PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM RESEARCH TEST
NCAP-DRI-PAEB-20-06

2020 Land Rover Range Rover Sport HSE

DYNAMIC RESEARCH, INC.
355 Van Ness Avenue
Torrance, California 90501

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Final Report

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U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
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Prepared By: J. Lenkeit, Program Manager Date: 7 December 2020

N. Watanabe, Test Engineer (Day Test)

S. Judy, A. Ricci, Test Engineers (Night Test)

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16. Abstract

These research tests were conducted on the subject 2020 Land Rover Range Rover Sport HSE in accordance with the specifications of the National Highway Traffic Safety Administration’s draft test procedure in docket NHTSA-2019-0102-0005 to confirm the performance of a Pedestrian Automatic Emergency Braking system, with modifications to include use of an articulated pedestrian test mannequin and additional tests speeds and lighting conditions.

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Section I

INTRODUCTION

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

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

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

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

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

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

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

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

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

Section II

DATA SHEETS

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

2020 Land Rover Range Rover Sport HSE

VIN: *SALWR2SU9LA71xxxx*

Day Test Date: *7/22/2020*

Night Test Date: *7/21/2020*

System Setting: *System on*

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	35		
S1b	40	*	*
S1c	40		
S1d	*	*	*
S1e	40	*	*
S1f			
S1g			
S4a	35	16	*
S4b	40		
S4c	45	40	*

* 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.

2020 Land Rover Range Rover Sport HSE

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	4	13.3						
35	5	4	28.6						
40	5	2	18.1						

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11				3	0	0.1	3	0	0.1
16	5	5	16.3	3	0	0.0	3	0	0.0
20	5	3	12.2						
30	5	5	30.2						
40	4	2	20.6	2	0	0.1	3	0	0.0
45	4	0	21.6						
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	8	6	12.3						
40	5	4	33.3						

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

2020 Land Rover Range Rover Sport HSE

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11	3	0	0.1	3	0	0.2	4	0	0.2
16	4	1	3.9	3	0	0.3	3	0	0.0
40	4	1	19.7	3	0	0.2	3	0	0.0

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
35				2	0	0.9	3	0	0.1
40	5	4	34.4	3	0	0.5	3	0	0.2
45	5	0	22.8						
50	3	0	26.1						

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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	1.0	0.0
2	1.0	0.0
3	0.1	0.0
4	1.0	0.0
5		0.0
6		0.0

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11							3	0	0.0
16	5	5	16.3	5	4	12.9	3	0	0.0
35	5	4	33.9	3	0	0.0			
40	5	2	37.0	3	0	0.0	2	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	16.2						
40	6	6	40.2						

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11							4	0	0.1
16	5	5	16.1	4	1	4.1	3	0	0.4
40	5	4	32.6	5	5	40.2	3	0	0.2
45	6	5	38.5	4	1	25.0			
50	4	1	25.6	4	1	24.0			

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 2: VEHICLE DATA

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2020 Land Rover Range Rover Sport HSE

TEST VEHICLE INFORMATION

VIN: *SALWR2SU9LA71xxxx*

Body Style: *SUV* Color: *Portofino Blue*

Date Received: *6/19/2020* Odometer Reading: *62 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Jaguar Land Rover Ltd.*

Date of manufacture: *01/20*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard:	Front:	*275/45 R21*
	Rear:	*275/45 R21*
Recommended cold tire pressure:	Front:	*250 kPa (37 psi)*
	Rear:	*300 kPa (44 psi)*

TIRES

Tire manufacturer and model: *Pirelli Scorpion*

Front tire size: *275/45 R21 110Y*

Rear tire size: *275/45 R21 110Y*

Front tire DOT prefix: *XN 8M 325E*

Rear tire DOT prefix: *XN 8M 325E*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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DAYTIME TEST GENERAL INFORMATION

Test date: *7/22/2020*

AMBIENT CONDITIONS

Air temperature: *27.8 C (82 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: *250 kPa (37 psi)*

Rear: *300 kPa (44 psi)*

NIGHTTIME TEST GENERAL INFORMATION

Test date: *7/21/2020*

AMBIENT CONDITIONS

Air temperature: *33.9 C (93 F)*

Wind speed: *2.6 m/s (5.8 mph)*

X Wind speed ≤ 10 m/s (22 mph)

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

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

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

OBSTRUCTION VEHICLES

Forward obstructing vehicle: *1999 Honda Accord*

Rear obstructing vehicle: *2012 Toyota Highlander*

VEHICLE PREPARATION (NIGHT)

Verify the following:

All non-consumable fluids at 100% capacity:	**X**
Fuel tank is full:	**X**
Tire pressures are set to manufacturer's recommended cold tire pressure:	**X**

Front: *250 kPa (37 psi)*

Rear: *300 kPa (44 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*700.3 kg (1544 lb)*	Right Front:	*576.5 kg (1271 lb)*
Left Rear:	*568.8 kg (1254 lb)*	Right Rear:	*669.5 kg (1476 lb)*
		Total:	*2515.1 kg (5545 lb)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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2020 Land Rover Range Rover Sport HSE

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

Autonomous Emergency Braking (AEB) - [Shown as Emergency Braking on Monroney]

Type and location of sensors the system uses:

Stereo Vision Cameras located near the rearview mirror.

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

___ Yes

X No

If yes, please provide a full description.

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

How is the PAEB alert presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

___ Vibration

___ Other

Describe the method by which the driver is alerted. For example, if the warning is a light, where is it located, its color, size, words or symbol, does it flash on and off, etc. If it is a sound, describe if it is 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.

A red symbol comprising a triangle with an exclamation point within is located in the instrument cluster message center. When the PAEB system detects a pedestrian, the symbol lights above the words "Autonomous Emergency Braking active". See Appendix A, Figure A15.

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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

____ No

If yes, please provide a full description.

The calibration involves driving the vehicle at 15 mph alongside a series of stationary vehicles spaced at 20 m. Ten passes are made with the stationary vehicles on the left and another ten passes are made with the stationary vehicles on the right.

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

Minimum: *3 mph (5 km/h) (Per manufacturer supplied information)*

Maximum: *37 mph (60km/h) for pedestrians crossing in front of and pedestrians walking longitudinally away from or toward the vehicle (Per manufacturer supplied information)*

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

____ No

If yes, please provide a full description.

AEB won't activate within 10 secs of previous activation.

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

____ No

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

Buttons on the side of the steering wheel are used to access vehicle setup menus displayed in the instrument cluster. Cycle through the menu options to the "Collision avoidance" menu then scroll down to "AEB". The check box indicates system on or off. See Appendix A, Figure A13.

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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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.

Vehicle detection Autonomous Emergency Braking (AEB) does not operate if:

- *The vehicle is negotiating a tight corner.*
- *The forward-facing cameras are dirty or obscured.*
- *The vehicle's speed is below 3 mph (5km/h), or above 50 mph (80 km/h).*
- *Visibility is impaired due to severe weather conditions, e.g., heavy rain, fog, or snow.*

In addition to the items listed for the vehicle detection AEB system, the pedestrian detection AEB system does not operate if:

- *The vehicles speed is above 37 mph (60 km/h).*
- *The detected object is not identified as a pedestrian.*
- *The height of the object is less than 39 in (1 m).*
- *The pedestrian detection AEB system cannot determine that the target object is a pedestrian. For example, if the pedestrian is carrying a large object.*

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. <u>S1 TEST SCENARIOS</u>

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.

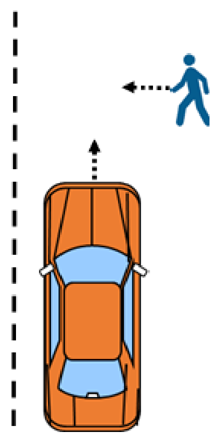


Figure 1. Scenarios S1a, b, c; Nearside Crossing Adult Pedestrian Walking 25/50/75% Overlap

- 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.

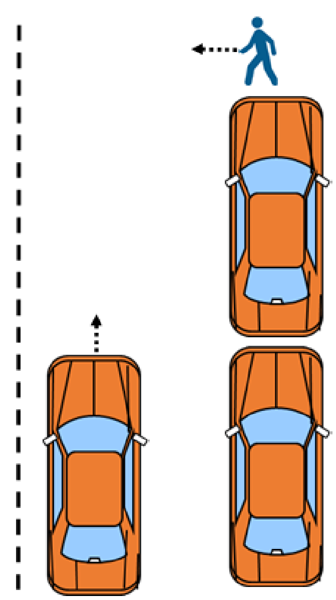


Figure 2. Scenario S1d; Nearside Obstructed Crossing Child Running, 50% Overlap

- 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.

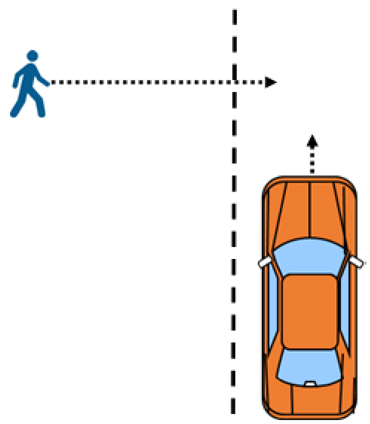


Figure 3. Scenario S1e; Offside Crossing Adult Running 50% Overlap

- 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.

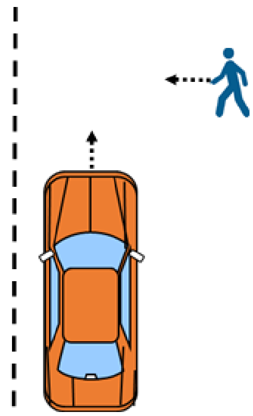


Figure 4. Scenario S1f; Nearside Crossing Adult Walking Stops Short

- 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.

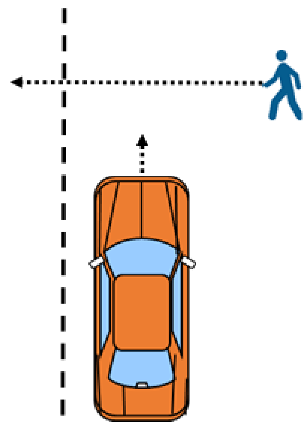


Figure 5. Scenario S1g; Nearside Crossing Adult Walking Clears Path

- 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).

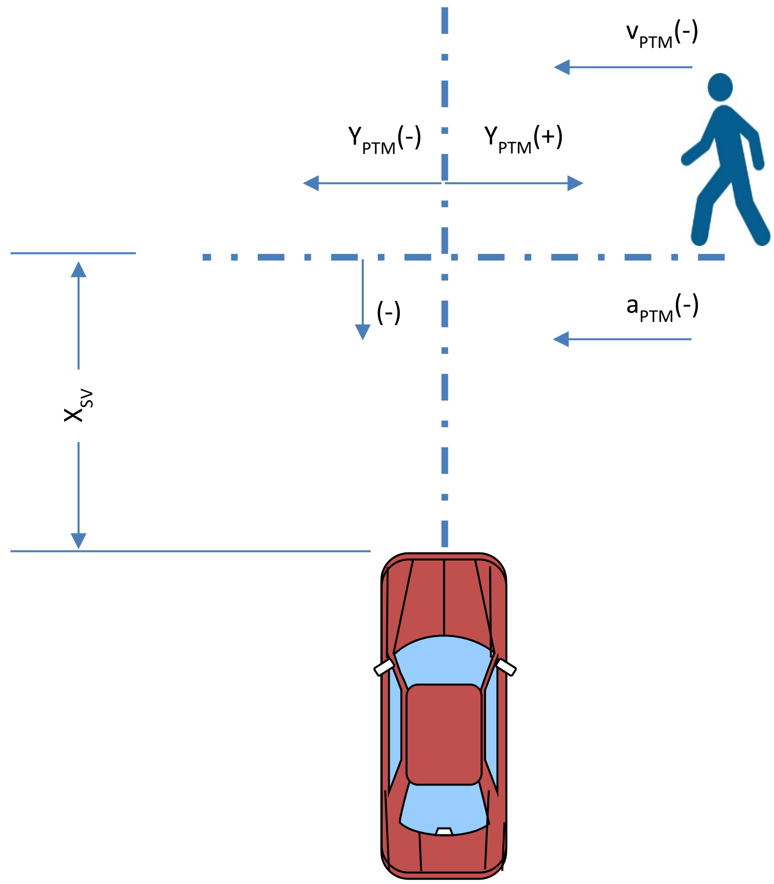


Figure 6. Coordinate System for Validation of Scenario 1

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.

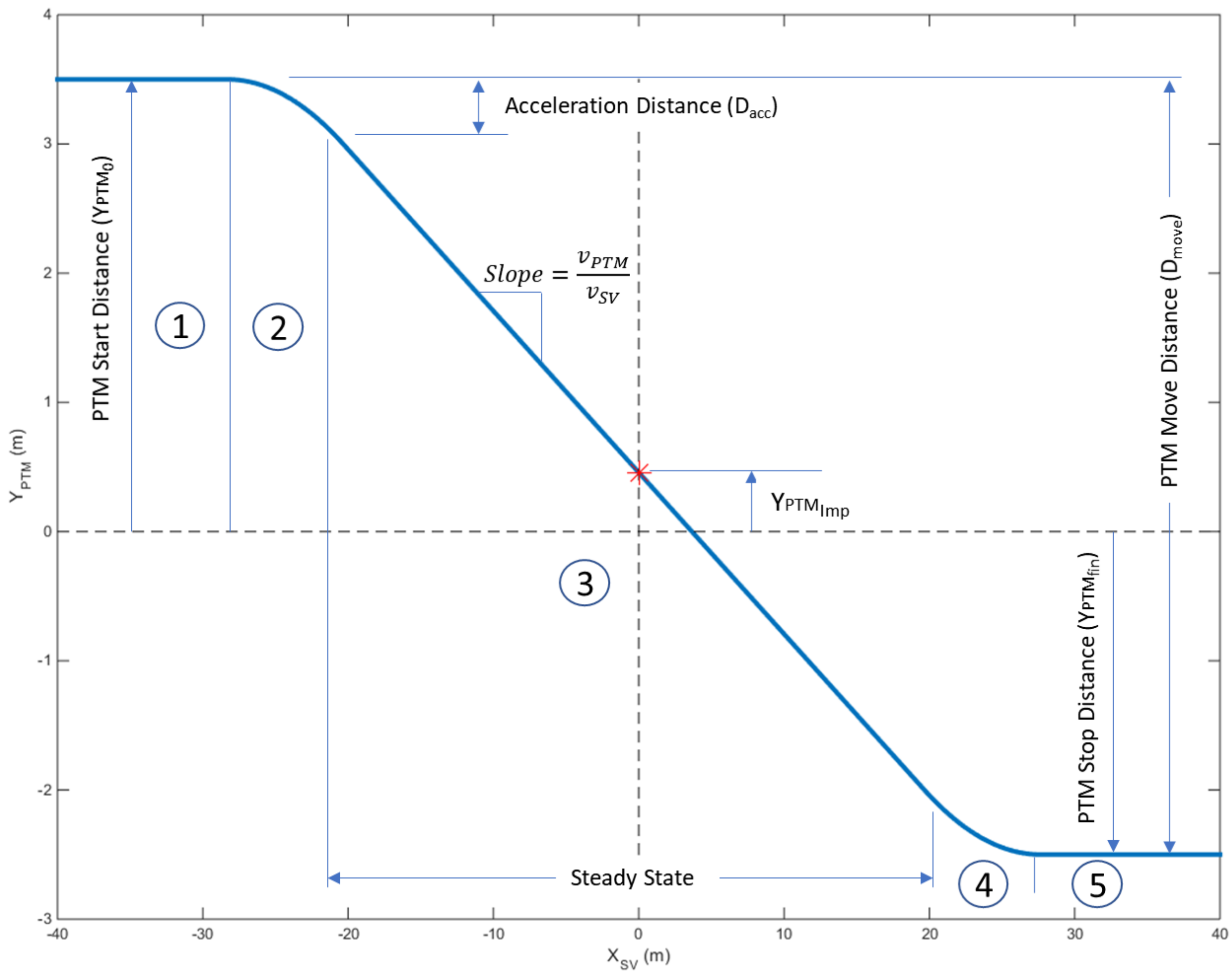


Figure 7. PTM Lateral Lane Position as a Function of SV Longitudinal Lane Position

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):

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

Domain 2 (Acceleration):

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

where,

a_{PTM} = PTM acceleration, defined by scenario

X_{SV} = measured SV longitudinal lane position

Domain 3 (Steady State):

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

Domain 4 (Deceleration):

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

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

Domain 5 (Stationary):

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

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

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

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

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

3. OBSTRUCTION VEHICLES

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.

[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 front initial brake temperature (IBT) was between 149°F (65°C) and 212°F (100°C) at the onset of each test.
    - If the IBT was less than 149°F (65°C), the brakes were heated to the IBT by making one or more brake applications from a speed of 31.1 mph (50 km/h), at a deceleration rate not greater than 0.31g (3 m/s²).
    - If the IBT was greater than 212°F (100°C), the SV was driven at speeds up to 62.1 mph (100 km/h) until the IBT specified in this section was reached.
- The SV was driven at the nominal speed specified for each test. The speed tolerance was ±1.0 km/h.
- 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. S4 TEST SCENARIOS

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

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

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

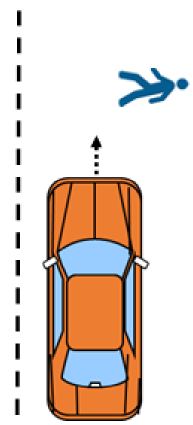


Figure 8. Scenario S4a; Nearside Standing Adult Facing Away From SV, 25% Overlap

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

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

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

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

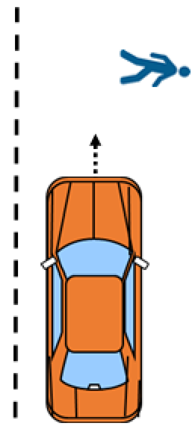


Figure 9. Scenario S4b; Nearside Standing Adult Facing Towards SV, 25% Overlap

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

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

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

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

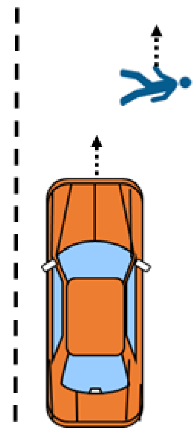


Figure 10. Scenario S4c; Nearside Walking Adult Away From SV, 25% Overlap

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

c. Validity Period

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

d. End-of-Test Instructions

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

The test trial was then complete.

e. Number of Test Trial Repeats

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

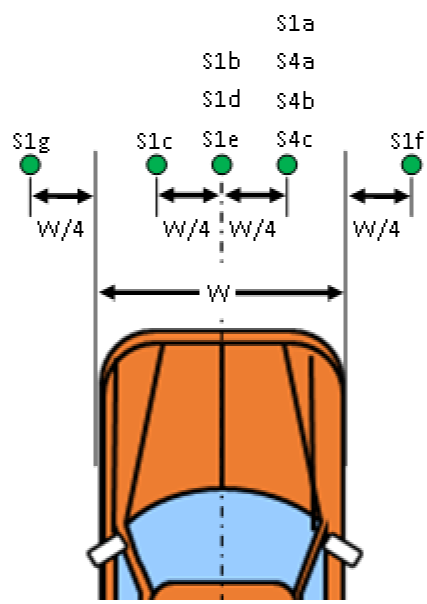


Figure 11. Offset Conditions

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

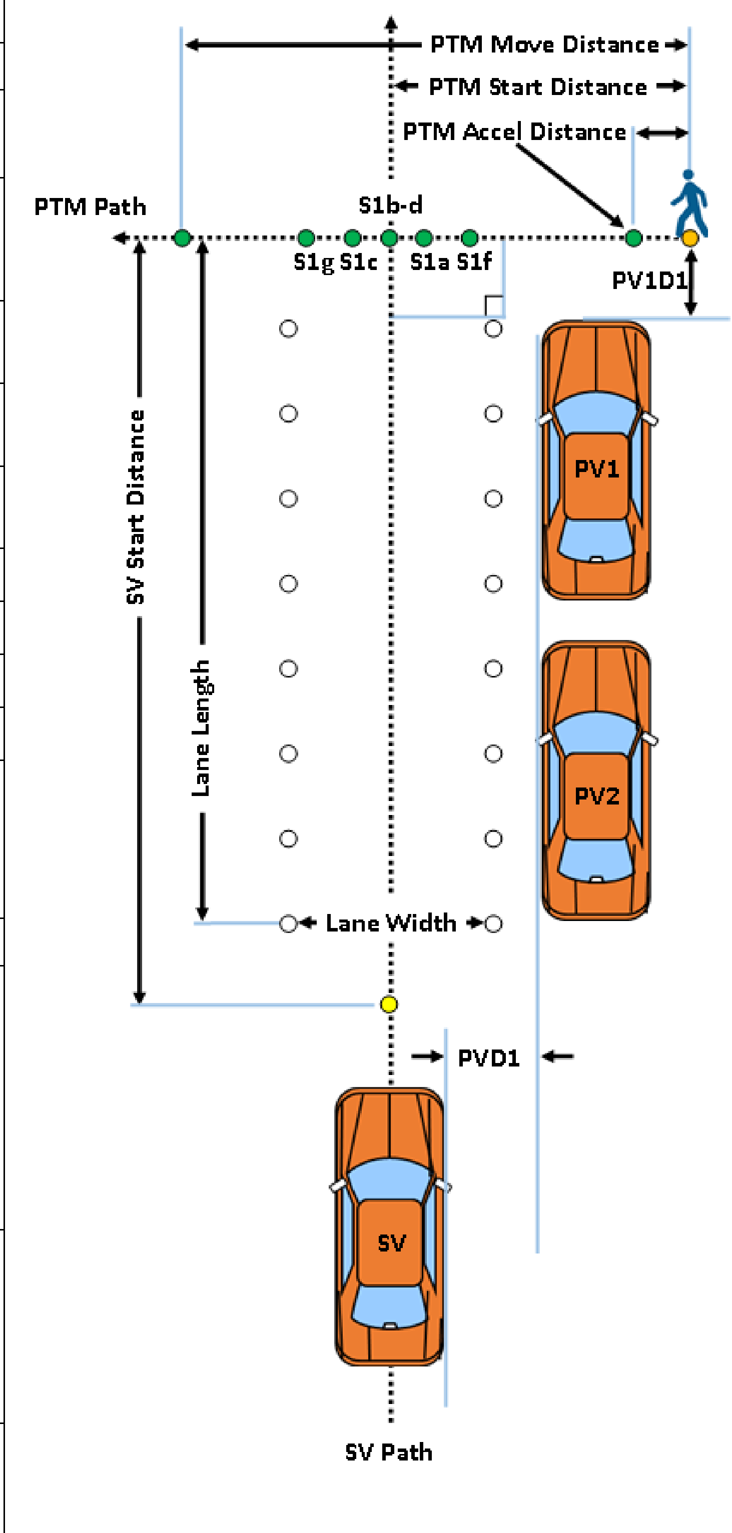


Table 4. Summary of S1e Scenario Setup

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

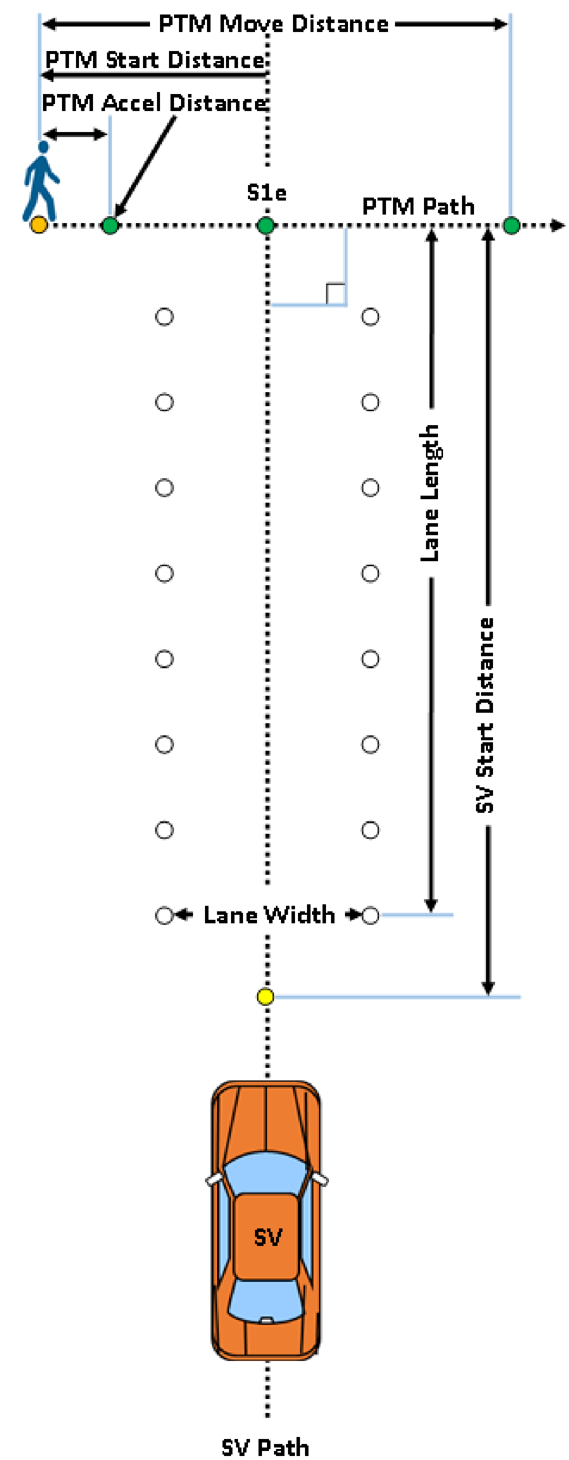


Table 5. Summary of S4a-b Scenarios Setup

S4a-b Scenario		
PTM Type	Adult	
PTM Location	Nearside In-Path	
PTM Action	S4a	Stationary Facing Away
	S4b	Stationary Facing Towards
PTM Move Distance	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

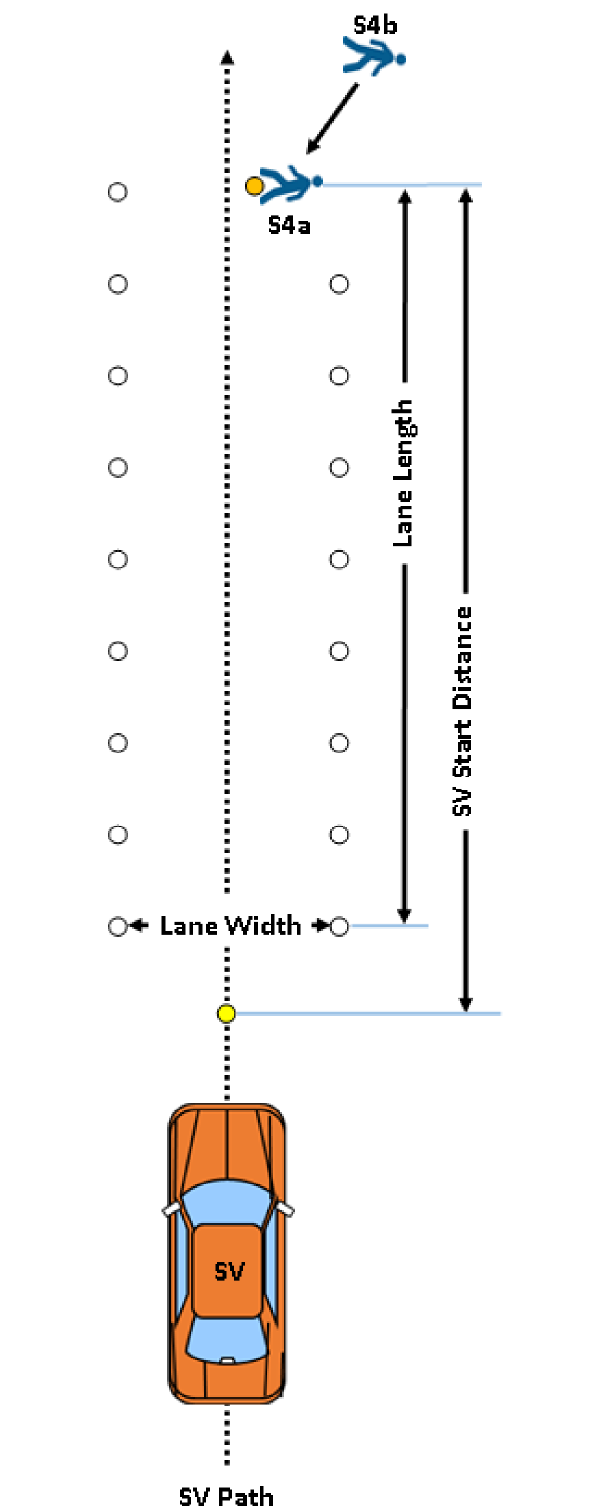
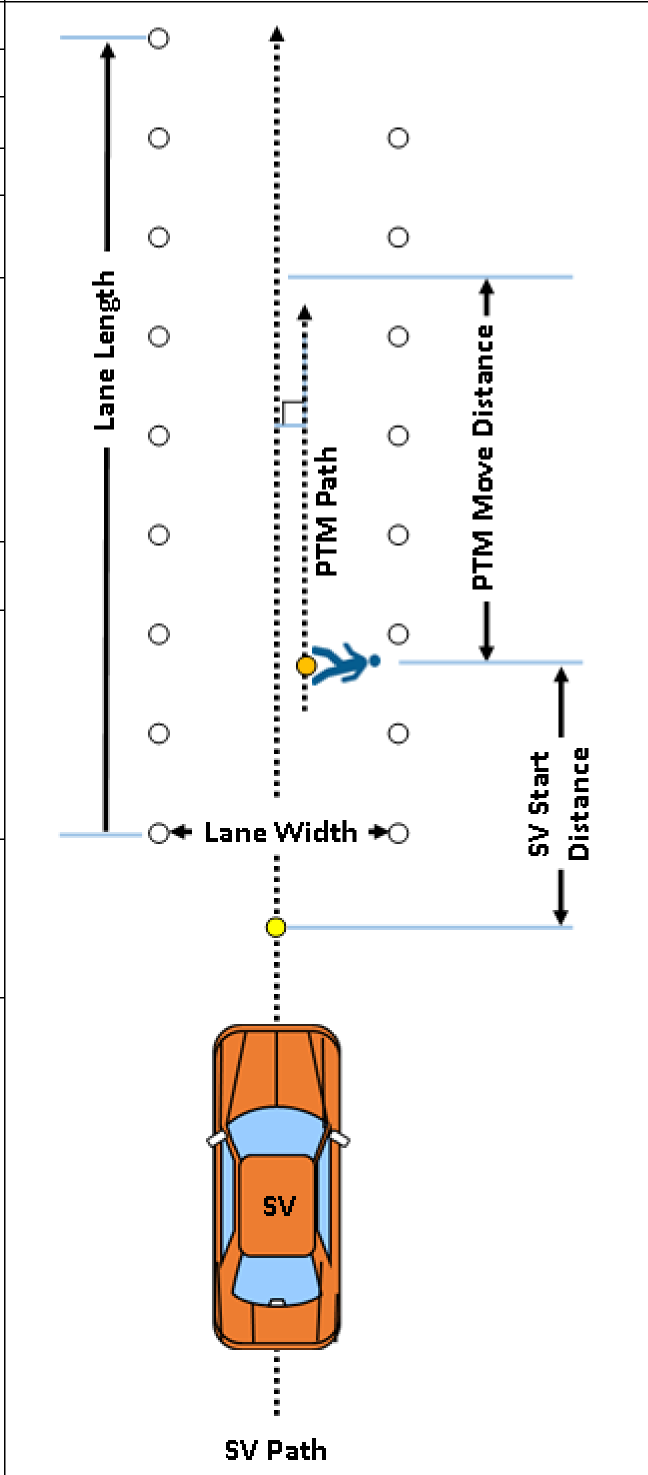


Table 6. Summary of S4c Scenario Setup

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

Drawing illustrates setup but is not to scale



E. Pre-Test Brake Burnishing

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

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

1. SV BRAKE WARM-UP AND TEMPERATURE MAINTENANCE DURING TESTING

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

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

F. Pedestrian Test Mannequin and Motion System

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

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

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

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

G. Instrumentation

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

Table 7. Test Instrumentation and Equipment

<table>
<tr><th>Type</th><th>Output</th><th>Range</th><th>Accuracy, Other Primary Specs</th><th>Mfr, Model</th><th>Serial Number</th><th>Calibration Dates
Last
Due</th></tr>
<tr><td>Tire Pressure Gauge</td><td>Vehicle Tire Pressure</td><td>0-100 psi</td><td>< 1% error between 20 and</td><td>Omega DPG8001</td><td>18111410000</td><td>By: DRI
Date: 5/4/2020
Due: 5/4/2021</td></tr>
<tr><td>Platform Scales</td><td>Vehicle Total, Wheel, and Axle Load</td><td>2200 lb/platform</td><td>0.1% of reading</td><td>Intercomp SW wireless</td><td>0410MN20001</td><td>By: DRI
Date: 4/20/2020
Due: 4/20/2021</td></tr>
<tr><td>Linear (string) encoder</td><td>Throttle pedal travel</td><td>10 in
254 mm</td><td>0.1 in
2.54 mm</td><td>UniMeasure LX-EP</td><td>45040532</td><td>By: DRI
Date: 7/2/2020
Due: 7/2/2021</td></tr>
<tr><td>SV Multi-Axis Inertial Sensing System</td><td rowspan="2">Position;
Longitudinal, Lateral, and Vertical Accels;
Lateral, Longitudinal and Vertical Velocities;
Roll, Pitch, Yaw Rates;
Roll, Pitch, Yaw Angles</td><td rowspan="2">Latitude: ±90º
Longitude: ±180º
Altitude: 0-18 km
Velocity: 0-1000 knots Accel: ±5g
Angular Rate: ±300 º/s
Angular Disp: ±180º</td><td rowspan="2">Position: ±2 cm
Velocity: 0.1 km/h
Accel: ≤ 0.05%
Angular Rate: ≤ 0.05%
Roll/Pitch Angle: ±0.05º
Heading Angle: ±0.1º</td><td rowspan="2">Oxford xNAV 550</td><td>015360</td><td>By: Oxford Technical Solutions
Date: 1/31/2020
Due: 1/31/2022</td></tr>
<tr><td>PTT Multi-Axis Inertial Sensing System</td><td>015102</td><td>By: Oxford Technical Solutions
Date: 3/6/2020
Due: 3/6/2022</td></tr>
</table>

Table 7. Test Instrumentation and Equipment (continued)

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

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

H. Pre-Test Brake Burnishing

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

- The SV was loaded to its GVWR.

- From a speed of 49.7 mph (80 km/h), 200 stops were performed with an average deceleration of 0.31g (3.0 m/s^2) 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/s^2).
- If the IBT was greater than 212°F (100°C), the SV was driven at speeds up to 62.1 mph (100 km/h) until the IBT specified was reached.

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle As-Delivered

Figure A2. Rear View of Subject Vehicle As-Delivered

Figure A3. Front View of Subject Vehicle As-Tested

Figure A4. Rear View of Subject Vehicle As-Tested

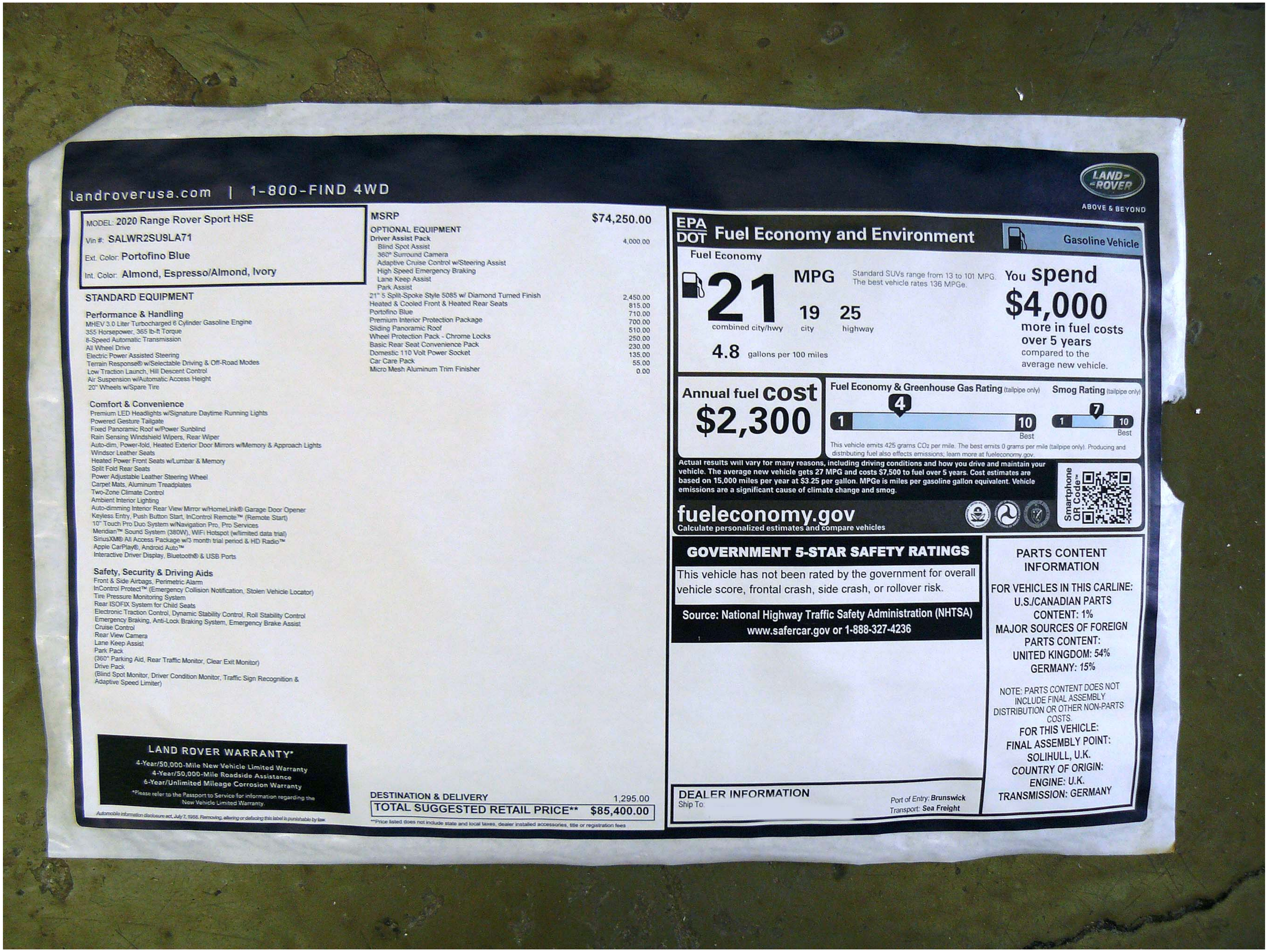


Figure A5. Window Sticker (Monroney Label)

Figure A6. Vehicle Certification Label

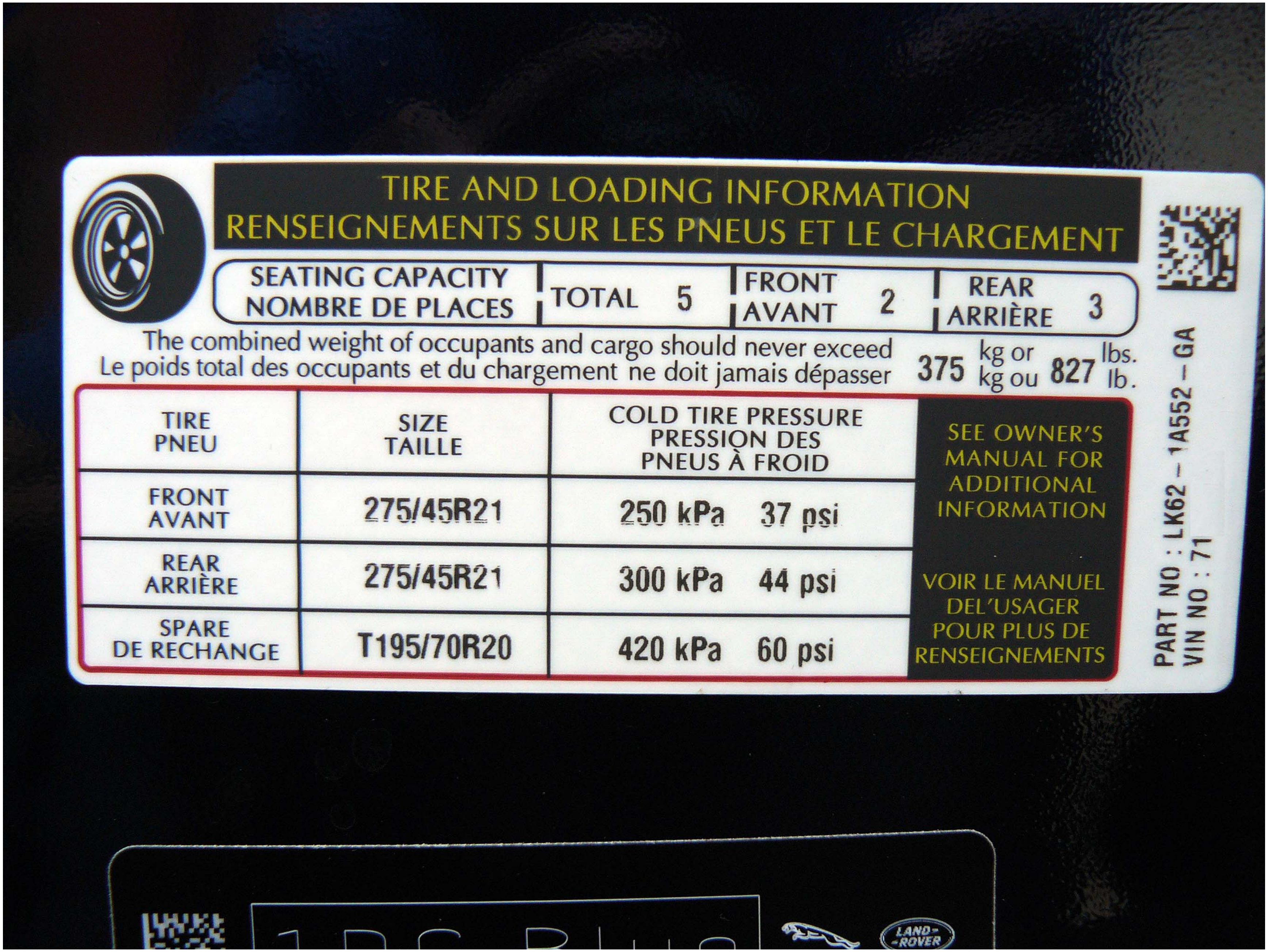


Figure A7. Tire Placard

Figure A8. Adult and Child Pedestrian Surrogates and Motion Platform

Figure A9. Obstruction Vehicles

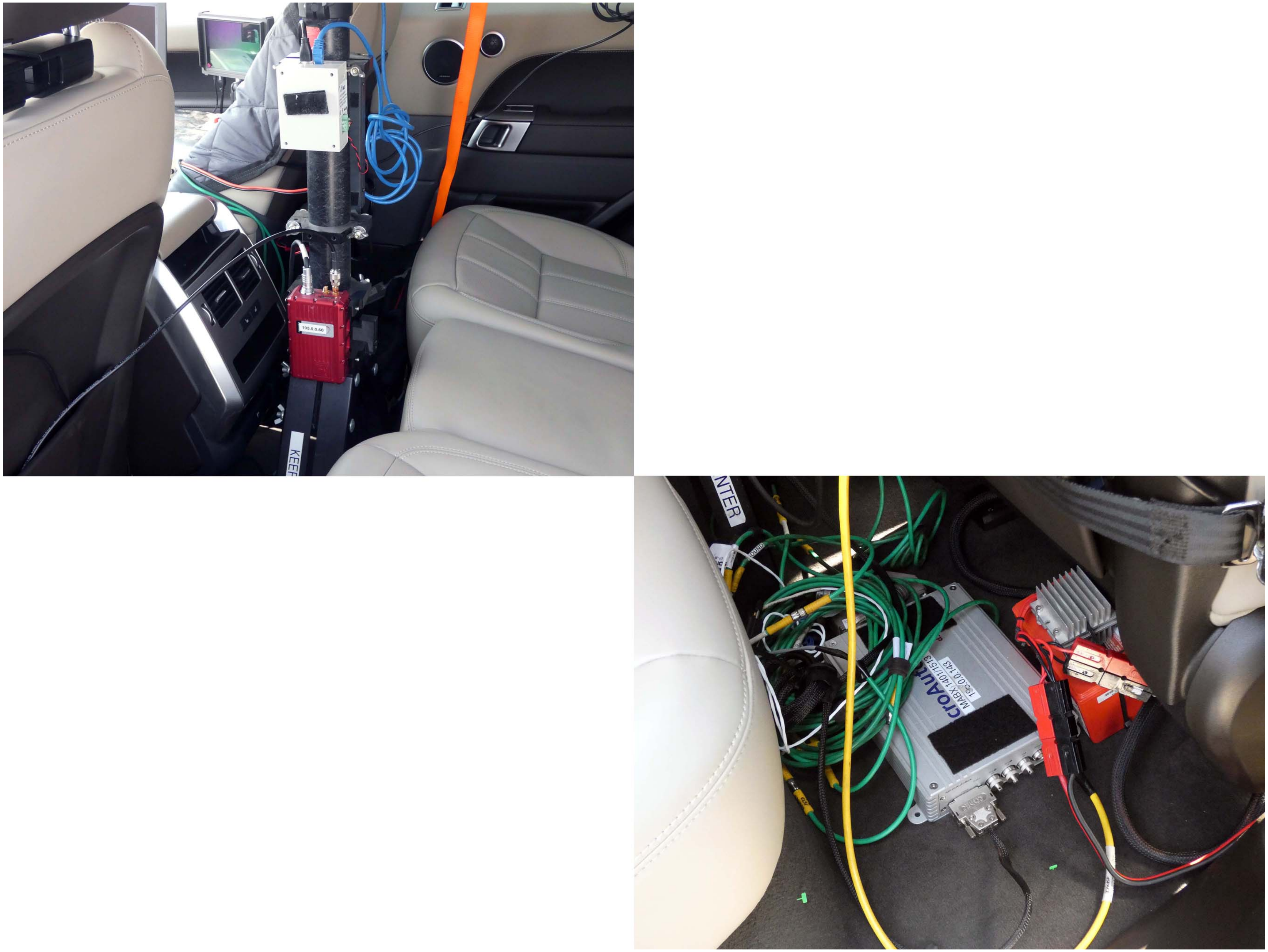


Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A11. Sensors for Detecting Auditory and Visual Alerts

Figure A12. Computer Installed in Subject Vehicle

Figure A13. PAEB Setup Menus

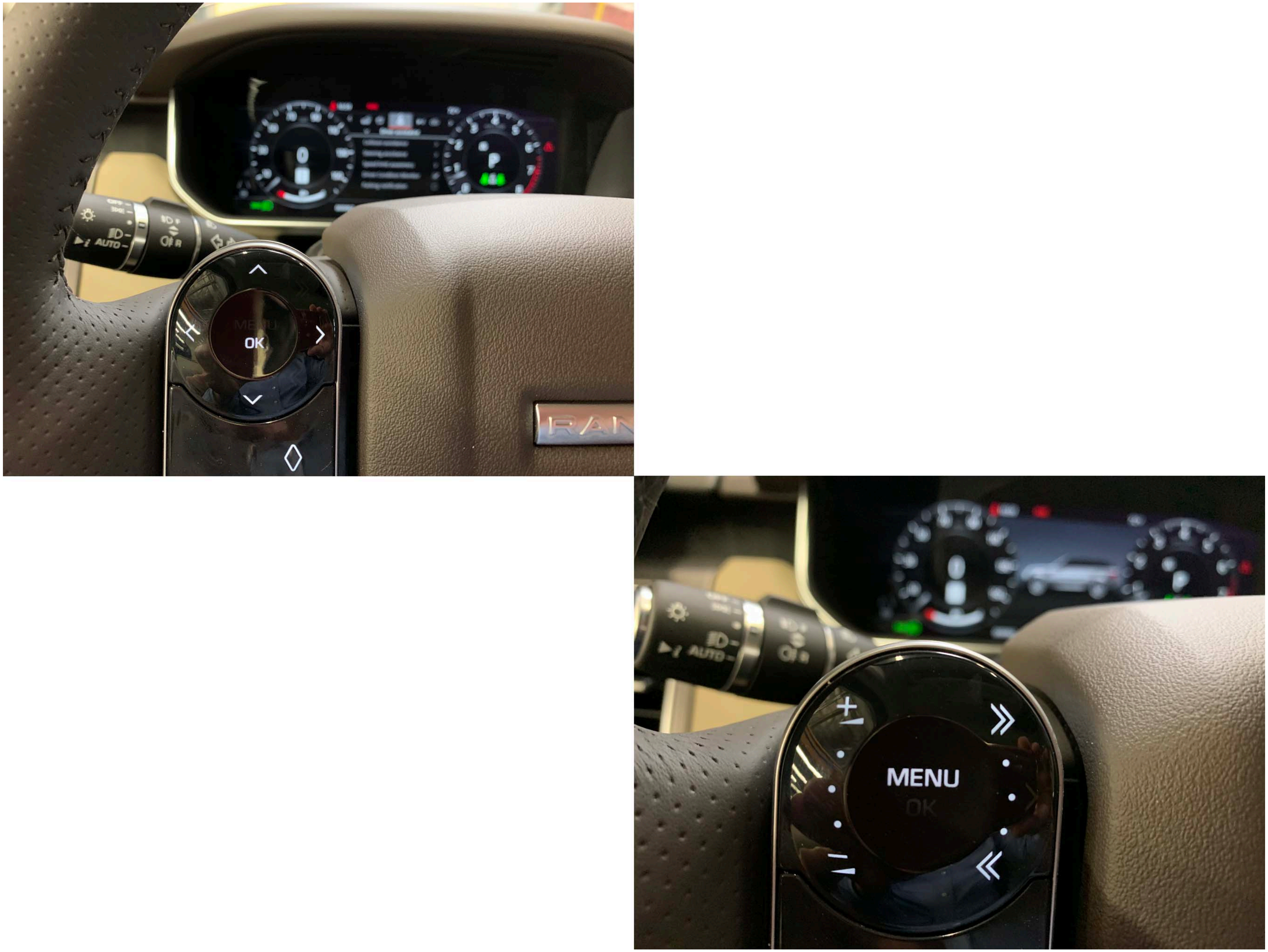


Figure A14. Controls for Changing Vehicle Parameters

Figure A15. Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

COLLISION AVOIDANCE SAFETY

Make sure the following warnings have been read and fully understood before driving the vehicle. Failure to use the collision avoidance systems safely could result in an accident, leading to serious injury or death.

⚠WARNING

Collision avoidance systems are not a substitute for driving safely, with due care and attention. Staying alert, driving safely, and being in control of the vehicle at all times is the responsibility of the driver.

⚠WARNING

Blind spot driving aids are a supplement to, not a replacement for, a safe driving style.

⚠WARNING

The driver is responsible for driving with due care and attention, and in a safe manner for the vehicle, the occupants, and other road users. The driver is responsible for detecting obstacles, and estimating the vehicle's distance from them, when maneuvering the vehicle. The driver should observe all road signs, road markings and any potential braking situations, and act appropriately.

⚠WARNING

Always use the door and rear-view mirrors. Drive safely at all times, and use the door and rear-view mirrors to help avoid accidents.

⚠WARNING

Blind spot driving aids may not function at all speeds, or in all weather conditions.

⚠WARNING

Blind spot driving aids do not correct errors of judgement when driving.

⚠WARNING

The radar and camera sensors used by the blind spot driving aids may become impaired by mud, rain, frost, ice, snow, road spray, etc. The blind spot driving aids ability to detect a vehicle in the driver's blind spot may subsequently be affected and may give false indications.

⚠WARNING

Do not attach stickers or objects to the rear bumper or to the windshield. Operation of the blind spot sensors and camera may subsequently become impaired. The blind spot driving aids ability to detect a vehicle in the driver's blind spot may subsequently be affected and may give false indications.

⚠WARNING

Do not attach stickers or other objects to the door mirrors, as the blind spot icons and indicators may become obscured. Obscuring the icons and indicators could increase the risk of a collision during a vehicle maneuver.

⚠WARNING

The blind spot monitor system may not be able to give adequate warning of vehicles approaching very quickly from behind.

⚠WARNING

The blind spot monitor system may not be able to detect all vehicles and may also detect objects such as roadside barriers, etc.

⚠WARNING

Do not use blind spot assist when a trailer is connected. The trailer may provide miscalculations or false indications. False indications could increase the risk of a collision during a vehicle maneuver.

⚠WARNING

The radar sensor must be calibrated if it is replaced, its mounting is replaced, or it becomes misaligned, e.g., as a result of impact damage. Contact a retailer/authorized repairer.

FORWARD ALERT

⚠WARNING

Make sure the relevant safety warnings have been read and understood before driving the vehicle. See 193, COLLISION AVOIDANCE SAFETY.

⚠WARNING

Forward alert may not react to slow-moving vehicles. Always drive with due care and attention. Driving without due care and attention greatly increases the risk of an accident.

Forward alert monitors an area in front of the vehicle. The driver is warned if forward alert detects an object within the detection area. The instrument panel also displays a warning message if the vehicle is traveling between 18 mph (30 km/h) and 50 mph (80 km/h). The driver is responsible for taking appropriate action.

Three forward alert sensitivity settings are available:

- Normal.
- Medium.
- High.

Warnings sound and the instrument panel displays a warning message if forward alert detects an object in front of the vehicle.

Forward alert can be switched on and off via the **Driver assistance** instrument panel menu. See **65, INSTRUMENT PANEL MENU**.

Forward alert sensitivity can be adjusted. See **194, CHANGING THE FORWARD ALERT SENSITIVITY**.

CHANGING THE FORWARD ALERT SENSITIVITY

Forward alert has three different sensitivity settings. The default setting is **Normal**.

The sensitivity of the forward alert feature can be changed as follows:

1. Switch the vehicle's ignition on.
2. Select **Collision avoidance** from the **Driver assistance** instrument panel menu. See **65, INSTRUMENT PANEL MENU**.
3. Use the steering wheel controls to highlight the required setting: **Normal**, **Medium**, or **High**.

4. Press and release the **OK** button on the steering wheel.

The forward alert sensitivity setting is retained in the vehicle's memory after the vehicle is switched off.

AUTONOMOUS EMERGENCY BRAKING (AEB) SAFETY

Make sure the following warnings have been read and fully understood before driving the vehicle. Failure to understand the Autonomous Emergency Braking (AEB) system could result in an accident, leading to serious injury or death.

⚠WARNING

The AEB system is a driving aid only. The driver is responsible for driving with due care and attention, and in a safe manner for the vehicle, the occupants, and other road users. The driver should observe all road signs, road markings and any potential emergency braking situations, and act appropriately.

⚠WARNING

The AEB system uses forward-facing cameras to detect real vehicles and pedestrians, plus other certified target objects. AEB is not designed to detect any other objects, including non-industry approved targets.

⚠WARNING

In order for AEB to operate, it must be able to detect a clear image of the object and be able to determine its movement. If neither of these occur, the AEB system may not operate.

⚠WARNING

Seat belts should be worn by all vehicle occupants, for every trip, no matter how short. Failure to do so greatly increases the risk of death or serious injury in the event of an accident.

⚠WARNING

Make sure that the windshield is kept clean and that the camera's line of sight is not obstructed by labels, stickers, etc. Failure to do so can cause incorrect AEB operation.

Note: *AEB efficiency is dependent on the condition of the current driving surface and the vehicle's speed, tires, and braking system.*

Note: *When a vehicle is parked outside, in full sunlight and in high ambient temperatures, the forward-facing camera may reach an internal temperature of 210°F (99°C). In this state, the instrument panel displays the warning message* ***AEB not available****. When the forward-facing camera cools to less than 190°F (88°C), normal operation is resumed, and the warning message extinguishes.*

Note: *When driving off-road, it is recommended to switch off the AEB system.*

Note: *When the vehicle's ignition is first switched on, AEB may require an initialisation period before it is fully functional. AEB efficiency is limited during this period.*

AUTONOMOUS EMERGENCY BRAKING (AEB)

⚠WARNING

Make sure the relevant safety warnings have been read and understood before driving the vehicle. See 195, AUTONOMOUS EMERGENCY BRAKING (AEB) SAFETY.

Note: *Not all vehicles are fitted with Autonomous Emergency Braking (AEB). Consult a retailer/authorized repairer for confirmation.*

AEB uses forward-facing cameras, located above the rear-view mirror, to help identify an imminent risk of collision with:

- Another vehicle traveling in front.
- A crossing pedestrian.

In most instances, AEB helps reduce the severity of an impact. In some cases, AEB helps to stop the vehicle before an impact takes place.

AEB automatically switches on, every time the vehicle's ignition is switched on.

If required, AEB can be switched off via the **Driver assistance** instrument panel menu. See **65, INSTRUMENT PANEL MENU**.

AEB operates at speeds above 3 mph (5 km/h). The vehicle detection AEB system is able to operate at speeds of up to 50 mph (80 km/h). The pedestrian detection AEB systems is able to operate at speeds of up to 37 mph (60 km/h).

If an imminent risk of a collision is detected, the system automatically applies the brakes. The instrument panel also displays the message **AEB active** while AEB is operating.

⚠WARNING

If AEB brings the vehicle to a stop, the brakes continue to hold the vehicle stationary for a few seconds. After this period, the driver must resume full control of the vehicle. Failure to take back full control of the vehicle could result in an accident, leading to serious injury or death.

Note: *The brake lights are automatically operated in heavy braking situations.*

The driver can override AEB operation by turning the steering wheel, or pressing the accelerator pedal. When overridden, AEB cancels its request for braking to make sure that the driver remains in full control of the vehicle.

After AEB has been activated, a warning sounds and the instrument panel displays the message **AEB was activated**.

AUTONOMOUS EMERGENCY BRAKING (AEB) LIMITATIONS

Vehicle detection Autonomous Emergency Braking (AEB) does not operate if:

- The vehicle is negotiating a tight corner.
- The forward-facing cameras are dirty or obscured.
- The vehicle's speed is below 3 mph (5 km/h), or above 50 mph (80 km/h).
- Visibility is impaired due to severe weather conditions, e.g., heavy rain, fog, or snow.

In addition to the items listed for the vehicle detection AEB system, the pedestrian detection AEB system does not operate if:

- The vehicles speed is above 37 mph (60 km/h).
- The detected object is not identified as a pedestrian.
- The height of the object is less than 39 in (1 m).
- The pedestrian detection AEB system cannot determine that the target object is a pedestrian. For example, if the pedestrian is carrying a large object.

ADVANCED EMERGENCY BRAKE ASSIST (AEBA)

⚠WARNING

Make sure the relevant safety warnings have been read and understood before driving the vehicle. See 193, COLLISION AVOIDANCE SAFETY.

Advanced Emergency Brake Assist (AEBA) prepares the braking system if it detects a collision is imminent. If the driver subsequently presses the brake pedal, full braking force is applied immediately.

If forward alert is switched on, AEBA activates after the instrument panel displays the warning message **Forward alert**. AEBA automatically applies a light braking force. Full braking force is applied immediately when the driver presses the brake pedal.

AEBA still operates if forward alert is switched off.

ADVANCED EMERGENCY BRAKE ASSIST (AEBA) LIMITATIONS

Make sure the following warnings have been read and fully understood before driving the vehicle. The Advanced Emergency Brake Assist (AEBA) feature does not take away the requirement to always drive with due care and attention. Driving without due care and attention could result in an accident, leading to serious injury or death.

⚠WARNING

The AEBA feature may not react to slow-moving vehicles.

⚠WARNING

The AEBA feature does not react to stationary vehicles or vehicles traveling in the opposite direction.

⚠WARNING

In some circumstances, warnings may not display in the instrument panel. For example, if the distance to the vehicle ahead is very small. Another example includes when carrying out a collision avoidance maneuver by making large steering wheel and pedal movements.

AEBA operates at speeds above approximately 5 mph (8 km/h).

HIGH-SPEED EMERGENCY BRAKING

⚠WARNING

Make sure the relevant safety warnings have been read and understood before driving the vehicle. See 193, COLLISION AVOIDANCE SAFETY.

To extinguish an instrument panel warning or information message, press the **OK** button on the steering wheel controls.

Note: *Extinguishing displayed warning and information messages does not clear or rectify a detected fault.*

Note: *If a warning message is manually extinguished, the instrument panel illuminates an amber or red warning lamp until the cause of the message is rectified.*

If a persistent fault is detected, the warning message displays each time the ignition is switched on. In this event, follow any on-screen instructions or seek qualified assistance.

Instrument panel messages are displayed in order of importance. If more than one instrument panel message is active, each message is displayed in turn for 2 seconds. High importance warning messages are displayed first. The displayed warning messages can also be accompanied by an audible tone.

Some warning messages can also display the handbook symbol. For information regarding warning messages and any action required, refer to the warning and information lamps section of the Owner's Handbook. Follow any on-screen instructions, if displayed. The instrument panel displays a warning message until the detected fault is rectified.

USING THE TRIP COMPUTER

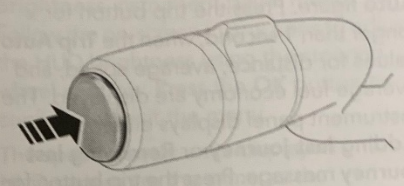
The trip computer displays information and stores data for a series of trips.

A trip is the distance traveled since the last memory reset via the trip computer. The maximum trip distance display is 9 999.9 (km or miles). The trip distance then automatically resets to zero.

Select the **Trip** and **Trip bank** instrument panel menus to display the required trip, i.e., **Trip A**, **Trip B**, or **Trip Auto**. See **65, INSTRUMENT PANEL MENU**.

The trip computer can be configured to display the trip units in miles or km. Select the **Trip** and **Units** instrument panel menus.

To configure the trip content options to be available for display in the instrument panel, select the **Trip** and **Content** instrument panel menus.



E197183

Press and release the trip button to change the trip content option displayed in the instrument panel.

The available trip content options are as follows:

- **Date**.
- **Average speed**.
- **Average economy**.
- **Instantaneous economy**.
- **Range**.
- **Battery range**: Hybrid vehicles only.
- **Trip distance**.

Some of the trip content values can be reset to zero. Select and display the relevant trip content option. Press and hold the trip buttons for 2 seconds.

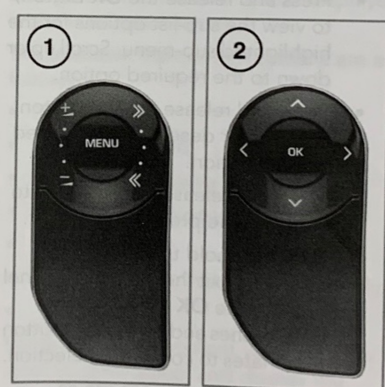
1. **CHARGE** zone: When the vehicle is decelerating during braking or overrun, the electric motor regenerates energy and supplies a charge to the hybrid battery. The charge zone indicates the instantaneous amount of the regenerated energy.
2. **0% POWER**: Indicates when there is no energy being consumed or regenerated.
3. Power gauge marker: Moves to indicate the current power being delivered by the engine and the electric motor.
4. **ECO** zone: Driving in this zone helps to reduce energy consumption.
5. Engine start marker: Displays when the Electric Vehicle (EV) mode is active and indicates the maximum power output of the electric motor. If the current power demand exceeds the start marker position, the engine is started for temporary use. In this event the EV mode is suspended and the engine start marker illuminates gray. If the EV mode is deselected or canceled the engine start marker extinguishes.
6. **READY** or **OFF** status: Indicates when the vehicle is ready to be driven.
7. **EV**: Illuminates to confirm selection of the EV mode via the center console button. See **135, ELECTRIC VEHICLE (EV) MODE**.
   If selected, **SAVE** replaces **EV**. See **138, SAVE**.
8. **100% POWER**: Indicates the maximum power output for the engine.
9. **BOOST** zone: Indicates when the engine and the electric motor are combined to increase the total power output.
10. Gear selector status display.
11. Hybrid battery charge gauge: Indicates the state of charge.

INSTRUMENT PANEL MENU

⚠WARNING

Do not operate the instrument panel controls while the vehicle is moving. Doing so may cause driver distraction, potentially resulting in an accident and causing serious injury or death.

Use the instrument panel menus to configure the instrument panel display and some vehicle features. Use the controls mounted on the left side of the steering wheel to display and navigate through the instrument panel menus.



E200493

Operate the instrument panel menus as follows:

1. **MENU** button: Press and release to display the instrument panel menus. The **MENU** button extinguishes and the **OK** button illuminates.
   The menus do not display if the instrument panel displays any warning or information messages. In this event, press the **OK** button to clear each message after reading and taking any required action. See **66, WARNING AND INFORMATION MESSAGES**.
2. Operate the buttons as follows:
   - Press the **>** button or the **<** button, to scroll through and highlight the required main menu option, displayed at the top of the information panel. The relevant sub-menu list is automatically displayed.
   - Press the **∧** button or the **∨** button, to scroll through the sub-menu list and highlight the required menu.
   - Press and release the **OK** button, to view the sub-list options for the highlighted sub-menu. Scroll up or down to the required option.
   - Press and release the **OK** button to select or deselect the required sub-list option.
   - Press and release the **<** button to return to the previous menu list.
   - Press and hold the **<** button to close and exit the instrument panel menus. The **OK** button extinguishes and the **MENU** button illuminates to confirm deselection.

The displayed menu options are as follows:

- **Phone**: Only available when a phone is connected.
- **Media**.
- **Driver assistance**.
- **Trip**.
- **Display**. The interactive driver display is configurable. Use the **Display layout** menu to select a **Two dial**, **One dial**, **Full map**, **Media**, or a **Driver assistance** view.
- **Head-up display**.
- **Vehicle settings**.

⚠WARNING

Before making any changes to the Vehicle settings, make sure to read and fully understand the relevant sections and topics of the Owner's Handbook. Failure to do so can lead to serious injury or death.

- **Vehicle info**: Some options are only available before the engine starts.

WARNING AND INFORMATION MESSAGES

⚠WARNING

Do not ignore any warning or information messages displayed in the instrument panel. Take appropriate action as soon as possible. Failure to do so may result in death, serious injury, or serious damage to the vehicle.

The instrument panel displays warning messages if specific driver action is required, or to accompany illuminated warning lamps. For example, in the event that a vehicle system fault is detected.

The instrument panel displays information messages if specific driver action is required, or for driver information. For example, to confirm and assist with the selection or deselection of some vehicle features.

APPENDIX C

Run Log

Run Log for Daytime Tests

Subject Vehicle: *2020 Land Rover Range Rover Sport HSE* Test Date: *7/22/2020*

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 run										
2	**S1a**	**16**	**Day**	Y	0.63	0.35	16.3	1.11	0.62	NC	
3				Y	0.57	0.05	16.6	1.13	0.52	NC	
4				Y	0.65	0.51	16.6	1.14	0.68	NC	
5				Y	0.61	0.25	16.4	1.13	0.59	NC	
6				N							SV speed
7				Y		0.00	0.7	0.03		Contact	No warning, no AEB
13	**S1a**	**35**	**Day**	Y	1.40	1.05	34.9	1.01	0.94	NC	
14				Y	1.38	0.80	35.1	1.02	0.90	NC	
15				Y	1.54	1.08	34.8	1.01	0.92	NC	
16				N							SV speed
17				Y	1.31	0.00	3.0	0.31	0.90	Contact	
18				N							PTM lateral

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
19	**S1a**	**35**	**Day**	N							PTM lateral
20				Y	1.39	0.51	35.2	1.04	0.87	NC	
8	**S1a**	**40**	**Day**	Y	0.97	0.01	40.5	1.07	0.89	NC	
9				Y	1.45	0.00	1.8	0.12		Contact	No AEB
10				Y	1.44	0.00	6.5	0.53	1.14	Contact	
11				Y	1.43	0.83	39.9	1.02	1.22	NC	
12				Y	1.52	0.00	1.9	0.13		Contact	No AEB
21	Static run										
22	**S1b**	**16**	**Day**	Y	0.61	0.28	16.2	1.08	0.59	NC	
23				Y	0.63	0.36	16.6	1.07	0.60	NC	
24				Y	0.66	0.43	15.8	1.07	0.61	NC	
25				Y	0.64	0.39	16.2	1.06	0.66	NC	
26				N							Leg fell off
27				Y	0.67	0.47	16.5	1.06	0.65	NC	
34	**S1b**	**20**	**Day**	Y		0.00	0.0	0.01		Contact	No warning, no AEB
35				Y	0.66	0.09	20.2	0.93	0.61	NC	
36				Y		0.00	0.0	0.02		Contact	No warning, no AEB
37				Y	0.71	0.47	20.2	0.97	0.67	NC	
38				Y	0.74	0.74	20.4	0.97	0.73	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
39	**S1b**	**30**	**Day**	Y	1.57	0.37	30.0	0.97	0.81	NC	
40				Y	1.51	0.36	30.1	0.96	0.84	NC	
41				Y	1.23	0.39	30.5	0.99	0.79	NC	
42				Y	1.45	0.48	30.0	1.02	0.83	NC	
43				Y	1.00	0.93	30.5	1.05	0.88	NC	
28	**S1b**	**40**	**Day**	Y	1.52	0.40	39.5	1.00	0.95	NC	
29				Y	1.54	0.43	40.6	0.99	0.97	NC	
30				N							Femur fell out of dummy
31				Y	1.31	0.00	2.0	0.12		Contact	No AEB
32				Y		0.00	0.4	0.04		Contact	No warning, no AEB
33				N							Throttle
47	**S1b**	**45**	**Day**	N							Lateral error
48				Y	1.52	0.00	7.9	0.82	0.70	Contact	
49				Y	1.57	0.00	27.8	0.98	1.07	Contact	
50				Y	1.42	0.00	27.6	0.98	1.06	Contact	
51				N							Data dropout, brake hit
52				Y	1.52	0.00	23.3	0.99	0.85	Contact	
44	**S1b**	**50**	**Day**	Y	0.86	0.00	3.2	0.33	0.77	Contact	
45				Y	1.68	0.00	6.0	0.74	0.64	Contact	
46				Y	1.61	0.00	20.0	0.96	0.78	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
53	Static run										
54	**S1c**	**16**	**Day**	Y	0.64	0.44	16.4	1.06	0.67	NC	
55				N							PTM error brake switch
56				Y	0.58	0.17	15.3	1.05	0.84	NC	
57				N							PTM error
58				N							PTM error
59				Y	0.67	0.47	16.3	1.10	0.66	NC	
60				Y		0.00	0.0	0.04		Contact	No warning, no AEB
61				Y		0.00	1.3	0.05		Contact	No warning, legs were not moving
62				Y	0.63	0.29	16.6	1.11	0.61	NC	
63				Y	0.64	0.28	16.0	1.12	0.63	NC	
64				N							PTM lateral
65				Y	0.58	0.14	16.1	1.11	0.57	NC	
66	**S1c**	**40**	**Day**	N							Leg fell off
67				N							Leg fell off
68				Y	1.53	0.15	36.2	1.03	0.91	NC	
69				Y	1.53	0.53	40.3	1.02	1.19	NC	
70				Y	1.56	0.35	37.4	1.03	1.01	NC	
71				N							Leg fell off
72				Y	1.54	0.53	38.8	1.04	1.14	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
73	**S1c**	**40**	**Day**	Y	1.57	0.00	14.0	0.92	0.90	Contact	
155	**S1d**	**11**	**Day**	N							PTM lateral error
156				Y		0.00	0.2	0.02		Contact	No warning, no AEB
157				Y		0.00	0.1	0.03		Contact	No warning, no AEB
158				N							PTM lateral error
159				Y		0.00	0.1	0.03		Contact	No warning, no AEB
146	Static run										
147	**S1d**	**16**	**Day**	N							PTM lateral error
148				Y		0.00	0.0	0.05		Contact	No warning, no AEB
149				N							PTM lateral error
150				N							SV speed, PTM lateral error
151				Y		0.00	0.3	0.04		Contact	No warning, no AEB
152				N							SV speed
153				Y	0.69	0.62	15.3	1.15	0.89	NC	
154				Y		0.00	0.0	0.04		Contact	No warning, no AEB
160	**S1d**	**40**	**Day**	Y	1.03	0.37	39.2	1.08	0.94	NC	
161				Y	0.96	0.00	32.4	1.05	0.90	Contact	
162				Y	0.99	0.00	2.1	0.14		Contact	Peak decel not above AEB activation threshold
163				Y	0.49	0.00	5.0	0.69	0.45	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
164	Static run										
74	Static run										
75	**S1e**	**40**	**Day**	Y	1.53	0.32	38.4	1.01	0.95	NC	
76				Y	1.17	0.50	39.7	1.02	1.01	NC	
77				Y	1.15	0.07	35.8	1.04	0.92	NC	
78				Y	1.09	1.03	35.6	1.02	1.00	NC	
79				Y	0.82	0.00	22.3	1.03	0.77	Contact	
83	**S1e**	**45**	**Day**	Y	1.44	0.00	29.0	1.02	0.87	Contact	
84				Y	1.03	0.00	32.0	1.02	0.92	Contact	
85				Y	1.02	0.00	21.1	1.03	0.77	Contact	
86				N							Wrong test type
87				Y	0.66	0.00	9.8	0.93	0.57	Contact	
88				Y	0.86	0.00	22.2	0.99	0.78	Contact	
80	**S1e**	**50**	**Day**	Y	1.46	0.00	24.4	1.00	0.84	Contact	
81				Y	1.21	0.00	24.7	1.01	0.85	Contact	
82				Y	1.49	0.00	29.2	1.02	1.09	Contact	
89	Static run										
90	**S1f**	**40**	**Day**	N							Throttle
91				Y	1.48	0.00	29.1	1.01	0.91	NC	
92				Y	1.57	0.00	40.2	0.98	1.19	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
93	**S1f**	**40**	**Day**	Y	1.31	0.00	2.0	0.05		NC	No AEB
94				Y	1.54	0.00	37.2	1.01	0.99	NC	
95	**S1g**	**40**	**Day**	N							PTM error
96				Y		0.00	0.0	0.02		NC	No warning, no AEB
97				Y		0.00	0.6	0.03		NC	No warning, no AEB
98				Y		0.00	0.2	0.04		NC	No warning, no AEB
99				Y		0.00	0.0	0.01		NC	No warning, no AEB
100				Y		0.00	0.7	0.02		NC	No warning, no AEB
101				Y		0.00	0.0	0.02		NC	No warning, no AEB
102	Static run										
103	**S4a**	**16**	**Day**	Y	0.61	0.37	16.5	1.07	0.63	NC	
104				Y	0.59	0.17	16.3	1.03	0.57	NC	
105				Y	0.62	0.39	16.0	1.06	0.64	NC	
106				Y	0.60	0.28	16.5	1.06	0.59	NC	
107				Y	0.64	0.47	16.4	1.06	0.65	NC	
113	**S4a**	**35**	**Day**	N							PP error
114				Y	1.50	0.00	28.9	1.01	0.82	Contact	
115				Y	1.43	0.26	35.5	1.01	0.88	NC	
116				Y	1.46	0.03	35.2	1.04	0.85	NC	
117				Y	1.47	0.42	35.3	1.00	1.14	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
118	**S4a**	**35**	**Day**	Y	1.48	0.05	34.5	1.09	1.18	NC	
108	**S4a**	**40**	**Day**	Y	1.43	0.00	36.8	1.00	0.93	Contact	
109				Y	1.42	0.43	39.5	1.00	0.98	NC	
110				Y	1.38	0.00	37.7	0.98	0.89	Contact	
111				Y	1.46	0.50	39.6	1.00	1.01	NC	
112				Y	1.40	0.00	31.4	0.97	0.91	Contact	
119	Static run										
120	**S4b**	**16**	**Day**	Y	0.74	0.93	15.1	1.08	0.77	NC	
121				Y	0.64	0.45	16.8	1.05	0.62	NC	
122				Y	0.70	0.75	16.4	1.03	0.74	NC	
123				Y	0.65	0.56	16.6	1.05	0.90	NC	
124				Y	0.70	0.75	16.1	1.06	0.71	NC	
125	**S4b**	**40**	**Day**	Y	1.49	0.03	40.5	1.01	0.93	NC	
126				Y	1.48	0.90	40.7	1.03	1.04	NC	
127				Y	1.44	0.50	40.3	1.02	0.98	NC	
128				Y	1.47	0.36	40.2	0.99	0.91	NC	
129				Y	1.47	0.48	39.9	1.04	0.97	NC	
130				Y	1.46	1.58	39.5	1.02	1.06	NC	
131	Static run										
132	**S4c**	**16**	**Day**	Y	0.55	0.23	16.4	1.07	0.52	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
133	**S4c**	**16**	**Day**	Y	0.45	0.05	16.3	1.10	0.46	NC	
134				Y	0.51	0.11	15.6	1.09	0.49	NC	
135				Y	0.48	0.02	16.2	1.08	0.43	NC	
136				Y	0.53	0.19	16.0	0.98	0.50	NC	
137	**S4c**	**40**	**Day**	Y	1.80	1.05	40.2	1.08	0.92	NC	
138				Y	1.79	2.00	39.4	1.04	1.04	NC	
139				Y	1.82	0.00	3.2	0.37	0.89	Contact	
140				Y	1.51	0.65	40.3	1.05	0.88	NC	
141				Y	1.46	1.76	39.9	1.03	0.99	NC	
165	Static run										
166	**S4c**	**45**	**Day**	Y	1.67	1.03	45.2	1.02	1.20	NC	
167				Y	1.63	0.00	4.8	0.67	0.72	Contact	
168				Y	1.64	1.01	45.4	1.03	0.98	NC	
169				Y	1.70	1.65	45.1	1.02	1.23	NC	
170				Y	1.65	1.97	45.2	1.00	1.25	NC	
171				Y	1.67	1.25	45.2	1.02	1.38	NC	
172	Static run										
142	**S4c**	**50**	**Day**	Y	1.71	0.00	1.7	0.09		Contact	No AEB
143				Y	1.46	0.00	19.1	1.06	0.74	Contact	
144				Y	1.75	1.03	50.0	1.02	1.30	NC	
145				Y	1.83	0.00	31.5	1.01	0.90	Contact	

Run Log for Nighttime Tests

Subject Vehicle: *2020 Land Rover Range Rover Sport HSE*

Test Date: *7/21/2020*

Adult Pedestrian Test Mannequin: *Articulated 4A Adult*

Test Driver: *S. Judy, A. Ricci*

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
23	**S1b**	**11**	**High Beam**	Y		0.00	0.3	0.01		Contact	No warning, no AEB
24				Y		0.00	0.0	0.02		Contact	No warning, no AEB
25				Y		0.00	0.1	0.01		Contact	No warning, no AEB
26	Static										
6	**S1b**	**16**	**High Beam**	Y		0.00	0.0	0.04		Contact	No warning, no AEB
7				Y		0.00	0.1	0.02		Contact	No warning, no AEB
8				N							SV Speed
9				N							SV Speed

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
10	**S1b**	**16**	**High Beam**	N							PTM lateral error
11				Y		0.00	0.0	0.03		Contact	No warning, no AEB
16	**S1b**	**40**	**High Beam**	Y		0.00	0.2	0.02		Contact	No warning, no AEB
17				Y		0.00	0.0	0.02		Contact	No warning, no AEB
18				N							SV Speed
19				N							PTM lateral error
118	**S1d**	**11**	**High Beam**	Y		0.00	0.4	0.03		Contact	No warning, no AEB
119				Y		0.00	0.3	0.03		Contact	No warning, no AEB
120				Y		0.00	0.0	0.03		Contact	No warning, no AEB
104	**S1d**	**16**	**High Beam**	Y		0.00	0.7	0.03		Contact	No warning, no AEB
105				Y		0.00	0.1	0.04		Contact	No warning, no AEB
106				Y		0.00	0.2	0.03		Contact	No warning, no AEB
110	**S1d**	**40**	**High Beam**	Y		0.00	0.5	0.02		Contact	No warning, no AEB
111				Y		0.00	0.0	0.01		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
112	**S1d**	**40**	**High Beam**	Y		0.00	0.0	0.02		Contact	No warning, no AEB
42	**S1e**	**35**	**High Beam**	Y		0.00	0.9	0.06		Contact	No warning, no AEB
43				Y	1.37	0.00	0.9	0.07		Contact	No PAEB
44				N							Throttle
45	Static										
34	**S1e**	**40**	**High Beam**	Y		0.00	0.7	0.05		Contact	No warning, no AEB
35				N							SV Speed
36				Y		0.00	0.0	0.03		Contact	Pedestrian leg fell off, no warning
37				N							Throttle
38				Y		0.00	0.8	0.08		Contact	No warning, no AEB
82	**S4a**	**16**	**High Beam**	Y	0.62	0.25	15.9	1.14	0.61	NC	
83				Y		0.00	0.0	0.03		Contact	No warning, no AEB
84				Y	0.62	0.32	16.7	1.16	0.63	NC	
85				Y	0.64	0.20	16.0	1.15	0.58	NC	
86				Y	0.59	0.07	16.0	1.16	0.53	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
97	**S4a**	**35**	**High Beam**	Y		0.00	0.0	0.04		Contact	No warning, no AEB
98				Y		0.00	0.0	0.03		Contact	No warning, no AEB
99				Y		0.00	0.1	0.03		Contact	No warning, no AEB
90	**S4a**	**40**	**High Beam**	Y		0.00	0.0	0.03		Contact	No warning, no AEB
91				Y		0.00	0.0	0.03		Contact	No warning, no AEB
92				Y		0.00	0.0	0.02		Contact	No warning, no AEB
51	**S4c**	**16**	**High Beam**	N							SV Speed
52				Y	0.53	0.17	16.4	1.08	0.48	NC	
53				Y		0.00	0.0	0.03		Contact	No warning, no AEB
54				Y		0.00	0.1	0.03		Contact	No warning, no AEB
55				Y		0.00	0.0	0.02		Contact	No warning, no AEB
59	**S4c**	**40**	**High Beam**	N							SV speed
60				Y	1.71	3.20	40.6	1.05	1.13	NC	
61				Y	1.72	2.97	40.0	1.06	1.15	NC	
62				Y	1.73	0.64	40.2	1.02	0.86	NC	
63				Y	1.65	2.53	40.4	1.05	1.04	NC	

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
64	**S4c**	**40**	**High Beam**	Y	1.69	2.89	40.0	1.05	1.10	NC	
73	**S4c**	**45**	**High Beam**	Y	1.65	0.00	17.7	1.08	0.70	Contact	
74				Y	1.62	1.43	45.7	1.04	1.00	NC	
75				Y	1.63	0.00	34.9	1.03	0.93	Contact	
76				Y	1.67	0.00	1.5	0.09		Contact	NO PAEB TTC
77	Static										
69	**S4c**	**50**	**High Beam**	Y	1.59	0.00	21.6	1.04	0.77	Contact	
70				Y	1.65	0.00	23.0	1.02	0.79	Contact	
71				Y	1.58	0.57	49.8	1.05	0.98	NC	
72				Y	1.63	0.00	1.6	0.42	0.27	Contact	
20	**S1b**	**11**	**Low Beam**	Y		0.00	0.2	0.02		Contact	No warning, no AEB
21				Y		0.00	0.1	0.02		Contact	No warning, no AEB
22				Y		0.00	0.0	0.02		Contact	No warning, no AEB
1	Static Run										
2	**S1b**	**16**	**Low Beam**	Y		0.00	0.0	0.03		Contact	No warning, no AEB
3				N							SV speed
4				Y		0.00	0.0	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
5	**S1b**	**16**	**Low Beam**	Y		0.00	0.0	0.03		Contact	No warning, no AEB
12	**S1b**	**40**	**Low Beam**	Y		0.00	0.0	0.04		Contact	No warning, no AEB
13				N							SV Yaw Rate
14				Y		0.00	0.0	0.02		Contact	No warning, no AEB
15				Y		0.00	0.0	0.04		Contact	No warning, no AEB
113	**S1d**	**11**	**Low Beam**	Y		0.00	0.0	0.01		Contact	No warning, no AEB
114				N							PTM lateral error, Driver Braking
115				Y		0.00	0.1	0.00		Contact	No warning, no AEB
116				Y		0.00	0.2	0.03		Contact	No warning, no AEB
117				Y		0.00	0.5	0.02		Contact	No warning, no AEB
100	Static Run (1m)										
101	**S1d**	**16**	**Low Beam**	Y		0.00	0.0	0.01		Contact	No warning, no AEB
102				Y		0.00	0.0	0.02		Contact	No warning, no AEB
103				Y		0.00	0.0	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
107	**S1d**	**40**	**Low Beam**	Y		0.00	0.0	0.04		Contact	No warning, no AEB
108				Y		0.00	0.0	0.04		Contact	No warning, no AEB
109				Y		0.00	0.0	0.03		Contact	No warning, no AEB
39	**S1e**	**35**	**Low Beam**	Y		0.00	0.3	0.05		Contact	No warning, no AEB
40				Y		0.00	0.0	0.04		Contact	No warning, no AEB
41				Y		0.00	0.0	0.01		Contact	No warning, no AEB
27	Static Run										
28	**S1e**	**40**	**Low Beam**	Y		0.00	0.0	0.06		Contact	No warning, no AEB
29				N							PTM lateral error
30				N							SV speed
31											**Static**
32				Y		0.00	0.3	0.04		Contact	No warning, no AEB
33				Y		0.00	0.3	0.03		Contact	No warning, no AEB
93	**S4a**	**11**	**Low Beam**	Y		0.00	0.0	0.01		Contact	No warning, no AEB
94				N							SV speed

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
95	**S4a**	**11**	**Low Beam**	Y		0.00	0.1	0.01		Contact	No warning, no AEB
96				Y		0.00	0.0	0.01		Contact	No warning, no AEB
78	Static Run										
79	**S4a**	**16**	**Low Beam**	Y		0.00	0.0	0.04		Contact	No warning, no AEB
80				Y		0.00	0.1	0.03		Contact	No warning, no AEB
81				Y		0.00	0.0	0.03		Contact	No warning, no AEB
87	**S4a**	**40**	**Low Beam**	Y		0.00	0.1	0.02		Contact	No warning, no AEB
88				Y		0.00	0.0	0.04		Contact	No warning, no AEB
89				N							SV speed
65	**S4c**	**11**	**Low Beam**	Y		0.00	0.2	0.01		Contact	No warning, no AEB
66				Y		0.00	0.0	0.01		Contact	No warning, no AEB
67				Y		0.00	0.0	0.01		Contact	No warning, no AEB
68				Y		0.00	0.0	0.01		Contact	No warning, no AEB
46	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
47	**S4c**	**16**	**Low Beam**	Y		0.00	0.9	0.03		Contact	No warning, no AEB
48				Y		0.00	0.3	0.03		Contact	No warning, no AEB
49				N							SV speed
50				Y		0.00	0.1	0.03		Contact	No warning, no AEB
56	**S4c**	**40**	**Low Beam**	Y		0.00	0.0	0.02		Contact	No warning, no AEB
57				Y		0.00	0.0	0.01		Contact	No warning, no AEB
58				Y		0.00	0.5	0.04		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. When no warning is detected the plot will display “No Wng” in red except that for scenarios S1f and S1g, for which no contact is the appropriate result, “No Warning” will be displayed in black.

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

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

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

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

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

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

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

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

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

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

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

Envelopes and Thresholds

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

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

Color Codes

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

Color codes can be broken into four categories:

1. Time-varying data color codes:

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

2. Validation envelope and threshold color codes:

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

3. Individual data point color codes:

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

4. Text color codes:

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

Other Notations

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

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

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

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

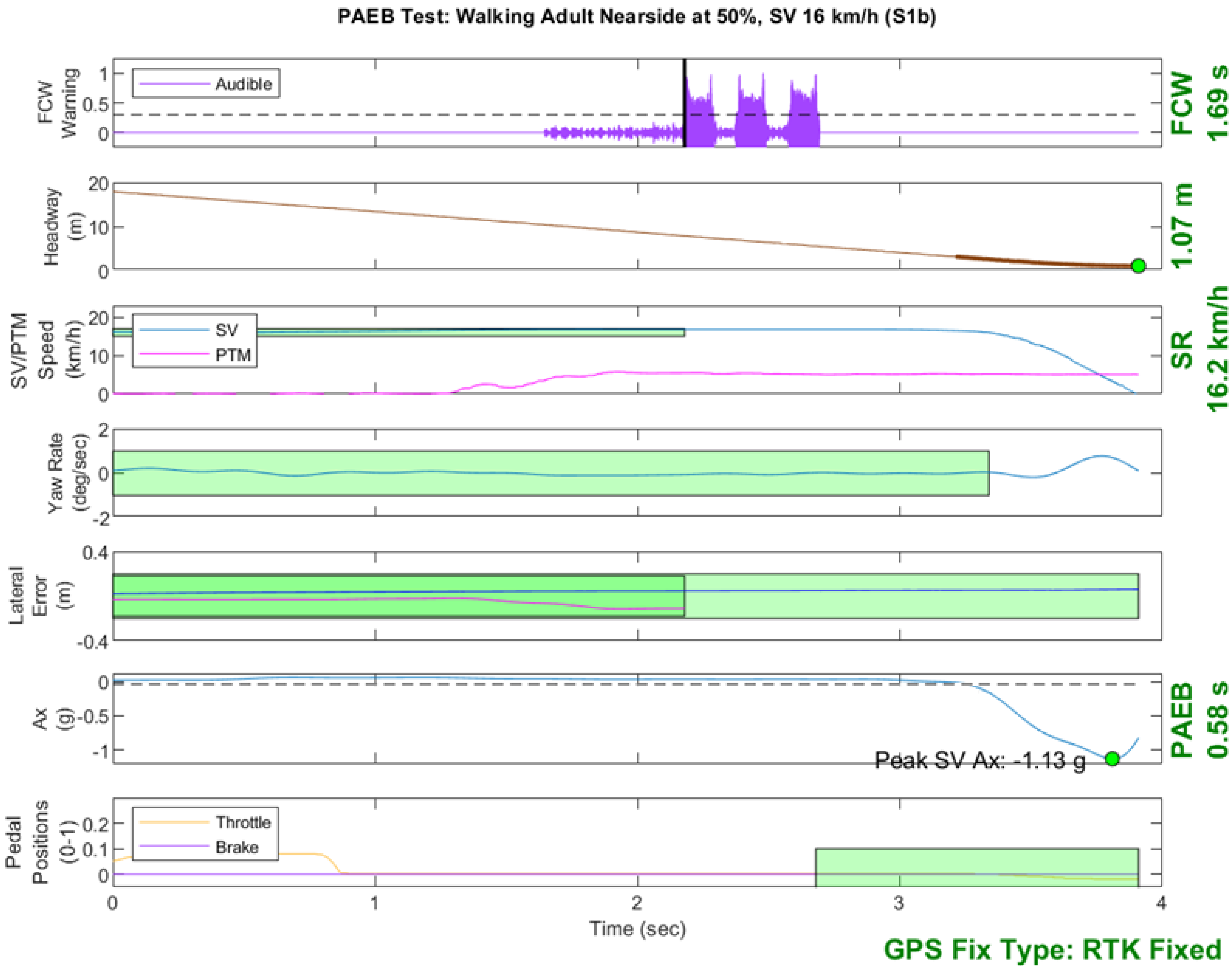


Figure D1. Example Time History for a Passing Run

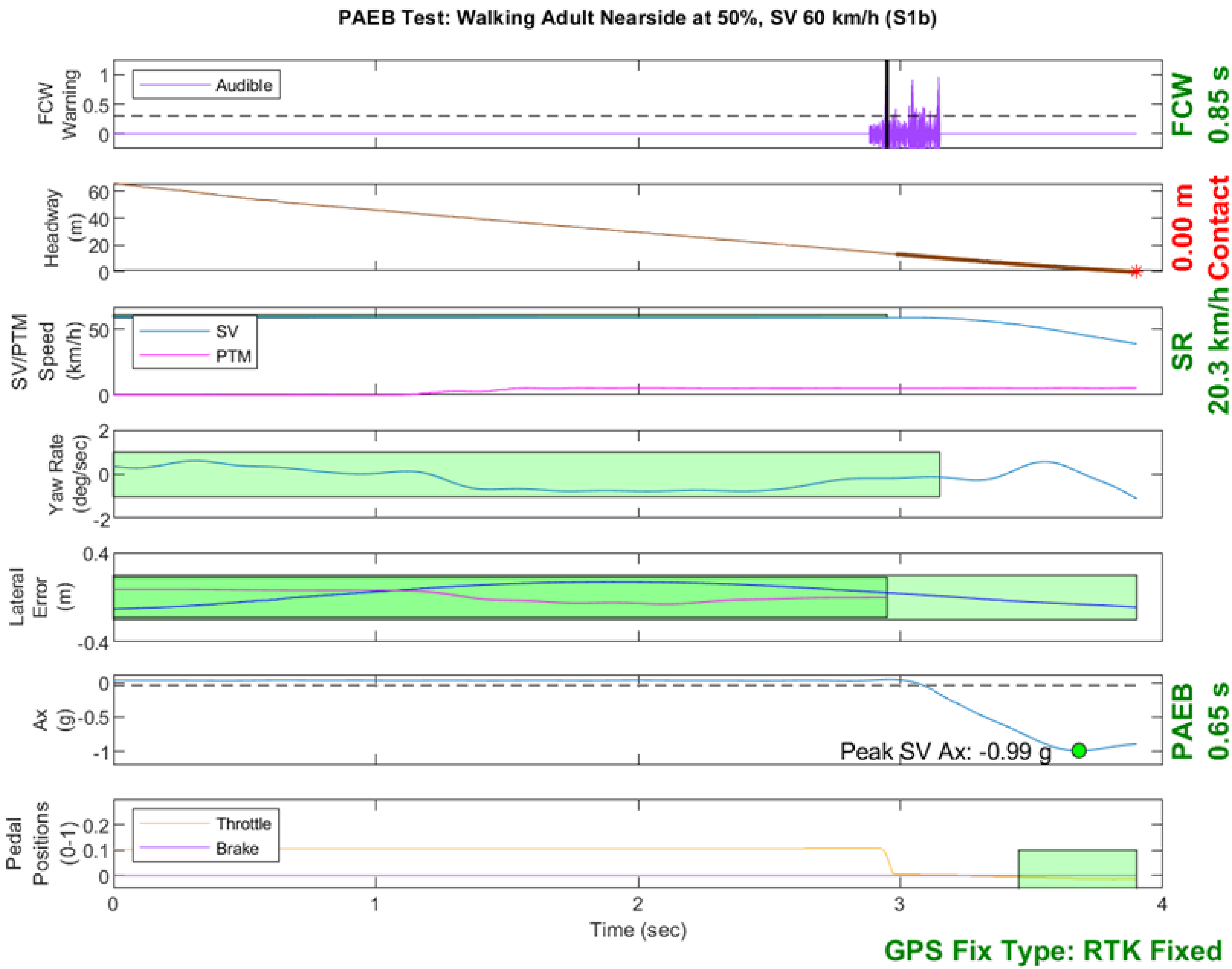


Figure D2. Example Time History for a Failed Run

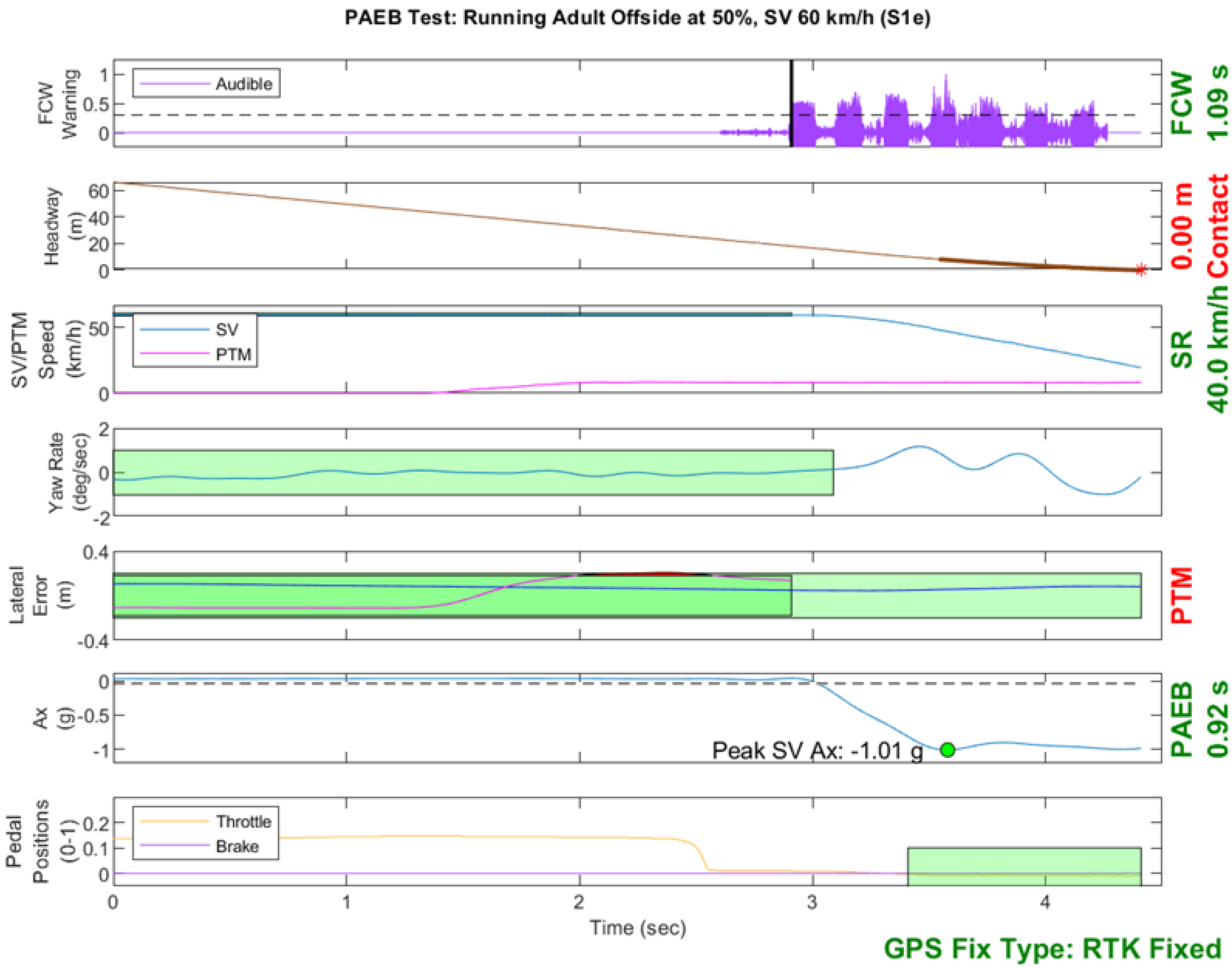


Figure D3. Example Time History for an Invalid Run Due to PTM Lateral Error

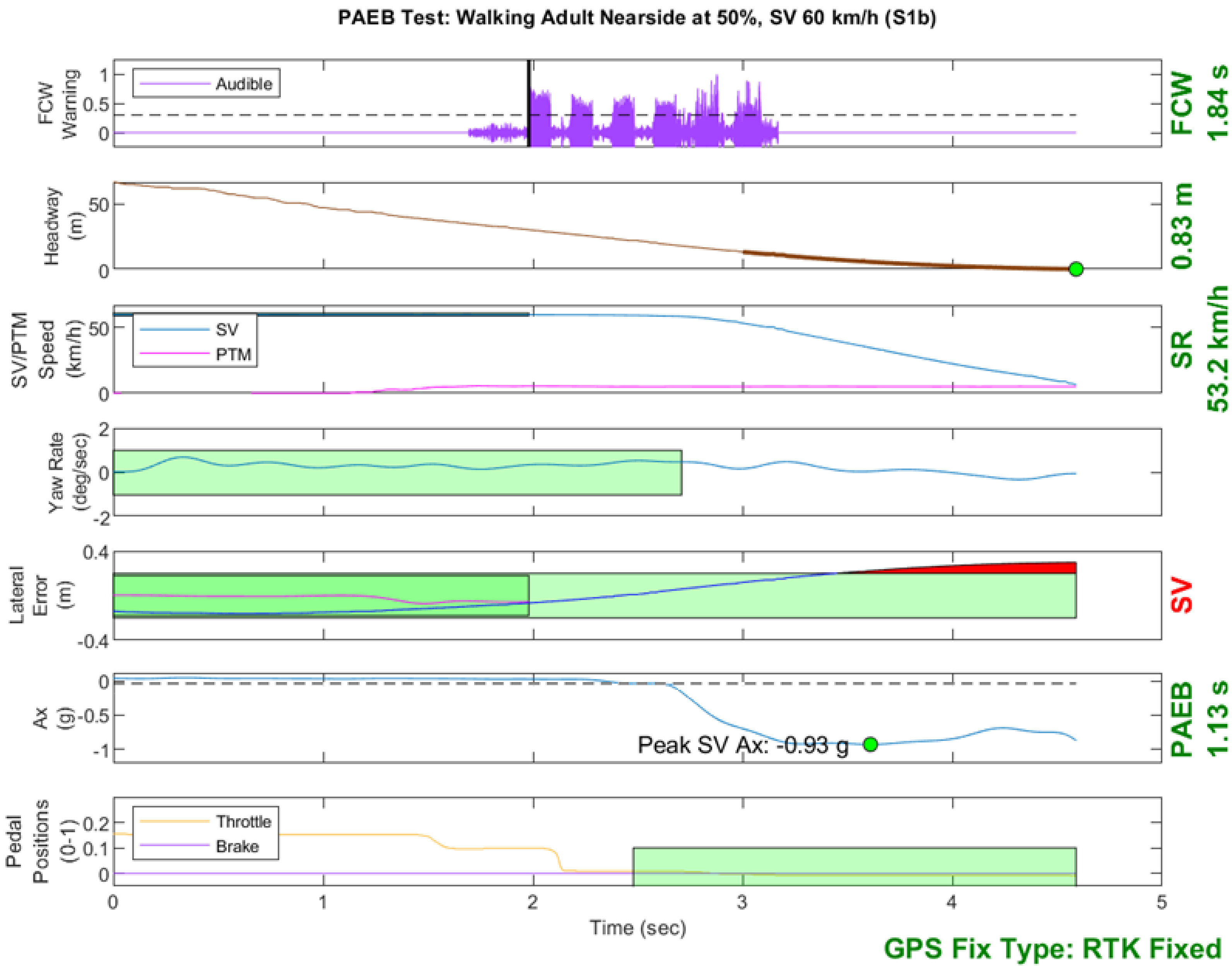


Figure D4. Example Time History for an Invalid Run Due to SV Lateral Error

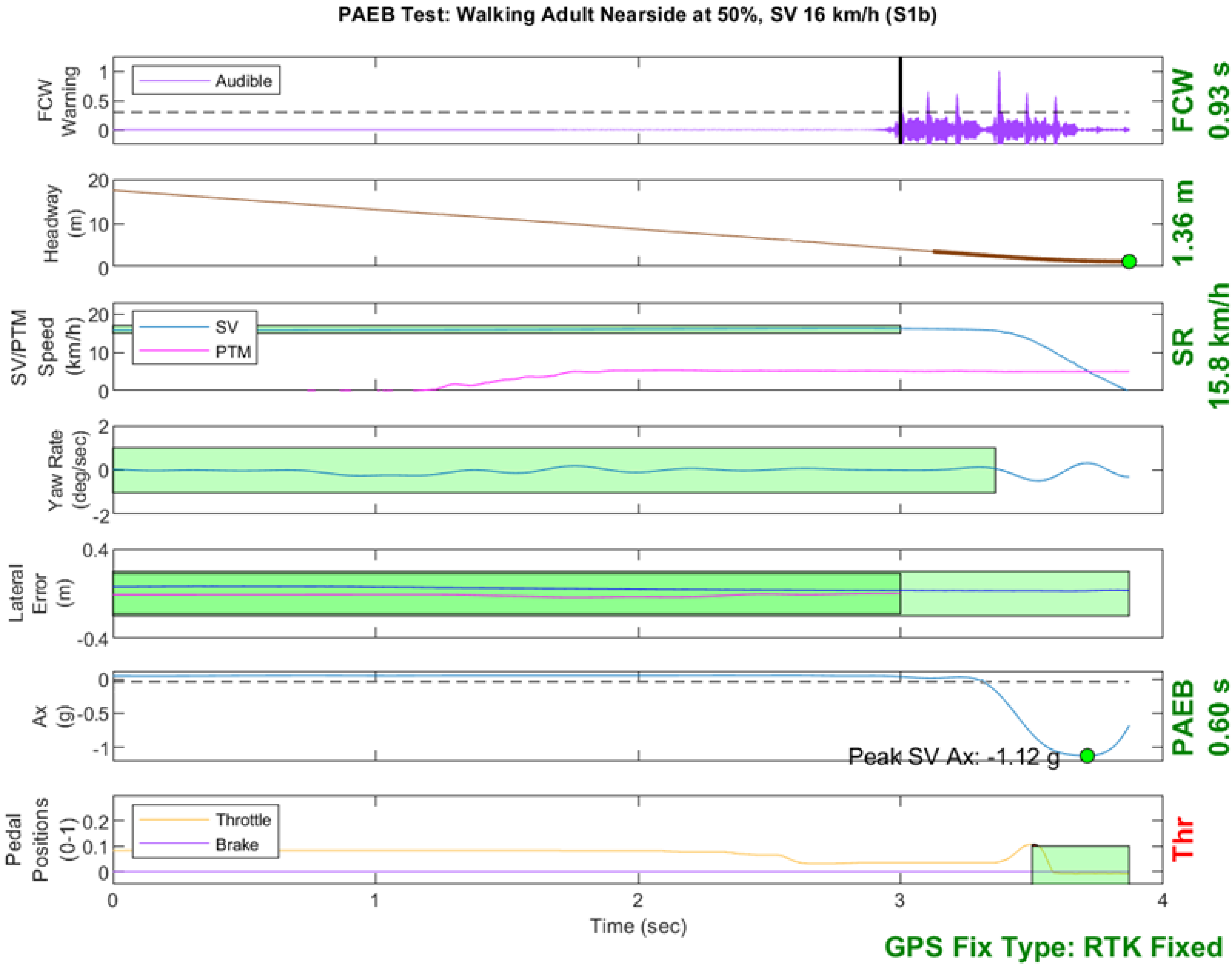


Figure D5. Example Time History for an Invalid Run Due to Throttle Error

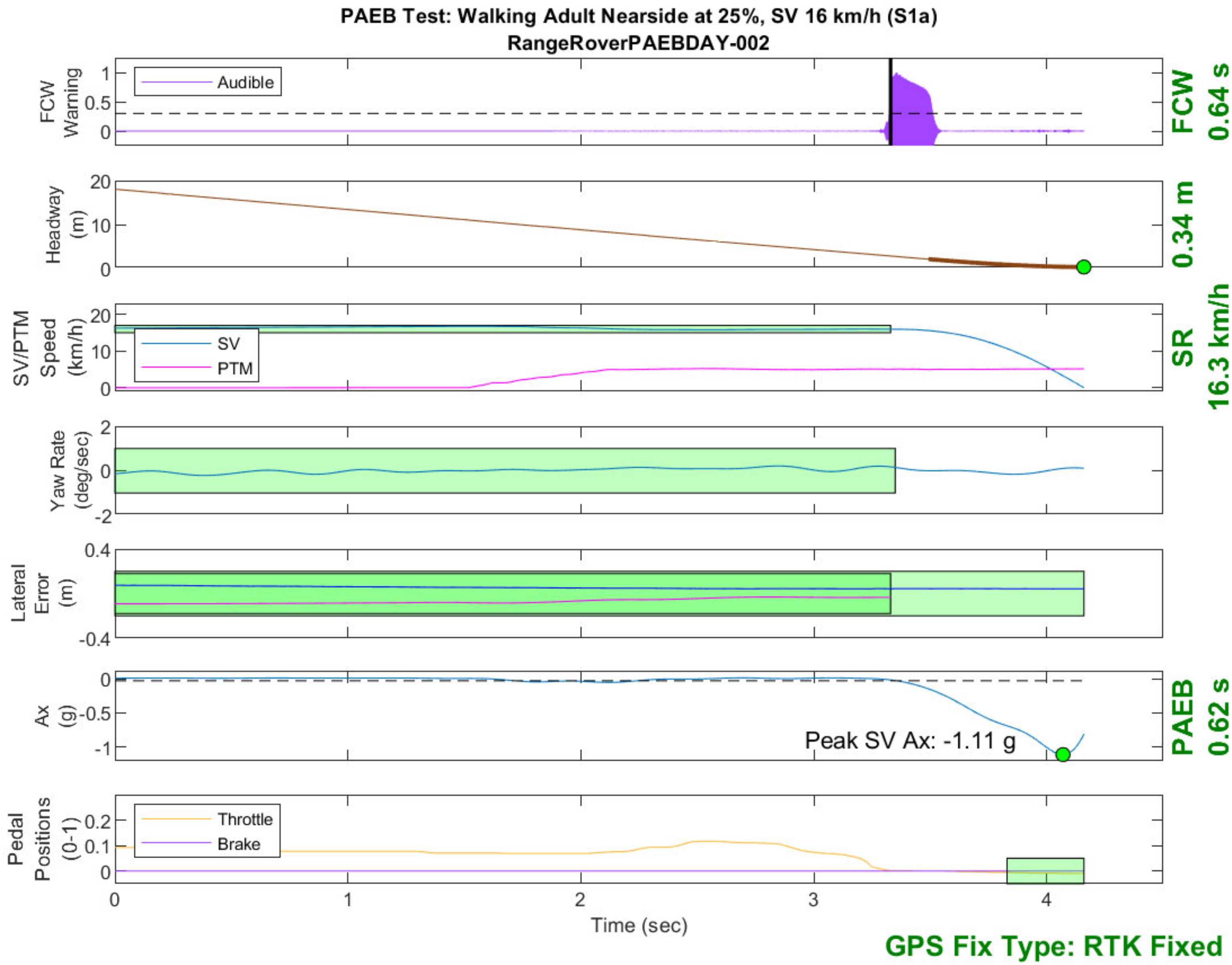


Figure D6. Time History for PAEB Run 2, S1a, Daytime, 16 km/h

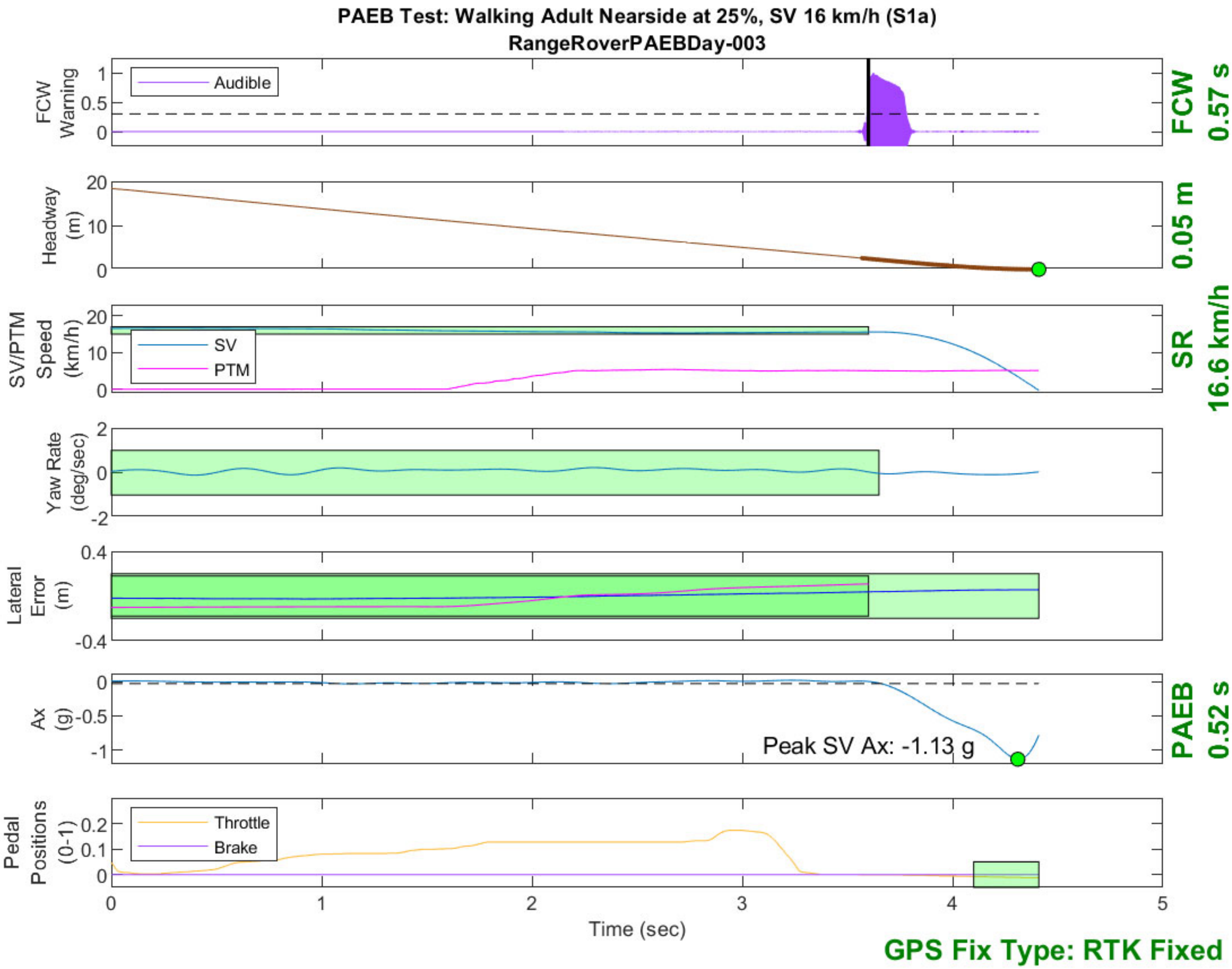


Figure D7. Time History for PAEB Run 3, S1a, Daytime, 16 km/h

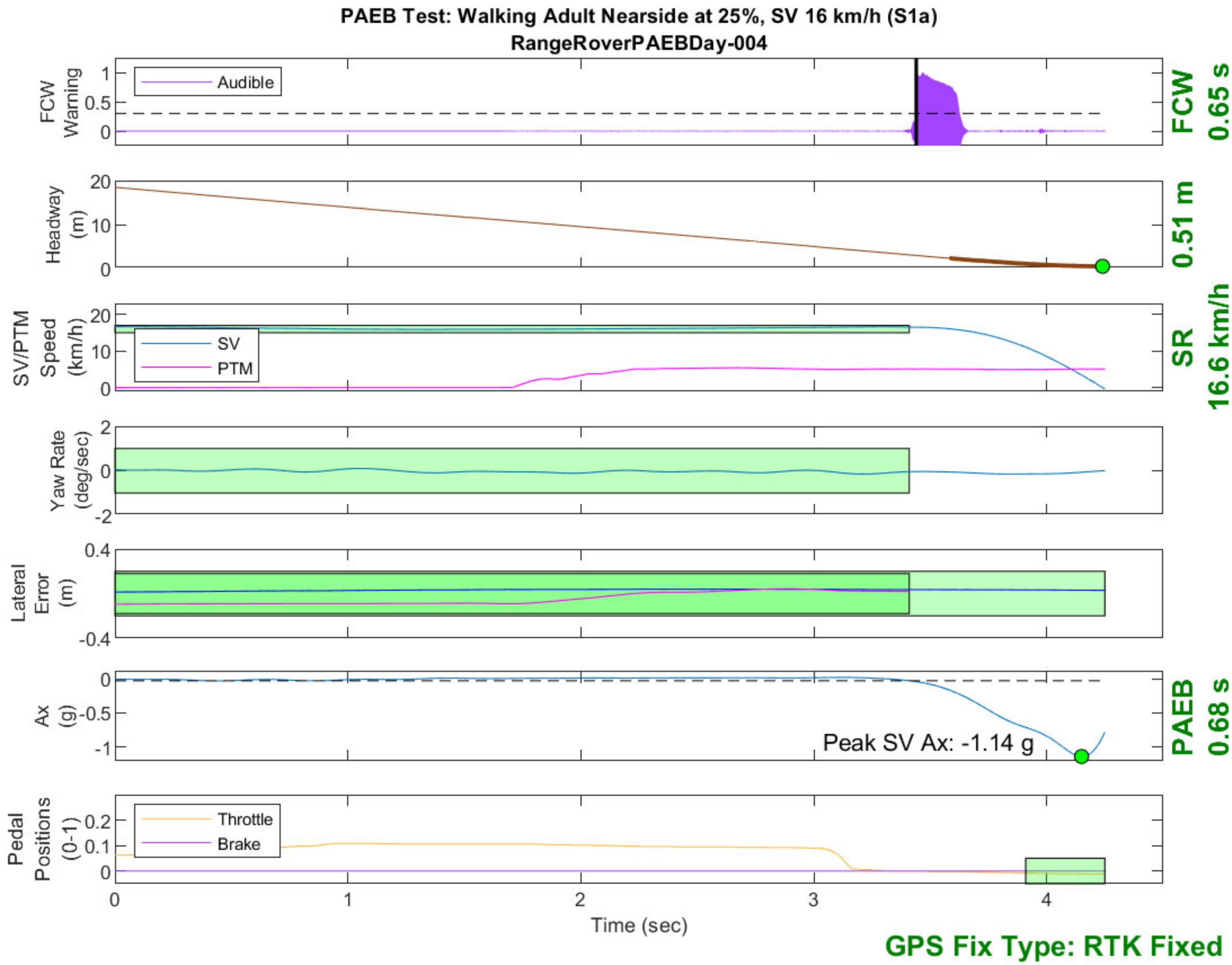


Figure D8. Time History for PAEB Run 4, S1a, Daytime, 16 km/h

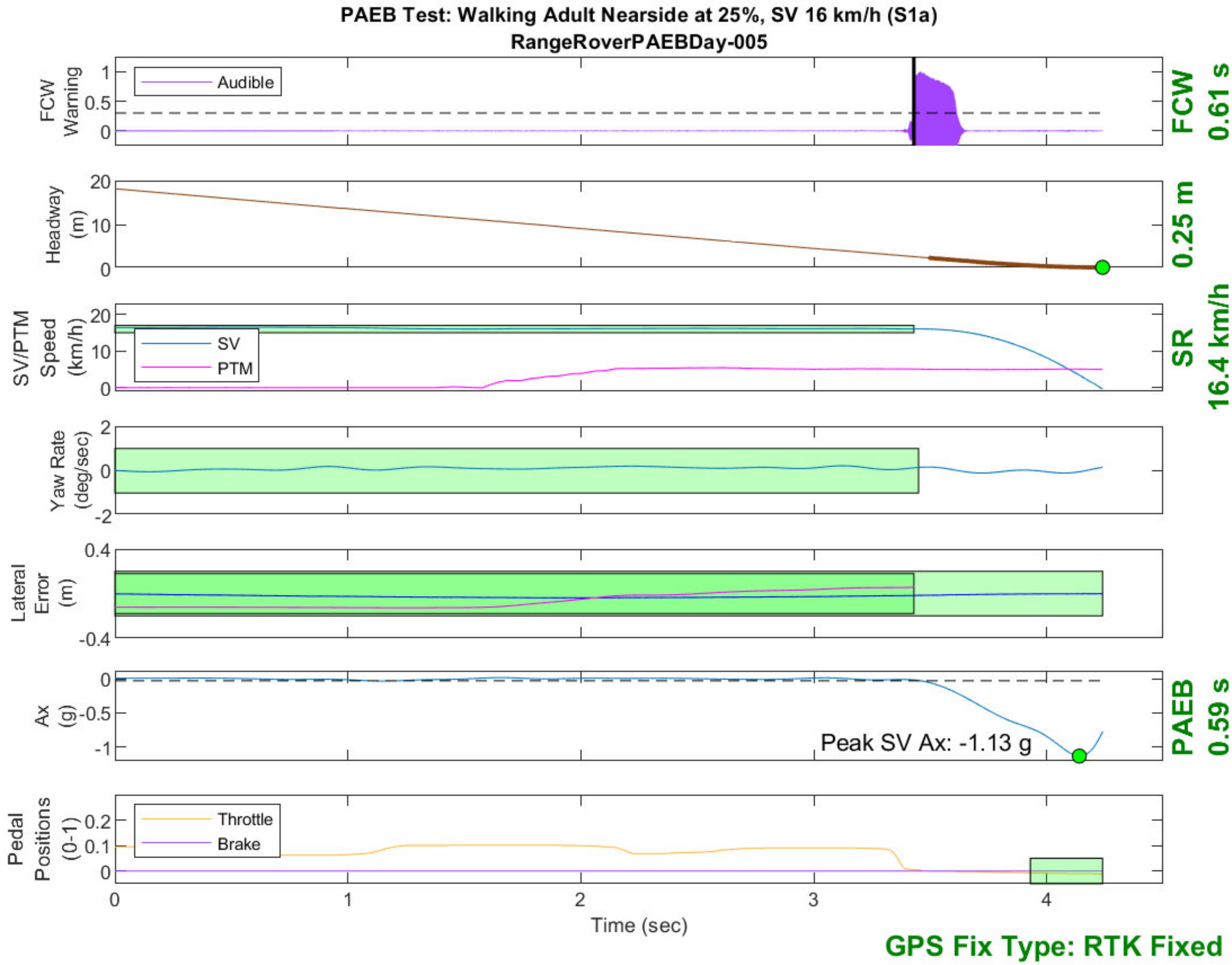


Figure D9. Time History for PAEB Run 5, S1a, Daytime, 16 km/h

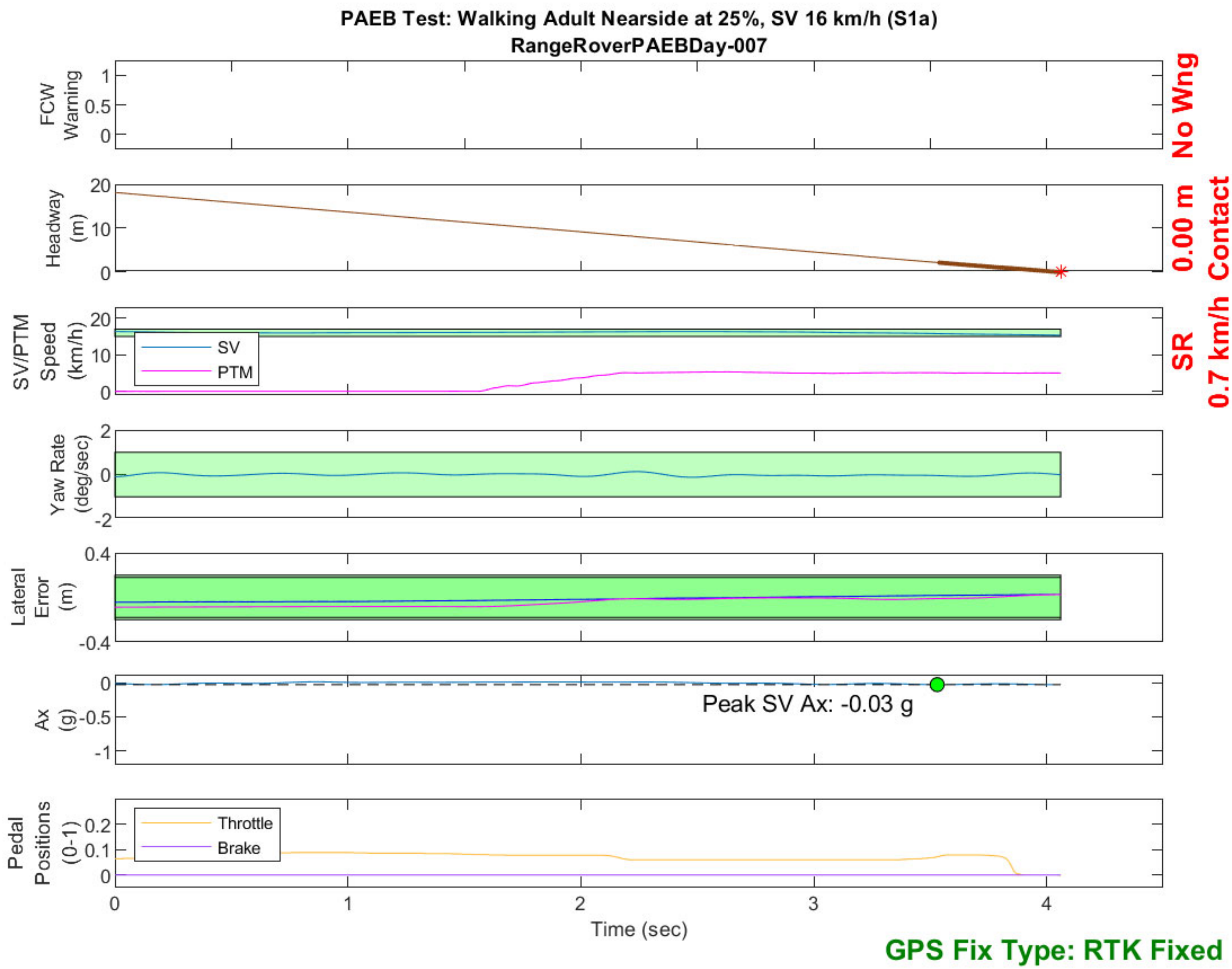


Figure D10. Time History for PAEB Run 7, S1a, Daytime, 16 km/h

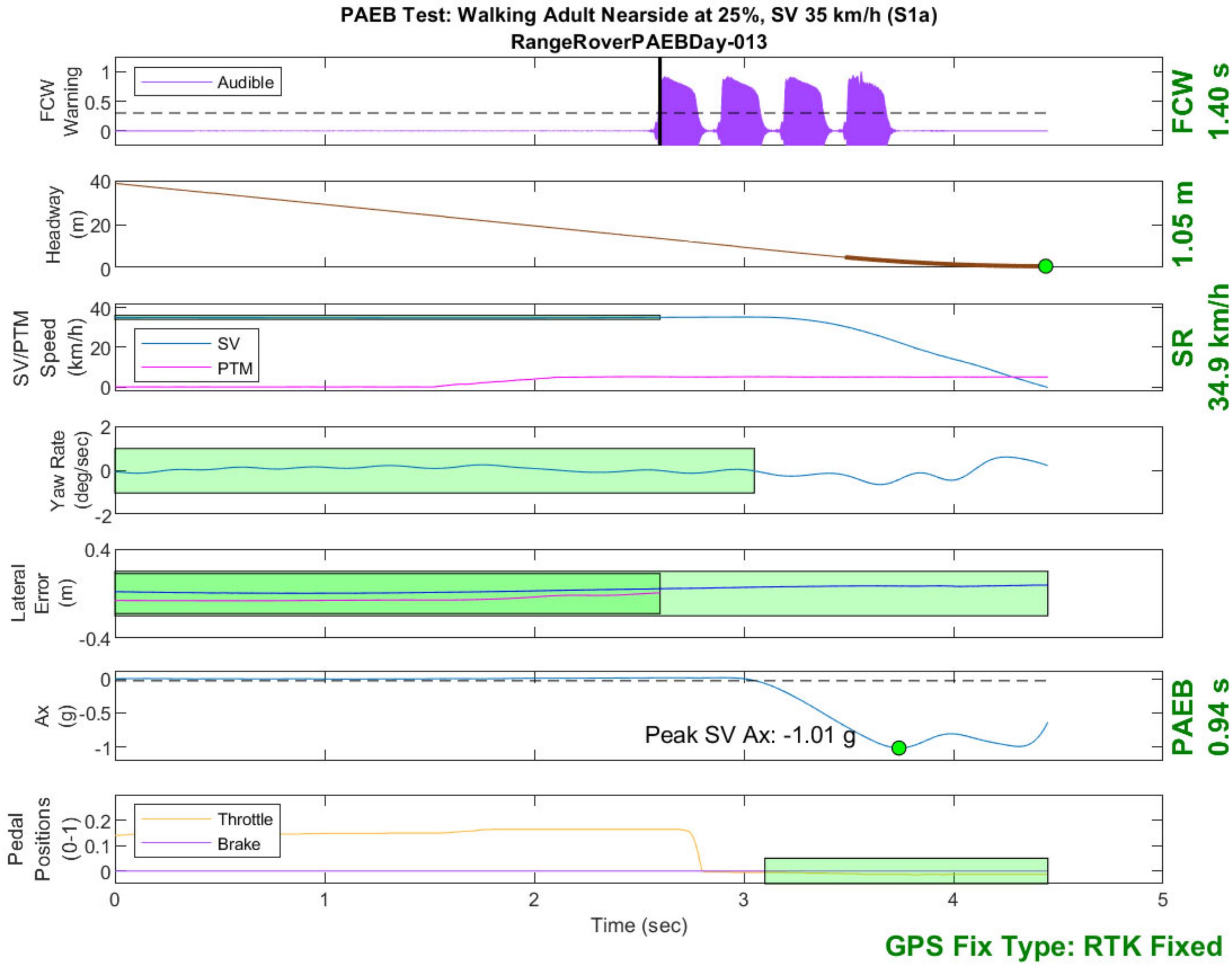


Figure D11. Time History for PAEB Run 13, S1a, Daytime, 35 km/h

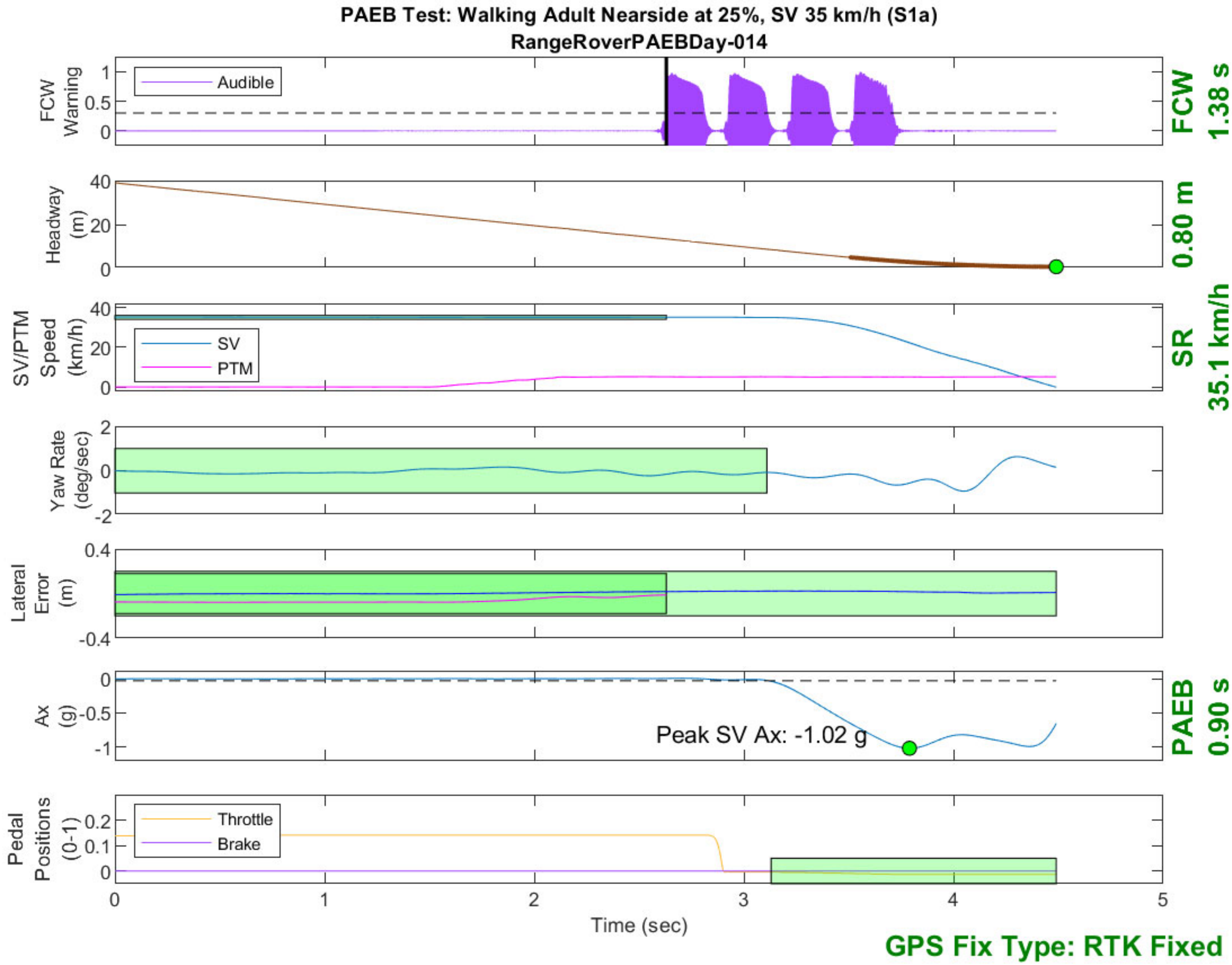


Figure D12. Time History for PAEB Run 14, S1a, Daytime, 35 km/h

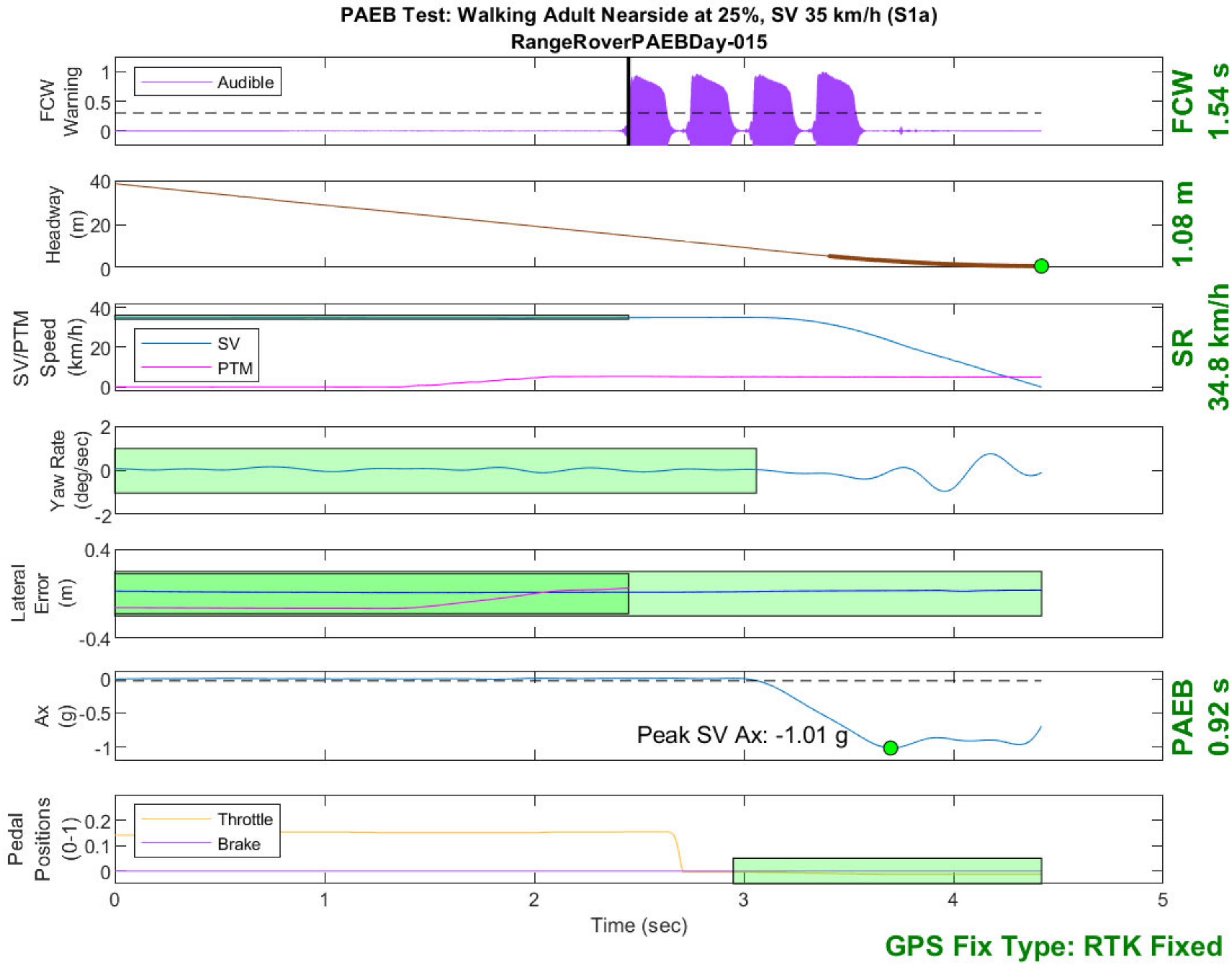


Figure D13. Time History for PAEB Run 15, S1a, Daytime, 35 km/h

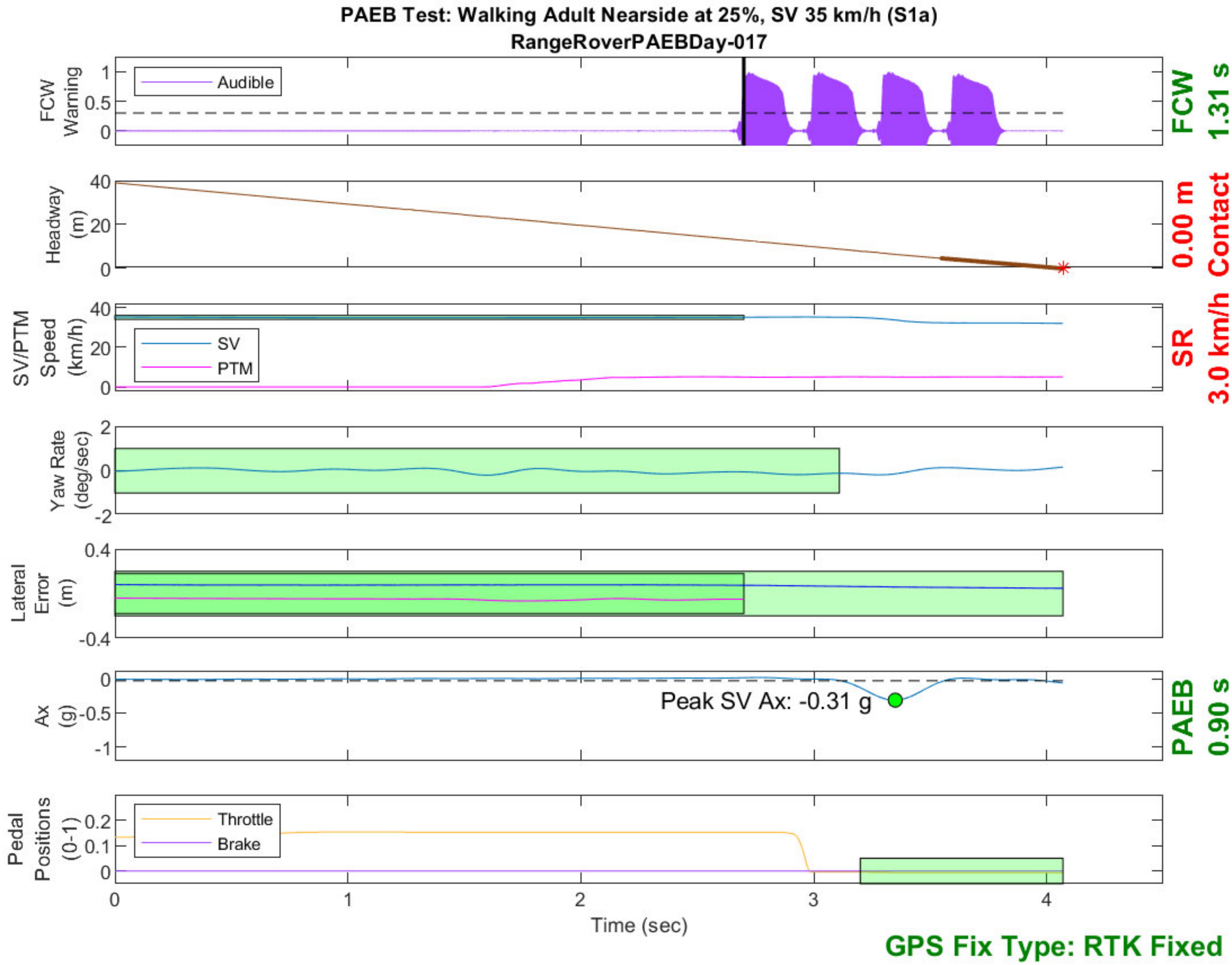


Figure D14. Time History for PAEB Run 17, S1a, Daytime, 35 km/h

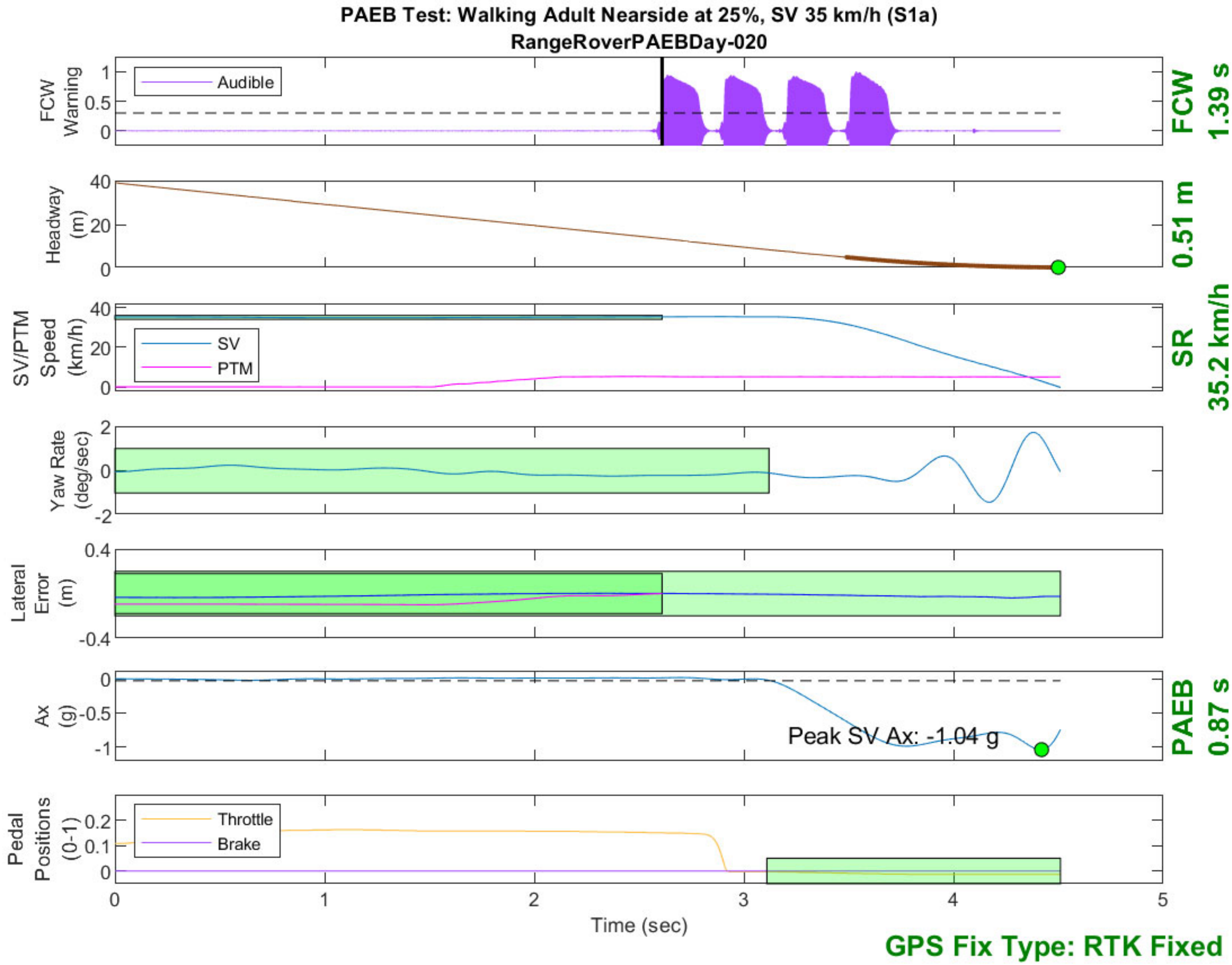


Figure D15. Time History for PAEB Run 20, S1a, Daytime, 35 km/h

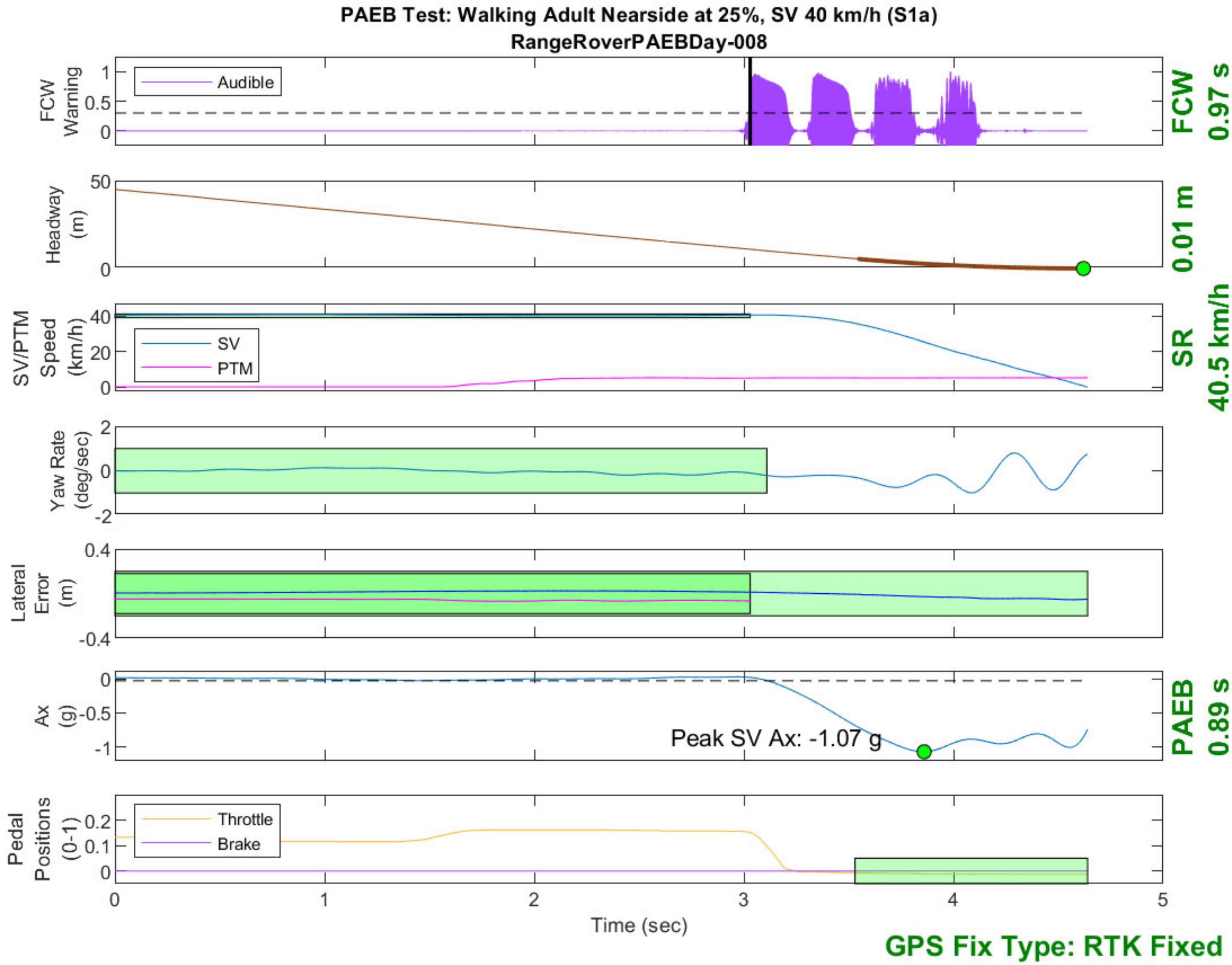


Figure D16. Time History for PAEB Run 8, S1a, Daytime, 40 km/h

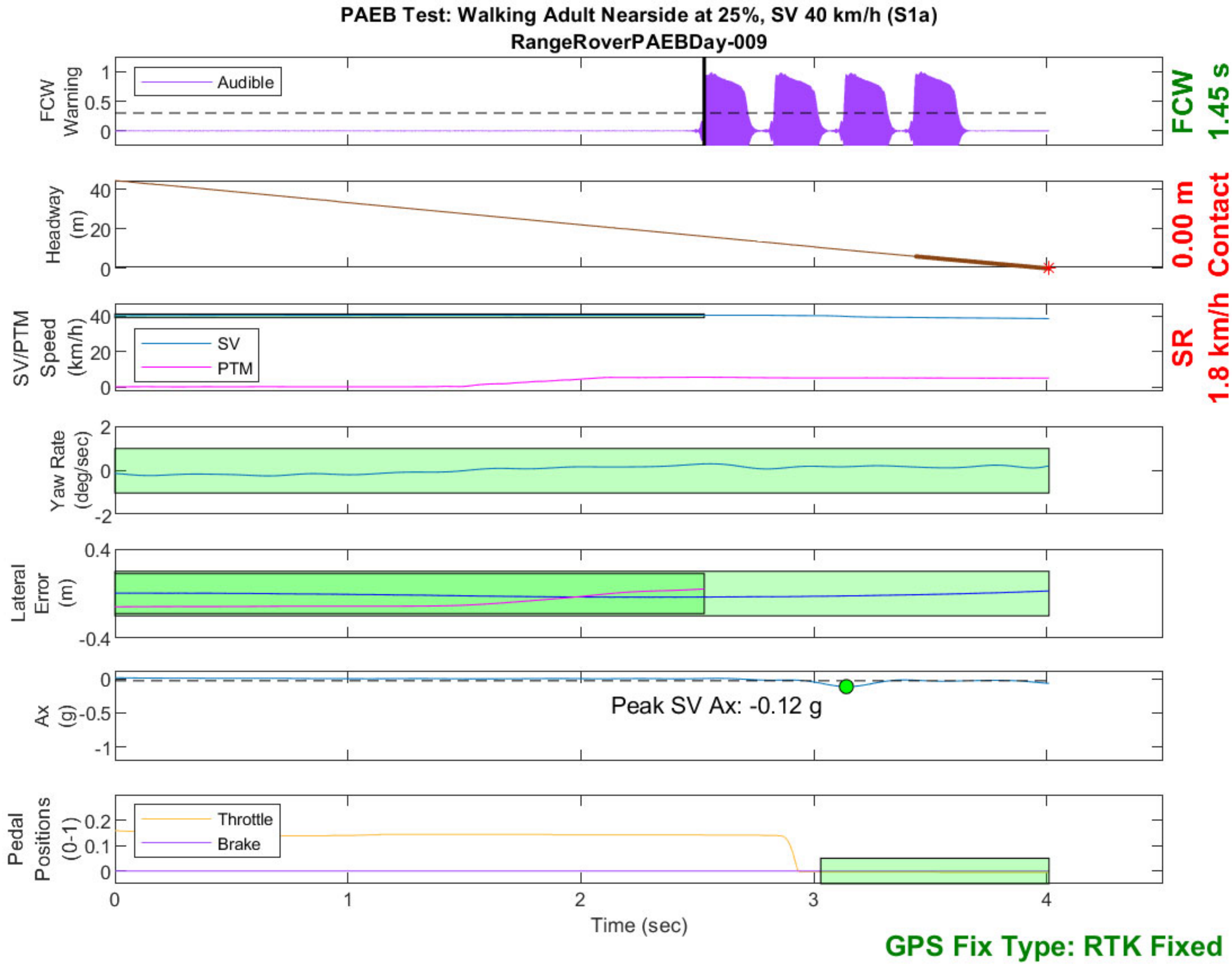


Figure D17. Time History for PAEB Run 9, S1a, Daytime, 40 km/h

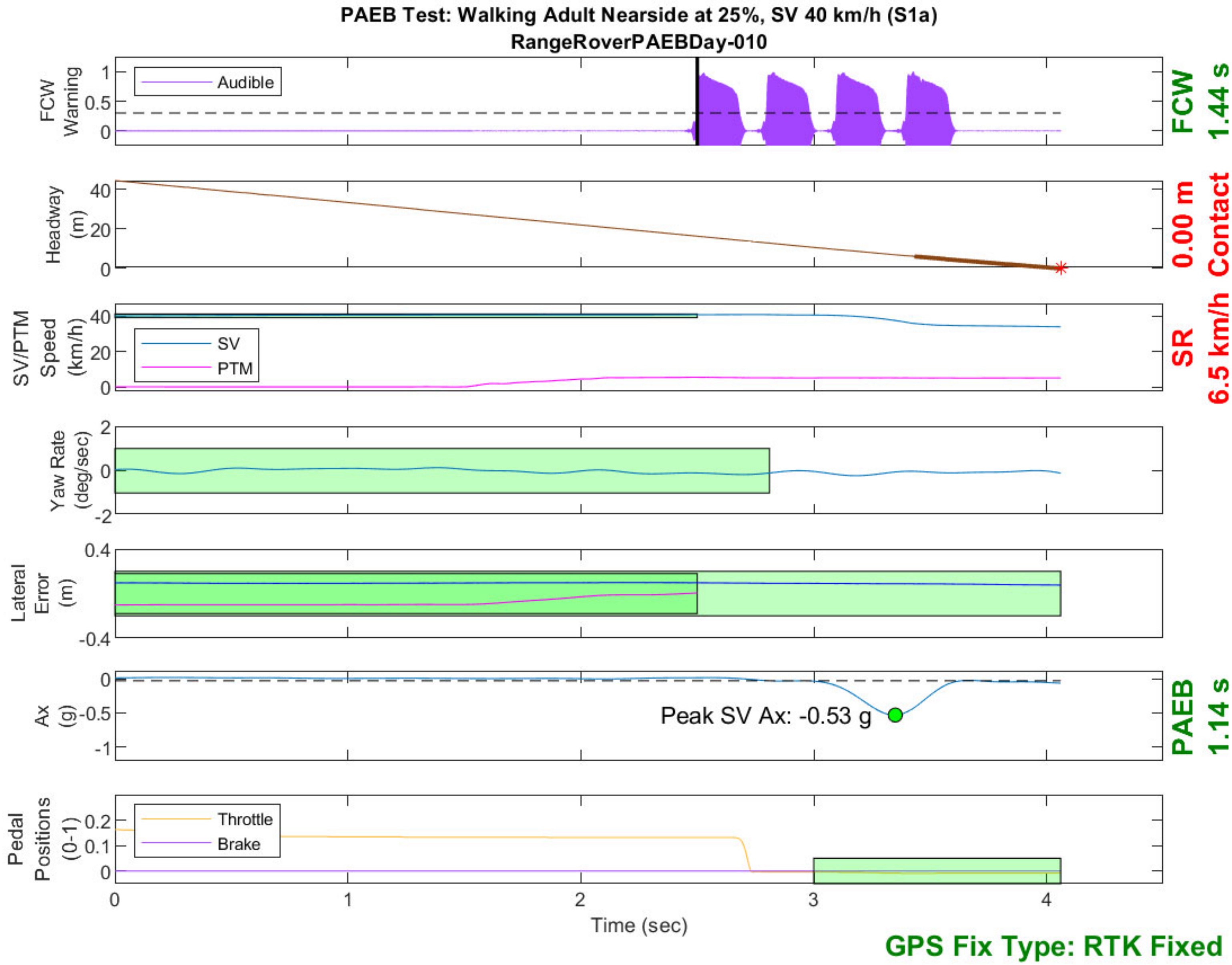


Figure D18. Time History for PAEB Run 10, S1a, Daytime, 40 km/h

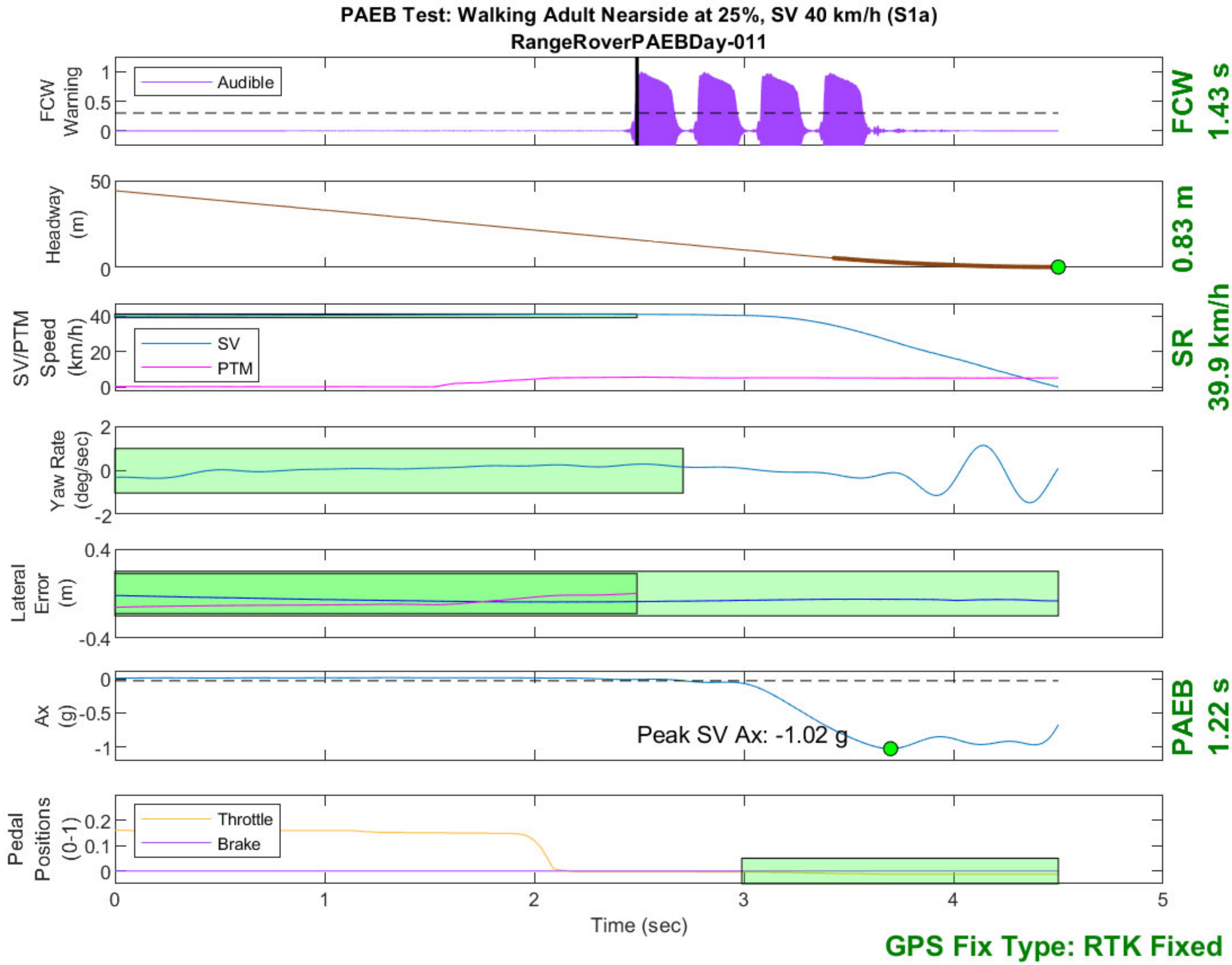


Figure D19. Time History for PAEB Run 11, S1a, Daytime, 40 km/h

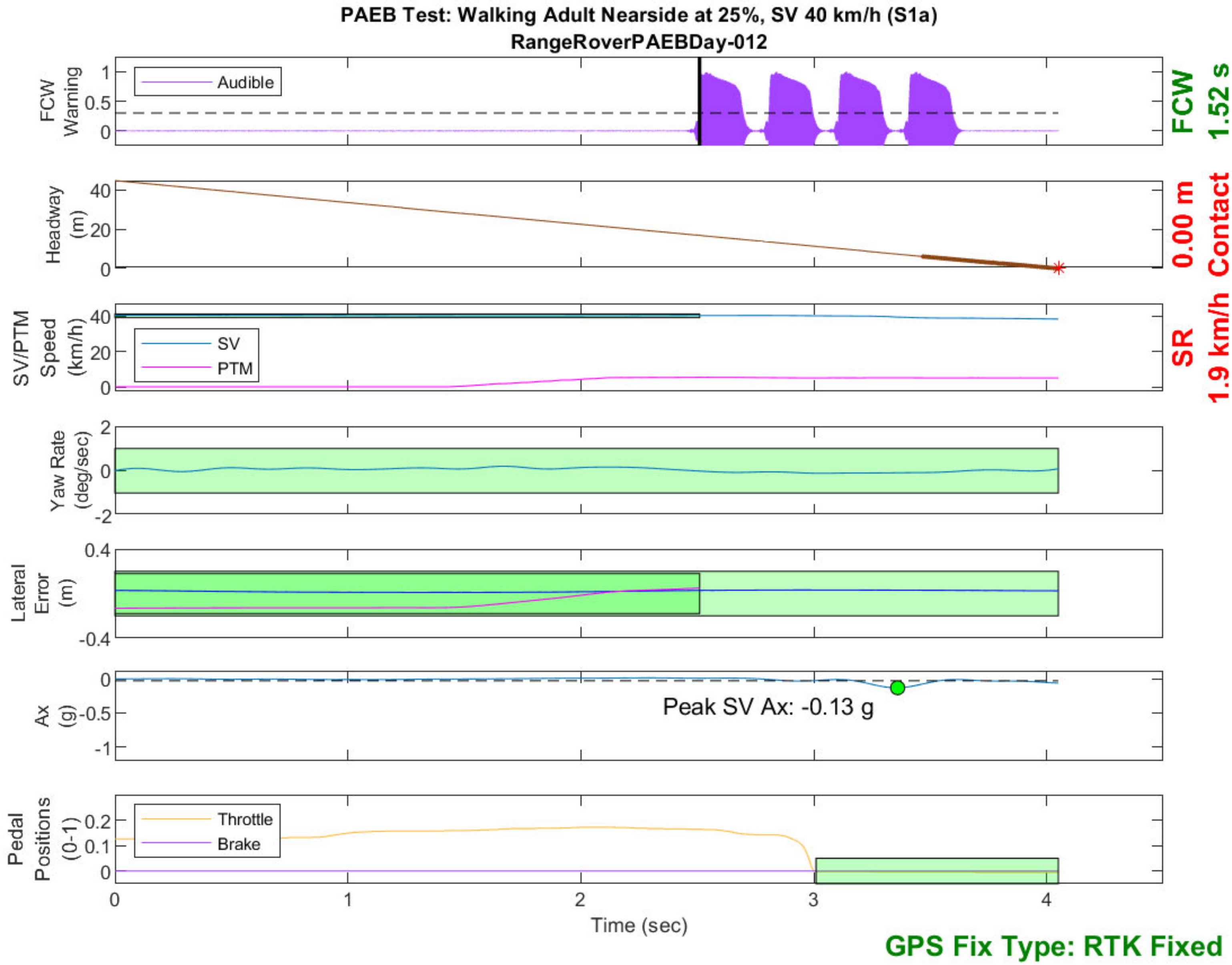


Figure D20. Time History for PAEB Run 12, S1a, Daytime, 40 km/h

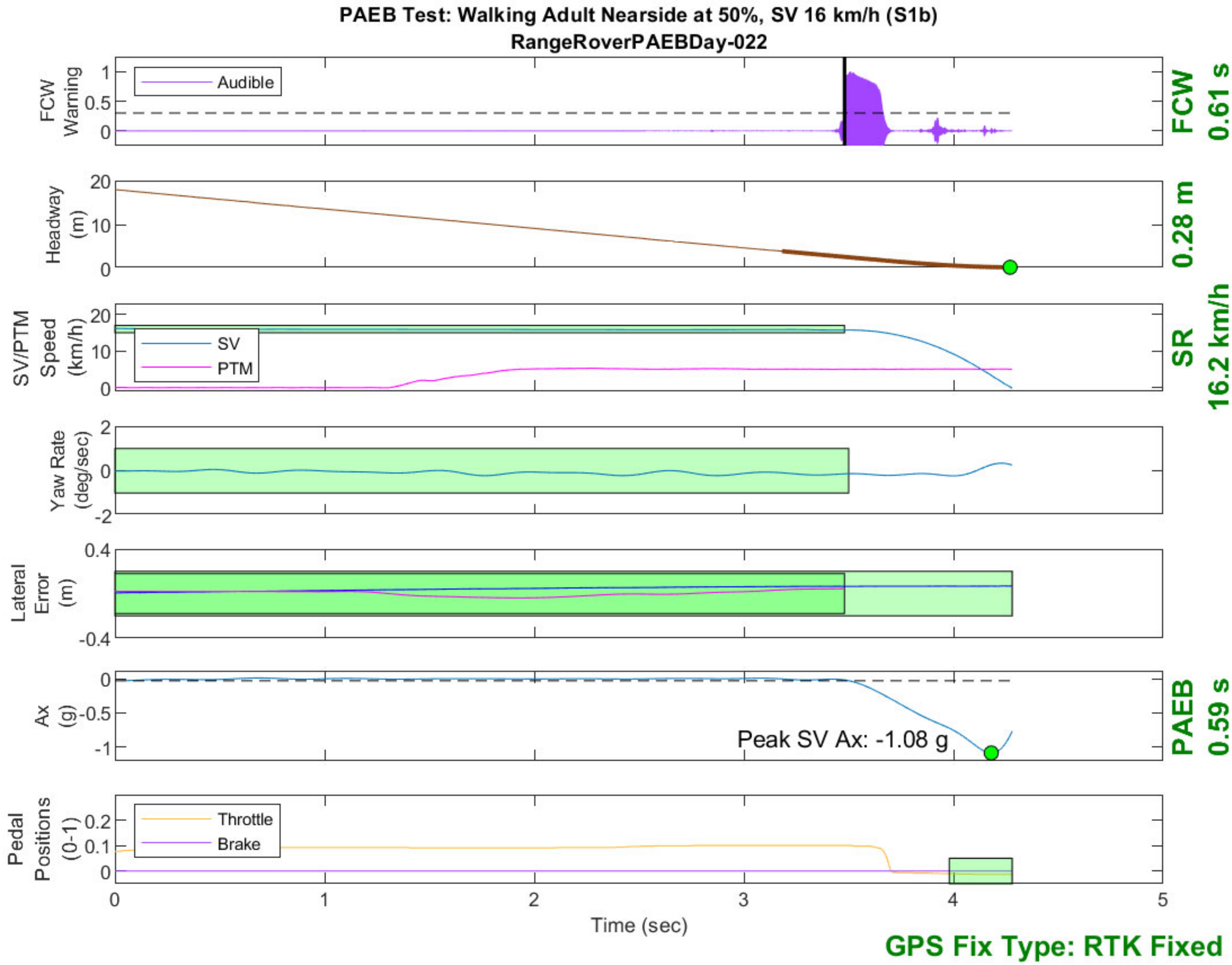


Figure D21. Time History for PAEB Run 22, S1b, Daytime, 16 km/h

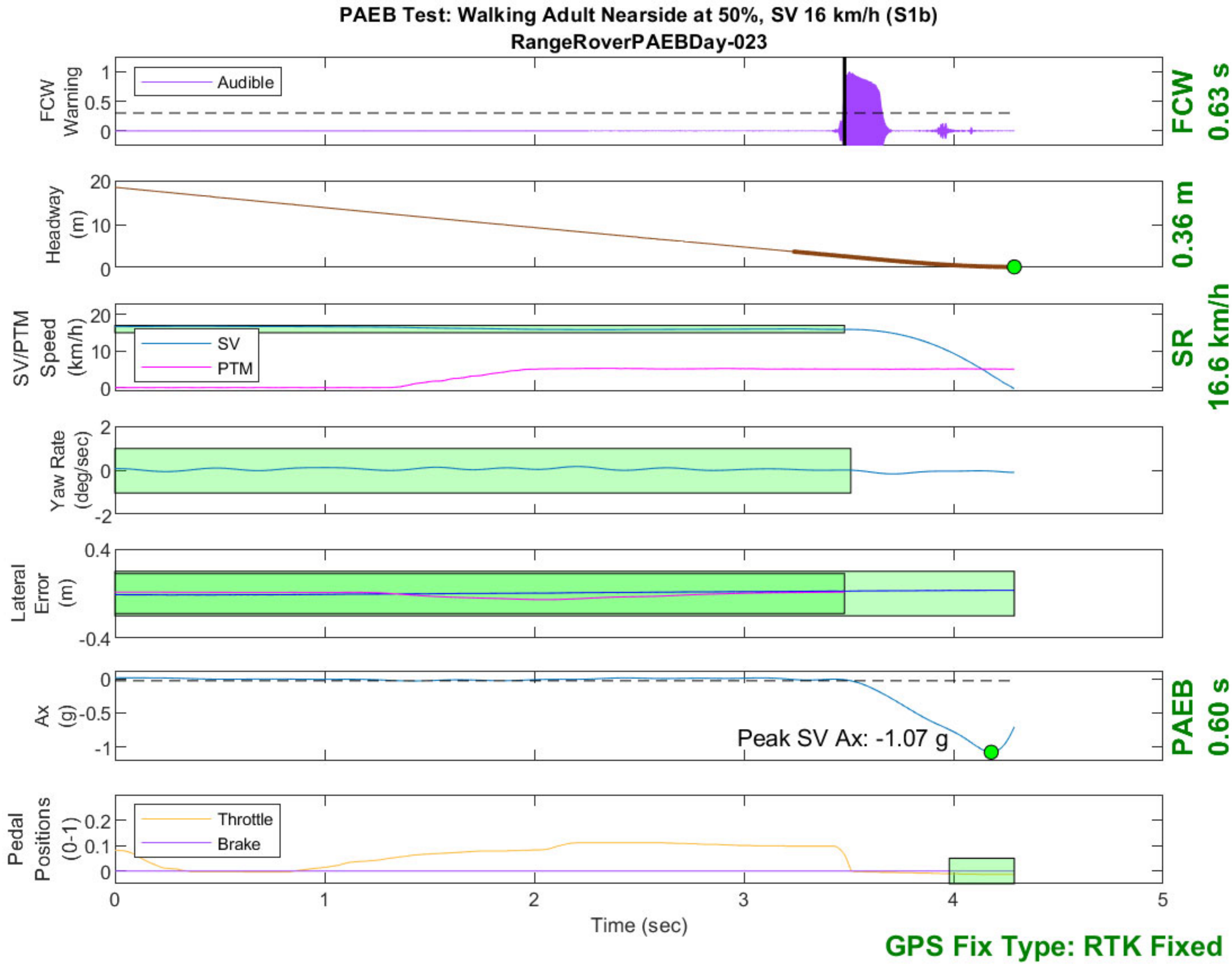


Figure D22. Time History for PAEB Run 23, S1b, Daytime, 16 km/h

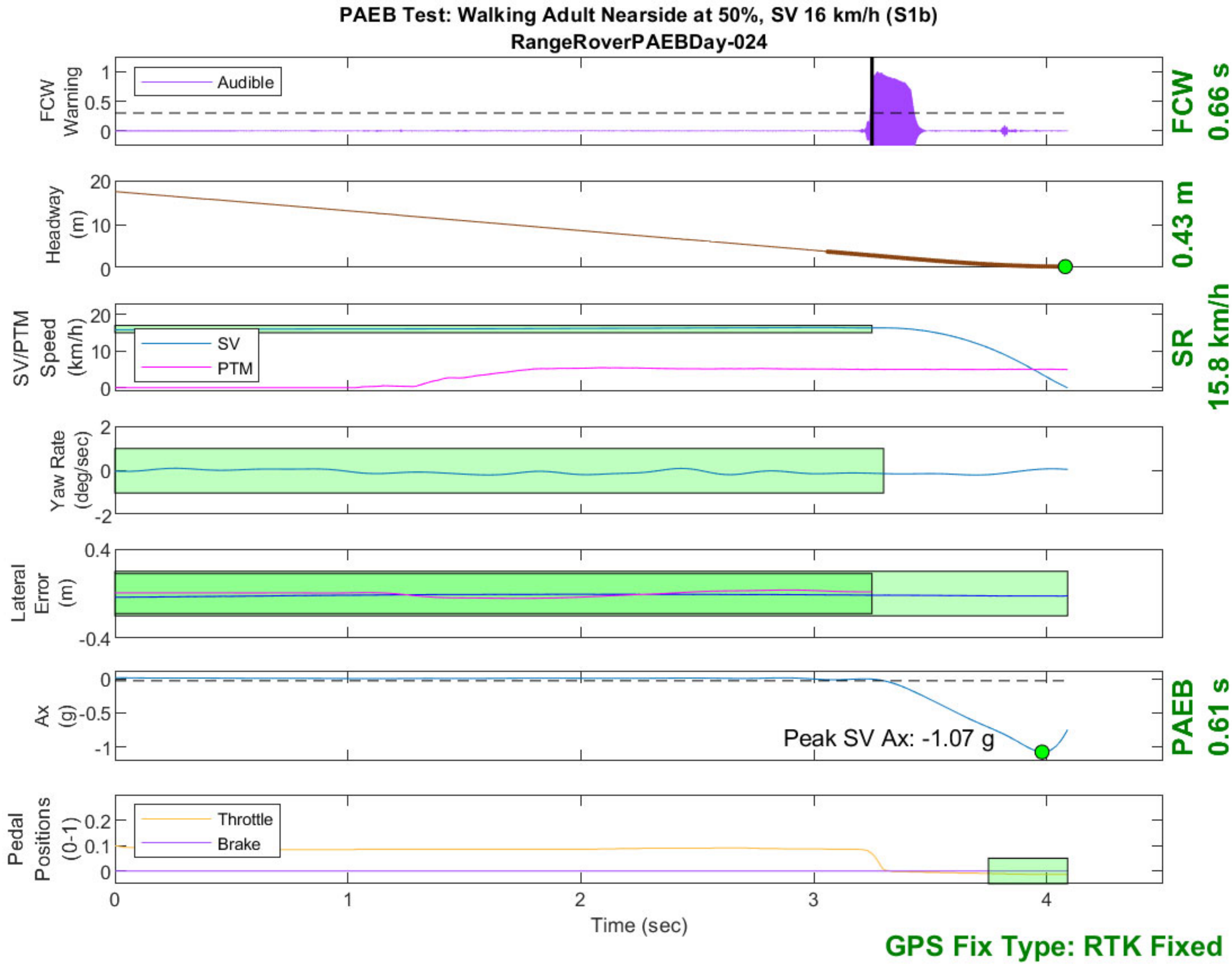


Figure D23. Time History for PAEB Run 24, S1b, Daytime, 16 km/h

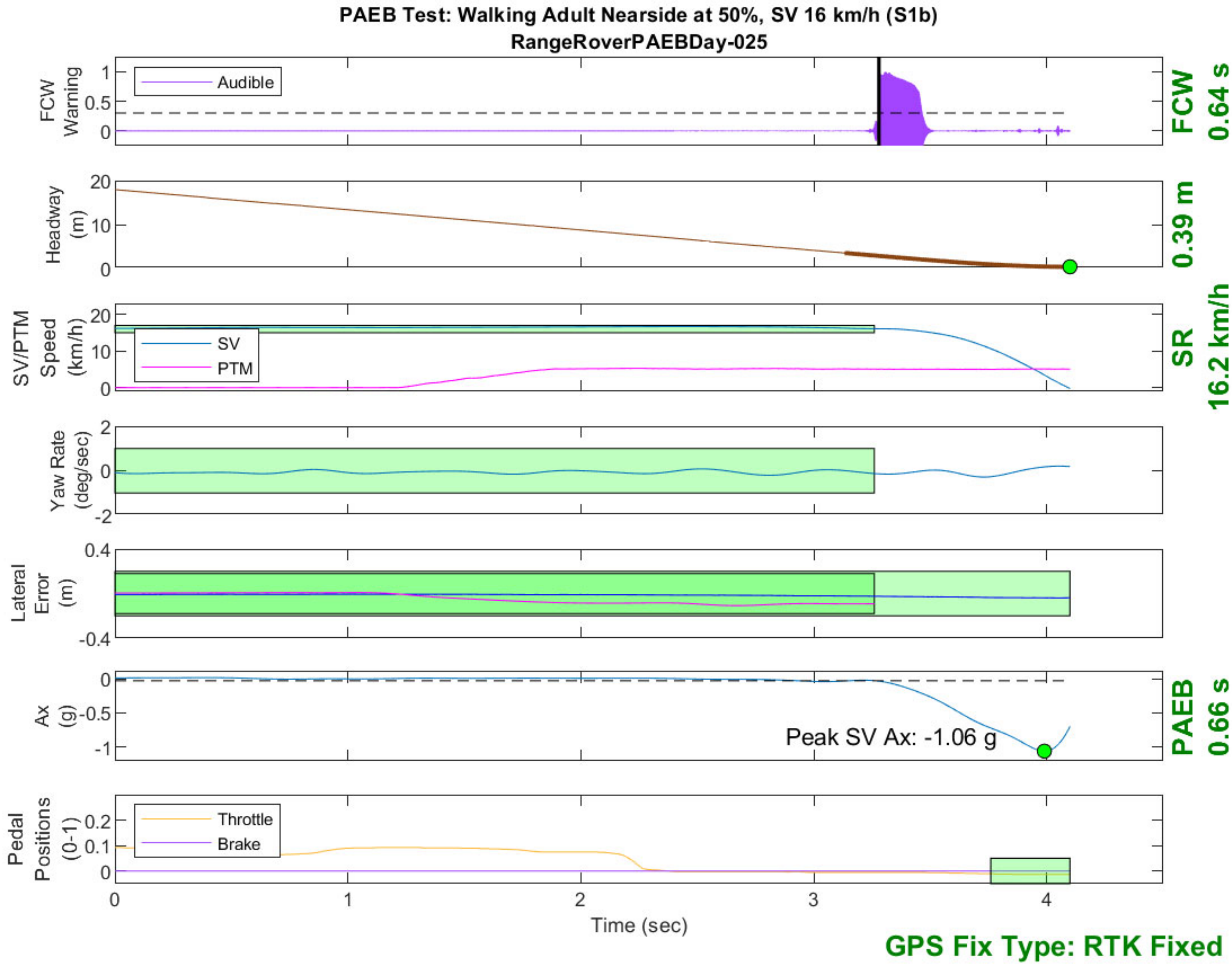


Figure D24. Time History for PAEB Run 25, S1b, Daytime, 16 km/h

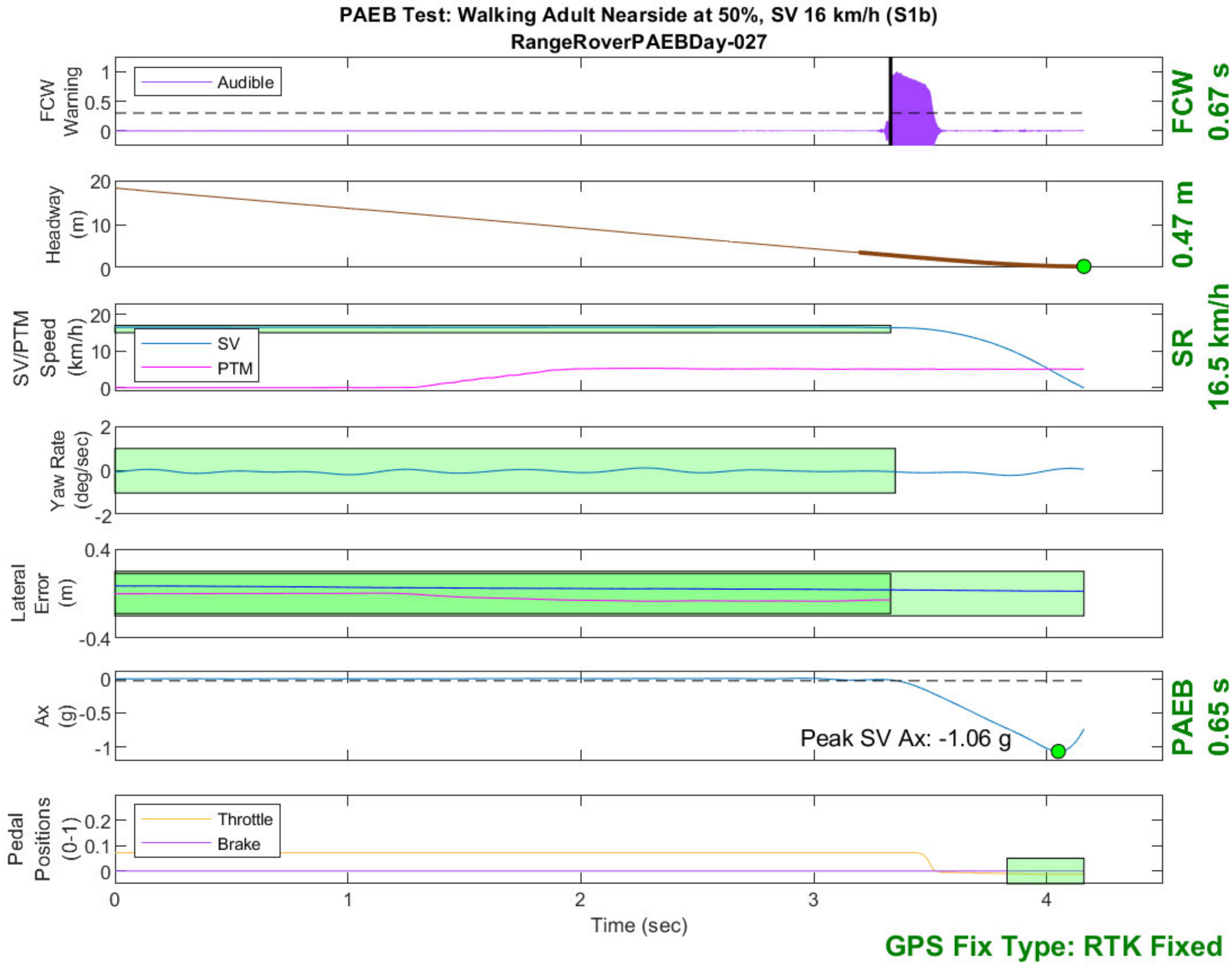


Figure D25. Time History for PAEB Run 27, S1b, Daytime, 16 km/h

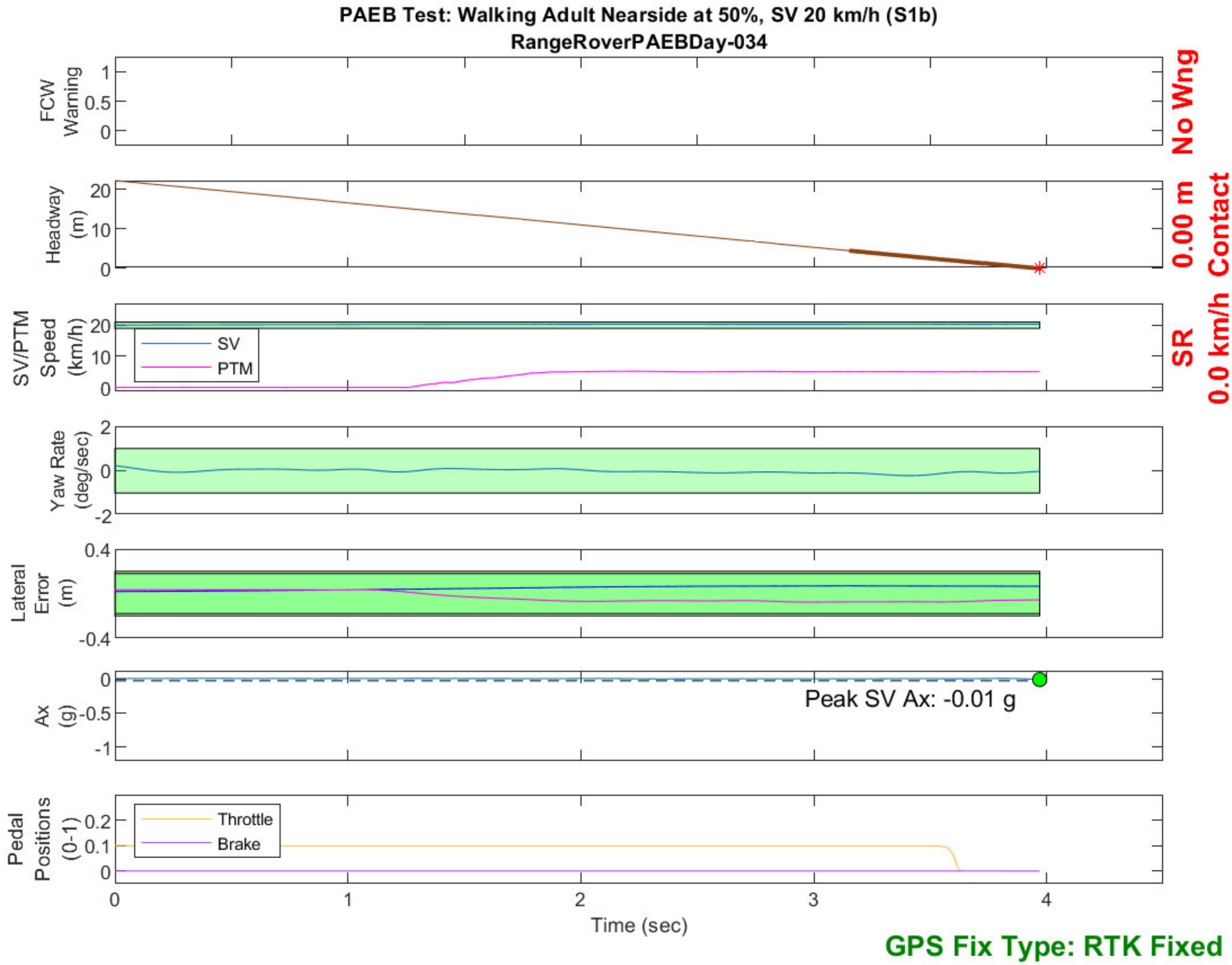


Figure D26. Time History for PAEB Run 34, S1b, Daytime, 20 km/h

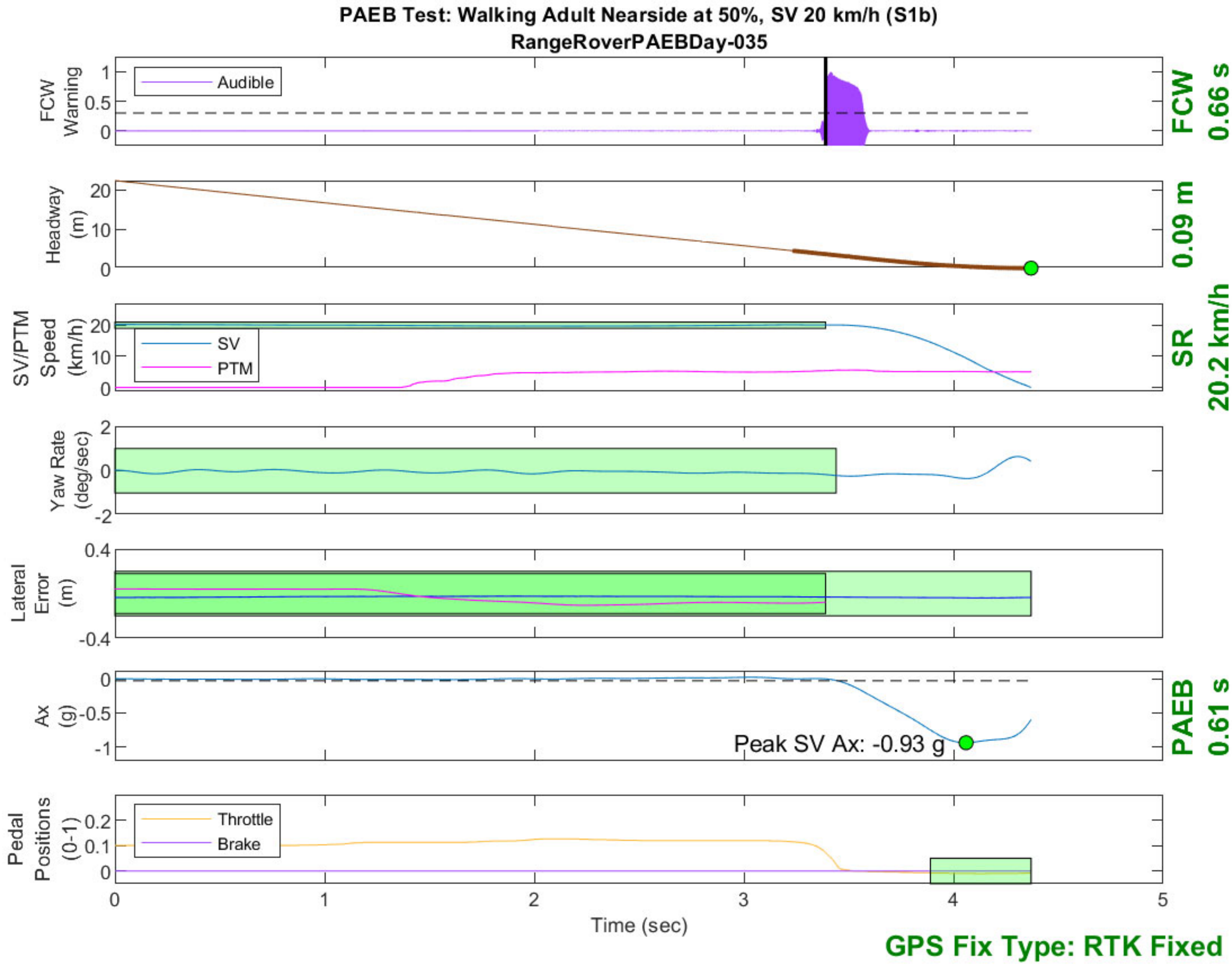


Figure D27. Time History for PAEB Run 35, S1b, Daytime, 20 km/h

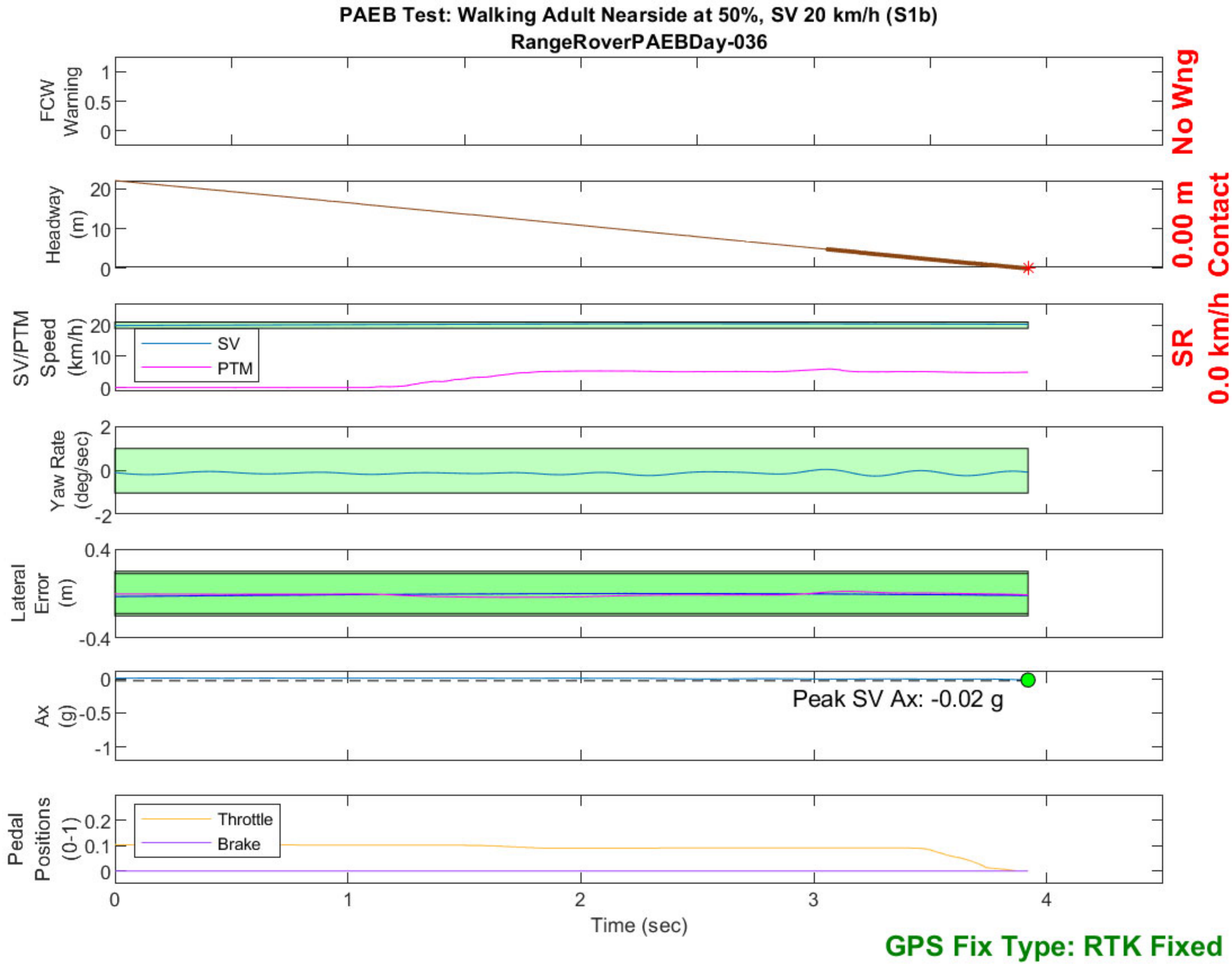


Figure D28. Time History for PAEB Run 36, S1b, Daytime, 20 km/h

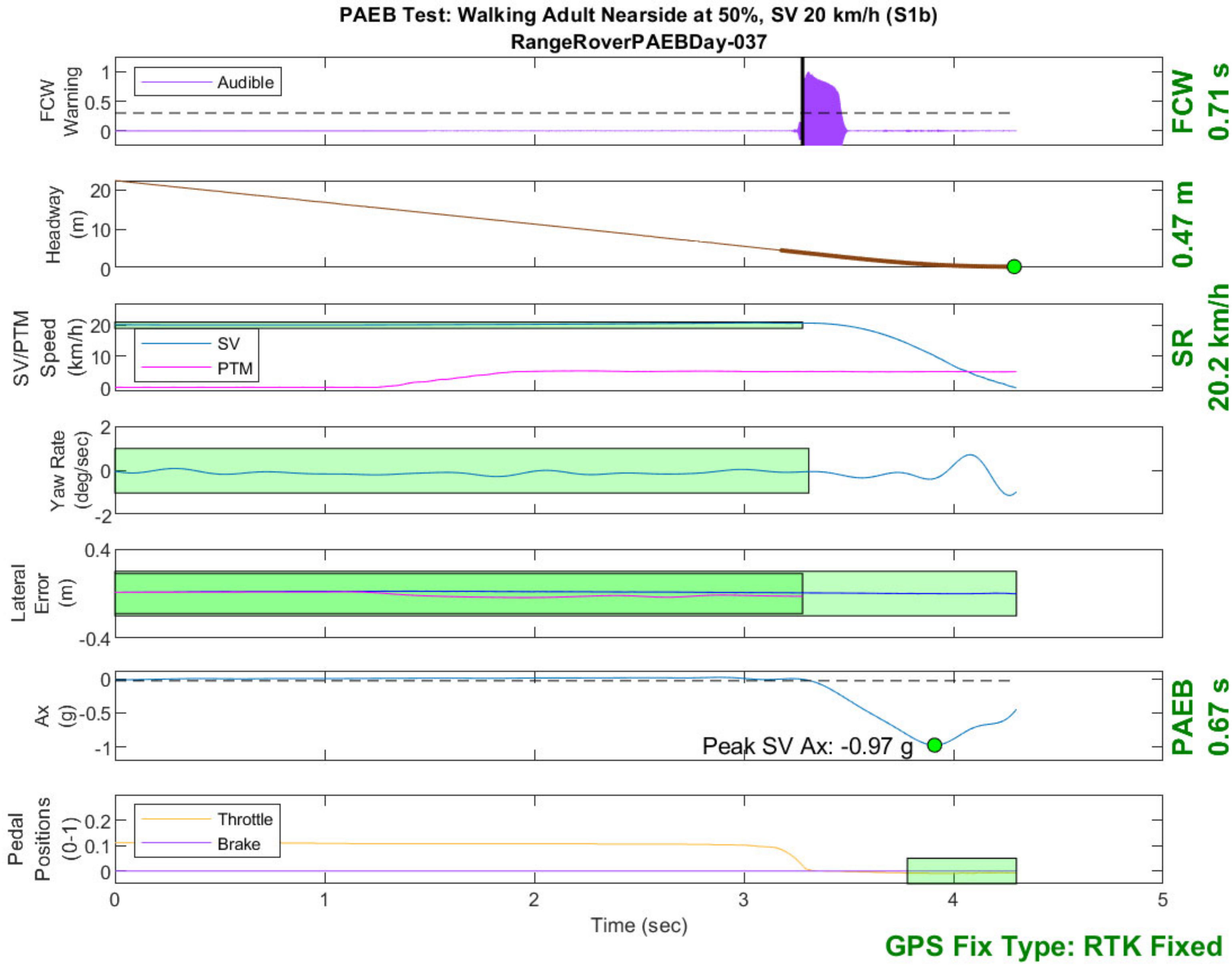


Figure D29. Time History for PAEB Run 37, S1b, Daytime, 20 km/h

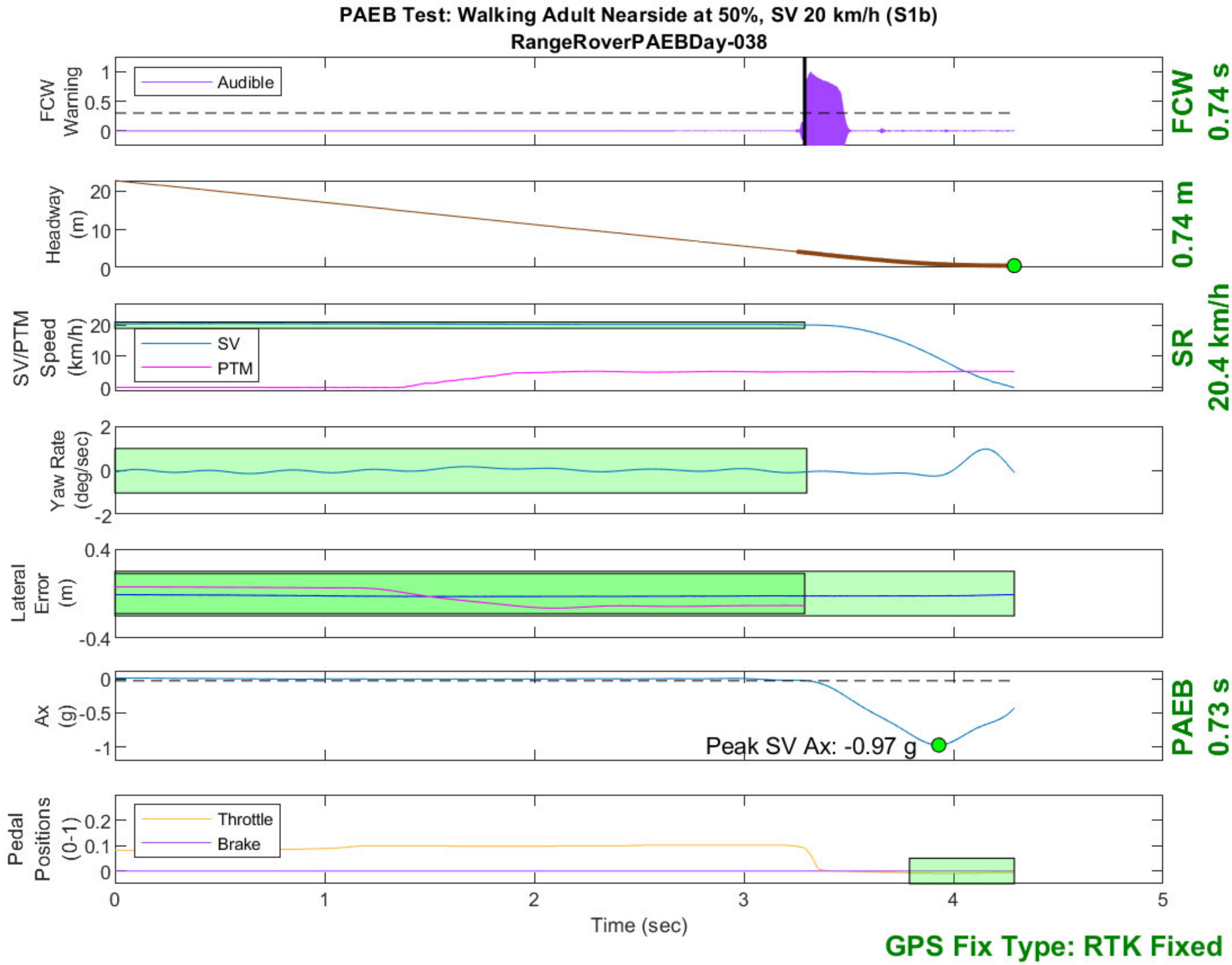


Figure D30. Time History for PAEB Run 38, S1b, Daytime, 20 km/h

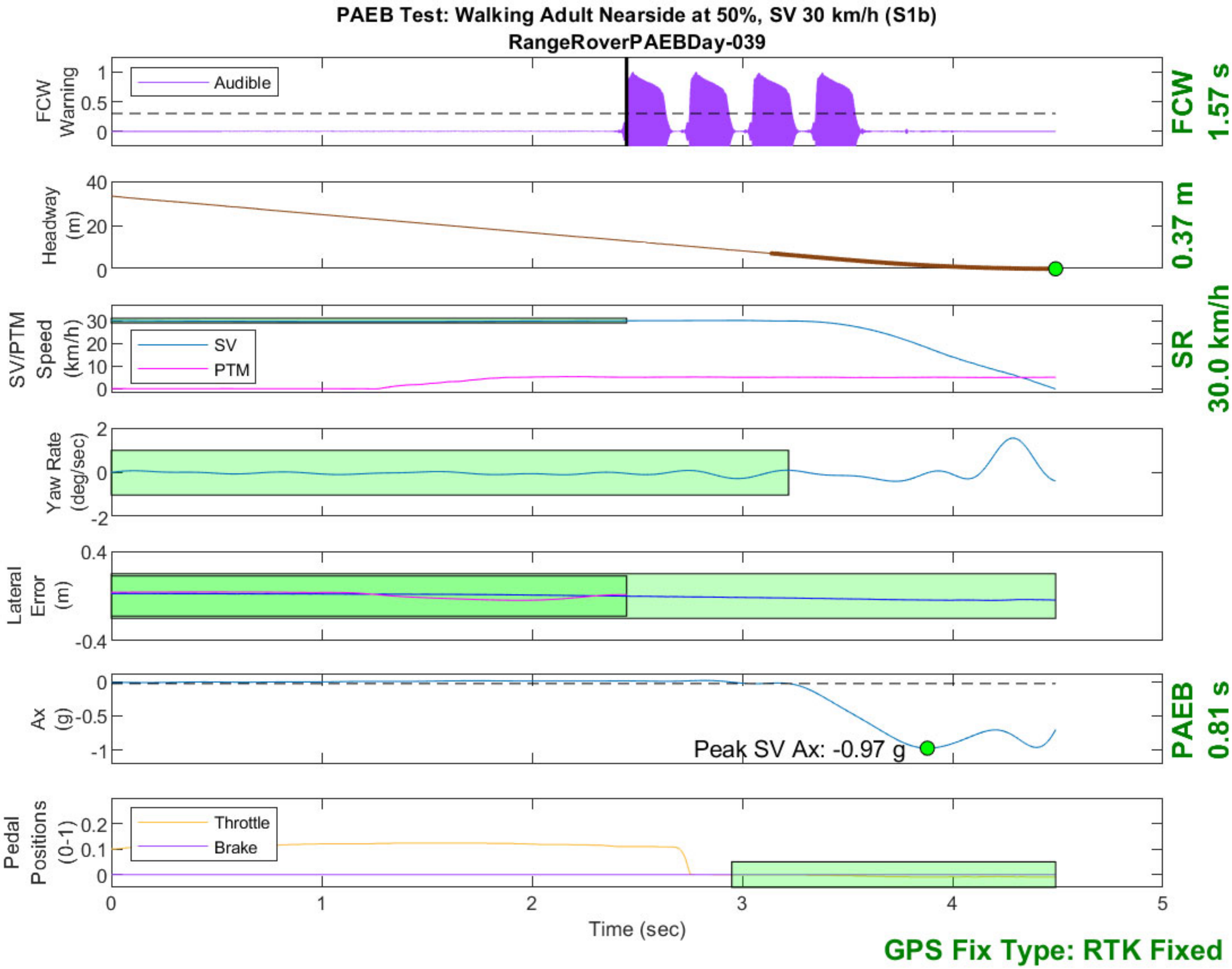


Figure D31. Time History for PAEB Run 39, S1b, Daytime, 30 km/h

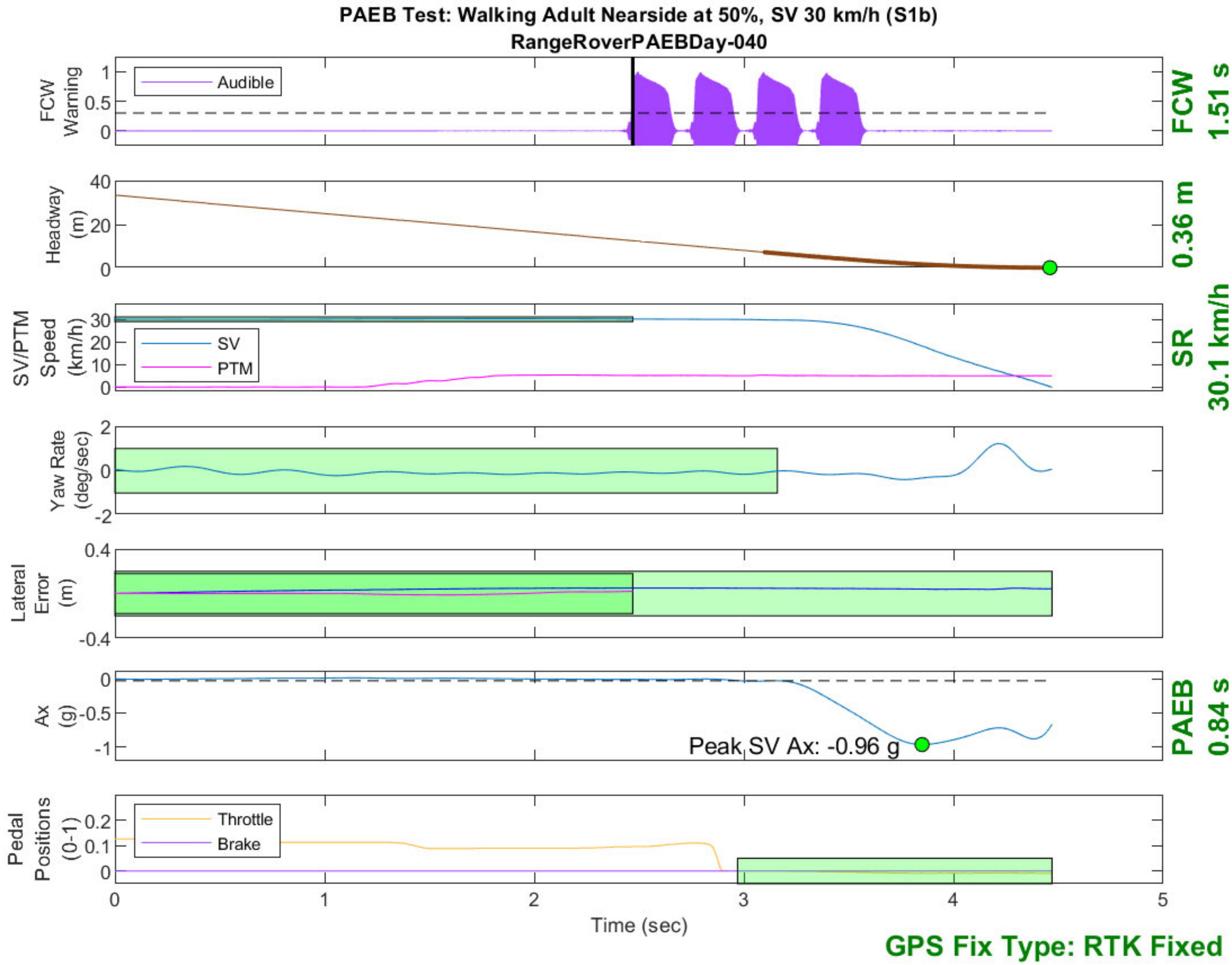


Figure D32. Time History for PAEB Run 40, S1b, Daytime, 30 km/h

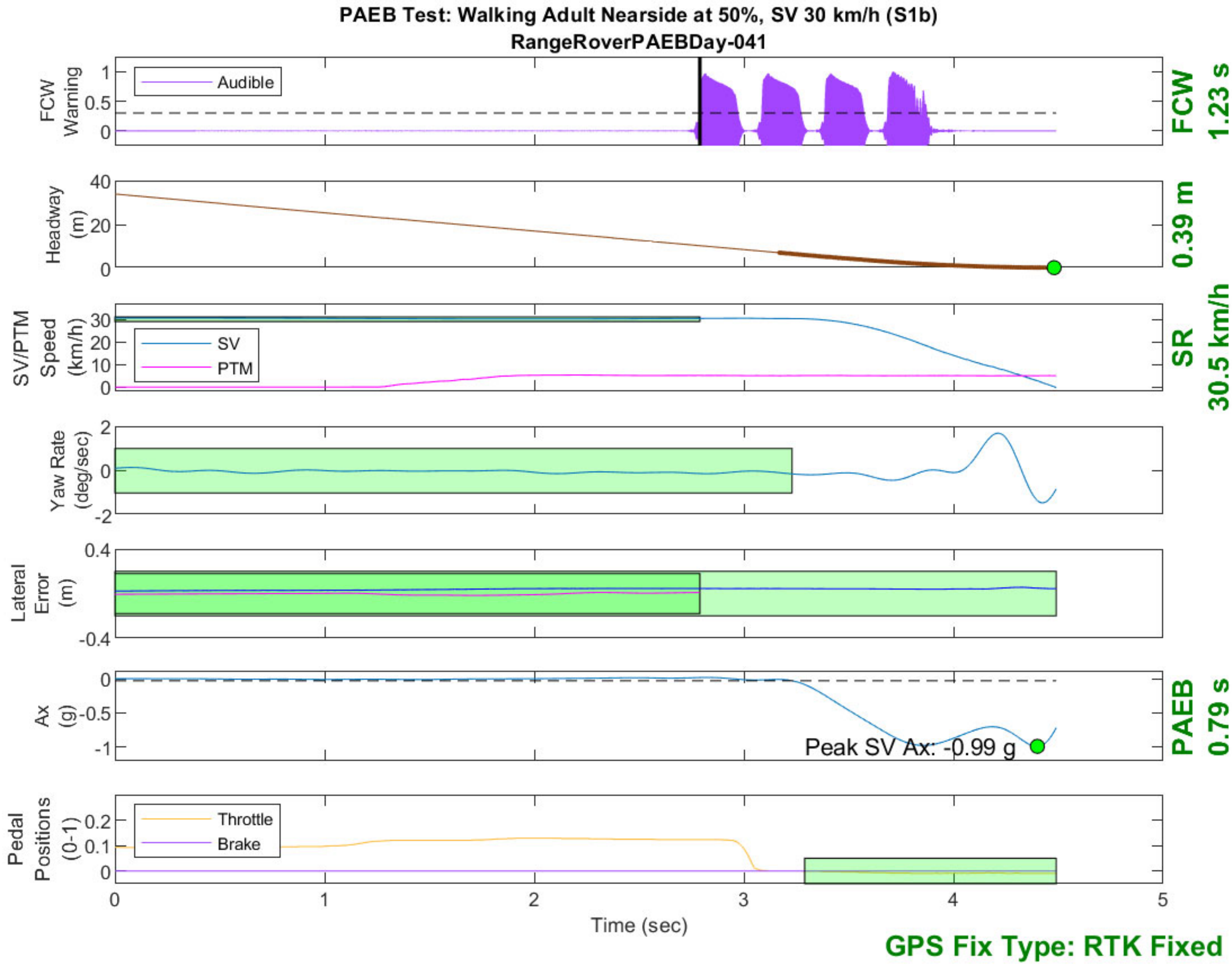


Figure D33. Time History for PAEB Run 41, S1b, Daytime, 30 km/h

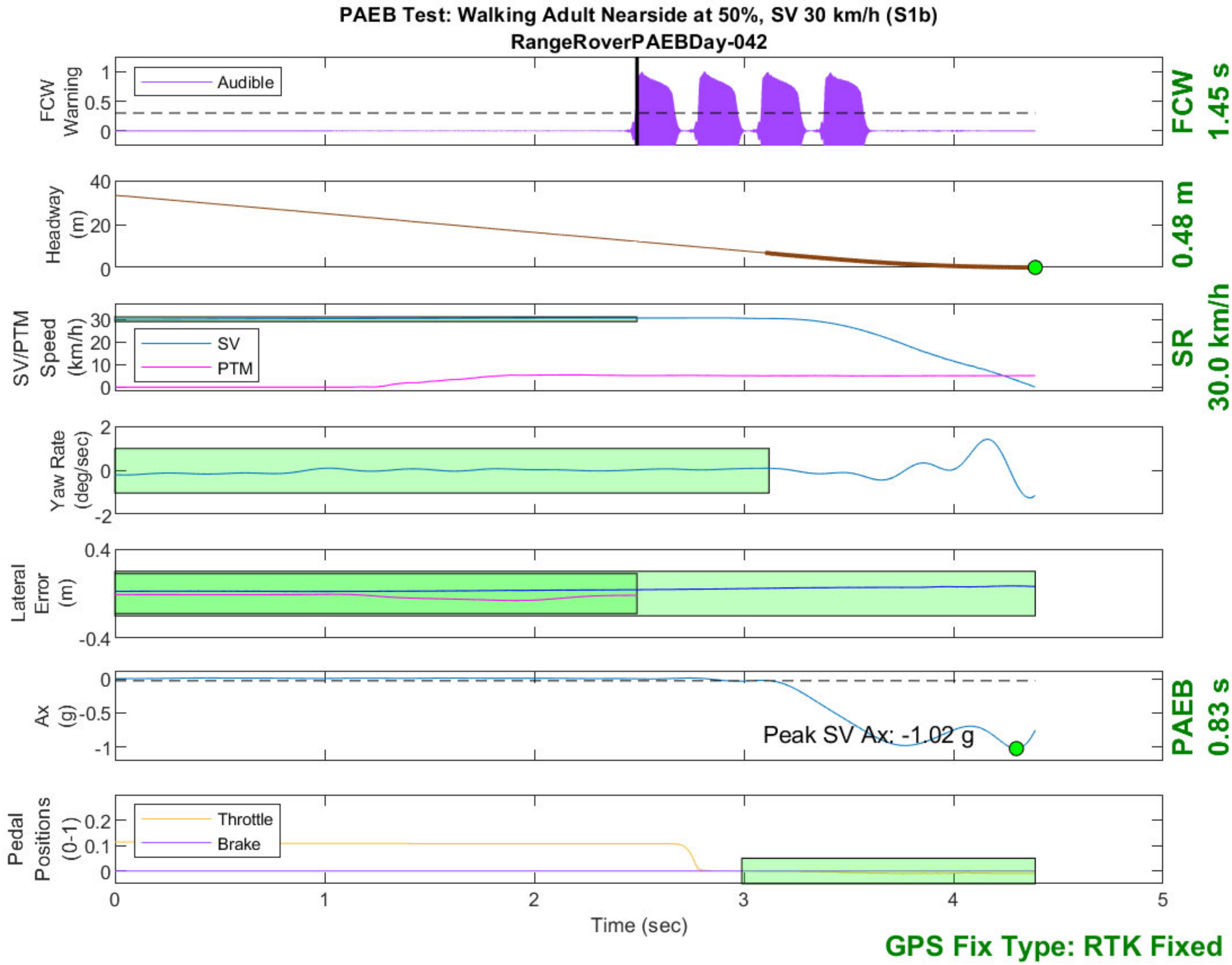


Figure D34. Time History for PAEB Run 42, S1b, Daytime, 30 km/h

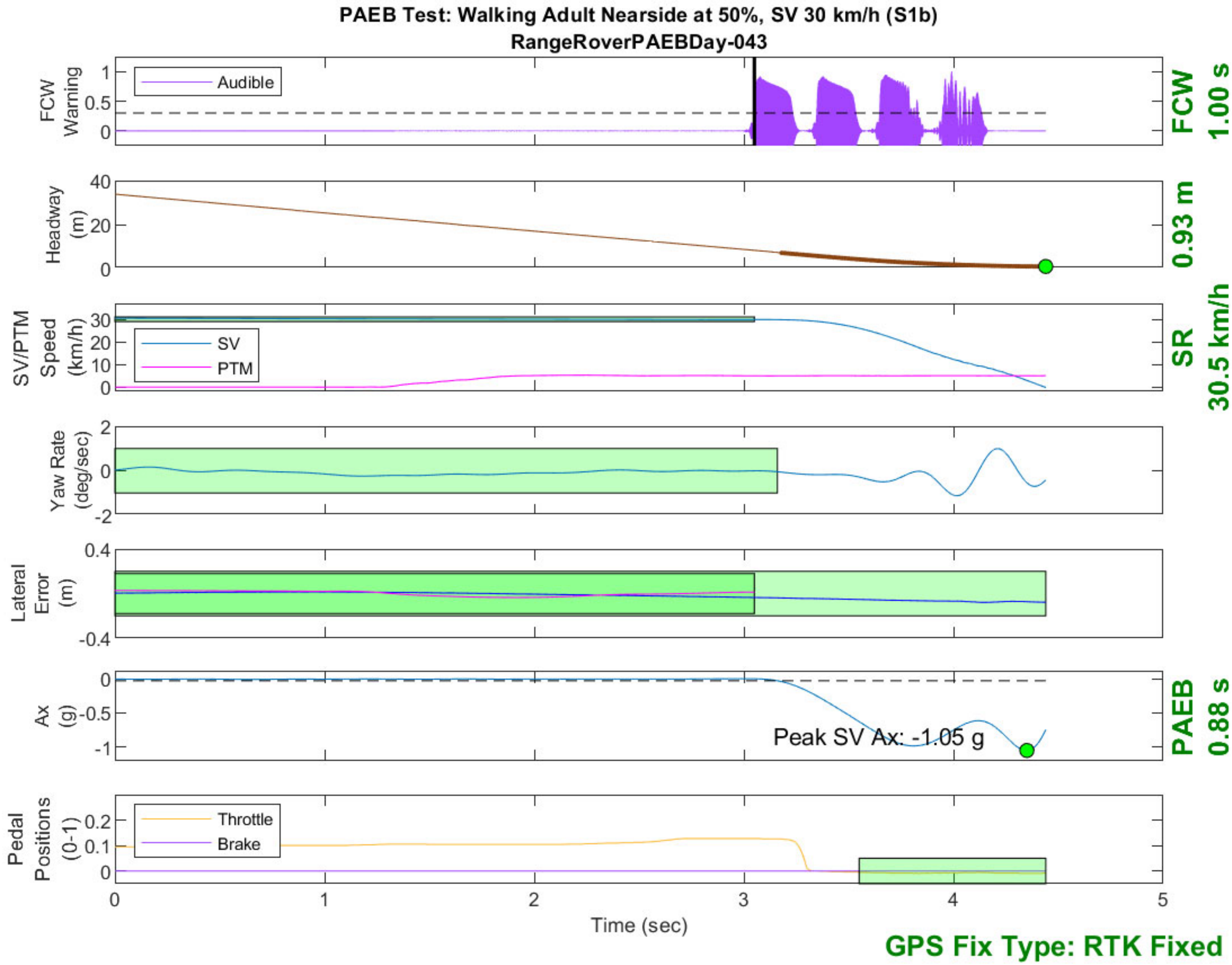


Figure D35. Time History for PAEB Run 43, S1b, Daytime, 30 km/h

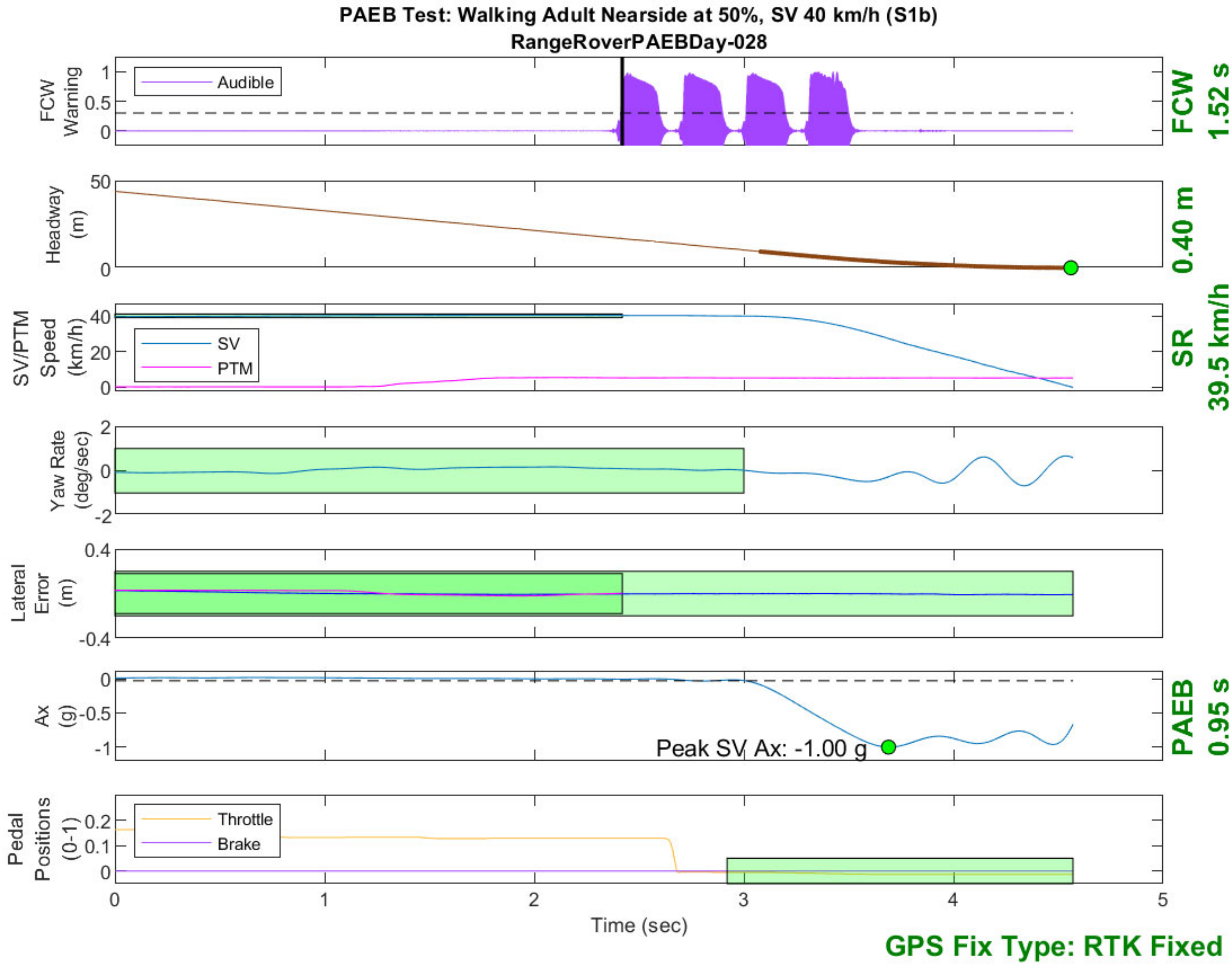


Figure D36. Time History for PAEB Run 28, S1b, Daytime, 40 km/h

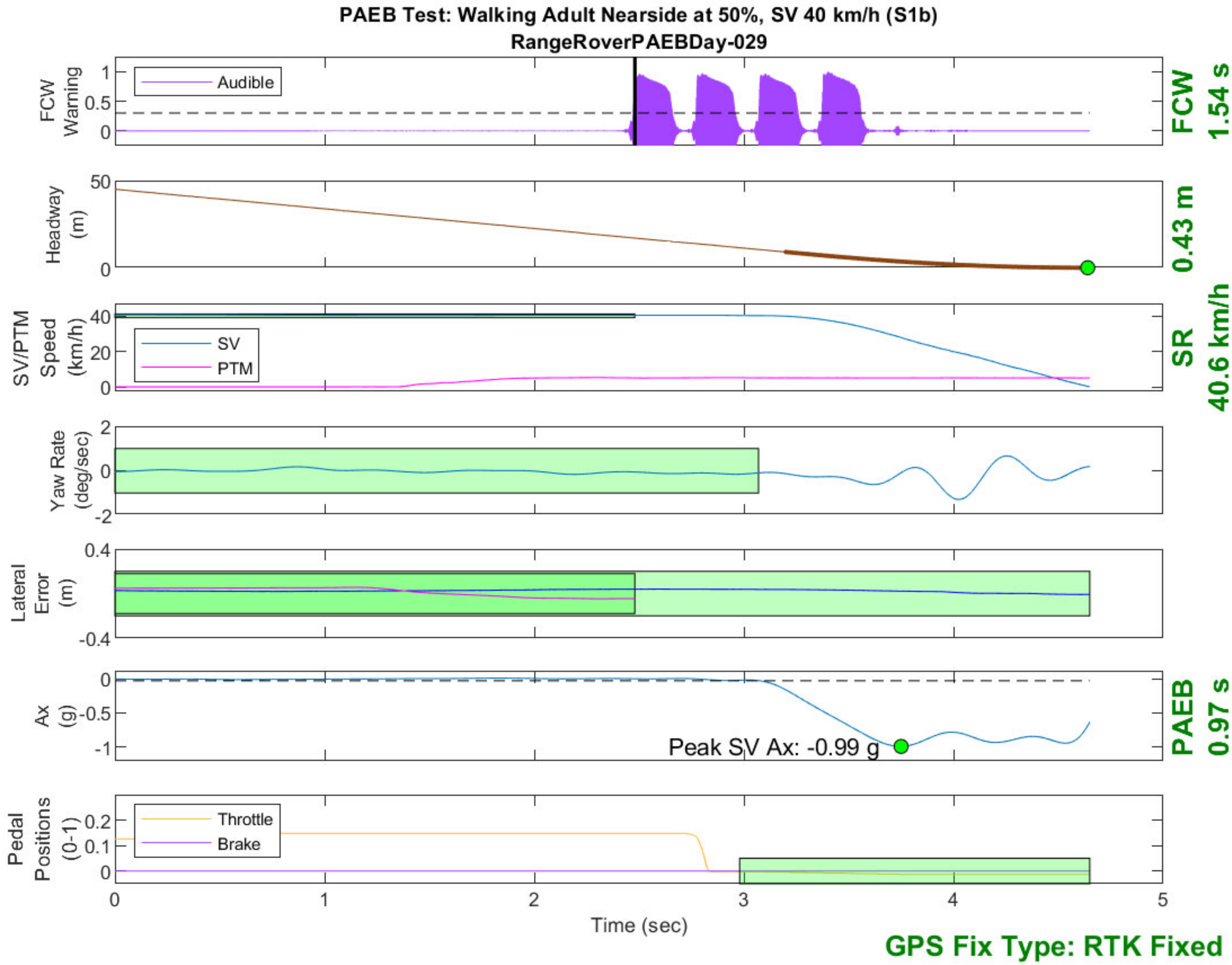


Figure D37. Time History for PAEB Run 29, S1b, Daytime, 40 km/h

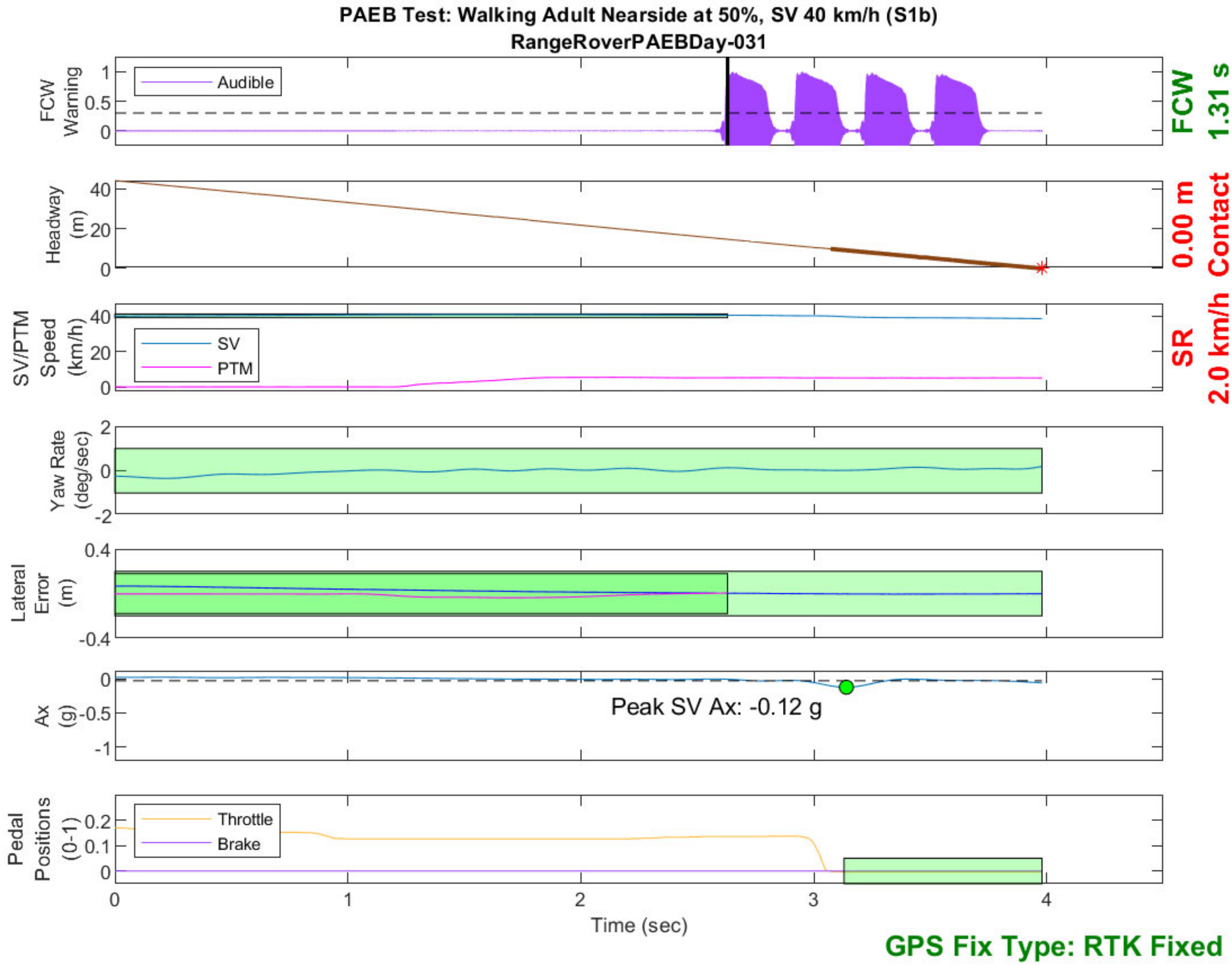


Figure D38. Time History for PAEB Run 31, S1b, Daytime, 40 km/h

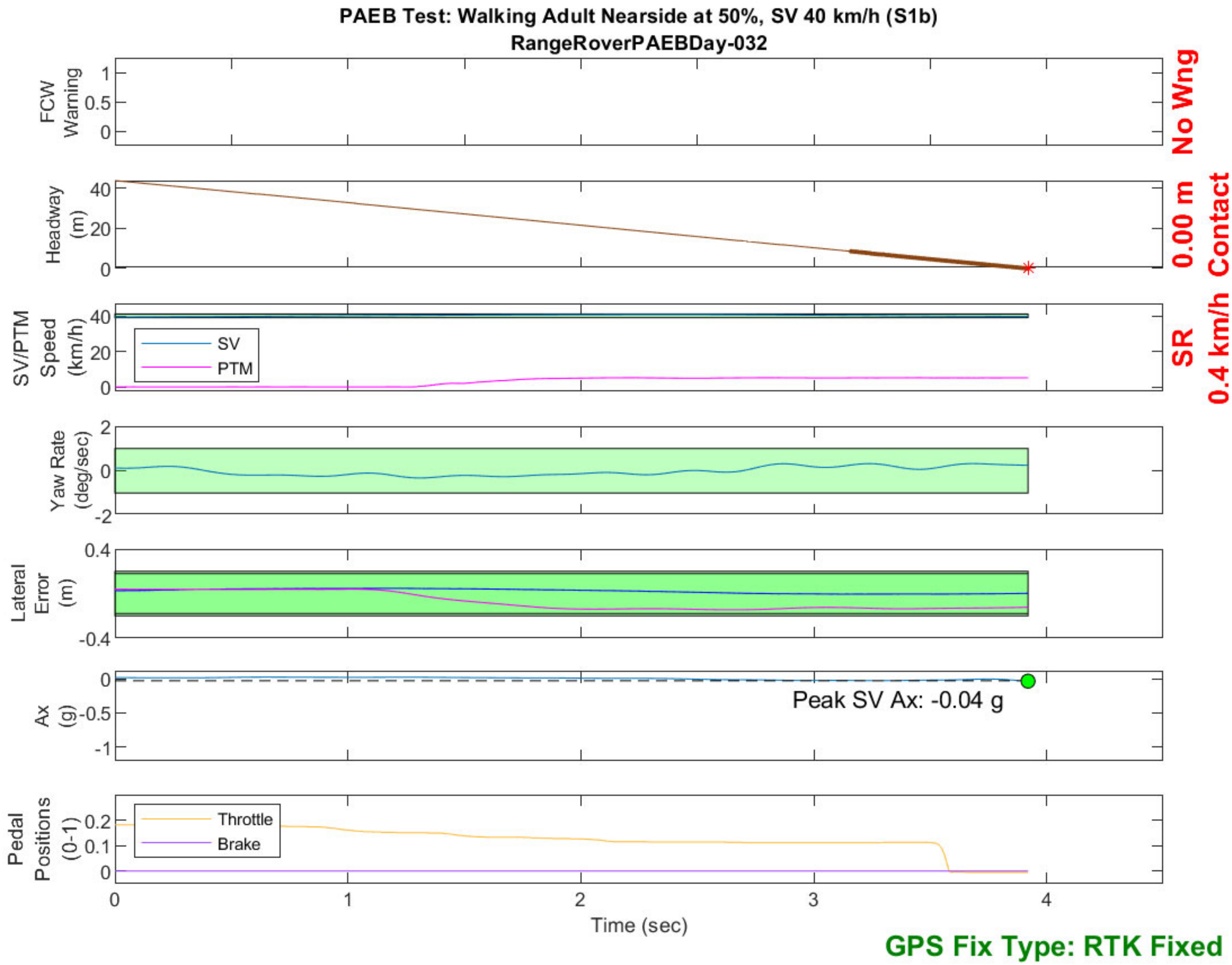


Figure D39. Time History for PAEB Run 32, S1b, Daytime, 40 km/h

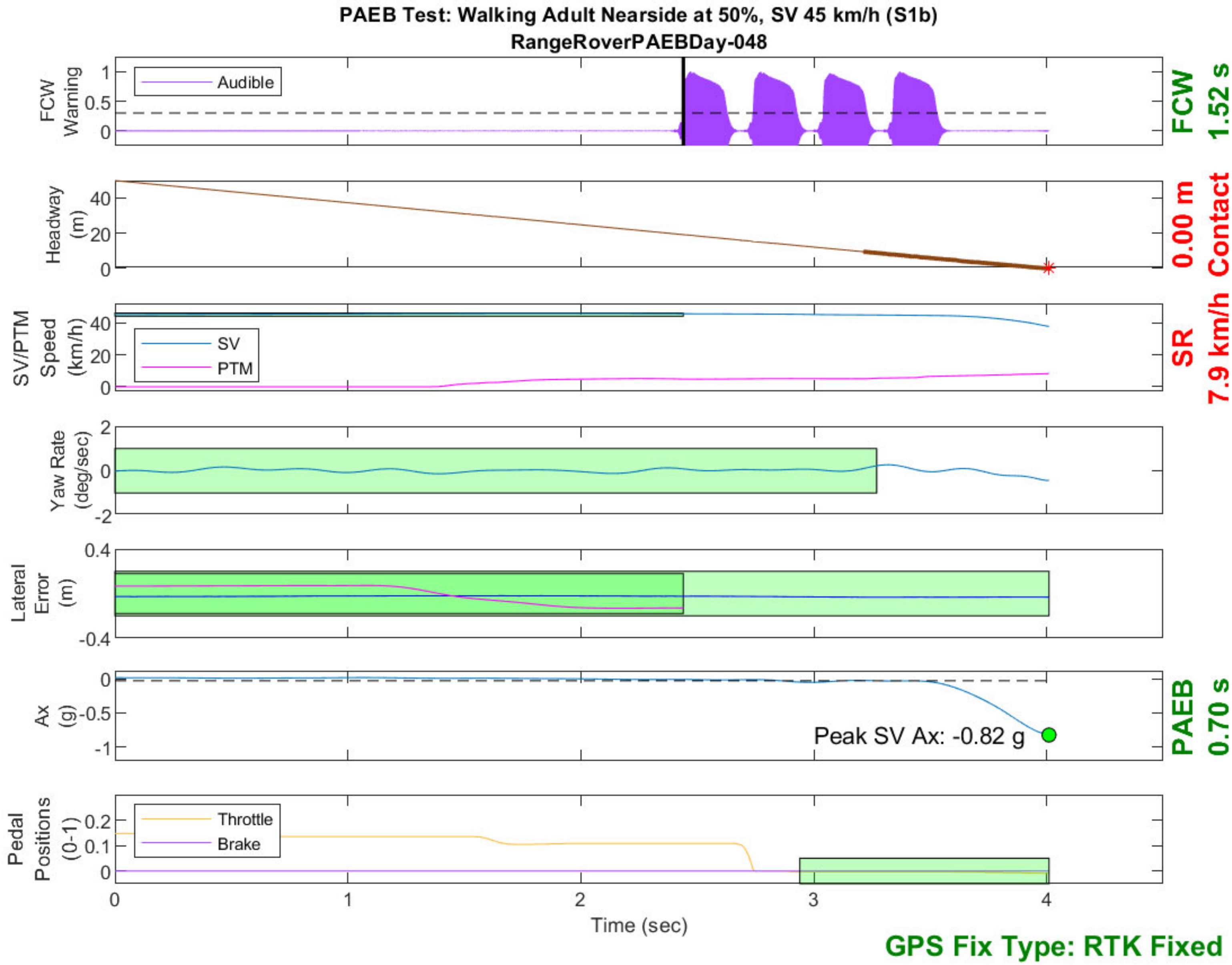


Figure D40. Time History for PAEB Run 48, S1b, Daytime, 45 km/h

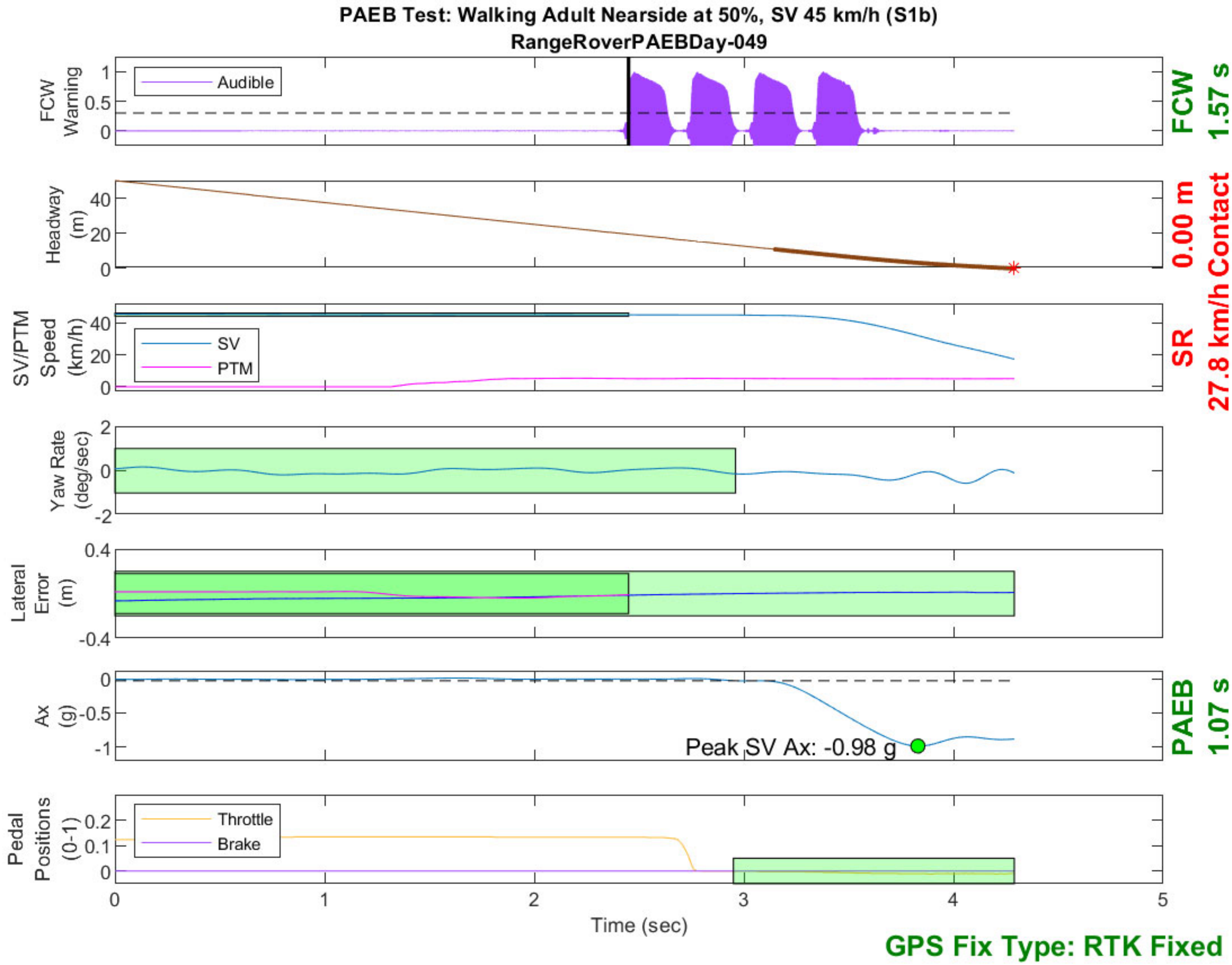


Figure D41. Time History for PAEB Run 49, S1b, Daytime, 45 km/h

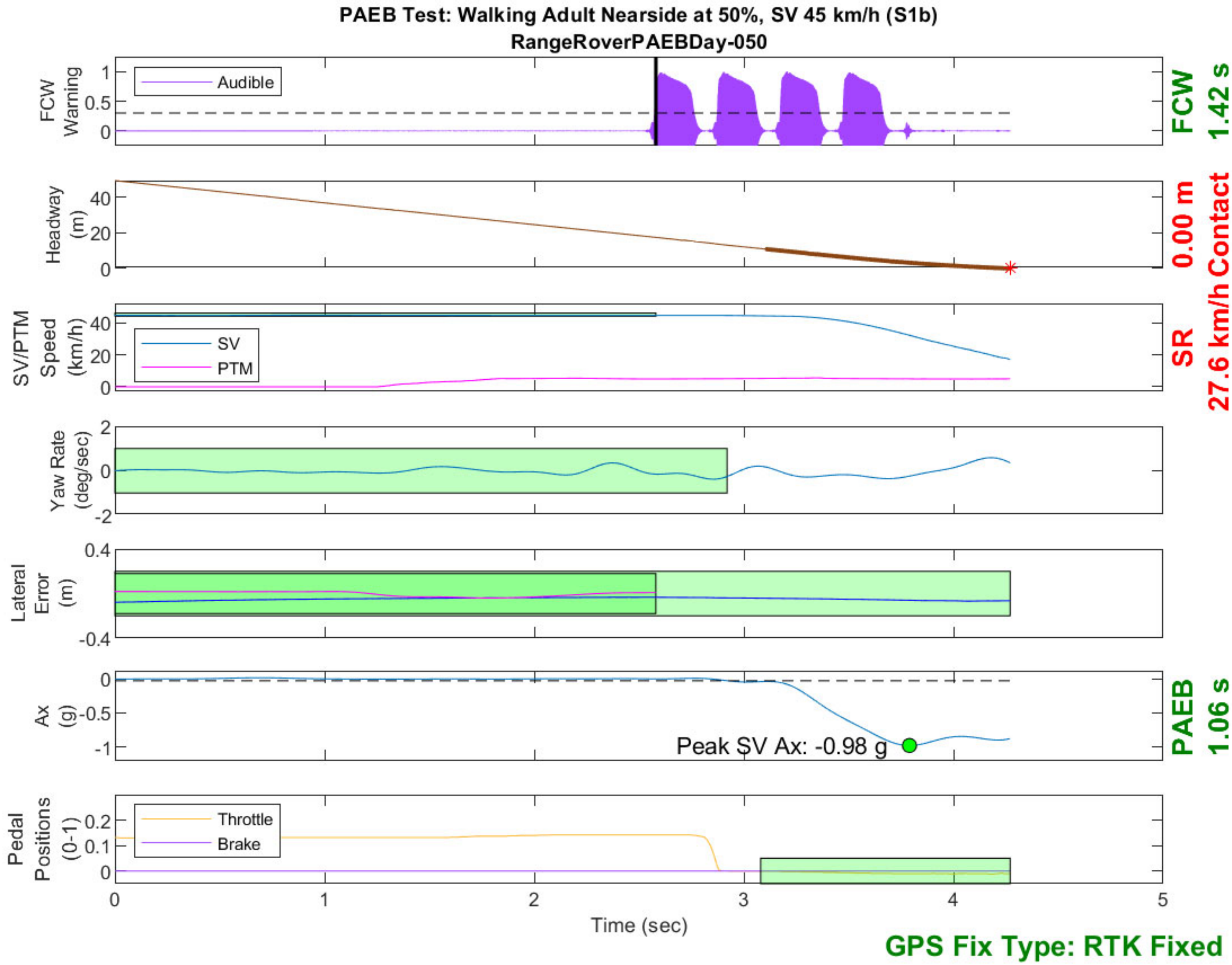


Figure D42. Time History for PAEB Run 50, S1b, Daytime, 45 km/h

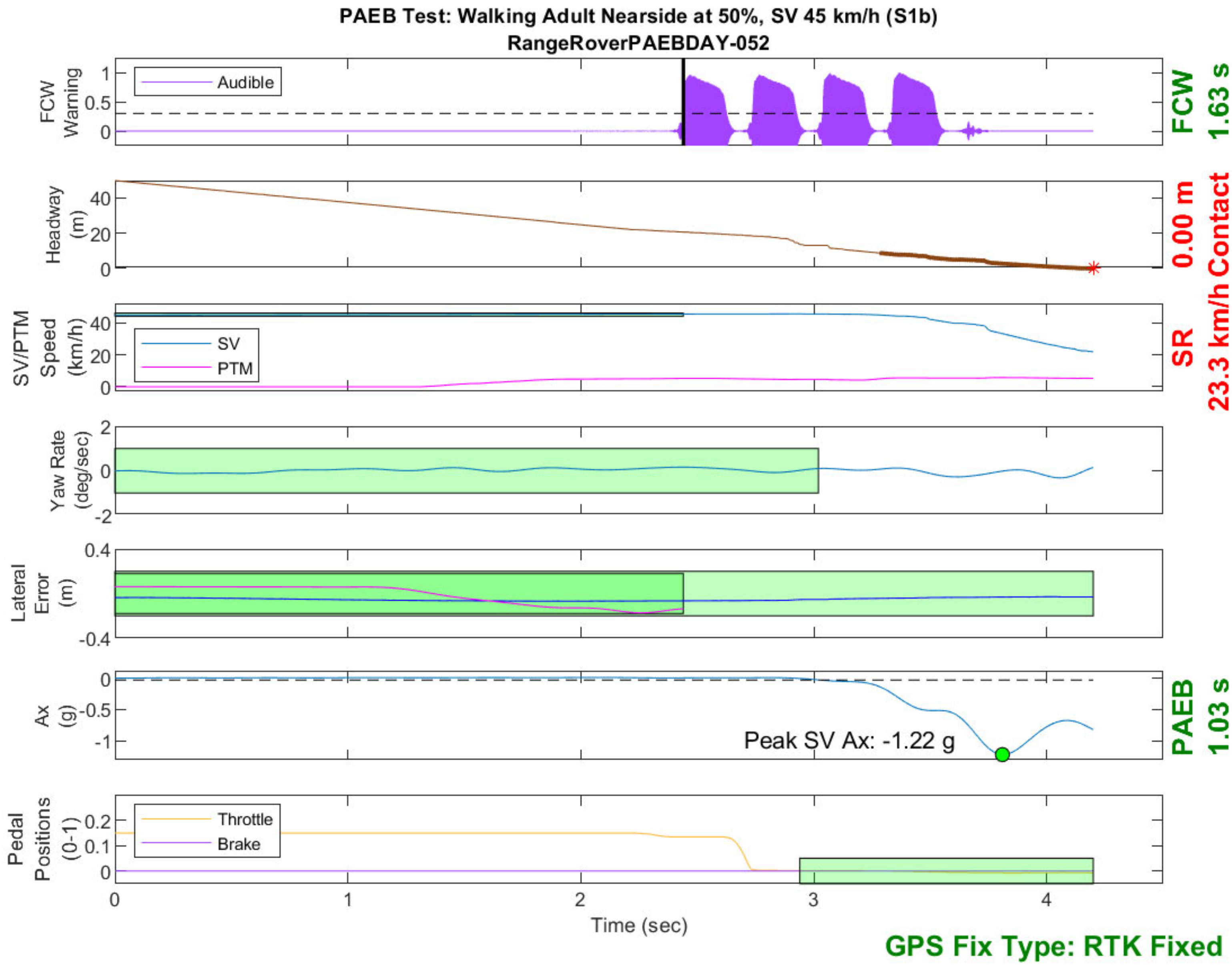


Figure D43. Time History for PAEB Run 52, S1b, Daytime, 45 km/h

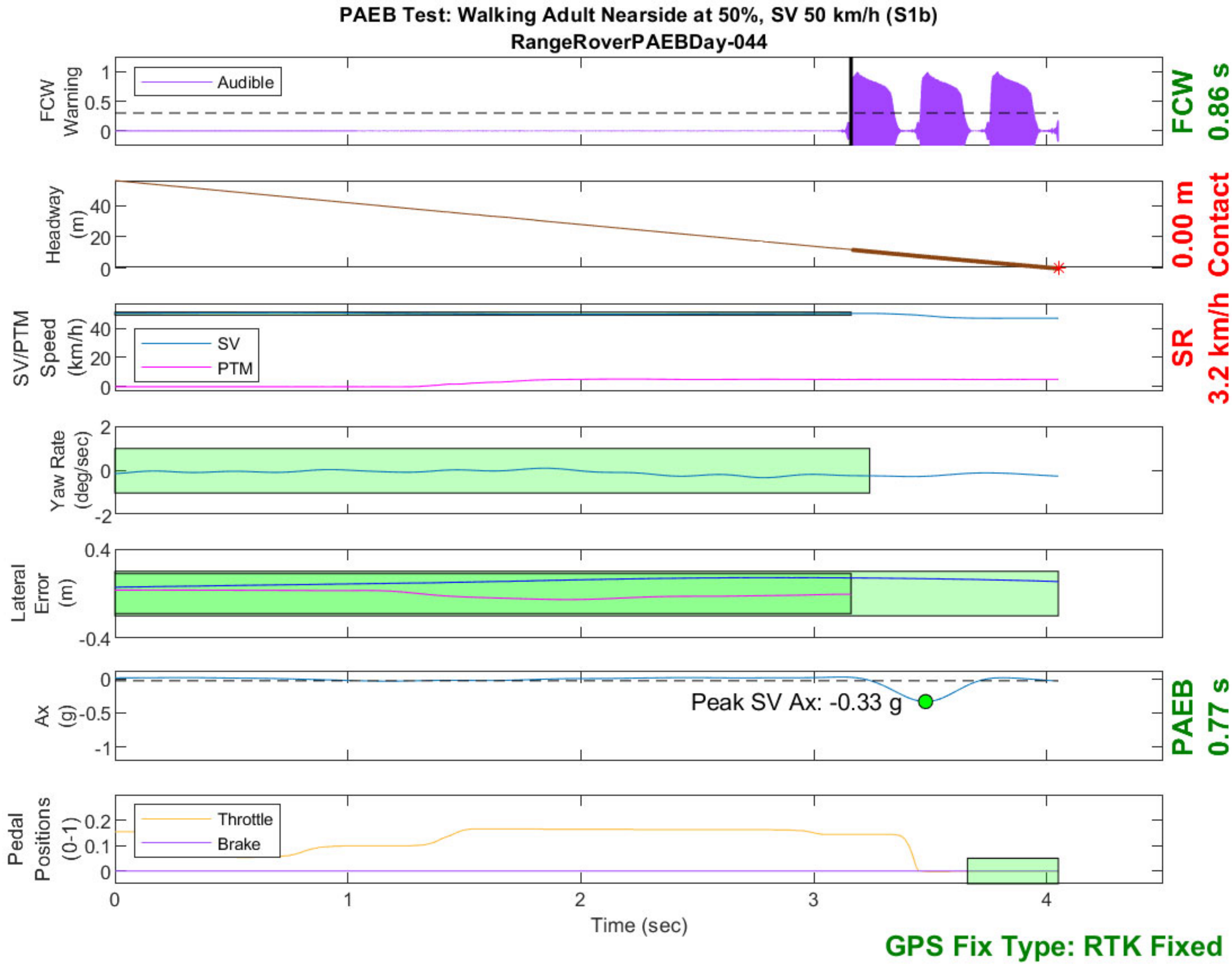


Figure D44. Time History for PAEB Run 44, S1b, Daytime, 50 km/h

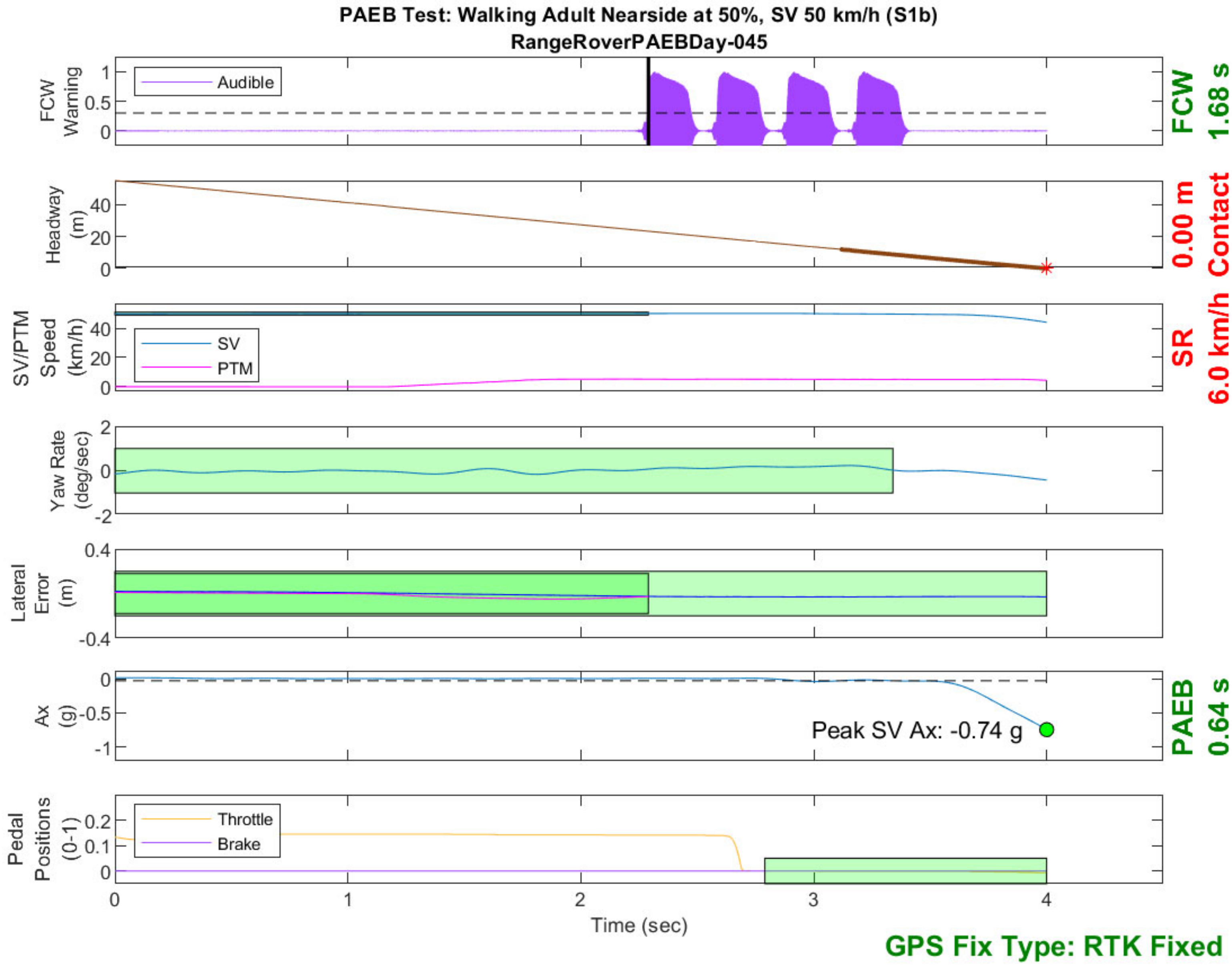


Figure D45. Time History for PAEB Run 45, S1b, Daytime, 50 km/h

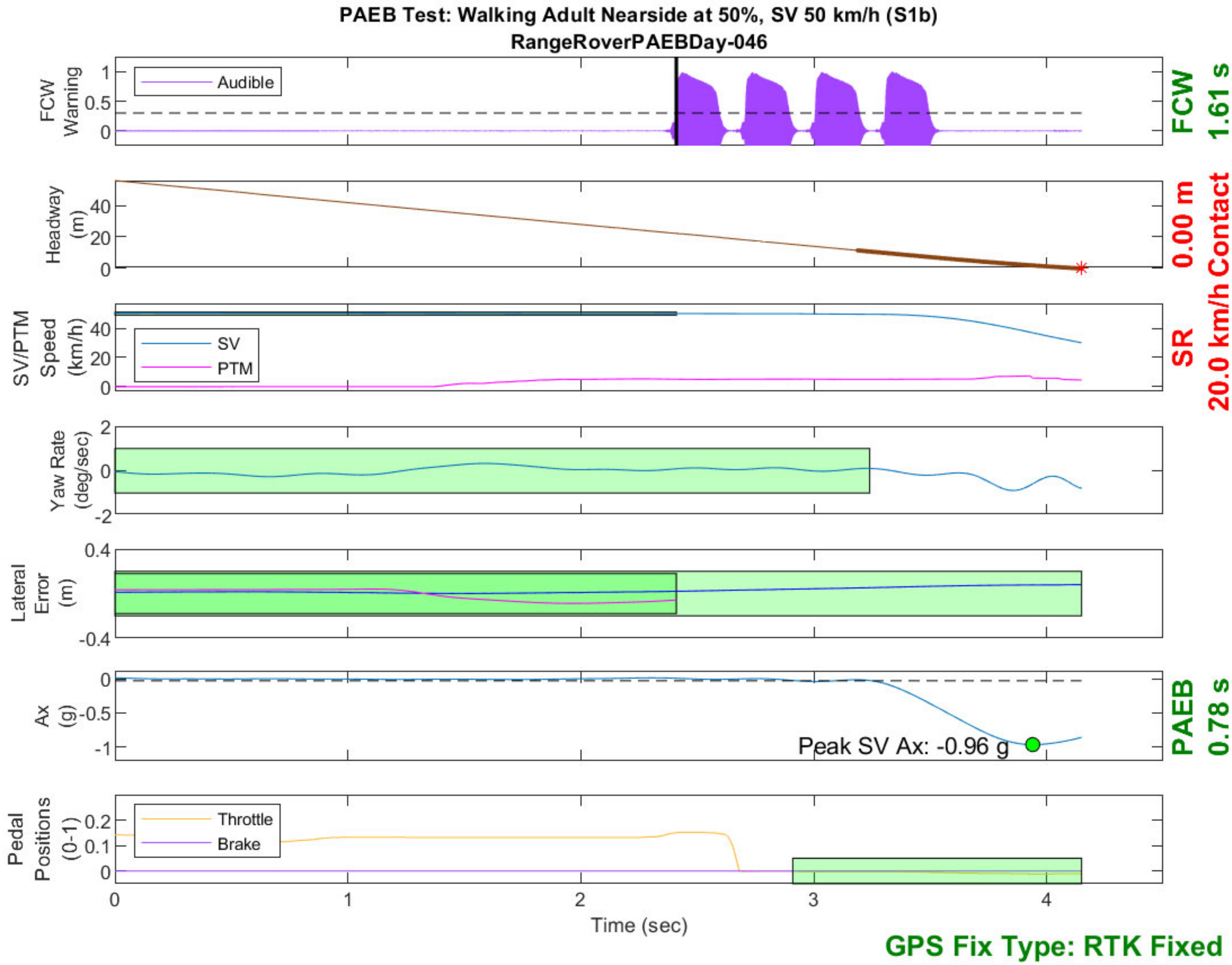


Figure D46. Time History for PAEB Run 46, S1b, Daytime, 50 km/h

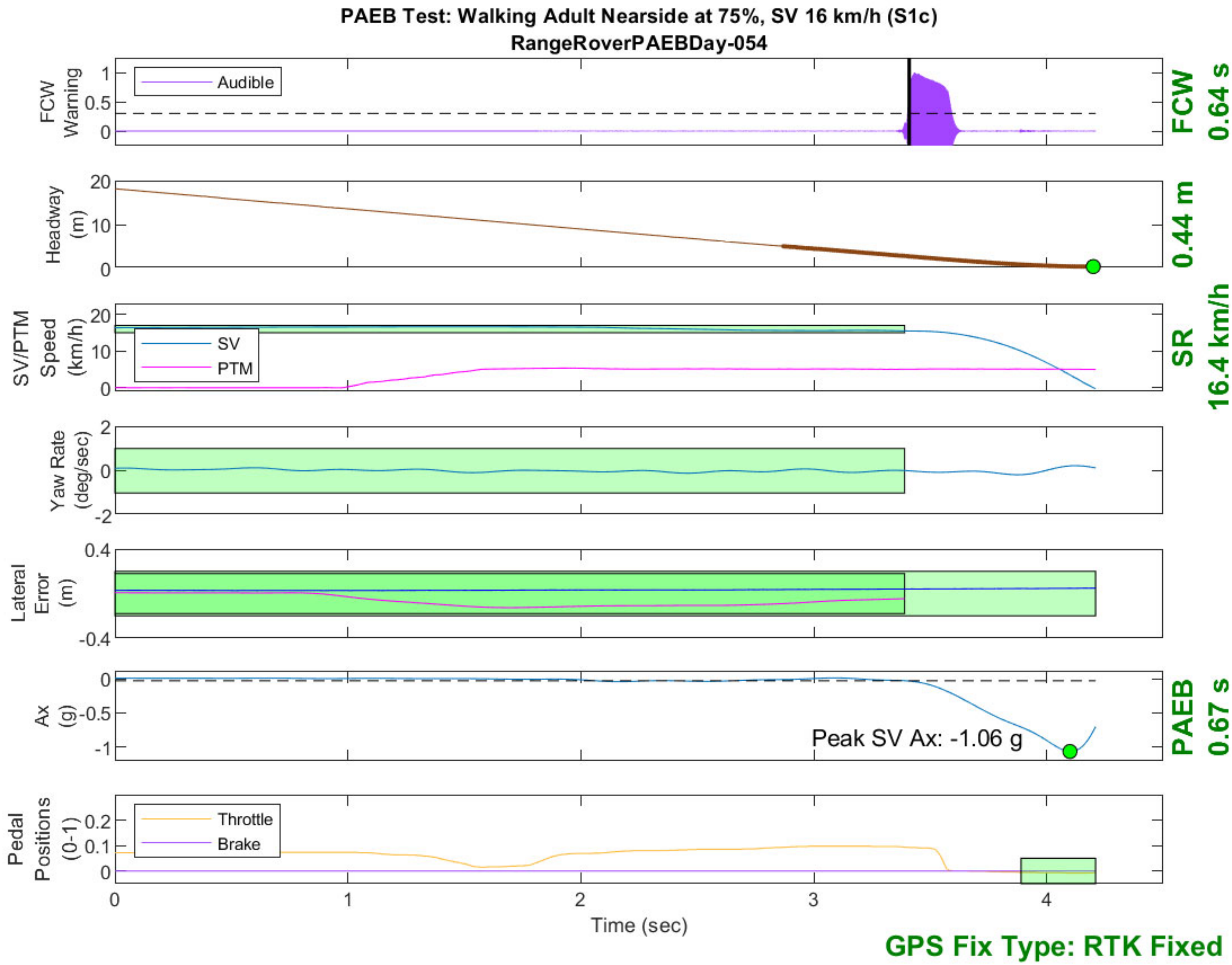


Figure D47. Time History for PAEB Run 54, S1c, Daytime, 16 km/h

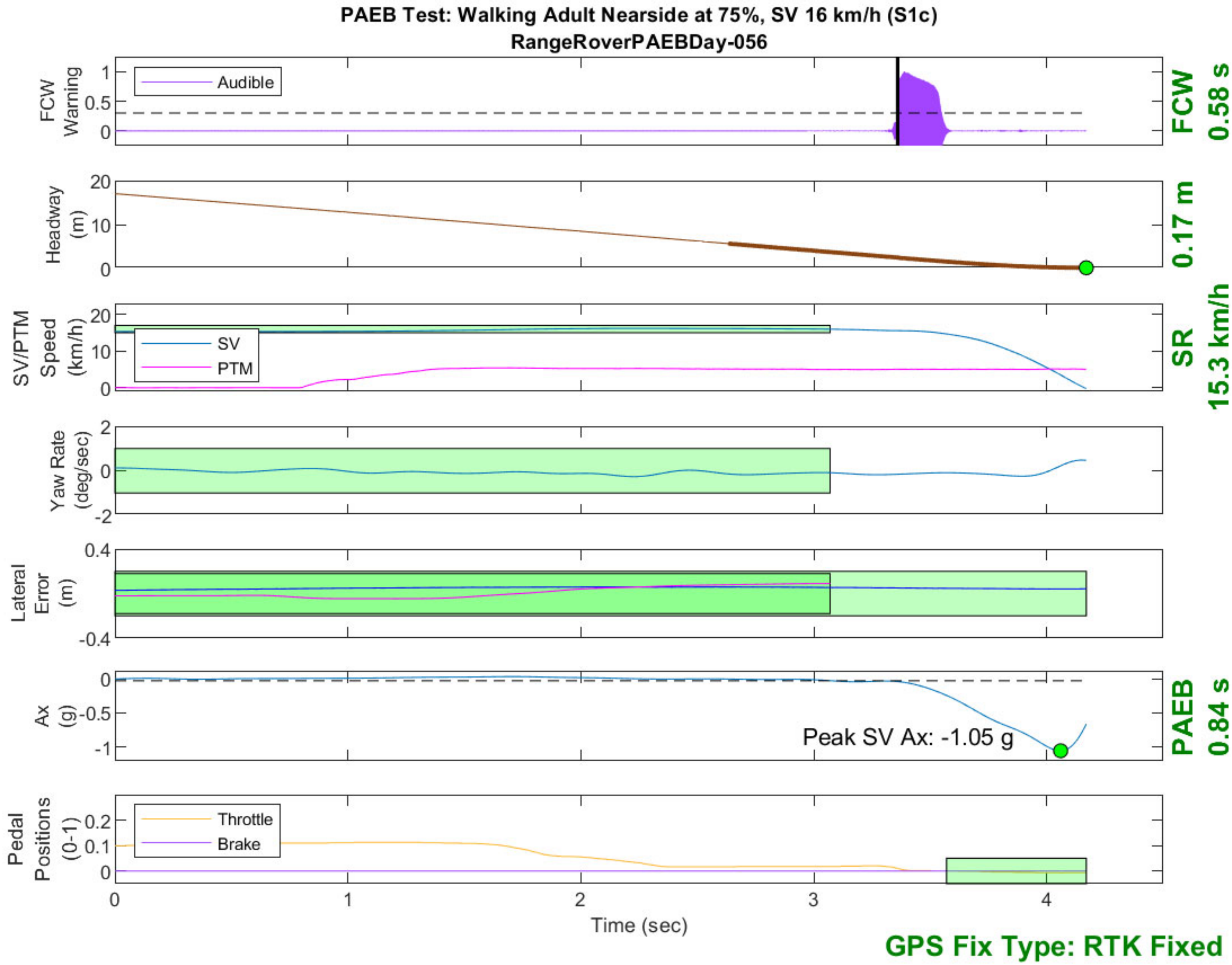


Figure D48. Time History for PAEB Run 56, S1c, Daytime, 16 km/h

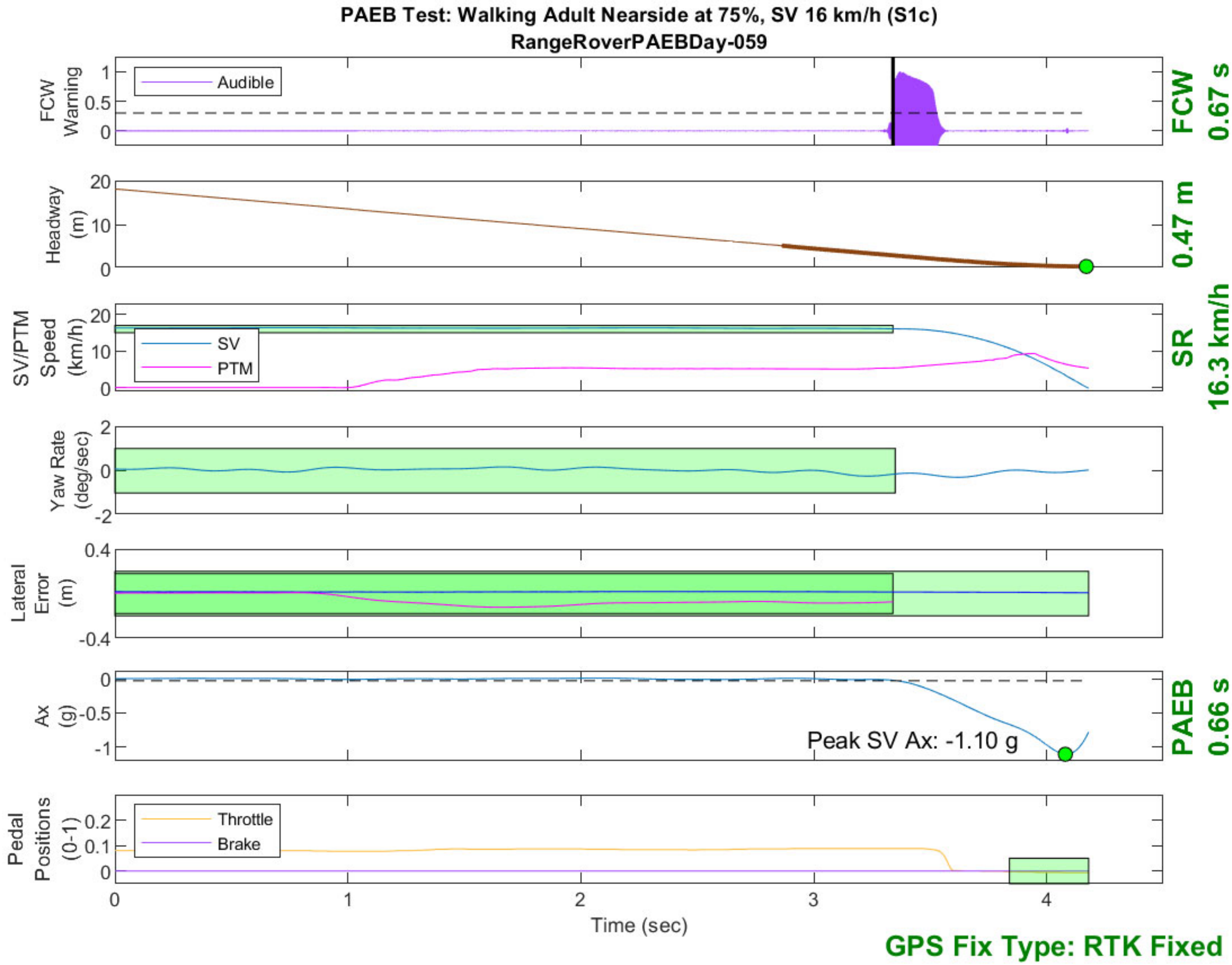


Figure D49. Time History for PAEB Run 59, S1c, Daytime, 16 km/h

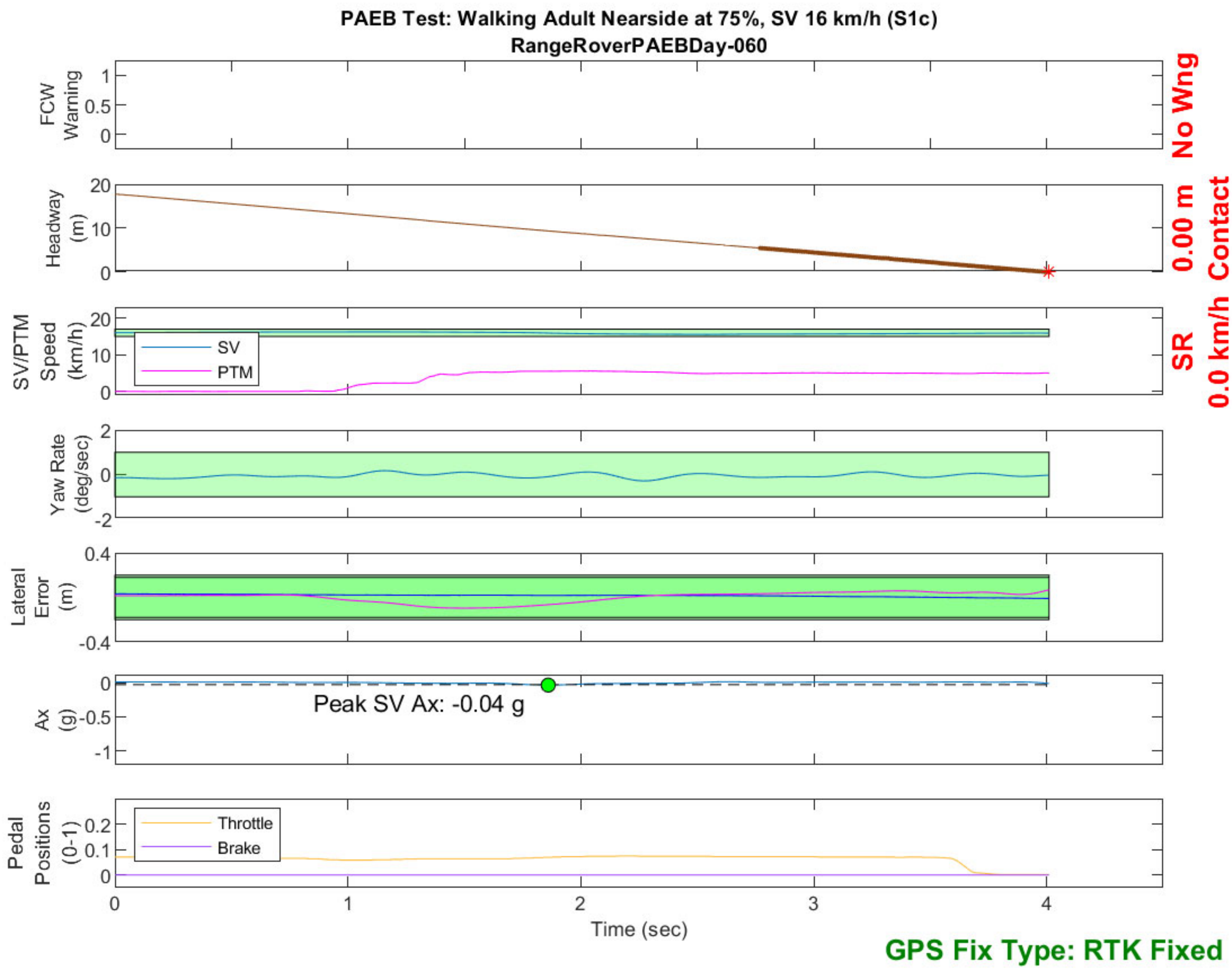


Figure D50. Time History for PAEB Run 60, S1c, Daytime, 16 km/h

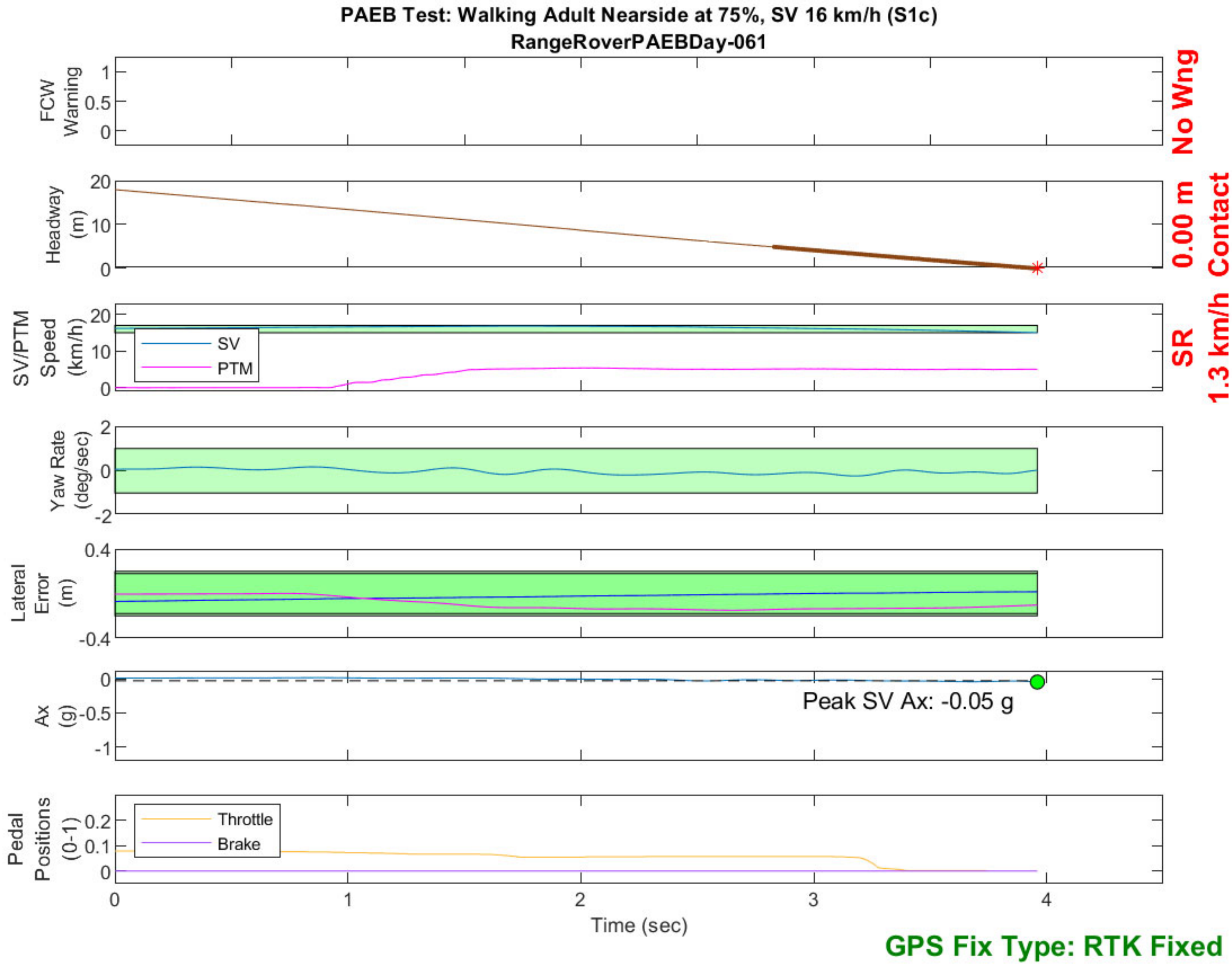


Figure D51. Time History for PAEB Run 61, S1c, Daytime, 16 km/h

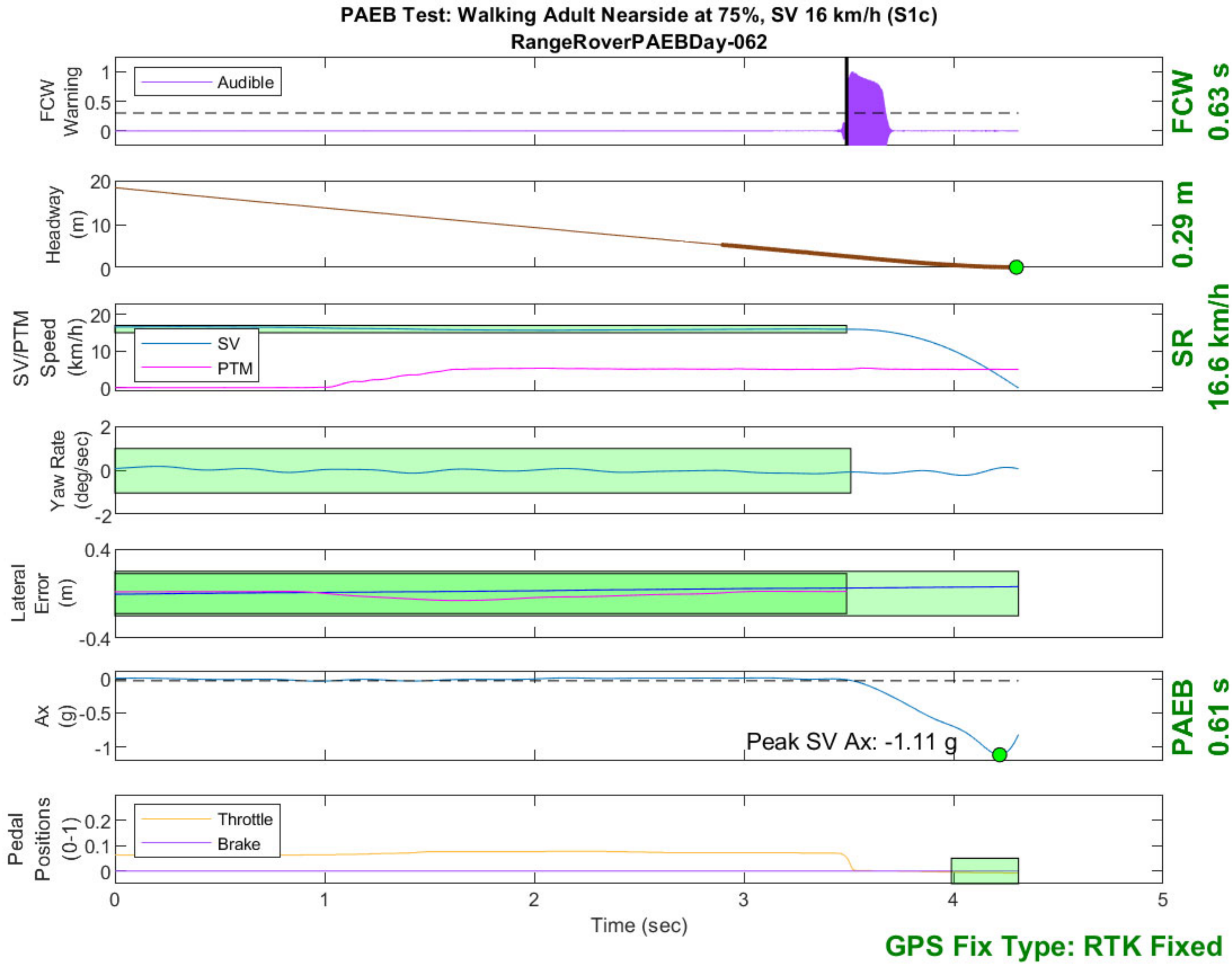


Figure D52. Time History for PAEB Run 62, S1c, Daytime, 16 km/h

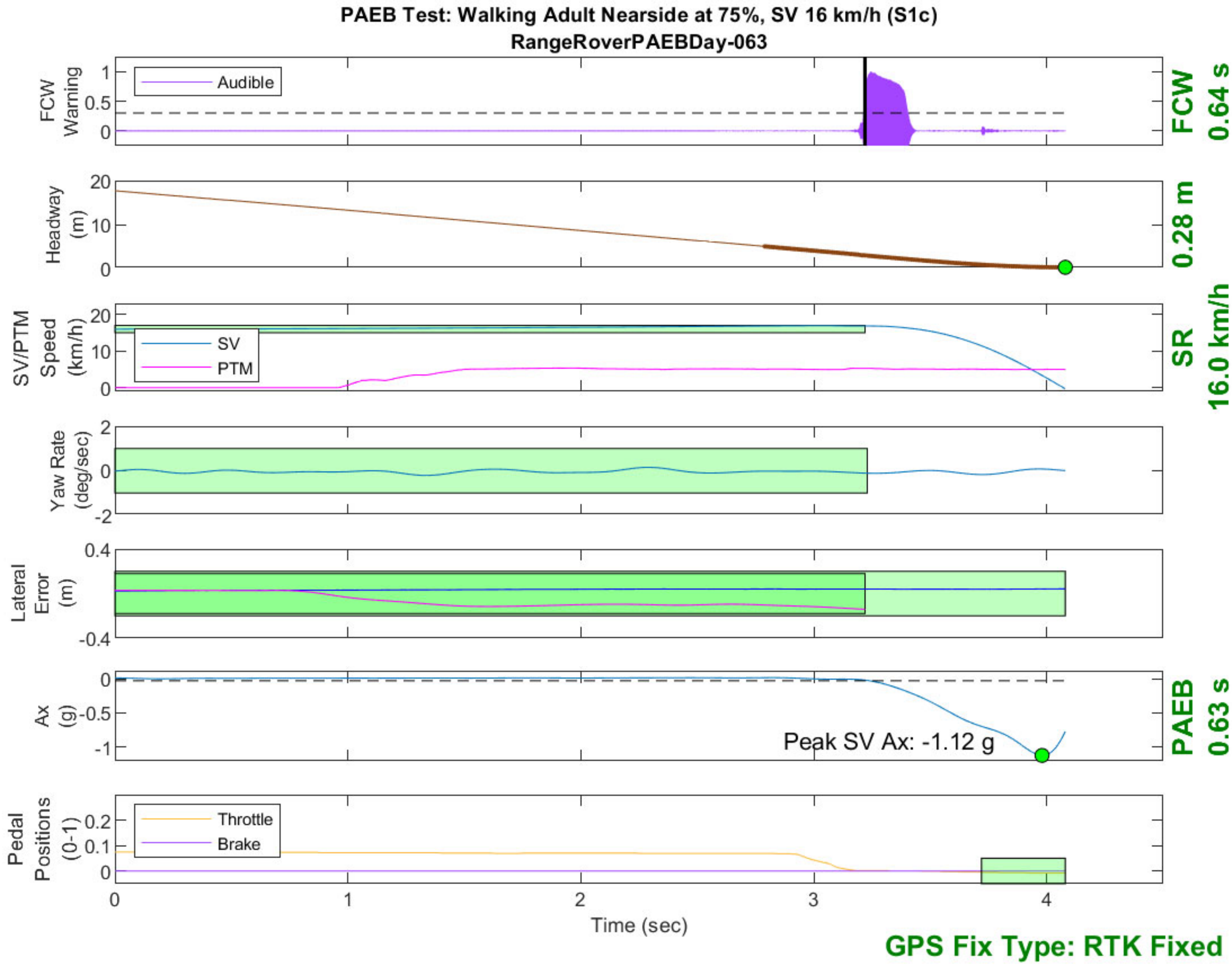


Figure D53. Time History for PAEB Run 63, S1c, Daytime, 16 km/h

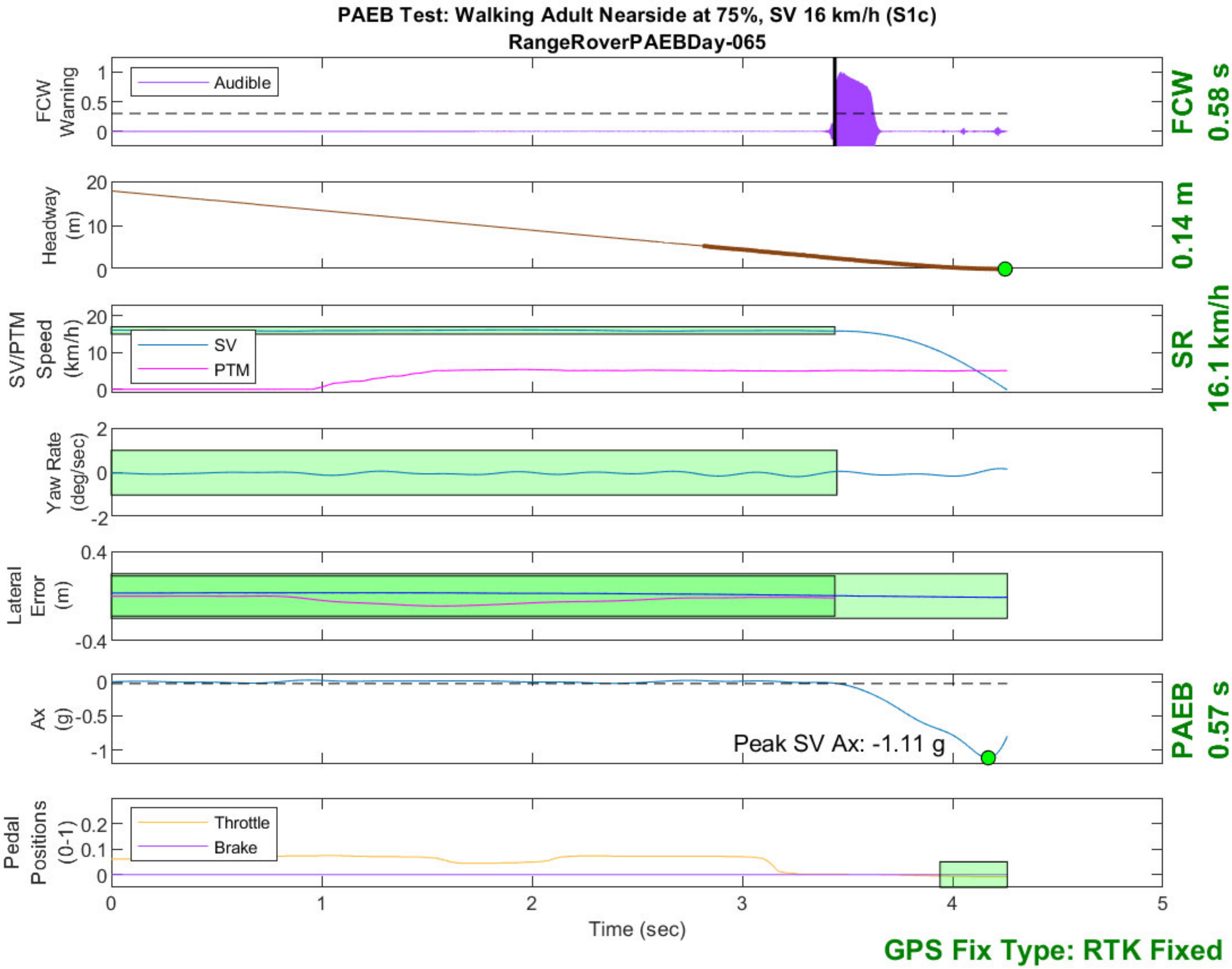


Figure D54. Time History for PAEB Run 65, S1c, Daytime, 16 km/h

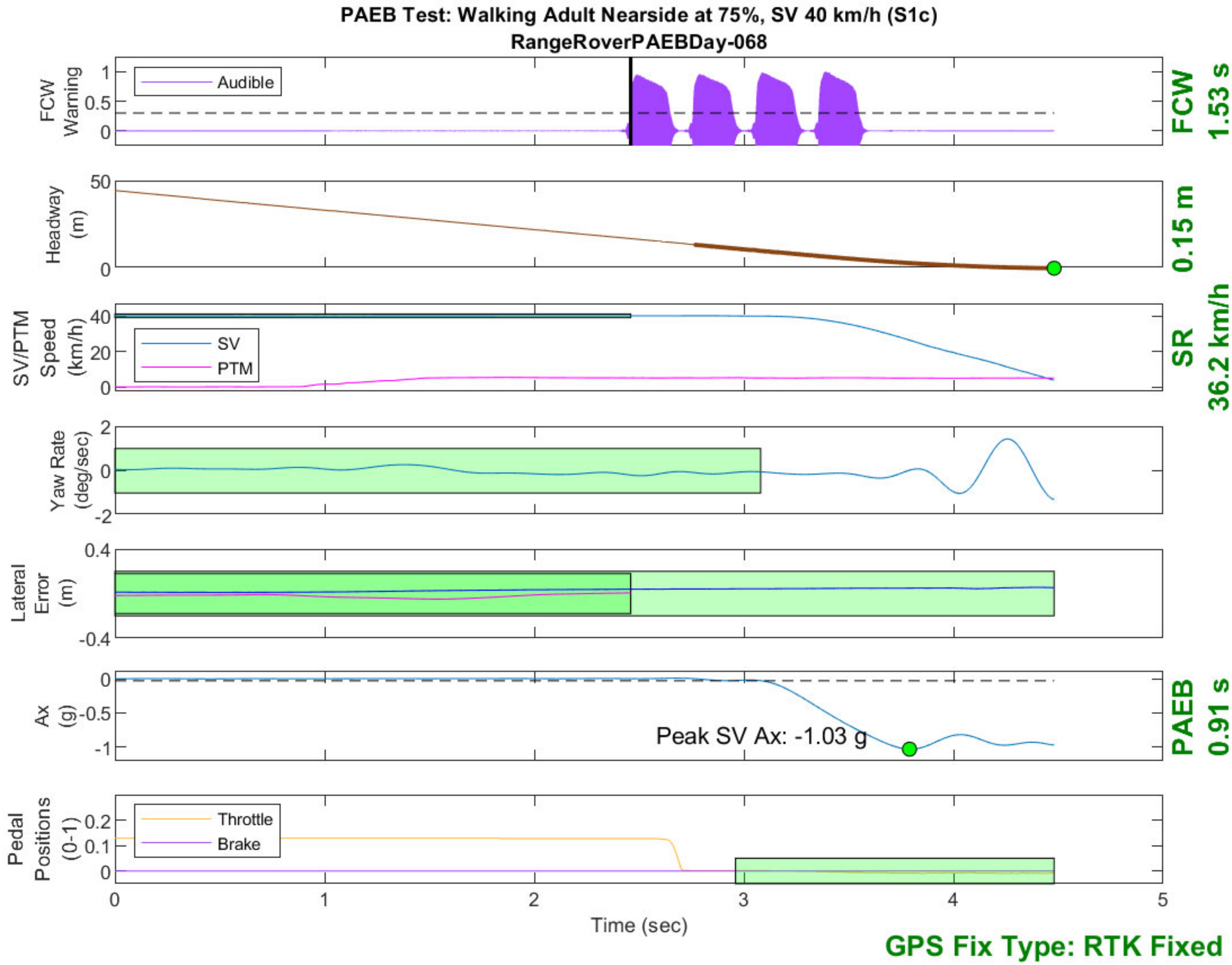


Figure D55. Time History for PAEB Run 68, S1c, Daytime, 40 km/h

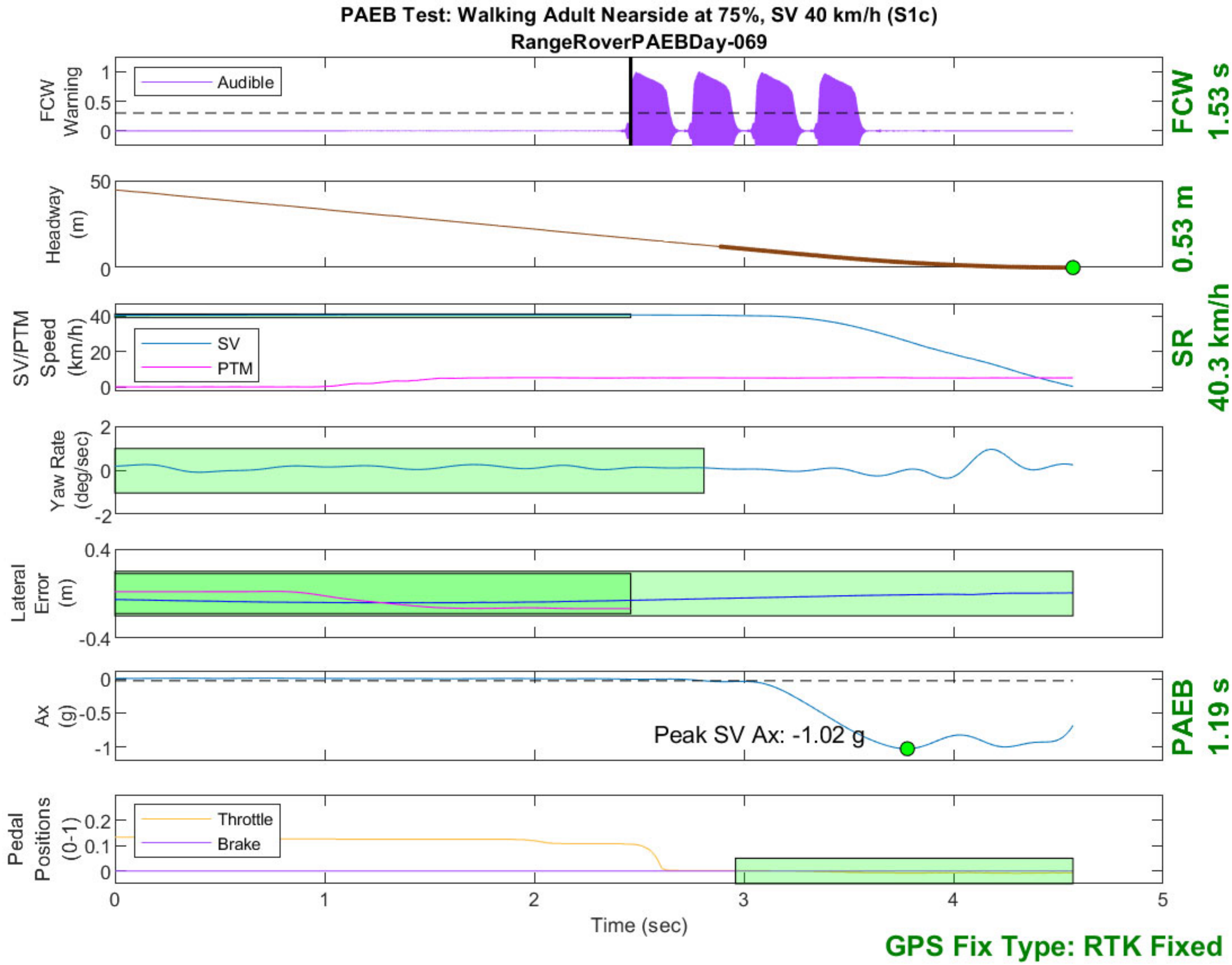


Figure D56. Time History for PAEB Run 69, S1c, Daytime, 40 km/h

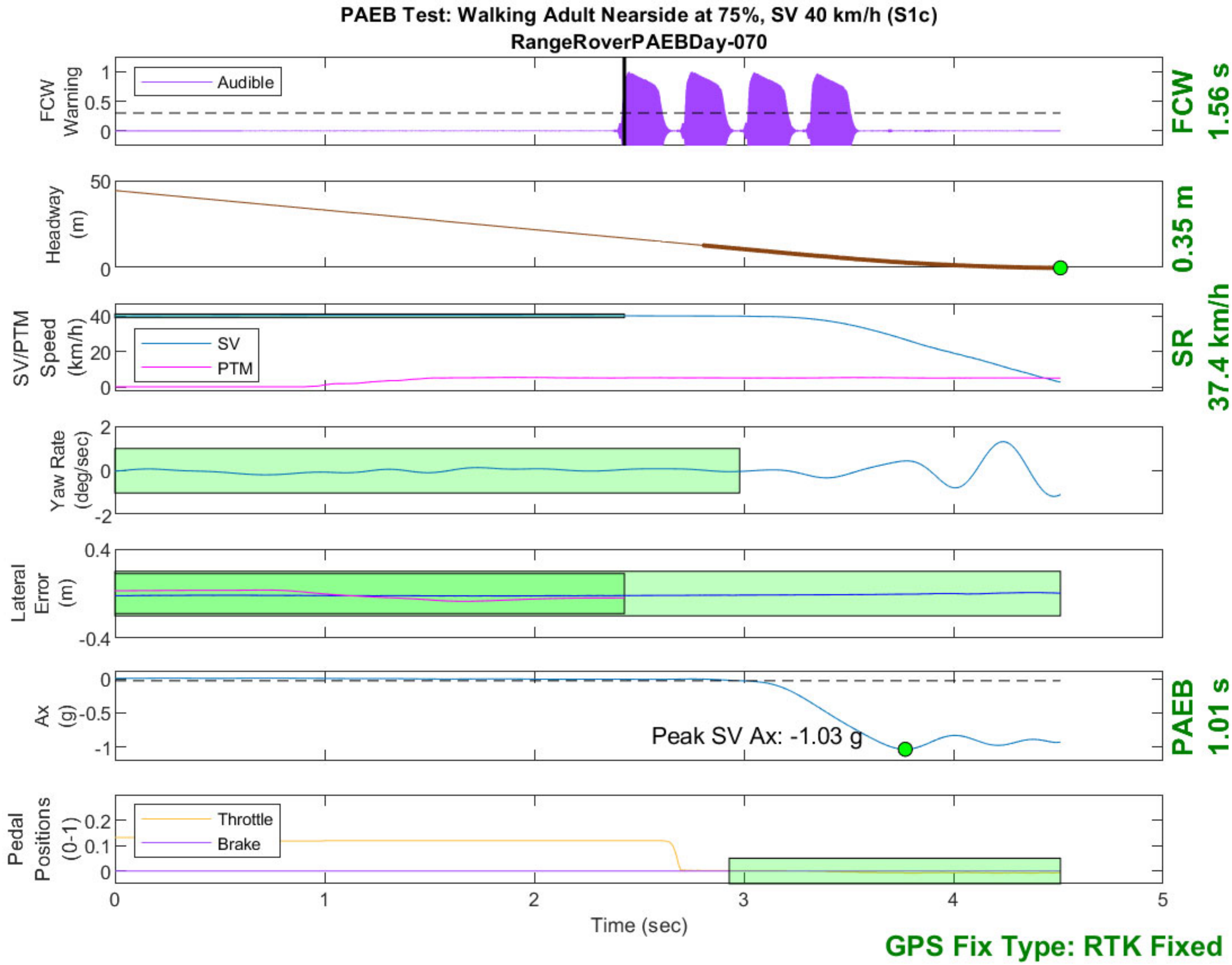


Figure D57. Time History for PAEB Run 70, S1c, Daytime, 40 km/h

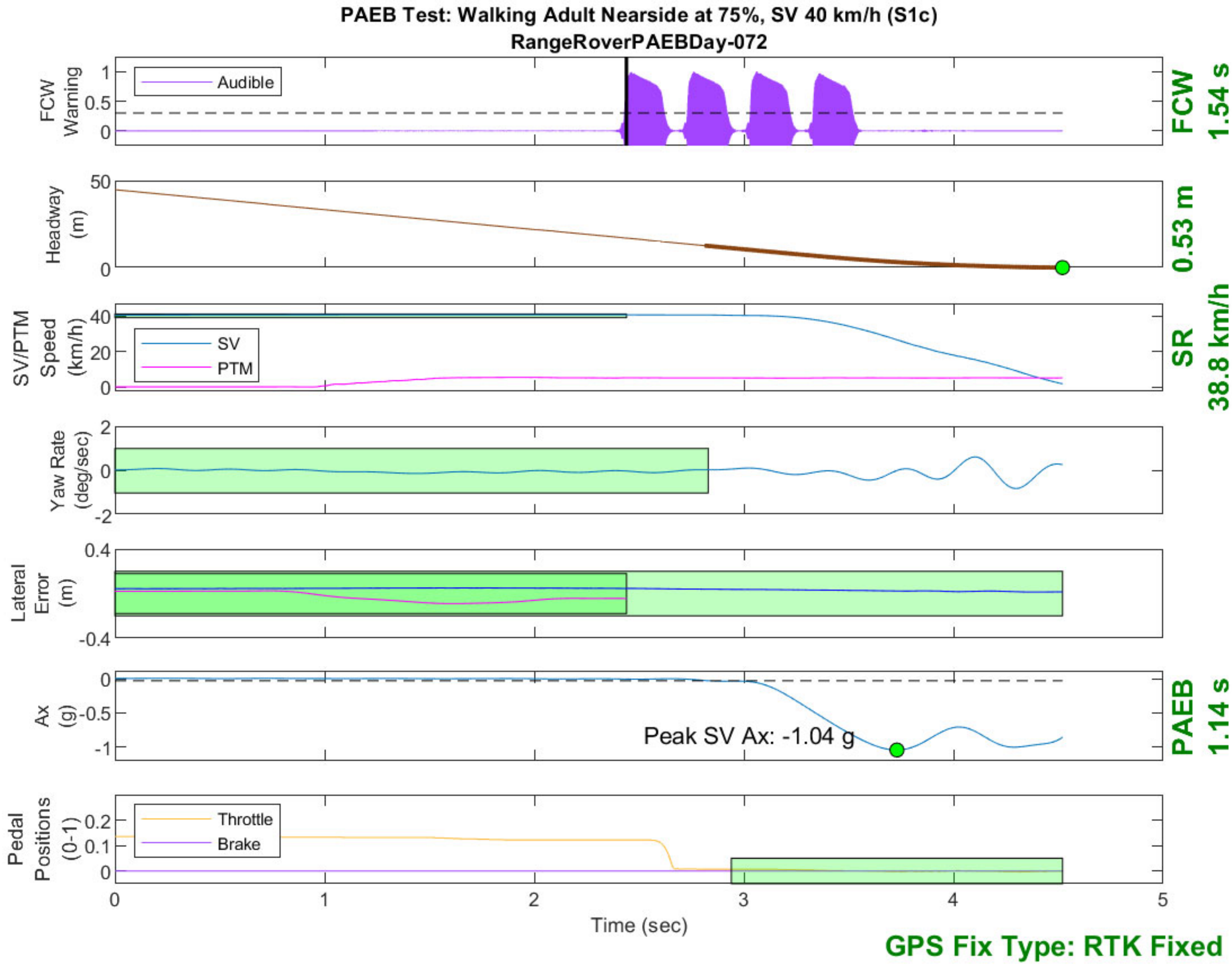


Figure D58. Time History for PAEB Run 72, S1c, Daytime, 40 km/h

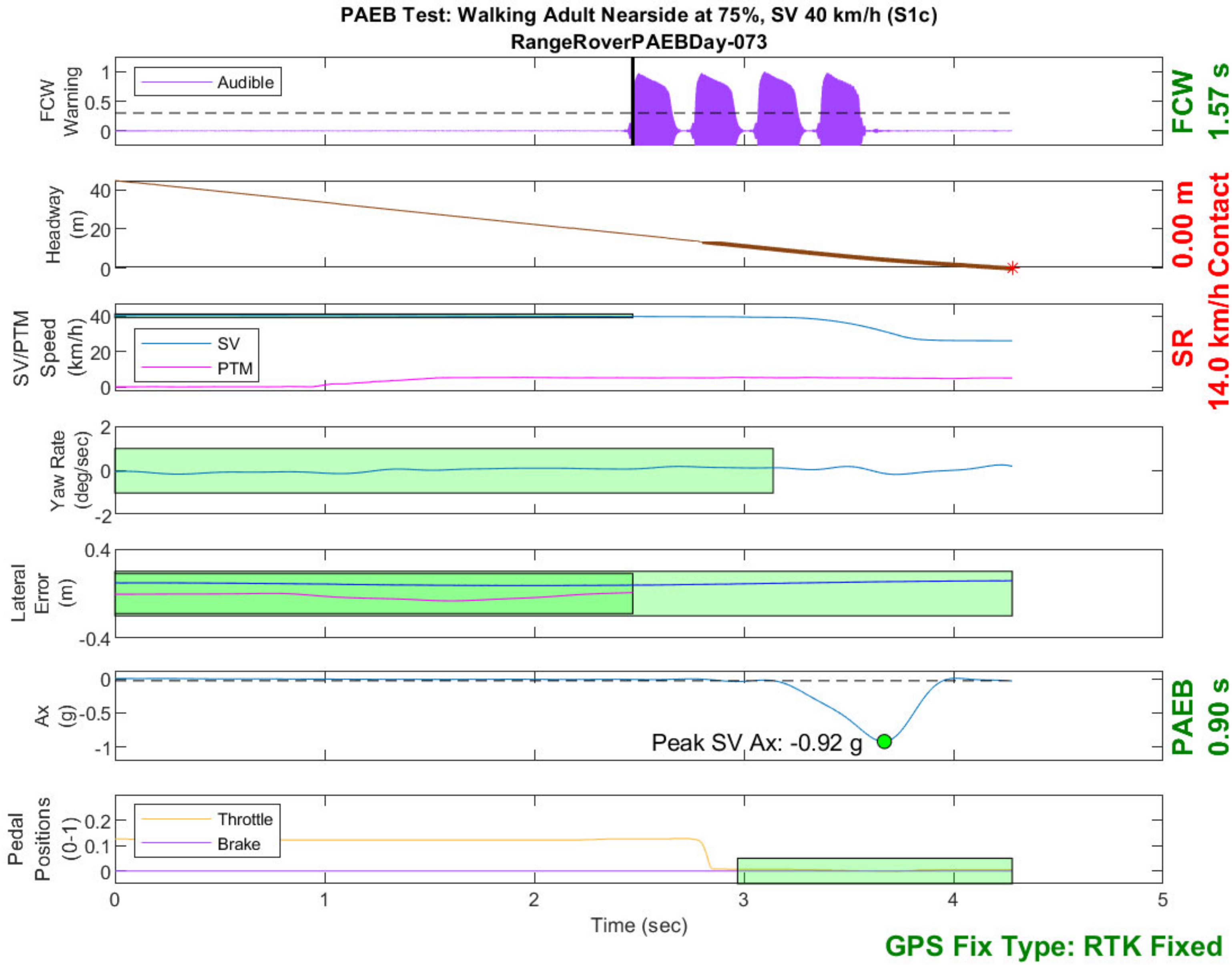


Figure D59. Time History for PAEB Run 73, S1c, Daytime, 40 km/h

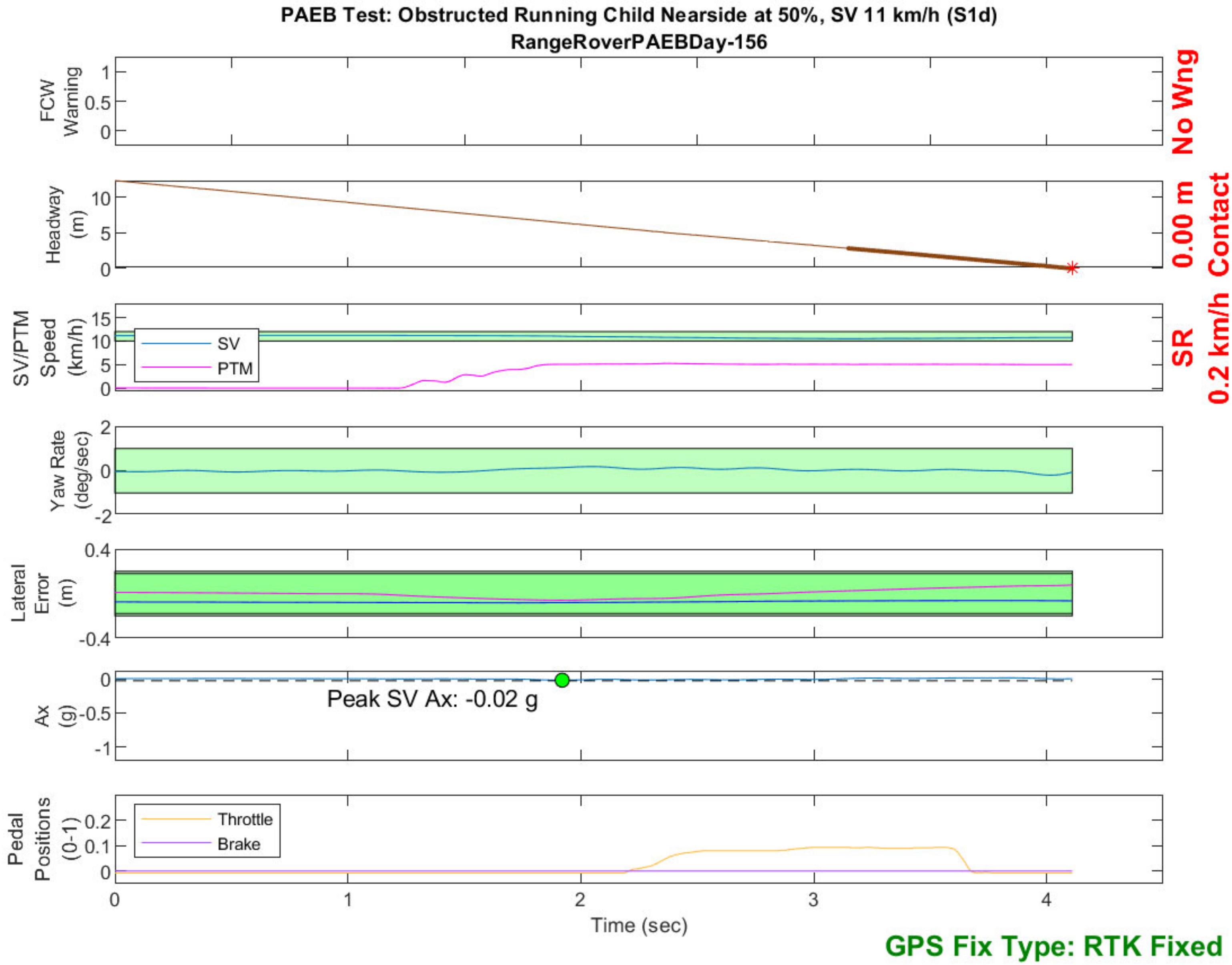


Figure D60. Time History for PAEB Run 156, S1d, Daytime, 11 km/h

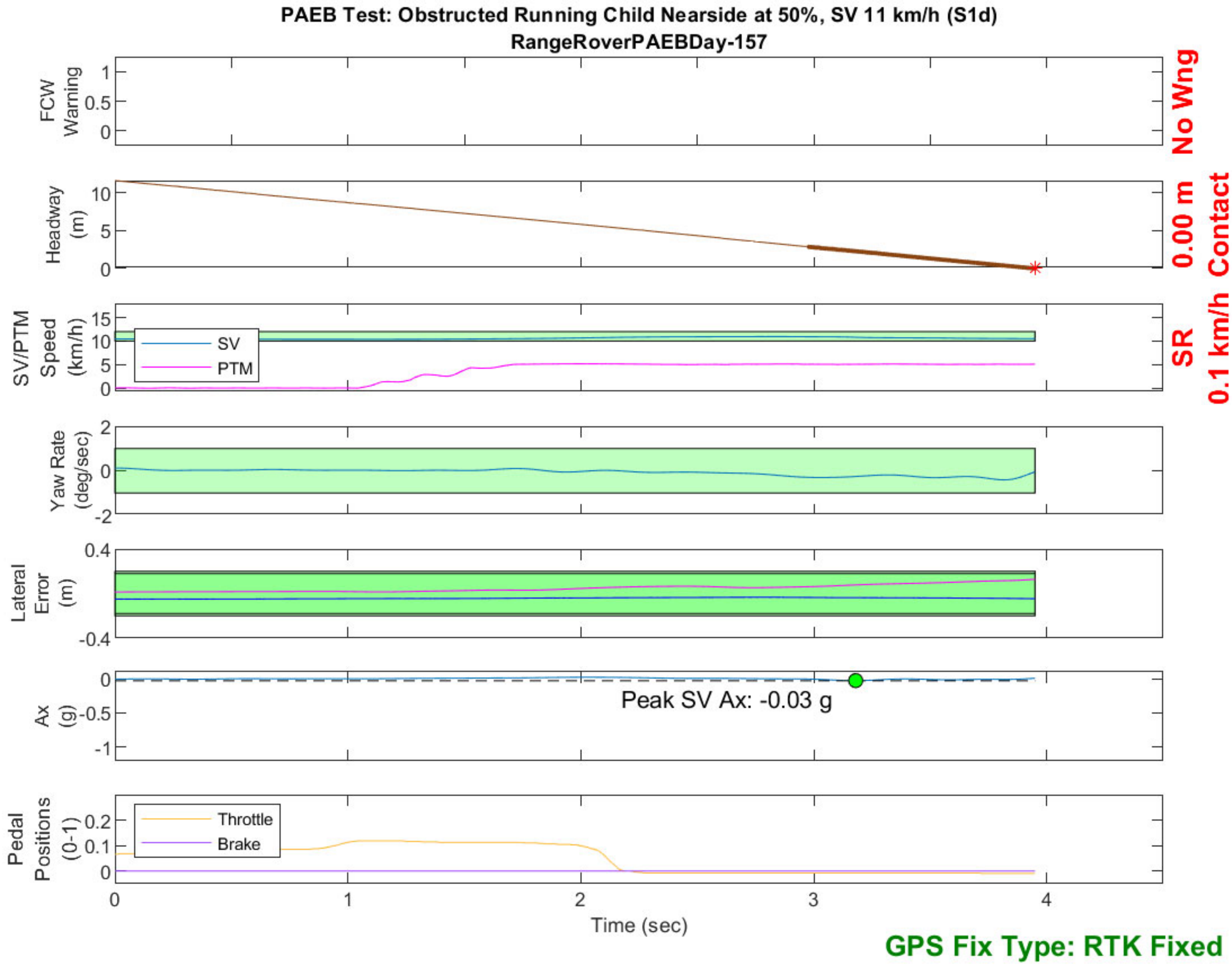


Figure D61. Time History for PAEB Run 157, S1d, Daytime, 11 km/h

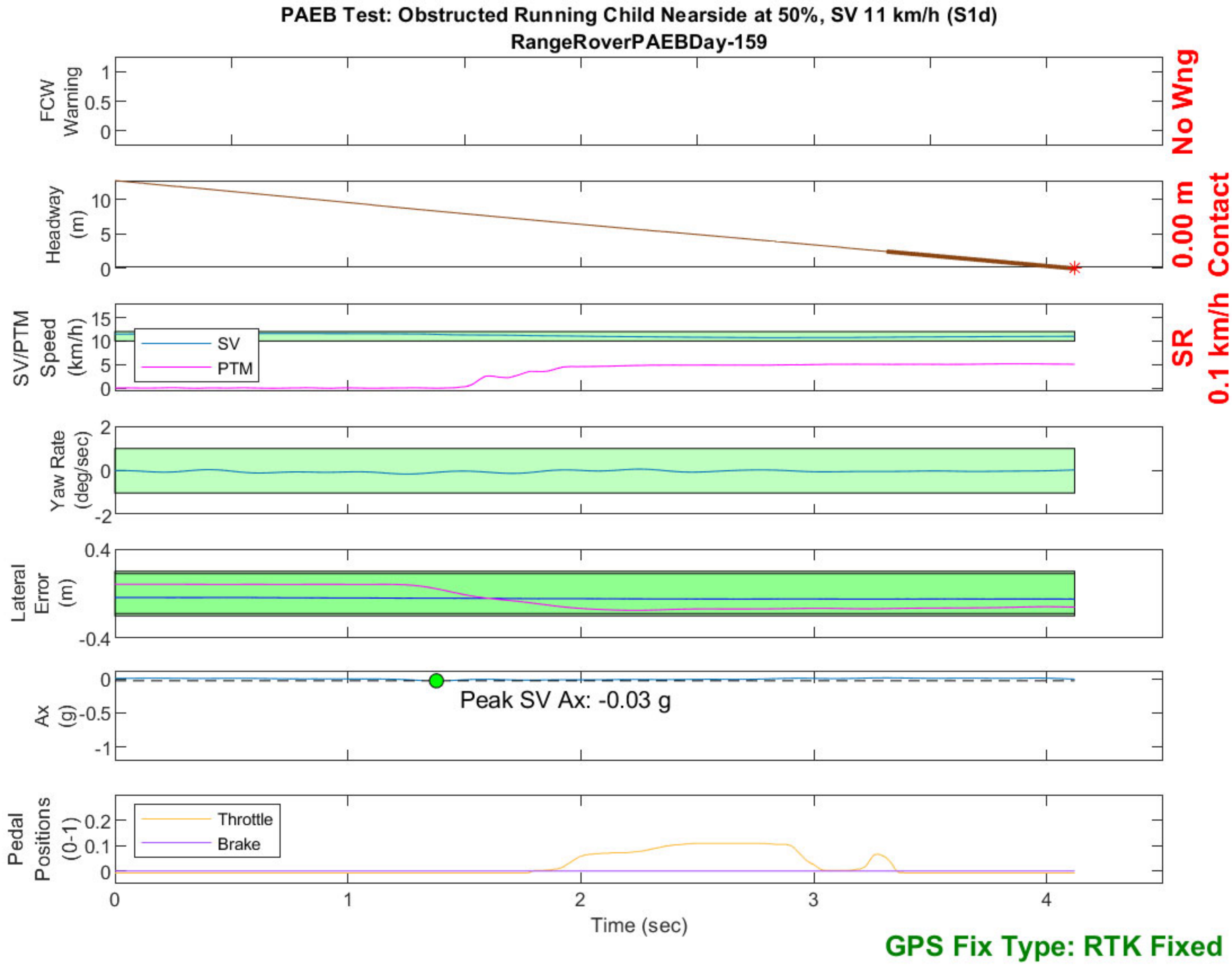


Figure D62. Time History for PAEB Run 159, S1d, Daytime, 11 km/h

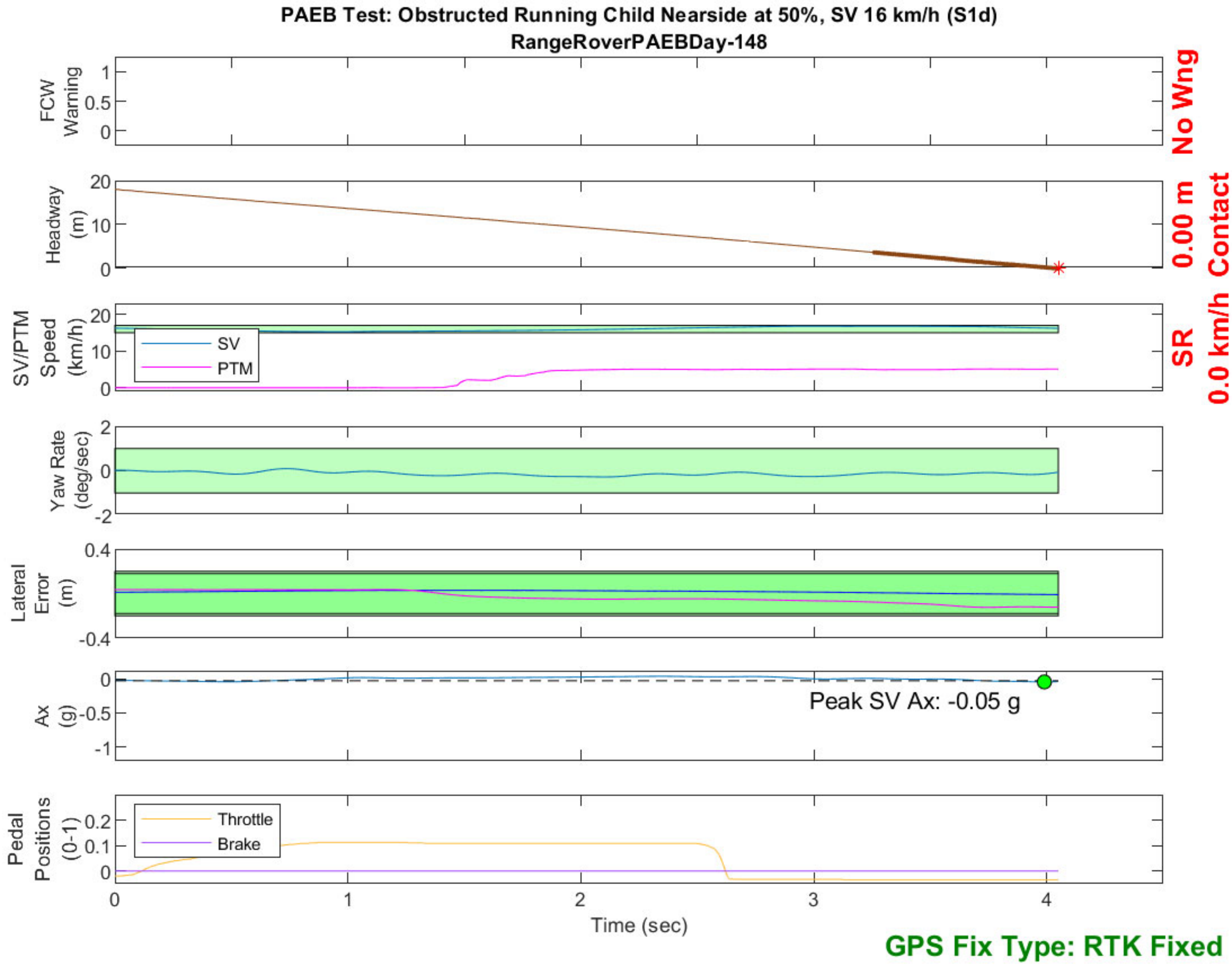


Figure D63. Time History for PAEB Run 148, S1d, Daytime, 16 km/h

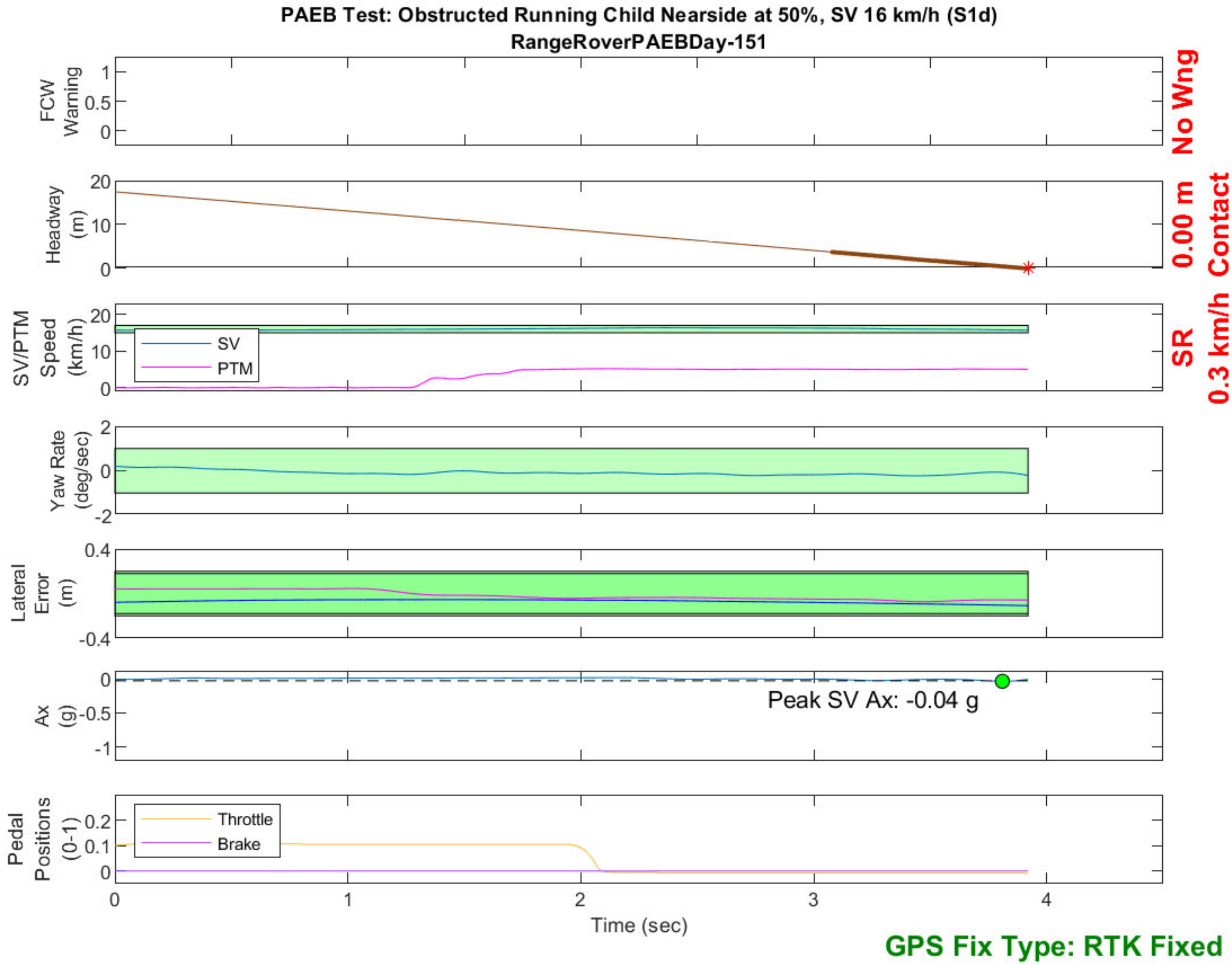


Figure D64. Time History for PAEB Run 151, S1d, Daytime, 16 km/h

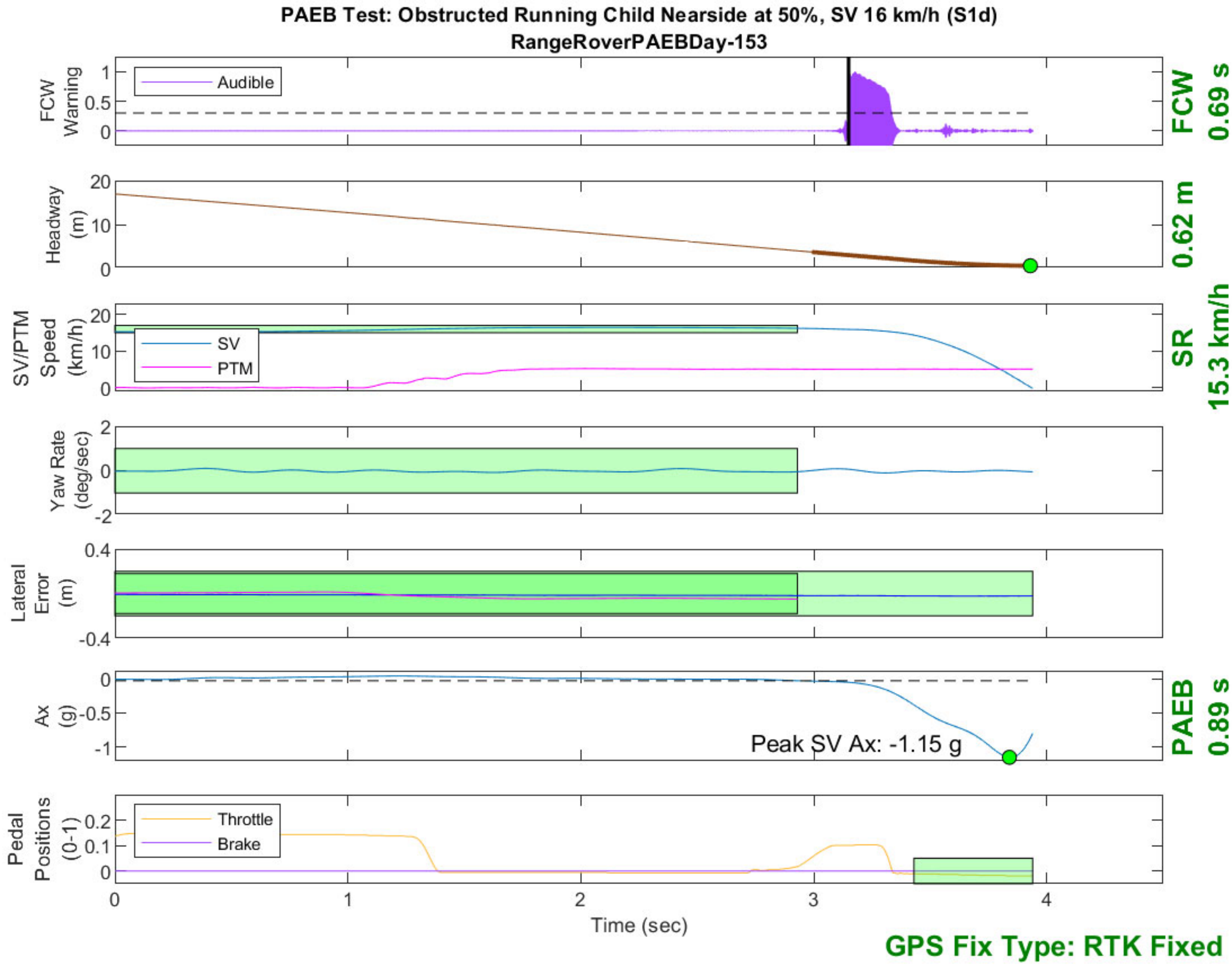


Figure D65. Time History for PAEB Run 153, S1d, Daytime, 16 km/h

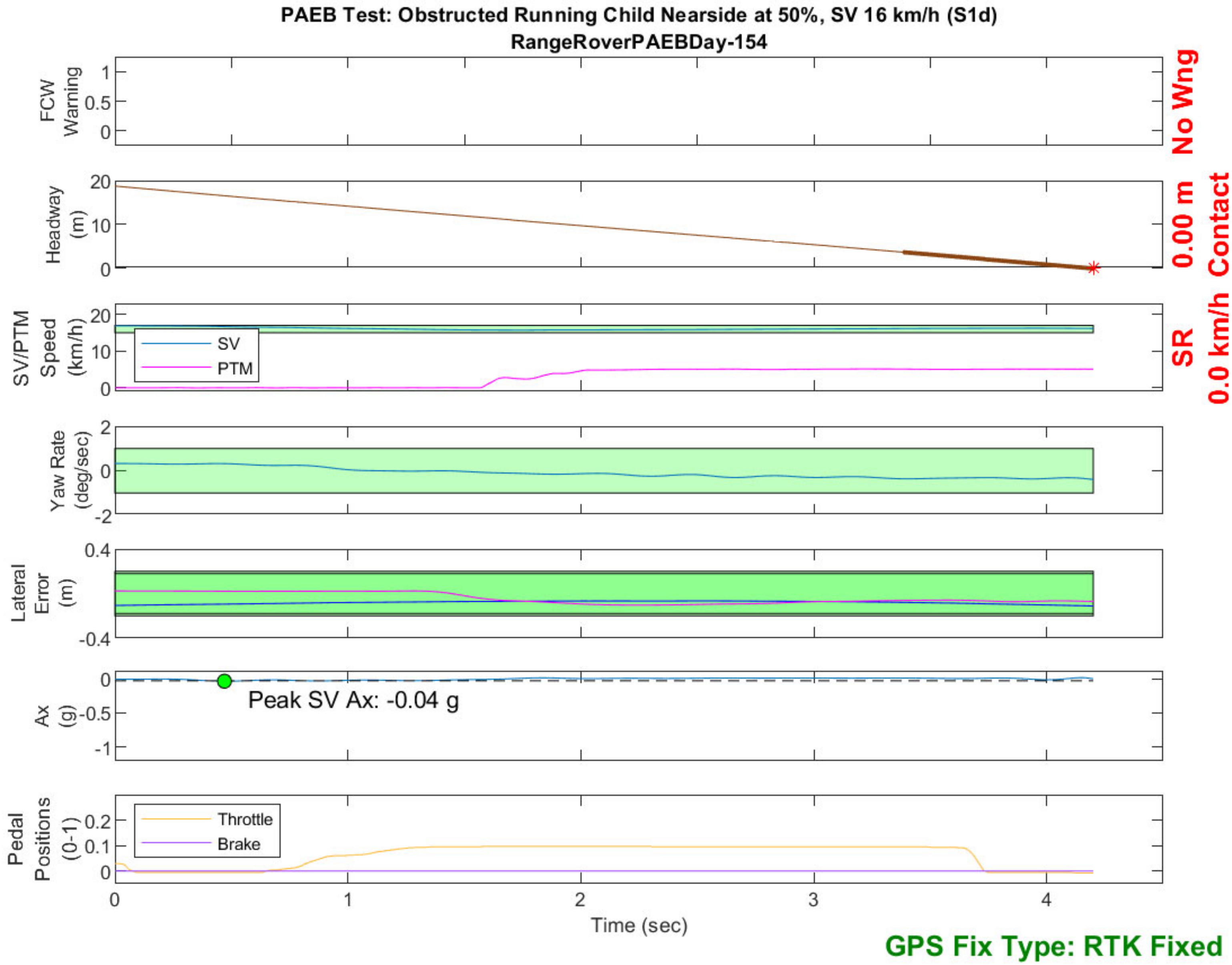


Figure D66. Time History for PAEB Run 154, S1d, Daytime, 16 km/h

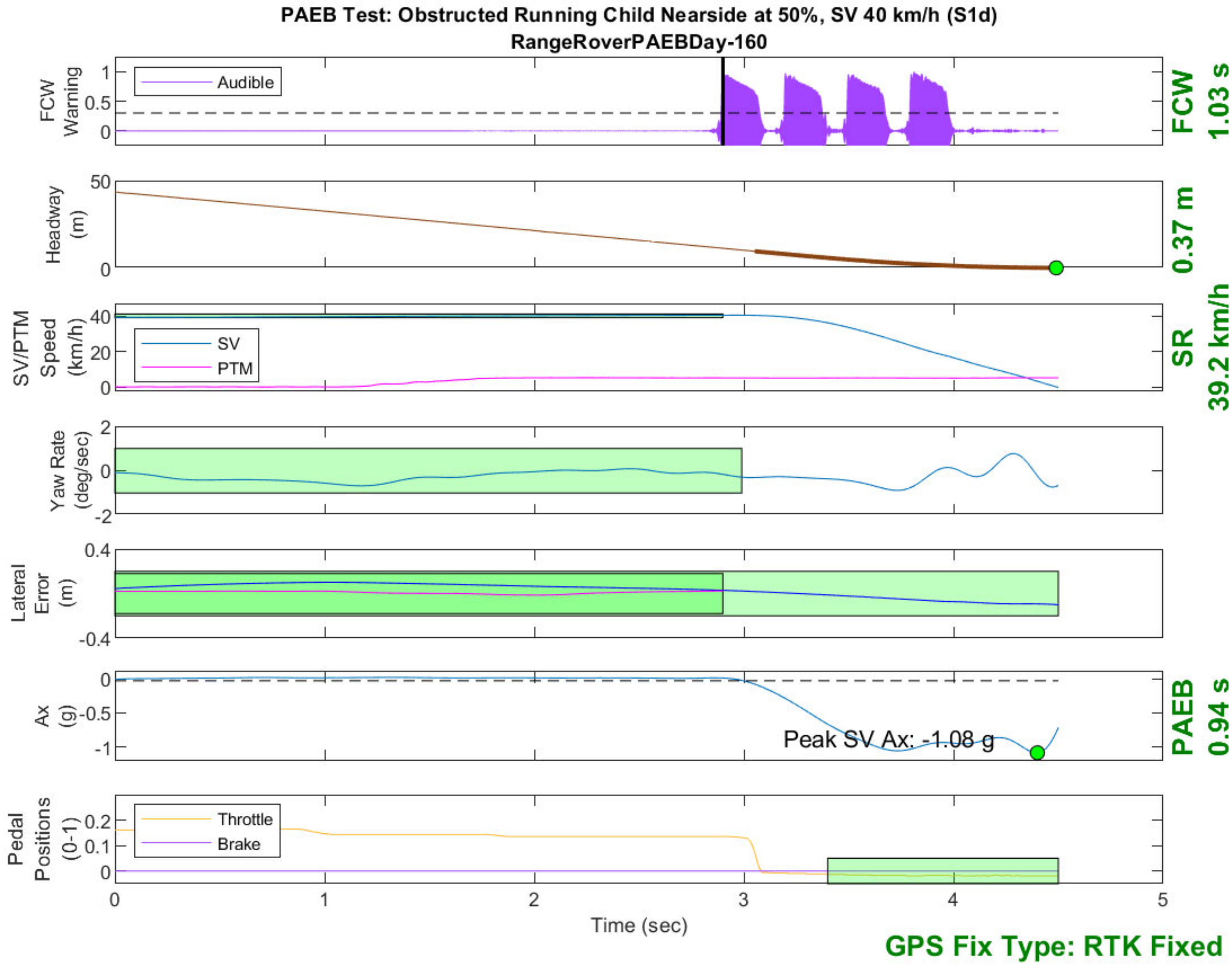


Figure D67. Time History for PAEB Run 160, S1d, Daytime, 40 km/h

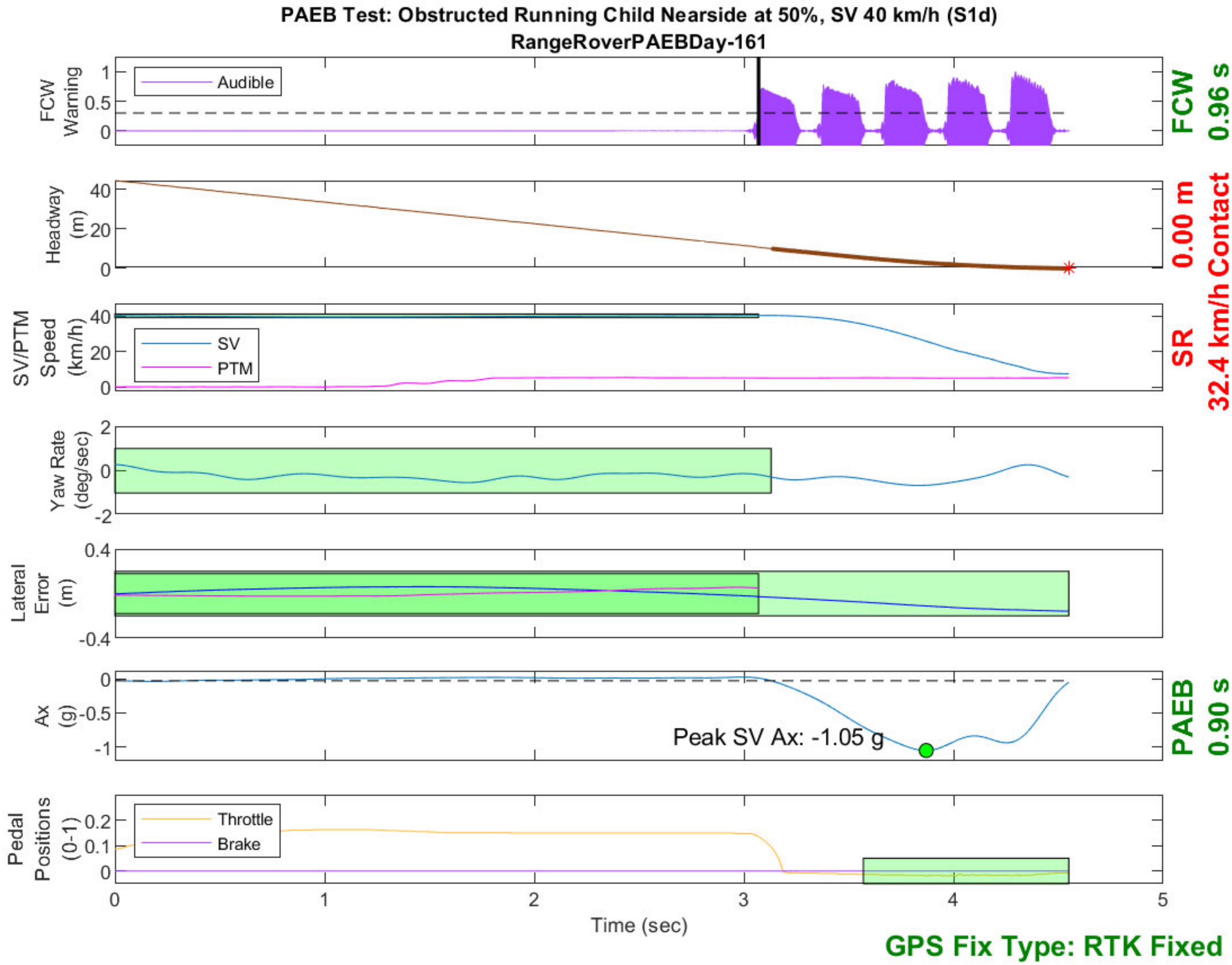


Figure D68. Time History for PAEB Run 161, S1d, Daytime, 40 km/h

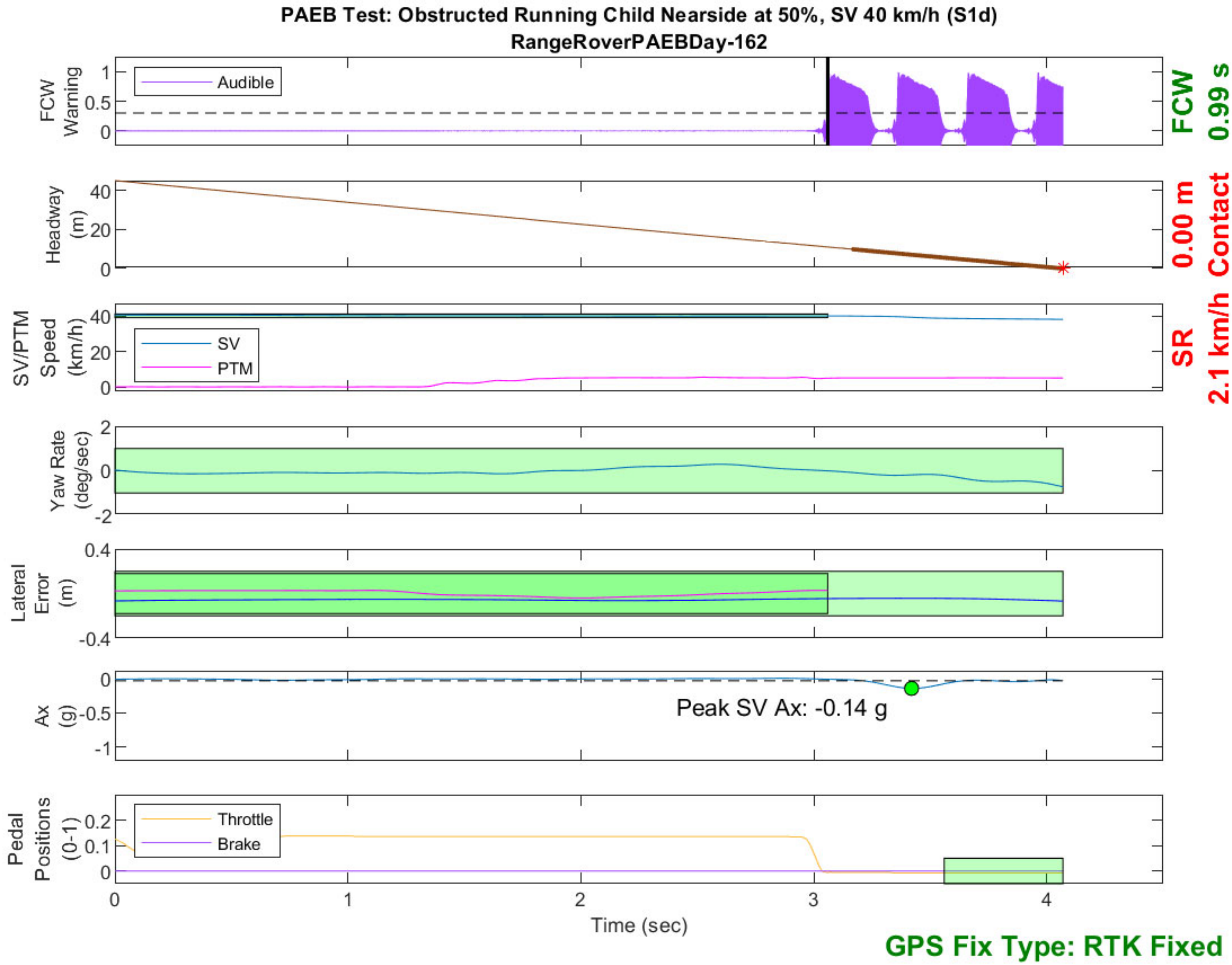


Figure D69. Time History for PAEB Run 162, S1d, Daytime, 40 km/h

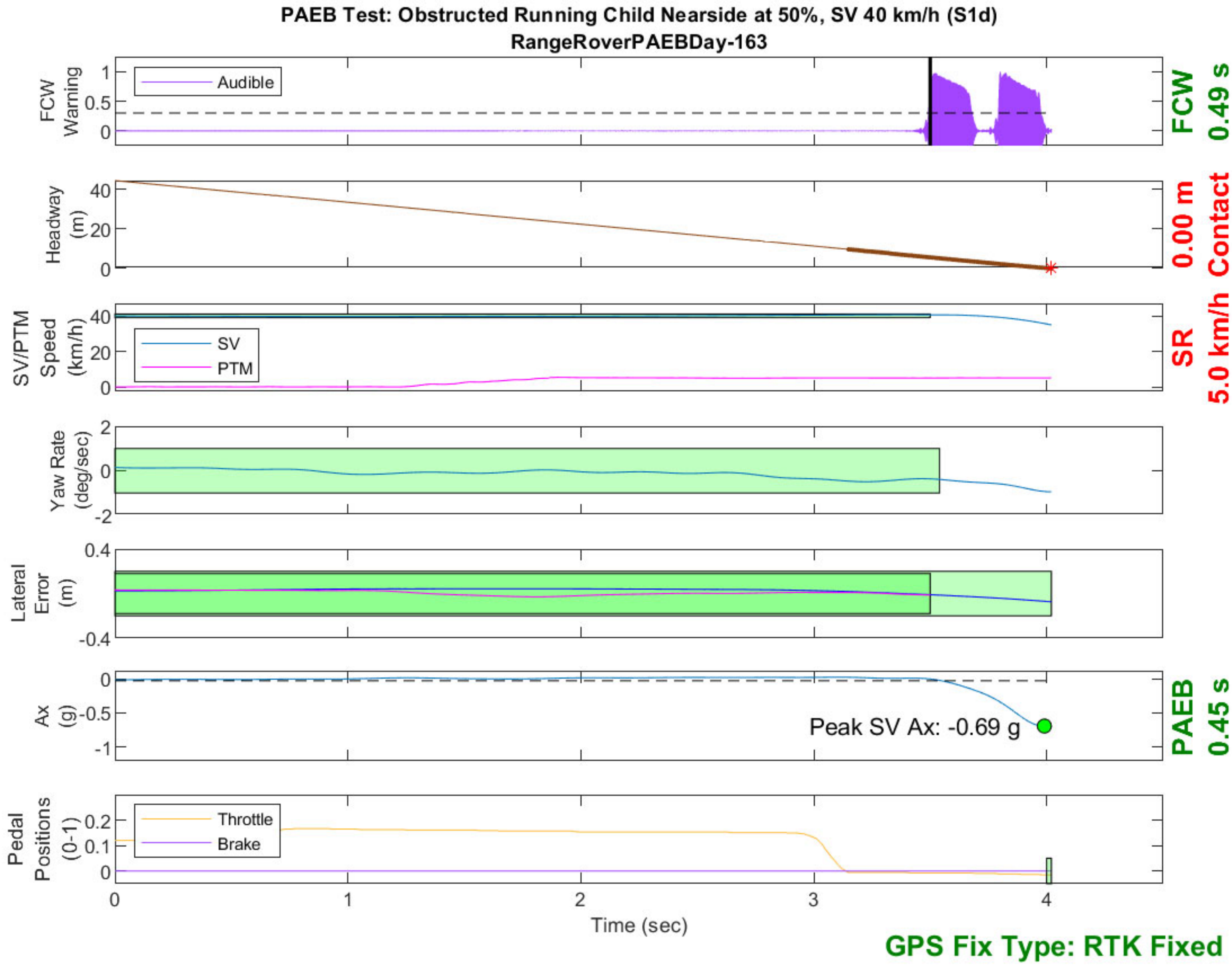


Figure D70. Time History for PAEB Run 163, S1d, Daytime, 40 km/h

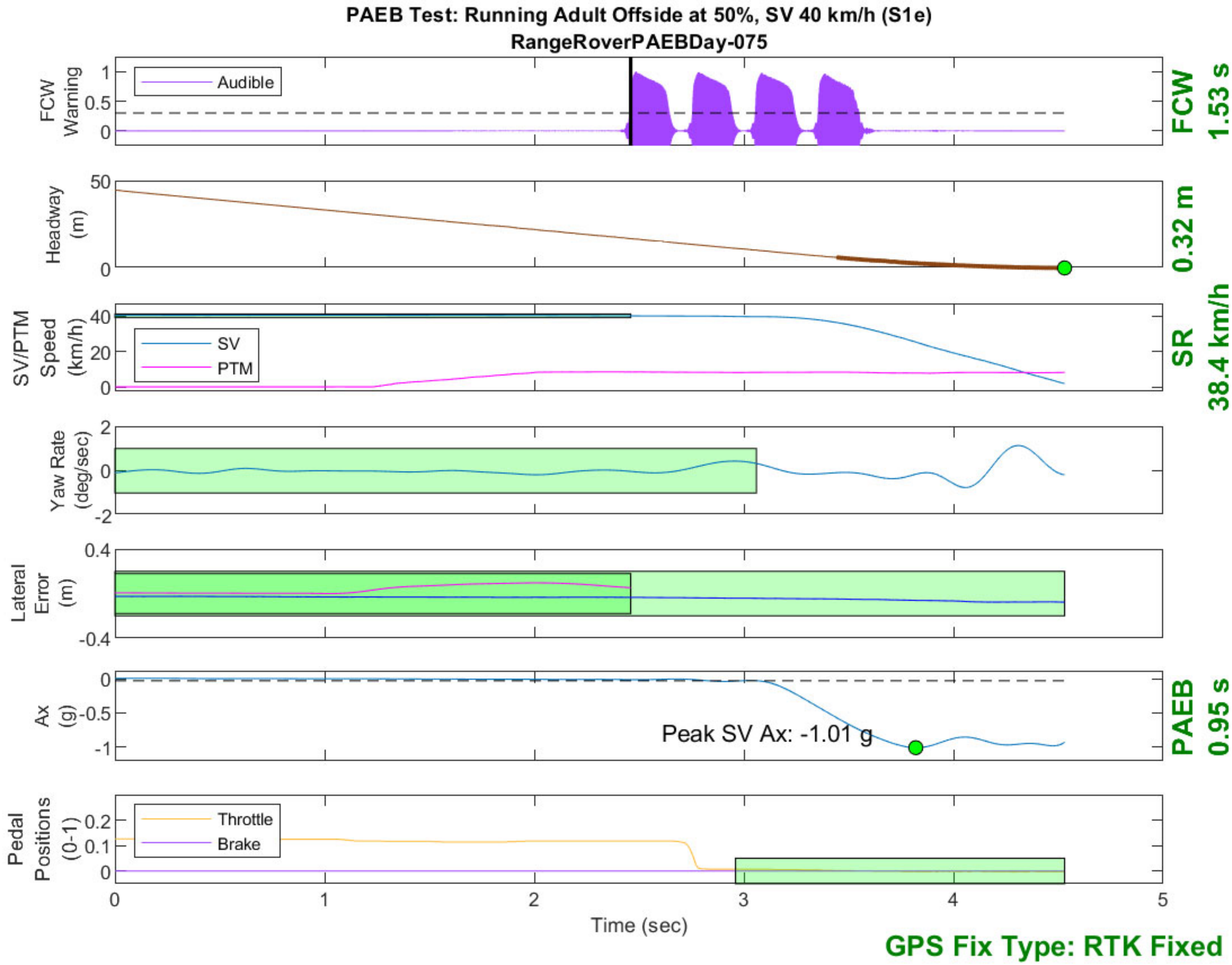


Figure D71. Time History for PAEB Run 75, S1e, Daytime, 40 km/h

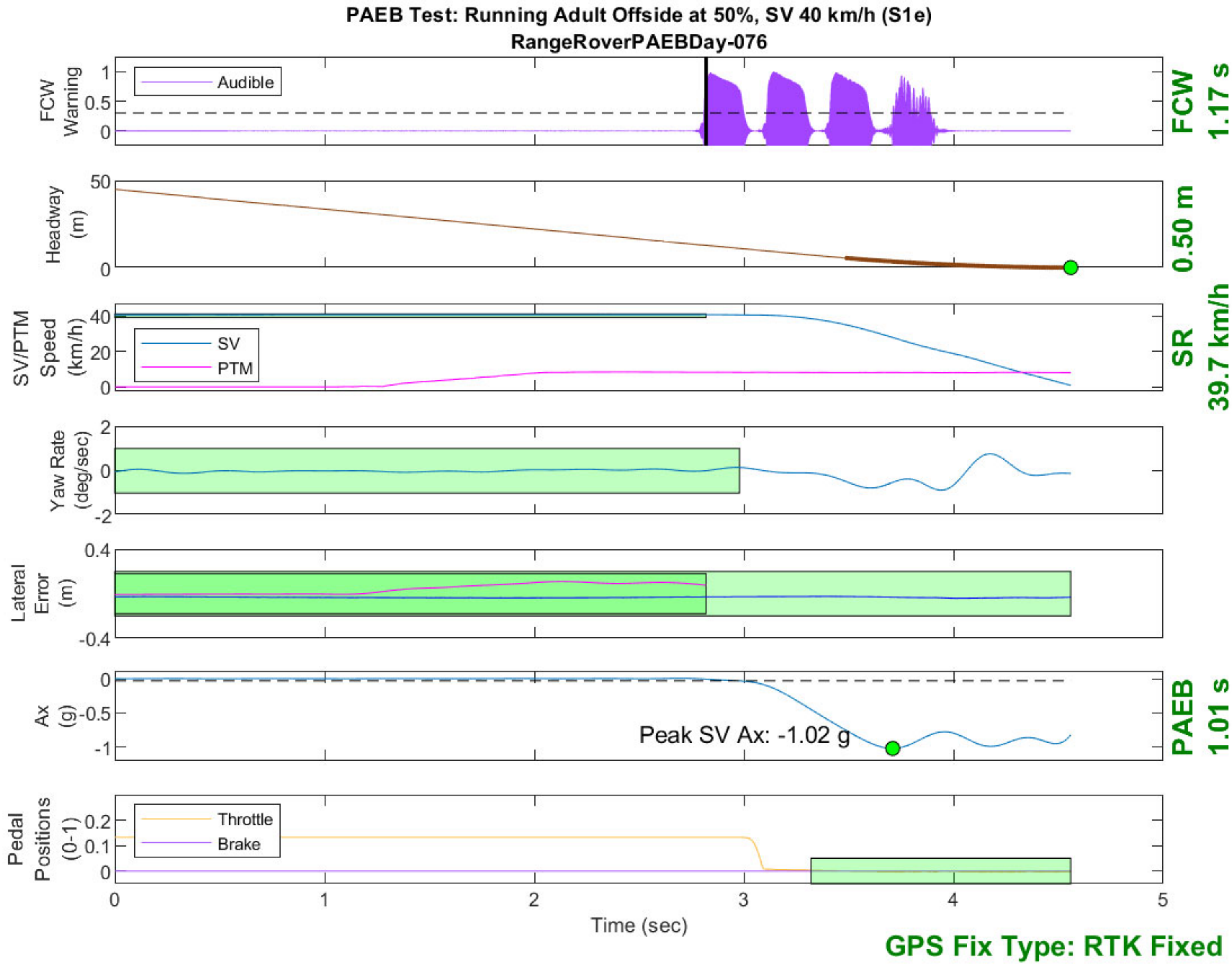


Figure D72. Time History for PAEB Run 76, S1e, Daytime, 40 km/h

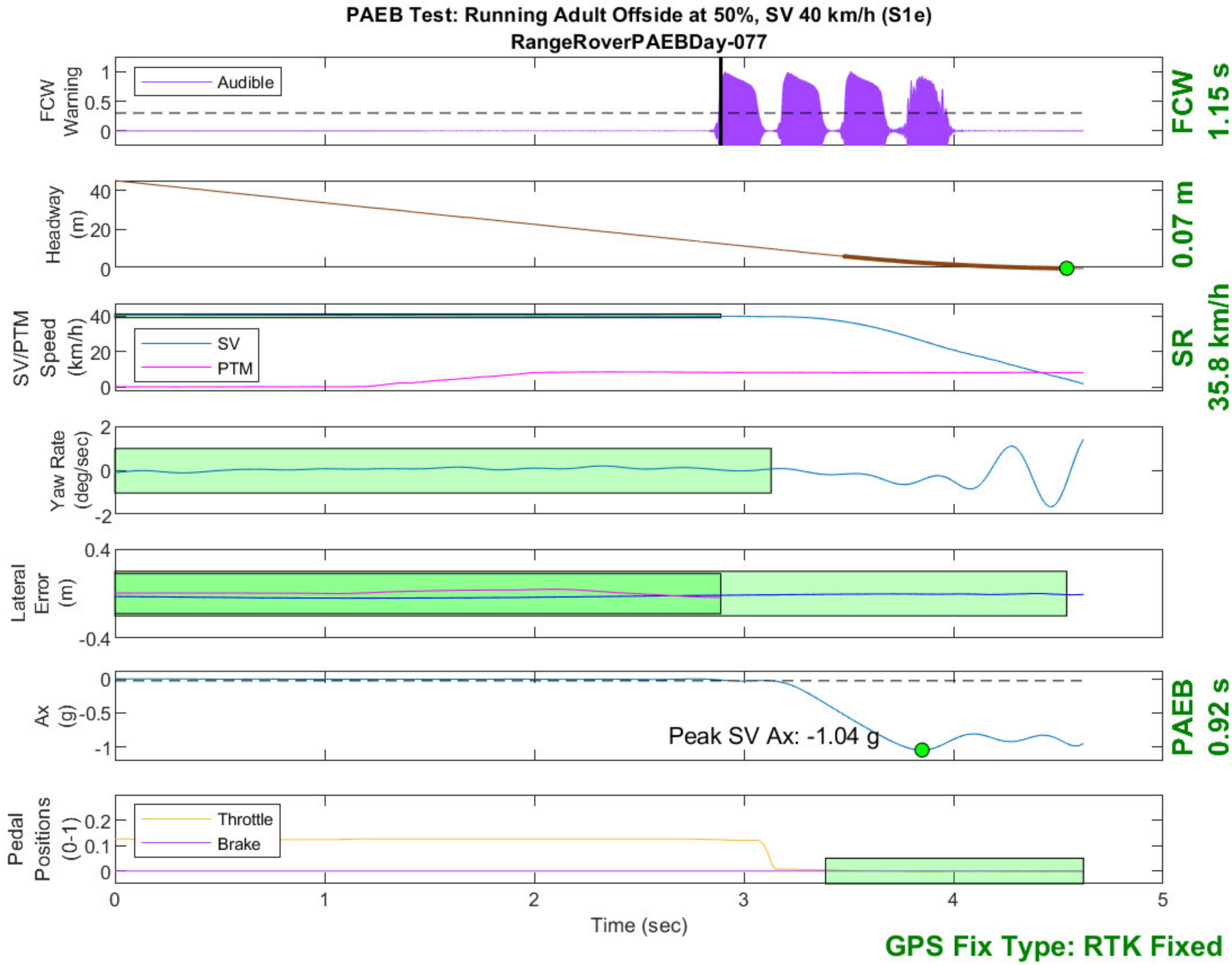


Figure D73. Time History for PAEB Run 77, S1e, Daytime, 40 km/h

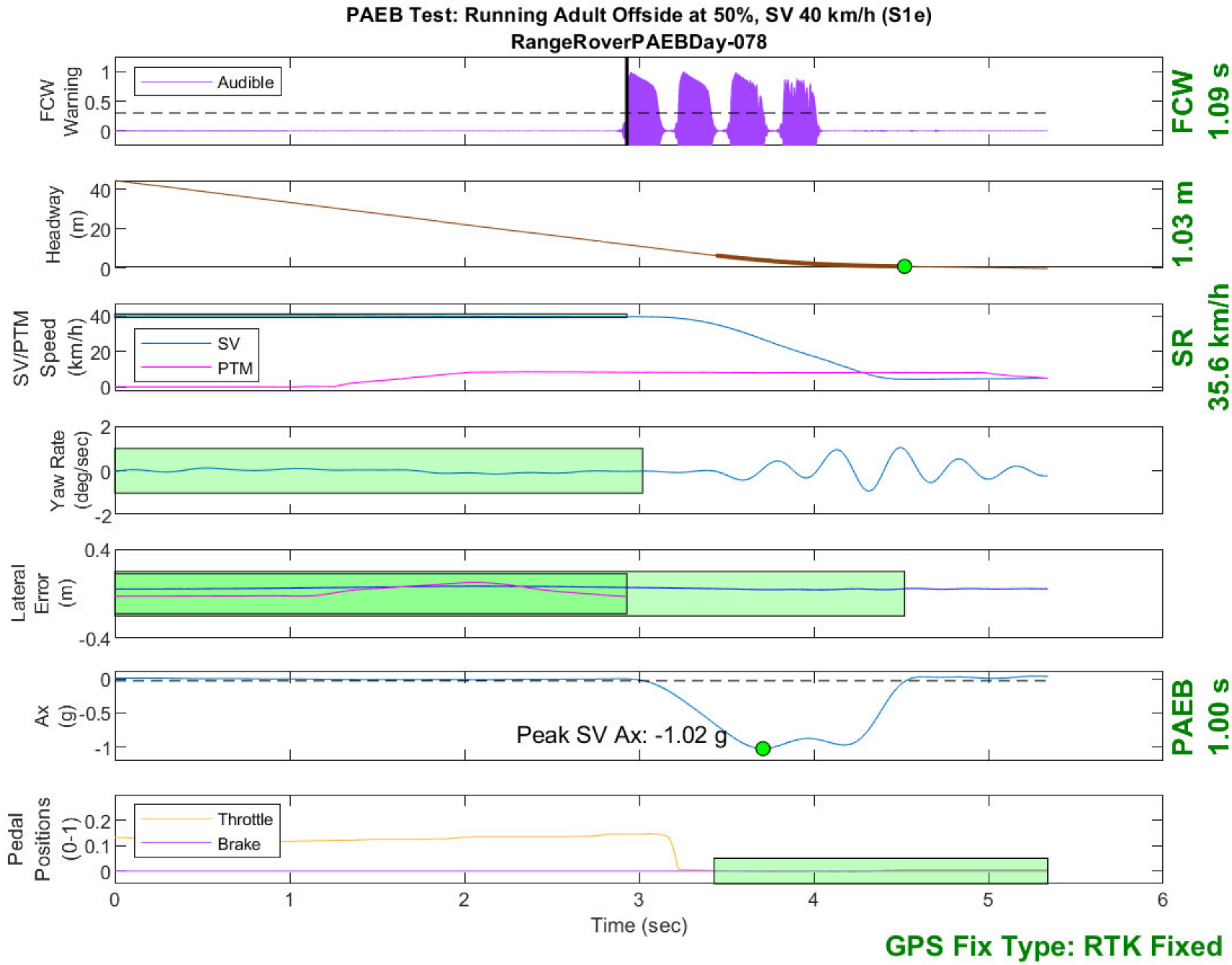


Figure D74. Time History for PAEB Run 78, S1e, Daytime, 40 km/h

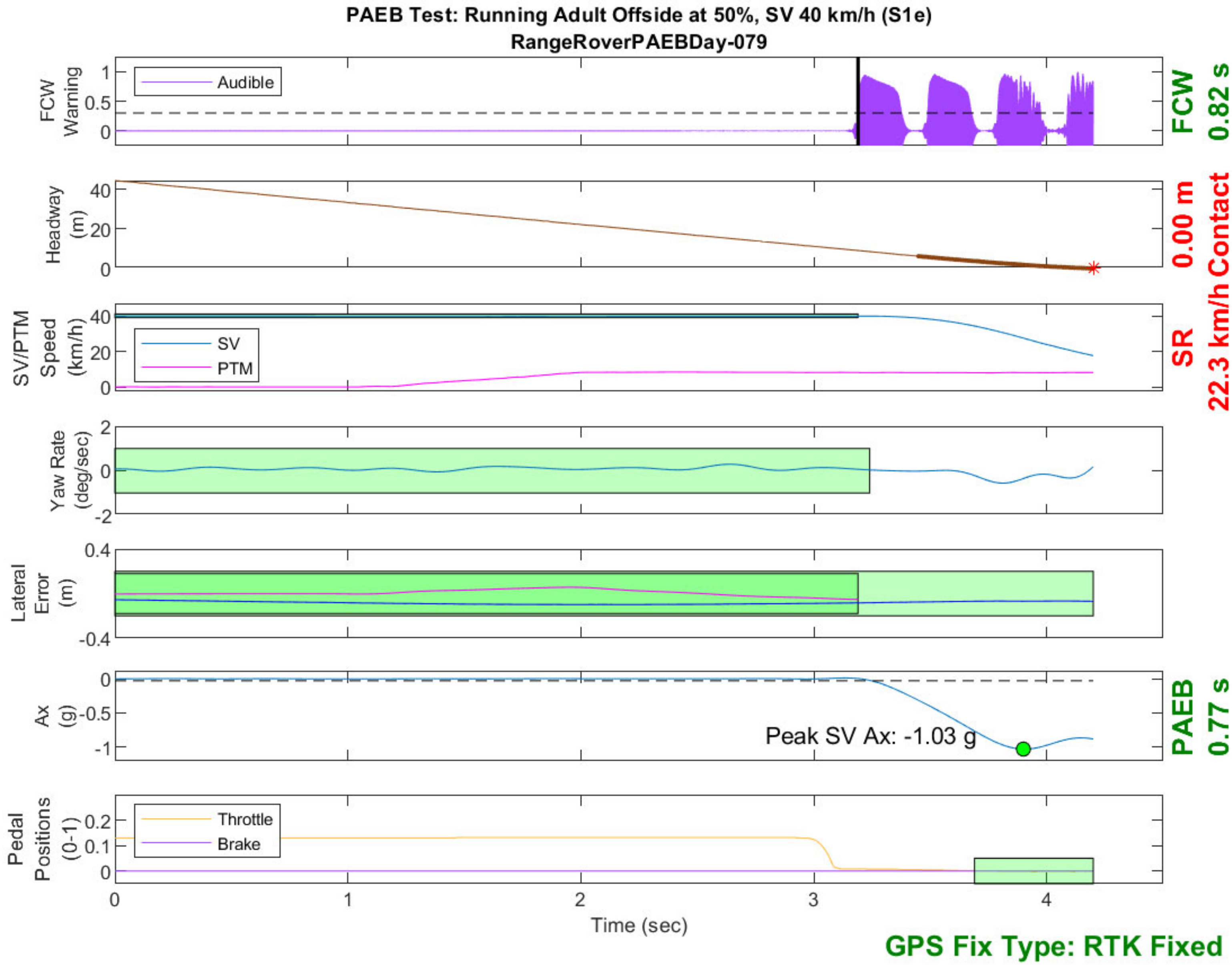


Figure D75. Time History for PAEB Run 79, S1e, Daytime, 40 km/h

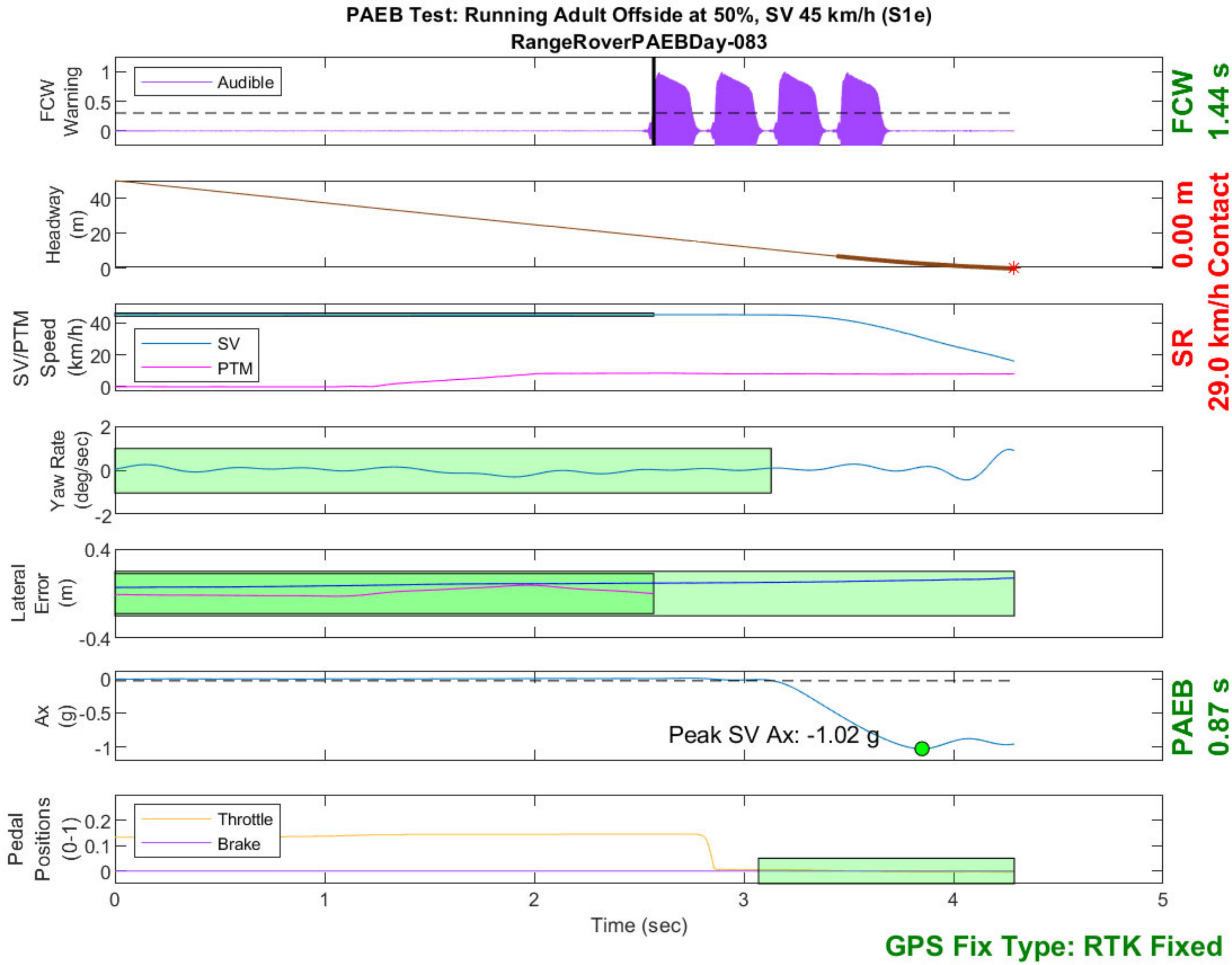


Figure D76. Time History for PAEB Run 83, S1e, Daytime, 45 km/h

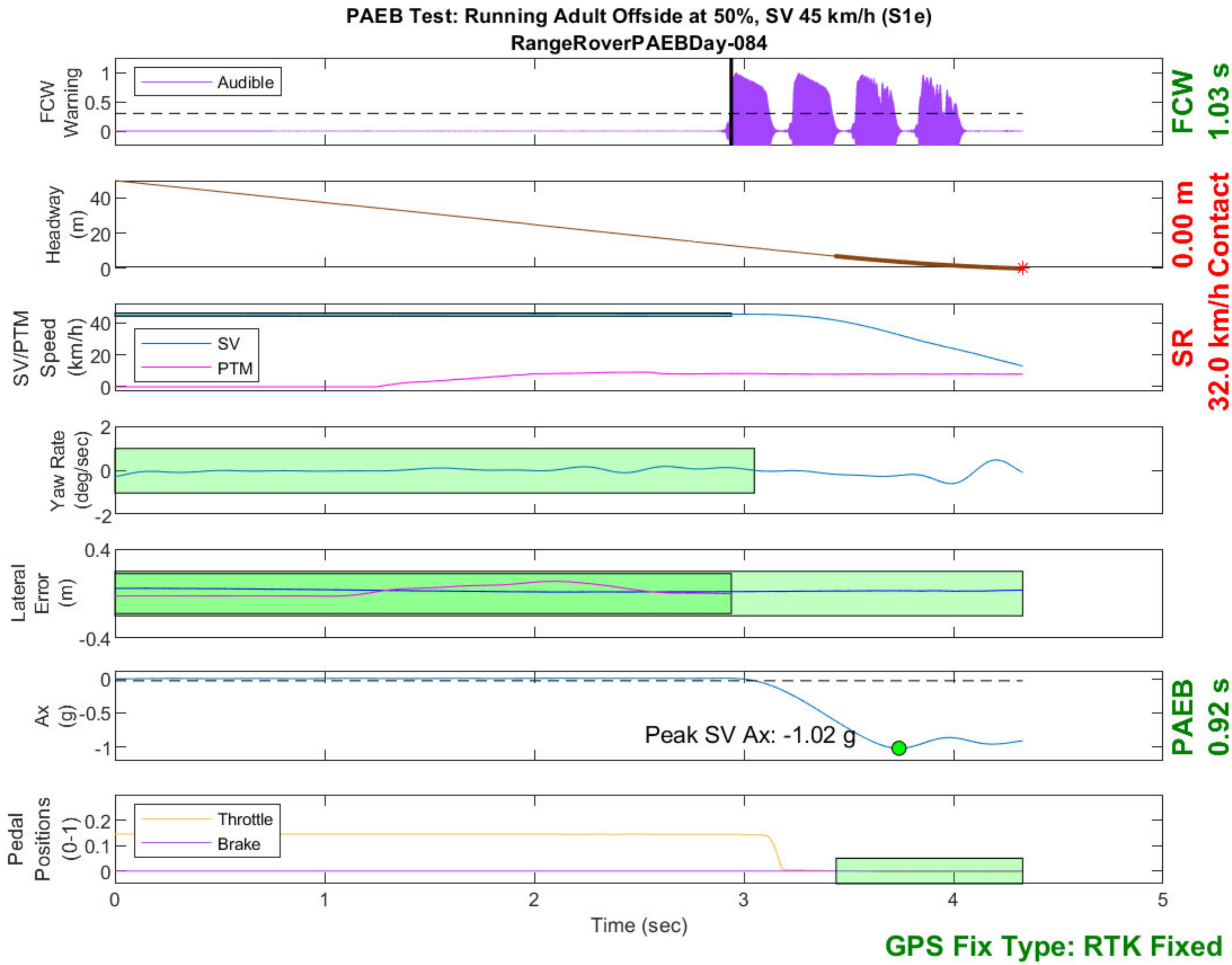


Figure D77. Time History for PAEB Run 84, S1e, Daytime, 45 km/h

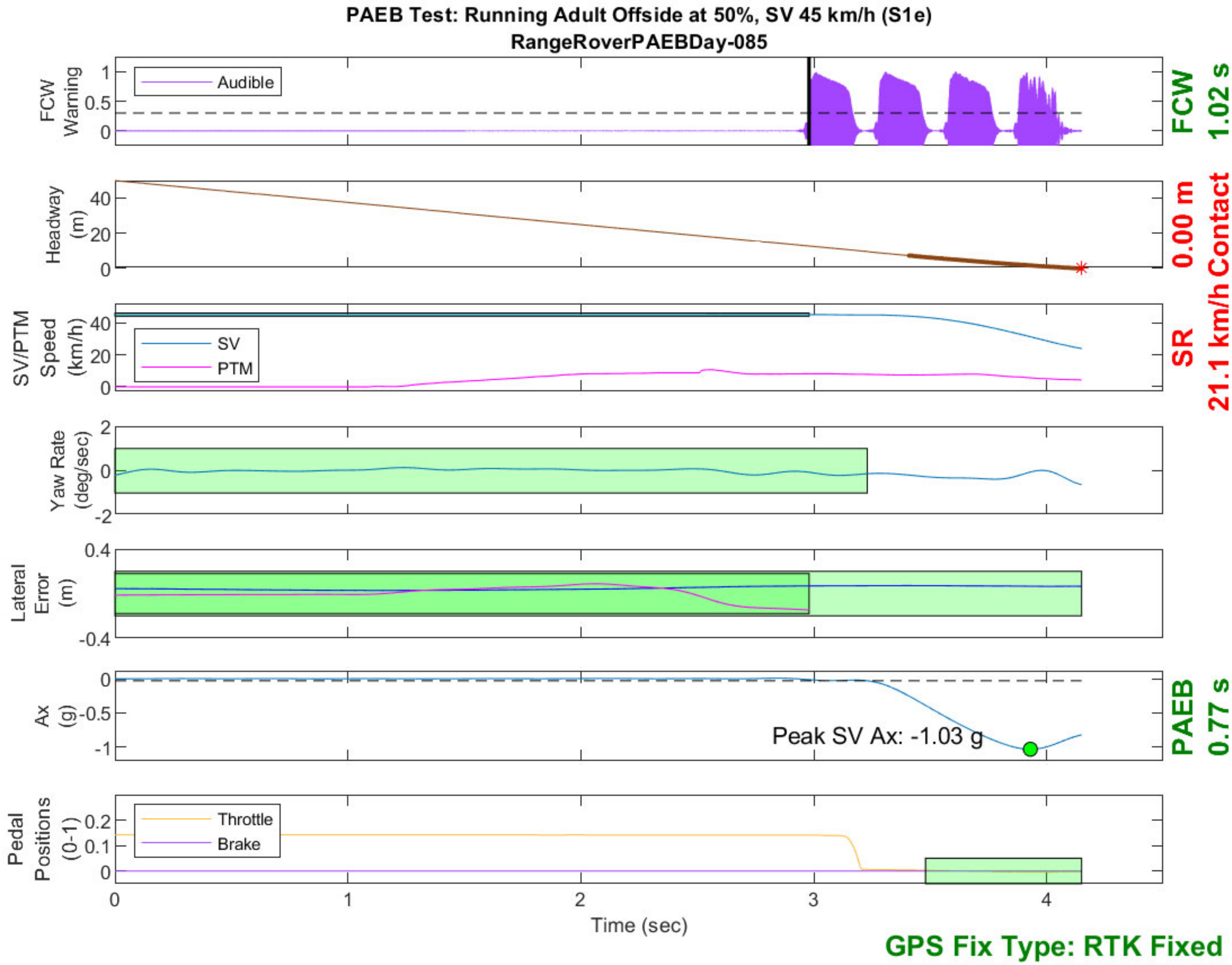


Figure D78. Time History for PAEB Run 85, S1e, Daytime, 45 km/h

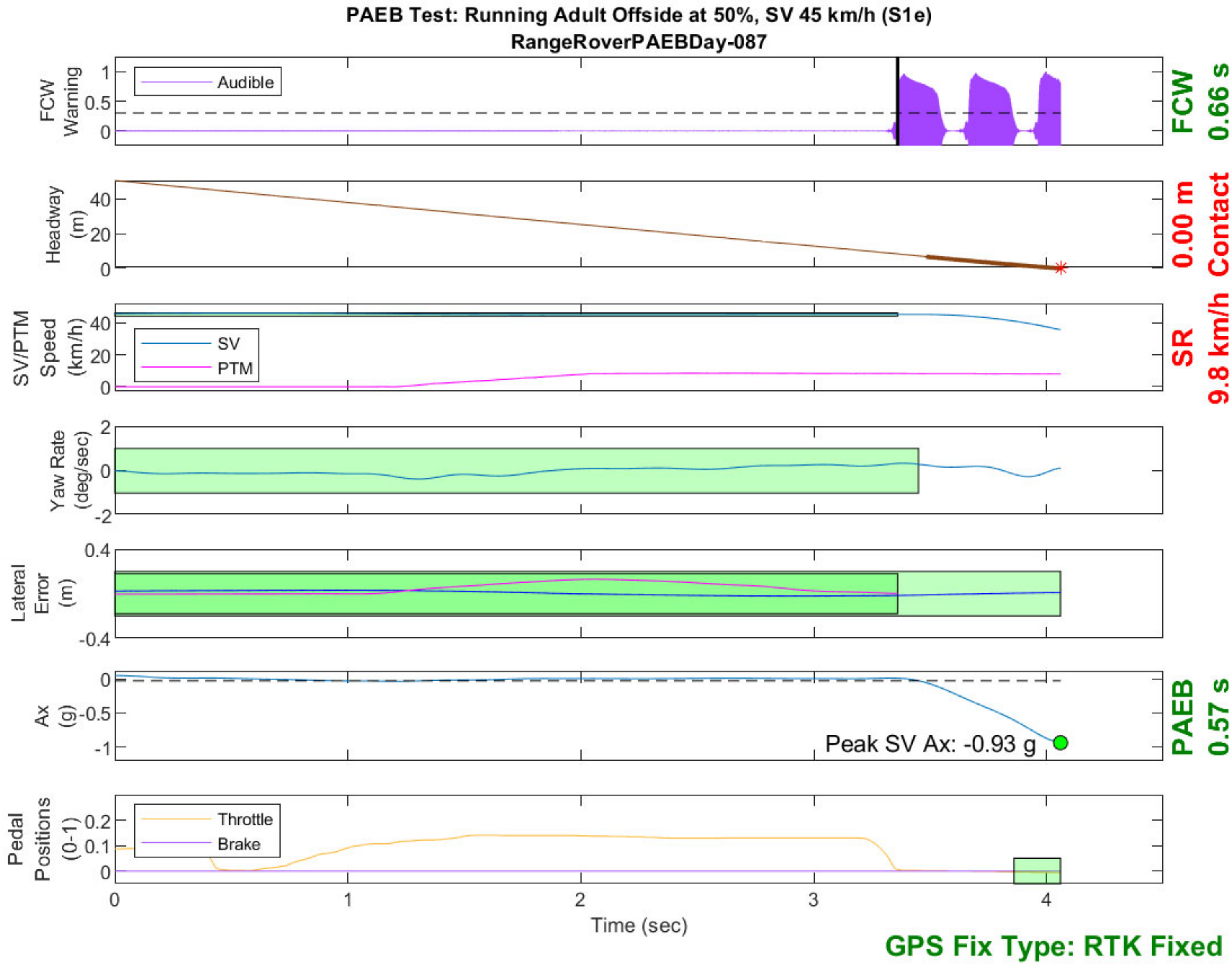


Figure D79. Time History for PAEB Run 87, S1e, Daytime, 45 km/h

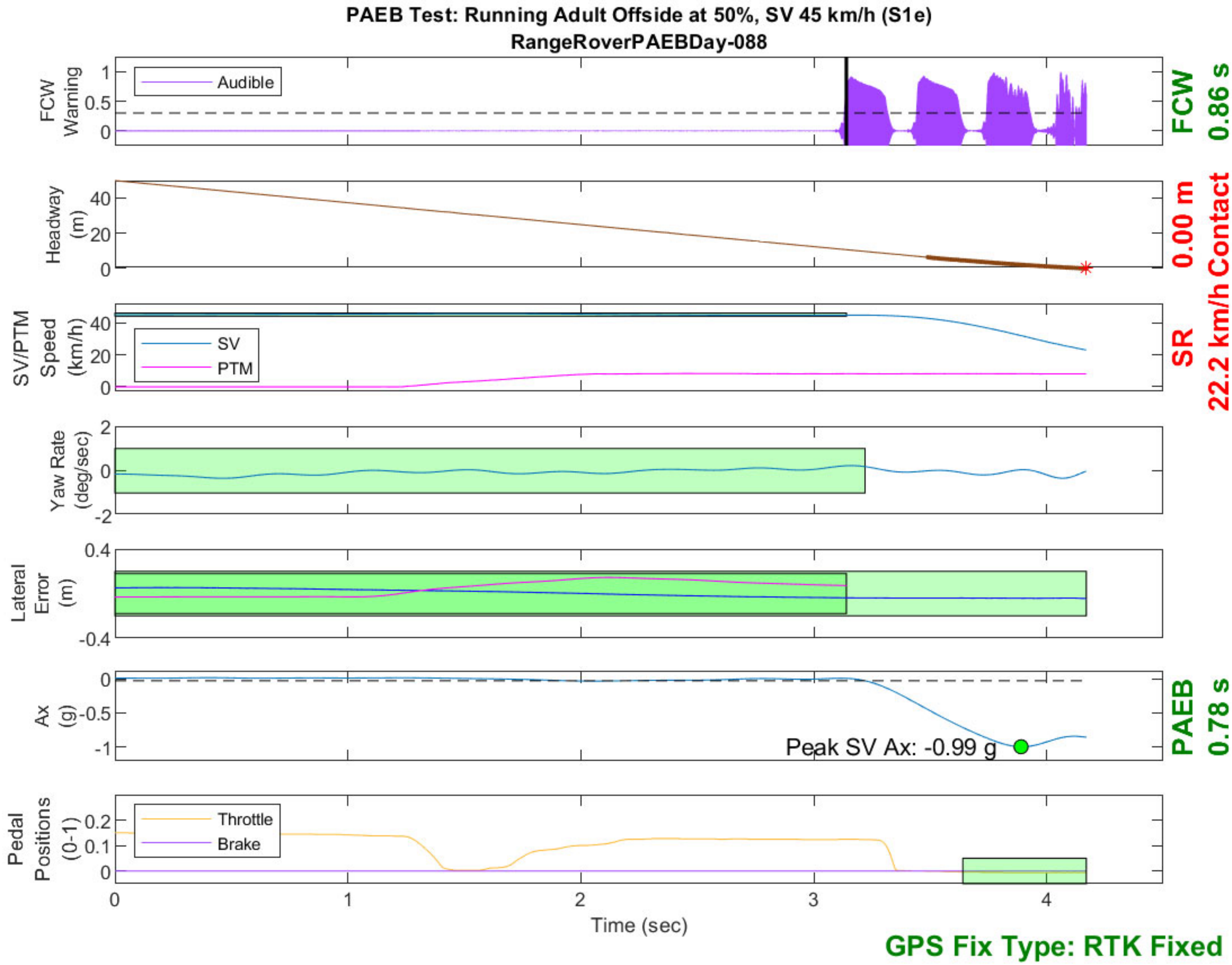


Figure D80. Time History for PAEB Run 88, S1e, Daytime, 45 km/h

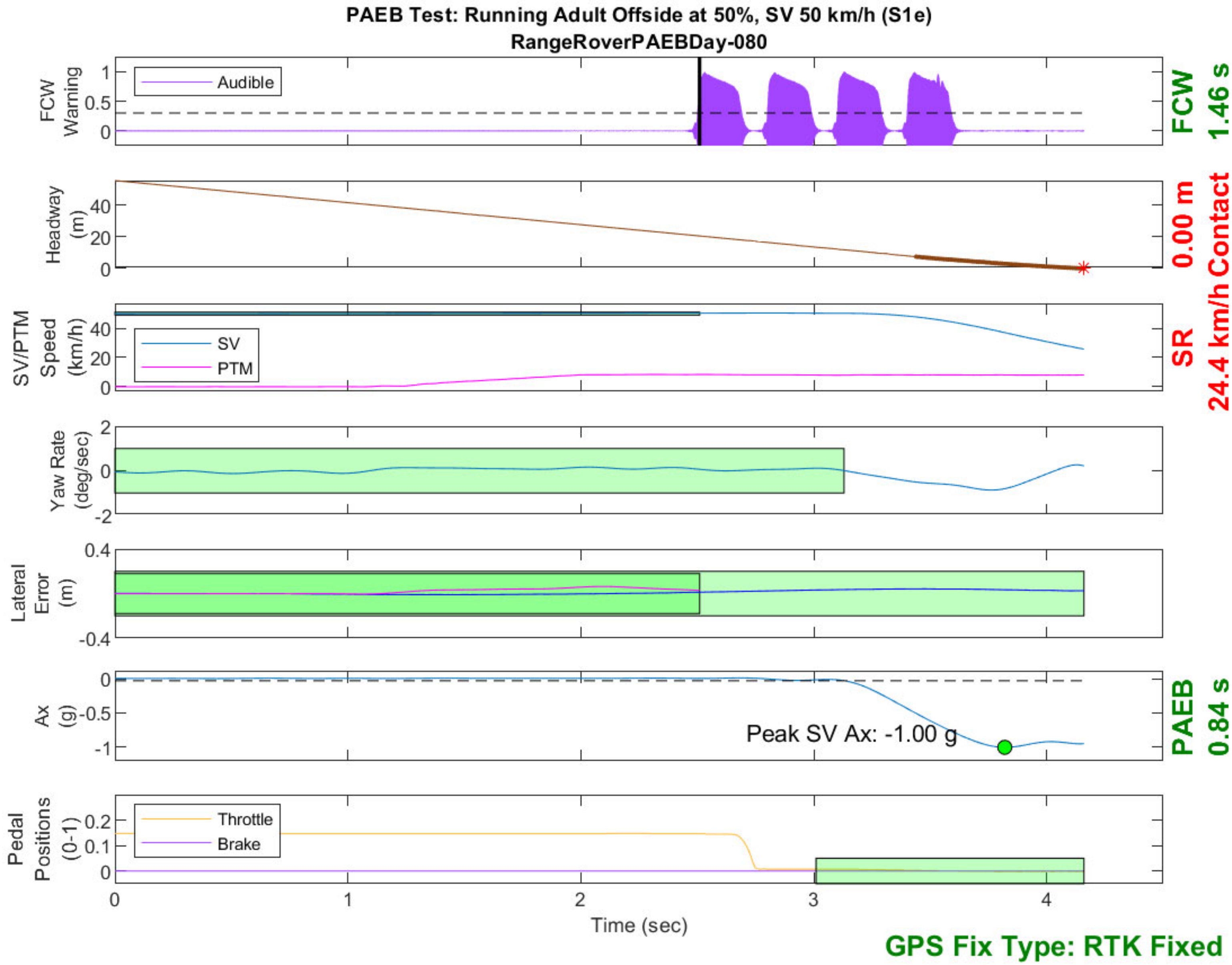


Figure D81. Time History for PAEB Run 80, S1e, Daytime, 50 km/h

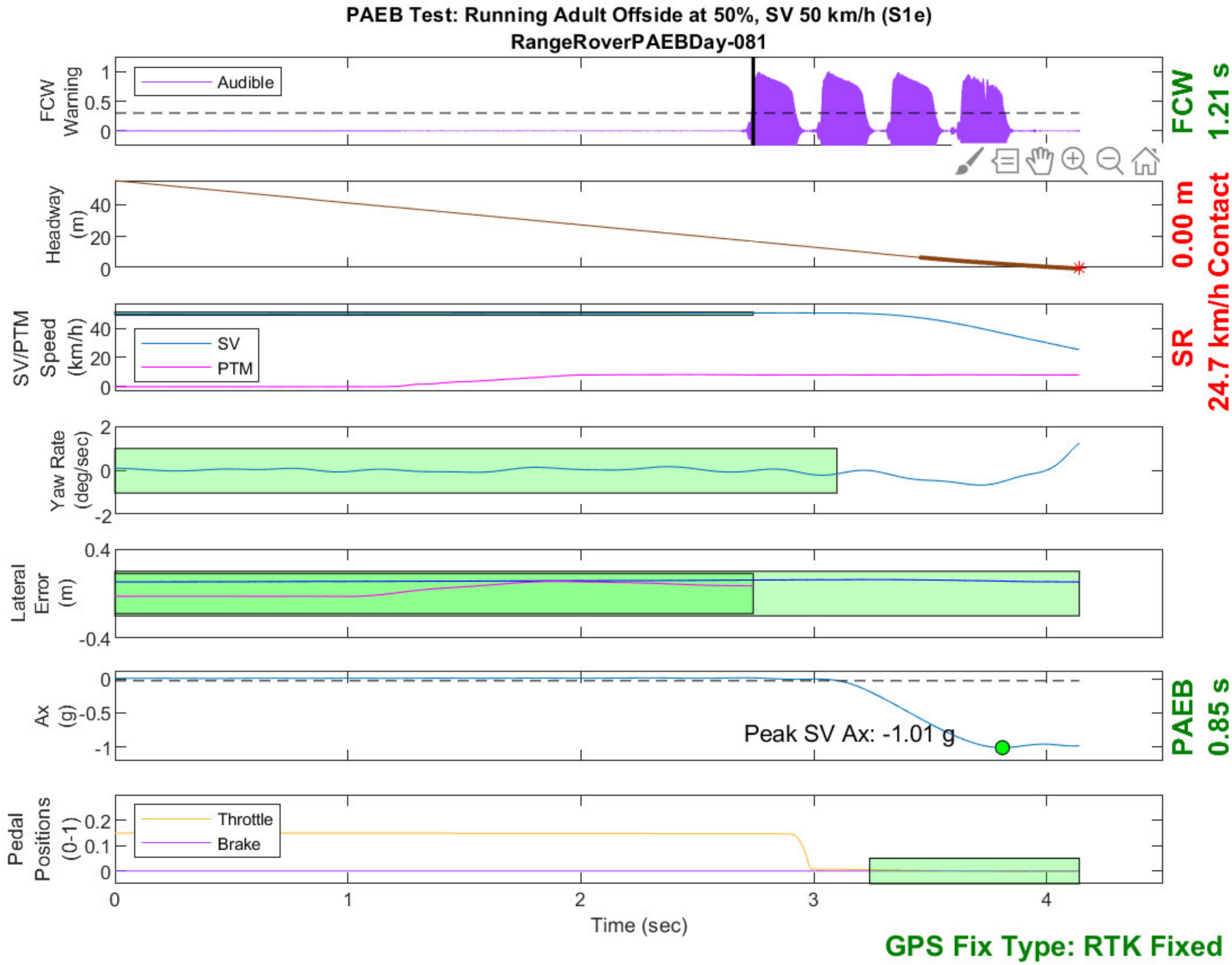


Figure D82. Time History for PAEB Run 81, S1e, Daytime, 50 km/h

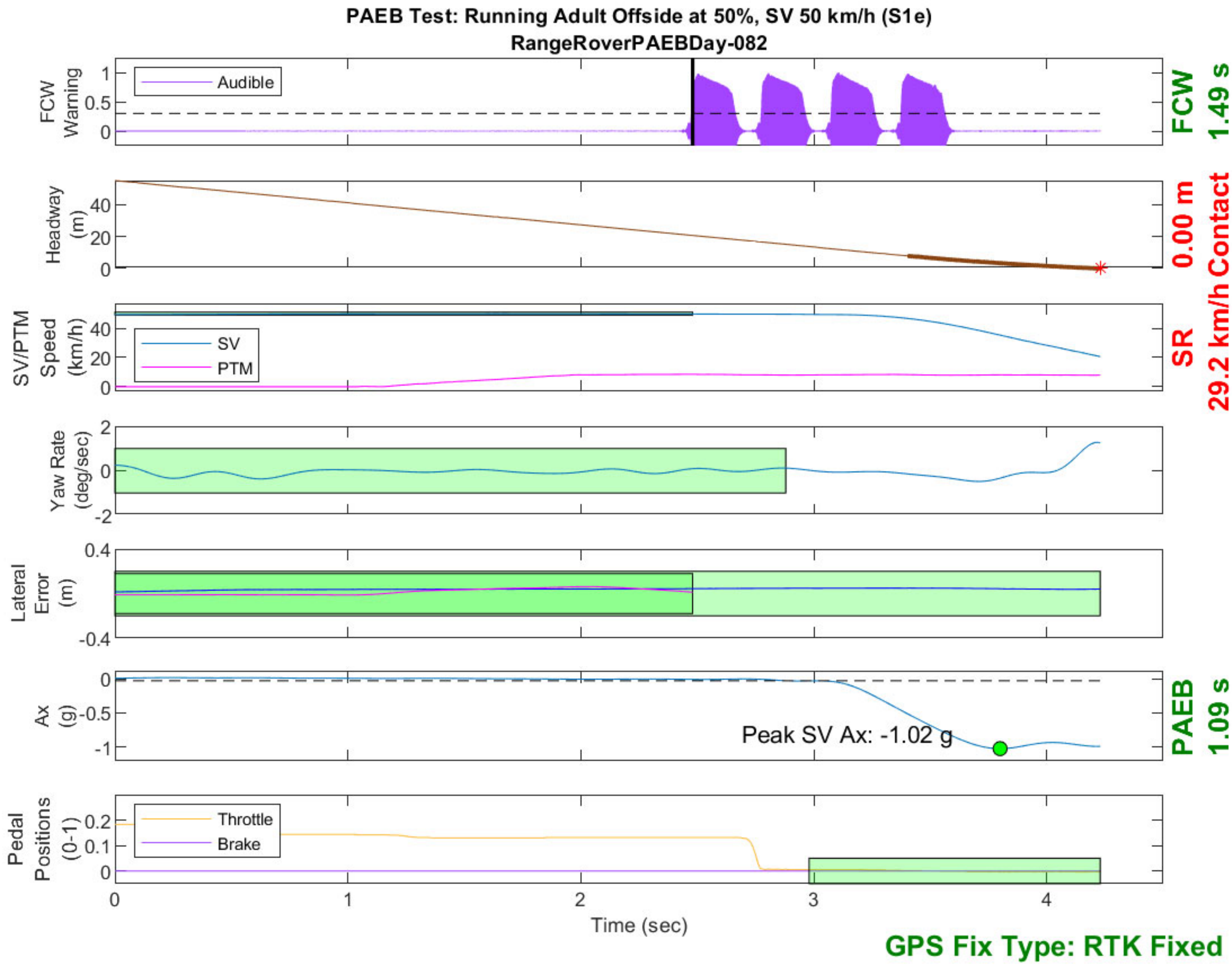


Figure D83. Time History for PAEB Run 82, S1e, Daytime, 50 km/h

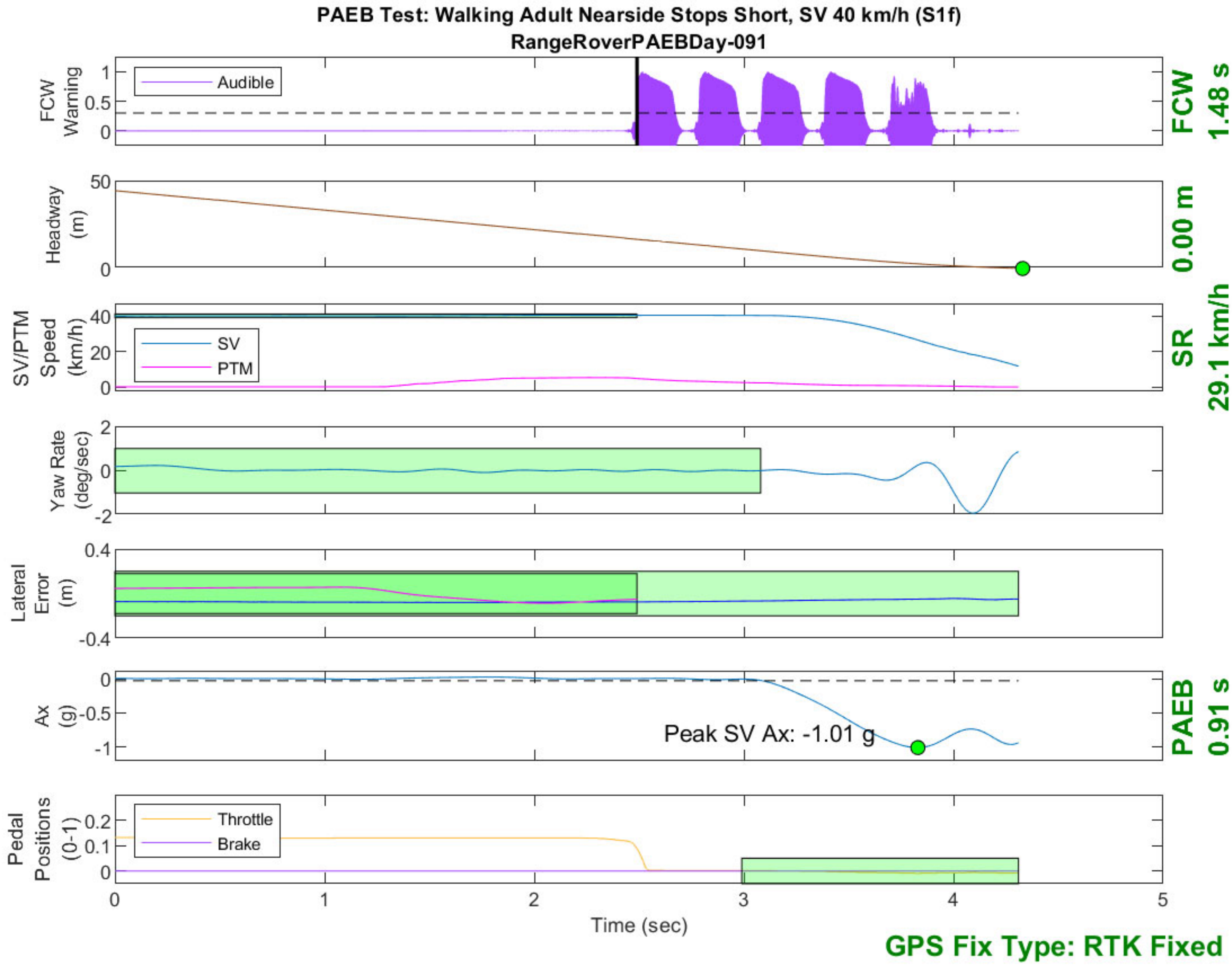


Figure D84. Time History for PAEB Run 91, S1f, Daytime, 40 km/h

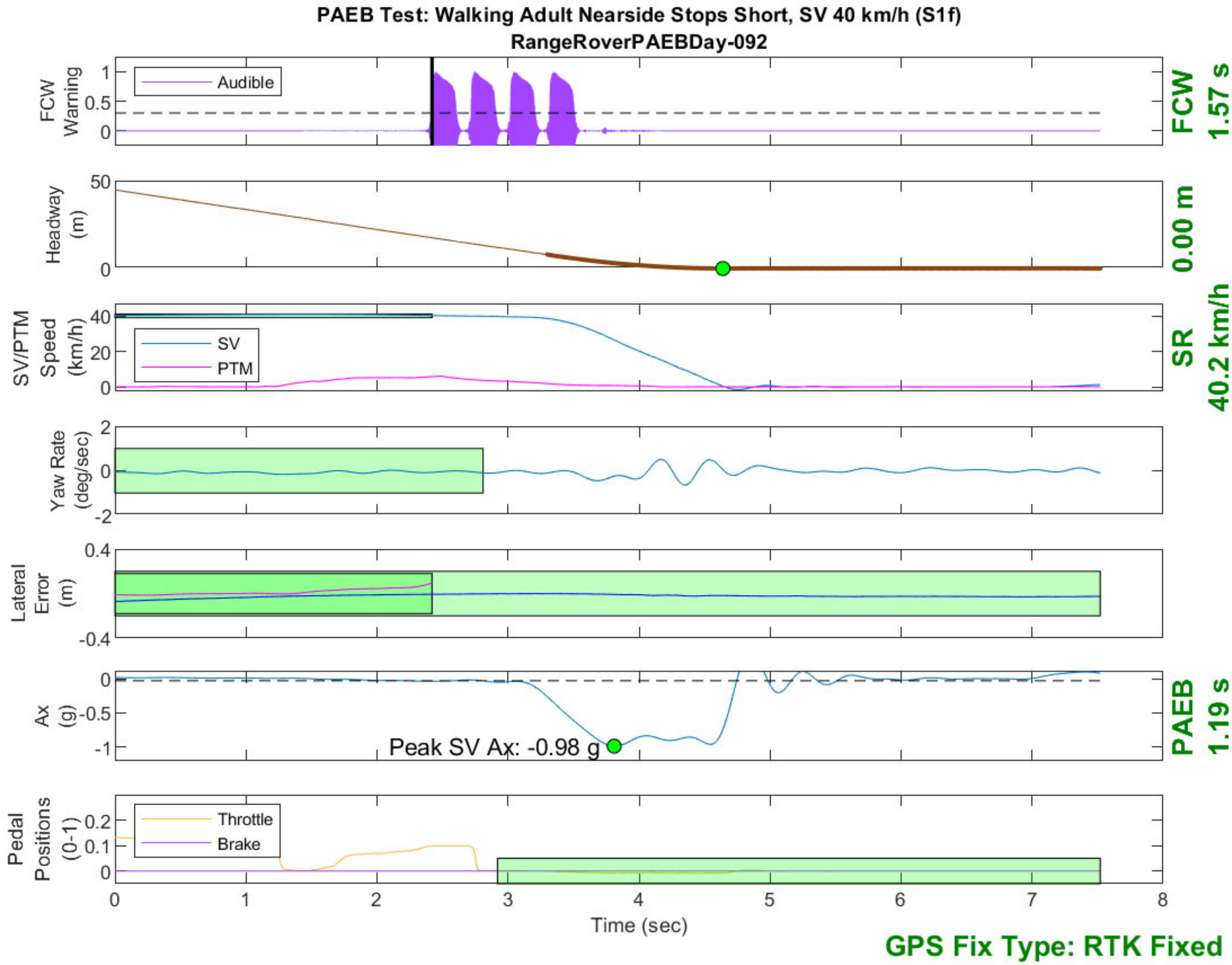


Figure D85. Time History for PAEB Run 92, S1f, Daytime, 40 km/h

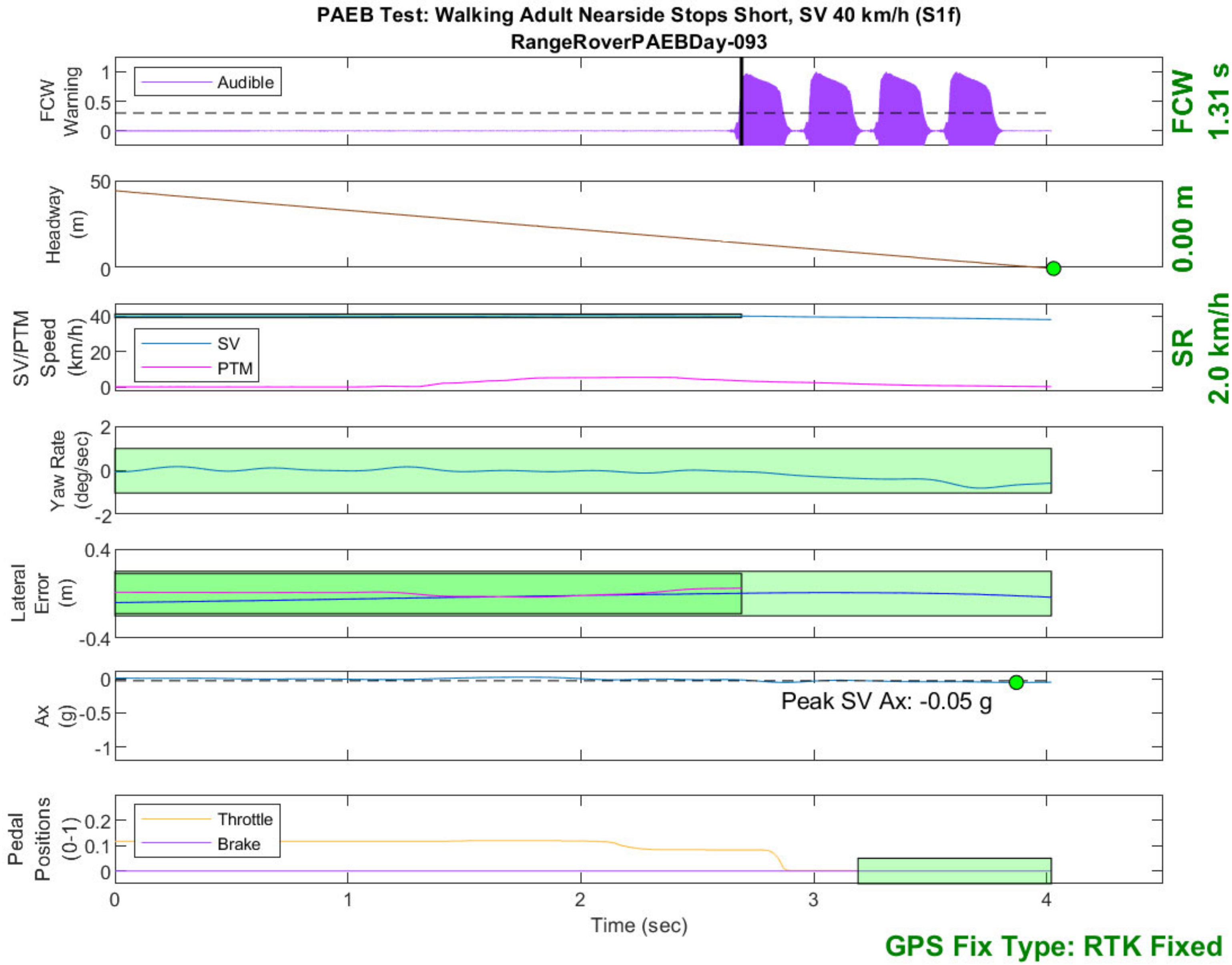


Figure D86. Time History for PAEB Run 93, S1f, Daytime, 40 km/h

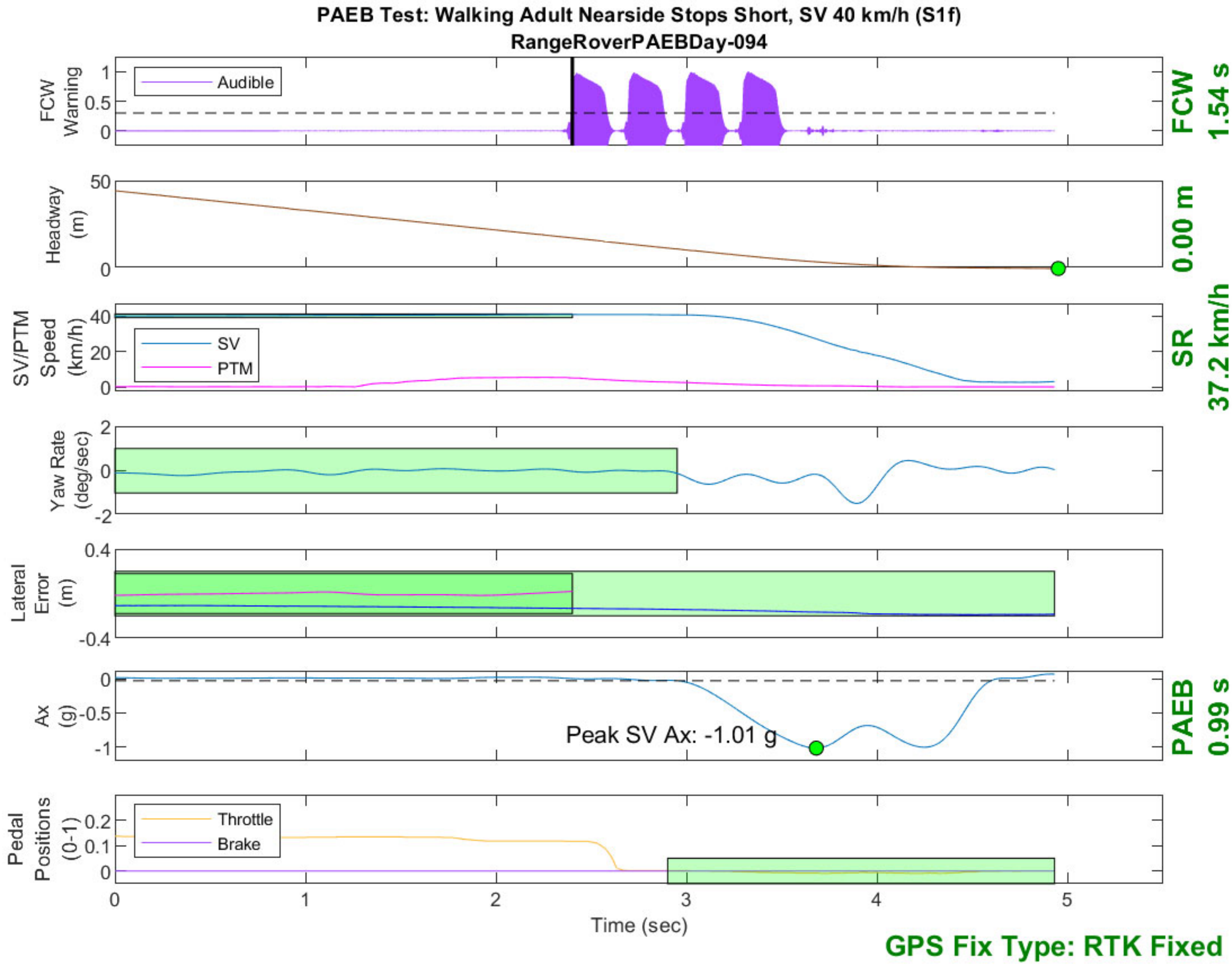


Figure D87. Time History for PAEB Run 94, S1f, Daytime, 40 km/h

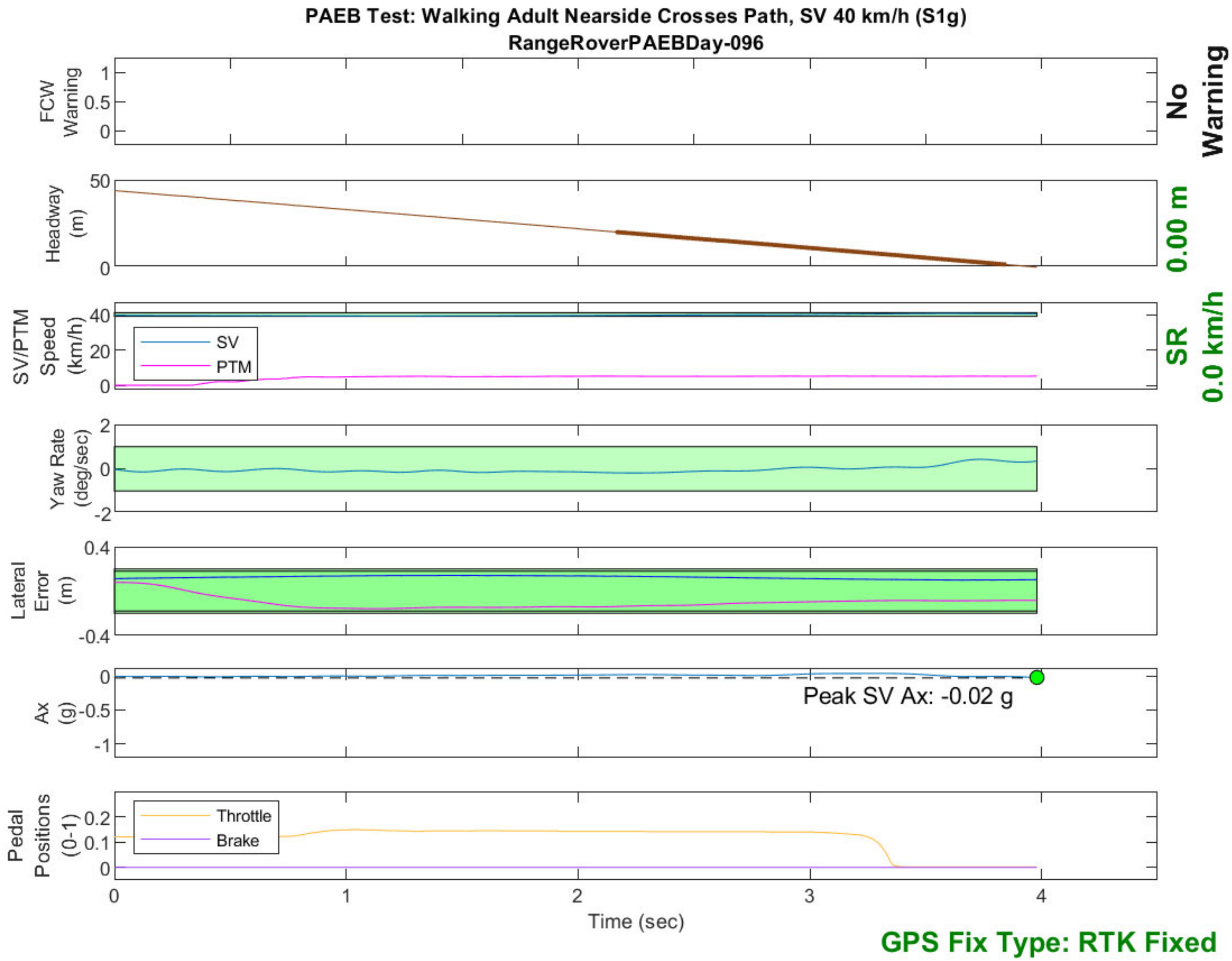


Figure D88. Time History for PAEB Run 96, S1g, Daytime, 40 km/h

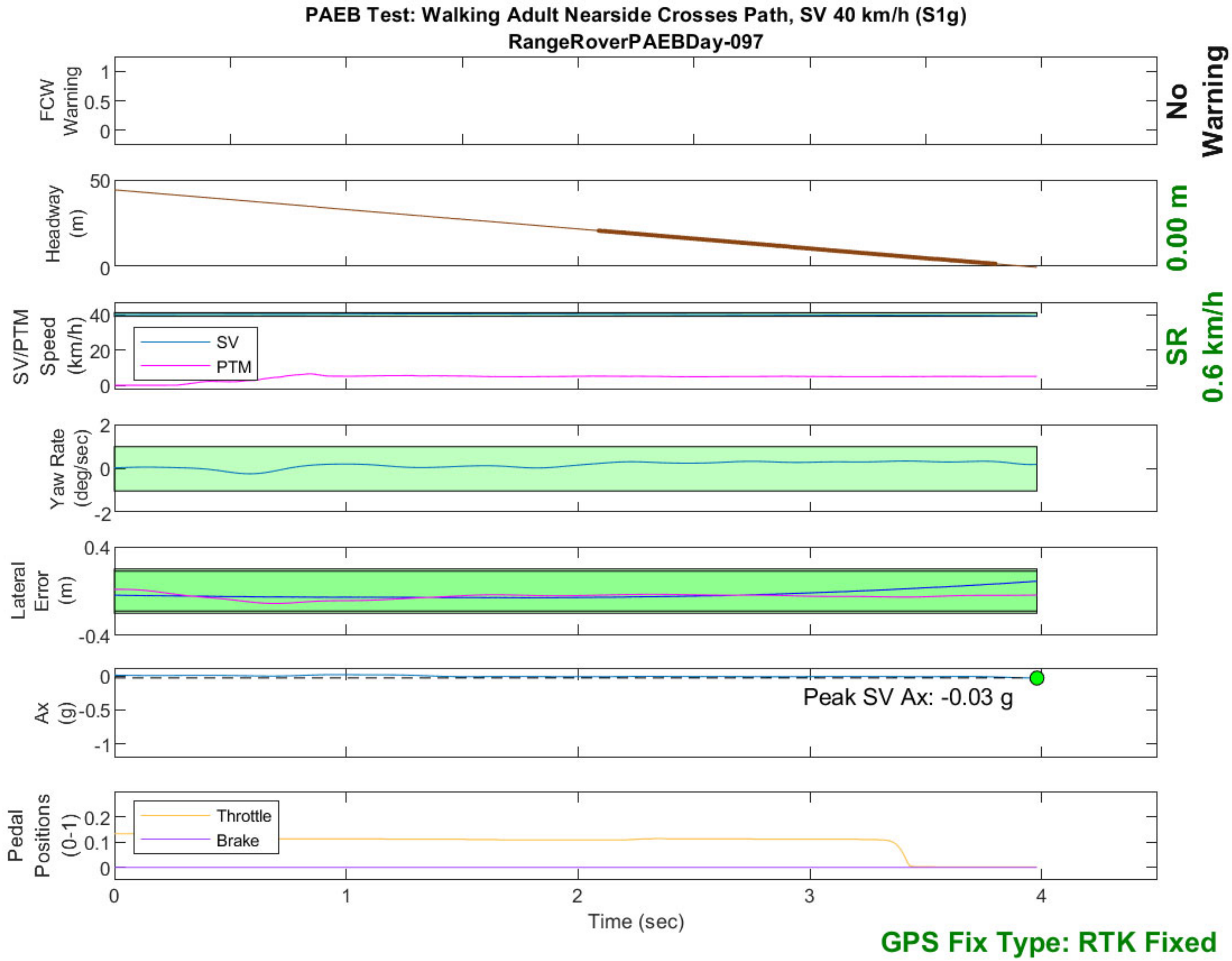


Figure D89. Time History for PAEB Run 97, S1g, Daytime, 40 km/h

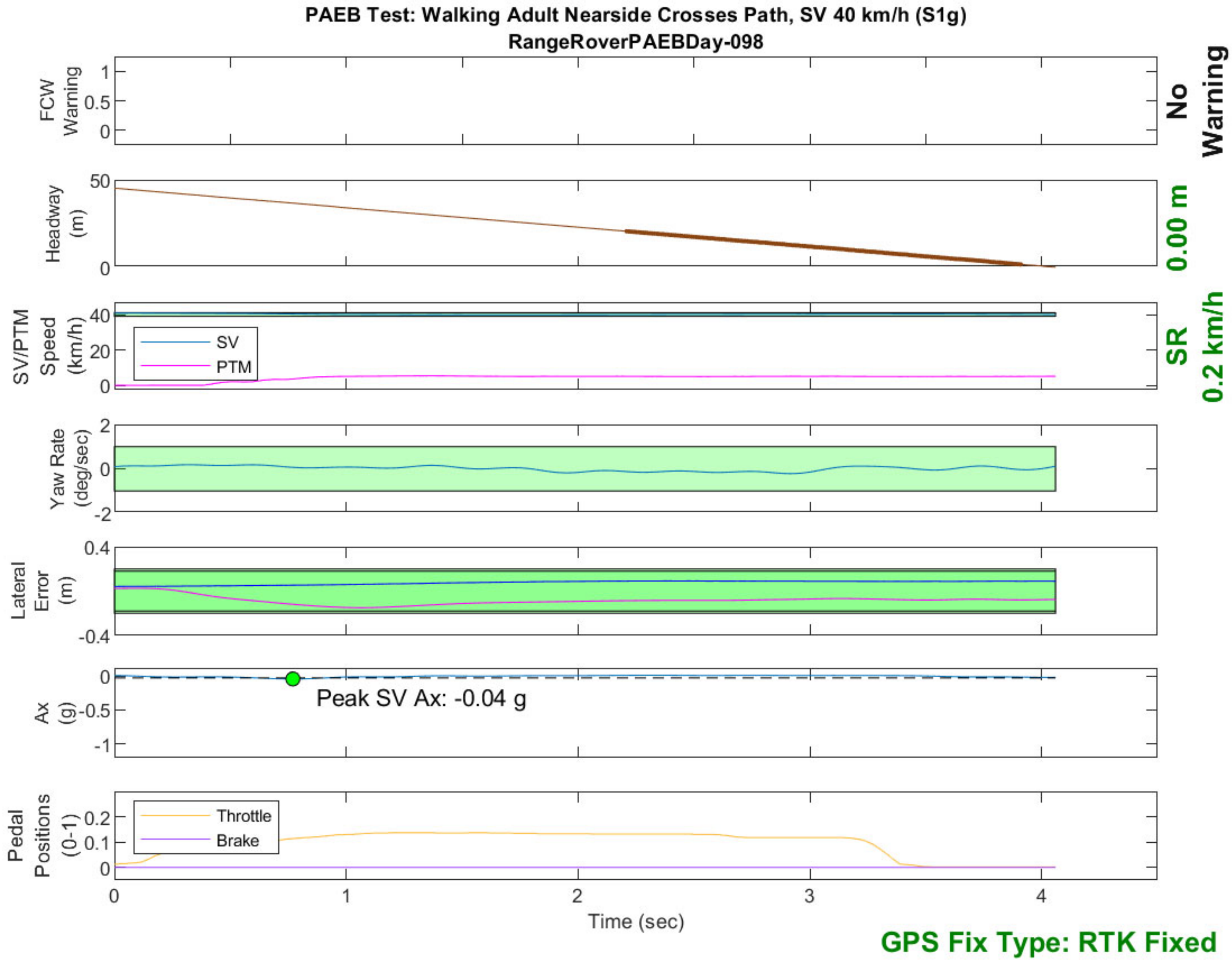


Figure D90. Time History for PAEB Run 98, S1g, Daytime, 40 km/h

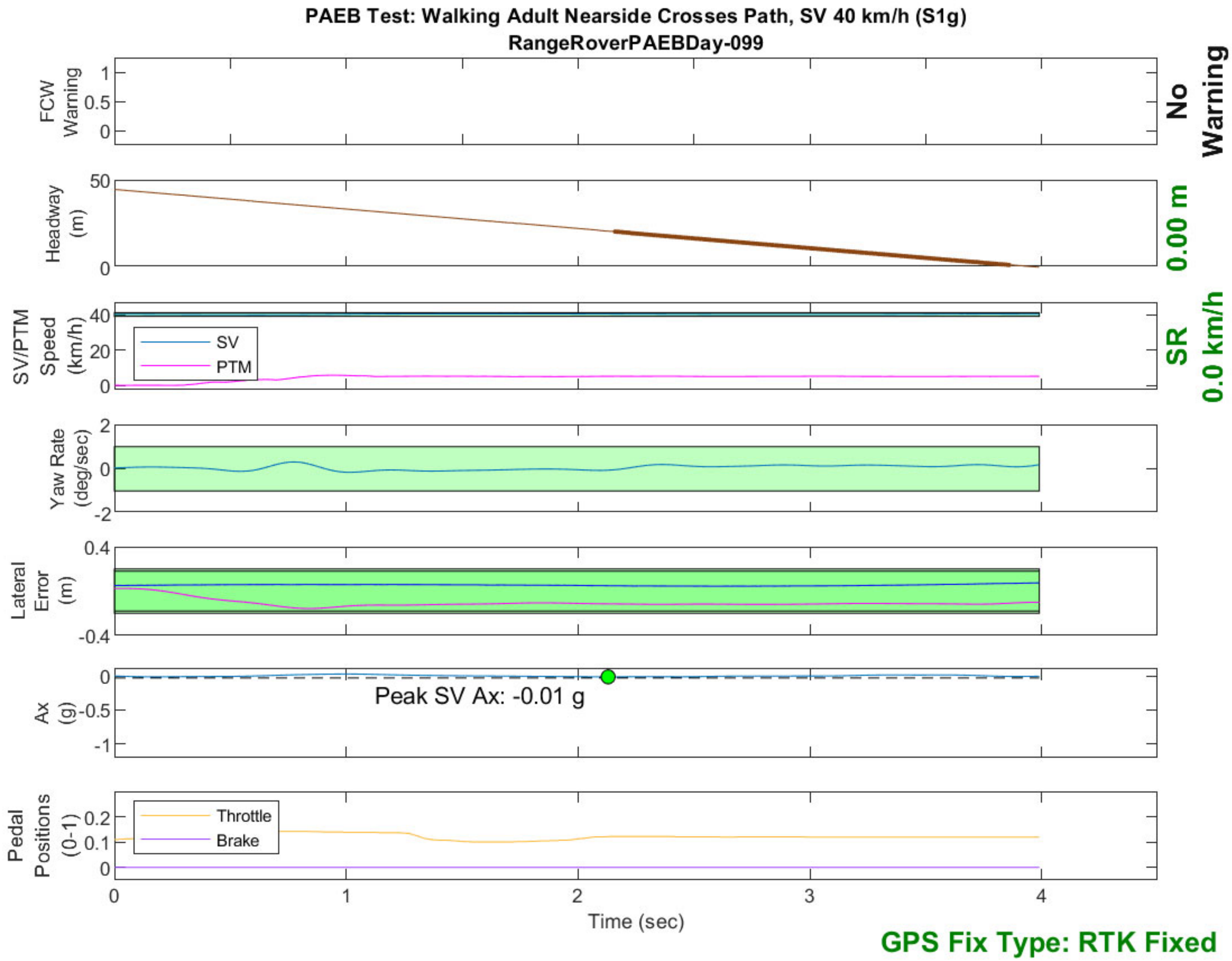


Figure D91. Time History for PAEB Run 99, S1g, Daytime, 40 km/h

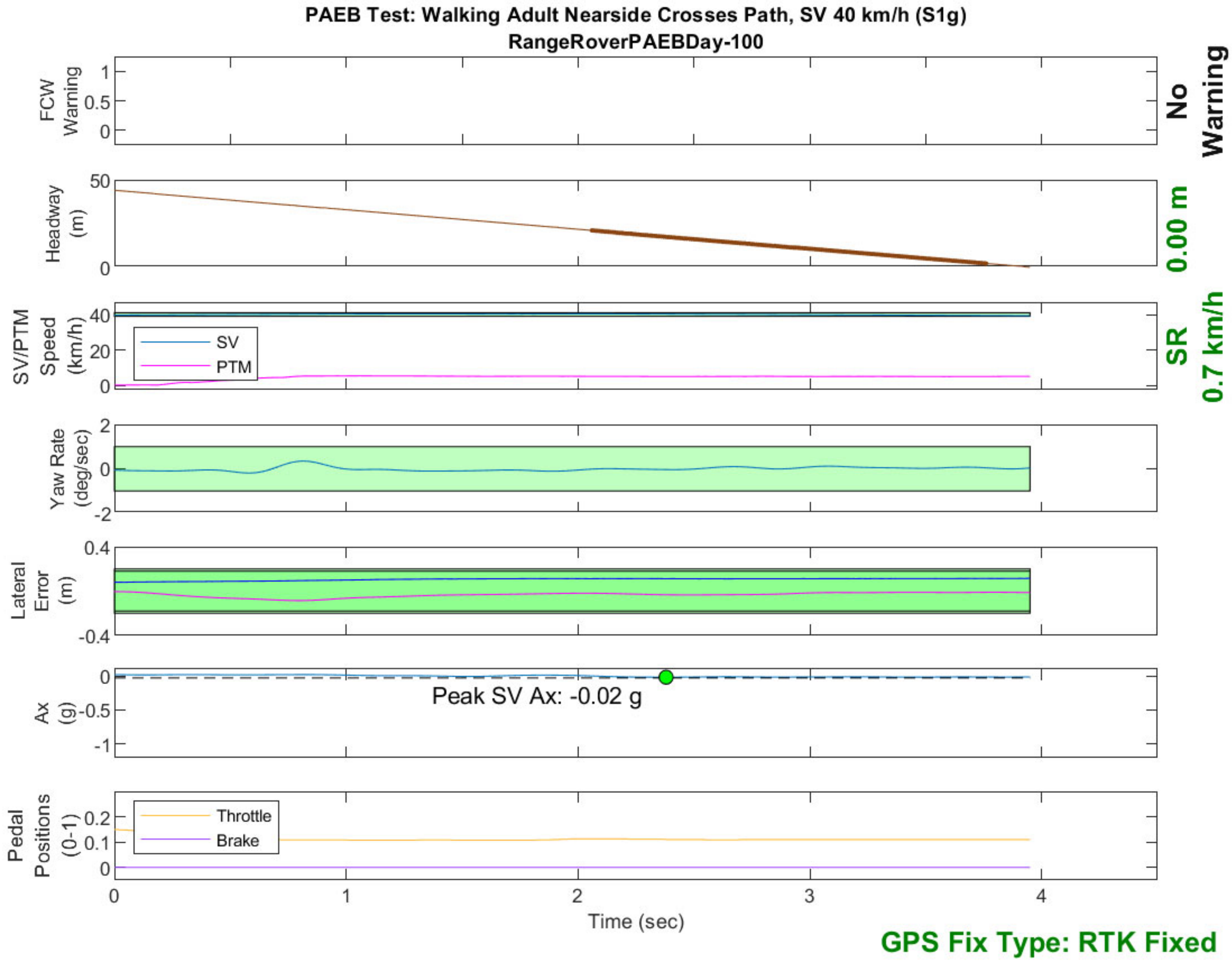


Figure D92. Time History for PAEB Run 100, S1g, Daytime, 40 km/h

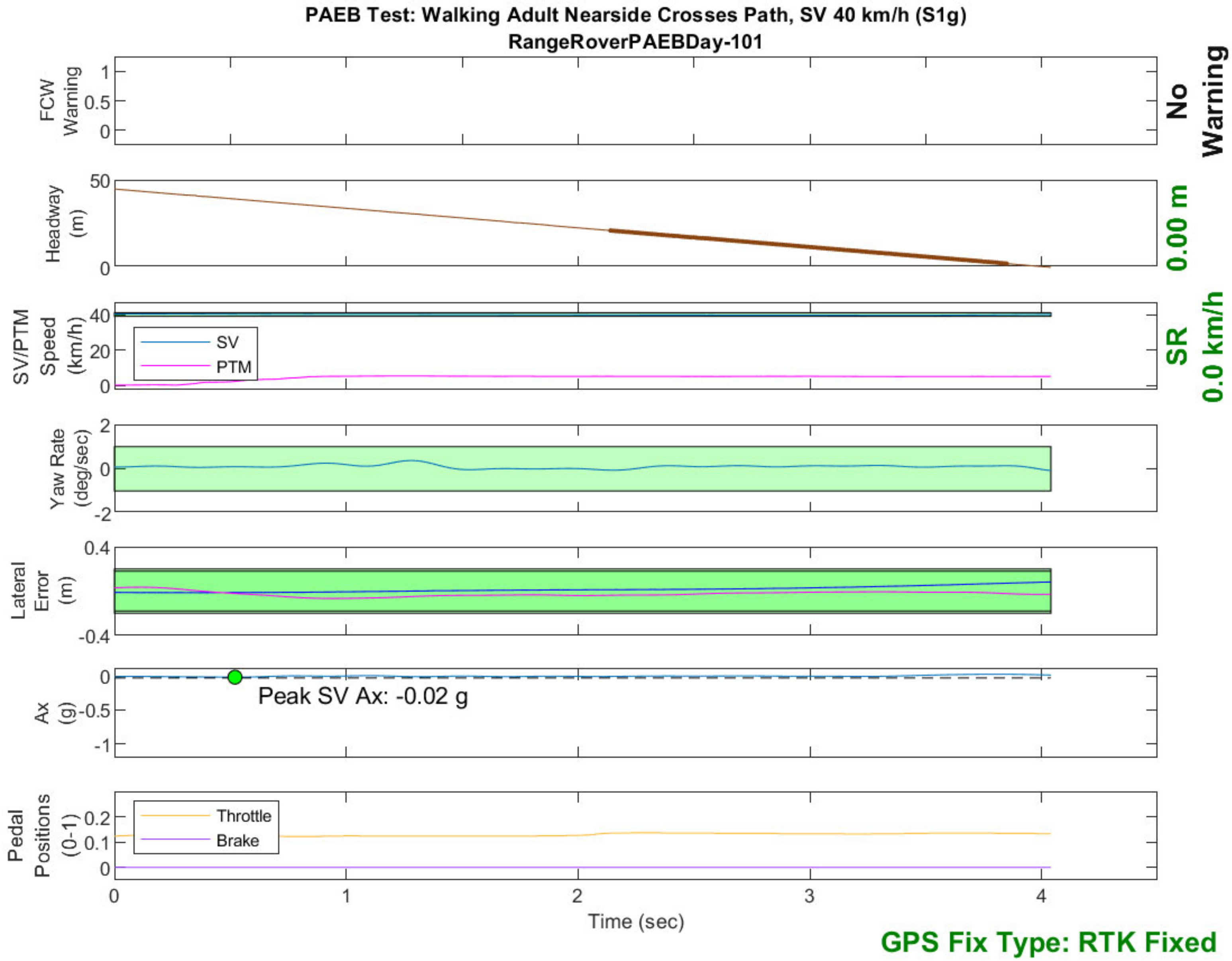


Figure D93. Time History for PAEB Run 101, S1g, Daytime, 40 km/h

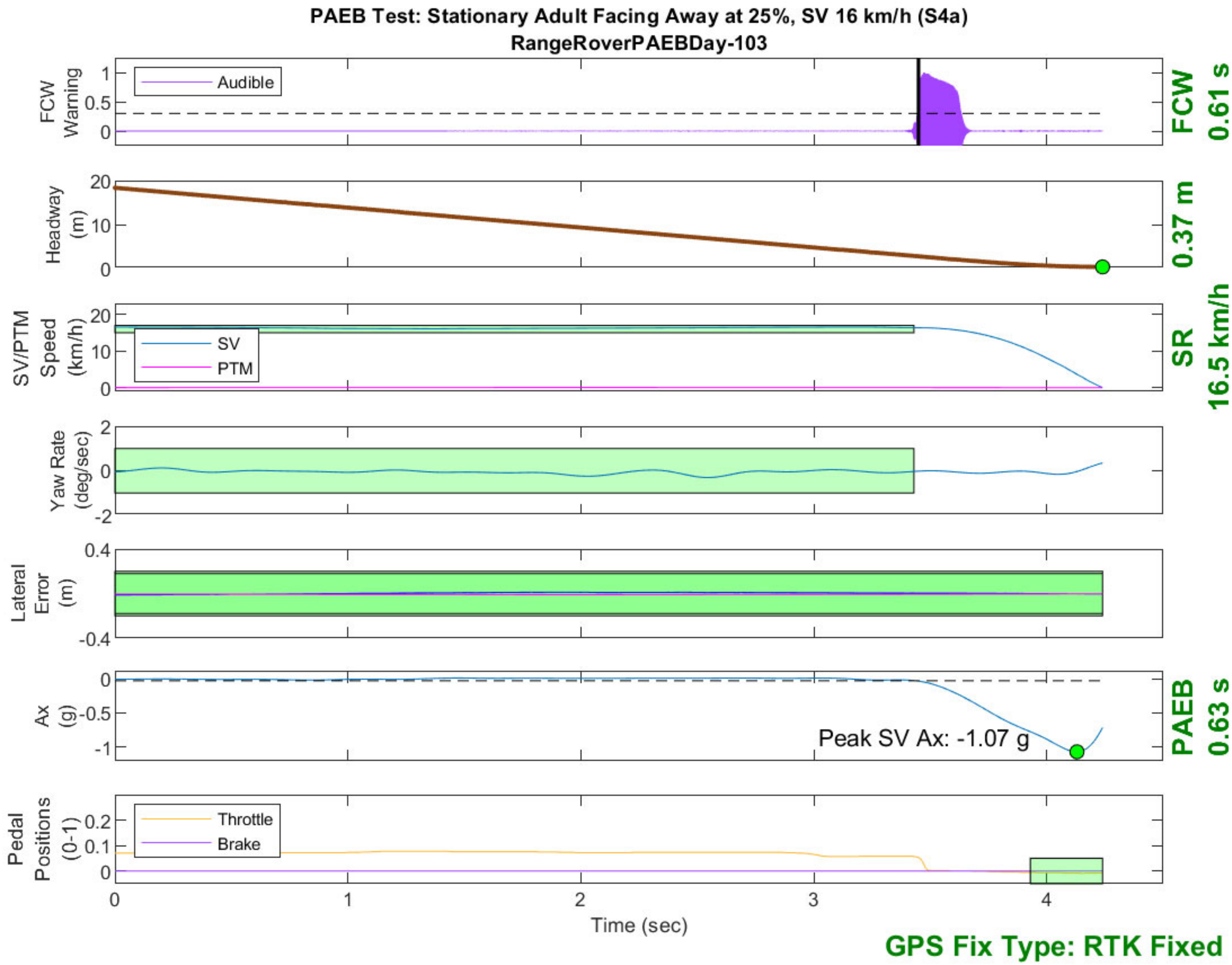


Figure D94. Time History for PAEB Run 103, S4a, Daytime, 16 km/h

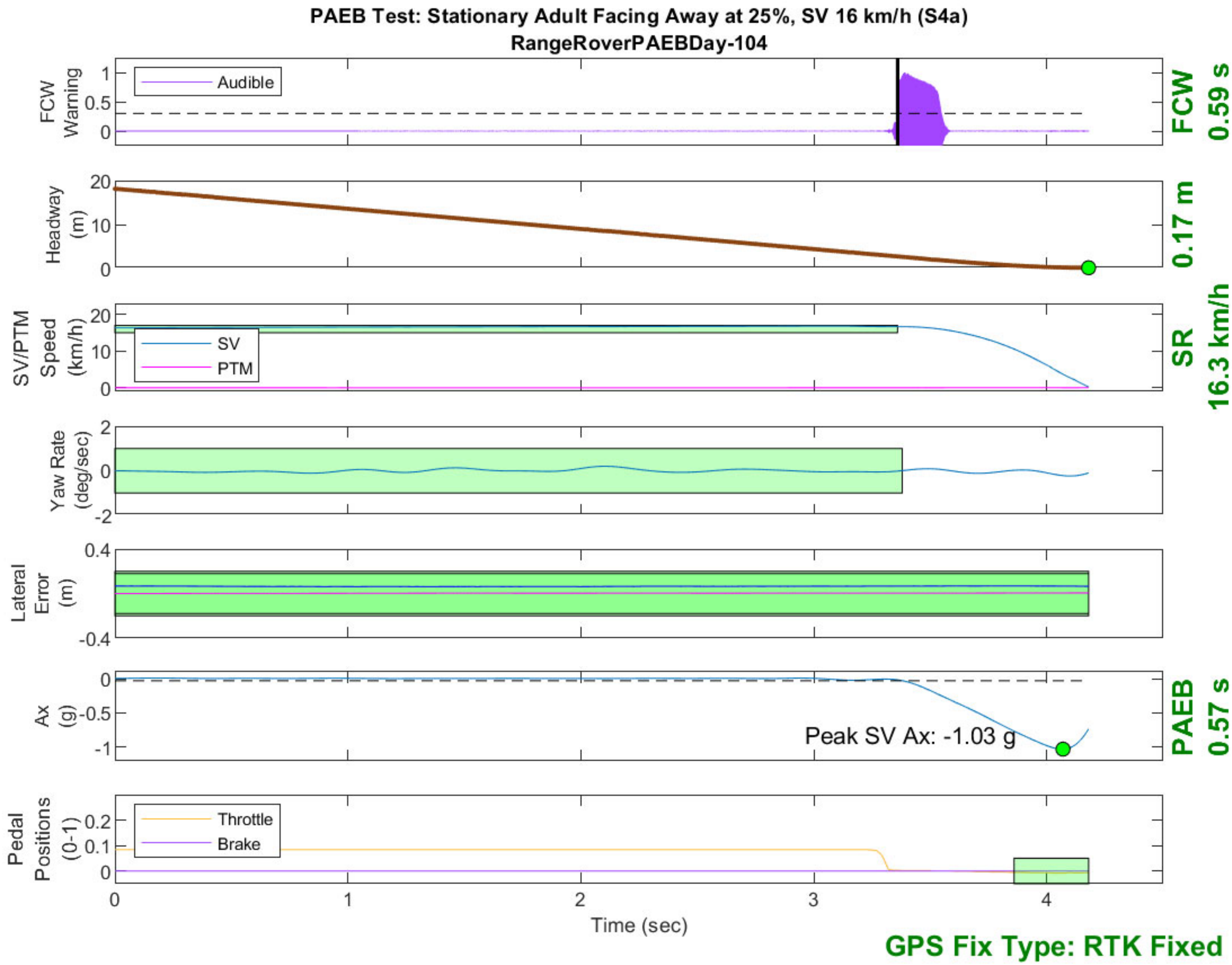


Figure D95. Time History for PAEB Run 104, S4a, Daytime, 16 km/h

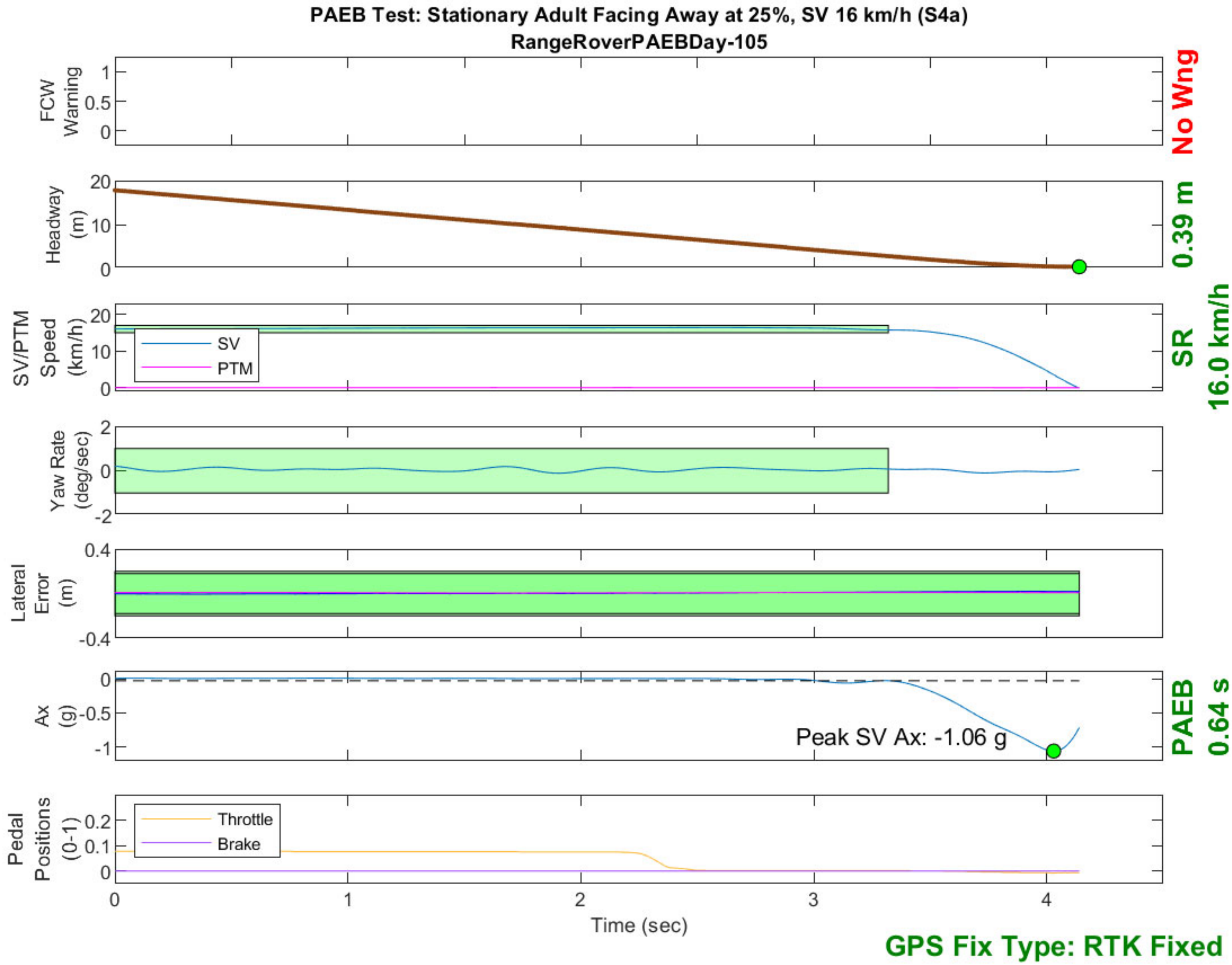


Figure D96. Time History for PAEB Run 105, S4a, Daytime, 16 km/h

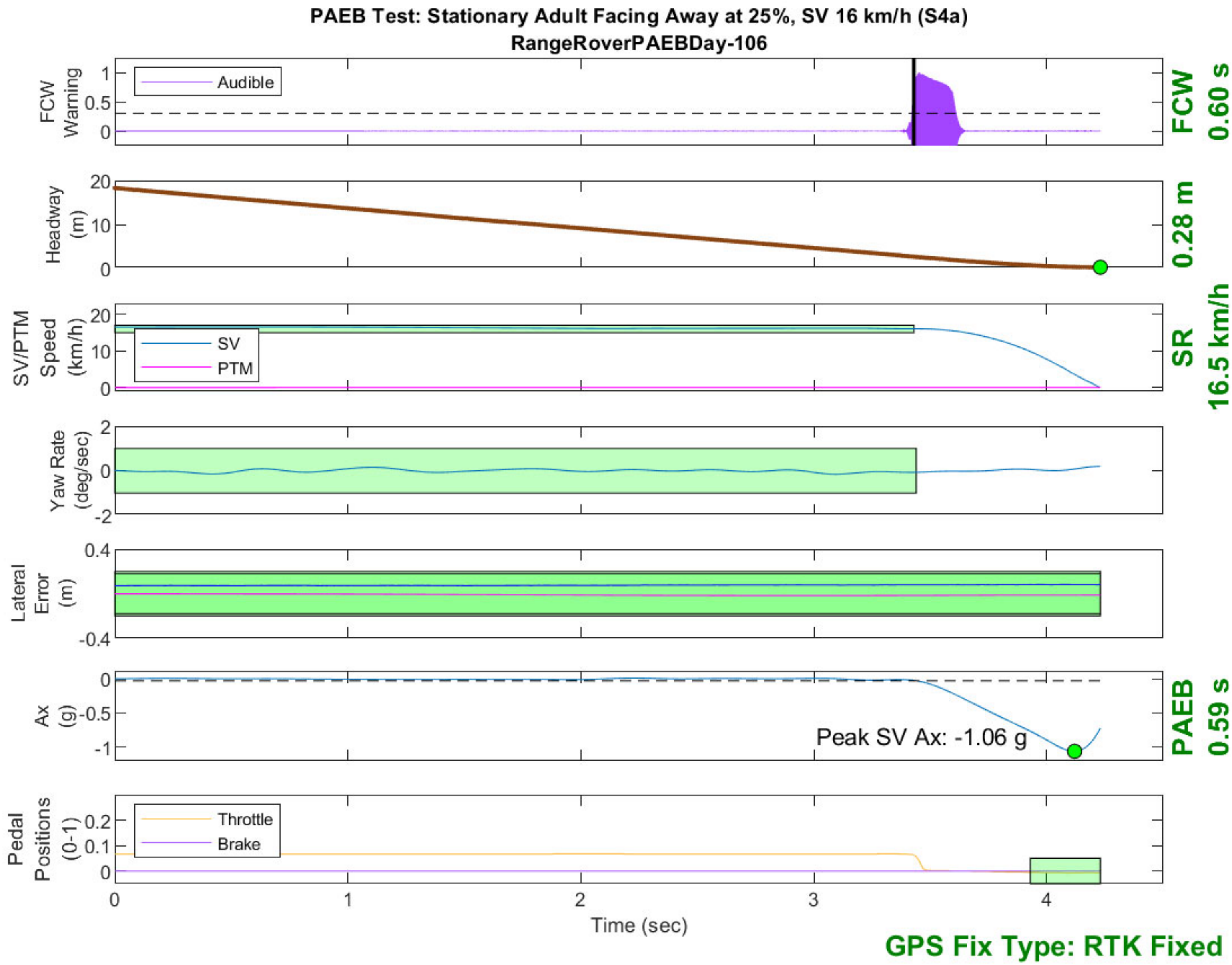


Figure D97. Time History for PAEB Run 106, S4a, Daytime, 16 km/h

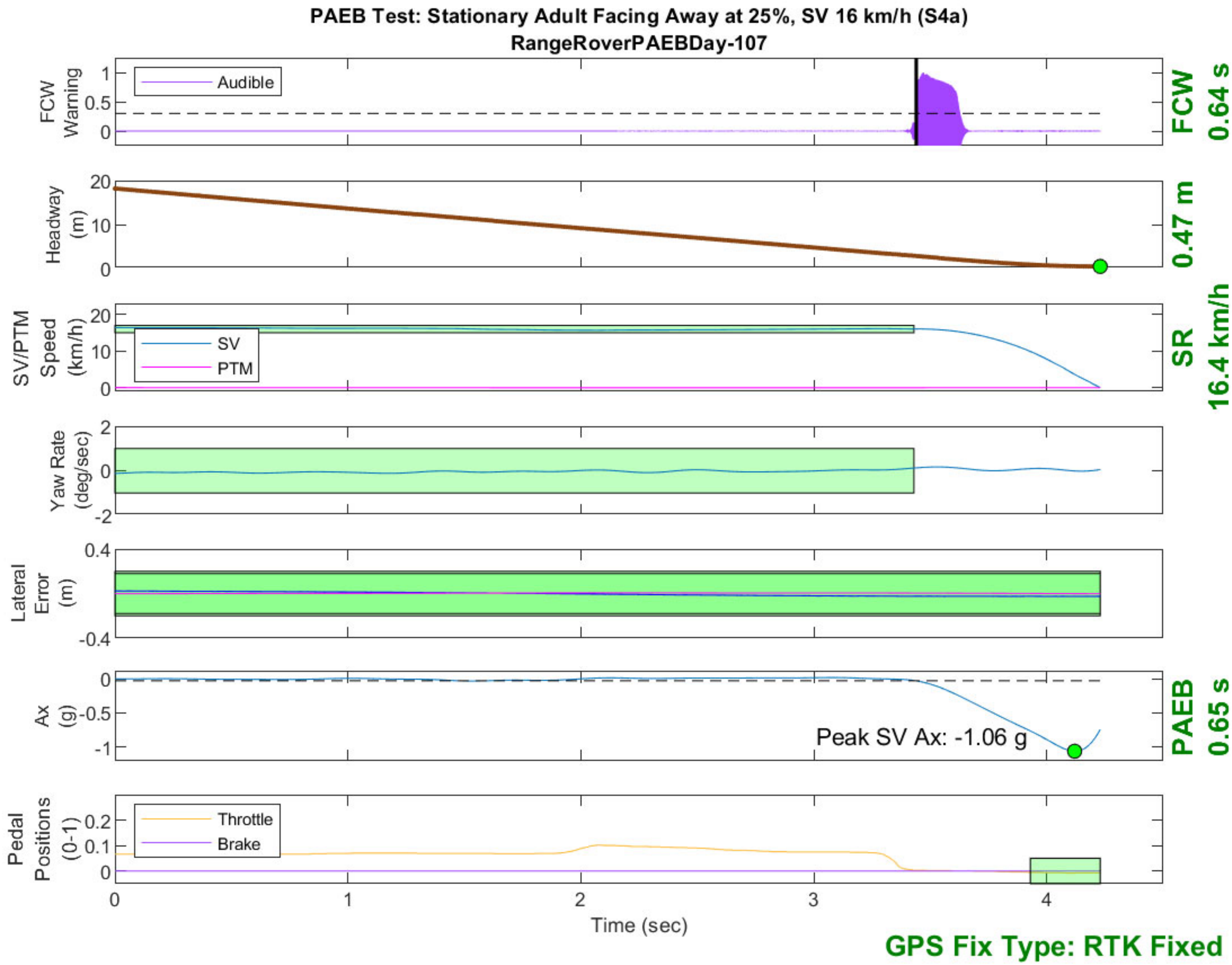


Figure D98. Time History for PAEB Run 107, S4a, Daytime, 16 km/h

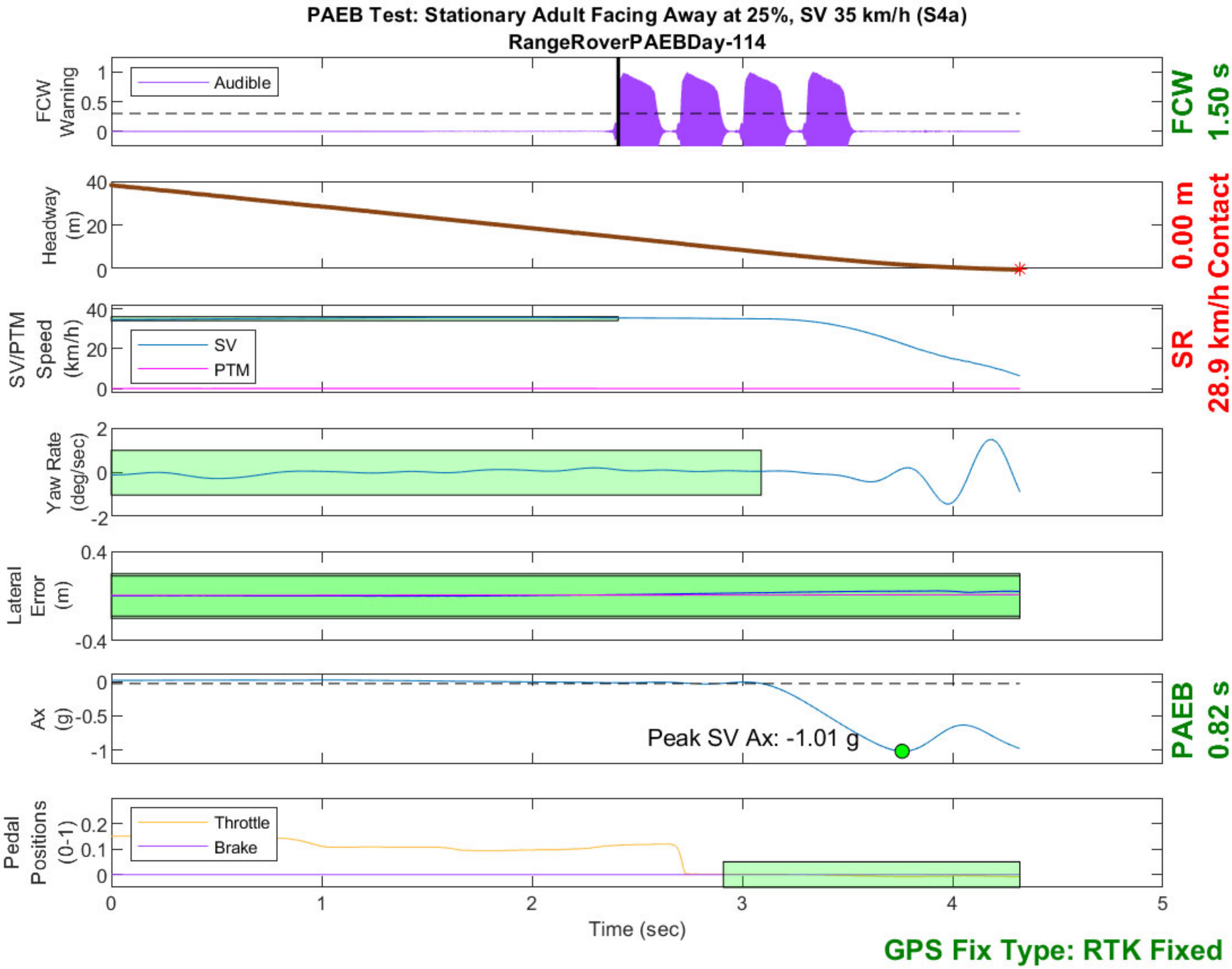


Figure D99. Time History for PAEB Run 114, S4a, Daytime, 35 km/h

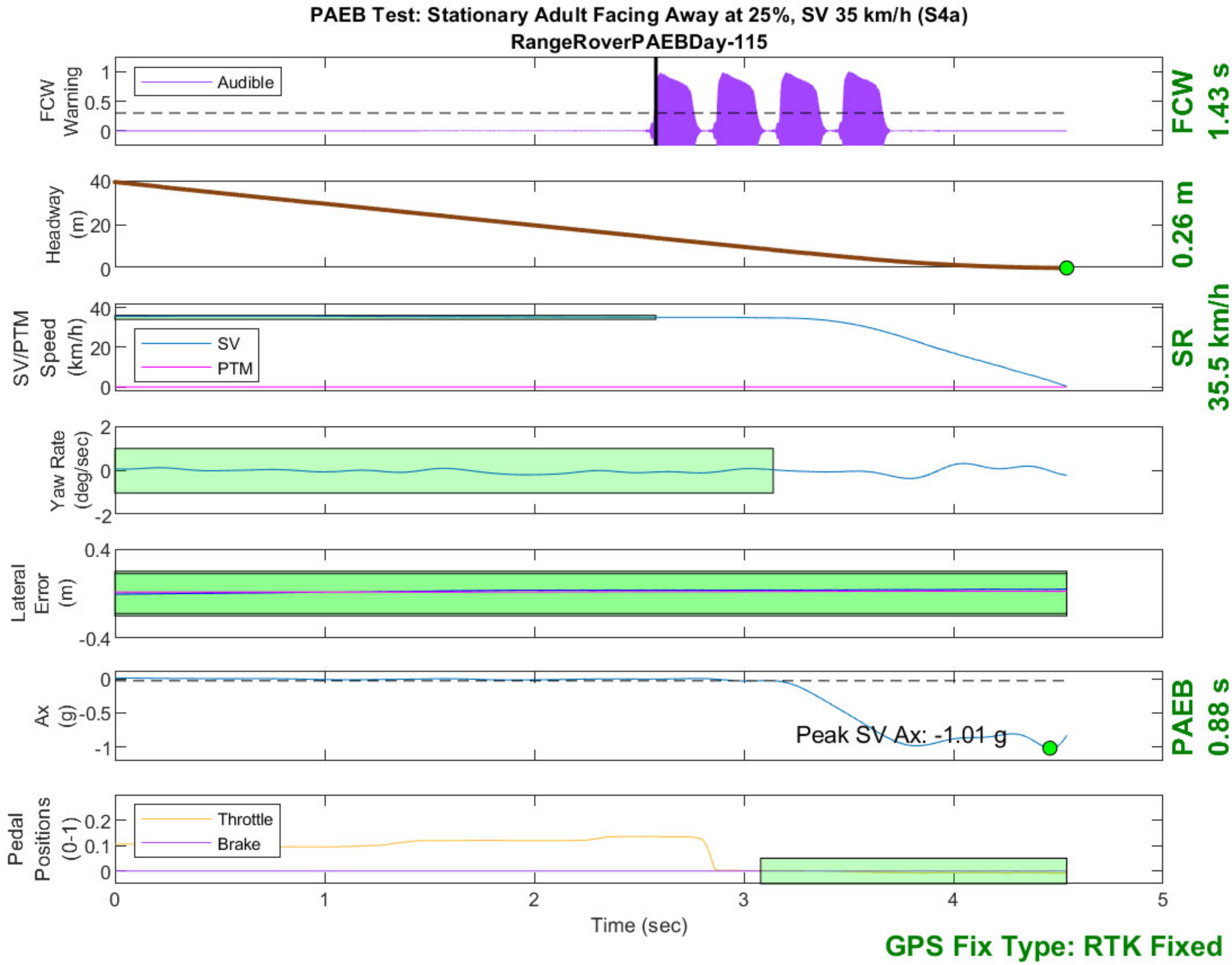


Figure D100. Time History for PAEB Run 115, S4a, Daytime, 35 km/h

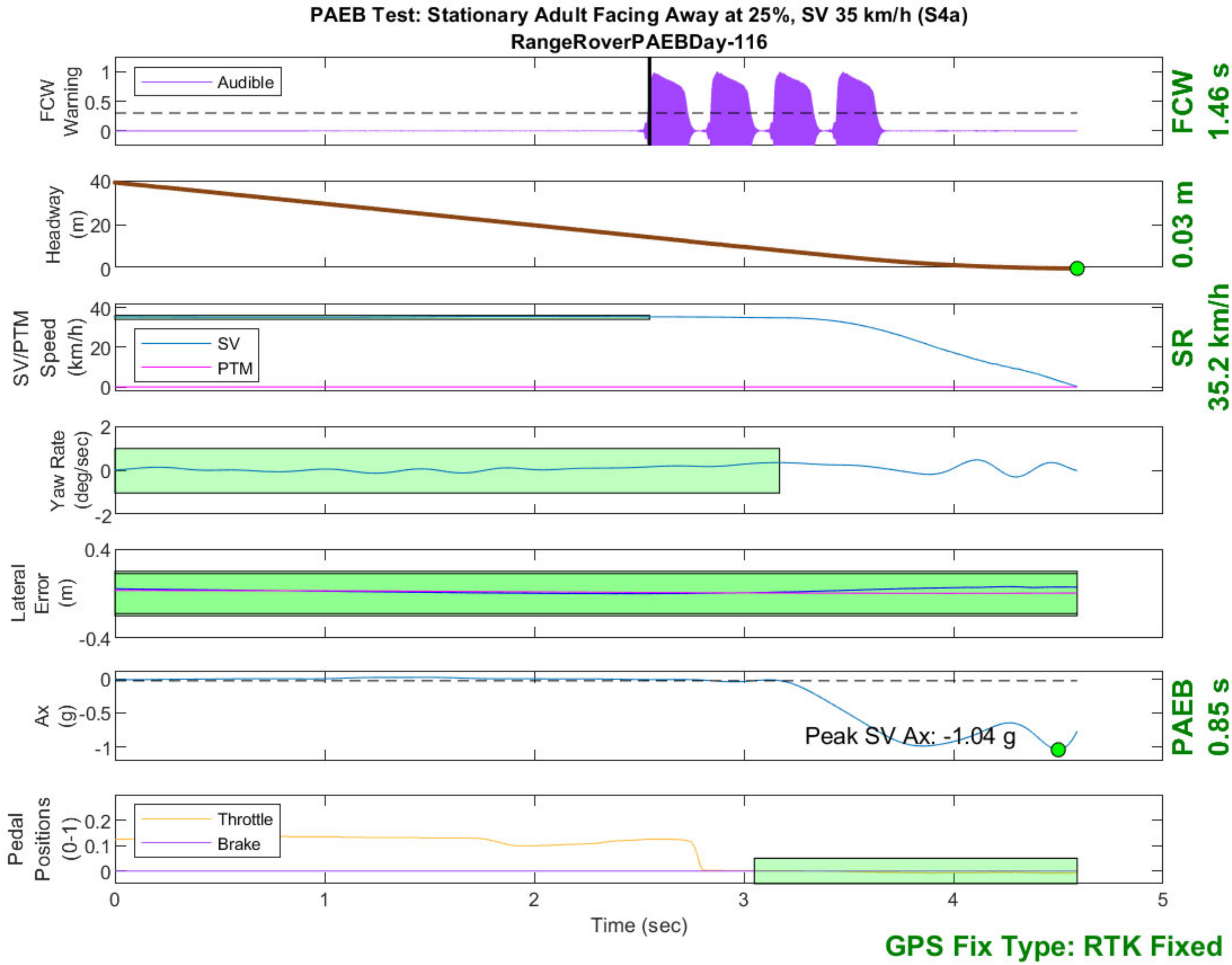


Figure D101. Time History for PAEB Run 116, S4a, Daytime, 35 km/h

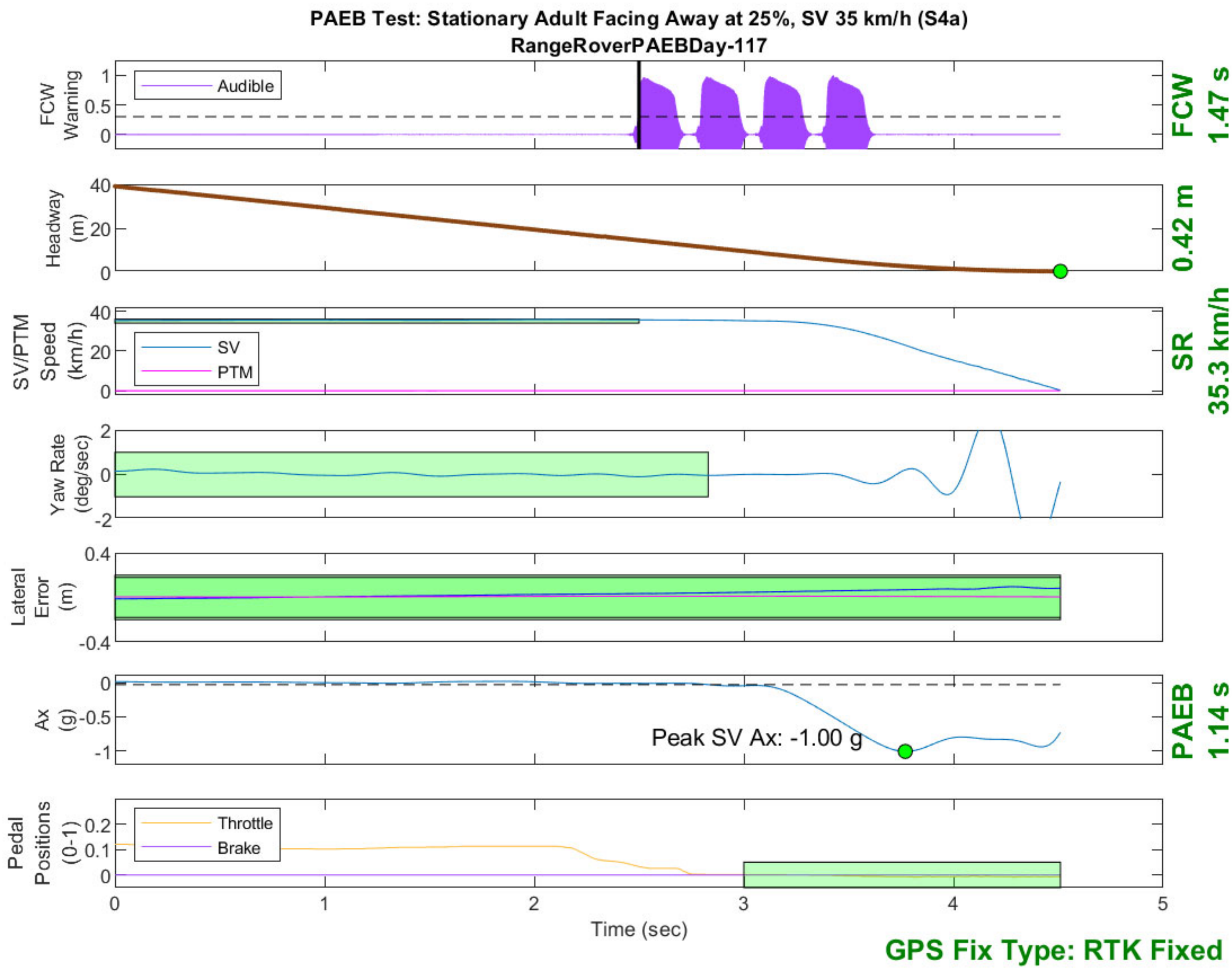


Figure D102. Time History for PAEB Run 117, S4a, Daytime, 35 km/h

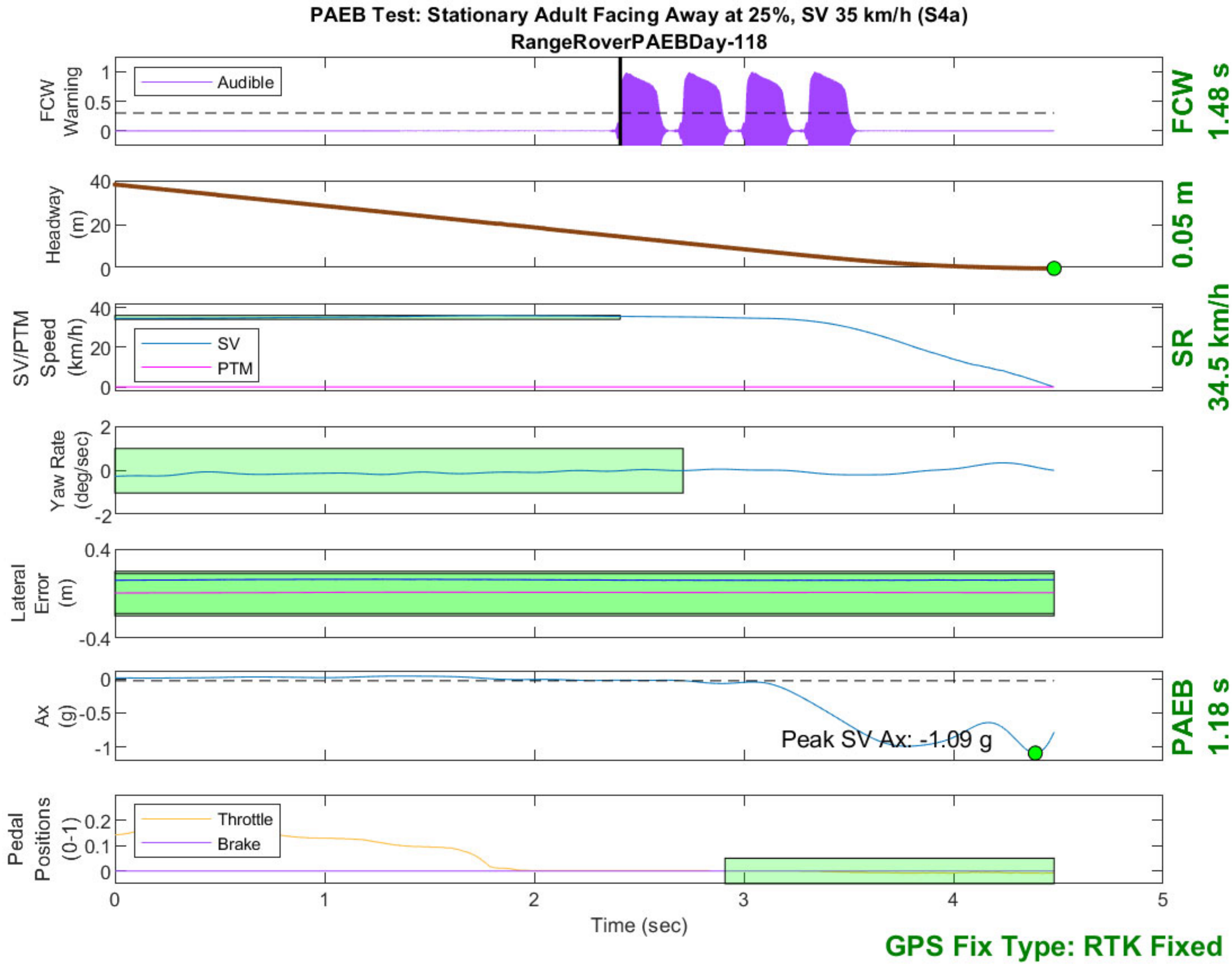


Figure D103. Time History for PAEB Run 118, S4a, Daytime, 35 km/h

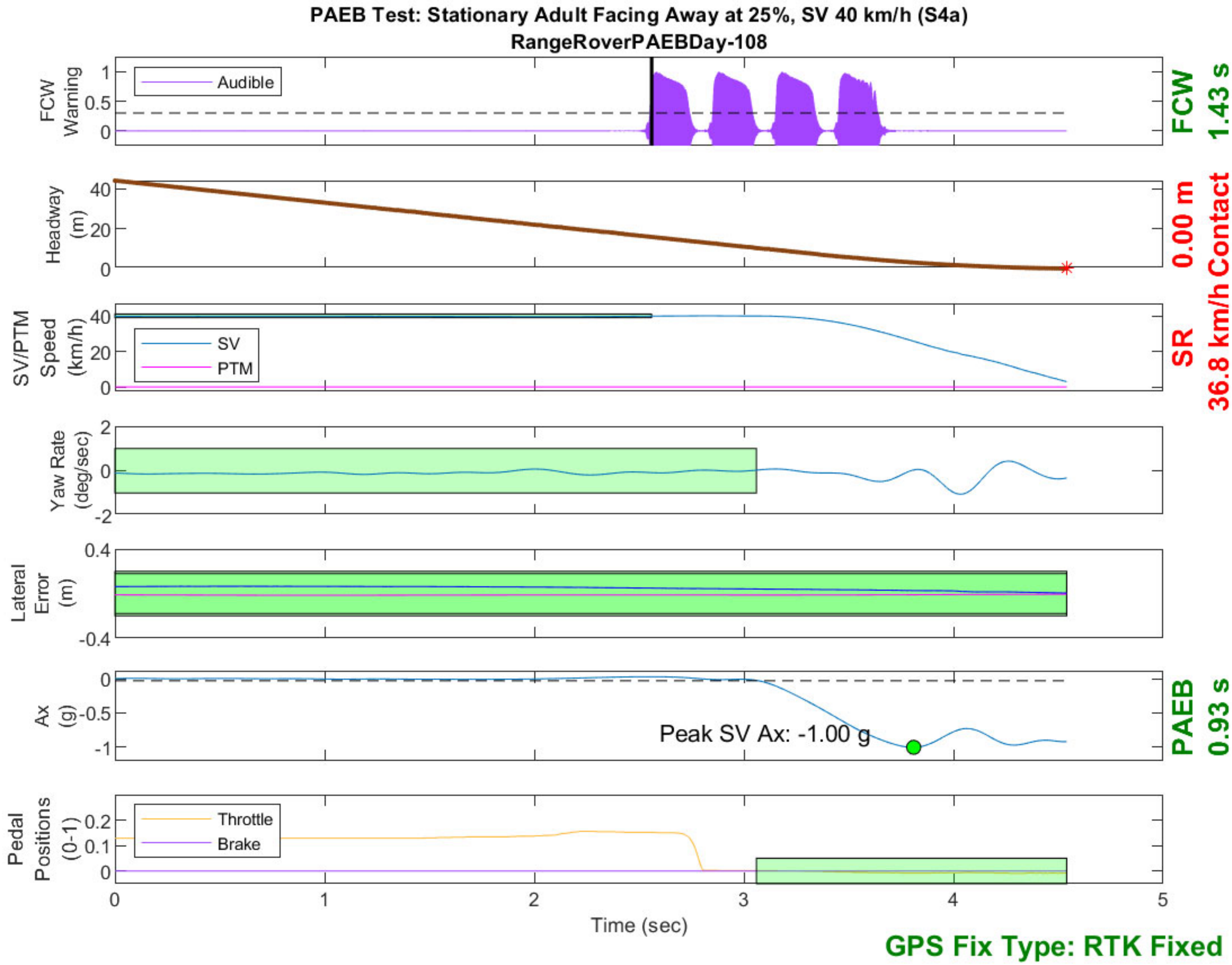


Figure D104. Time History for PAEB Run 108, S4a, Daytime, 40 km/h

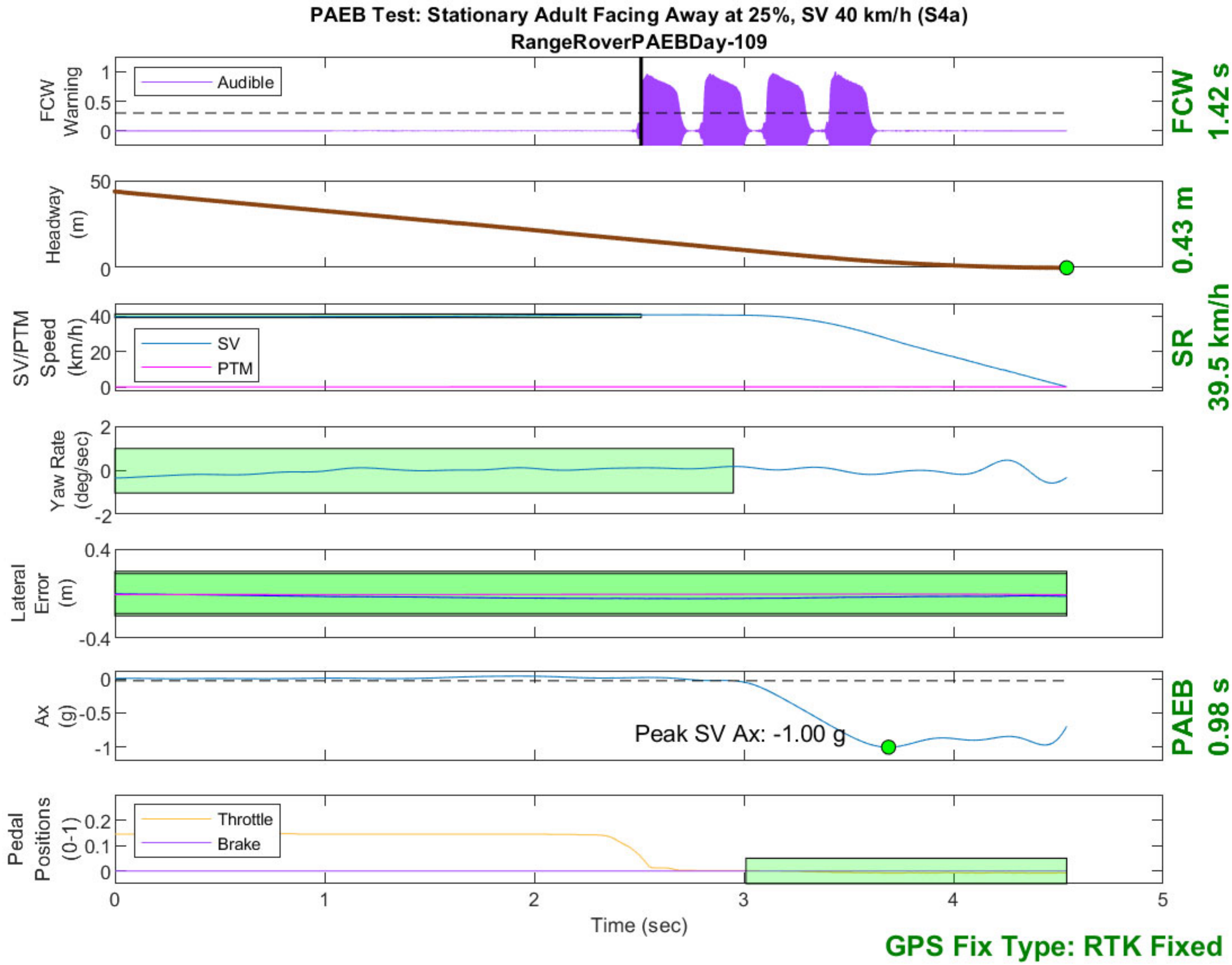


Figure D105. Time History for PAEB Run 109, S4a, Daytime, 40 km/h

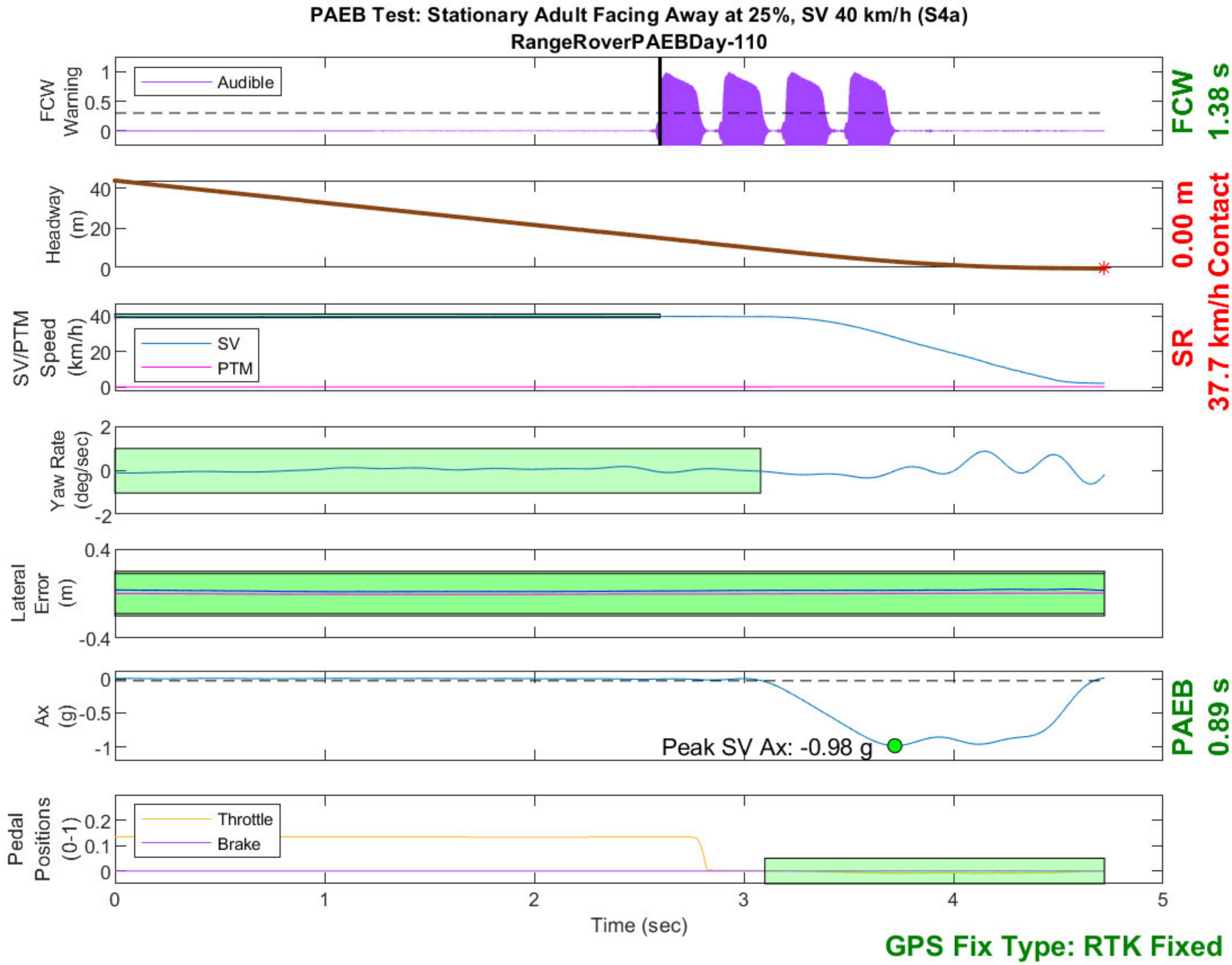


Figure D106. Time History for PAEB Run 110, S4a, Daytime, 40 km/h

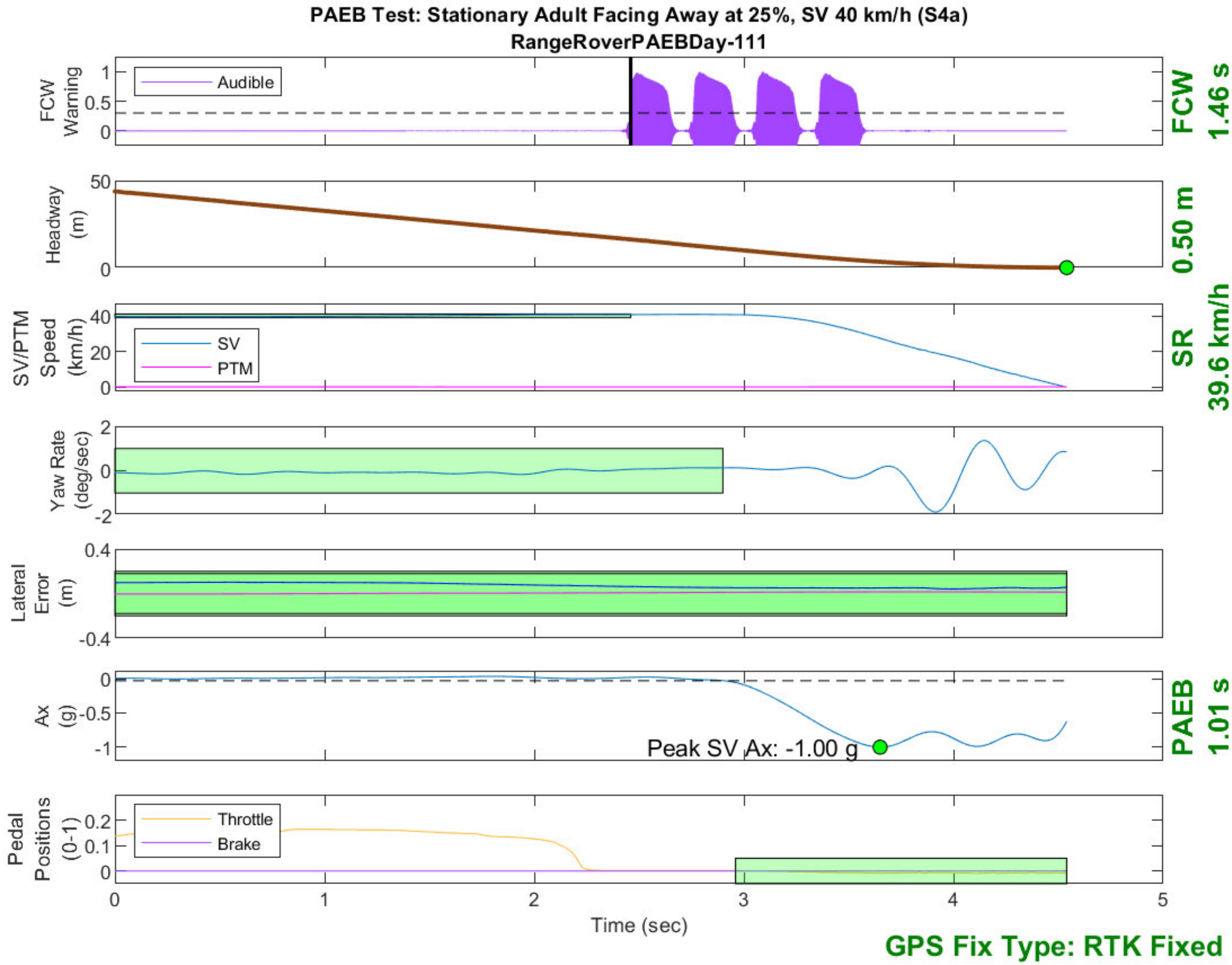


Figure D107. Time History for PAEB Run 111, S4a, Daytime, 40 km/h

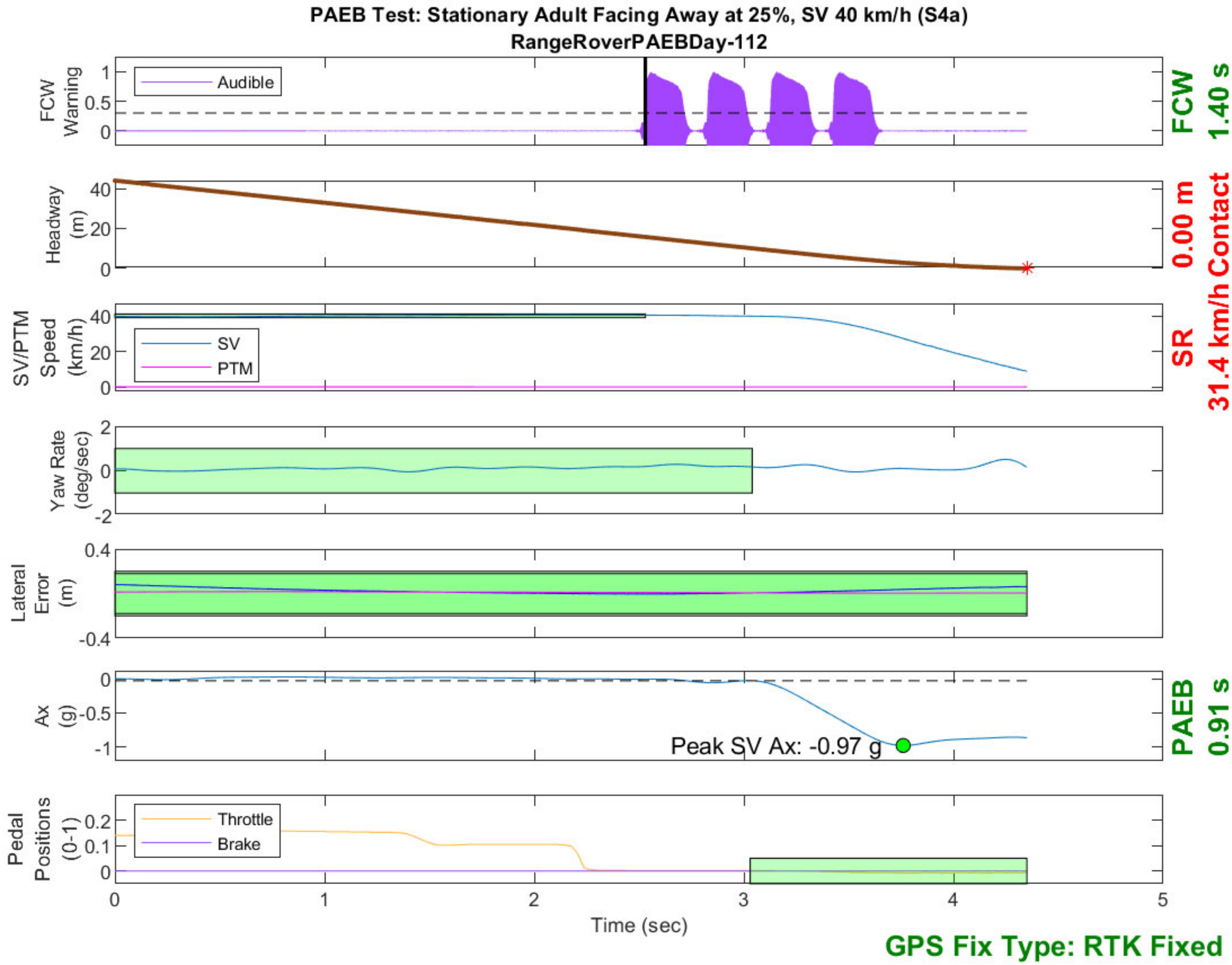


Figure D108. Time History for PAEB Run 112, S4a, Daytime, 40 km/h

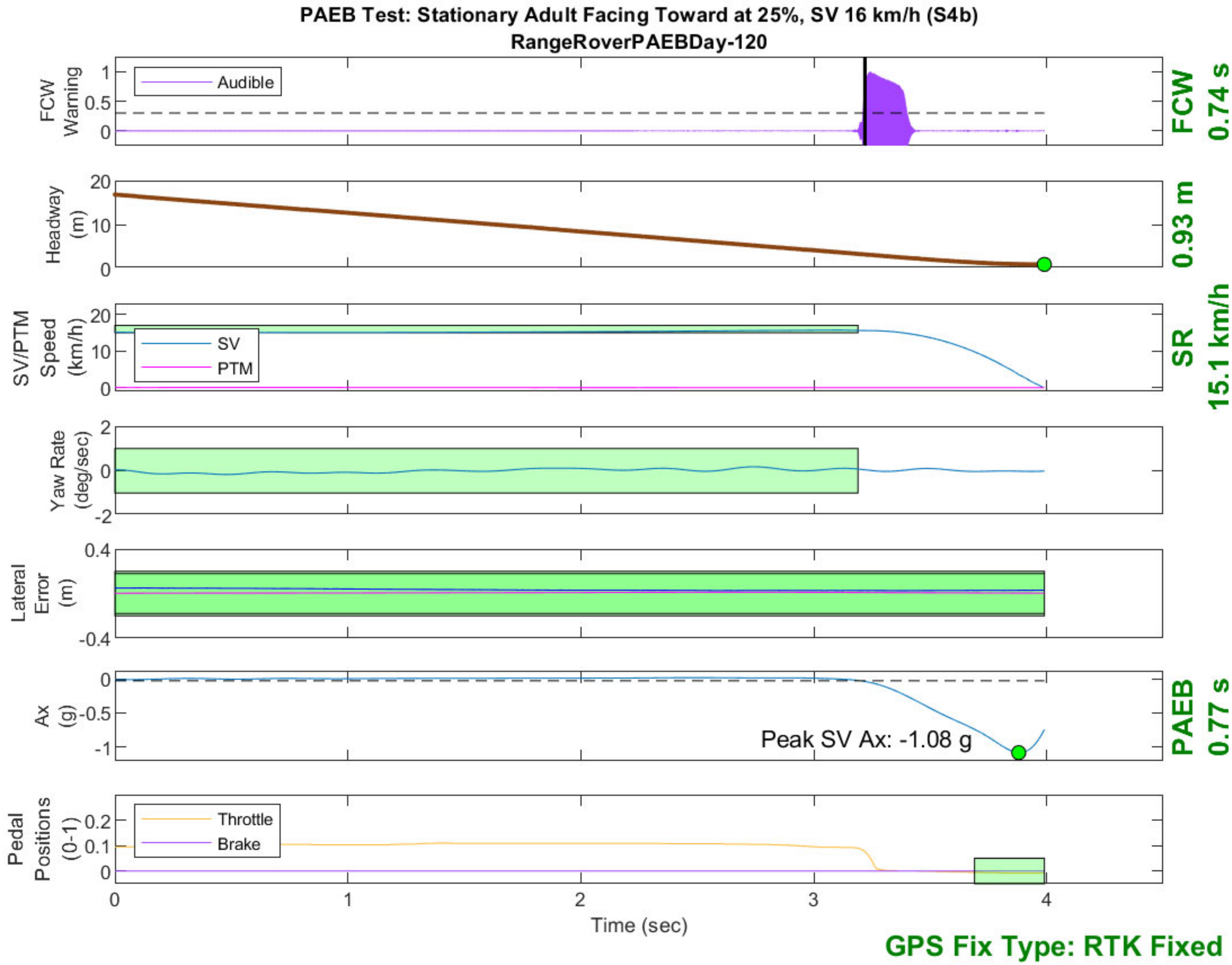


Figure D109. Time History for PAEB Run 120, S4b, Daytime, 16 km/h

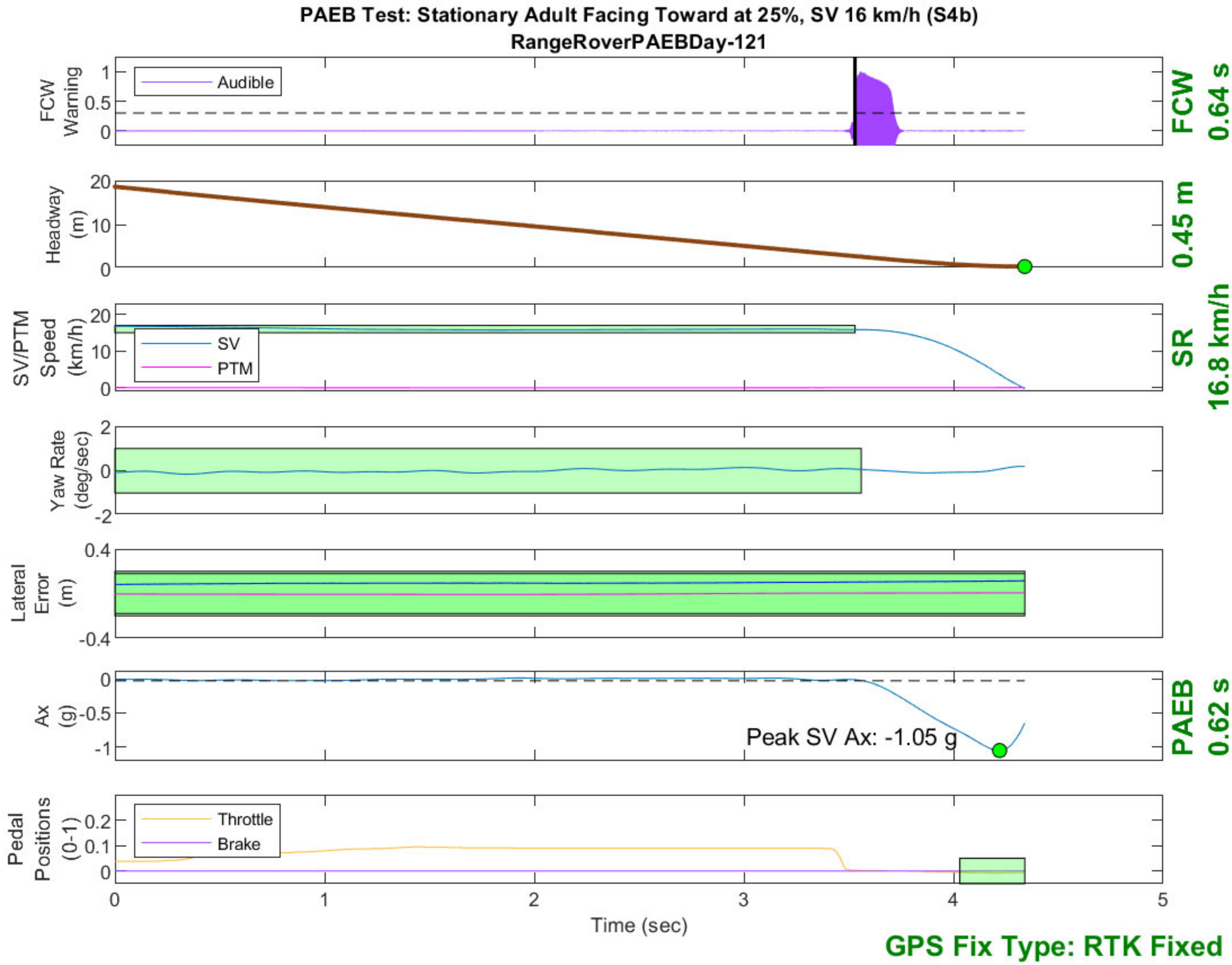


Figure D110. Time History for PAEB Run 121, S4b, Daytime, 16 km/h

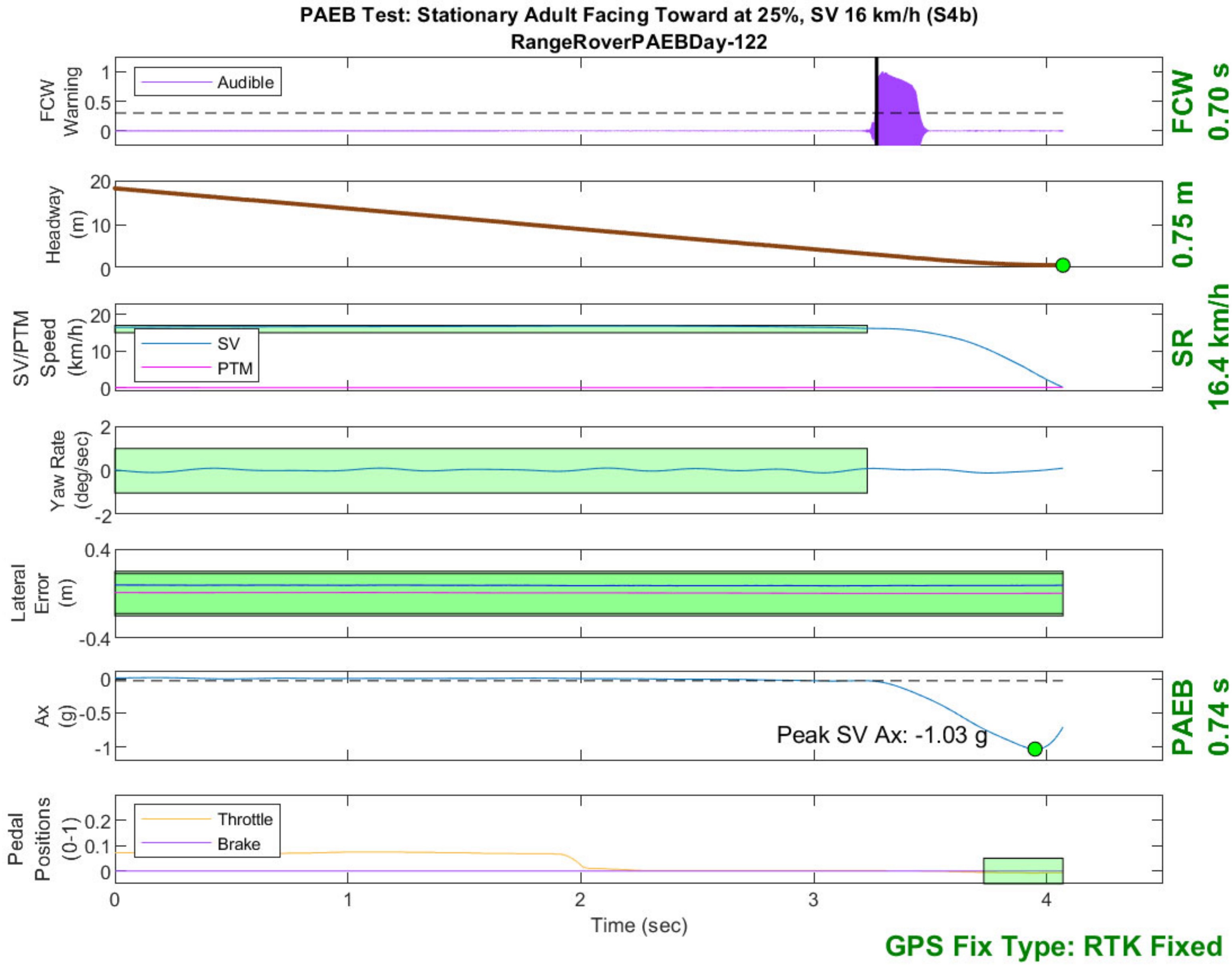


Figure D111. Time History for PAEB Run 122, S4b, Daytime, 16 km/h

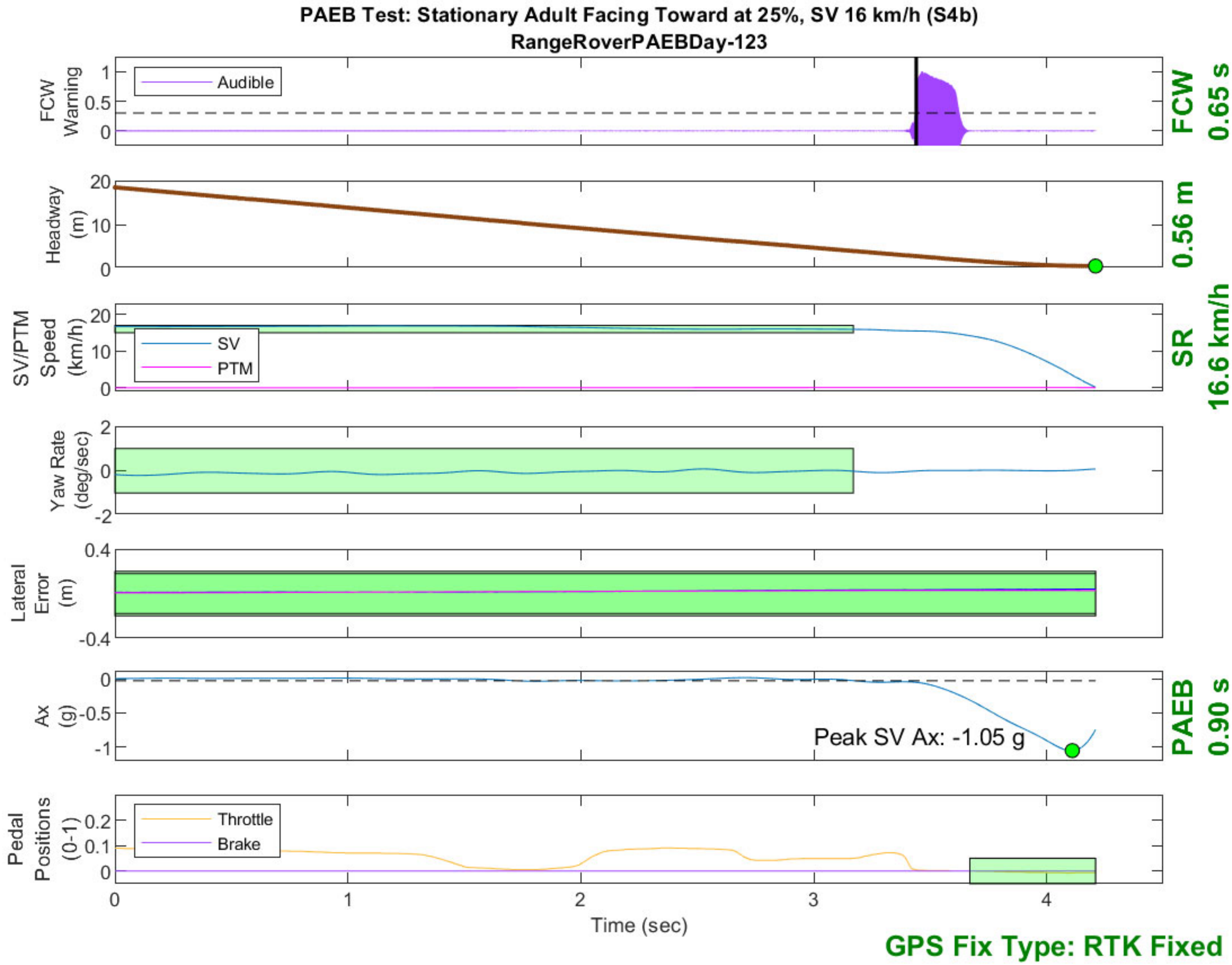


Figure D112. Time History for PAEB Run 123, S4b, Daytime, 16 km/h

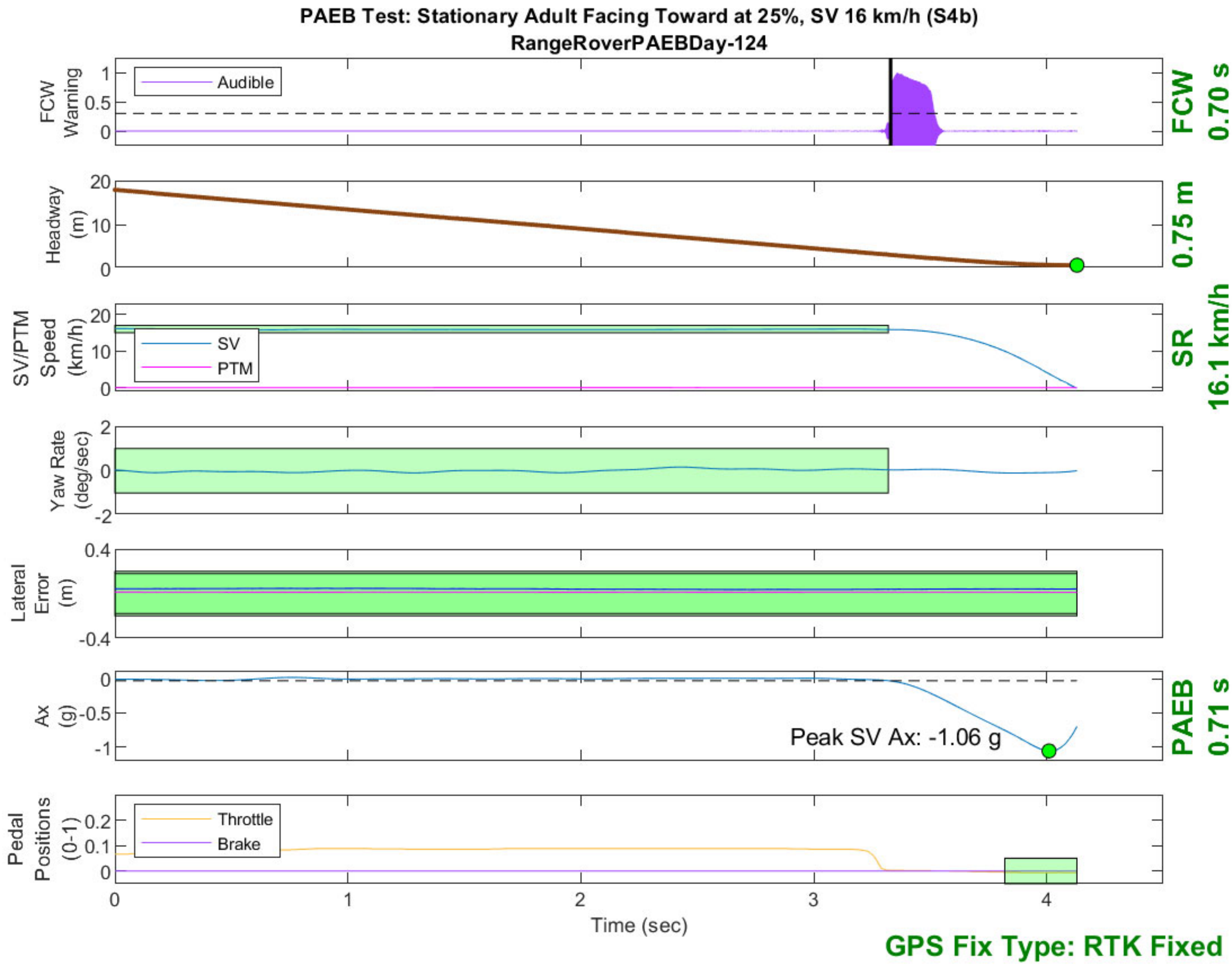


Figure D113. Time History for PAEB Run 124, S4b, Daytime, 16 km/h

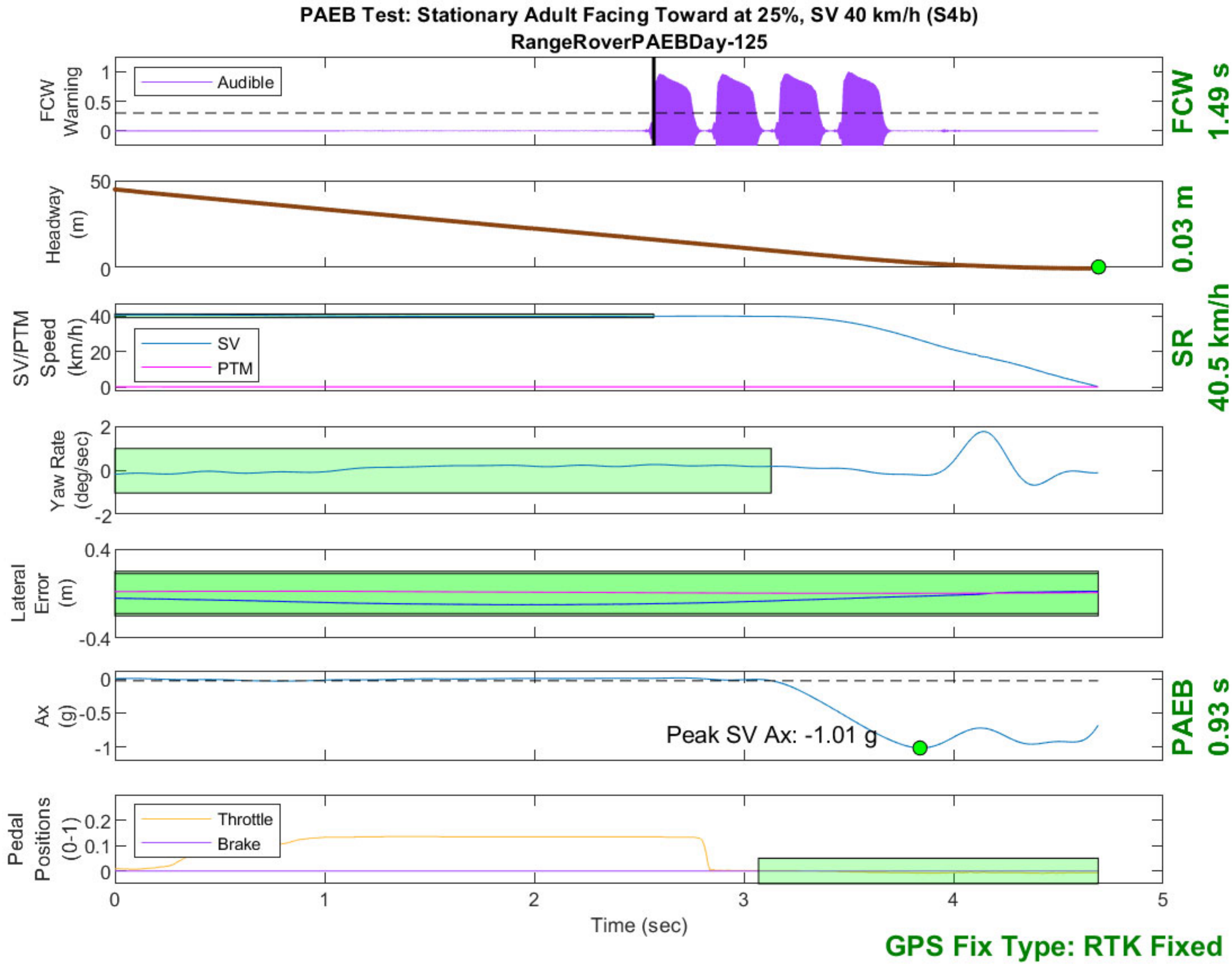


Figure D114. Time History for PAEB Run 125, S4b, Daytime, 40 km/h

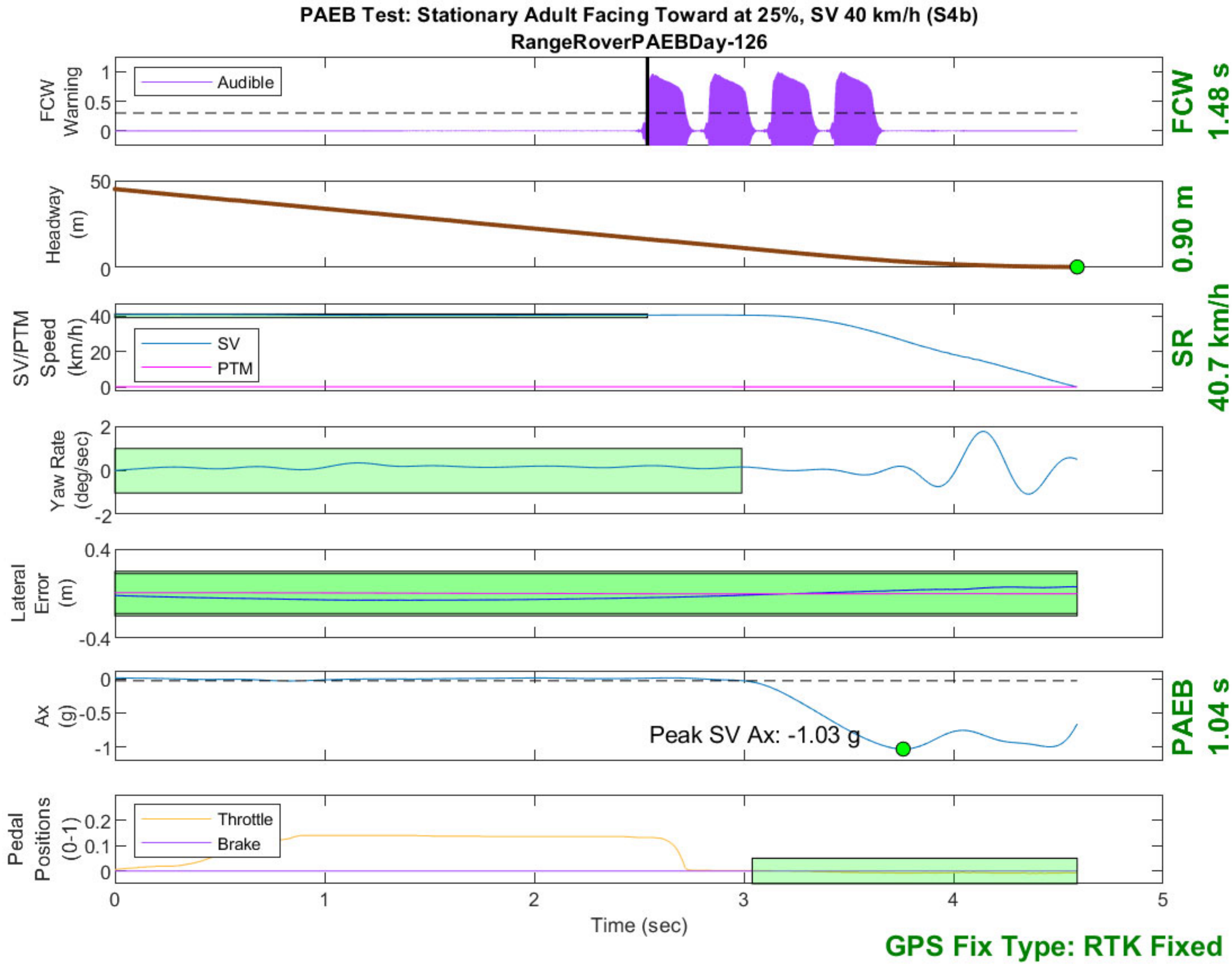


Figure D115. Time History for PAEB Run 126, S4b, Daytime, 40 km/h

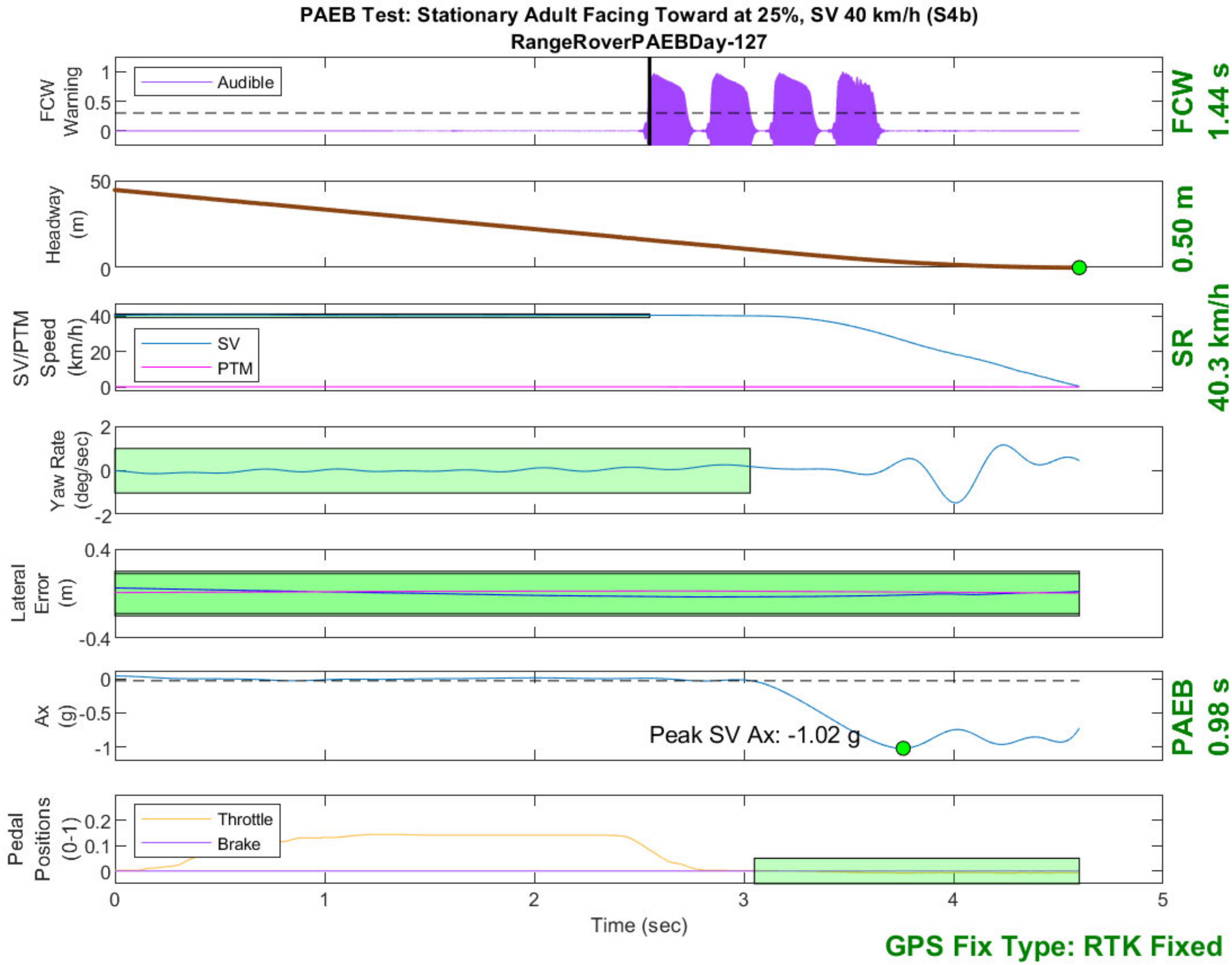


Figure D116. Time History for PAEB Run 127, S4b, Daytime, 40 km/h

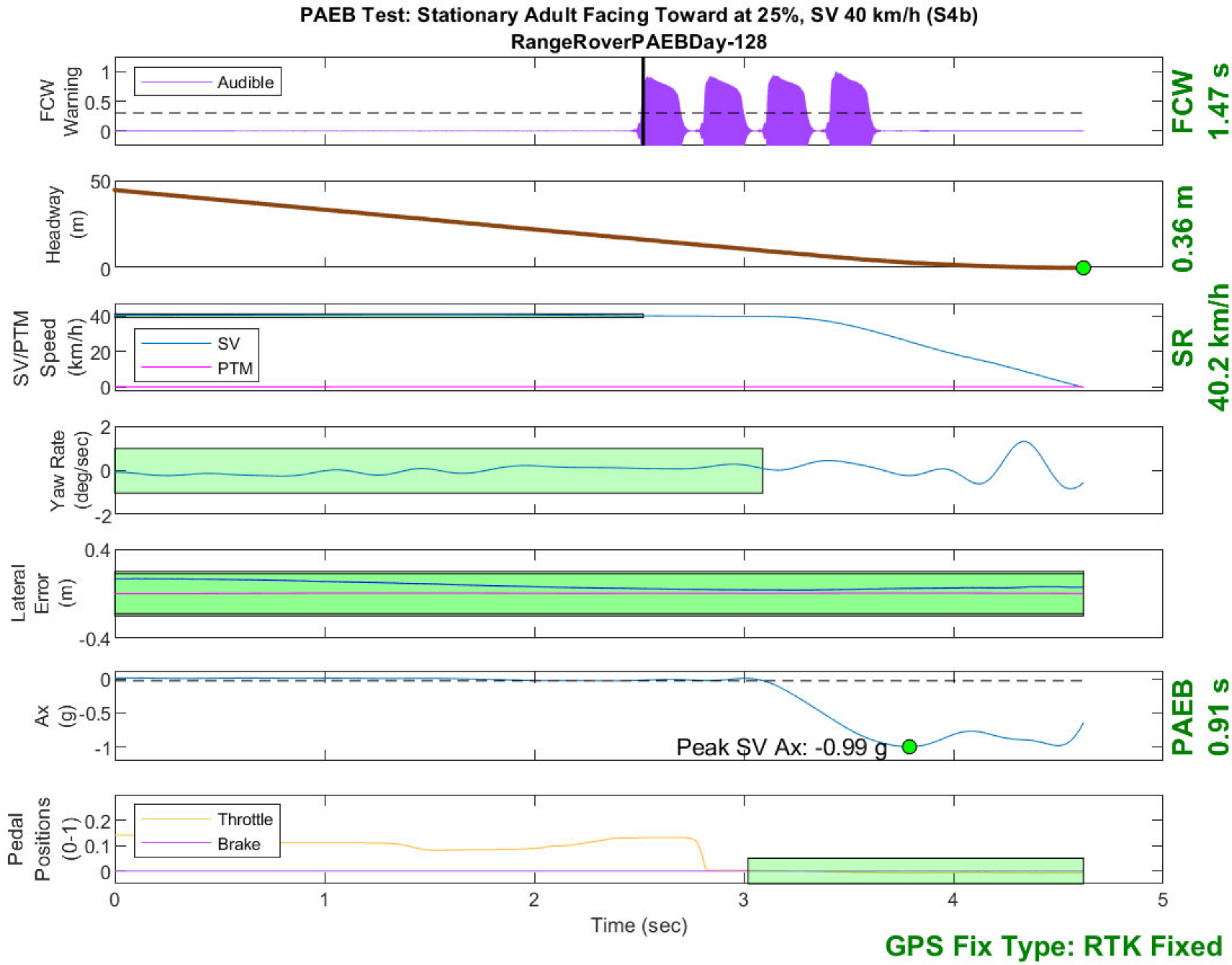


Figure D117. Time History for PAEB Run 128, S4b, Daytime, 40 km/h

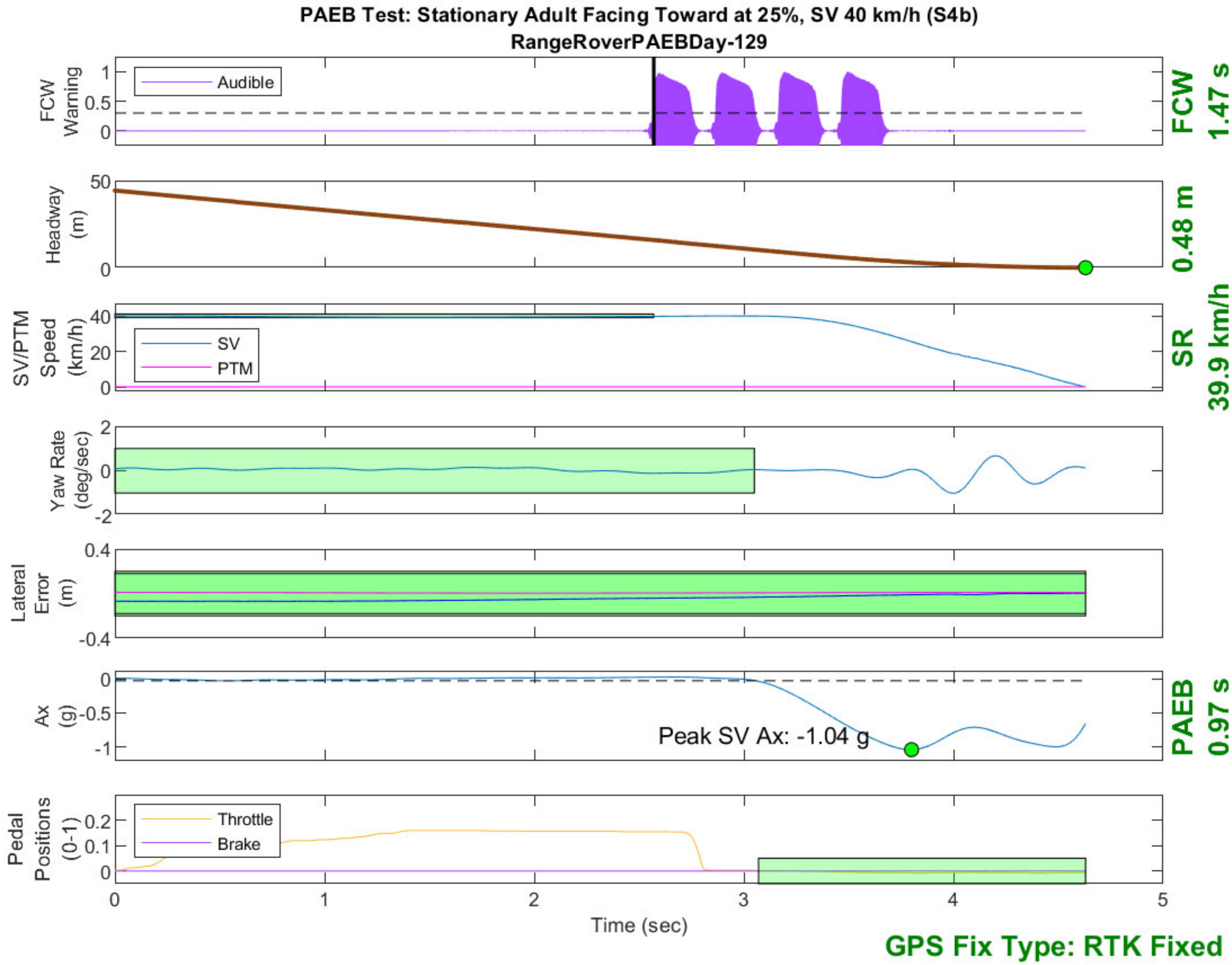


Figure D118. Time History for PAEB Run 129, S4b, Daytime, 40 km/h

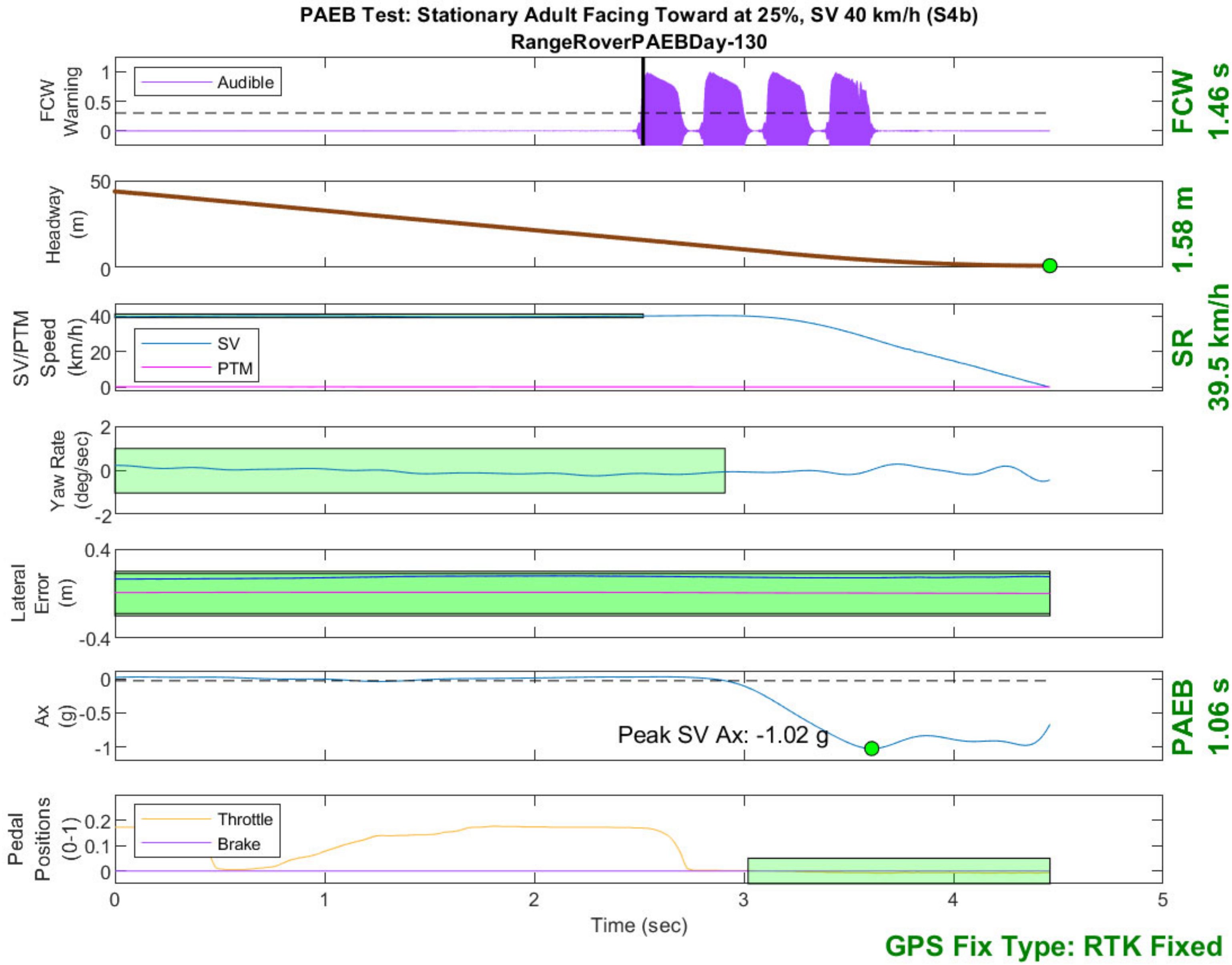


Figure D119. Time History for PAEB Run 130, S4b, Daytime, 40 km/h

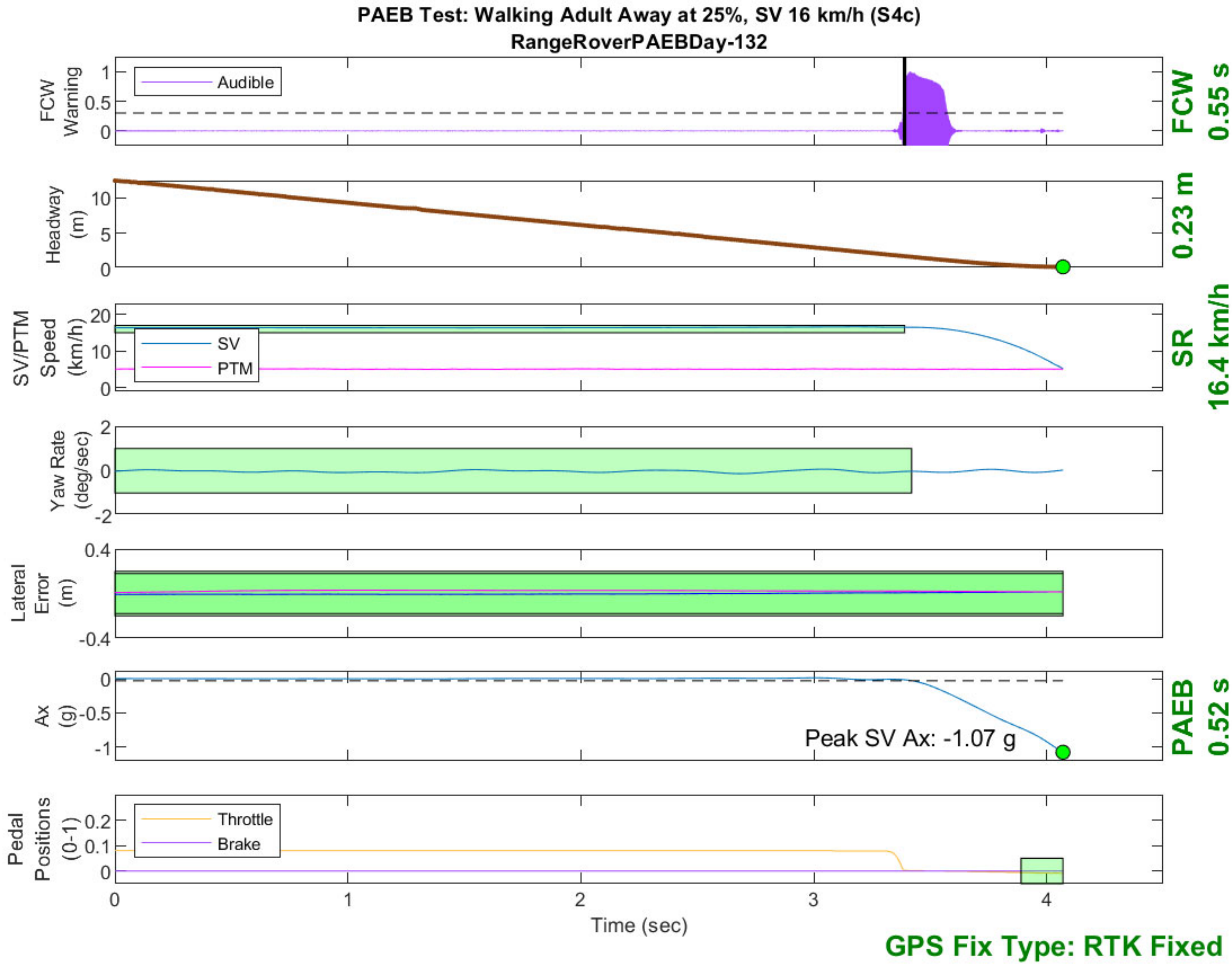


Figure D120. Time History for PAEB Run 132, S4c, Daytime, 16 km/h

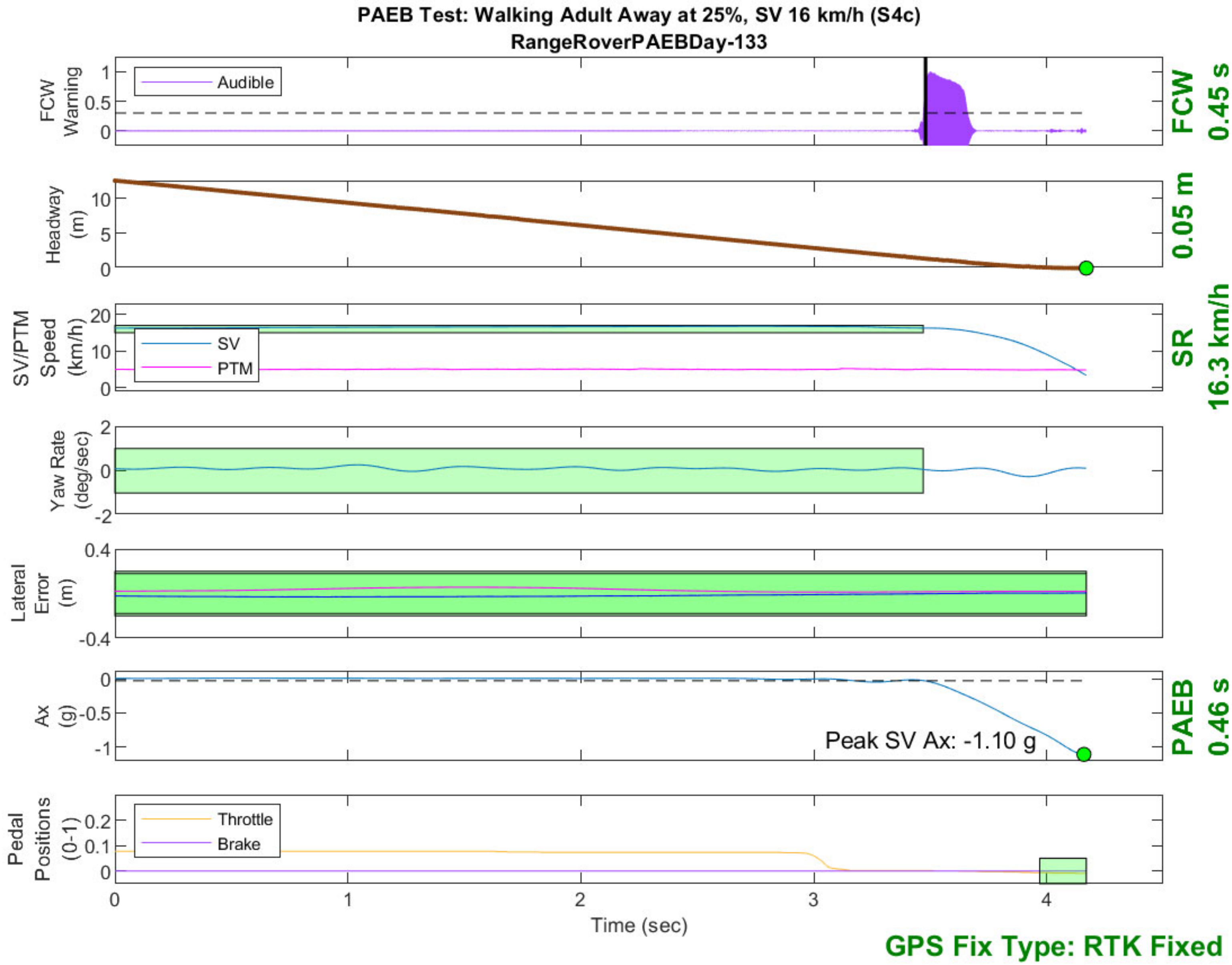


Figure D121. Time History for PAEB Run 133, S4c, Daytime, 16 km/h

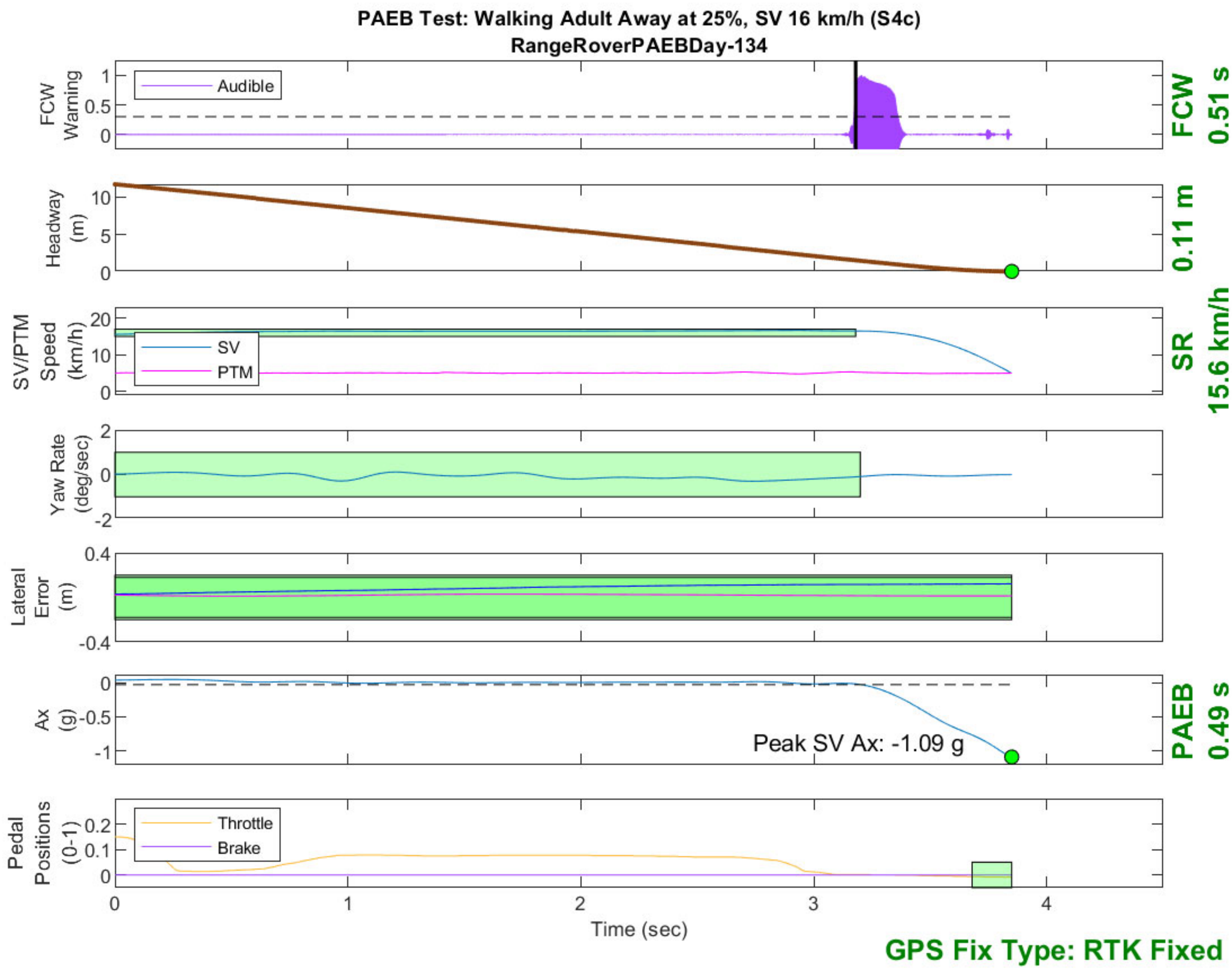


Figure D122. Time History for PAEB Run 134, S4c, Daytime, 16 km/h

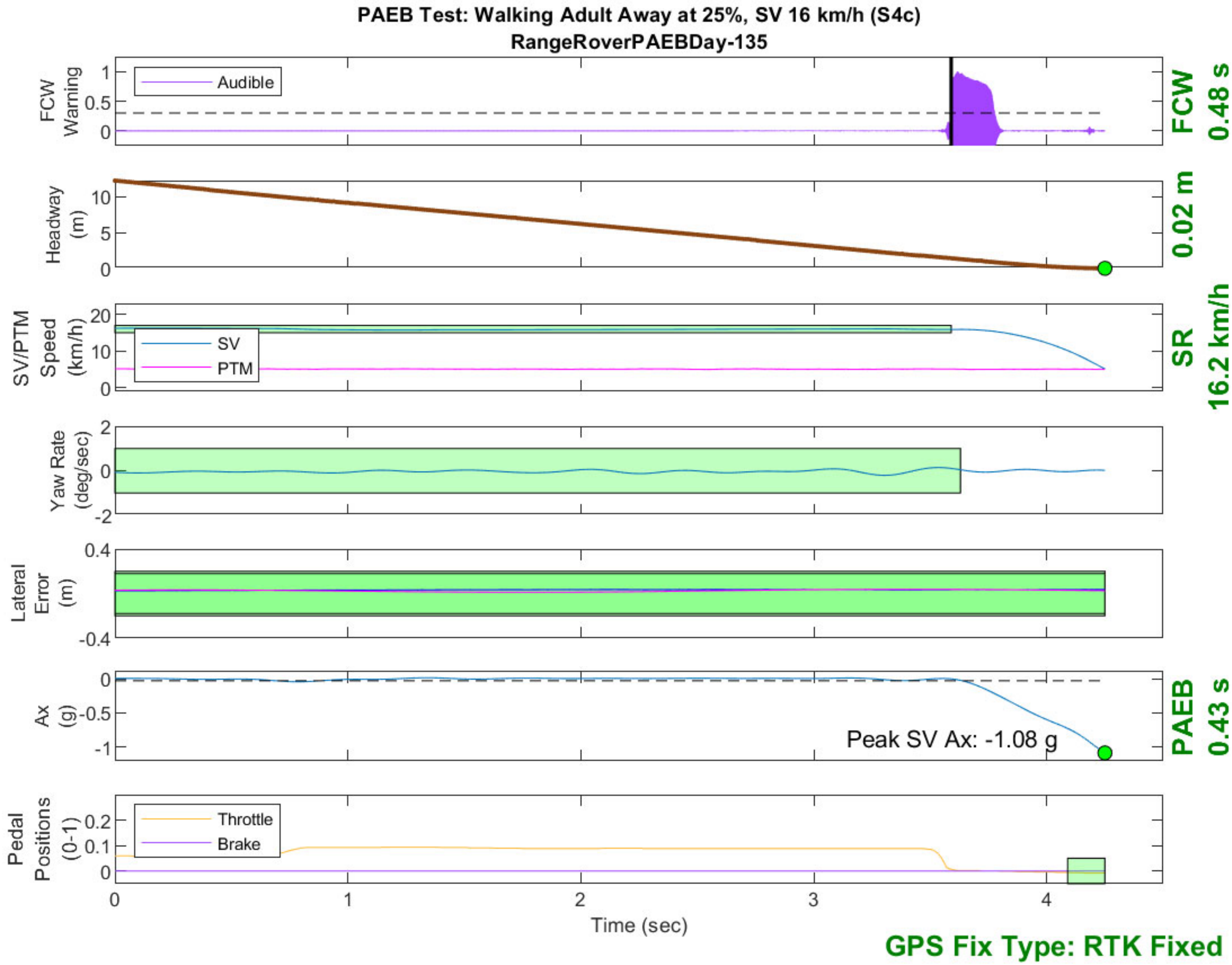


Figure D123. Time History for PAEB Run 135, S4c, Daytime, 16 km/h

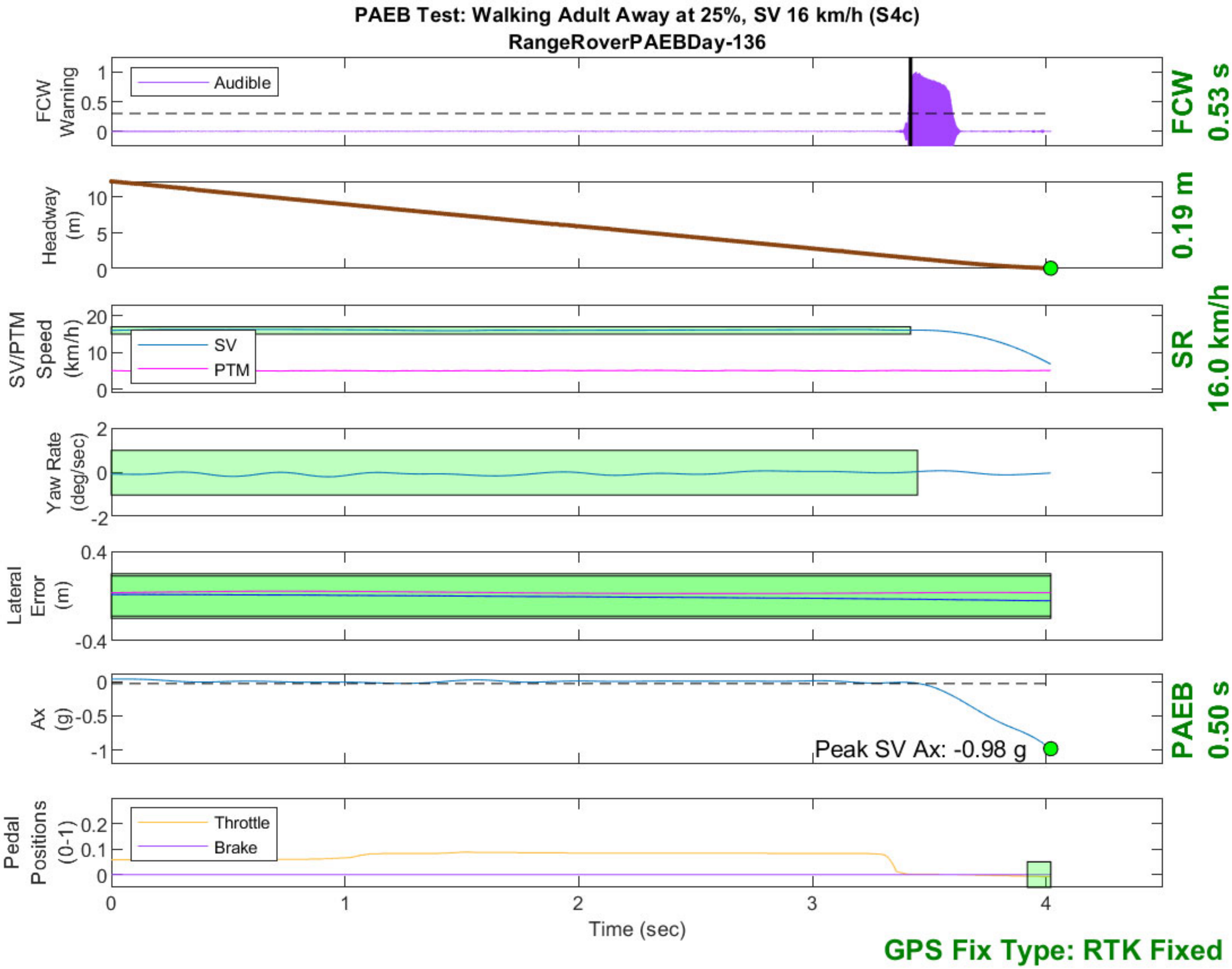


Figure D124. Time History for PAEB Run 136, S4c, Daytime, 16 km/h

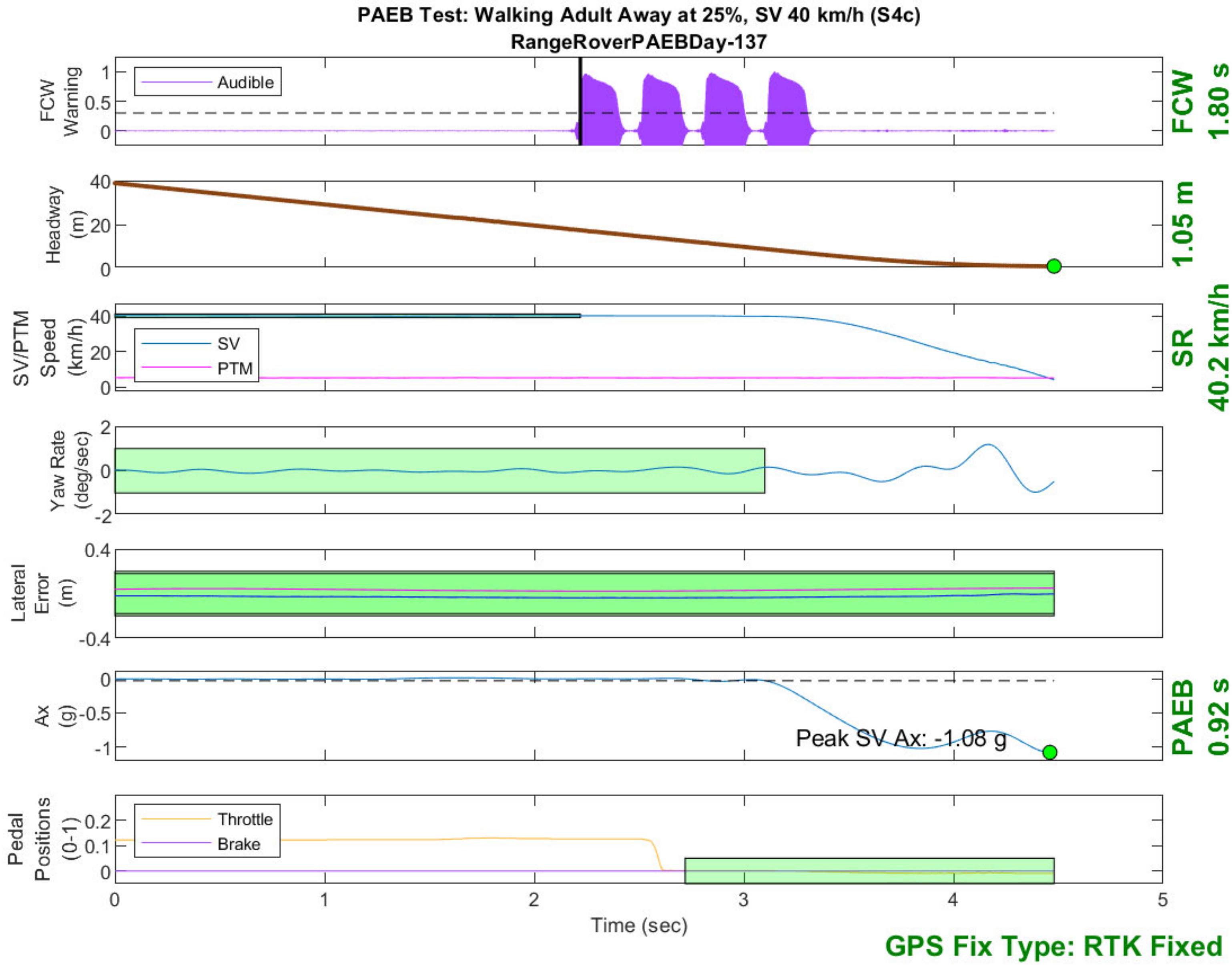


Figure D125. Time History for PAEB Run 137, S4c, Daytime, 40 km/h

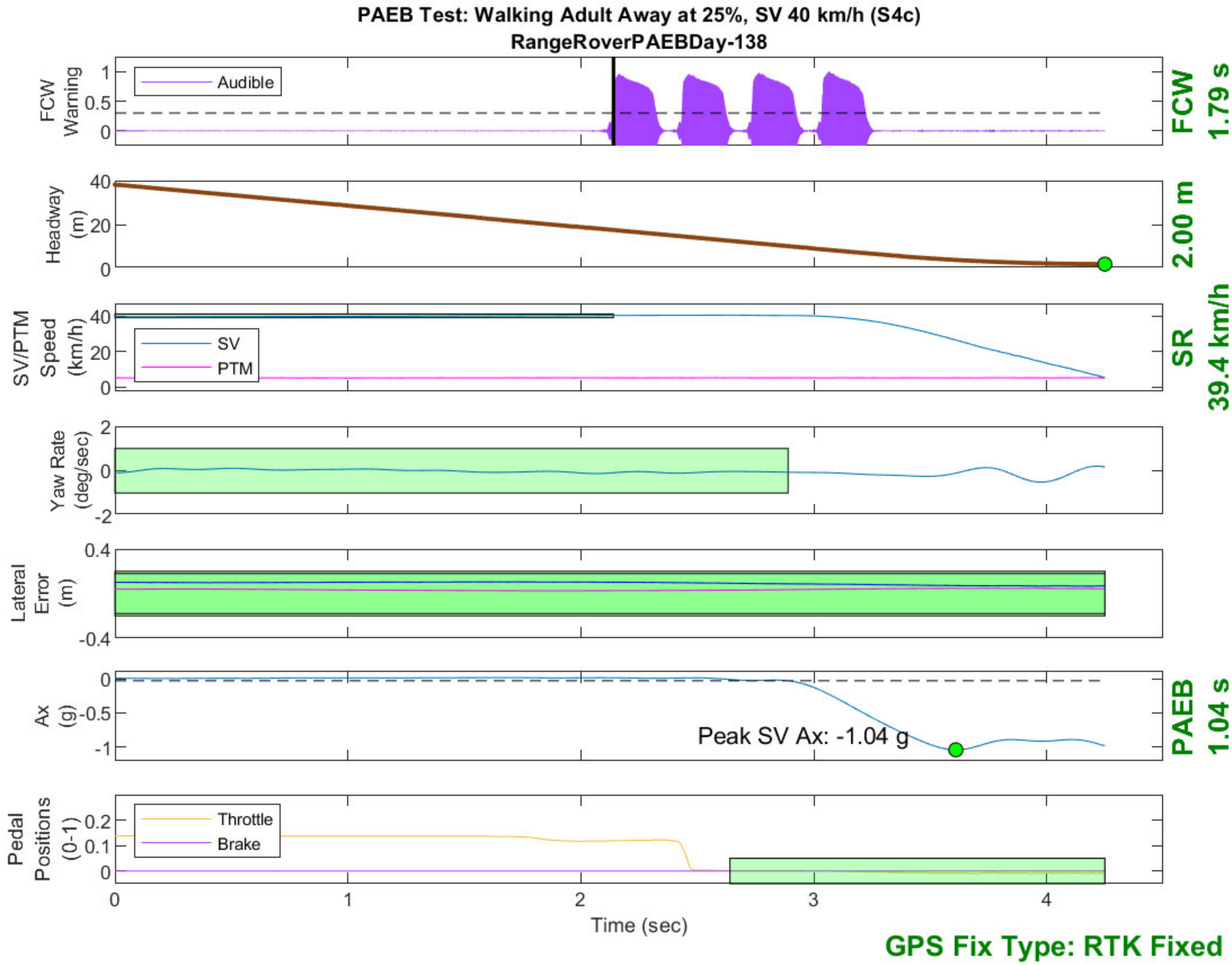


Figure D126. Time History for PAEB Run 138, S4c, Daytime, 40 km/h

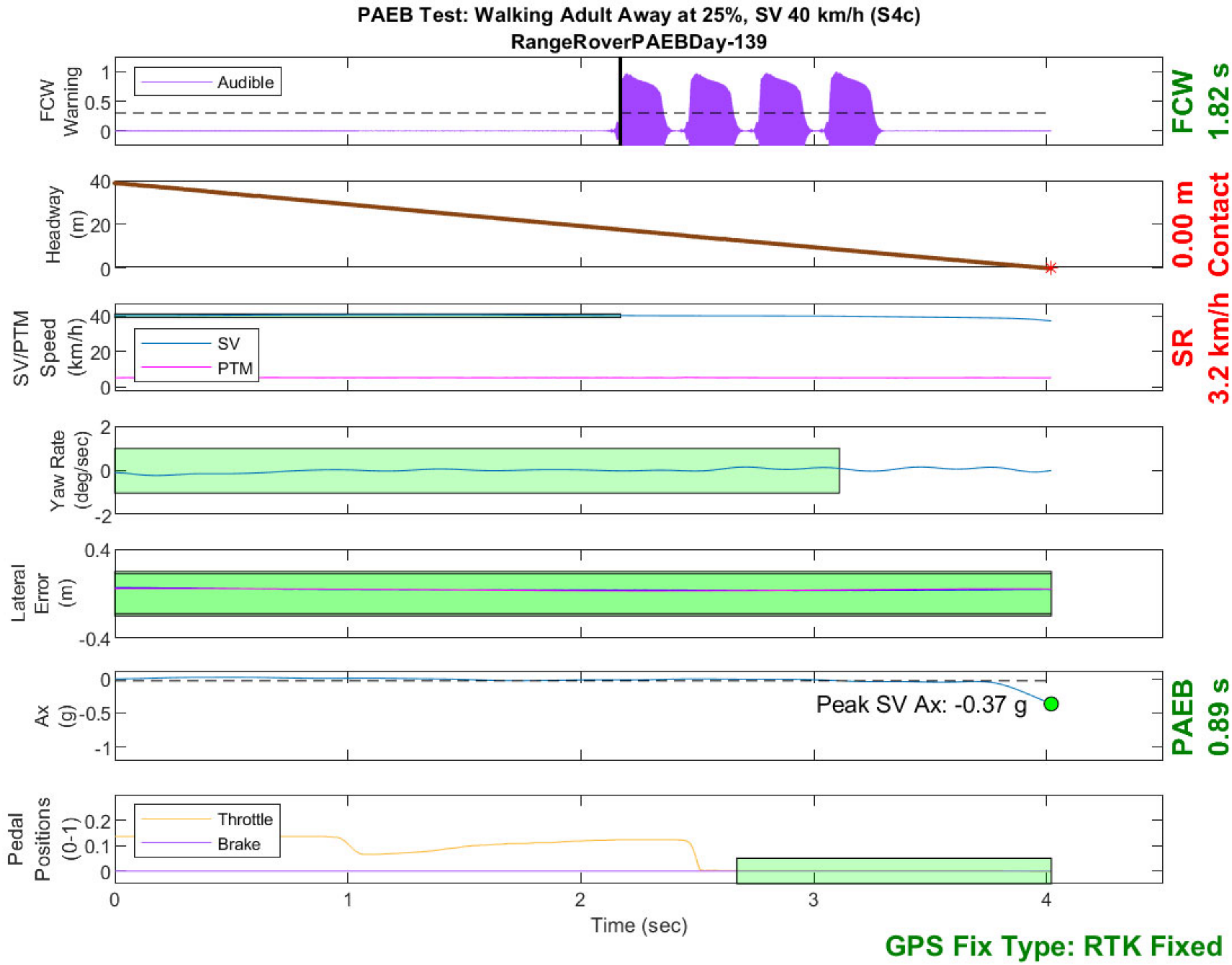


Figure D127. Time History for PAEB Run 139, S4c, Daytime, 40 km/h

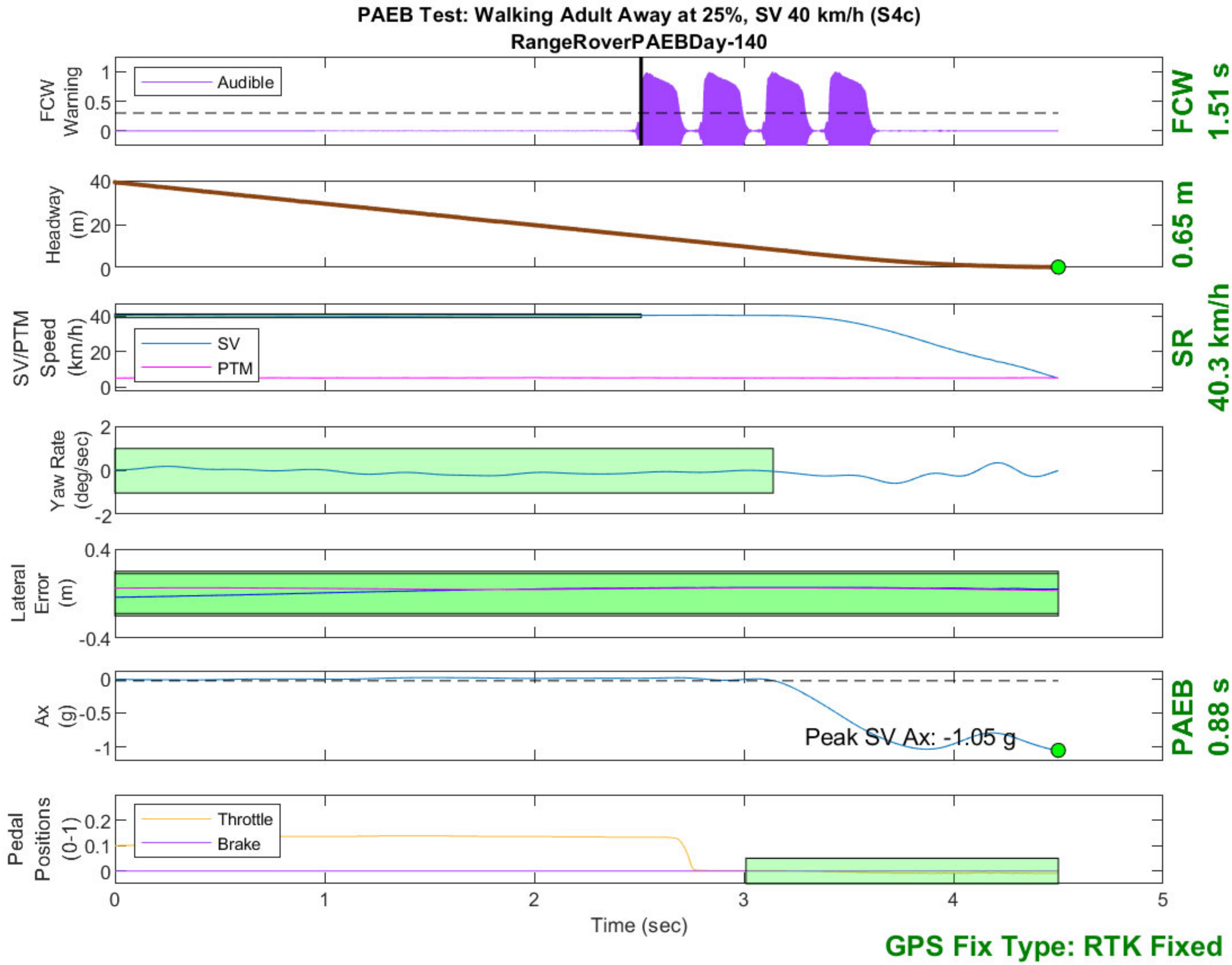


Figure D128. Time History for PAEB Run 140, S4c, Daytime, 40 km/h

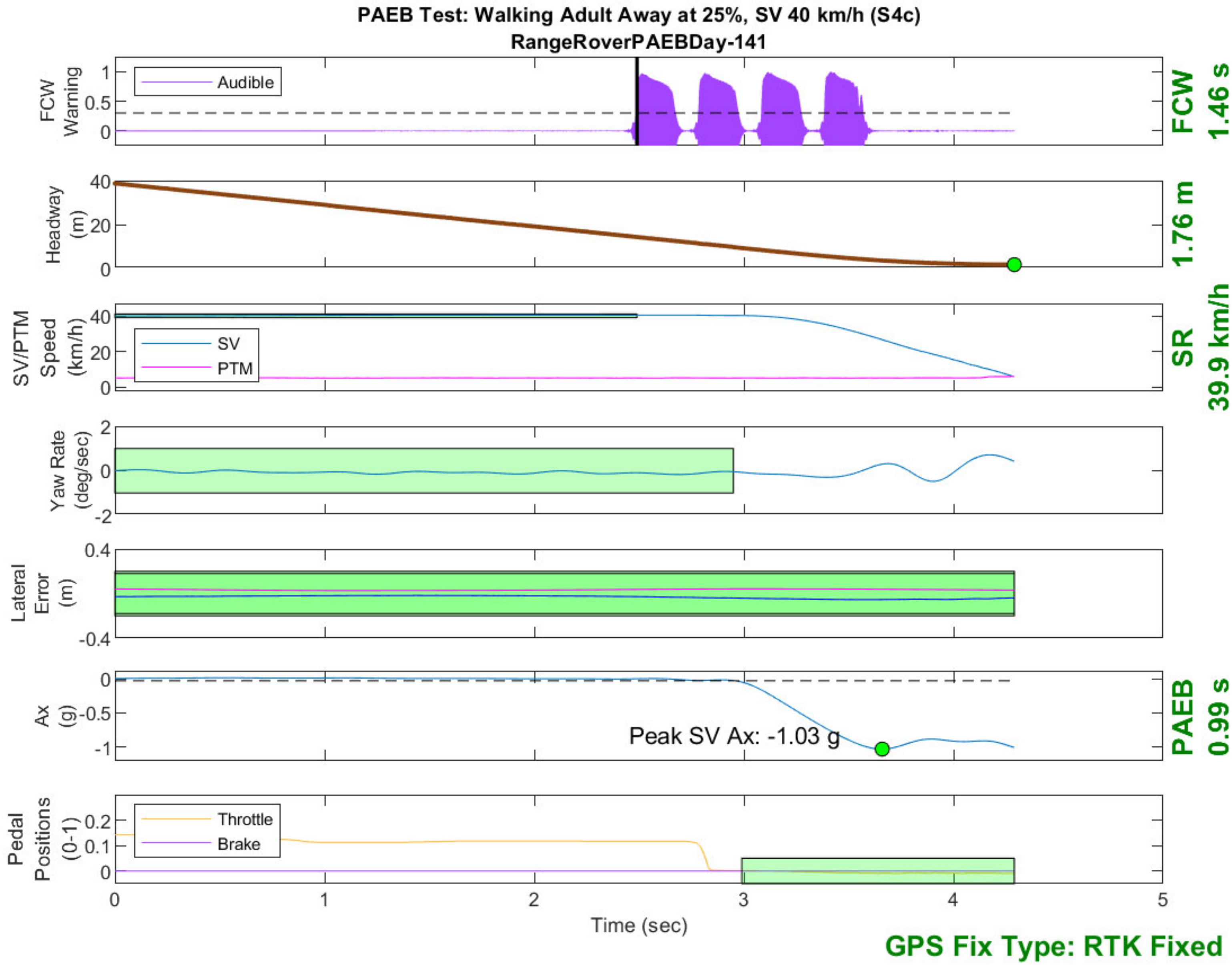


Figure D129. Time History for PAEB Run 141, S4c, Daytime, 40 km/h

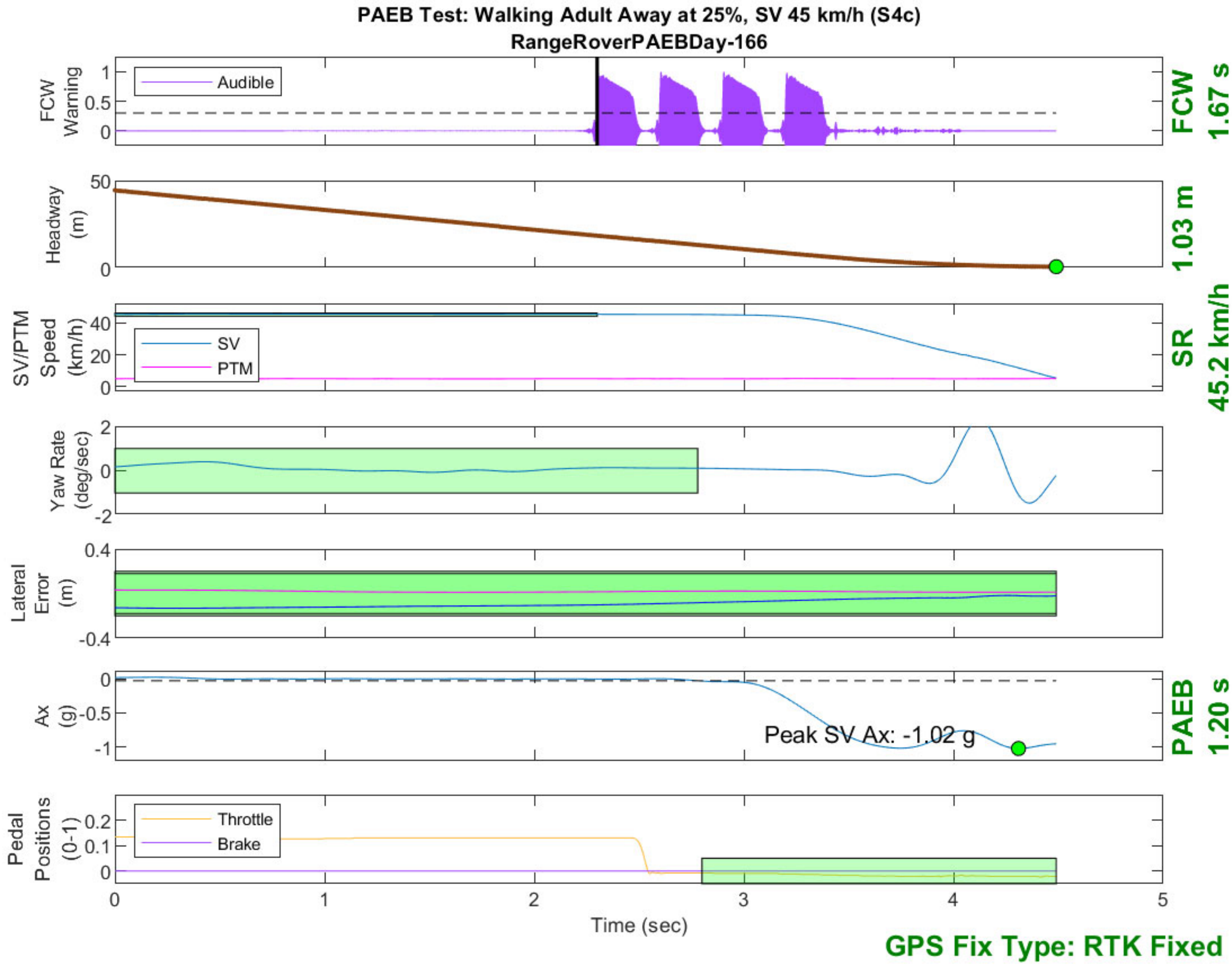


Figure D130. Time History for PAEB Run 166, S4c, Daytime, 45 km/h

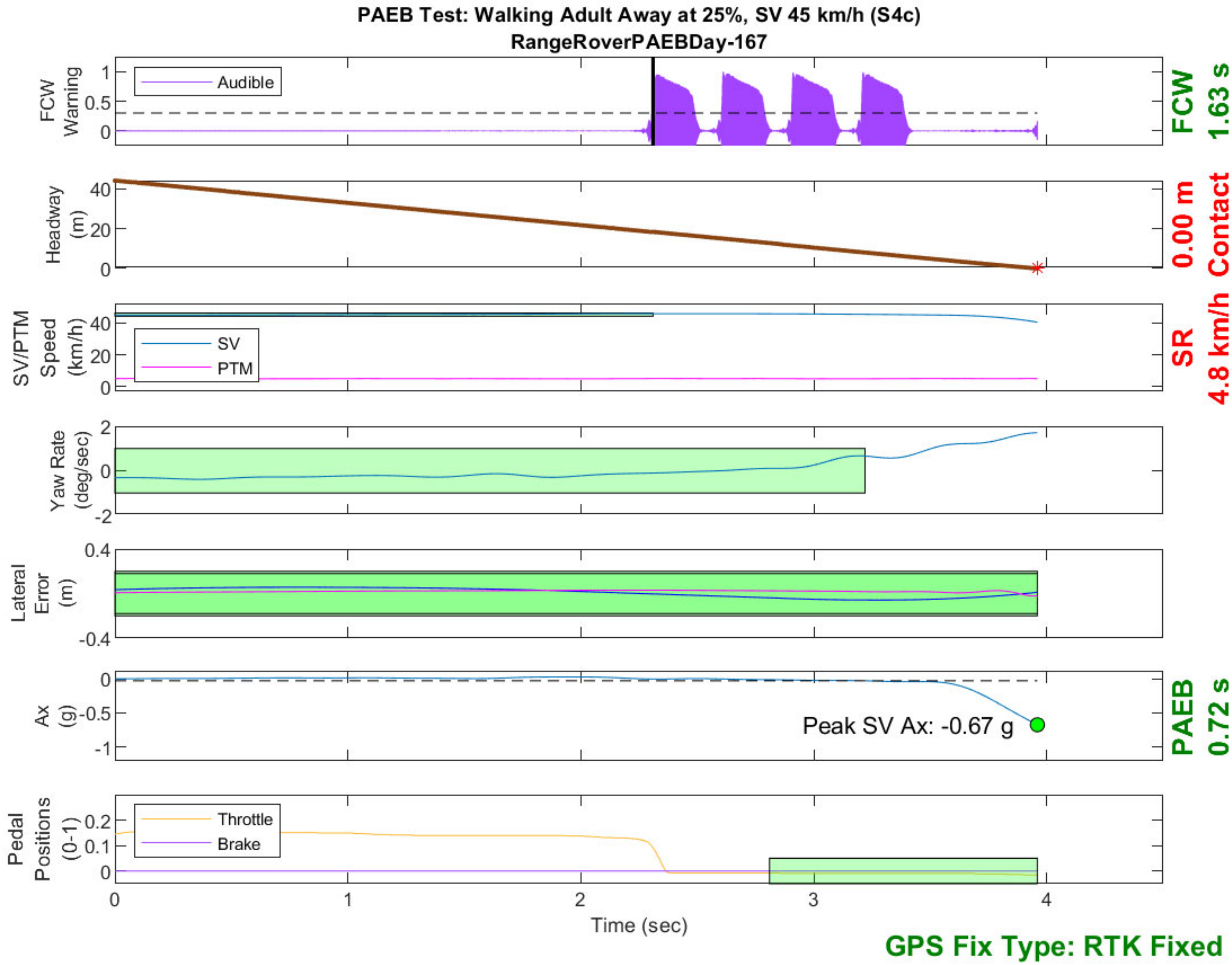


Figure D131. Time History for PAEB Run 167, S4c, Daytime, 45 km/h

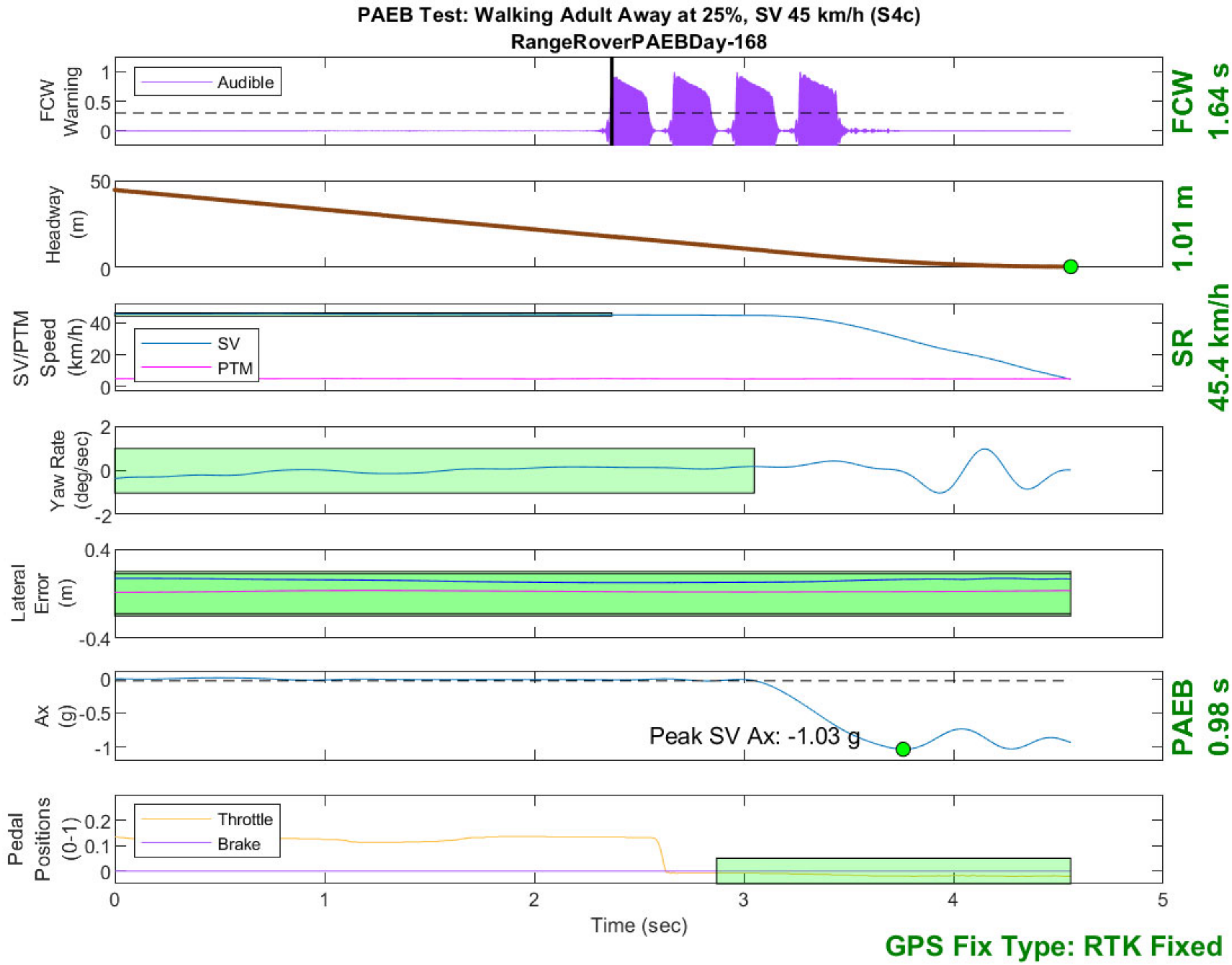


Figure D132. Time History for PAEB Run 168, S4c, Daytime, 45 km/h

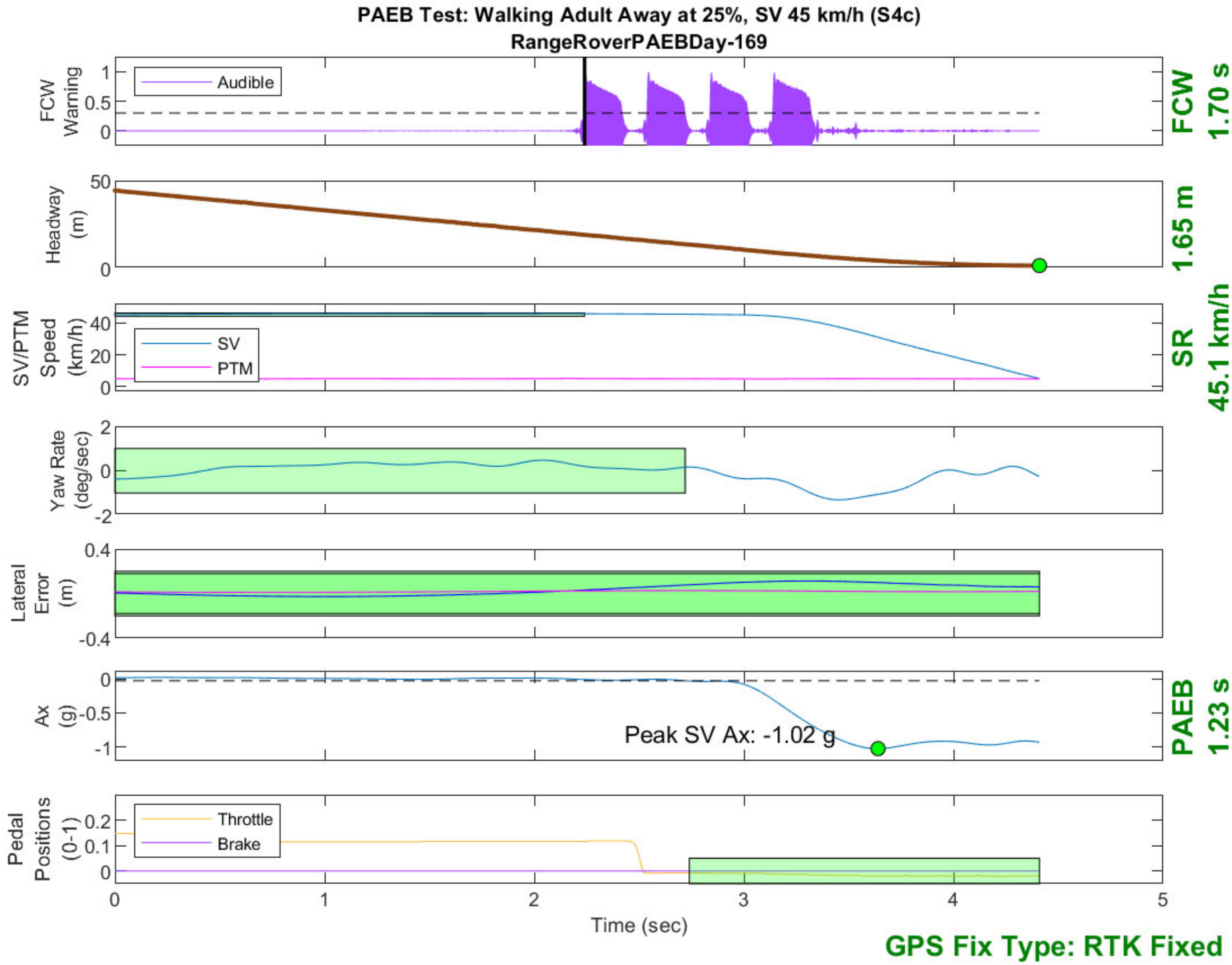


Figure D133. Time History for PAEB Run 169, S4c, Daytime, 45 km/h

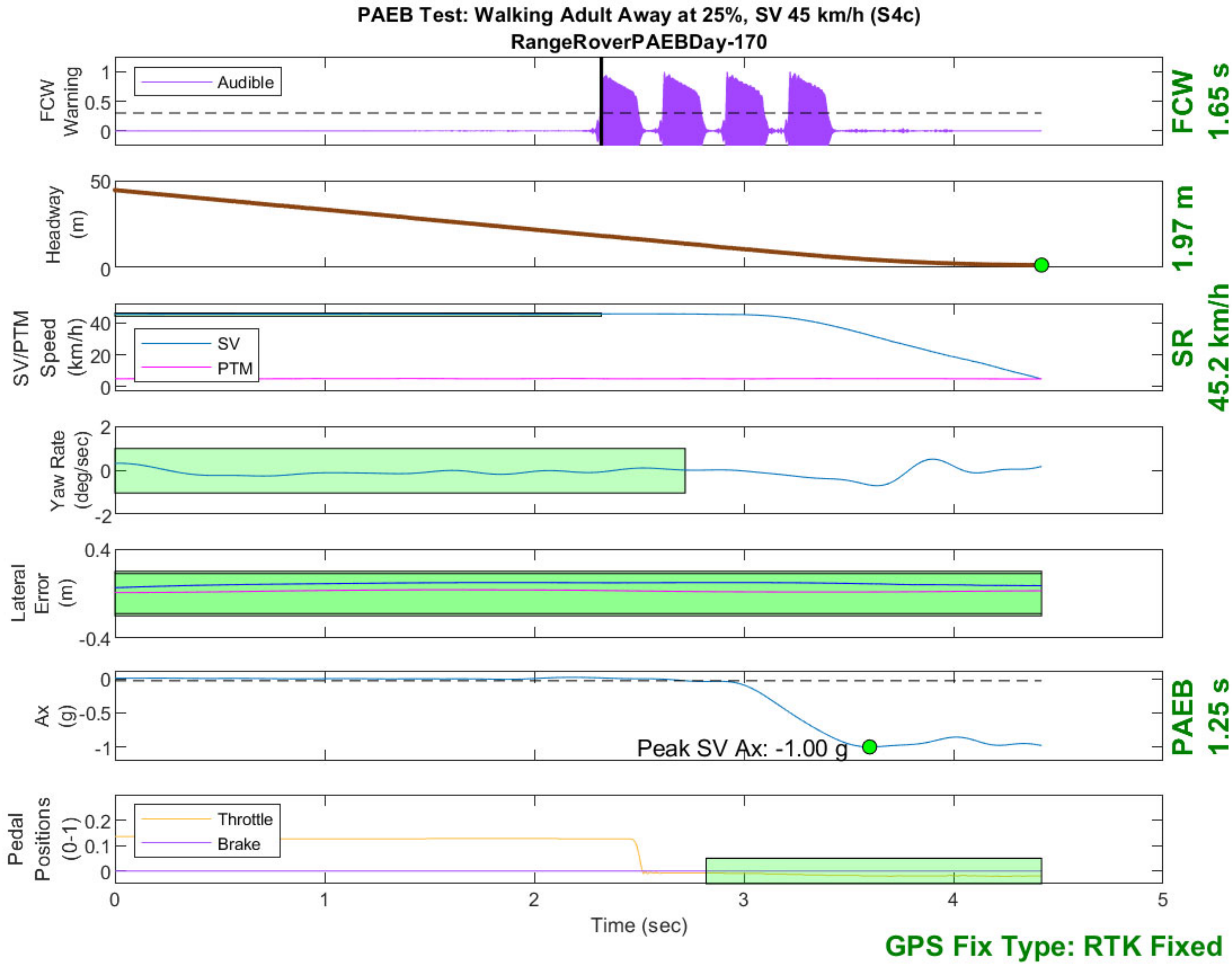


Figure D134. Time History for PAEB Run 170, S4c, Daytime, 45 km/h

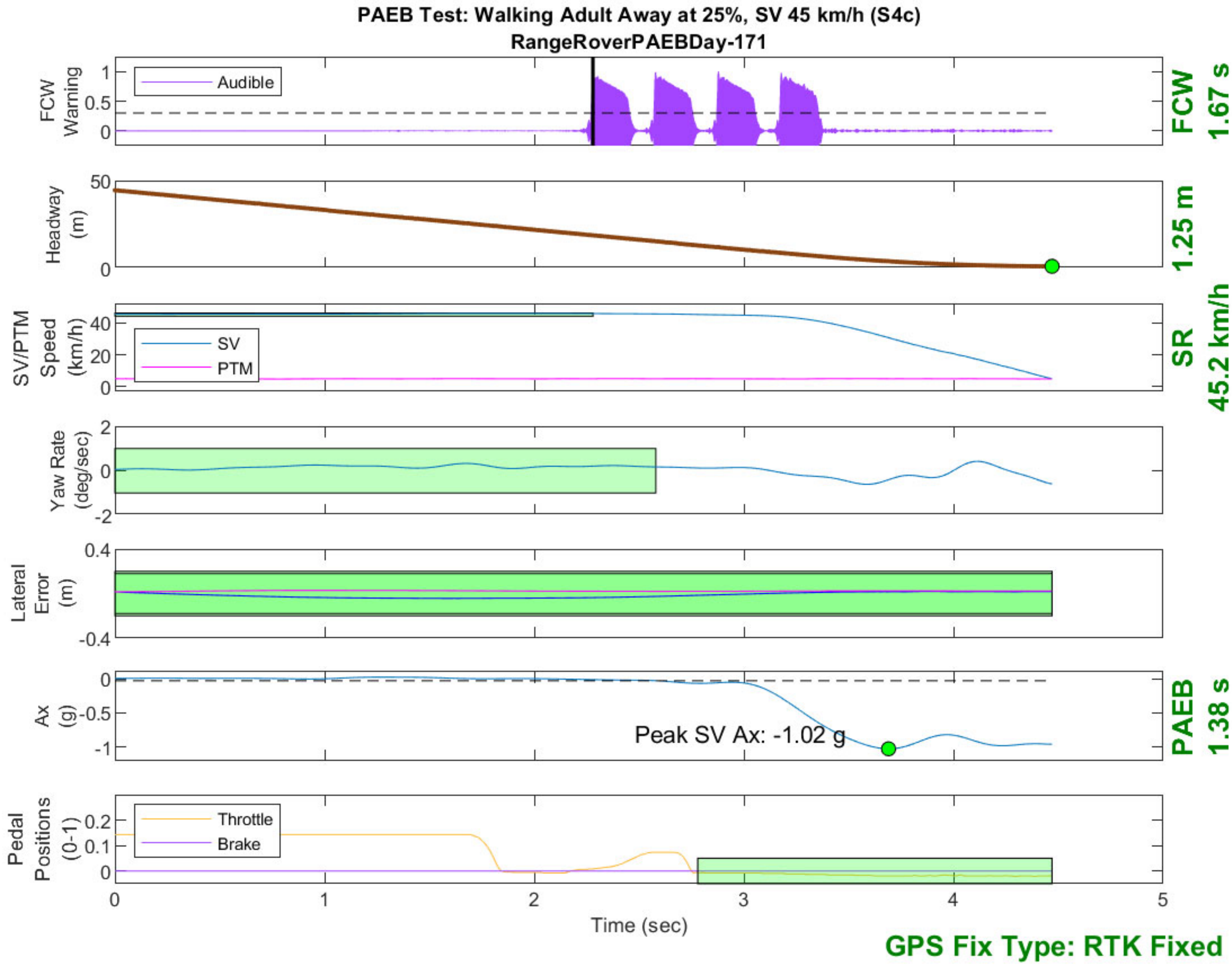


Figure D135. Time History for PAEB Run 171, S4c, Daytime, 45 km/h

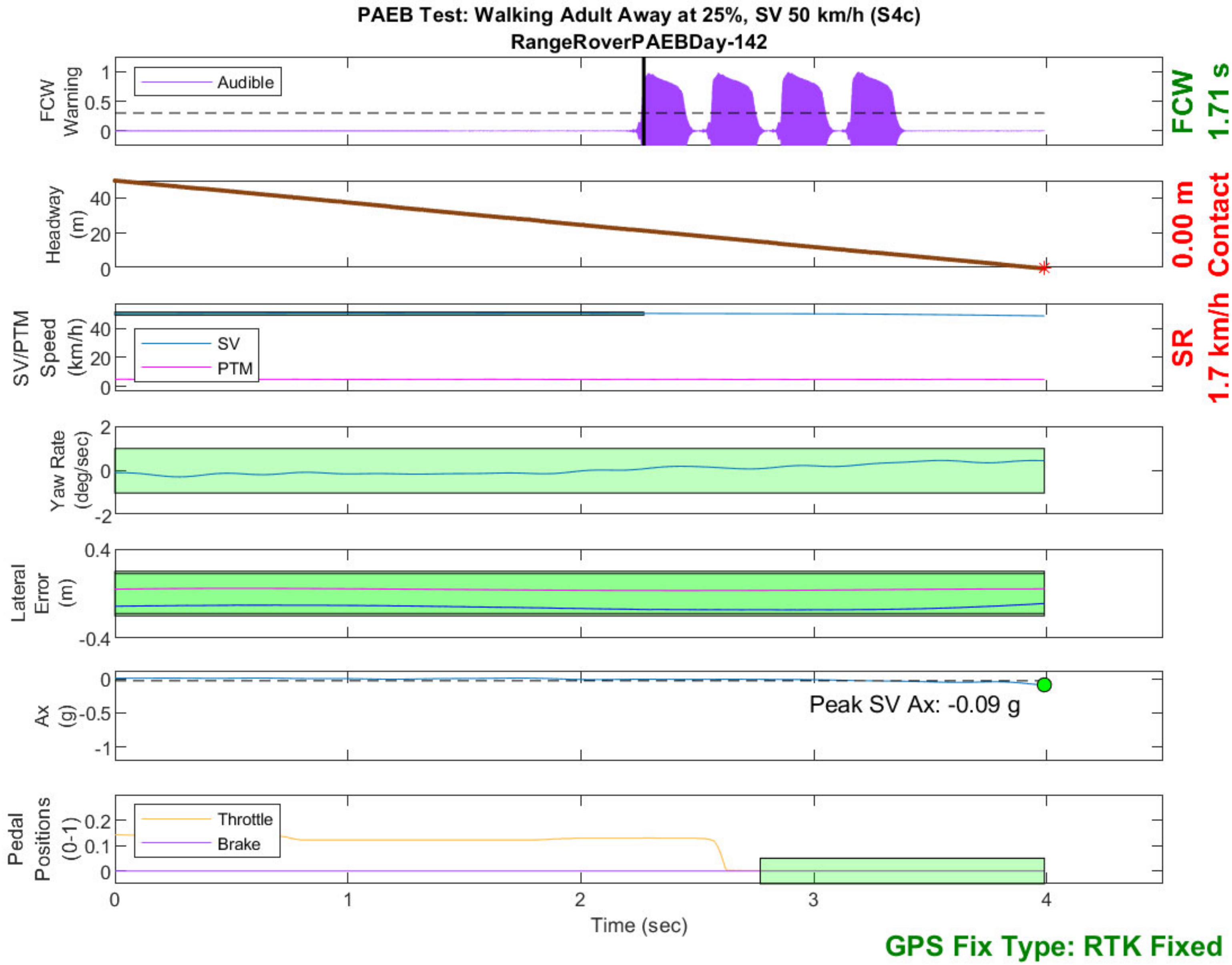


Figure D136. Time History for PAEB Run 142, S4c, Daytime, 50 km/h

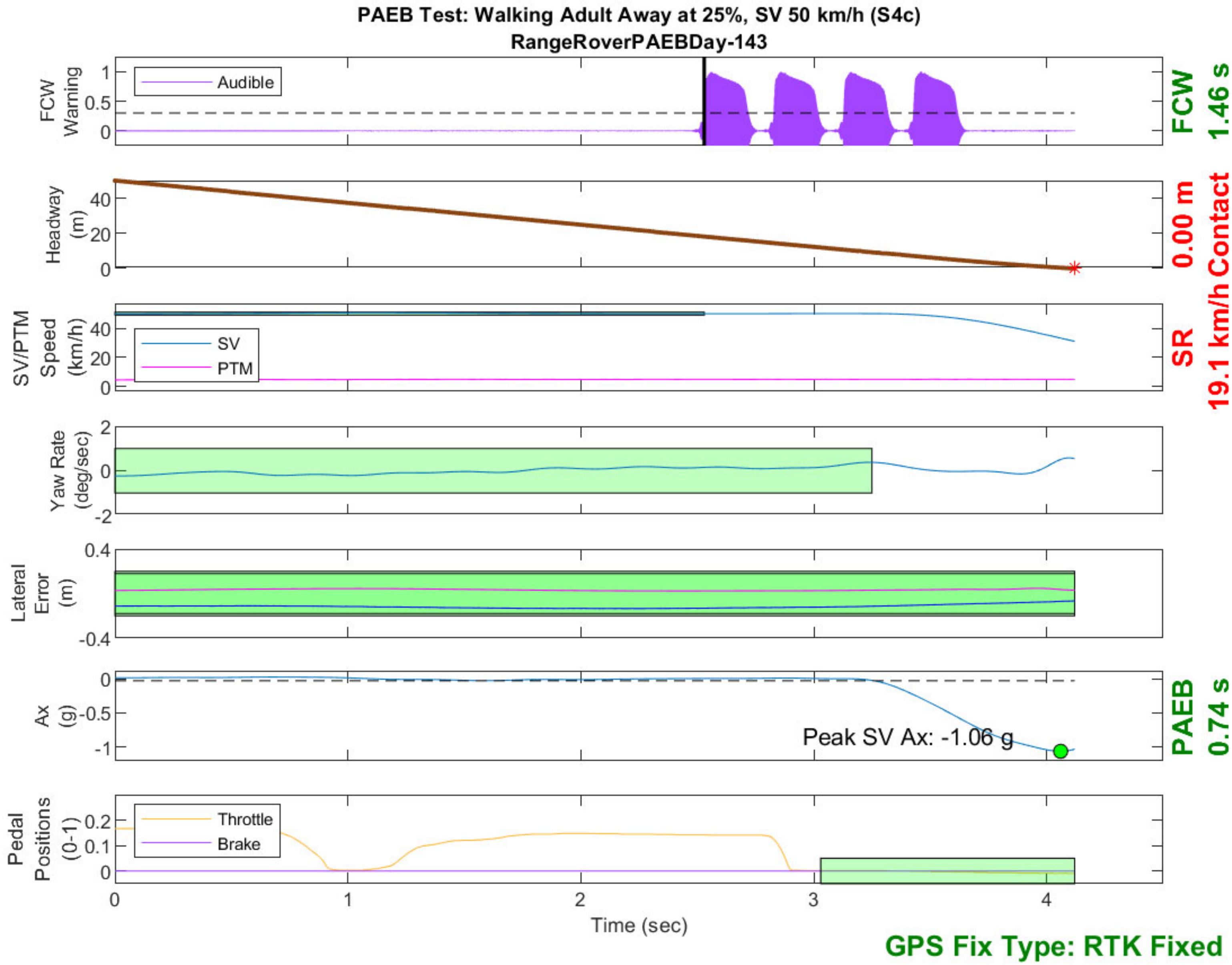


Figure D137. Time History for PAEB Run 143, S4c, Daytime, 50 km/h

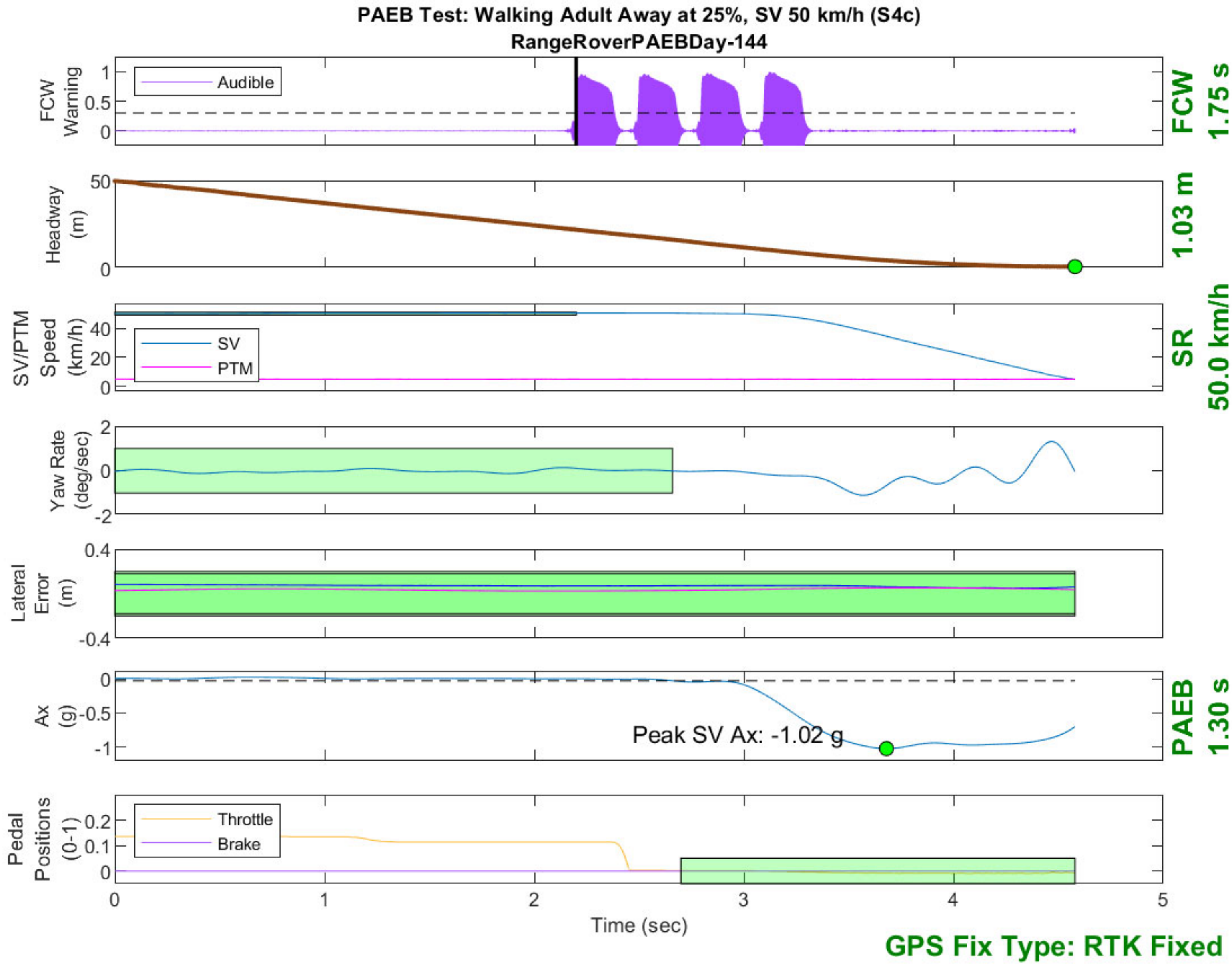


Figure D138. Time History for PAEB Run 144, S4c, Daytime, 50 km/h

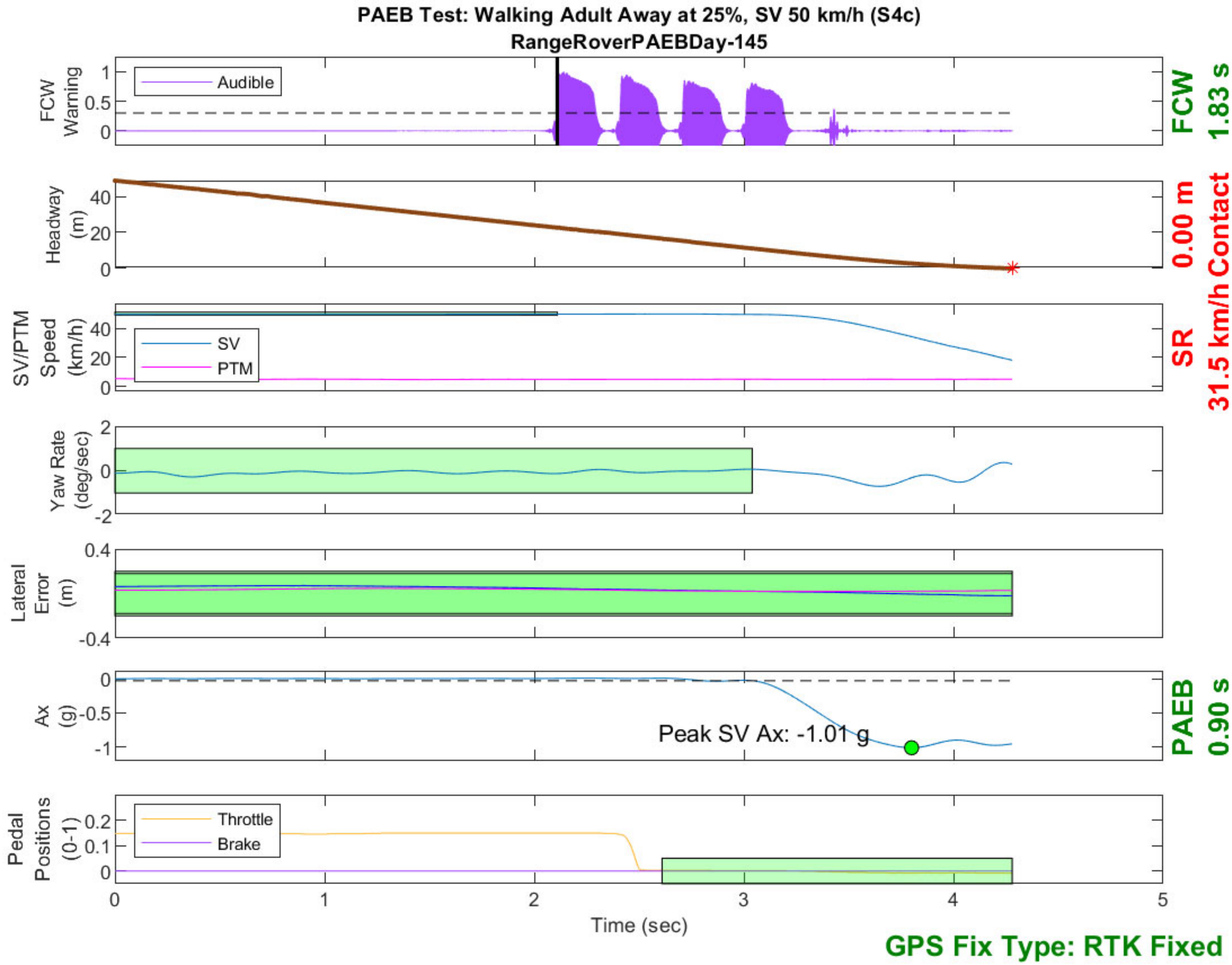


Figure D139. Time History for PAEB Run 145, S4c, Daytime, 50 km/h

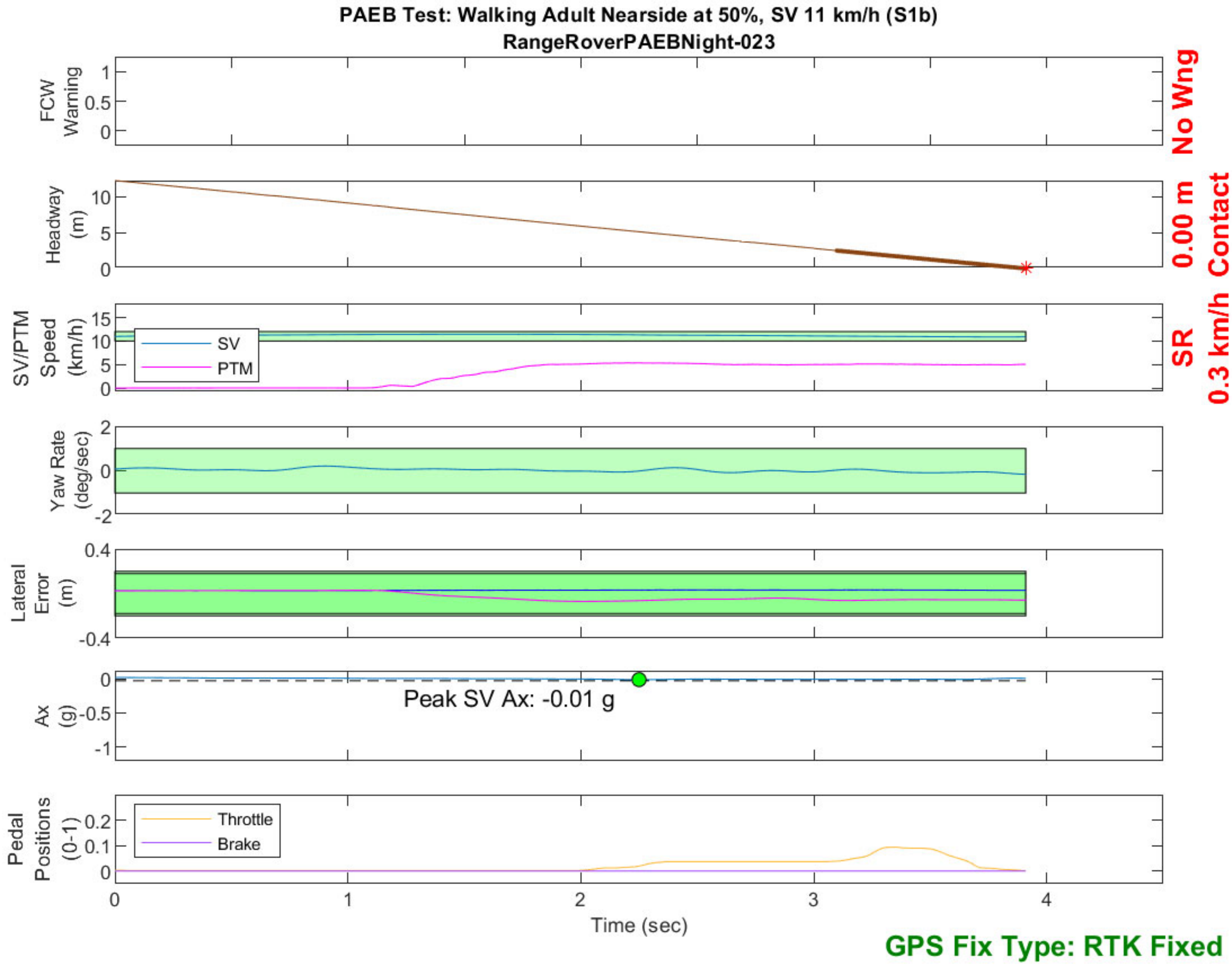


Figure D140. Time History for PAEB Run 23, S1b, Night, High Beam, 11 km/h

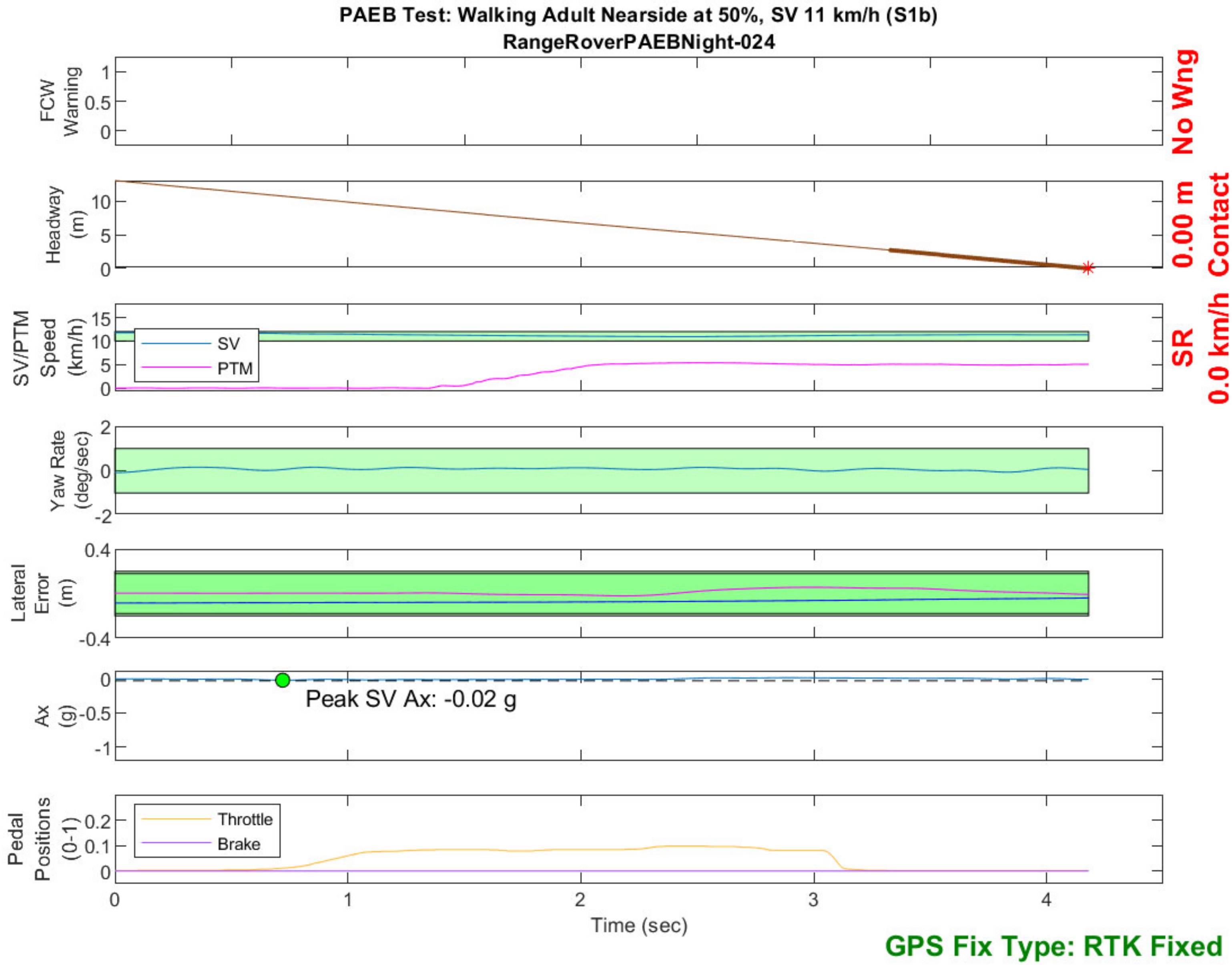


Figure D141. Time History for PAEB Run 24, S1b, Night, High Beam, 11 km/h

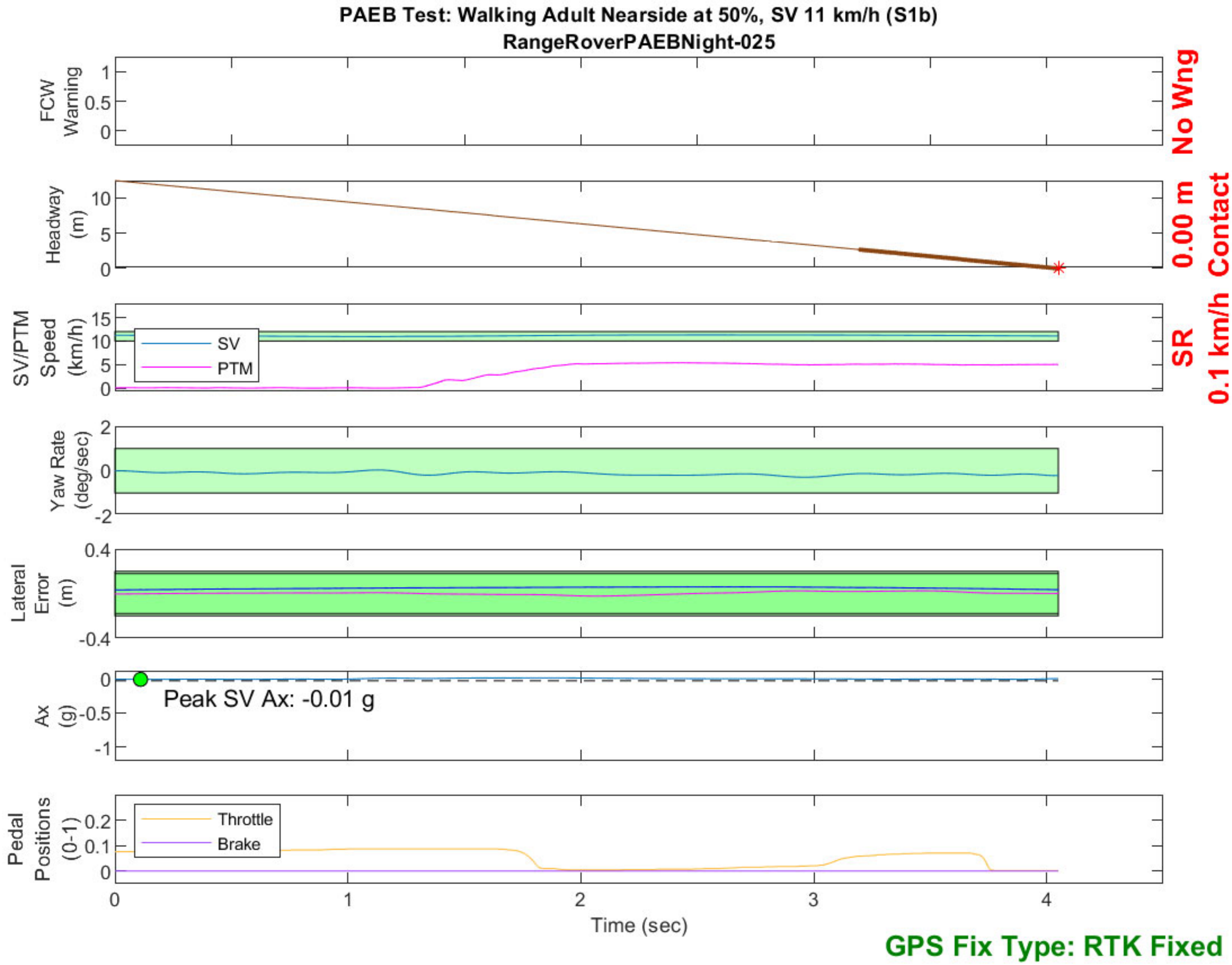


Figure D142. Time History for PAEB Run 25, S1b, Night, High Beam, 11 km/h

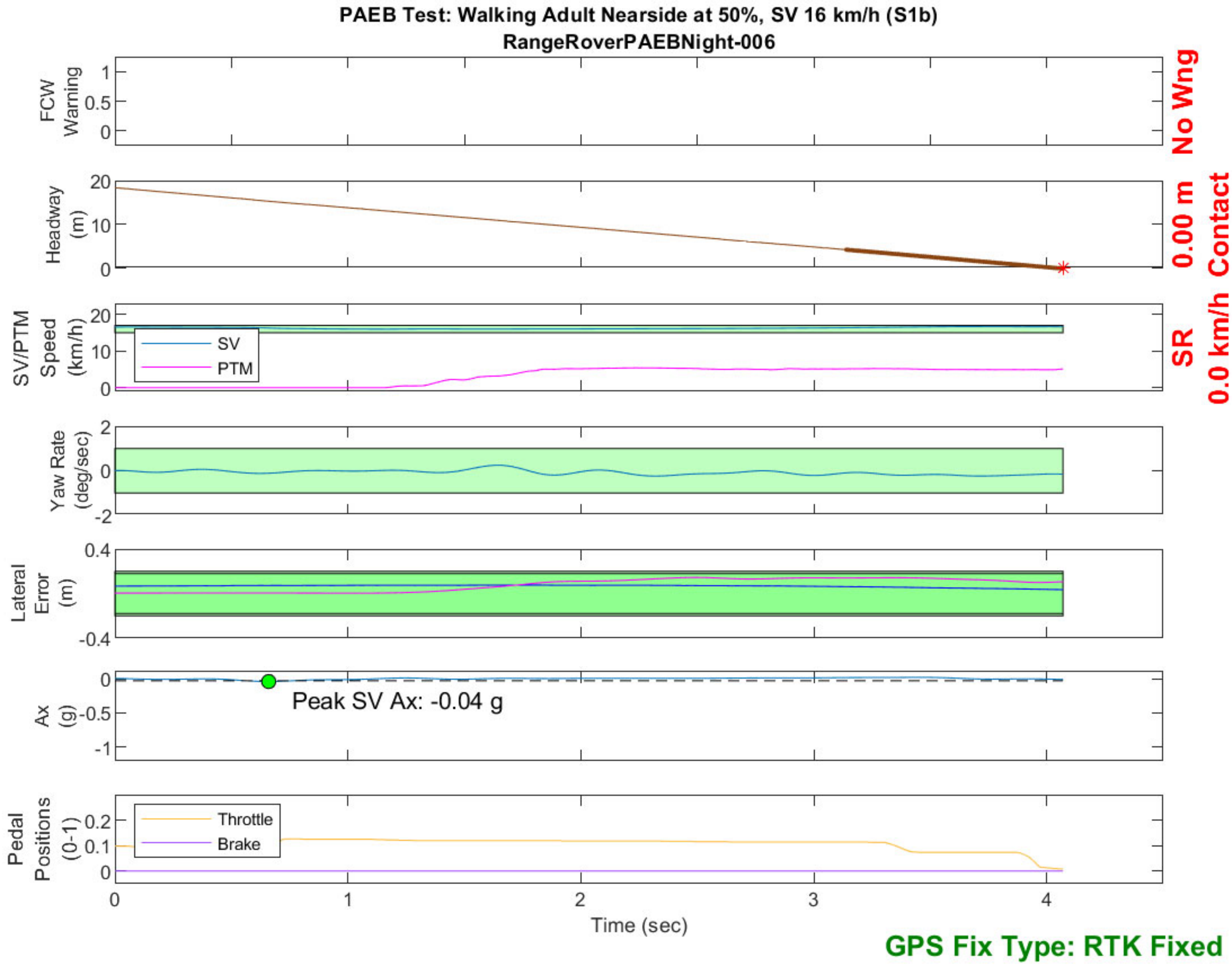


Figure D143. Time History for PAEB Run 6, S1b, Night, High Beam, 16 km/h

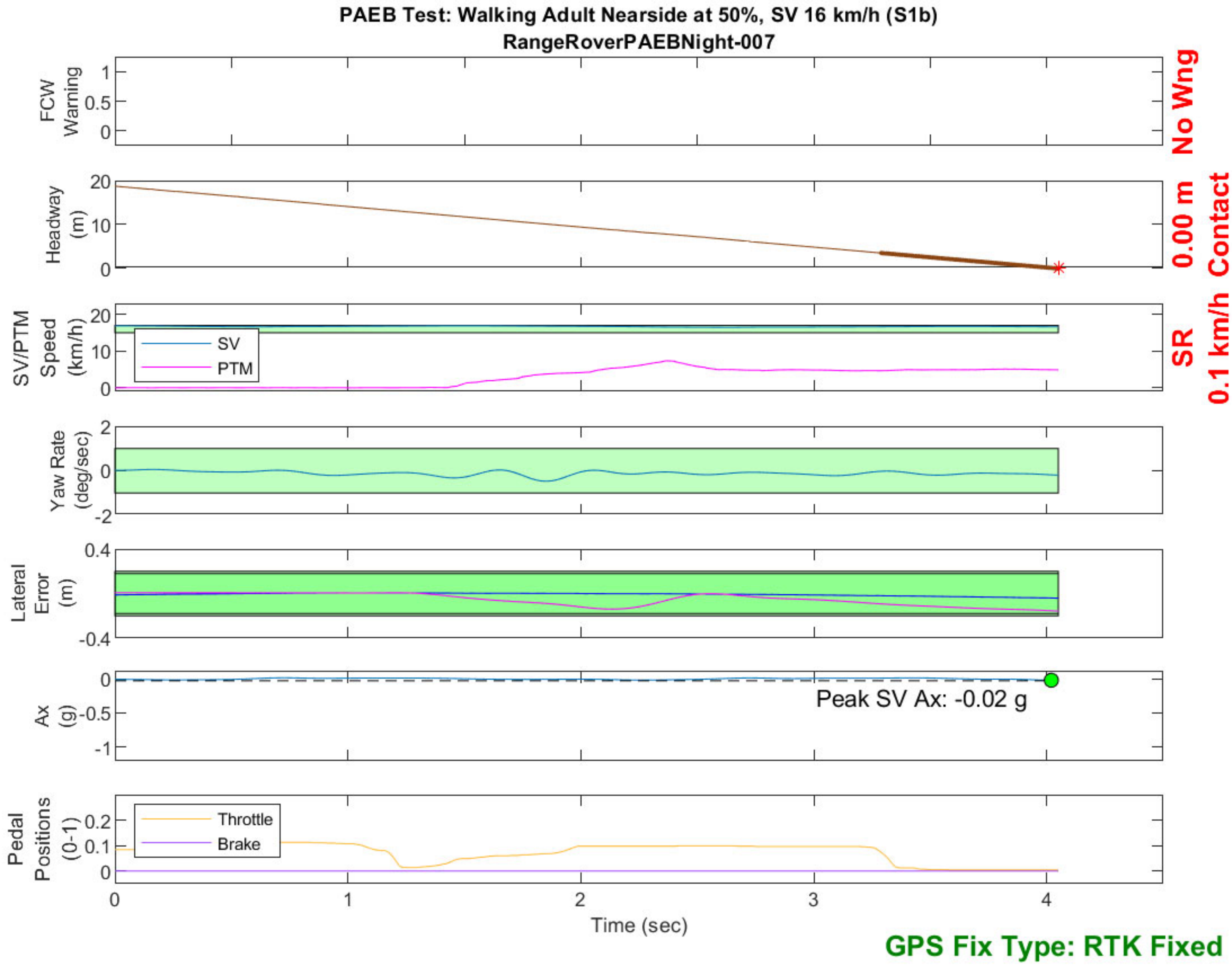


Figure D144. Time History for PAEB Run 7, S1b, Night, High Beam, 16 km/h

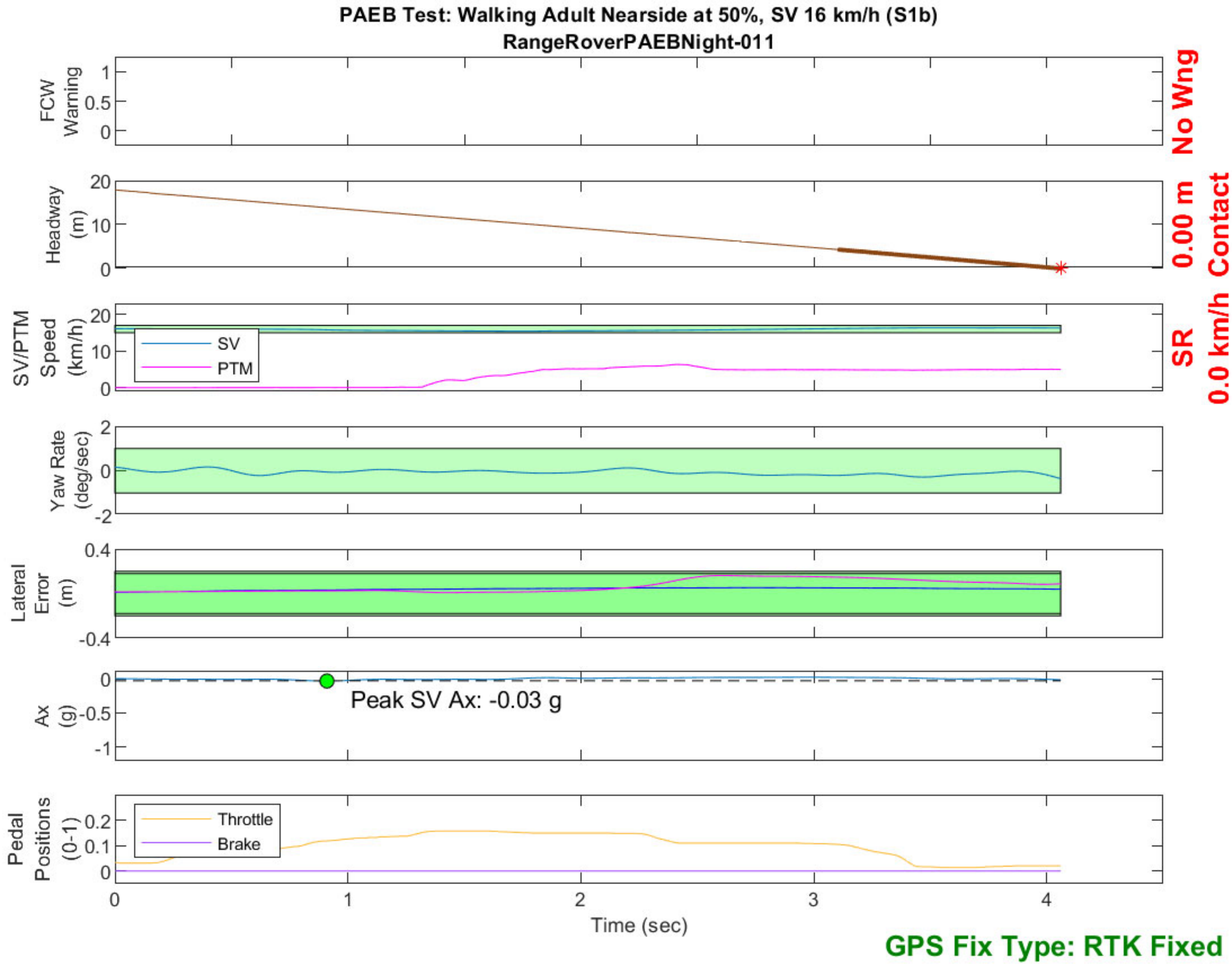


Figure D145. Time History for PAEB Run 11, S1b, Night, High Beam, 16 km/h

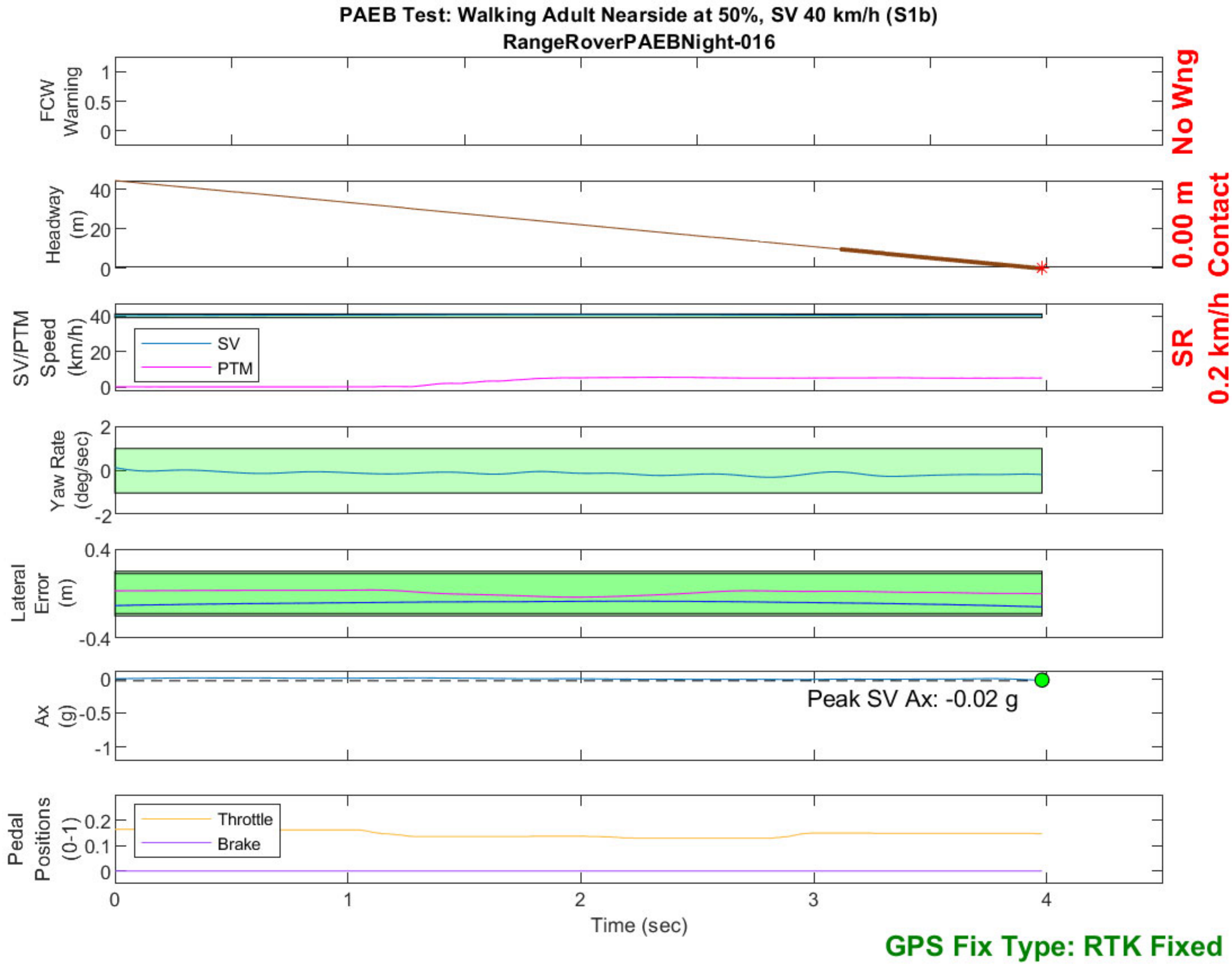


Figure D146. Time History for PAEB Run 16, S1b, Night, High Beam, 40 km/h

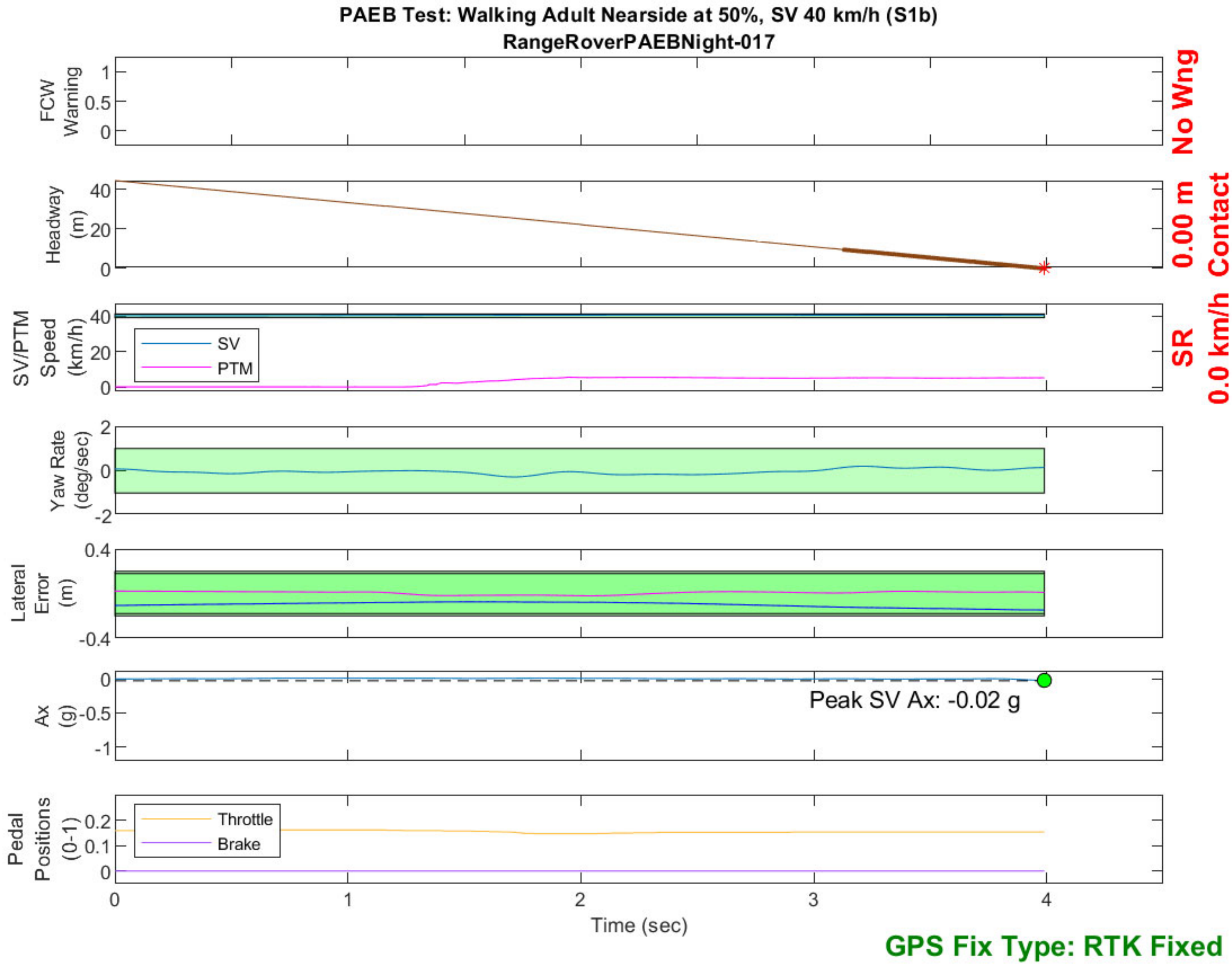


Figure D147. Time History for PAEB Run 17, S1b, Night, High Beam, 40 km/h

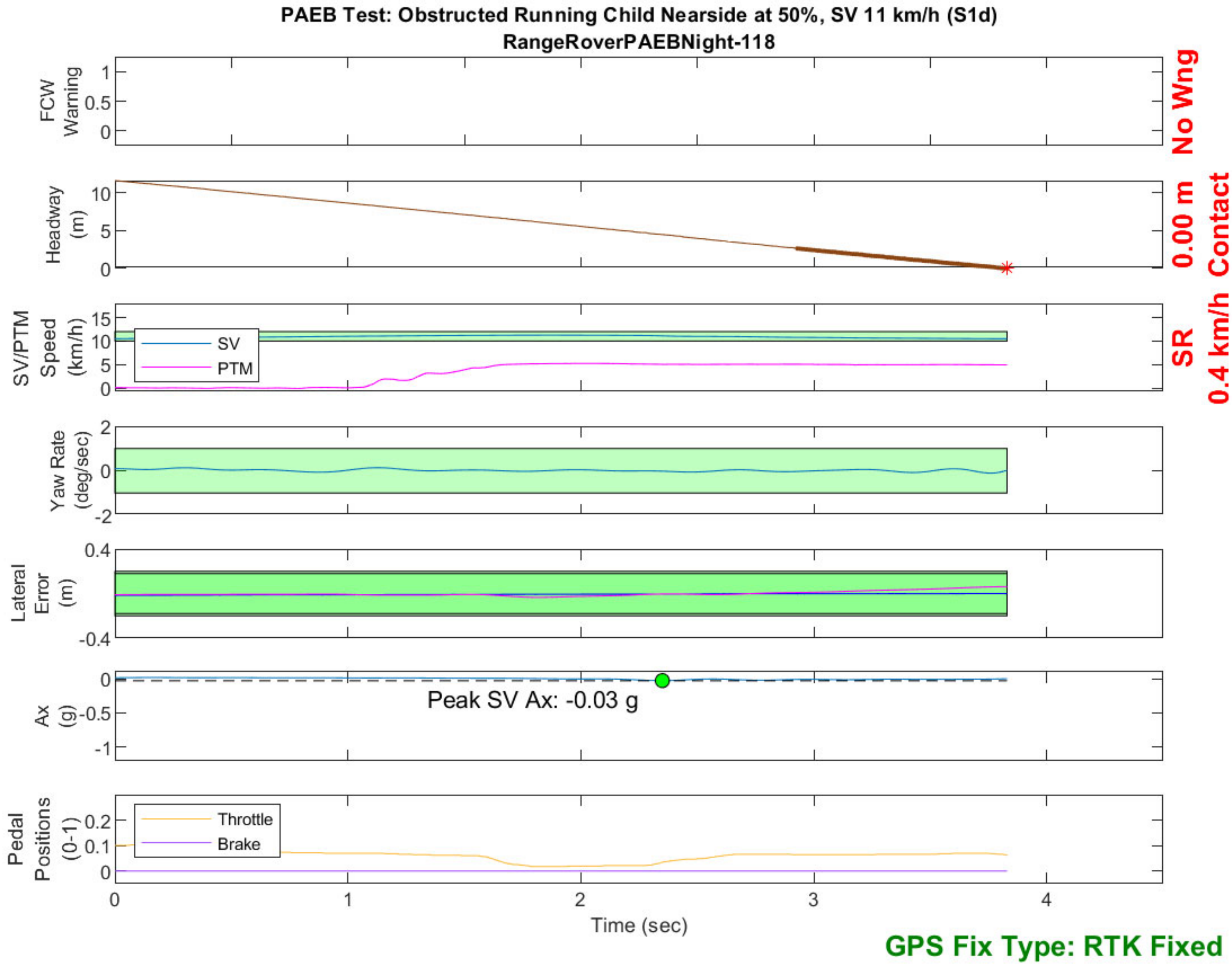


Figure D148. Time History for PAEB Run 118, S1d, Night, High Beam, 11 km/h

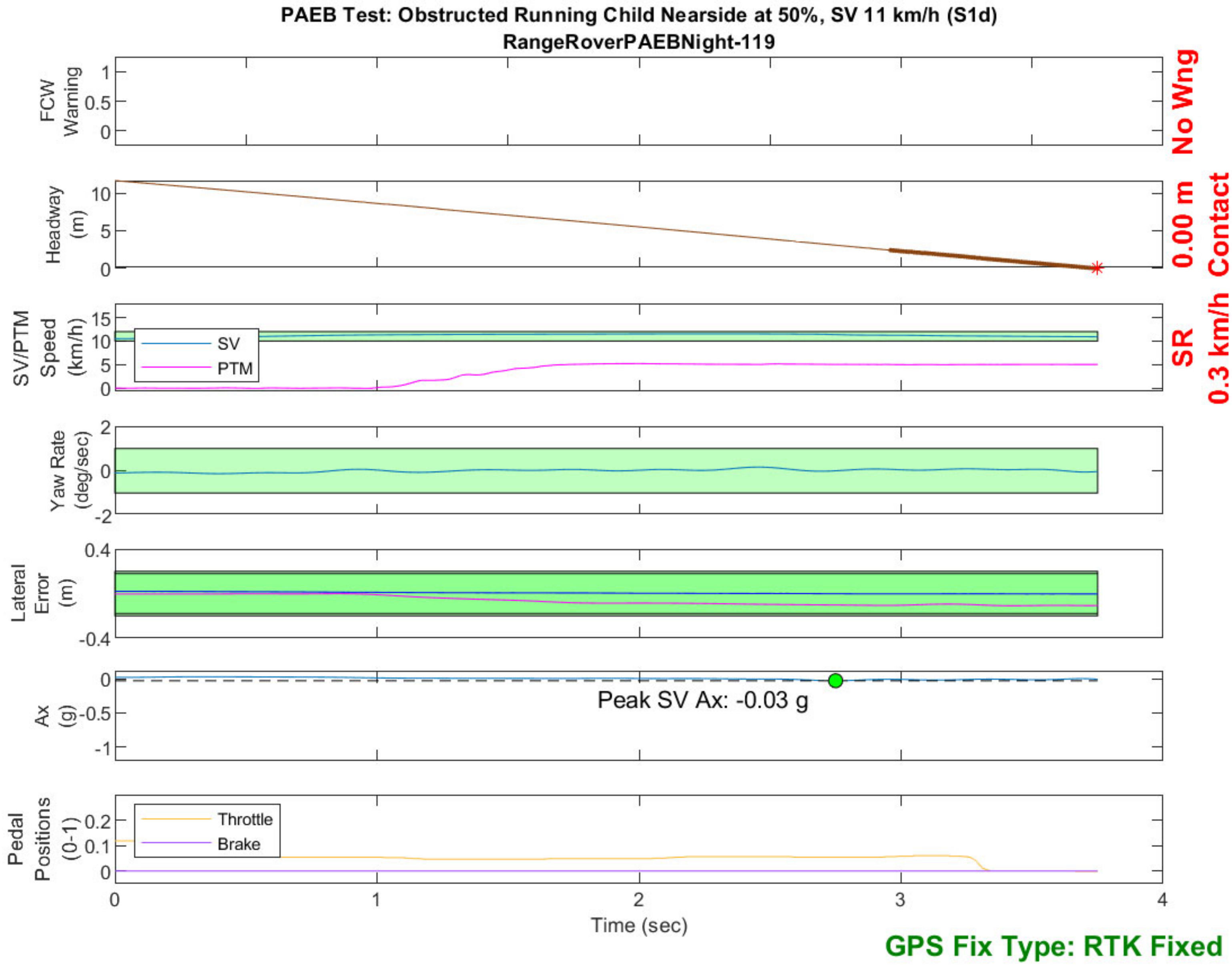


Figure D149. Time History for PAEB Run 119, S1d, Night, High Beam, 11 km/h

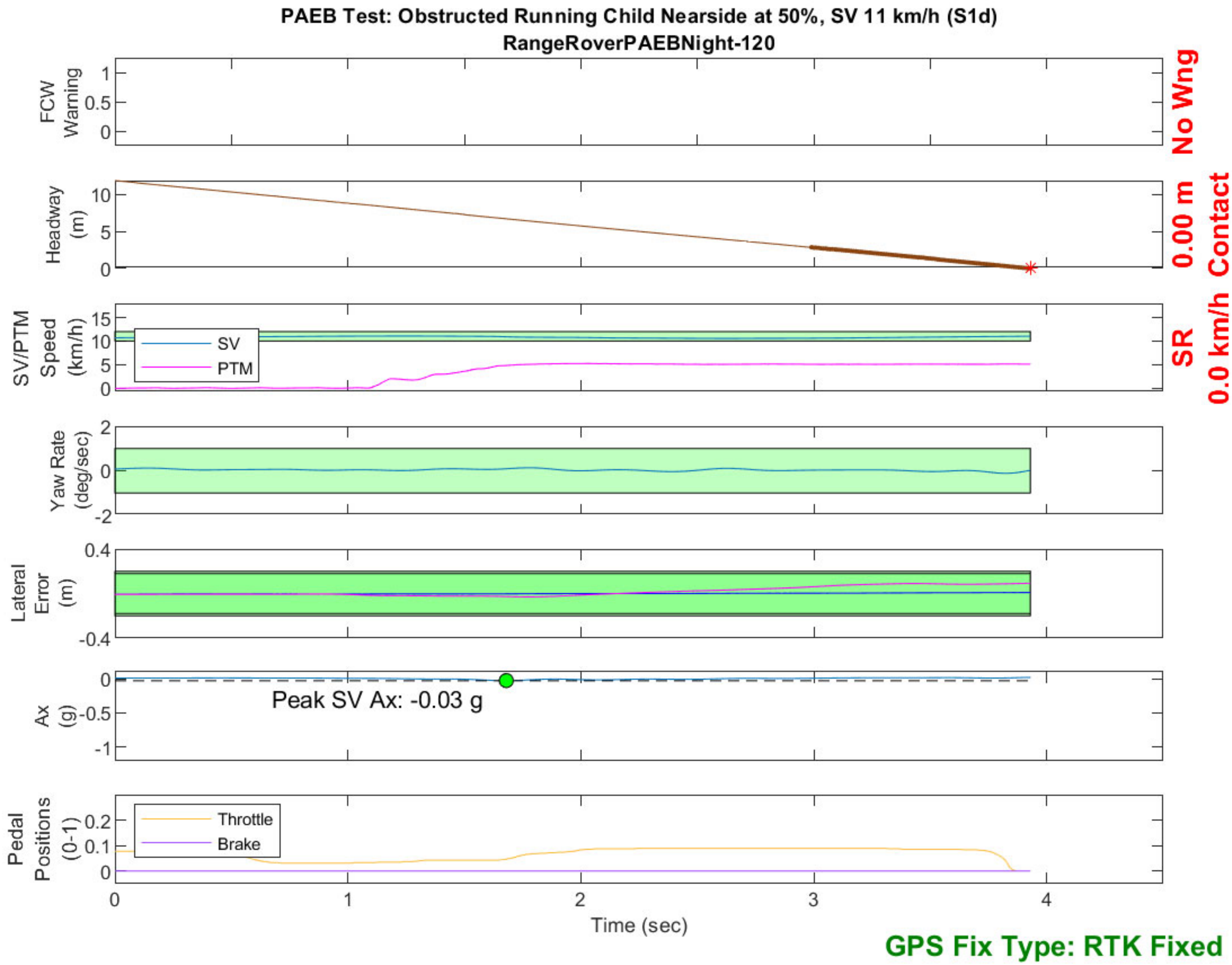


Figure D150. Time History for PAEB Run 120, S1d, Night, High Beam, 11 km/h

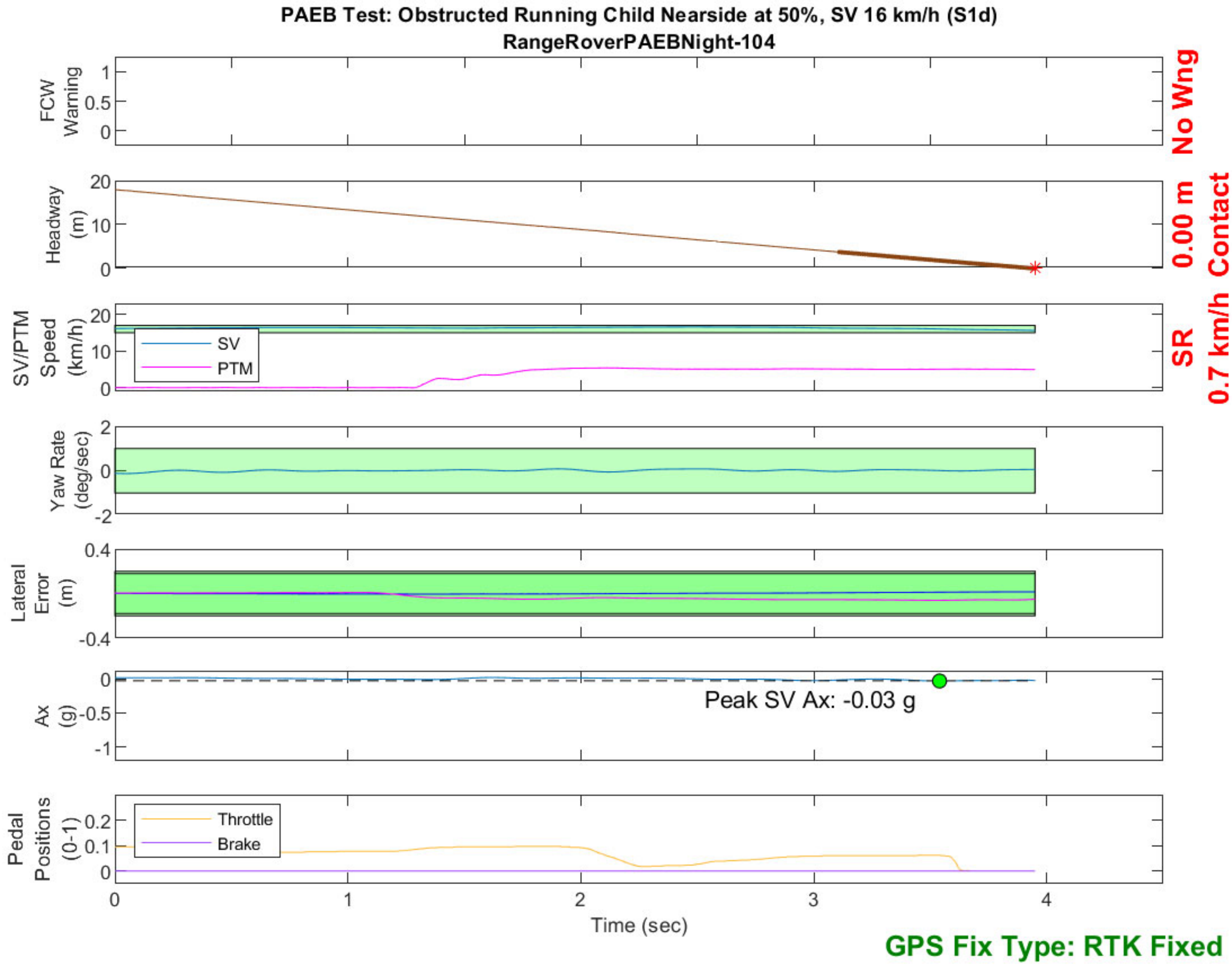


Figure D151. Time History for PAEB Run 104, S1d, Night, High Beam, 16 km/h

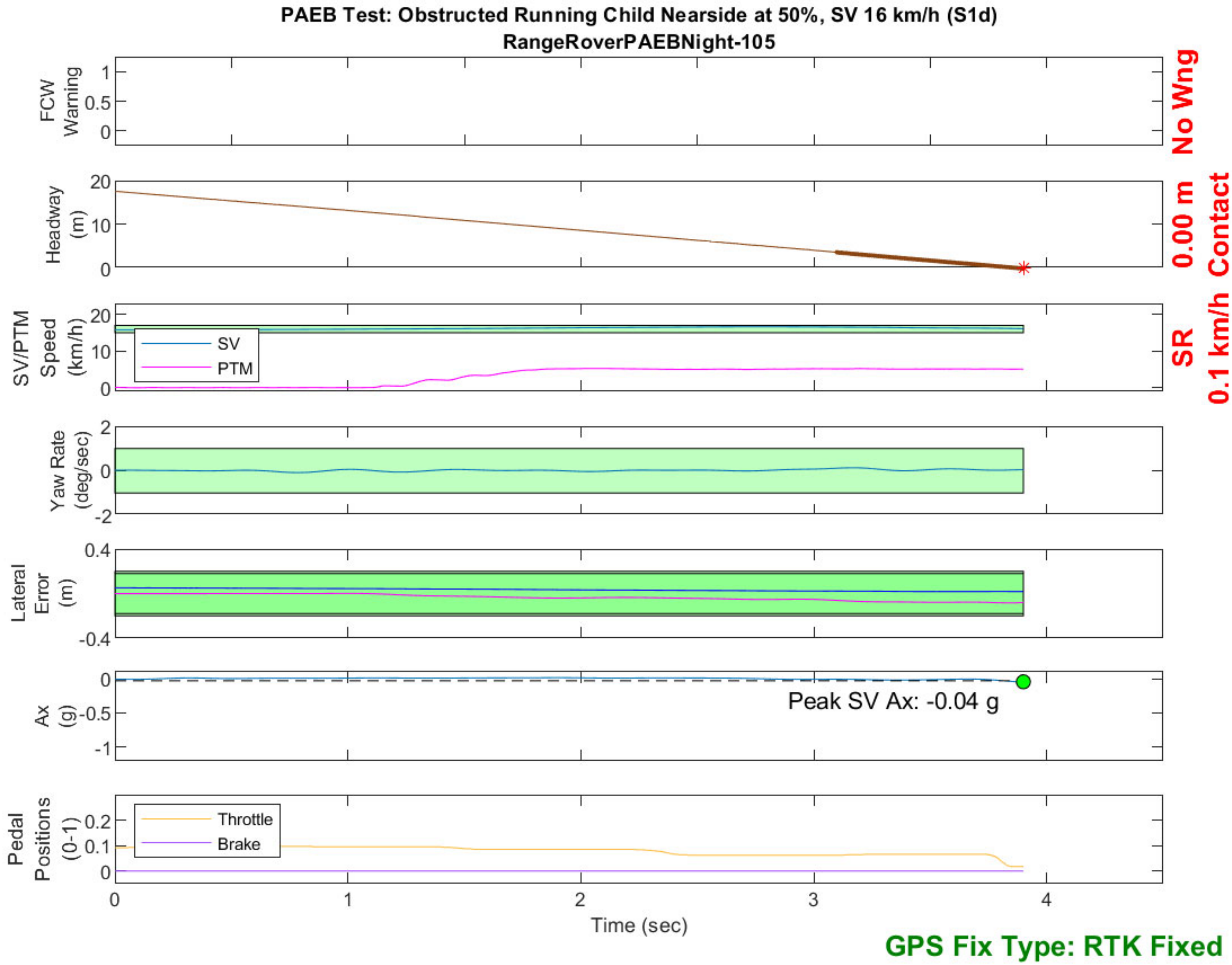


Figure D152. Time History for PAEB Run 105, S1d, Night, High Beam, 16 km/h

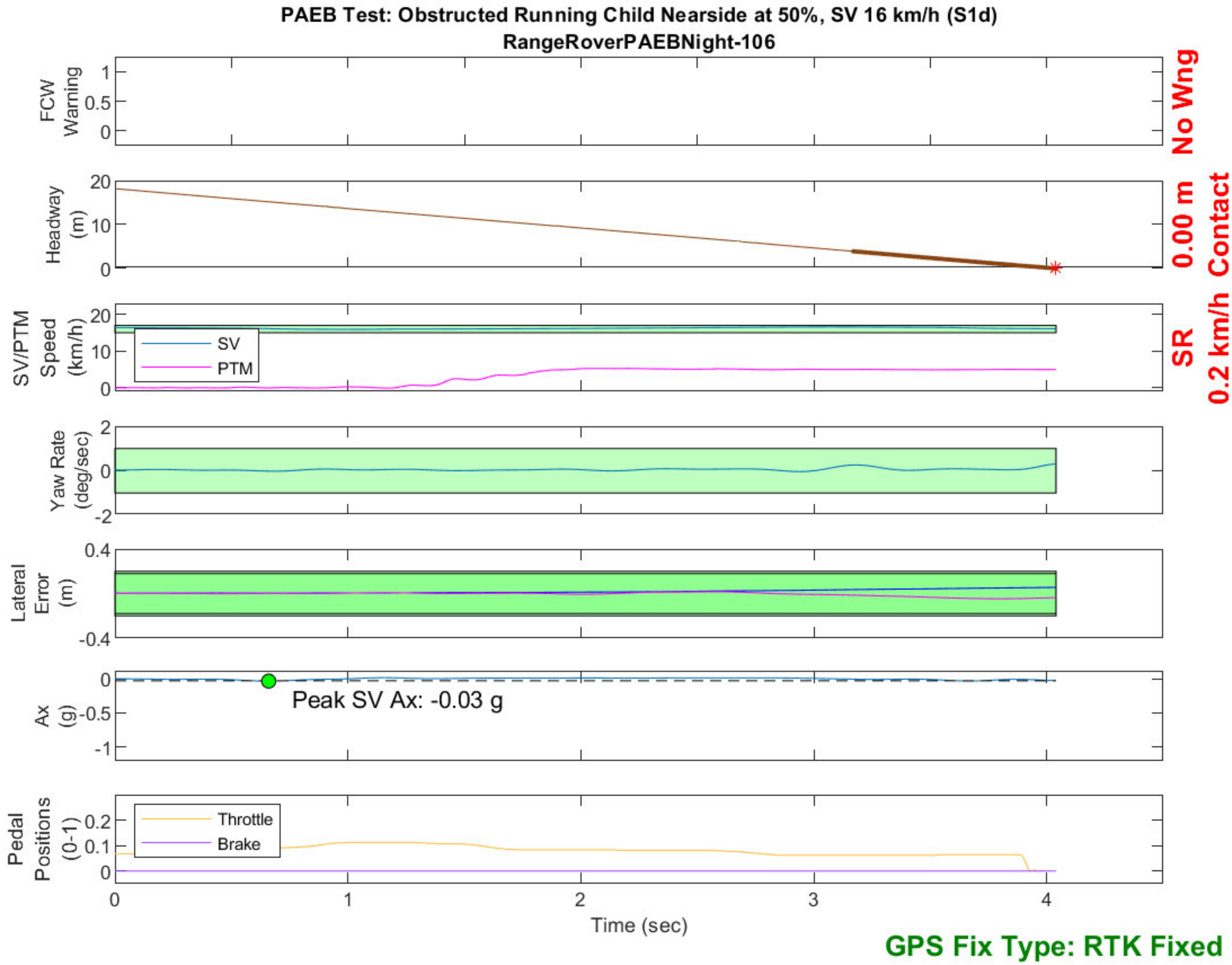


Figure D153. Time History for PAEB Run 106, S1d, Night, High Beam, 16 km/h

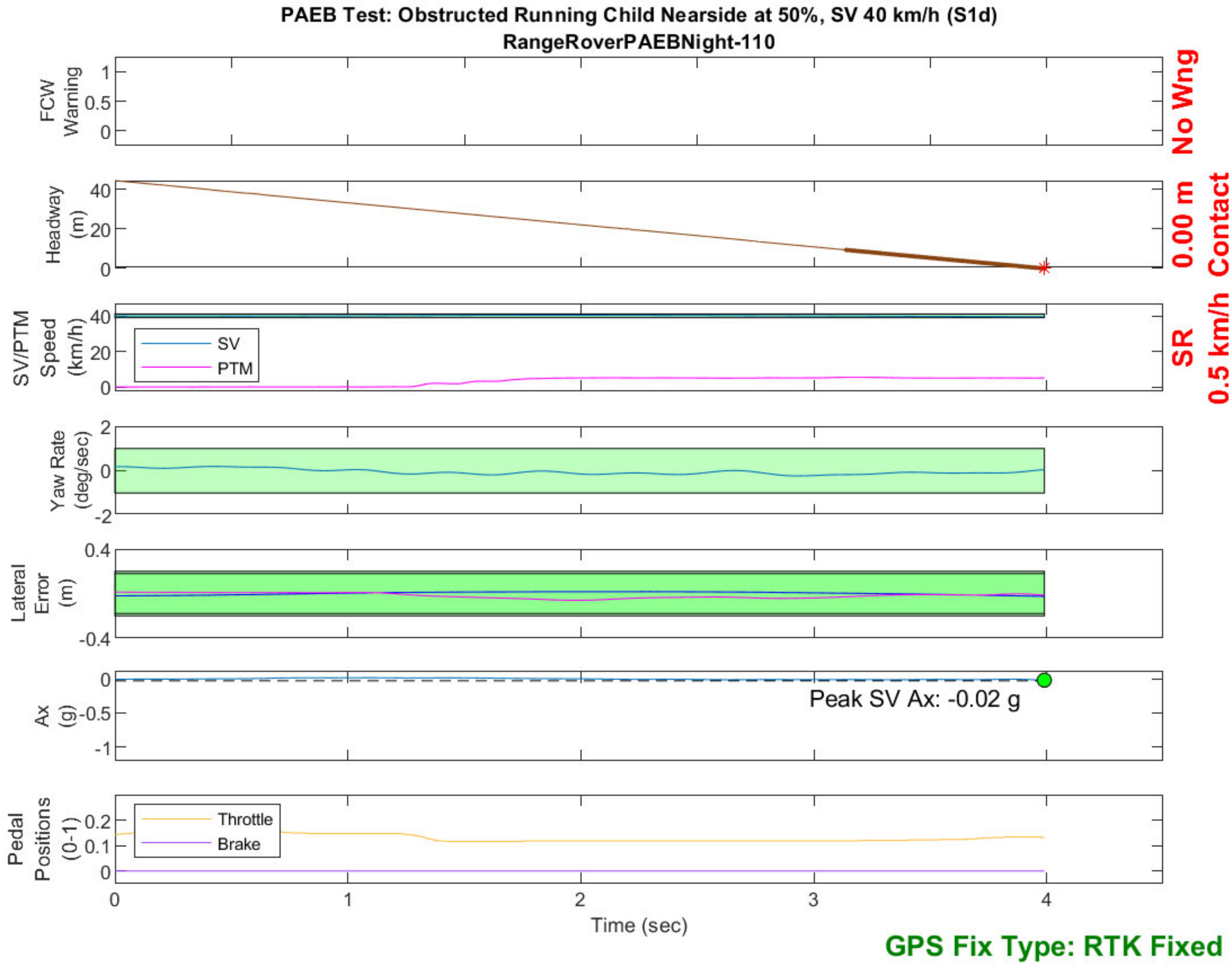


Figure D154. Time History for PAEB Run 110, S1d, Night, High Beam, 40 km/h

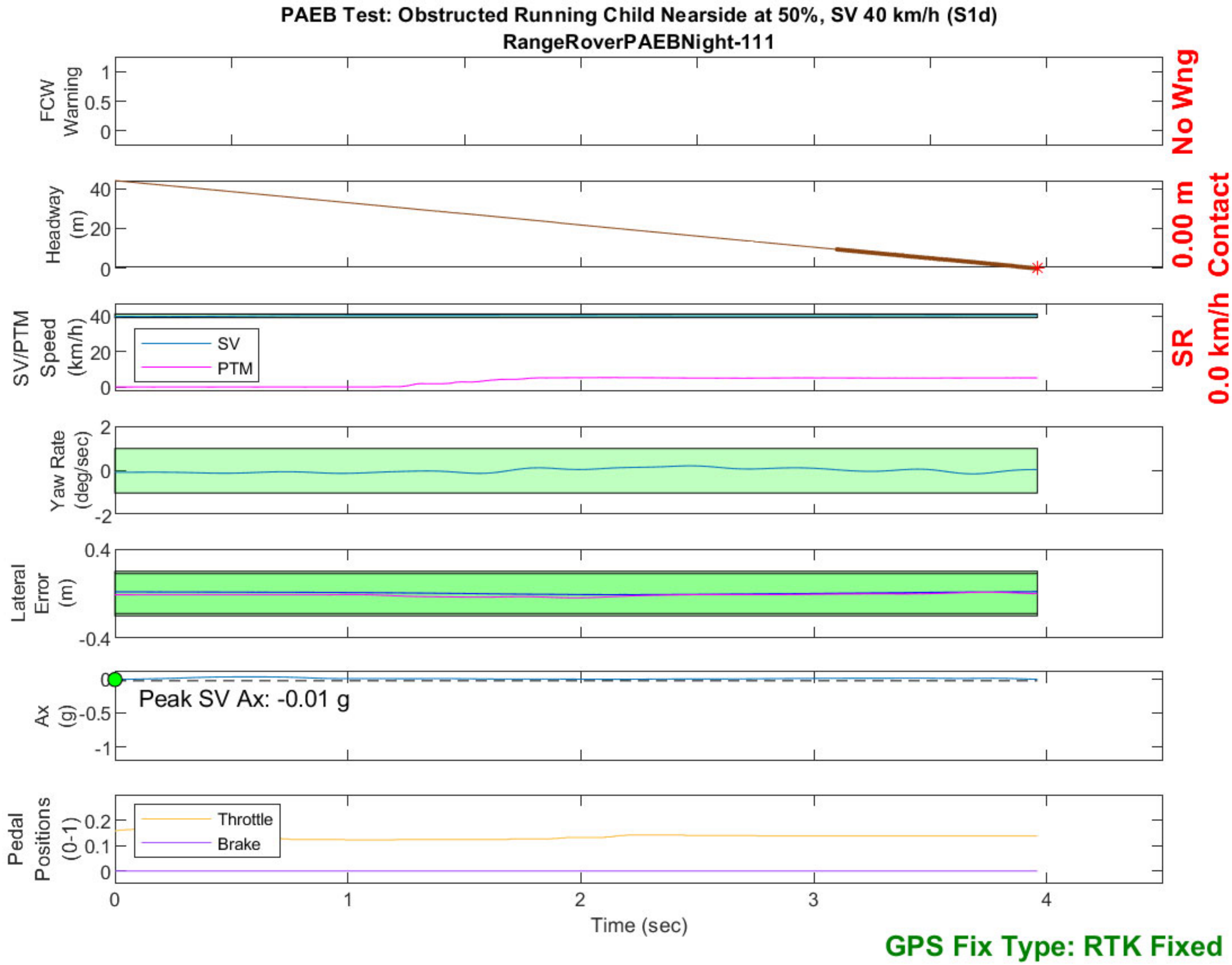


Figure D155. Time History for PAEB Run 111, S1d, Night, High Beam, 40 km/h

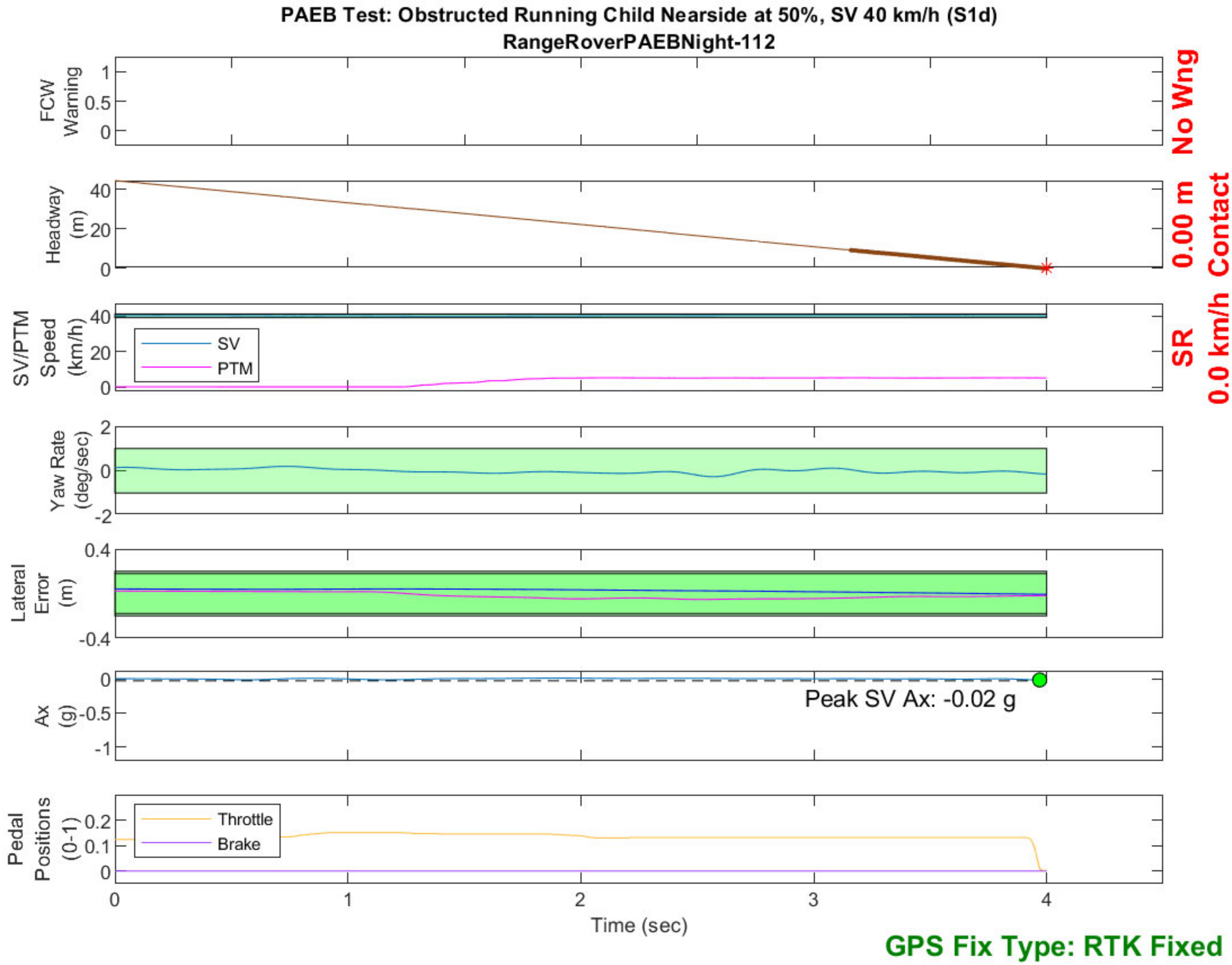


Figure D156. Time History for PAEB Run 112, S1d, Night, High Beam, 40 km/h

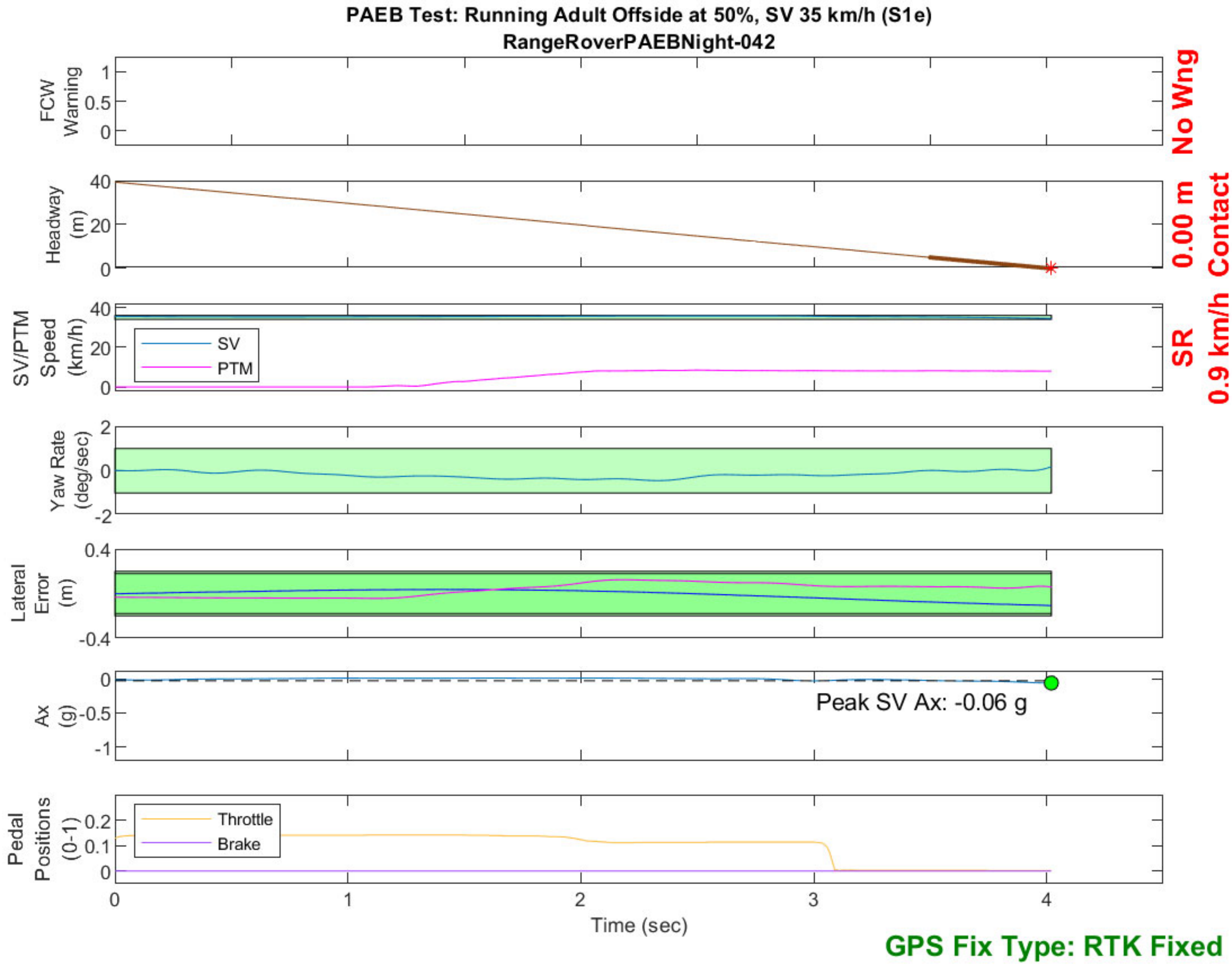


Figure D157. Time History for PAEB Run 42, S1e, Night, High Beam, 35 km/h

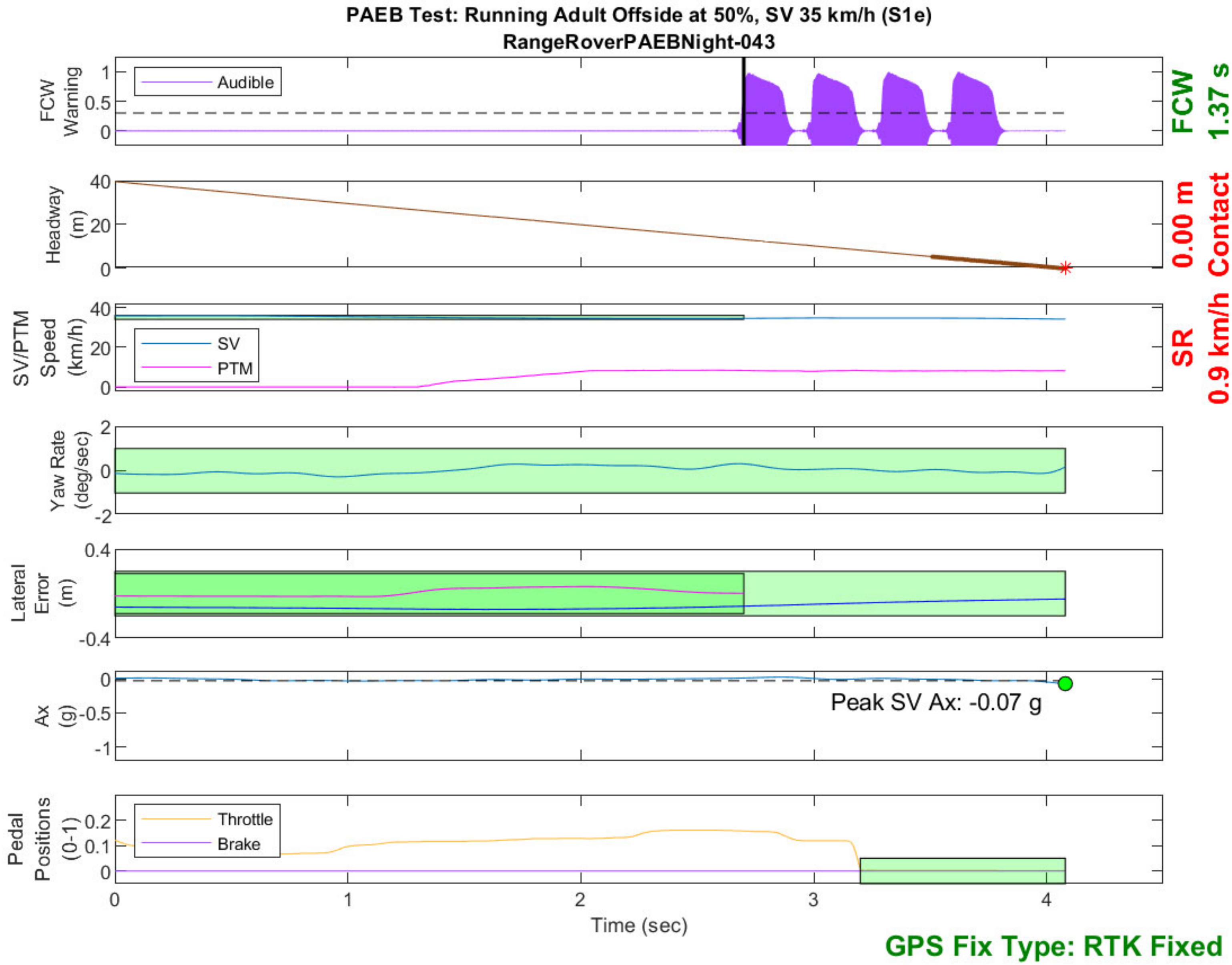


Figure D158. Time History for PAEB Run 43, S1e, Night, High Beam, 35 km/h

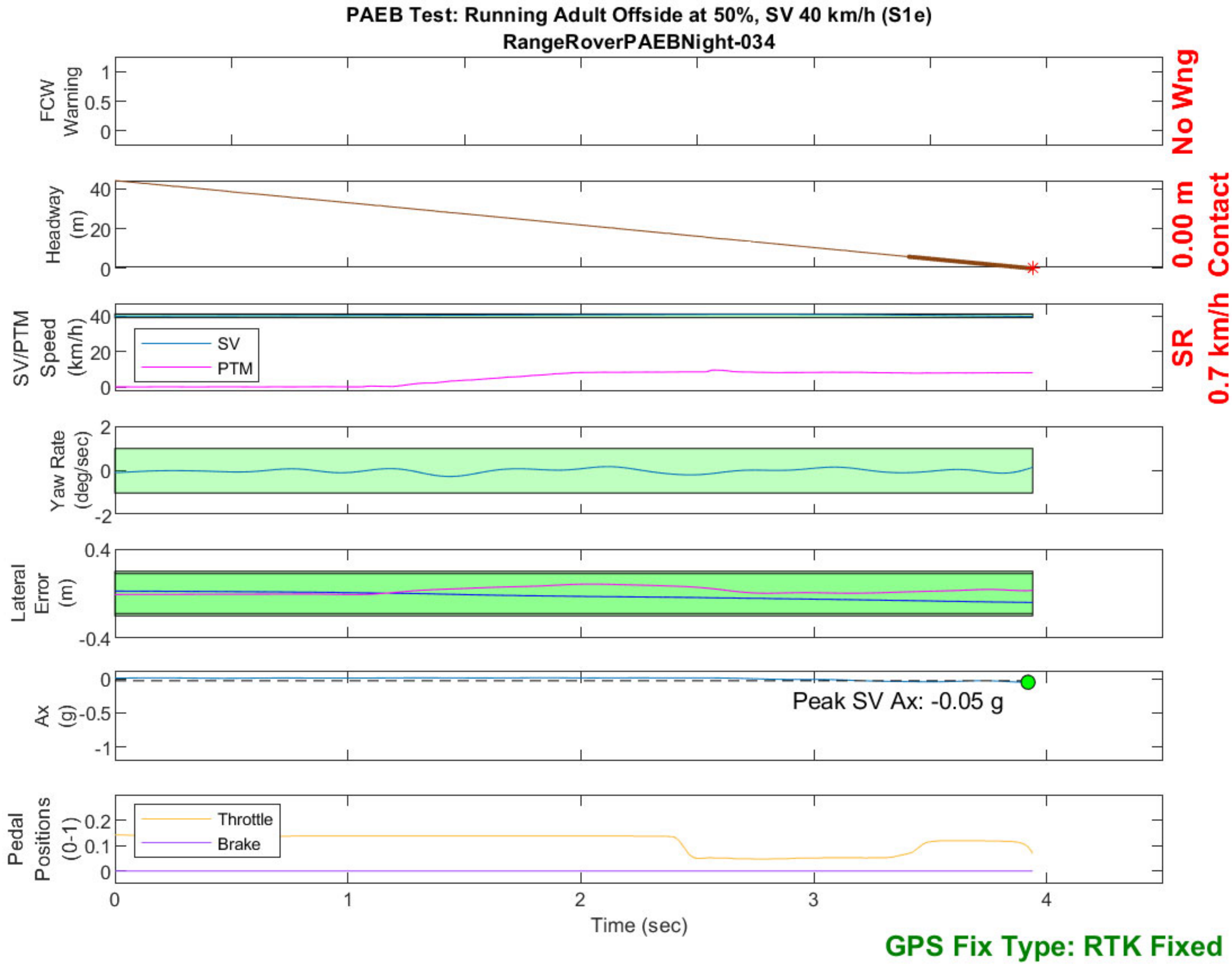


Figure D159. Time History for PAEB Run 34, S1e, Night, High Beam, 40 km/h

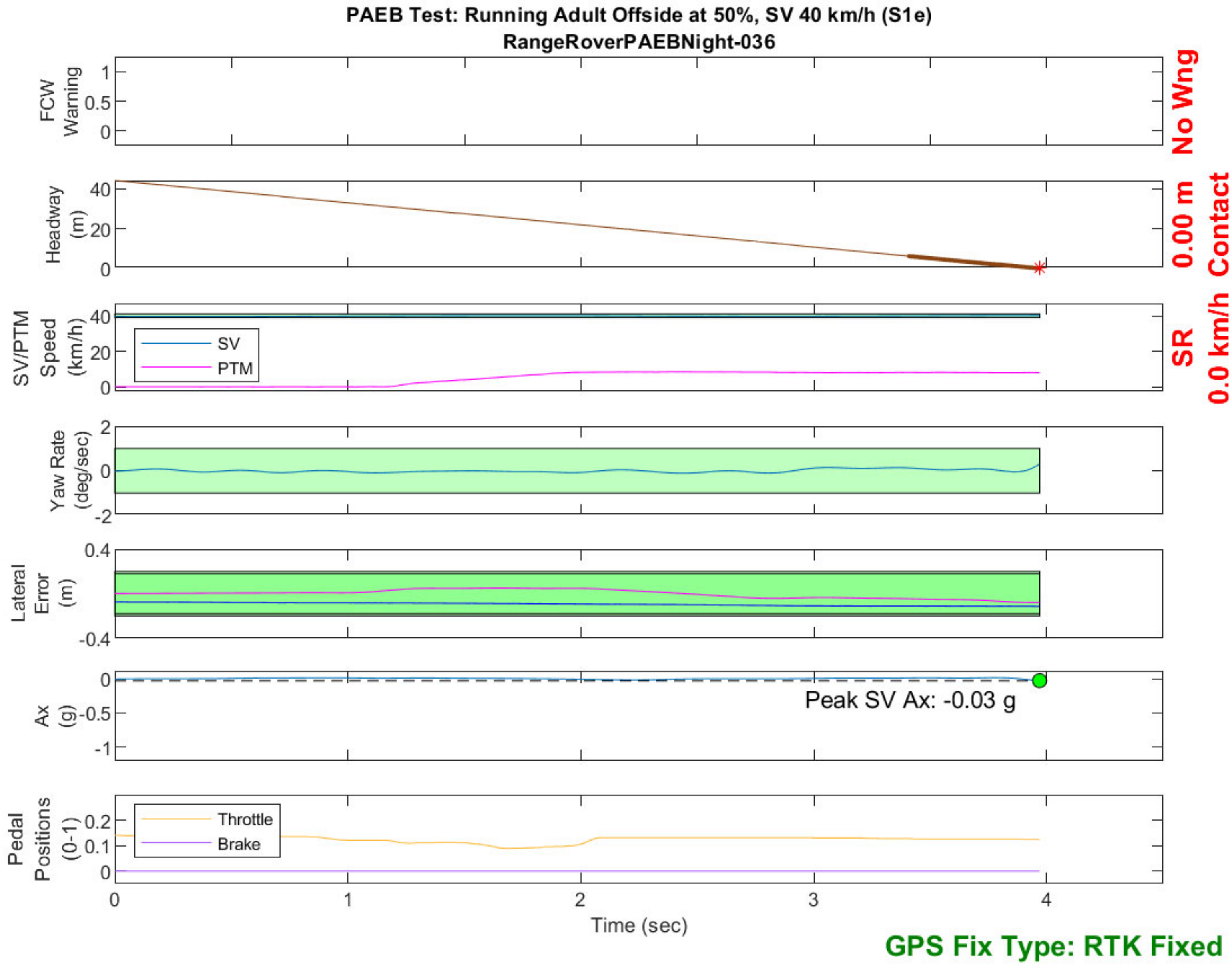


Figure D160. Time History for PAEB Run 36, S1e, Night, High Beam, 40 km/h

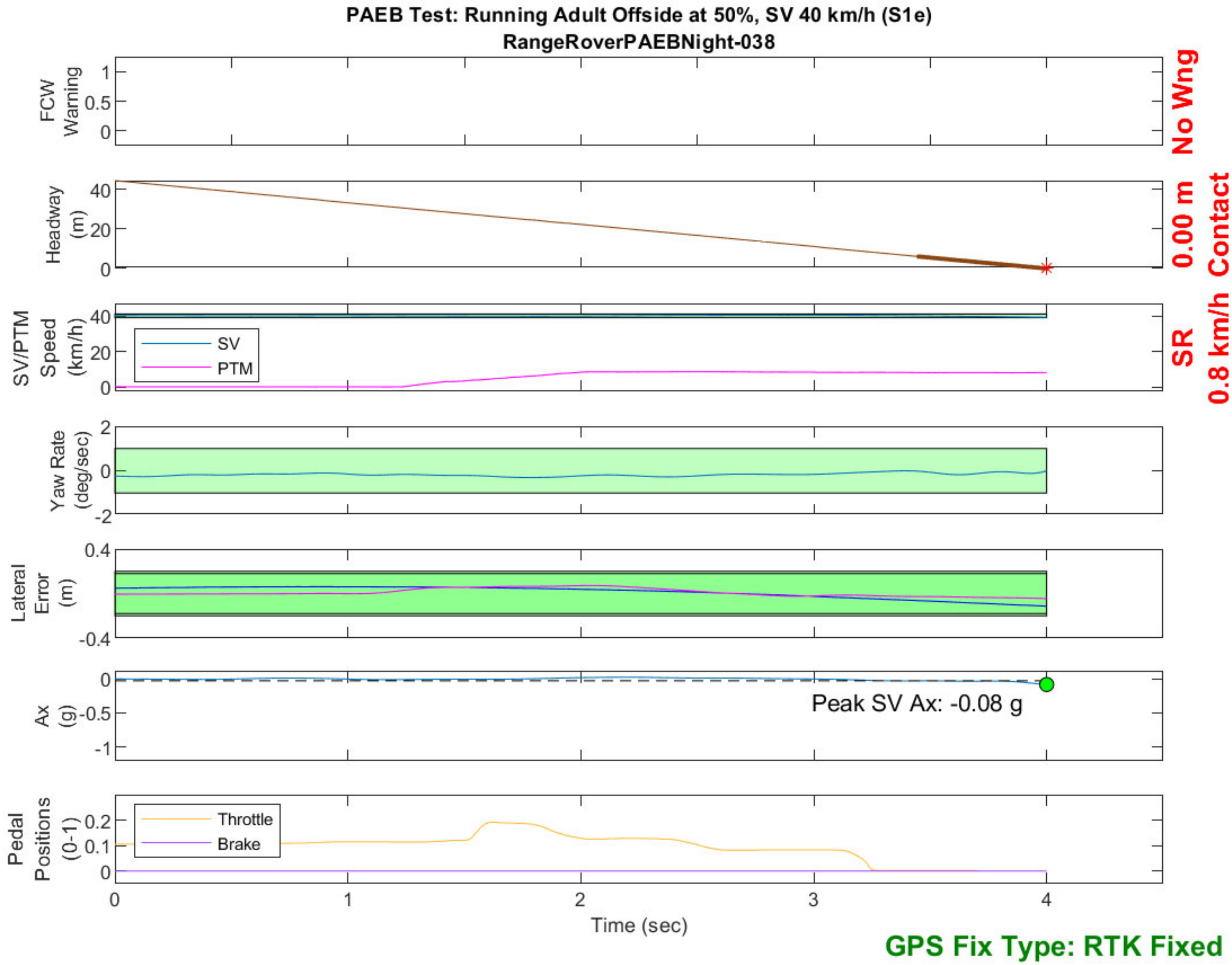


Figure D161. Time History for PAEB Run 38, S1e, Night, High Beam, 40 km/h

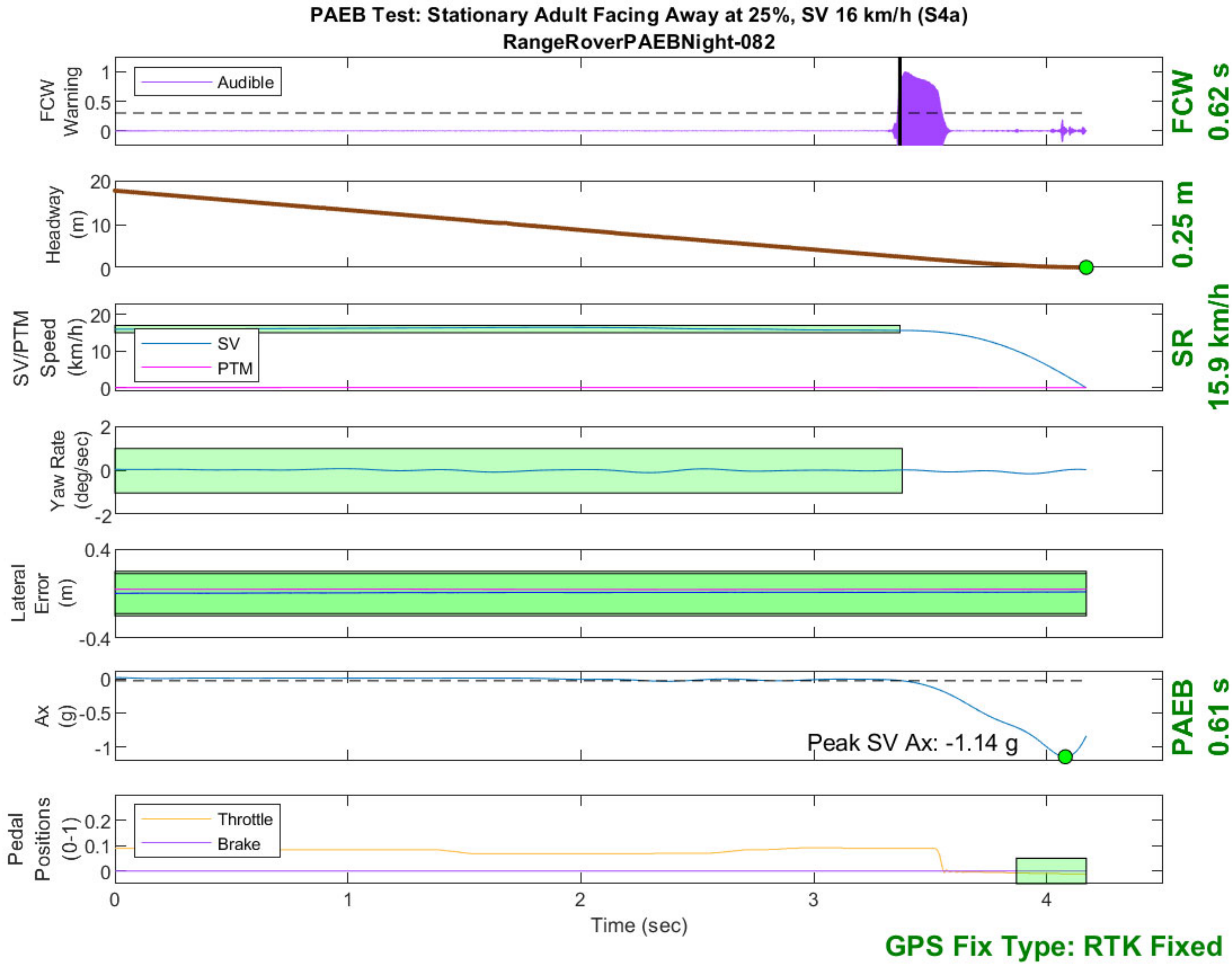


Figure D162. Time History for PAEB Run 82, S4a, Night, High Beam, 16 km/h

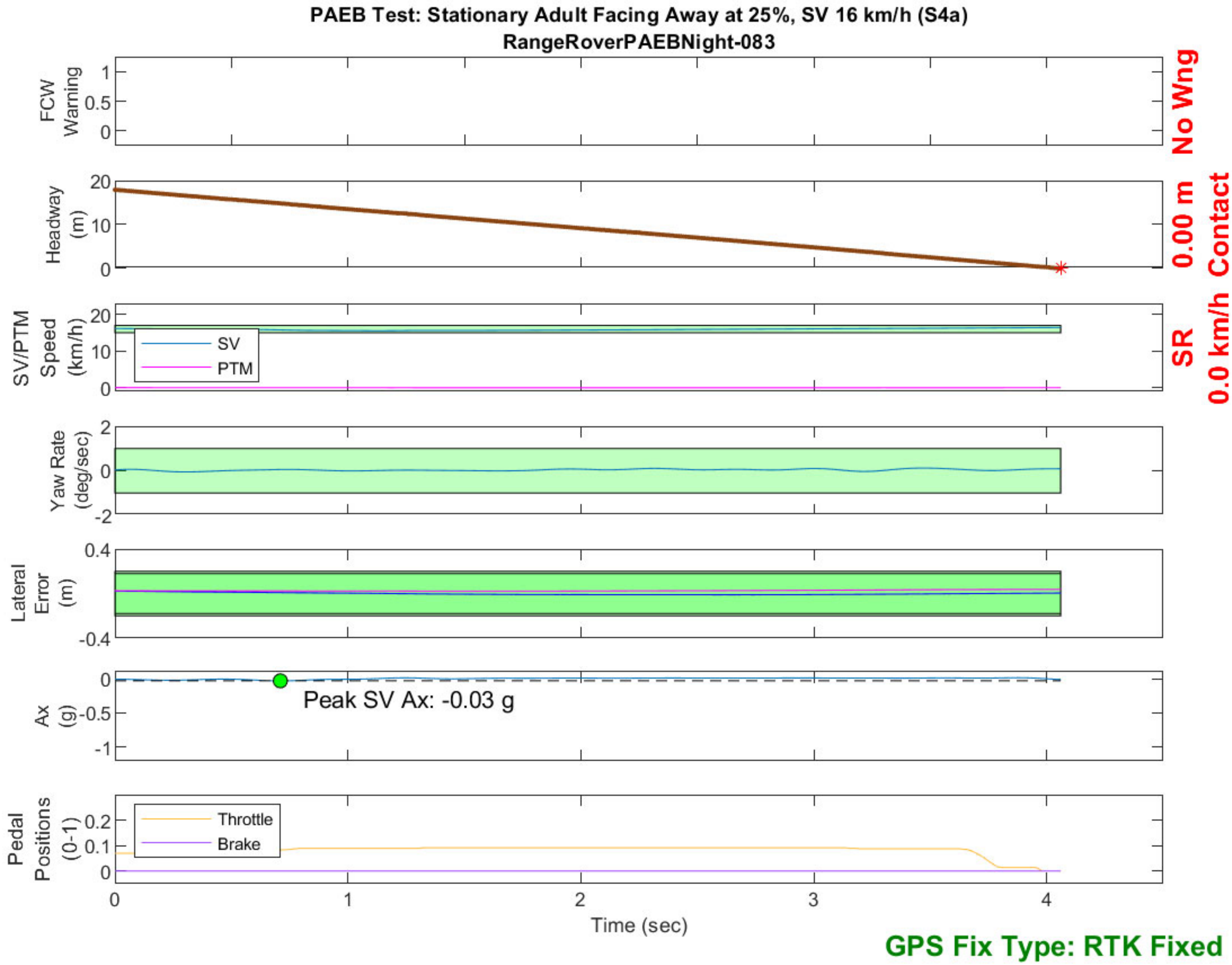


Figure D163. Time History for PAEB Run 83, S4a, Night, High Beam, 16 km/h

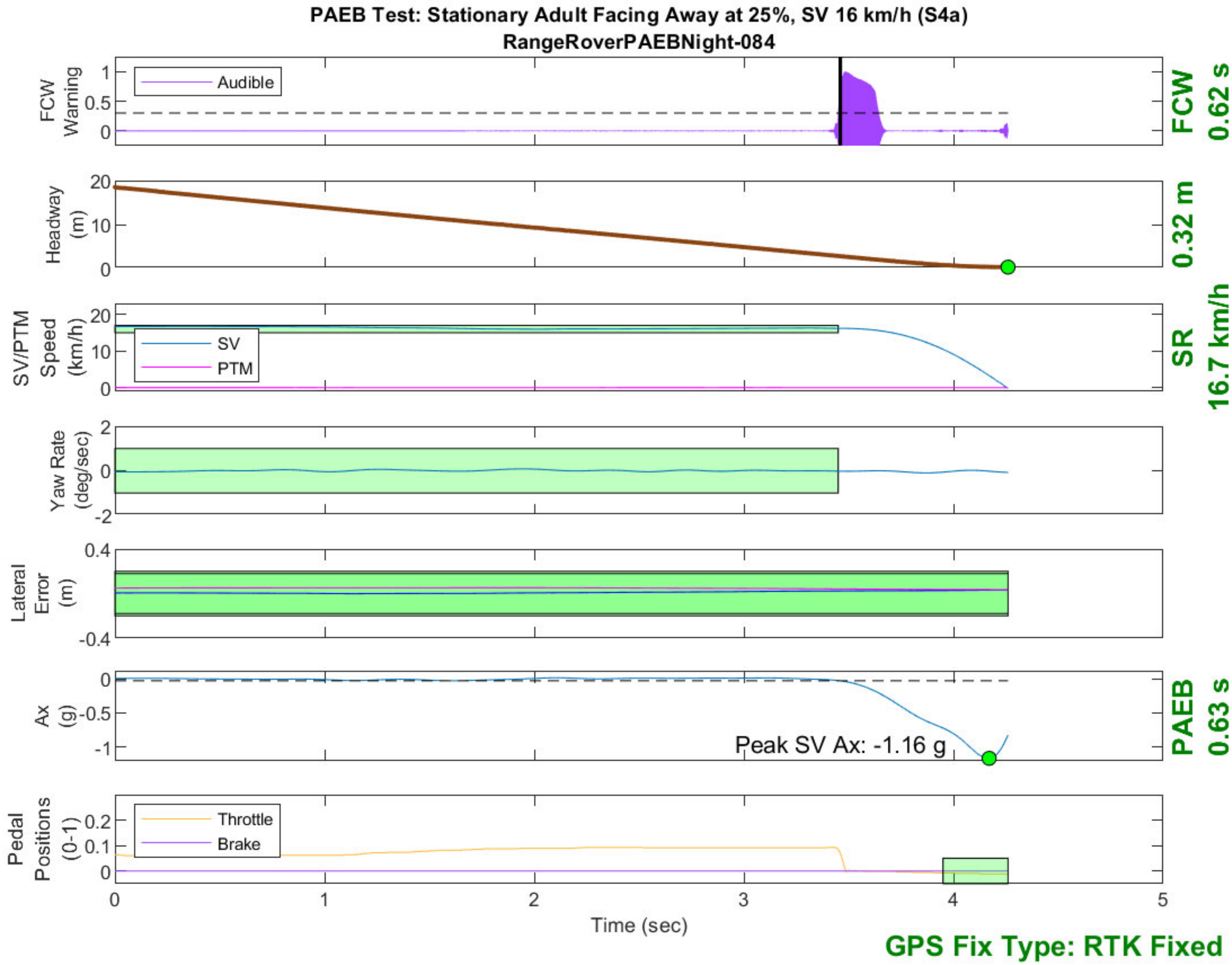


Figure D164. Time History for PAEB Run 84, S4a, Night, High Beam, 16 km/h

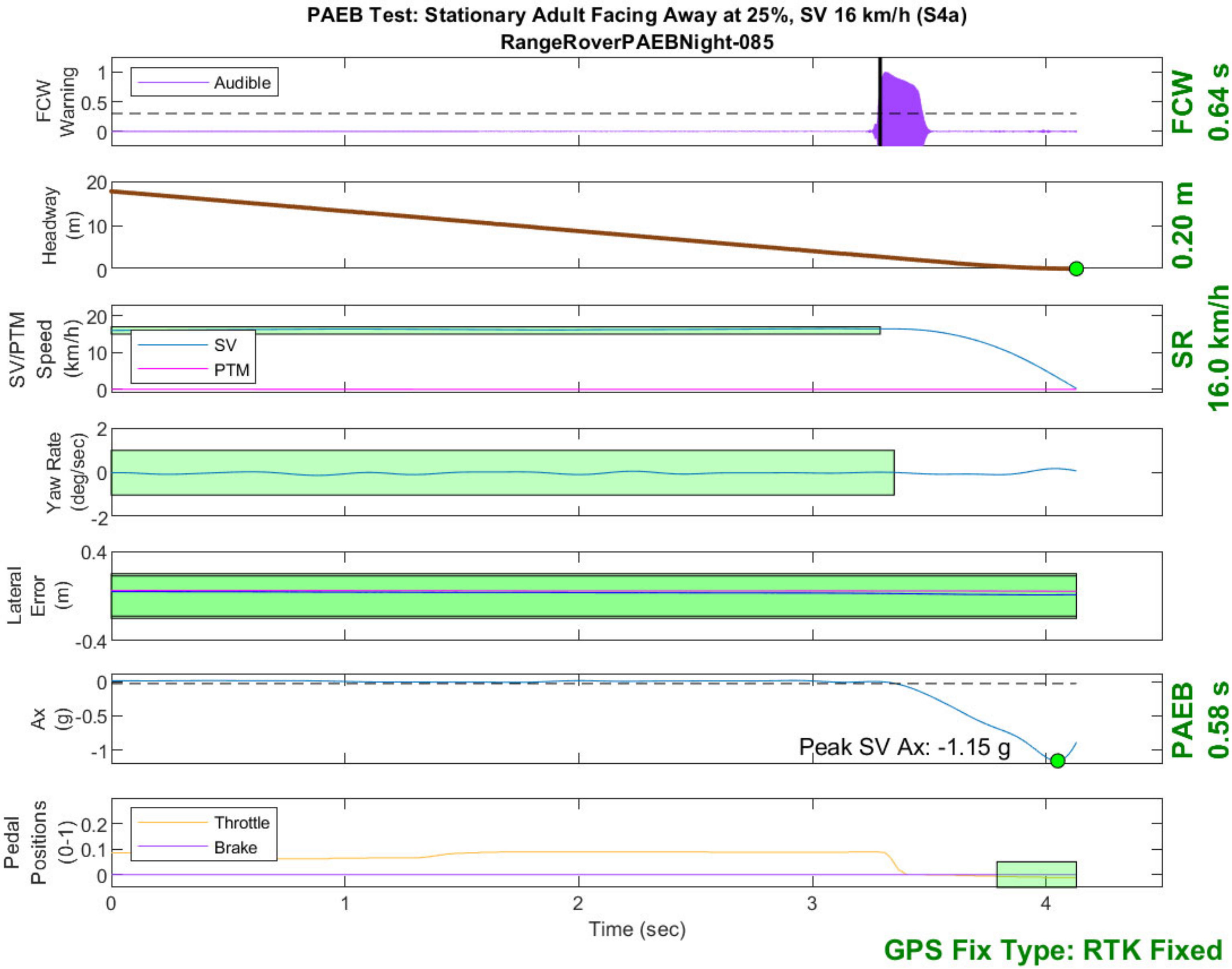


Figure D165. Time History for PAEB Run 85, S4a, Night, High Beam, 16 km/h

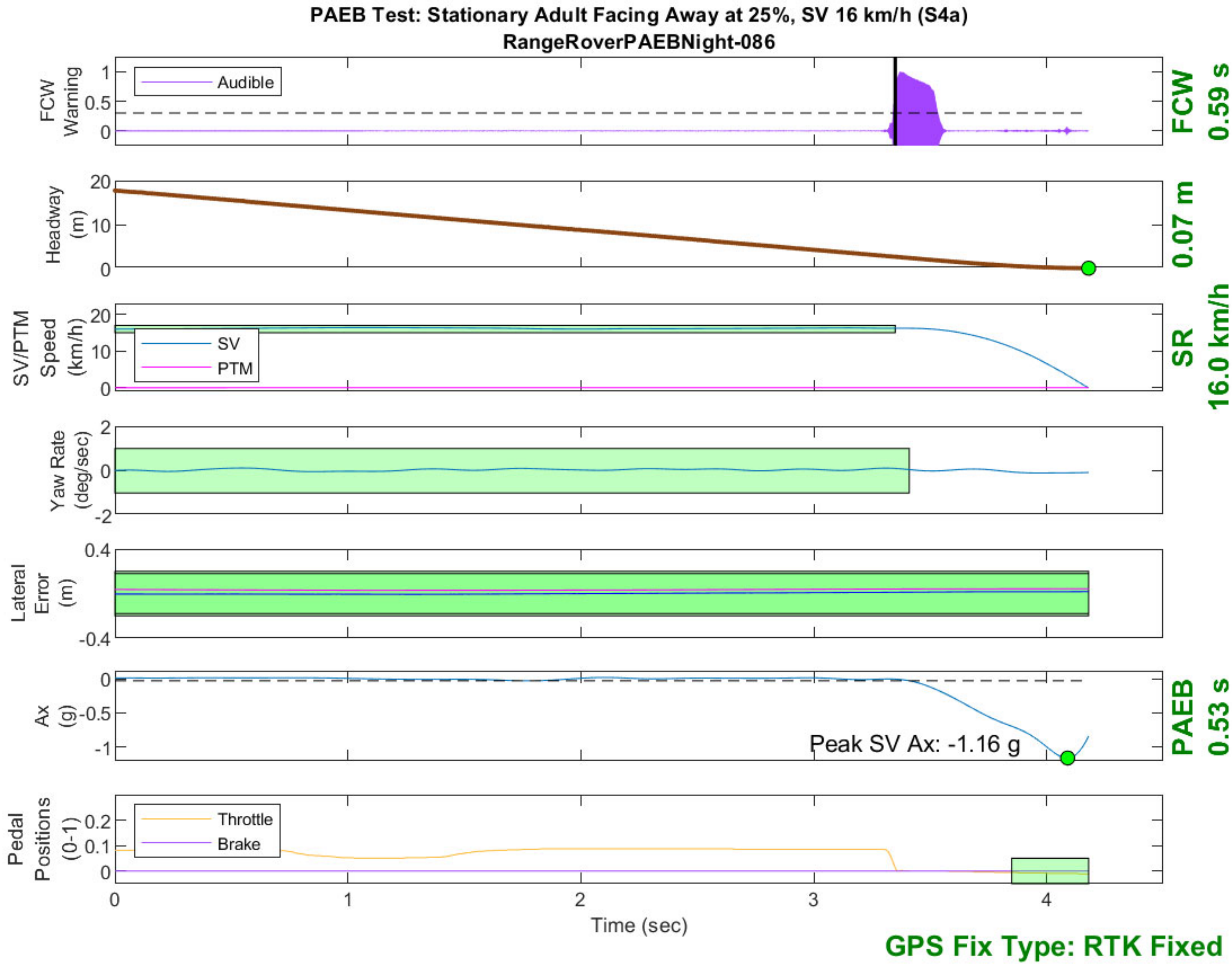


Figure D166. Time History for PAEB Run 86, S4a, Night, High Beam, 16 km/h

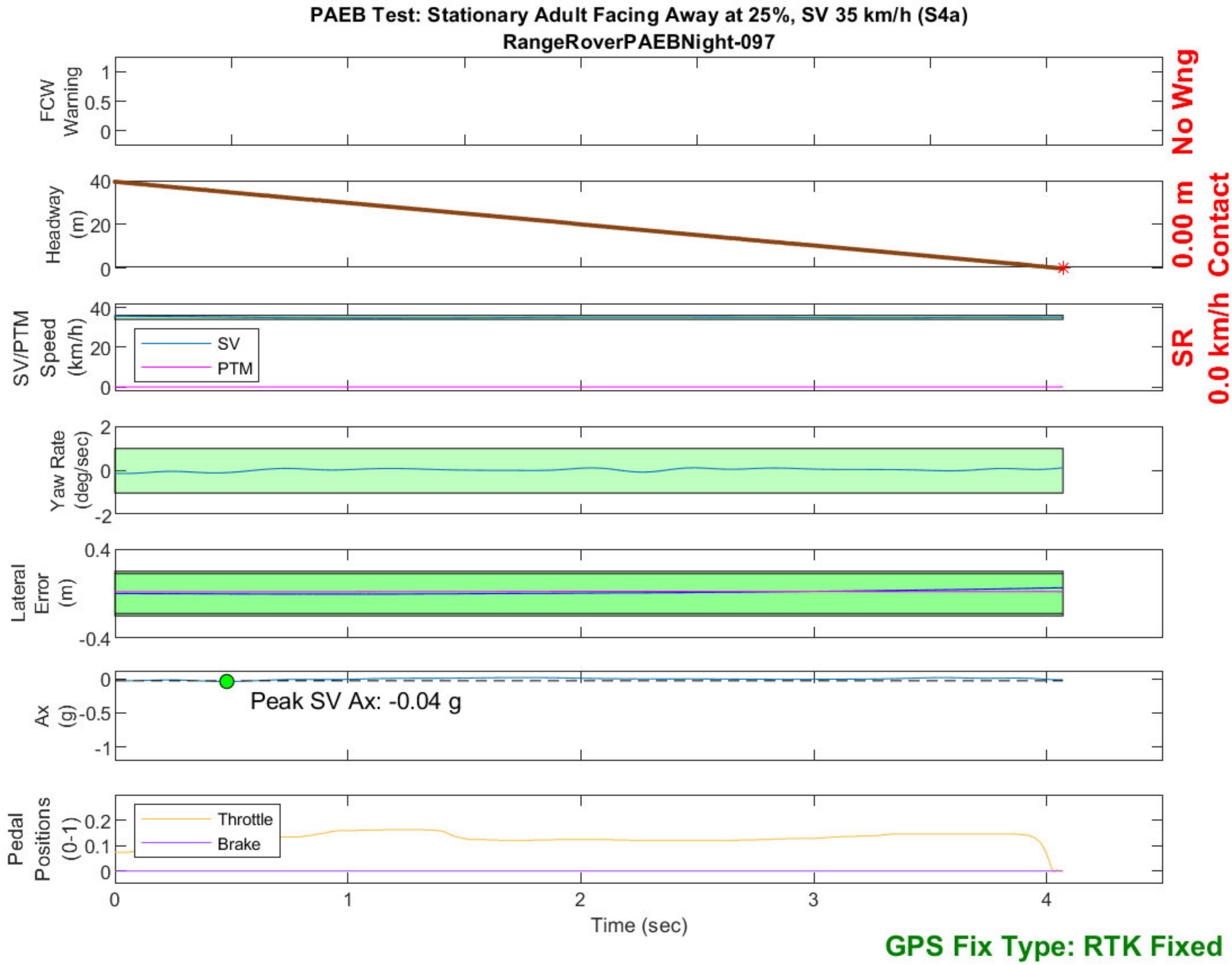


Figure D167. Time History for PAEB Run 97, S4a, Night, High Beam, 35 km/h

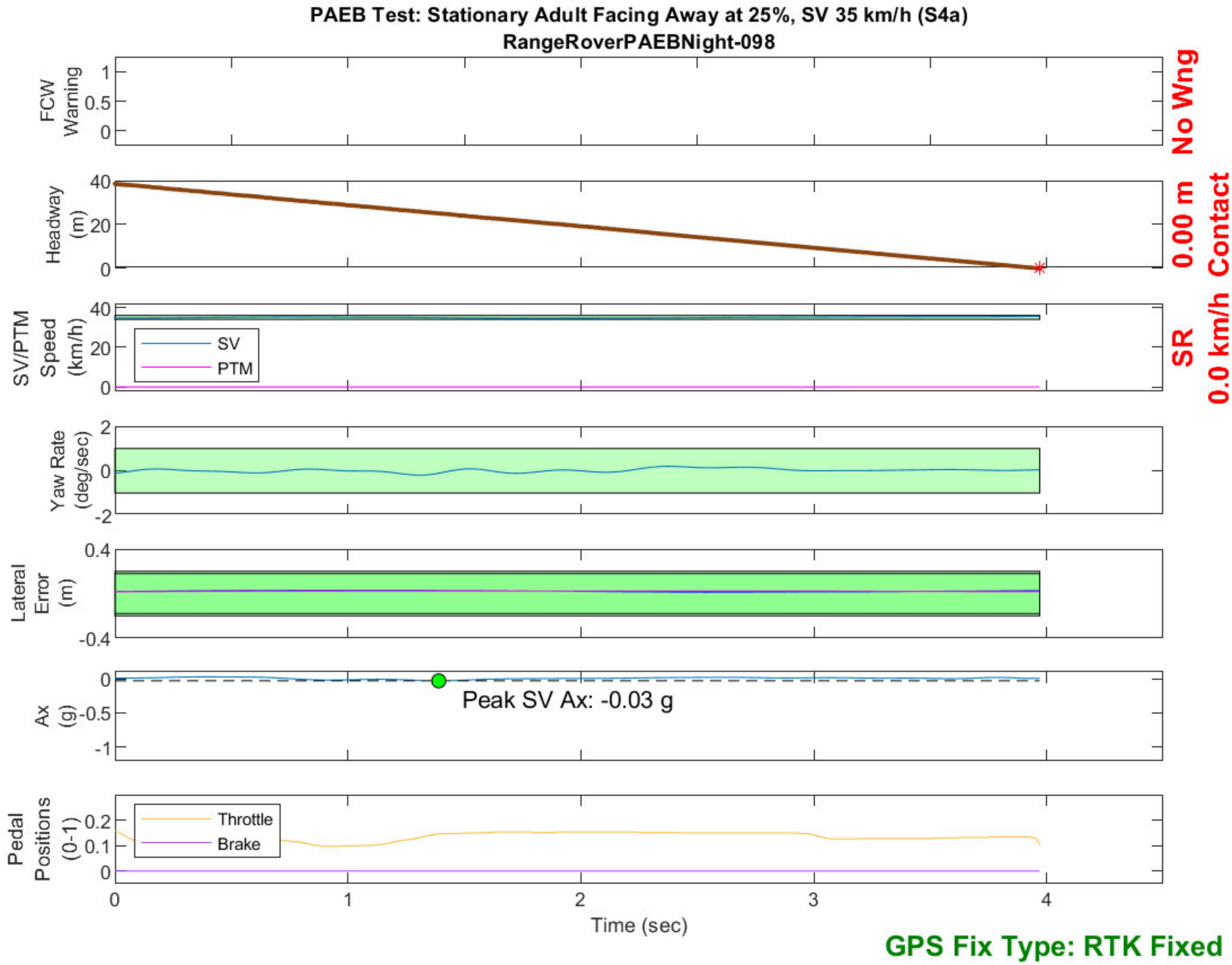


Figure D168. Time History for PAEB Run 98, S4a, Night, High Beam, 35 km/h

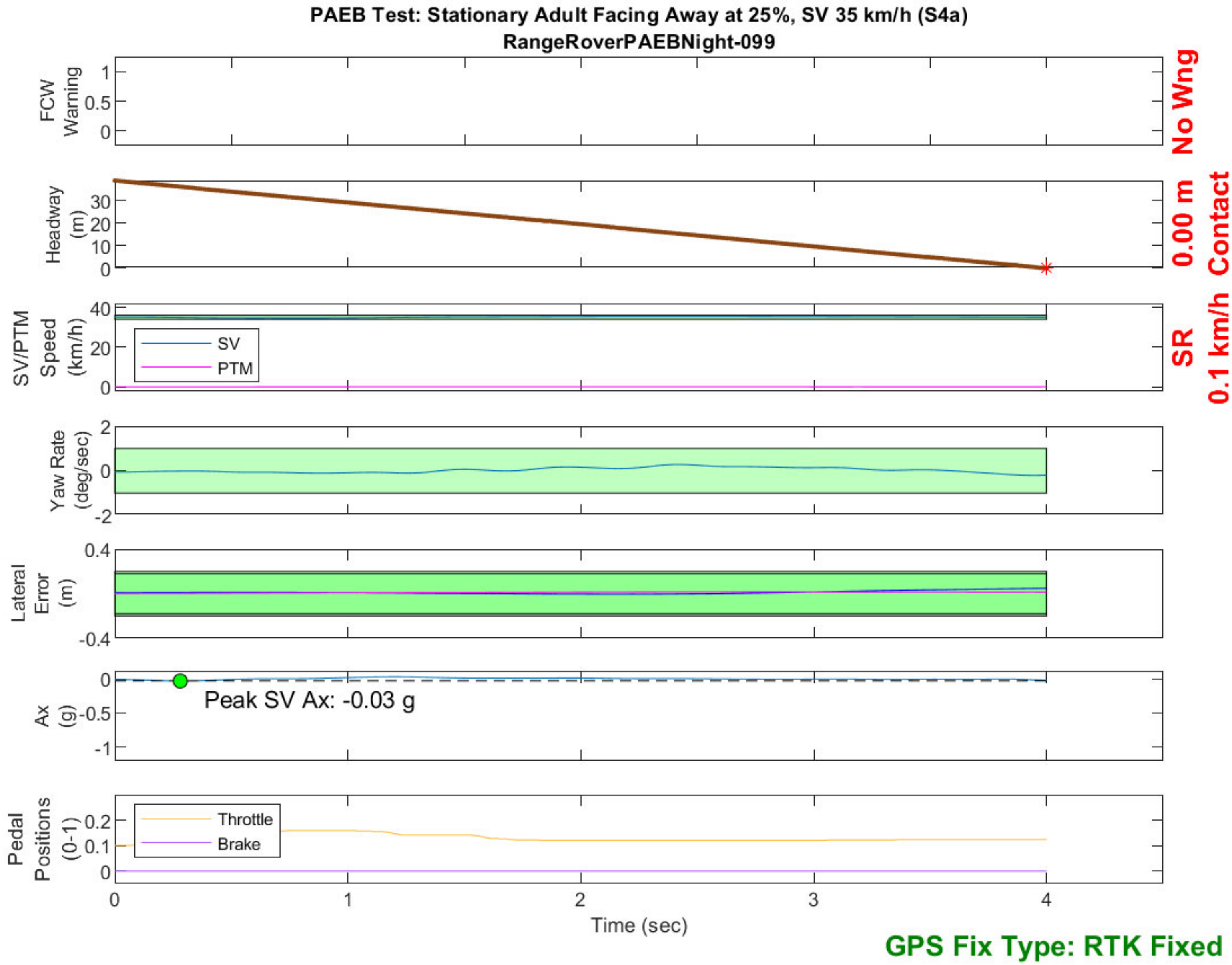


Figure D169. Time History for PAEB Run 99, S4a, Night, High Beam, 35 km/h

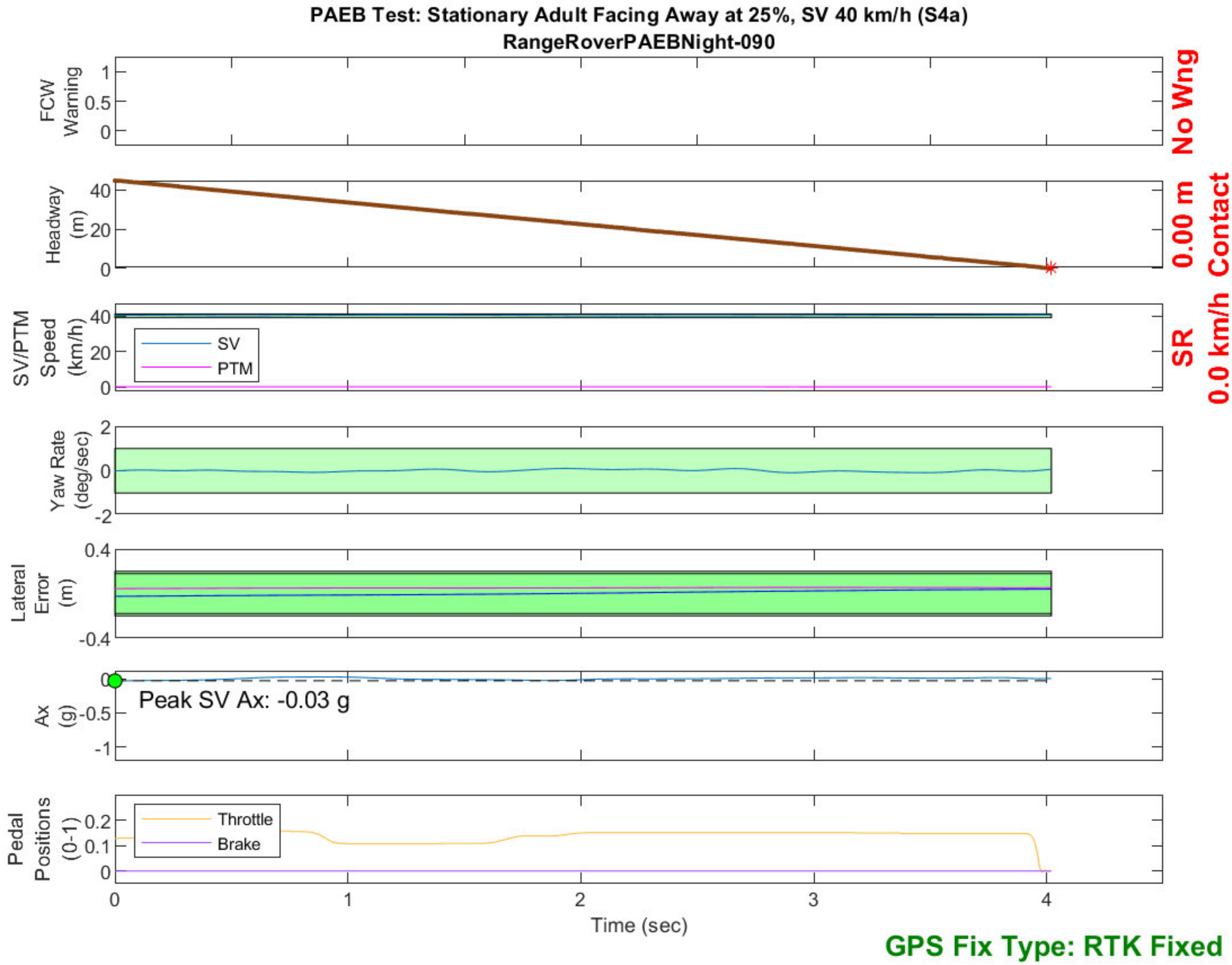


Figure D170. Time History for PAEB Run 90, S4a, Night, High Beam, 40 km/h

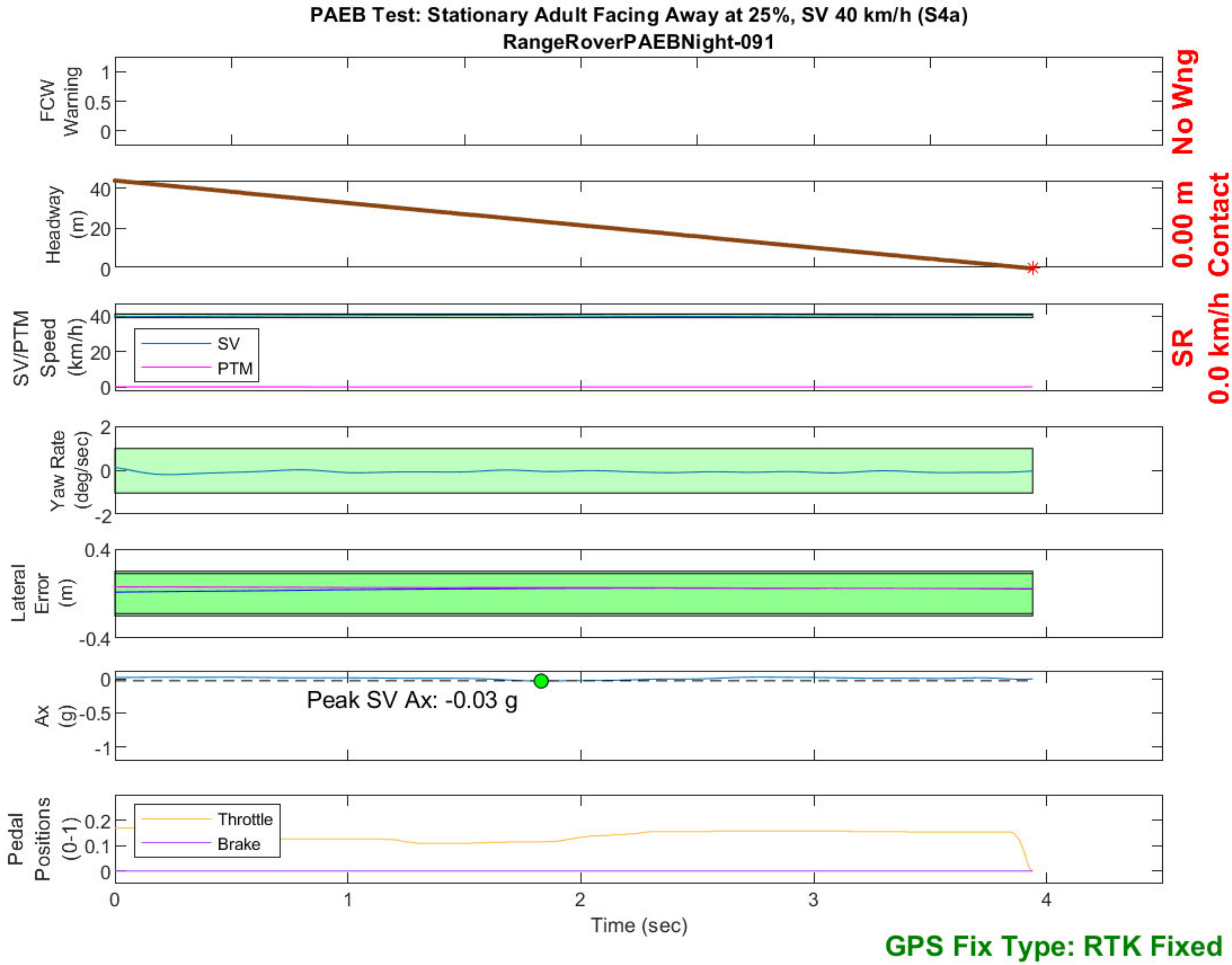


Figure D171. Time History for PAEB Run 91, S4a, Night, High Beam, 40 km/h

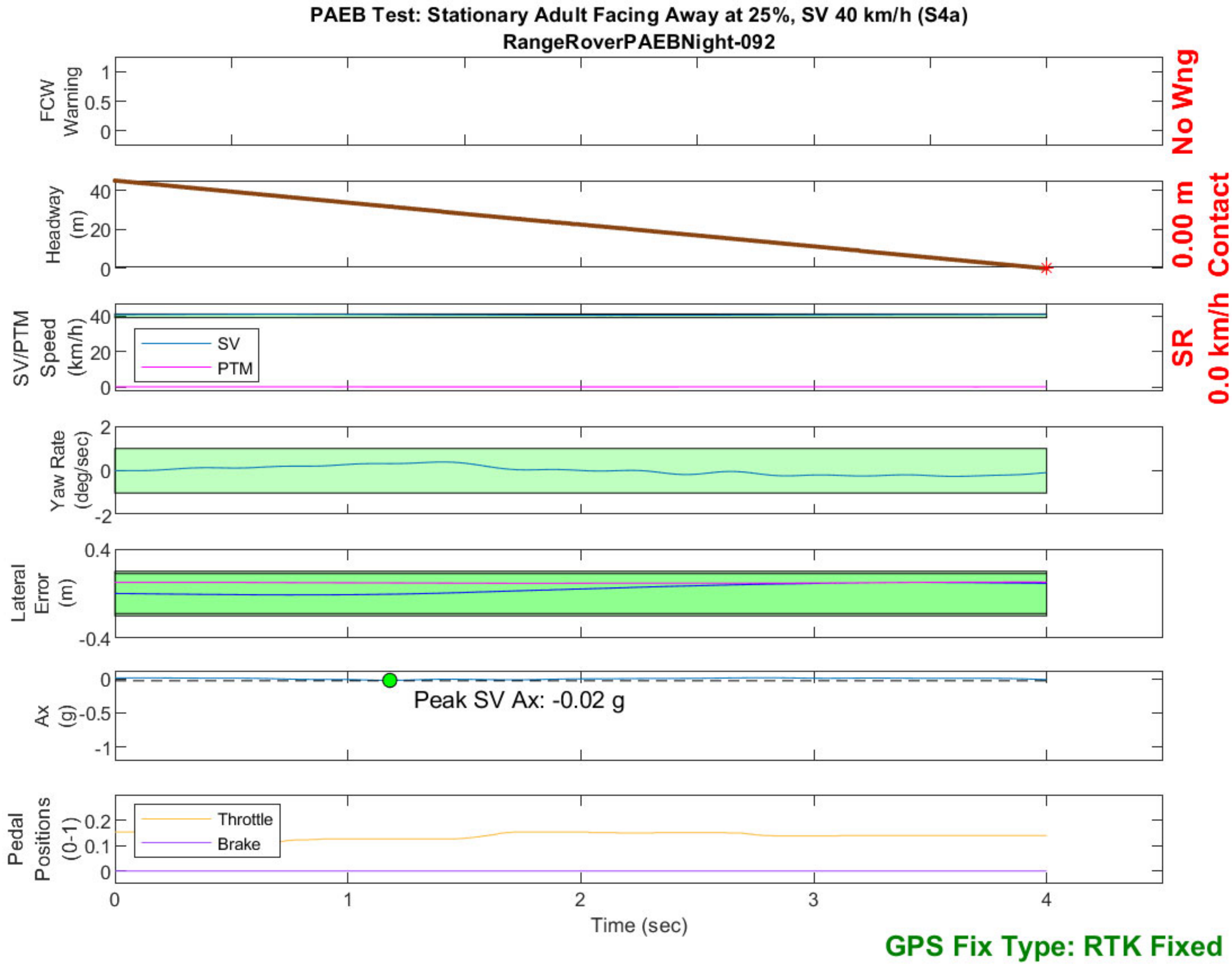


Figure D172. Time History for PAEB Run 92, S4a, Night, High Beam, 40 km/h

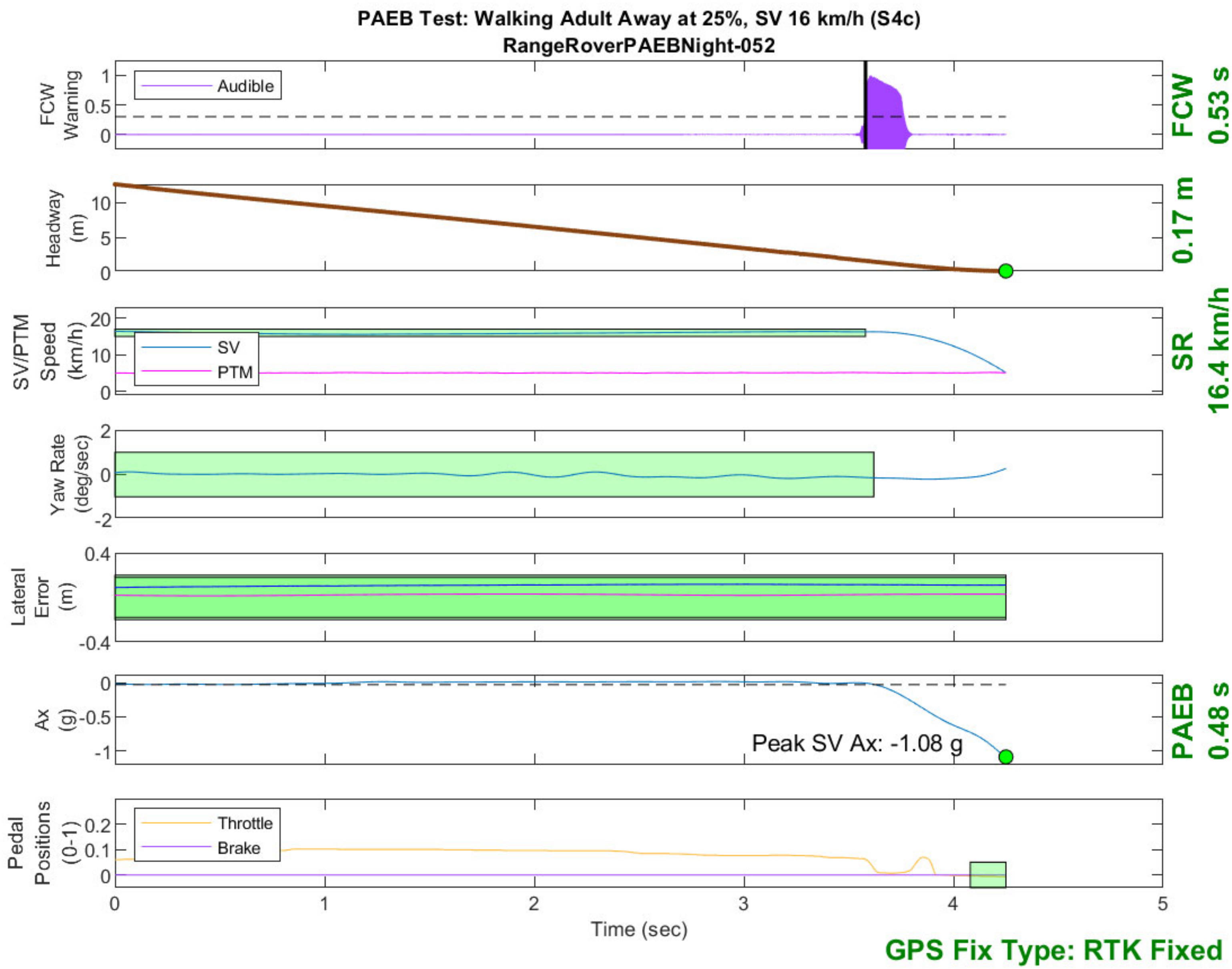


Figure D173. Time History for PAEB Run 52, S4c, Night, High Beam, 16 km/h

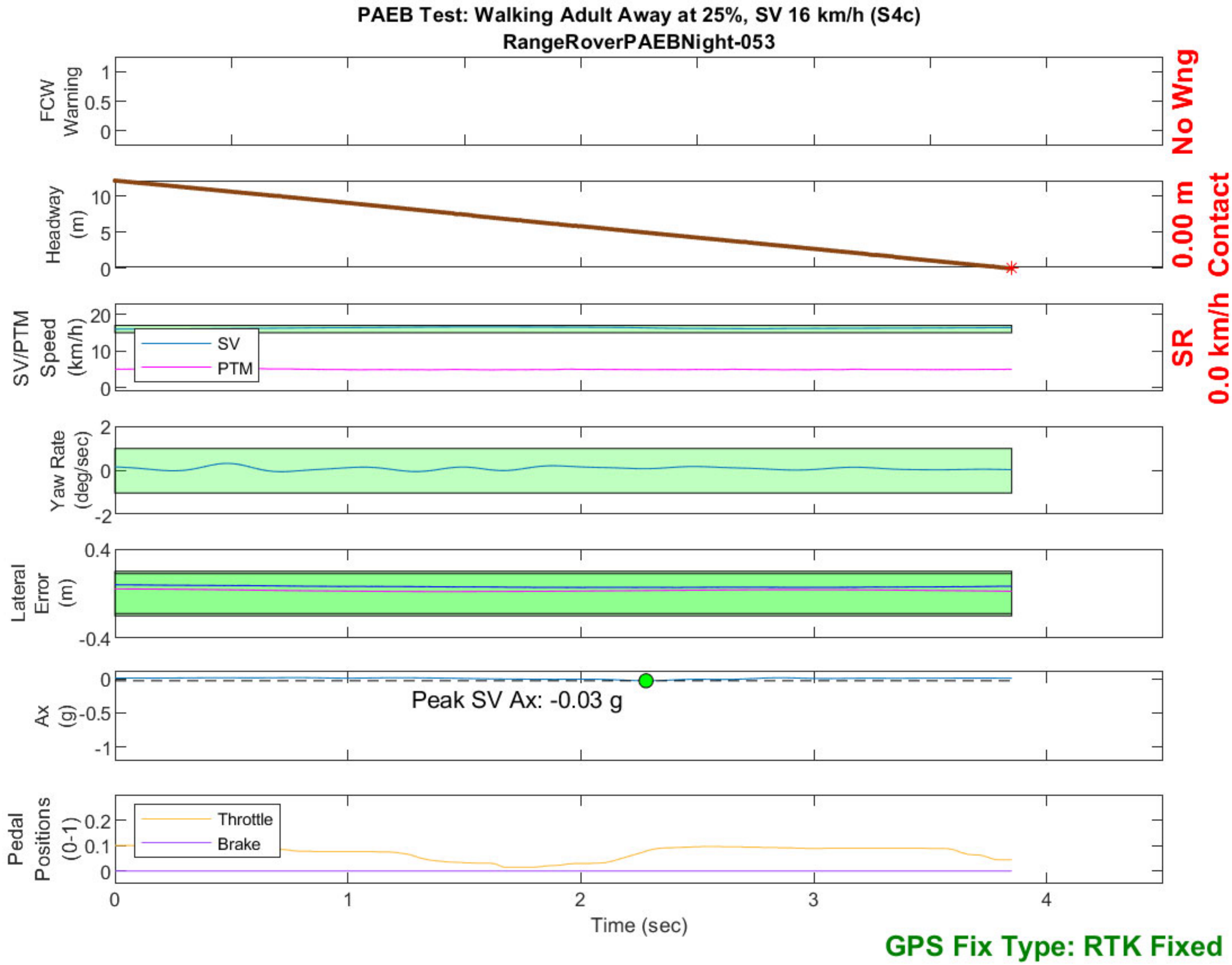


Figure D174. Time History for PAEB Run 53, S4c, Night, High Beam, 16 km/h

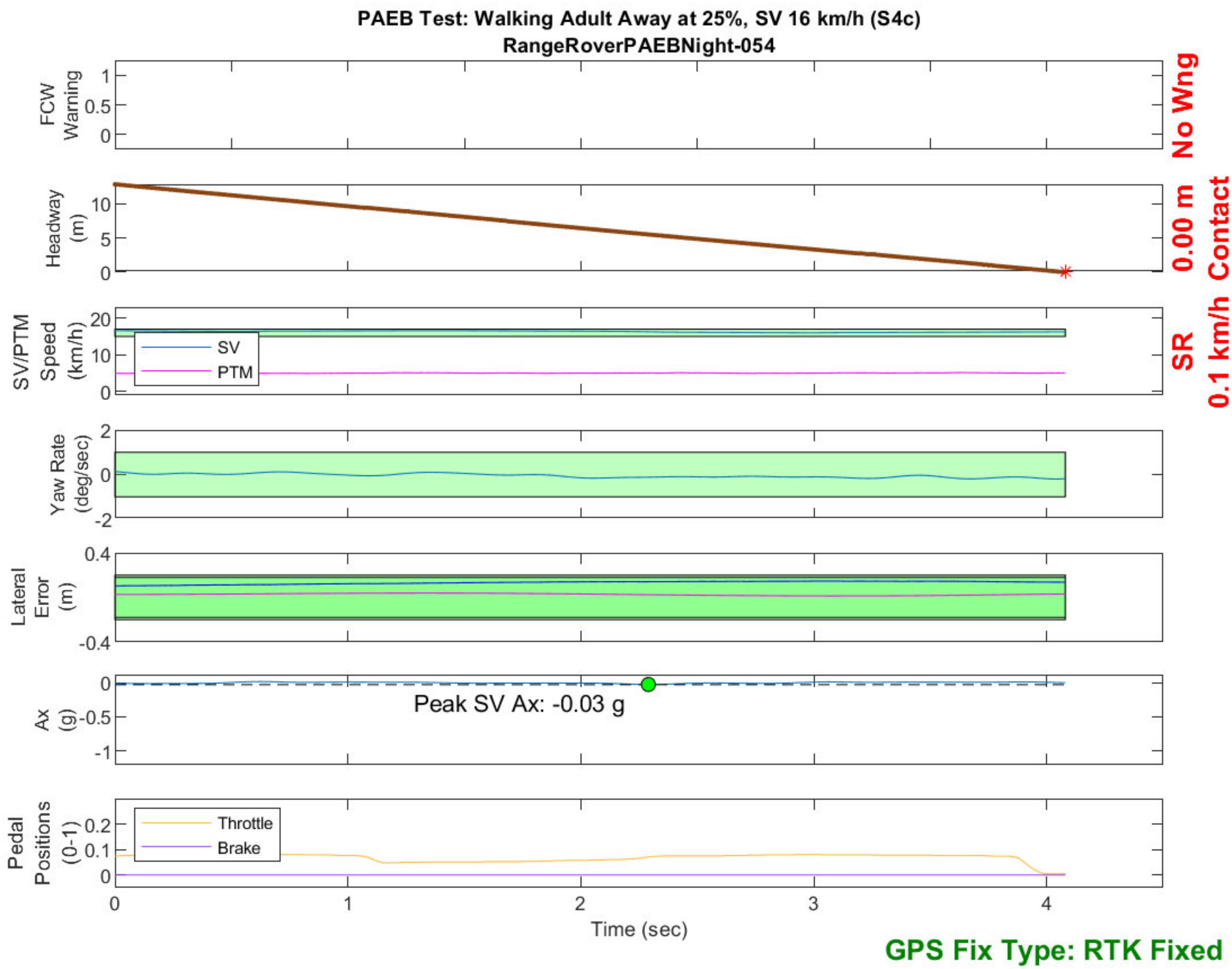


Figure D175. Time History for PAEB Run 54, S4c, Night, High Beam, 16 km/h

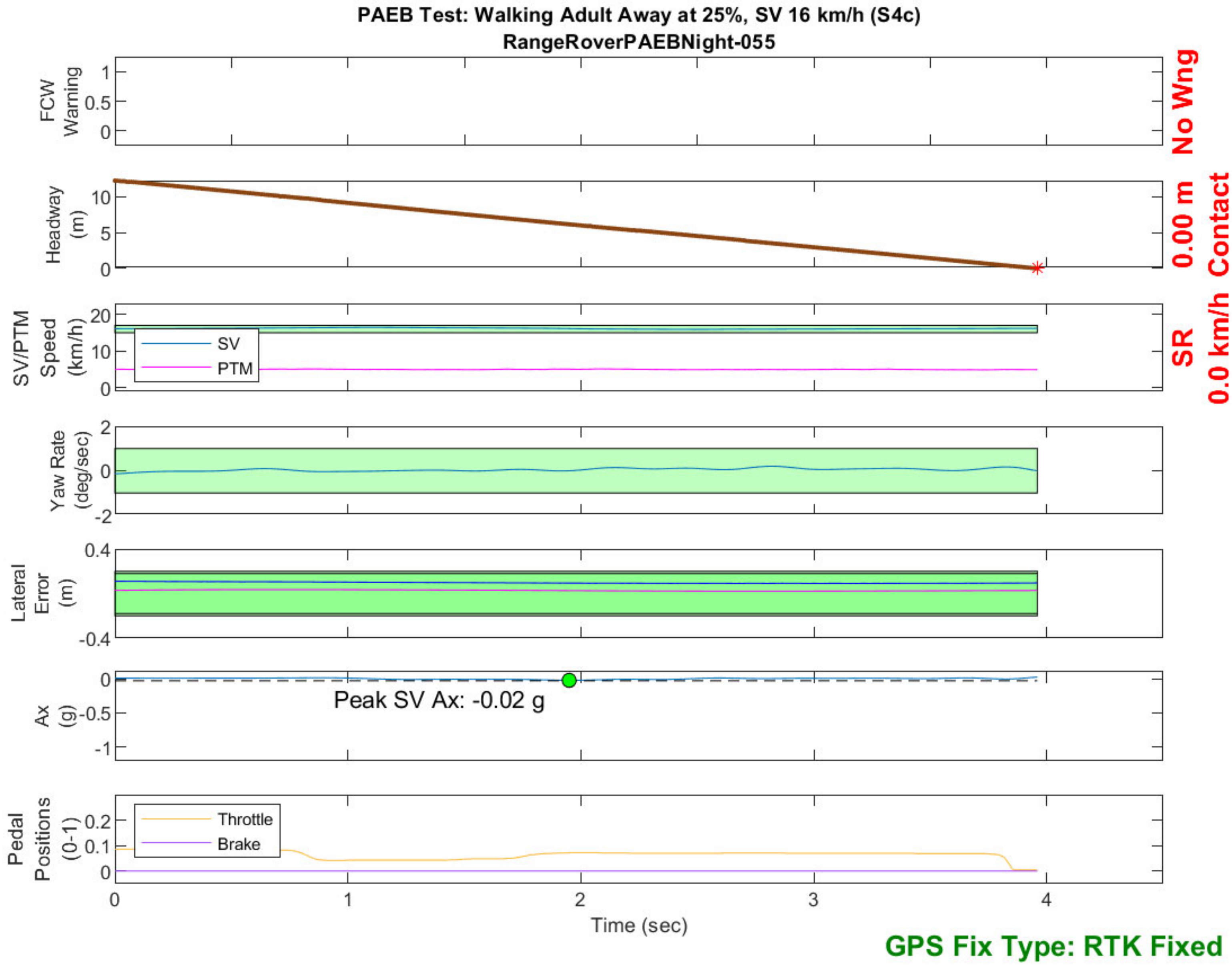


Figure D176. Time History for PAEB Run 55, S4c, Night, High Beam, 16 km/h

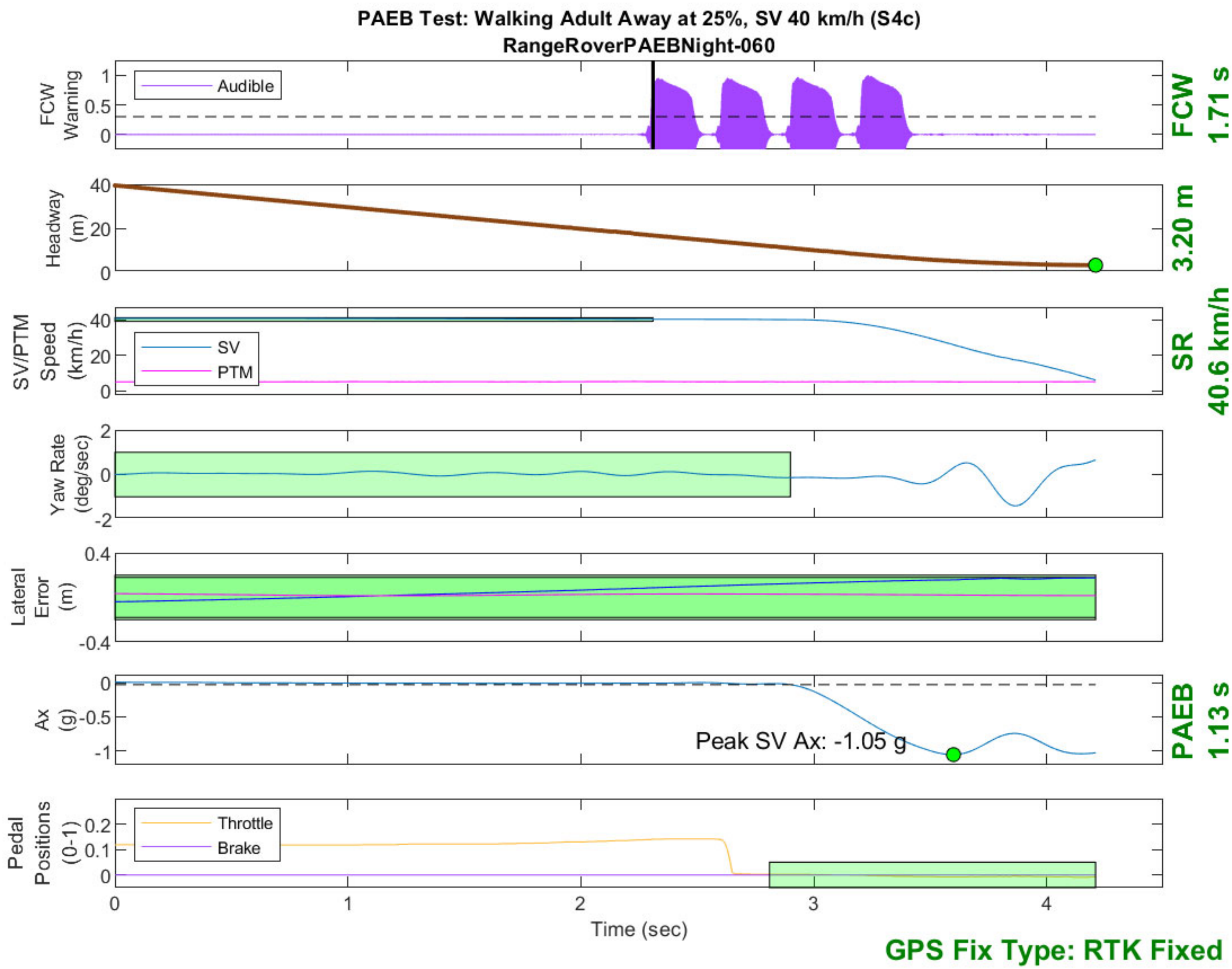


Figure D177. Time History for PAEB Run 60, S4c, Night, High Beam, 40 km/h

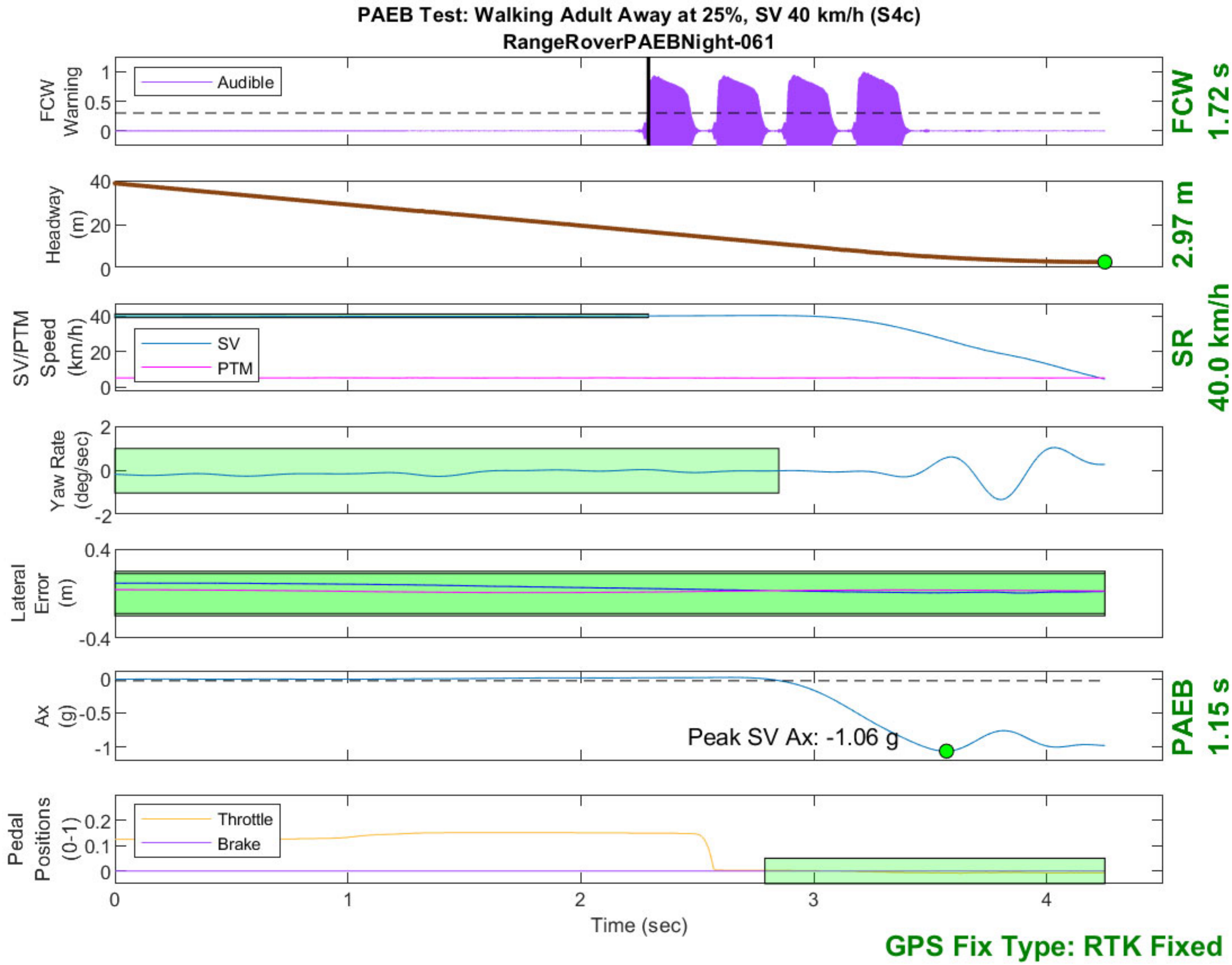


Figure D178. Time History for PAEB Run 61, S4c, Night, High Beam, 40 km/h

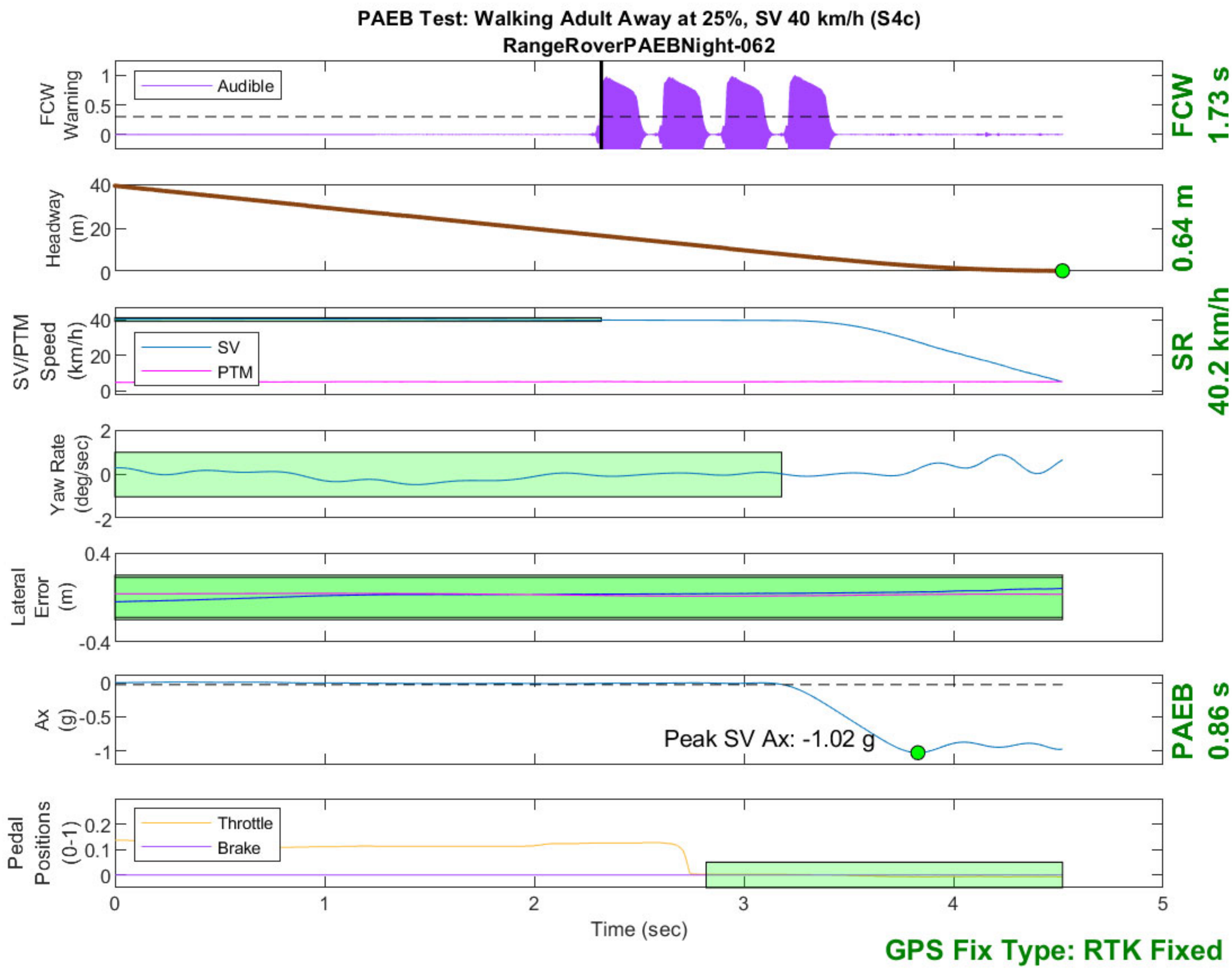


Figure D179. Time History for PAEB Run 62, S4c, Night, High Beam, 40 km/h

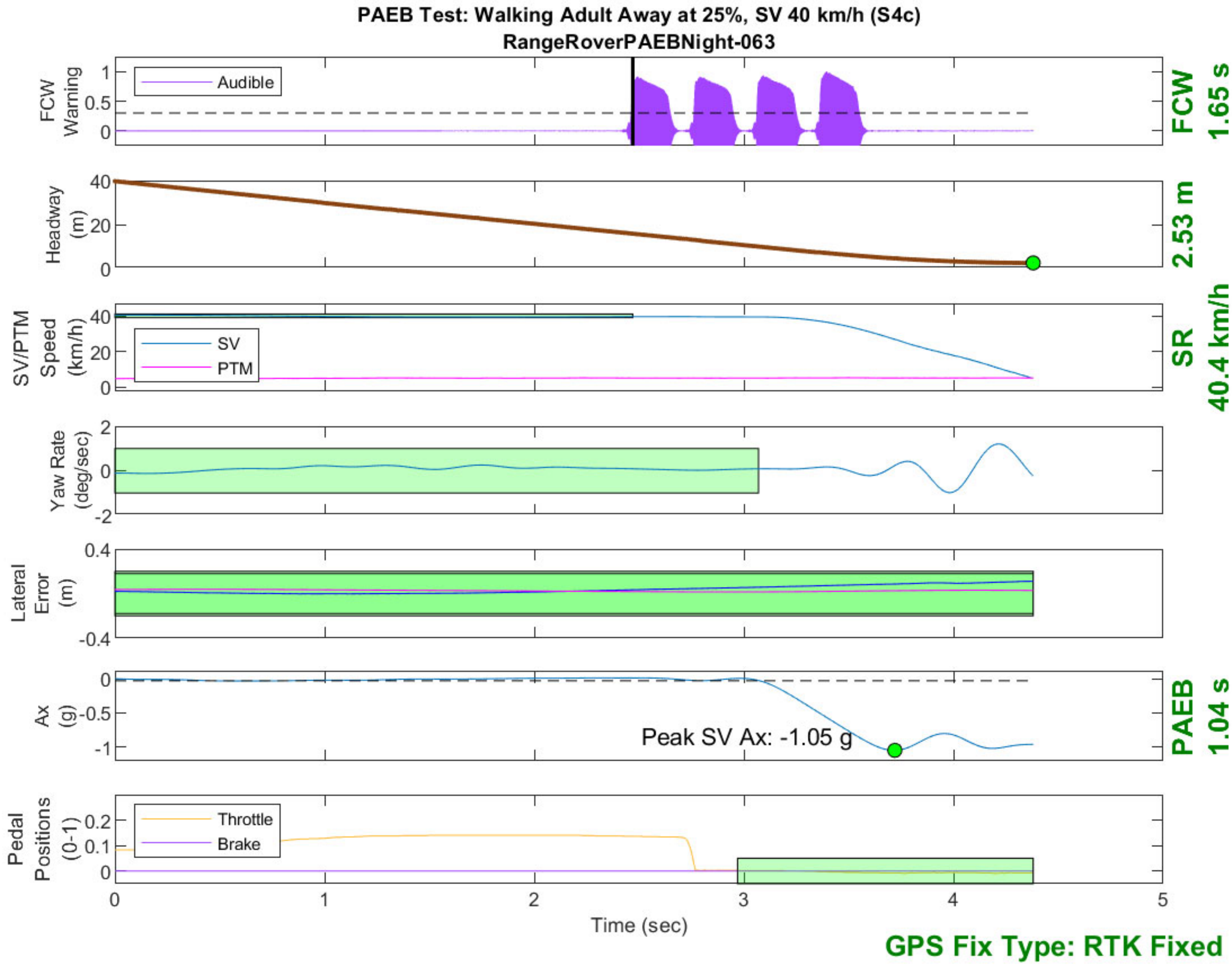


Figure D180. Time History for PAEB Run 63, S4c, Night, High Beam, 40 km/h

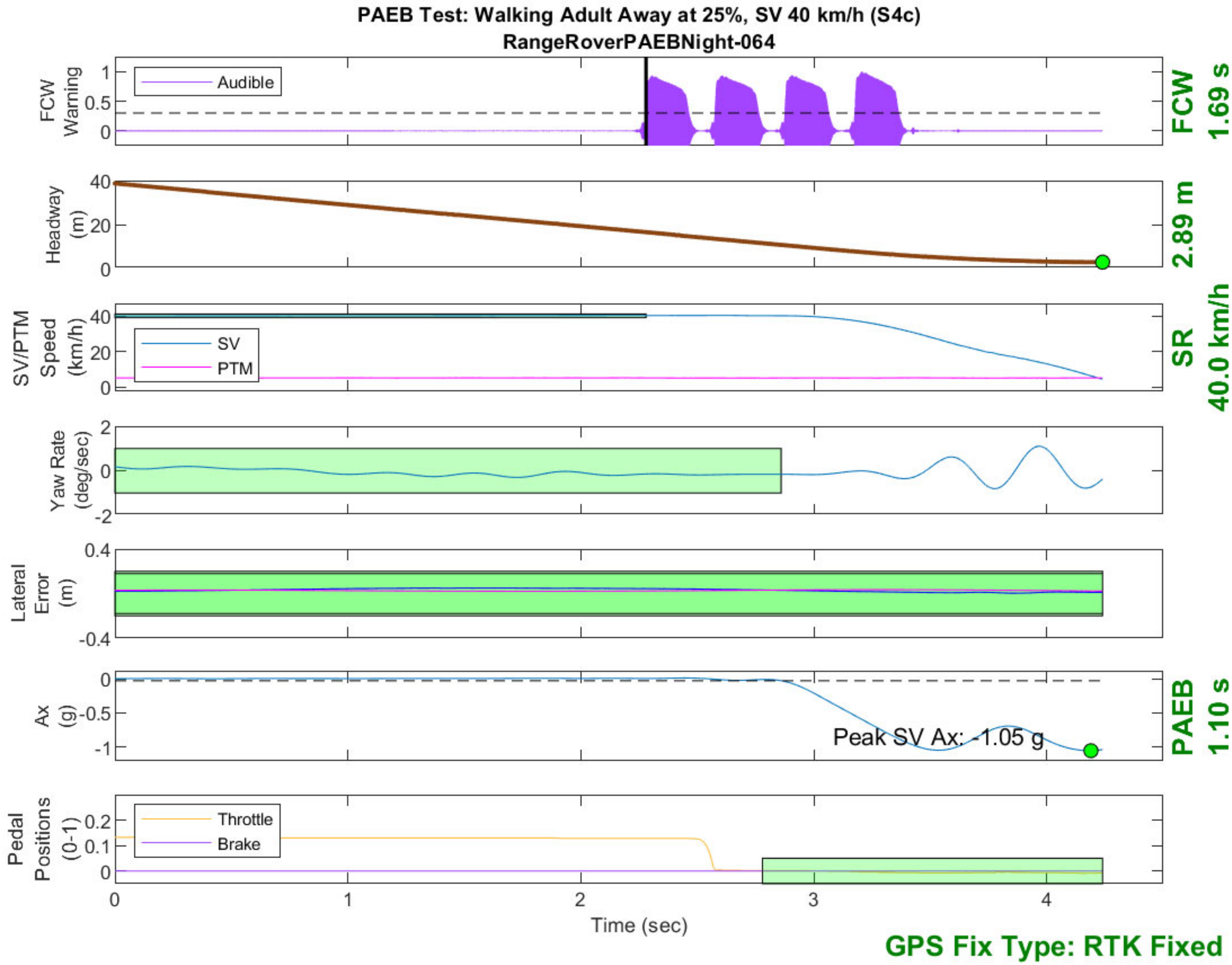


Figure D181. Time History for PAEB Run 64, S4c, Night, High Beam, 40 km/h

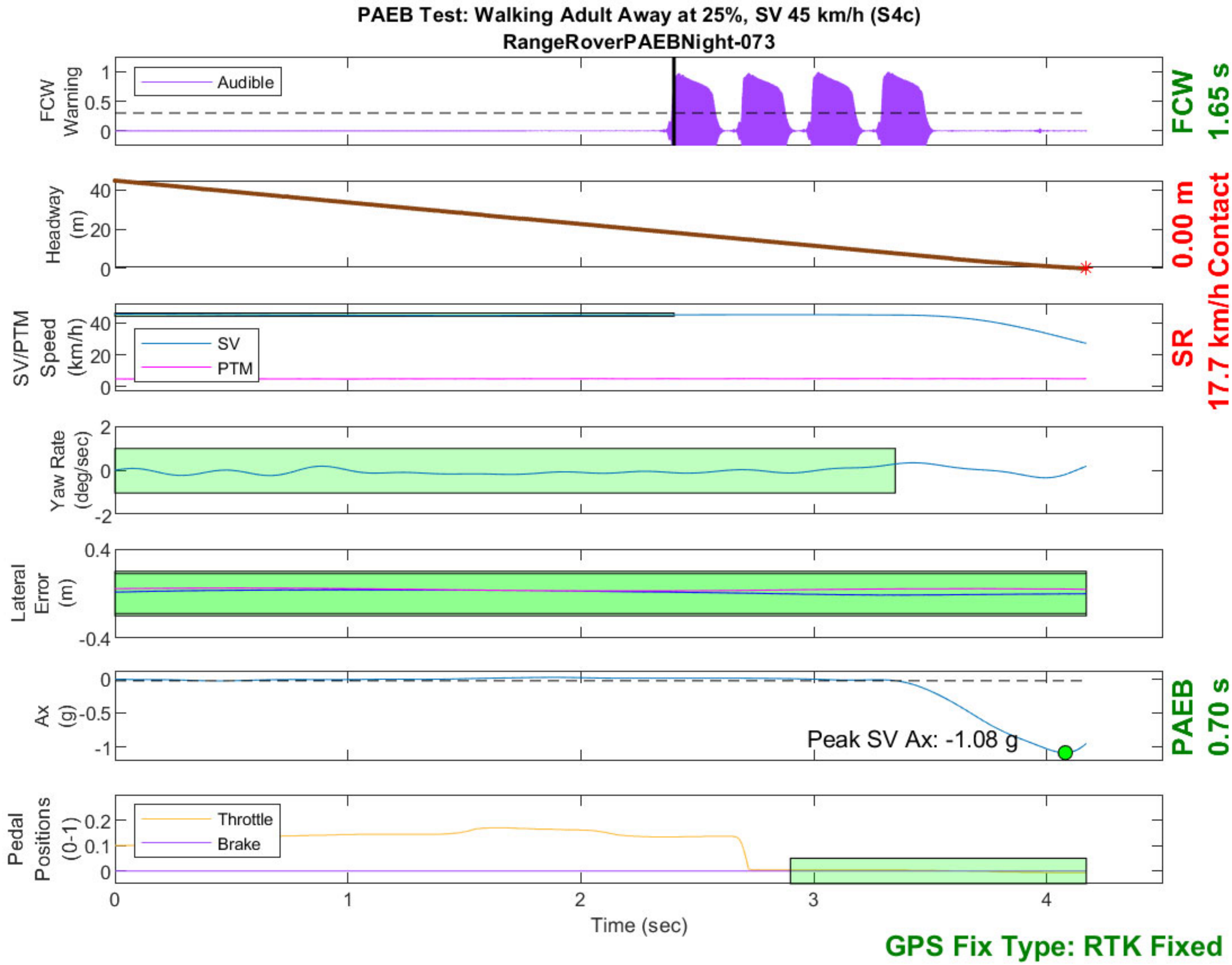


Figure D182. Time History for PAEB Run 73, S4c, Night, High Beam, 45 km/h

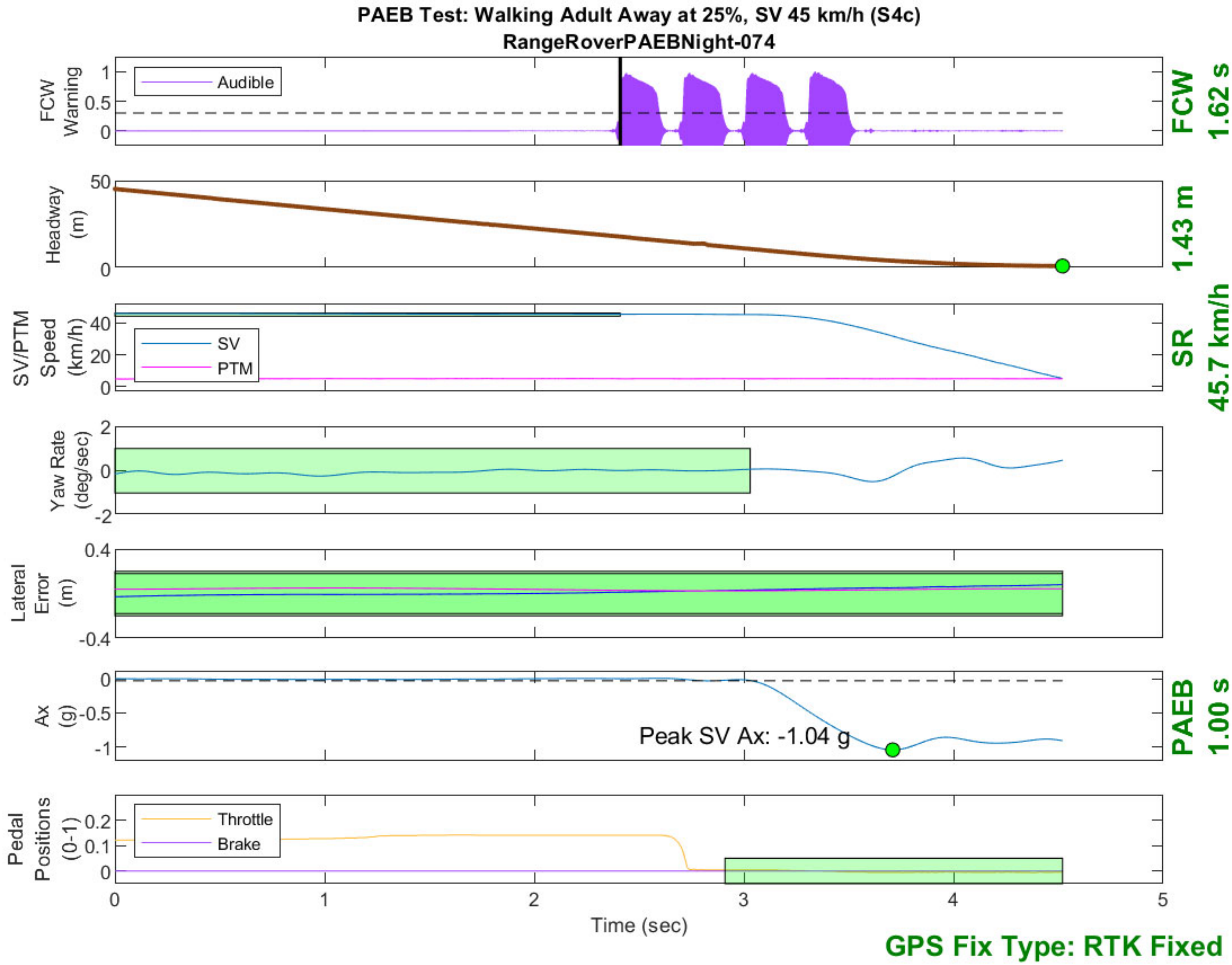


Figure D183. Time History for PAEB Run 74, S4c, Night, High Beam, 45 km/h

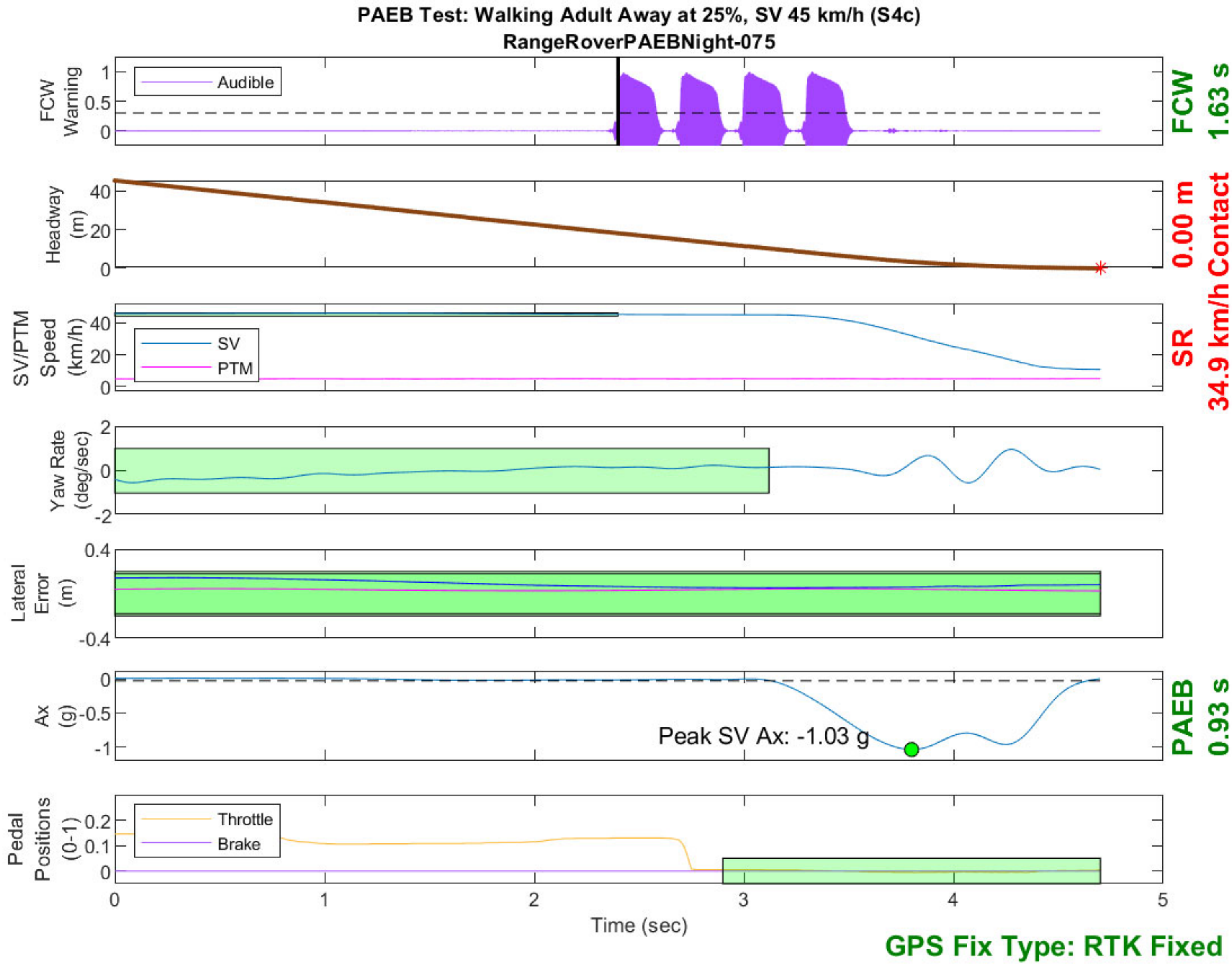


Figure D184. Time History for PAEB Run 75, S4c, Night, High Beam, 45 km/h

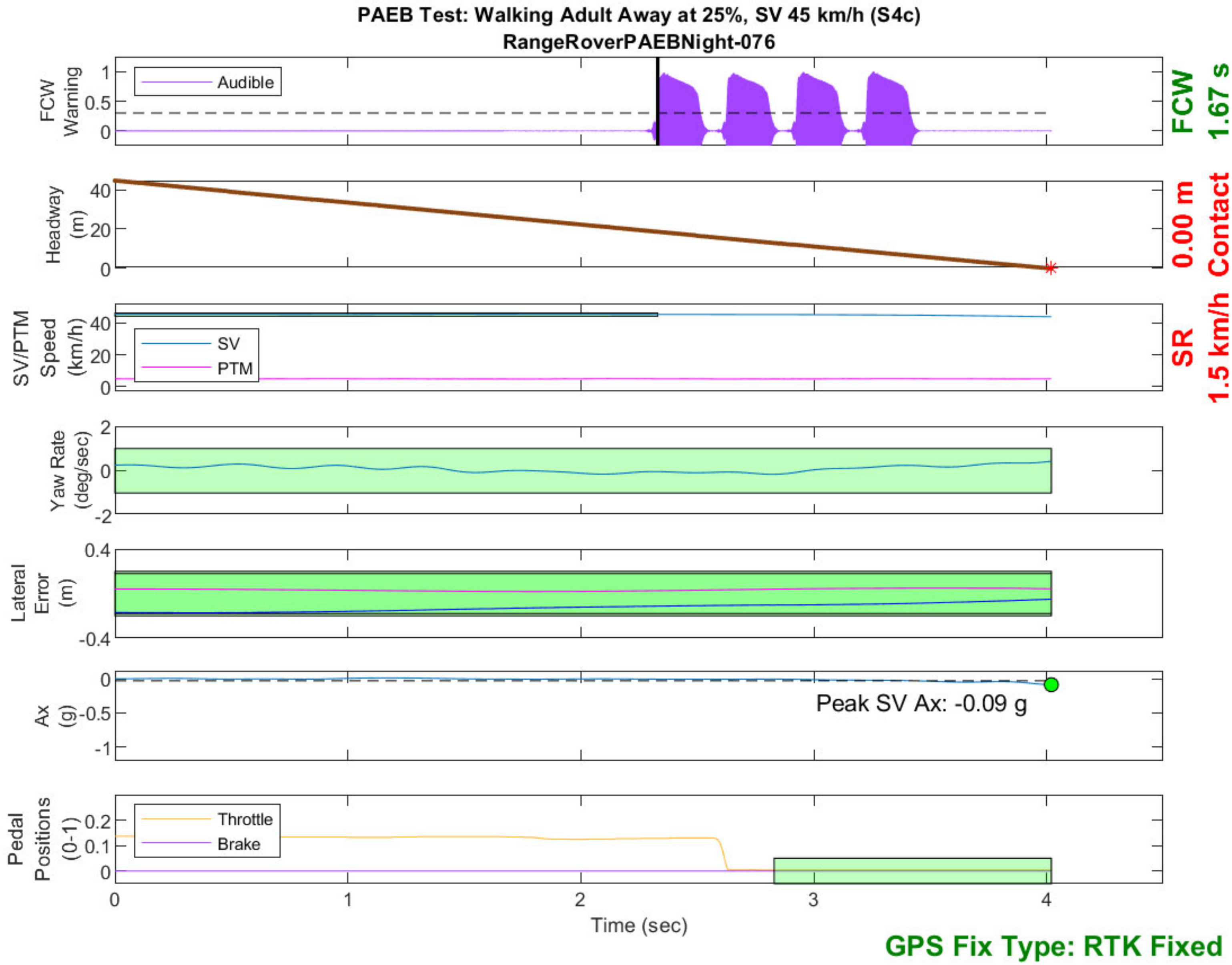


Figure D185. Time History for PAEB Run 76, S4c, Night, High Beam, 45 km/h

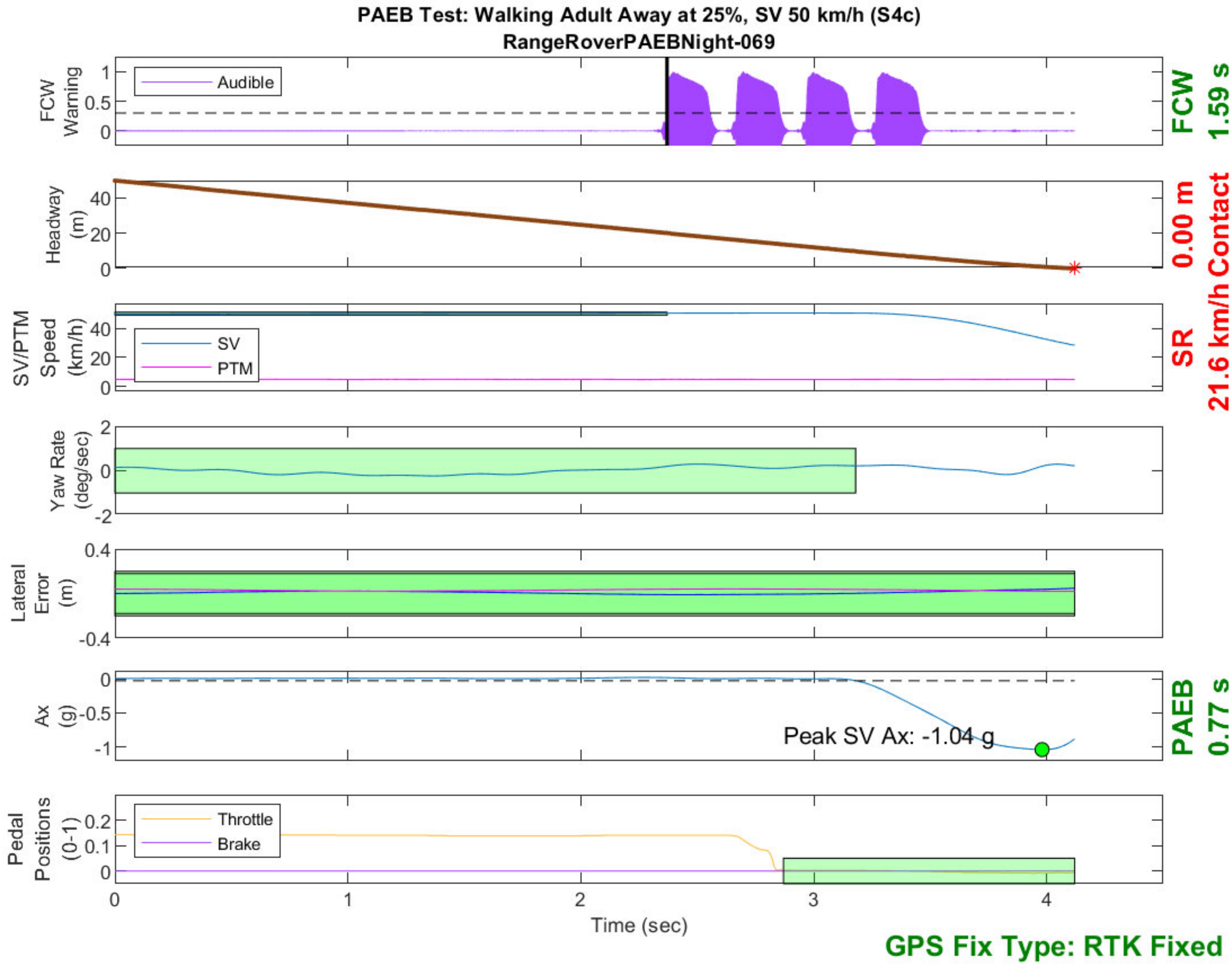


Figure D186. Time History for PAEB Run 69, S4c, Night, High Beam, 50 km/h

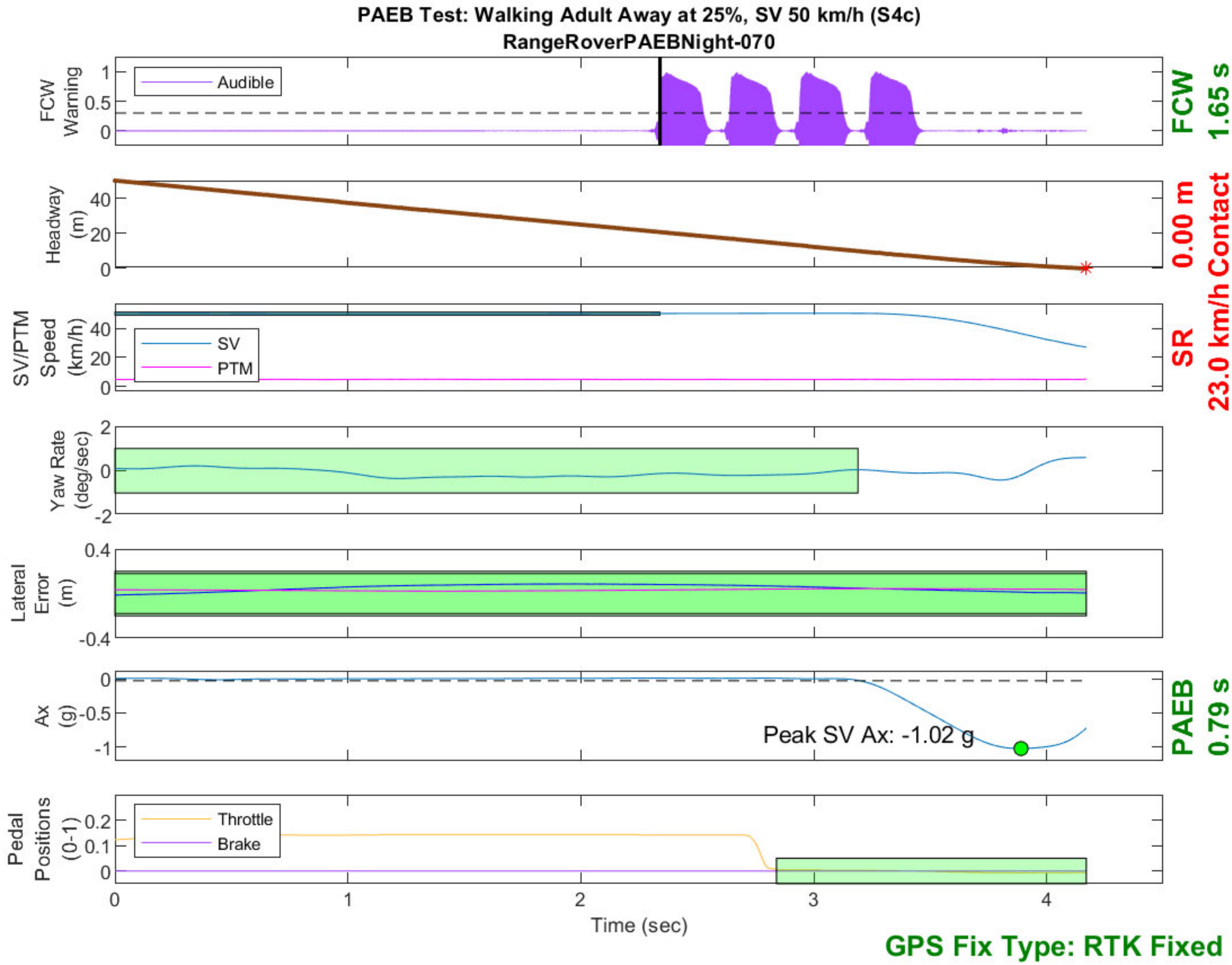


Figure D187. Time History for PAEB Run 70, S4c, Night, High Beam, 50 km/h

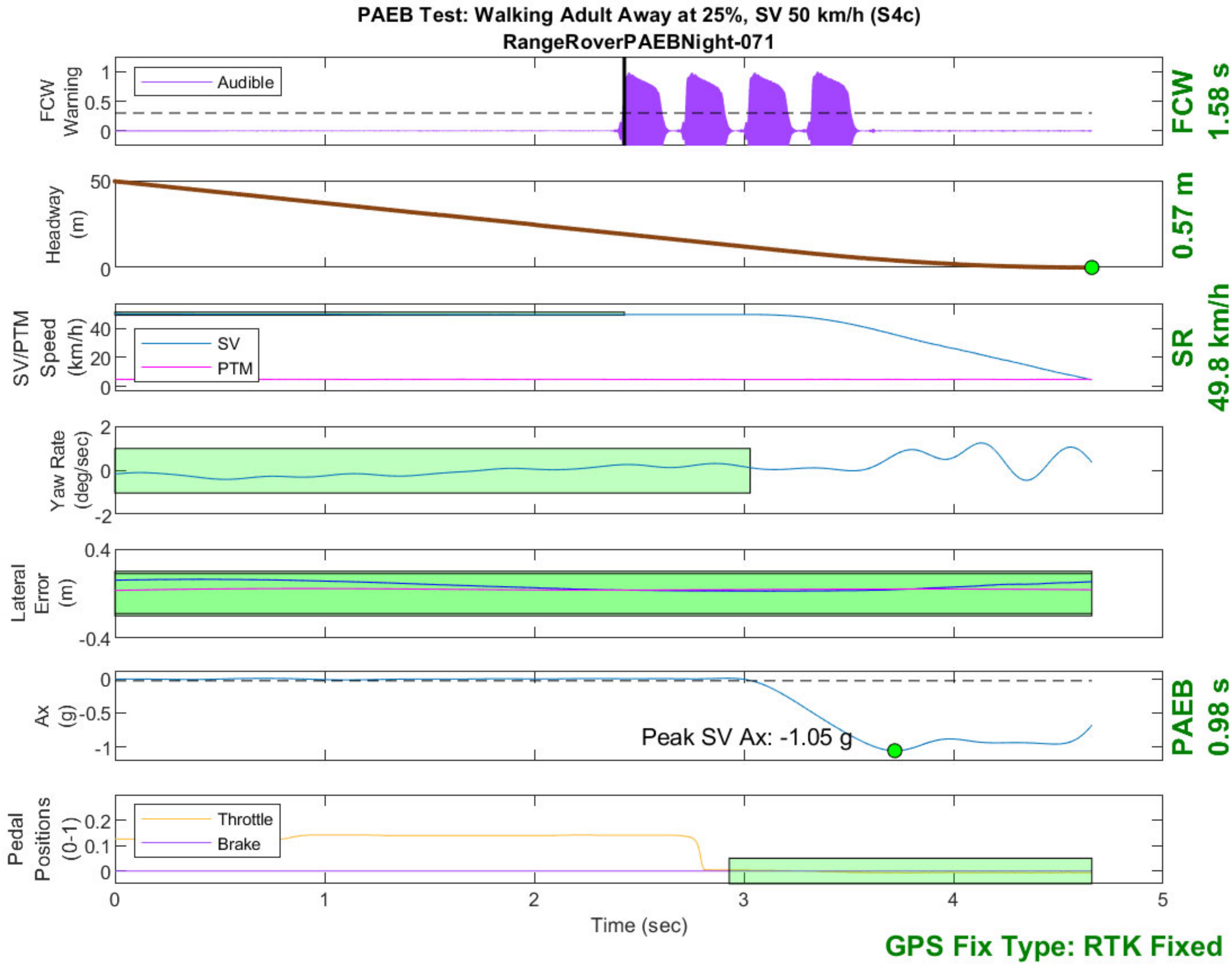


Figure D188. Time History for PAEB Run 71, S4c, Night, High Beam, 50 km/h

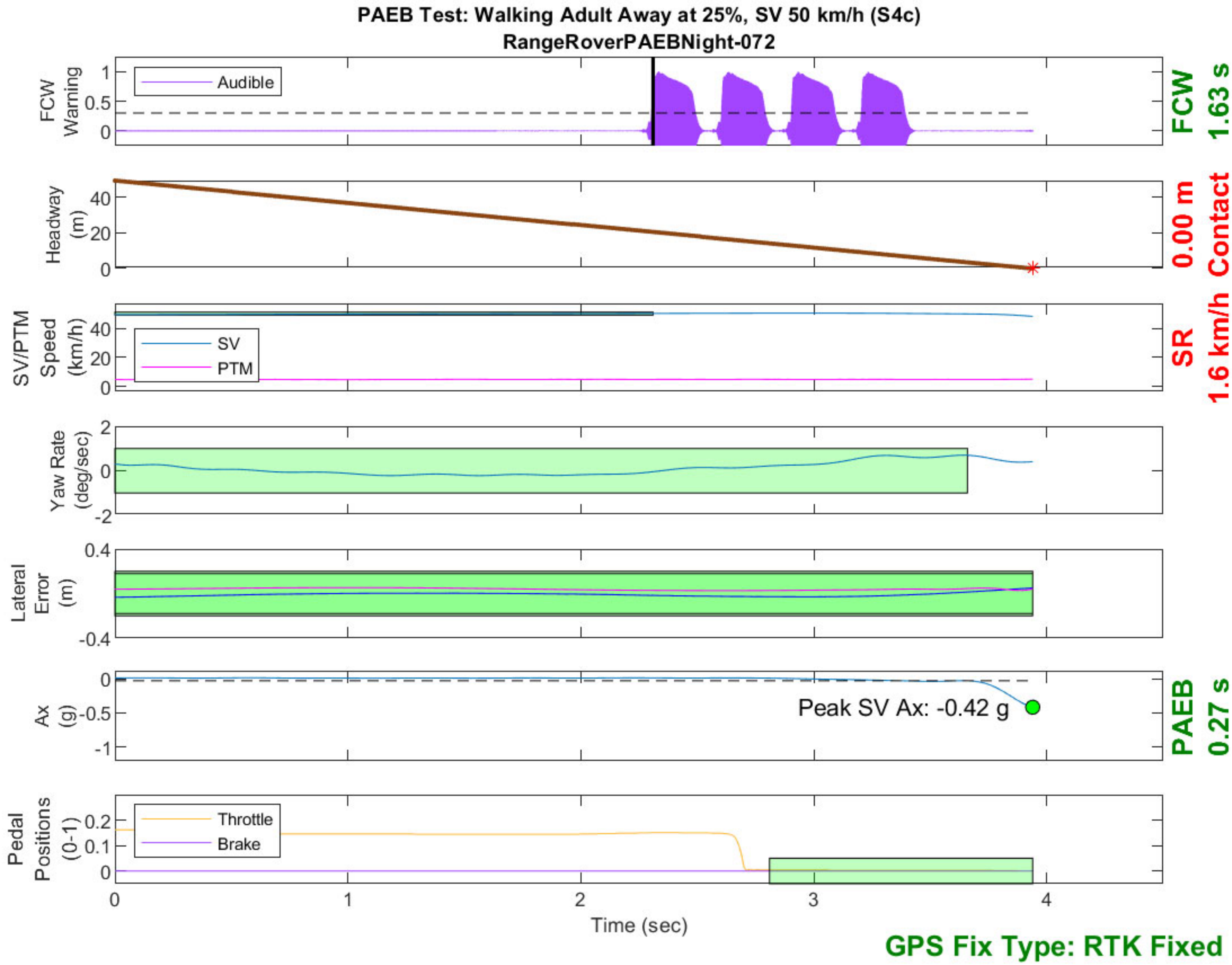


Figure D189. Time History for PAEB Run 72, S4c, Night, High Beam, 50 km/h

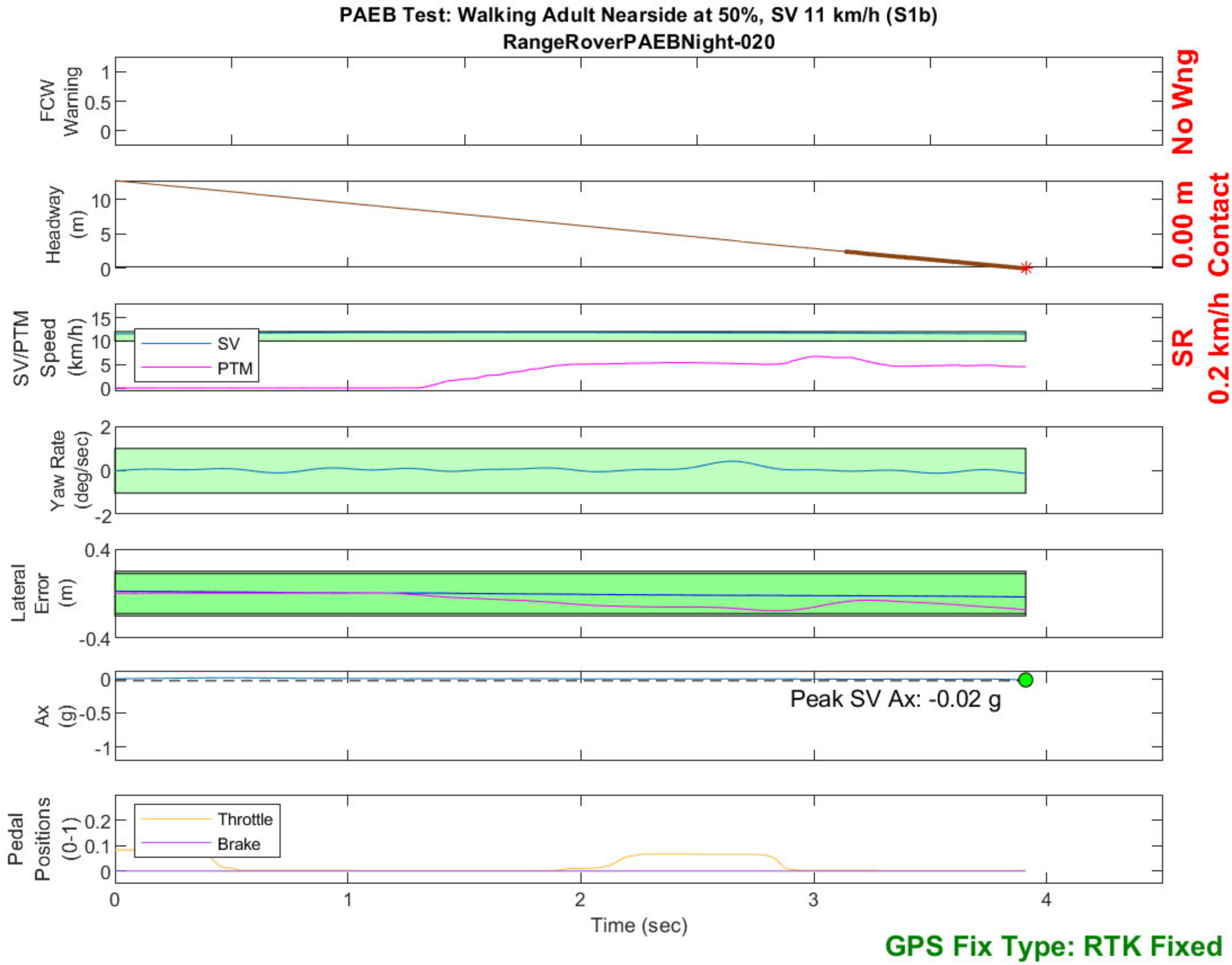


Figure D190. Time History for PAEB Run 20, S1b, Night, Low Beam, 11 km/h

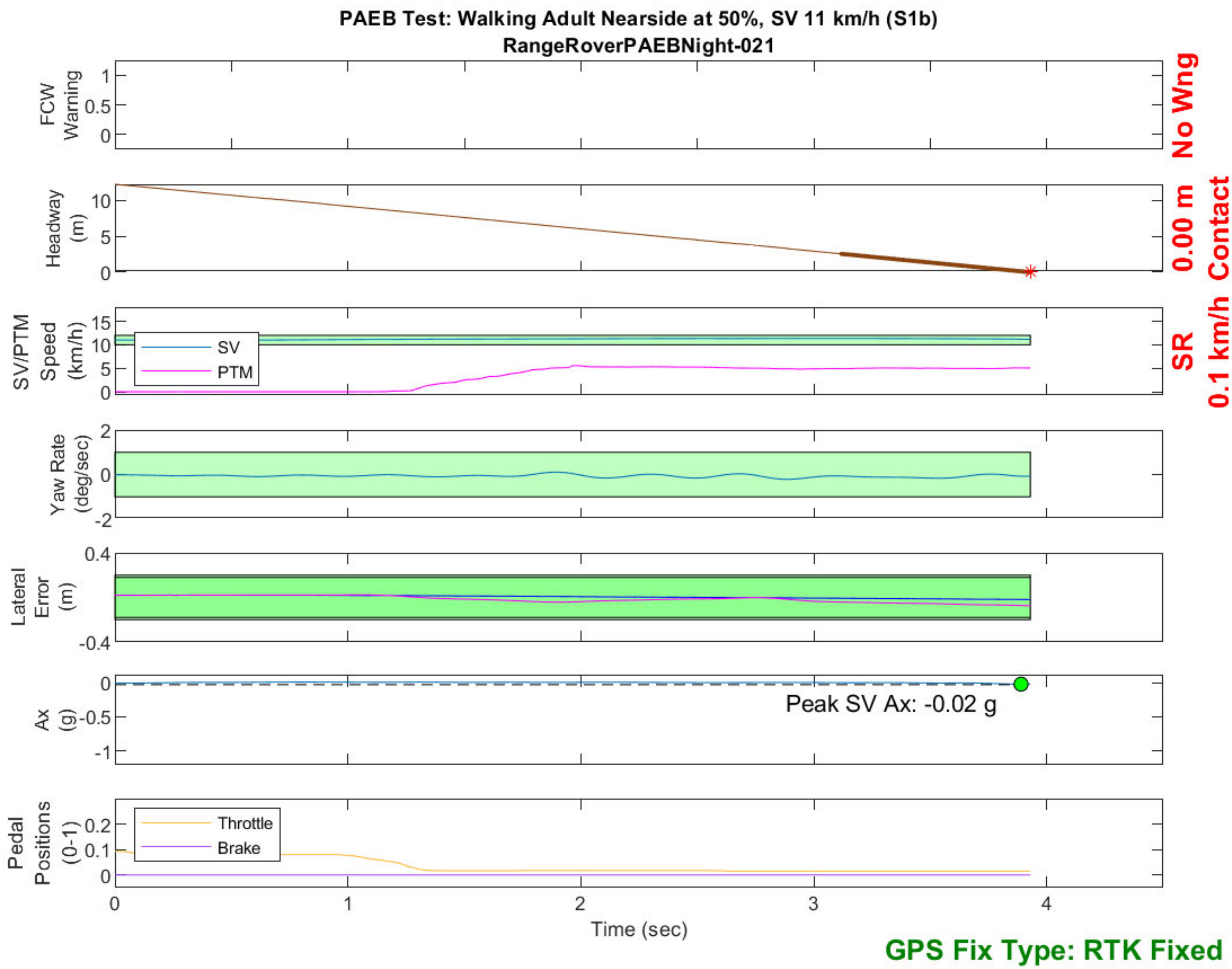


Figure D191. Time History for PAEB Run 21, S1b, Night, Low Beam, 11 km/h

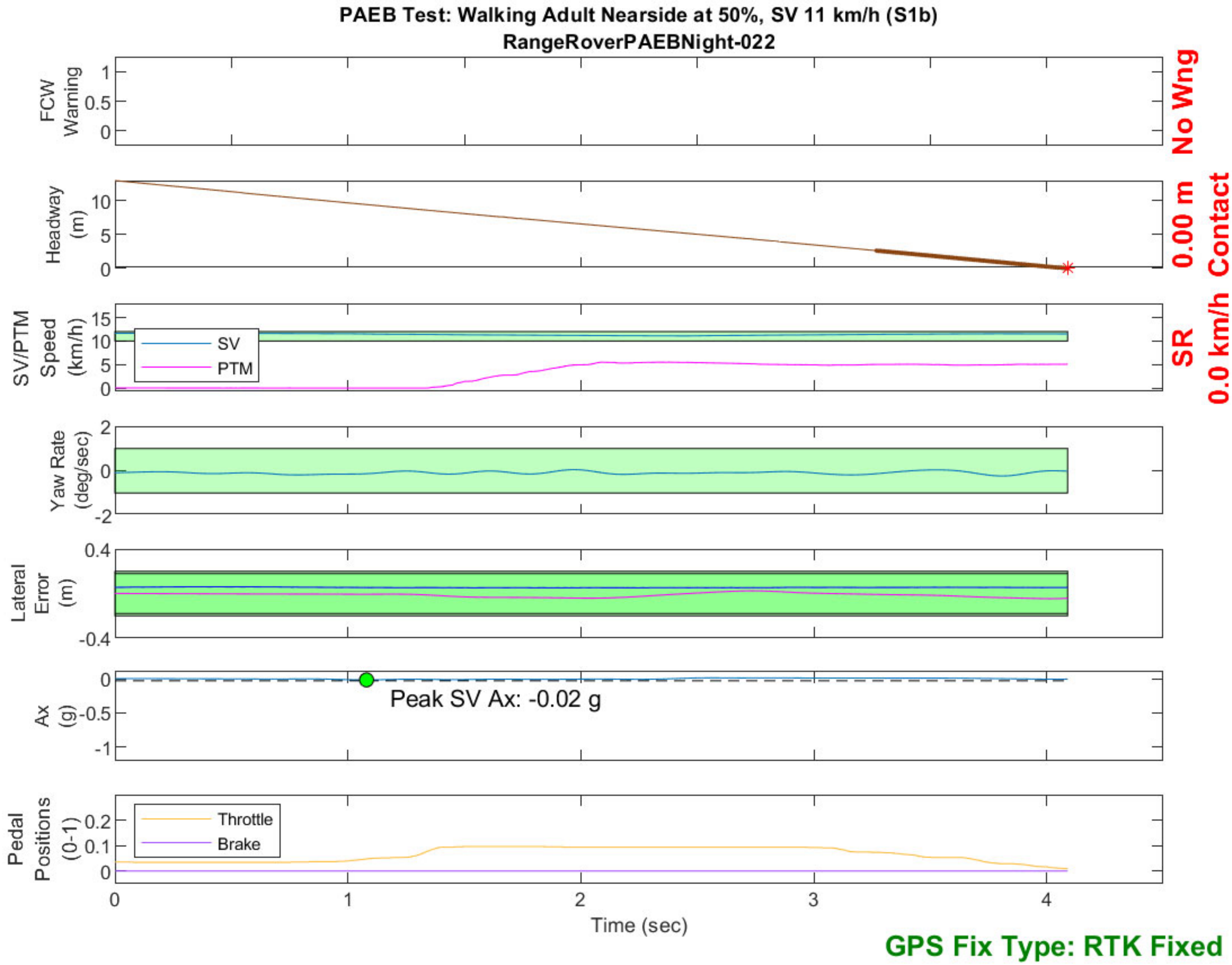


Figure D192. Time History for PAEB Run 22, S1b, Night, Low Beam, 11 km/h

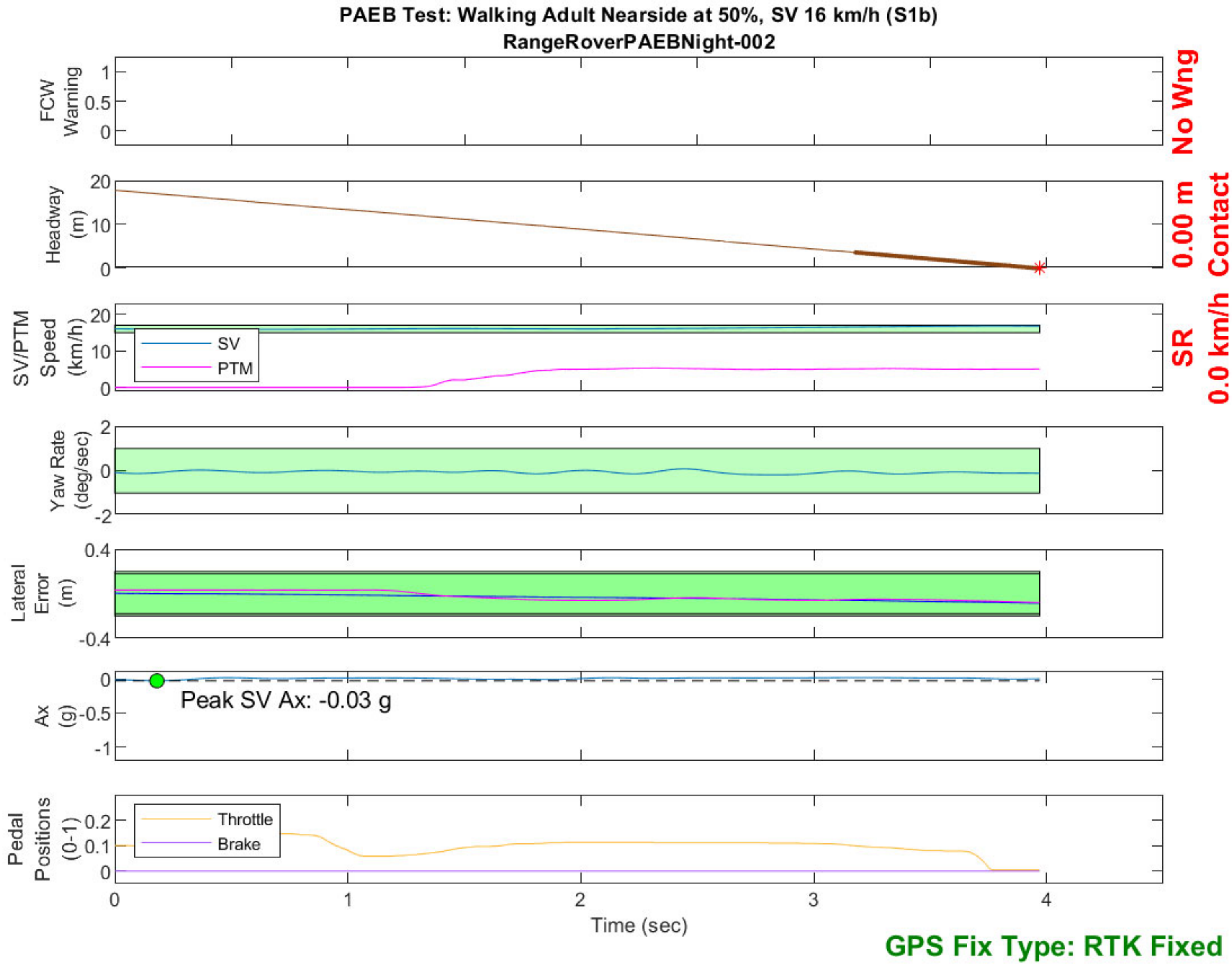


Figure D193. Time History for PAEB Run 2, S1b, Night, Low Beam, 16 km/h

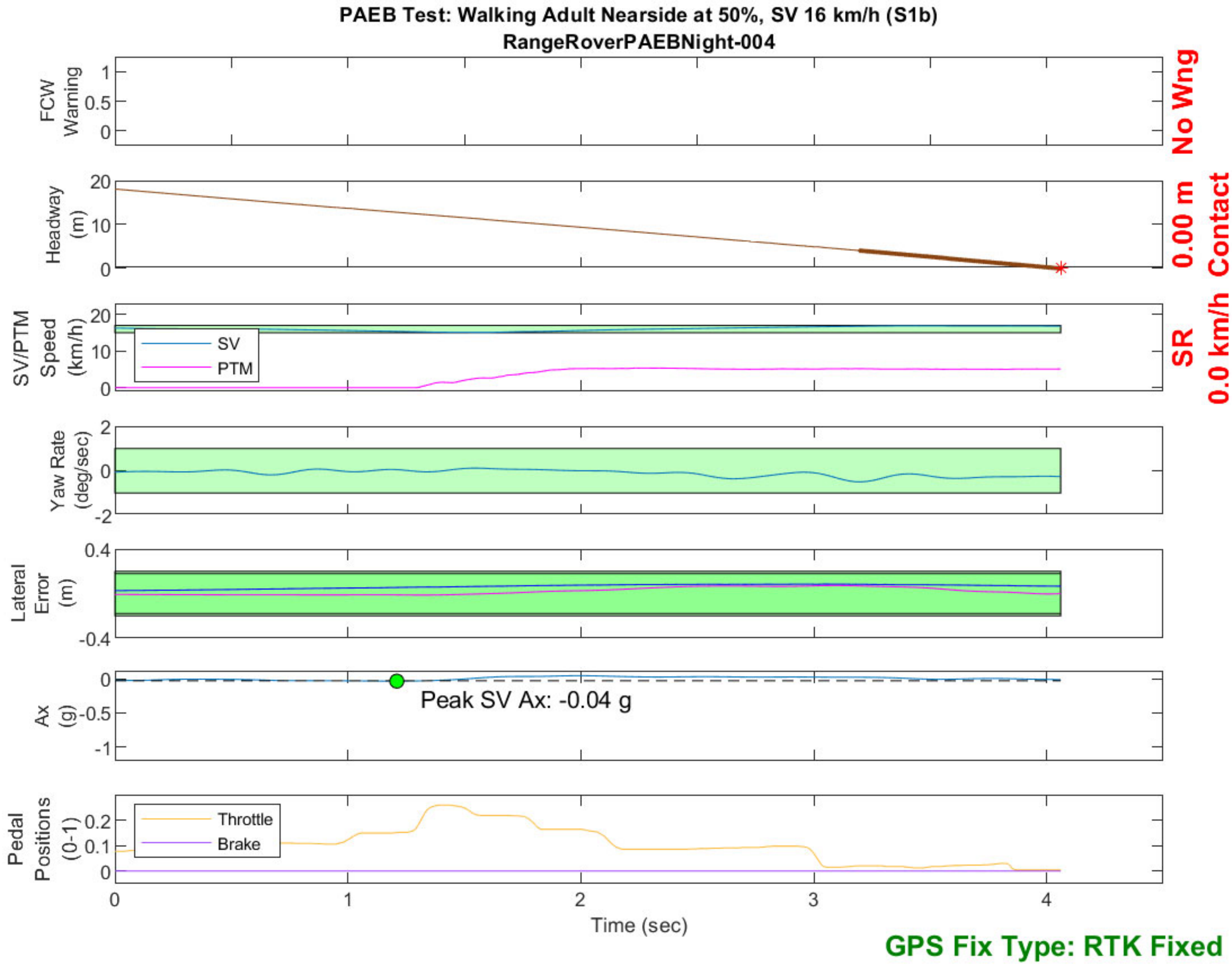


Figure D194. Time History for PAEB Run 4, S1b, Night, Low Beam, 16 km/h

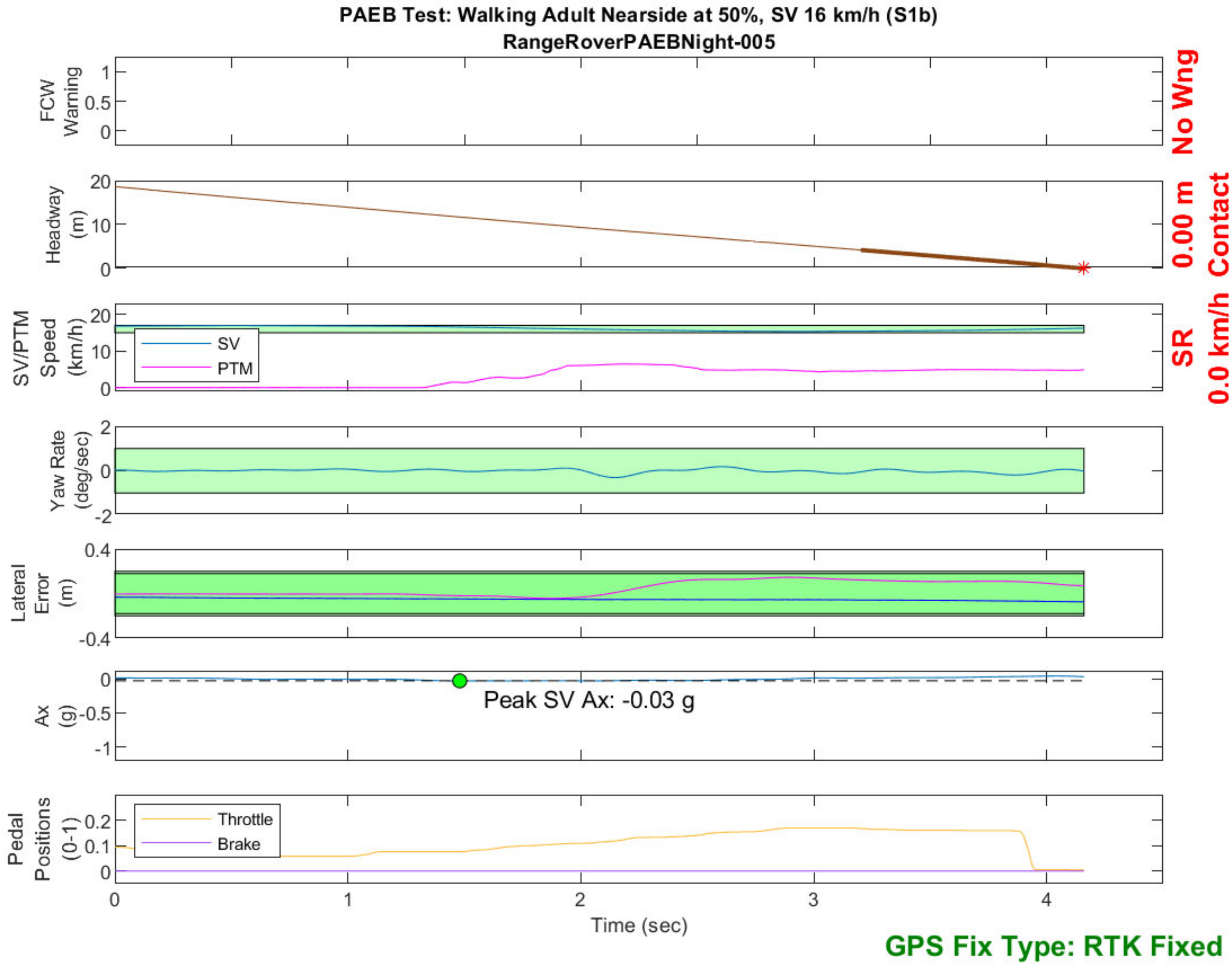


Figure D195. Time History for PAEB Run 5, S1b, Night, Low Beam, 16 km/h

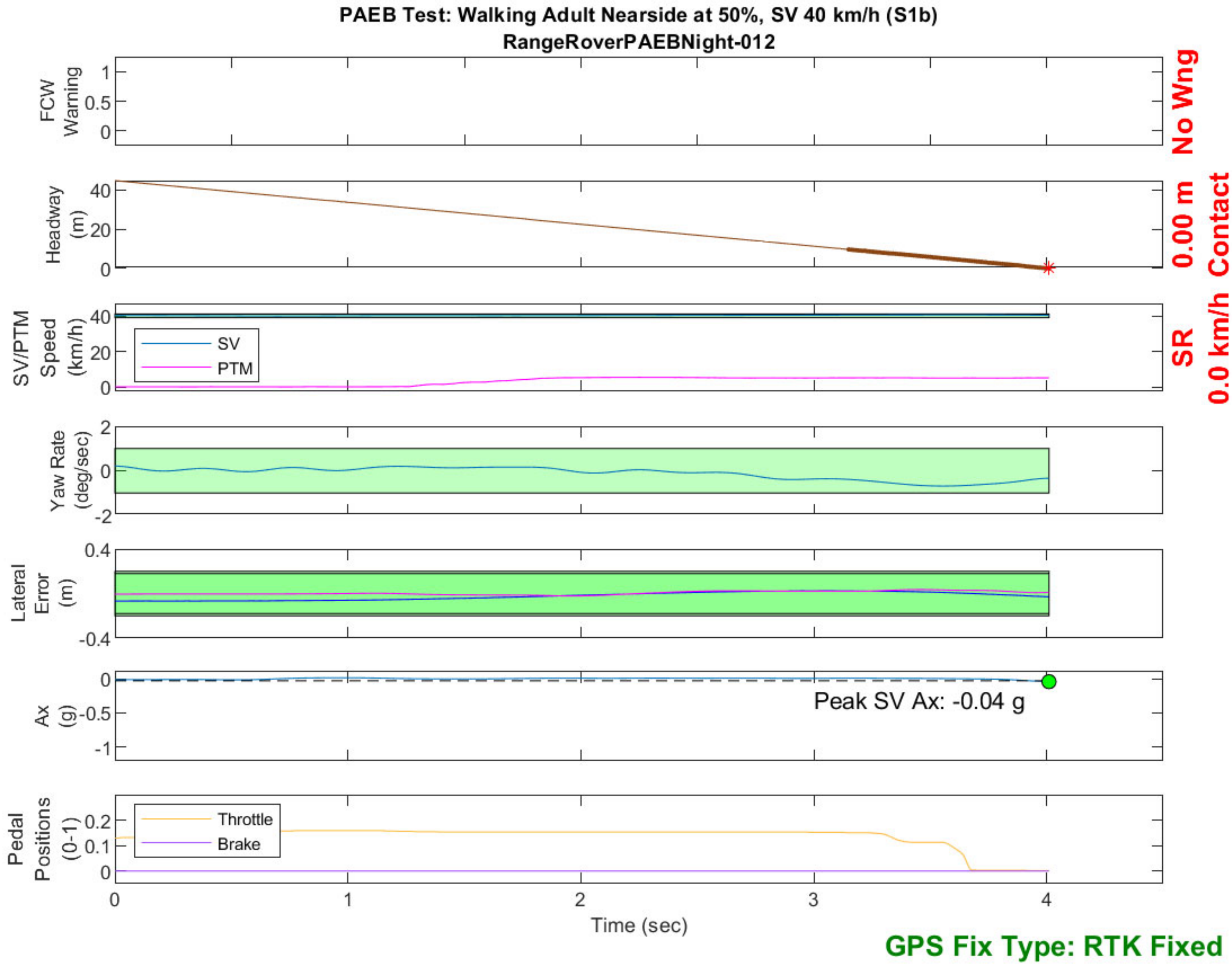


Figure D196. Time History for PAEB Run 12, S1b, Night, Low Beam, 40 km/h

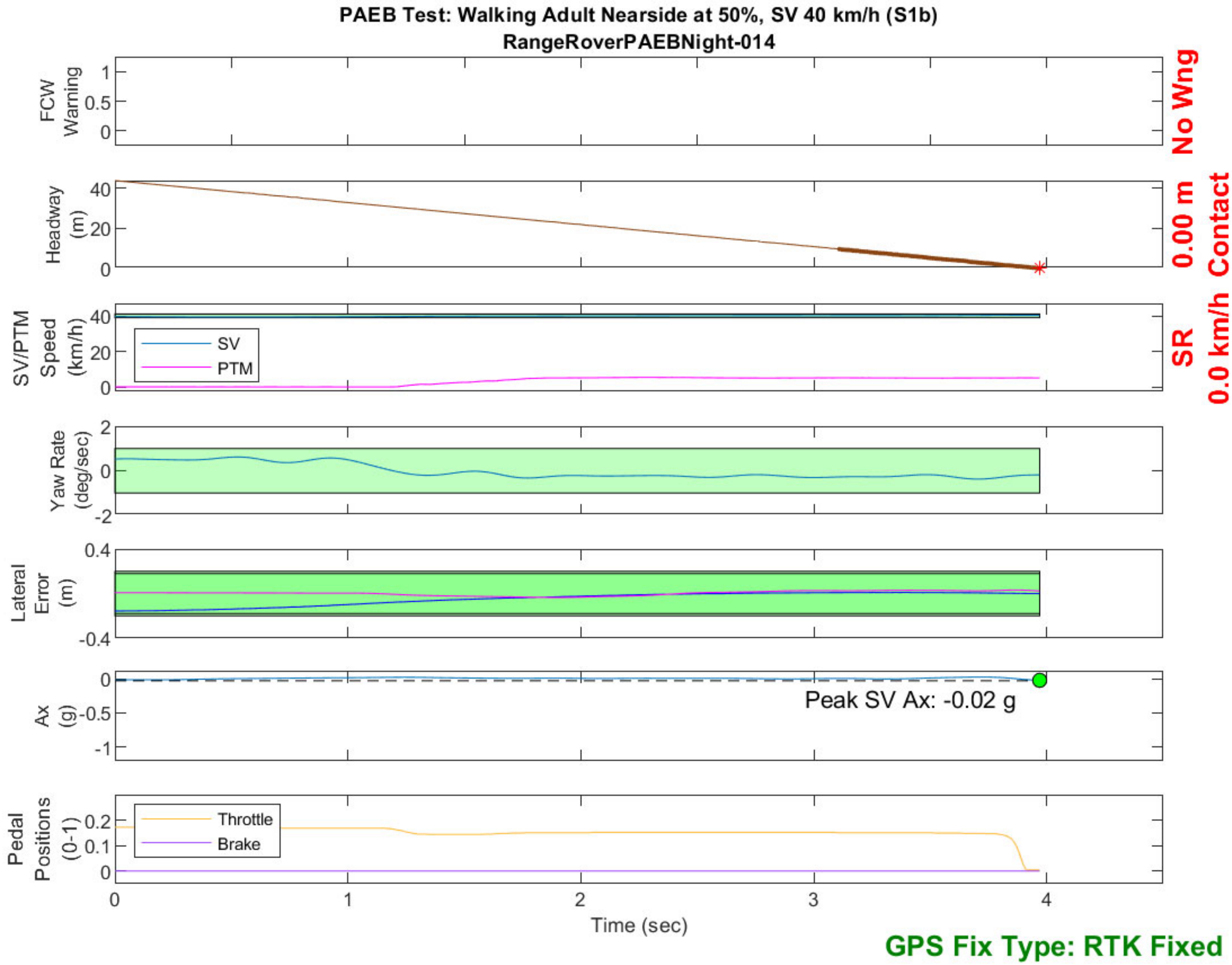


Figure D197. Time History for PAEB Run 14, S1b, Night, Low Beam, 40 km/h

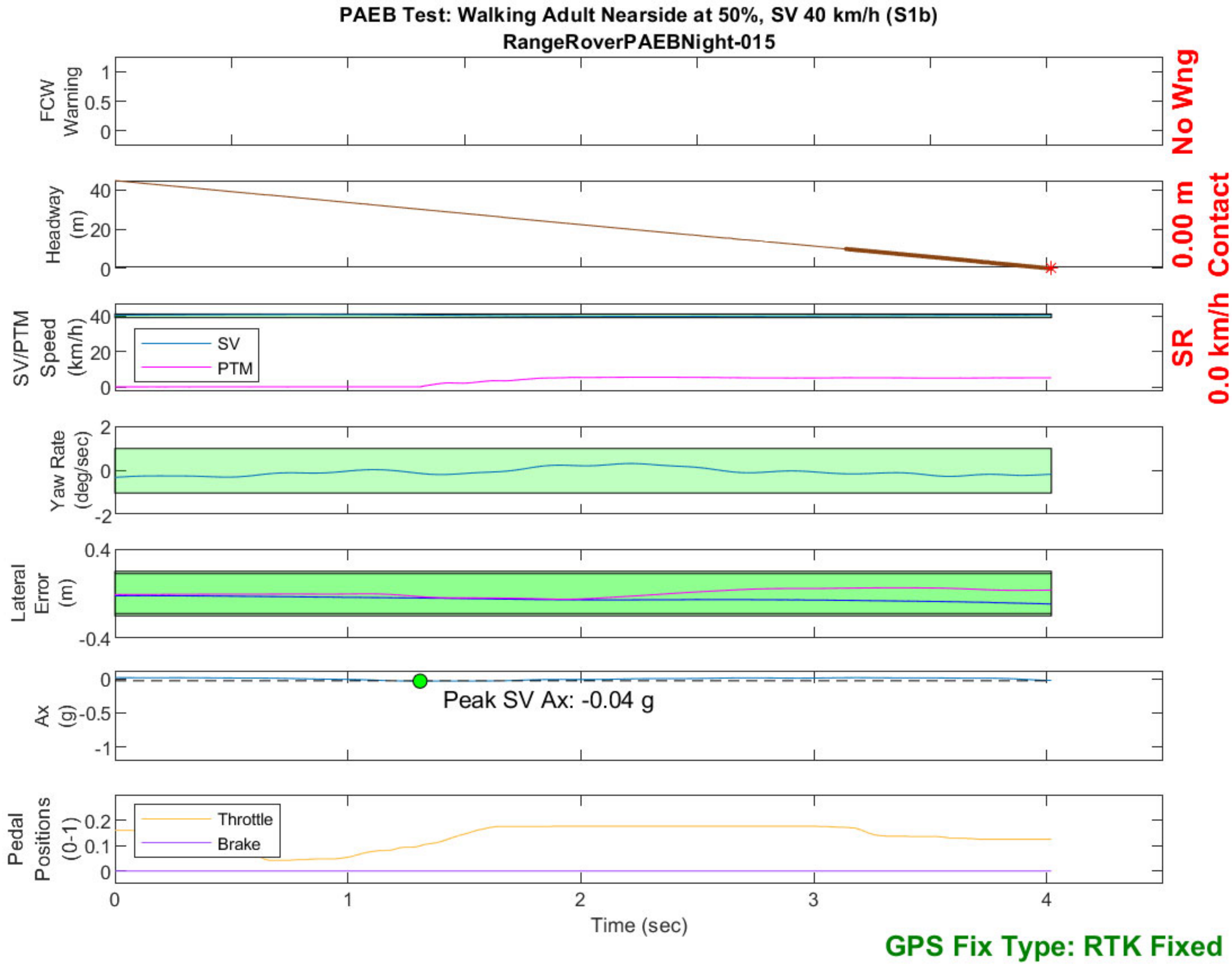


Figure D198. Time History for PAEB Run 15, S1b, Night, Low Beam, 40 km/h

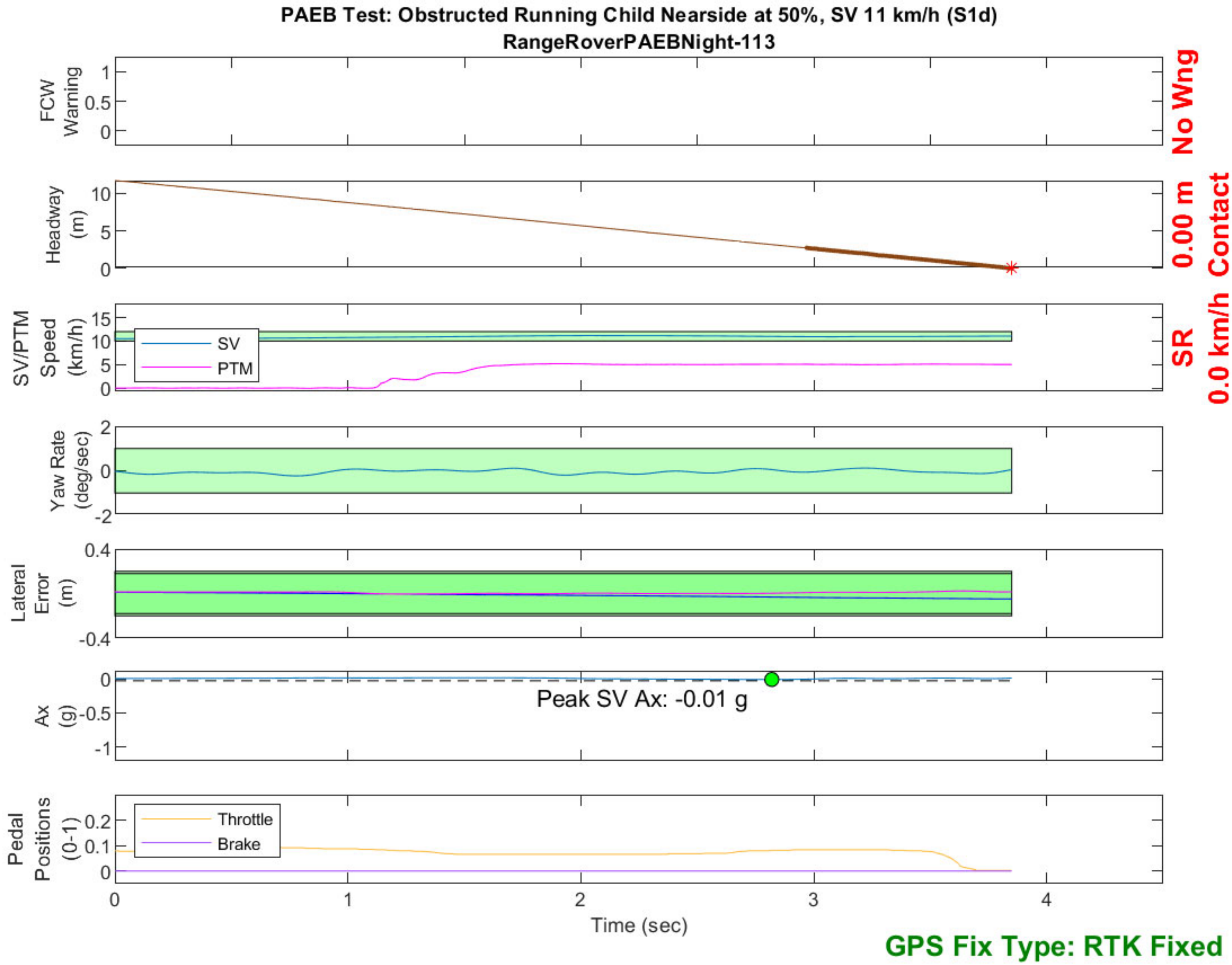


Figure D199. Time History for PAEB Run 113, S1d, Night, Low Beam, 11 km/h

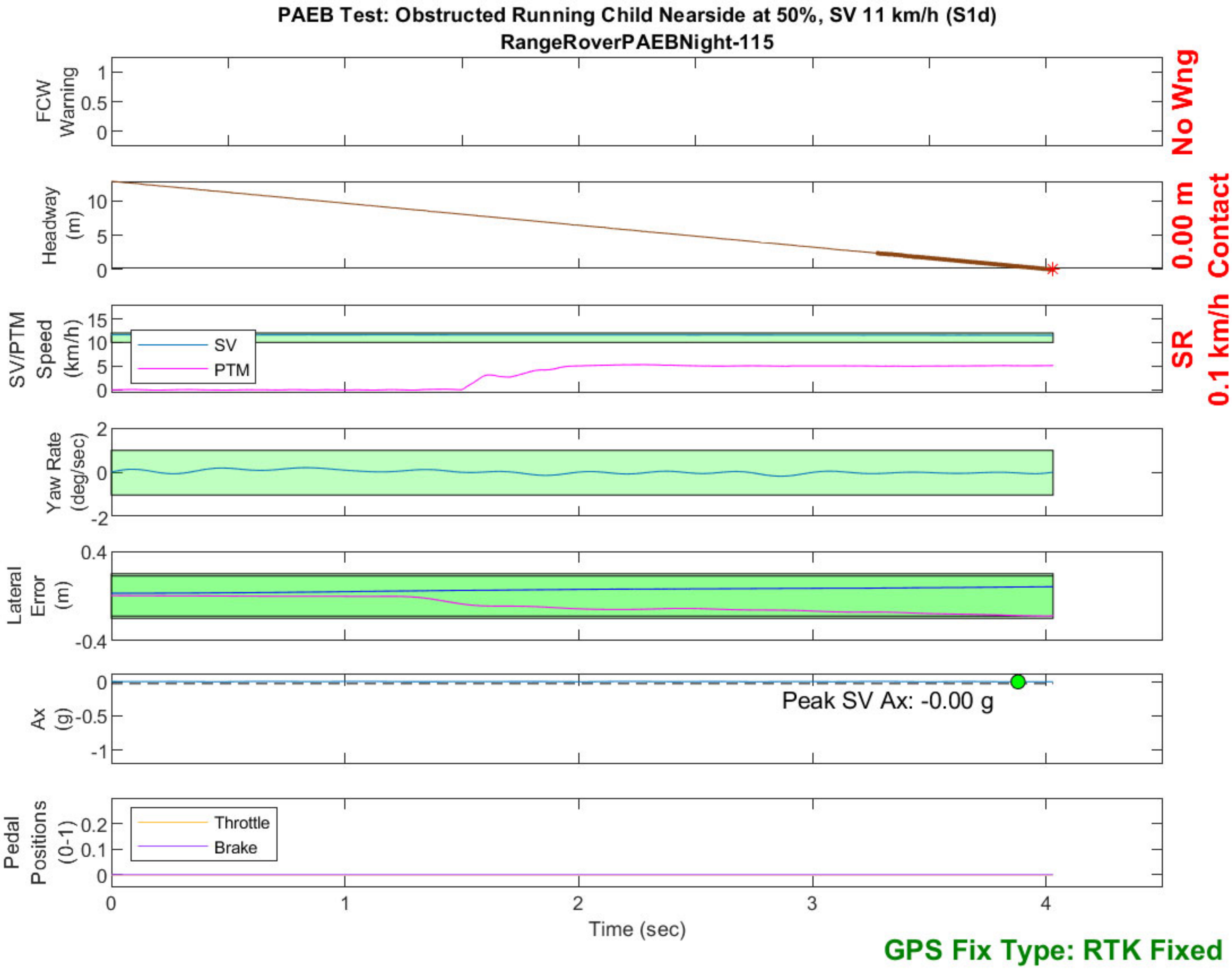


Figure D200. Time History for PAEB Run 115, S1d, Night, Low Beam, 11 km/h

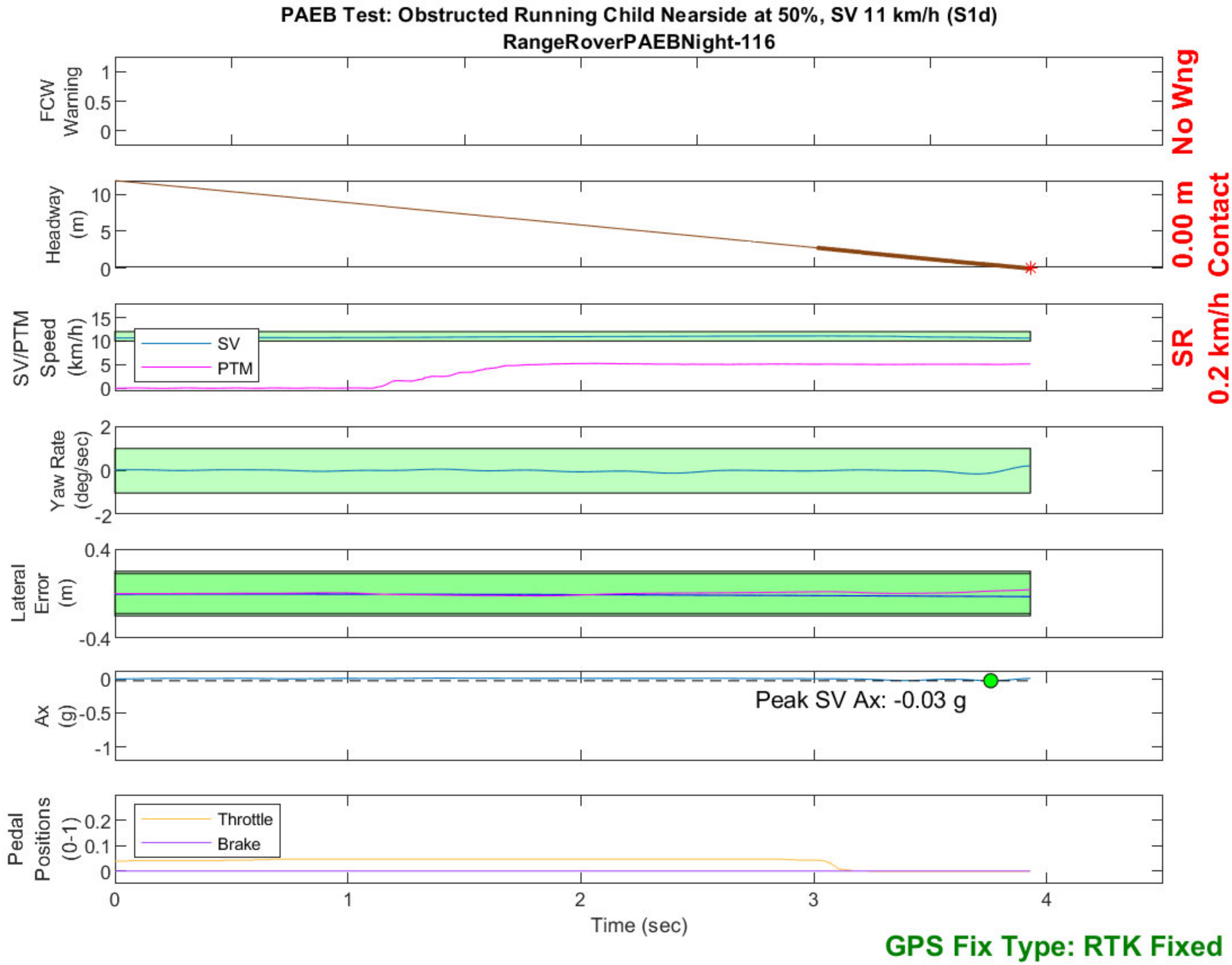


Figure D201. Time History for PAEB Run 116, S1d, Night, Low Beam, 11 km/h

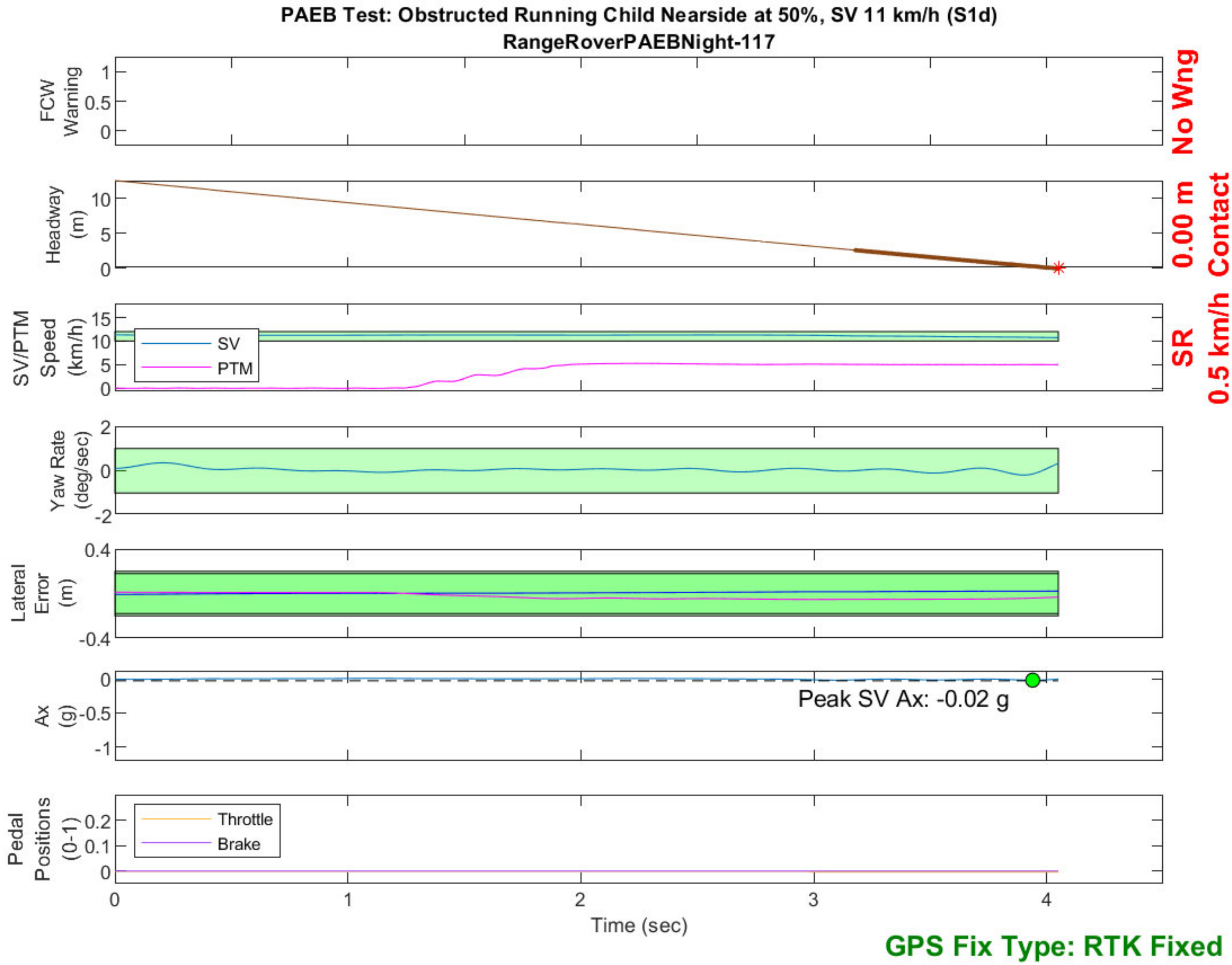


Figure D202. Time History for PAEB Run 117, S1d, Night, Low Beam, 11 km/h

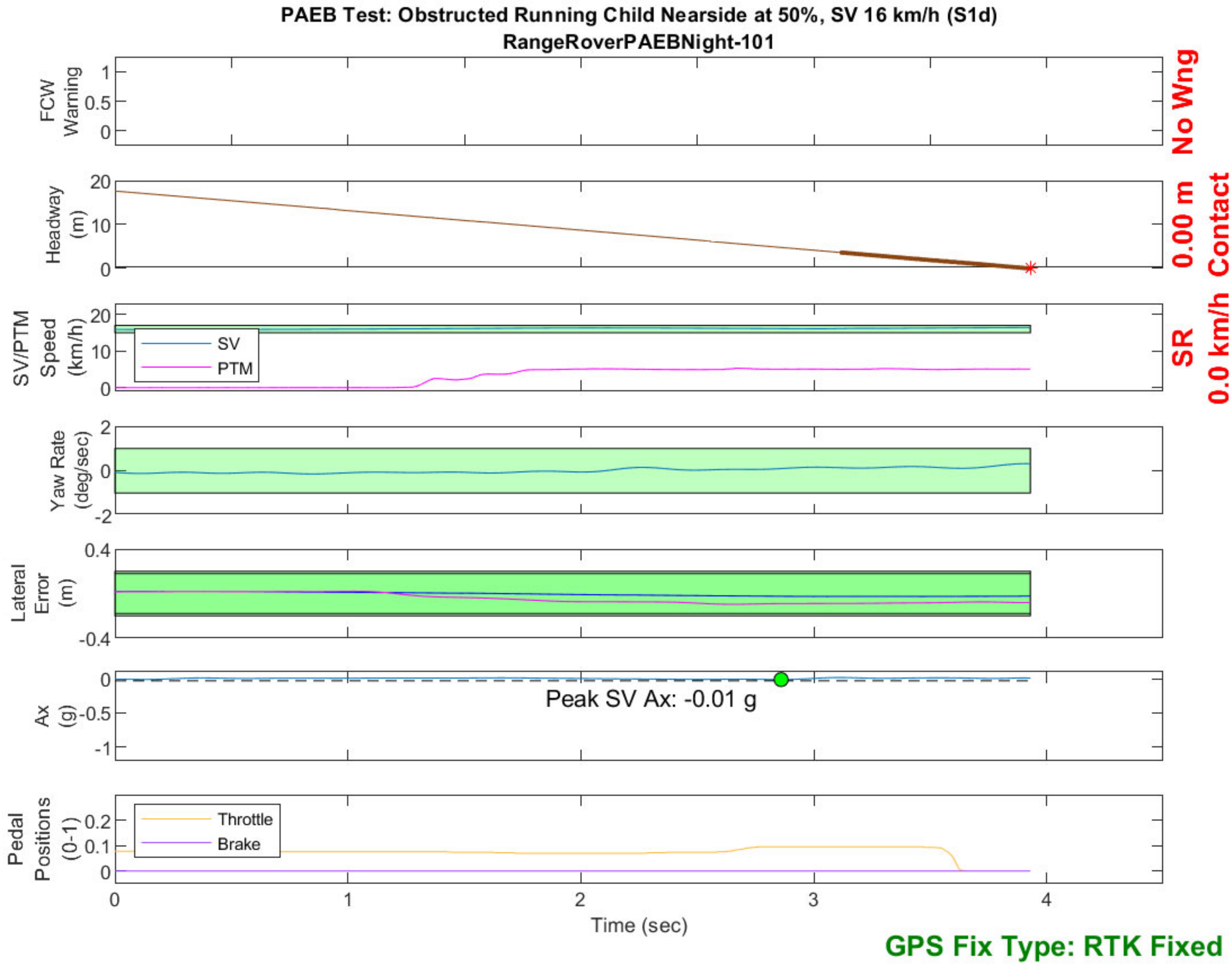


Figure D203. Time History for PAEB Run 101, S1d, Night, Low Beam, 16 km/h

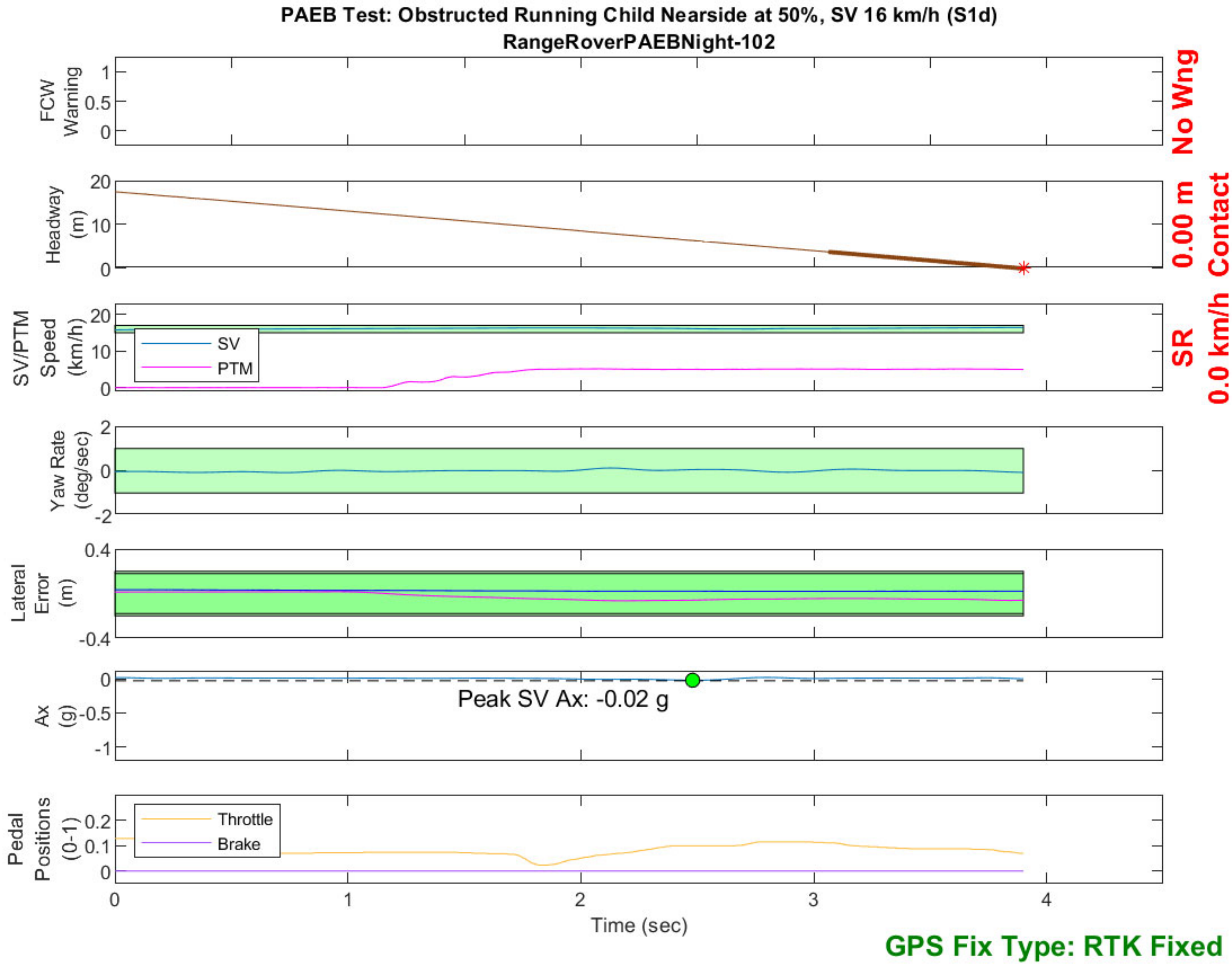


Figure D204. Time History for PAEB Run 102, S1d, Night, Low Beam, 16 km/h

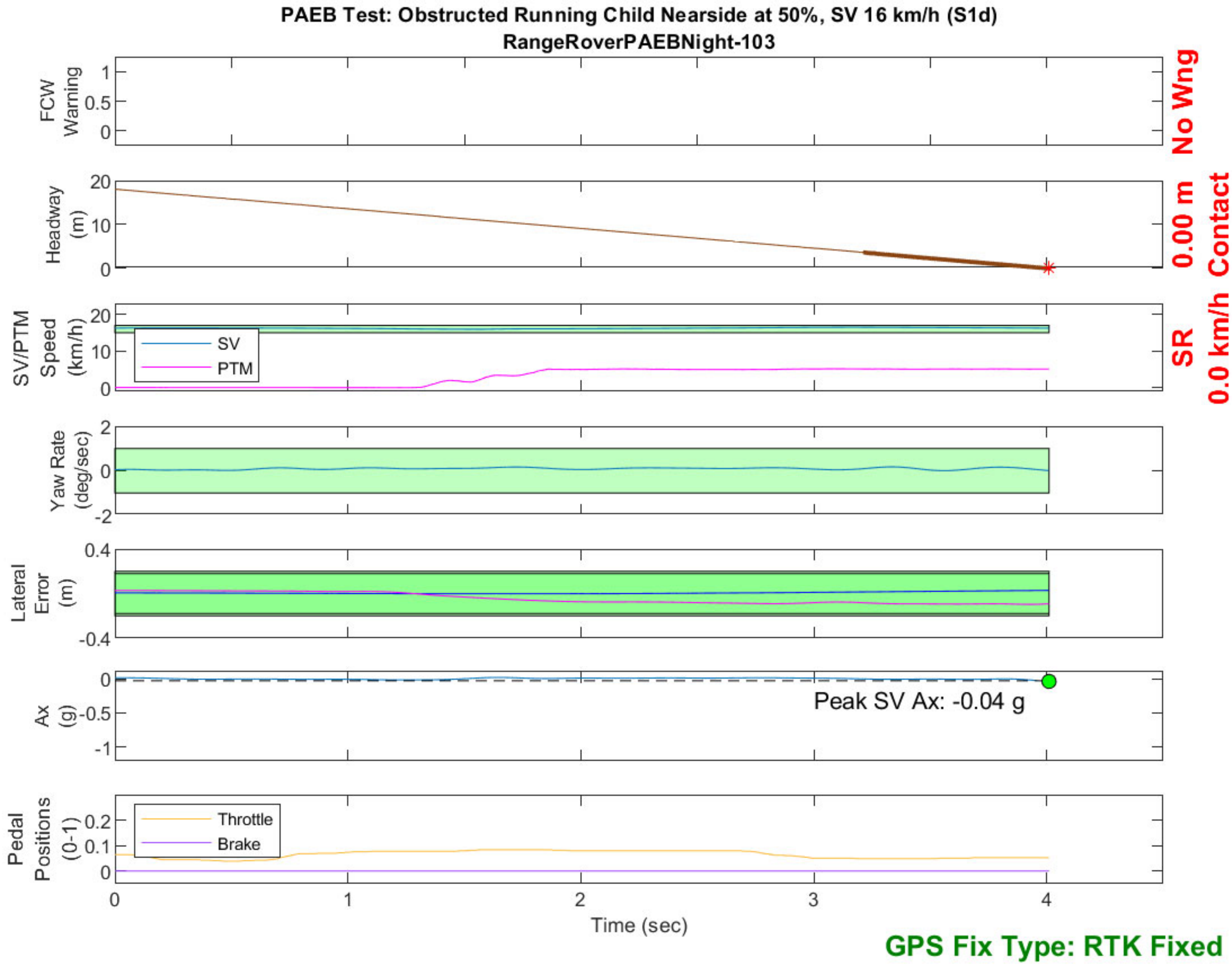


Figure D205. Time History for PAEB Run 103, S1d, Night, Low Beam, 16 km/h

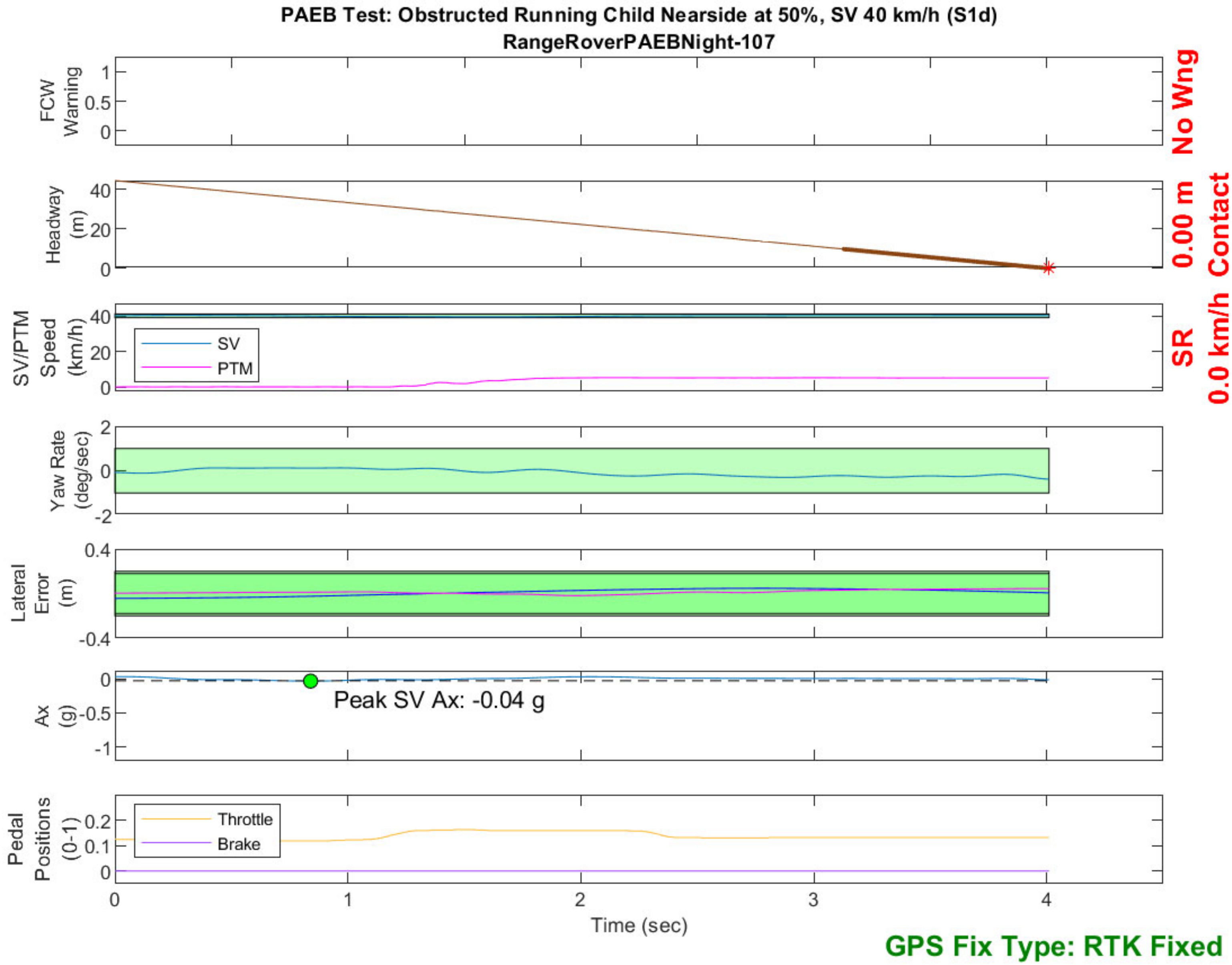


Figure D206. Time History for PAEB Run 107, S1d, Night, Low Beam, 40 km/h

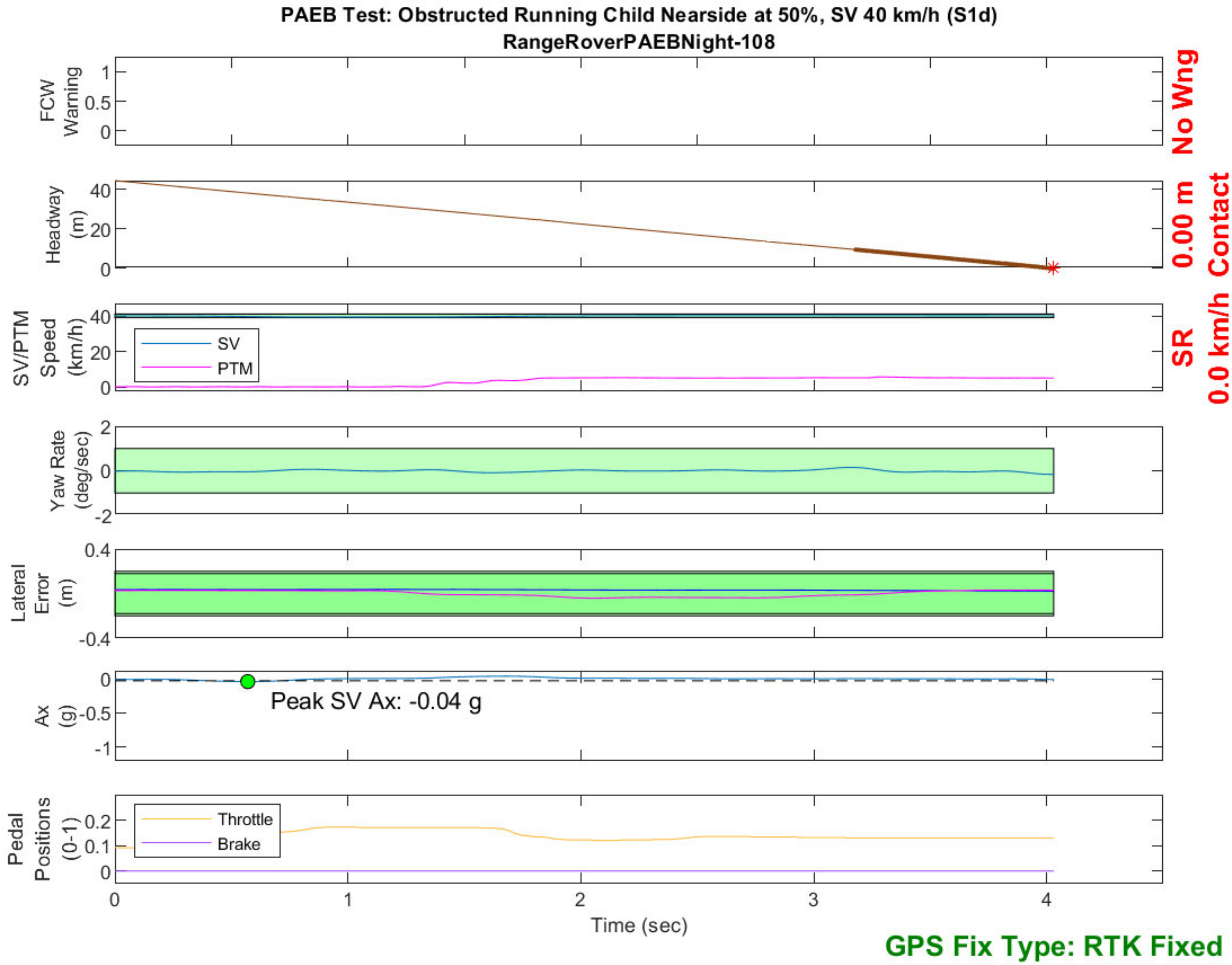


Figure D207. Time History for PAEB Run 108, S1d, Night, Low Beam, 40 km/h

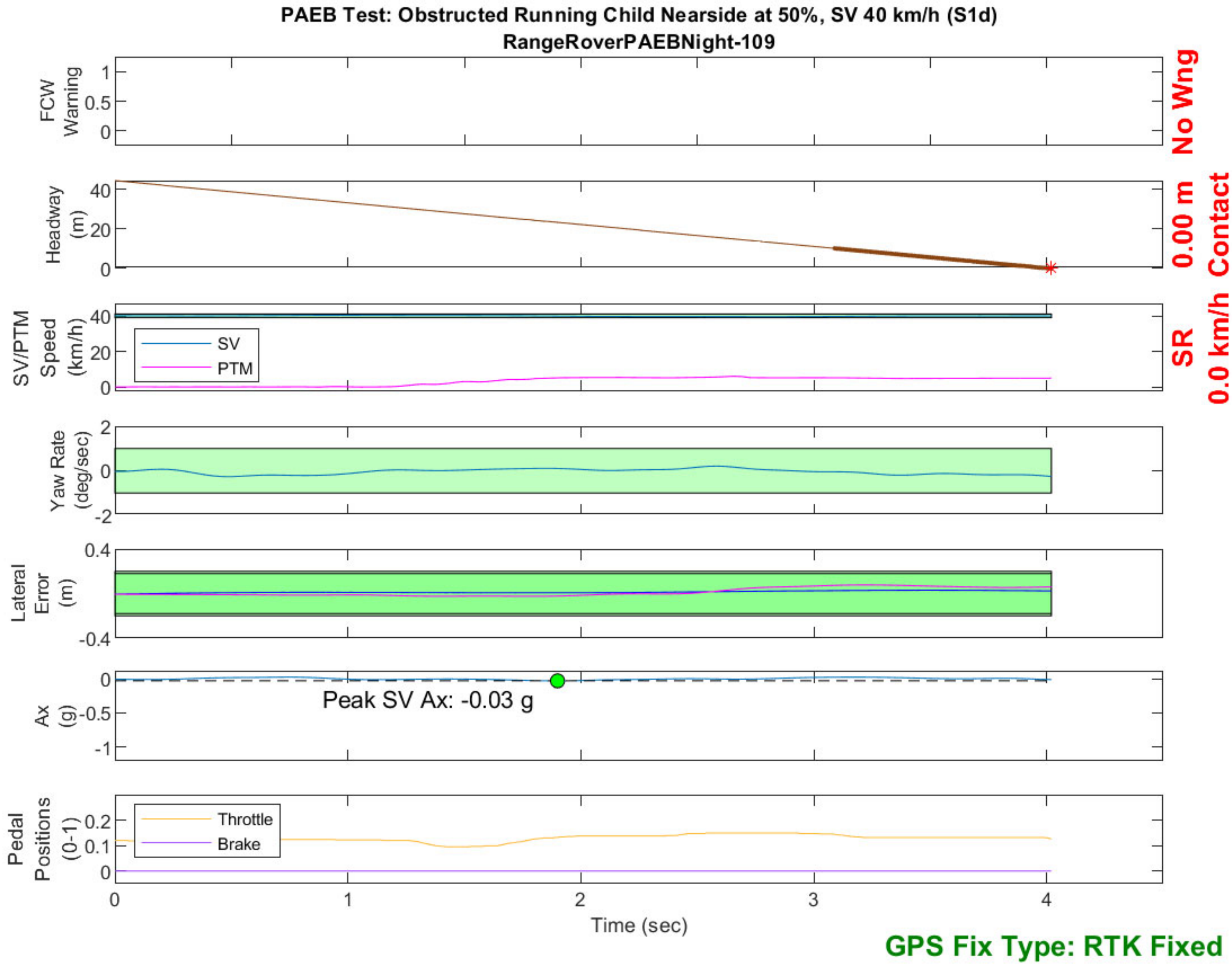


Figure D208. Time History for PAEB Run 109, S1d, Night, Low Beam, 40 km/h

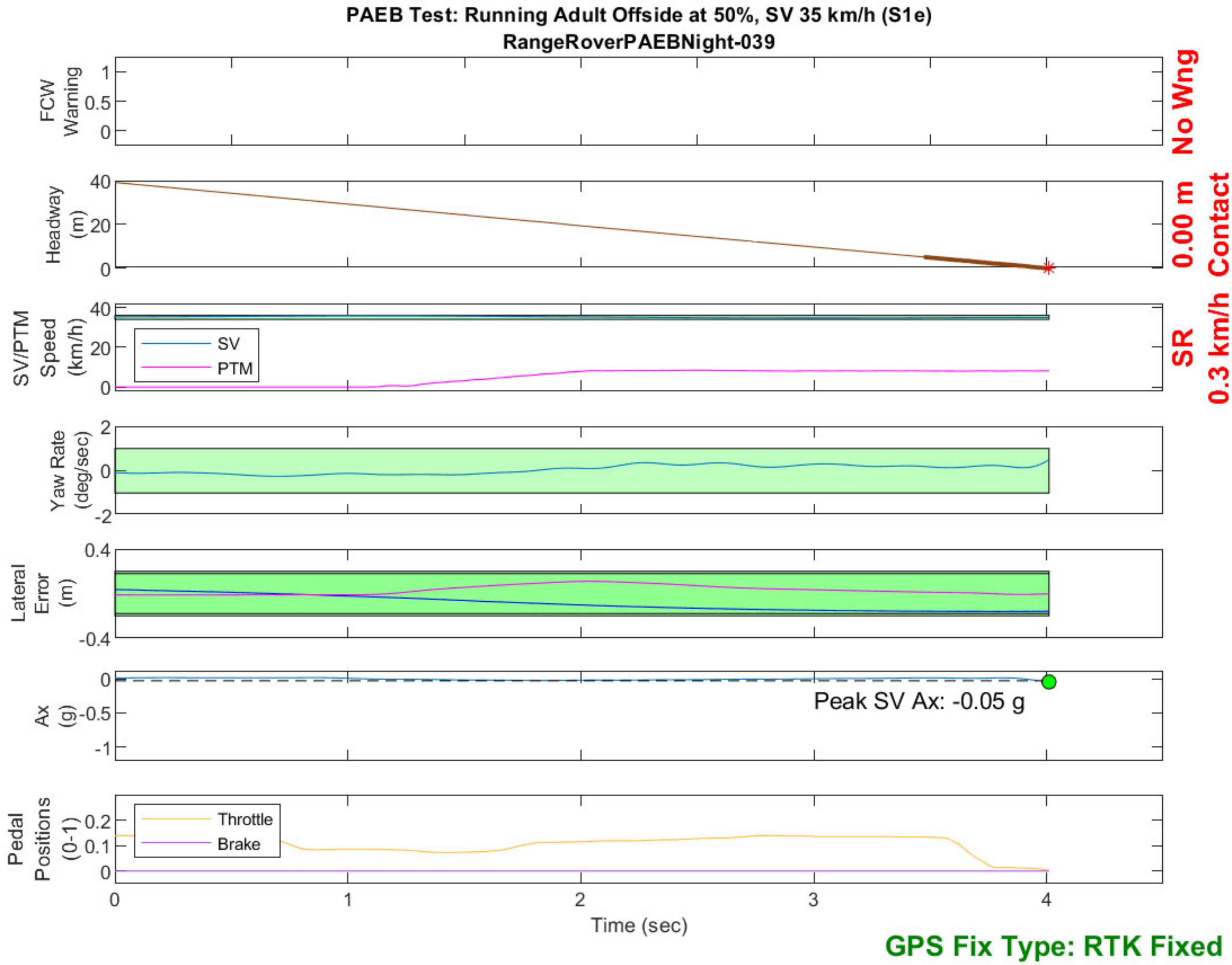


Figure D209. Time History for PAEB Run 39, S1e, Night, Low Beam, 35 km/h

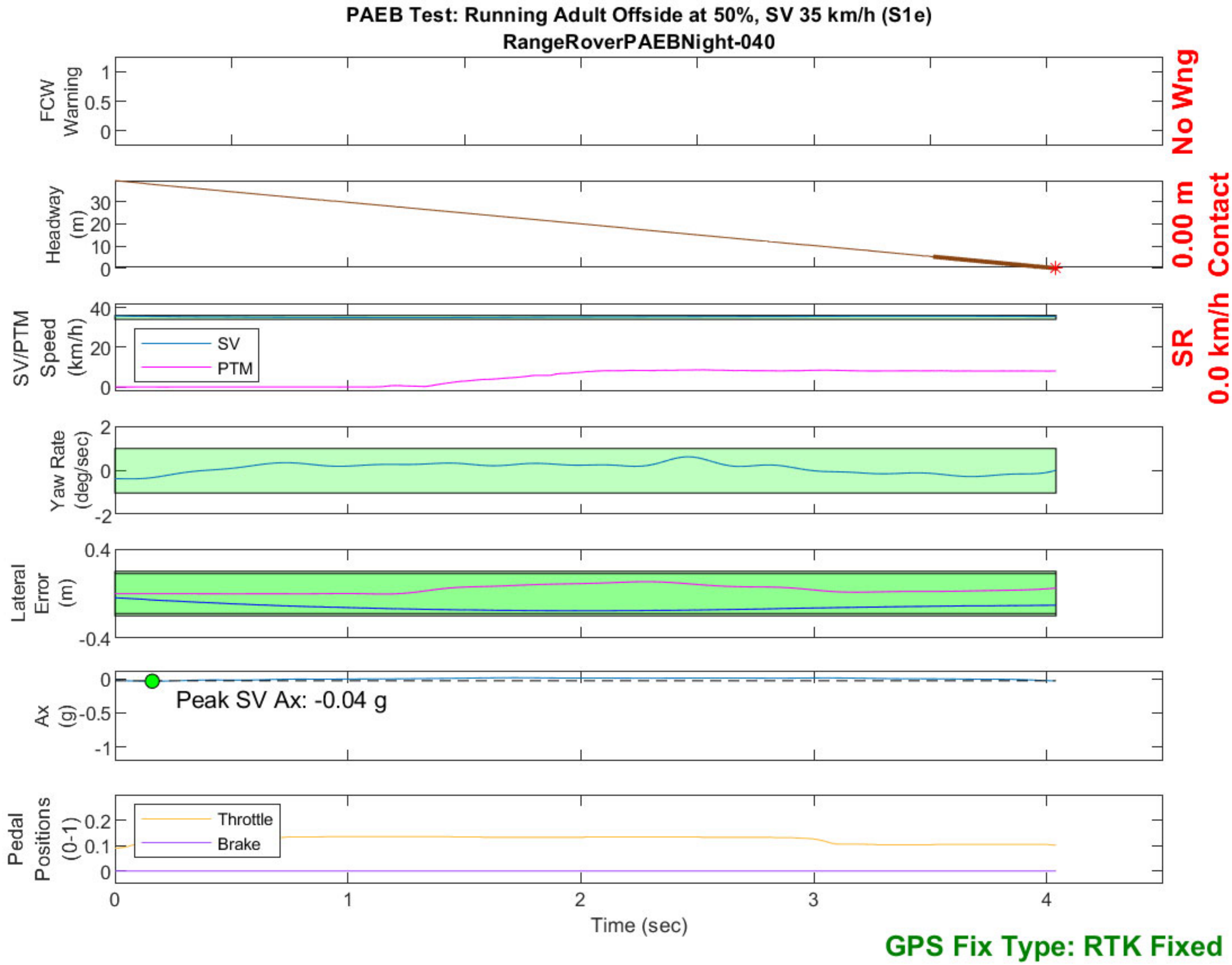


Figure D210. Time History for PAEB Run 40, S1e, Night, Low Beam, 35 km/h

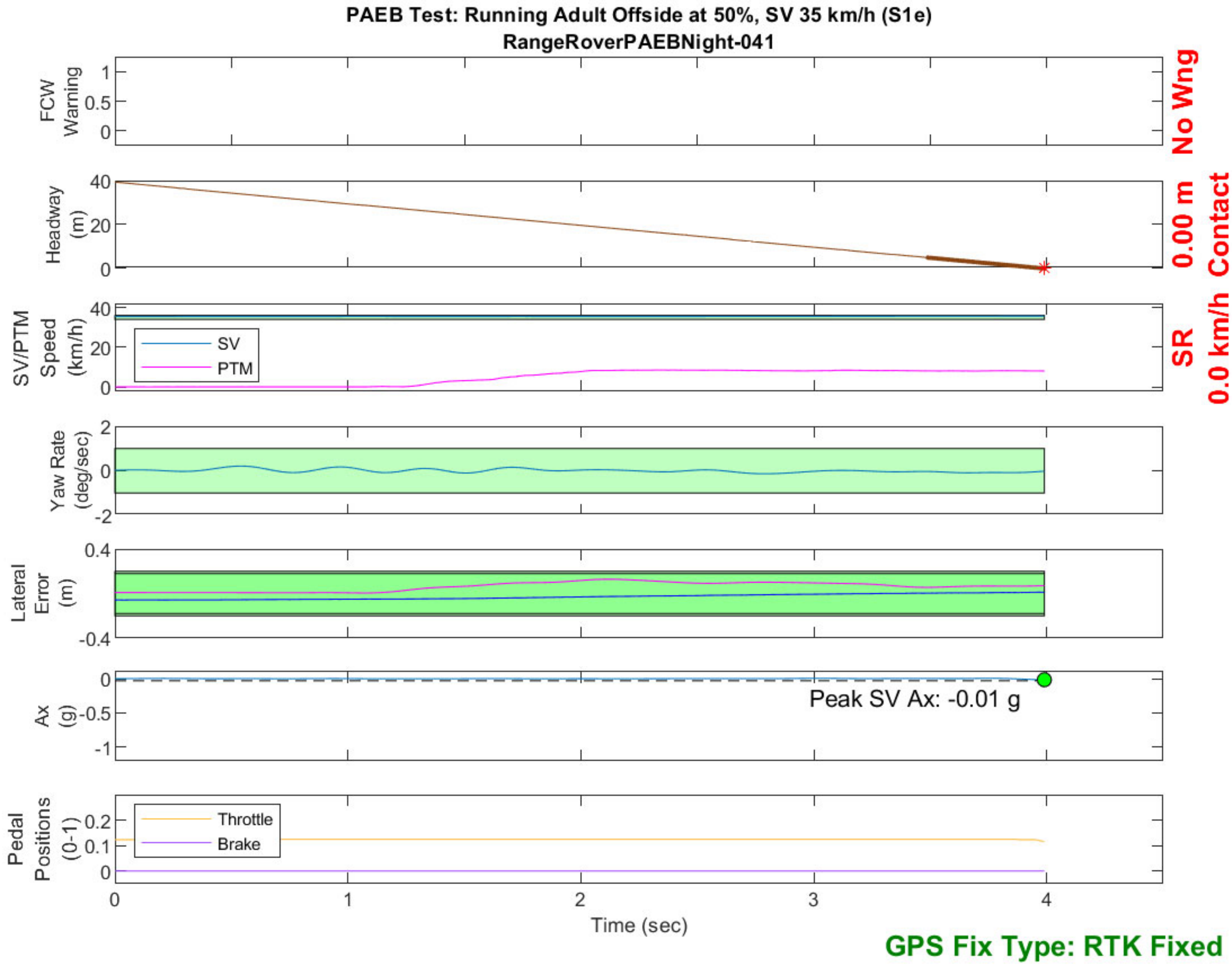


Figure D211. Time History for PAEB Run 41, S1e, Night, Low Beam, 35 km/h

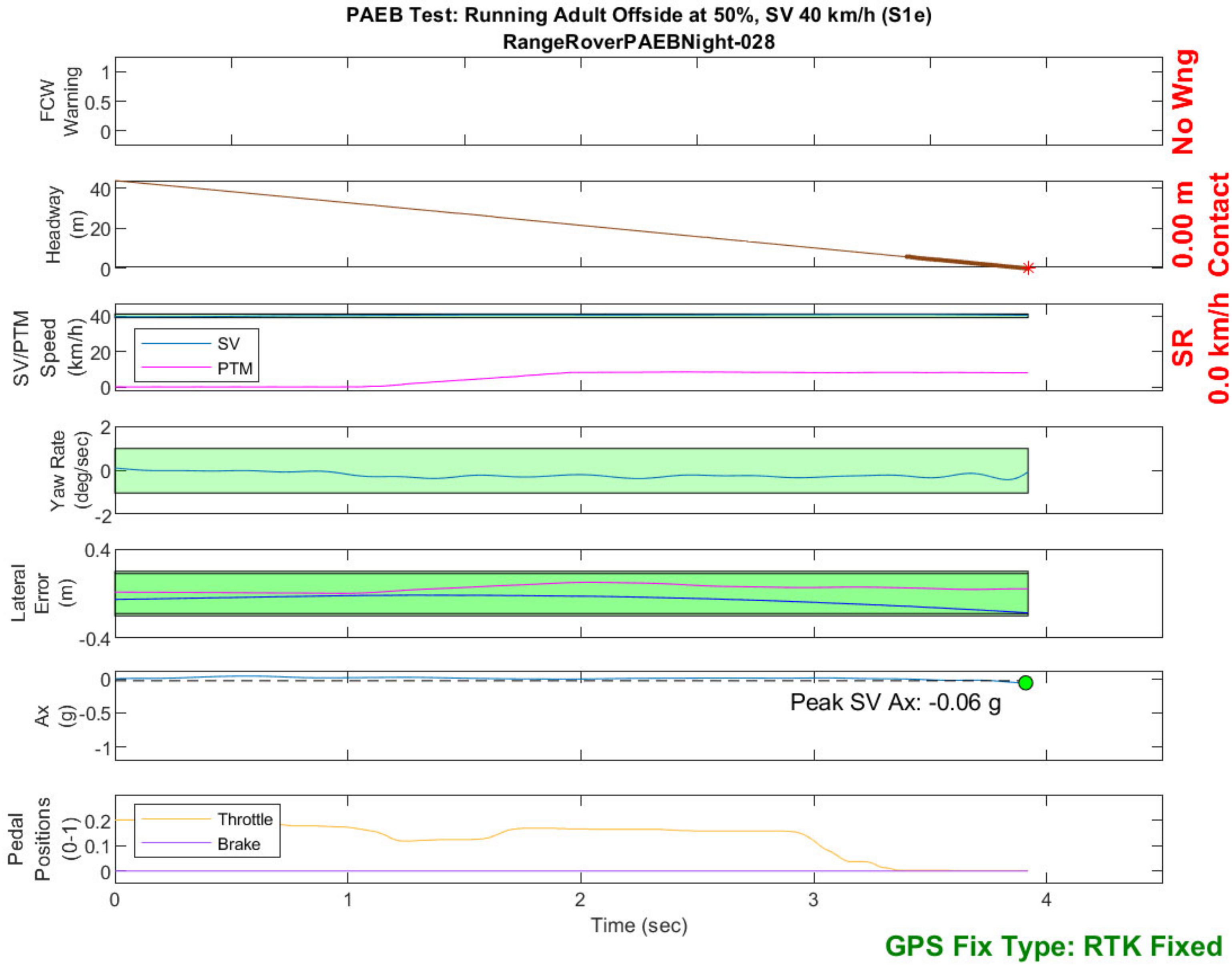


Figure D212. Time History for PAEB Run 28, S1e, Night, Low Beam, 40 km/h

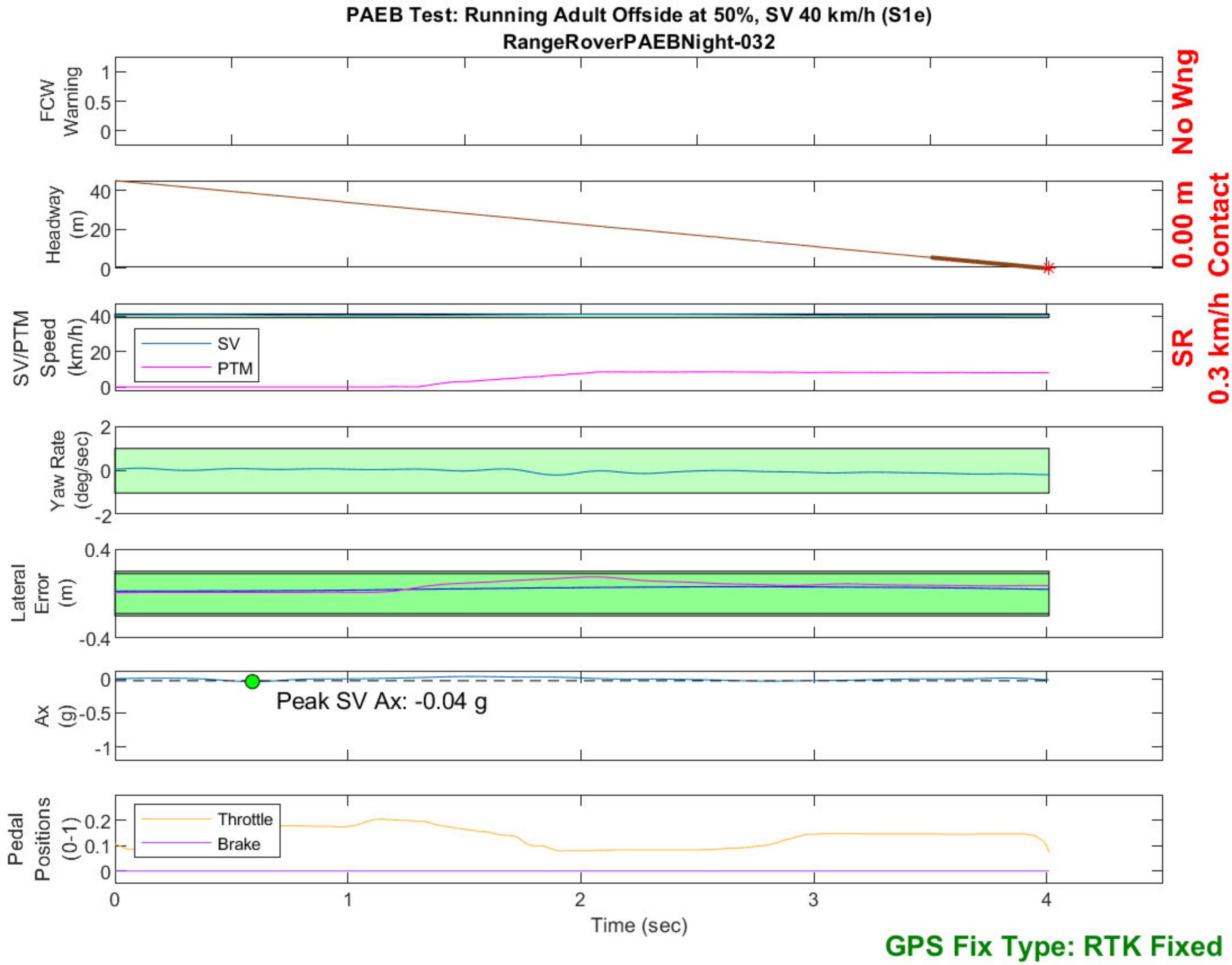


Figure D213. Time History for PAEB Run 32, S1e, Night, Low Beam, 40 km/h

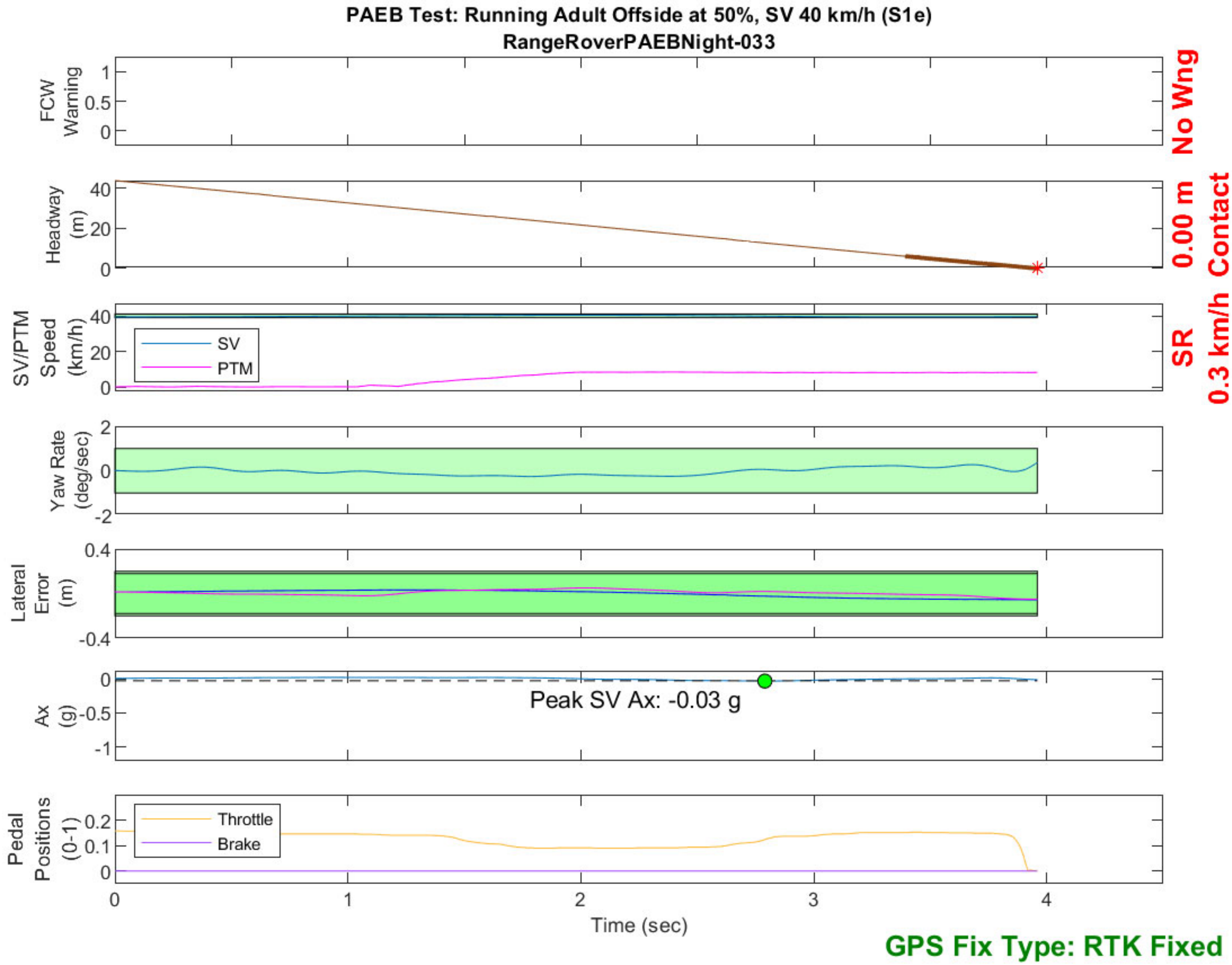


Figure D214. Time History for PAEB Run 33, S1e, Night, Low Beam, 40 km/h

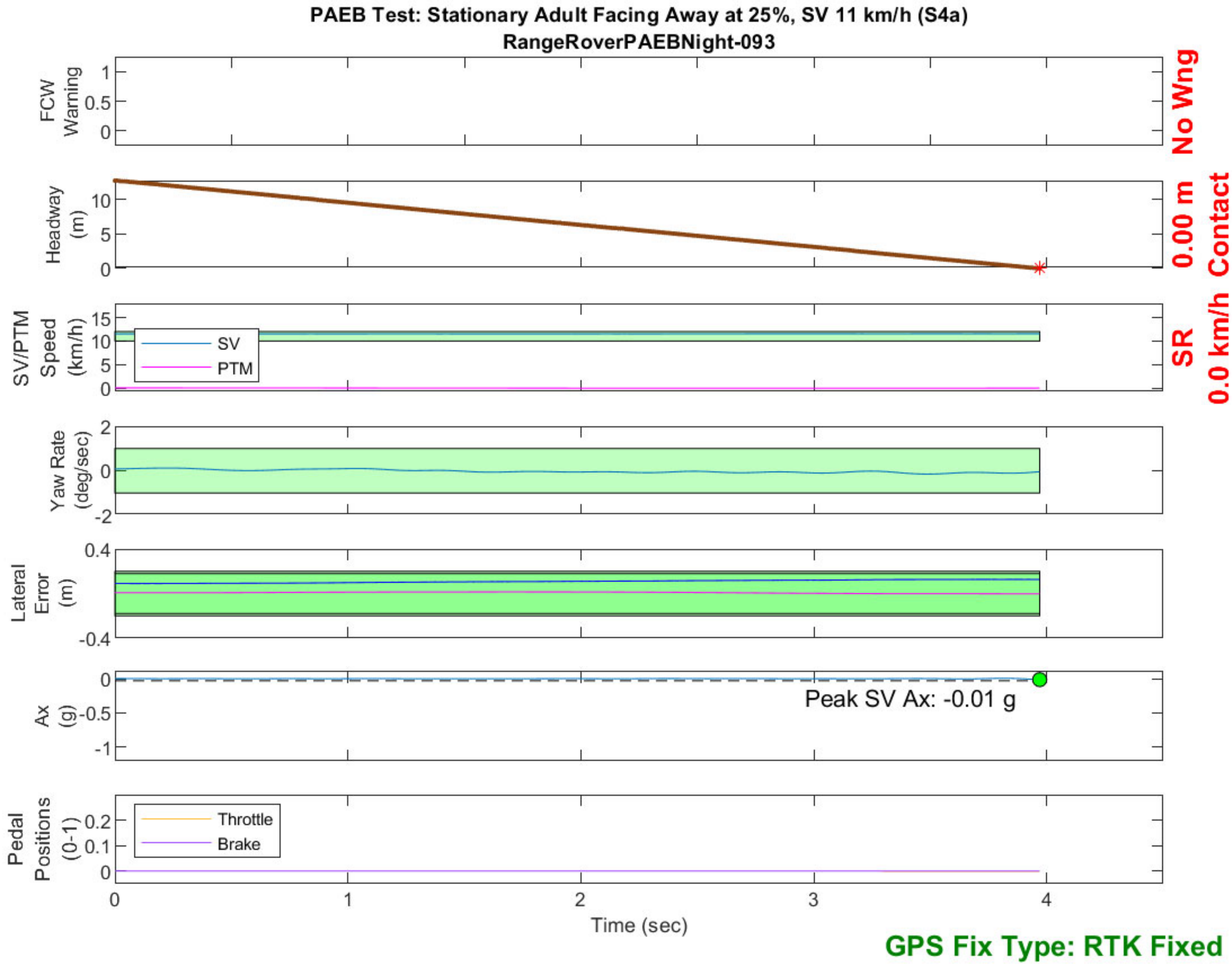


Figure D215. Time History for PAEB Run 93, S4a, Night, Low Beam, 11 km/h

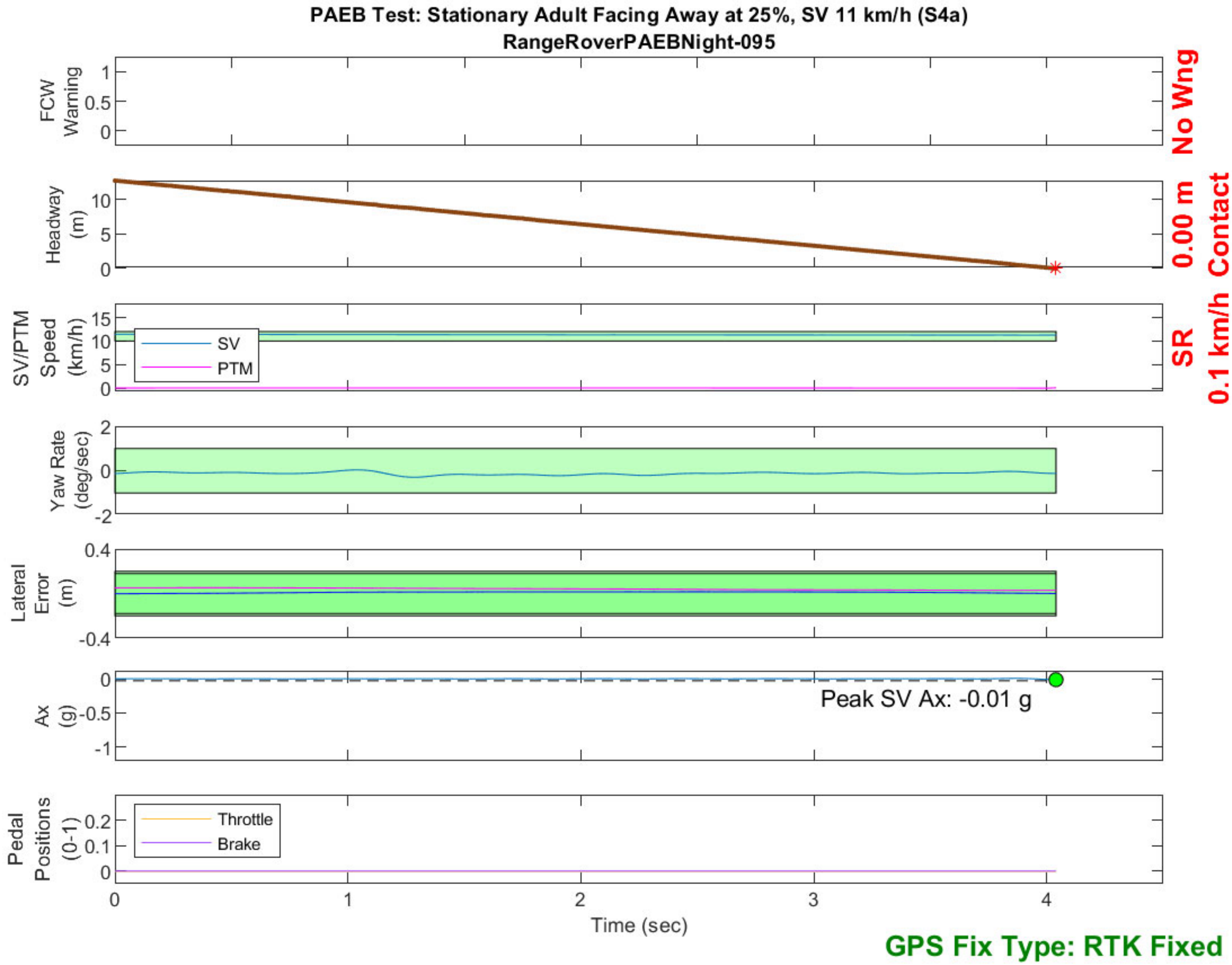


Figure D216. Time History for PAEB Run 95, S4a, Night, Low Beam, 11 km/h

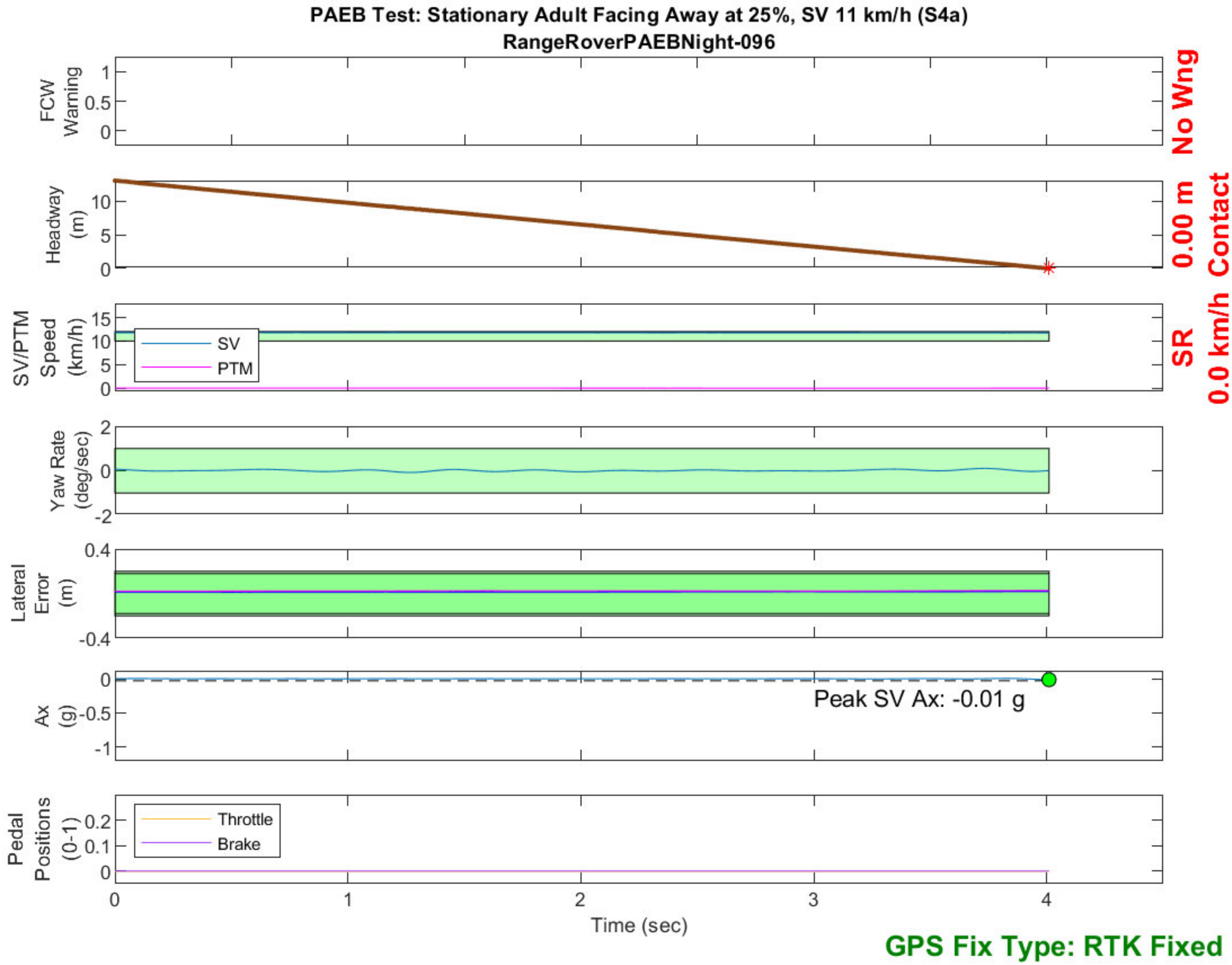


Figure D217. Time History for PAEB Run 96, S4a, Night, Low Beam, 11 km/h

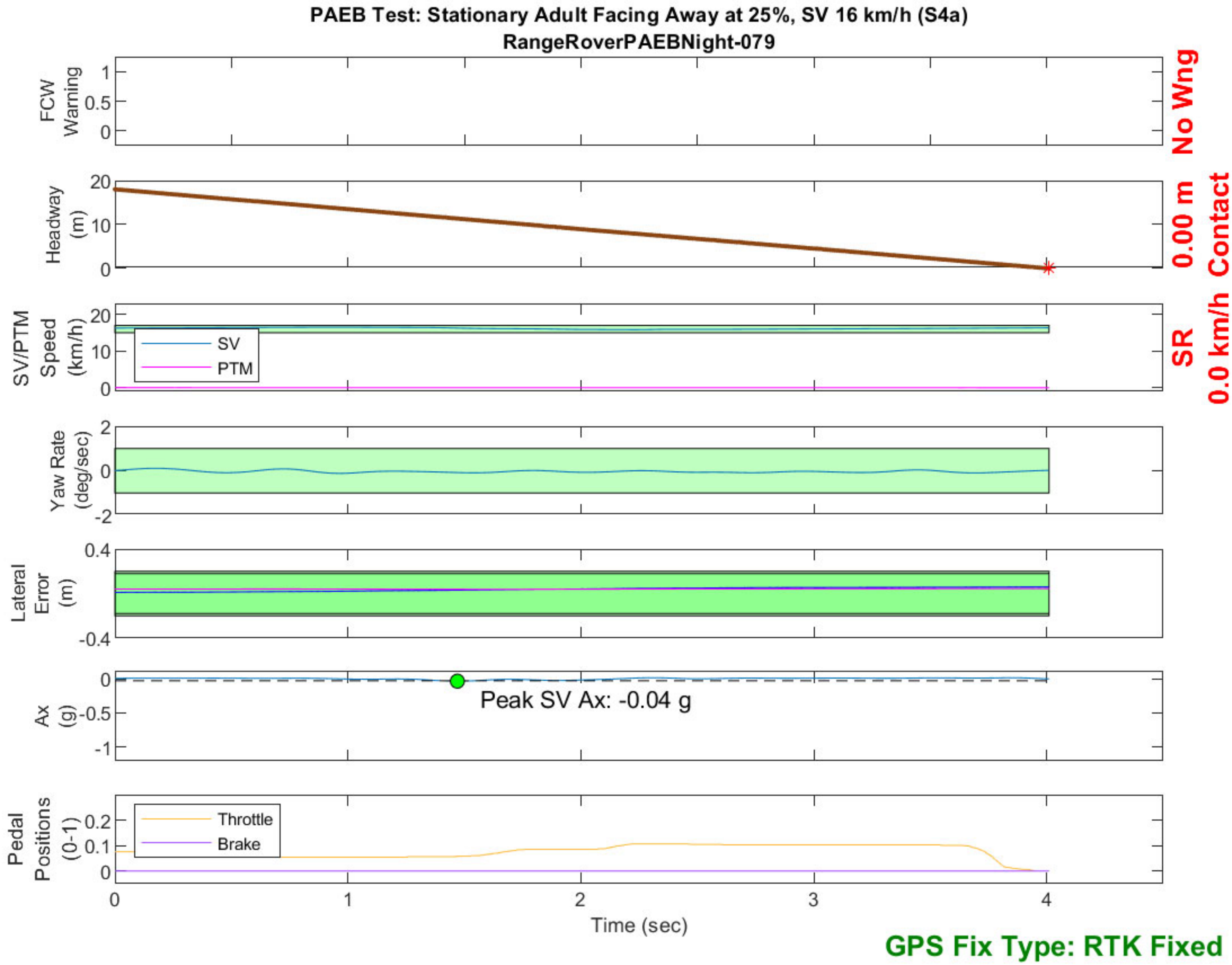


Figure D218. Time History for PAEB Run 79, S4a, Night, Low Beam, 16 km/h

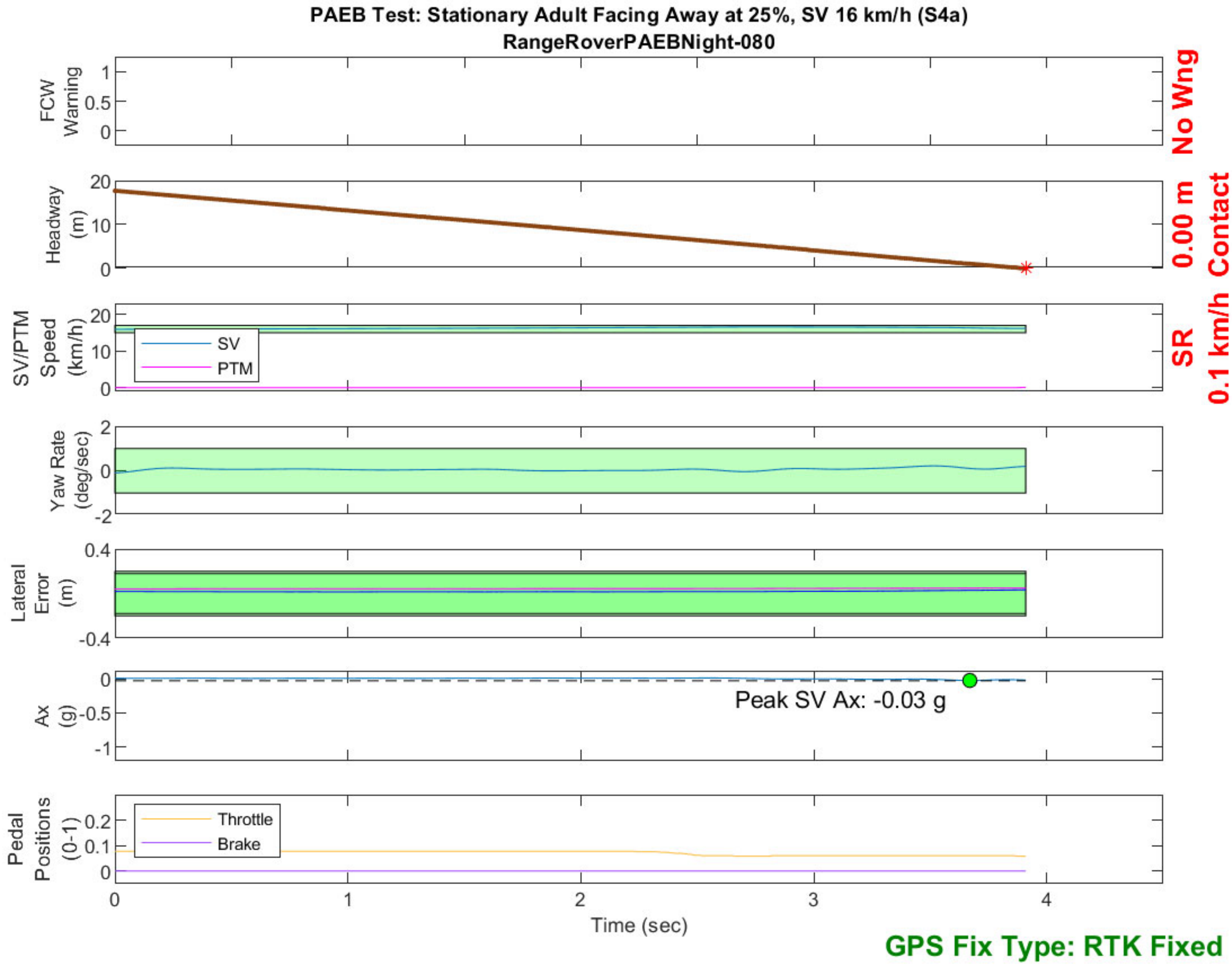


Figure D219. Time History for PAEB Run 80, S4a, Night, Low Beam, 16 km/h

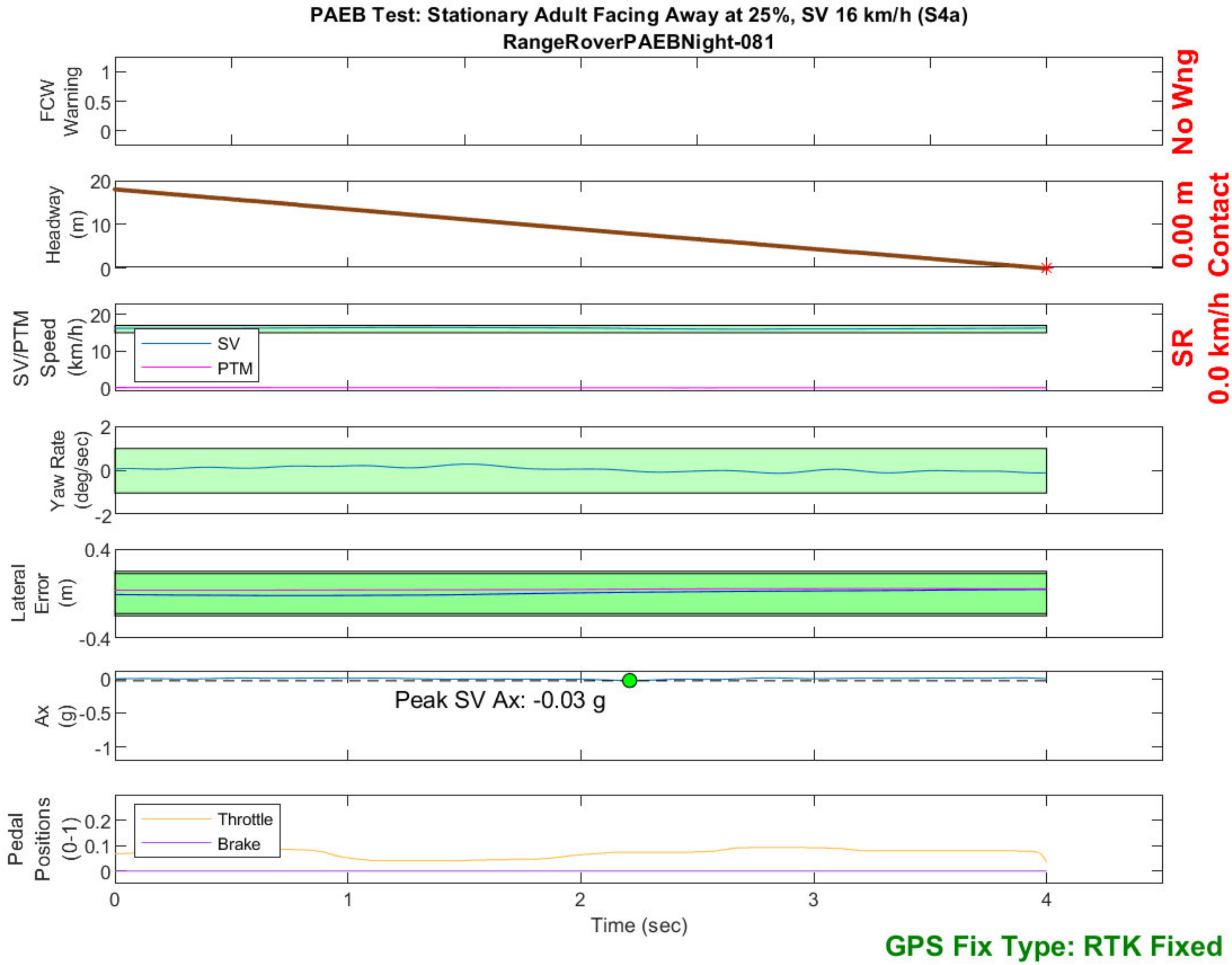


Figure D220. Time History for PAEB Run 81, S4a, Night, Low Beam, 16 km/h

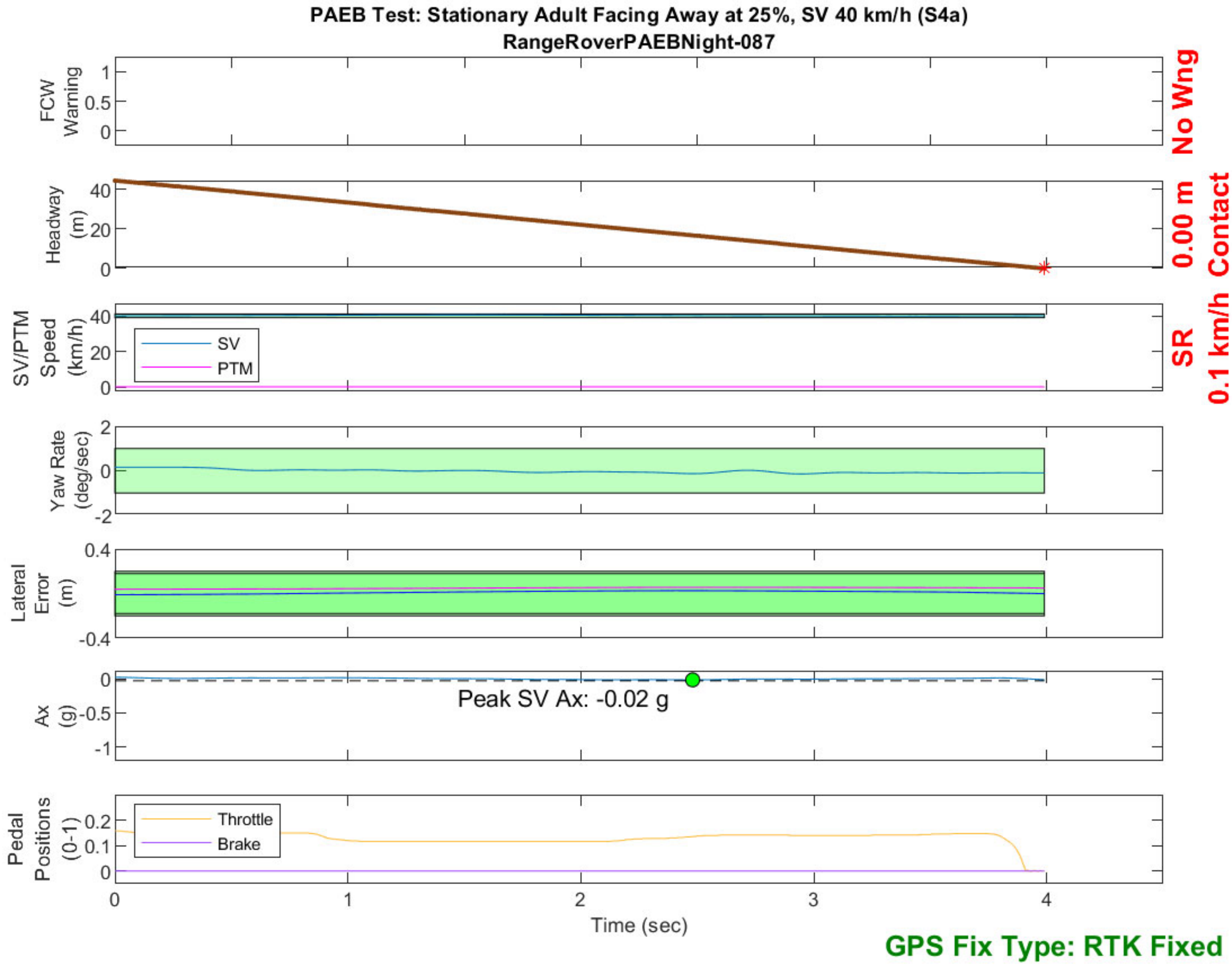


Figure D221. Time History for PAEB Run 87, S4a, Night, Low Beam, 40 km/h

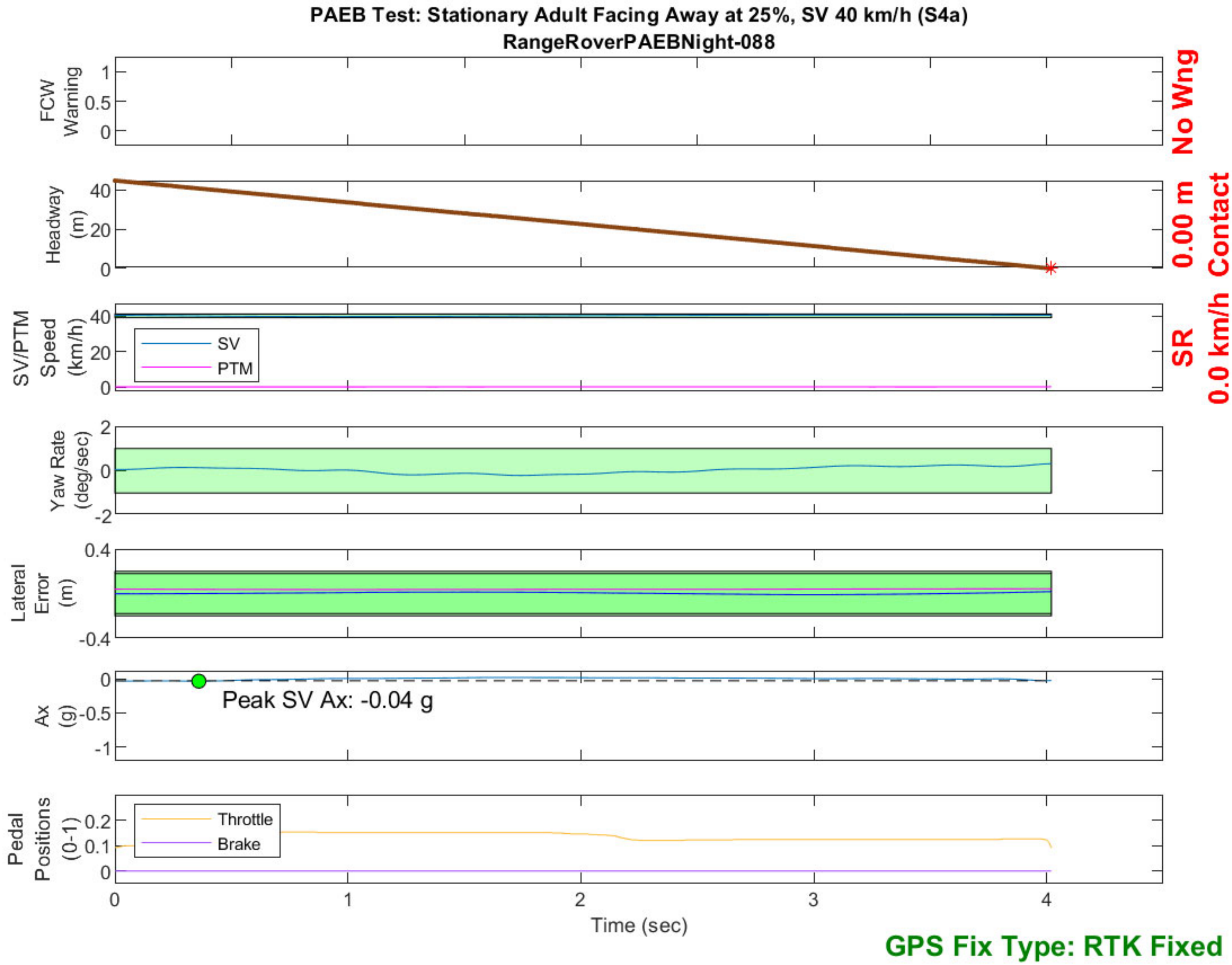


Figure D222. Time History for PAEB Run 88, S4a, Night, Low Beam, 40 km/h

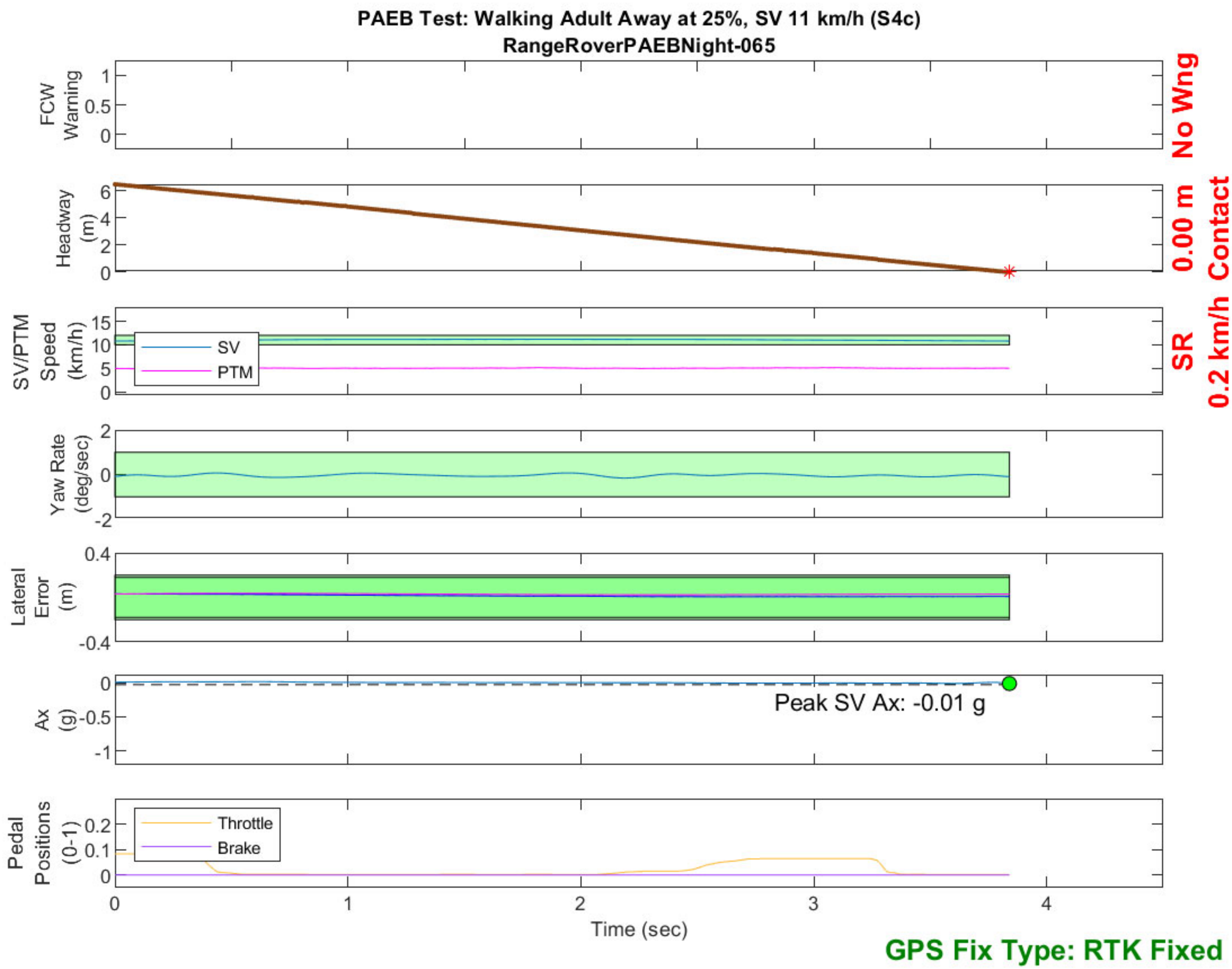


Figure D223. Time History for PAEB Run 65, S4c, Night, Low Beam, 11 km/h

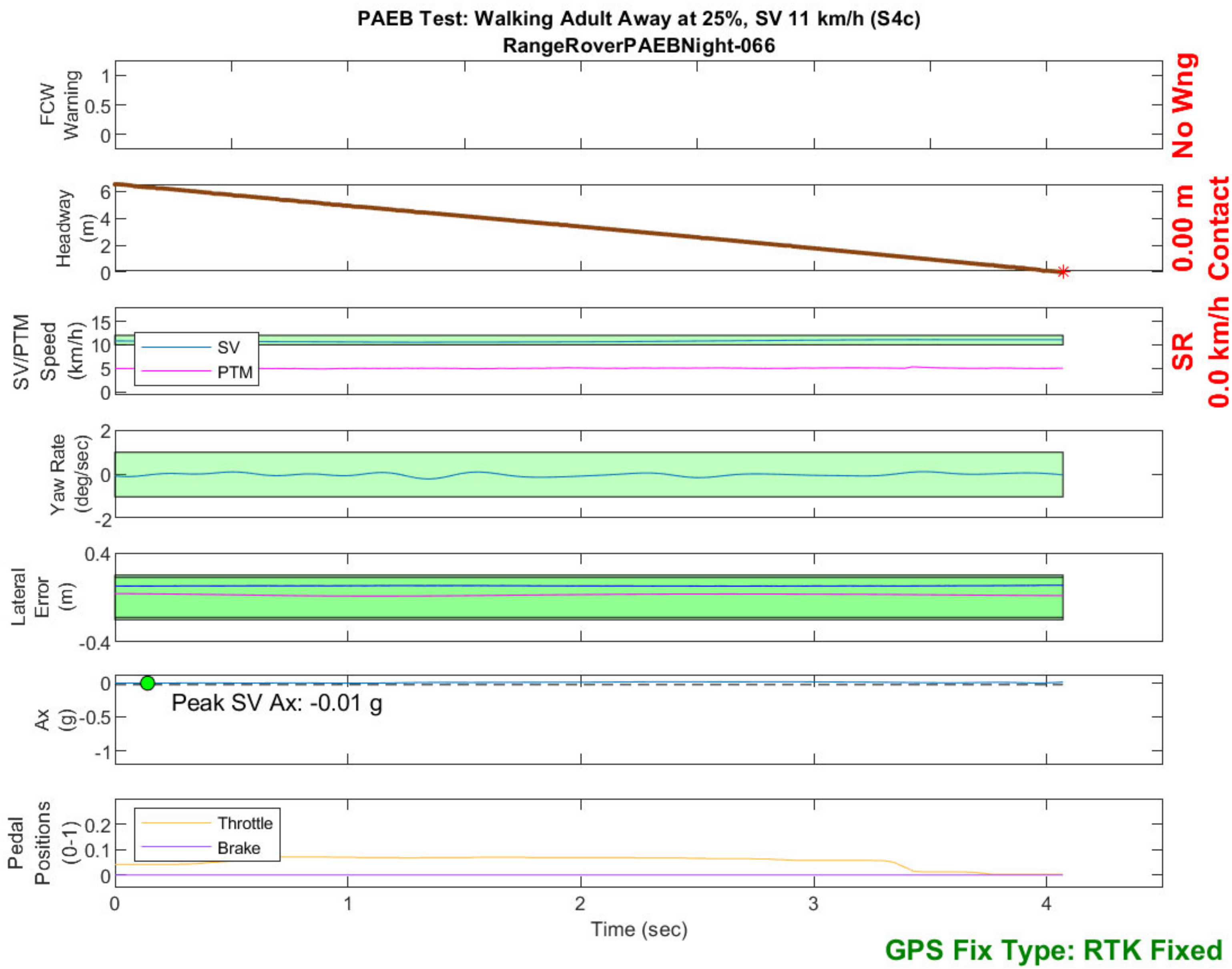


Figure D224. Time History for PAEB Run 66, S4c, Night, Low Beam, 11 km/h

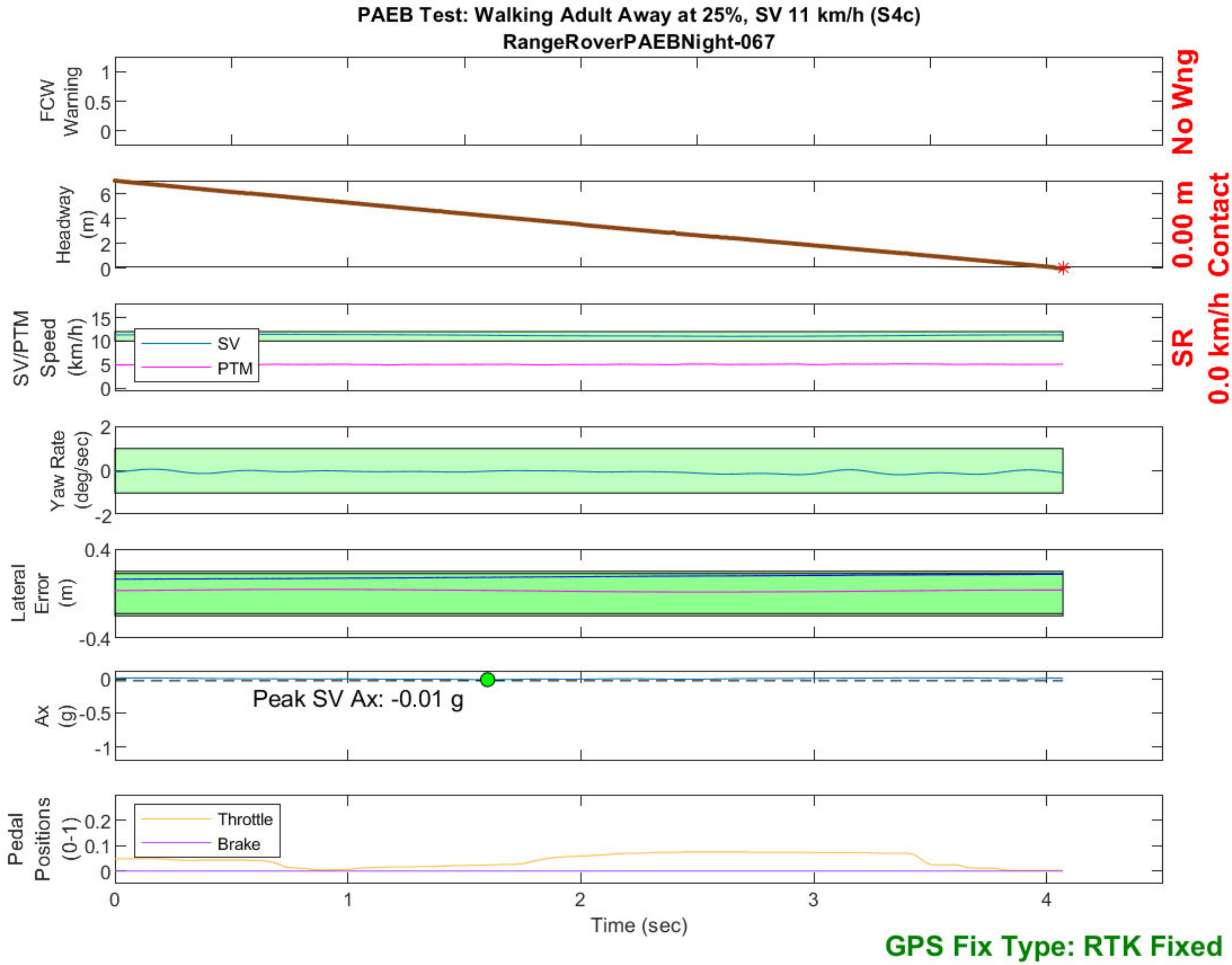


Figure D225. Time History for PAEB Run 67, S4c, Night, Low Beam, 11 km/h

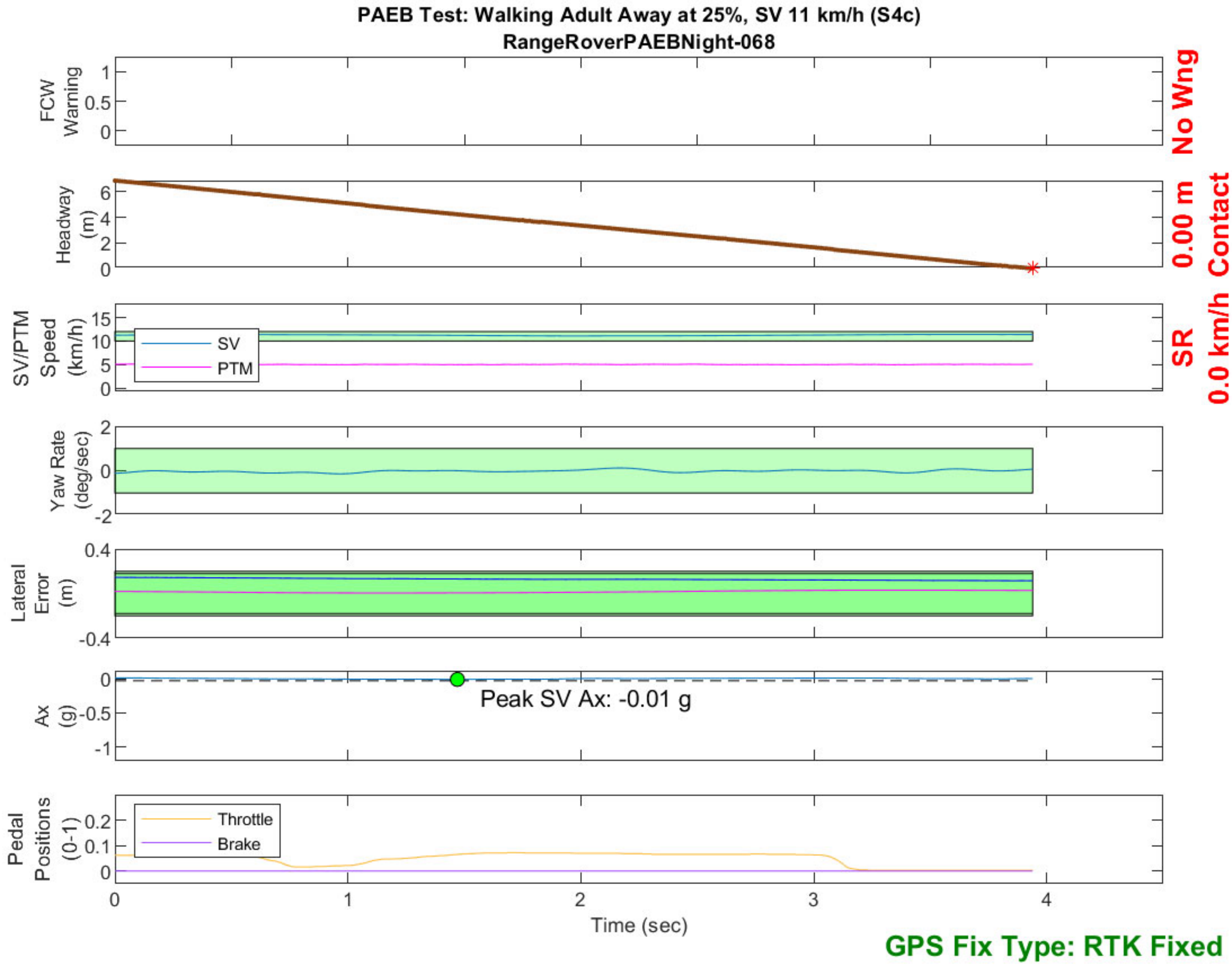


Figure D226. Time History for PAEB Run 68, S4c, Night, Low Beam, 11 km/h

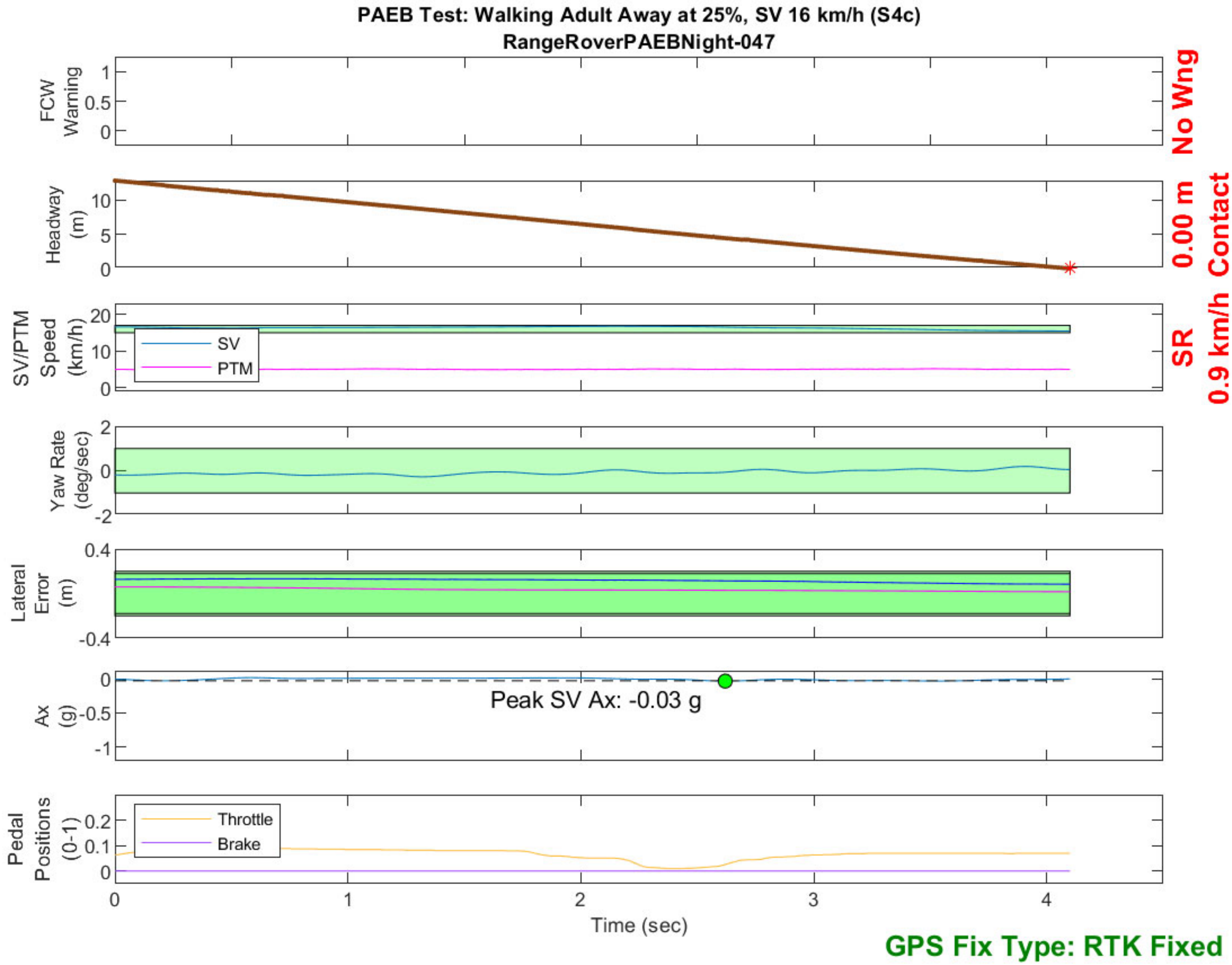


Figure D227. Time History for PAEB Run 47, S4c, Night, Low Beam, 16 km/h

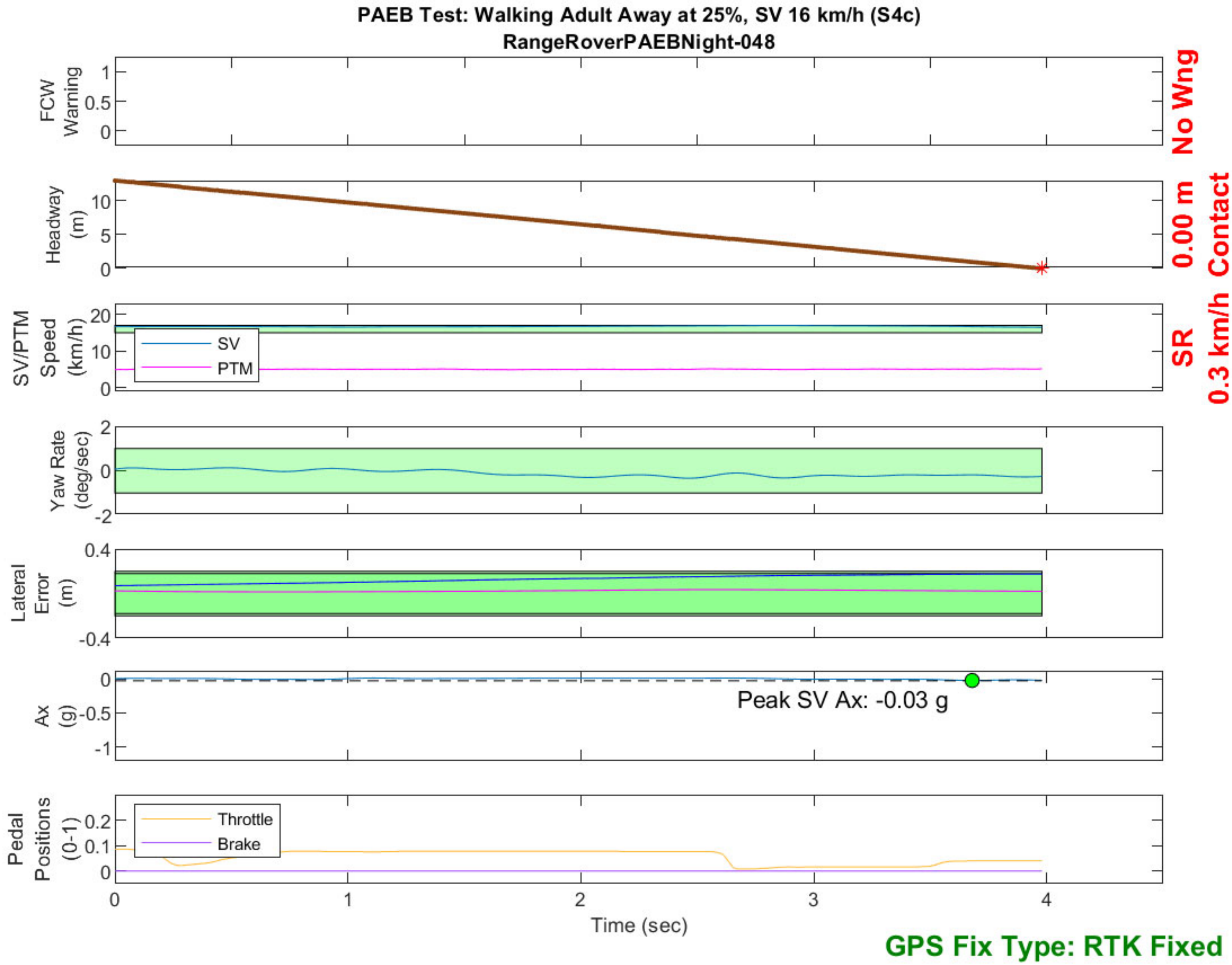


Figure D228. Time History for PAEB Run 48, S4c, Night, Low Beam, 16 km/h

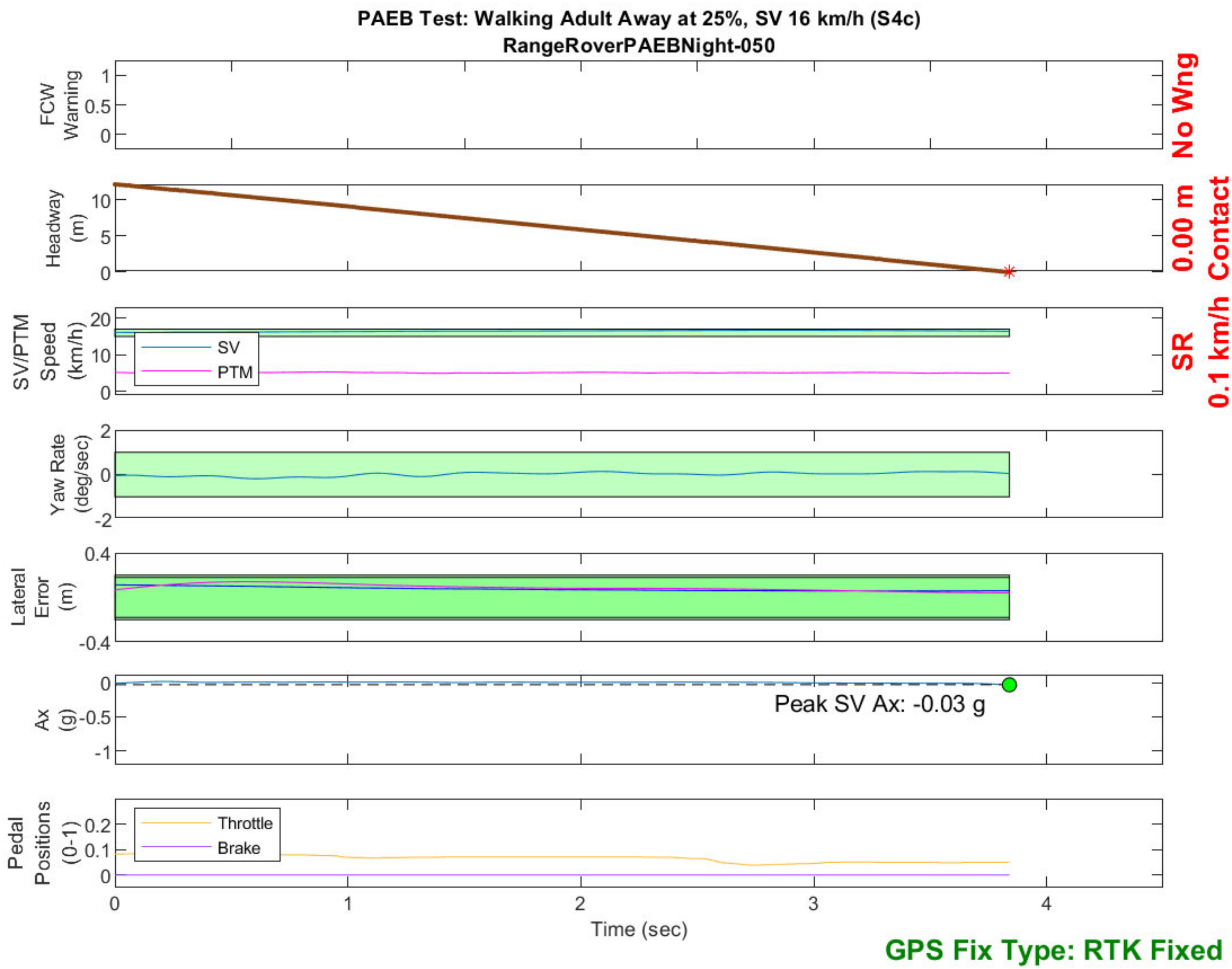


Figure D229. Time History for PAEB Run 50, S4c, Night, Low Beam, 16 km/h

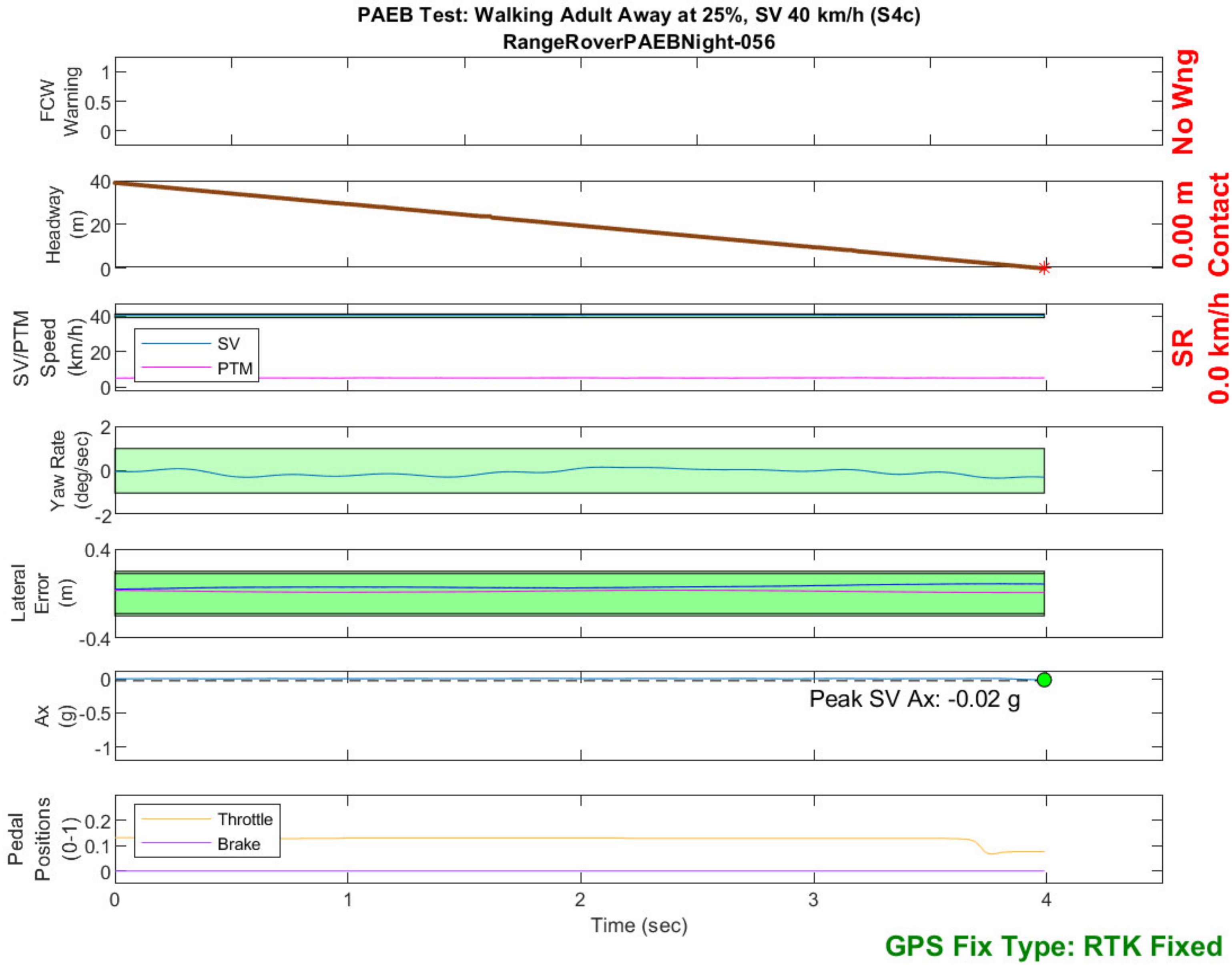


Figure D230. Time History for PAEB Run 56, S4c, Night, Low Beam, 40 km/h

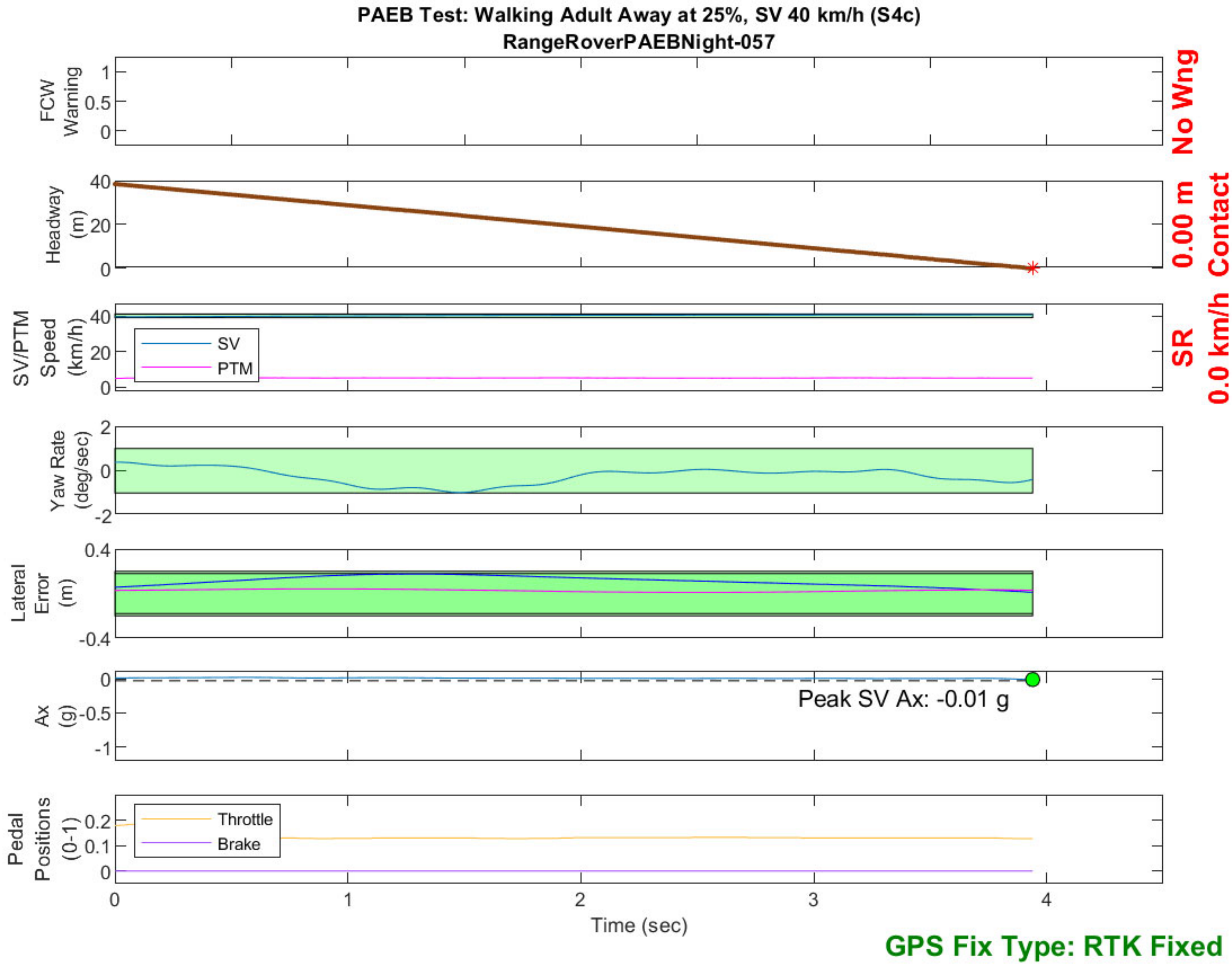


Figure D231. Time History for PAEB Run 57, S4c, Night, Low Beam, 40 km/h

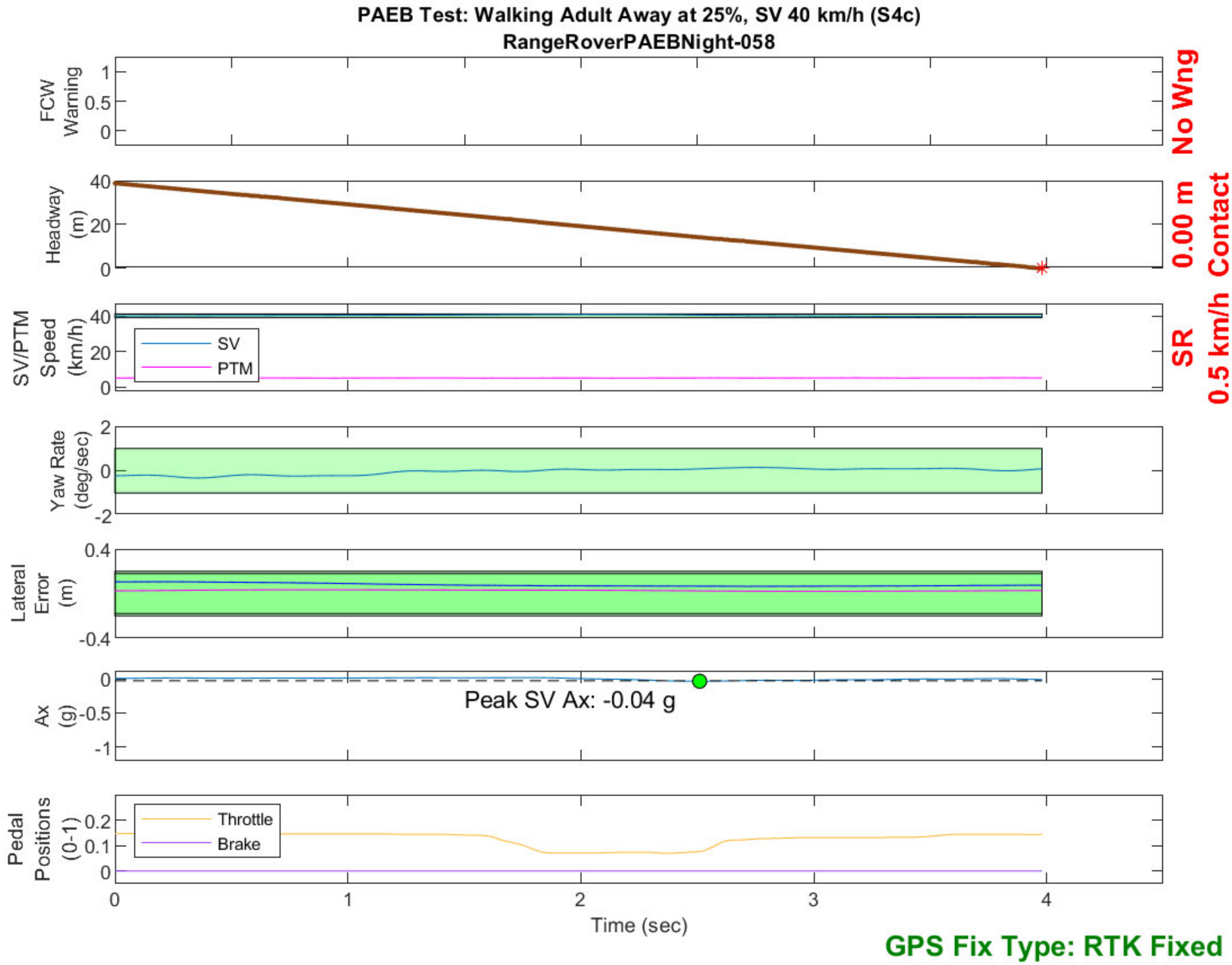


Figure D232. Time History for PAEB Run 58, S4c, Night, Low Beam, 40 km/h