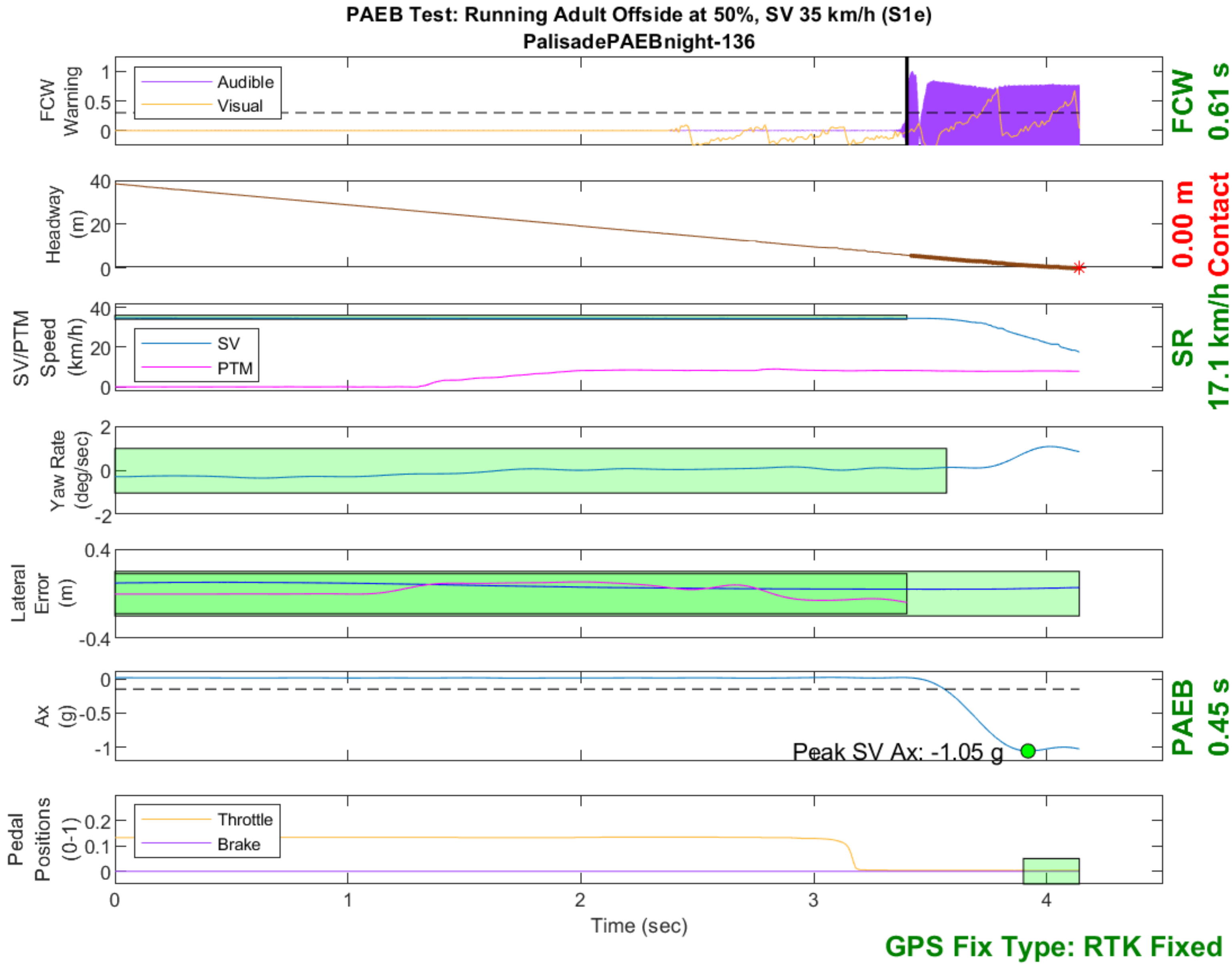


Figure D256. Time History for PAEB Run 136, S1e, Night, Low Beam, 35 km/h

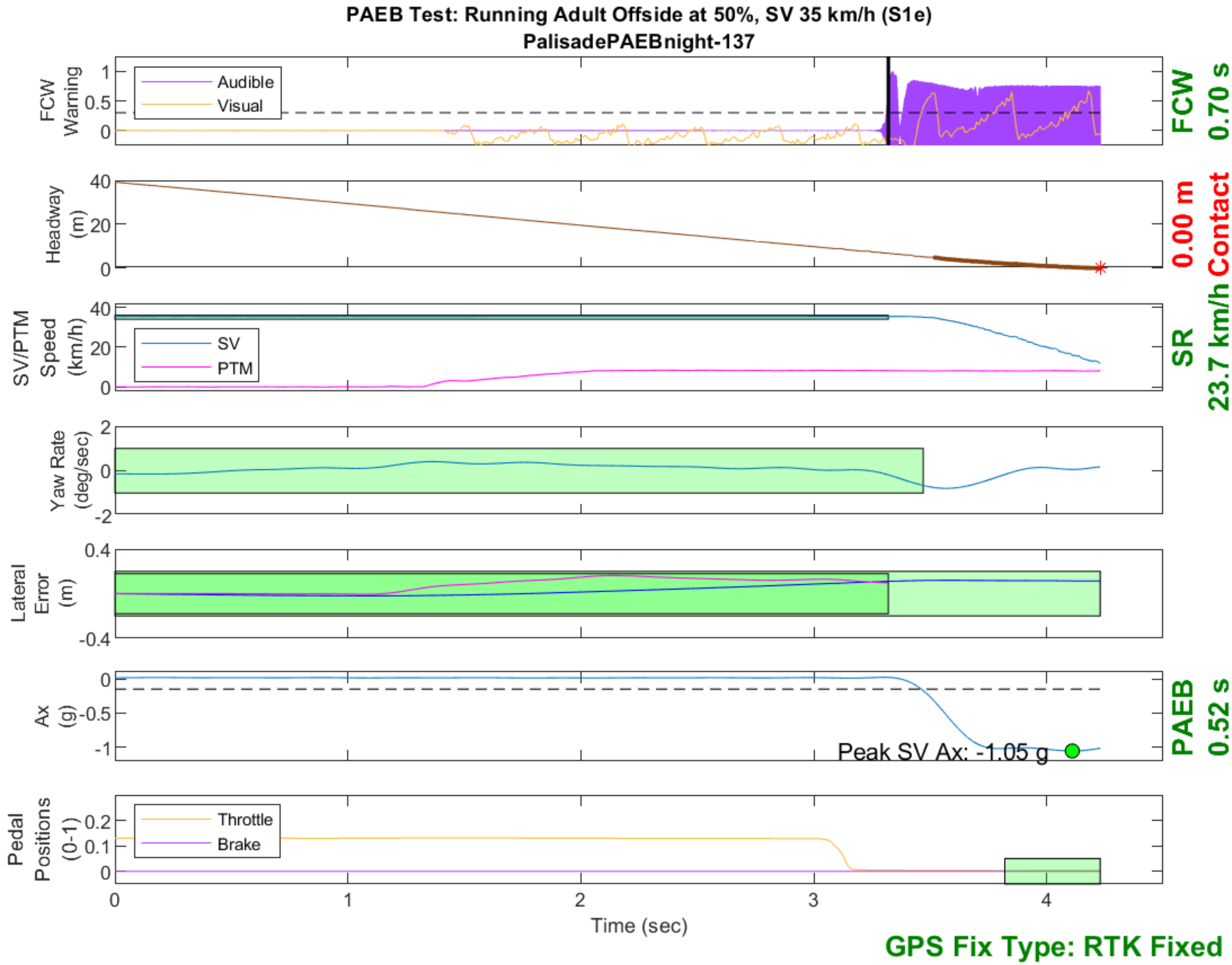


Figure D257. Time History for PAEB Run 137, S1e, Night, Low Beam, 35 km/h

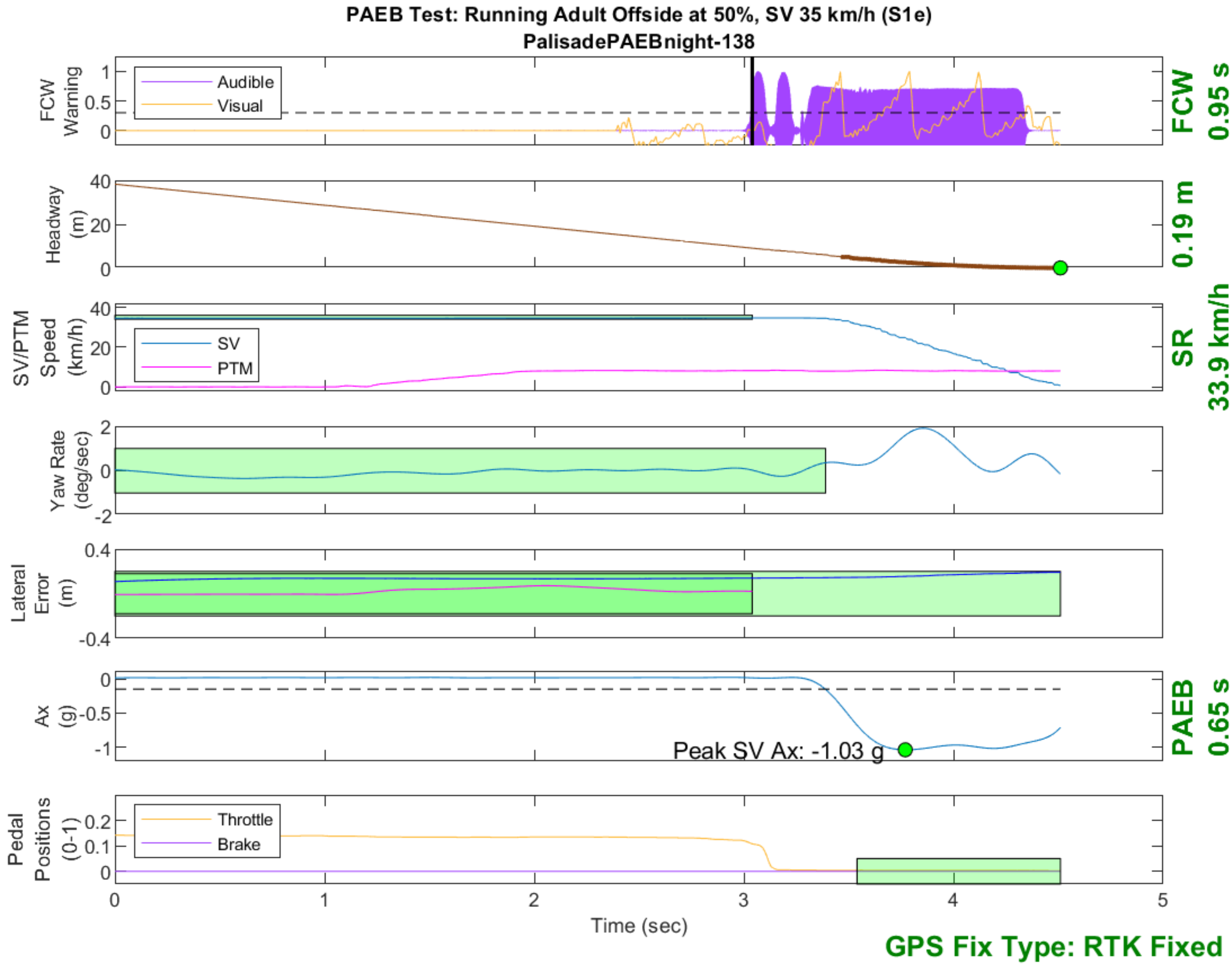


Figure D258. Time History for PAEB Run 138, S1e, Night, Low Beam, 35 km/h

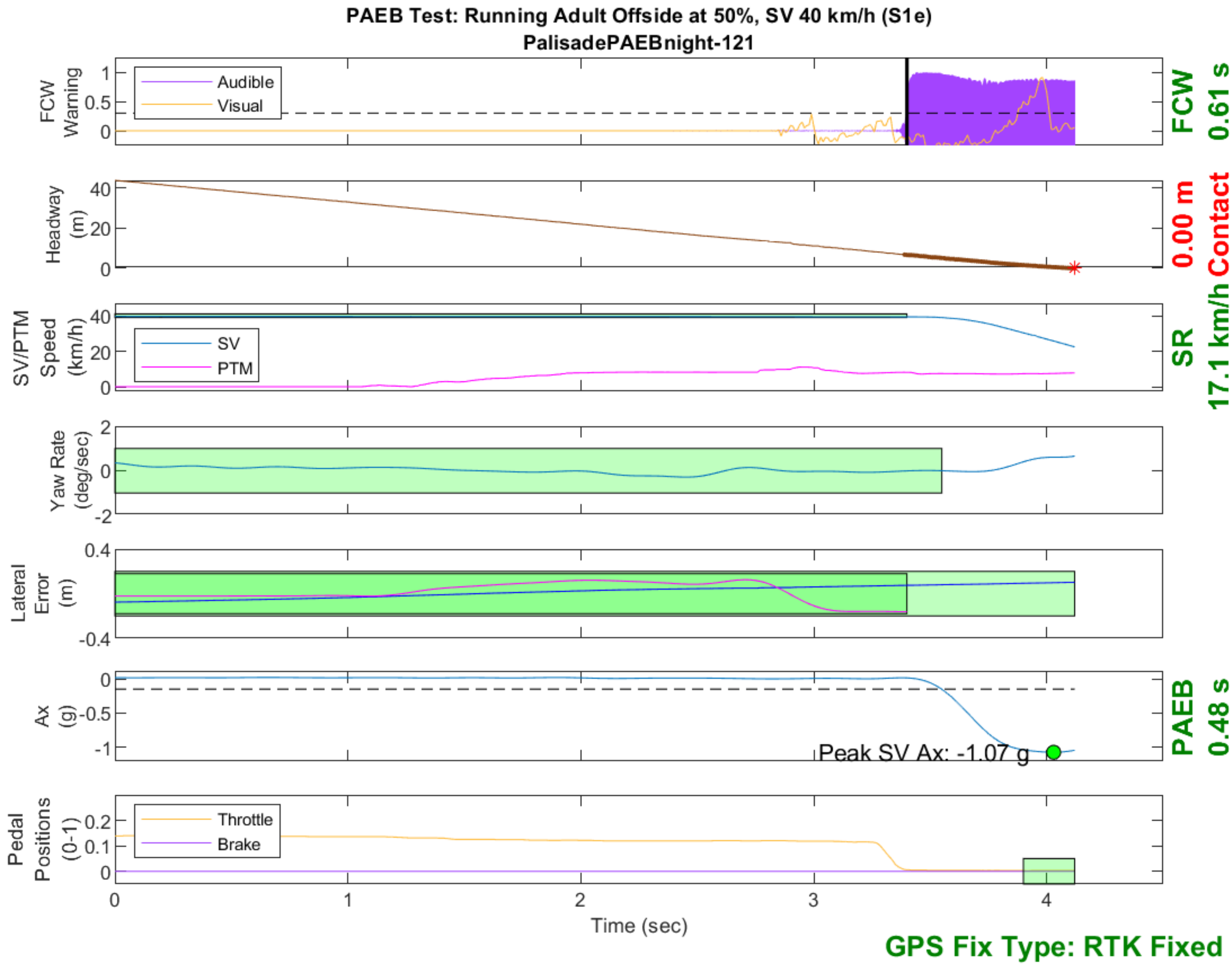


Figure D259. Time History for PAEB Run 121, S1e, Night, Low Beam, 40 km/h

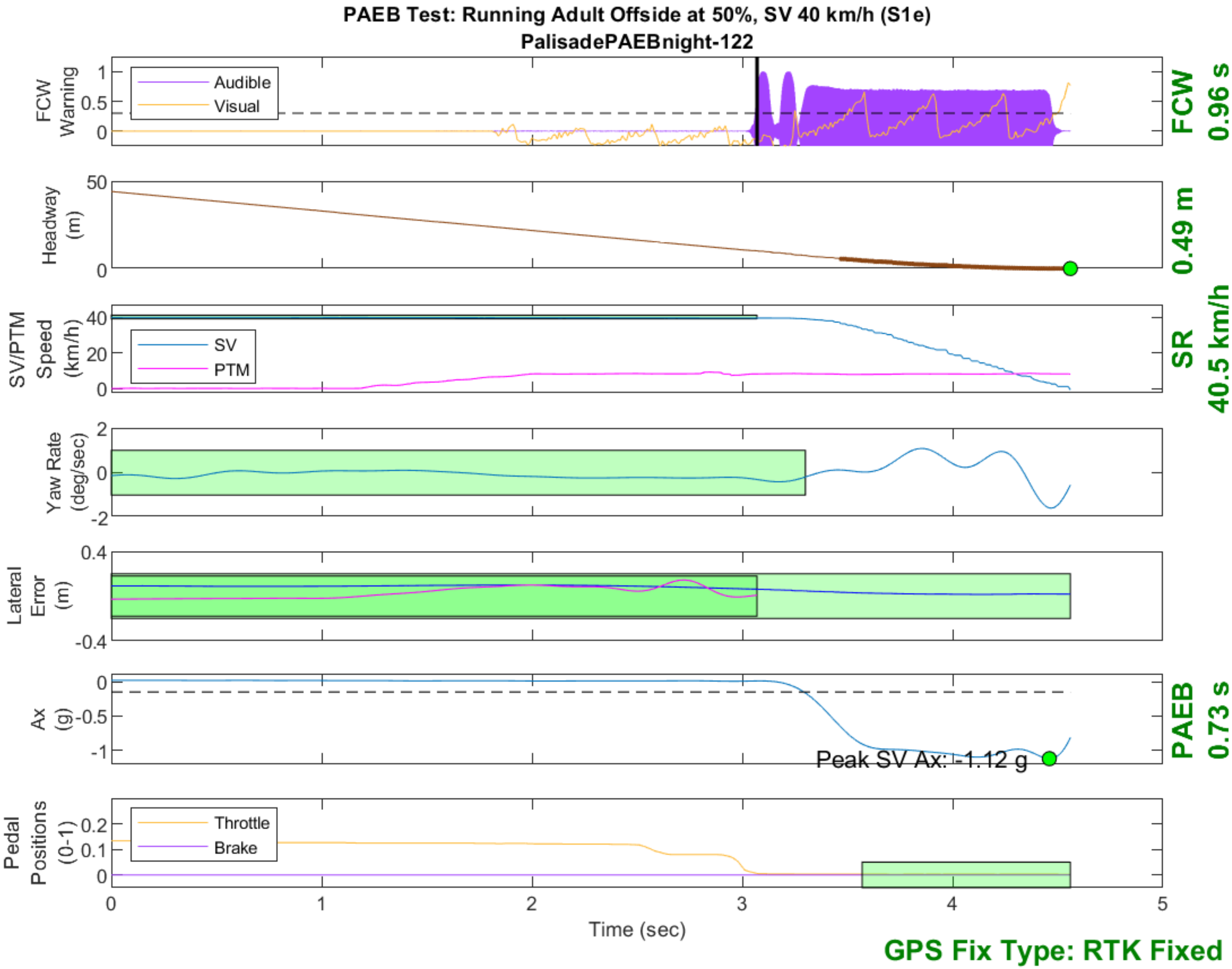


Figure D260. Time History for PAEB Run 122, S1e, Night, Low Beam, 40 km/h

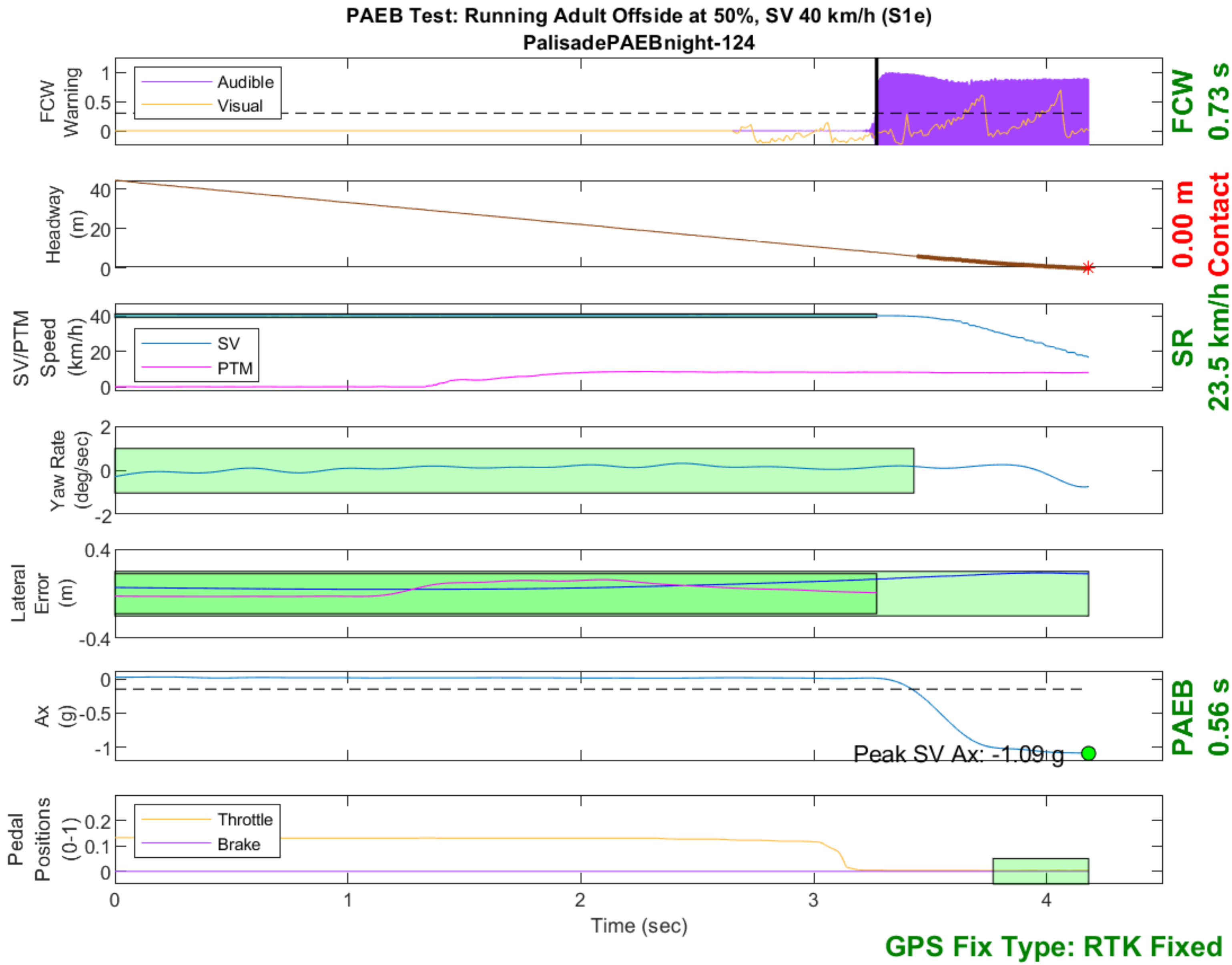


Figure D261. Time History for PAEB Run 124, S1e, Night, Low Beam, 40 km/h

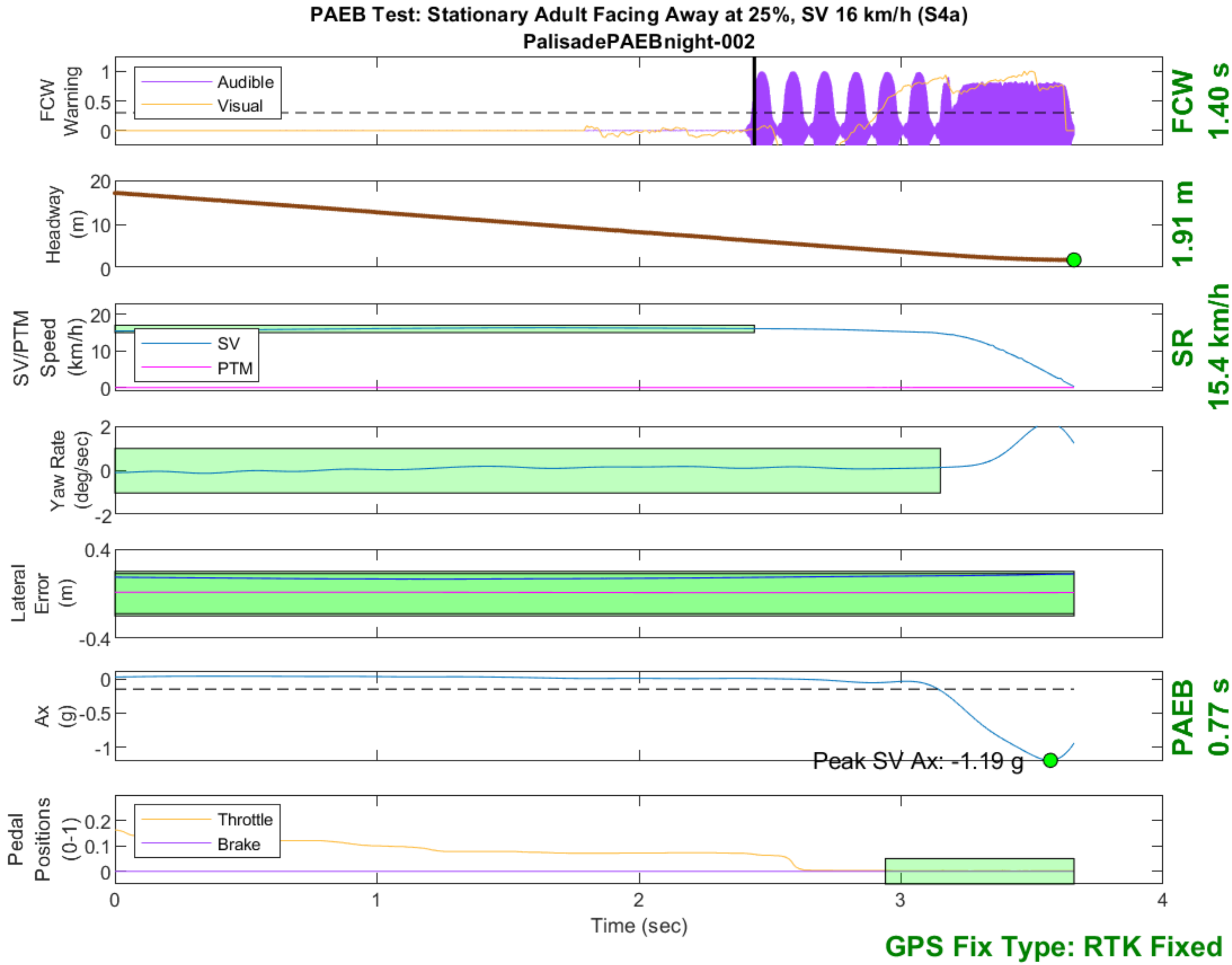


Figure D262. Time History for PAEB Run 2, S4a, Night, Low Beam, 16 km/h

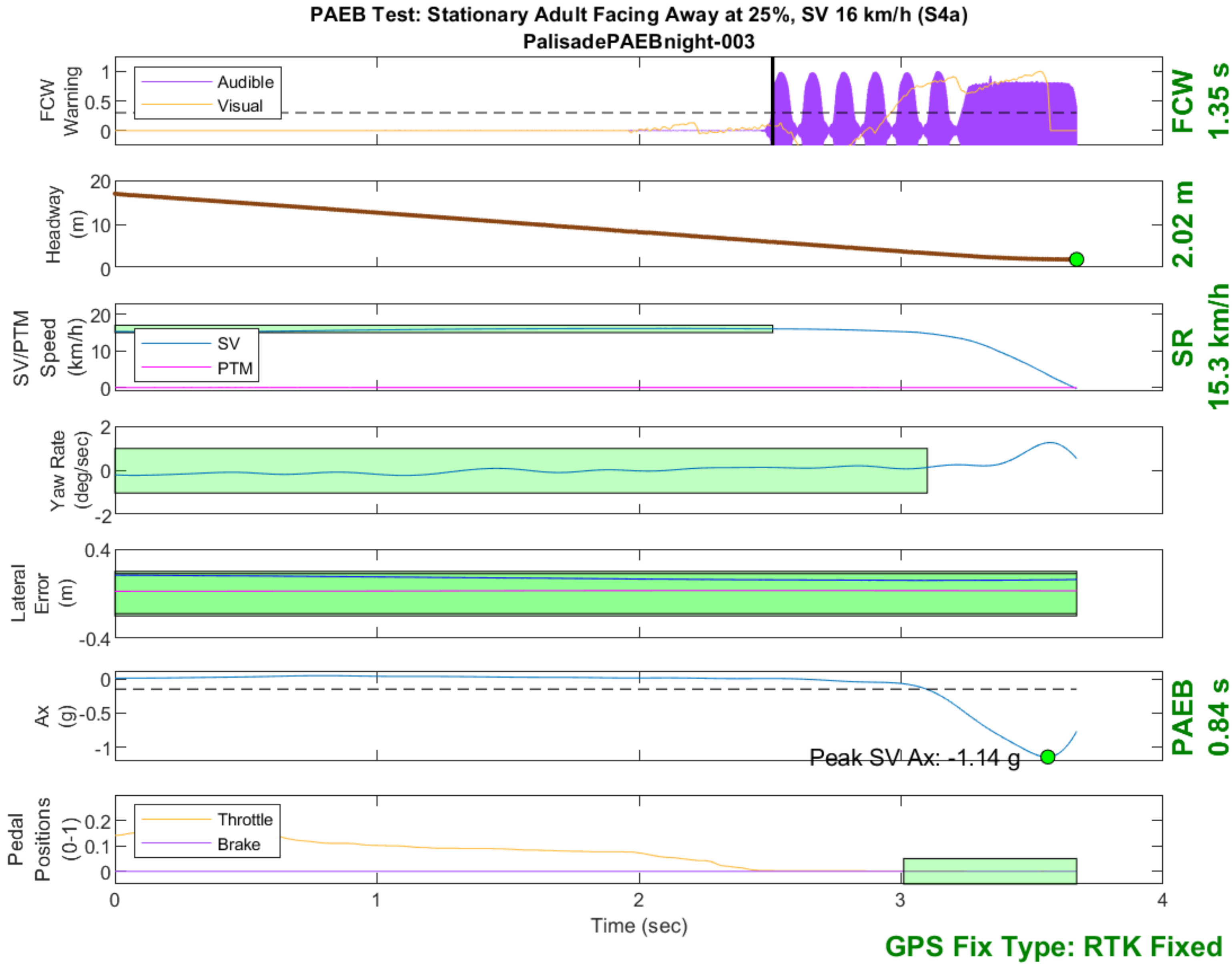


Figure D263. Time History for PAEB Run 3, S4a, Night, Low Beam, 16 km/h

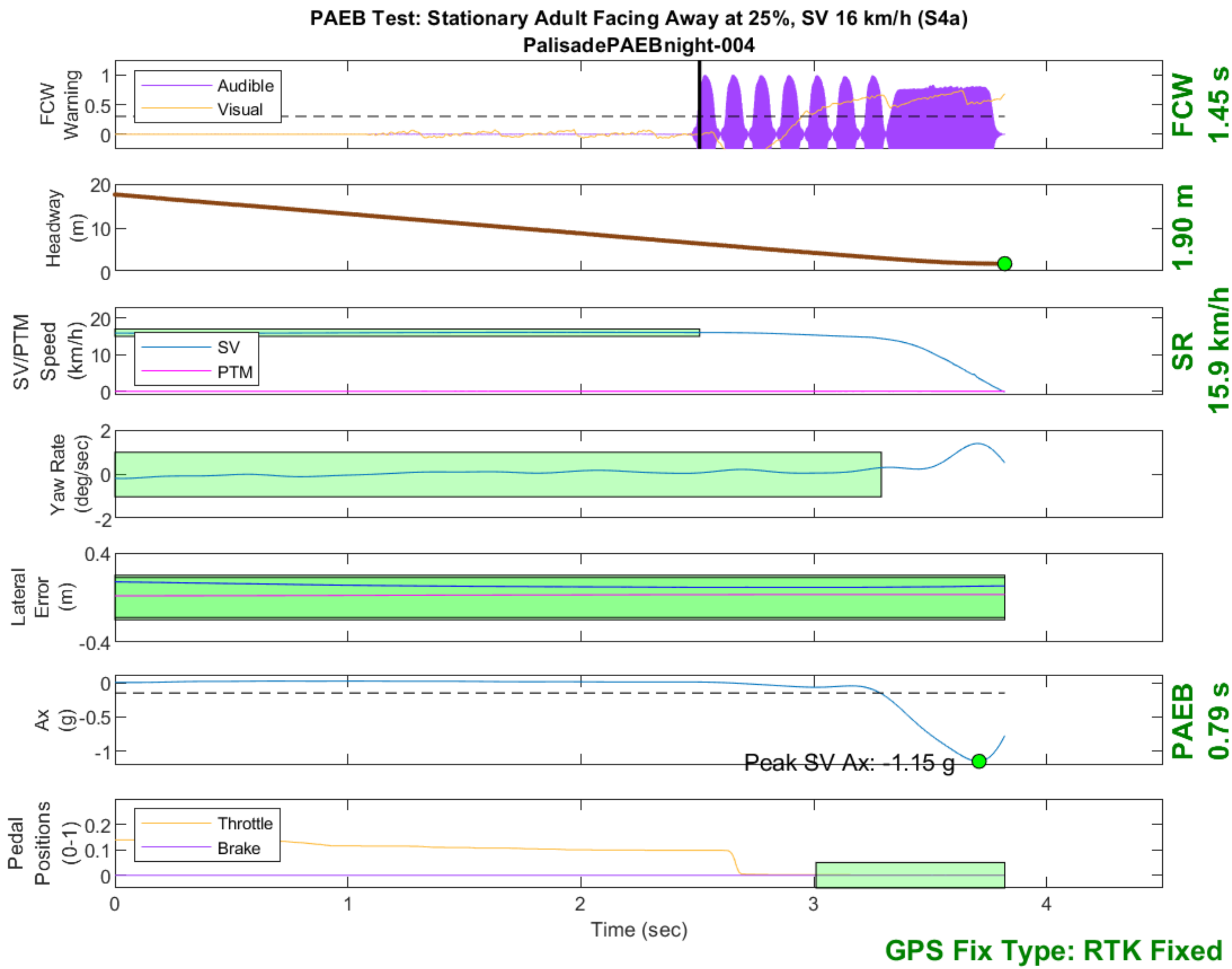


Figure D264. Time History for PAEB Run 4, S4a, Night, Low Beam, 16 km/h

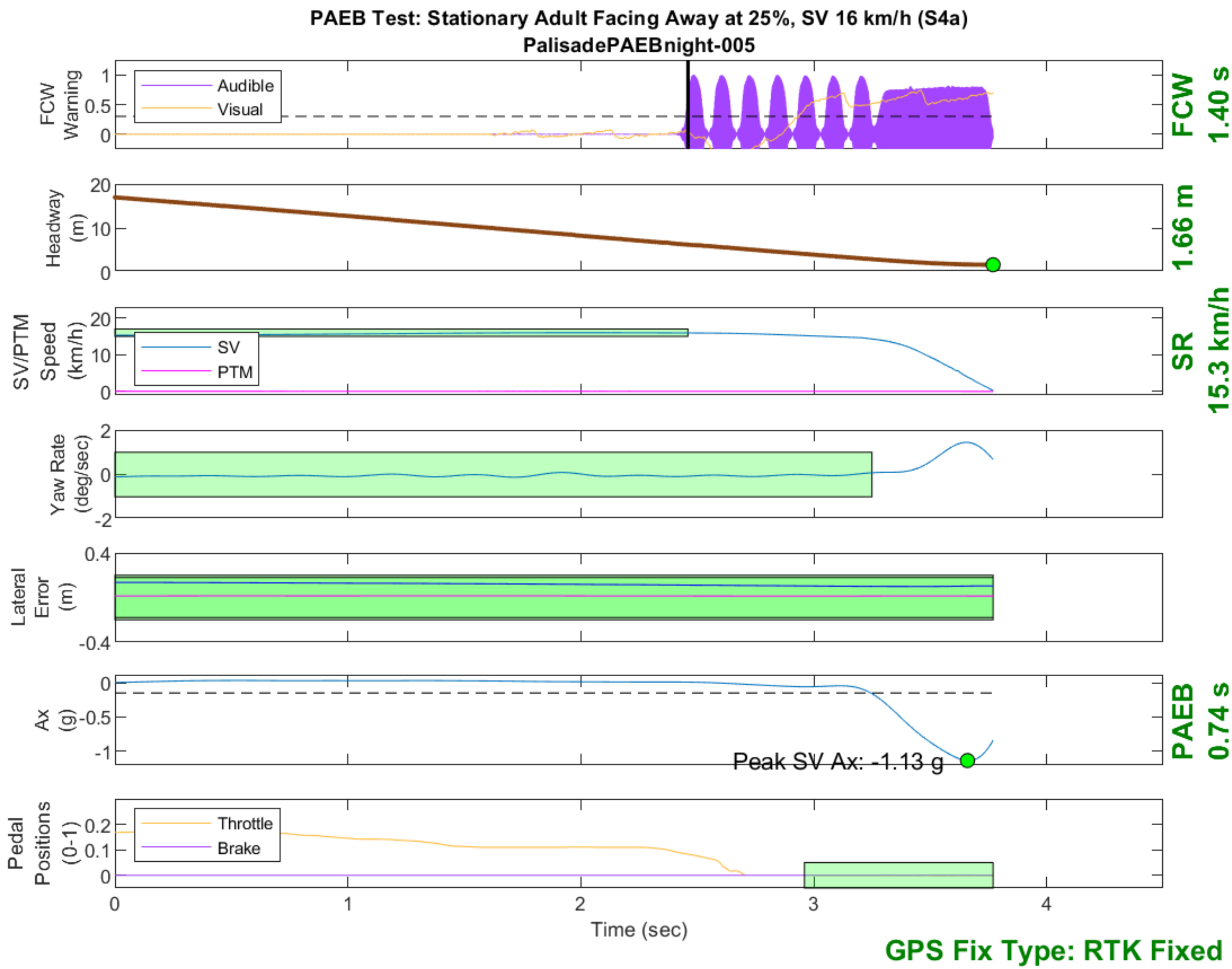


Figure D265. Time History for PAEB Run 5, S4a, Night, Low Beam, 16 km/h

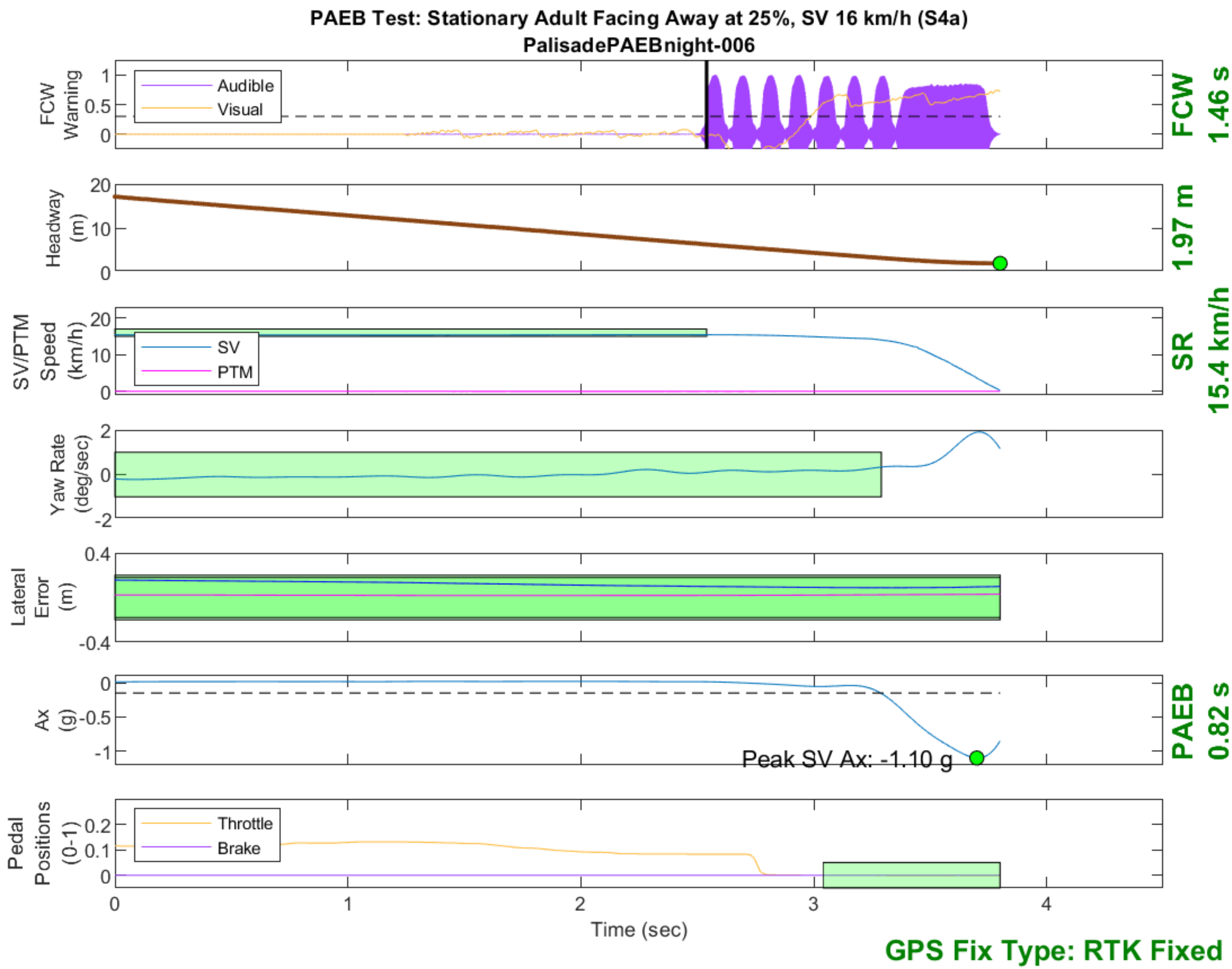


Figure D266. Time History for PAEB Run 6, S4a, Night, Low Beam, 16 km/h

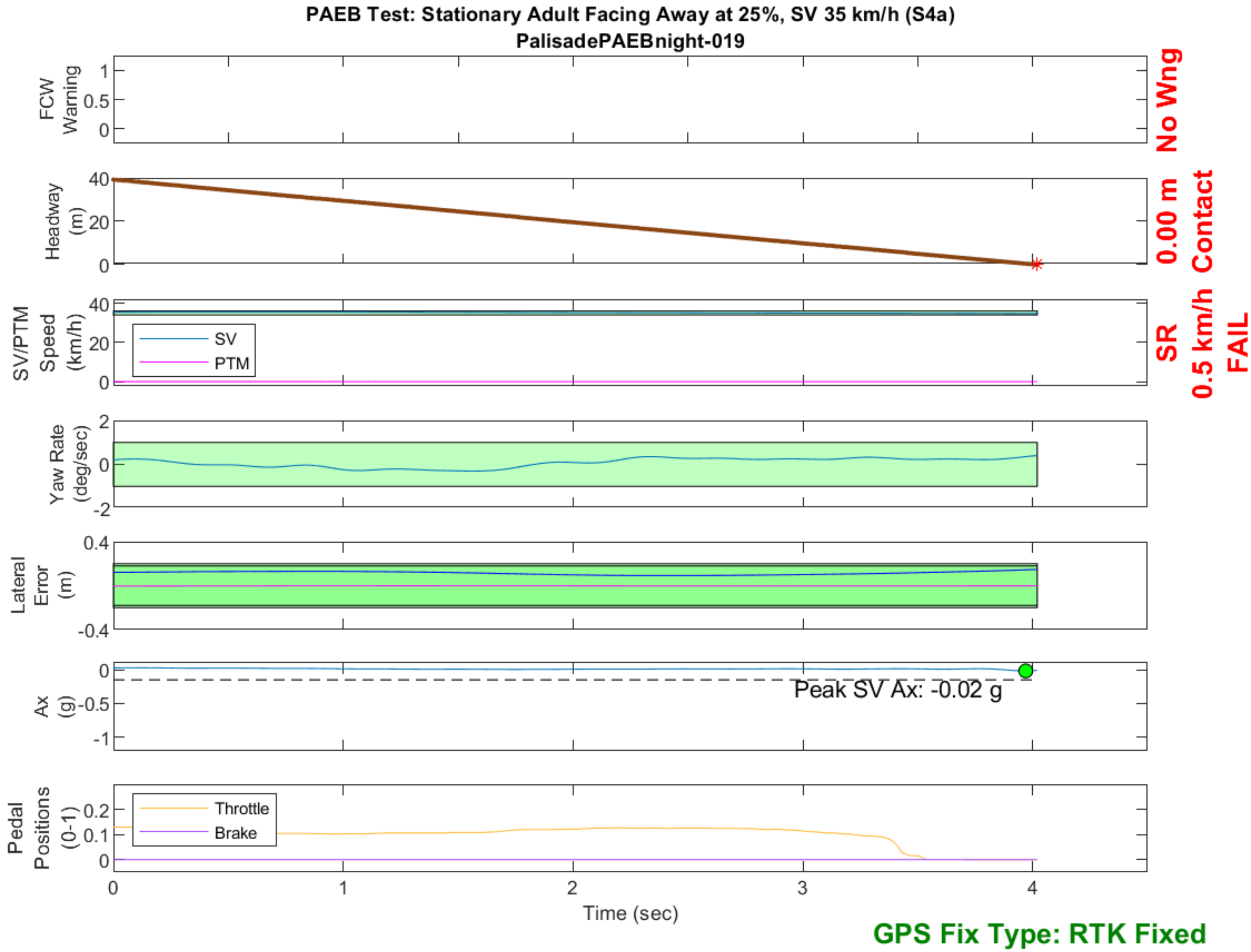


Figure D267. Time History for PAEB Run 19, S4a, Night, Low Beam, 35 km/h

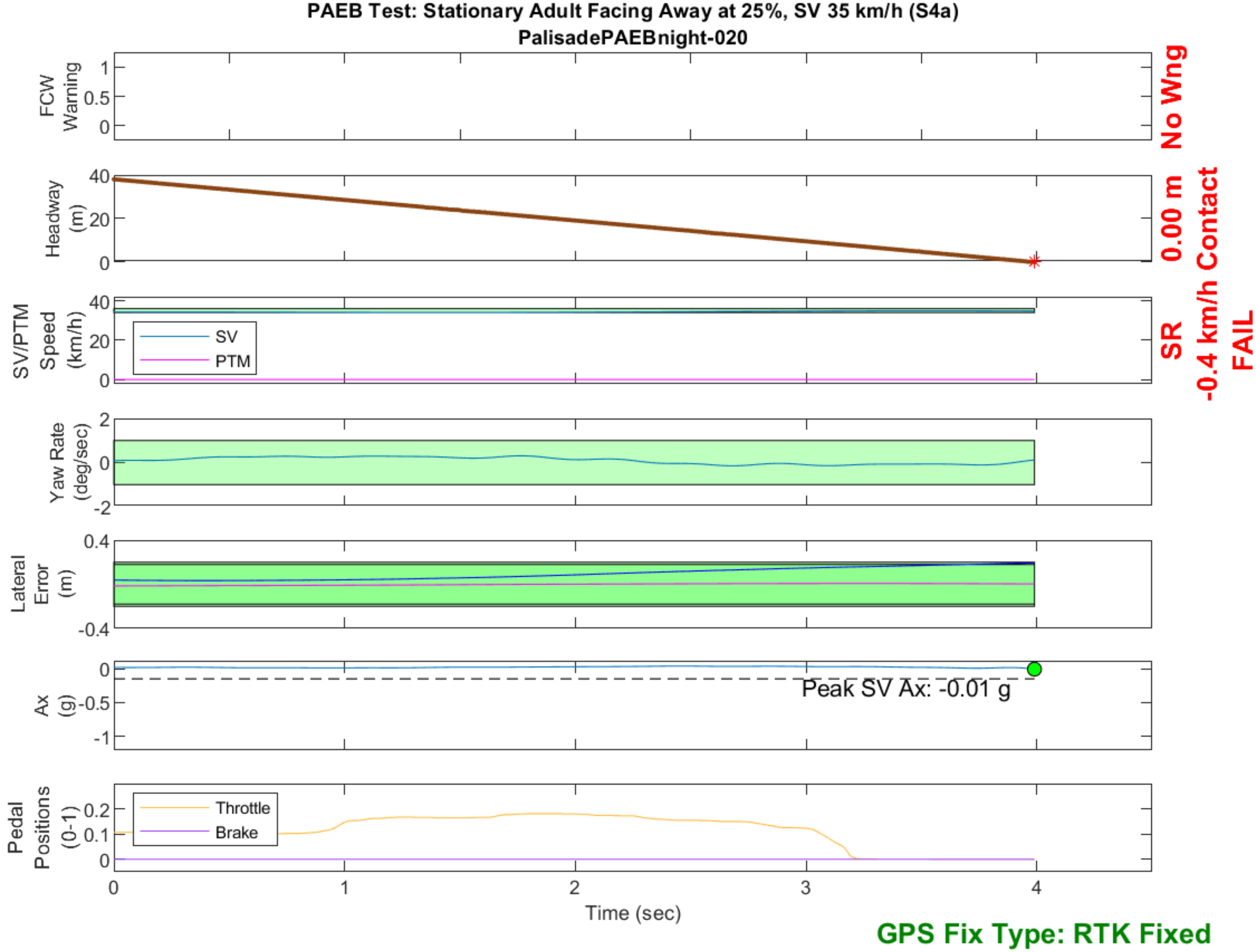


Figure D268. Time History for PAEB Run 20, S4a, Night, Low Beam, 35 km/h

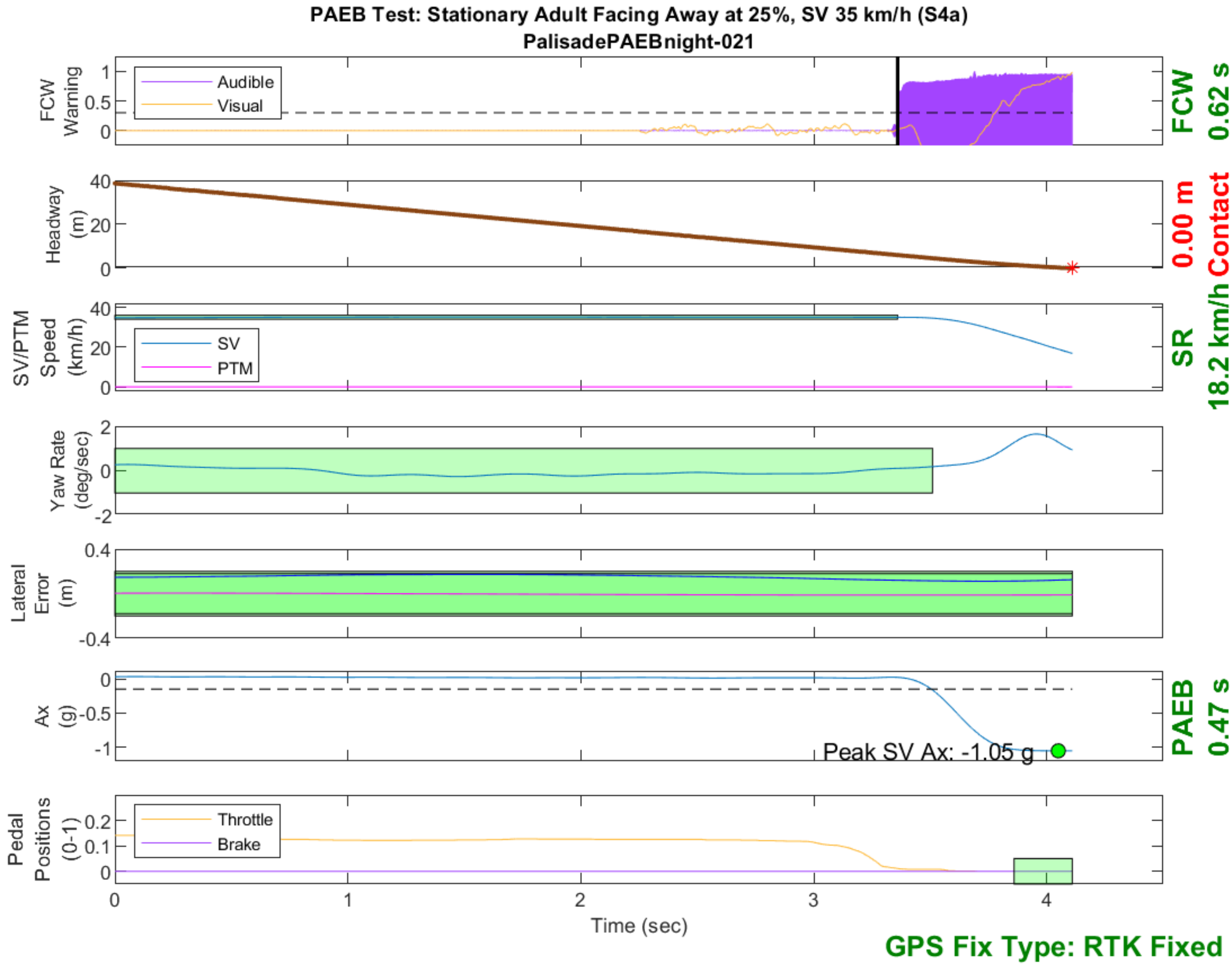


Figure D269. Time History for PAEB Run 21, S4a, Night, Low Beam, 35 km/h

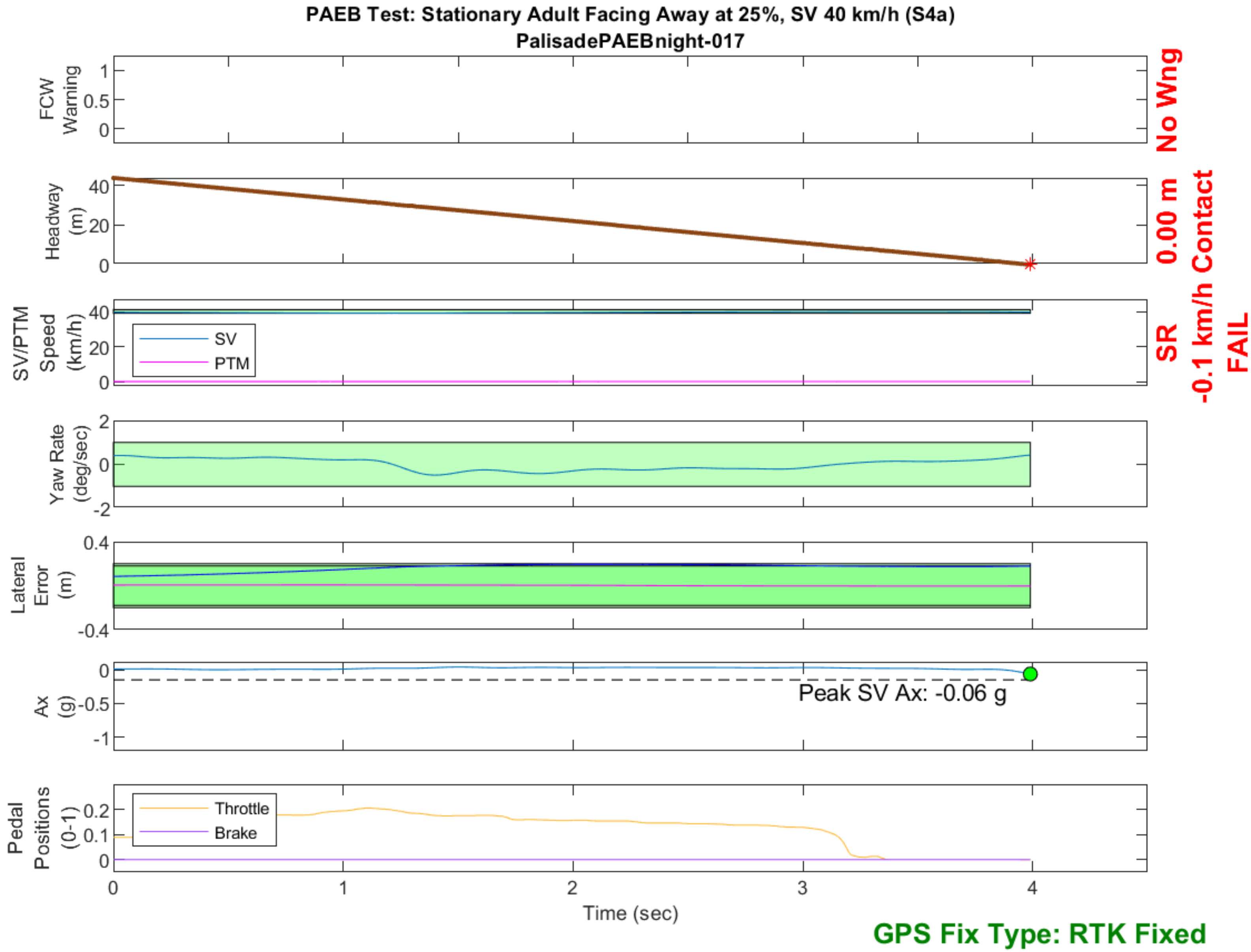


Figure D270. Time History for PAEB Run 17, S4a, Night, Low Beam, 40 km/h

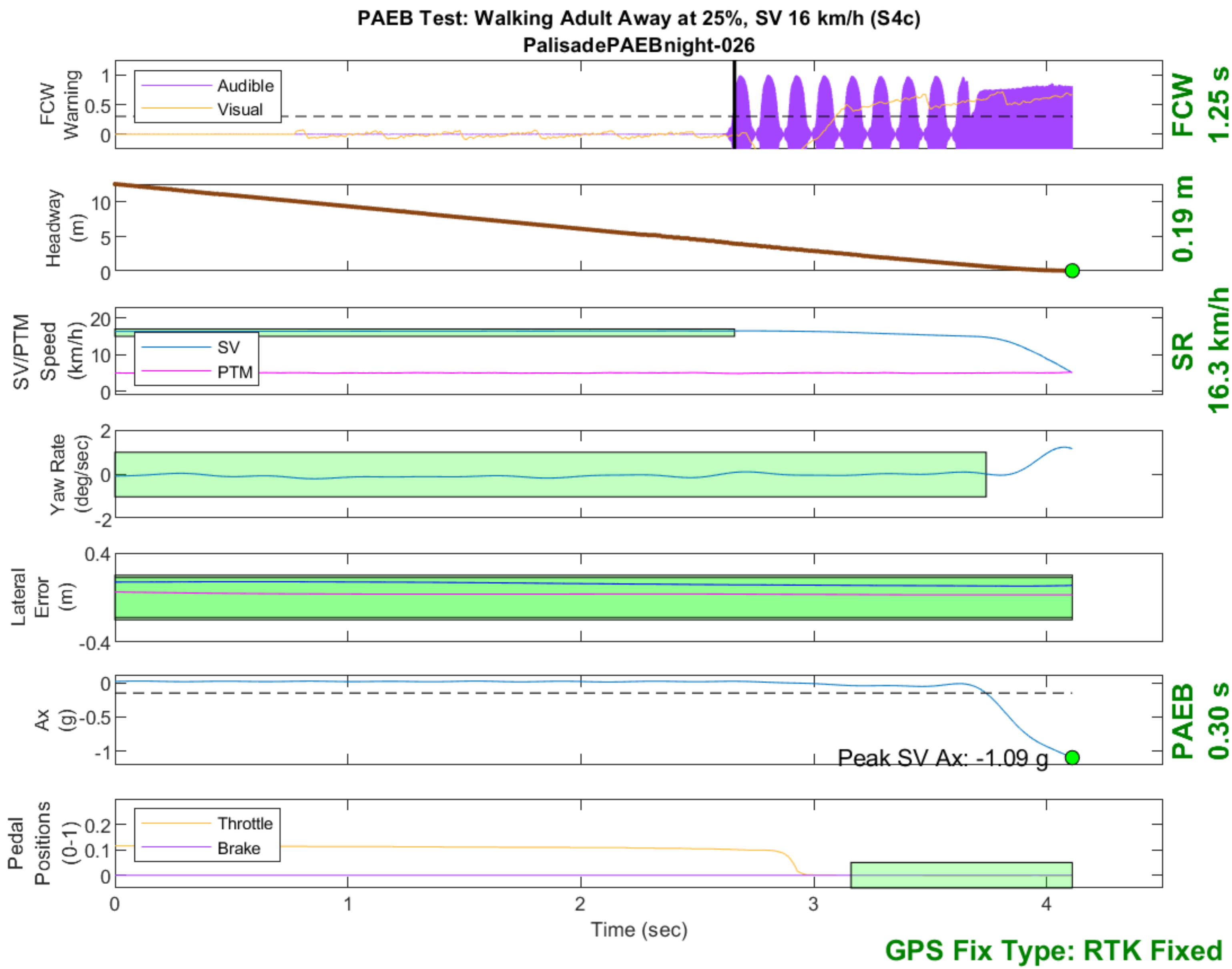


Figure D271. Time History for PAEB Run 26, S4c, Night, Low Beam, 16 km/h

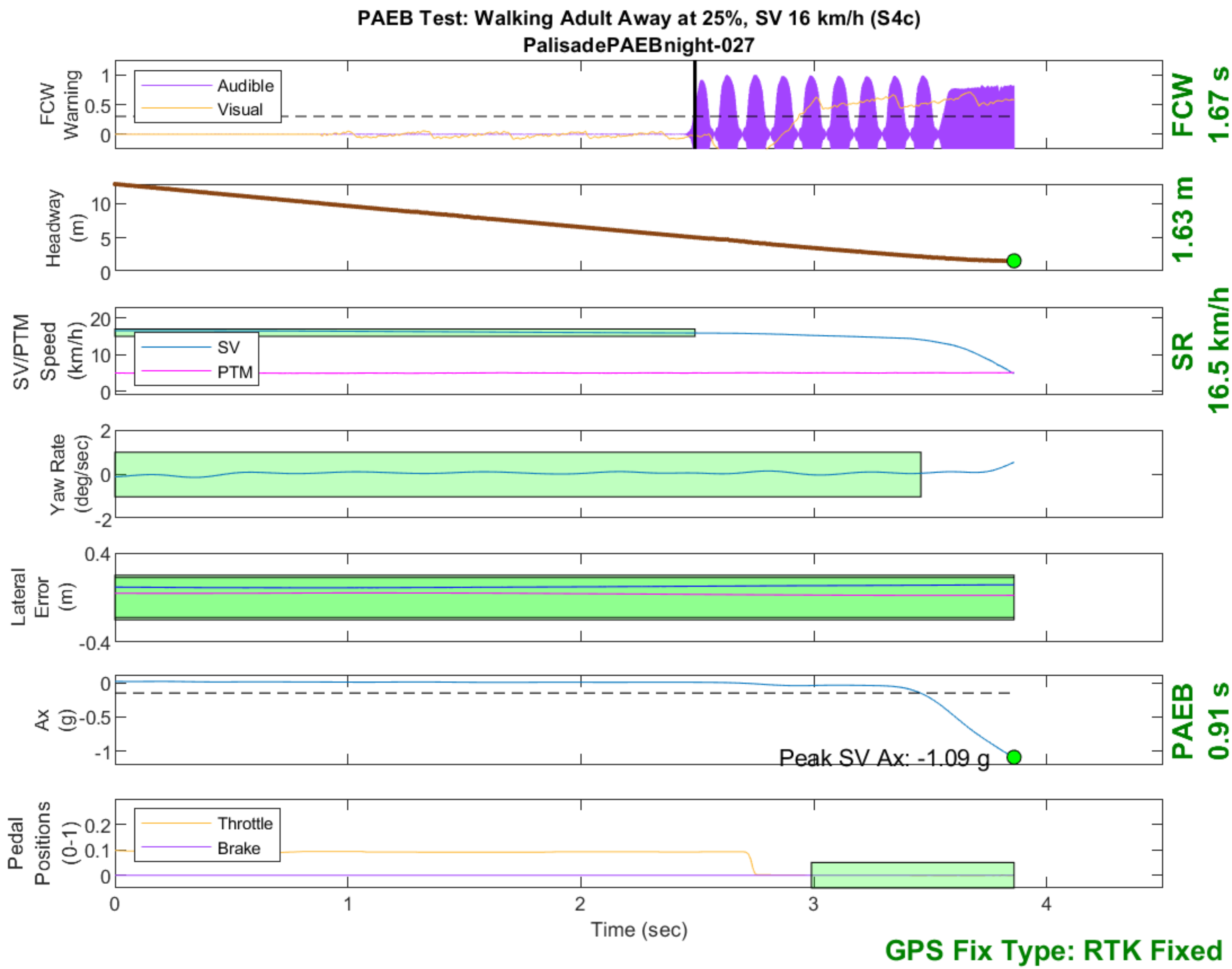


Figure D272. Time History for PAEB Run 27, S4c, Night, Low Beam, 16 km/h

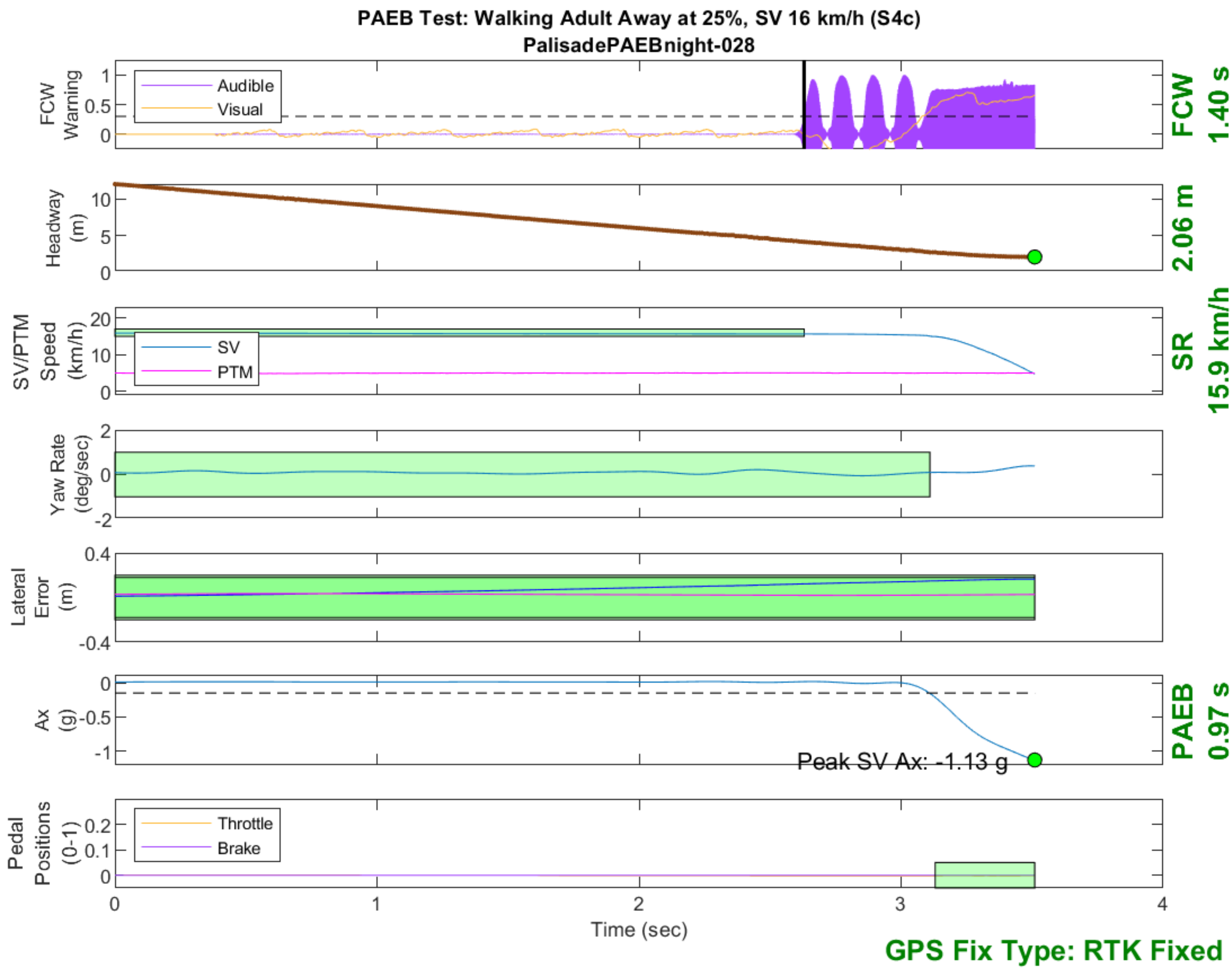


Figure D273. Time History for PAEB Run 28, S4c, Night, Low Beam, 16 km/h

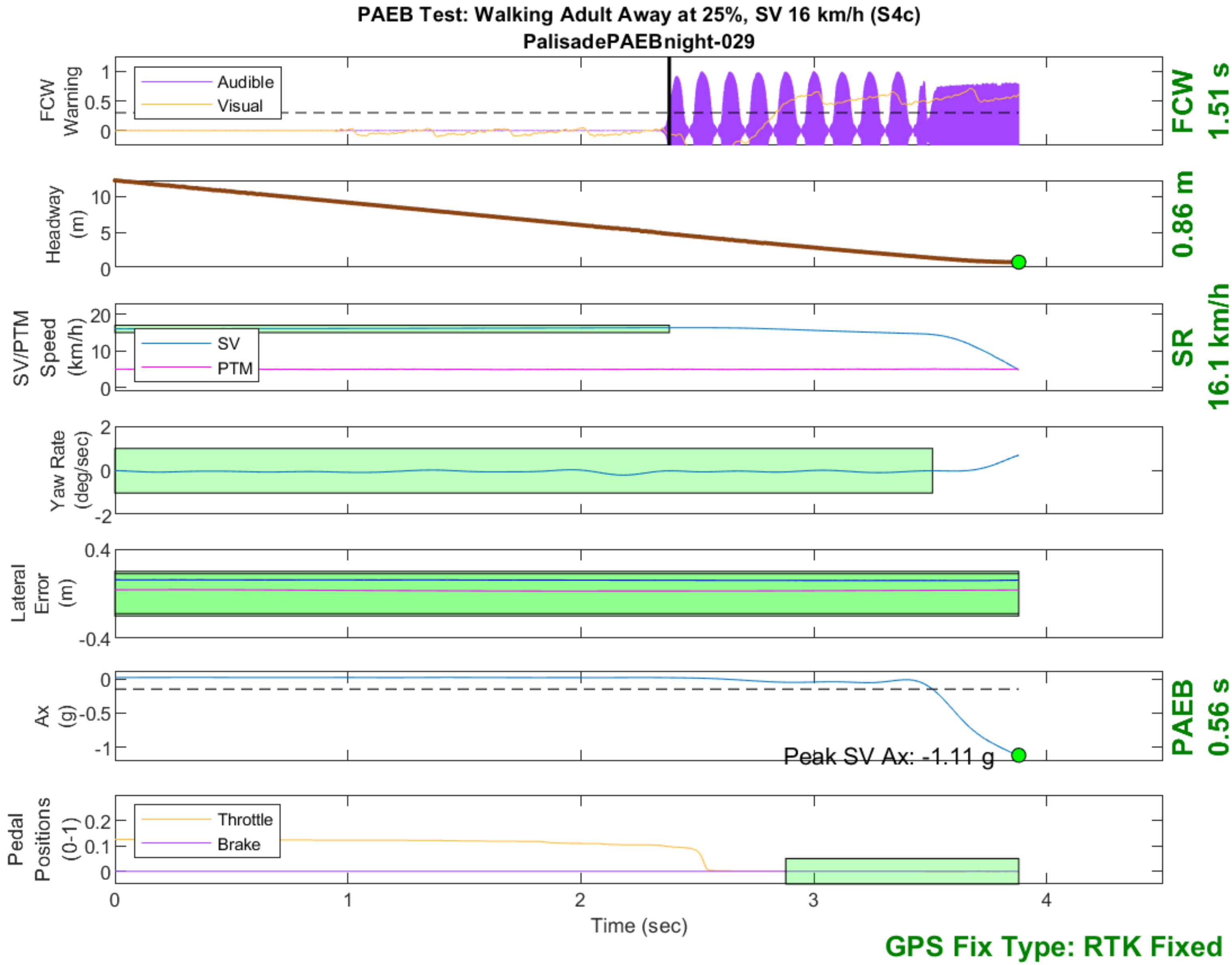


Figure D274. Time History for PAEB Run 29, S4c, Night, Low Beam, 16 km/h

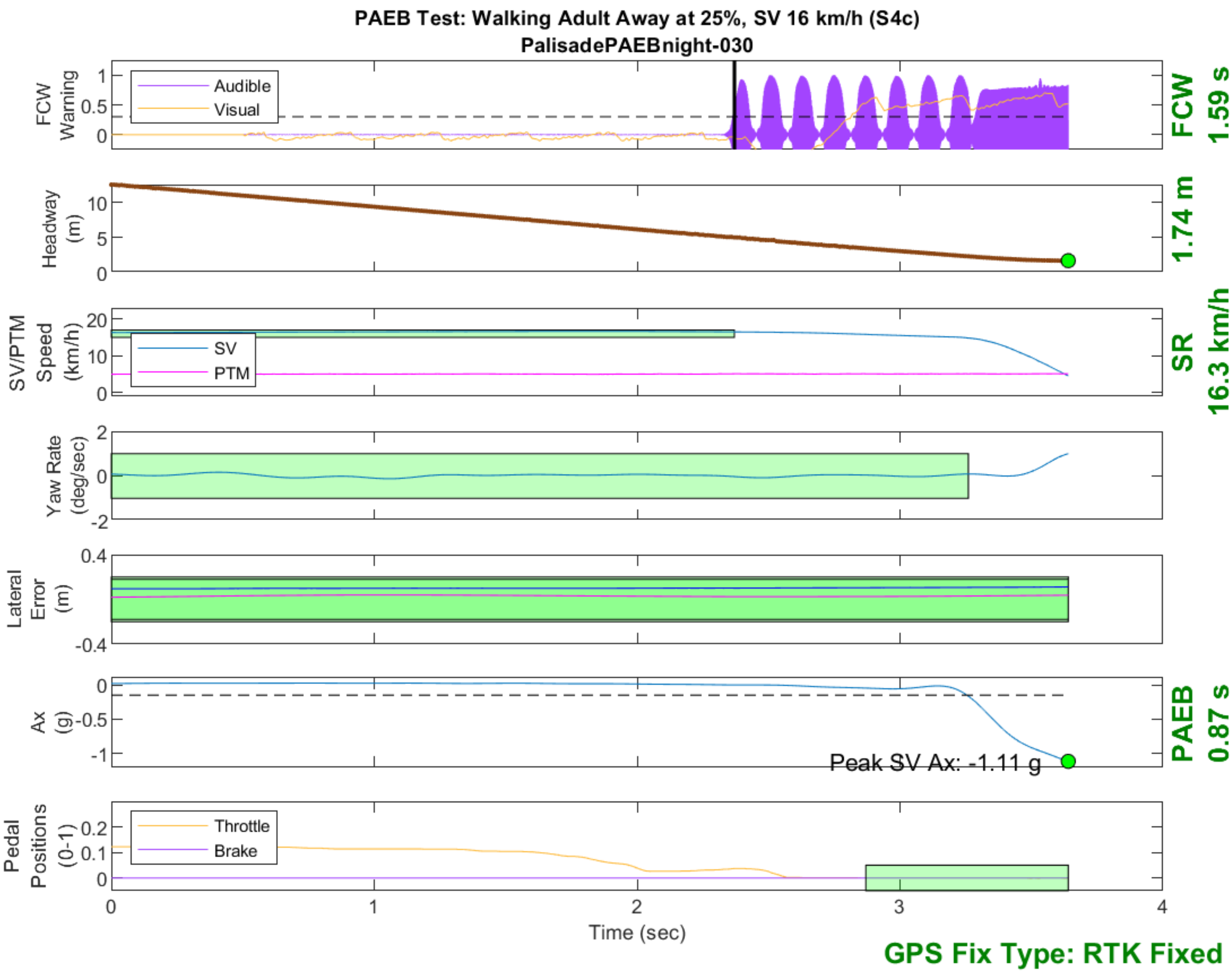


Figure D275. Time History for PAEB Run 30, S4c, Night, Low Beam, 16 km/h

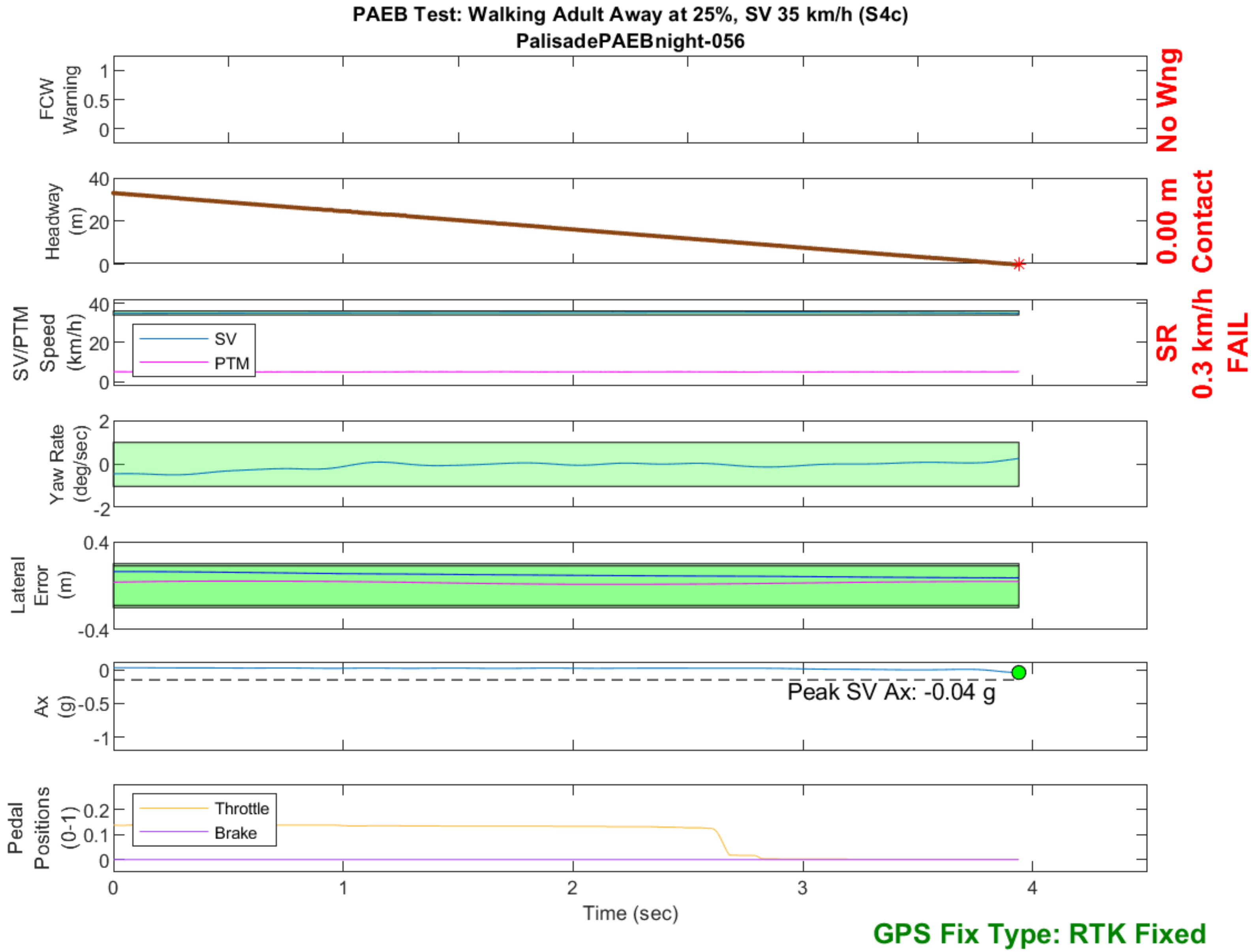


Figure D276. Time History for PAEB Run 56, S4c, Night, Low Beam, 35 km/h

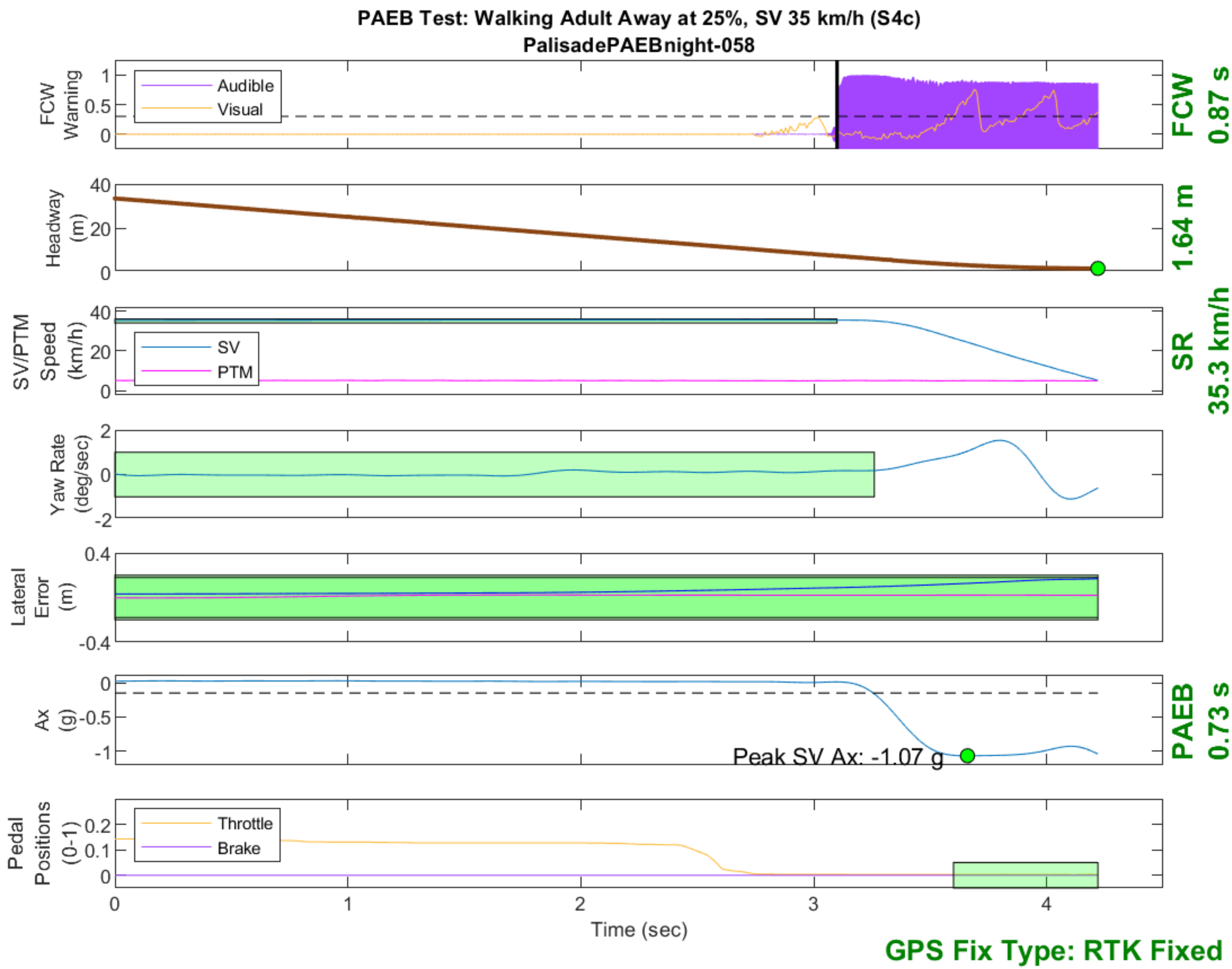


Figure D277. Time History for PAEB Run 58, S4c, Night, Low Beam, 35 km/h

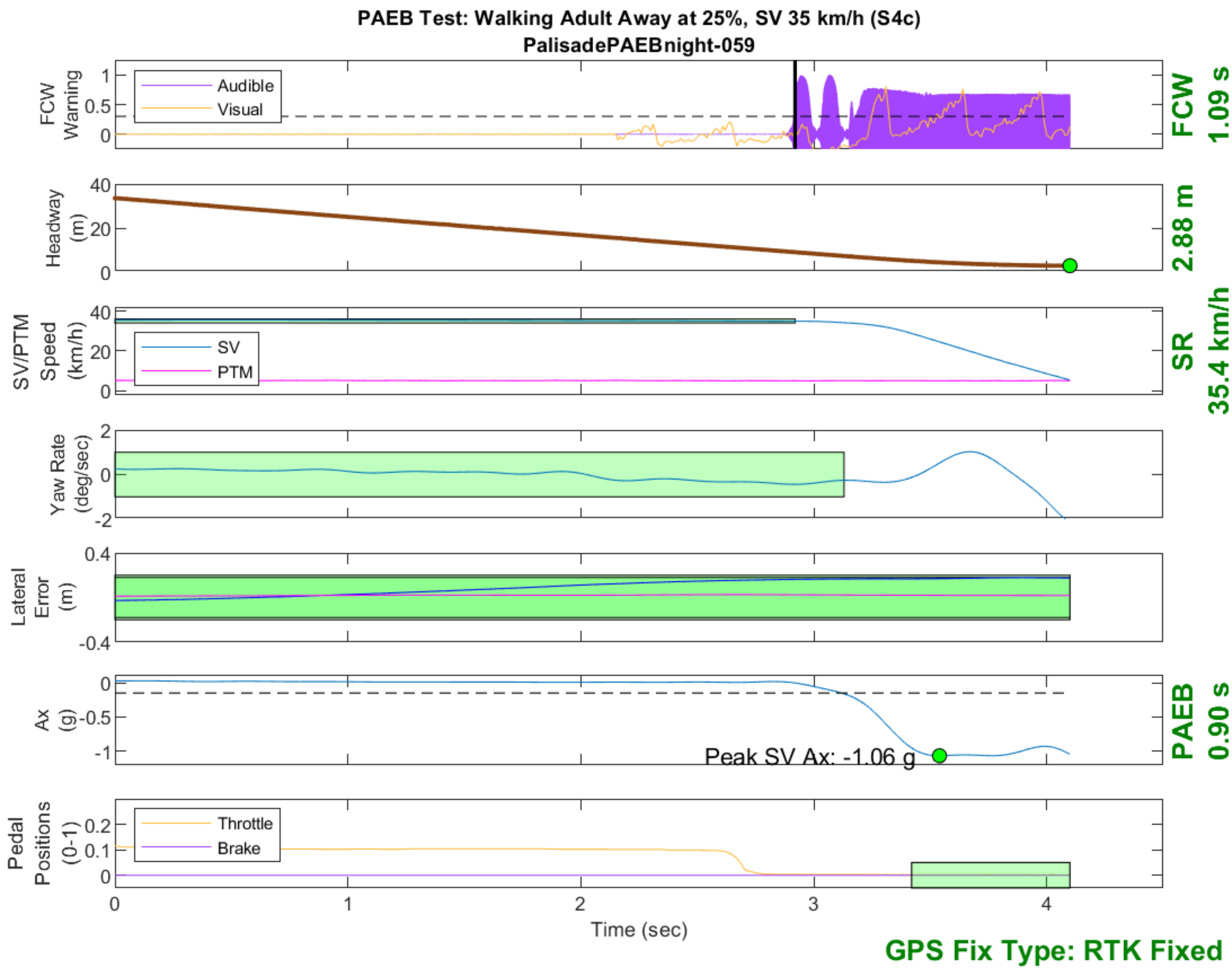


Figure D278. Time History for PAEB Run 59, S4c, Night, Low Beam, 35 km/h

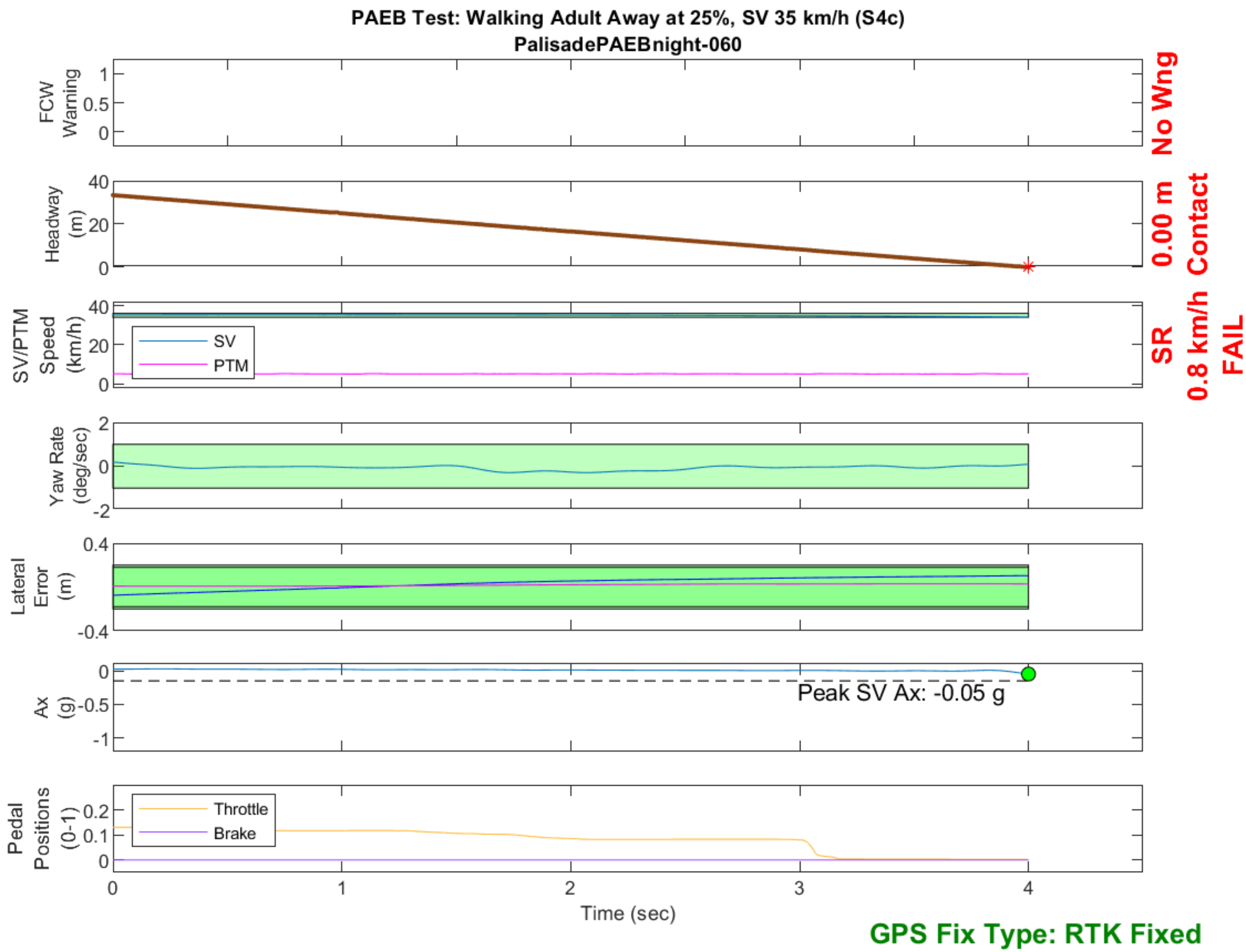


Figure D279. Time History for PAEB Run 60, S4c, Night, Low Beam, 35 km/h

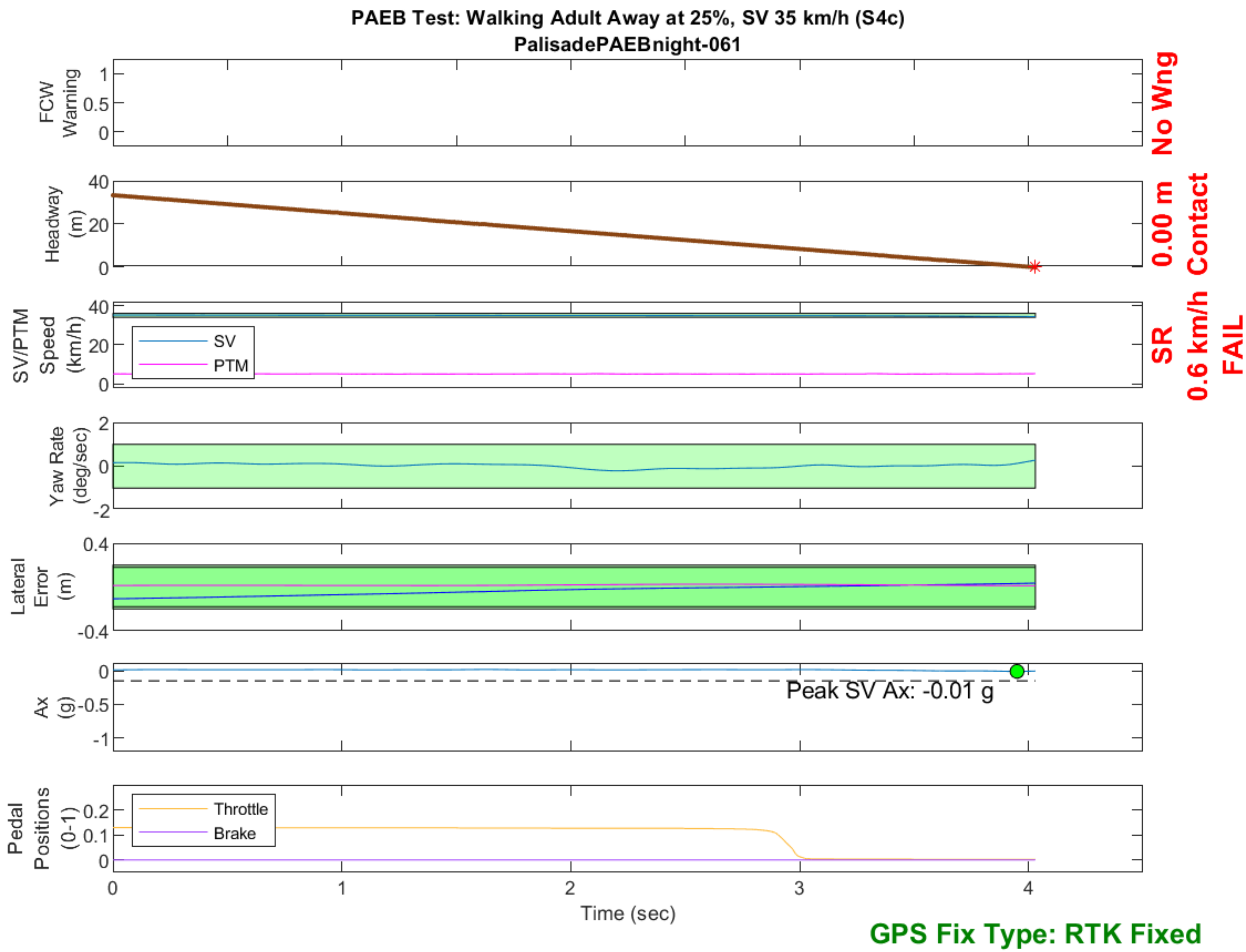


Figure D280. Time History for PAEB Run 61, S4c, Night, Low Beam, 35 km/h

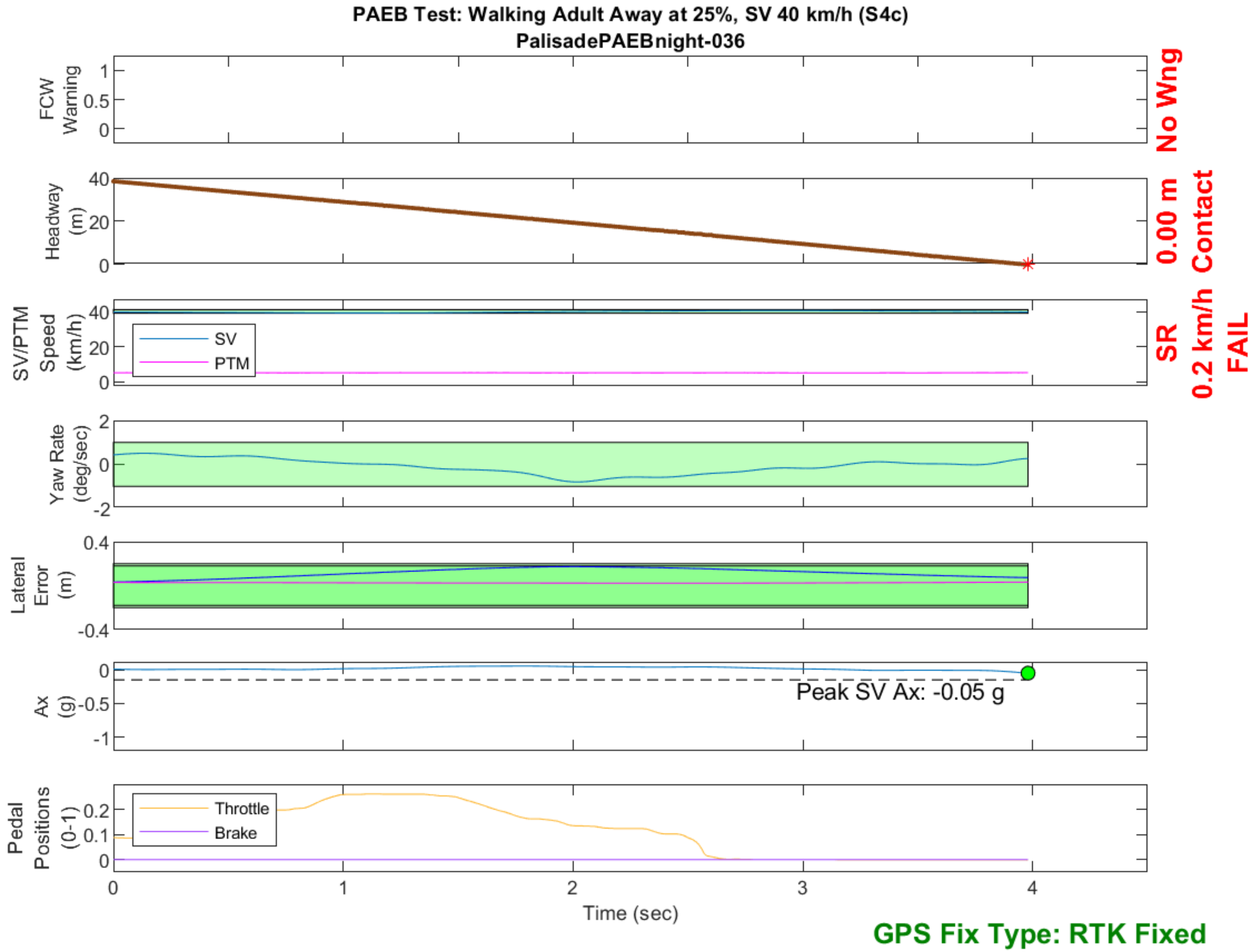


Figure D281. Time History for PAEB Run 36, S4c, Night, Low Beam, 40 km/h

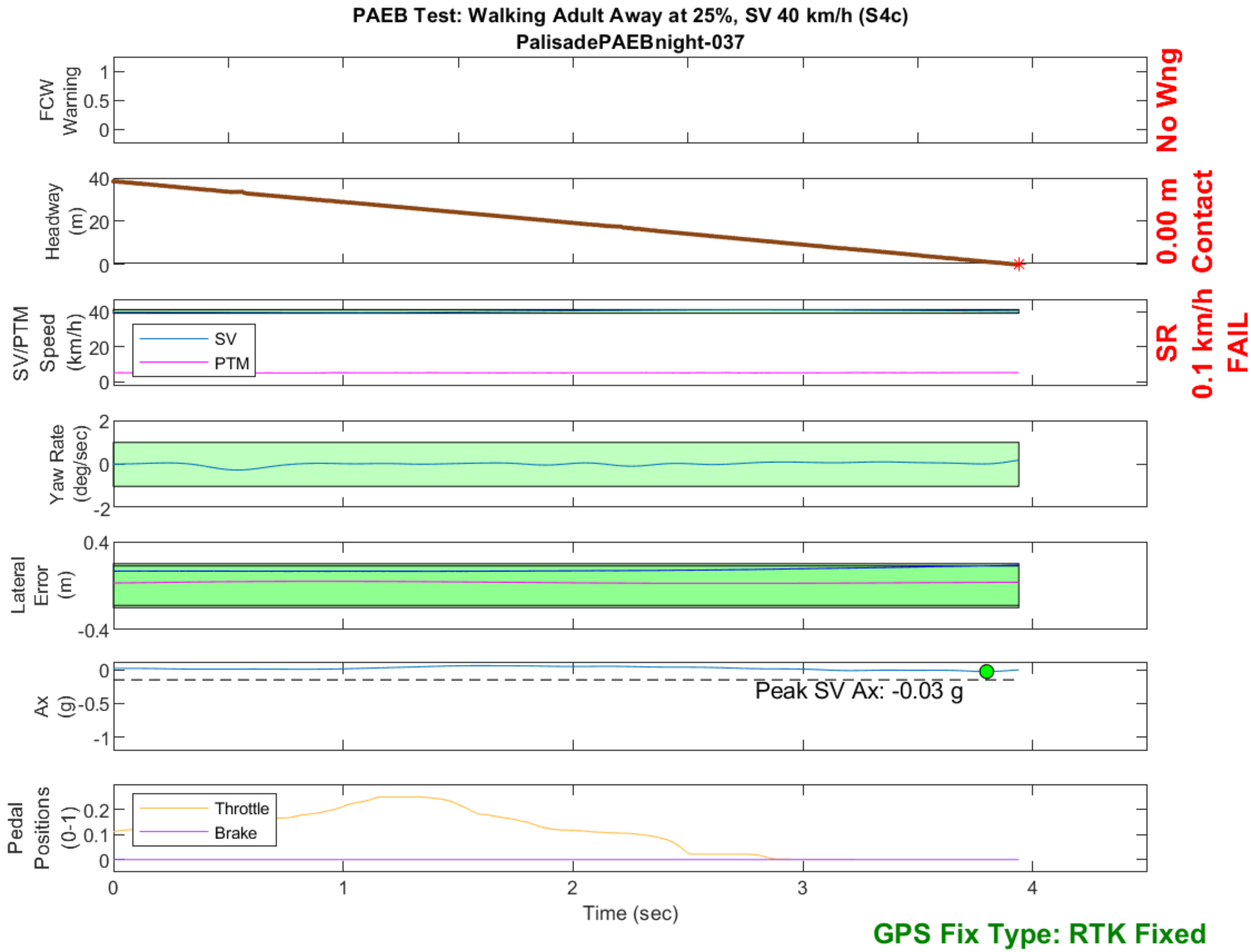


Figure D282. Time History for PAEB Run 37, S4c, Night, Low Beam, 40 km/h

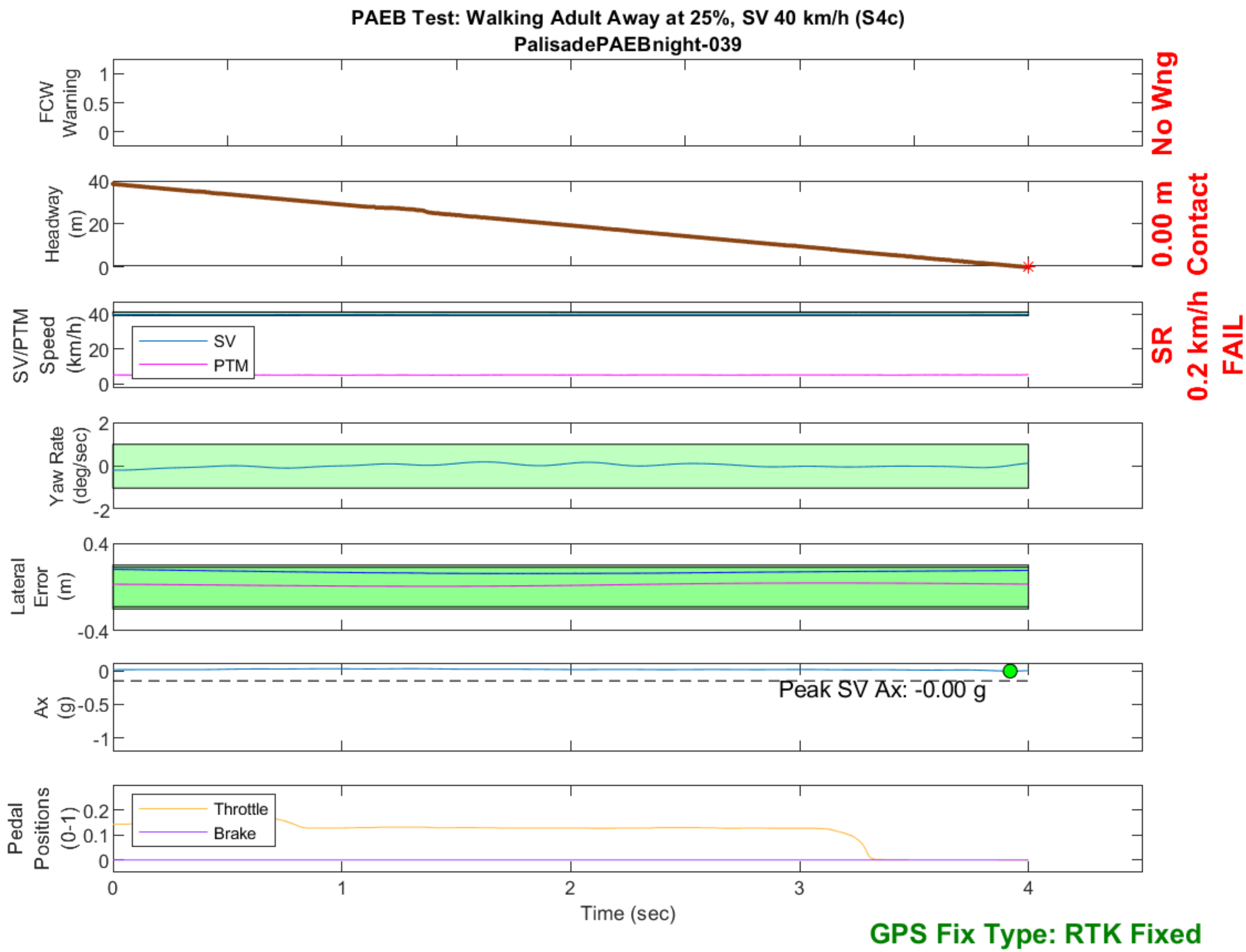


Figure D283. Time History for PAEB Run 39, S4c, Night, Low Beam, 40 km/h