PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM RESEARCH TEST
NCAP-DRI-PAEB-20-04

2020 Honda Odyssey EX-L

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14 January 2021

Final Report

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U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
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16. Abstract These research tests were conducted on the subject 2020 Honda Odyssey EX-L 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 Honda Odyssey EX-L. 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

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2020 Honda Odyssey EX-L

VIN: *5FNRL6H77LB05xxxx*

Day Test Date: *4/8/2020*

Night Test Date: *4/10/2020*

System Setting: *Normal*

Upper Capabilities

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

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

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

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11	4	0	0.0						
16	3	0	0.3						
40	3	0	N/A (LMB*)						

* Last Moment Braking- note that speed reduction for LMB runs are not included in the calculation for Average Speed Reduction

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	5	0	0.0	3	0	0.2
16	3	0	0.5	7	0	0.2	5	0	0.3
40	3	0	0.0	3	0	N/A (LMB)	3	0	N/A (LMB)

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	
11	5	0	0.2						
16	3	0	0.2						
40	3	0	2.3						

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	0.0	7	0	0.0
16	3	0	0.0	3	0	0.2	3	0	0.0
40	4	1	N/A (LMB)	3	0	0.0	3	0	0.2

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

2020 Honda Odyssey EX-L

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	
40	3	0	0.1	3	0	0.2	4	0	0.0

S1f, S1g: Peak Deceleration Summary

(Day tests only)

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

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

Trial Number	S1f SV: 40 km/h PTM: 5 km/h	S1g SV: 40 km/h PTM: 5 km/h
	Peak Deceleration (g)	
1	0.03	0.03
2	0.03	0.02
3	0.03	0.02
4	0.01	0.01
5	0.02	0.02
6	0.02	

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

2020 Honda Odyssey EX-L

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	0.2	3	0	0.1	3	0	0.0
16	3	0	0.4	3	0	0.5	4	0	0.4
40	3	0	1.3	3	0	0.4	3	0	0.9

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	
11	3	0	0.9						
16	3	0	0.7						
40	3	0	9.7						

2020 Honda Odyssey EX-L

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

Speed (km/h)	Daytime			Night-High Beam			Night-Low Beam		
	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)	# of Valid Trials		Avg Speed Reduction (km/h)
	Total	Without Contact		Total	Without Contact		Total	Without Contact	
11	3	0	0.3	4	0	0.0	6	0	0.0
16	6	2	6.8	3	0	0.1	2	0	0.1
40	3	0	2.4	3	0	1.1	4	0	0.5

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 2: VEHICLE DATA

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2020 Honda Odyssey EX-L

TEST VEHICLE INFORMATION

VIN: *5FNRL6H77LB05xxxx*

Body Style: *Minivan* Color: *Platinum White Pearl*

Date Received: *3/16/2020* Odometer Reading: *38 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *HONDA MFG. OF ALABAMA, LLC*

Date of manufacture: *02/20*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/60R18 103H*

Rear: *235/60R18 103H*

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

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *BRIDGESTONE TURANZA EL440*

Front tire size: *235/60R18 103H*

Rear tire size: *235/60R18 103H*

Front tire DOT prefix: *DOT 7X45 JB2*

Rear tire DOT prefix: *DOT 7X45 JB2*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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2020 Honda Odyssey EX-L

DAYTIME TEST GENERAL INFORMATION

Test date: *4/8/2020*

AMBIENT CONDITIONS

Air temperature: *22.2 C (72 F)*

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

X Wind speed ≤ 10 m/s (22 mph)

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

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

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

OBSTRUCTION VEHICLES

Forward obstructing vehicle: *1999 Honda Accord*

Rear obstructing vehicle: *2012 Toyota Highlander*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM

DATA SHEET 3: TEST CONDITIONS

2020 Honda Odyssey EX-L

VEHICLE PREPARATION (DAY)

Verify the following:

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

Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

2020 Honda Odyssey EX-L

NIGHTTIME TEST GENERAL INFORMATION

Test date: *4/10/2020*

AMBIENT CONDITIONS

Air temperature: *16.1 C (61 F)*

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

X Wind speed ≤ 10 m/s (22 mph)

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

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

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

OBSTRUCTION VEHICLES

Forward obstructing vehicle: *1999 Honda Accord*

Rear obstructing vehicle: *2012 Toyota Highlander*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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2020 Honda Odyssey EX-L

VEHICLE PREPARATION (NIGHT)

Verify the following:

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

Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 3: TEST CONDITIONS

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2020 Honda Odyssey EX-L

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*616.9 kg (1360 lb)*	Right Front:	*596.0 kg (1314 lb)*
Left Rear:	*497.6 kg (1097 lb)*	Right Rear:	*478.1 kg (1054 lb)*
		Total:	*2188.6 kg (4825 lb)*

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

2020 Honda Odyssey EX-L

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

Collision Mitigation Braking System (CMBS)

Type and location of sensors the system uses:

Fusion of radar and mono camera.

The radar sensor is located in the front grille and the front sensor camera is mounted to the interior side of the windshield, behind the rear view mirror.

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

X Yes

___ No

If yes, please provide a full description.

The system settings are accessed through a touch screen in the center of the console (Appendix A, Figures A13 and A14). The menu hierarchy is:

- *Settings*
  - *Vehicle*
    - *Driver Assist System Setup*
      - *Forward Collision Warning Distance*
        - *Select distance: Long/Normal/Short*

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

How is the PAEB alert presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

X Vibration

___ Other

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

2020 Honda Odyssey EX-L

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.

Visual alert:

Location, size: Multi-Information Display in the instrument panel. Please see the Owner's Manual, Page 114 in Appendix B and Appendix A, Figure A16 (note that the color is not shown correctly in this figure).

Color: Orange,

Words "BRAKE"

Flashes On/Off

Audible: Repeated beep

Vibration: Steering wheel vibration for oncoming detected vehicles.

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

____ No

If yes, please provide a full description.

Initial learning (or after ignition reset) is undertaken using a section of roadway with lane markers on both sides of the vehicle.

This procedure is needed only once before all PAEB testing and should be performed in the "Normal" system setting.

Conditions:

- *Lane markers on both sides of the vehicle 100～300 m*
- *Solid or dashed lines*
- *100 m: Three round trips*
- *300 m: Two round trips*
- *3.5 m – 4.3 m between inner parts of the lines*
- *100 mm line width*
- *25 mph*

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

Minimum: *5 km/h (3.1 mph) (Per manufacturer supplied information)*

Maximum: *No upper limit (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.

Yes, CMBS indicator in Multi Information Display comes on if deactivated.

To avoid deactivation, turn off the ignition switch after every test and calibrate the camera before every test.

PEDESTRIAN AUTOMATIC EMERGENCY BRAKING

DATA SHEET 4: PEDESTRIAN AUTOMATIC EMERGENCY BRAKING SYSTEM OPERATION

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2020 Honda Odyssey EX-L

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.

A push button located to the left of the steering column can be used to deactivate CMBS (Appendix A, Figure A15).

Press and hold the button until the beeper sounds to switch the system on or off.

When the CMBS is off:

- *The CMBS indicator in the instrument panel comes on.*
- *A message on the driver information interface indicates that the system is off.*

The CMBS is turned on every time the vehicle is started, even if it was disabled during the previous ignition cycle.

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

____ No

If yes, please provide a full description.

The system limitations are described in the Owner's Manual, Pages 619 through 623. These pages are reproduced in Appendix B, Pages B-12 through B-16.

The system limitations that are specifically applicable to pedestrian detection are on page 621 of the Owner's Manual, reproduced on page B-13 of Appendix B.

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 4c, the 16 and 40 km/h speeds were considered to be the “non-conditional" speeds. Testing at these speeds was conducted without regard to whether the results showed that "consistent contact" occurred between the SV and PTM. Consistent contact was defined as the SV contacting the PTM in three or more test trials at a given speed. If this occurred, then testing at any higher speeds was not conducted. Rather, the speed would be stepped down by 5 km/h and testing of that scenario and lighting treatment would be conducted at that lower speed. This was done to more precisely identify the highest speed at which the vehicle's PAEB system was able to avoid colliding with the PTM.

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

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

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

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

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

An overview of each of the test procedures follows.

B. SV Approach to a Crossing Pedestrian (S1)

1. S1 TEST SCENARIOS

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

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

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

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

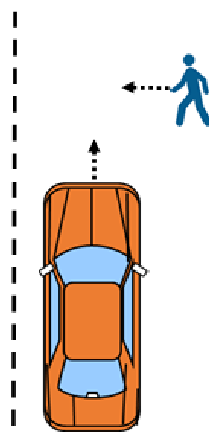


Figure 1. Scenarios S1a, b, c; Nearside Crossing Adult Pedestrian Walking 25/50/75% Overlap

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

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

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

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

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

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

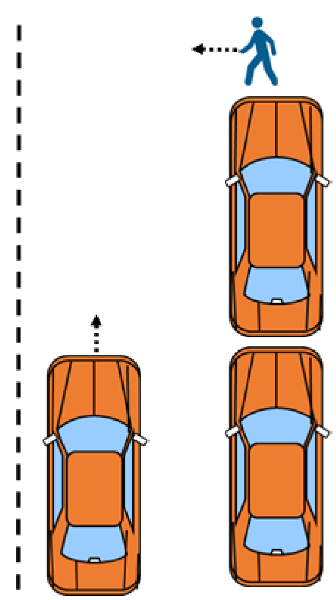


Figure 2. Scenario S1d; Nearside Obstructed Crossing Child Running, 50% Overlap

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

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

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

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

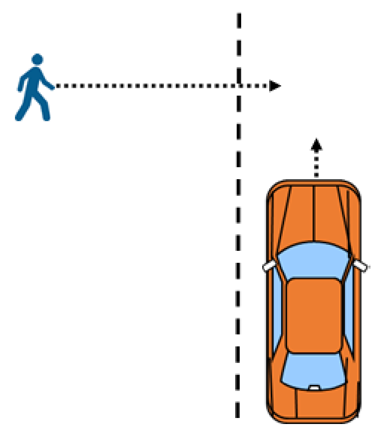


Figure 3. Scenario S1e; Offside Crossing Adult Running 50% Overlap

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

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

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

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

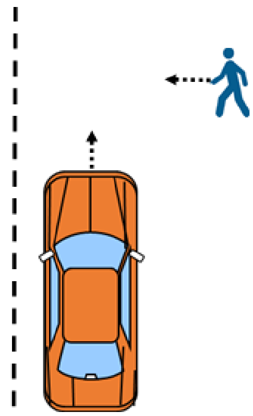


Figure 4. Scenario S1f; Nearside Crossing Adult Walking Stops Short

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

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

This test evaluates how the SV PAEB system will respond to a crossing adult pedestrian walking from the nearside that clears the vehicle's path.

Figure 5 below illustrates the setup for the S1g test condition. See Table 3 for details on the test setup.

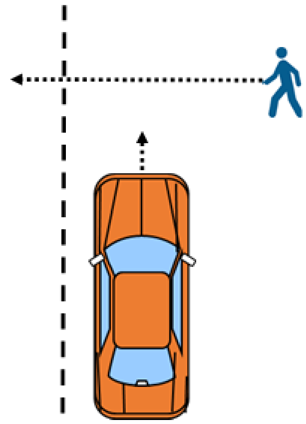


Figure 5. Scenario S1g; Nearside Crossing Adult Walking Clears Path

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

2. PEDESTRIAN TEST MANNEQUIN PLACEMENT AND MOVEMENT

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

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

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

a. PTM Position as a Function of SV Position

i. PTM Position Validity Criterion

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

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

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

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

ii. Methodology

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

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

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

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

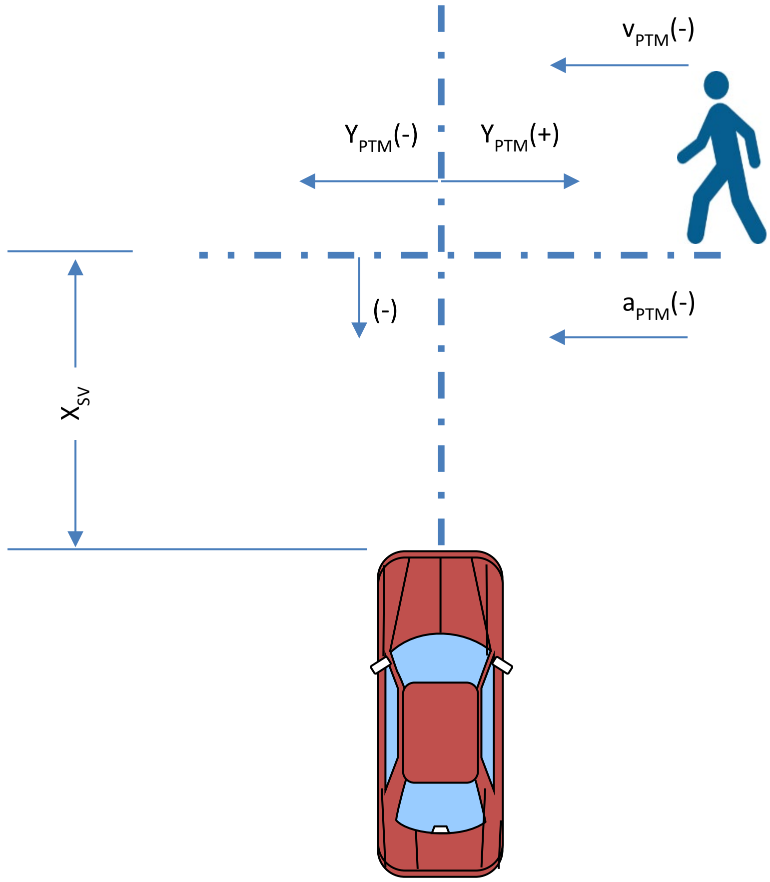


Figure 6. Coordinate System for Validation of Scenario 1

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

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

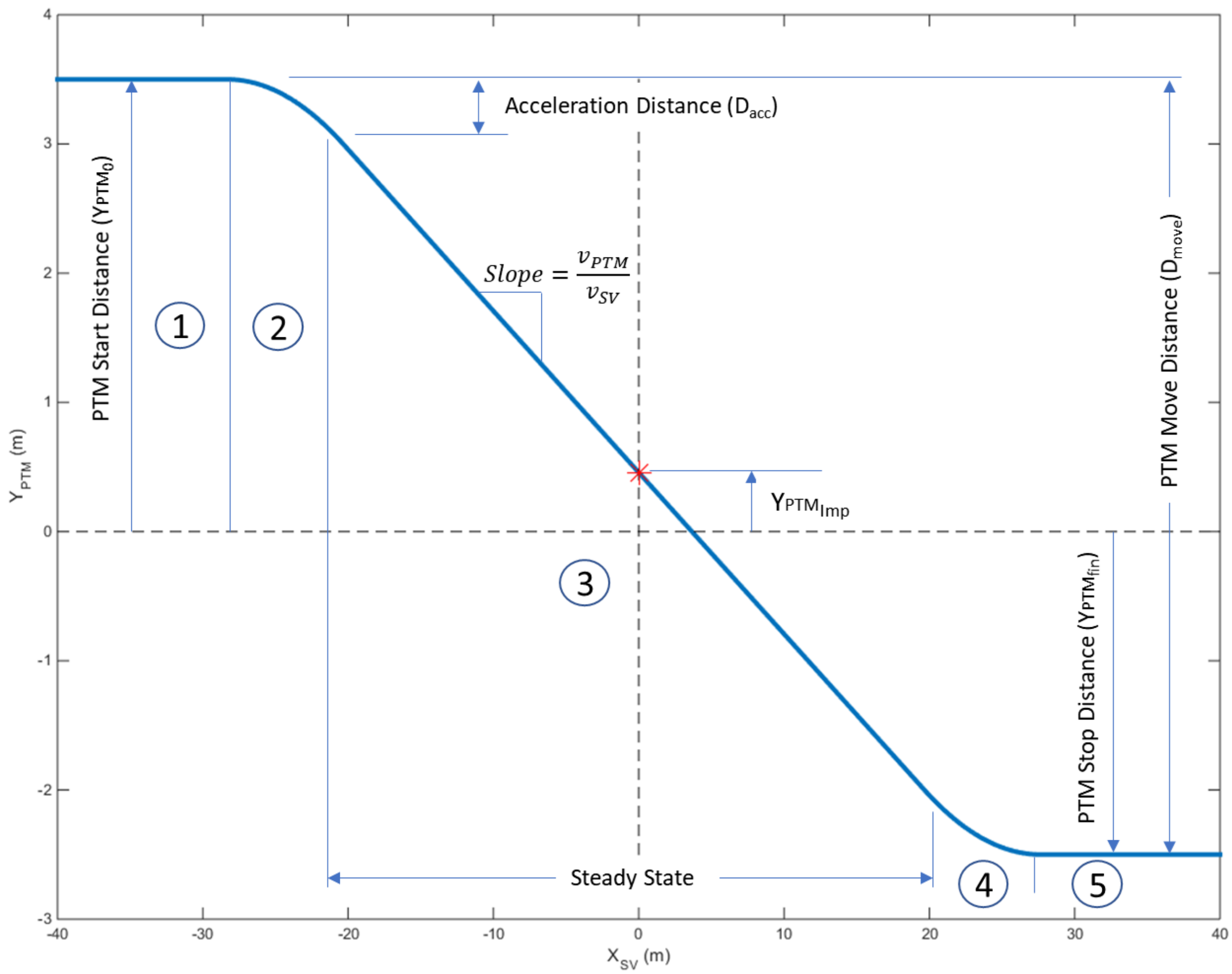


Figure 7. PTM Lateral Lane Position as a Function of SV Longitudinal Lane Position

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

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

proceeds in the lane (relevant only for scenario S1f)

The boundaries of these domains are:

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

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

Table 2. Domain Boundaries Per Scenario

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

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

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

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

where,

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

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

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

where,

$Y_{PTM_{fin}}$ = final position of PTM with respect to the lane

Y_{PTM_0} = initial position of PTM with respect to the lane

D_{move} = distance moved by the PTM, defined by scenario

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

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

where,

v_{PTM} = velocity of PTM, defined by scenario

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

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

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

where,

$\Delta X_{SV_{acc}}$ = Change in SV longitudinal lane position during the acceleration of the PTM

v_{SV} = SV velocity, defined by scenario

Computing the domain boundaries:

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

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

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

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

where,

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

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

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

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

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

Domain 1 (Stationary):

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

Domain 2 (Acceleration):

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

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.
- 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

[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.

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

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

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

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

g. Deceleration (S1f-g)

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

h. Pass/Fail Criteria

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

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

1. S4 TEST SCENARIOS

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

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

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

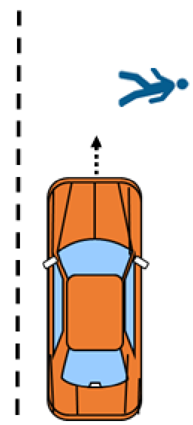


Figure 8. Scenario S4a; Nearside Standing Adult Facing Away From SV, 25% Overlap

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

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

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

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

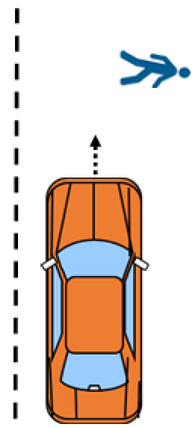


Figure 9. Scenario S4b; Nearside Standing Adult Facing Towards SV, 25% Overlap

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

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

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

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

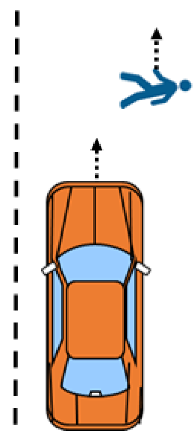


Figure 10. Scenario S4c; Nearside Walking Adult Away From SV, 25% Overlap

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

2. PEDESTRIAN TEST MANNEQUIN PLACEMENT AND MOVEMENT

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

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

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

3. SV ZERO POSITION

- The SV was centered on the SV path at the start of the test lane. The PTM was located on the PTM path which was parallel to the SV path inside the test lane located on the nearside. The SV overlap was 25% of the SV width, which was the distance between the SV centerline path and the PTM centerline path. The PTM faced the direction specified for each test scenario.

- The SV was positioned such that it just contacted the PTM. This was the "zero position." Note that the determination of whether there was a collision between the SV and PTM was based on whether the zero position had been crossed. Note also that the arms of the PTM were not considered contact points.
- The zero position was documented prior to, and immediately after, conduct of a test series.

4. LAST MOMENT BRAKING

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

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

5. TEST TRIAL CONDUCT AND VALIDITY

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

a. PTM Validity

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

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

- The PTM was at the start position distance on the PTM path and did not move until the triggering criteria for motion were met.

- When triggered, the PTM was accelerated to the test speed over the required distance and held at that test speed until a contact event or the SV speed was reduced to zero and no contact had occurred.
    - PTM speed: 5 km/h (3.1 mph) within an acceleration distance of 1.0 m (3.28 ft)
    - PTM position: ±0.18 m from the ideal lateral position within the lane, as a function of SV longitudinal position within the lane[3].
- While the PTM was in motion, the PTM path remained parallel to the SV path. Lateral deviations induced by wind, equipment, or surface conditions were monitored.

b. SV Validity

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

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

[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.

- With the exception of LMB (described above), the SV driver did not apply any force to the brake pedal until the end of the test unless the PTM was contacted by the SV.

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

c. Validity Period

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

d. End-of-Test Instructions

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

The test trial was then complete.

e. Number of Test Trial Repeats

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

f. Speed Reduction

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

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

g. Pass/Fail Criteria

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

D. Summary of Scenarios

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

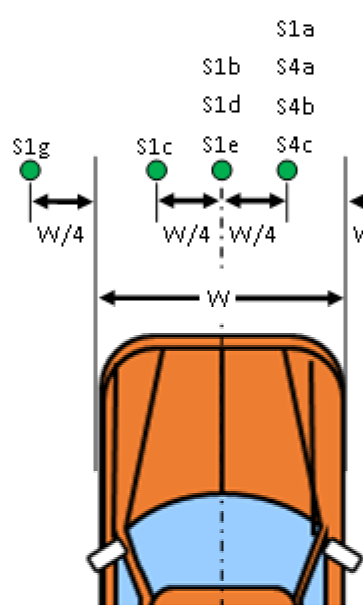


Figure 11. Offset Conditions

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

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

Drawing illustrates setup but is not to scale

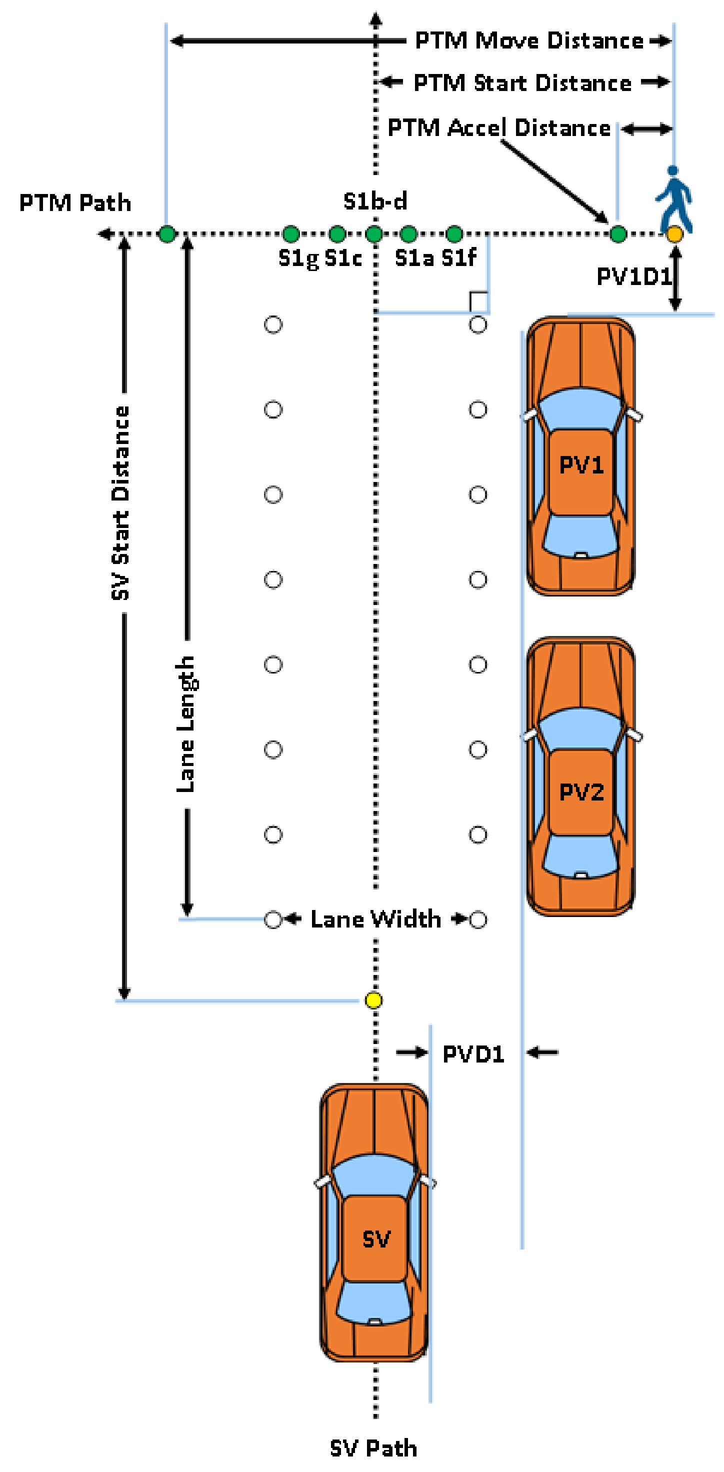


Table 4. Summary of S1e Scenario Setup

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

Drawing illustrates setup but is not to scale

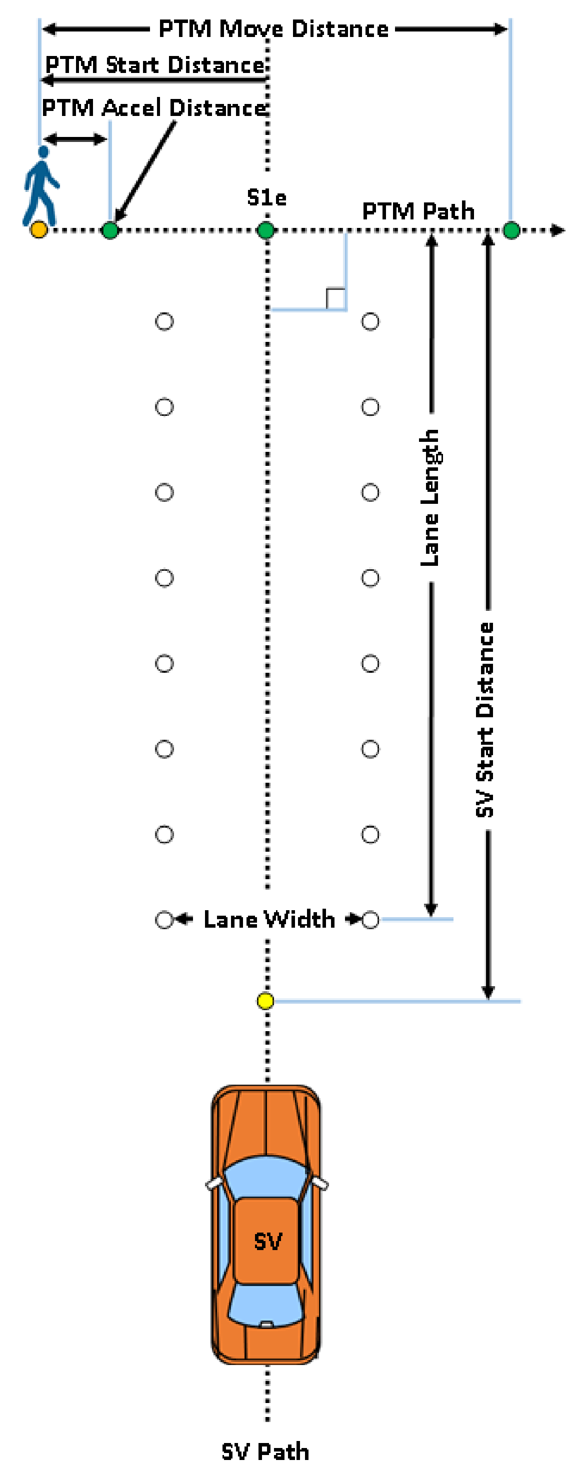


Table 5. Summary of S4a-b Scenarios Setup

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

Drawing illustrates setup but is not to scale

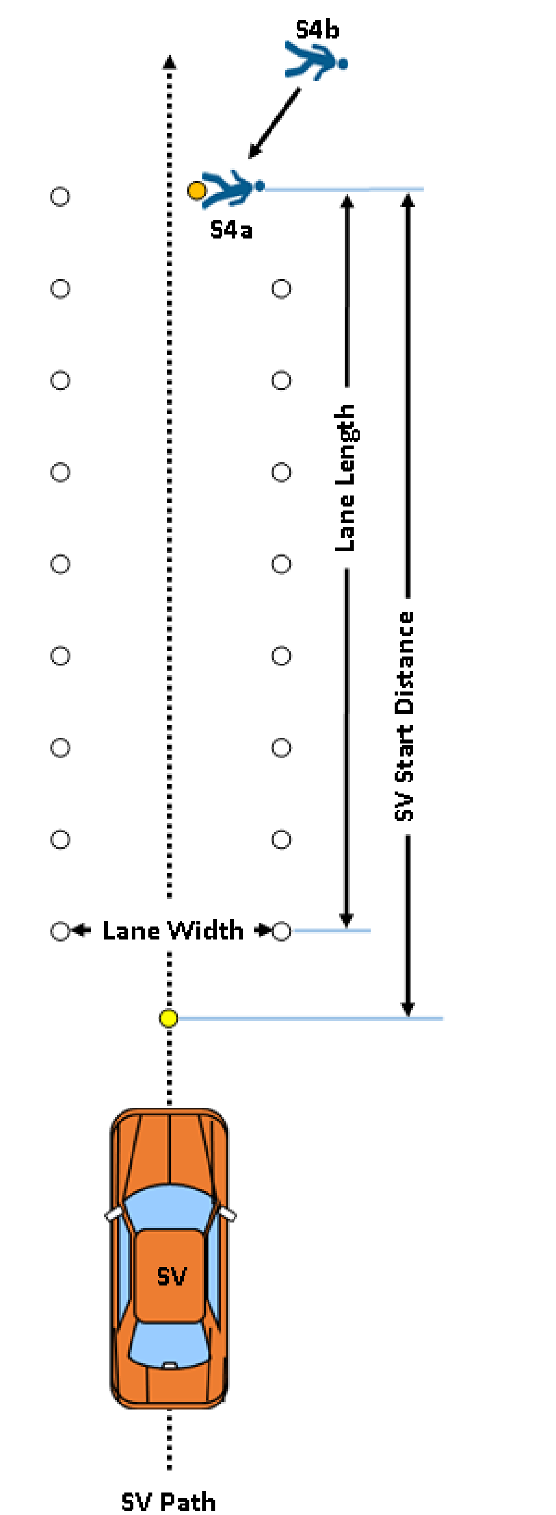
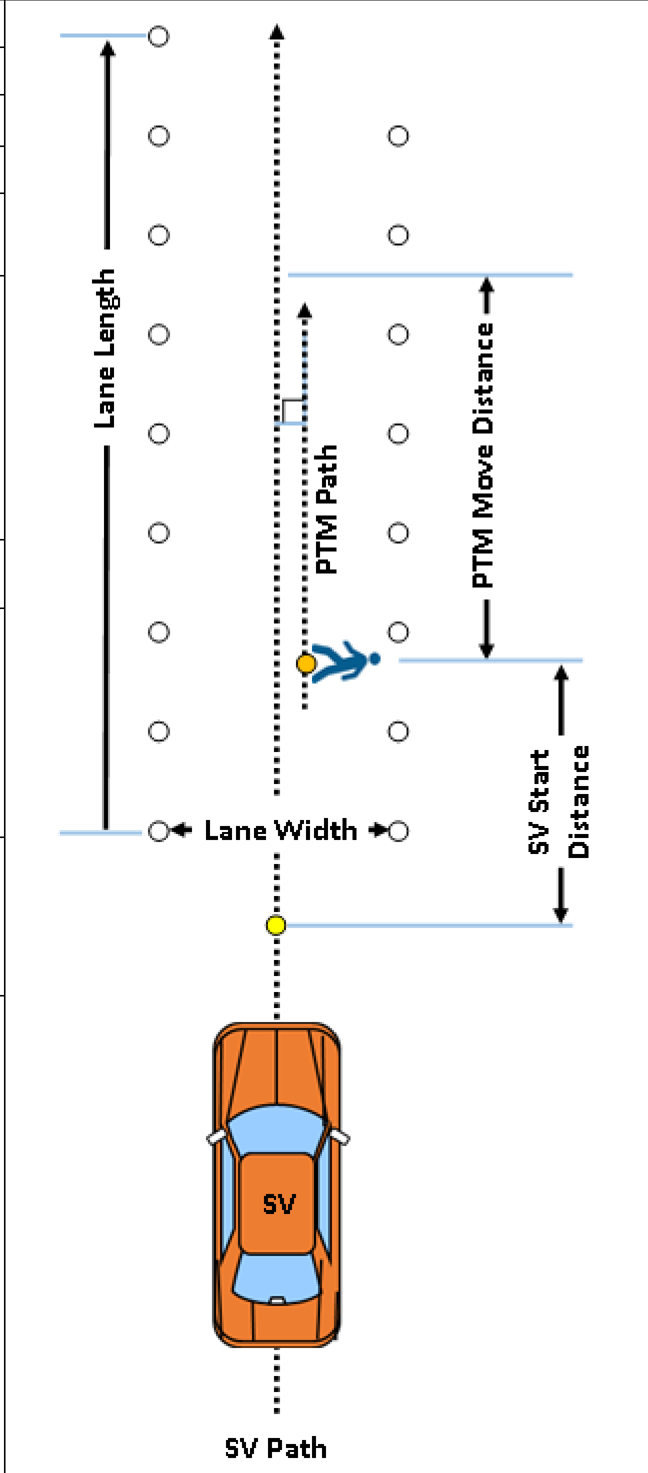


Table 6. Summary of S4c Scenario Setup

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



E. Pre-Test Brake Burnishing

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

- The SV was loaded to its GVWR.

- From a speed of 49.7 mph (80 km/h), 200 stops were performed with an average deceleration of 0.31g (3.0 m/s²) during each stop.

  - Each stop was performed with the transmission in gear.

  - The Initial Brake Temperature (IBT), defined as the average brake pad or lining friction material temperature on the highest-temperature axle of the SV at the onset of a test trial, was ≤ 100°C (212°F) at the onset of each stop.

  - The interval from the onset of one stop to the onset of the next was either the time necessary to reduce the IBT to ≤ 100°C (212°F), or the distance of 2 km (1.24 miles), whichever occurred first.

  - The vehicle was accelerated to 49.7 mph (80 km/h) after each stop and that speed was maintained until initiating the next.

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

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

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

F. Pedestrian Test Mannequin and Motion System

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

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

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

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

G. Instrumentation

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

Table 7. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi	< 1% error between 20 and	Omega DPG8001	18111410000	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 1/6/2020 Due: 1/6/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 5/10/2019 Due: 5/10/2020
SV Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90º Longitude: ±180º Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±5g Angular Rate: ±300 º/s Angular Disp: ±180º	Position: ±2 cm Velocity: 0.1 km/h Accel: ≤ 0.05% Angular Rate: ≤ 0.05% Roll/Pitch Angle: ±0.05º Heading Angle: ±0.1º	Oxford xNAV 550	015477	By: Oxford Technical Solutions Date: 9/12/2018 Due: 9/12/2020
PTT Multi-Axis Inertial Sensing System					24538	By: Oxford Technical Solutions Date: 2/24/2020 Due: 2/24/2022

Table 7. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2020 Due: 1/6/2021
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA
Type	**Description**			**Mfr, Model**		**Serial Number**
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board		549068
				I/O Board		588523

H. Pre-Test Brake Burnishing

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

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

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

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

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle As-Delivered

Figure A2. Rear View of Subject Vehicle As-Delivered

Figure A3. Front View of Subject Vehicle As-Tested

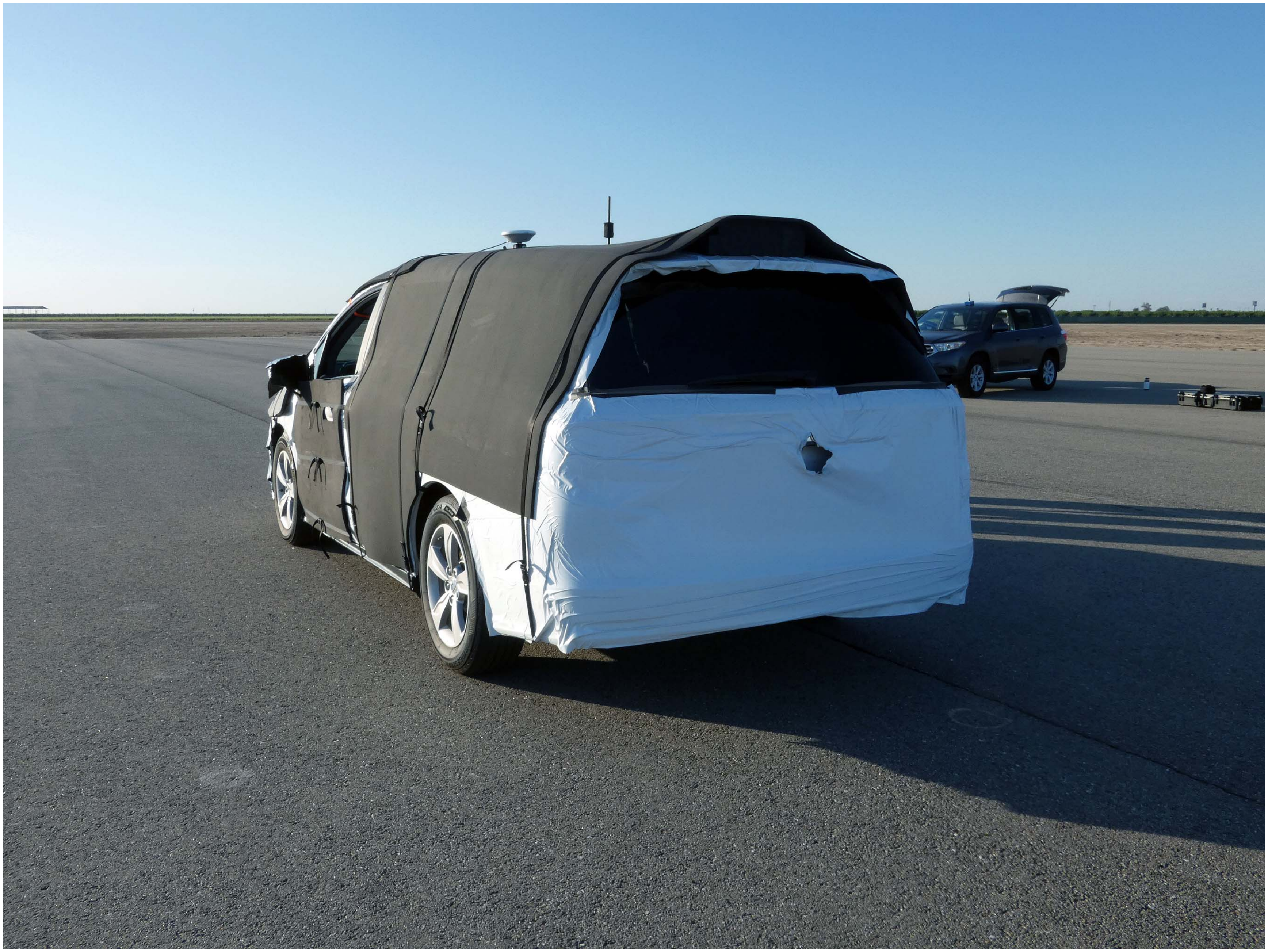


Figure A4. Rear View of Subject Vehicle As-Tested

Figure A5. Window Sticker (Monroney Label)

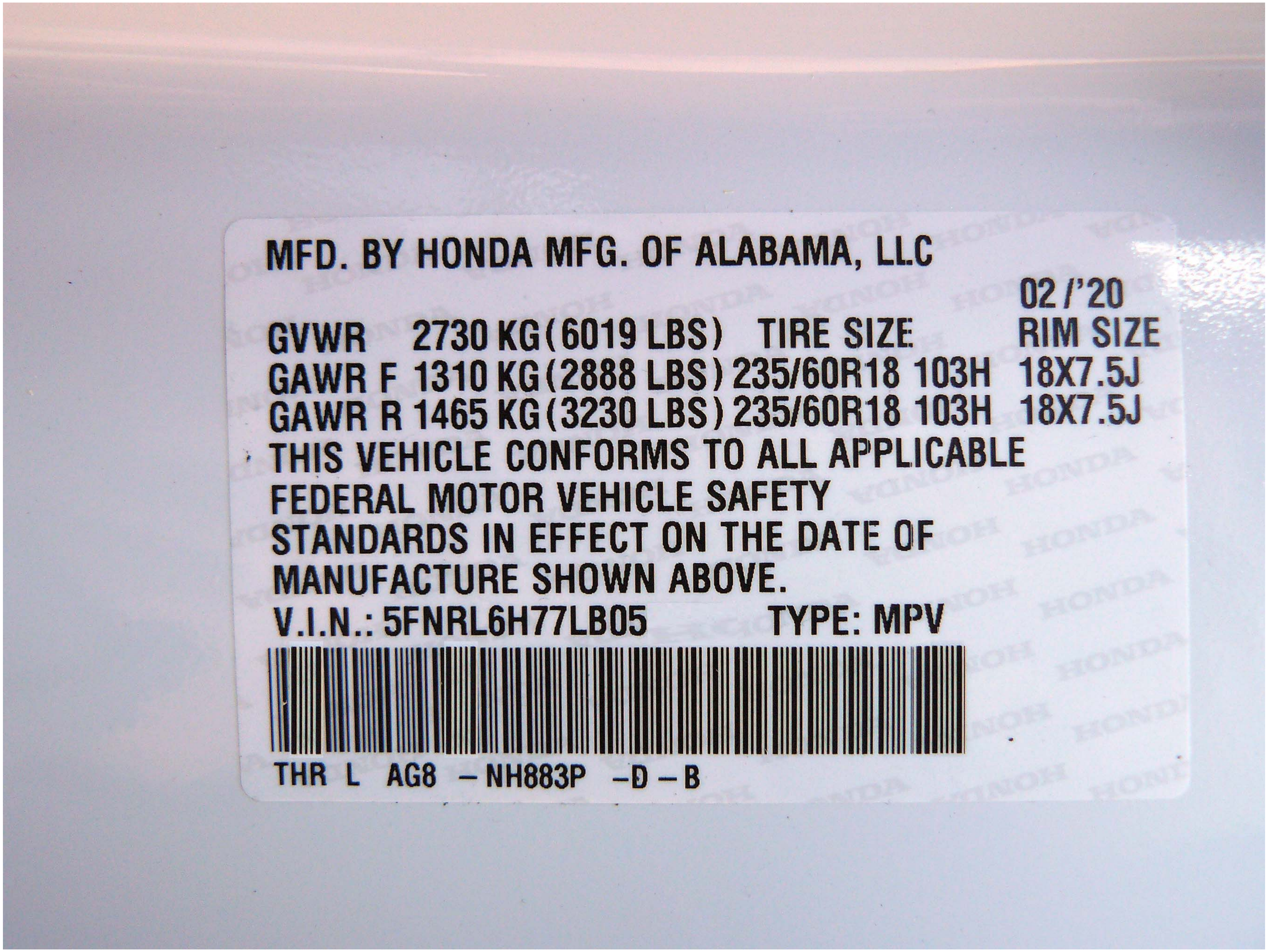


Figure A6. Vehicle Certification Label

Figure A7. Tire Placard

Figure A8. Adult and Child Pedestrian Surrogates and Motion Platform

Figure A9. 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

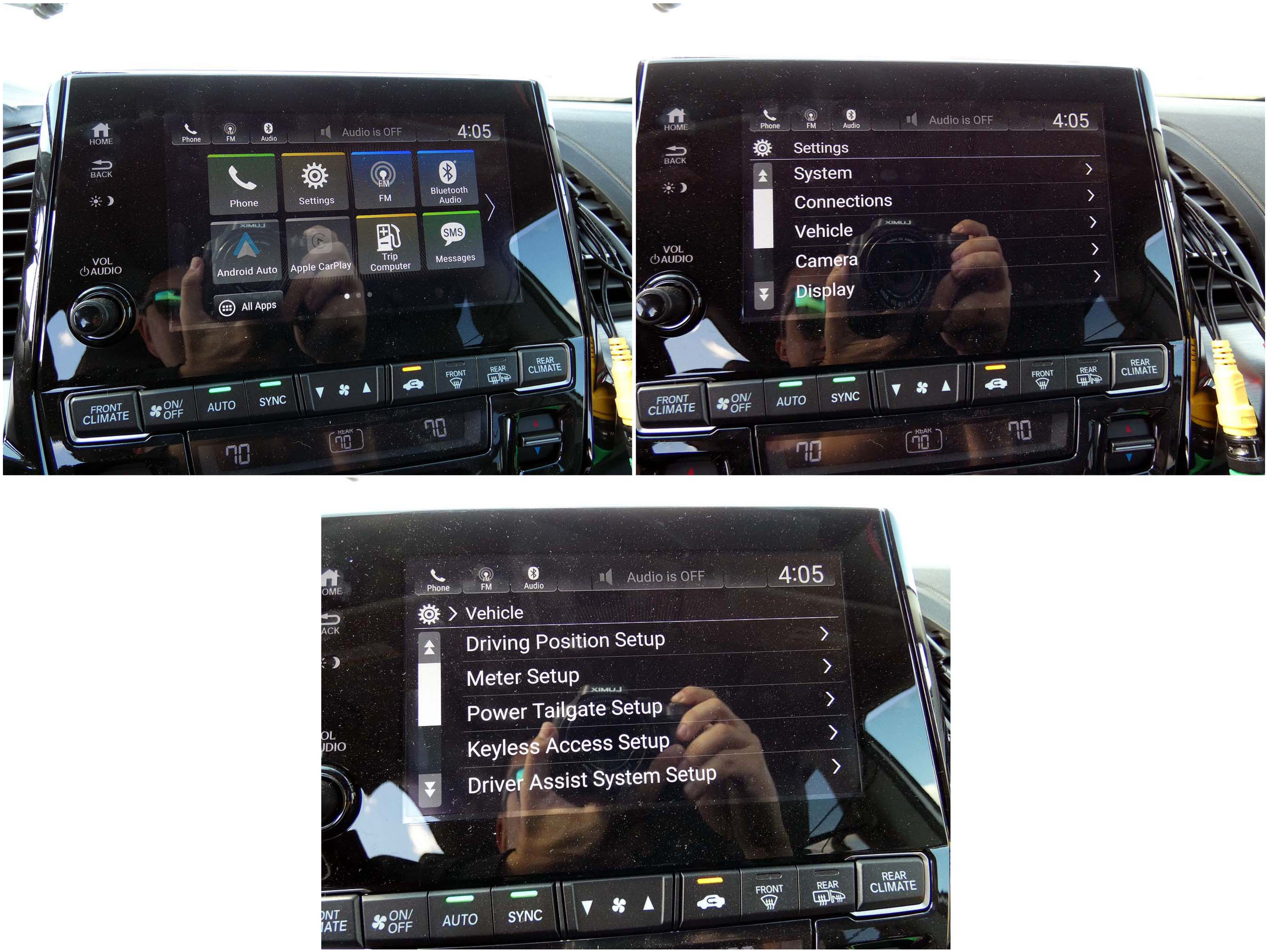


Figure A13. PAEB Setup Menus (page 1 of 2)

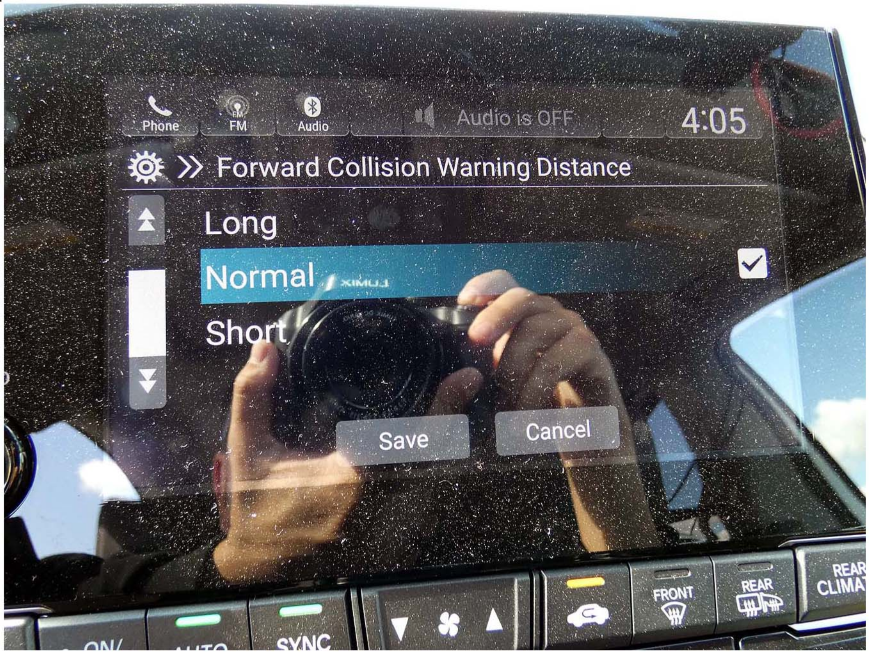


Figure A14. PAEB Setup Menus (page 2 of 2)

Figure A15. CMBS (AEB) On/Off Switch

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

Instrument Panel P. 83

Gauges P. 119/Driver Information Interface P. 120/System Indicators P. 84

System Indicators

- Malfunction Indicator Lamp
- Charging System Indicator
- Electric Power Steering (EPS) System Indicator
- Low Fuel Indicator
- Vehicle Stability Assist™ (VSA®) System Indicator
- VSA® **OFF** Indicator
- Automatic Brake Hold System Indicator
- Automatic Brake Hold Indicator (U.S. / Canada)
- Parking Brake and Brake System Indicator (Amber) (U.S. / Canada)
- Anti-lock Brake System (**ABS**) Indicator
- Blind spot information System Indicator*

System Indicators

- Lane Keeping Assist System (**LKAS**) Indicator (Green/ Amber)*
- Adaptive Cruise Control (**ACC**) Indicator (Green/ Amber)*

Lights Indicators

- Lights On Indicator
- High Beam Indicator
- Fog Light Indicator*
- Auto High-Beam Indicator*

System Indicators

- Turn Signal and Hazard Warning Indicators
- Low Tire Pressure/TPMS Indicator
- Parking Brake and Brake System Indicator (Red) (U.S. / Canada)
- Seat Belt Reminder Indicator
- Supplemental Restraint System Indicator
- **CRUISE MAIN** Indicator*
- **CRUISE CONTROL** Indicator*
- Econ Mode Indicator
- Auto Idle Stop System Indicator (Amber)/ Auto Idle Stop Indicator (Green)
- **Snow** Mode Indicator
- **Normal** Mode Indicator
- System Message Indicator
- Road Departure Mitigation (RDM) Indicator*
- Collision Mitigation Braking System™ (CMBS™) Indicator*

* Not available on all models

VSA® On and Off P. 597

- The Vehicle Stability Assist™ (VSA®) system helps stabilize the vehicle during cornering, and helps maintain traction while accelerating on loose or slippery road surfaces.
- VSA® comes on automatically every time you start the engine.
- To partially disable or fully restore VSA® function, press and hold the button until you hear a beep.

Cruise Control* P. 566

- Cruise control allows you to maintain a set speed without keeping your foot on the accelerator pedal.
- To use cruise control, press the **CRUISE** button, then press the **–/SET** button once you have achieved the desired speed (above 25 mph or 40 km/h).

CMBS™ On and Off*

P. 618

- When a possible collision is likely unavoidable, the CMBS™ can help you to reduce the vehicle speed and the severity of the collision.
- The CMBS™ is turned on every time you start the engine.
- To turn the CMBS™ on or off, press and hold the button until you hear a beep.

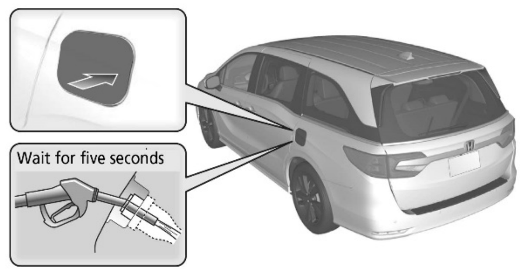
Tire Pressure Monitoring System (TPMS) with Tire Fill Assist P. 599, 726

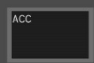
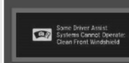
- The TPMS monitors tire pressure.
- TPMS is turned on automatically every time you start the engine.
- TPMS fill assist provides audible and visual guidance during tire pressure adjustment.

Refueling P. 637

Fuel recommendation:	**Unleaded gasoline, pump octane number 87 or higher**
Fuel tank capacity: 19.5 US gal (73.8 L)	

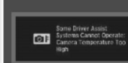
1. Unlock the driver's door.
   Locking/Unlocking the Doors from the Inside P. 156
2. Press firmly and then release the area indicated by the arrow to release the fuel filler door.
3. After refueling, wait for about five seconds before removing the filler nozzle.



Indicator	Name	On/Blinking	Explanation	Message
	Adaptive Cruise Control (**ACC**) Indicator (Green)*	• Comes on when the area around the camera is blocked by dirt, mud, etc. Stop your vehicle in a safe place, and wipe it off with a soft cloth. • May come on when driving in bad weather (rain, snow, fog, etc.)	• Have your vehicle checked by a dealer if the indicator and message come back on after you cleaned the area around the camera.	
	Collision Mitigation Braking System™ (CMBS™) Indicator*	• Comes on for a few seconds when you change the power mode to ON, then goes off. • Comes on when you deactivate the CMBS™. A driver information interface message appears for five seconds. • Comes on if there is a problem with the CMBS™.	• **Stays on constantly without the CMBS™ off** - Have your vehicle checked by a dealer. **Collision Mitigation Braking System™ (CMBS™)*** P. 615	 

Instrument Panel

* Not available on all models

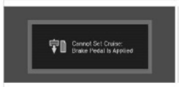
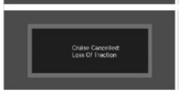
Indicator	Name	On/Blinking	Explanation	Message
	Collision Mitigation Braking System™ (CMBS™) Indicator*	• Comes on when the CMBS™ system shuts itself off.	• **Stays on** - The area around the camera is blocked by dirt, mud, etc. Stop your vehicle in a safe place, and wipe it off with a soft cloth. **Front Sensor Camera*** P. 569	
			• When the radar sensor gets dirty, stop your vehicle in a safe place, and wipe off dirt using a soft cloth. Indicator may take some time to go off after the radar sensor is cleaned. • Have your vehicle checked by a dealer if the indicator does not go off even after you clean the sensor cover. **Collision Mitigation Braking System™ (CMBS™)*** P. 615	
			• **Stays on** - The temperature inside the camera is too high. Use the climate control system to cool down the camera. The system activates when the temperature inside the camera cools down. **Front Sensor Camera*** P. 569	

* Not available on all models

Models with remote engine starter

Message	Condition	Explanation
	• Appears when you unlock and open the driver's door while the engine is running by remote engine start.	**Remote Engine Start with Vehicle Feedback*** P. 544

Models with ACC

Message	Condition	Explanation
	• Flashes when the system senses a likely collision with a vehicle in front of you.	• Take the appropriate means to prevent a collision (apply the brakes, change lanes, etc.) **Collision Mitigation Braking System™ (CMBS™)*** P. 615 **Adaptive Cruise Control (ACC)*** P. 571
	• Appears when ACC has been automatically canceled.	• You can resume the set speed after the condition that caused ACC to cancel improves. Press the **RES/+** button. **Adaptive Cruise Control (ACC)*** P. 571
	• Appears when pressing the **–/SET** button while the vehicle is moving and the brake pedal is depressed.	• ACC cannot be set. **Adaptive Cruise Control (ACC)*** P. 571
	• Appears if the VSA® or traction control function operates while ACC is in operation.	• ACC has been automatically canceled. **Adaptive Cruise Control (ACC)*** P. 571

Instrument Panel

* Not available on all models

Setup Group	Customizable Features		Description	Selectable Settings
Vehicle	Keyless Access Setup	Remote Start System On/Off	Turns the remote engine start feature on and off.	**ON**[*1]/**OFF**
		Walk Away Auto Lock	Changes the settings for the automatic locking the doors when you walk away from the vehicle while carrying the remote.	**Enable**/**Disable**[*1]
	Driver Assist System Setup*	Forward Collision Warning Distance	Changes at which distance CMBS™ alerts.	**Long**/**Normal**[*1]/**Short**
		ACC Forward Vehicle Detect Beep	Causes the system to beep when the system detects a vehicle, or when the vehicle goes out of the ACC range.	**ON**/**OFF**[*1]
		Road Departure Mitigation Setting	Changes the setting for the road departure mitigation system.	**Normal**[*1]/**Wide**/**Warning Only**
		Lane Keeping Assist Suspend Beep	Causes the system to beep when the LKAS is suspended.	**ON**/**OFF**[*1]
		Blind Spot Information*	Changes the setting for the blind spot information system.	**Audible and Visual Alert**[*1]/**Visual Alert**/**OFF**

*1:Default Setting

Features

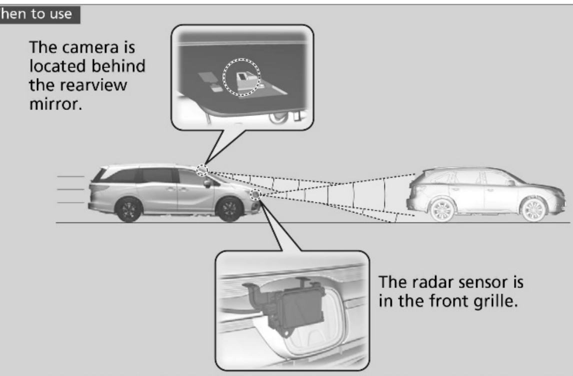
* Not available on all models

Collision Mitigation Braking System™ (CMBS™)*

Can assist you when there is a possibility of your vehicle colliding with a vehicle or a pedestrian detected in front of yours. The CMBS™ is designed to alert you when a potential collision is determined, as well as to reduce your vehicle speed to help minimize collision severity when a collision is deemed unavoidable.

■ How the system works

When to use



The system starts monitoring the roadway ahead when your vehicle speed is about 3 mph (5 km/h) and there is a vehicle in front of you.

The CMBS™ activates when:

- The speed difference between your vehicle and a vehicle or pedestrian detected in front of you becomes about 3 mph (5 km/h) and over with a chance of a collision.
- Your vehicle speed is about 62 mph (100 km/h) or less and there is a chance of a collision with an oncoming detected vehicle or a pedestrian in front of you.

▶Collision Mitigation Braking System™ (CMBS™)*

Important Safety Reminder

The CMBS™ is designed to reduce the severity of an unavoidable collision. It does not prevent a collision nor stop the vehicle automatically. It is still your responsibility to operate the brake pedal and steering wheel appropriately according to the driving conditions.

The CMBS™ may not activate or may not detect a vehicle in front of your vehicle under certain conditions:

▶ **CMBS™ Conditions and Limitations** P. 619

You can read about handling information for the camera equipped with this system.

▶ **Front Sensor Camera*** P. 569

Be careful not to have the radar sensor cover strongly impacted.

▶How the system works

Rapid vibrations on the steering wheel alert you when the your vehicle speed is between 19 and 62 mph (30 and 100 km/h) with an oncoming vehicle detected in front of you.

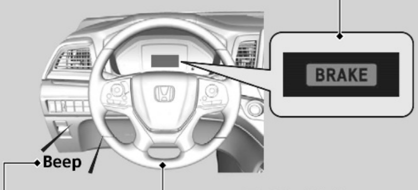
When the CMBS™ activates, it may automatically apply the brake. It will be canceled when your vehicle stops or a potential collision is not determined.

* Not available on all models

Continued

■ When the system activates

The system provides visual, audible and tactile alerts of a possible collision, and stops if the collision is avoided.
- Take appropriate action to prevent a collision (apply the brakes, change lanes, etc.)



At system's earliest collision alert stage, you can change the distance (**Long**/**Normal**/**Short**) between vehicles at which alerts will come on through audio/information screen setting options.

List of customizable options P. 461

■ Vibration alert on the steering wheel

When a potential collision to an oncoming detected vehicle is determined, the system alerts you with rapid vibration on the steering wheel, in addition to visual and audible alerts.

▶ Take appropriate action to prevent a collision (apply the brakes, operate the steering wheel, etc.).

When the system activates

The camera in the CMBS™ is also designed to detect pedestrians.
However, this pedestrian detection feature may not activate or may not detect a pedestrian in front of your vehicle under certain conditions.
Refer to the ones indicating the pedestrian detection limitations from the list.

CMBS™ Conditions and Limitations P. 619

Vibration alert on the steering wheel

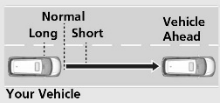
Vibration alert function is disabled when the electric power steering (EPS) system indicator comes on.

Electric Power Steering (EPS) System Indicator P. 91

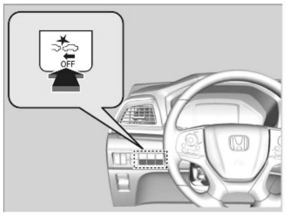
Driving

Collision Alert Stages

The system has three alert stages for a possible collision. However, depending on circumstances, the CMBS™ may not go through all of the stages before initiating the last stage.

Distance between vehicles		CMBS™			
		The sensors detect a vehicle	Audible & Visual WARNINGS	Steering Wheel	Braking
Stage one		There is a risk of a collision with the vehicle ahead of you.	When in **Long**, visual and audible alerts come on at a longer distance from a vehicle ahead than in **Normal** setting, and in **Short**, at a shorter distance than in **Normal**.	In case of an oncoming vehicle detected, rapid vibration is provided.	—
Stage two		The risk of a collision has increased, time to respond is reduced.	Visual and audible alerts.	—	Lightly applied
Stage three		The CMBS™ determines that a collision is unavoidable.		—	Forcefully applied

CMBS™ On and Off



Press and hold the button until the beeper sounds to switch the system on or off.

When the CMBS™ is off:

- The CMBS™ indicator in the instrument panel comes on.
- A message on the driver information interface reminds you that the system is off.

The CMBS™ is turned on every time you start the engine, even if you turned it off the last time you drove the vehicle.

CMBS™ On and Off

The CMBS™ may automatically shut off, and the CMBS™ indicator will come and stay on under certain conditions:

CMBS™ Conditions and Limitations P. 619

CMBS™ Conditions and Limitations

The system may automatically shut off and the CMBS™ indicator will come on under certain conditions. Some examples of these conditions are listed below. Other conditions may reduce some of the CMBS™ functions.

Front Sensor Camera* P. 569

Environmental conditions

- Driving in bad weather (rain, fog, snow, etc.).
- Sudden changes between light and dark, such as an entrance or exit of a tunnel.
- There is little contrast between objects and the background.
- Driving into low sunlight (e.g., at dawn or dusk).
- Strong light is reflected onto the roadway.
- Driving in the shadows of trees, buildings, etc.
- Roadway objects or structures are misinterpreted as vehicles and pedestrians.
- Reflections on the interior of the windshield.
- Driving at night or in a dark condition such as a tunnel.

Roadway conditions

- Driving on a snowy or wet roadway (obscured lane marking, vehicle tracks, reflected lights, road spray, high contrast).
- The road is hilly or the vehicle is approaching the crest of a hill.
- Driving on curvy, winding, or undulating roads.

CMBS™ Conditions and Limitations

Do not paint, or apply any coverings or paint to the radar sensor area. This can impact CMBS™ operation.

Have your vehicle checked by a dealer if you find any unusual behavior of the system (e.g., the warning message appears too frequently).

If the front of the vehicle is impacted in any of the following situations, the radar sensor may not work properly. Have your vehicle checked by a dealer:
- The vehicle mounted onto a bump, curb, chock, embankment, etc.
- You drive the vehicle where the water is deep.
- Your vehicle has a frontal collision.

If you need the radar sensor to be repaired, or removed, or the radar sensor cover is strongly impacted, turn off the system by pressing the CMBS™ **OFF** button and take your vehicle to a dealer.

* Not available on all models

Continued

■ Vehicle conditions

- Headlight lenses are dirty or the headlights are not properly adjusted.
- The outside of the windshield is blocked by dirt, mud, leaves, wet snow, etc.
- The inside of the windshield is fogged.
- An abnormal tire or wheel condition (wrong sized, varied size or construction, improperly inflated, compact spare tire, etc.).
- When tire chains are installed.
- The vehicle is tilted due to a heavy load or suspension modifications.
- The camera temperature gets too high.
- Driving with the parking brake applied.
- When the radar sensor in the front grille gets dirty.
- The vehicle is towing a trailer.

■ Detection limitations

- A vehicle or pedestrian suddenly crosses in front of you.
- The distance between your vehicle and the vehicle or pedestrian ahead of you is too short.
- A vehicle cuts in front of you at a slow speed, and it brakes suddenly.
- When you accelerate rapidly and approach the vehicle or pedestrian ahead of you at high speed.
- The vehicle ahead of you is a motorcycle, bicycle, mobility scooter or other small vehicle.
- When there are animals in front of your vehicle.
- When you drive on a curved, winding or undulating road that makes it difficult for the sensor to properly detect a vehicle in front of you.
- The speed difference between your vehicle and a vehicle or pedestrian in front of you is significantly large.
- An oncoming vehicle suddenly comes in front of you.
- Another vehicle suddenly comes in front of you at an intersection, etc.
- Your vehicle abruptly crosses over in front of an oncoming vehicle.
- When driving through a narrow iron bridge.
- When the lead vehicle suddenly slows down.

Limitations applicable to pedestrian detection only

- When there is a group of people in front of your vehicle walking together side by side.
- Surrounding conditions or belongings of the pedestrian alter the pedestrian's shape, preventing the system from recognizing that the person is a pedestrian.
- When the pedestrian is shorter than about 3.3 feet (1 meter) or taller than about 6.6 feet (2 meters) in height.
- When a pedestrian blends in with the background.
- When a pedestrian is bent over or squatting, or when their hands are raised or they are running.
- When several pedestrians are walking ahead in a group.
- When the camera cannot correctly identify that a pedestrian is present due to an unusual shape (holding luggage, body position, size).

Continued

■ Automatic shutoff

CMBS™ may automatically shut itself off and the CMBS™ indicator comes and stays on when:

- The temperature inside the system is high.
- You drive off-road or on a mountain road, or curved and winding road for an extended period.
- An abnormal tire condition is detected (wrong tire size, flat tire, etc.).
- The camera behind the rearview mirror, or the area around the camera, including the windshield, gets dirty.

Once the conditions that caused CMBS™ to shut off improve or are addressed (e.g., cleaning), the system comes back on.

APPENDIX C

Run Log

Run Log for Daytime Tests

Subject Vehicle: *2020 Honda Odyssey EX-L*

Test Date: *4/8/2020*

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
103	Static run										
104	S1a	11	Day	Y		0.00	0.0	0.01		Contact	No warning, no AEB
105				Y		0.00	0.0	0.02		Contact	No warning, no AEB
106				Y		0.00	0.0	0.01		Contact	No warning, no AEB
107				Y		0.00	0.1	0.03		Contact	No warning, no AEB
39	S1a	16	Day	Y		0.00	0.1	0.03		Contact	No warning, no AEB
40				Y		0.00	0.7	0.03		Contact	No warning, no AEB
41				N							SV speed
42				Y		0.00	0.2	0.02		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
43	S1a	40	Day	Y		0.00	5.3	0.77	0.33	Contact	No warning, last moment driver braking
44				Y		0.00	0.8	0.44	0.14	Contact	No warning, last moment driver braking
45				Y		0.00	4.1	0.90	0.24	Contact	No warning, last moment driver braking
46	Static run										
108	Static run										
109	S1b	11	Day	Y		0.00	0.2	0.01		Contact	No warning, no AEB
110				Y		0.00	0.1	0.01		Contact	No warning, no AEB
111				Y		0.00	0.0	0.00		Contact	No warning, no AEB
15	Static										
16	S1b	16	Day	N							PTT lateral error
17				N							PTT lateral error
18				Static Run Resume test 4/14							
19				Y		0.00	0.7	0.04		Contact	No warning, no AEB, PTT speed
20				Y		0.00	0.7	0.21	0.11	Contact	No warning
21				N							PTT lateral error
22				N							PTT lateral error

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
23	S1b	16	Day	Y		0.00	0.0	0.01		Contact	No warning, no AEB, PTT speed
24	S1b	40	Day	Y		0.00	0.0	0.04		Contact	No warning, no AEB
25				Y		0.00	0.4	0.29	0.11	Contact	No warning, Last moment driver braking
26				N							PTT lateral error
27				Y		0.00	15.2	1.05	0.54	Contact	No warning, last moment driver braking
112	Static run										
113	S1c	11	Day	Y		0.00	0.0	0.01		Contact	No warning, no AEB
114				Y		0.00	0.3	0.02		Contact	No warning, no AEB
115				Y		0.00	0.0	0.01		Contact	No warning, no AEB
116				Y		0.00	0.2	0.01		Contact	No Warning, no AEB
117				Y		0.00	0.3	0.01		Contact	No Warning, no AEB
28	Static run										
29	S1c	16	Day	N							SV speed
30				N							PTT lateral error
31				N							SV speed
32				Y		0.00	0.1	0.01		Contact	No warning, no AEB
33				Y		0.00	0.1	0.02		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
34	S1c	16	Day	Y		0.00	0.5	0.02		Contact	No warning, no AEB
35	S1c	40	Day	Y	1.32	0.00	3.7	0.18	1.14	Contact	
36				Y	0.3	0.00	1.0	0.21	0.22	Contact	
37				N							PTM lateral error
38				Y		0.00	4.6	0.91	0.26	Contact	No warning, no AEB, last moment driver braking
118	Static run										
119	S1d	11	Day	N							PTM lateral
120				Y		0.00	0.4	0.02		Contact	No Warning, no AEB
121				N							PTM lateral
122				Y		0.00	0.0	0.01		Contact	No warning, no AEB
123				Y		0.00	0.0	0.00		Contact	No warning, no AEB
1	Static run										
2	S1d	16	Day	N							PTT lateral error
3				N							PTT lateral error
4				Y		0.00	0.0	0.00		Contact	No warning, no AEB
5				N							PTT lateral error
6				Y		0.00	5.3	0.76	0.31	Contact	No warning, last moment driver braking

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
7	S1d	16	Day	Y		0.00	3.2	0.59	0.27	Contact	No warning, last moment driver braking
8	S1d	40	Day	N							SV Yaw
9				Y		0.00	30.9	1.05	0.78	Contact	No warning, last moment driver braking
10				N							PTT lateral error
11				N							PTT lateral error
12				Y		0.00	23.7	1.04	0.71	Contact	No warning, last moment driver braking
13				Y		0.41	39.7	1.02	0.80	NC	No warning, PAEB did occur, last moment driver braking
14				Y		0.00				Contact	No warning, last moment driver braking
47	Static run										
48	S1e	40	Day	Y		0.00	0.1	0.04		Contact	No warning, no AEB
49						0.00	0.1	0.04		Contact	No warning, no AEB
50						0.00	15.8	0.93	0.71	Contact	No warning, last moment driver braking

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
52	Static run										
53	S1f	40	Day	Y		0.00	-0.2	0.03		NC	
54				Y		0.00	0.0	0.00		NC	
55				Y		0.00	0.0	0.00		NC	
56				Y		0.00	0.1	0.01		NC	
57				Y		0.00	0.0	0.01		NC	
58				Y		0.00	0.0	0.00		NC	
59	Static run										
60	S1g	40	Day	Y		0.00	0.1	0.00		NC	No warning, no AEB
61				Y		0.00	0.0	0.01		NC	No warning, no AEB
62				N							PTM lateral
63				N							PTM lateral
64				N							PTM lateral
65				N							PTM lateral
66				Y		0.00	0.1	0.01		NC	No warning, no AEB
67				Y		0.00	0.0	0.01		NC	No warning, no AEB
68				Y		0.00	0.0	0.00		NC	No warning, no AEB
76	S4a	11	Day	Y	0.7	0.00	0.2	0.02		Contact	No AEB
77				Y	0.95	0.00	0.3	0.02		Contact	No AEB
78				Y	0.66	0.00	0.0	0.02		Contact	No AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
69	Static run										
70	S4a	16	Day	Y	1.93	0.00	0.6	0.02		Contact	No AEB
71				Y	1.78	0.00	0.5	0.02		Contact	No AEB
72				Y		0.00	0.0	0.02		Contact	No warning, no AEB
73	S4a	40	Day	Y	2.08	0.00	1.6	0.06		Contact	No AEB
74				Y	2.54	0.00	2.4	0.06		Contact	No AEB
75				Y	1.23	0.00	0.0	0.03		Contact	No AEB
86	S4b	11	Day	Y	0.7	0.00	0.0	0.01		Contact	No AEB
87				Y	0.65	0.00	0.0	0.01		Contact	No AEB
88				Y	1.53	0.00	2.8	0.22	0.46	Contact	
79	Static run										
80	S4b	16	Day	Y	1.88	0.00	0.9	0.02		Contact	No AEB
81				Y	1.96	0.00	0.4	0.02		Contact	No AEB
82				Y	1.78	0.00	0.7	0.02		Contact	No AEB
83	S4b	40	Day	Y	2.27	0.00	26.6	0.82	0.99	Contact	
84				Y	0.16	0.00	0.0	0.02		Contact	No AEB
85				Y	2.68	0.00	2.5	0.06		Contact	No AEB
99	S4c	11	Day	N							SV speed
100				Y		0.00	0.0	0.00		Contact	No warning, no AEB
101				Y	1.37	0.00	0.5	0.02		Contact	No AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
102	S4c	11	Day	Y		0.00	0.4	0.02		Contact	No warning, no AEB
89	Static run										
90	S4c	16	Day	Y	1.89	0.00	1.0	0.02		Contact	No AEB
91				Y		0.00	0.4	0.02		Contact	No warning, no AEB
92				Y	1.76	0.76	15.5	0.80	0.82	NC	
93				Y	1.81	0.00	0.6	0.02		Contact	No AEB
94				Y	1.7	0.80	16.1	0.81	0.77	NC	
95				Y	1.74	0.00	7.5	0.21	0.97	Contact	
96	S4c	40	Day	Y	2.29	0.00	2.3	0.07		Contact	No AEB
97				Y	2.19	0.00	3.1	0.20	0.81	Contact	
98				Y	2.29	0.00	1.7	0.07		Contact	No AEB

Run Log for Nighttime Tests

Subject Vehicle: *2020 Honda Odyssey EX-L*

Test Date: *4/10/2020*

Adult Pedestrian Test Mannequin: *Articulated 4A Adult*

Test Driver: *J. Robel*

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
68	S1b	11	NHB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
69				N							PTM Lateral
70				Y		0.00	0.0	0.02		Contact	No warning, no AEB
71				Y		0.00	0.0	0.03		Contact	No warning, no AEB
72				Y		0.00	0.0	0.01		Contact	No warning, no AEB
73				Y		0.00	0.0	0.01		Contact	No warning, no AEB
8	S1b	16	NHB	Y		0.00	0.1	0.02		Contact	No warning, no AEB
9				Y		0.00	0.5	0.03		Contact	No warning, no AEB
10				Y		0.00	0.1	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
11	S1b	16	NHB	Y		0.00	0.3	0.02		Contact	No warning, no AEB
12				Y		0.00	0.0	0.02		Contact	No warning, no AEB
13				Y		0.00	0.0	0.02		Contact	No warning, no AEB
14				N							Operator Headlights On
15				Y		0.00	0.2	0.03		Contact	No warning, no AEB
21	S1b	40	NHB	Y		0.00	13.2	1.02	0.48	Contact	No warning, last moment driver braking
22				Y		0.00	20.6	1.06	0.60	Contact	No warning, last moment driver braking
23				Y		0.00	20.9	1.06	0.61	Contact	No warning, last moment driver braking
24	Static Run										
108	S1d	11	NHB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
109				Y		0.00	0.0	0.02		Contact	No warning, no AEB
110				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
96	S1d	16	NHB	Y		0.00	0.5	0.02		Contact	No warning, no AEB
97				N							PTM Lateral
98				Y		0.00	0.0	0.03		Contact	No warning, no AEB
99				Y		0.00	0.0	0.03		Contact	No warning, no AEB
114	S1d	40	NHB	Y		0.00	0.0	0.02		Contact	No warning, no AEB
115				Y		0.00	0.0	0.02		Contact	No warning, no AEB
116				N							SV brakes applied
117				Y		0.00	0.0	0.02		Contact	No warning, no AEB
31	S1e	40	NHB	N							SV Brakes Applied
32				N							Lateral Error
33				Y		0.00	0.1	0.01		Contact	No warning, no AEB
34				Y		0.00	0.3	0.03		Contact	No warning, no AEB
35				Y		0.00	0.1	0.01		Contact	No warning, no AEB
36	Static Run										

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
85	S4a	11	NHB	Y	0.74	0.00	0.0	0.01		Contact	No AEB
86				Y	0.77	0.00	0.0	0.02		Contact	No AEB
87				N							PTM Lateral
88				Y	0.77	0.00	0.3	0.02		Contact	No AEB
79	S4a	16	NHB	Y	1.87	0.00	0.2	0.02		Contact	No AEB
80				Y	1.78	0.00	0.8	0.03		Contact	No AEB
81				Y	1.86	0.00	0.6	0.03		Contact	No AEB
121	S4a	40	NHB	Y	1.65	0.00	0.8	0.05		Contact	No AEB
122				Y	1.42	0.00	0.4	0.05		Contact	No AEB
123				N							SV Lateral
124				N							SV Lateral, Throttle
125				Y		0.00	0.0	0.02		Contact	No warning, no AEB
59	S4c	11	NHB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
60				Y		0.00	0.0	0.01		Contact	No warning, no AEB
61				Y	0.82	0.00	0.0	0.01		Contact	No AEB
62				Y		0.00	0.0	0.01		Contact	No warning, no AEB
63	Static Run										

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
42	S4c	16	NHB	Y	1.95	0.00	0.4	0.02		Contact	No AEB
43				Y		0.00	0.0	0.01		Contact	No warning, no AEB
44				Y	2.36	0.00	0.0	0.02		Contact	No AEB
45	Static Run										
50	S4c	40	NHB	Y	2.30	0.00	0.7	0.04		Contact	No AEB
51				Y	2.63	0.00	1.1	0.05		Contact	No AEB
52				Y	2.51	0.00	1.4	0.05		Contact	No AEB
64	S1b	11	NLB	Y		0.00	0.3	0.01		Contact	No warning, no AEB
65				N							PTM Lateral
66				Y		0.00	0.2	0.01		Contact	No warning, no AEB
67				Y		0.00	0.2	0.01		Contact	No warning, no AEB
1	Static Run										
2	S1b	16	NLB	Y		0.00	0.3	0.02		Contact	No warning, no AEB
3				Y		0.00	0.4	0.02		Contact	No warning, no AEB
4				Y		0.00	0.2	0.02		Contact	No warning, no AEB
5				Y		0.00	0.4	0.02		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
6	S1b	16	NLB								Static Run
7				Y		0.00	0.0	0.01		Contact	No warning, no AEB
16	S1b	40	NLB	Y		0.00	2.8	0.74	0.21	Contact	No warning, last moment driver braking
17				Y		0.00	24.3	1.03	0.66	Contact	No warning, last moment driver braking
18				N							Lateral Error
19				N							Lateral Error
20				Y		0.00	6.5	0.97	0.31	Contact	No warning, last moment driver braking
100	S1d	11	NLB	Y		0.00	0.0	0.02		Contact	No warning, no AEB
101				N							PTM Lateral
102				Y		0.00	0.0	0.01		Contact	No warning, no AEB
103				Y		0.00	0.0	0.01		Contact	No warning, no AEB
104				Y		0.00	0.0	0.01		Contact	No warning, no AEB
105				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
106	S1d	11	NLB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
107				Y		0.00	0.0	0.01		Contact	No warning, no AEB
90	Static Run										
91	S1d	16	NLB	Y		0.00	0.0	0.02		Contact	No warning, no AEB
92				N							PTM Lateral
93				N							PTM Lateral
94				Y		0.00	0.0	0.01		Contact	No warning, no AEB
95				Y		0.00	0.0	0.02		Contact	No warning, no AEB
111	S1d	40	NLB	Y		0.00	0.0	0.02		Contact	No warning, no AEB
112				Y		0.00	0.6	0.05		Contact	No warning, no AEB
113				Y		0.00	0.0	0.03		Contact	No warning, no AEB
25	Static Run										
26	S1e	40	NLB	Y		0.00	0.0	0.06		Contact	No warning, no AEB
27				N							Lateral Error
28				Y		0.00	0.0	0.02		Contact	No warning, no AEB

Run	Test Type	SV Speed (km/h)	Lighting Condition	Valid Run?	FCW TTC (s)	Minimum Distance (m)	Speed Reduction (km/h)	Peak Decel (g)	PAEB TTC (sec)	Contact/No Contact (NC)	Notes
29	S1e	40	NLB	Y		0.00	0.1	0.02		Contact	No warning, no AEB
30				Y		0.00	0.0	0.02		Contact	No warning, no AEB
82	S4a	11	NLB	Y	0.69	0.00	0.1	0.01		Contact	No AEB
83				Y	0.76	0.00	0.0	0.01		Contact	No AEB
84				Y	0.68	0.00	0.0	0.01		Contact	No AEB
74	Static Run										
75	S4a	16	NLB	Y	1.83	0.00	0.5	0.03		Contact	No AEB
76				Y	1.84	0.00	0.3	0.02		Contact	No AEB
77				Y		0.00	0.3	0.03		Contact	No warning, no AEB
78				Y	1.84	0.00	0.6	0.03		Contact	No AEB,
89	S4a	40	NLB	Y	2.69	0.00	1.4	0.02		Contact	No AEB
118											Static Run
119				Y	1.60	0.00	0.9	0.05		Contact	No AEB
120				Y	1.56	0.00	0.3	0.03		Contact	No AEB
53	S4c	11	NLB	Y		0.00	0.1	0.01		Contact	No warning, no AEB
54				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
55	S4c	11	NLB	Y		0.00	0.0	0.01		Contact	No warning, no AEB
56				Y		0.00	0.0	0.01		Contact	No warning, no AEB
57				Y		0.00	0.1	0.01		Contact	No warning, no AEB
58				Y		0.00	0.0	0.01		Contact	No warning, no AEB
37	Static Run										
38	S4c	16	NLB	N							SV Brakes Applied
39				N							Throttle
40				Y	2.30	0.00	0.1	0.01		Contact	No AEB
41				Y		0.00	0.0	0.01		Contact	No warning, no AEB
46	S4c	40	NLB	Y		0.00	0.1	0.04		Contact	No warning
47				Y		0.00	0.0	0.03		Contact	No warning, no AEB
48				Y		0.00	0.0	0.03		Contact	No warning, no AEB
49				Y	2.52	0.00	1.7	0.07		Contact	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. This is because the plan view of the front of a vehicle is generally not rectangular, and headway is calculated from the front-most point of the vehicle. It is possible to have zero headway without. Also, for scenarios S1f and S1g, zero headway is appropriate since these are false positive tests.

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

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

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

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

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

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

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

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

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

Envelopes and Thresholds

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

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

Color Codes

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

Color codes can be broken into four categories:

1. Time-varying data color codes:

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

2. Validation envelope and threshold color codes:

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

3. Individual data point color codes:

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

4. Text color codes:

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

Other Notations

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

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

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

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

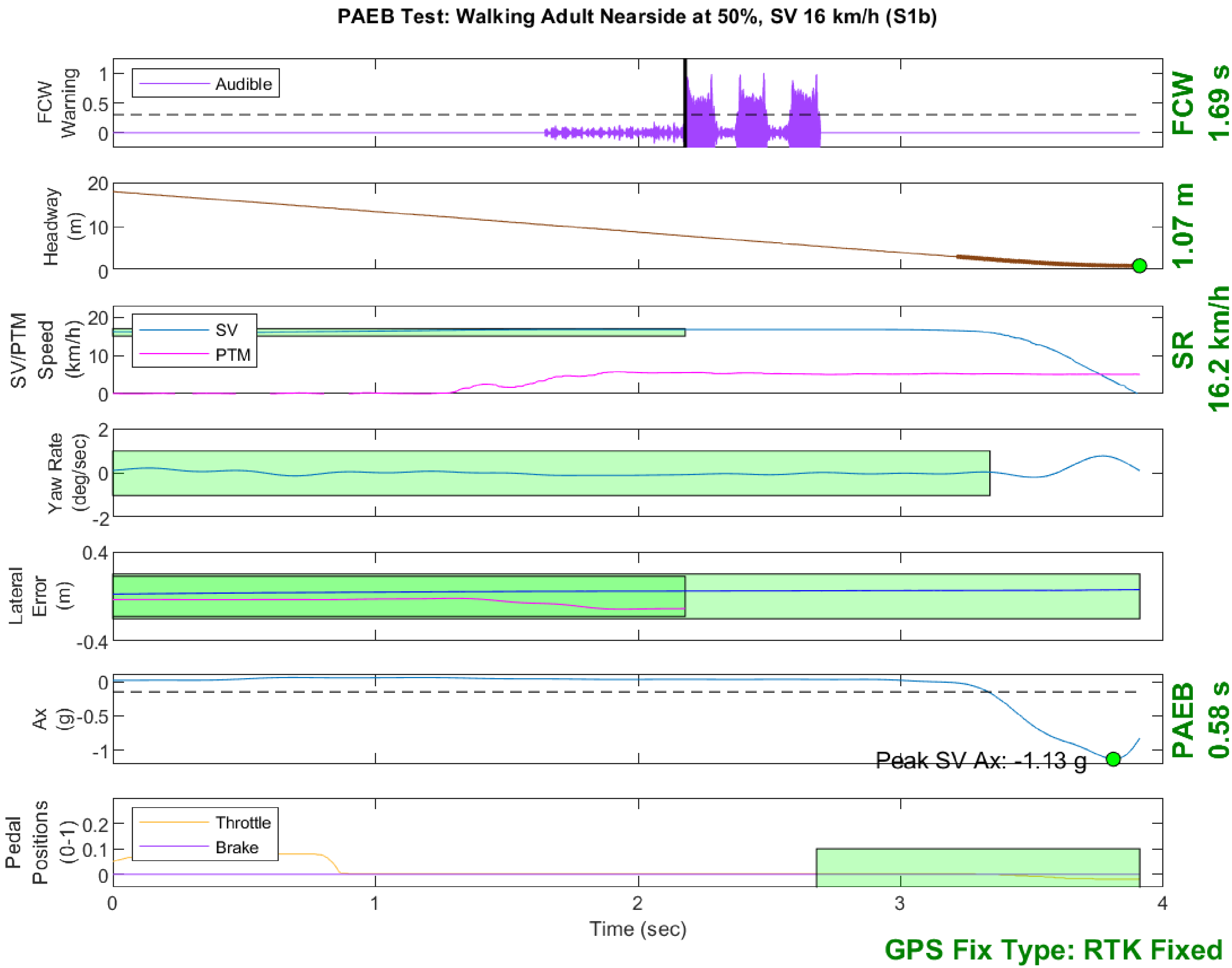


Figure D1. Example Time History for a Passing Run

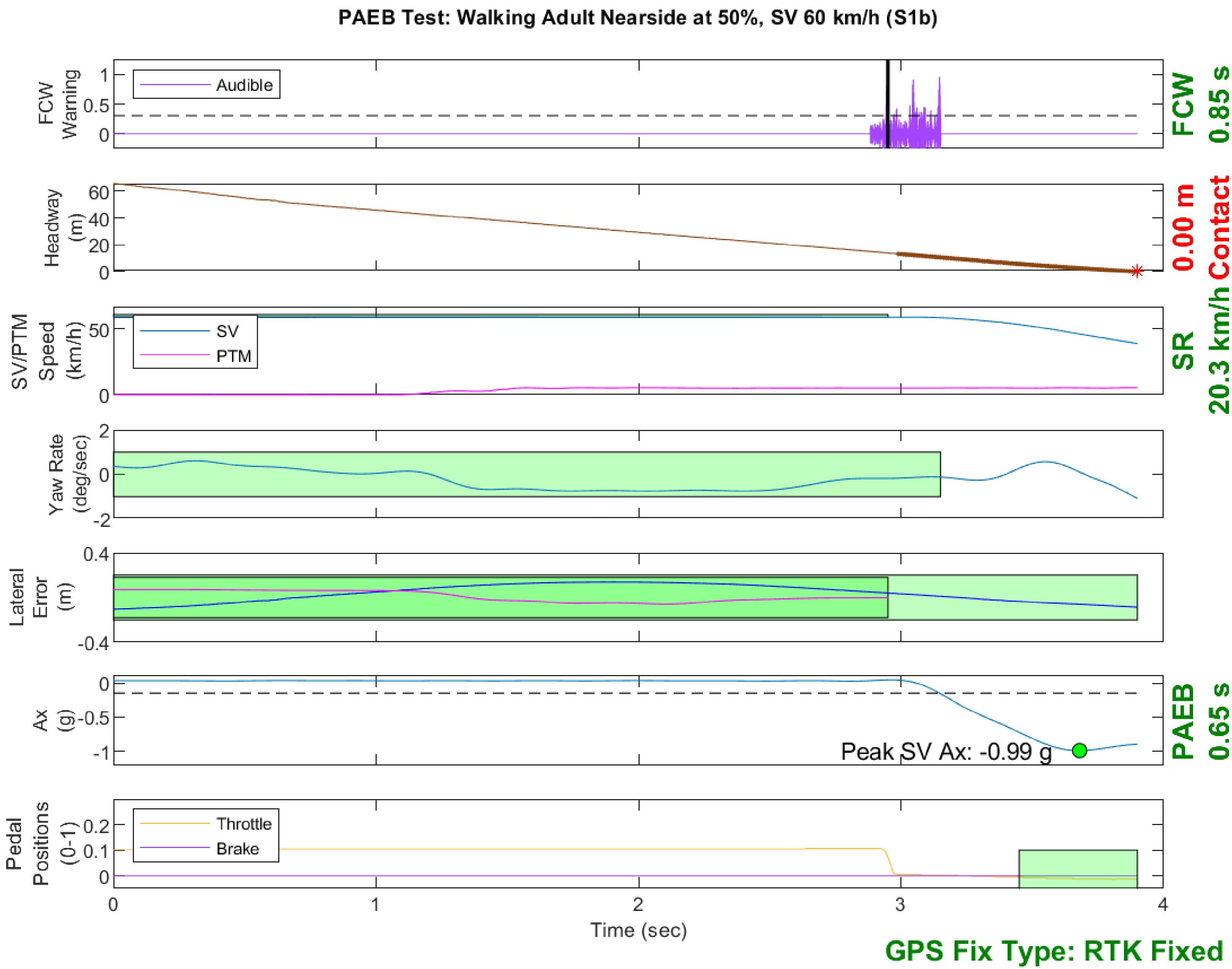


Figure D2. Example Time History for a Failed Run

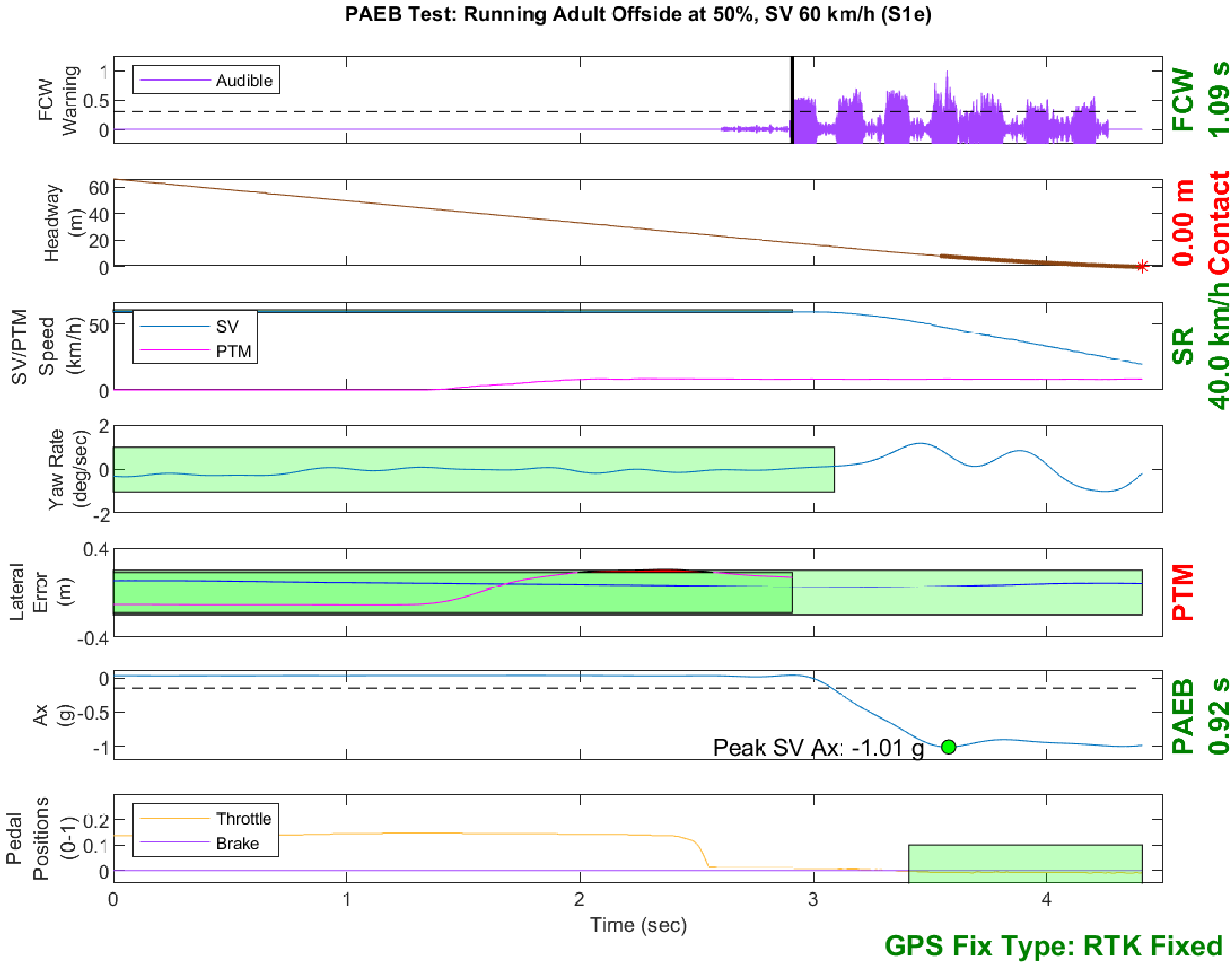


Figure D3. Example Time History for an Invalid Run Due to PTM Lateral Error

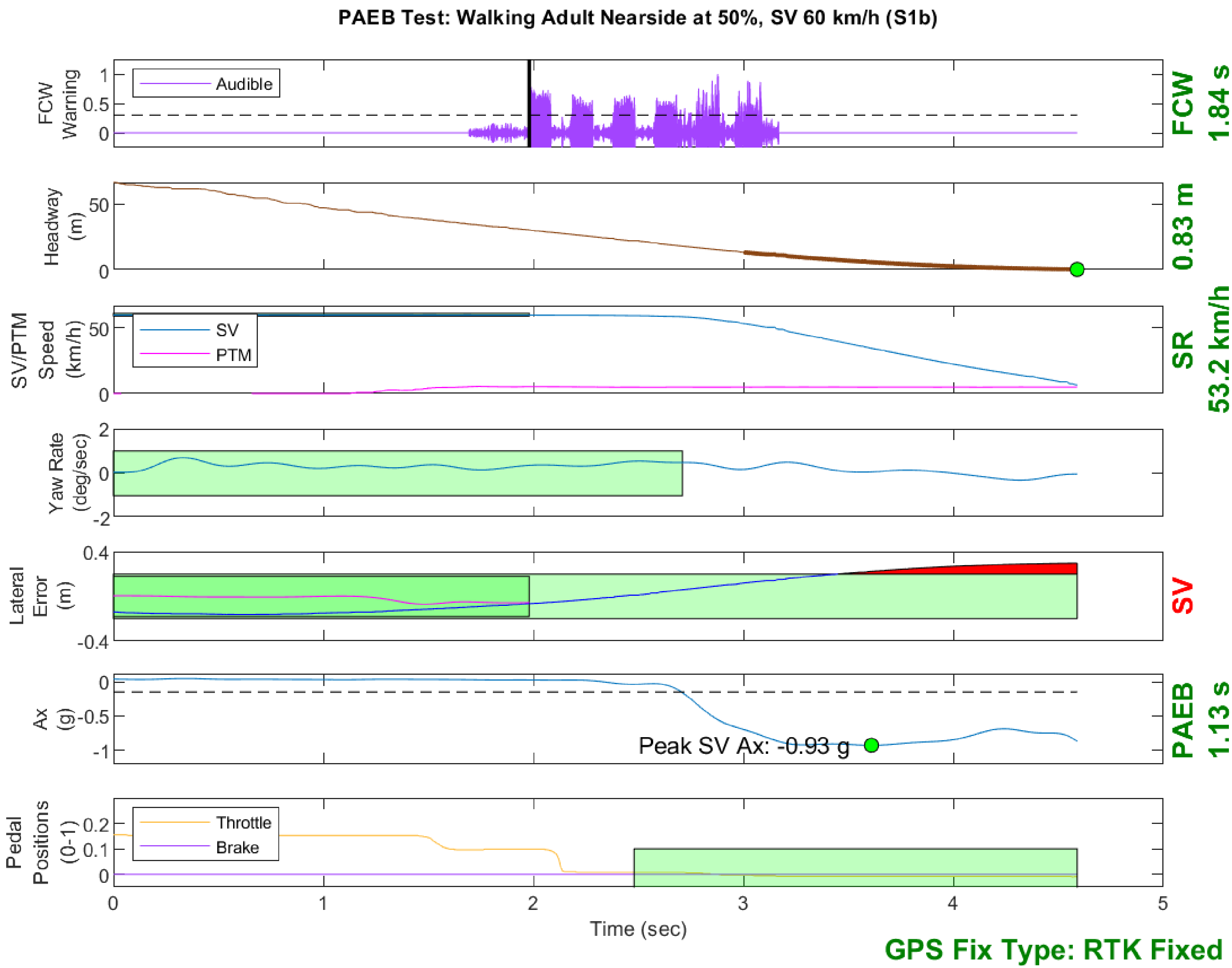


Figure D4. Example Time History for an Invalid Run Due to SV Lateral Error

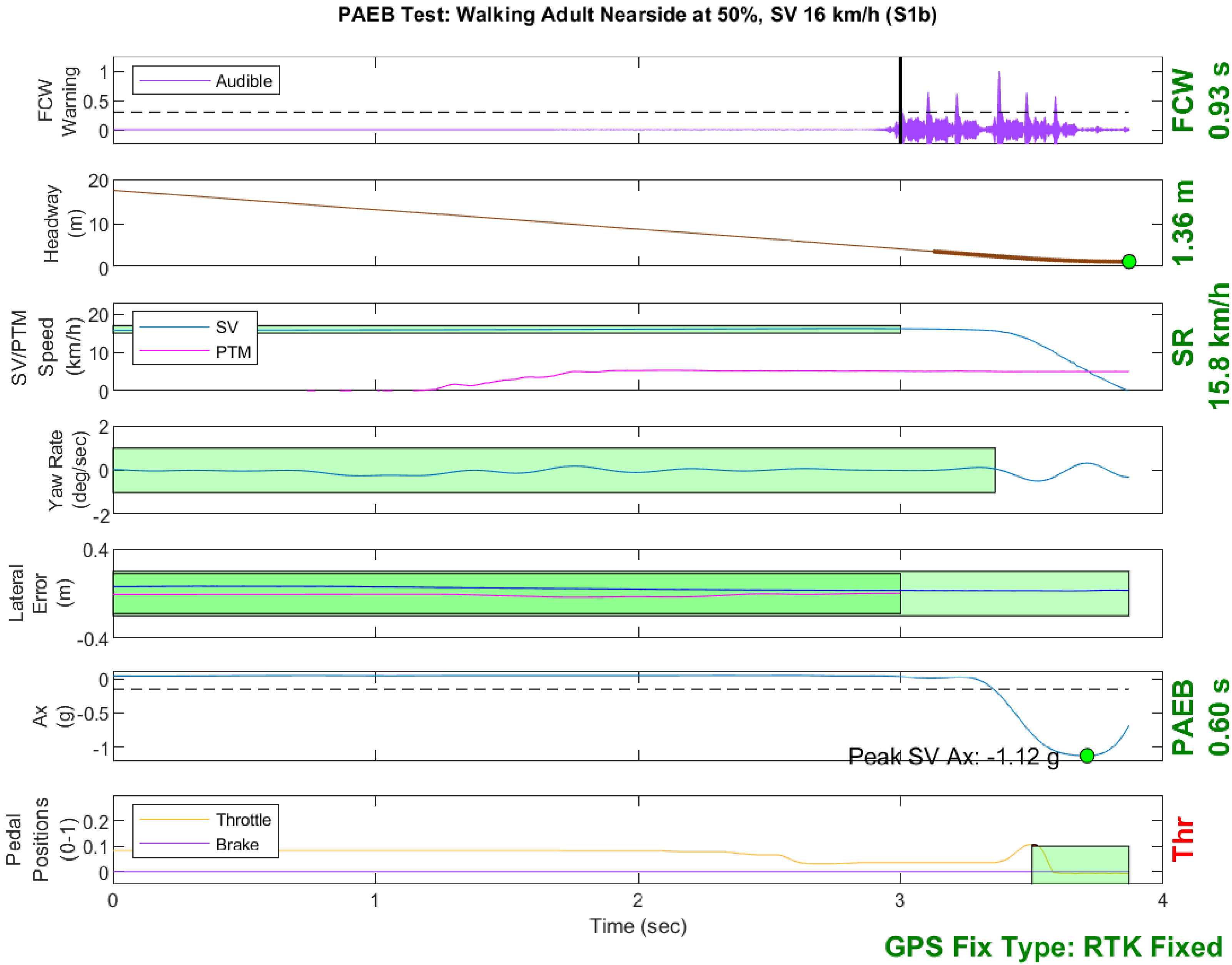


Figure D5. Example Time History for an Invalid Run Due to Throttle Error

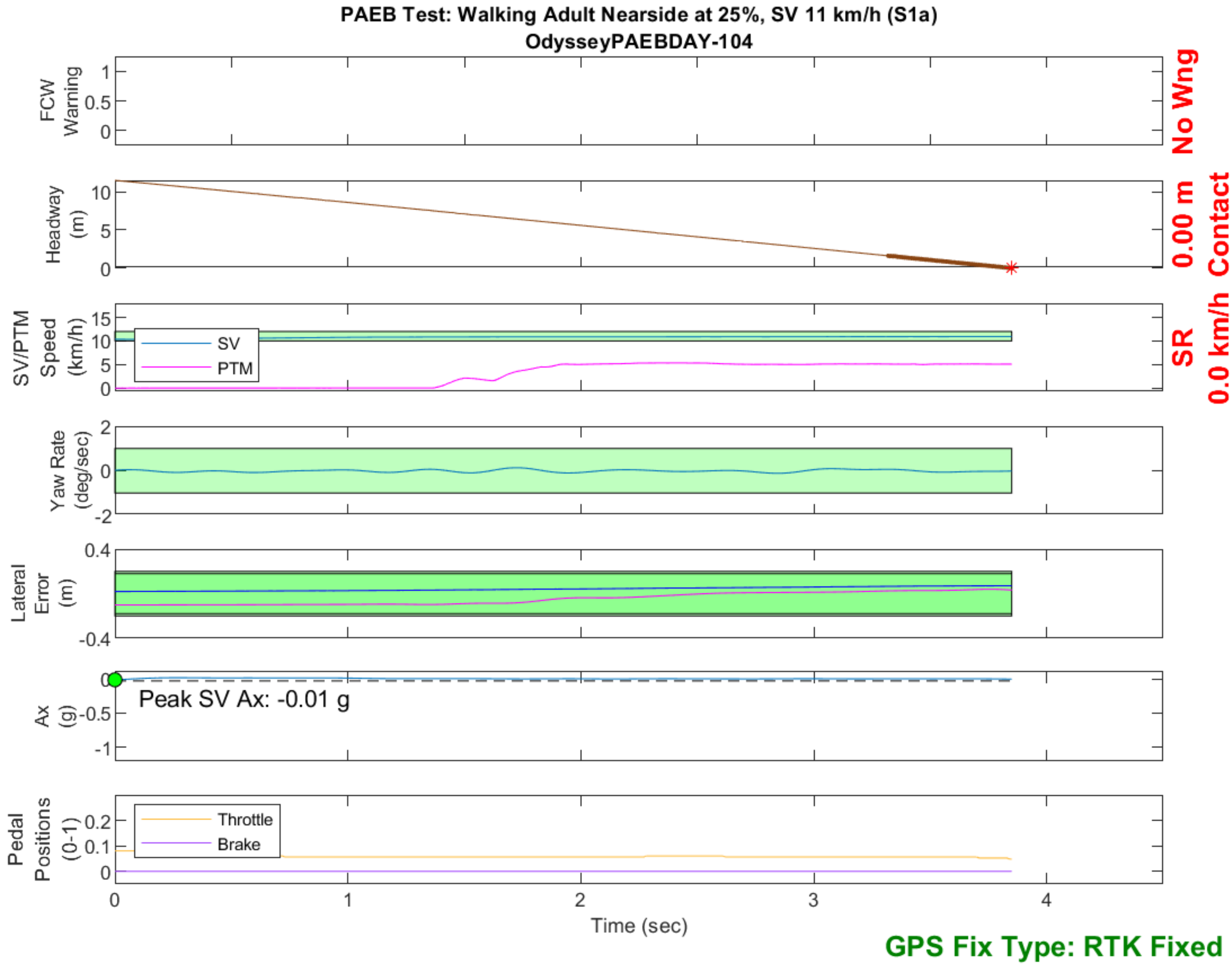


Figure D6. Time History for PAEB Run 104, S1a, Daytime, 11 km/h

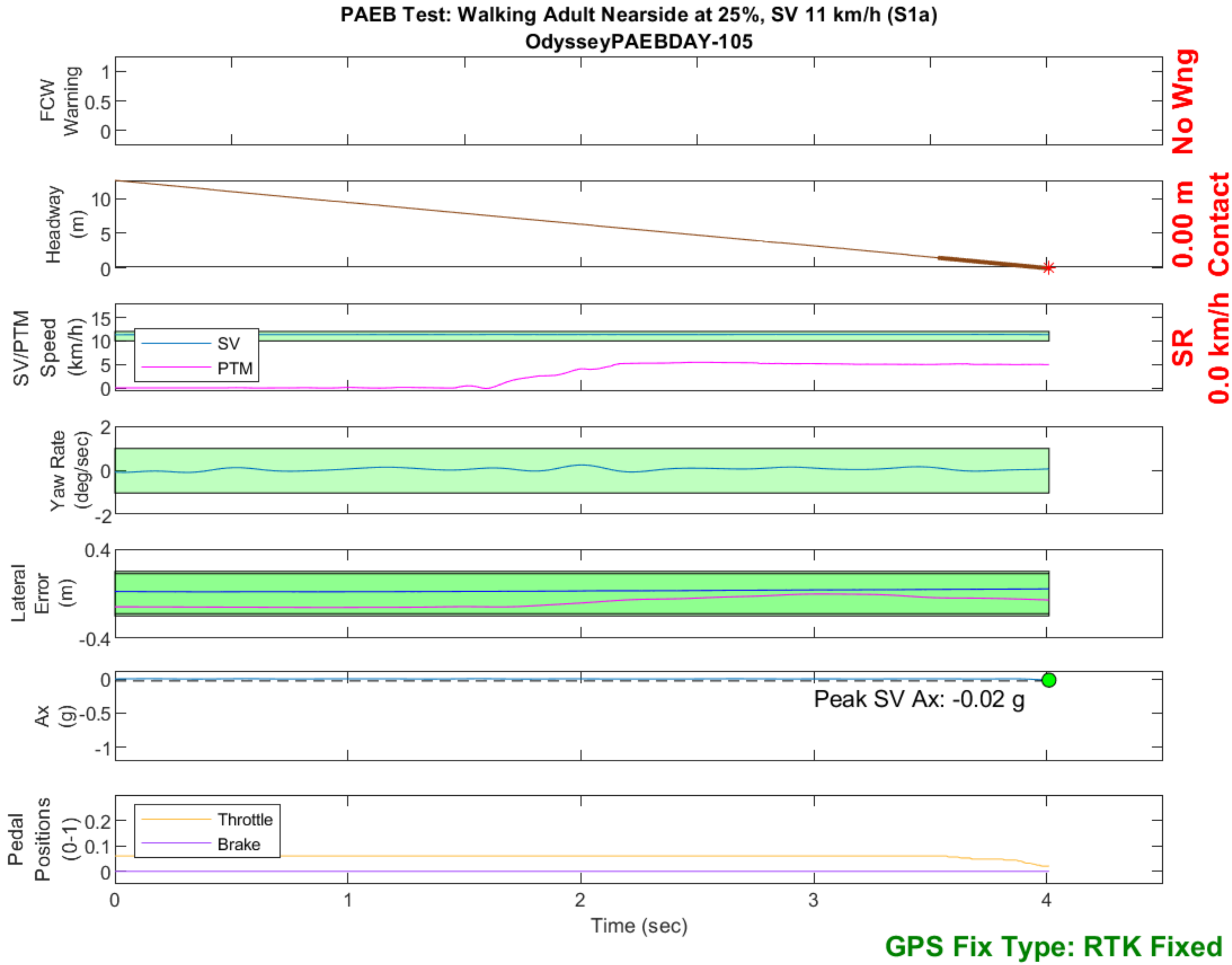


Figure D7. Time History for PAEB Run 105, S1a, Daytime, 11 km/h

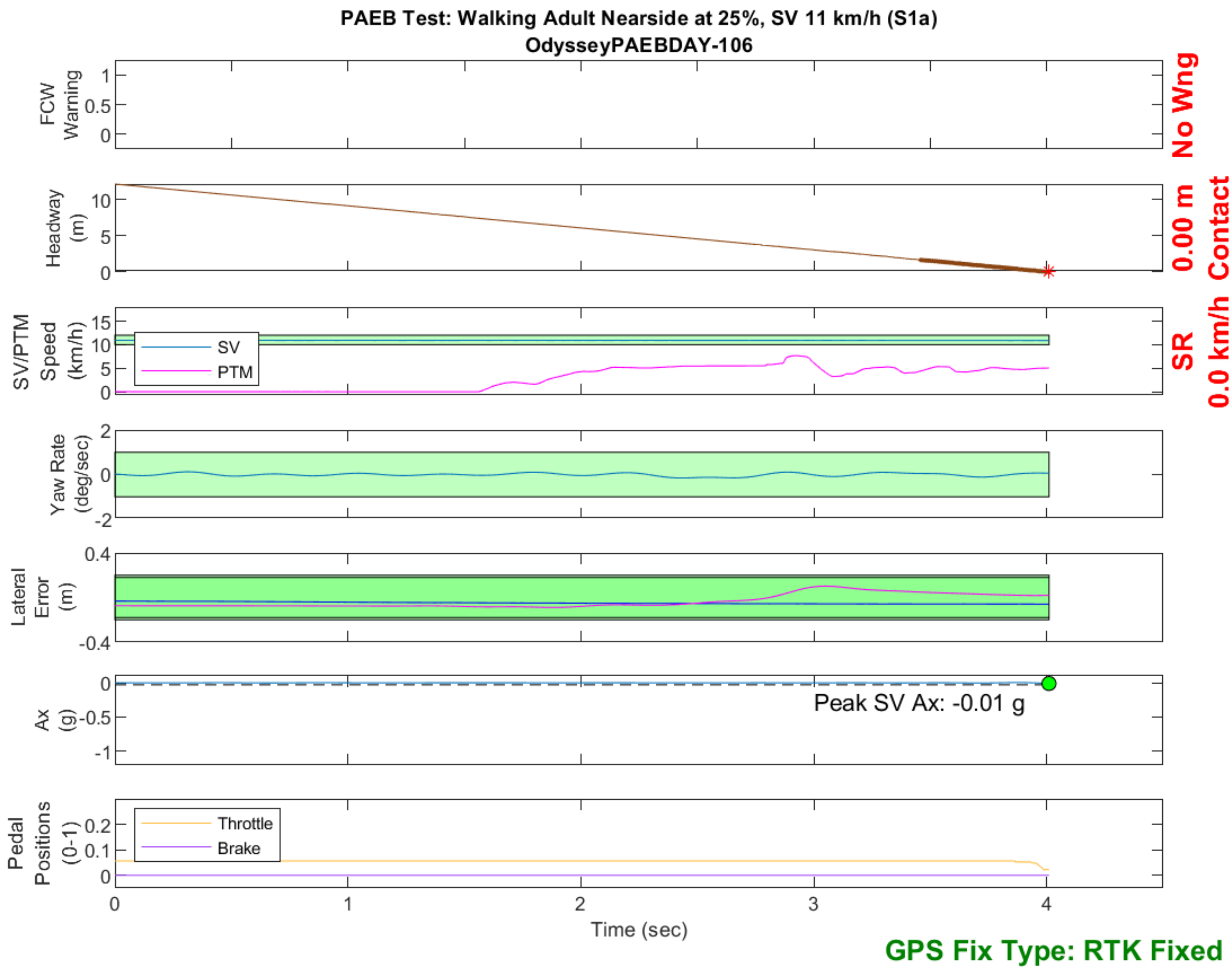


Figure D8. Time History for PAEB Run 106, S1a, Daytime, 11 km/h

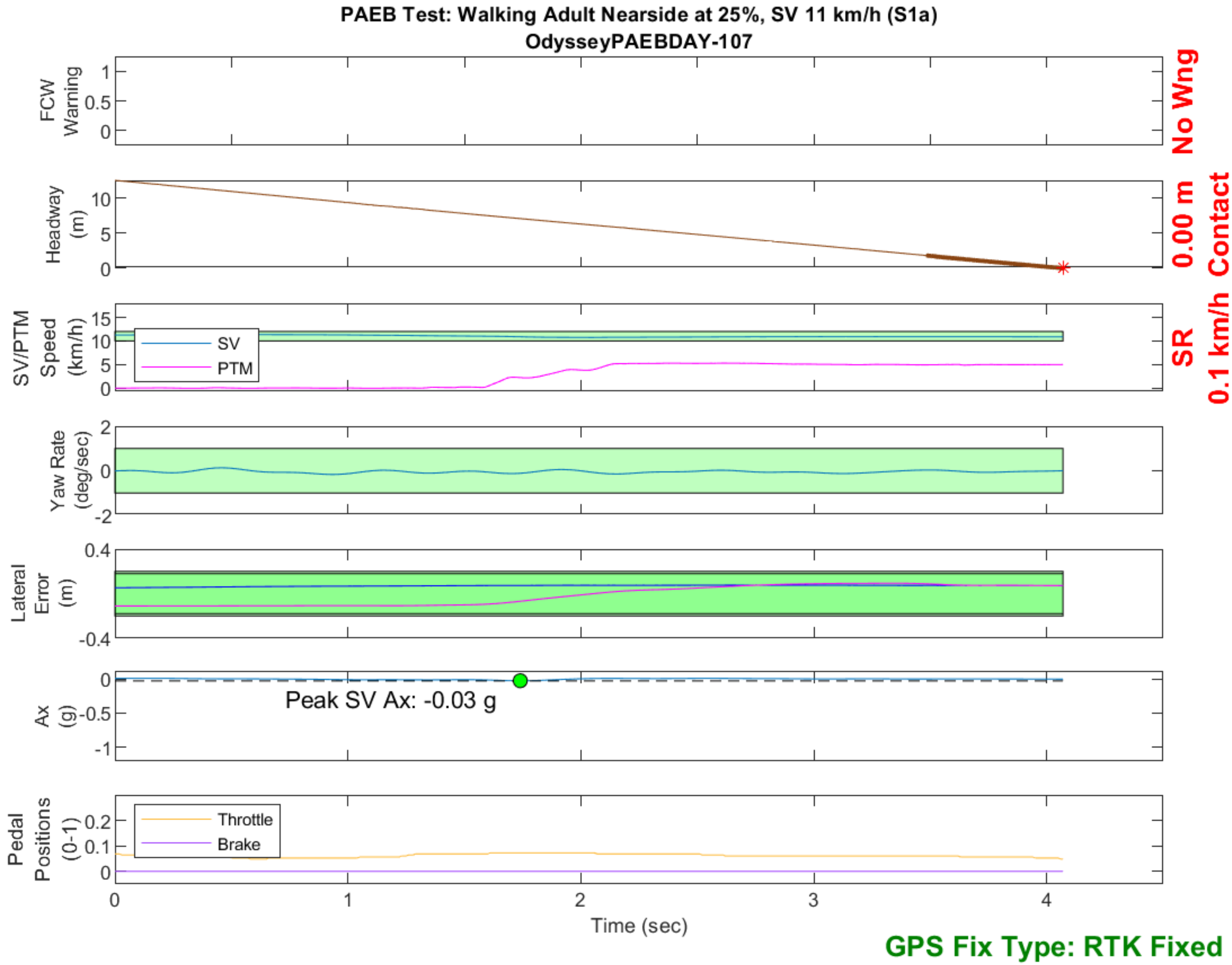


Figure D9. Time History for PAEB Run 107, S1a, Daytime, 11 km/h

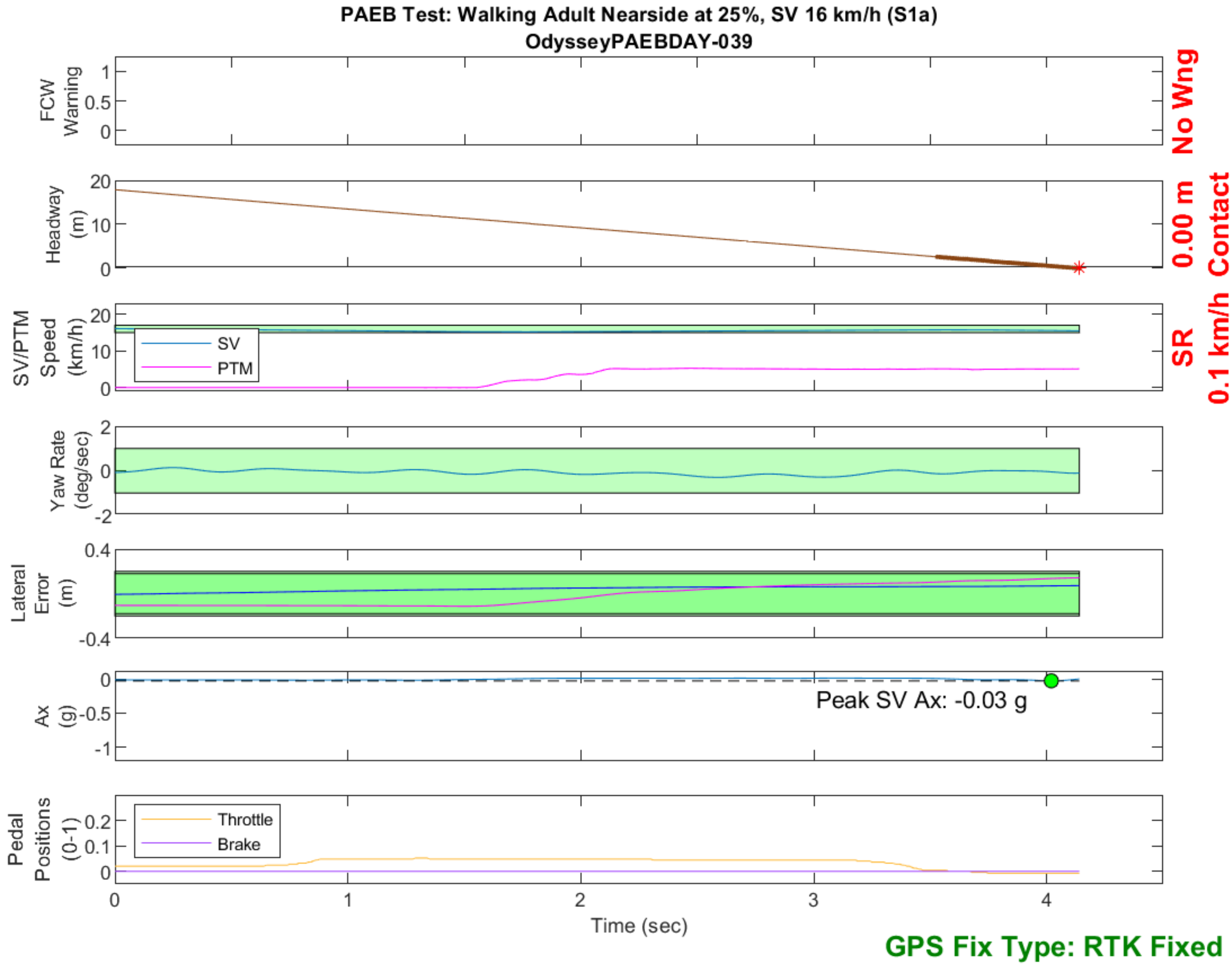


Figure D10. Time History for PAEB Run 39, S1a, Daytime, 16 km/h

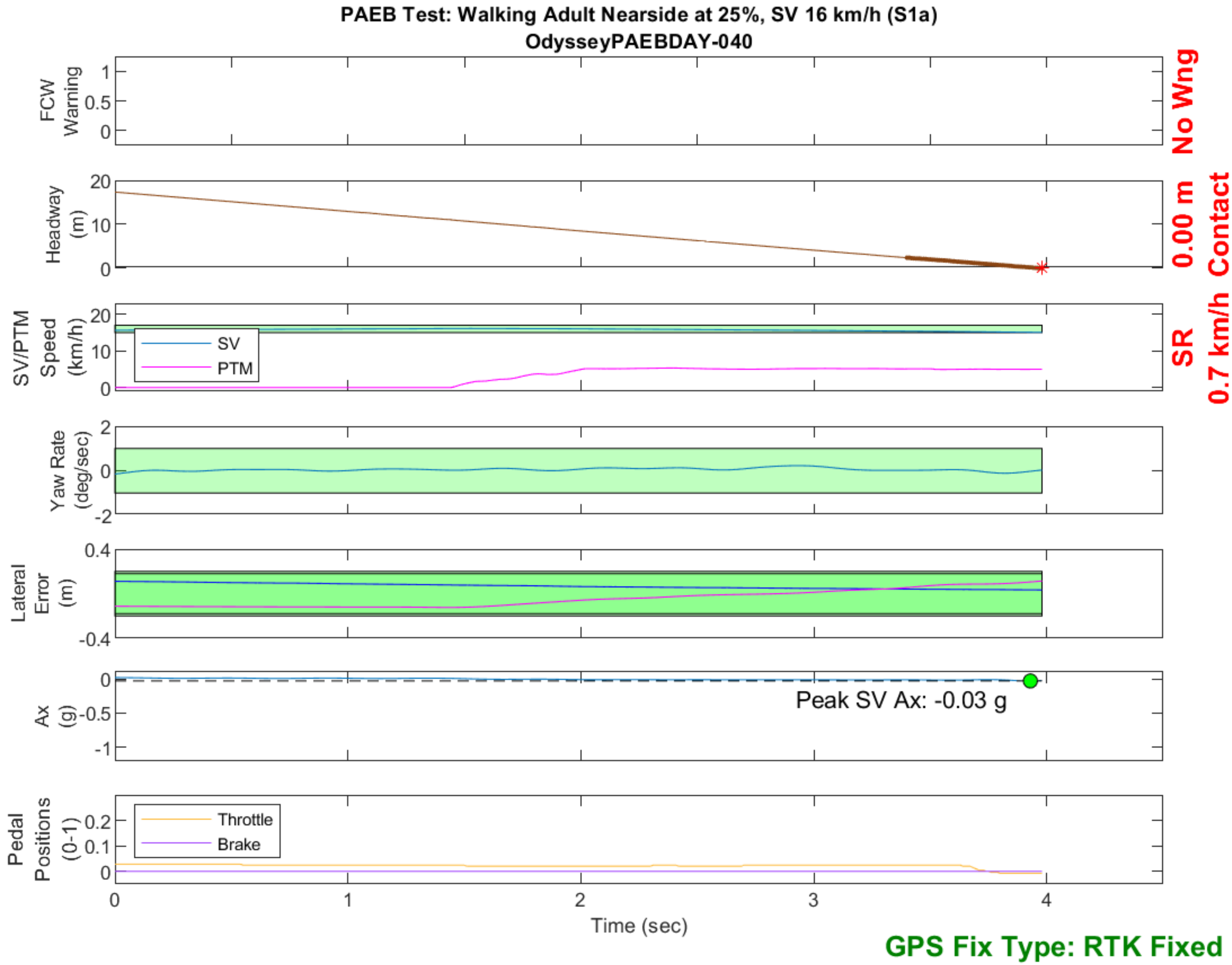


Figure D11. Time History for PAEB Run 40, S1a, Daytime, 16 km/h

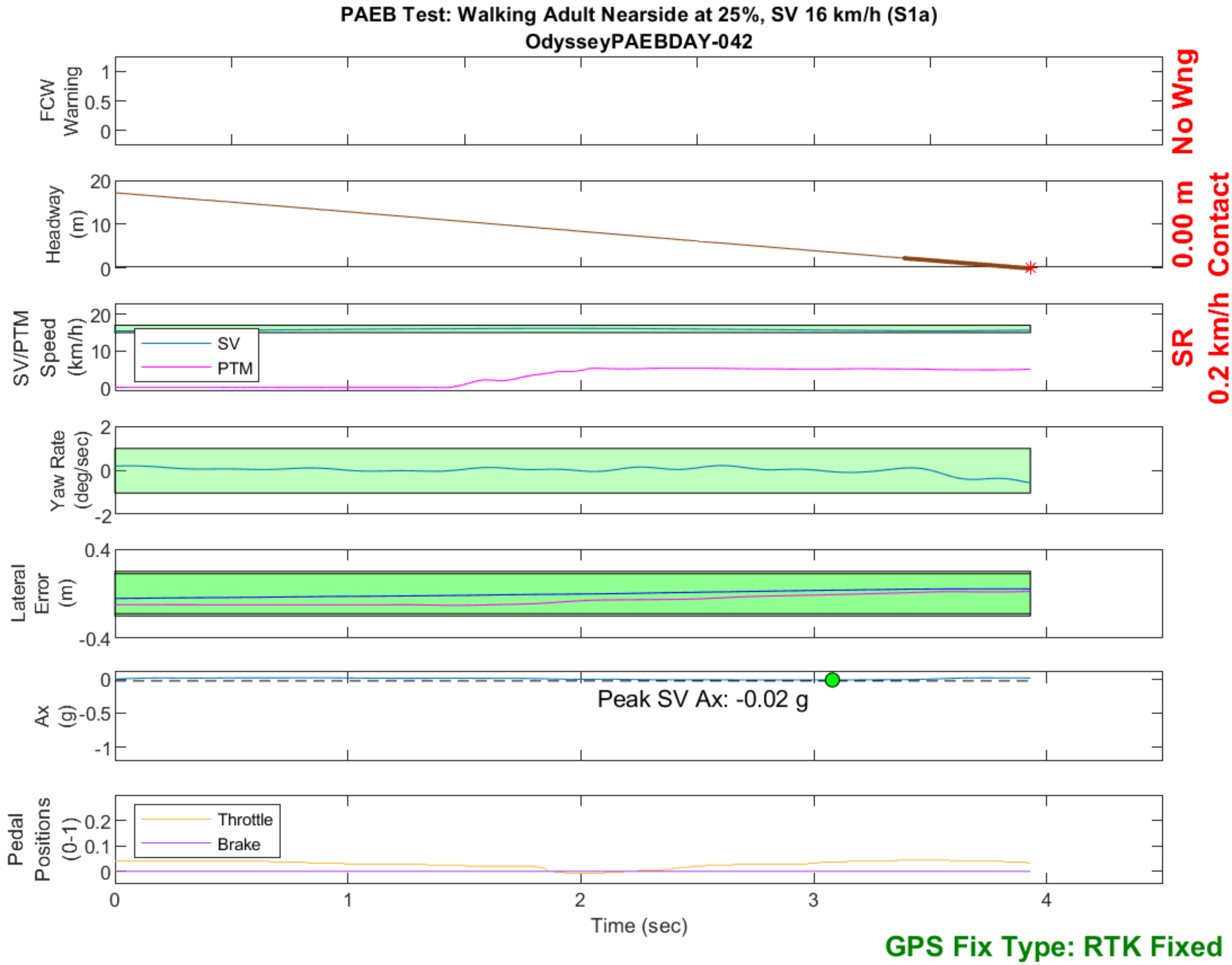


Figure D12. Time History for PAEB Run 42, S1a, Daytime, 16 km/h

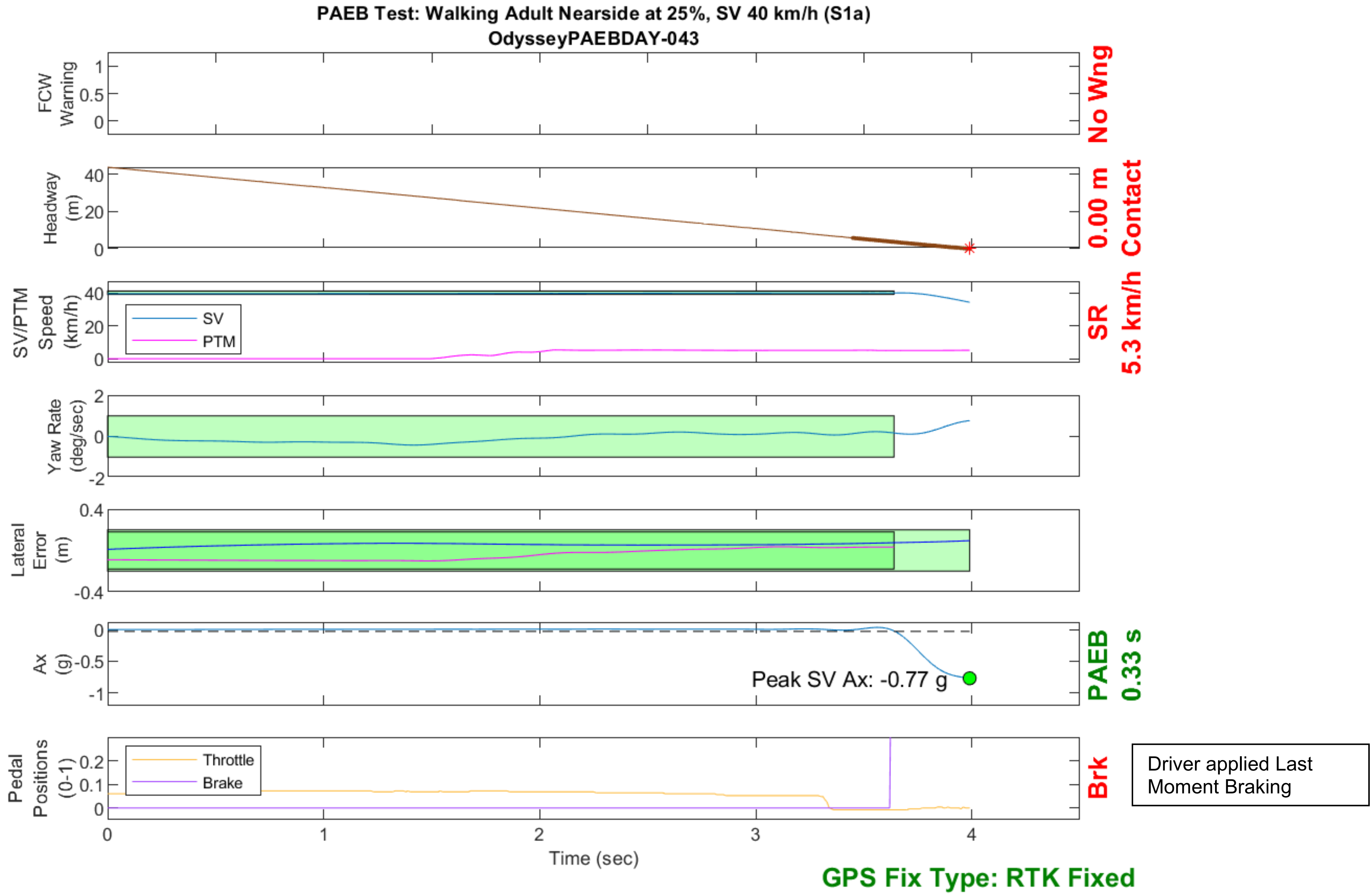


Figure D13. Time History for PAEB Run 43, S1a, Daytime, 40 km/h

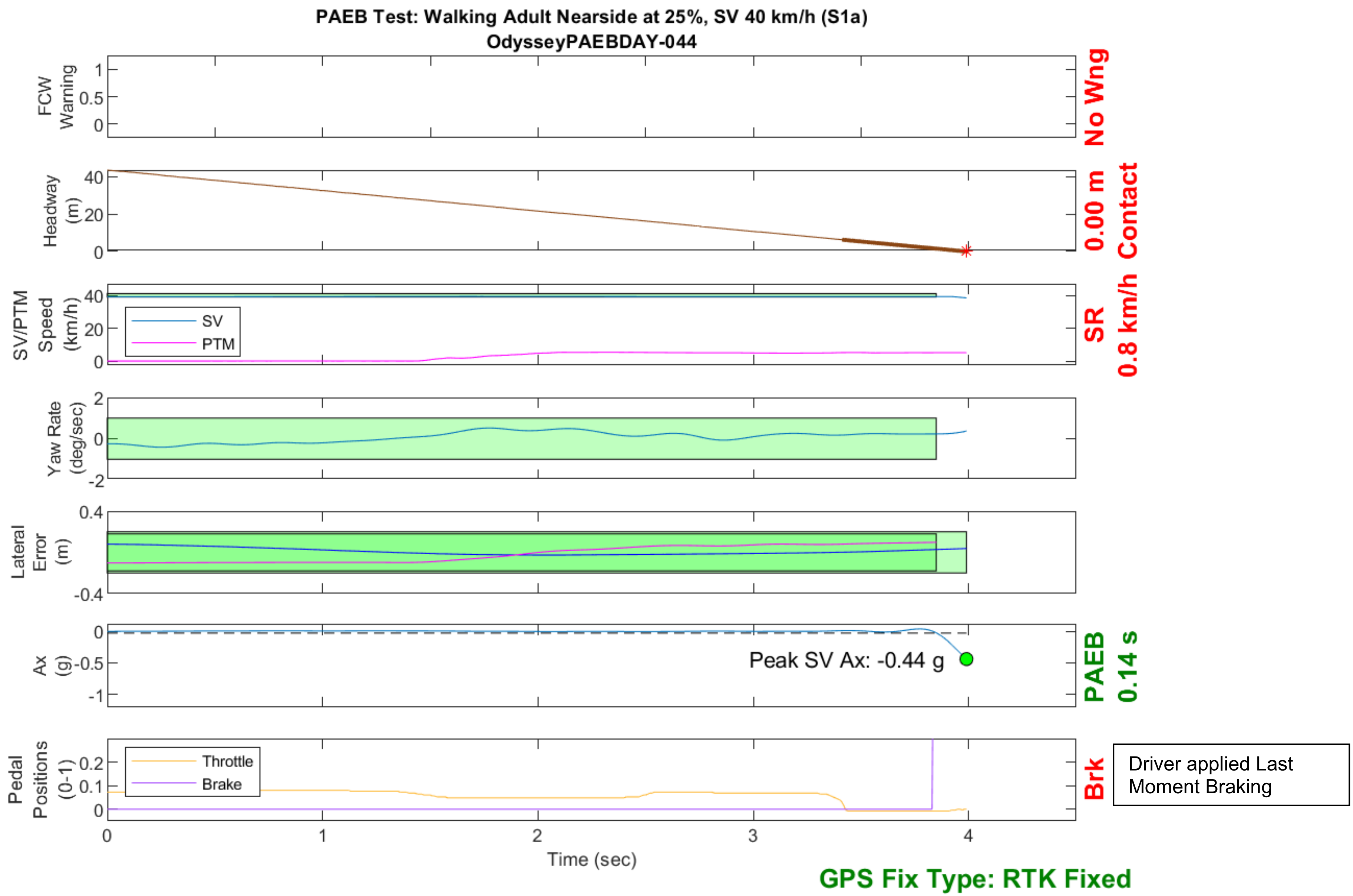


Figure D14. Time History for PAEB Run 44, S1a, Daytime, 40 km/h

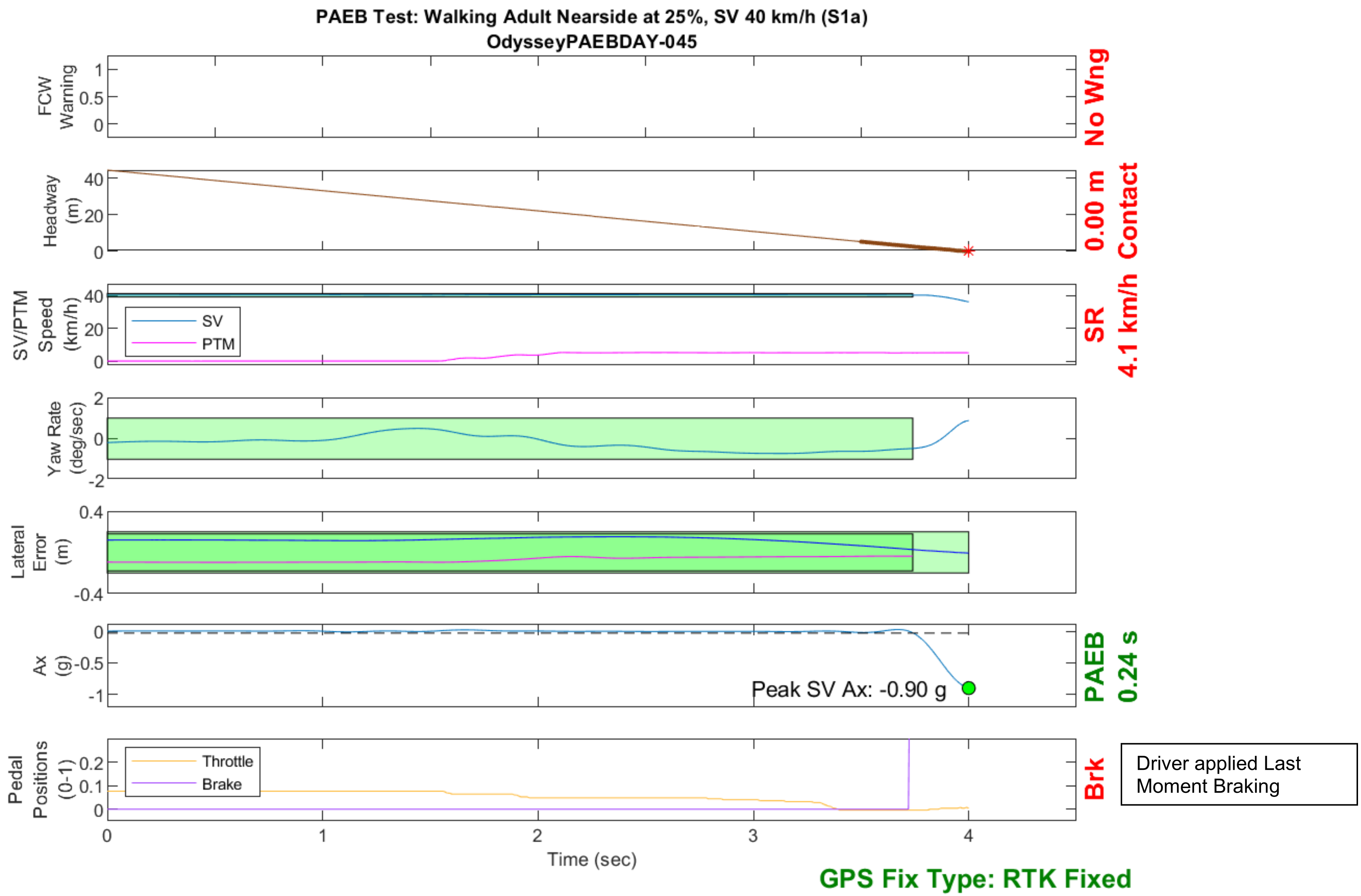


Figure D15. Time History for PAEB Run 45, S1a, Daytime, 40 km/h

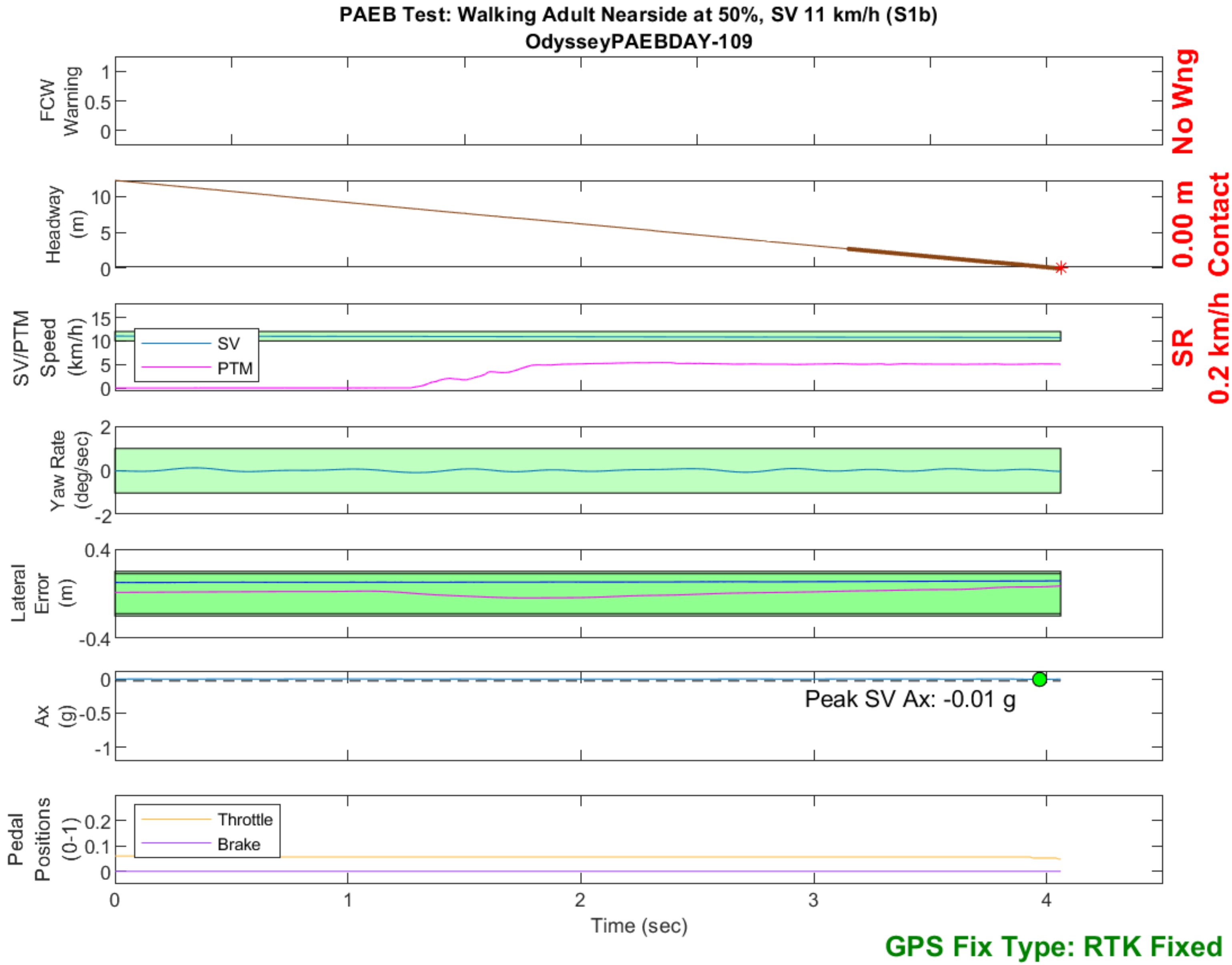


Figure D16. Time History for PAEB Run 109, S1b, Daytime, 11 km/h

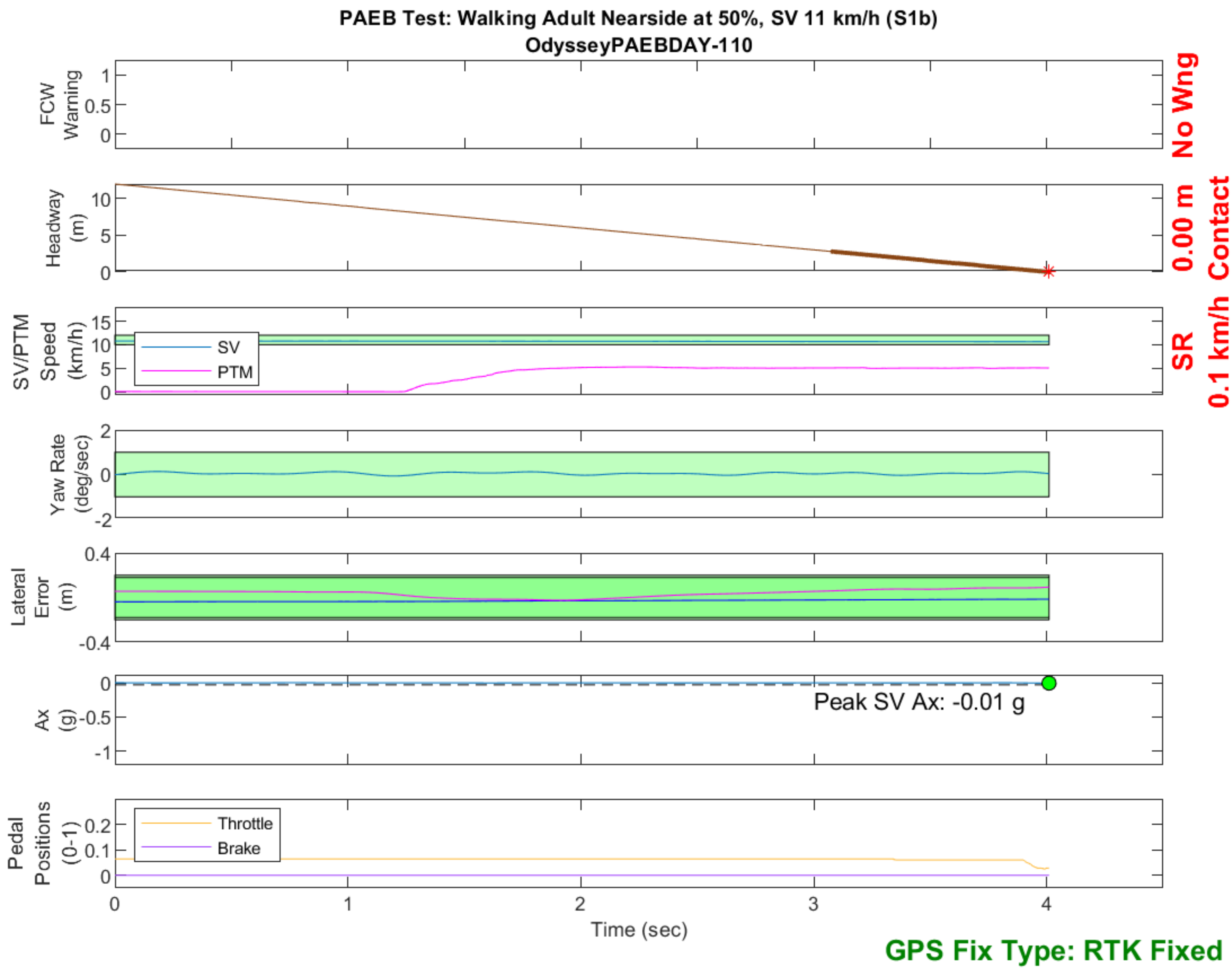


Figure D17. Time History for PAEB Run 110, S1b, Daytime, 11 km/h

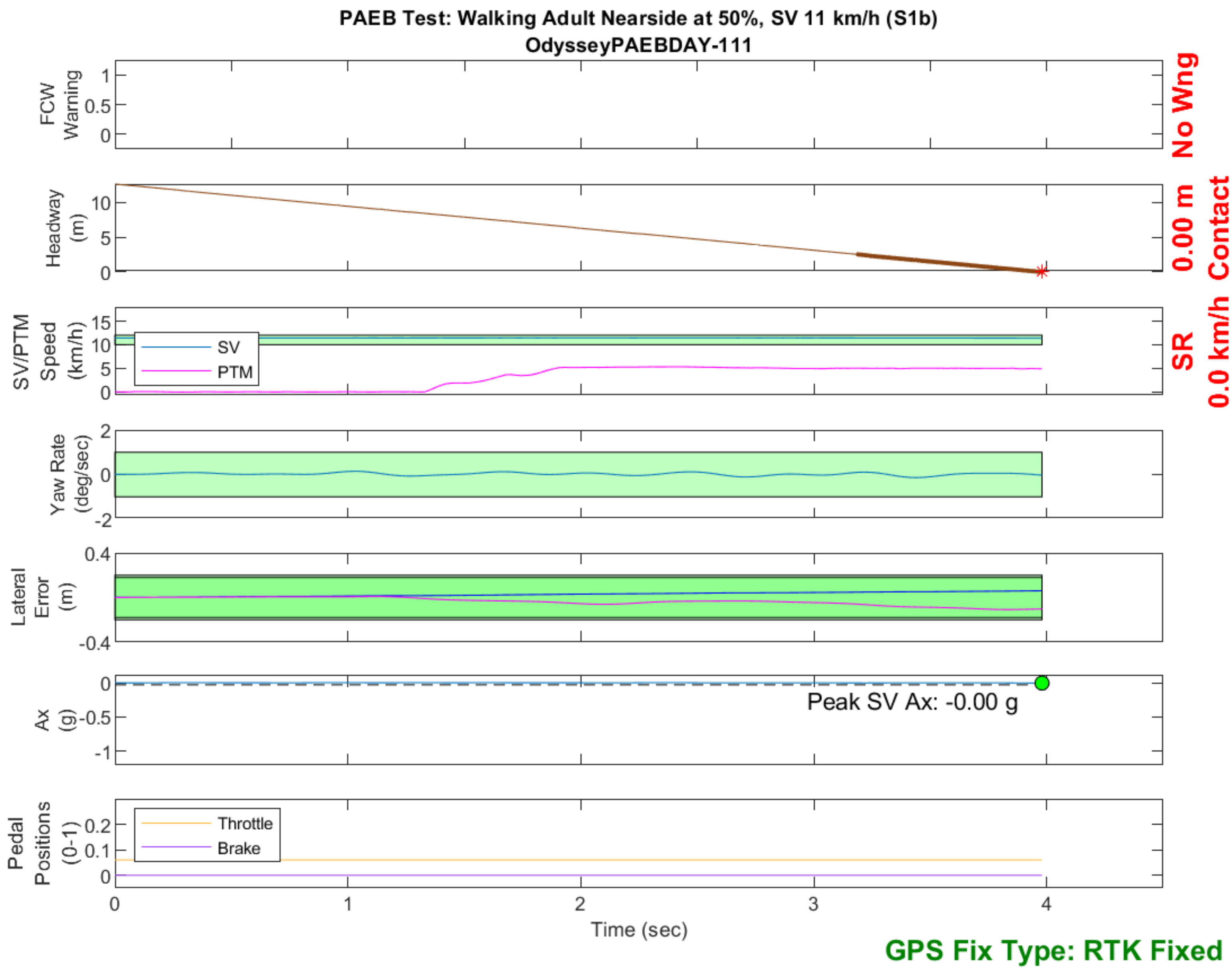


Figure D18. Time History for PAEB Run 111, S1b, Daytime, 11 km/h

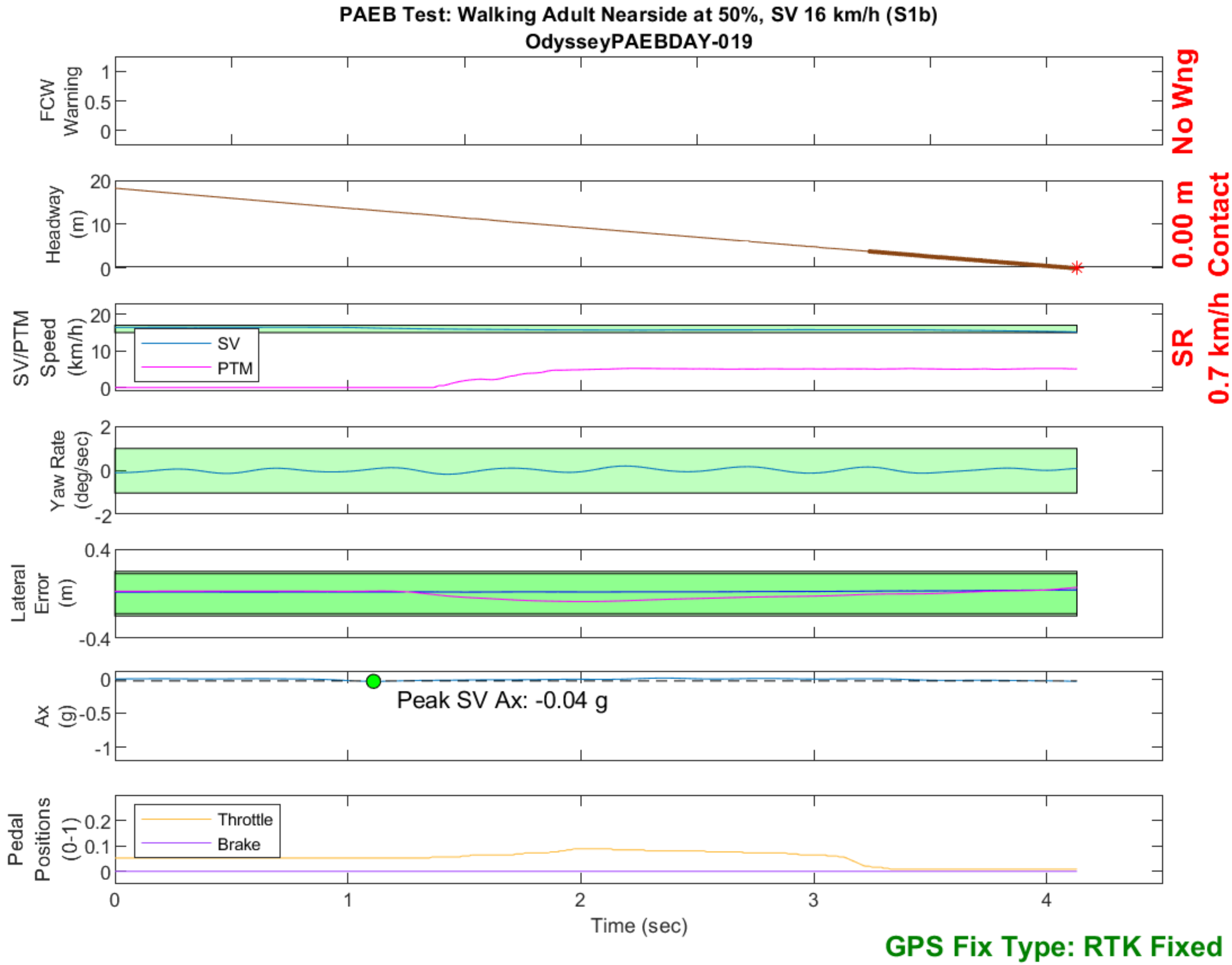


Figure D19. Time History for PAEB Run 19, S1b, Daytime, 16 km/h

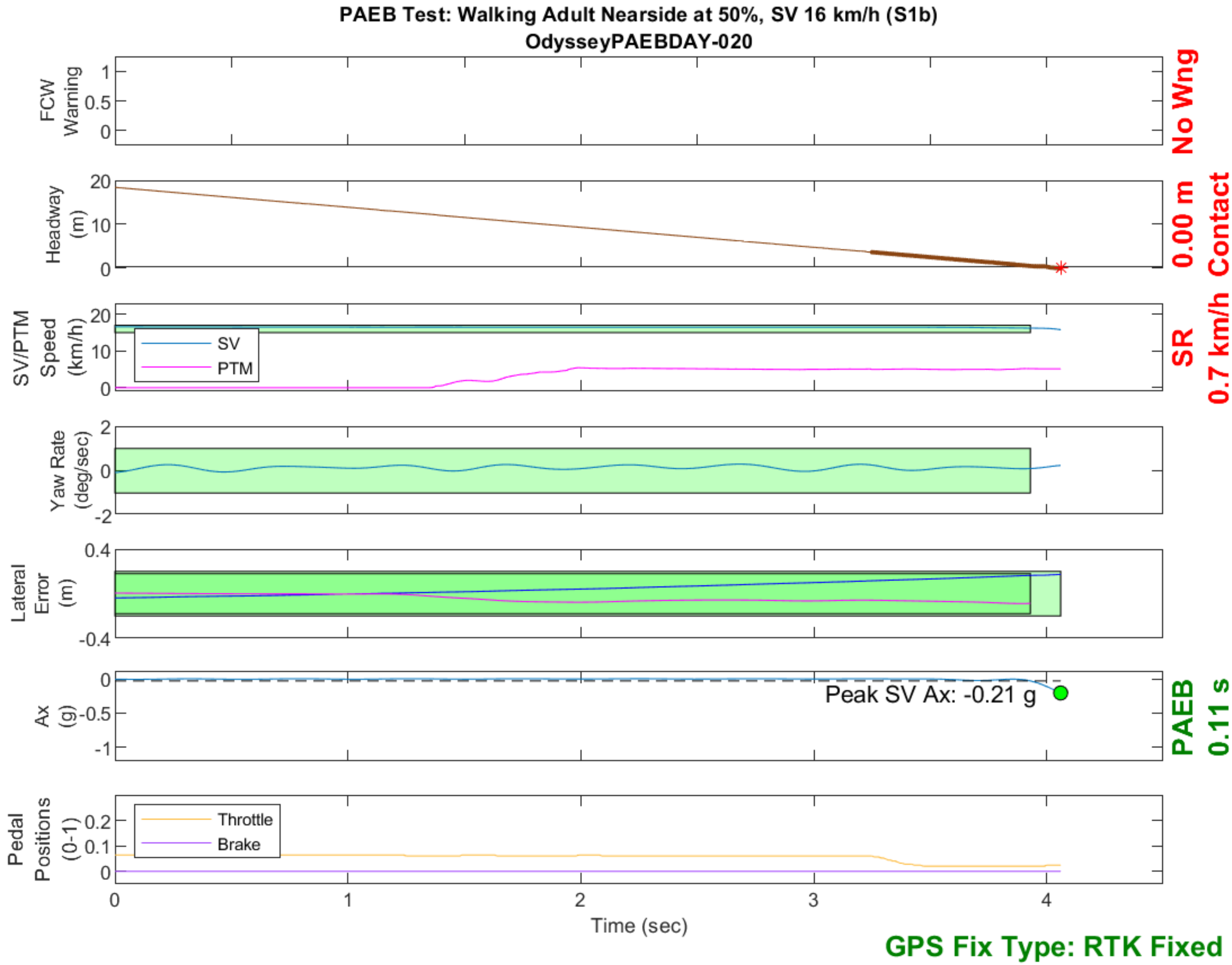


Figure D20. Time History for PAEB Run 20, S1b, Daytime, 16 km/h

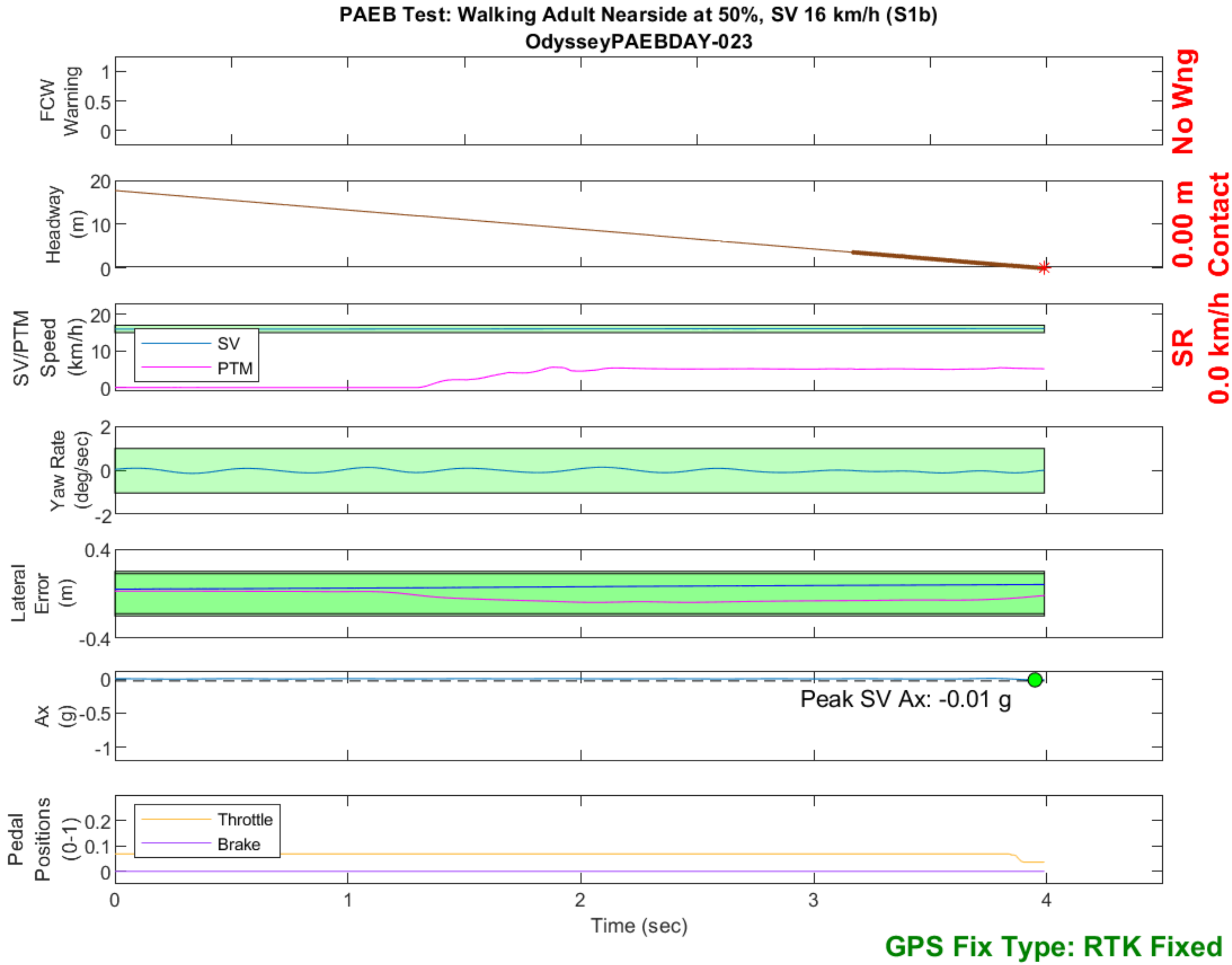


Figure D21. Time History for PAEB Run 23, S1b, Daytime, 16 km/h

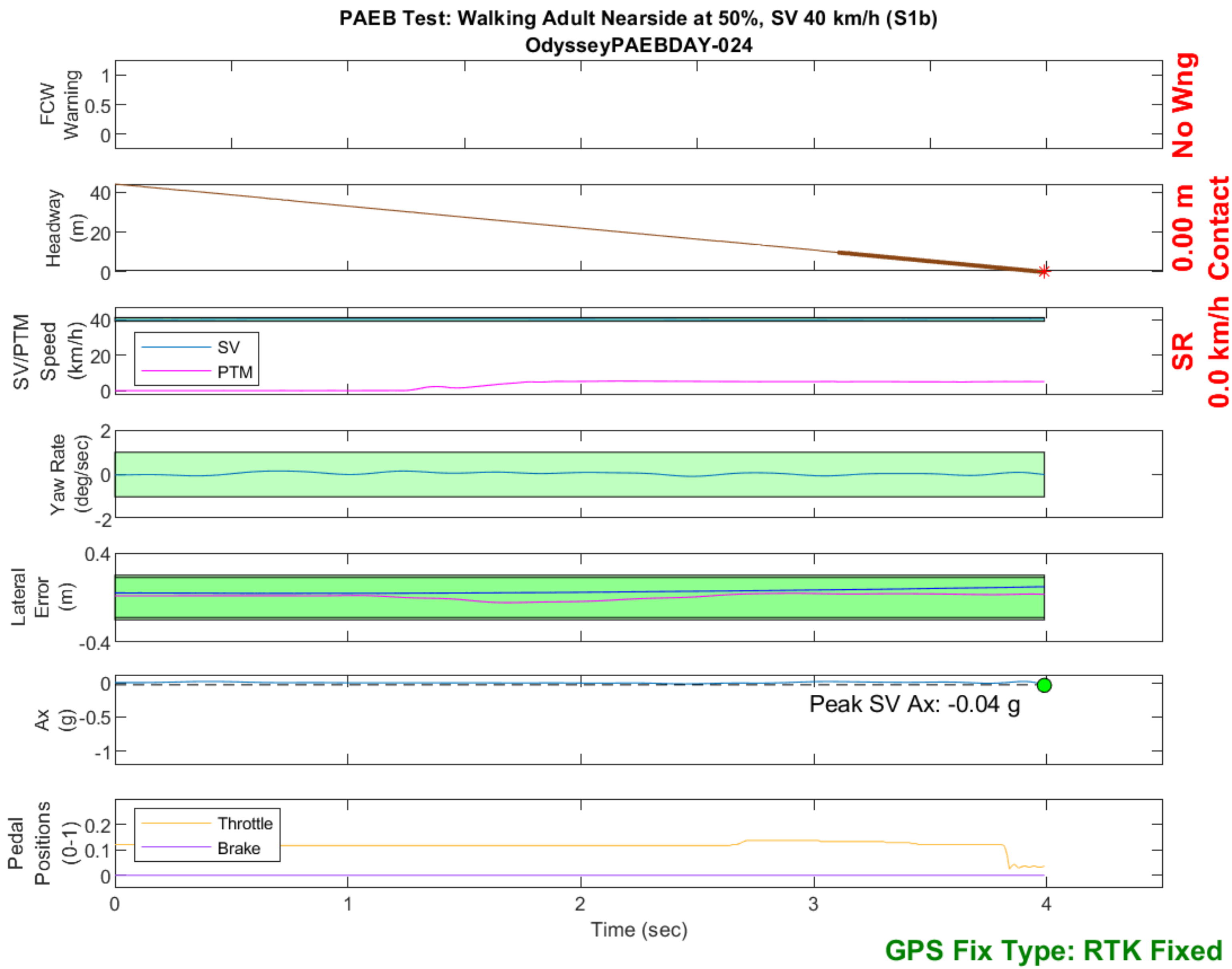


Figure D22. Time History for PAEB Run 24, S1b, Daytime, 40 km/h

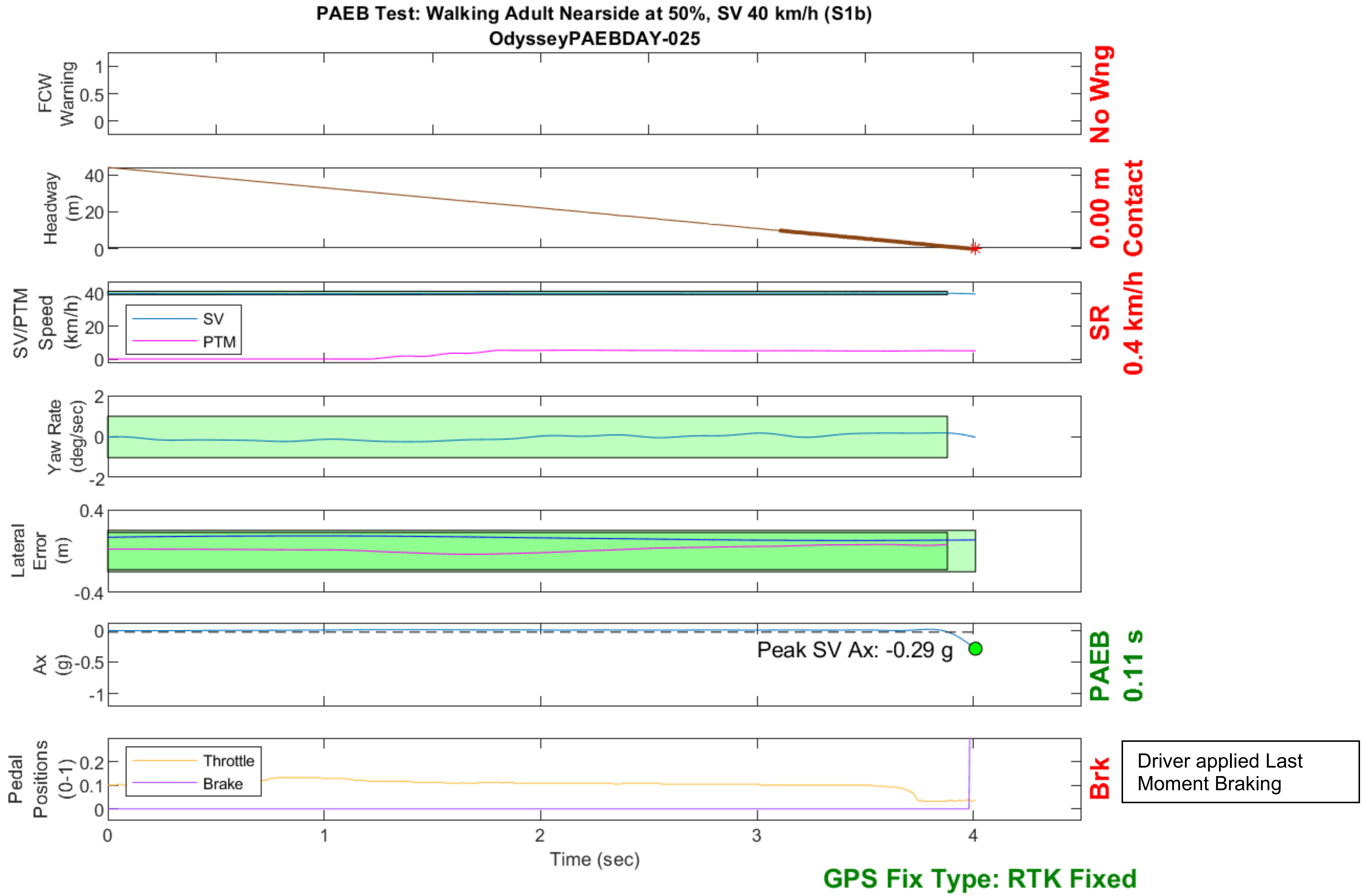


Figure D23. Time History for PAEB Run 25, S1b, Daytime, 40 km/h

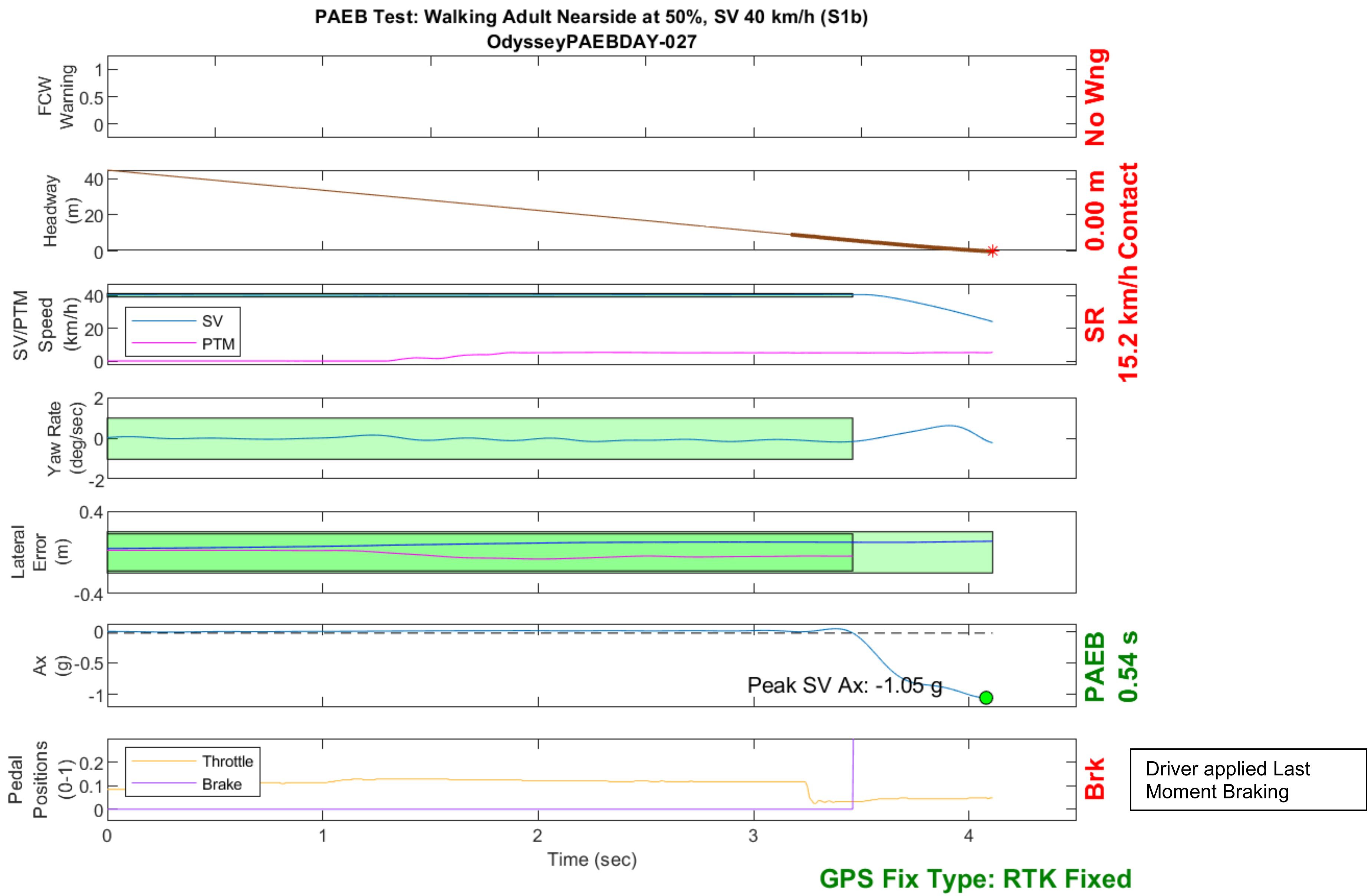


Figure D24. Time History for PAEB Run 27, S1b, Daytime, 40 km/h

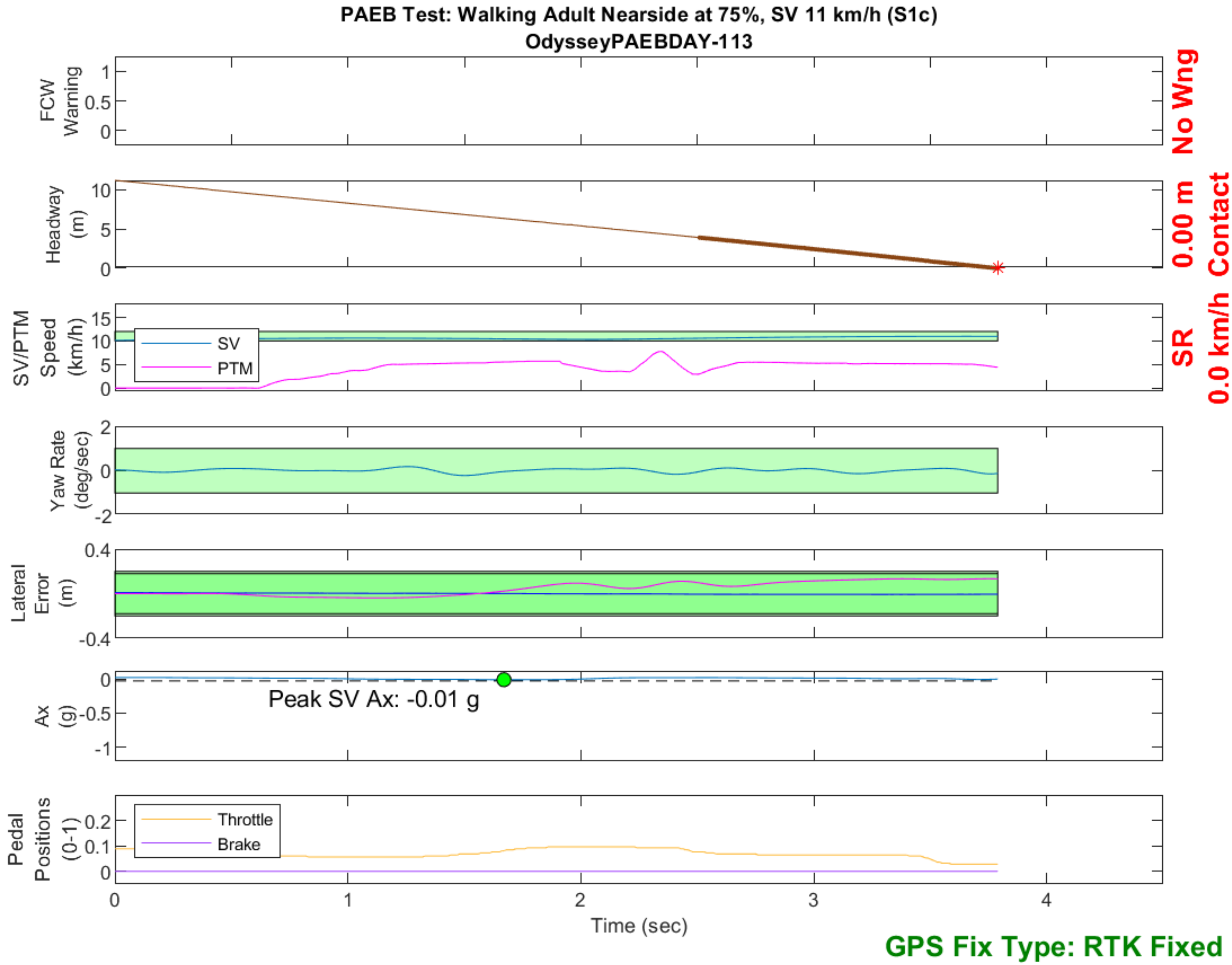


Figure D25. Time History for PAEB Run 113, S1c, Daytime, 11 km/h

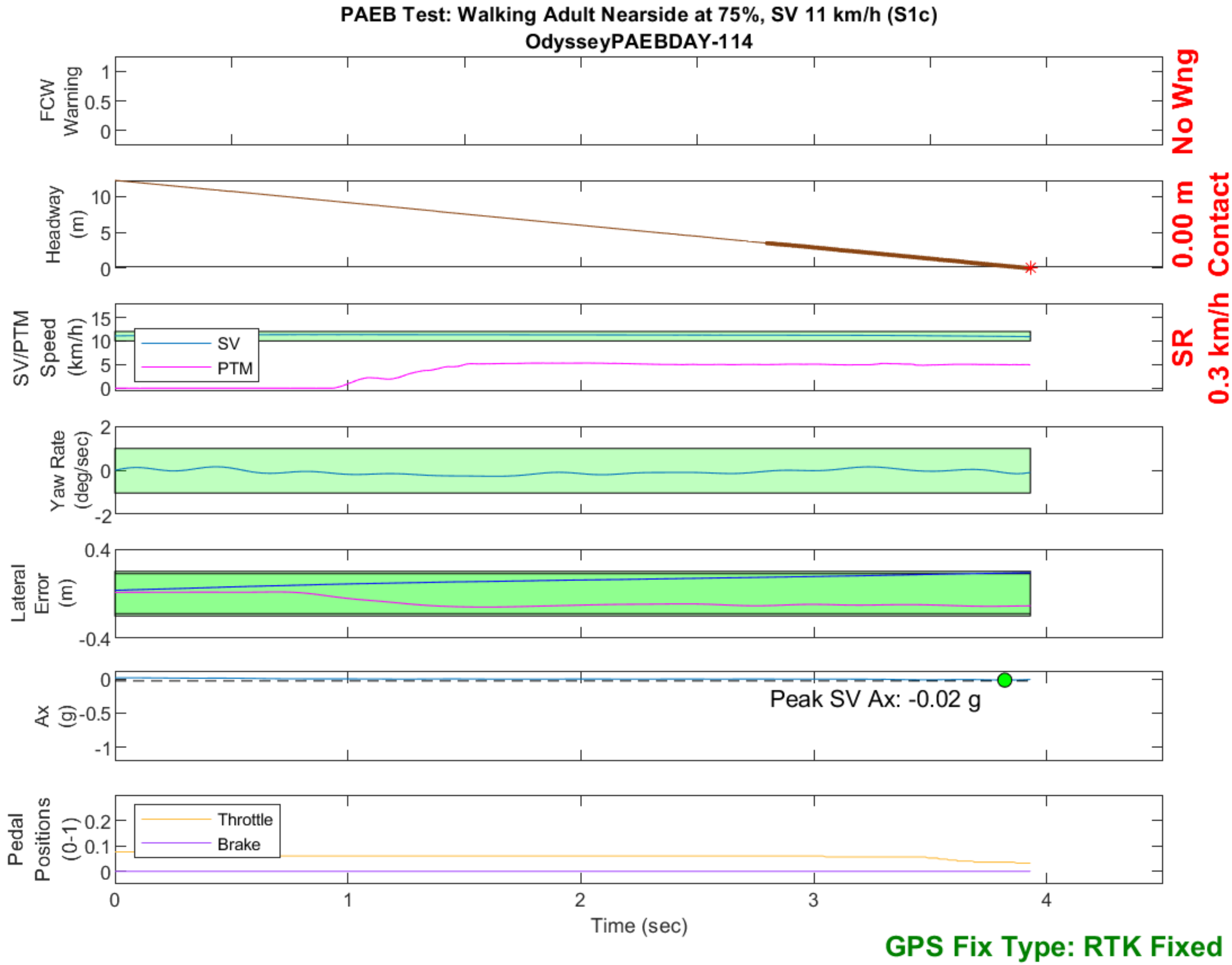


Figure D26. Time History for PAEB Run 114, S1c, Daytime, 11 km/h

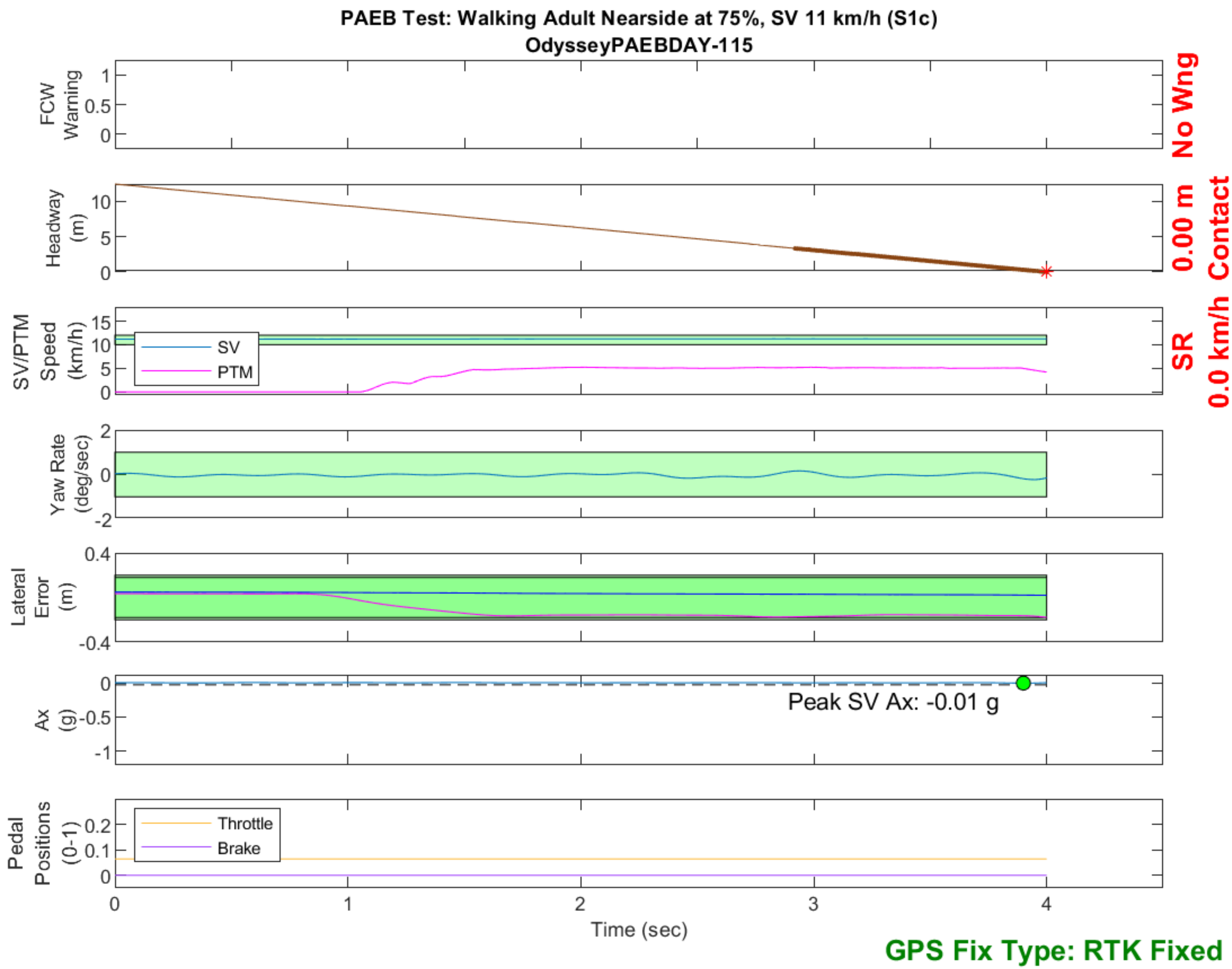


Figure D27. Time History for PAEB Run 115, S1c, Daytime, 11 km/h

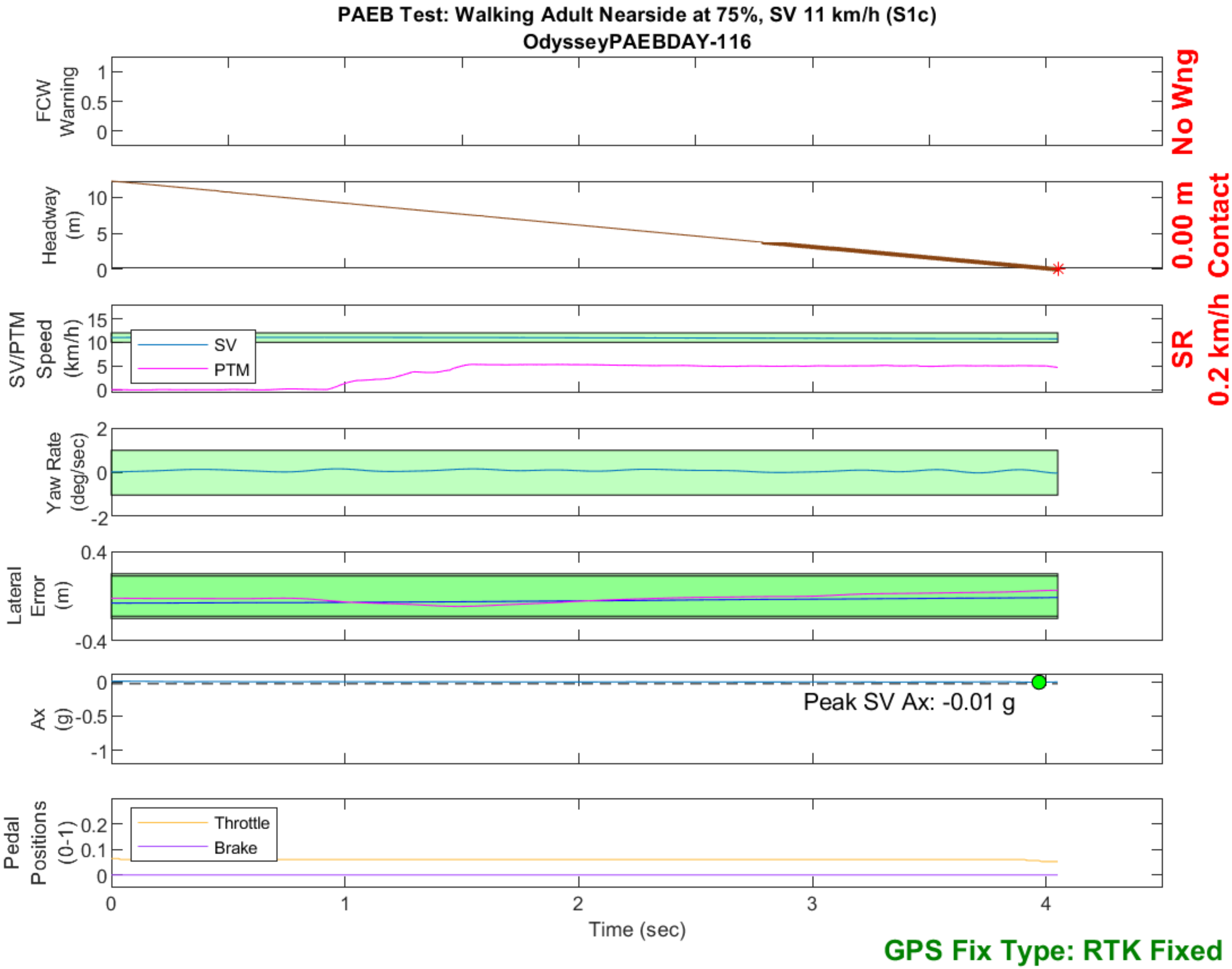


Figure D28. Time History for PAEB Run 116, S1c, Daytime, 11 km/h

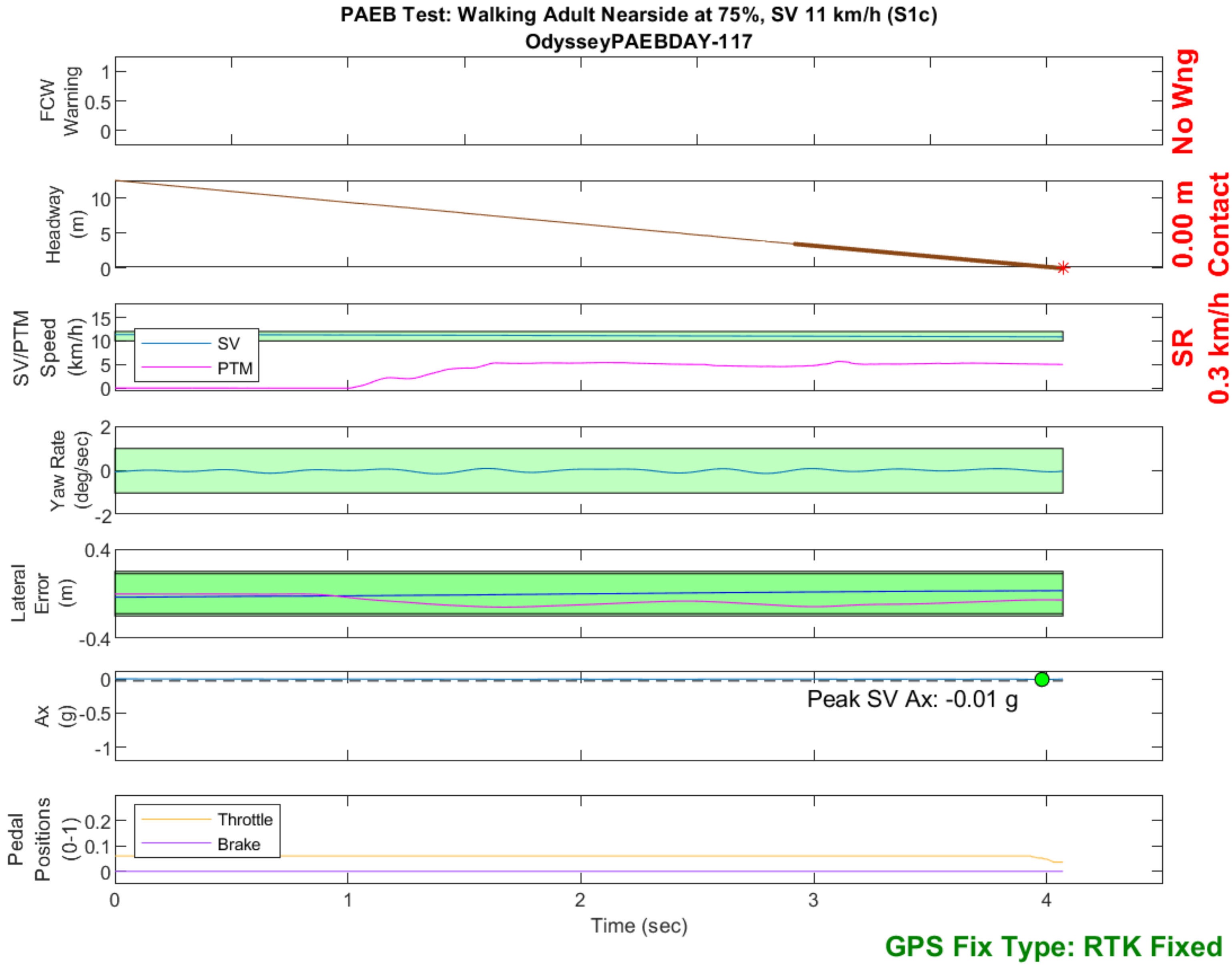


Figure D29. Time History for PAEB Run 117, S1c, Daytime, 11 km/h

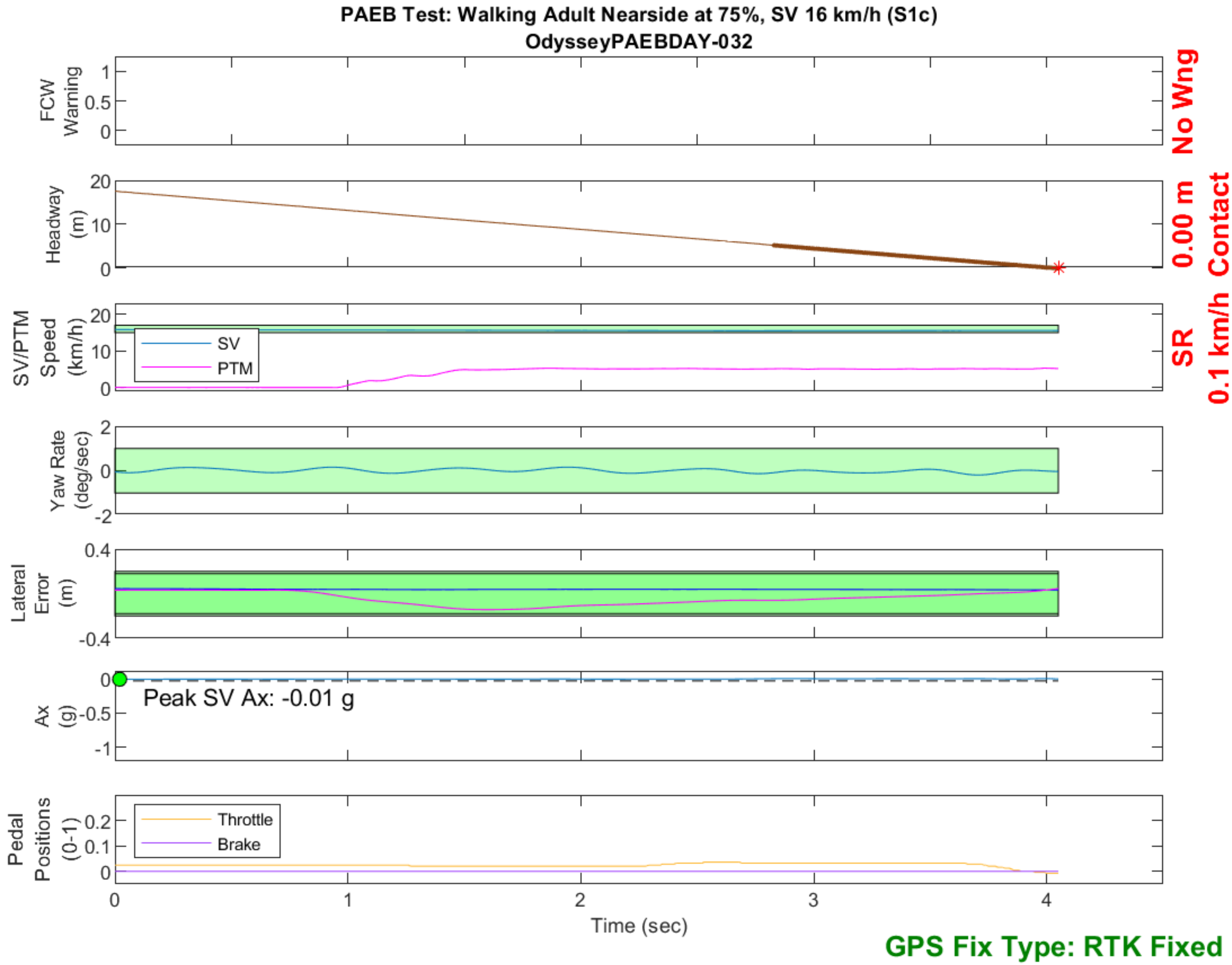


Figure D30. Time History for PAEB Run 32, S1c, Daytime, 16 km/h

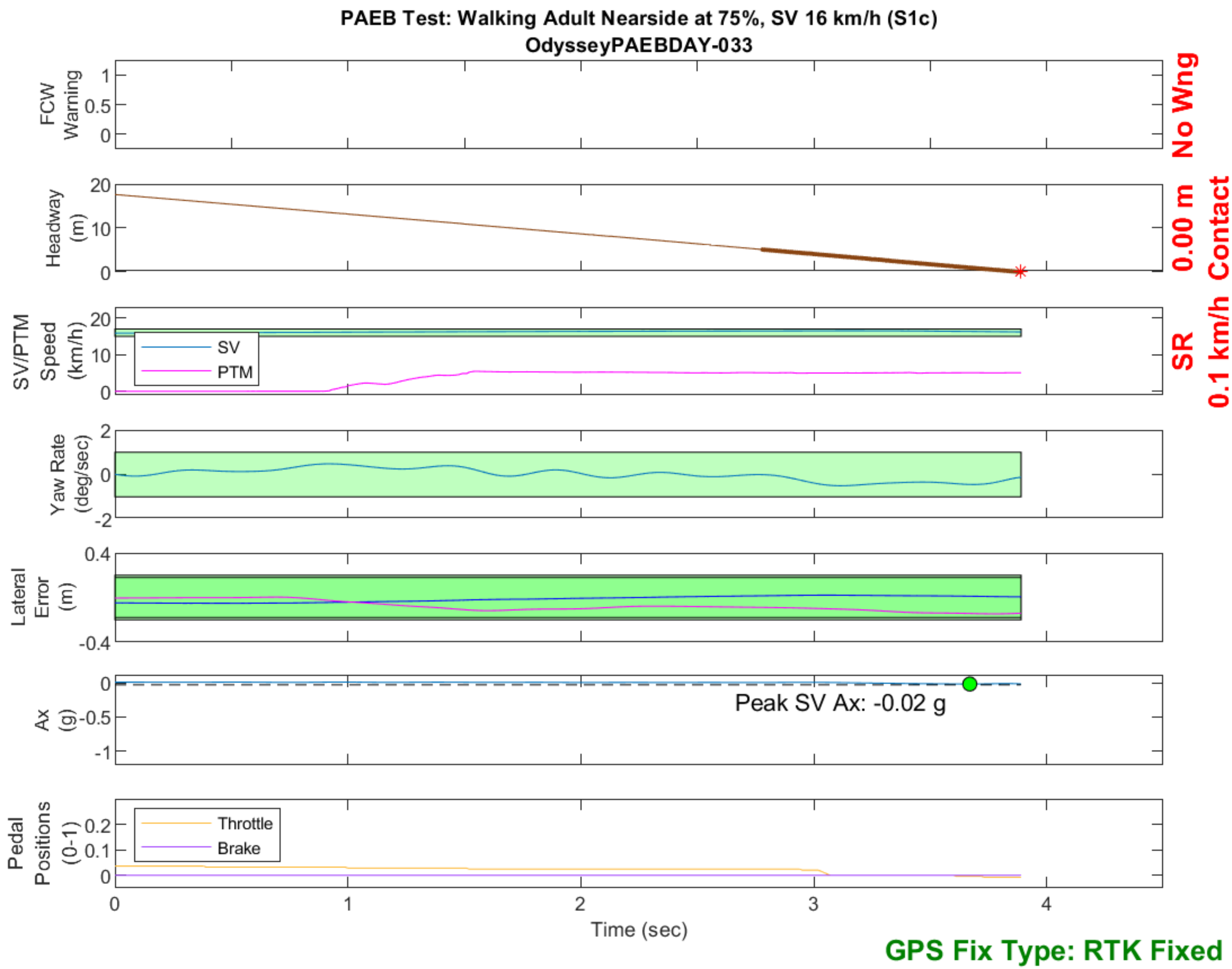


Figure D31. Time History for PAEB Run 33, S1c, Daytime, 16 km/h

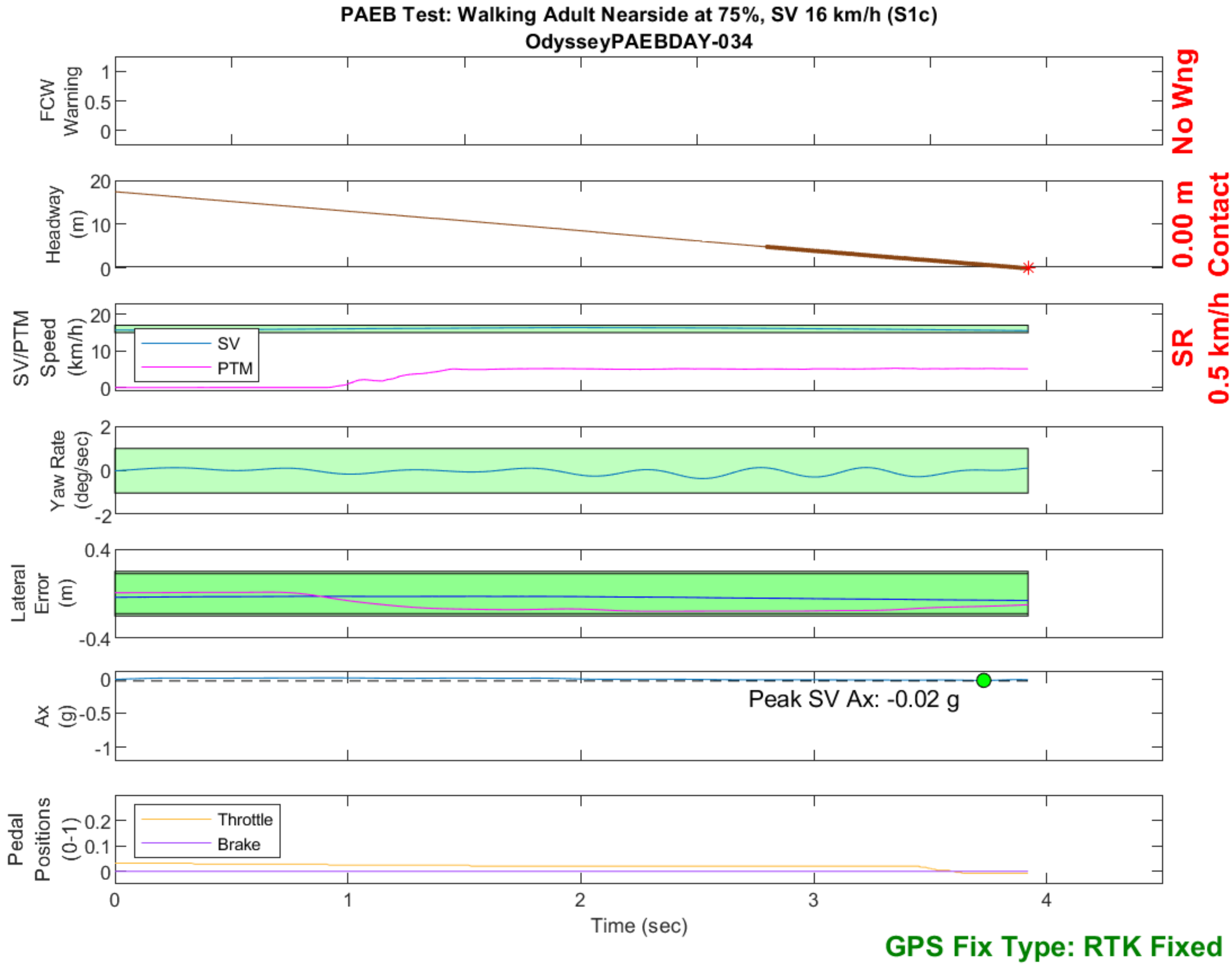


Figure D32. Time History for PAEB Run 34, S1c, Daytime, 16 km/h

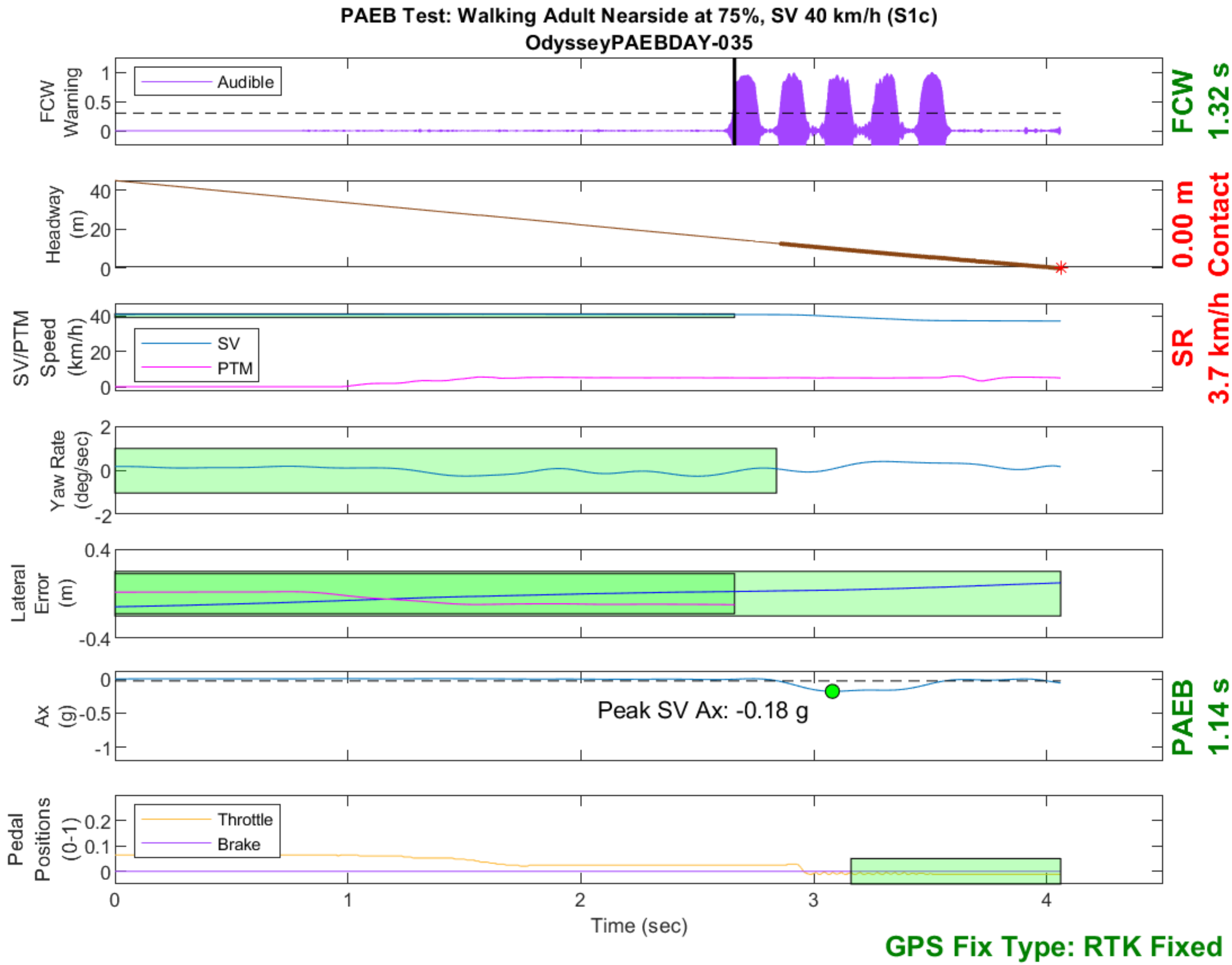


Figure D33. Time History for PAEB Run 35, S1c, Daytime, 40 km/h

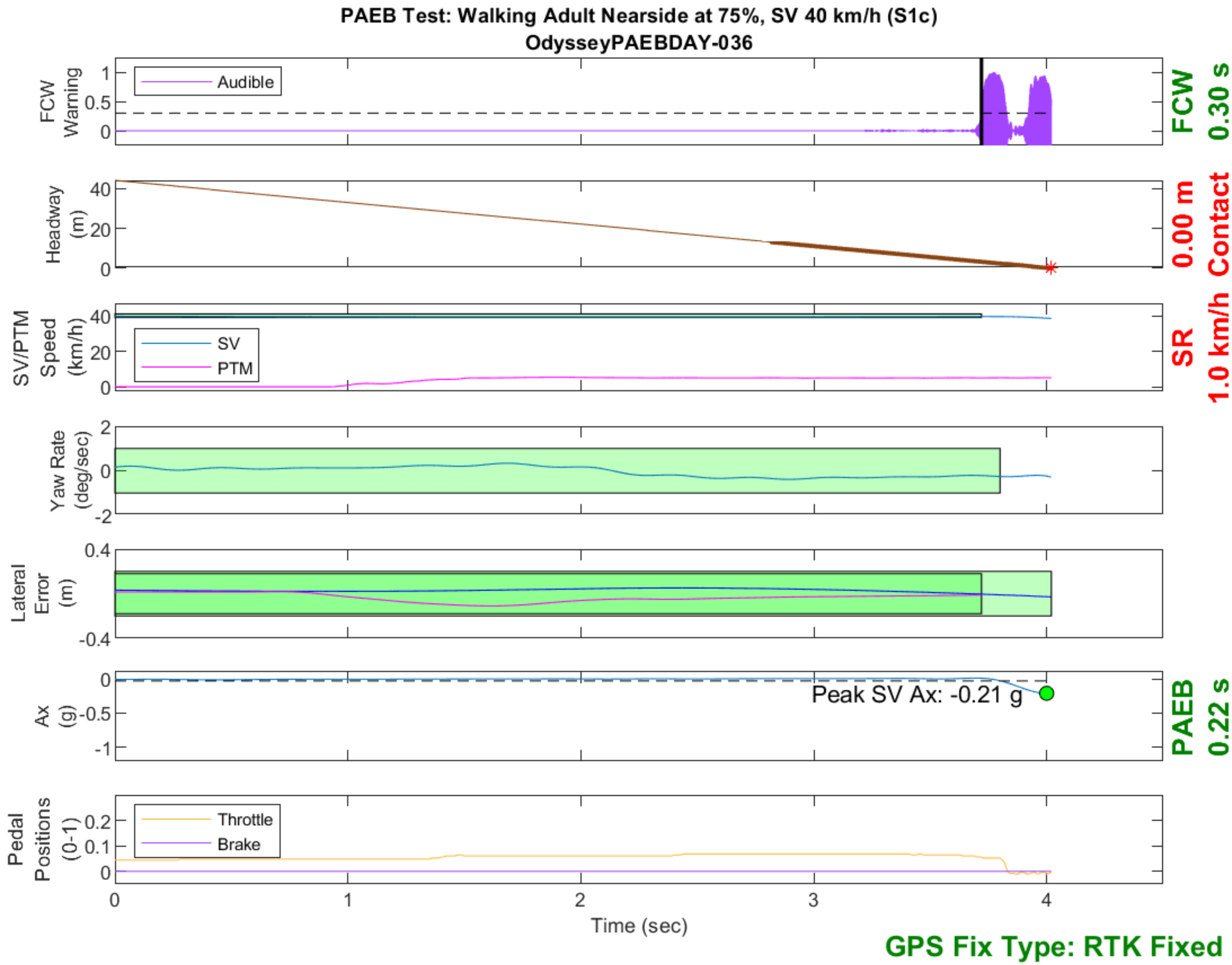


Figure D34. Time History for PAEB Run 36, S1c, Daytime, 40 km/h

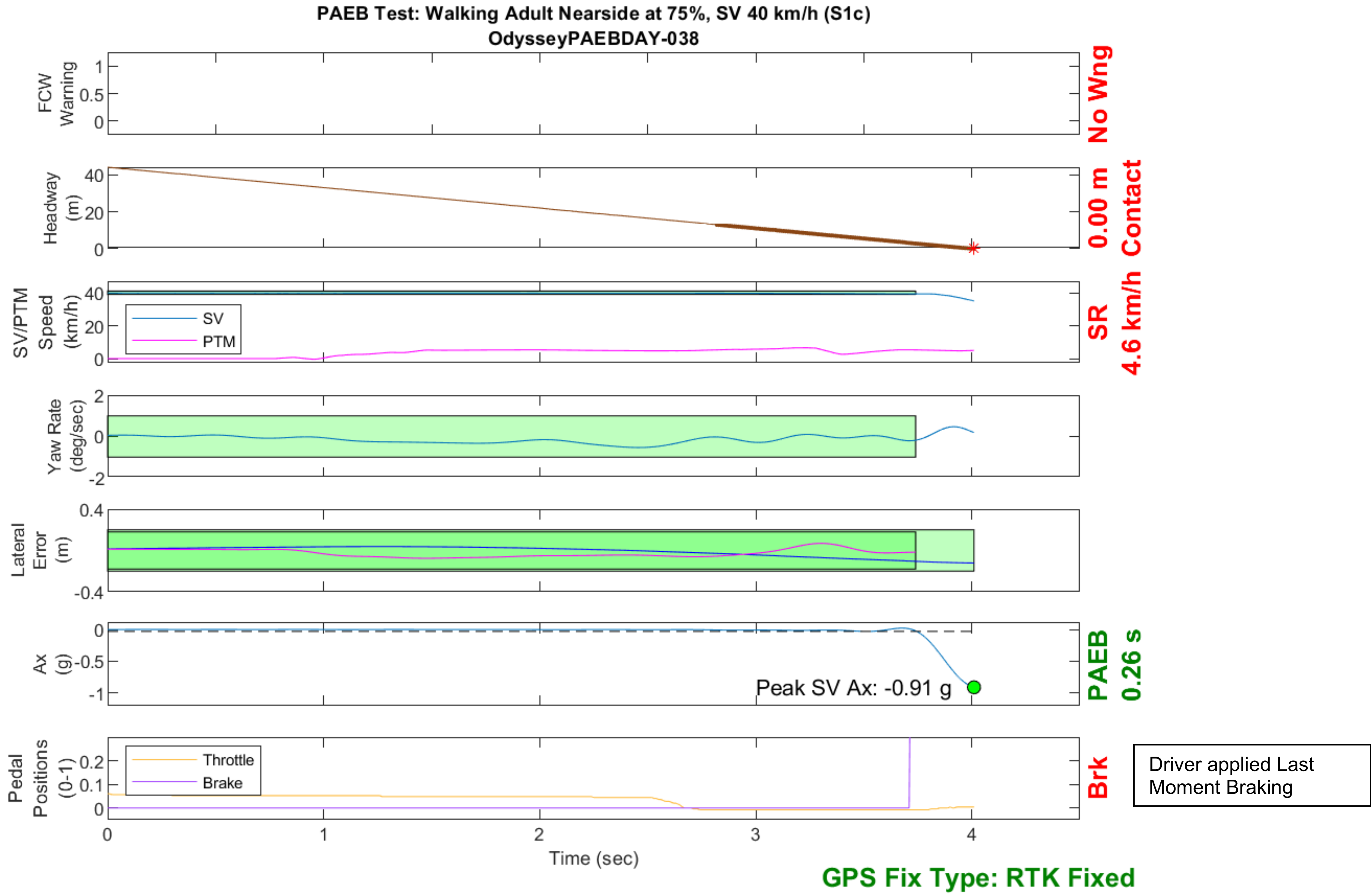


Figure D35. Time History for PAEB Run 38, S1c, Daytime, 40 km/h

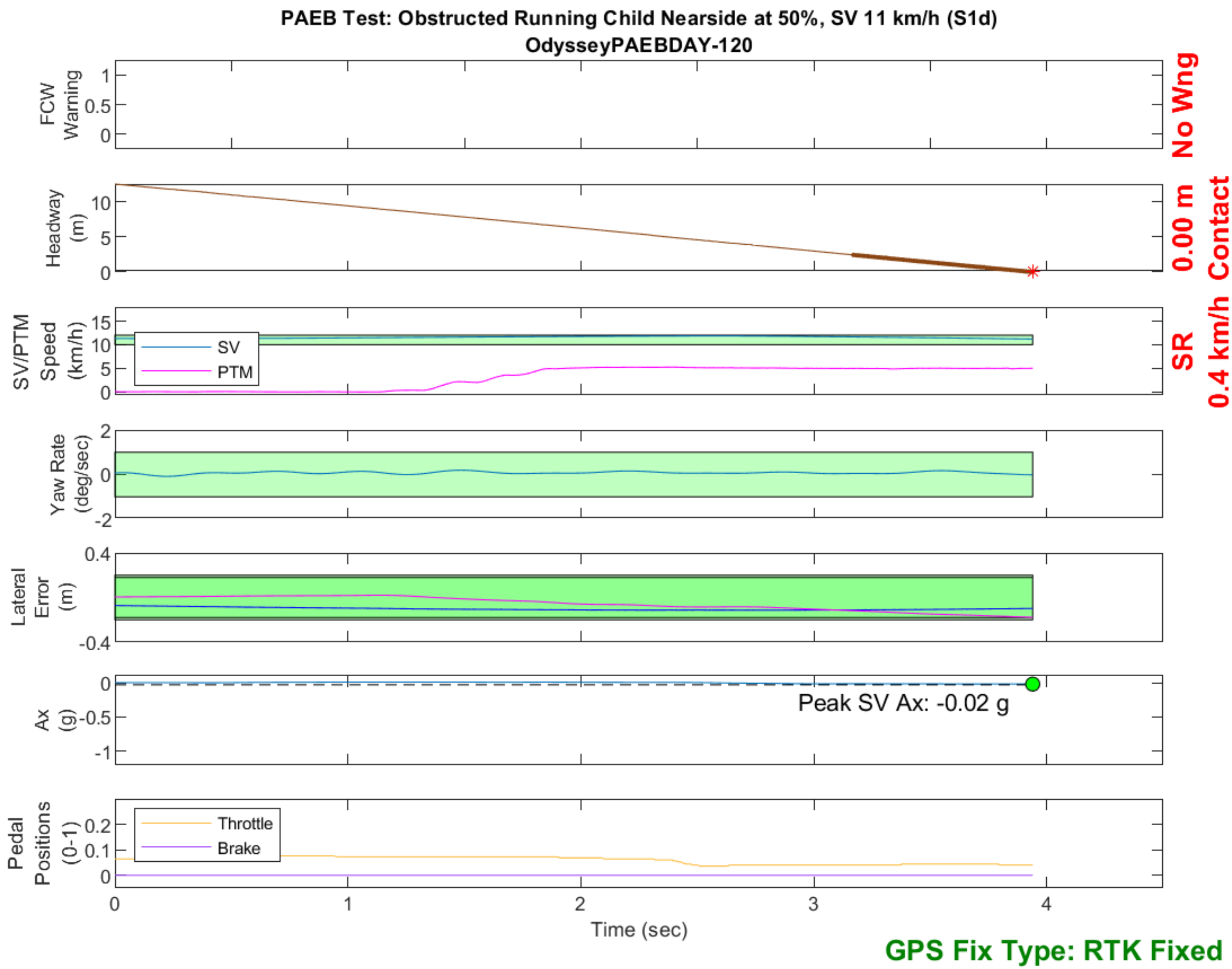


Figure D36. Time History for PAEB Run 120, S1d, Daytime, 11 km/h

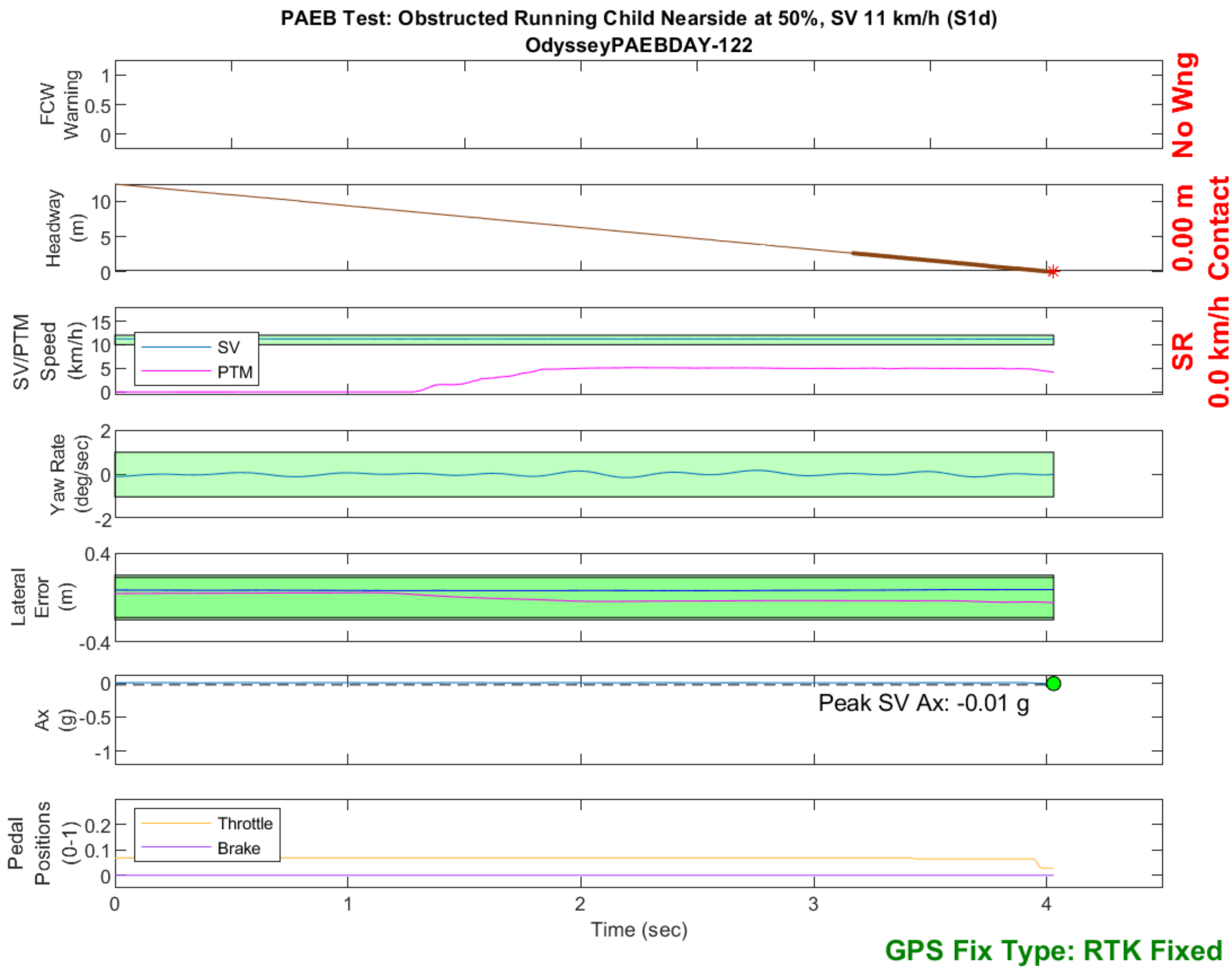


Figure D37. Time History for PAEB Run 122, S1d, Daytime, 11 km/h

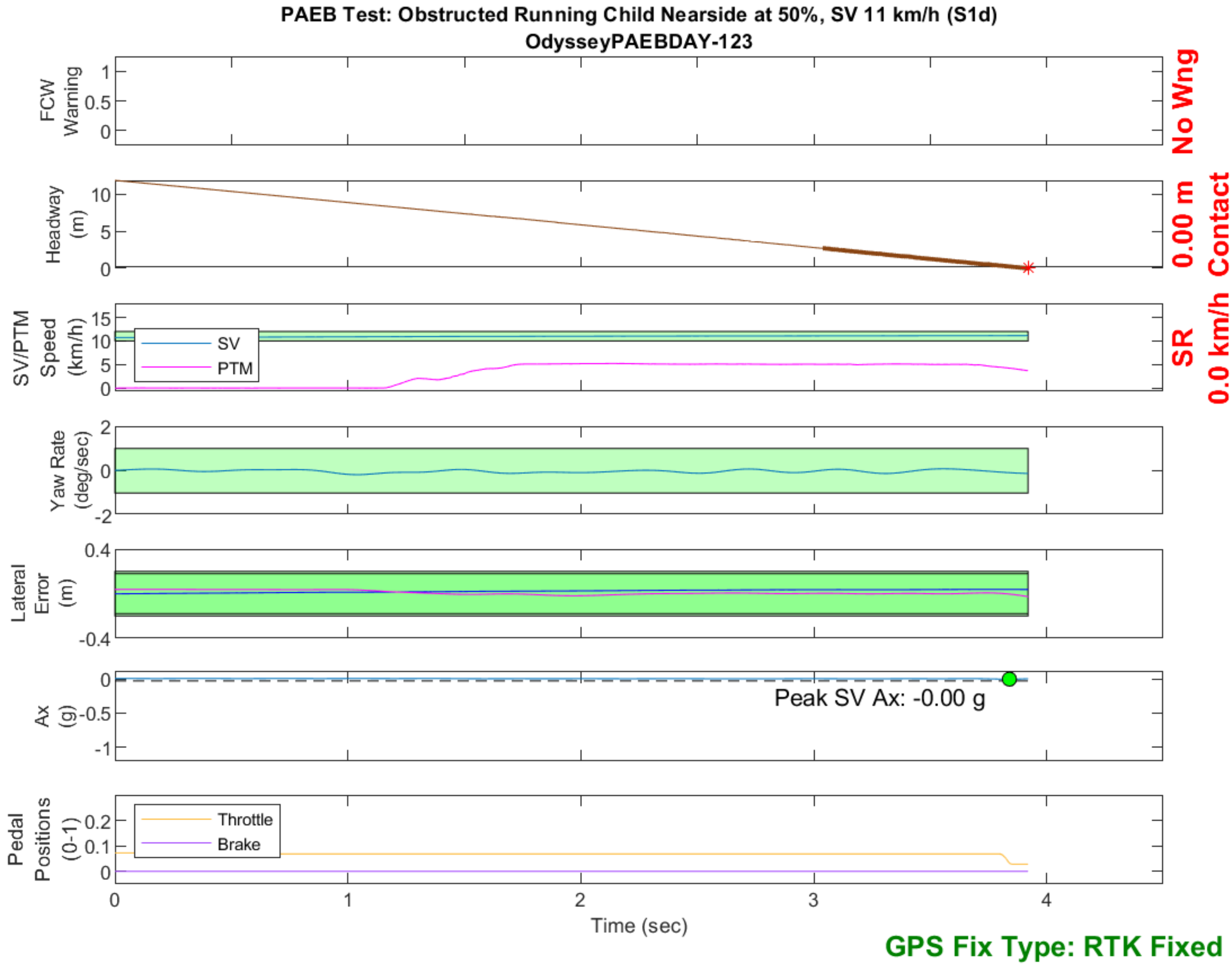


Figure D38. Time History for PAEB Run 123, S1d, Daytime, 11 km/h

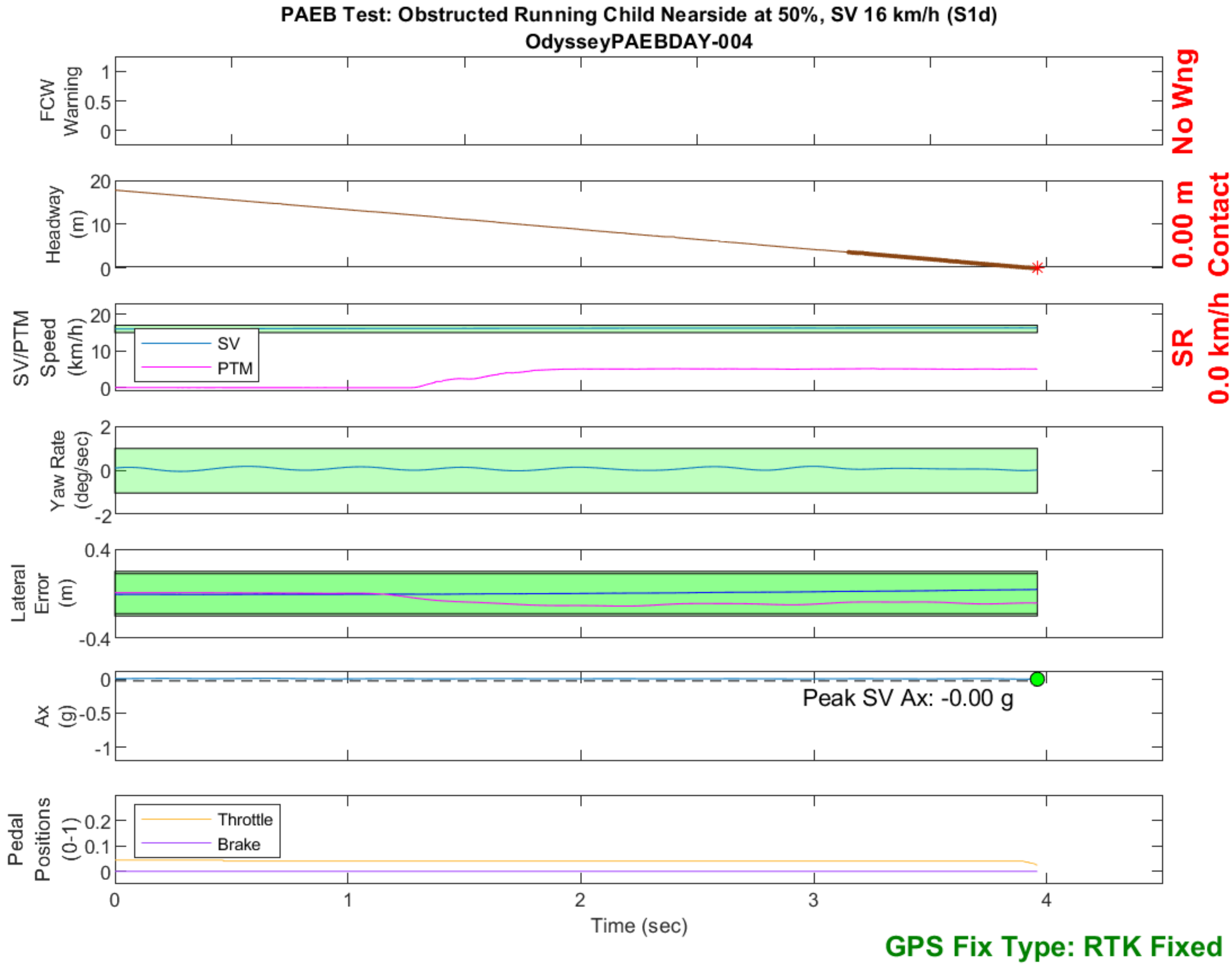


Figure D39. Time History for PAEB Run 4, S1d, Daytime, 16 km/h

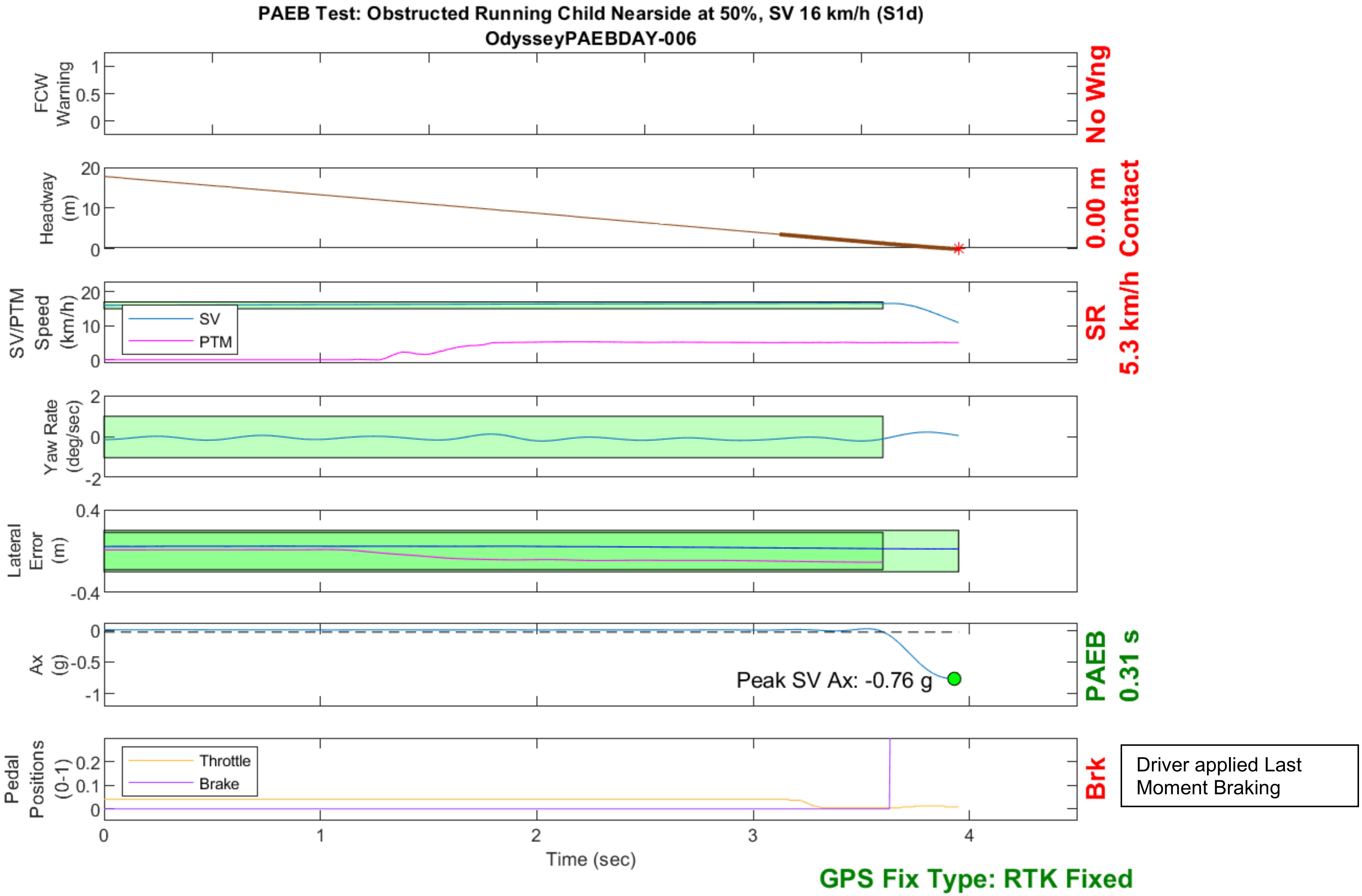


Figure D40. Time History for PAEB Run 6, S1d, Daytime, 16 km/h

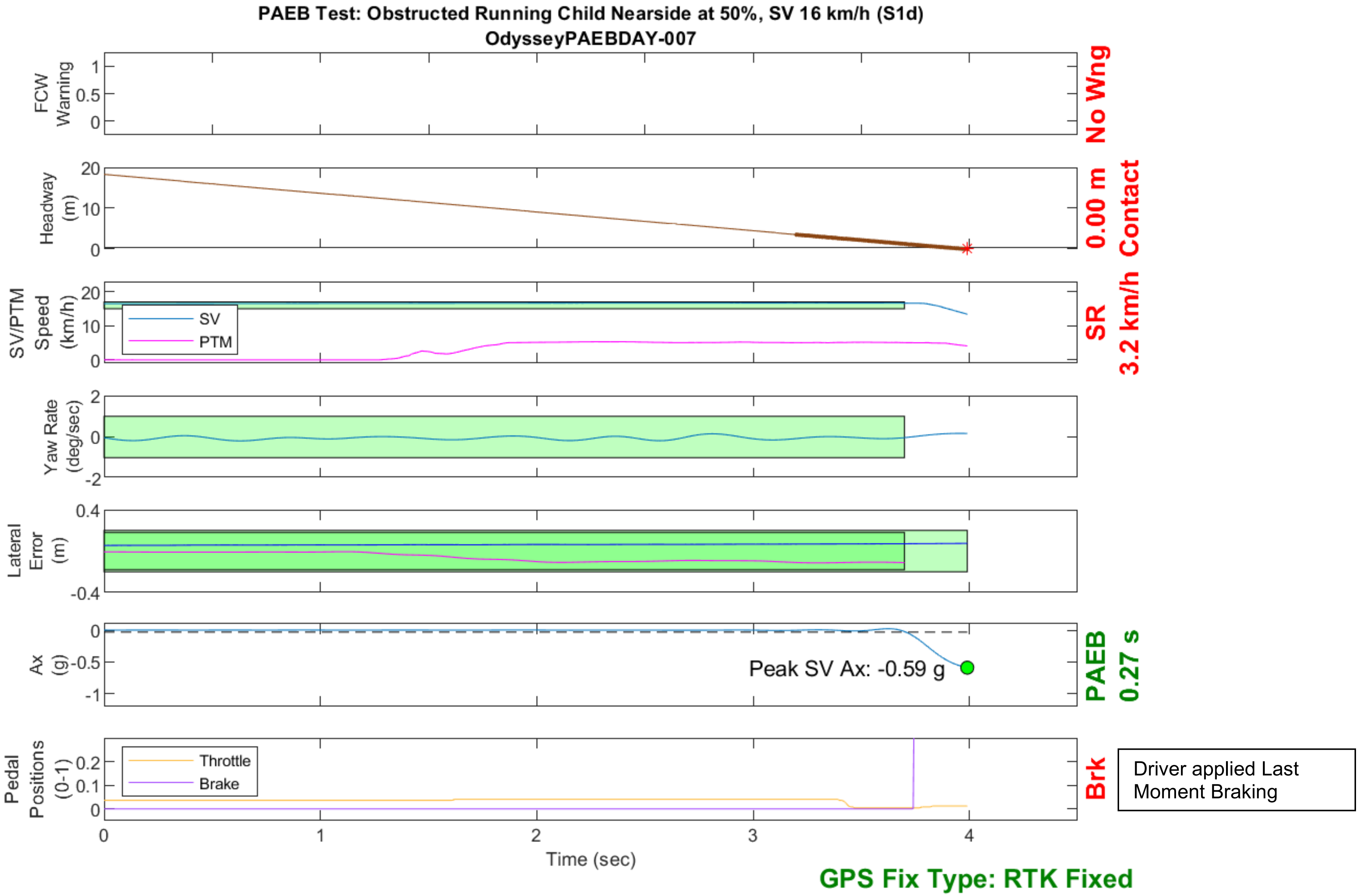


Figure D41. Time History for PAEB Run 7, S1d, Daytime, 16 km/h

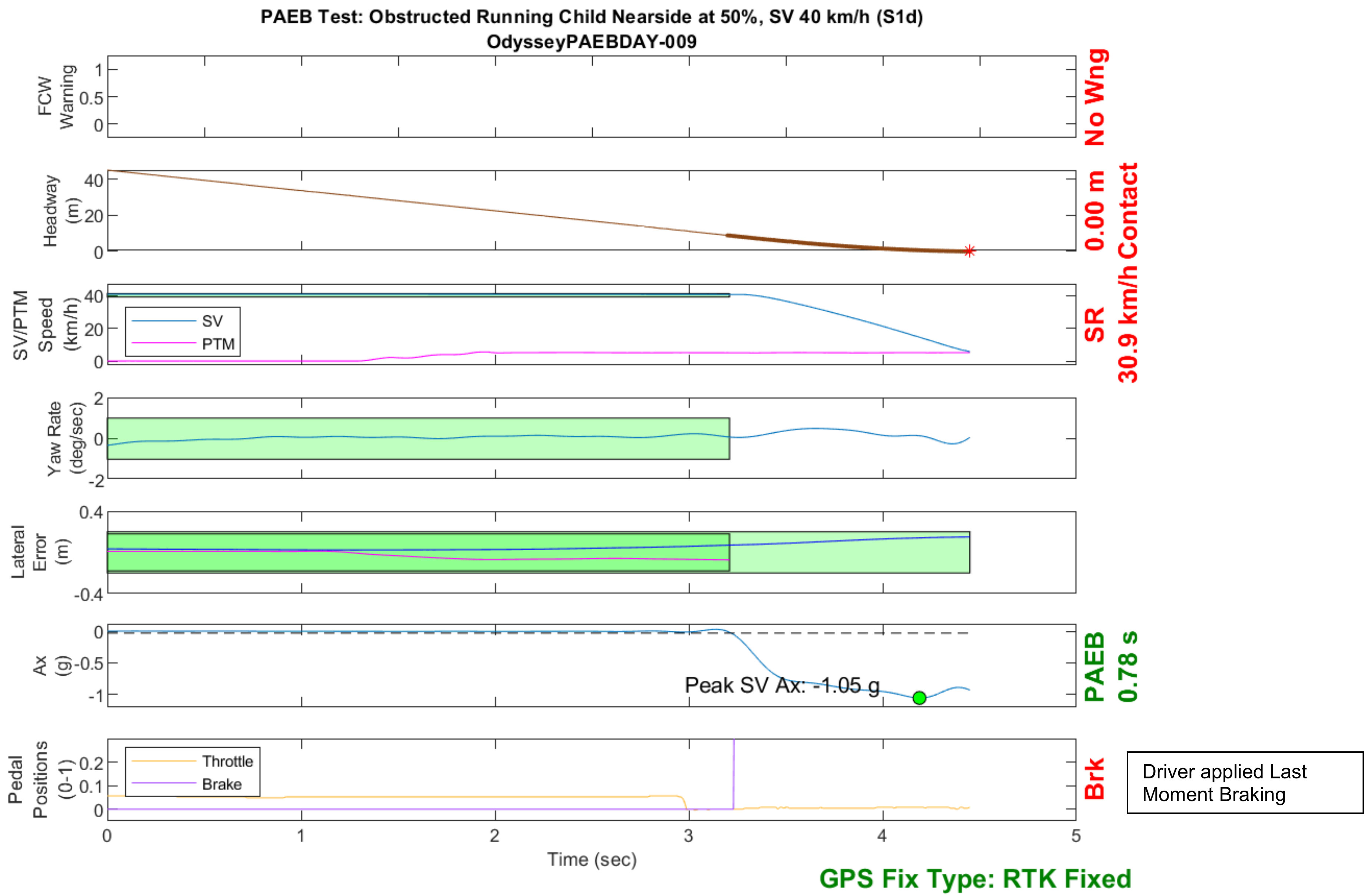


Figure D42. Time History for PAEB Run 9, S1d, Daytime, 40 km/h

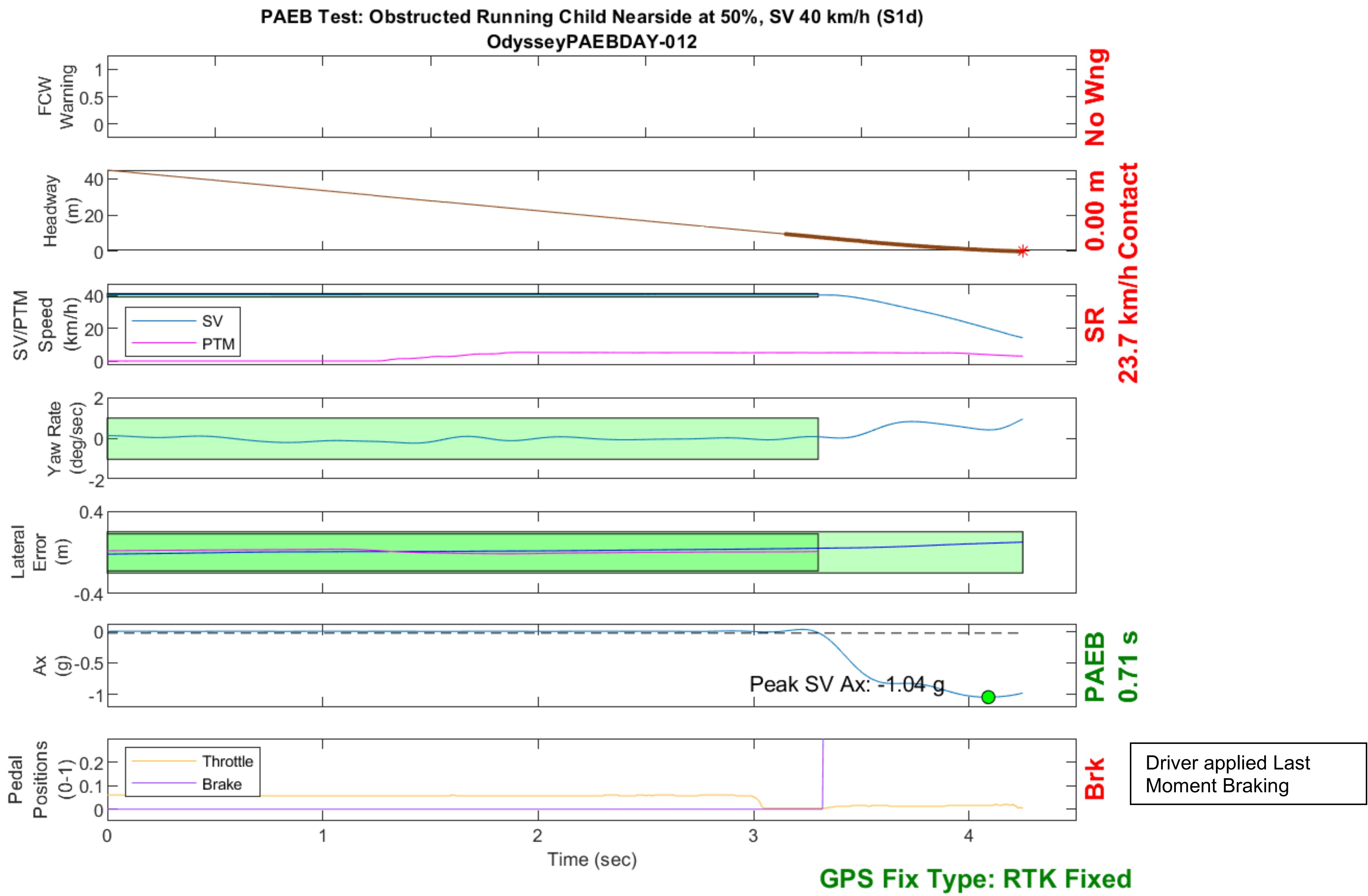


Figure D43. Time History for PAEB Run 12, S1d, Daytime, 40 km/h

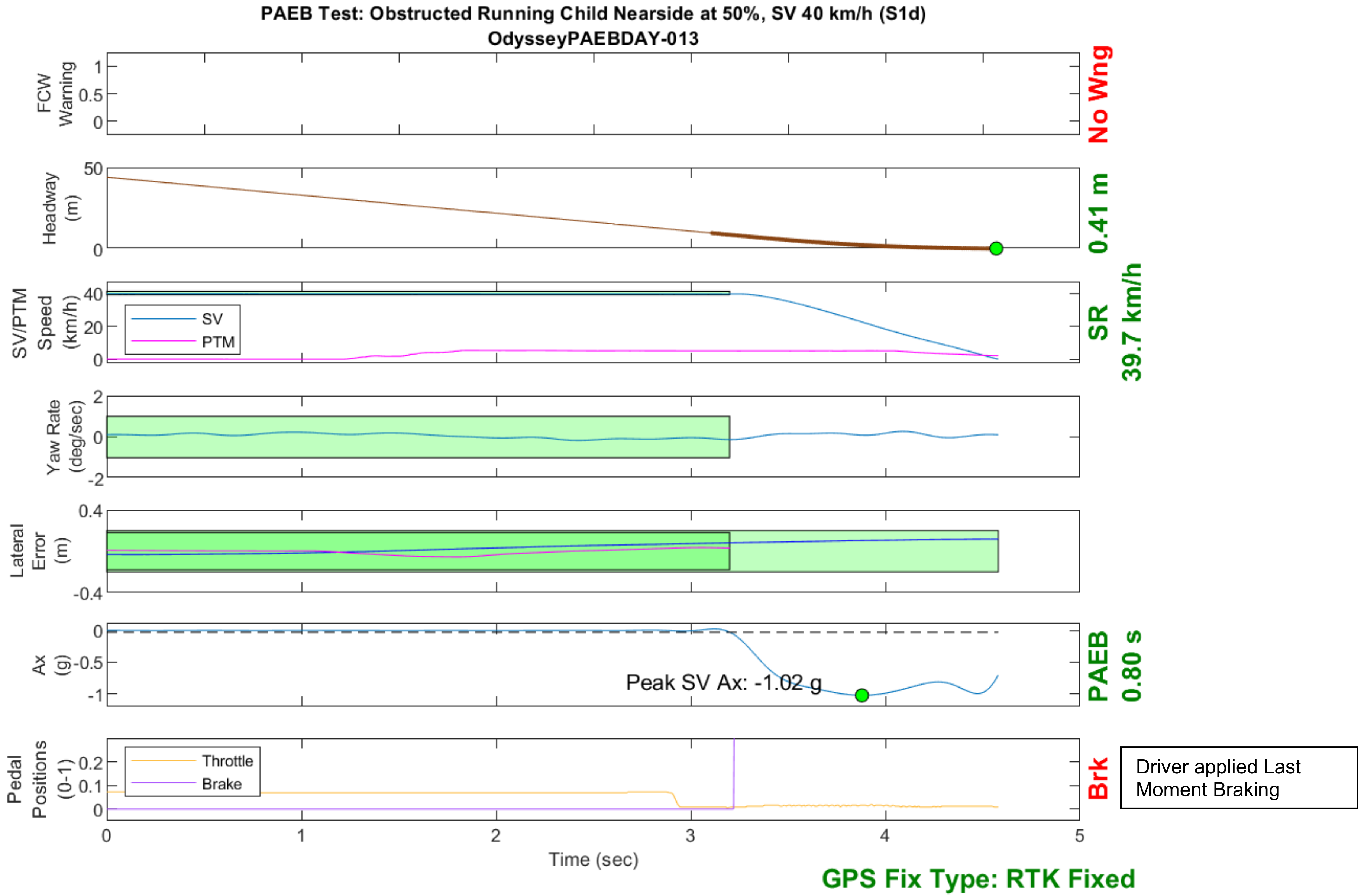


Figure D44. Time History for PAEB Run 13, S1d, Daytime, 40 km/h

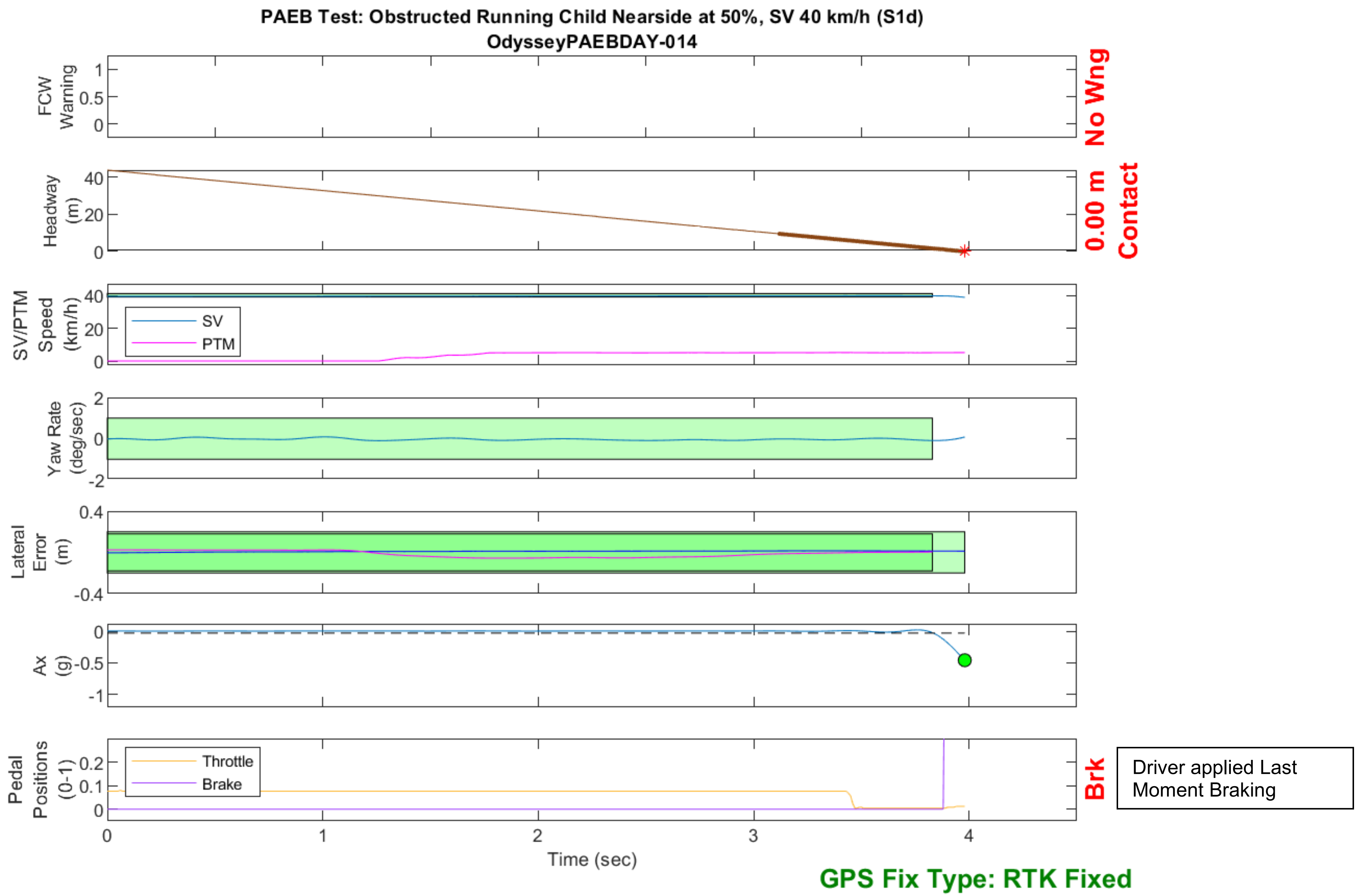


Figure D45. Time History for PAEB Run 14, S1d, Daytime, 40 km/h

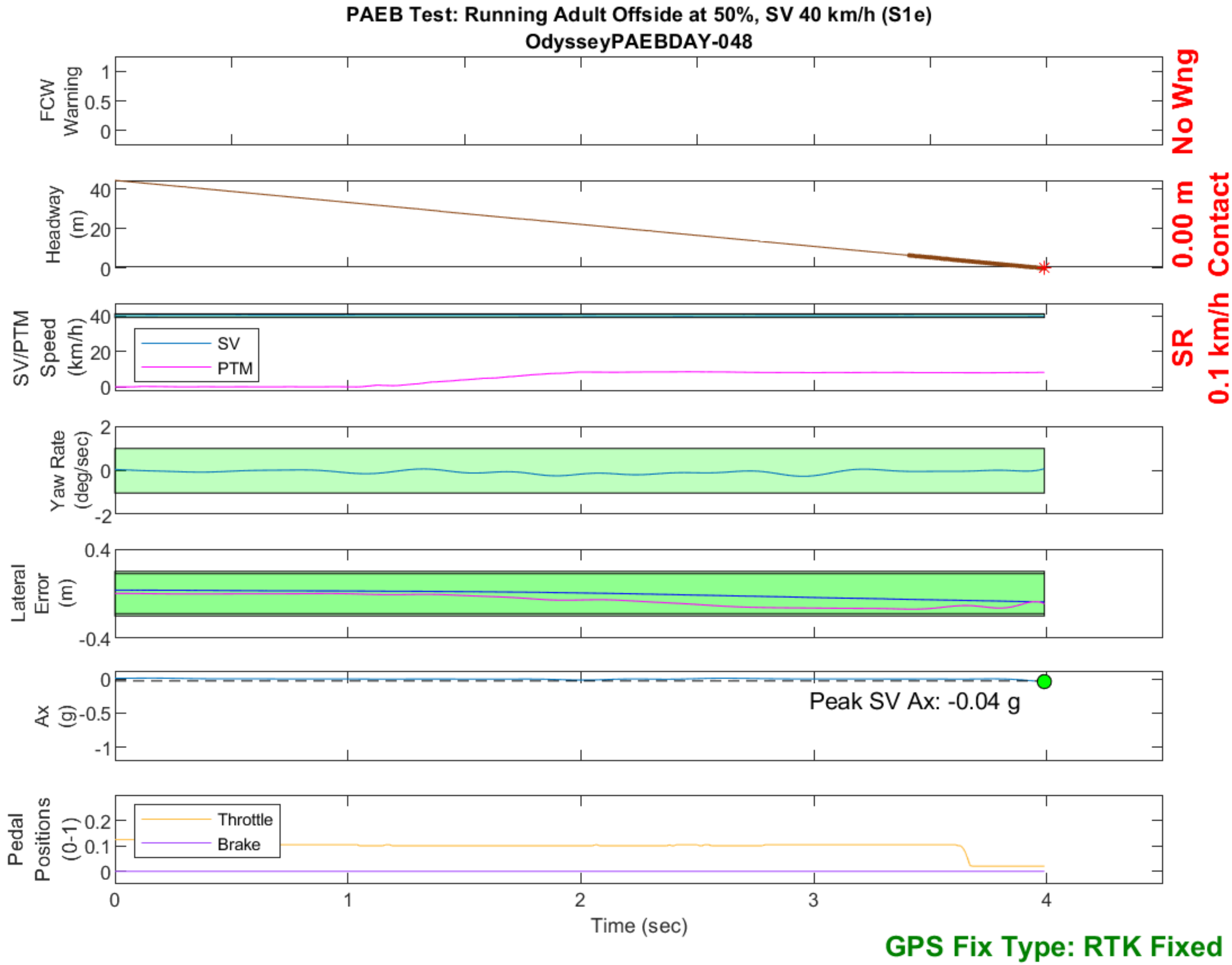


Figure D46. Time History for PAEB Run 48, S1e, Daytime, 40 km/h

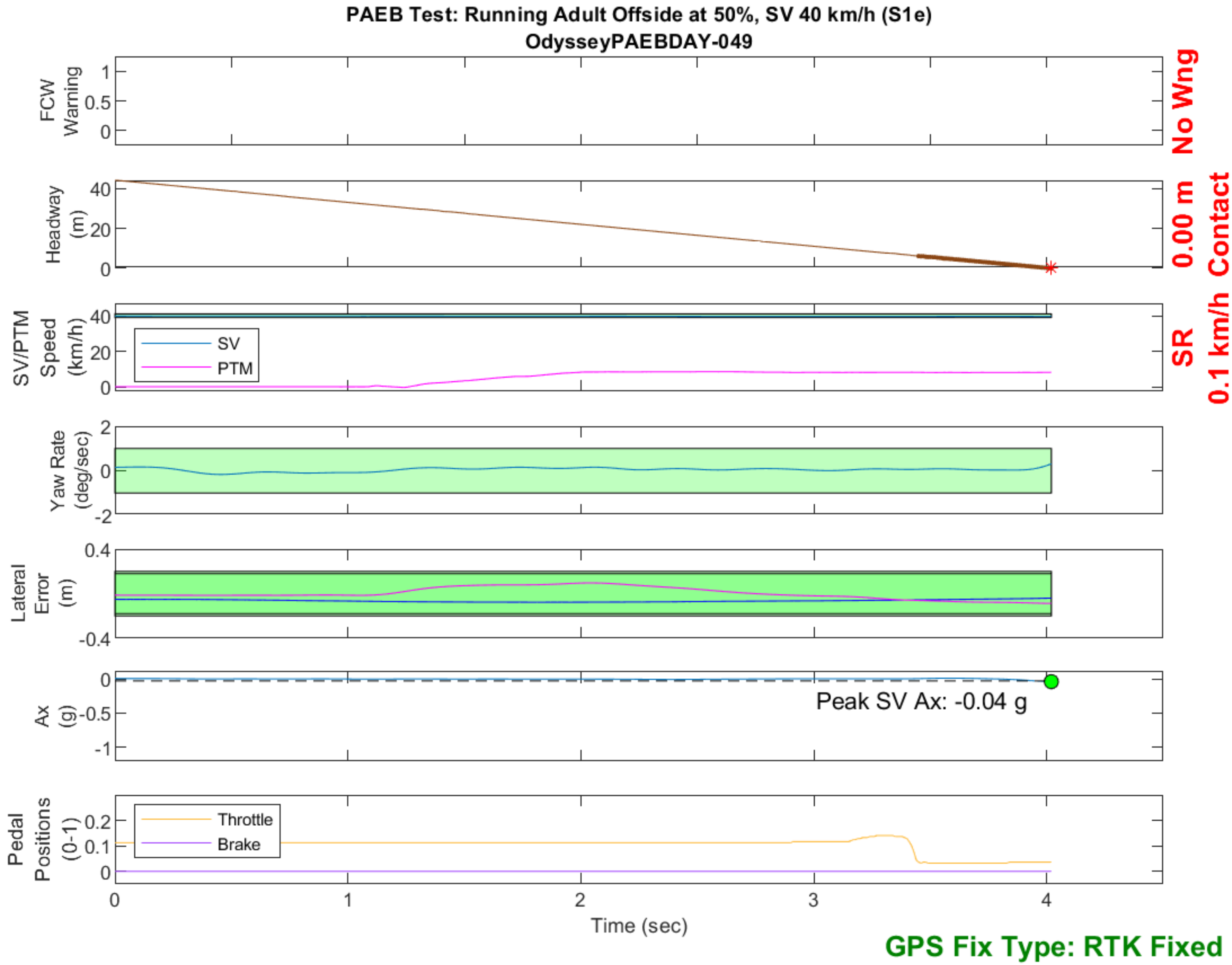


Figure D47. Time History for PAEB Run 49, S1e, Daytime, 40 km/h

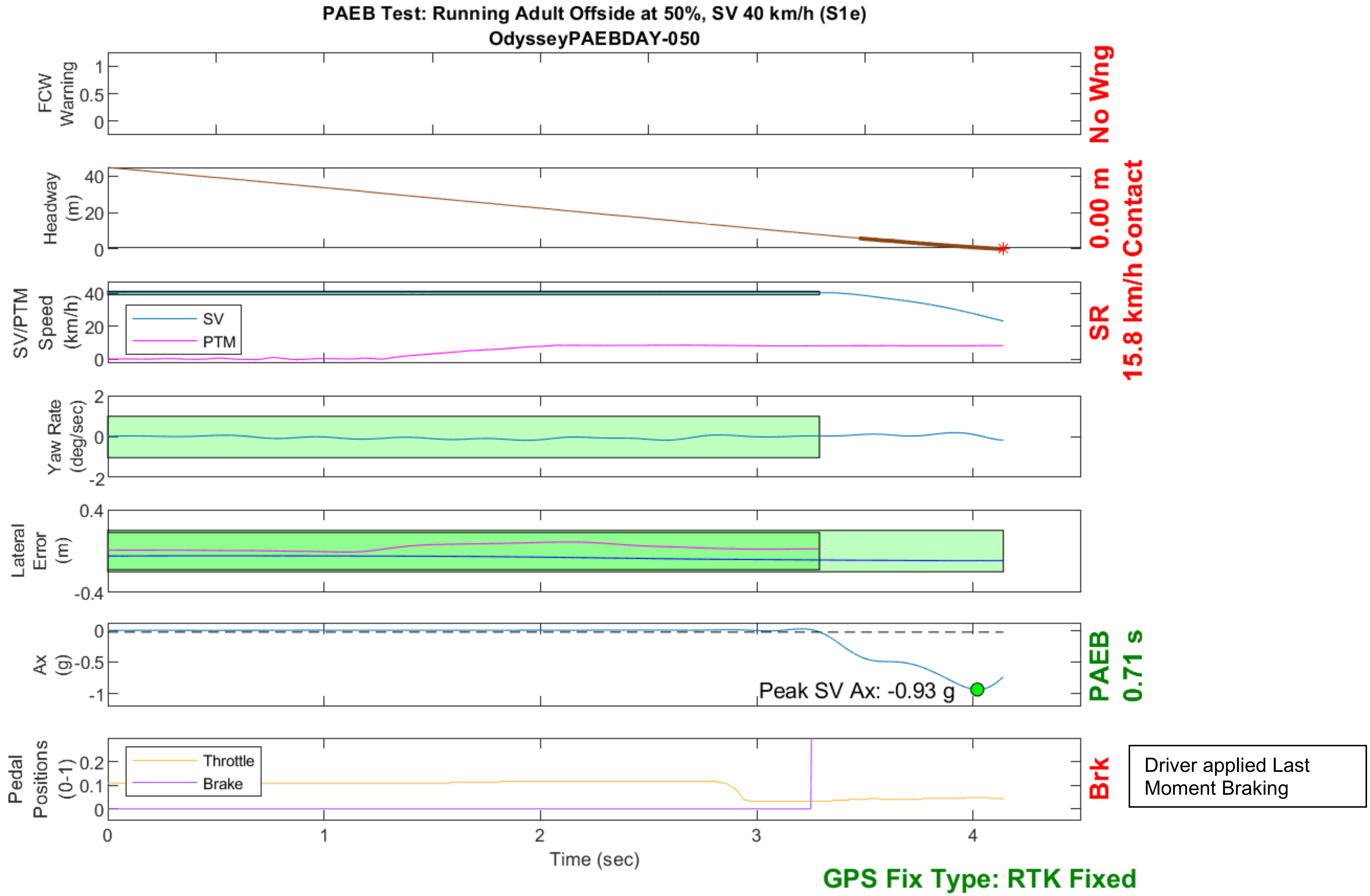


Figure D48. Time History for PAEB Run 50, S1e, Daytime, 40 km/h

Figure D49. Time History for PAEB Run 53, S1f, Daytime, 40 km/h

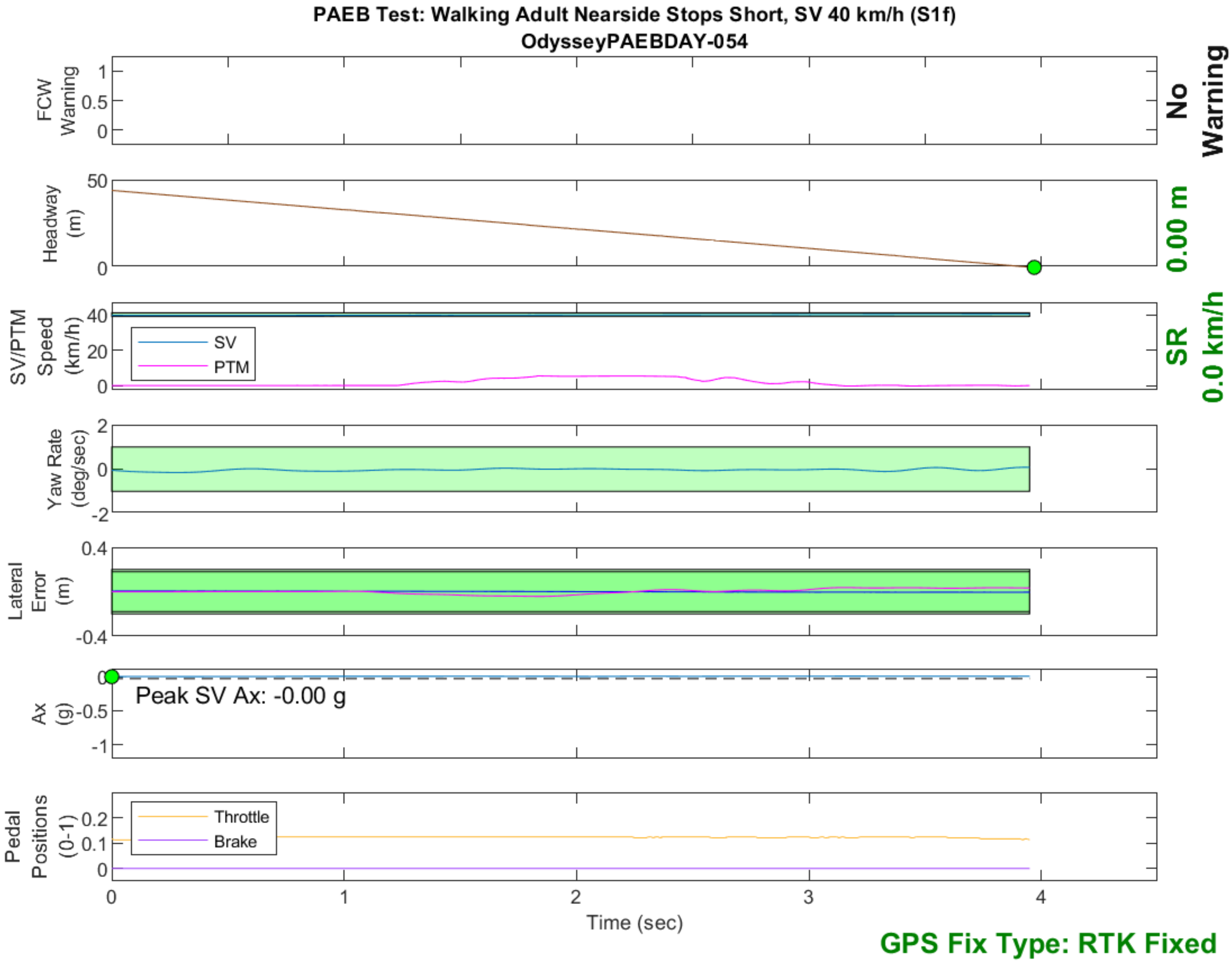


Figure D50. Time History for PAEB Run 54, S1f, Daytime, 40 km/h

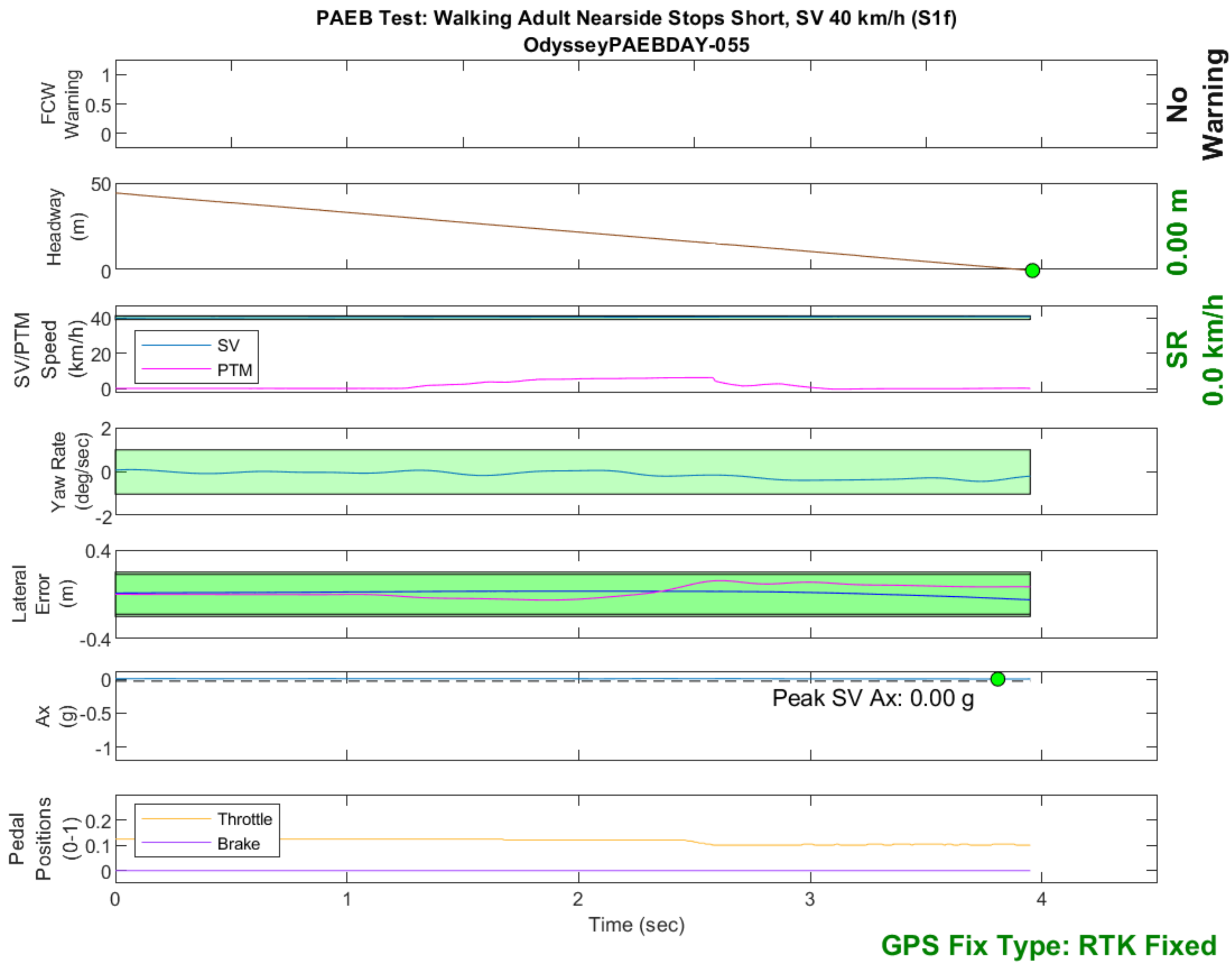


Figure D51. Time History for PAEB Run 55, S1f, Daytime, 40 km/h

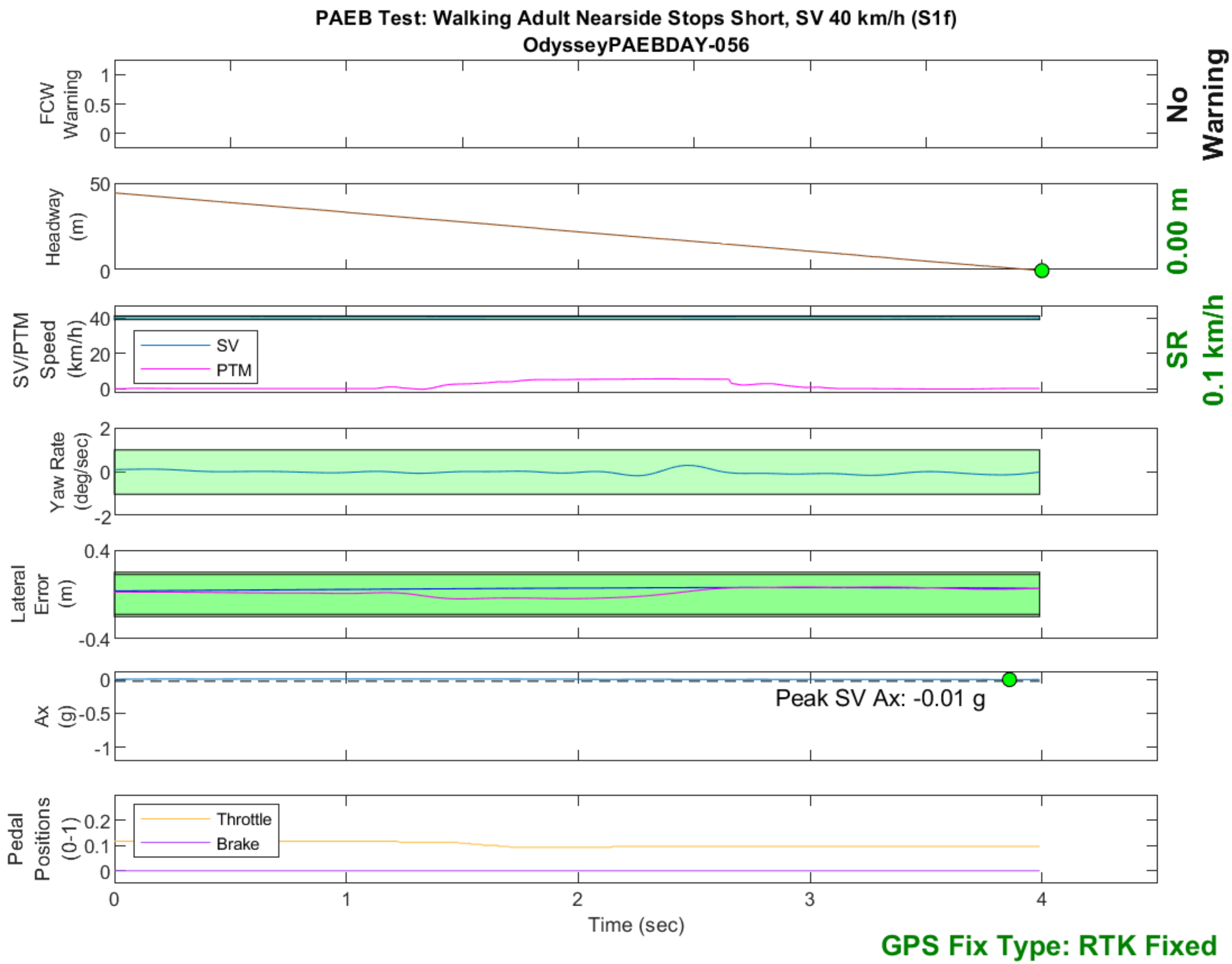


Figure D52. Time History for PAEB Run 56, S1f, Daytime, 40 km/h

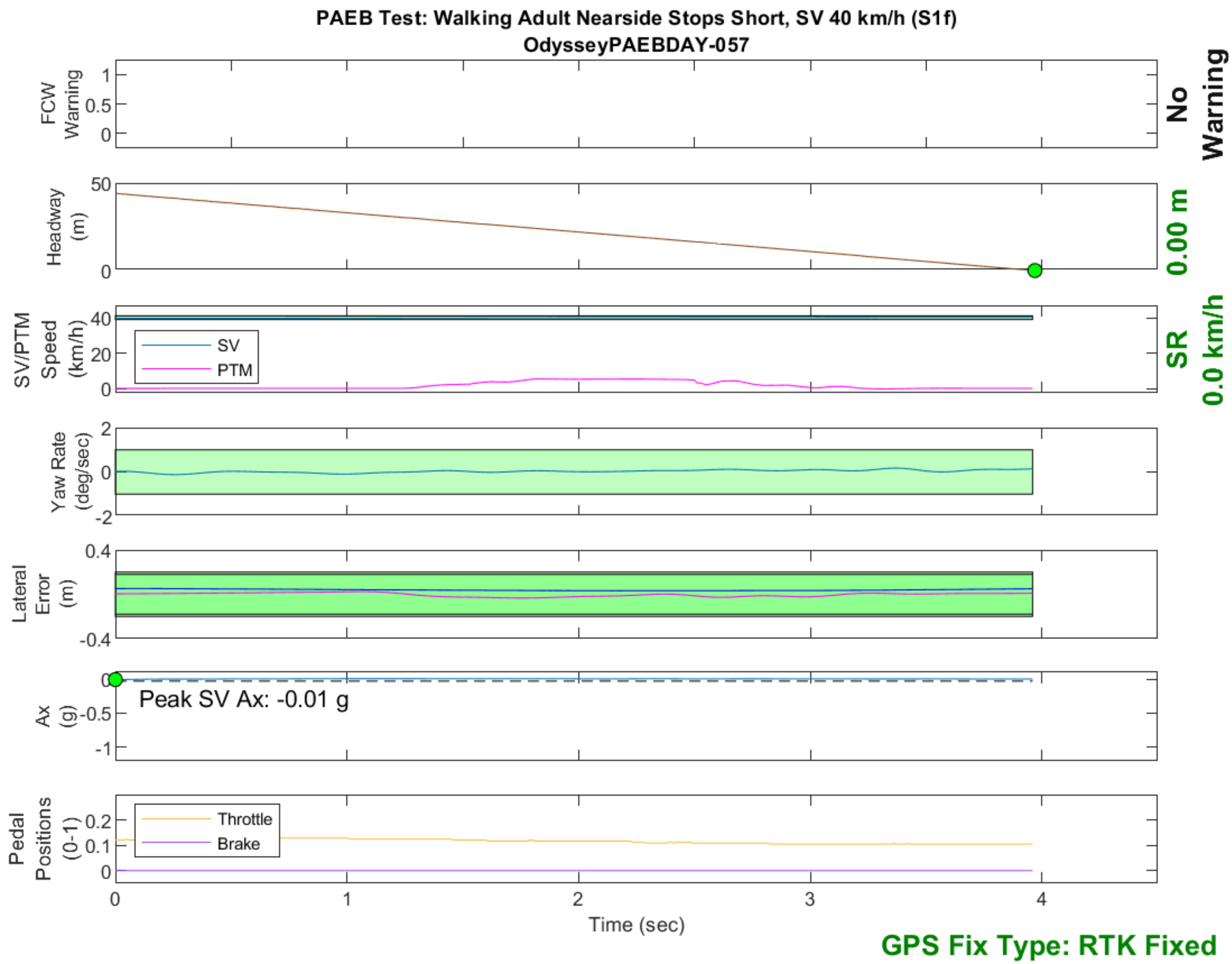


Figure D53. Time History for PAEB Run 57, S1f, Daytime, 40 km/h

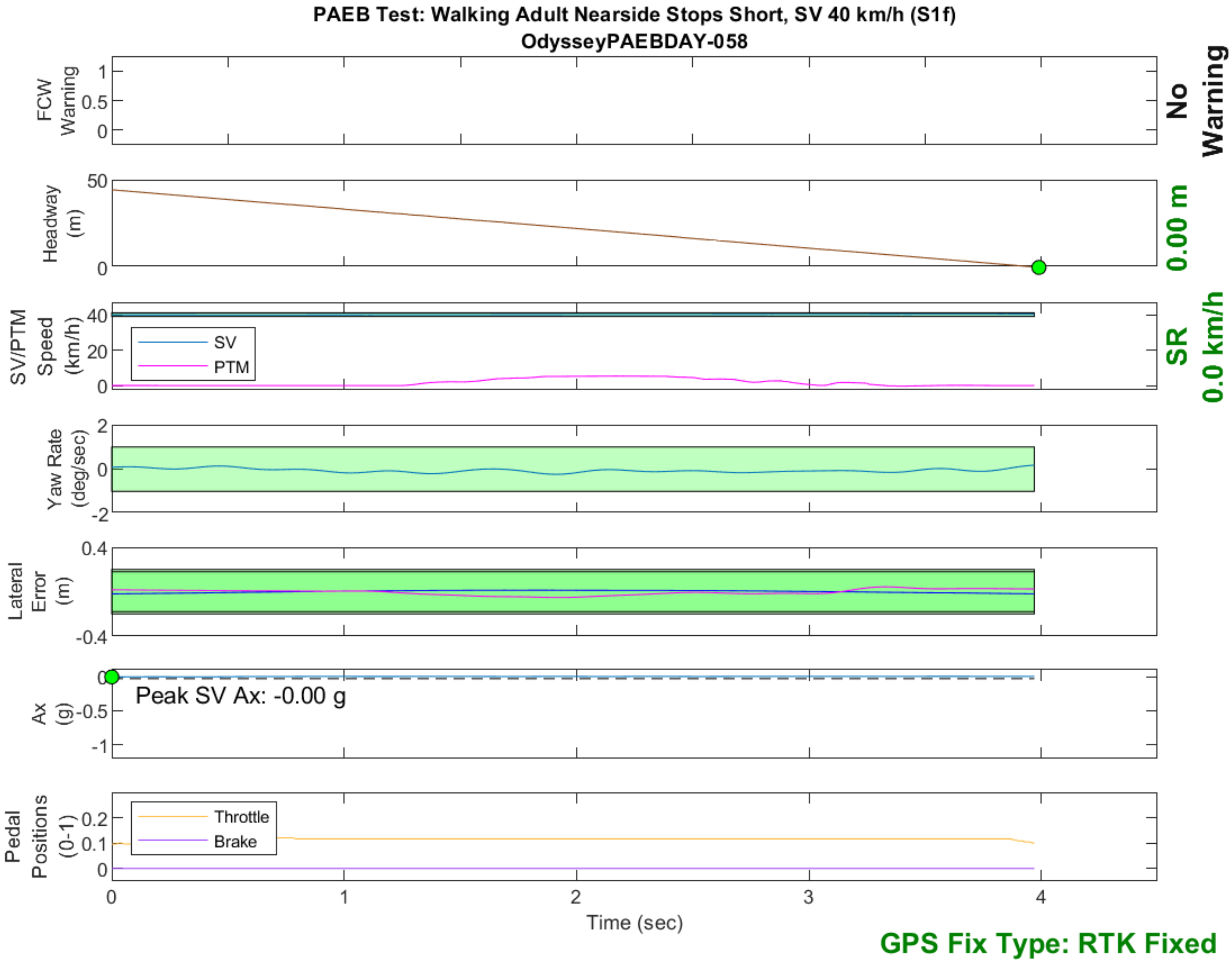


Figure D54. Time History for PAEB Run 58, S1f, Daytime, 40 km/h

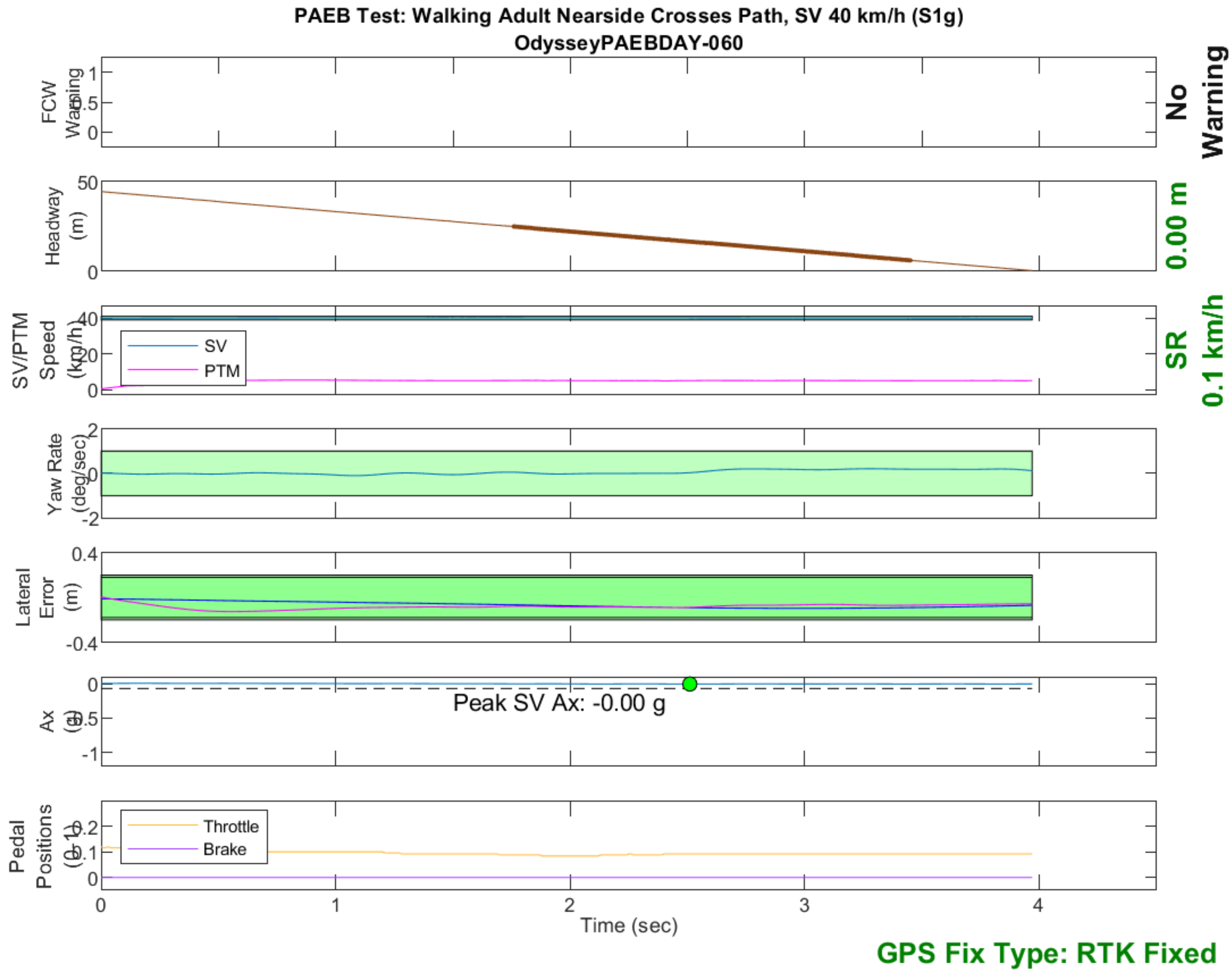


Figure D55. Time History for PAEB Run 60, S1g, Daytime, 40 km/h

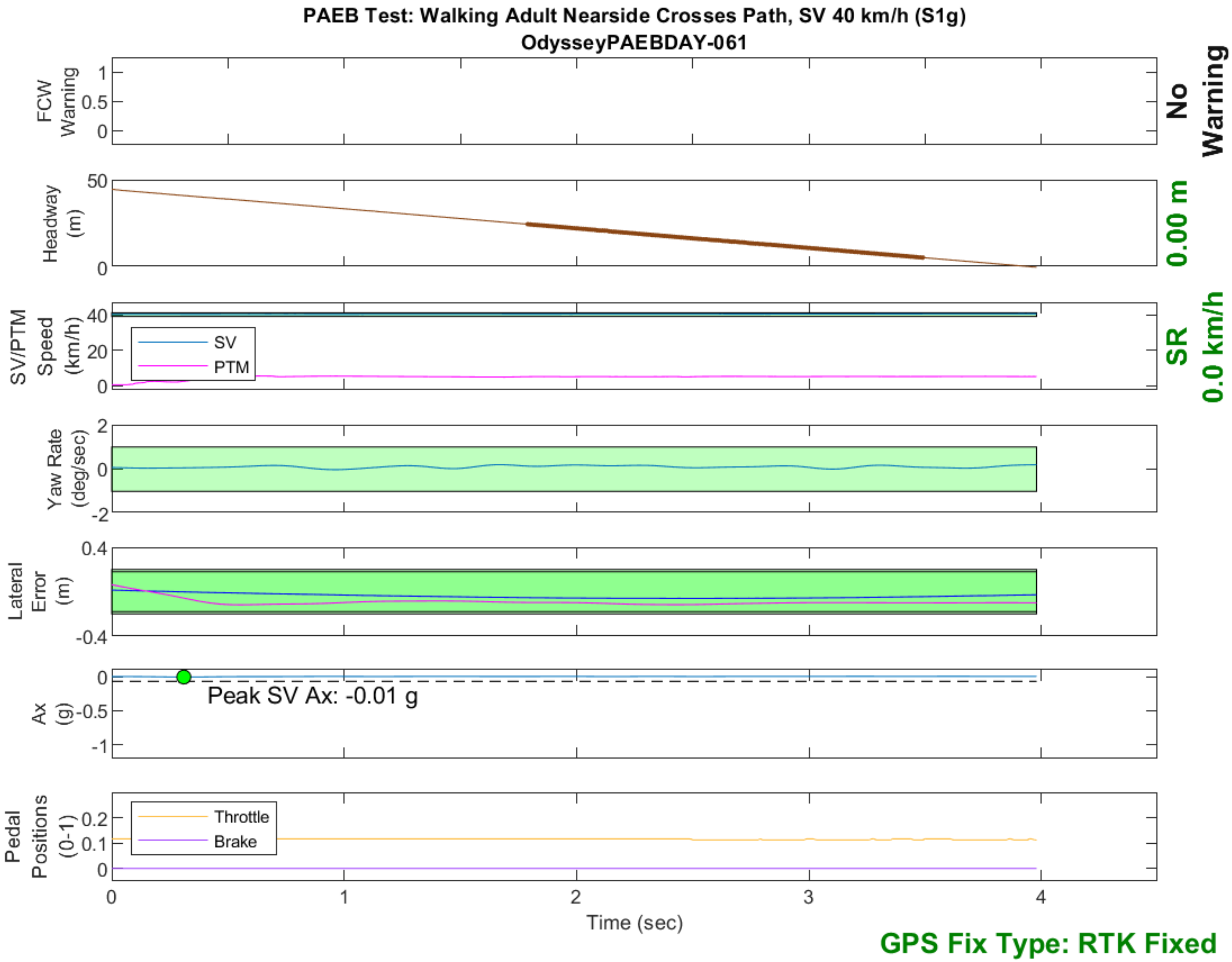


Figure D56. Time History for PAEB Run 61, S1g, Daytime, 40 km/h

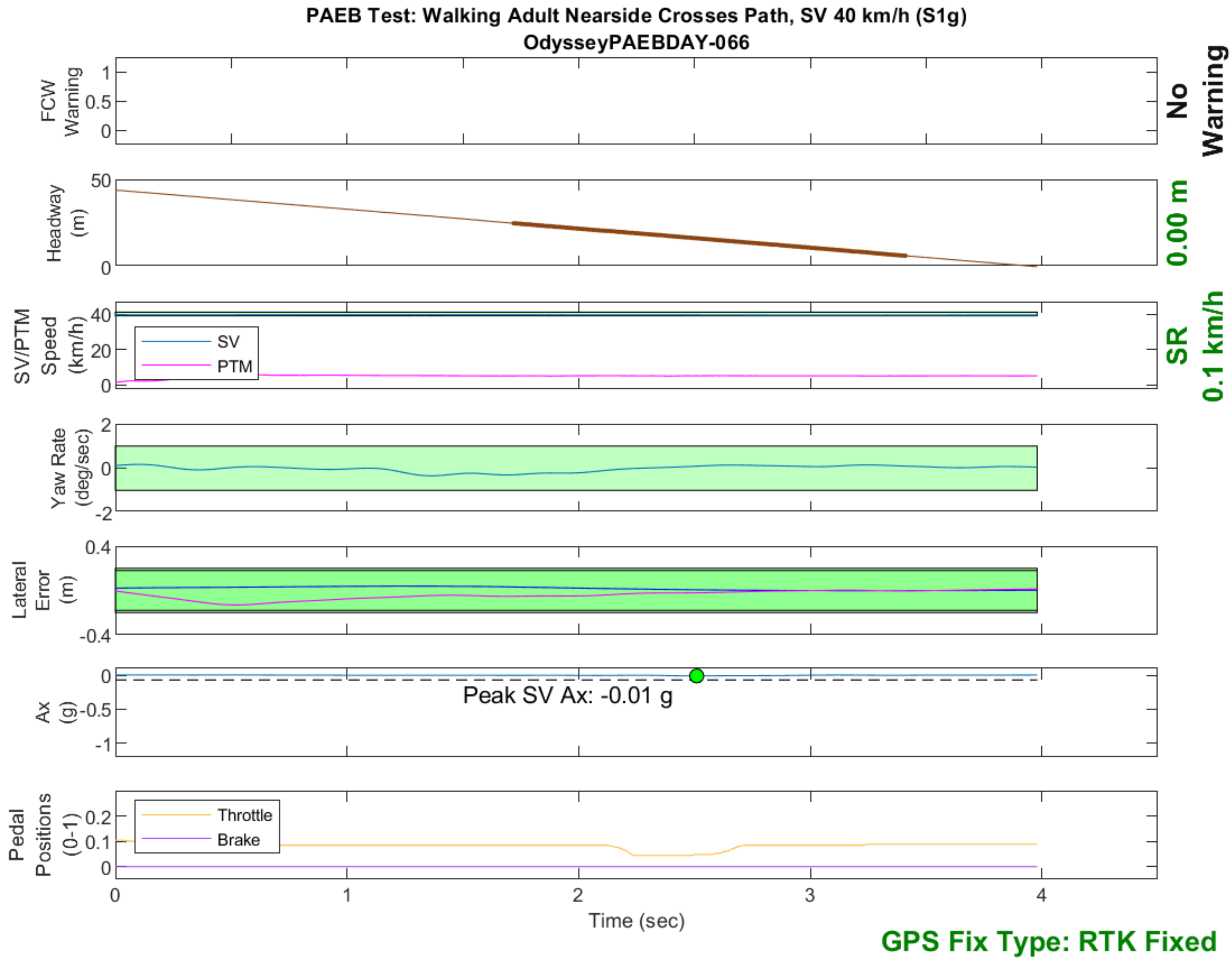


Figure D57. Time History for PAEB Run 66, S1g, Daytime, 40 km/h

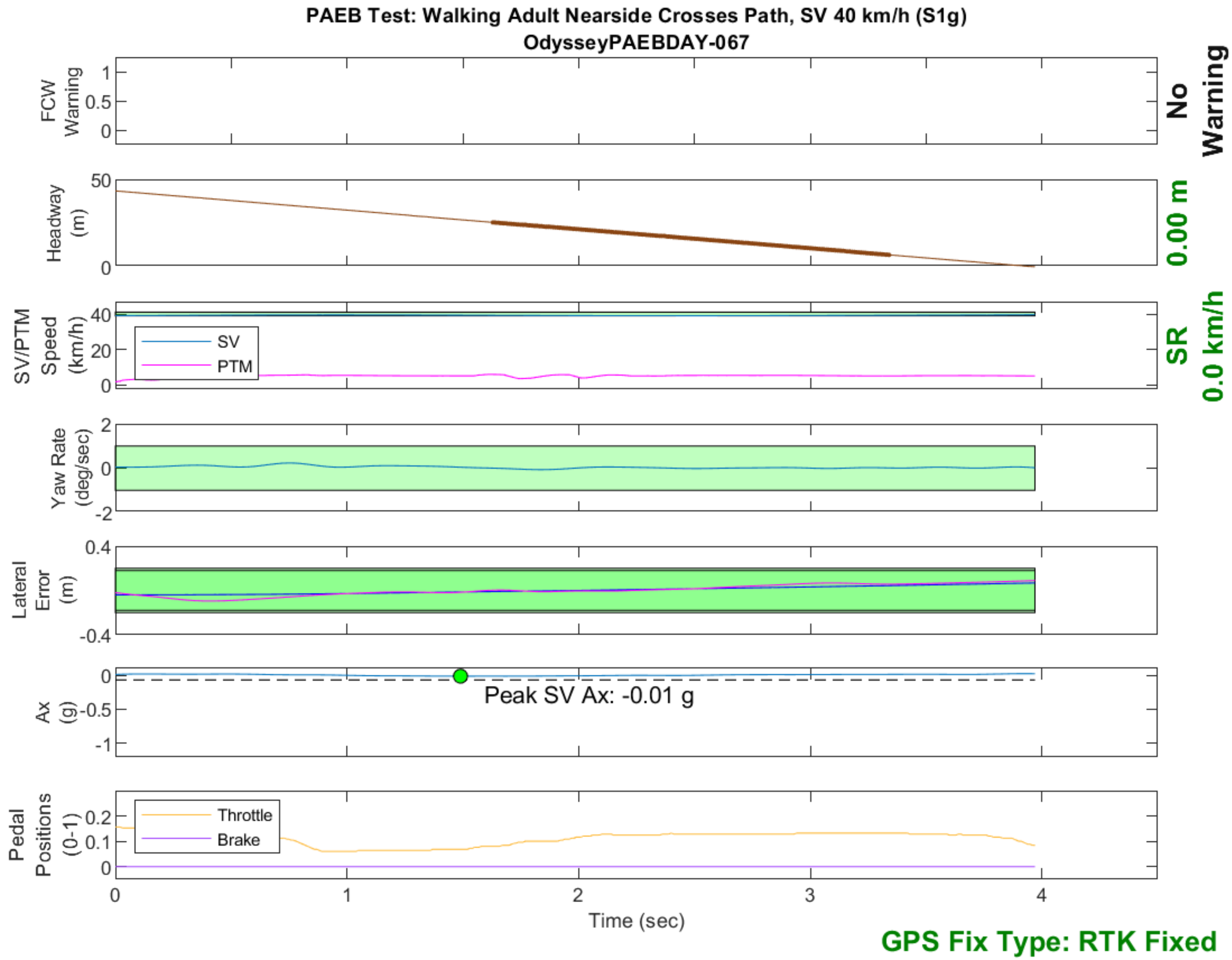


Figure D58. Time History for PAEB Run 67, S1g, Daytime, 40 km/h

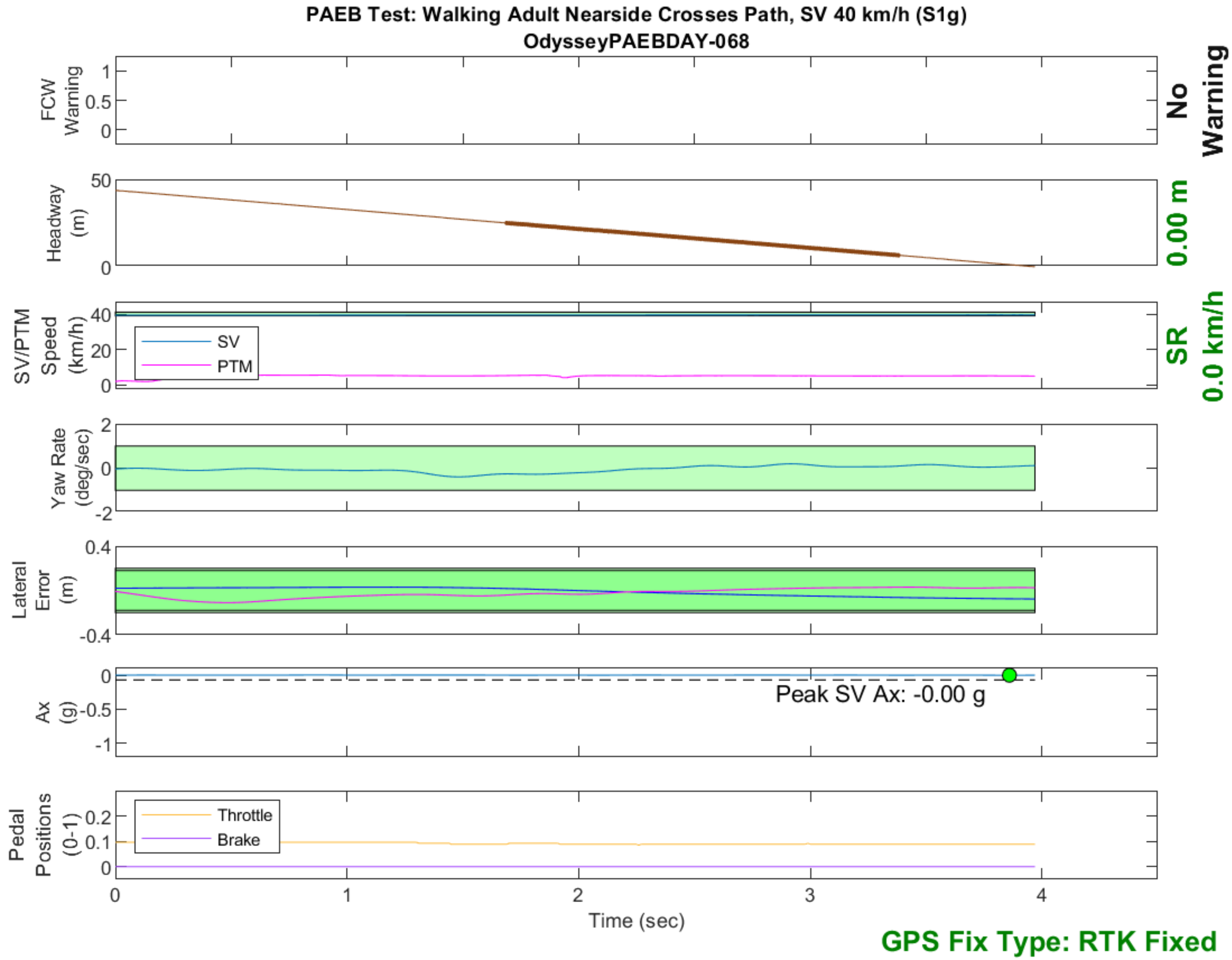


Figure D59. Time History for PAEB Run 68, S1g, Daytime, 40 km/h

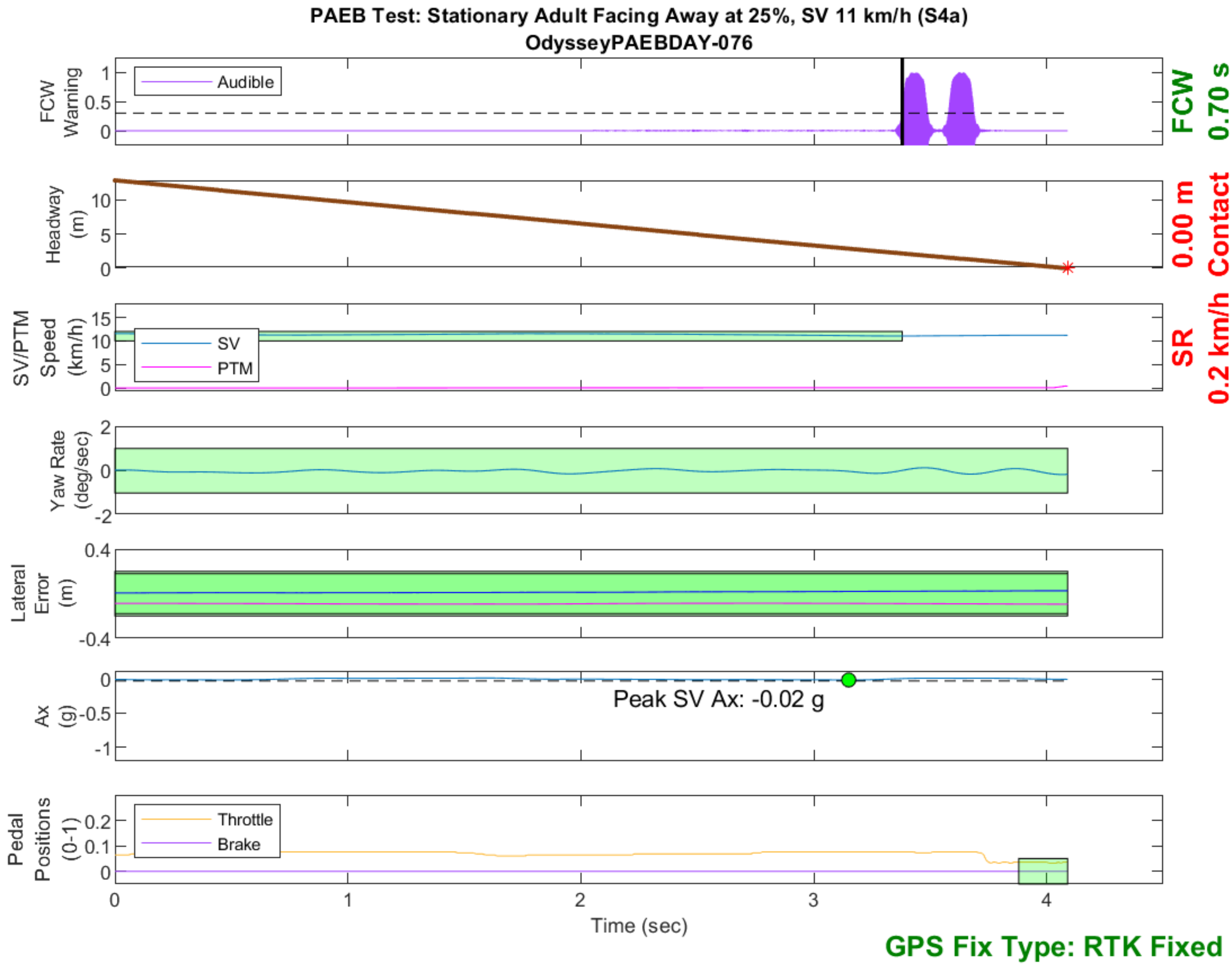


Figure D60. Time History for PAEB Run 76, S4a, Daytime, 11 km/h

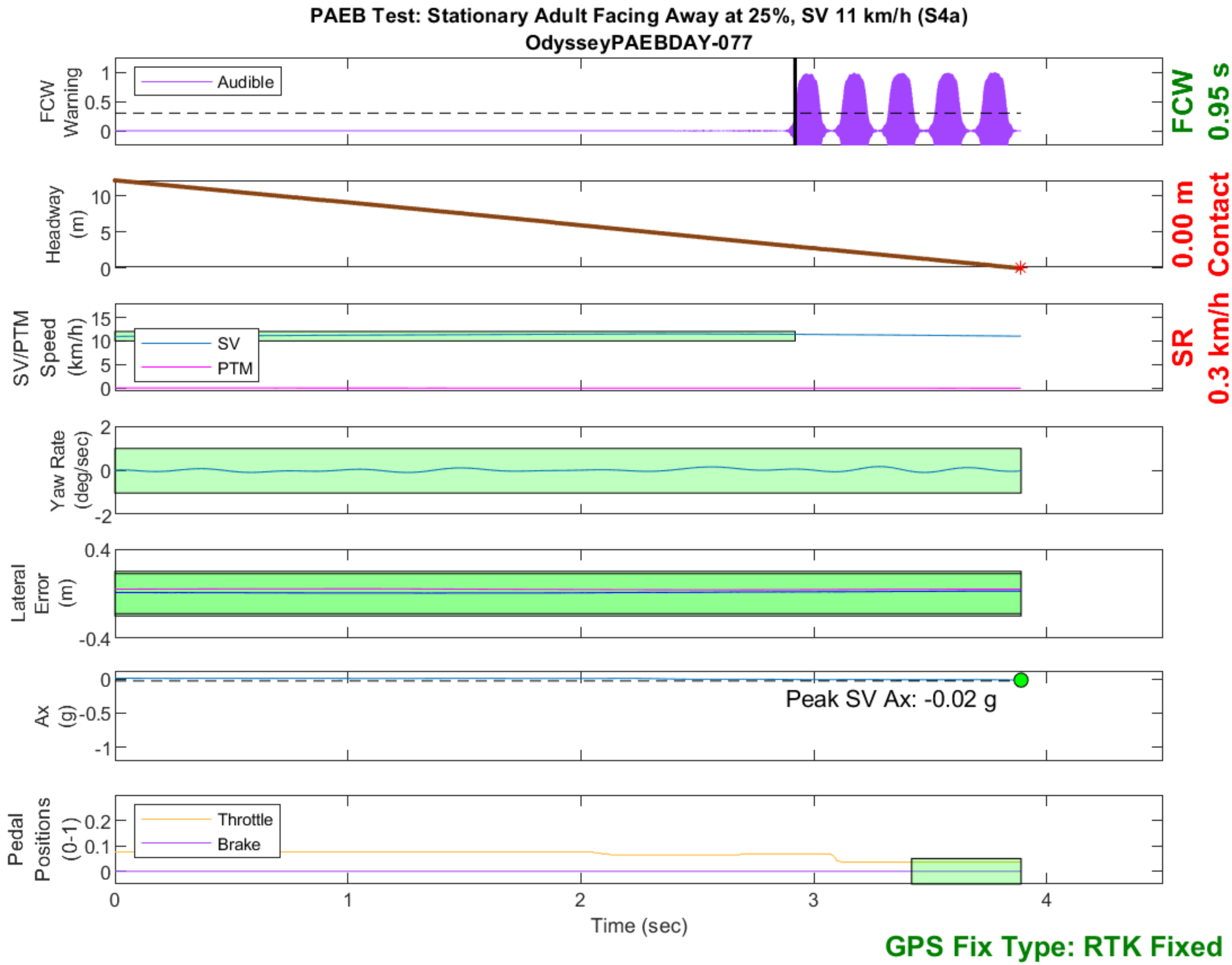


Figure D61. Time History for PAEB Run 77, S4a, Daytime, 11 km/h

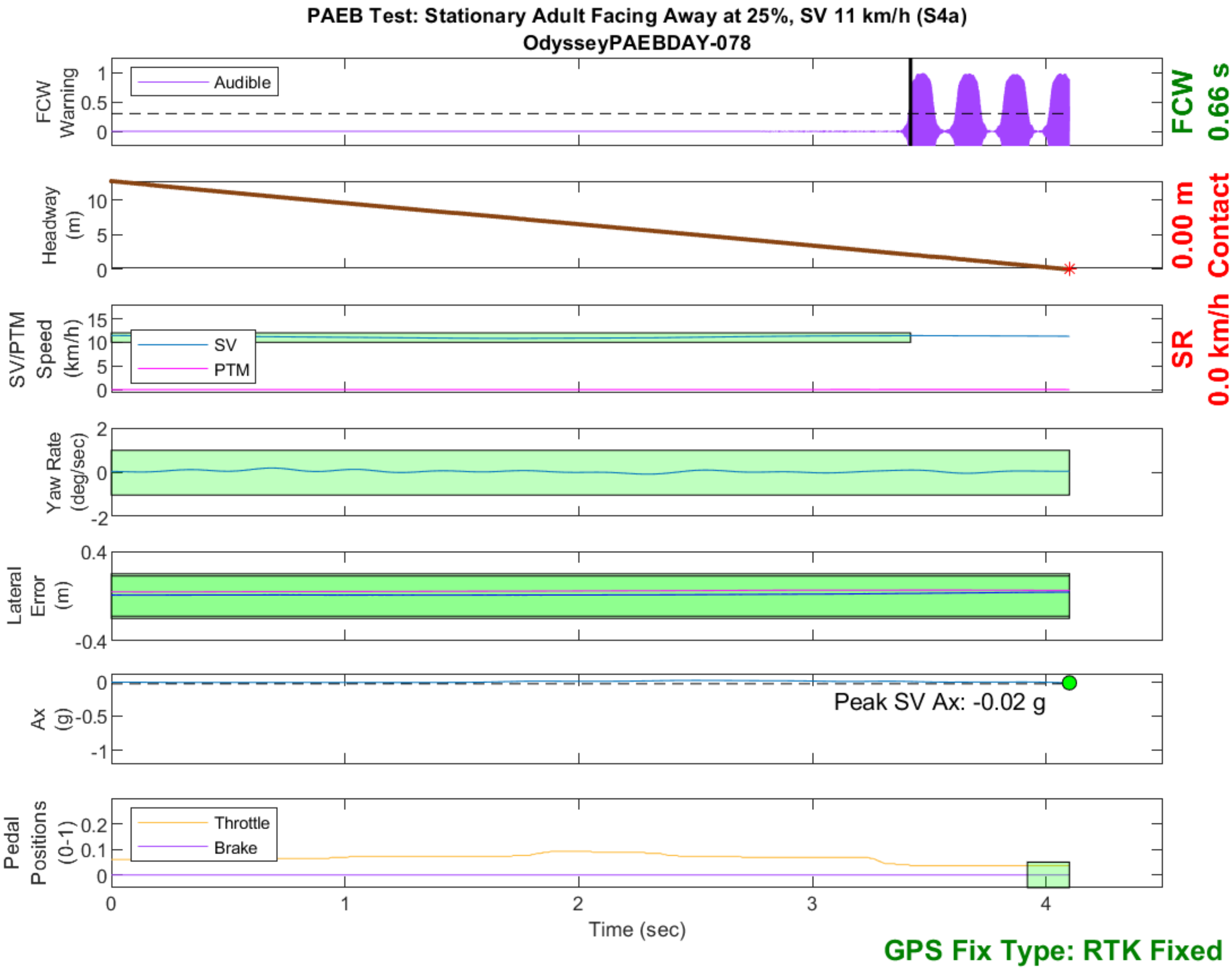


Figure D62. Time History for PAEB Run 78, S4a, Daytime, 11 km/h

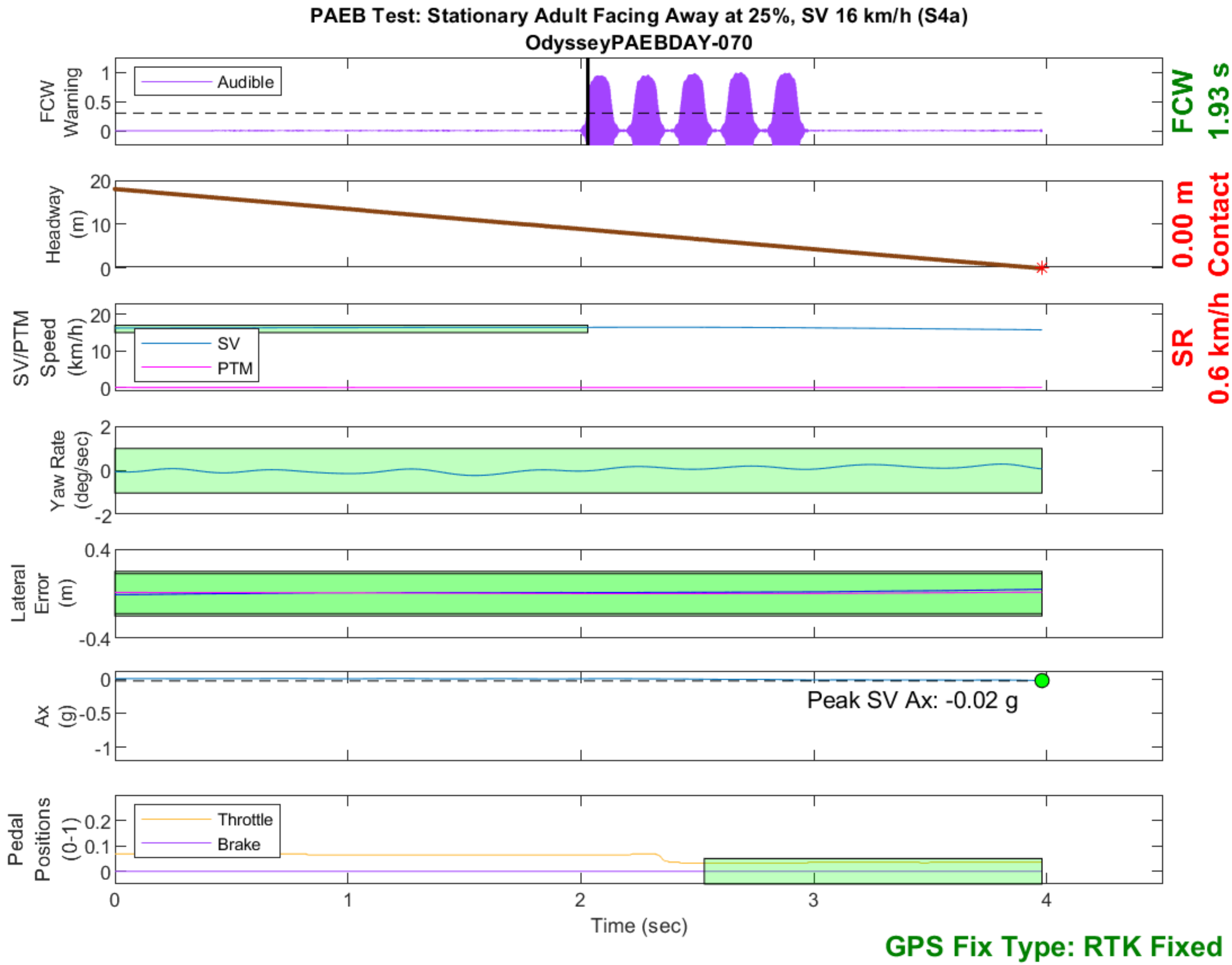


Figure D63. Time History for PAEB Run 70, S4a, Daytime, 16 km/h

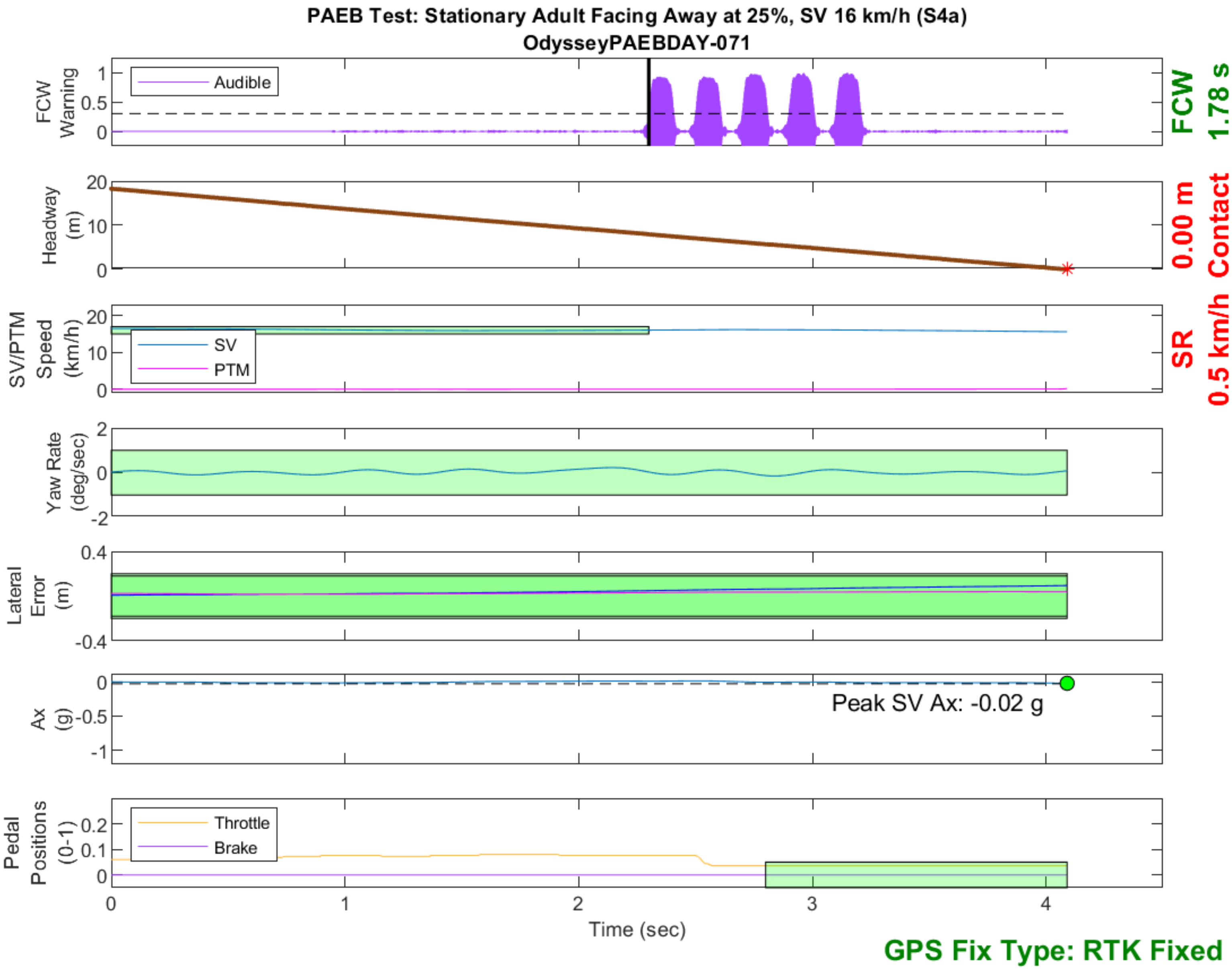


Figure D64. Time History for PAEB Run 71, S4a, Daytime, 16 km/h

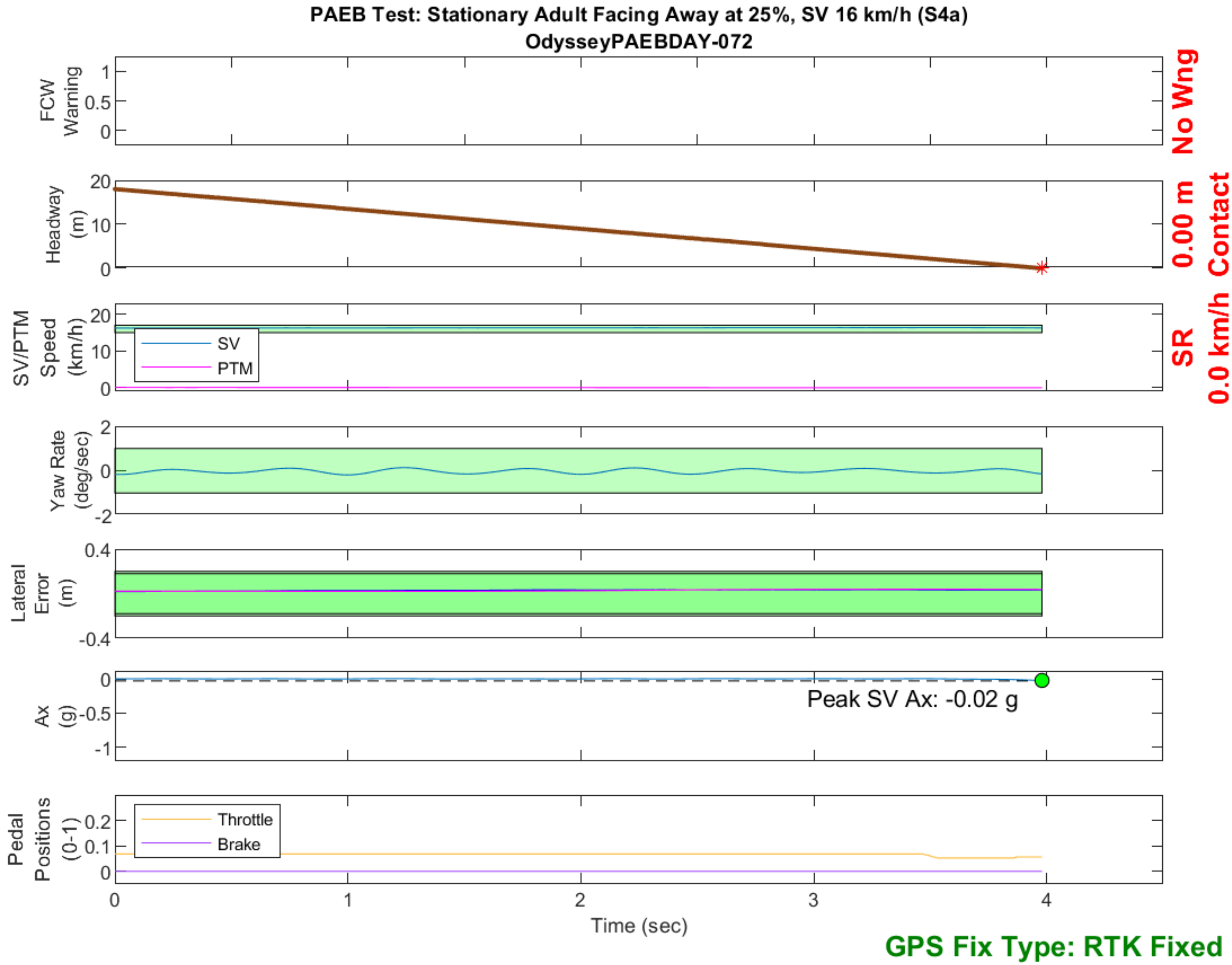


Figure D65. Time History for PAEB Run 72, S4a, Daytime, 16 km/h

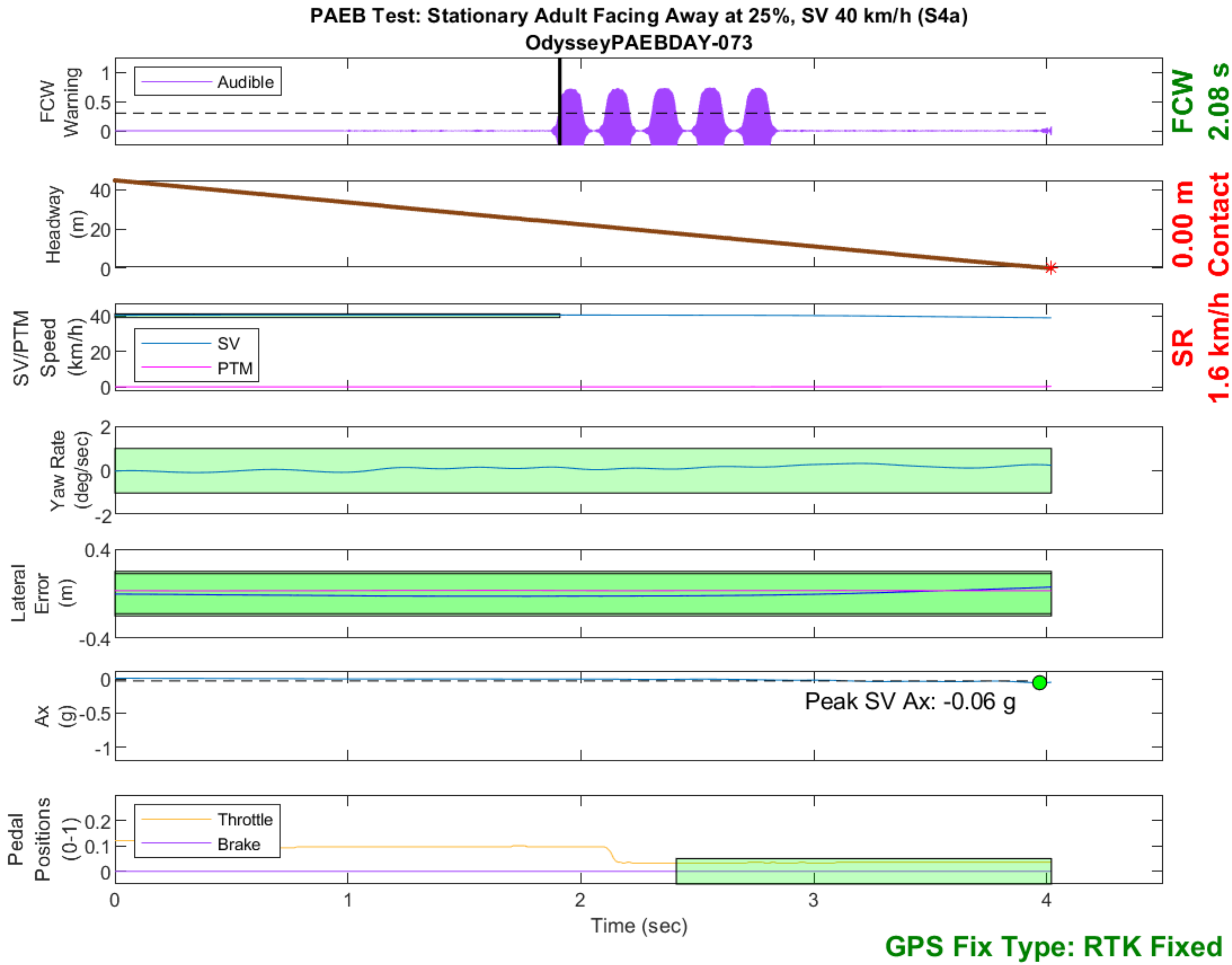


Figure D66. Time History for PAEB Run 73, S4a, Daytime, 40 km/h

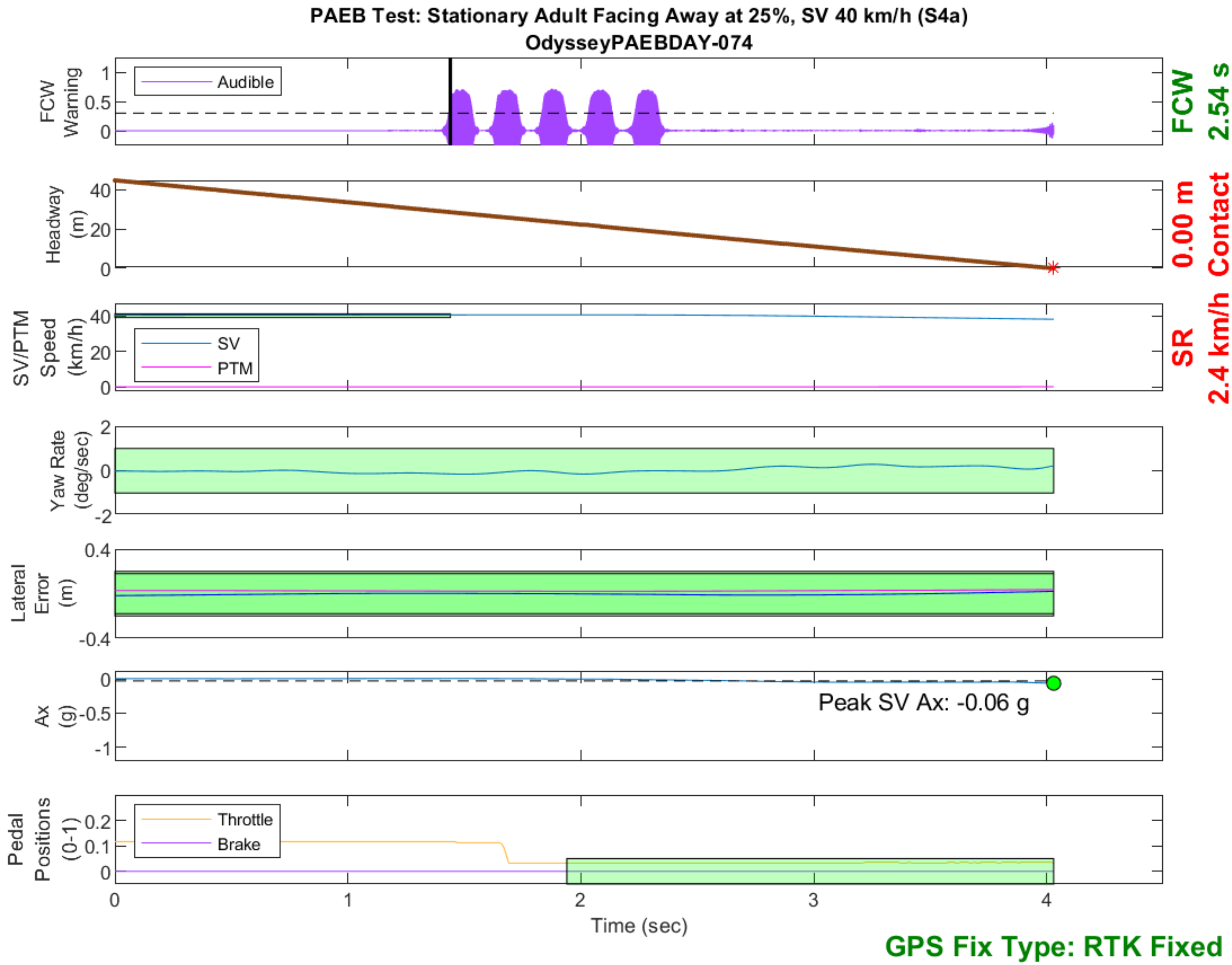


Figure D67. Time History for PAEB Run 74, S4a, Daytime, 40 km/h

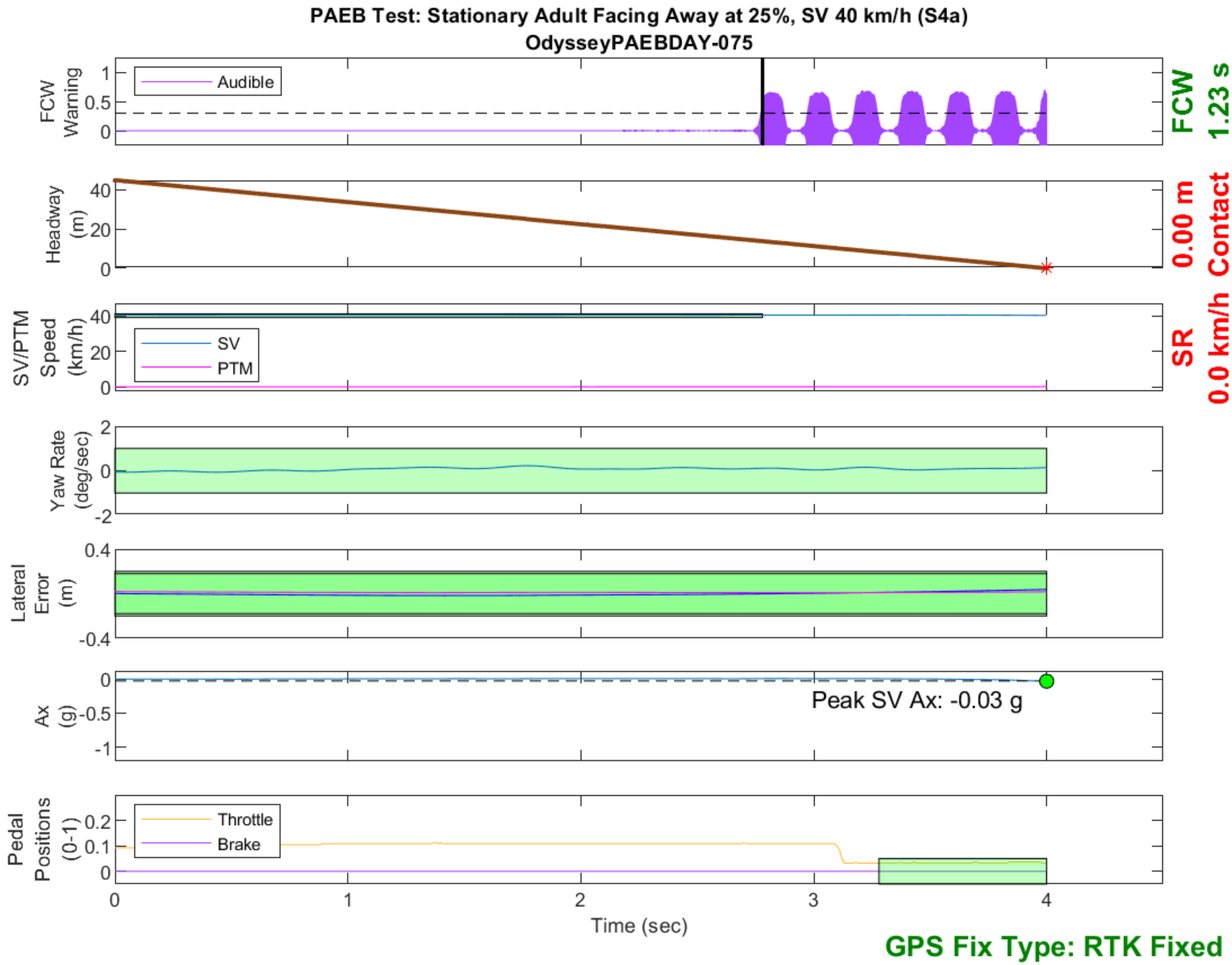


Figure D68. Time History for PAEB Run 75, S4a, Daytime, 40 km/h

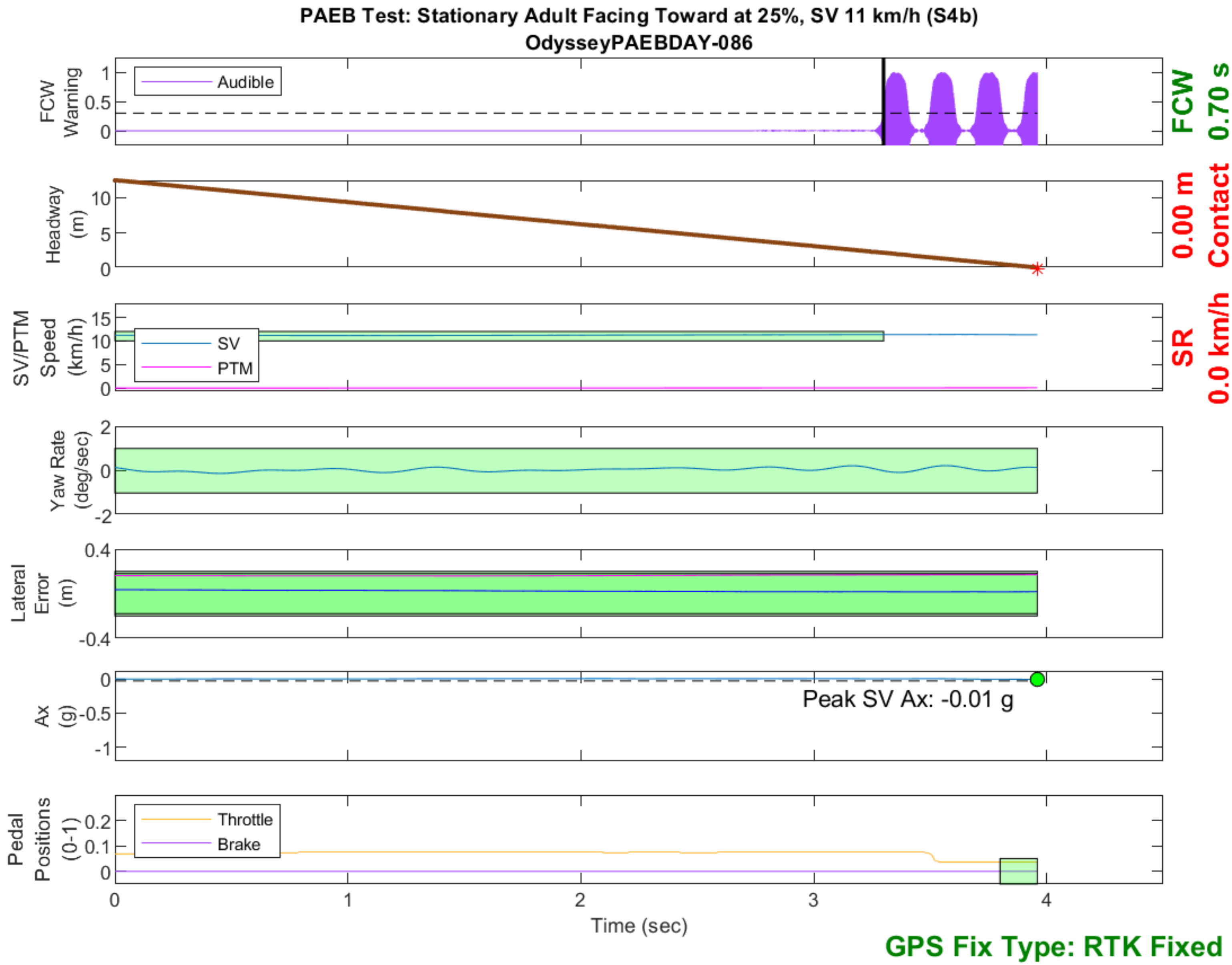


Figure D69. Time History for PAEB Run 86, S4b, Daytime, 11 km/h

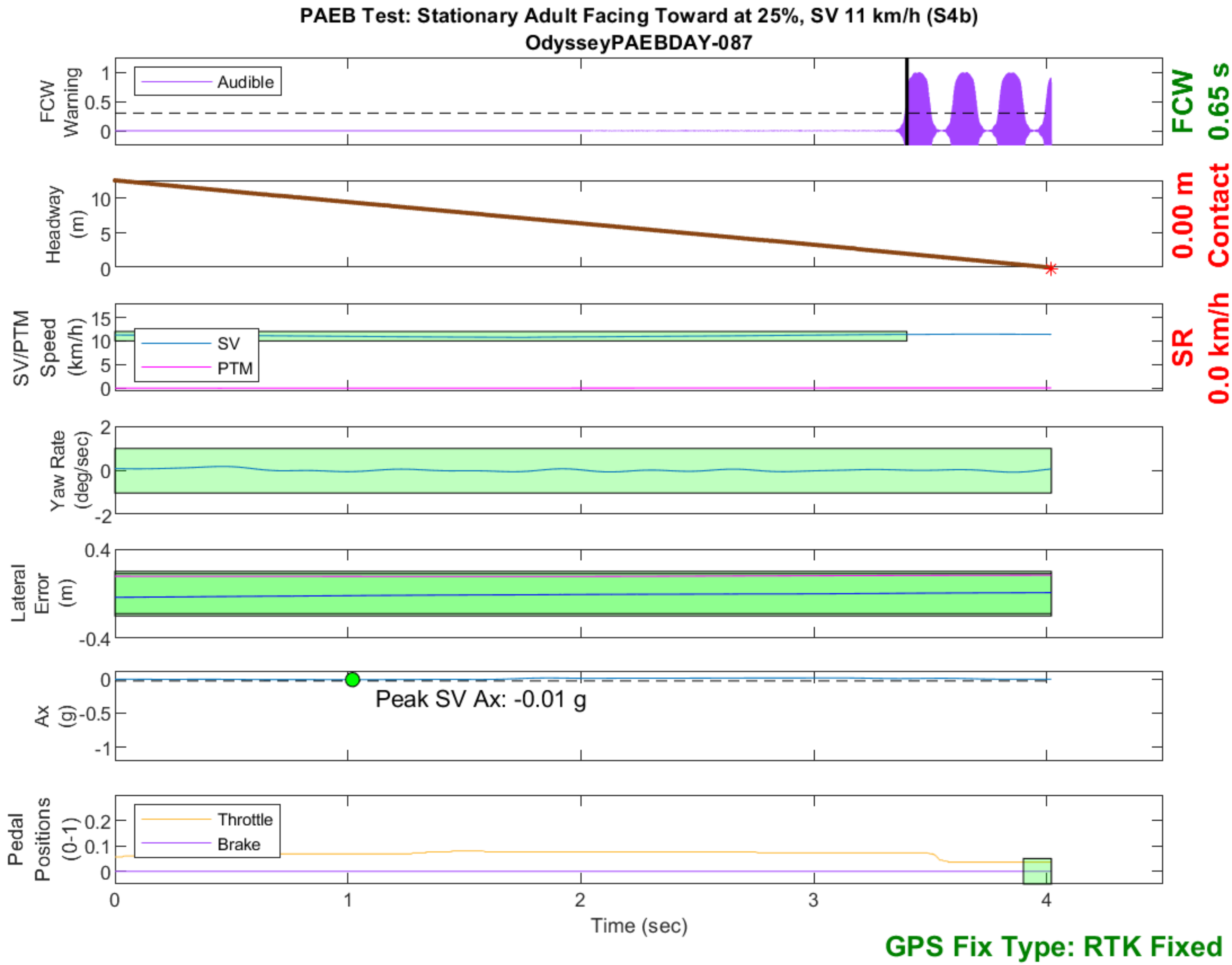


Figure D70. Time History for PAEB Run 87, S4b, Daytime, 11 km/h

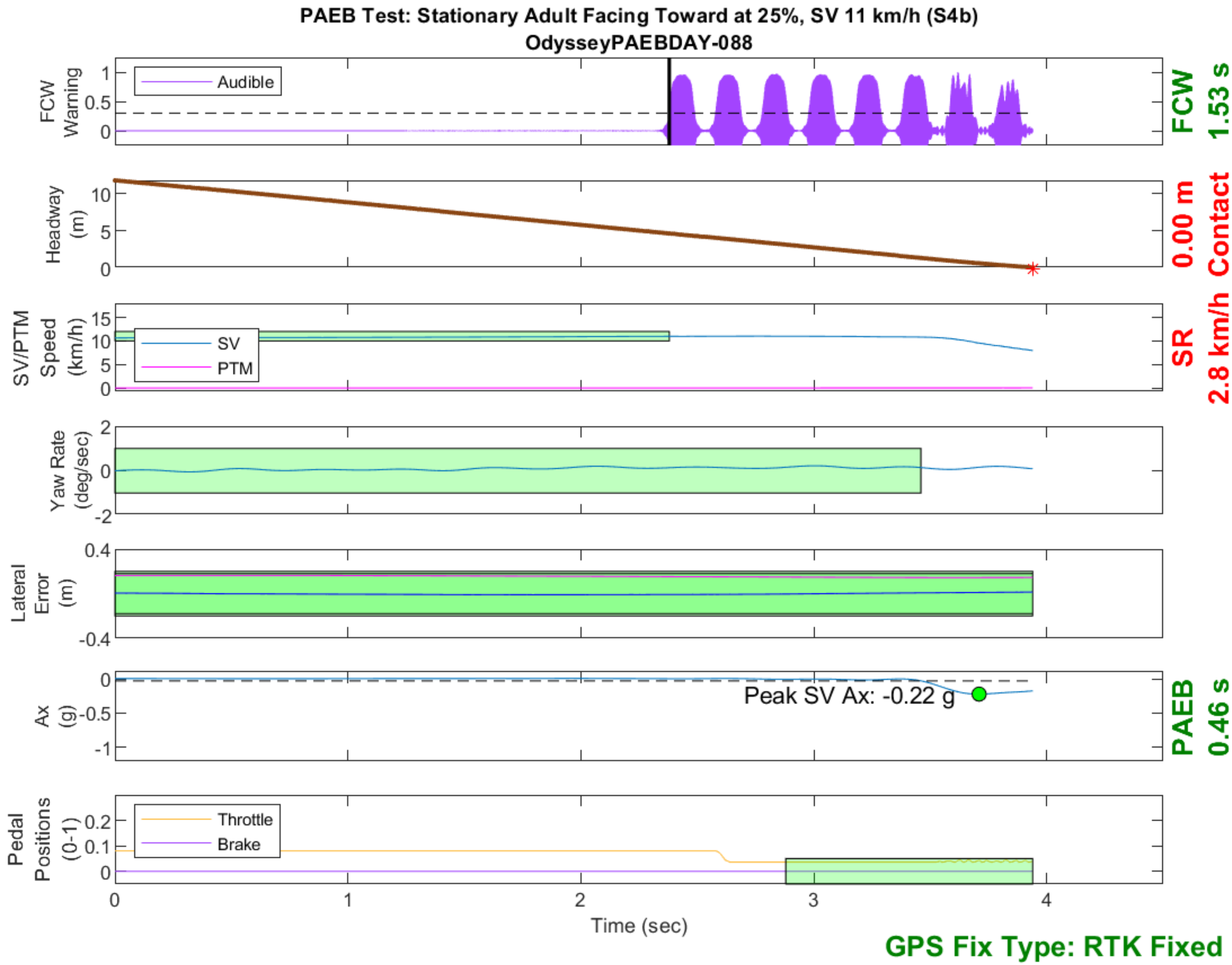


Figure D71. Time History for PAEB Run 88, S4b, Daytime, 11 km/h

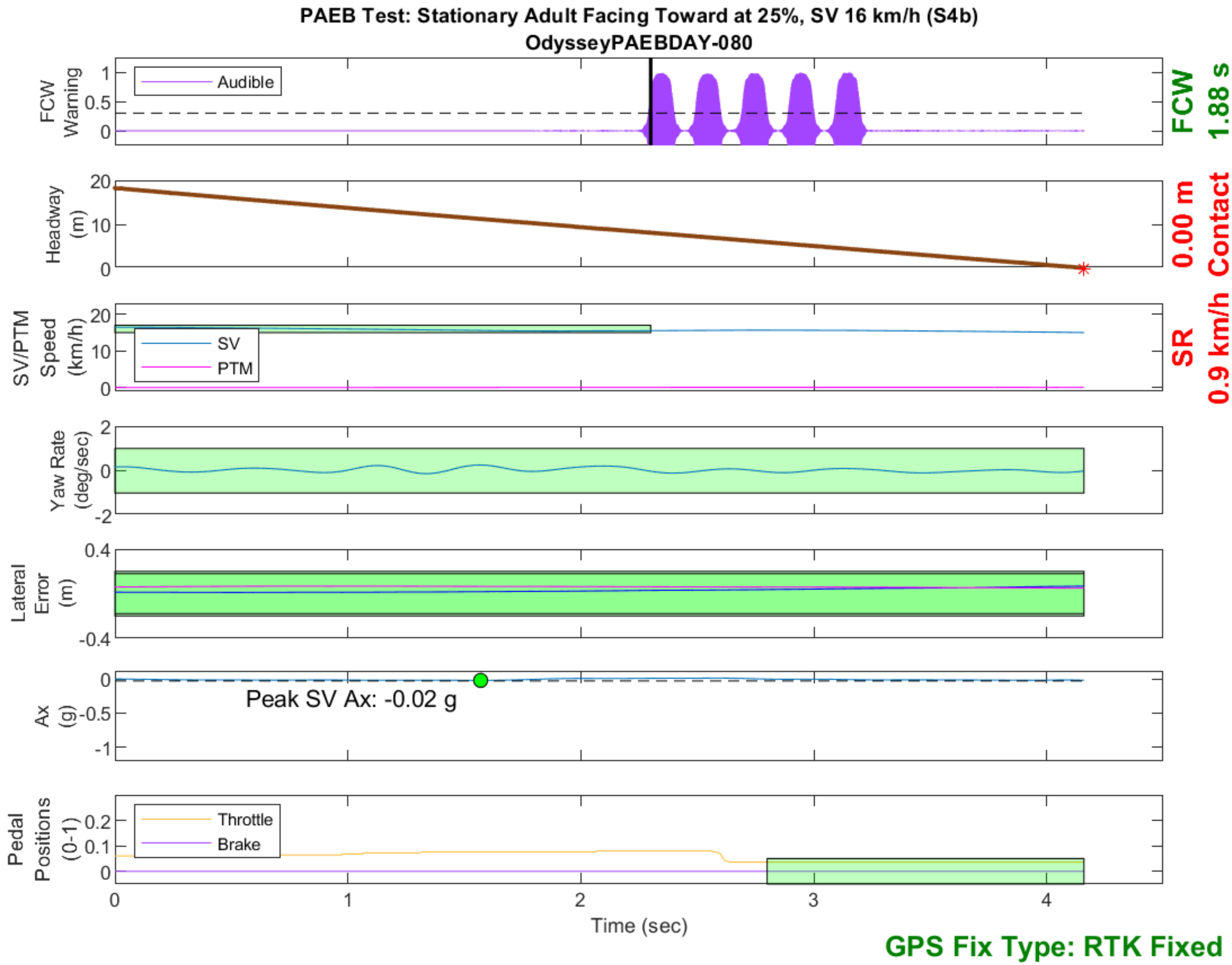


Figure D72. Time History for PAEB Run 80, S4b, Daytime, 16 km/h

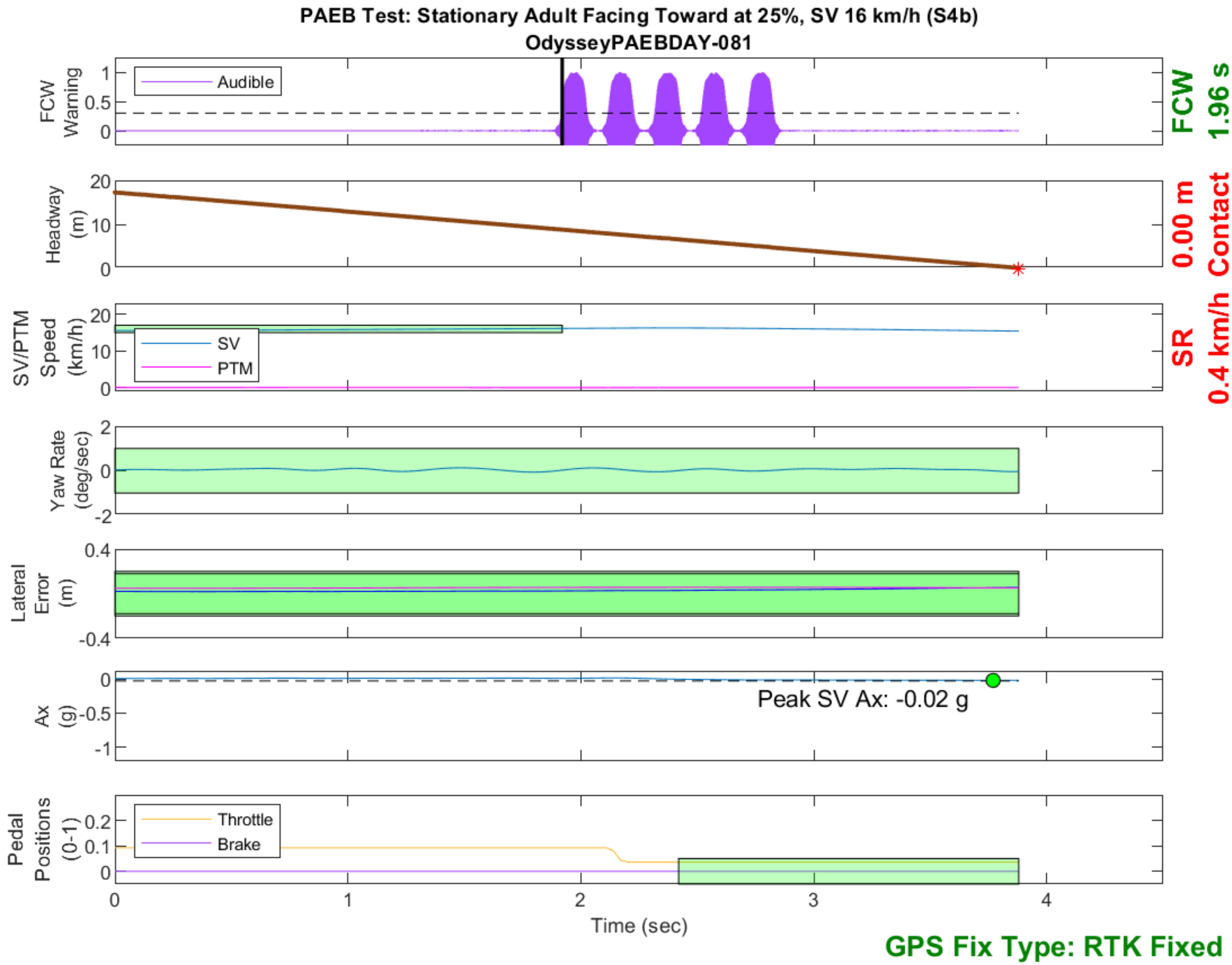


Figure D73. Time History for PAEB Run 81, S4b, Daytime, 16 km/h

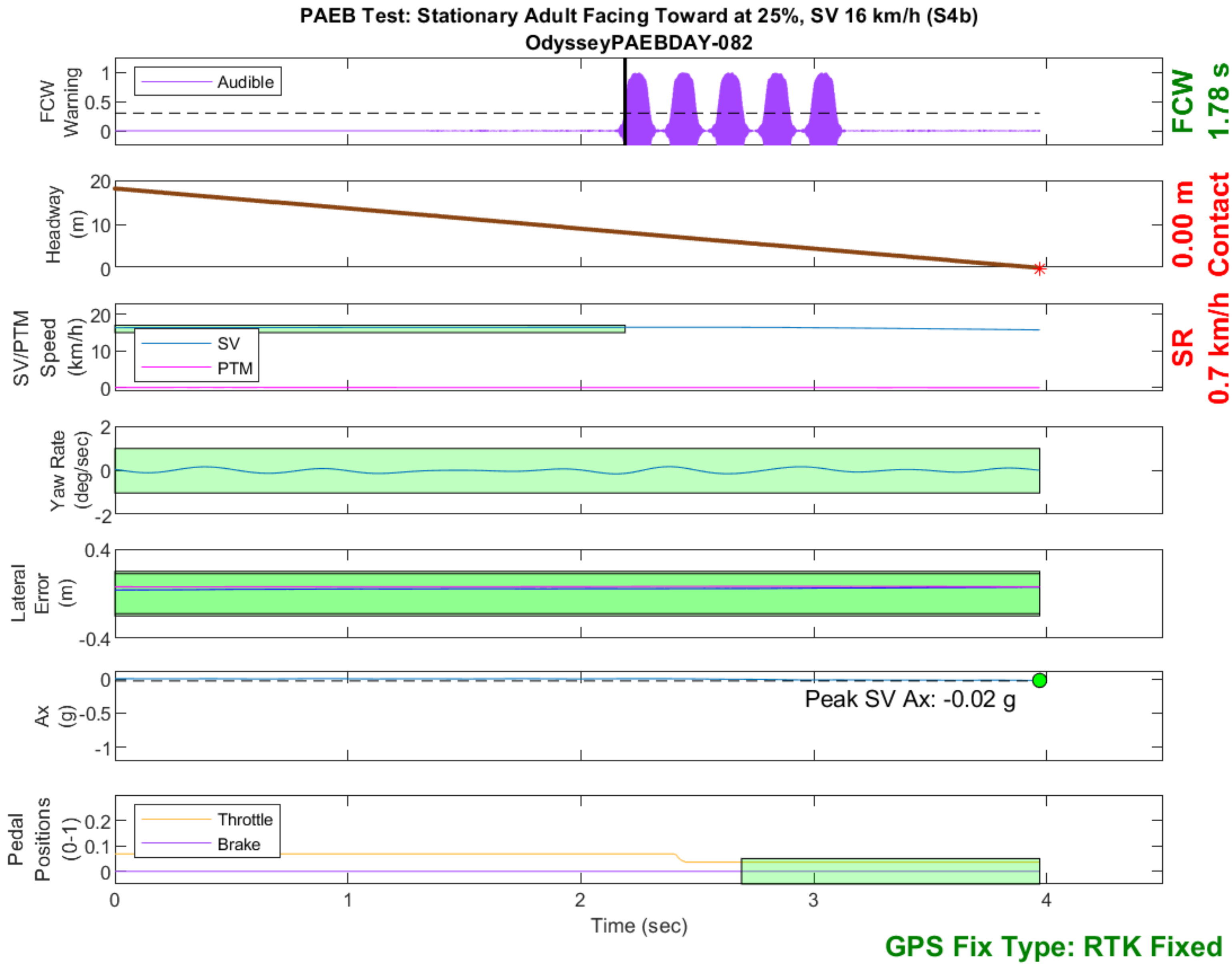


Figure D74. Time History for PAEB Run 82, S4b, Daytime, 16 km/h

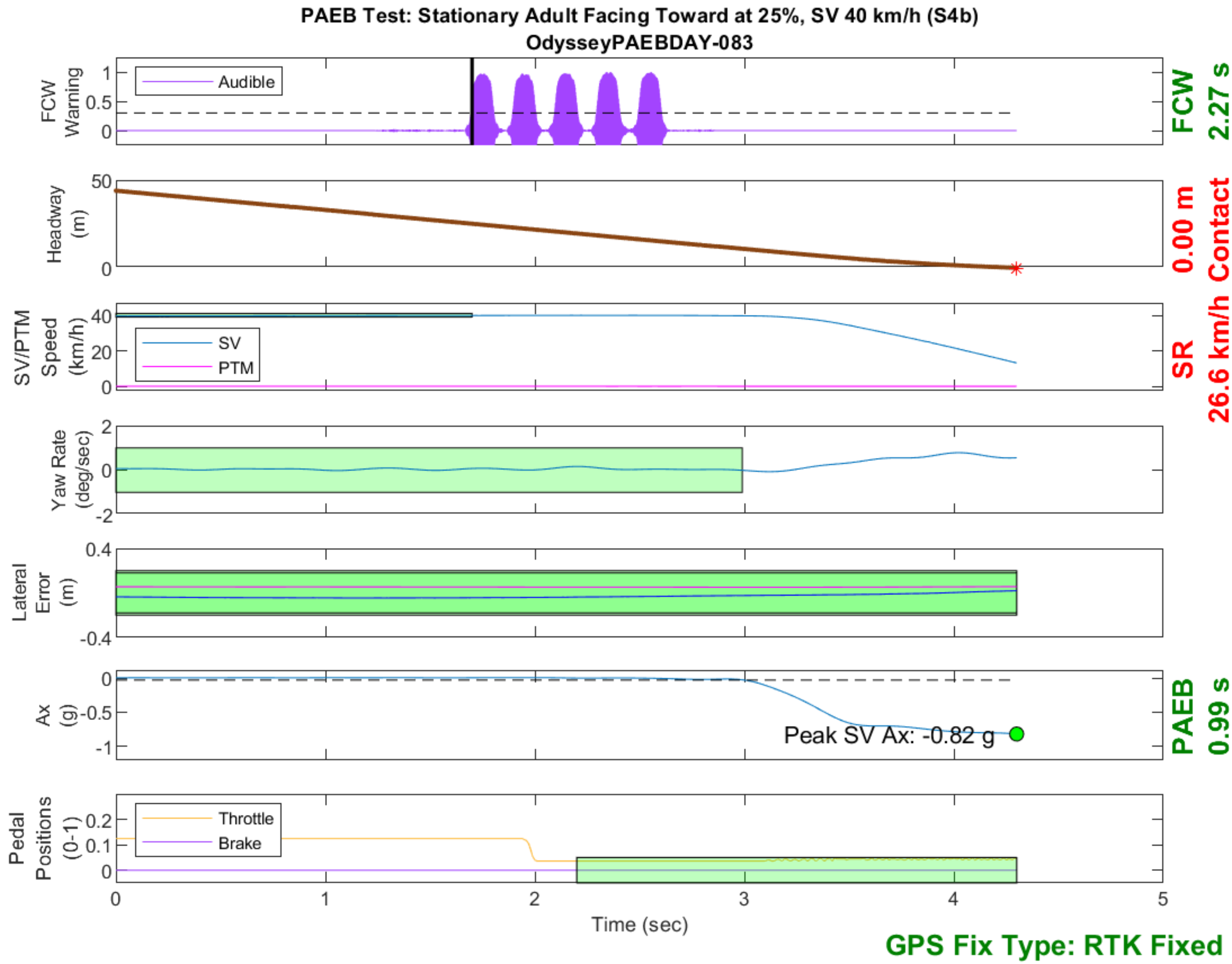


Figure D75. Time History for PAEB Run 83, S4b, Daytime, 40 km/h

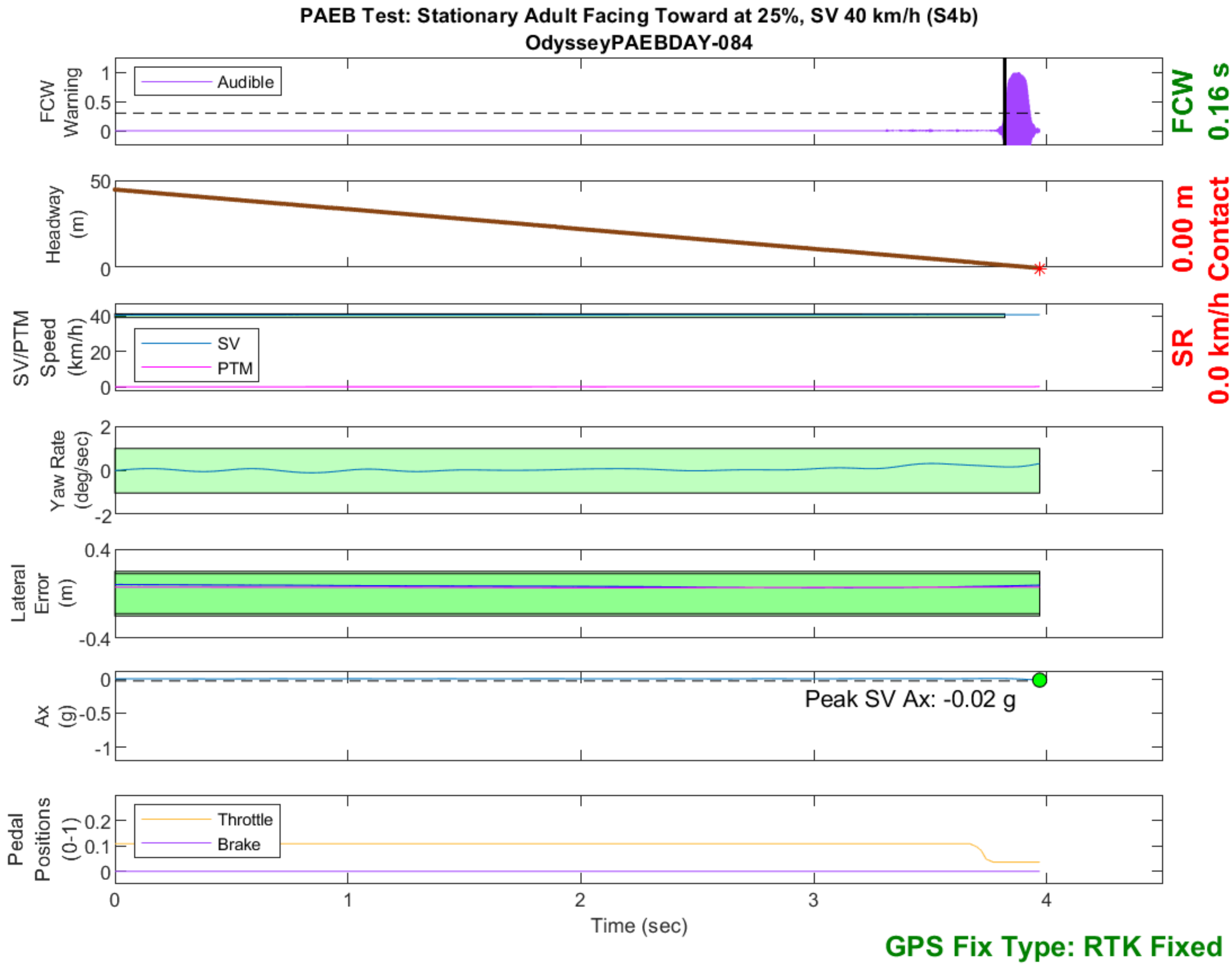


Figure D76. Time History for PAEB Run 84, S4b, Daytime, 40 km/h

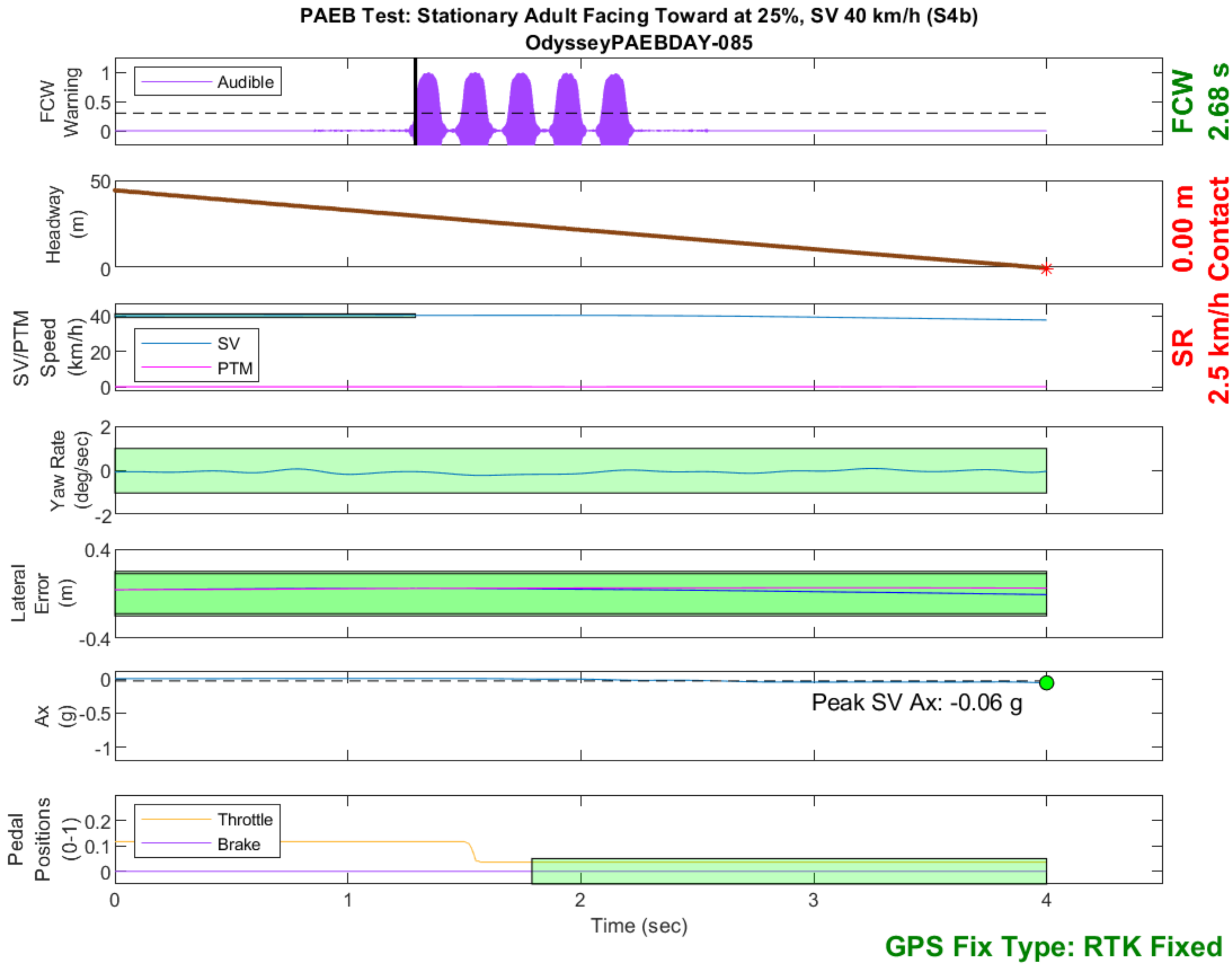


Figure D77. Time History for PAEB Run 85, S4b, Daytime, 40 km/h

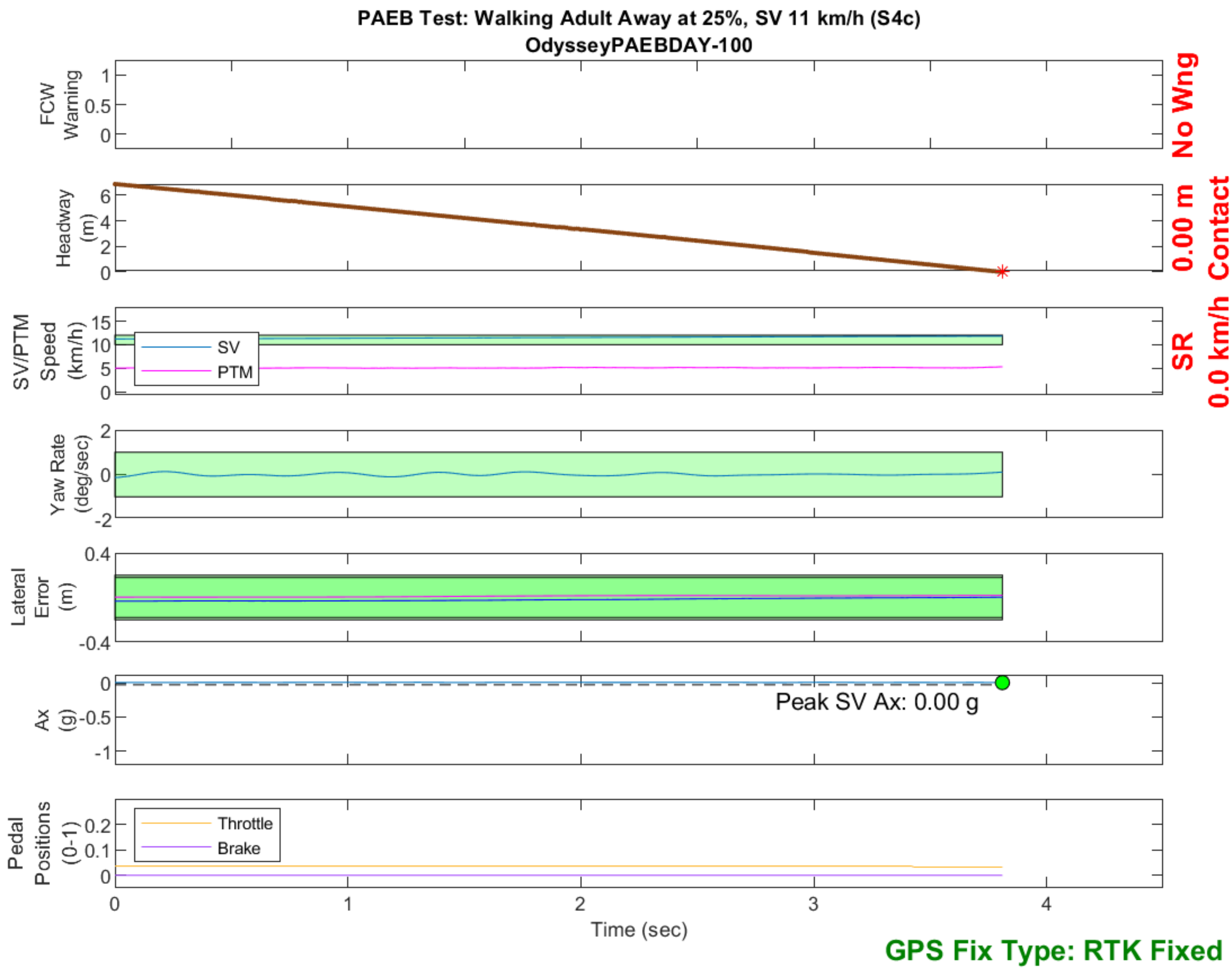


Figure D78. Time History for PAEB Run 100, S4c, Daytime, 11 km/h

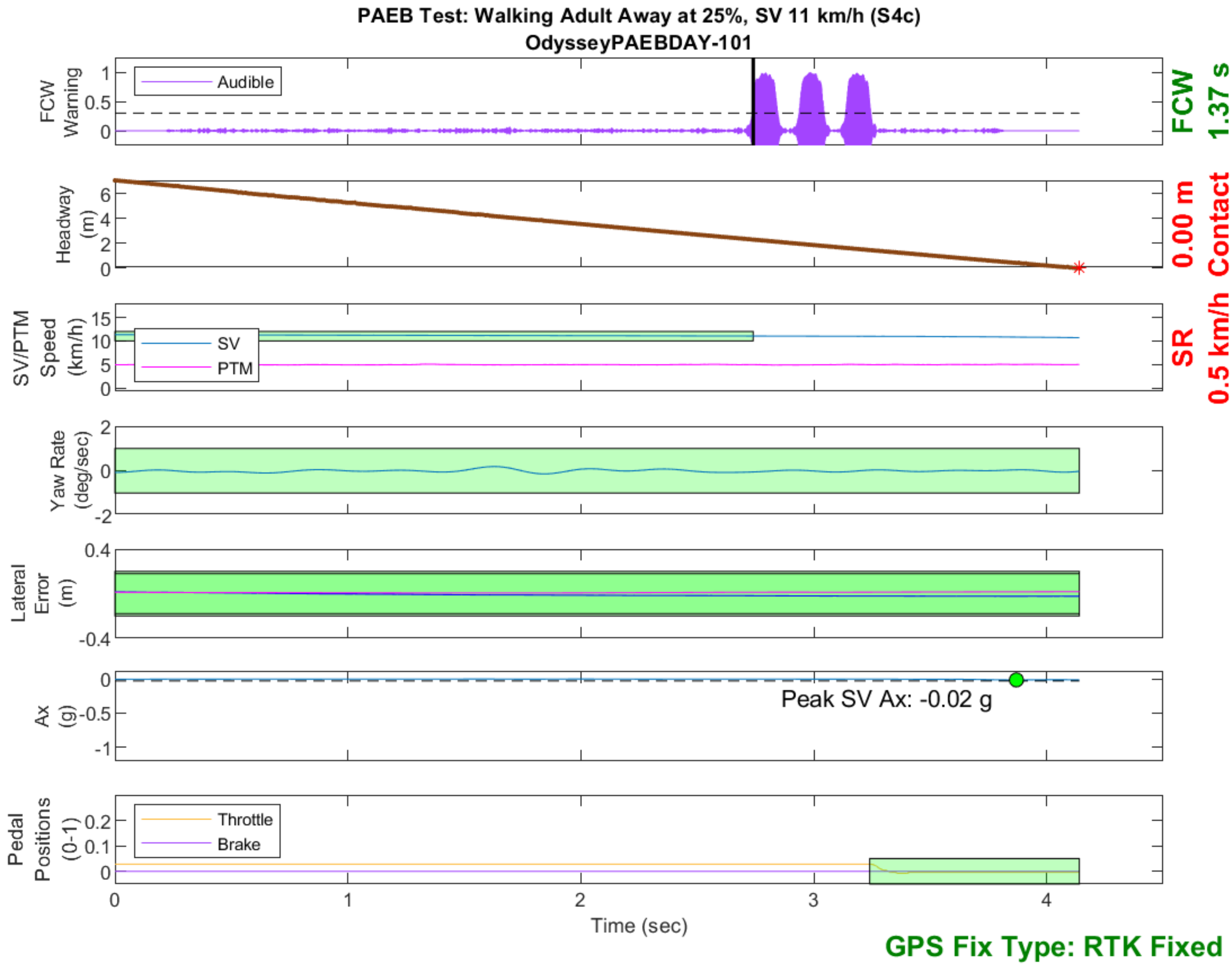


Figure D79. Time History for PAEB Run 101, S4c, Daytime, 11 km/h

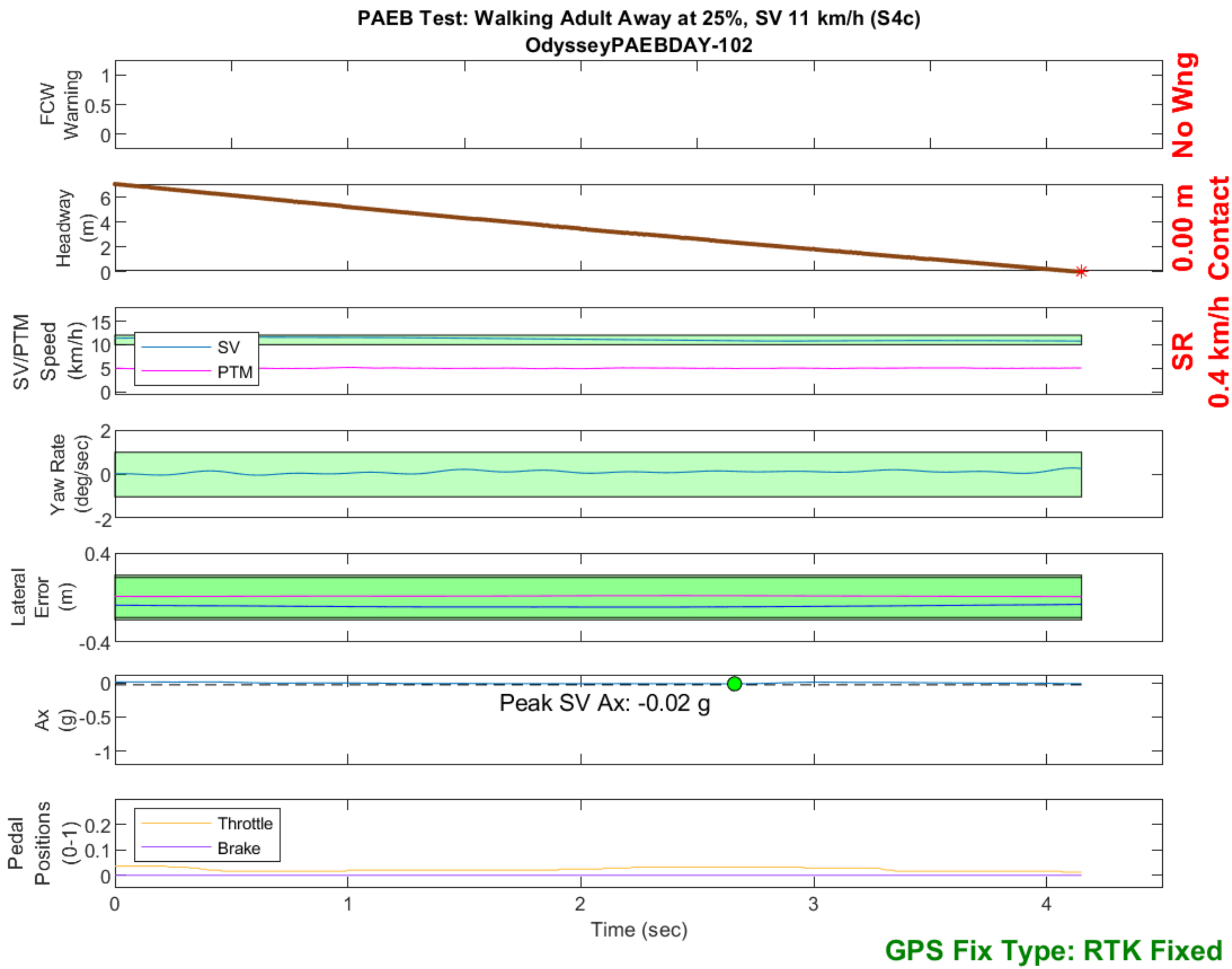


Figure D80. Time History for PAEB Run 102, S4c, Daytime, 11 km/h

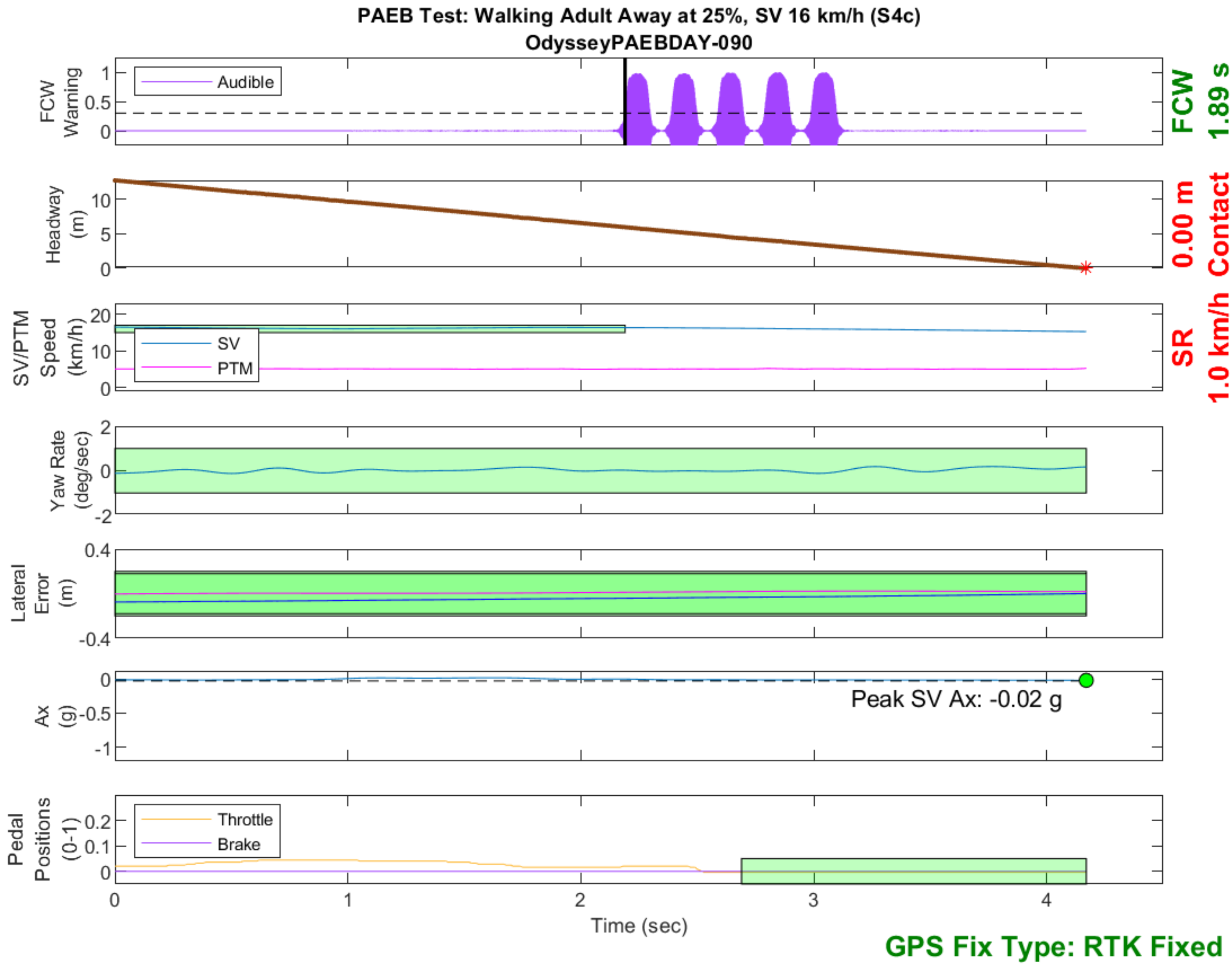


Figure D81. Time History for PAEB Run 90, S4c, Daytime, 16 km/h

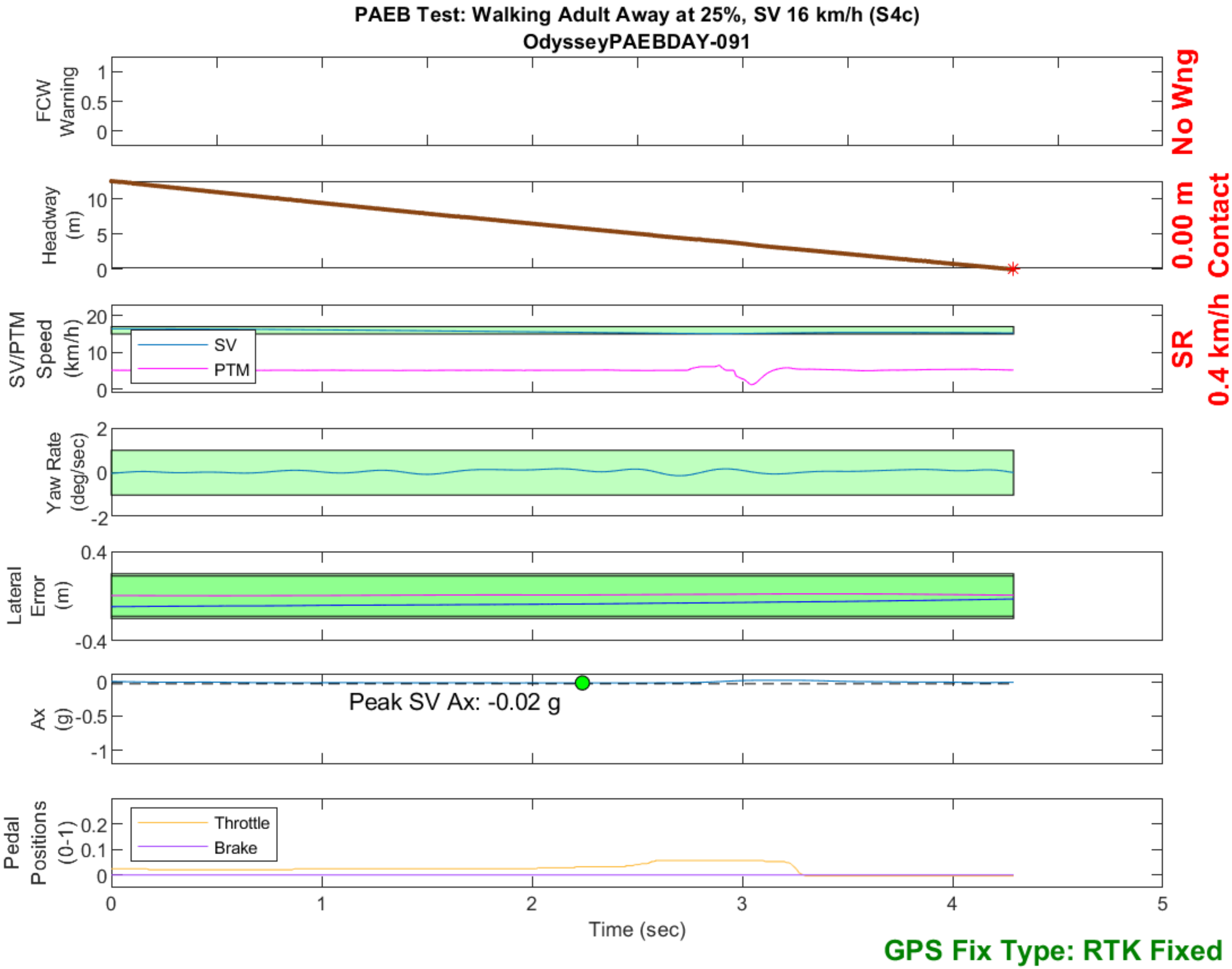


Figure D82. Time History for PAEB Run 91, S4c, Daytime, 16 km/h

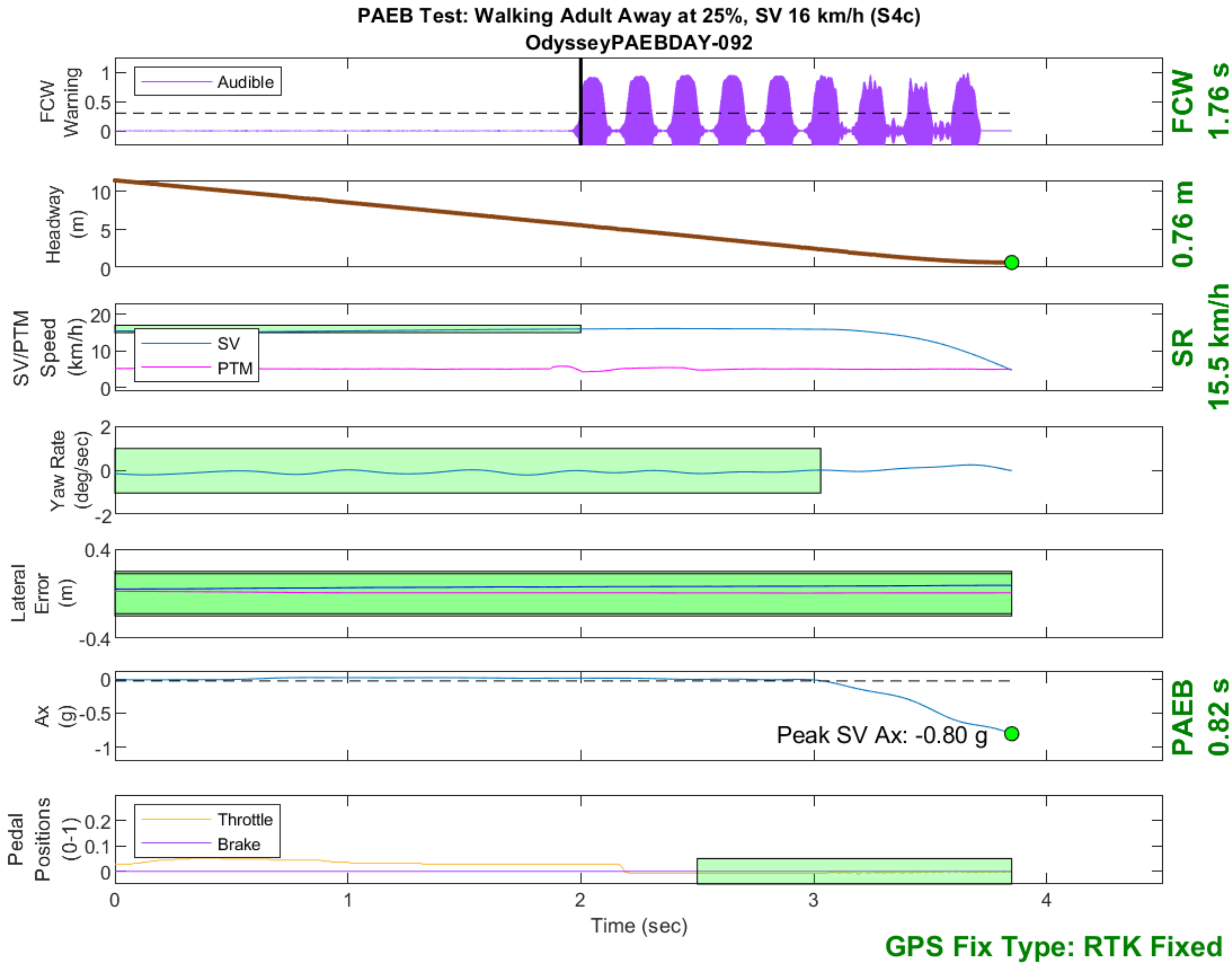


Figure D83. Time History for PAEB Run 92, S4c, Daytime, 16 km/h

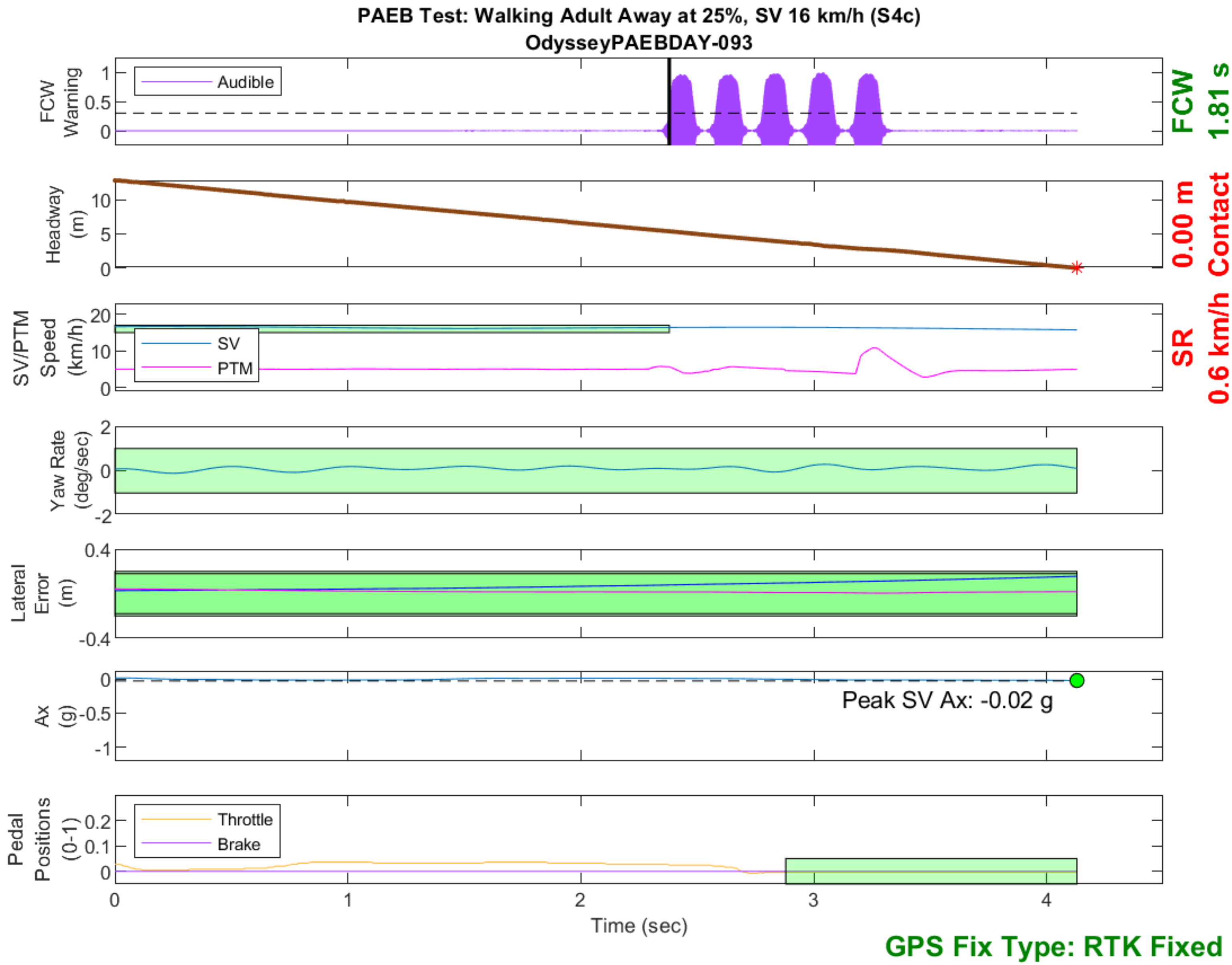


Figure D84. Time History for PAEB Run 93, S4c, Daytime, 16 km/h

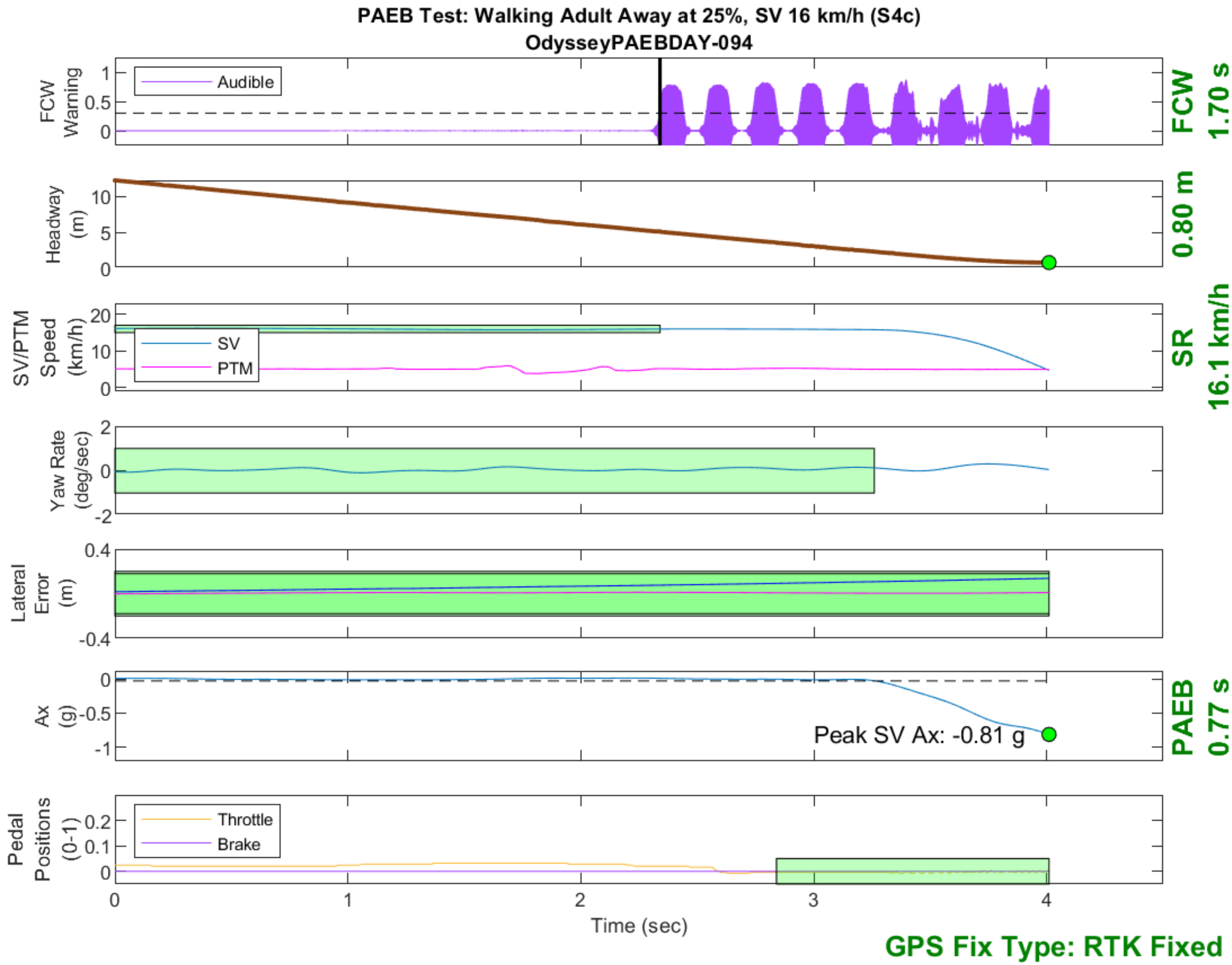


Figure D85. Time History for PAEB Run 94, S4c, Daytime, 16 km/h

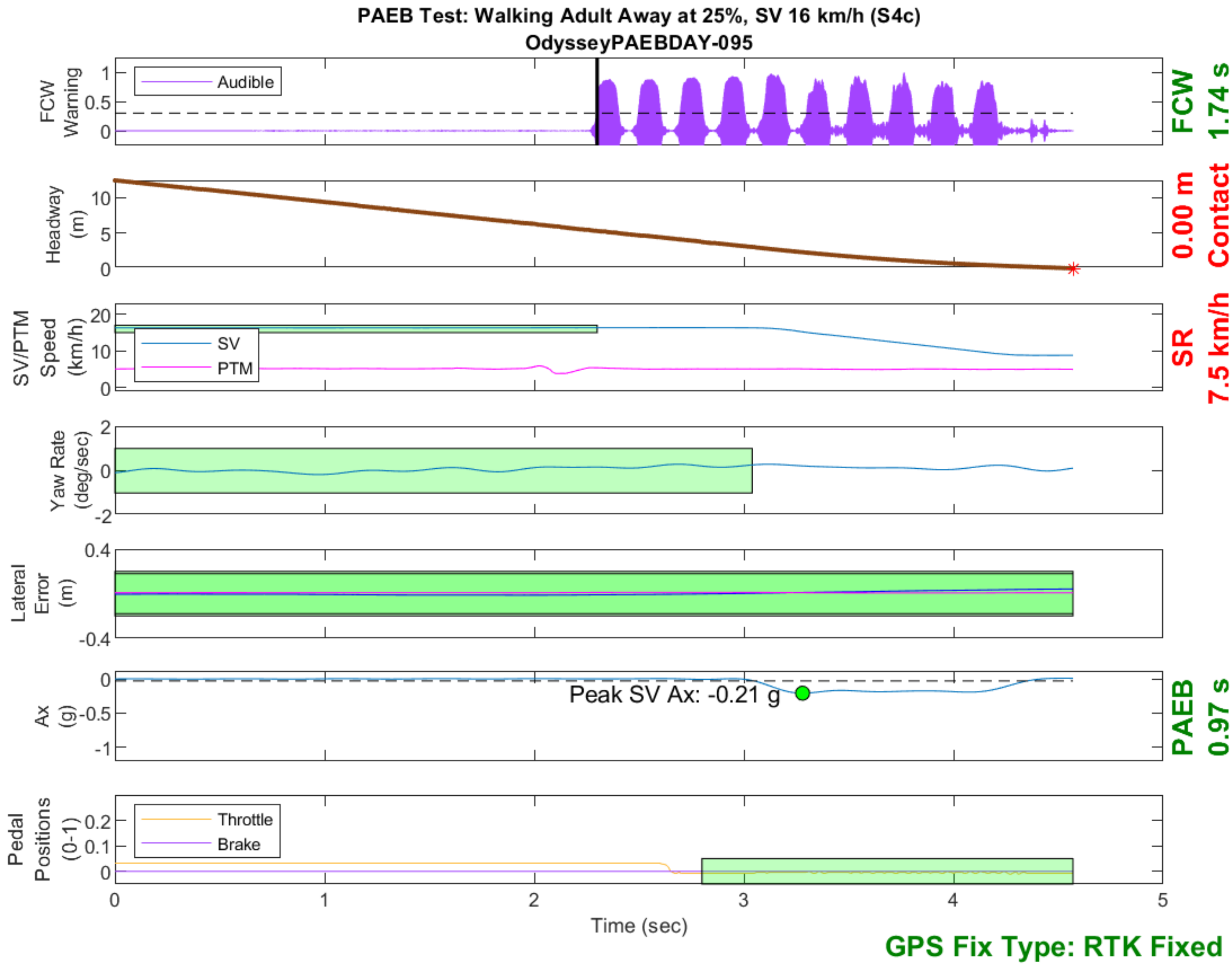


Figure D86. Time History for PAEB Run 95, S4c, Daytime, 16 km/h

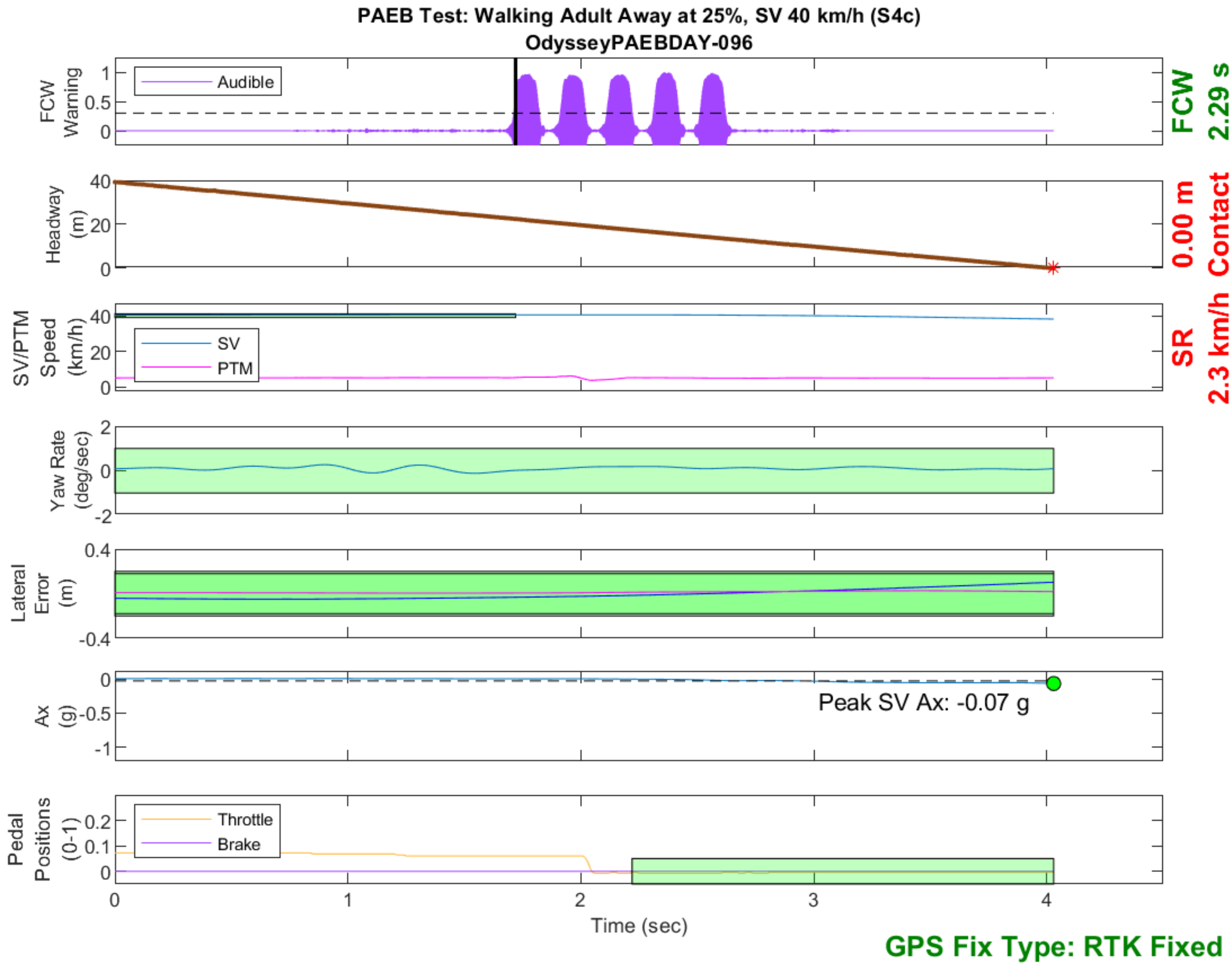


Figure D87. Time History for PAEB Run 96, S4c, Daytime, 40 km/h

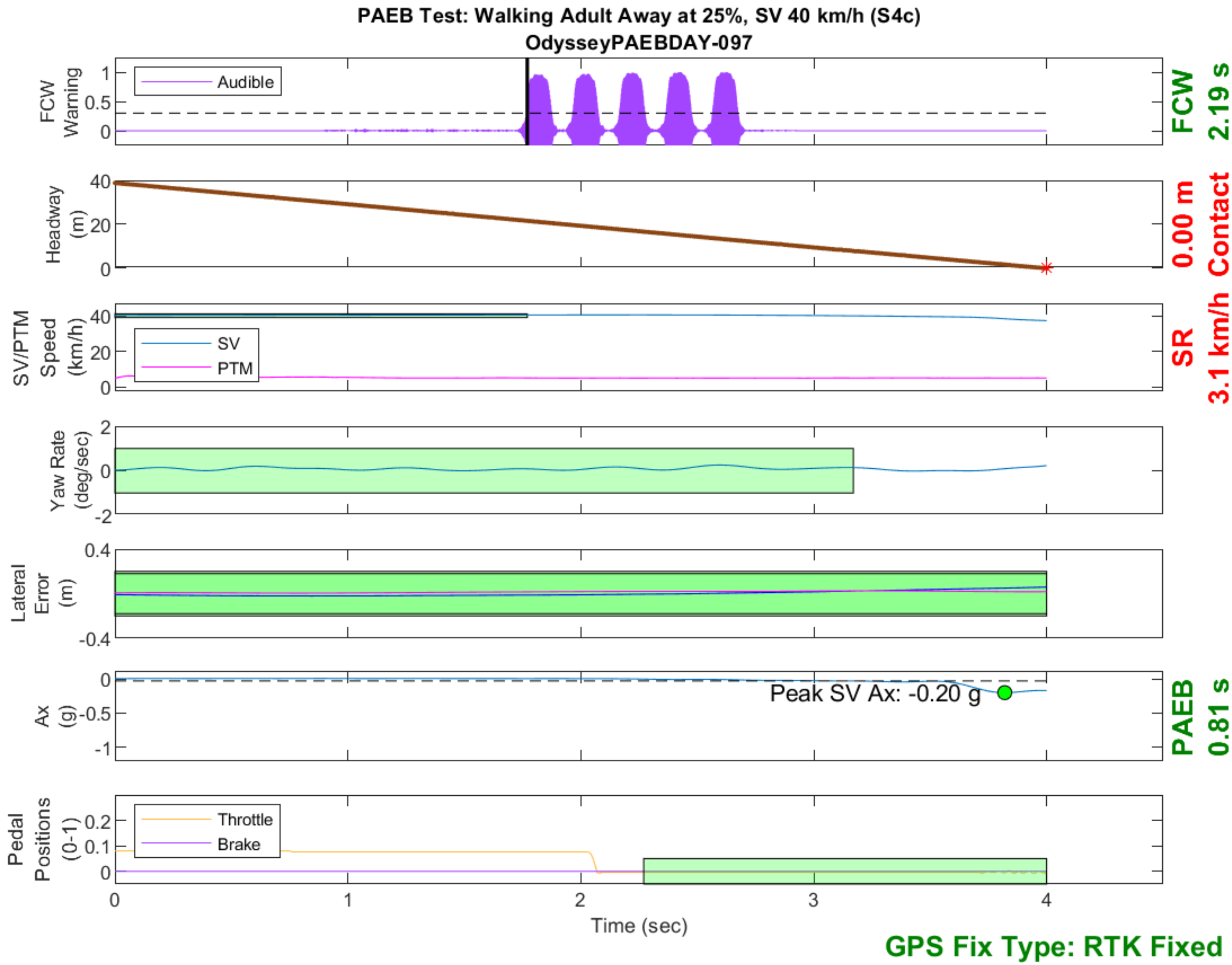


Figure D88. Time History for PAEB Run 97, S4c, Daytime, 40 km/h

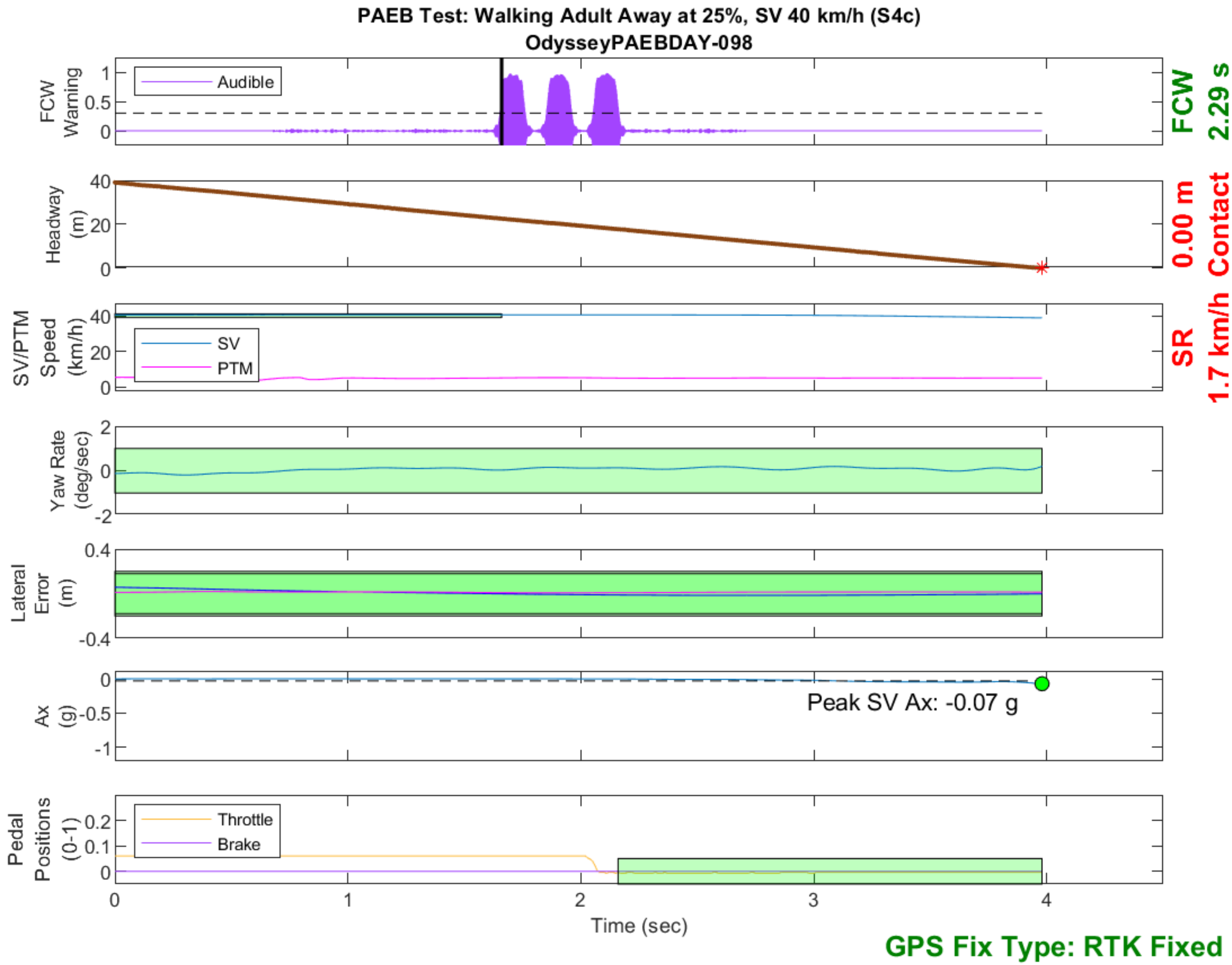


Figure D89. Time History for PAEB Run 98, S4c, Daytime, 40 km/h

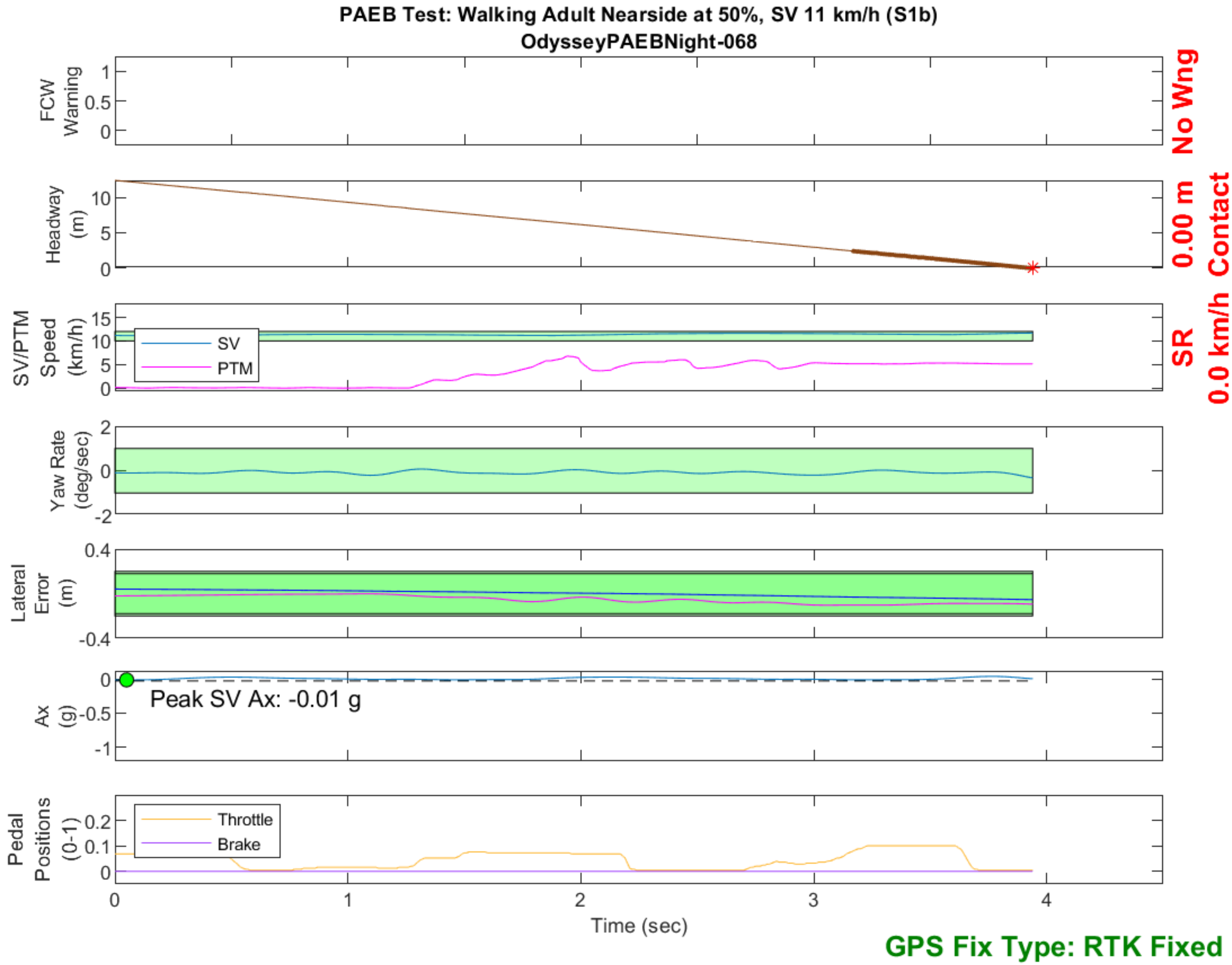


Figure D90. Time History for PAEB Run 68, S1b, Night, High Beam, 11 km/h

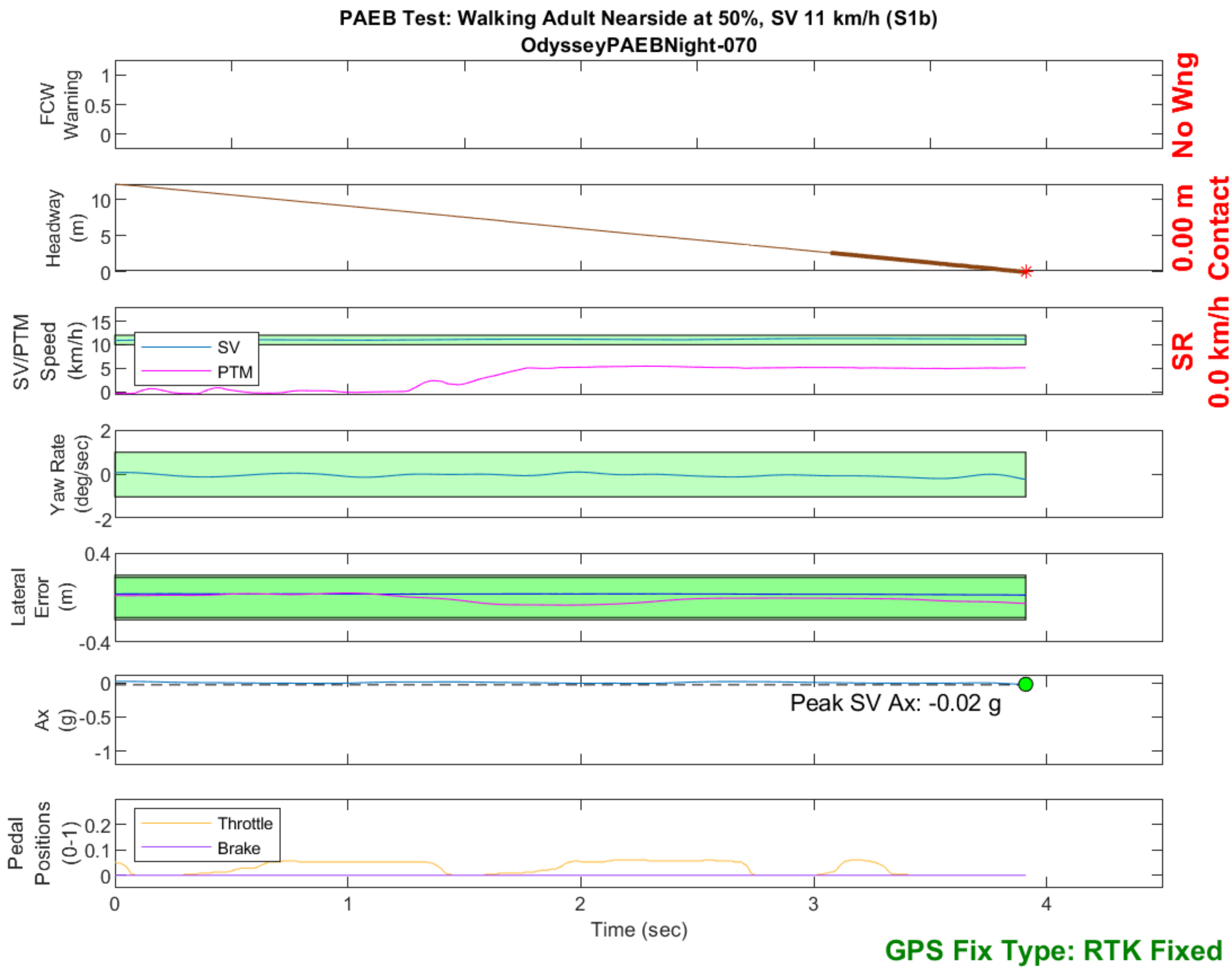


Figure D91. Time History for PAEB Run 70, S1b, Night, High Beam, 11 km/h

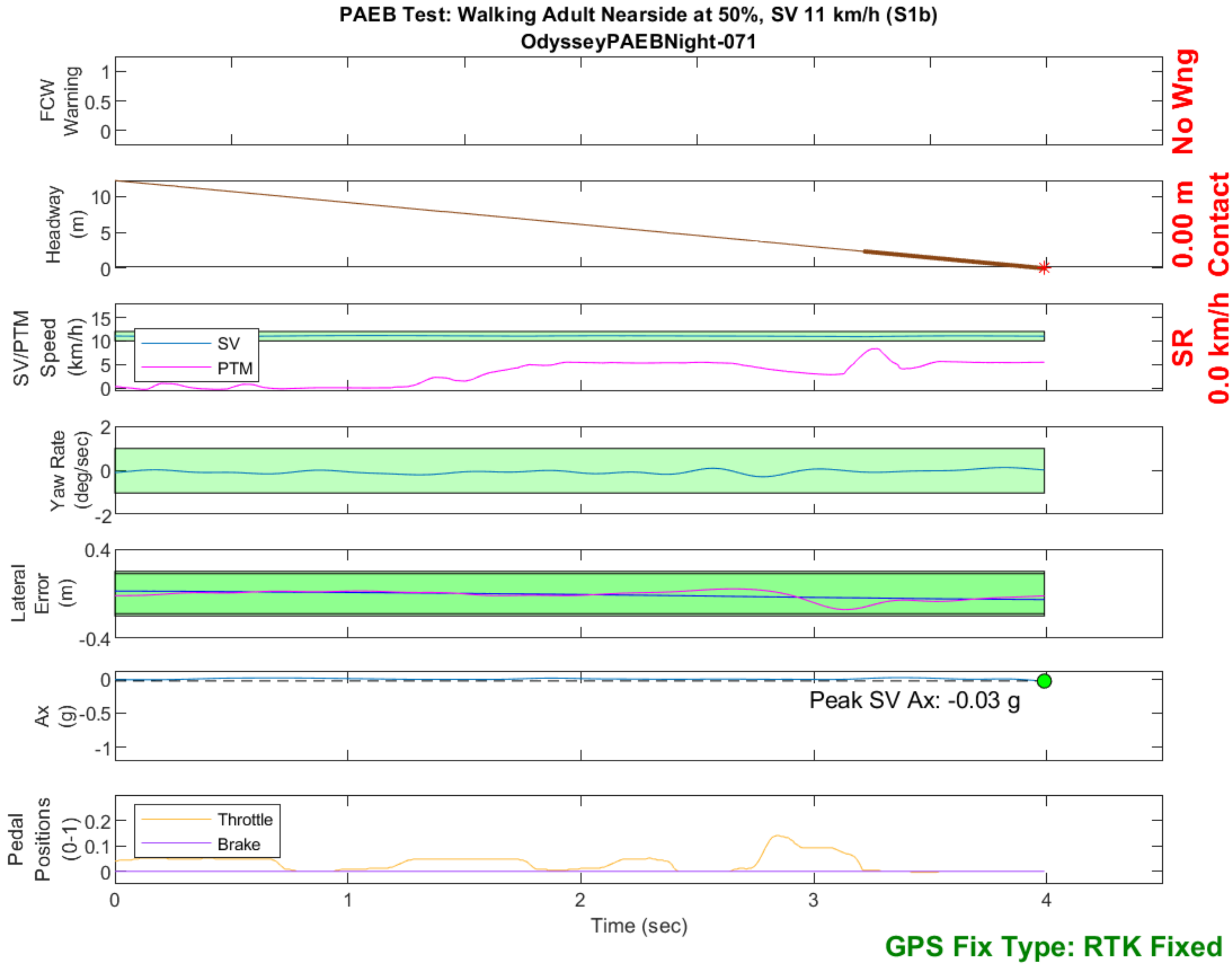


Figure D92. Time History for PAEB Run 71, S1b, Night, High Beam, 11 km/h

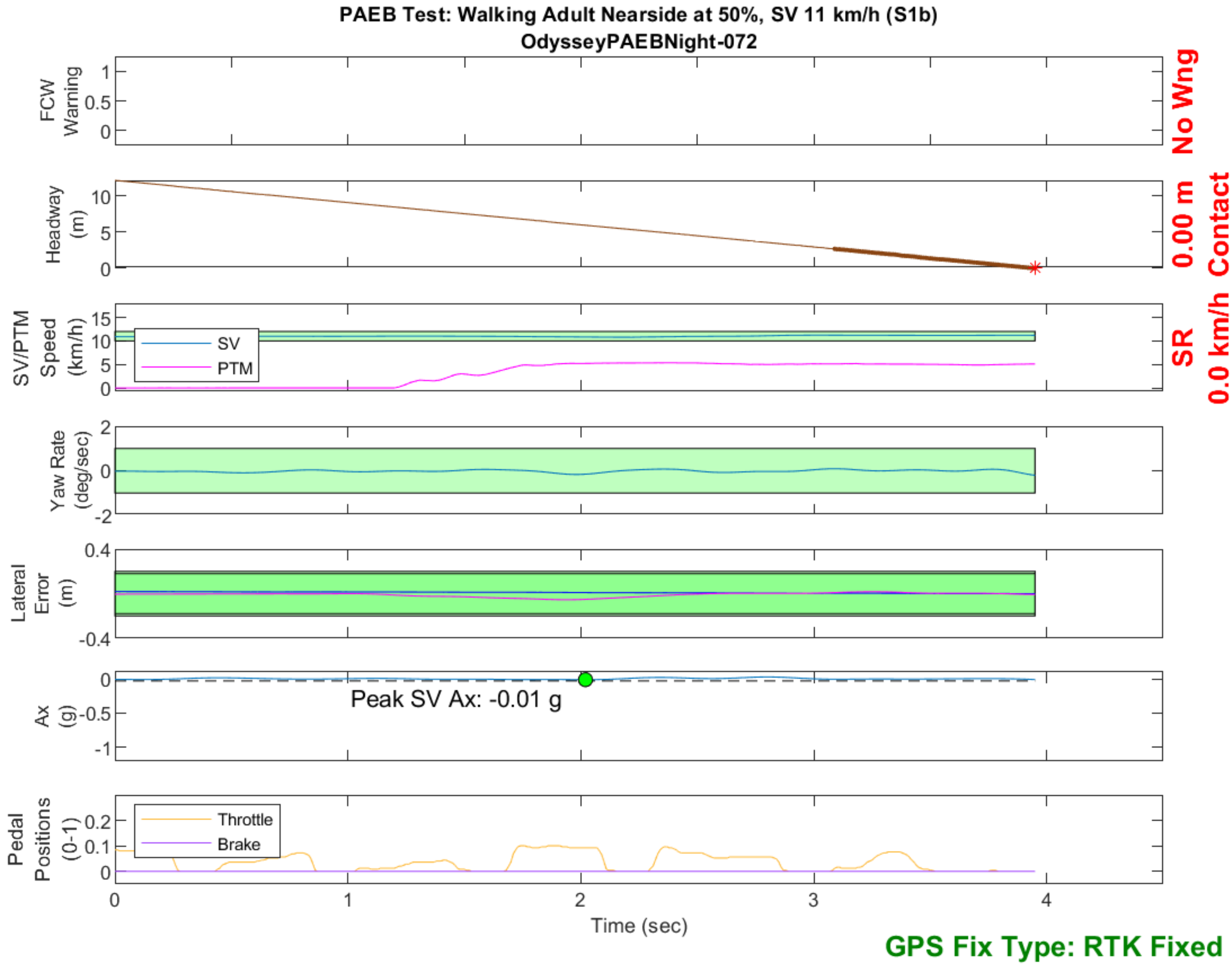


Figure D93. Time History for PAEB Run 72, S1b, Night, High Beam, 11 km/h

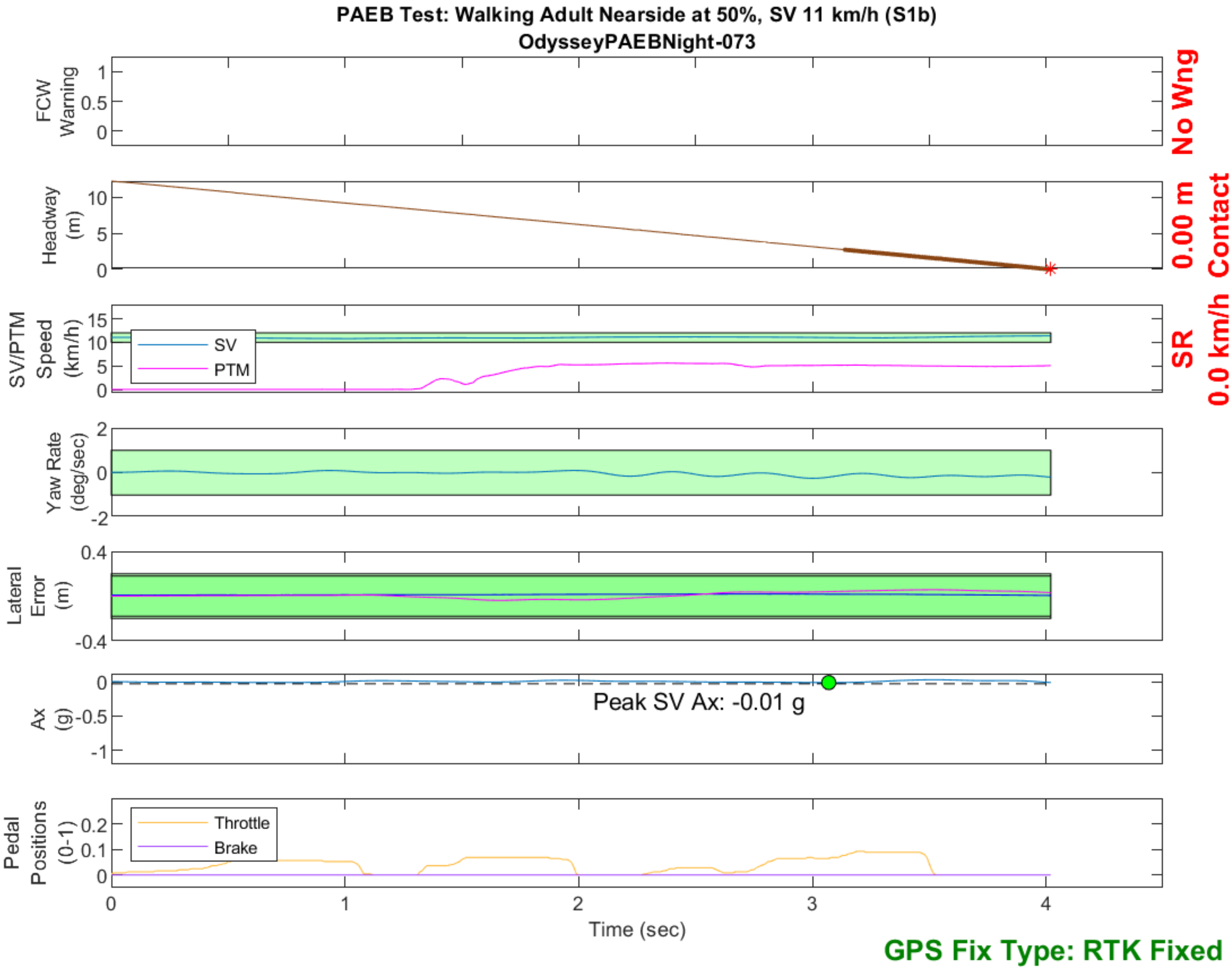


Figure D94. Time History for PAEB Run 73, S1b, Night, High Beam, 11 km/h

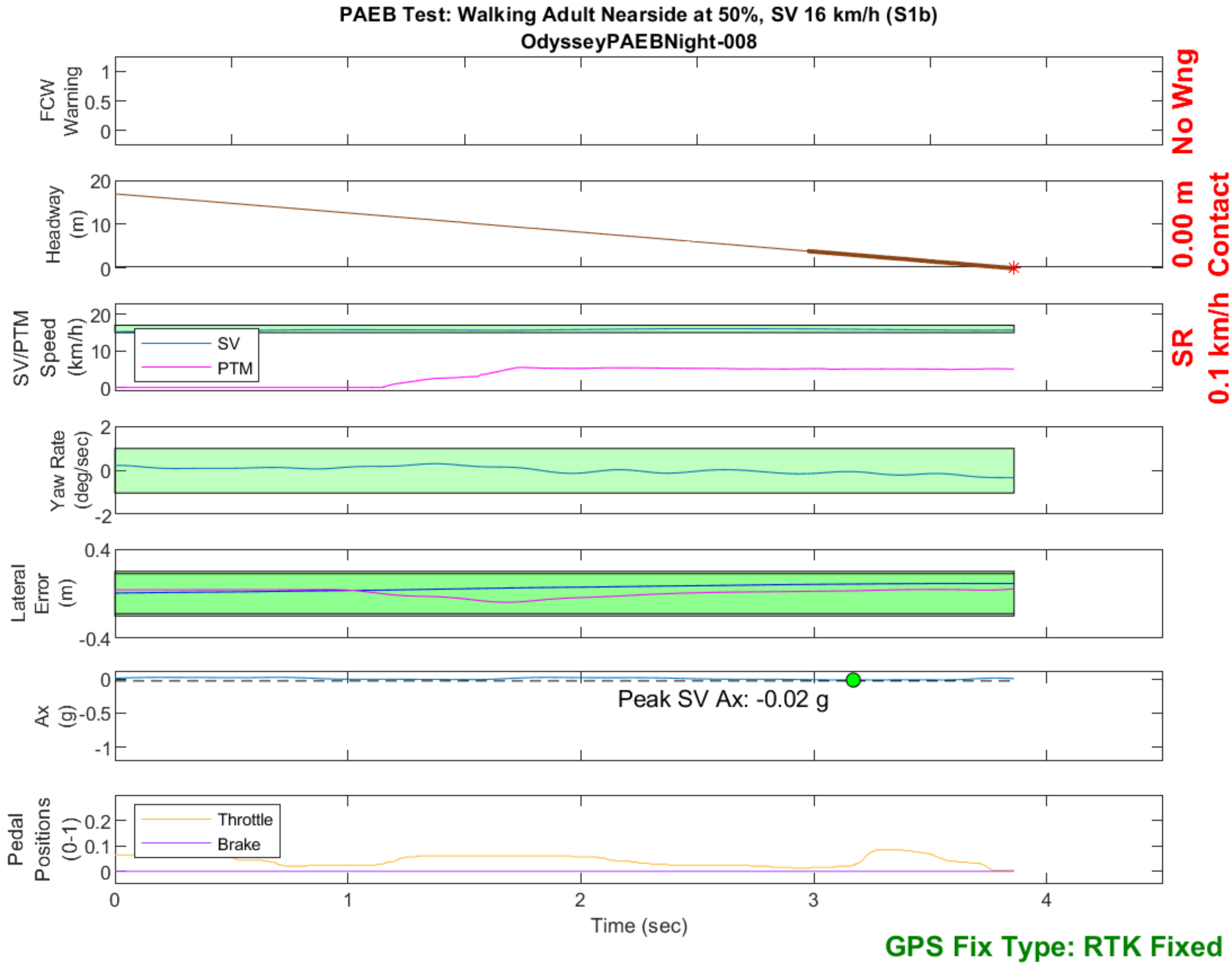


Figure D95. Time History for PAEB Run 8, S1b, Night, High Beam, 16 km/h

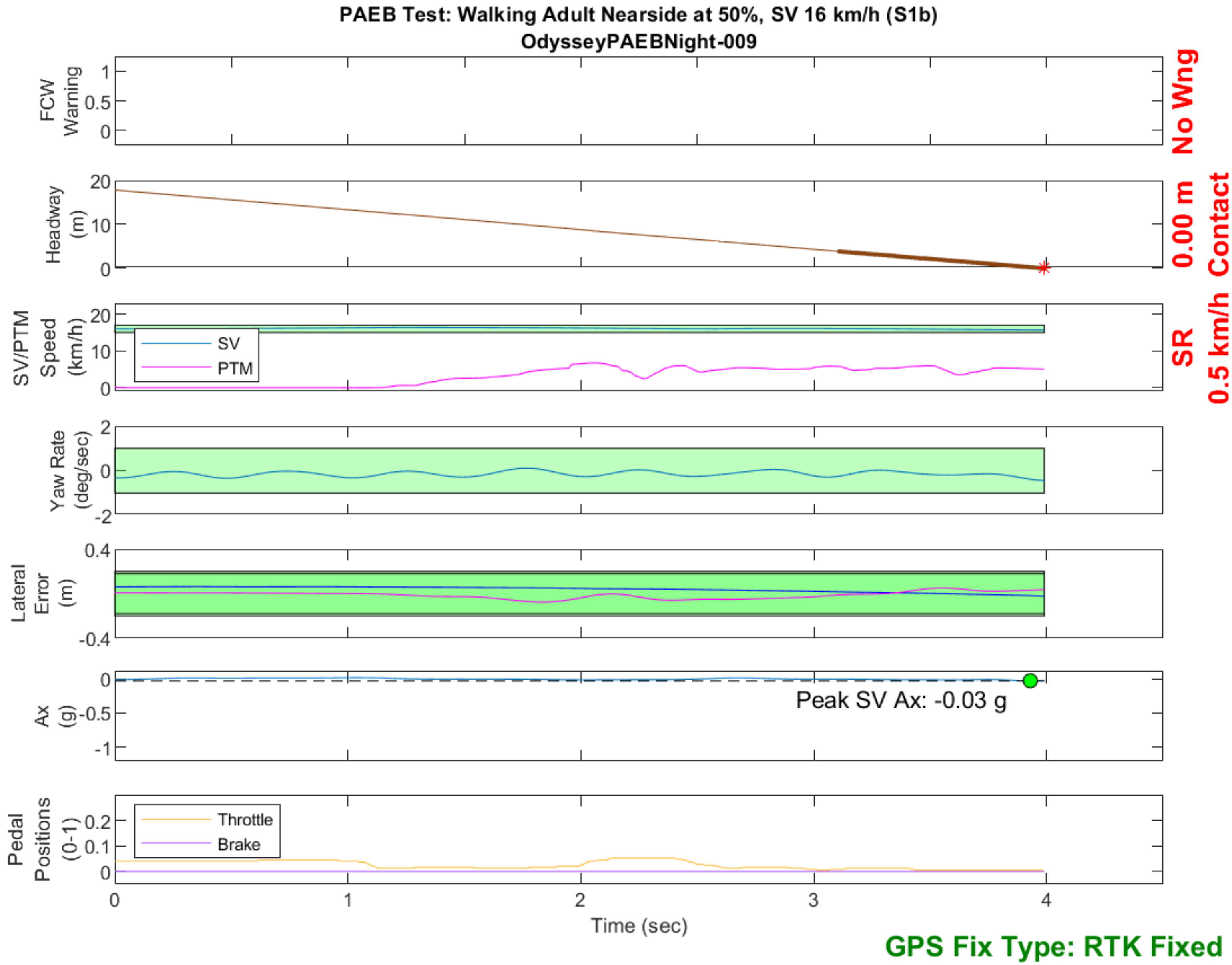


Figure D96. Time History for PAEB Run 9, S1b, Night, High Beam, 16 km/h

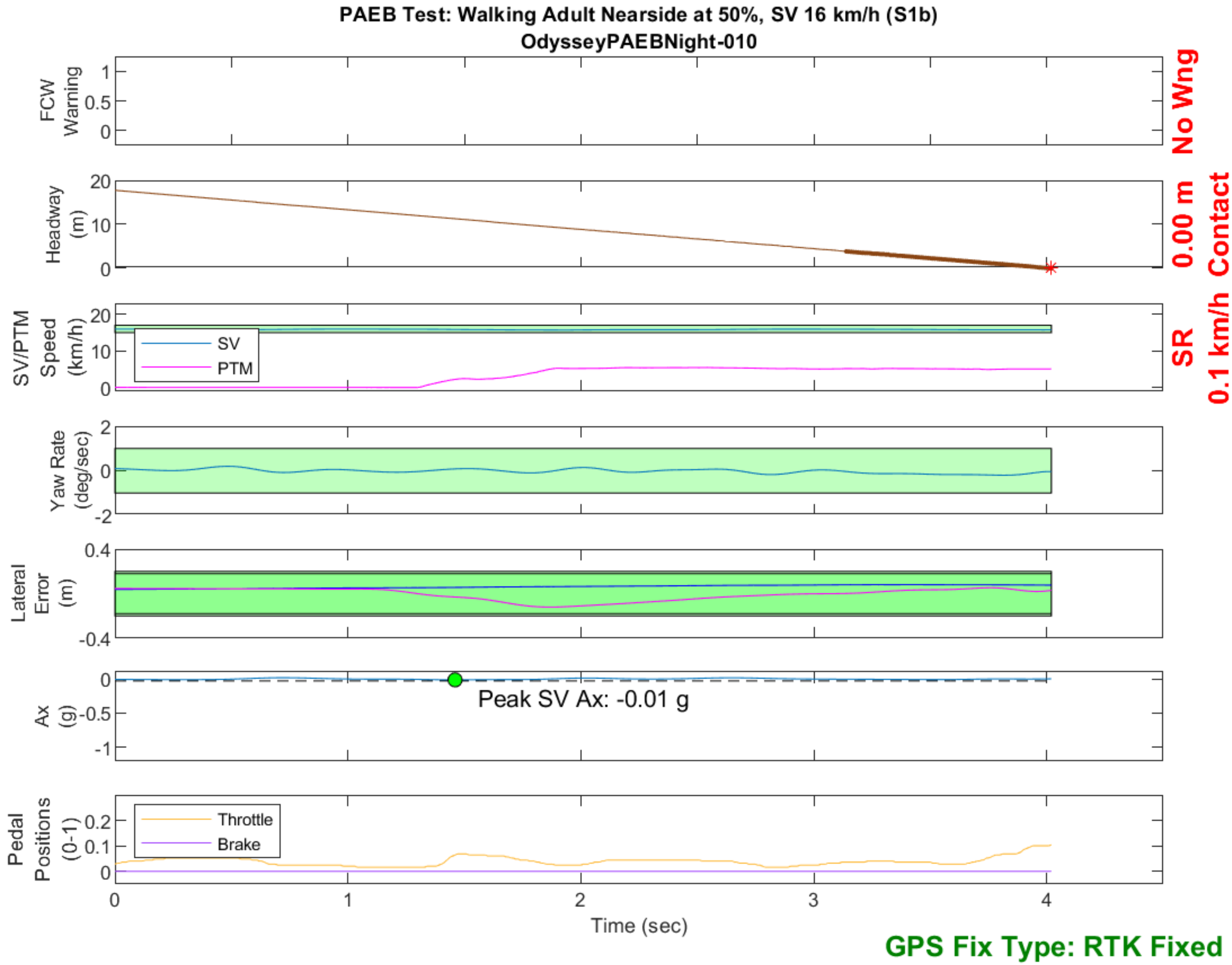


Figure D97. Time History for PAEB Run 10, S1b, Night, High Beam, 16 km/h

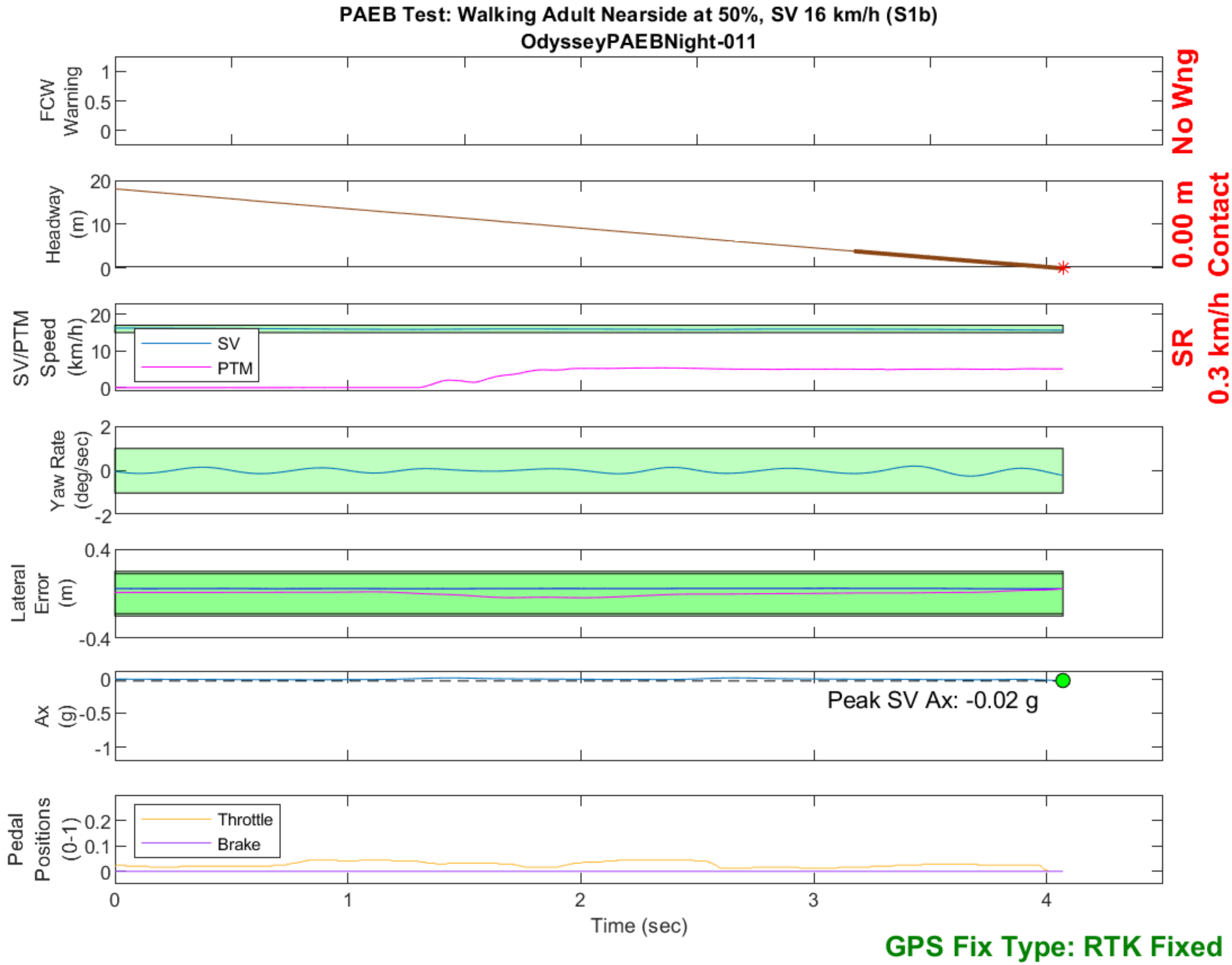


Figure D98. Time History for PAEB Run 11, S1b, Night, High Beam, 16 km/h

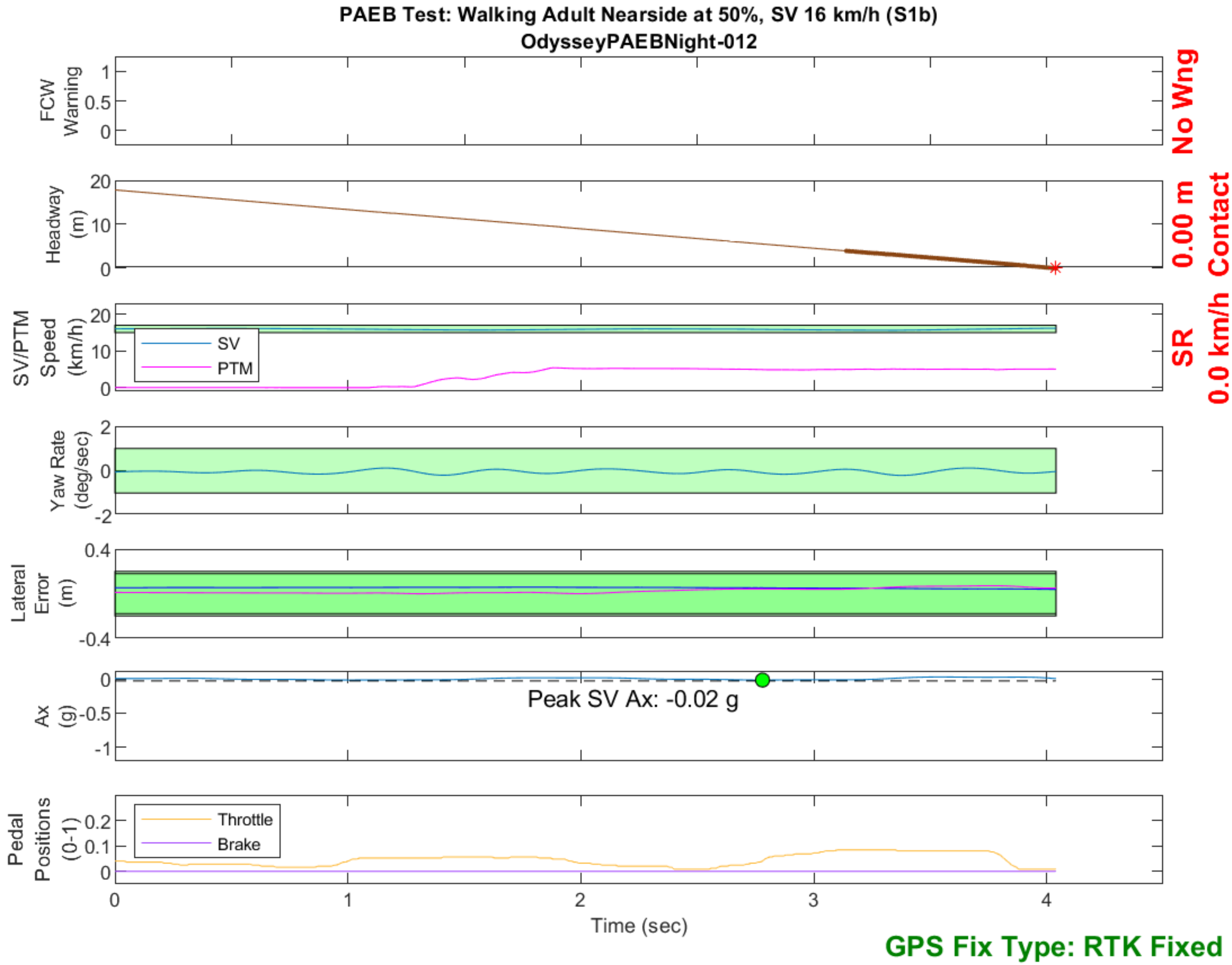


Figure D99. Time History for PAEB Run 12, S1b, Night, High Beam, 16 km/h

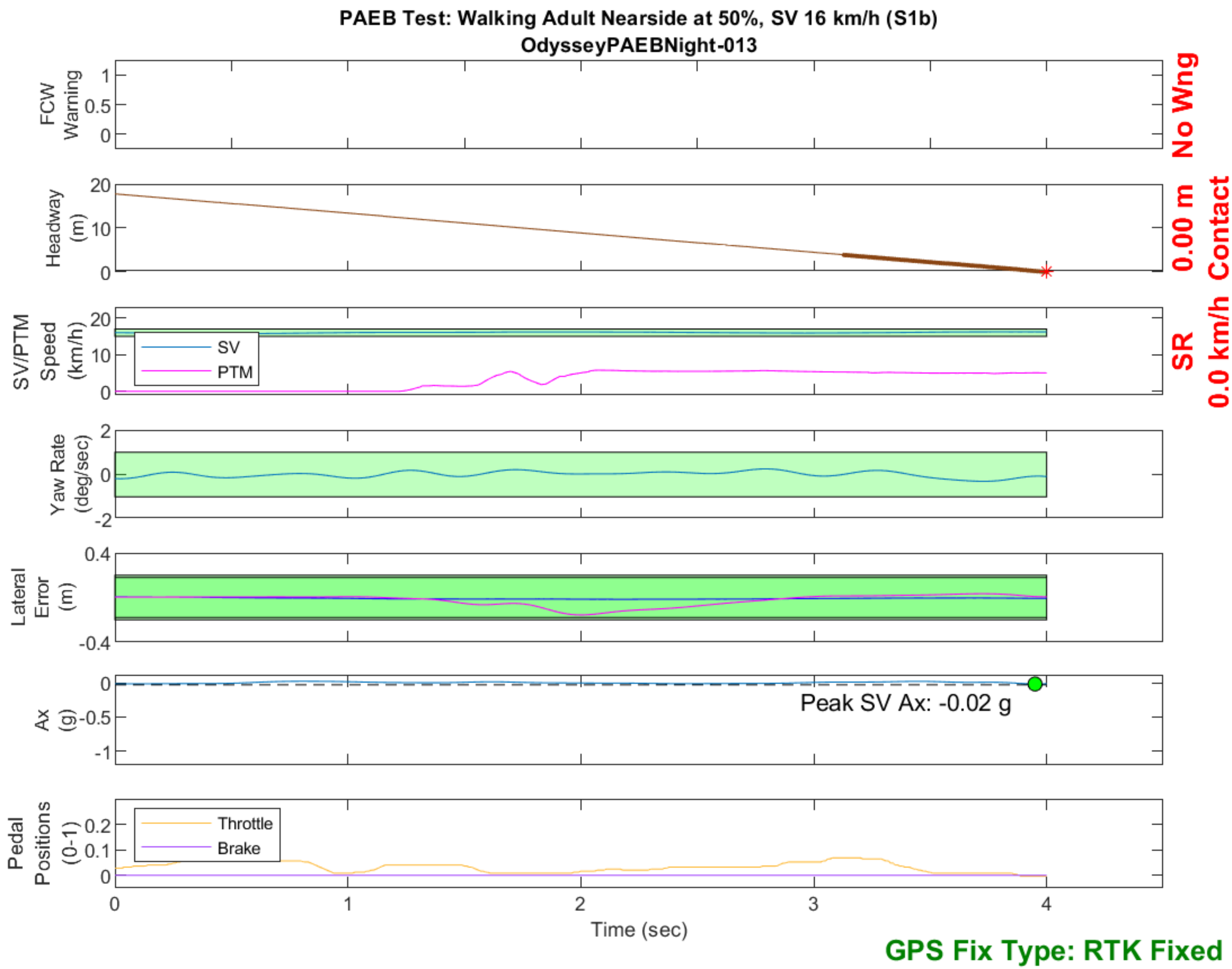


Figure D100. Time History for PAEB Run 13, S1b, Night, High Beam, 16 km/h

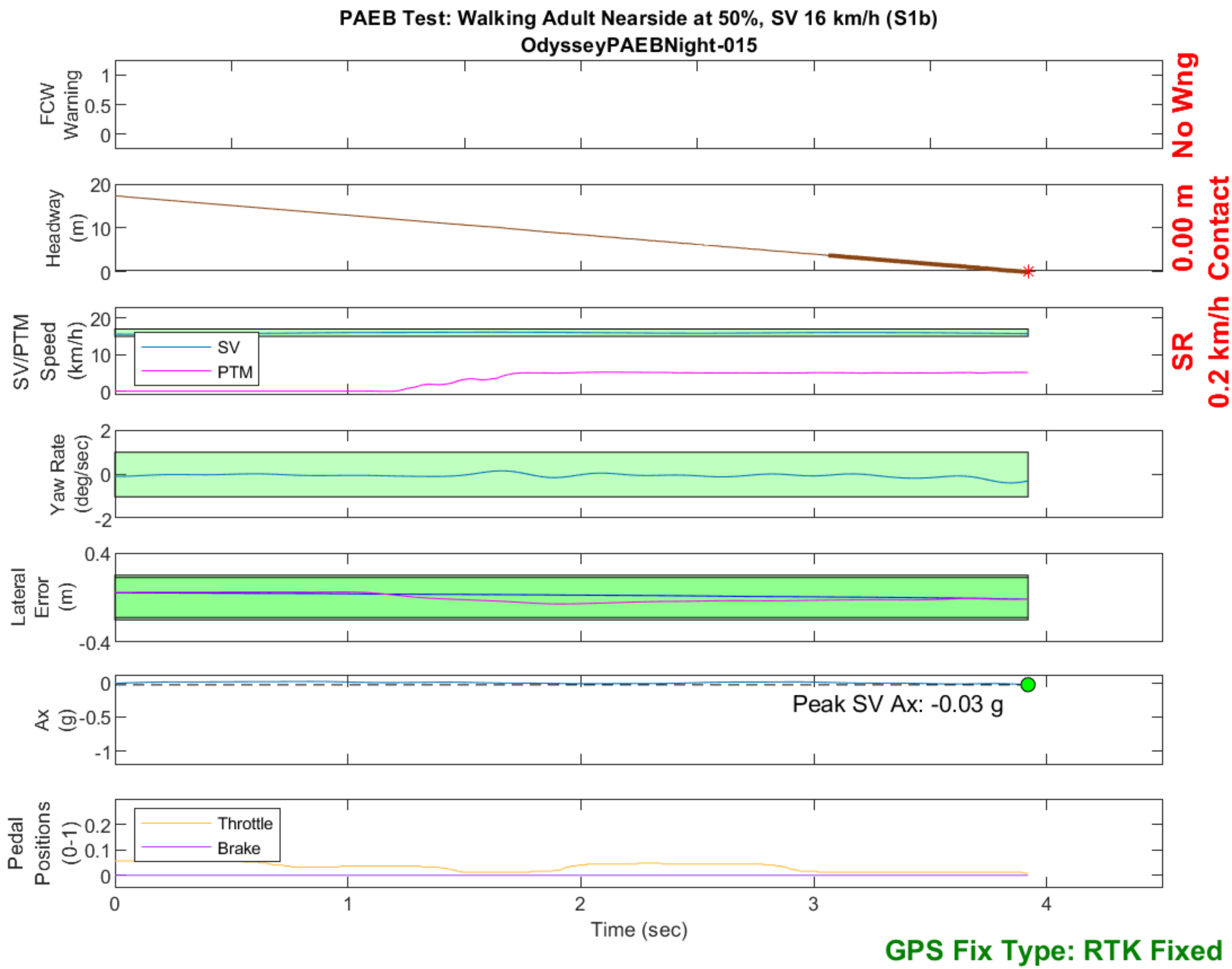


Figure D101. Time History for PAEB Run 15, S1b, Night, High Beam, 16 km/h

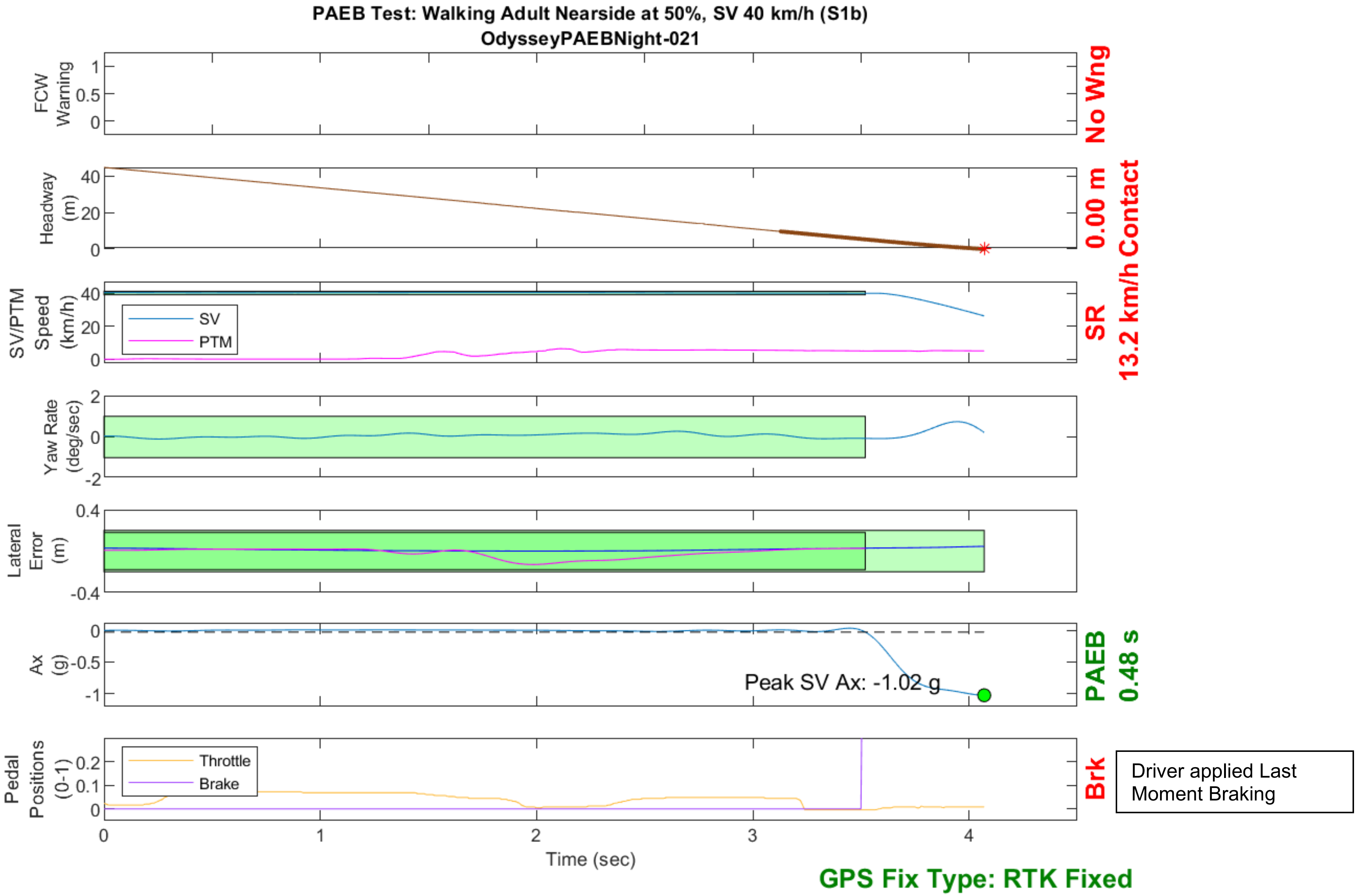


Figure D102. Time History for PAEB Run 21, S1b, Night, High Beam, 40 km/h

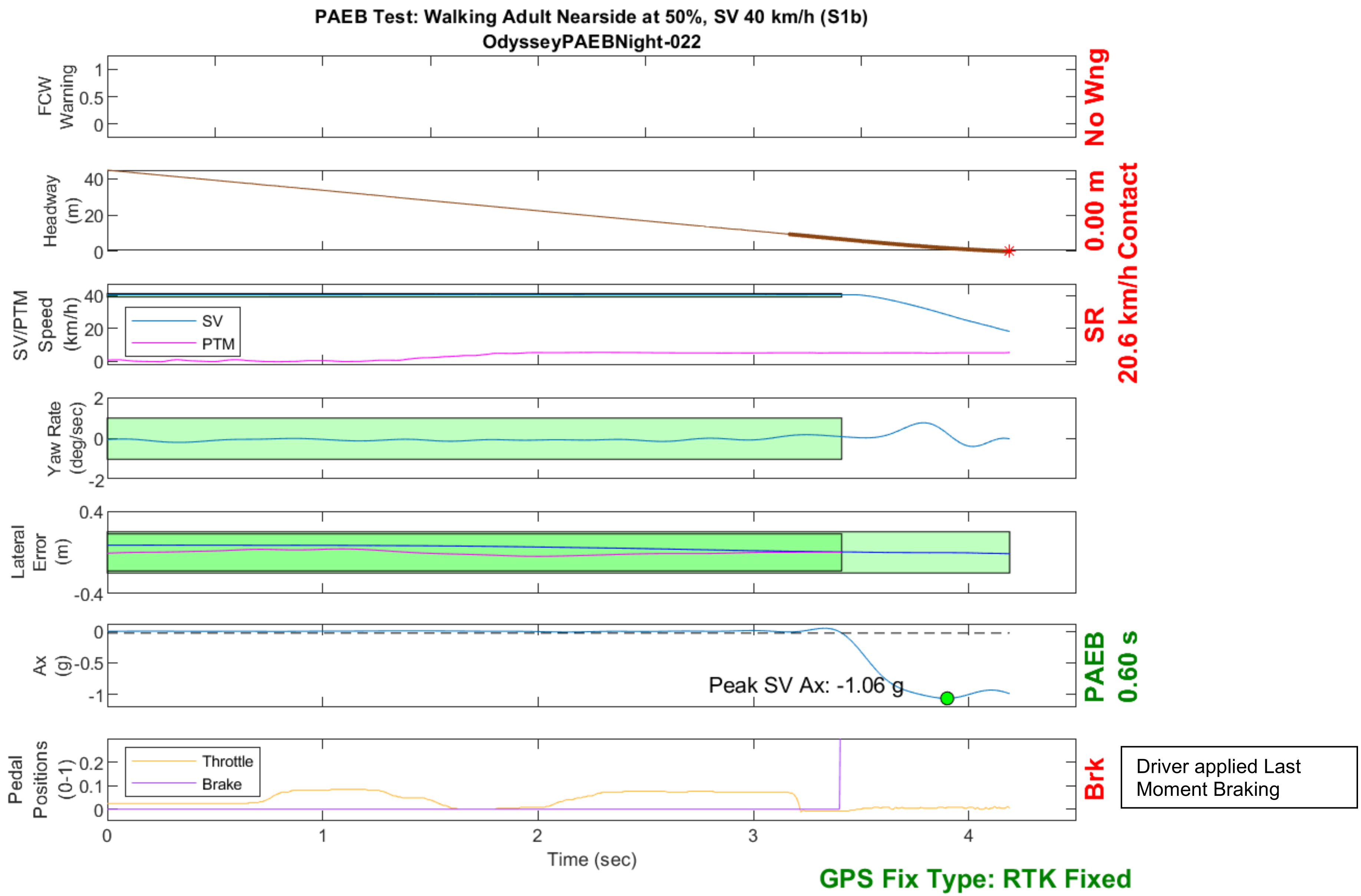


Figure D103. Time History for PAEB Run 22, S1b, Night, High Beam, 40 km/h

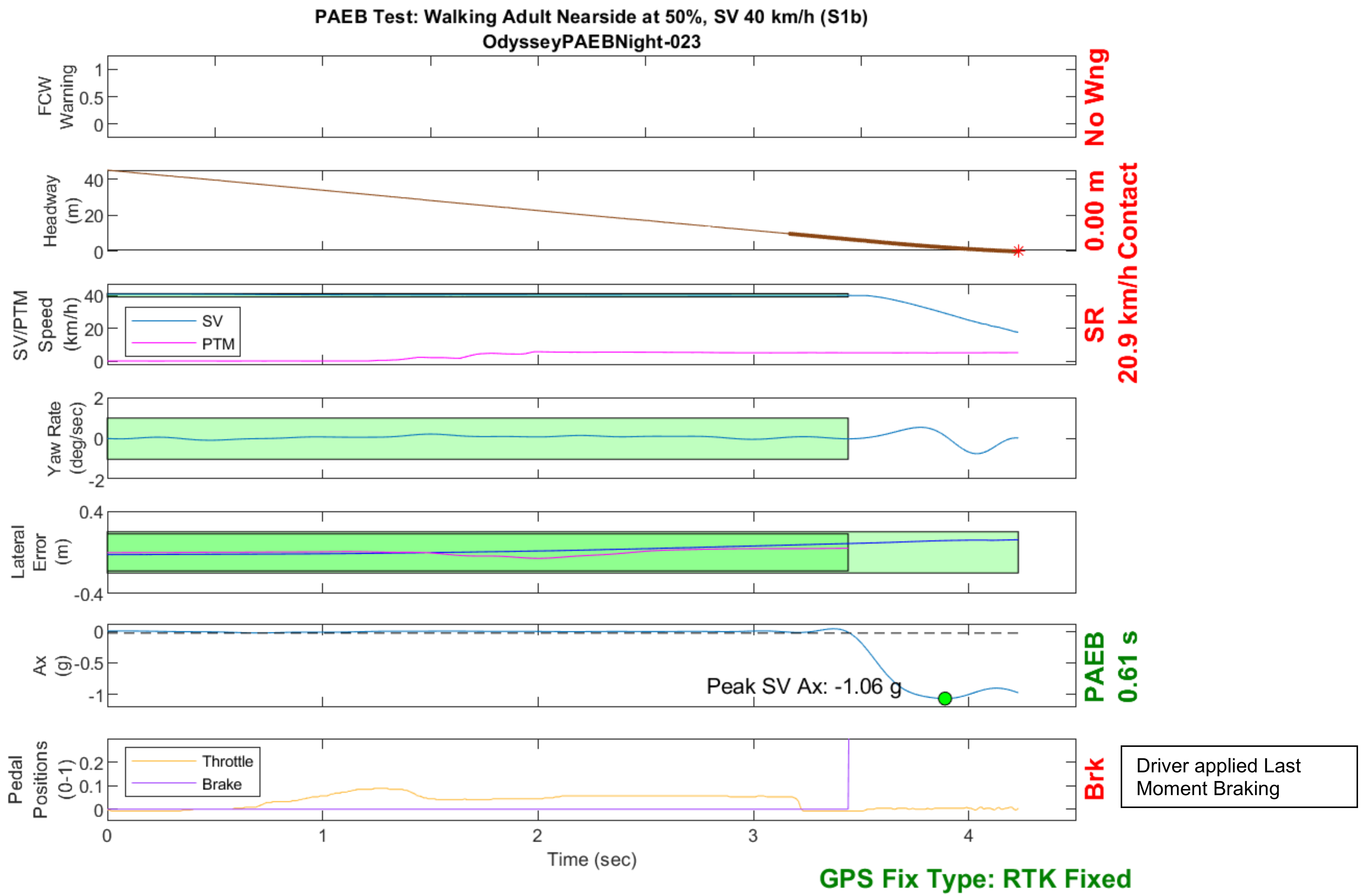


Figure D104. Time History for PAEB Run 23, S1b, Night, High Beam, 40 km/h

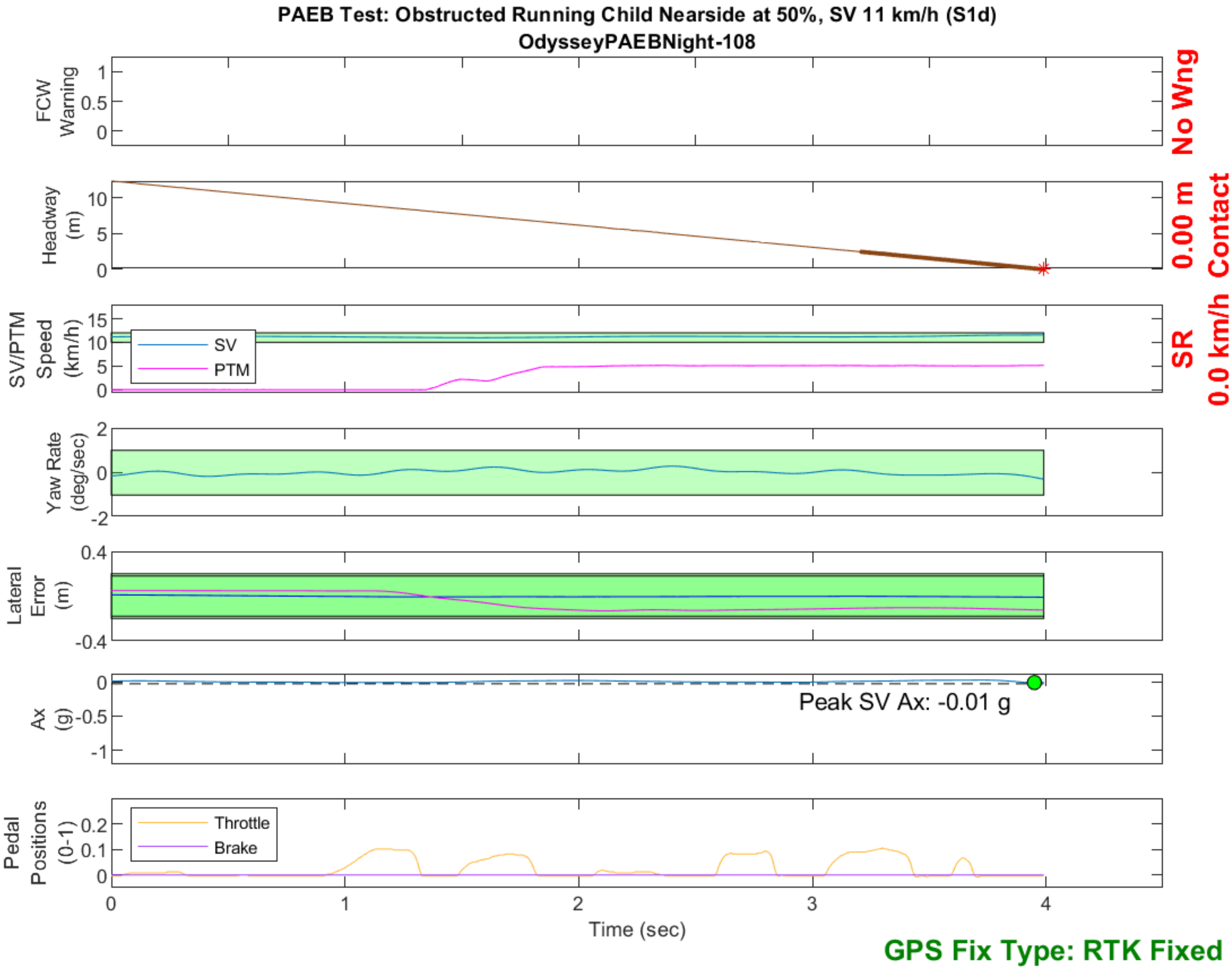


Figure D105. Time History for PAEB Run 108, S1d, Night, High Beam, 11 km/h

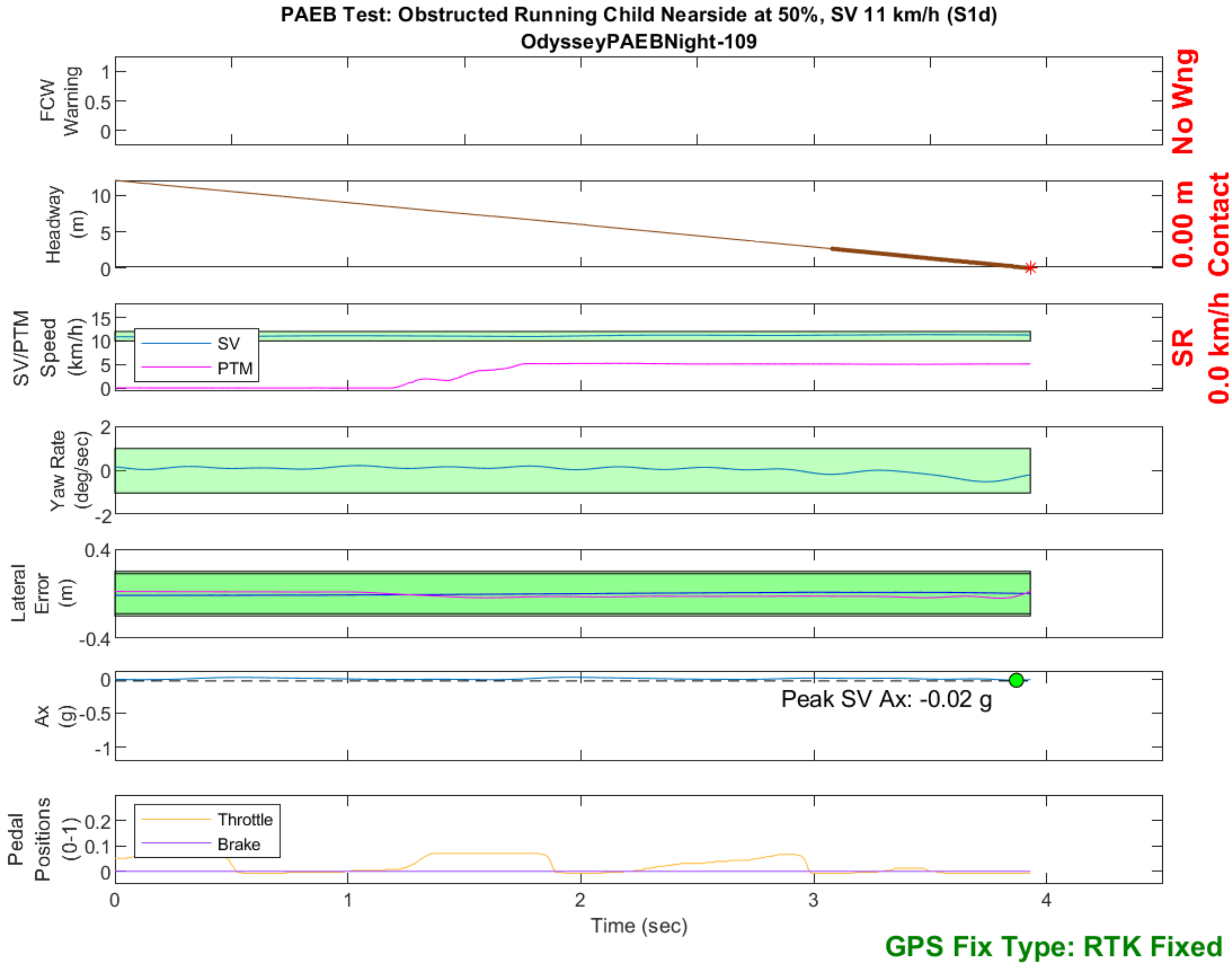


Figure D106. Time History for PAEB Run 109, S1d, Night, High Beam, 11 km/h

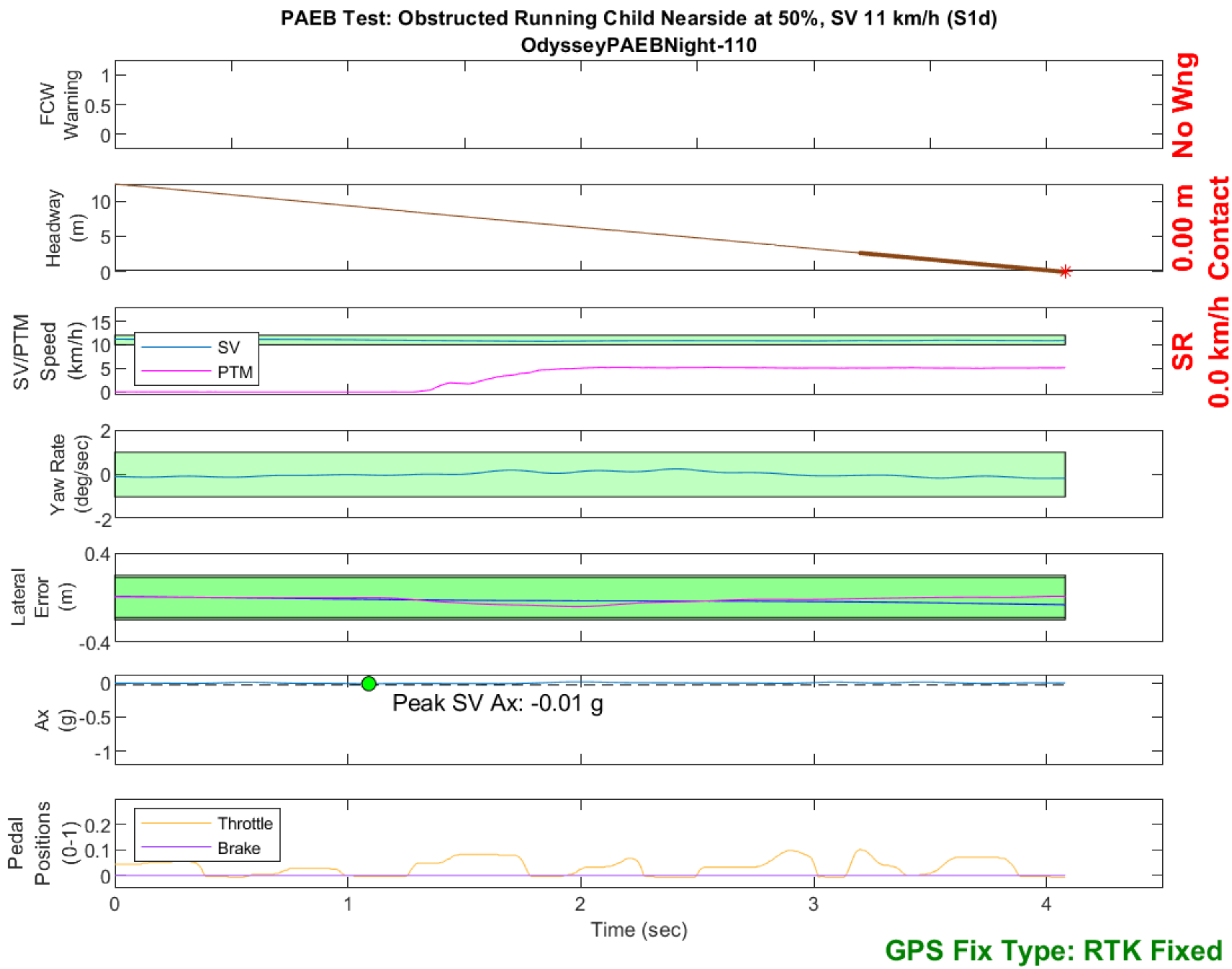


Figure D107. Time History for PAEB Run 110, S1d, Night, High Beam, 11 km/h

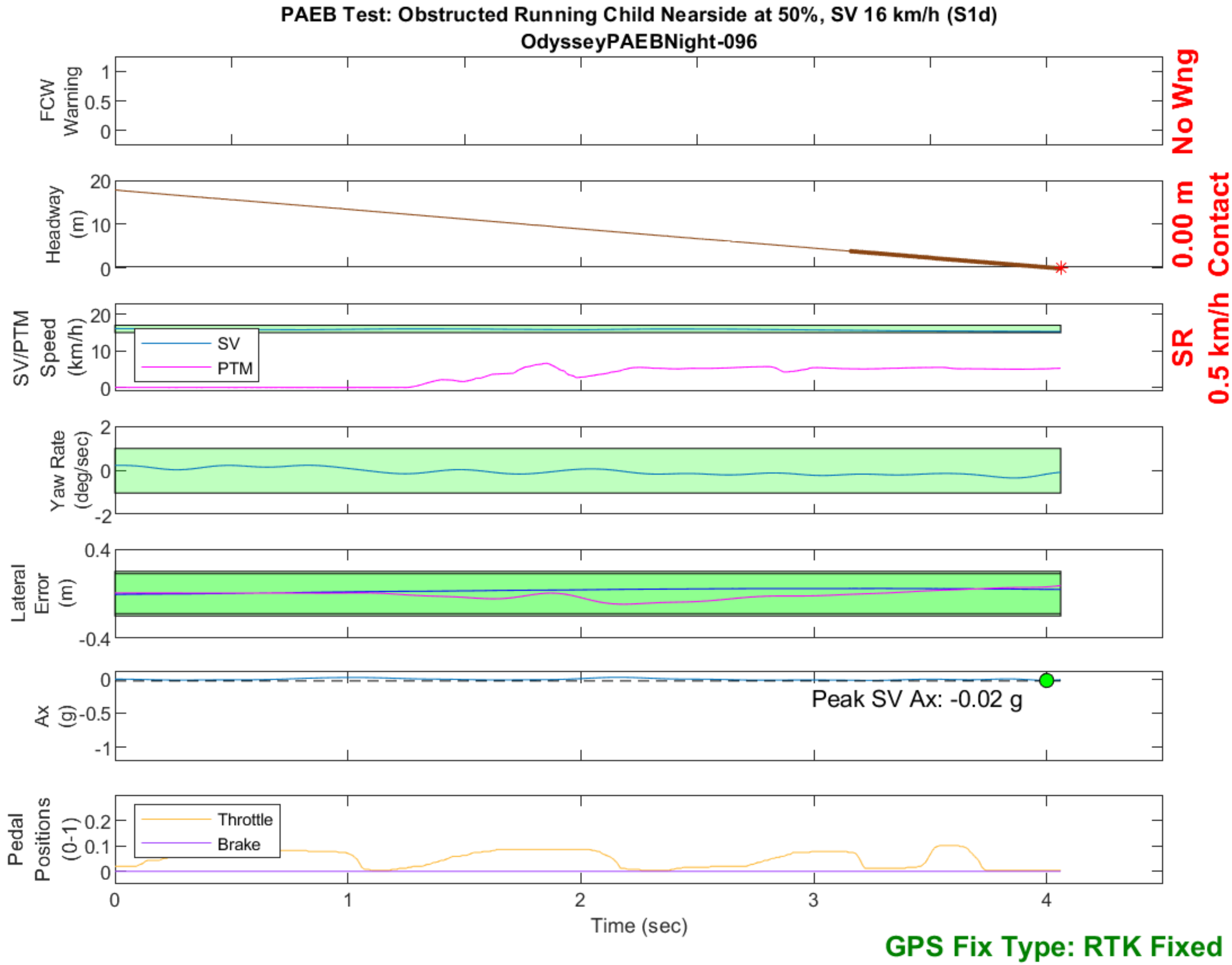


Figure D108. Time History for PAEB Run 96, S1d, Night, High Beam, 16 km/h

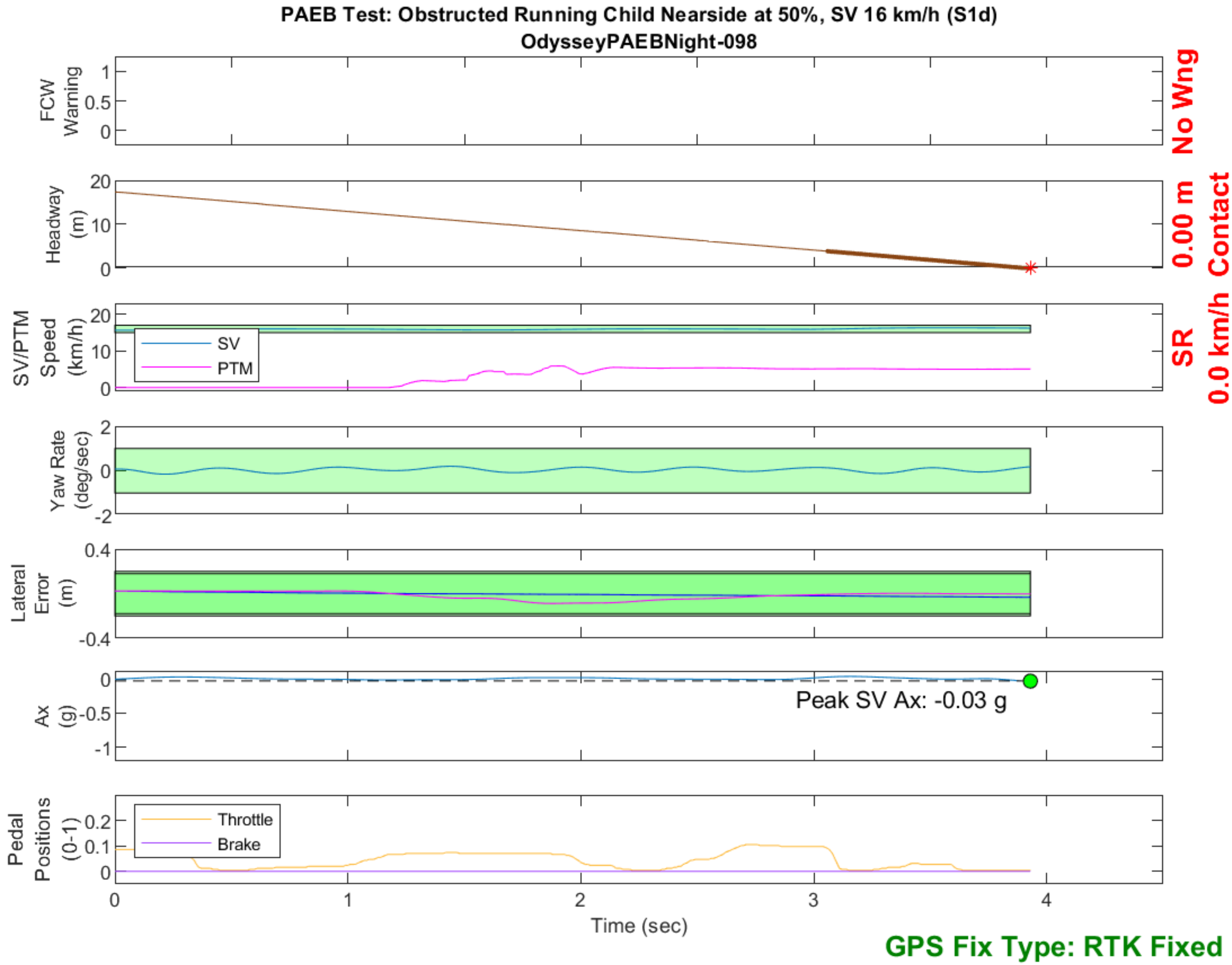


Figure D109. Time History for PAEB Run 98, S1d, Night, High Beam, 16 km/h

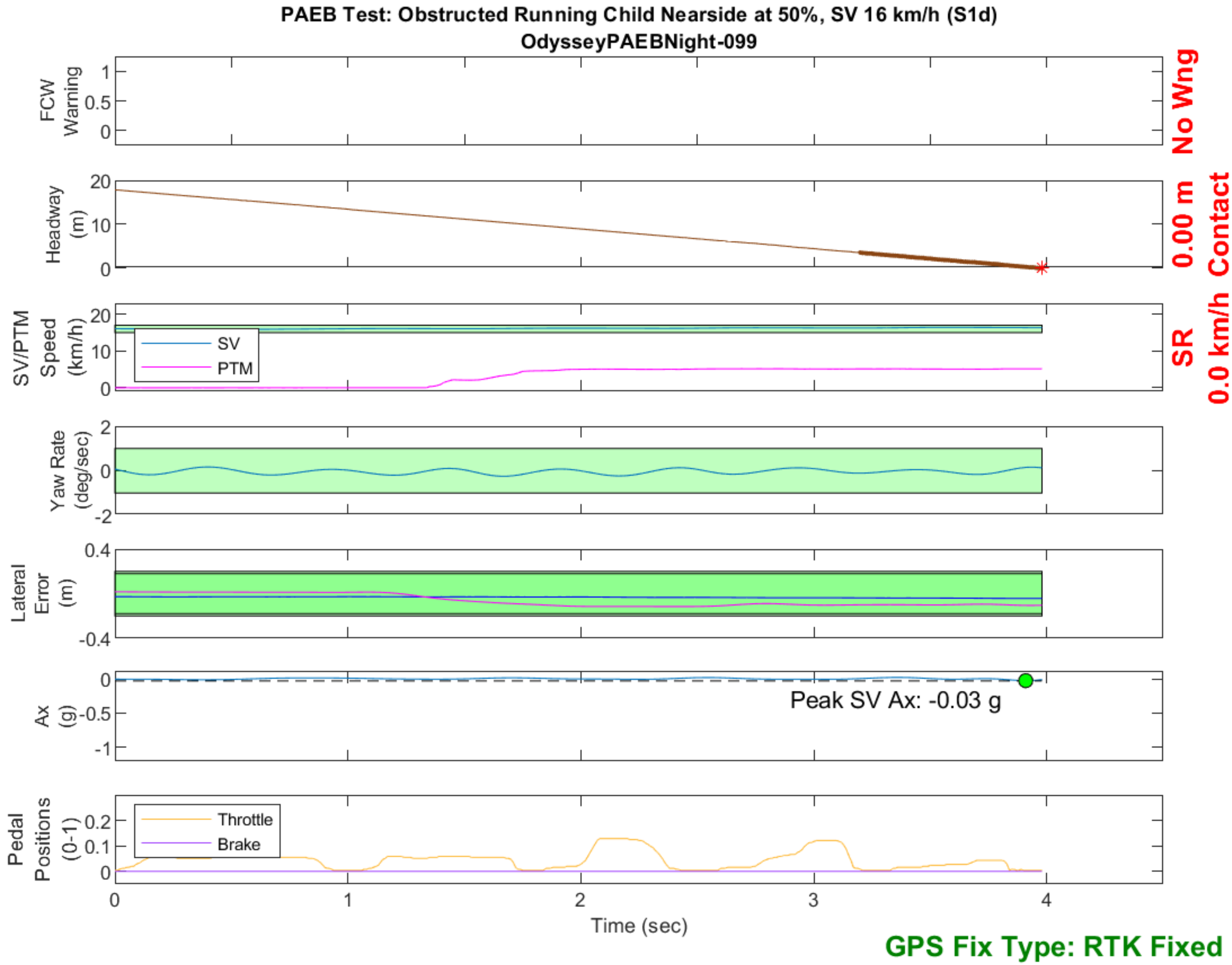


Figure D110. Time History for PAEB Run 99, S1d, Night, High Beam, 16 km/h

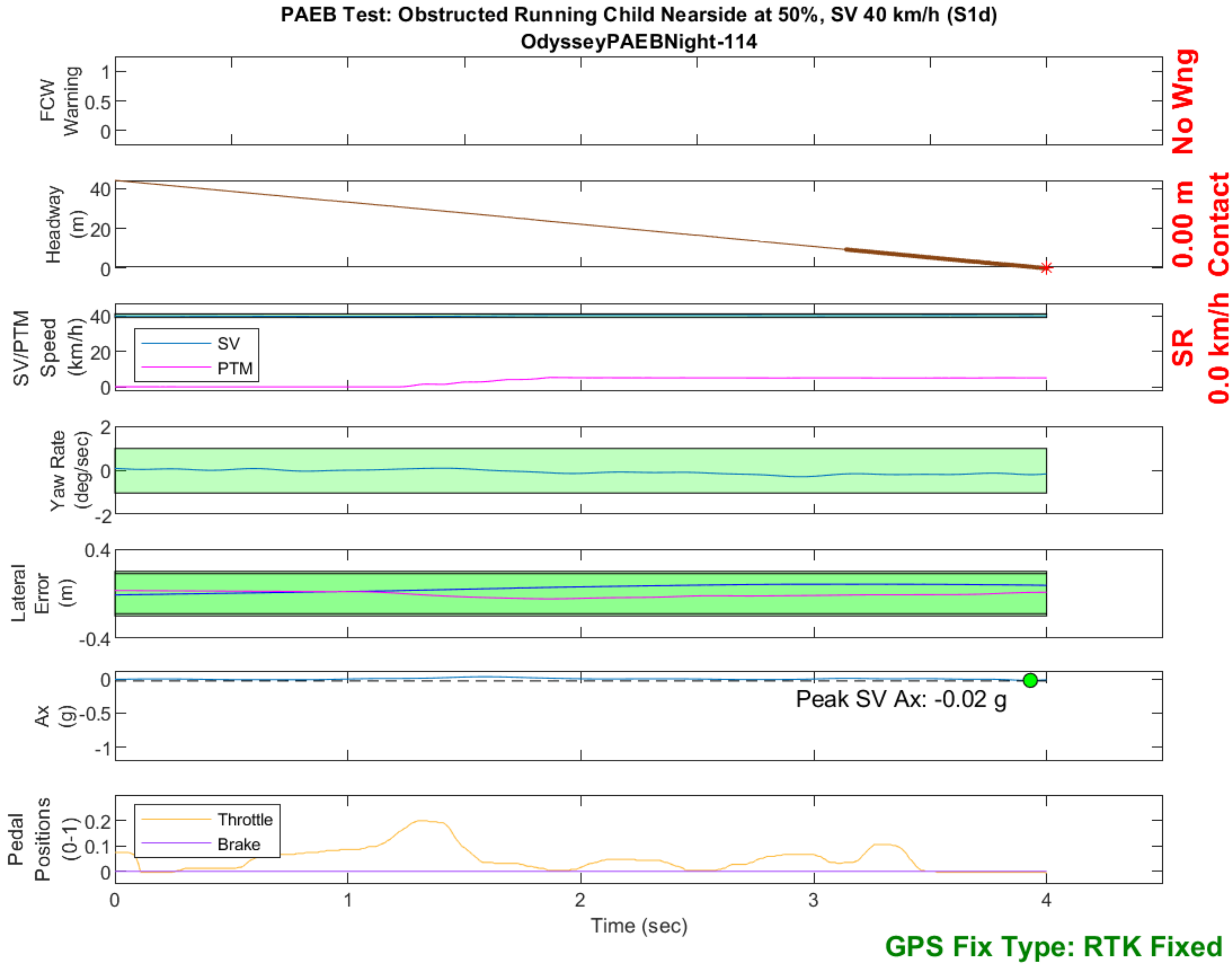


Figure D111. Time History for PAEB Run 114, S1d, Night, High Beam, 40 km/h

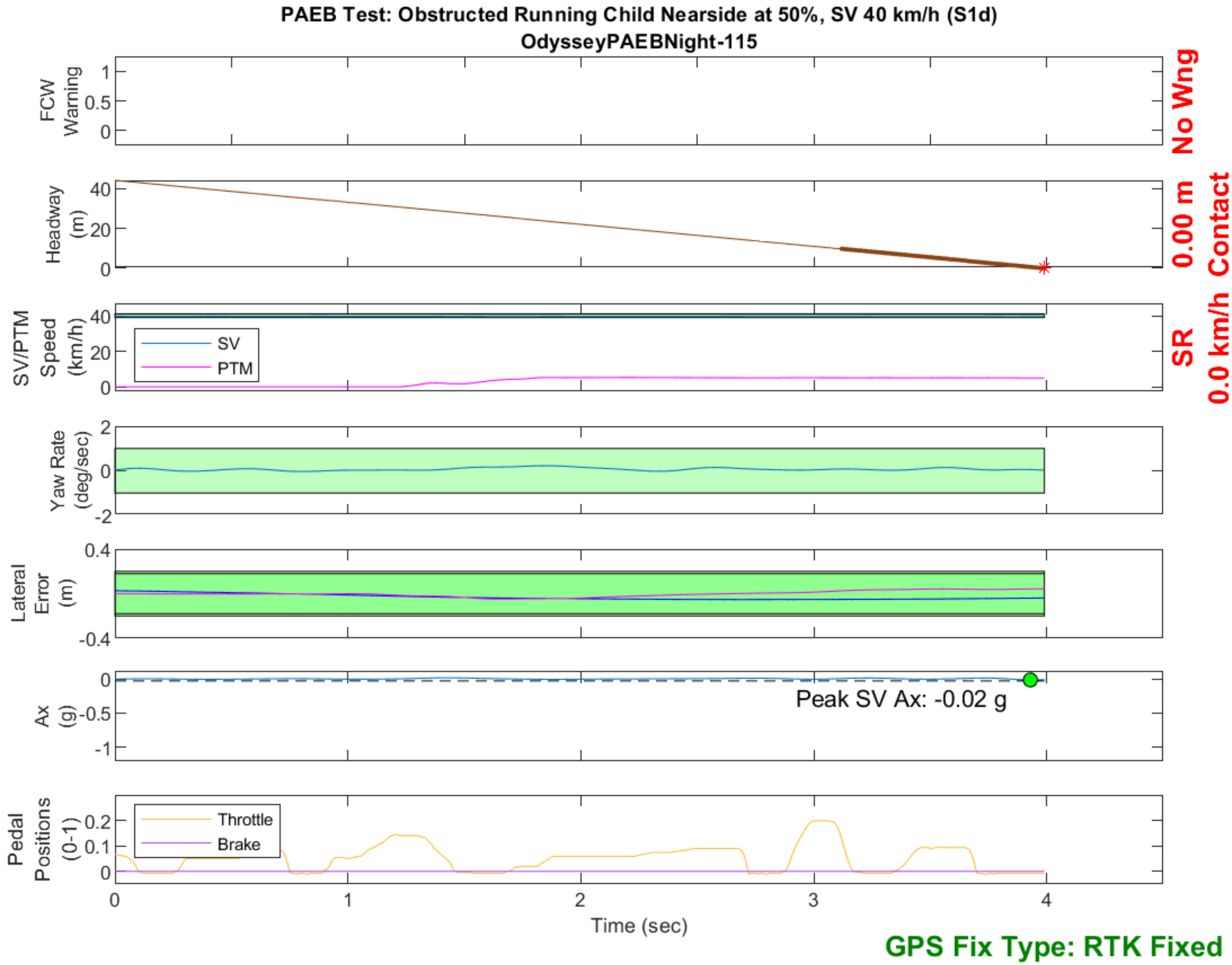


Figure D112. Time History for PAEB Run 115, S1d, Night, High Beam, 40 km/h

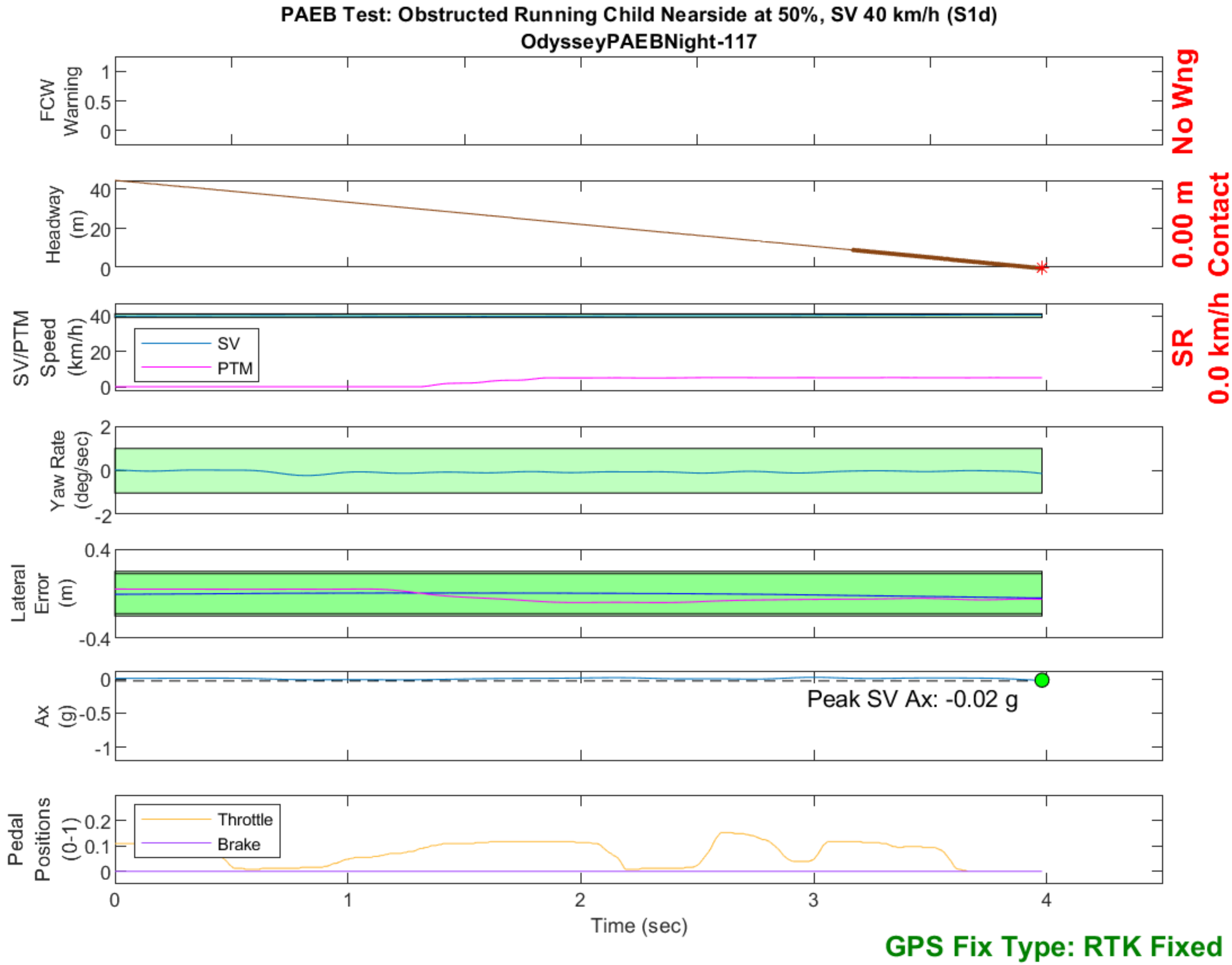


Figure D113. Time History for PAEB Run 117, S1d, Night, High Beam, 40 km/h

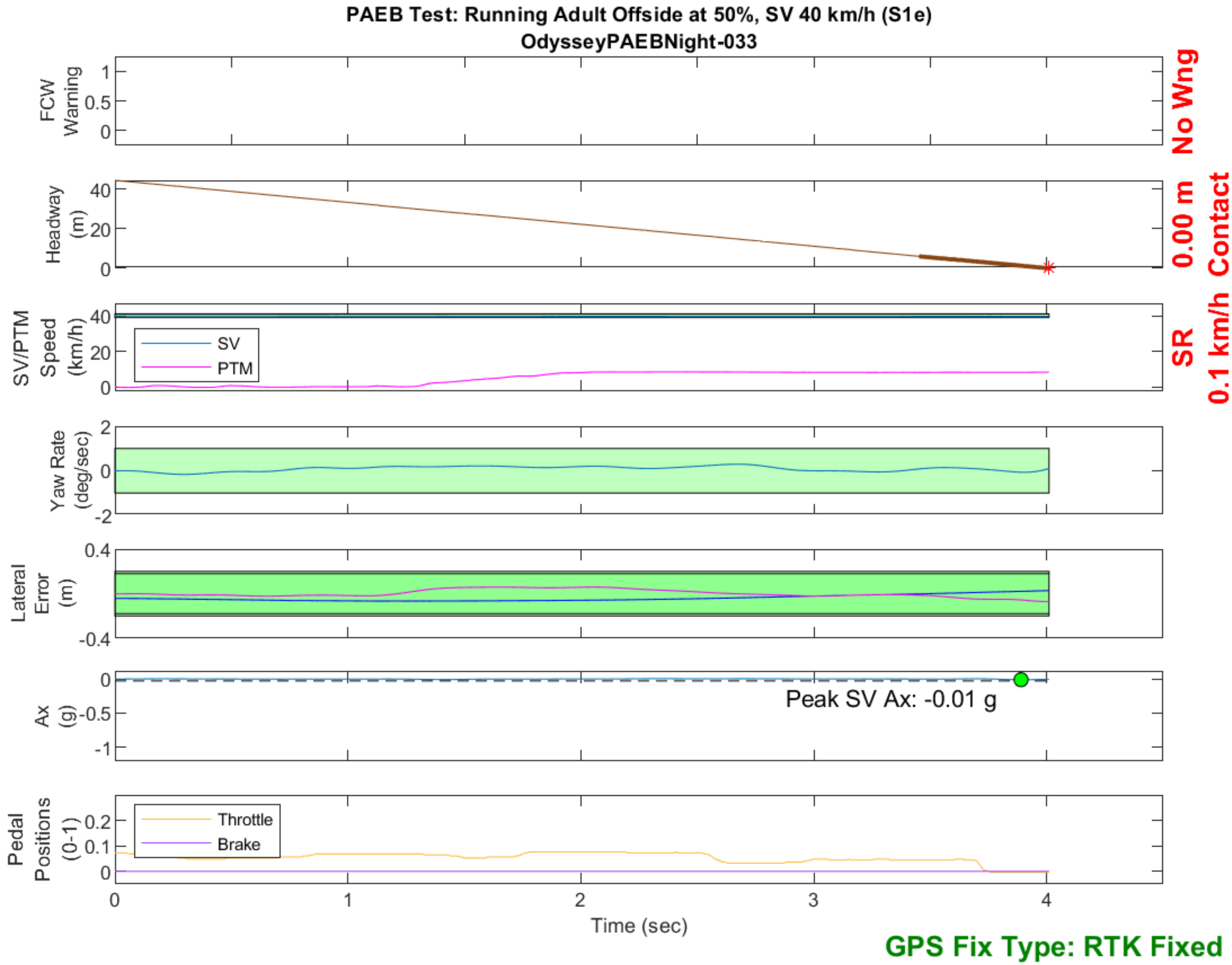


Figure D114. Time History for PAEB Run 33, S1e, Night, High Beam, 40 km/h

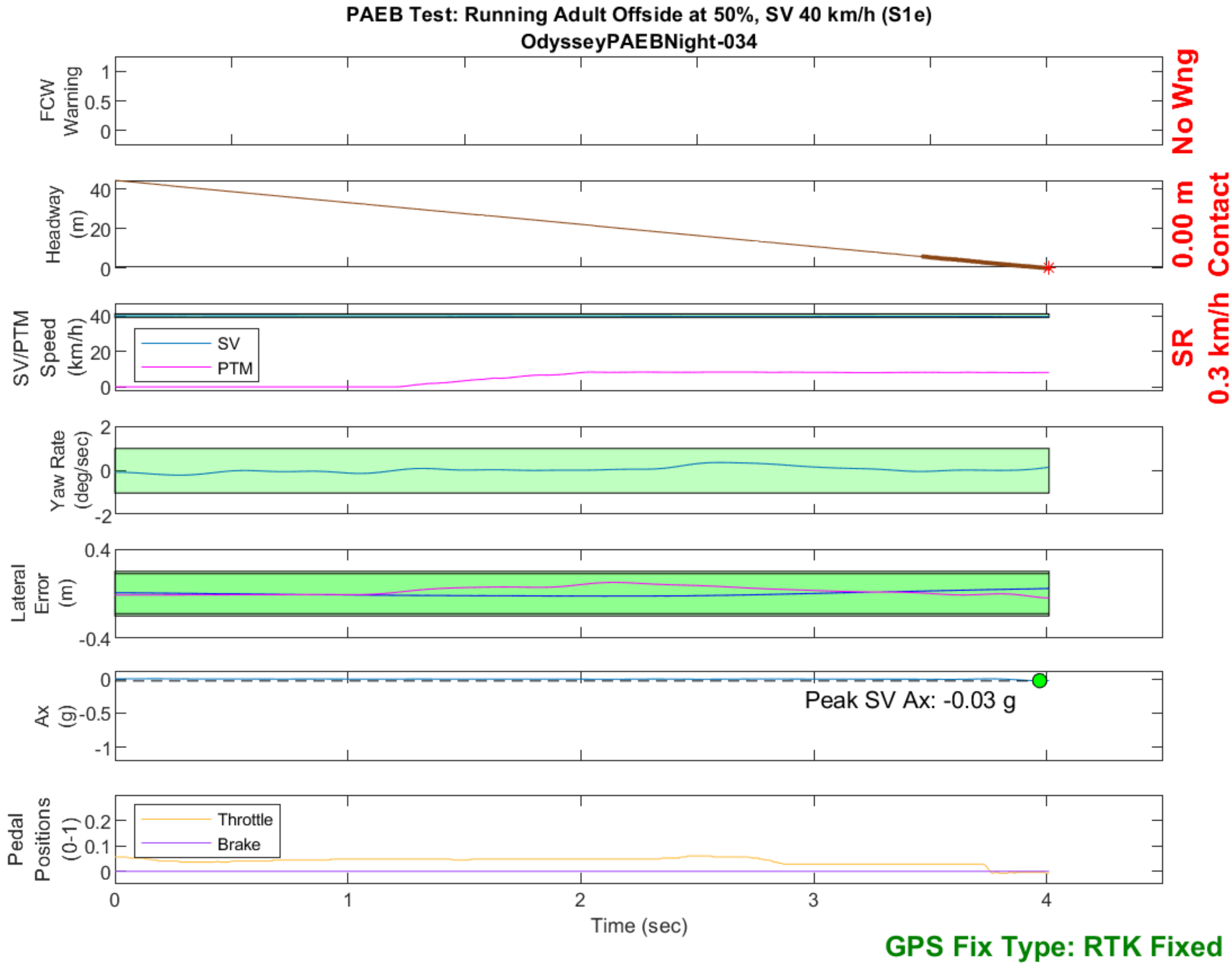


Figure D115. Time History for PAEB Run 34, S1e, Night, High Beam, 40 km/h

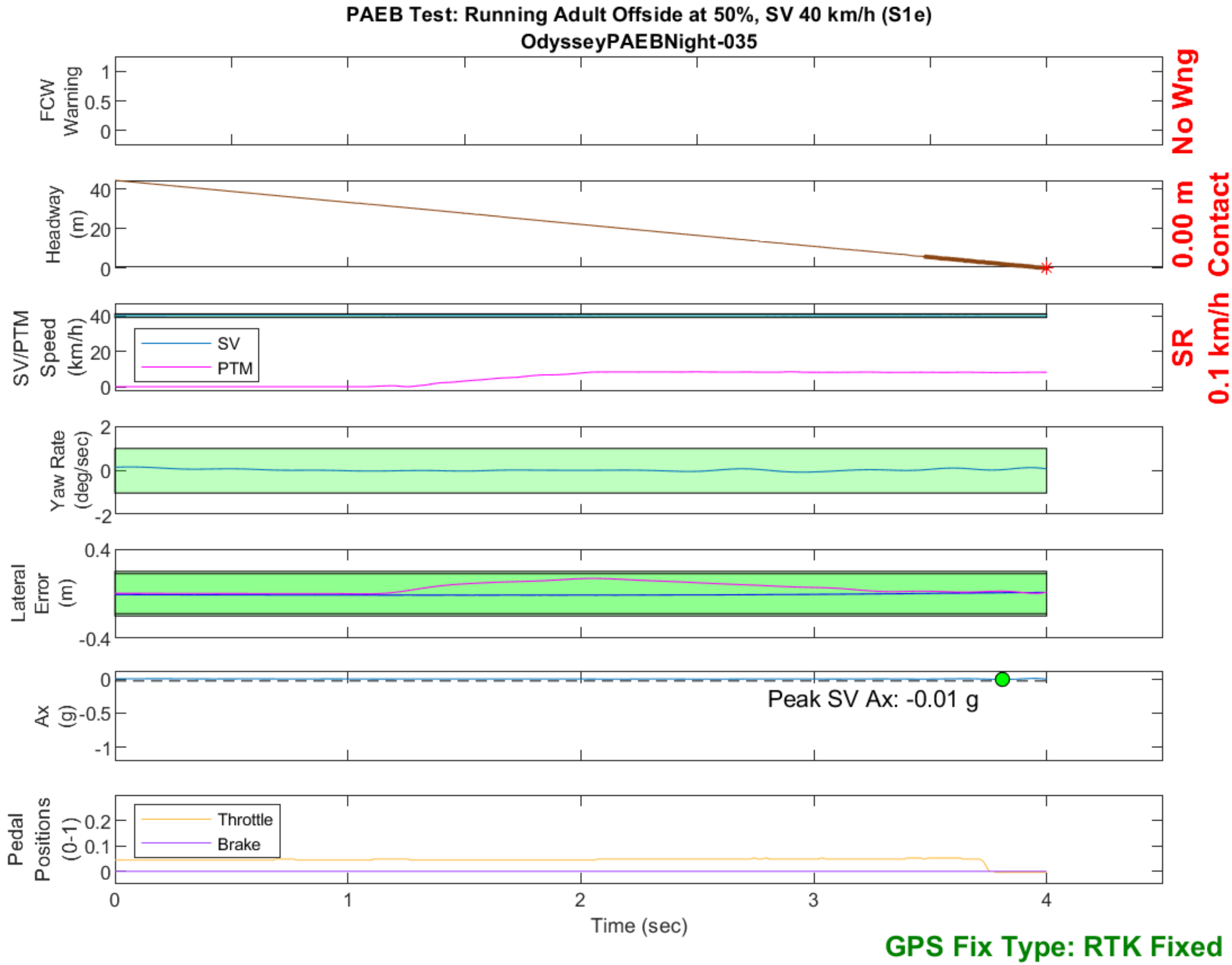


Figure D116. Time History for PAEB Run 35, S1e, Night, High Beam, 40 km/h

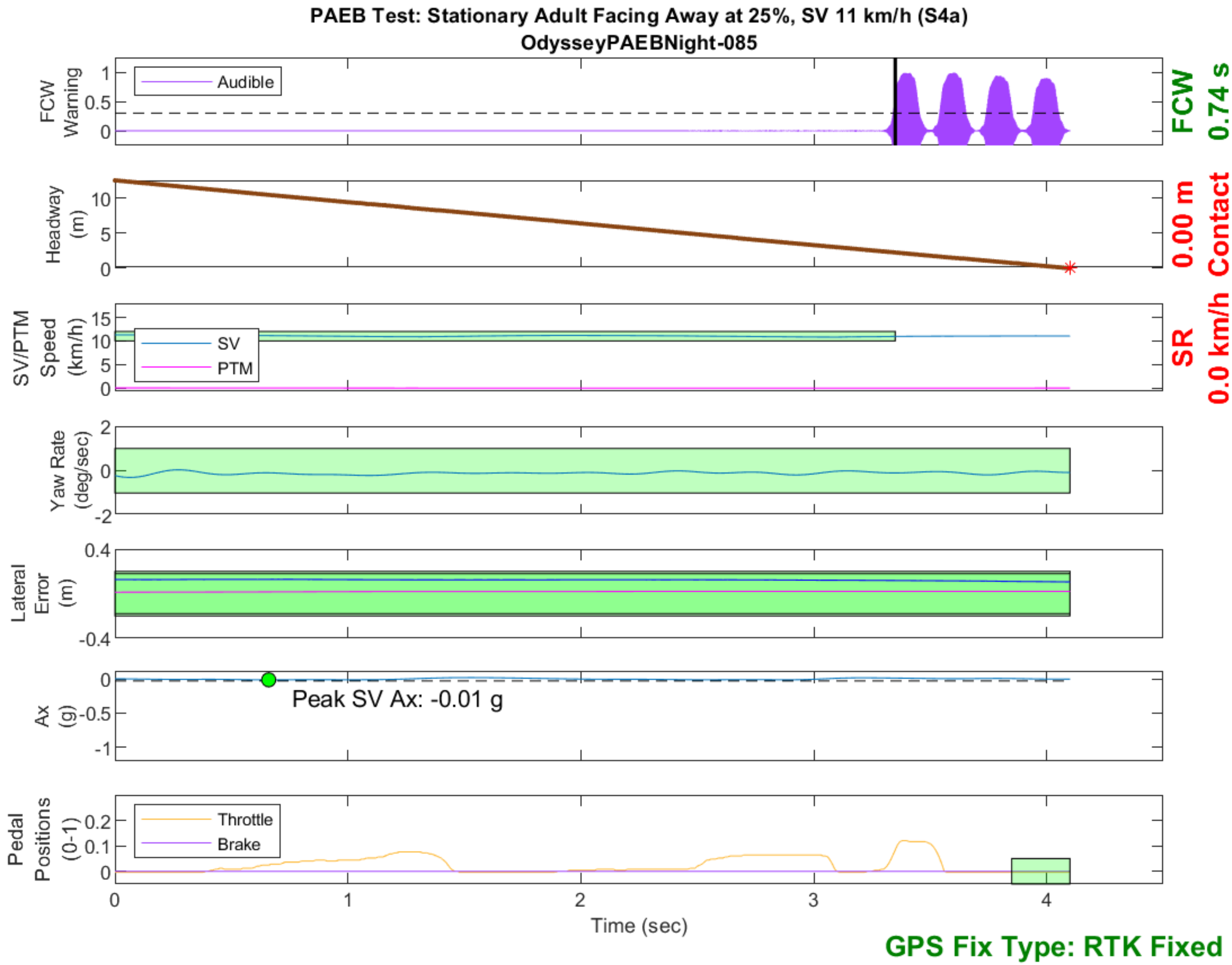


Figure D117. Time History for PAEB Run 85, S4a, Night, High Beam, 11 km/h

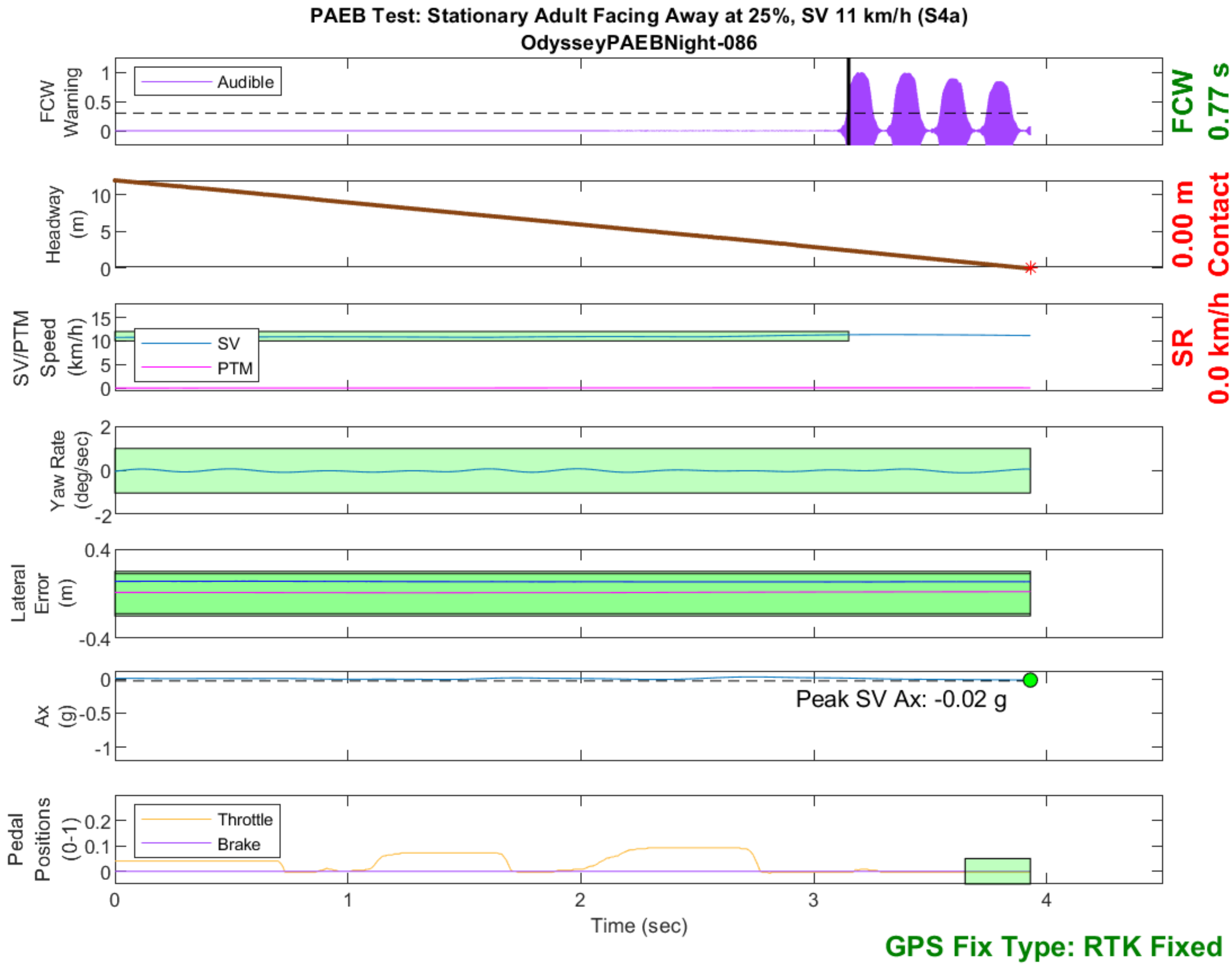


Figure D118. Time History for PAEB Run 86, S4a, Night, High Beam, 11 km/h

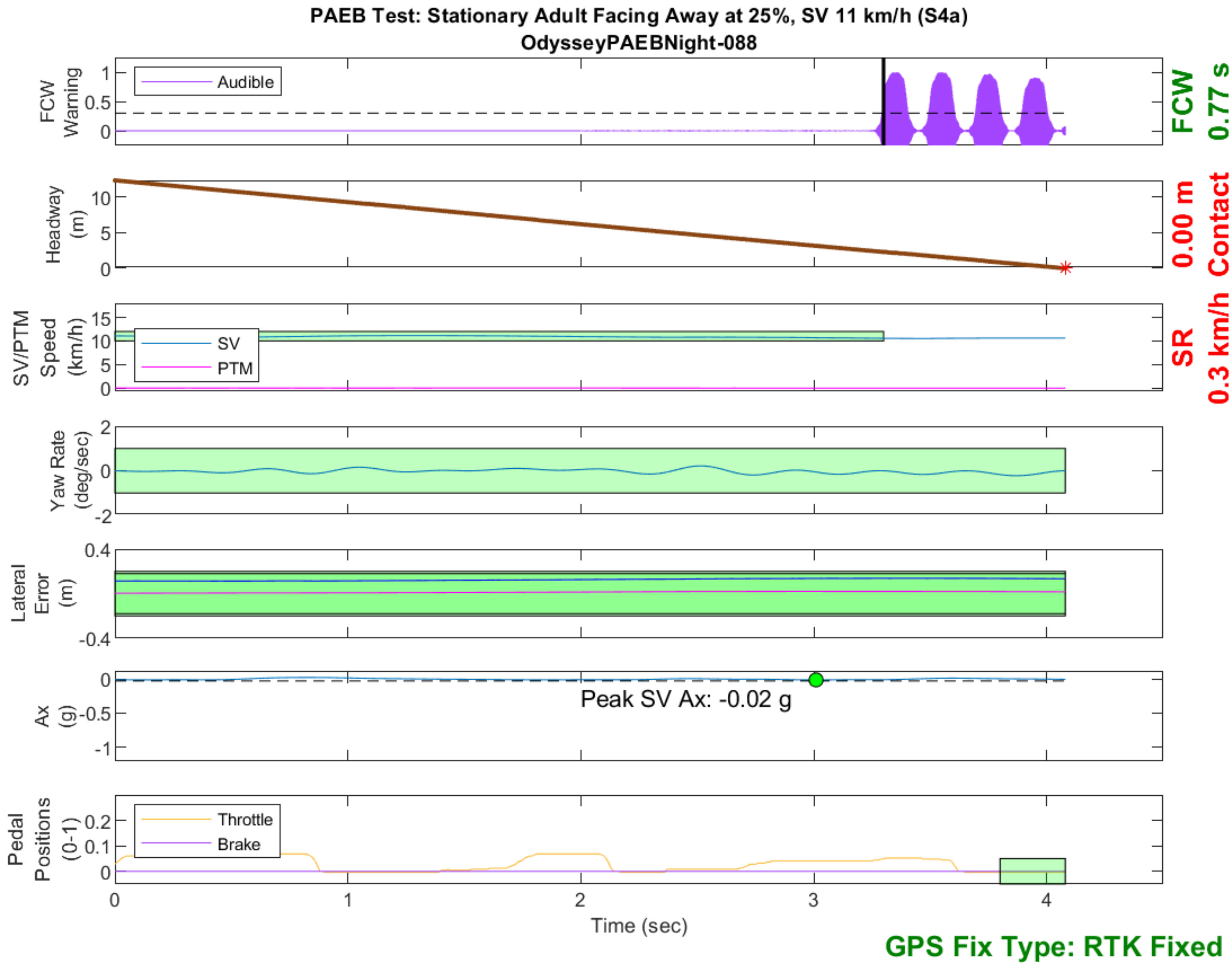


Figure D119. Time History for PAEB Run 88, S4a, Night, High Beam, 11 km/h

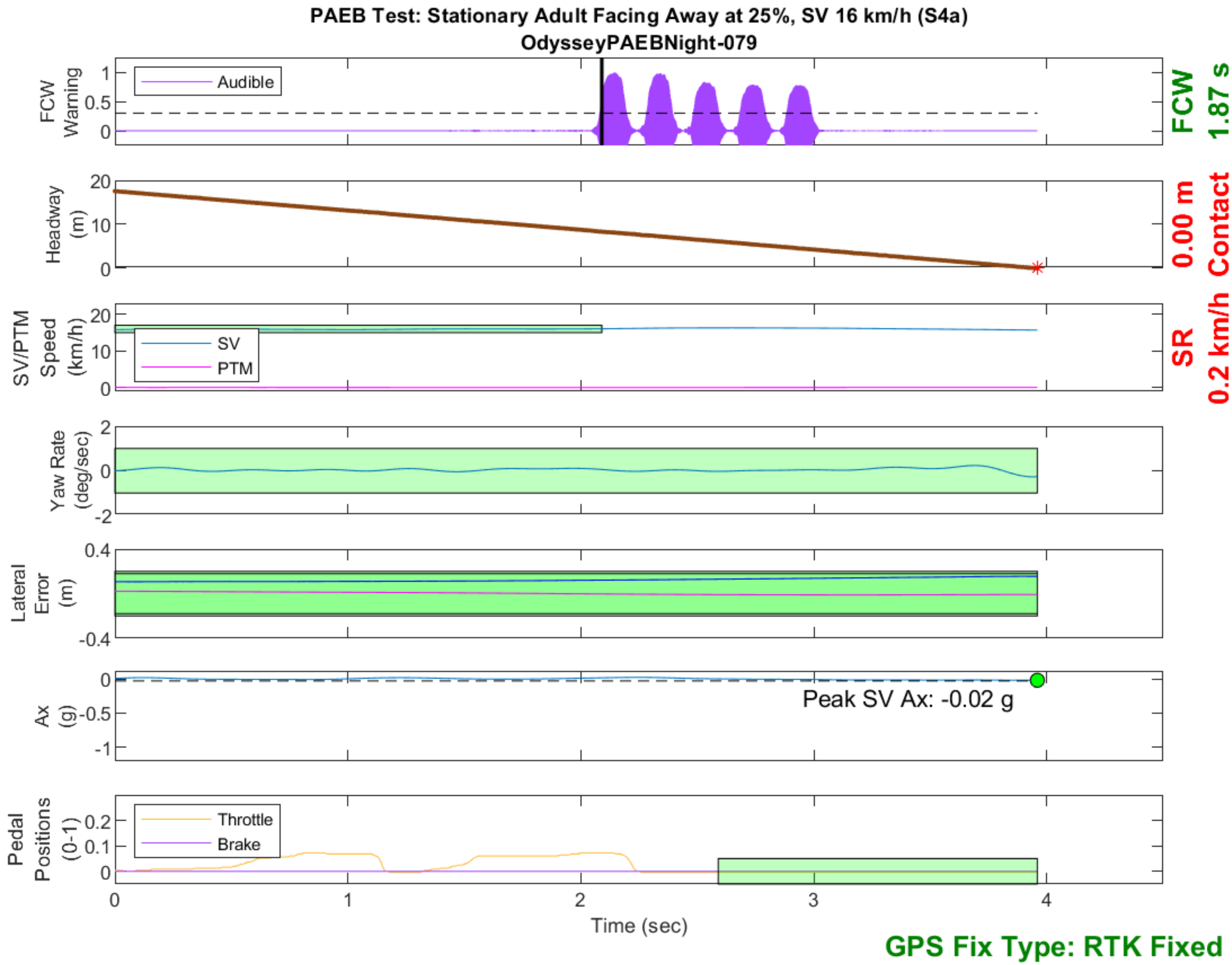


Figure D120. Time History for PAEB Run 79, S4a, Night, High Beam, 16 km/h

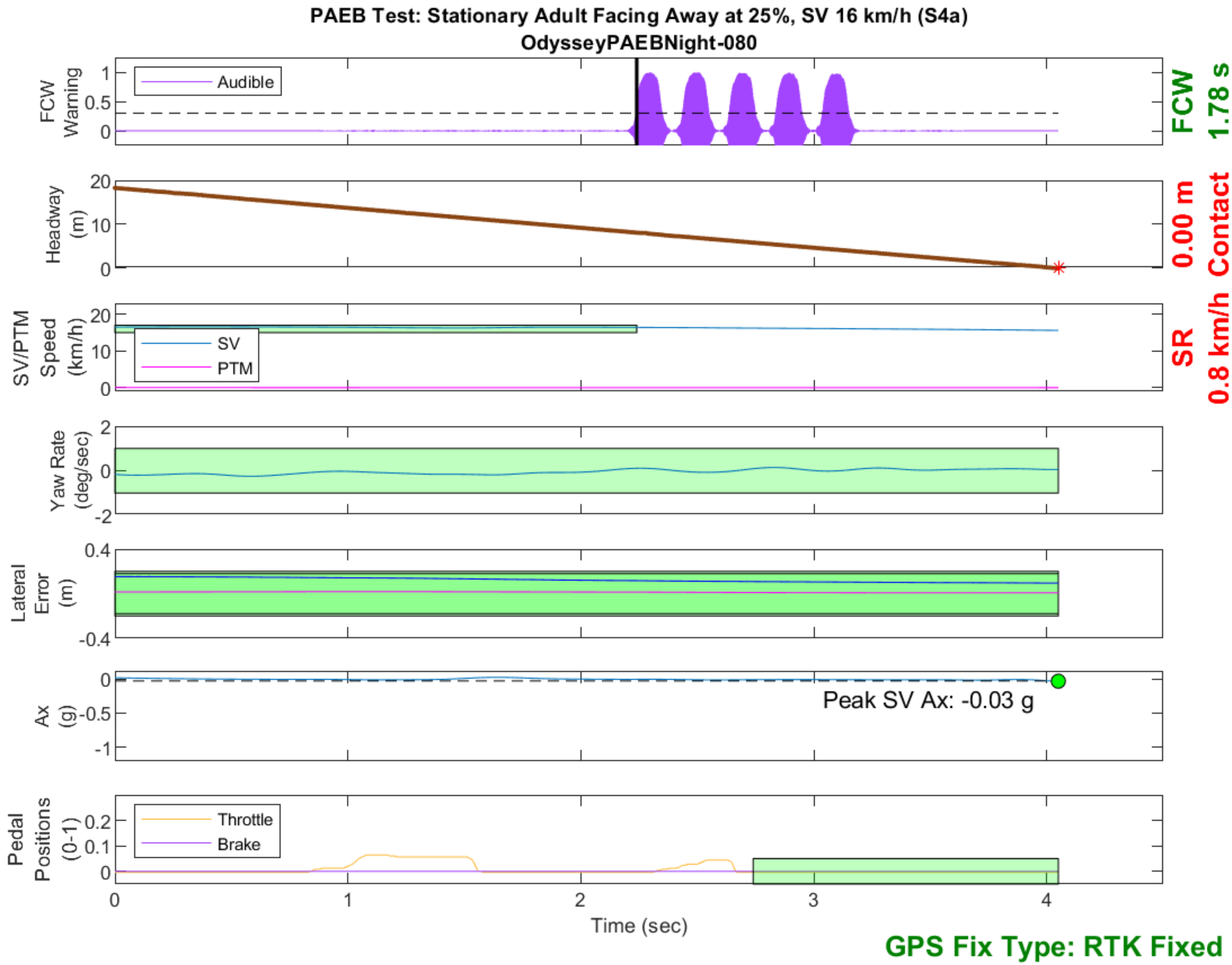


Figure D121. Time History for PAEB Run 80, S4a, Night, High Beam, 16 km/h

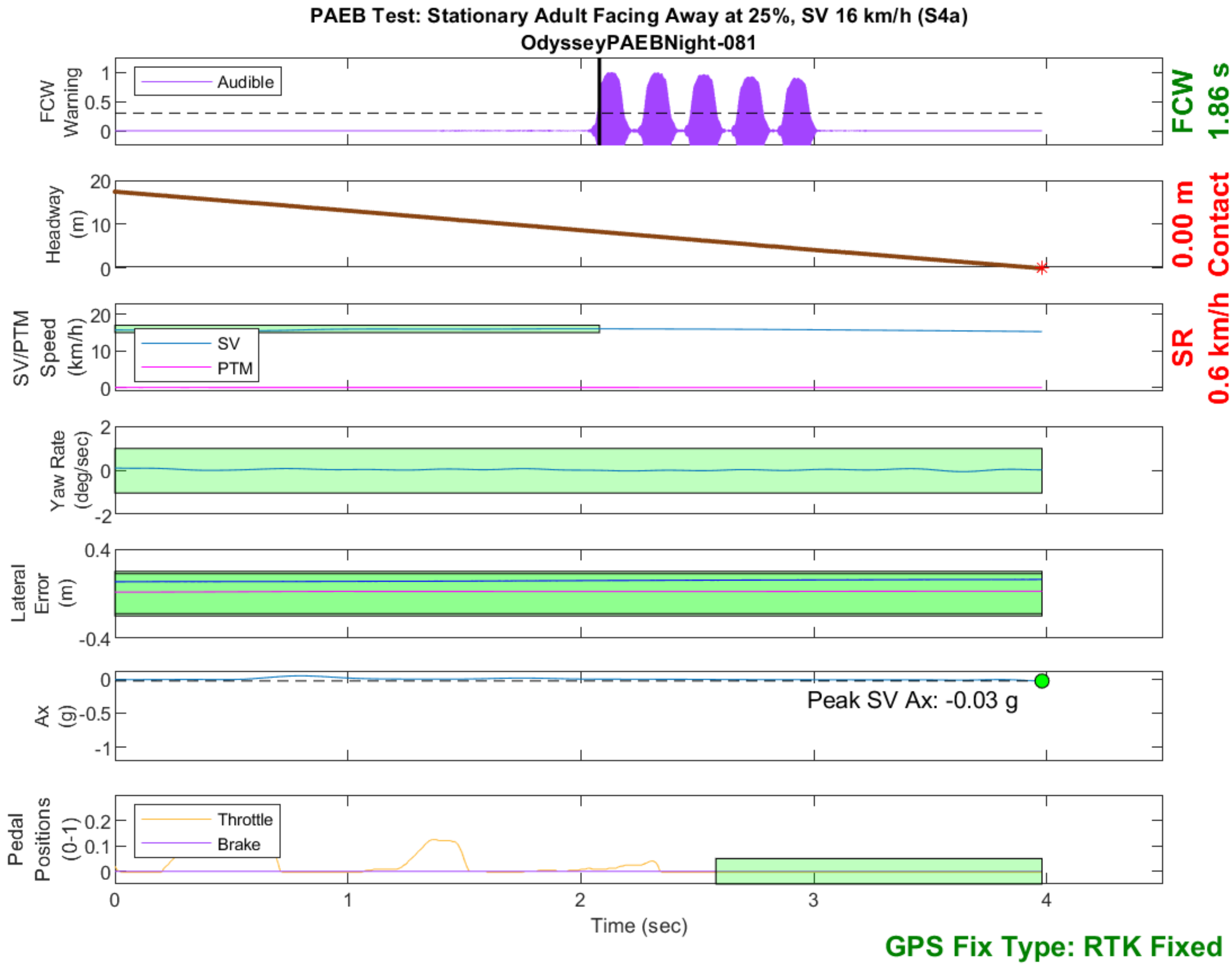


Figure D122. Time History for PAEB Run 81, S4a, Night, High Beam, 16 km/h

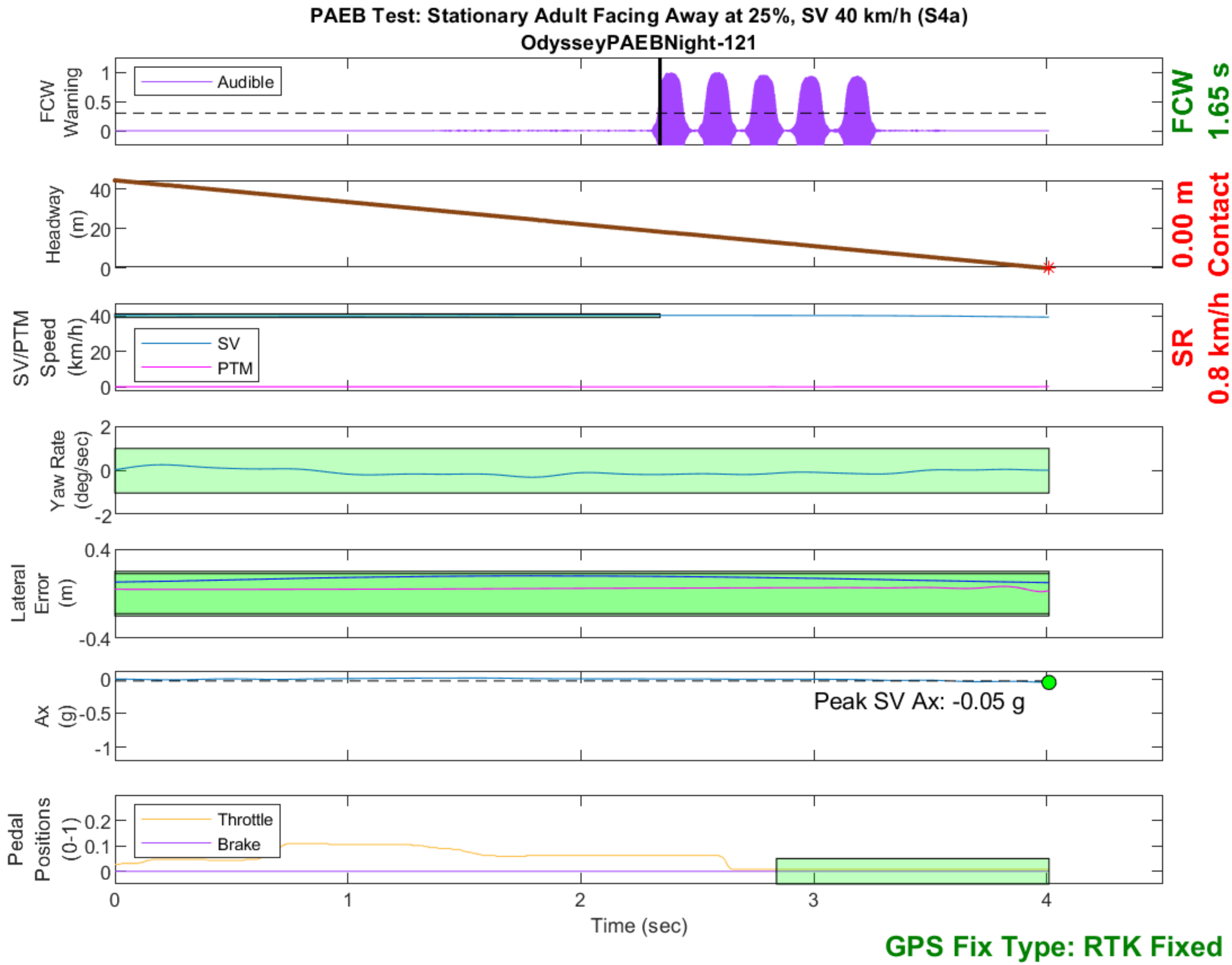


Figure D123. Time History for PAEB Run 121, S4a, Night, High Beam, 40 km/h

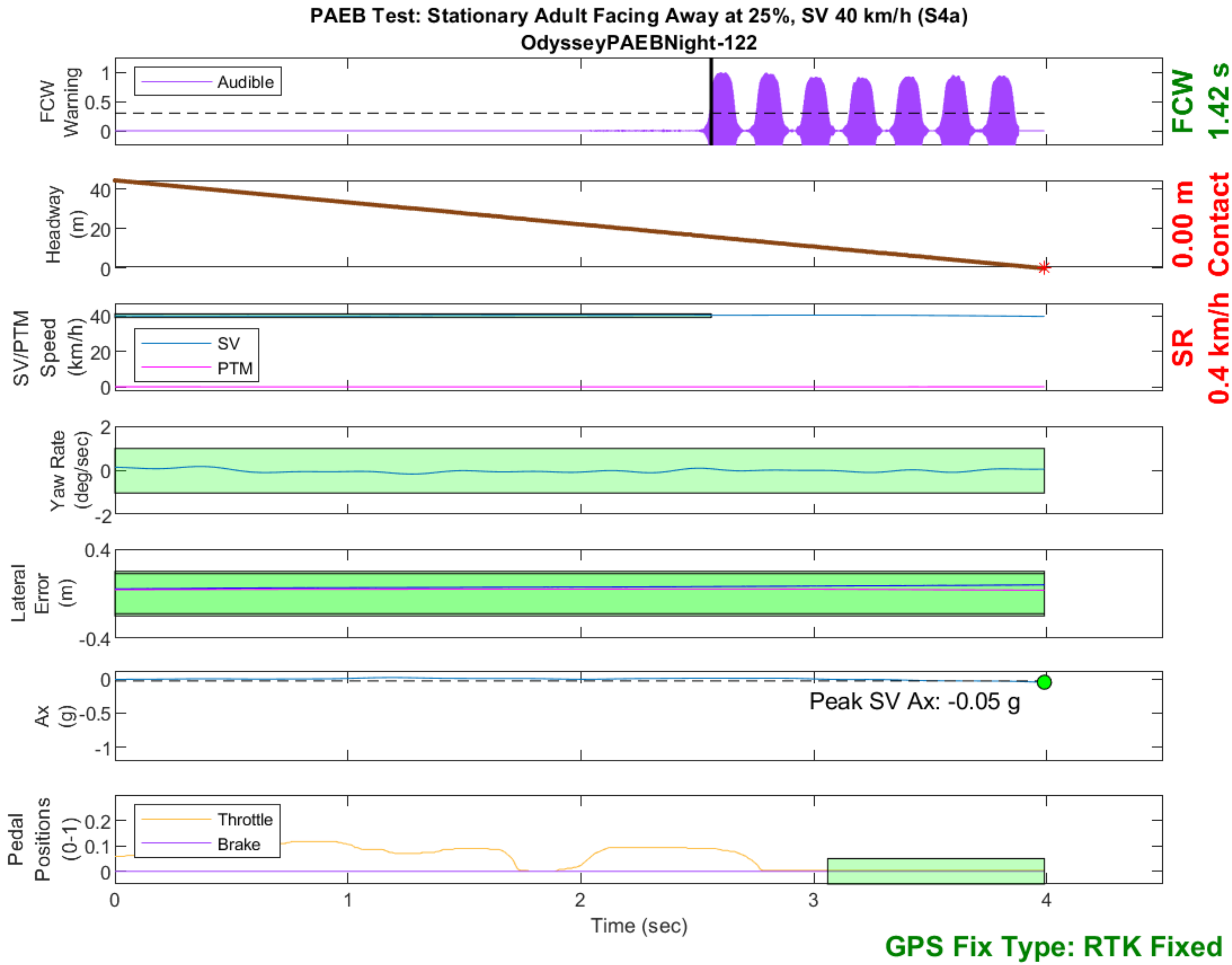


Figure D124. Time History for PAEB Run 122, S4a, Night, High Beam, 40 km/h

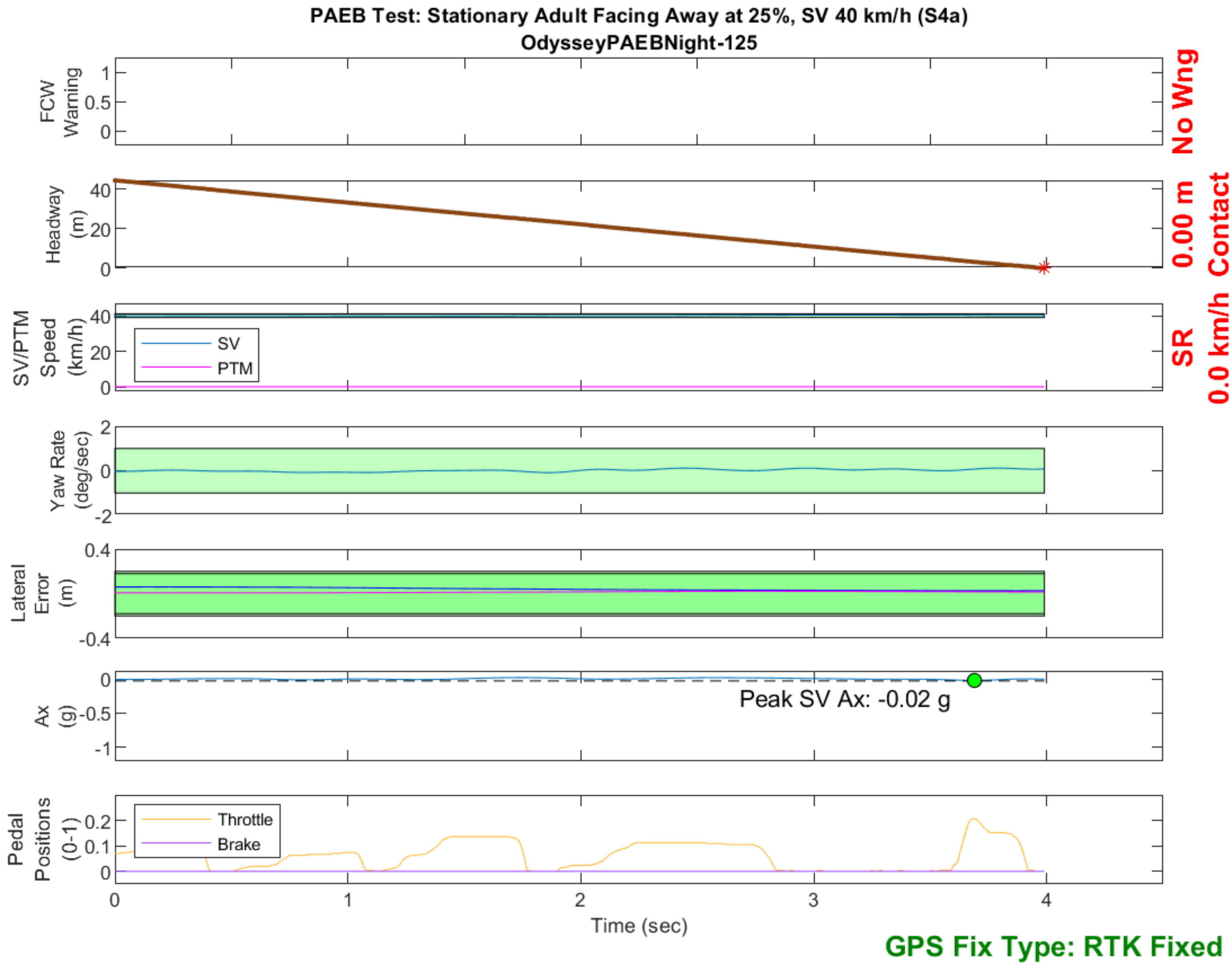


Figure D125. Time History for PAEB Run 125, S4a, Night, High Beam, 40 km/h

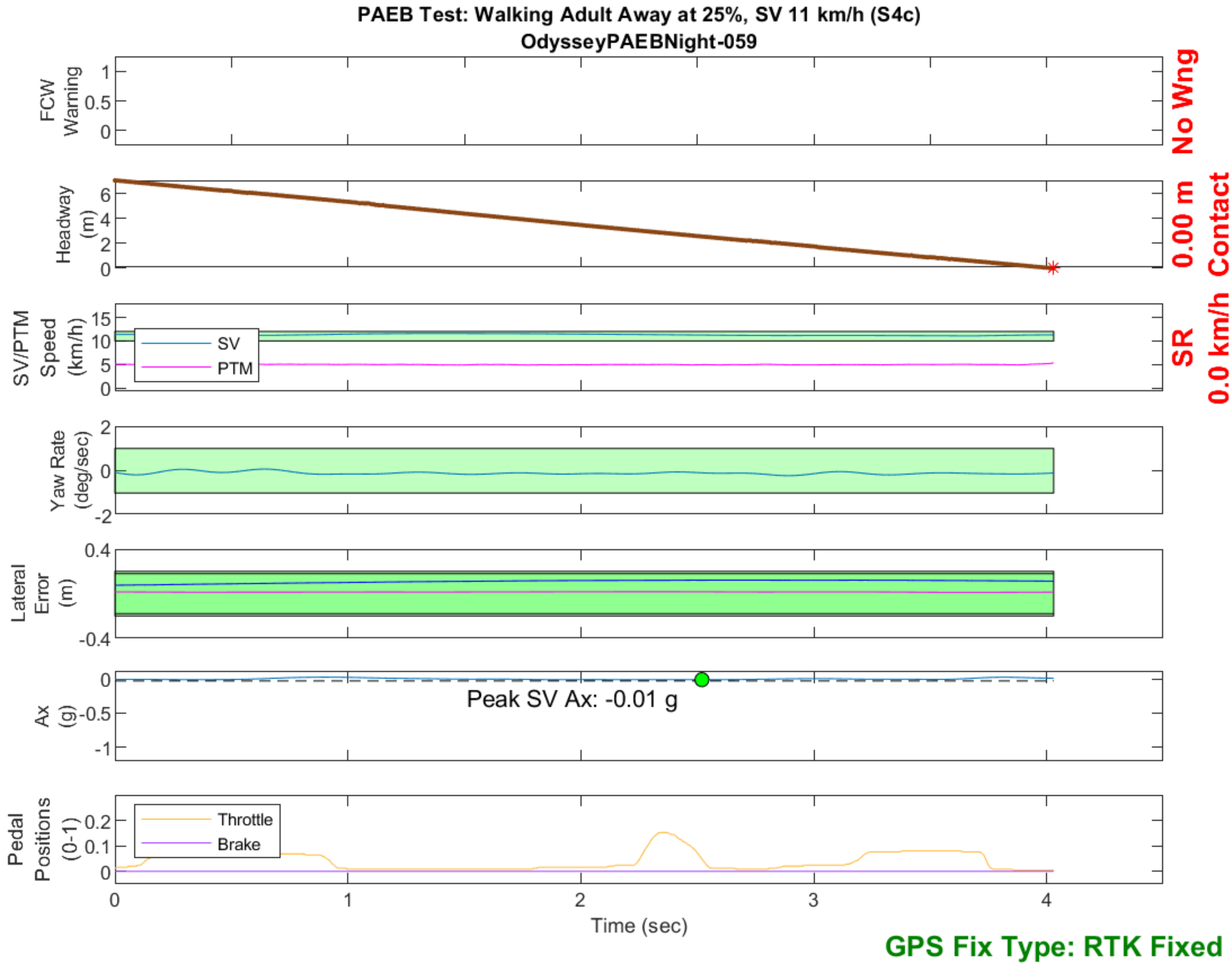


Figure D126. Time History for PAEB Run 59, S4c, Night, High Beam, 11 km/h

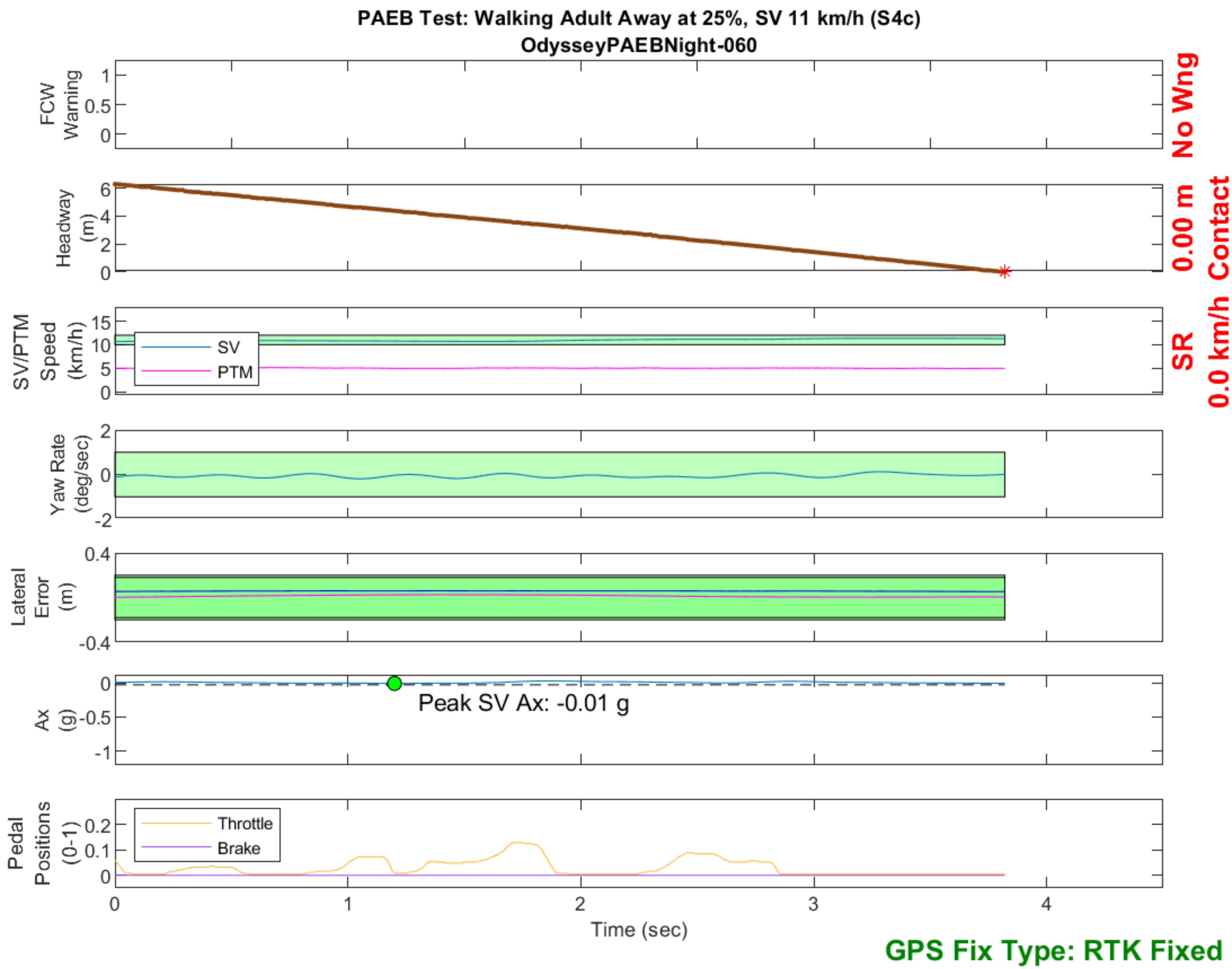


Figure D127. Time History for PAEB Run 60, S4c, Night, High Beam, 11 km/h

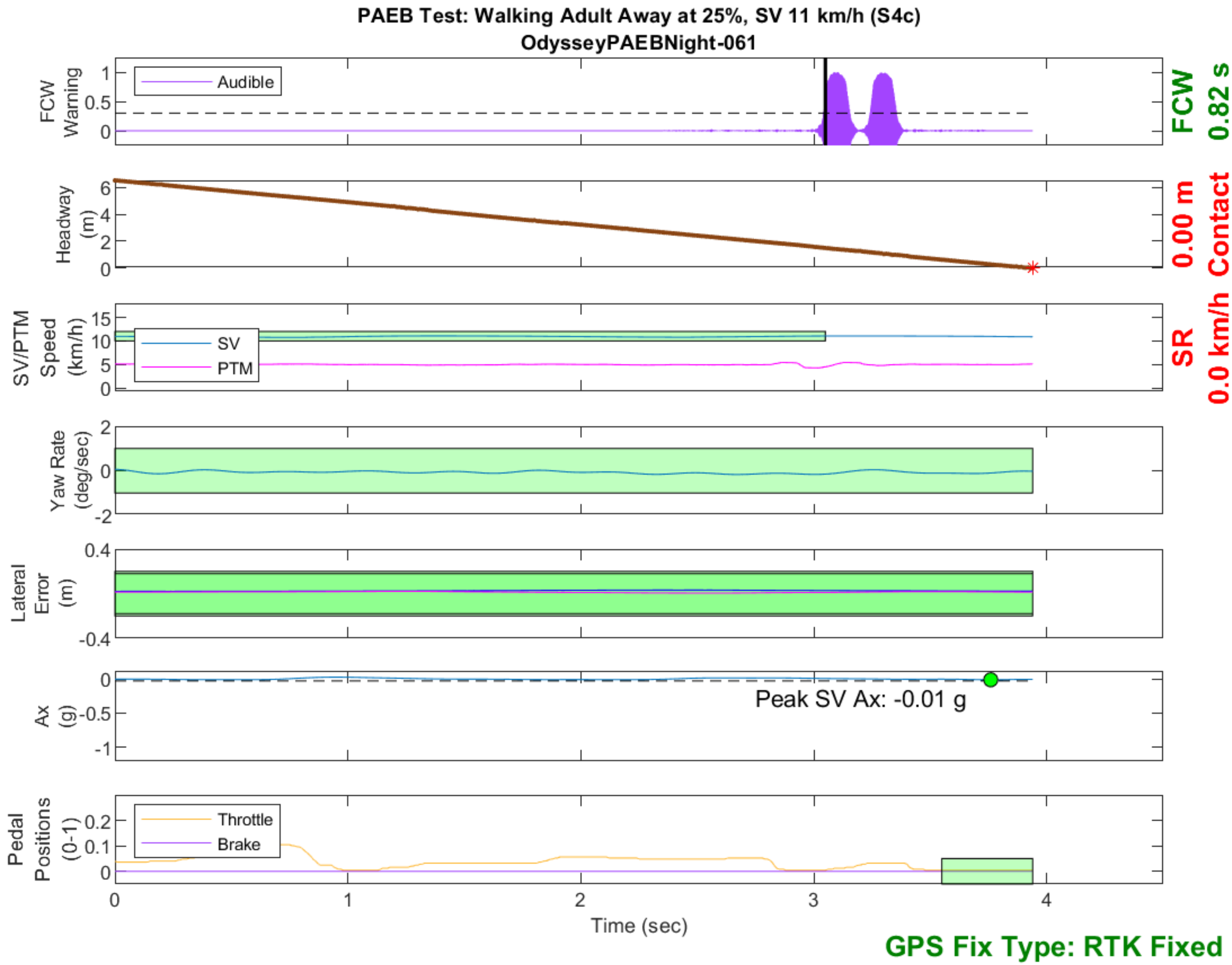


Figure D128. Time History for PAEB Run 61, S4c, Night, High Beam, 11 km/h

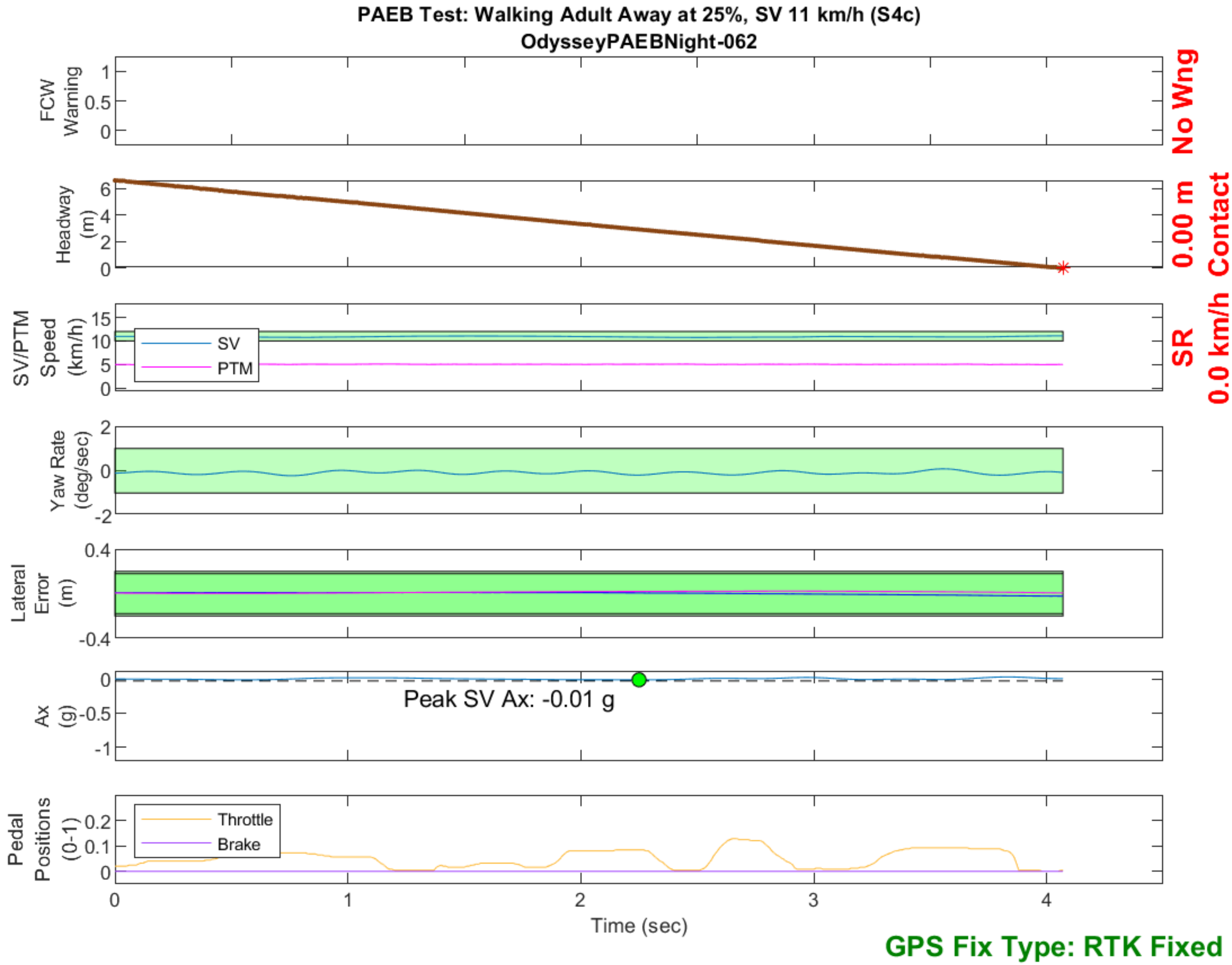


Figure D129. Time History for PAEB Run 62, S4c, Night, High Beam, 11 km/h

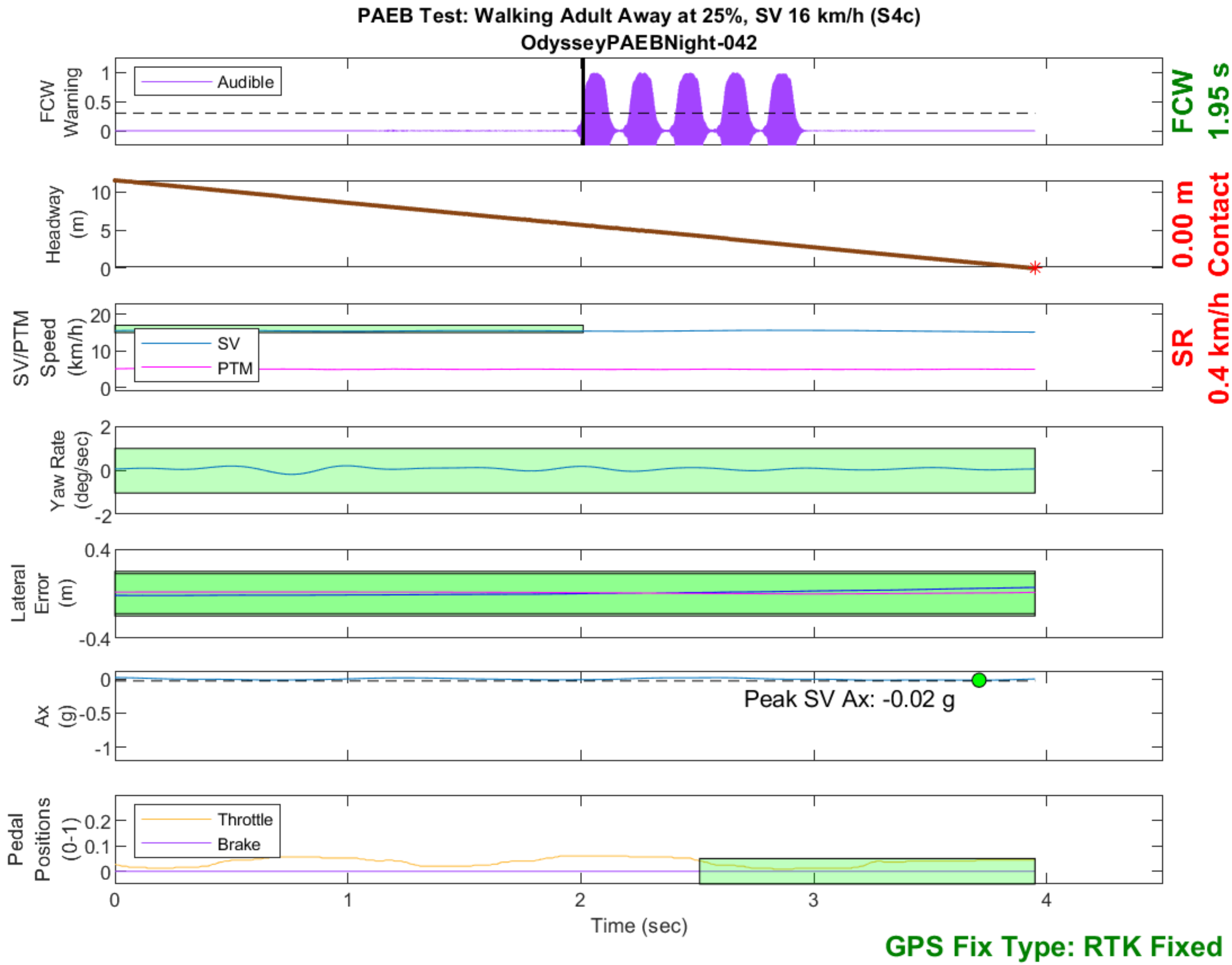


Figure D130. Time History for PAEB Run 42, S4c, Night, High Beam, 16 km/h

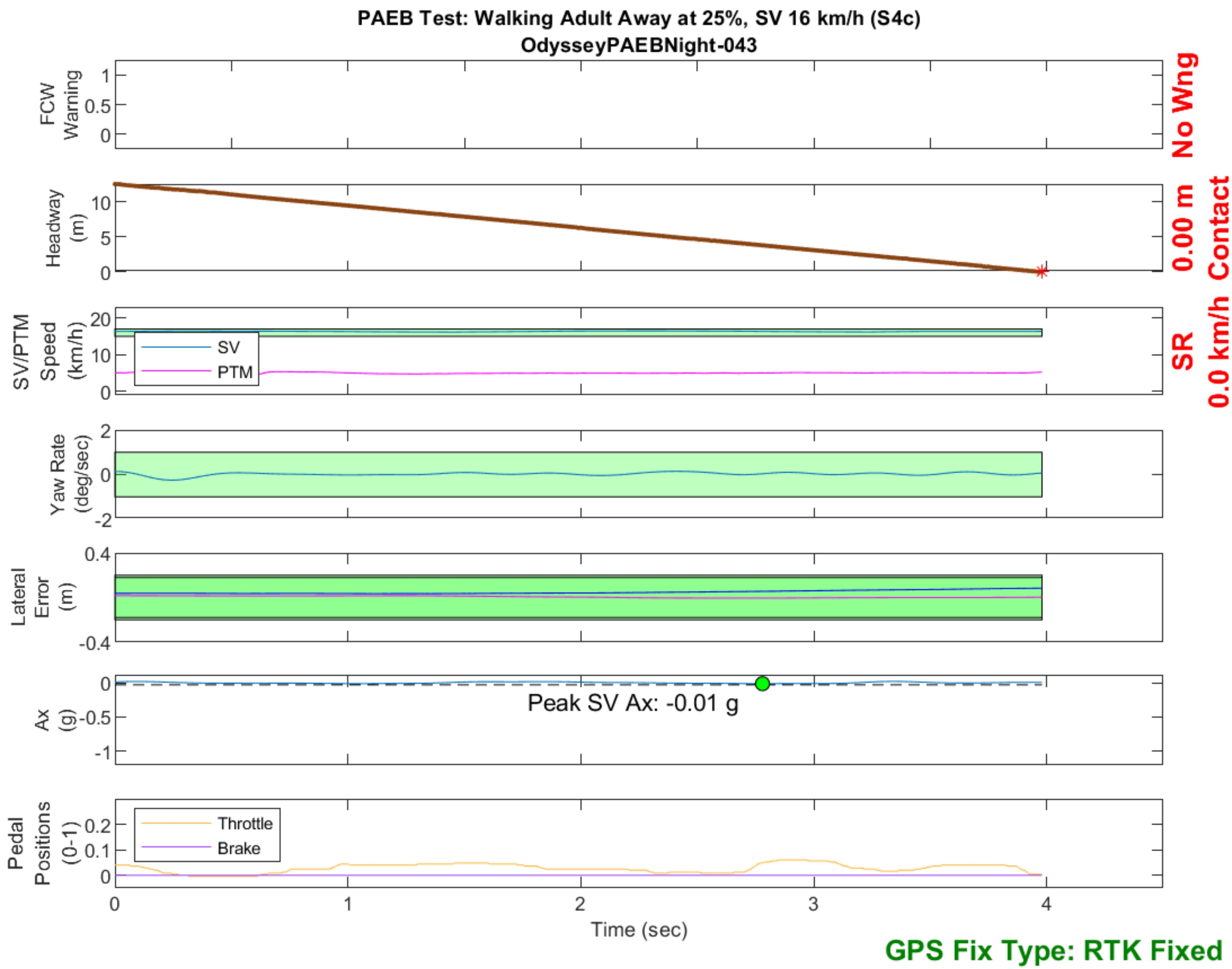


Figure D131. Time History for PAEB Run 43, S4c, Night, High Beam, 16 km/h

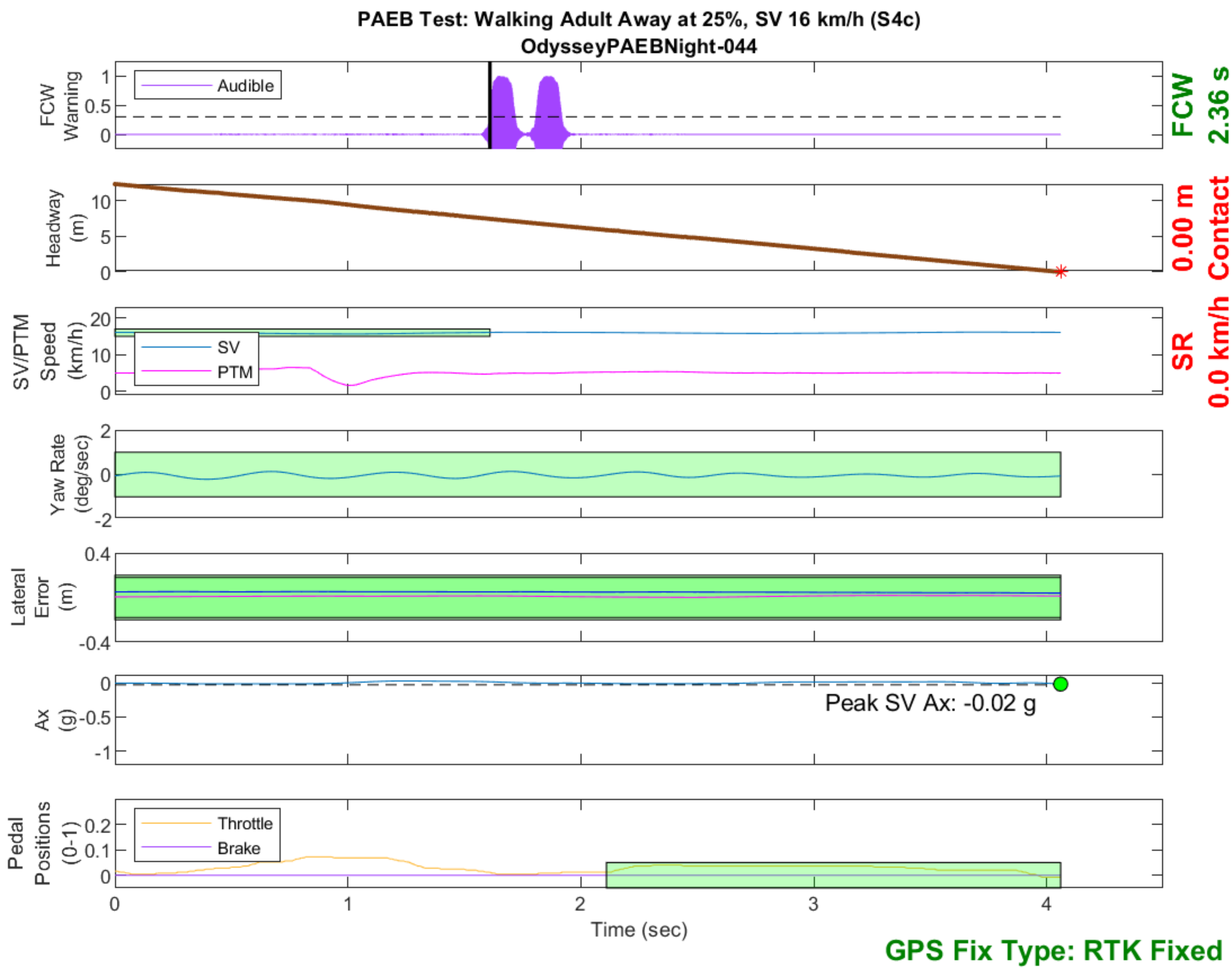


Figure D132. Time History for PAEB Run 44, S4c, Night, High Beam, 16 km/h

Figure D133. Time History for PAEB Run 50, S4c, Night, High Beam, 40 km/h

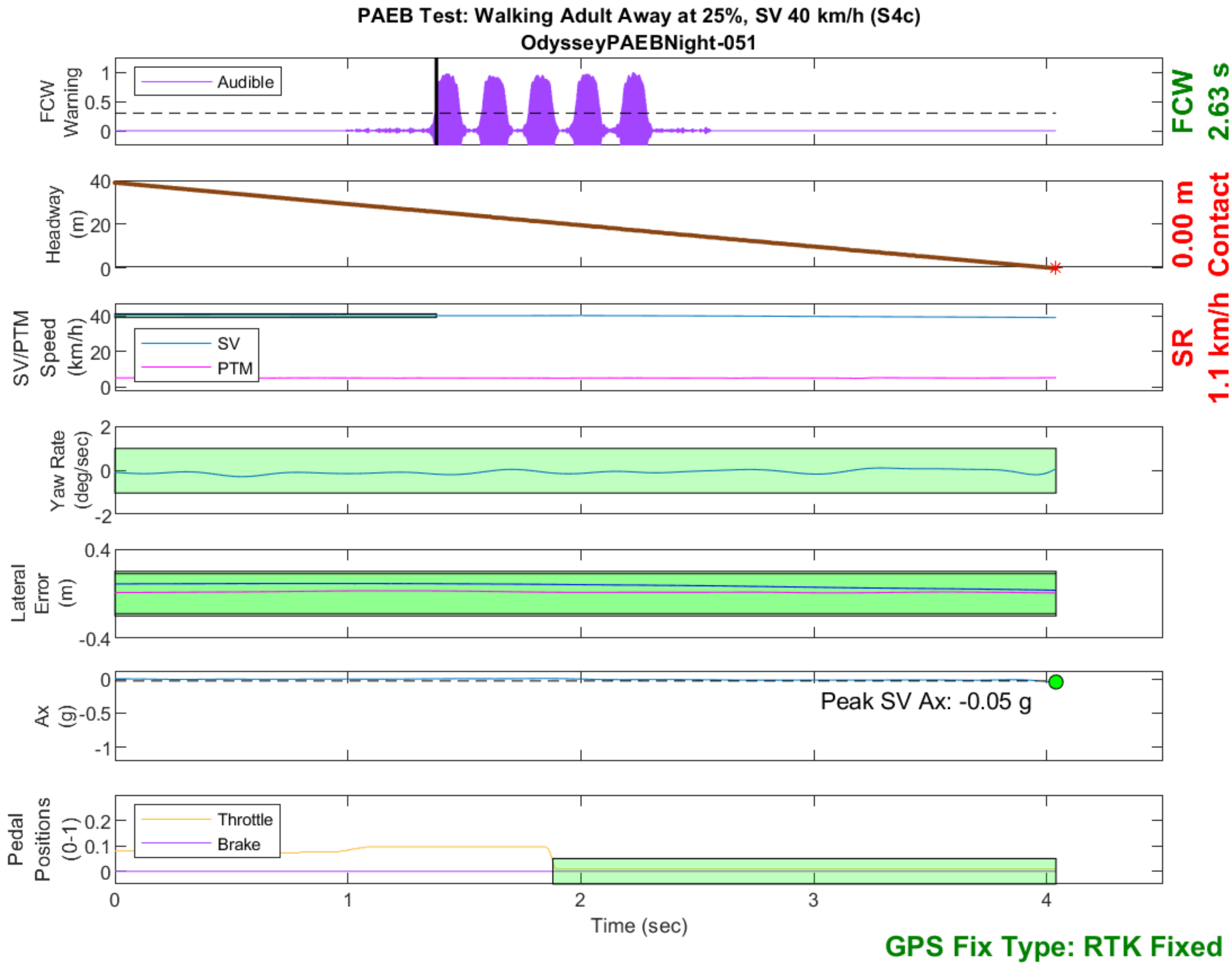


Figure D134. Time History for PAEB Run 51, S4c, Night, High Beam, 40 km/h

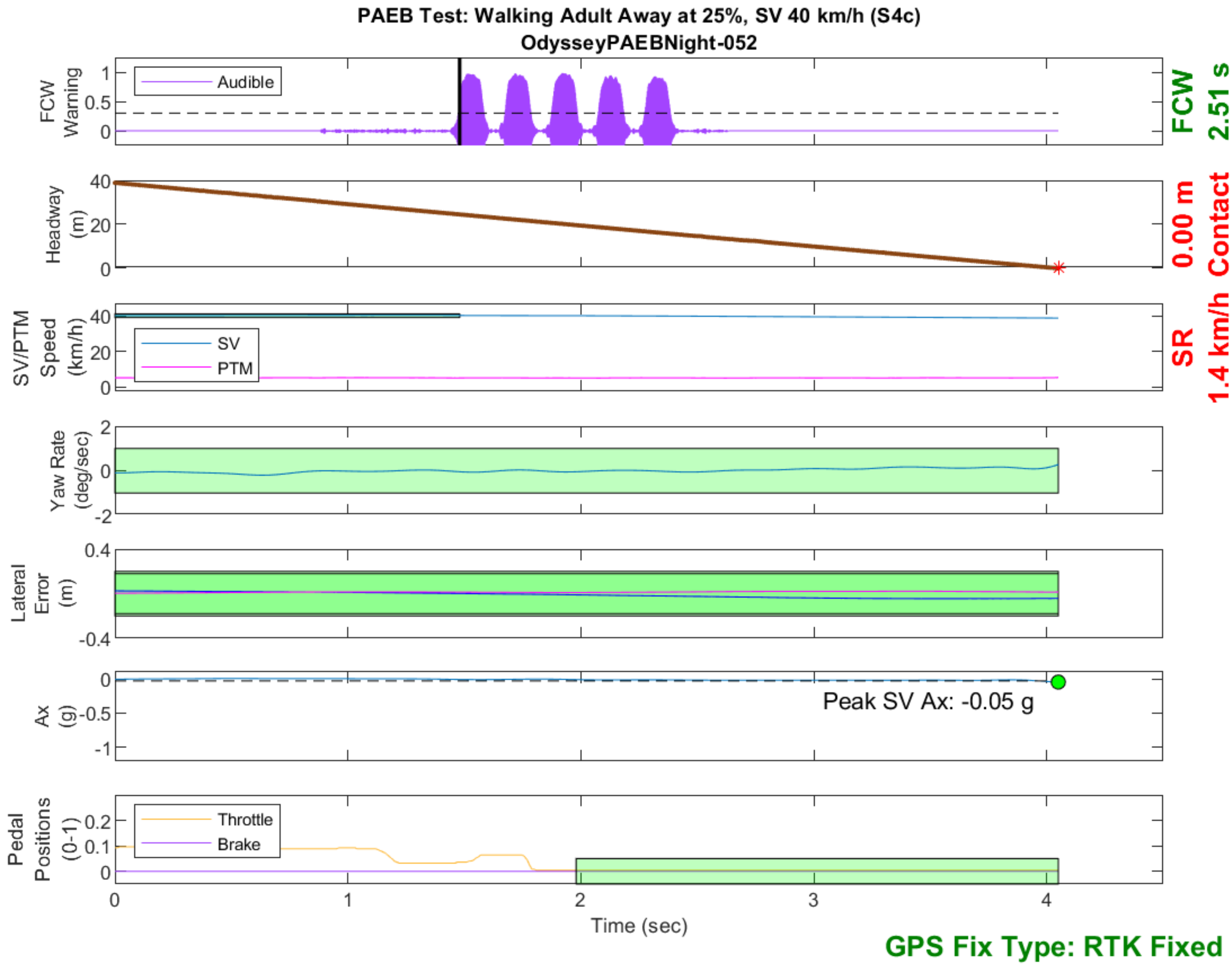


Figure D135. Time History for PAEB Run 52, S4c, Night, High Beam, 40 km/h

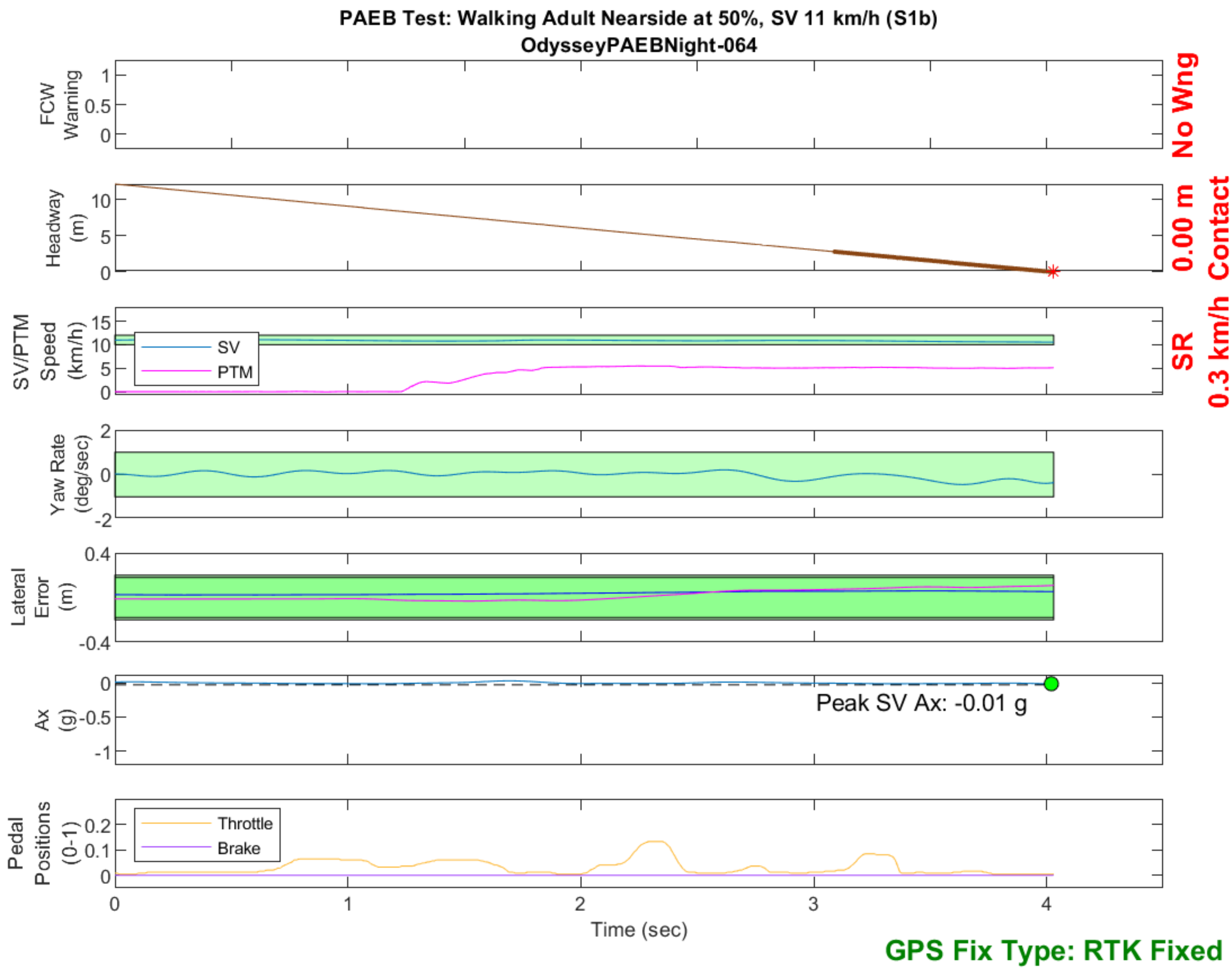


Figure D136. Time History for PAEB Run 64, S1b, Night, Low Beam, 11 km/h

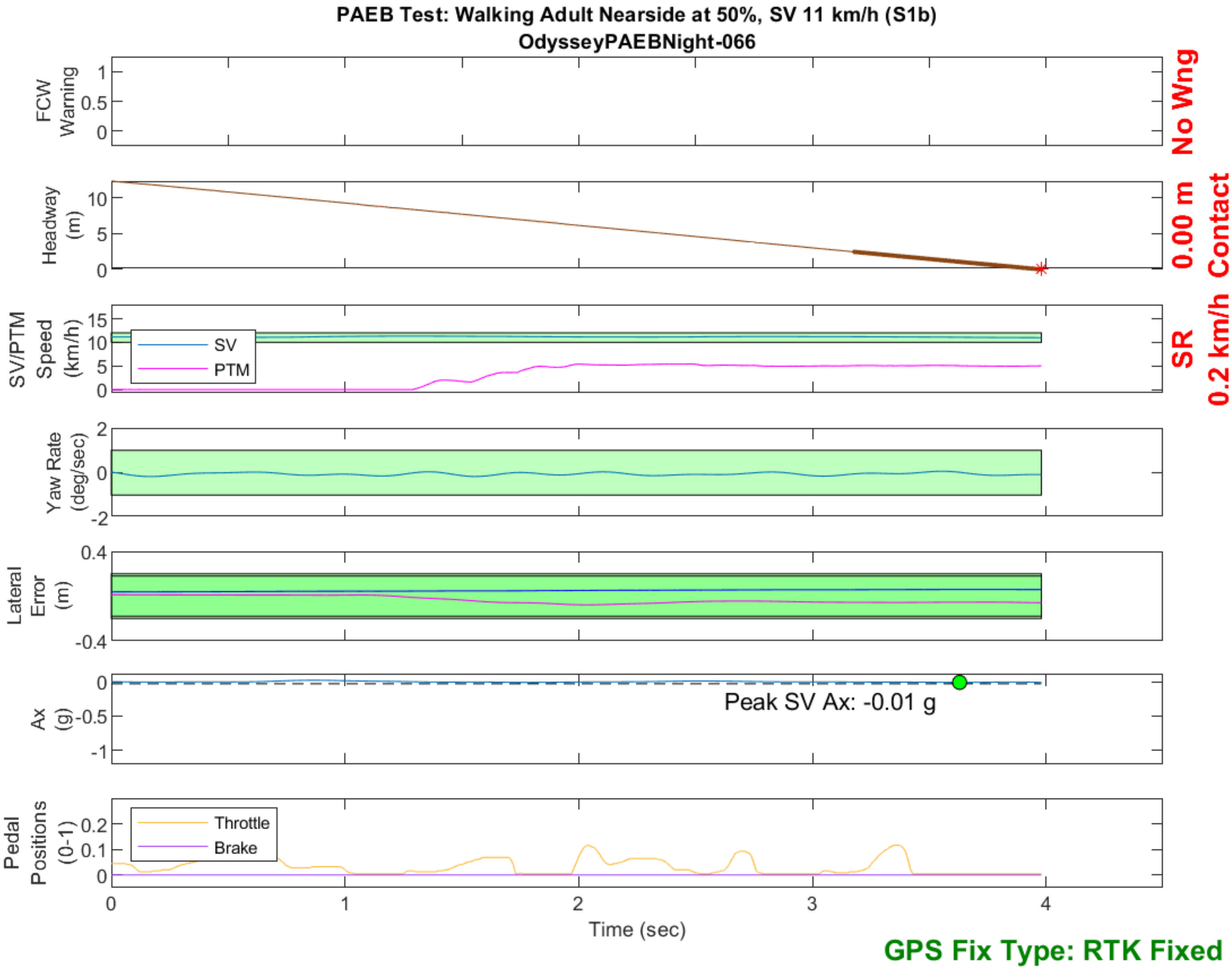


Figure D137. Time History for PAEB Run 66, S1b, Night, Low Beam, 11 km/h

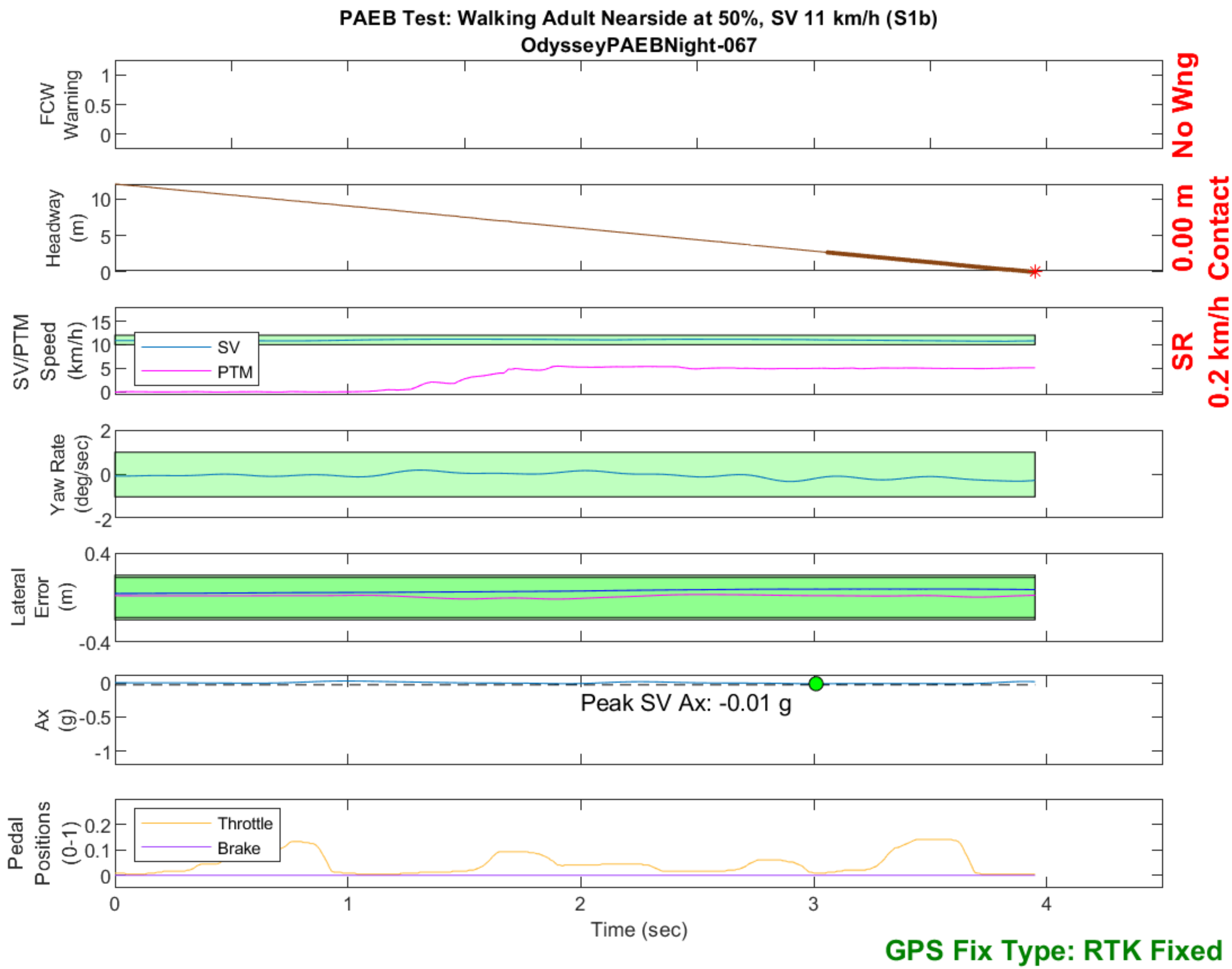


Figure D138. Time History for PAEB Run 67, S1b, Night, Low Beam, 11 km/h

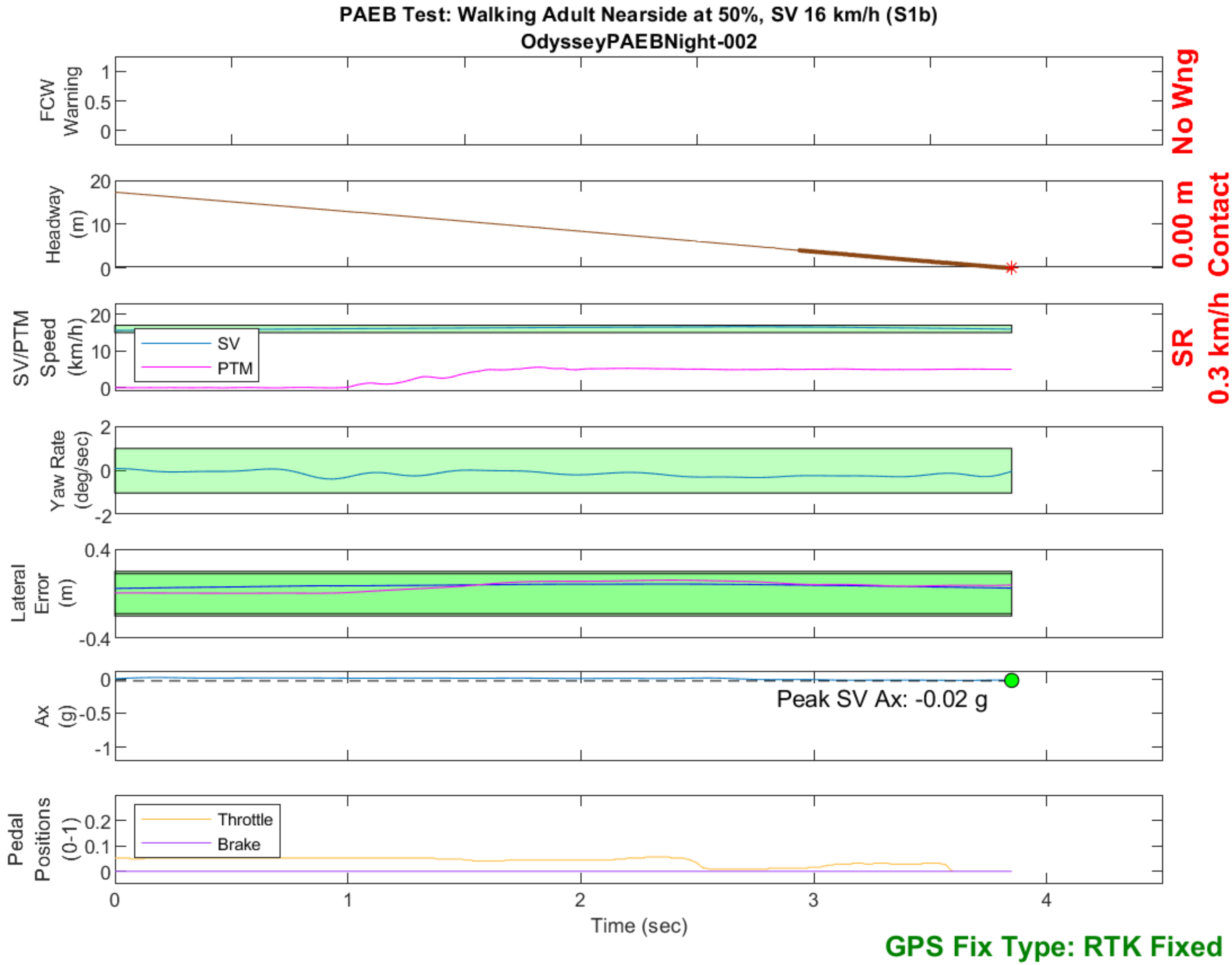


Figure D139. Time History for PAEB Run 2, S1b, Night, Low Beam, 16 km/h

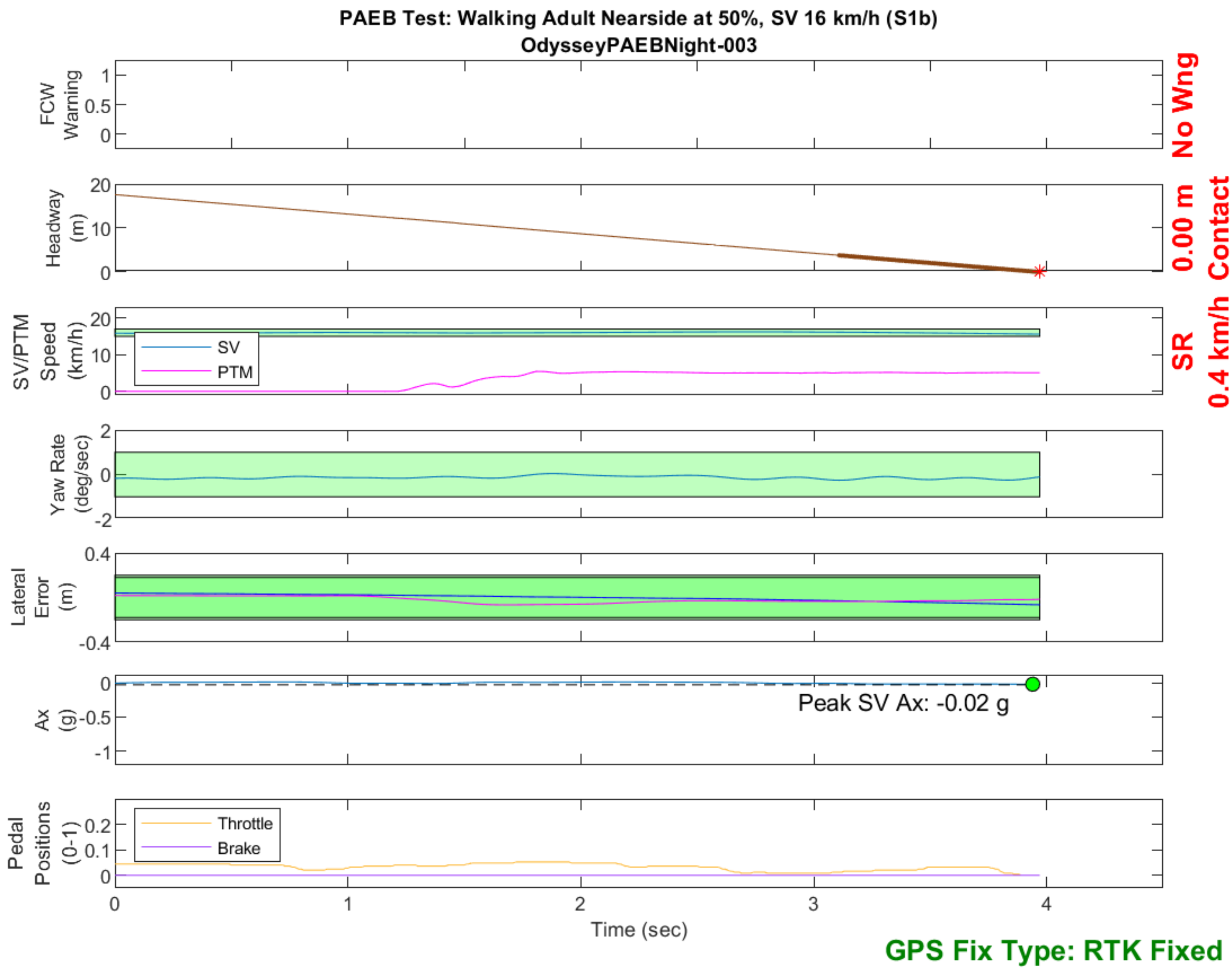


Figure D140. Time History for PAEB Run 3, S1b, Night, Low Beam, 16 km/h

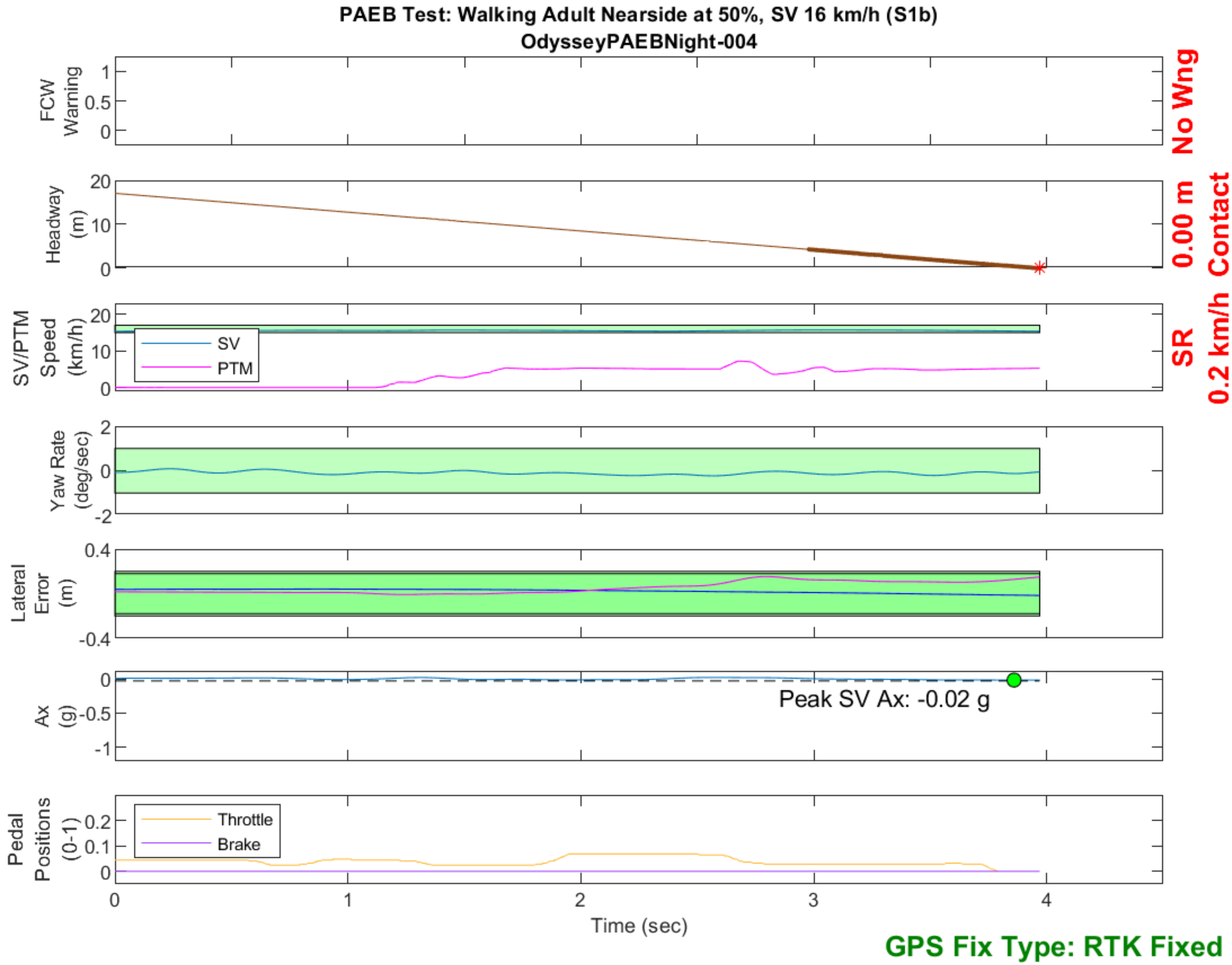


Figure D141. Time History for PAEB Run 4, S1b, Night, Low Beam, 16 km/h

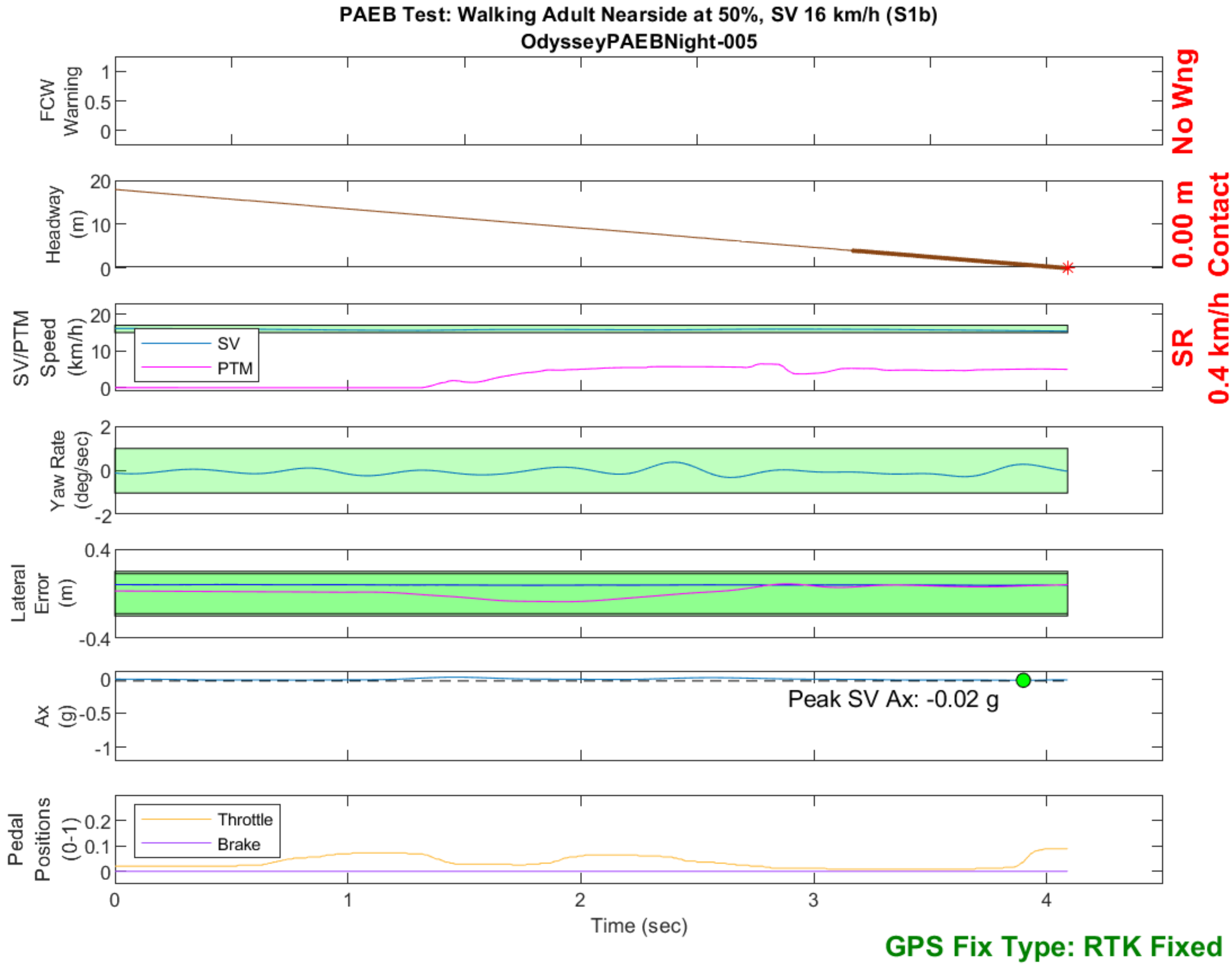


Figure D142. Time History for PAEB Run 5, S1b, Night, Low Beam, 16 km/h

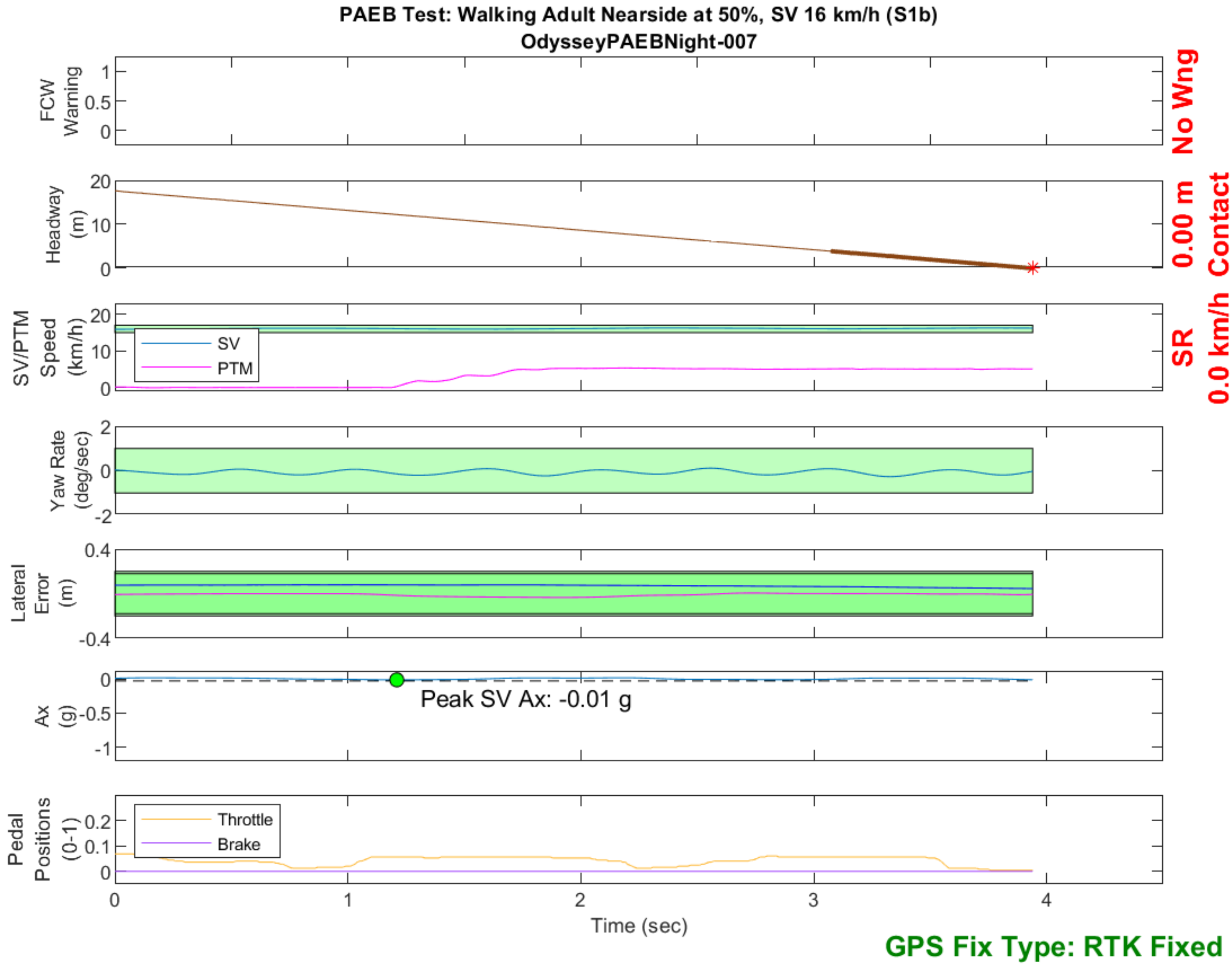


Figure D143. Time History for PAEB Run 7, S1b, Night, Low Beam, 16 km/h

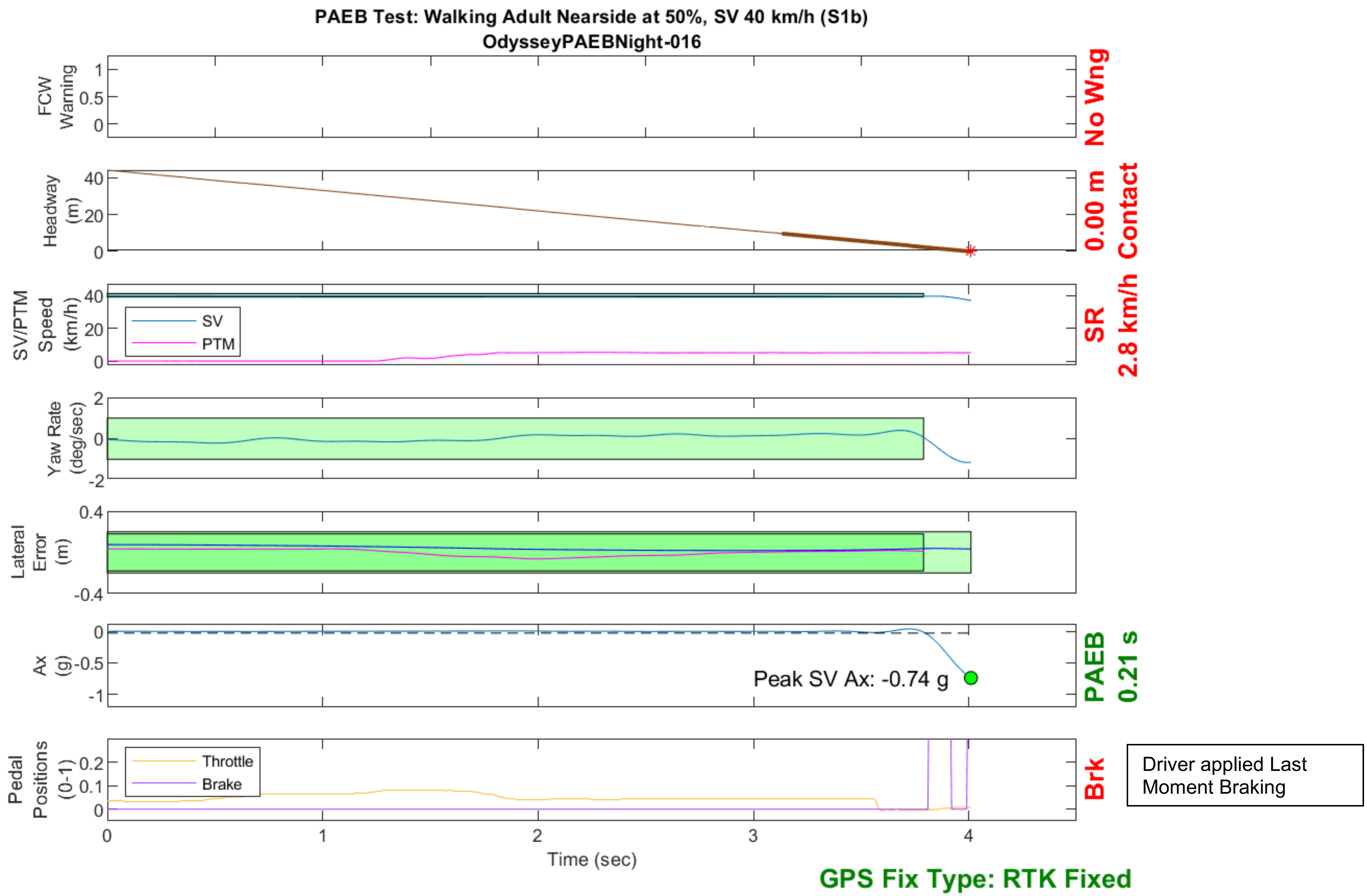


Figure D144. Time History for PAEB Run 16, S1b, Night, Low Beam, 40 km/h

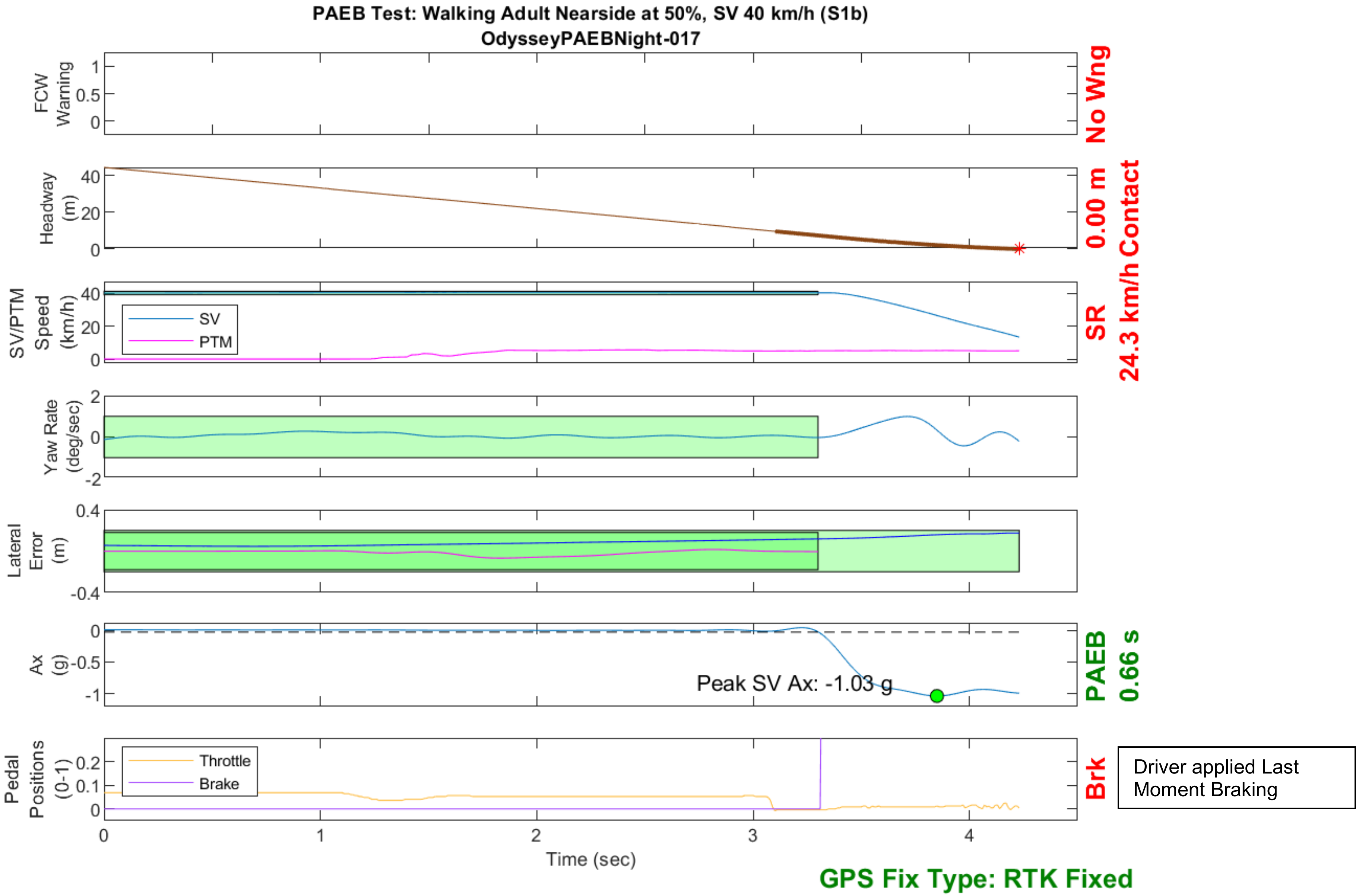


Figure D145. Time History for PAEB Run 17, S1b, Night, Low Beam, 40 km/h

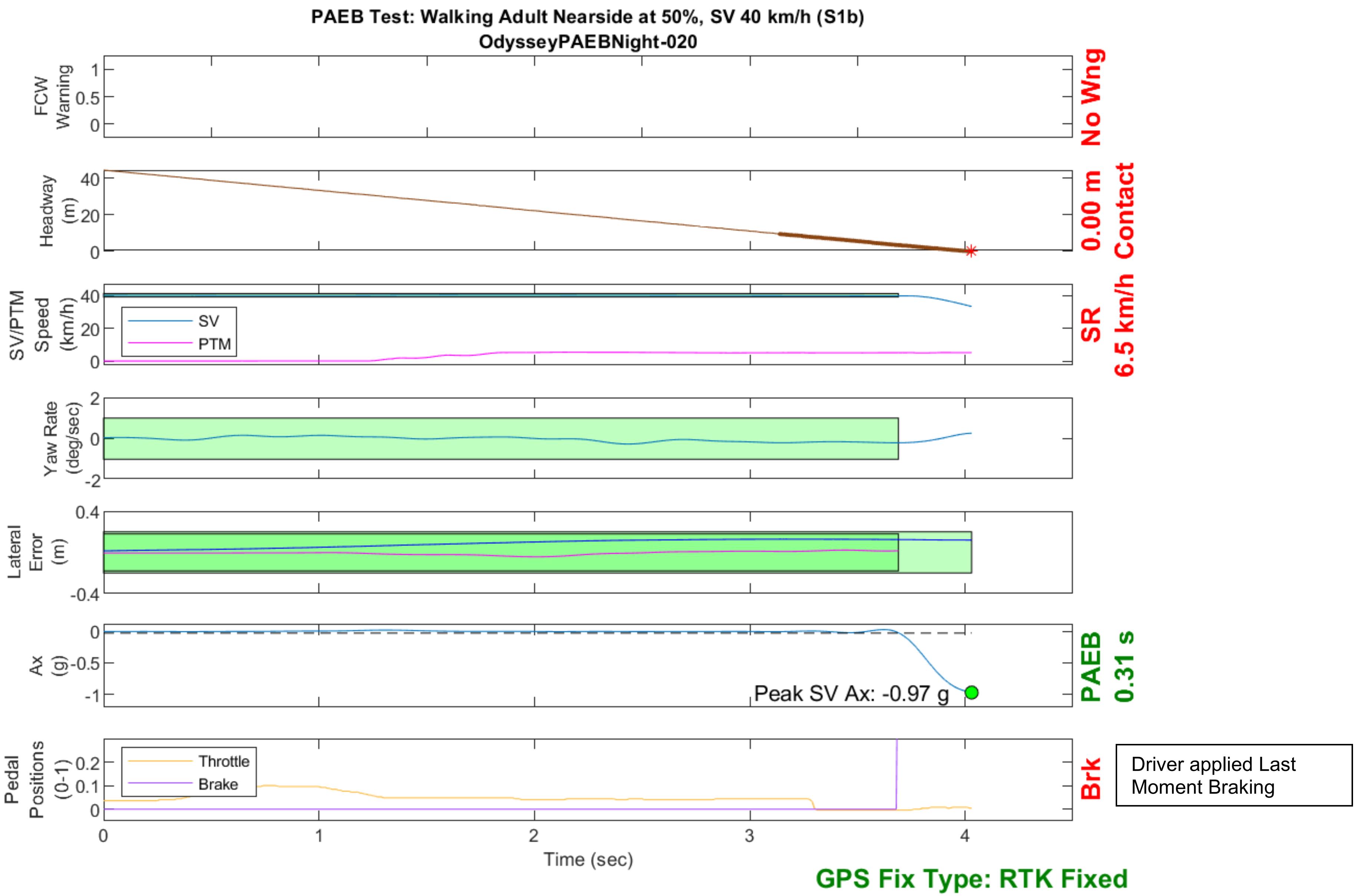


Figure D146. Time History for PAEB Run 20, S1b, Night, Low Beam, 40 km/h

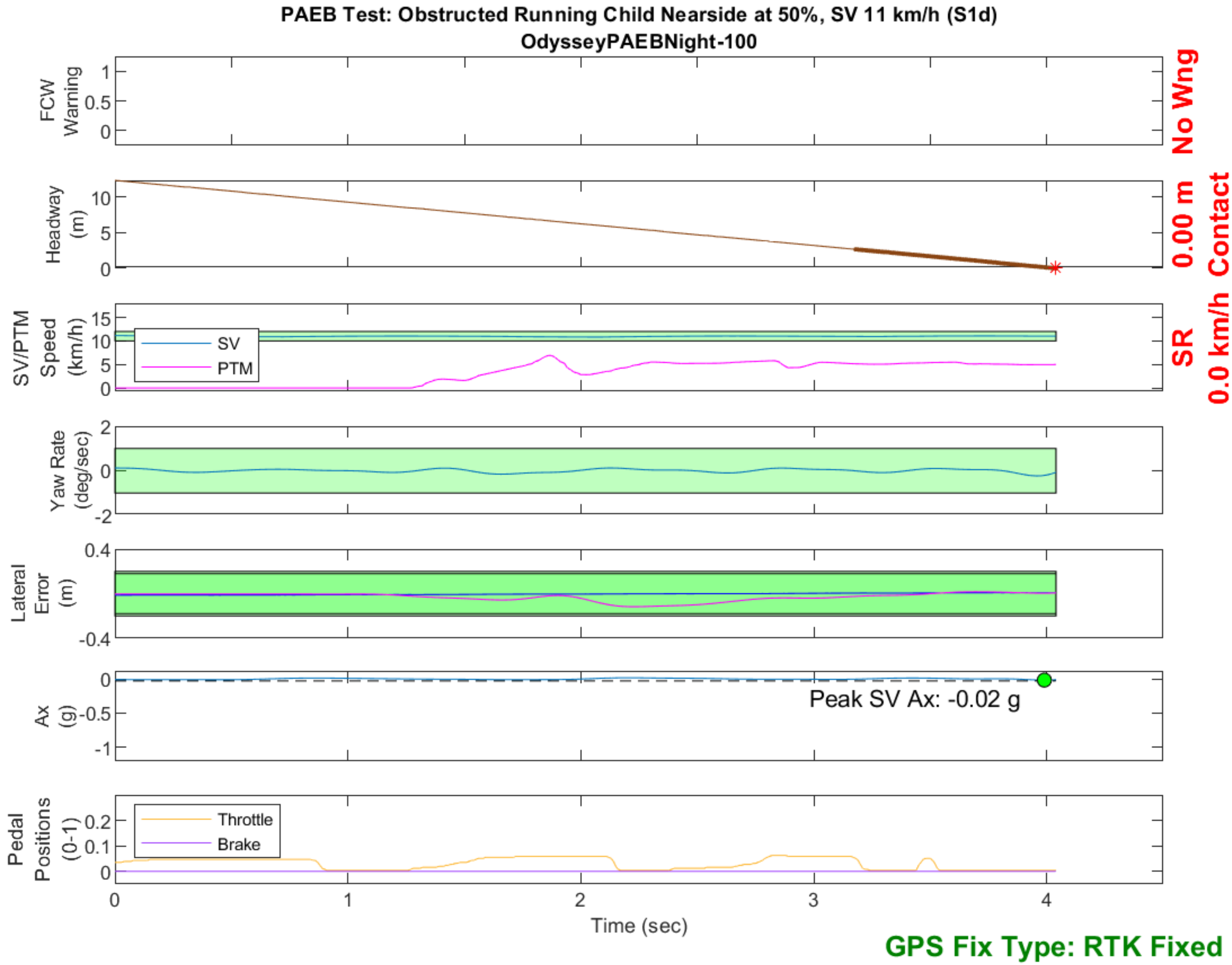


Figure D147. Time History for PAEB Run 100, S1d, Night, Low Beam, 11 km/h

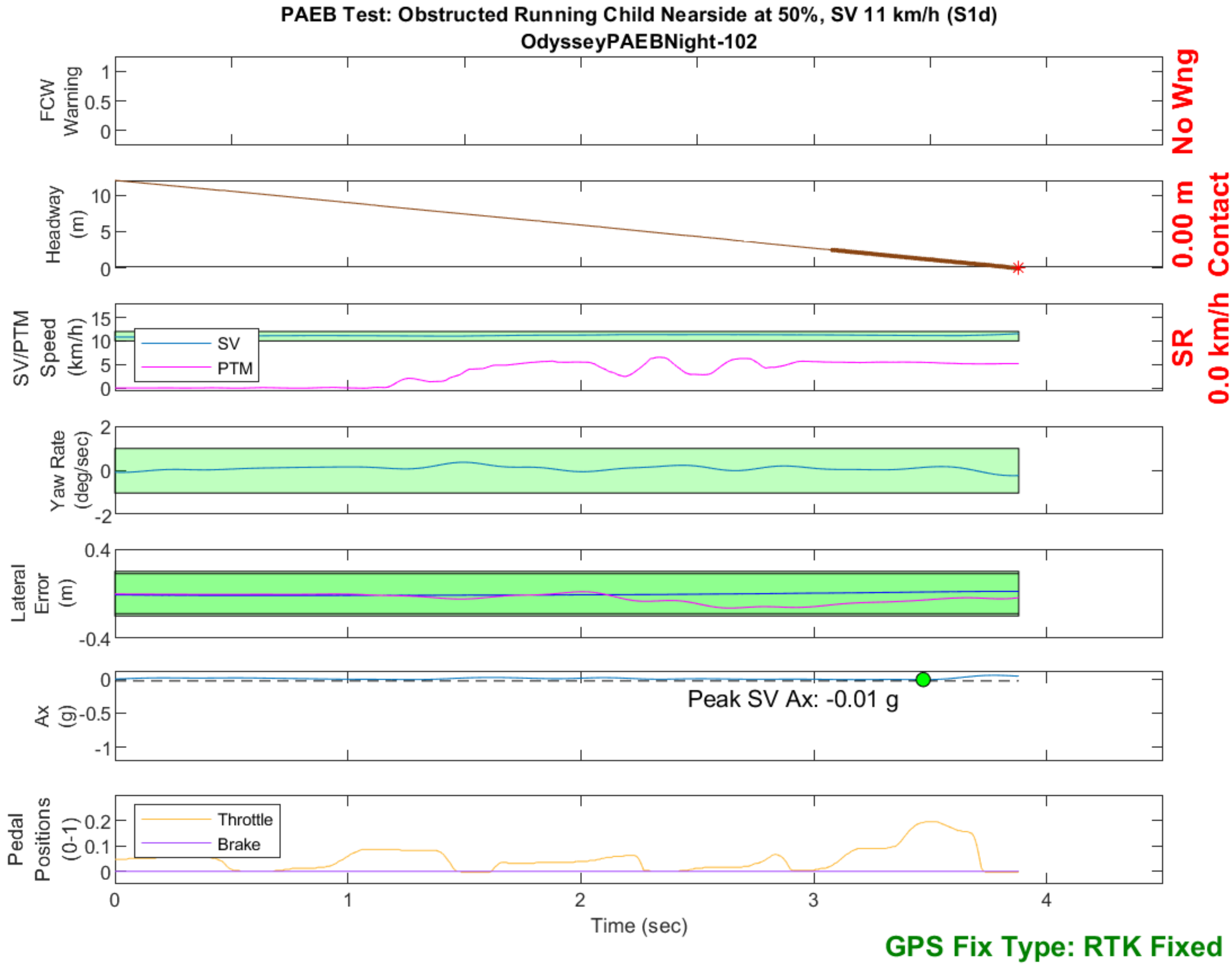


Figure D148. Time History for PAEB Run 102, S1d, Night, Low Beam, 11 km/h

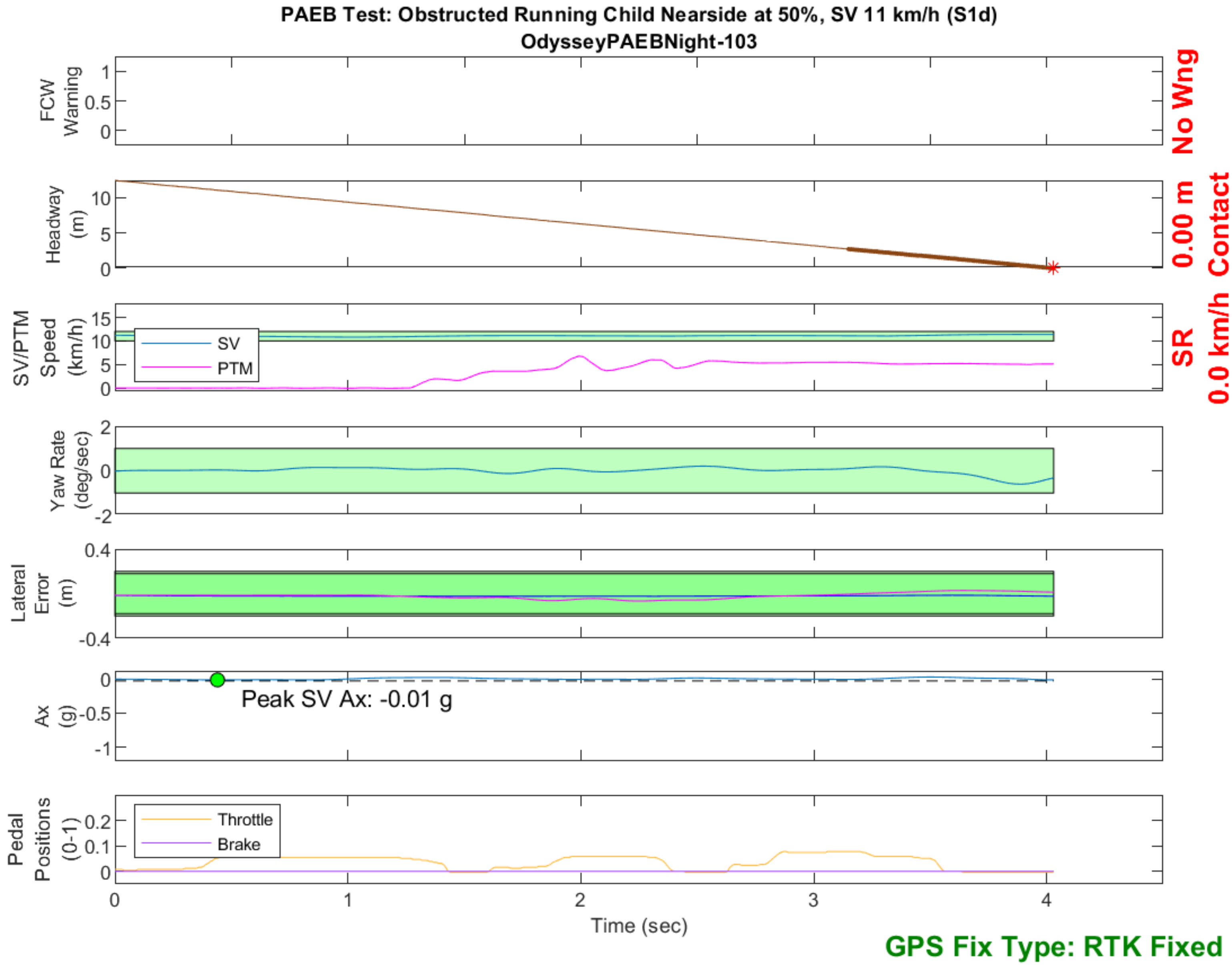


Figure D149. Time History for PAEB Run 103, S1d, Night, Low Beam, 11 km/h

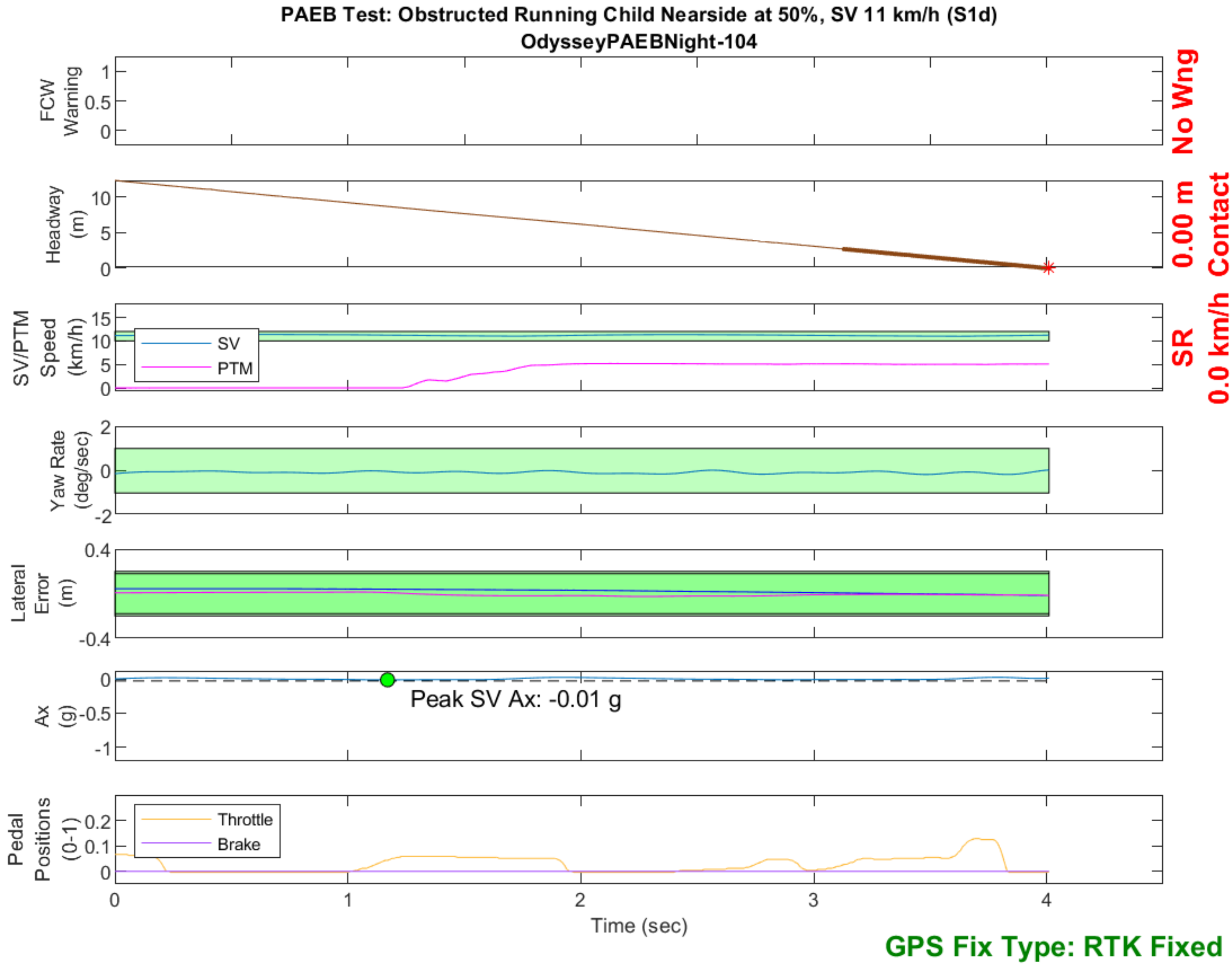


Figure D150. Time History for PAEB Run 104, S1d, Night, Low Beam, 11 km/h

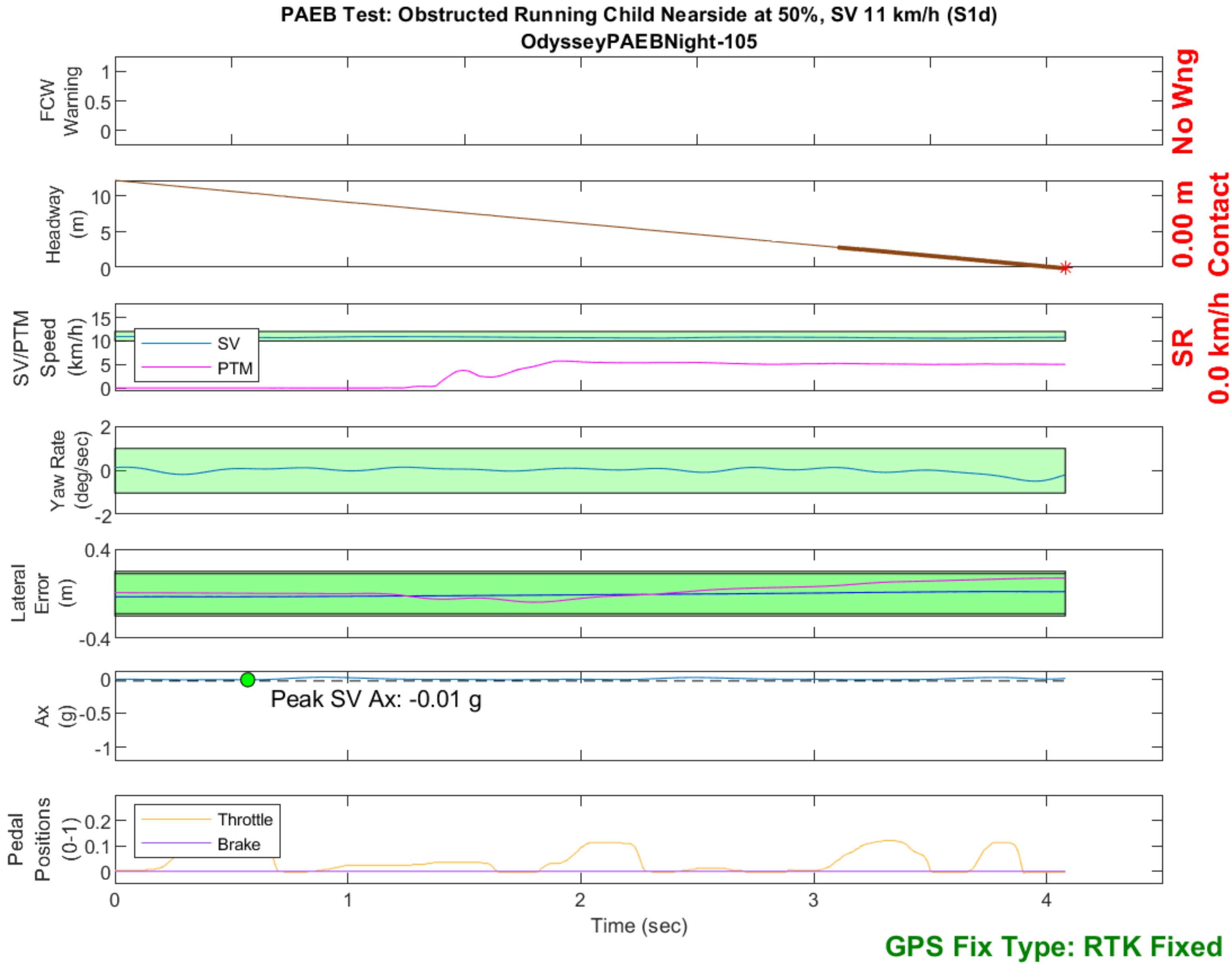


Figure D151. Time History for PAEB Run 105, S1d, Night, Low Beam, 11 km/h

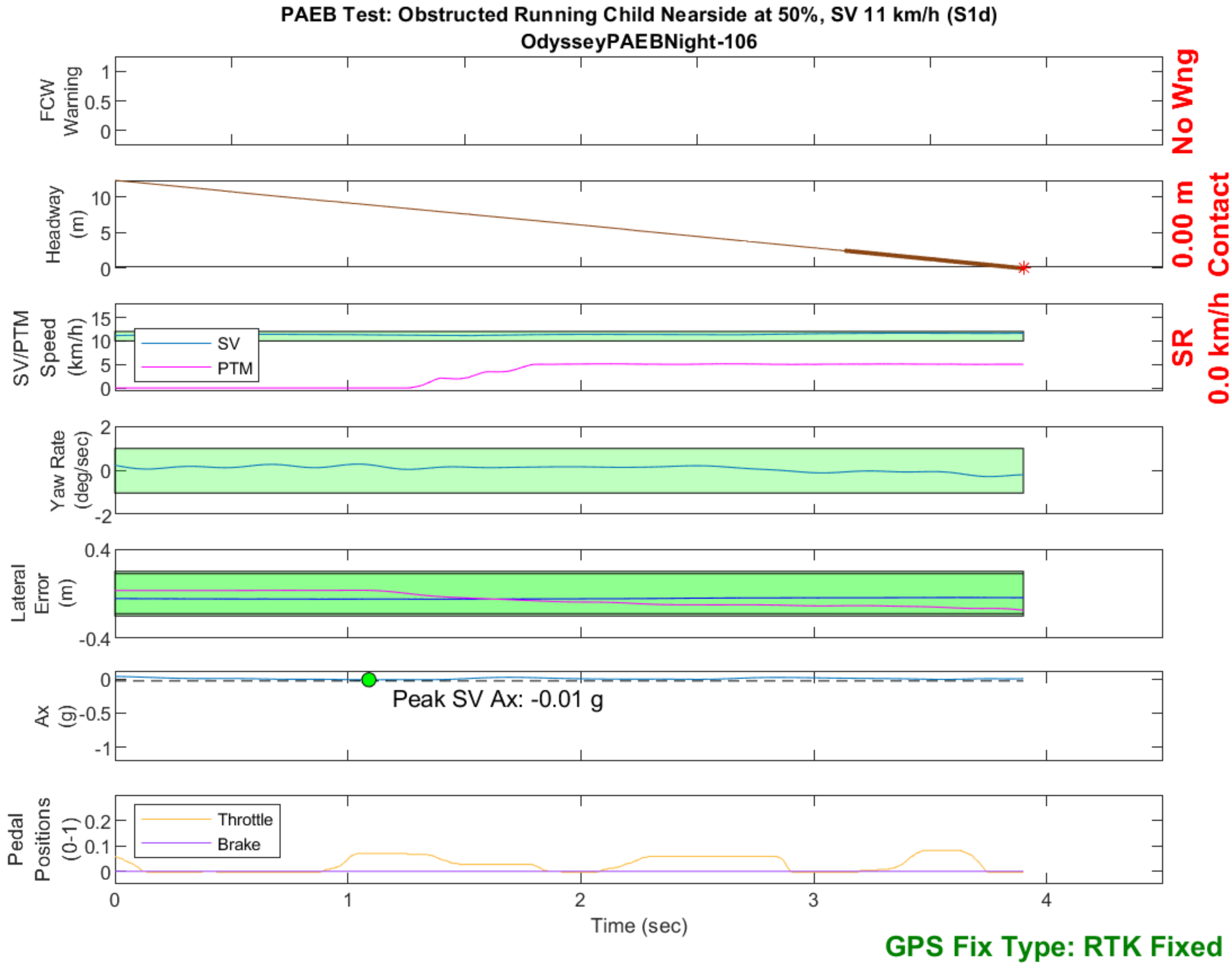


Figure D152. Time History for PAEB Run 106, S1d, Night, Low Beam, 11 km/h

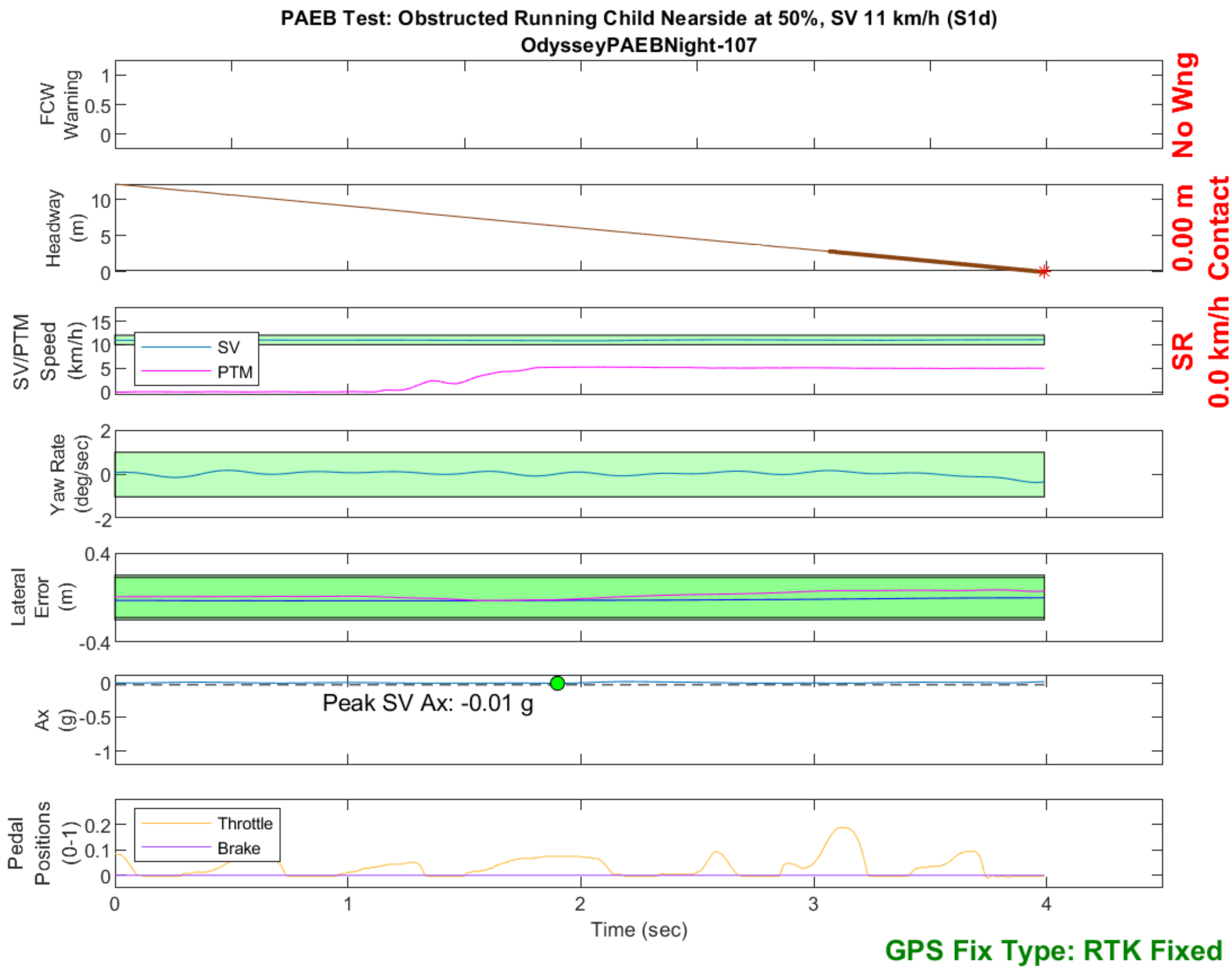


Figure D153. Time History for PAEB Run 107, S1d, Night, Low Beam, 11 km/h

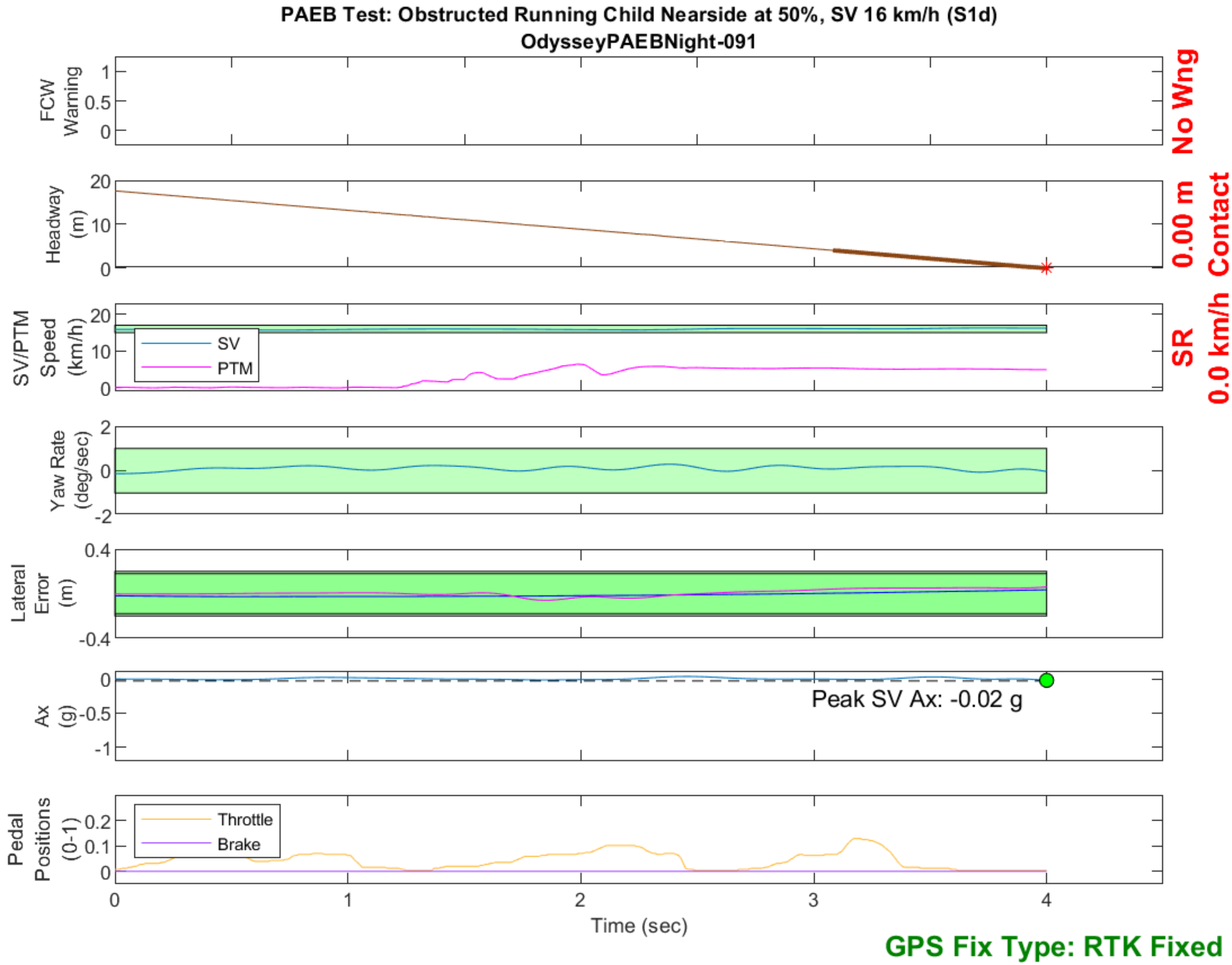


Figure D154. Time History for PAEB Run 91, S1d, Night, Low Beam, 16 km/h

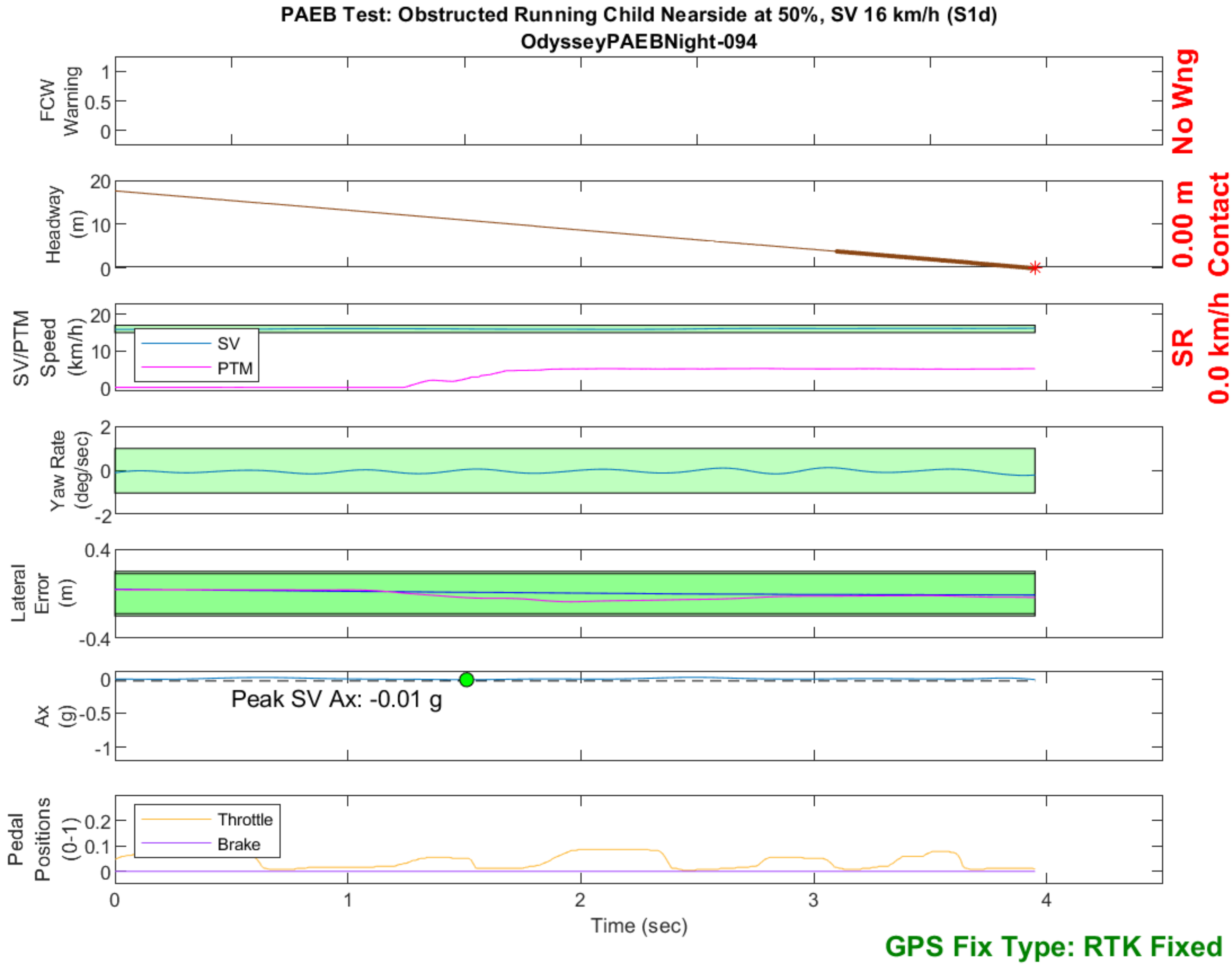


Figure D155. Time History for PAEB Run 94, S1d, Night, Low Beam, 16 km/h

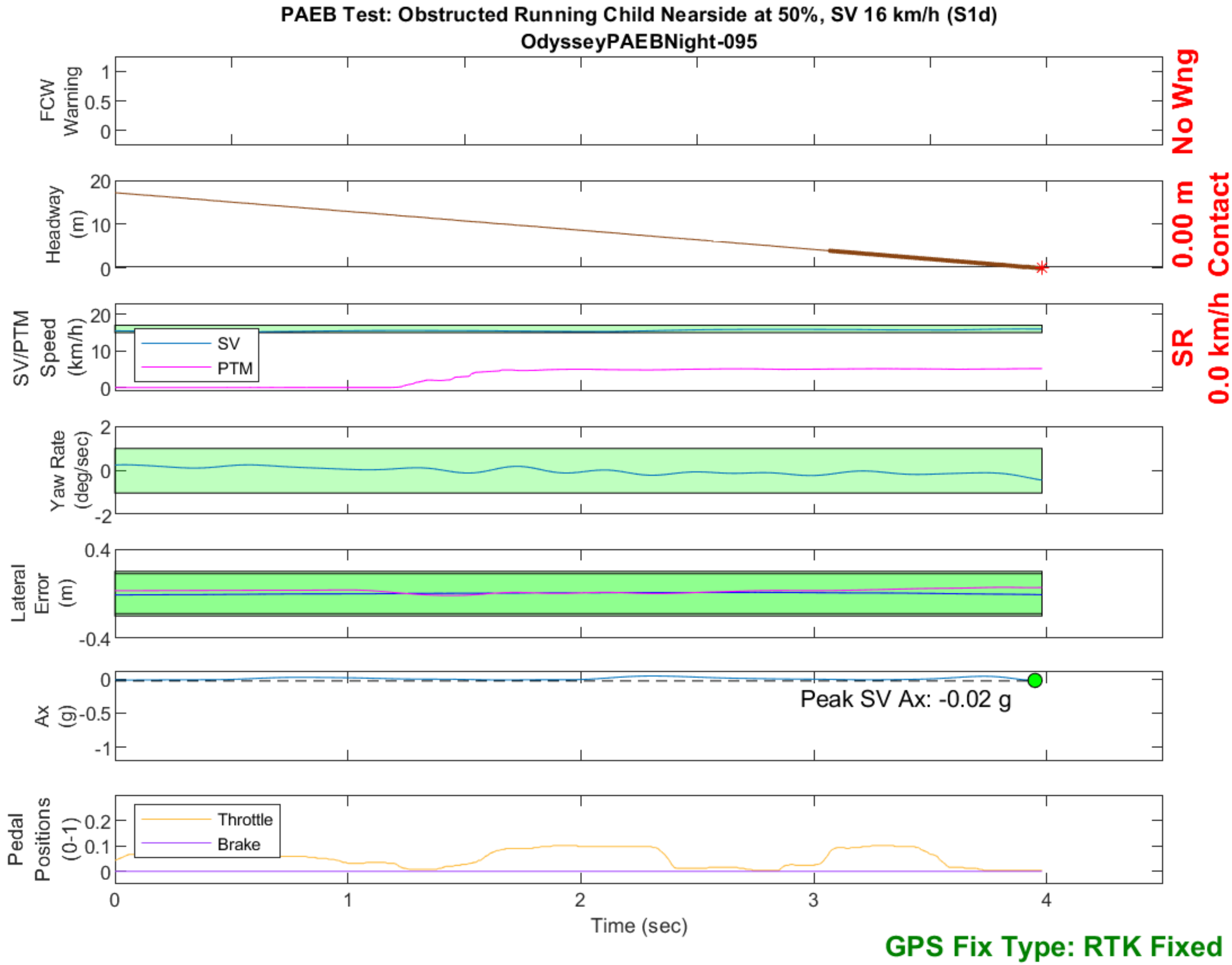


Figure D156. Time History for PAEB Run 95, S1d, Night, Low Beam, 16 km/h

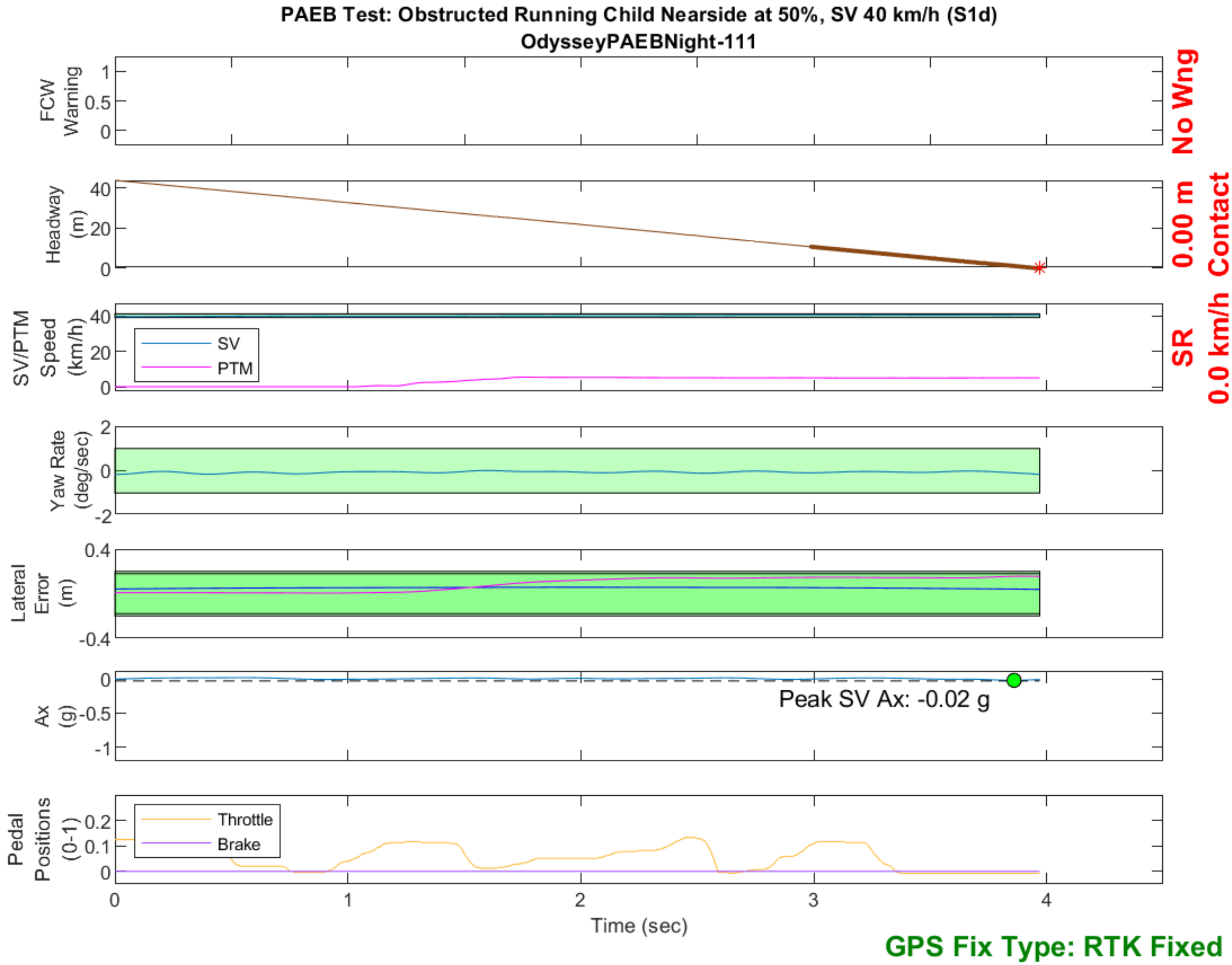


Figure D157. Time History for PAEB Run 111, S1d, Night, Low Beam, 40 km/h

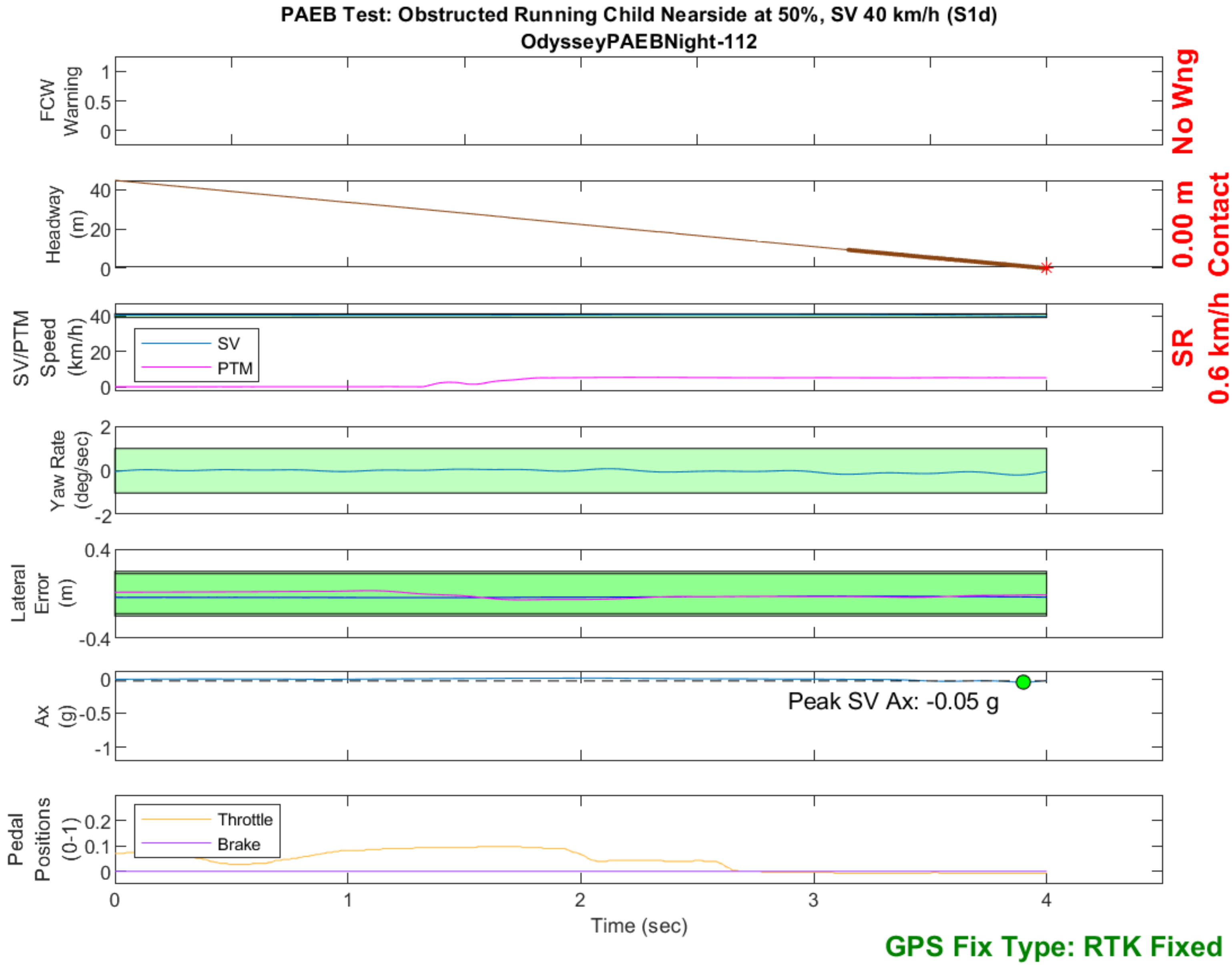


Figure D158. Time History for PAEB Run 112, S1d, Night, Low Beam, 40 km/h

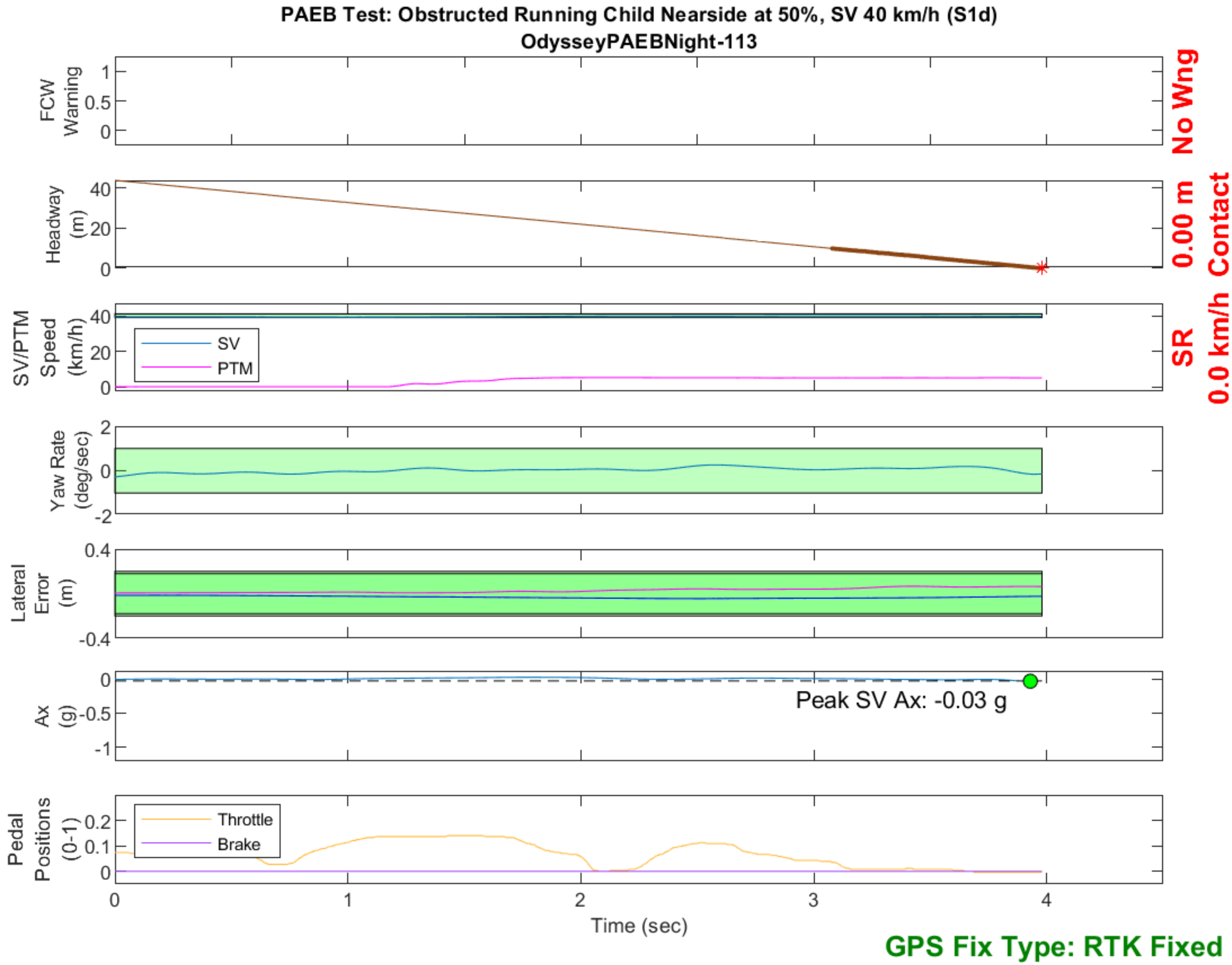


Figure D159. Time History for PAEB Run 113, S1d, Night, Low Beam, 40 km/h

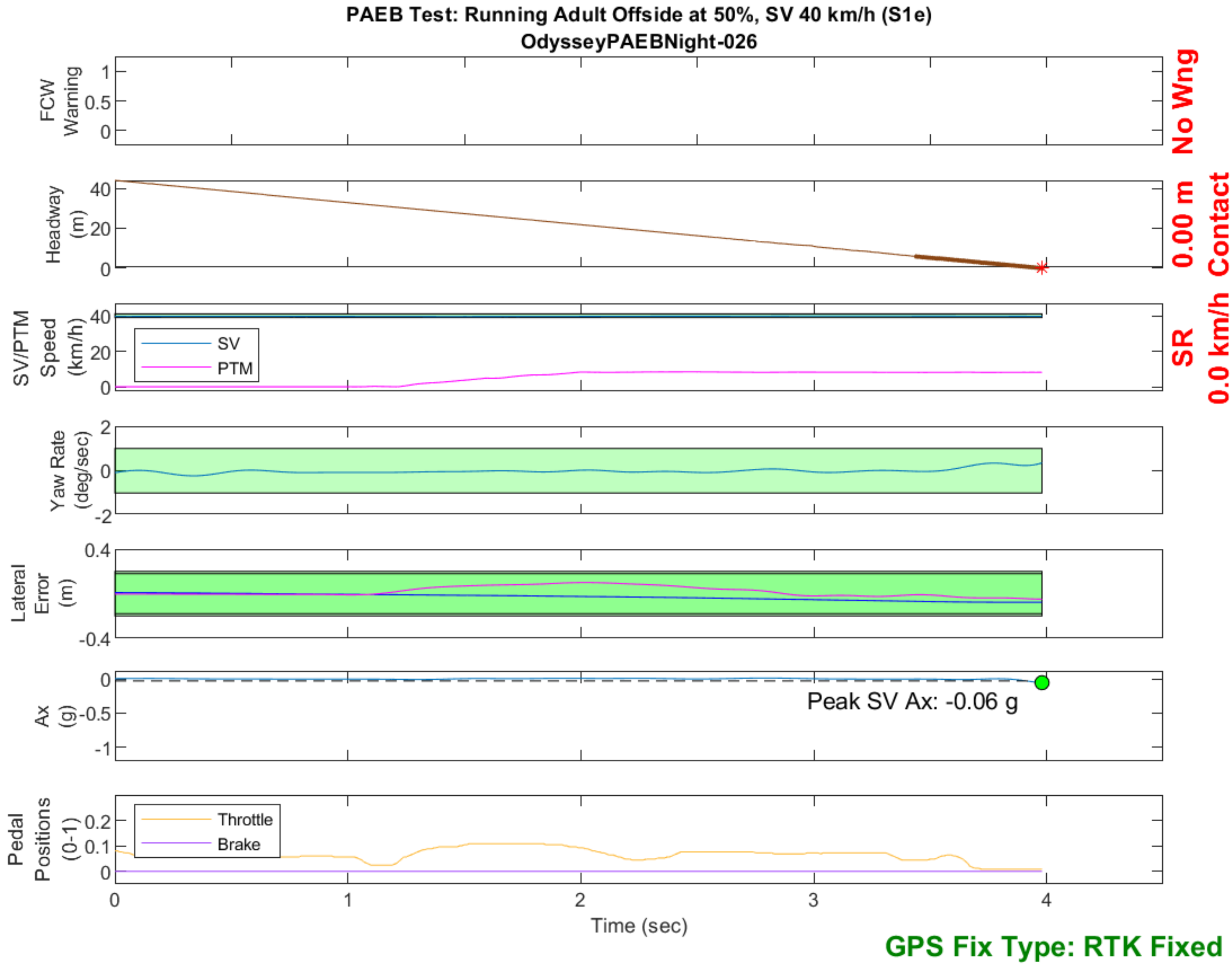


Figure D160. Time History for PAEB Run 26, S1e, Night, Low Beam, 40 km/h

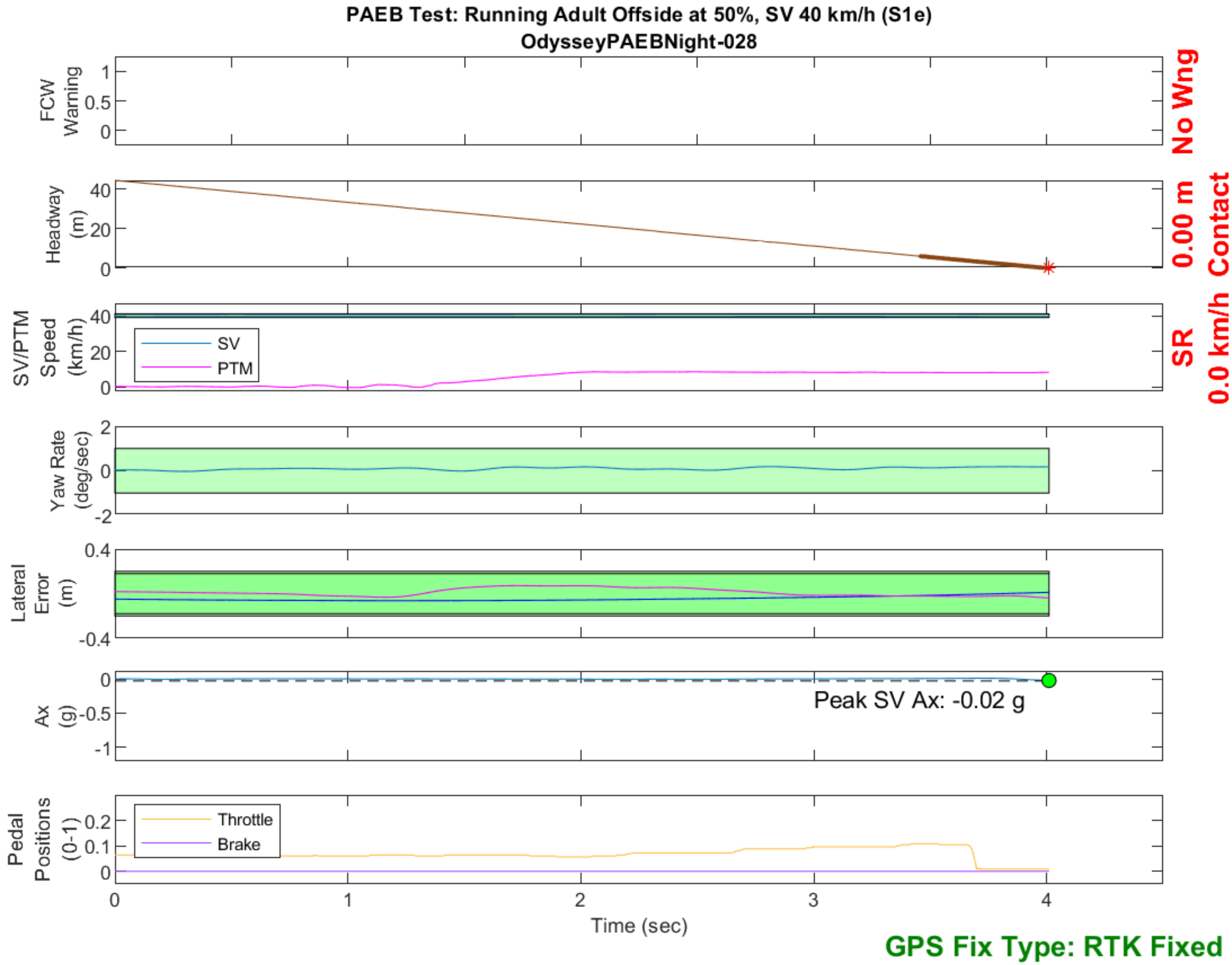


Figure D161. Time History for PAEB Run 28, S1e, Night, Low Beam, 40 km/h

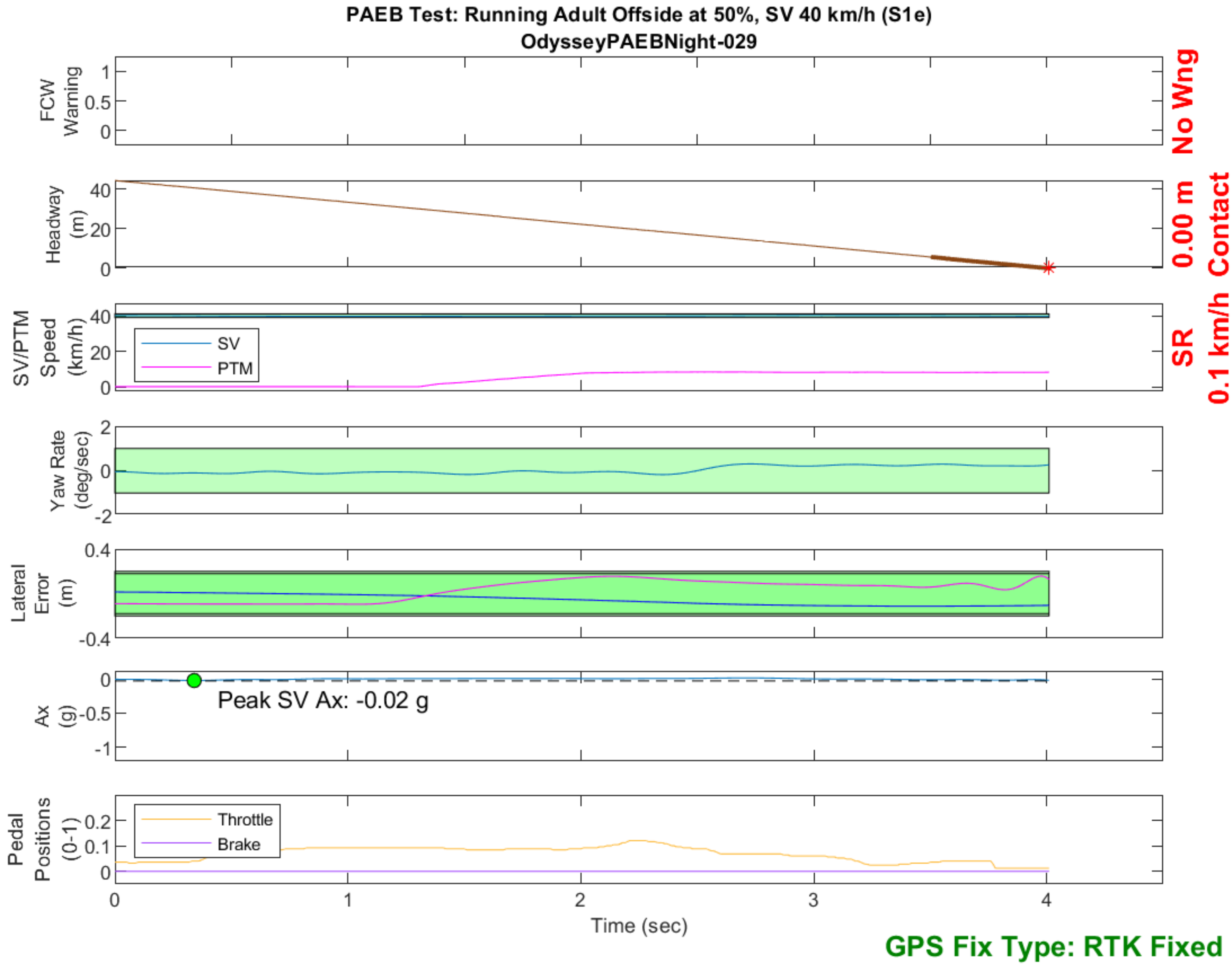


Figure D162. Time History for PAEB Run 29, S1e, Night, Low Beam, 40 km/h

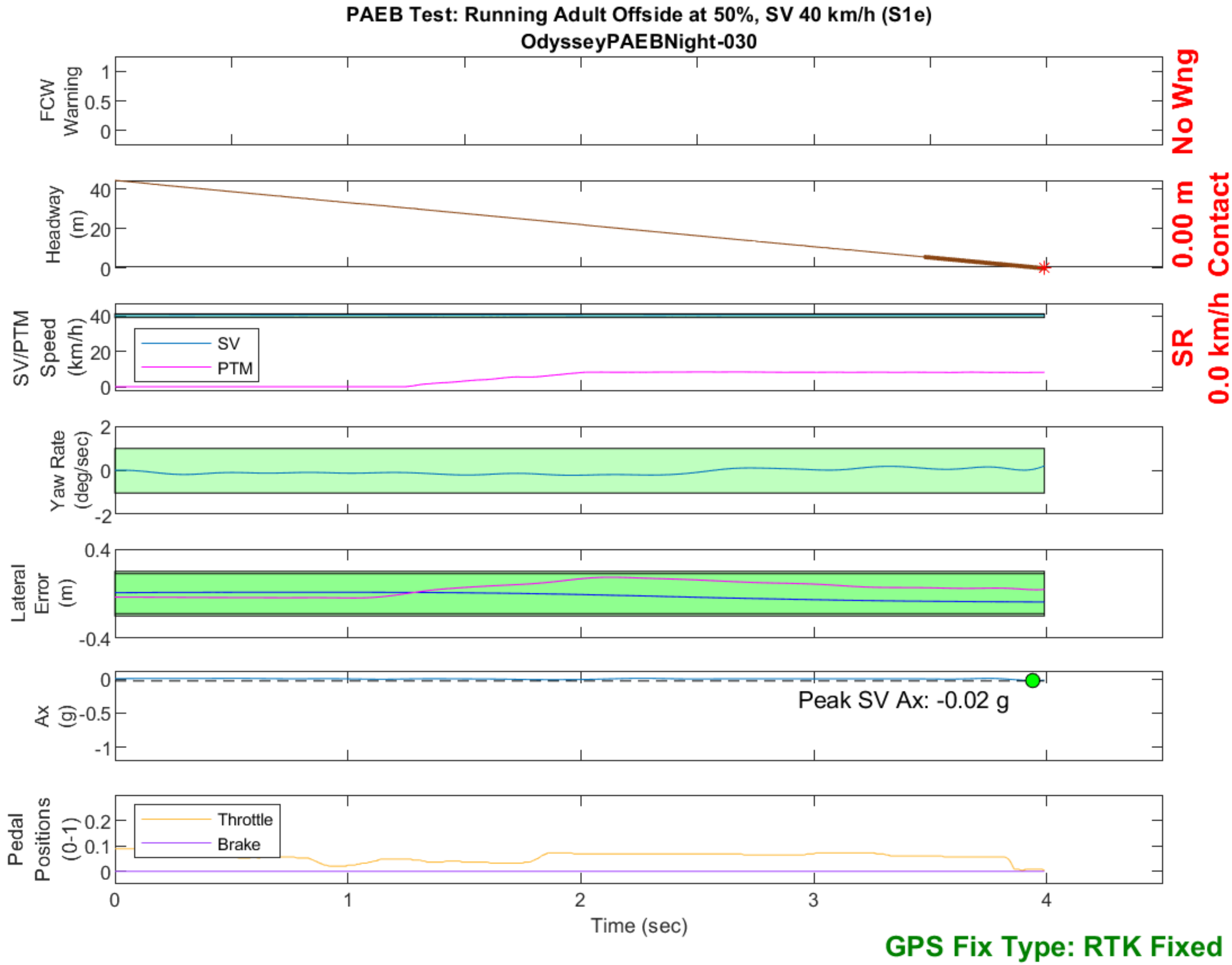


Figure D163. Time History for PAEB Run 30, S1e, Night, Low Beam, 40 km/h

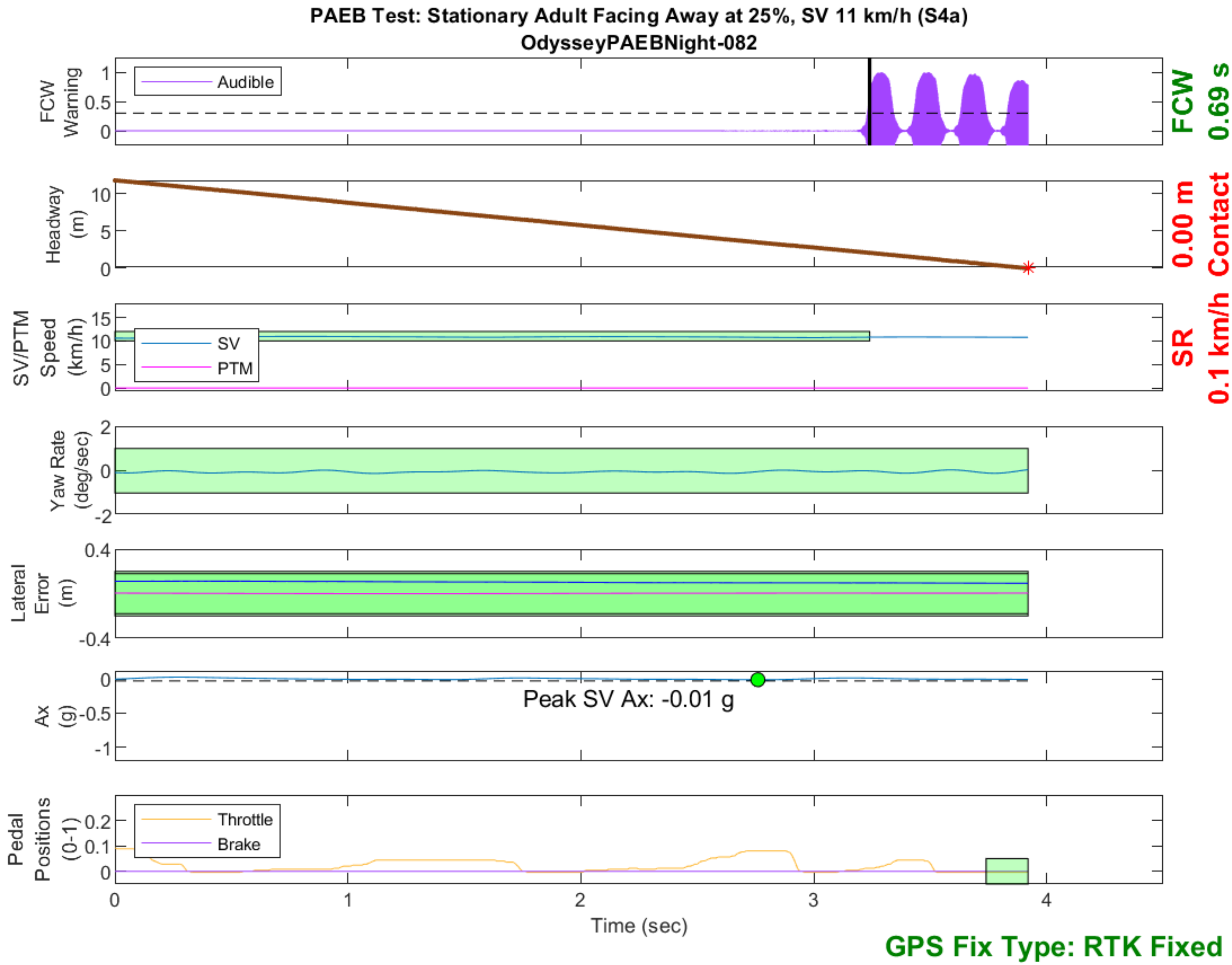


Figure D164. Time History for PAEB Run 82, S4a, Night, Low Beam, 11 km/h

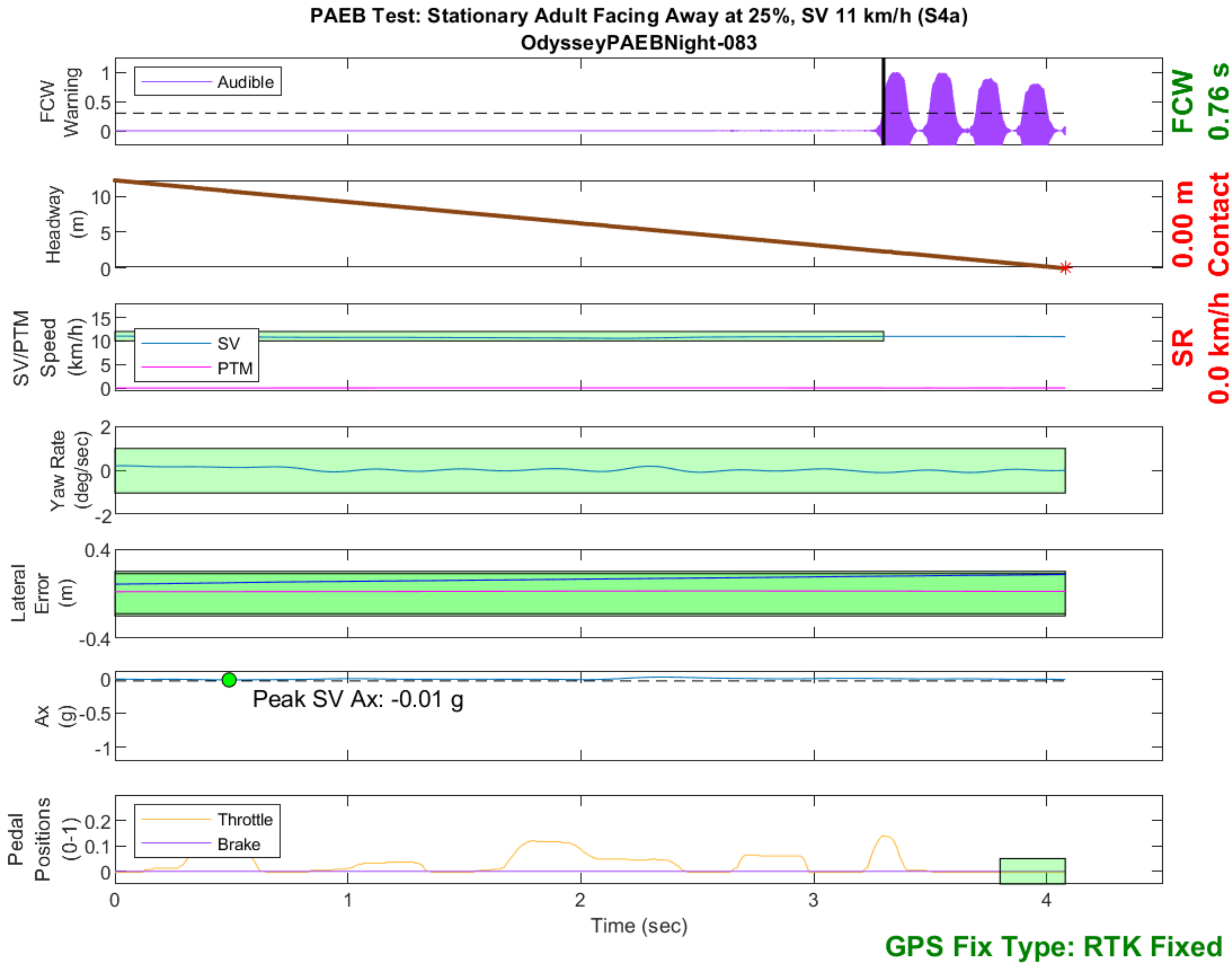


Figure D165. Time History for PAEB Run 83, S4a, Night, Low Beam, 11 km/h

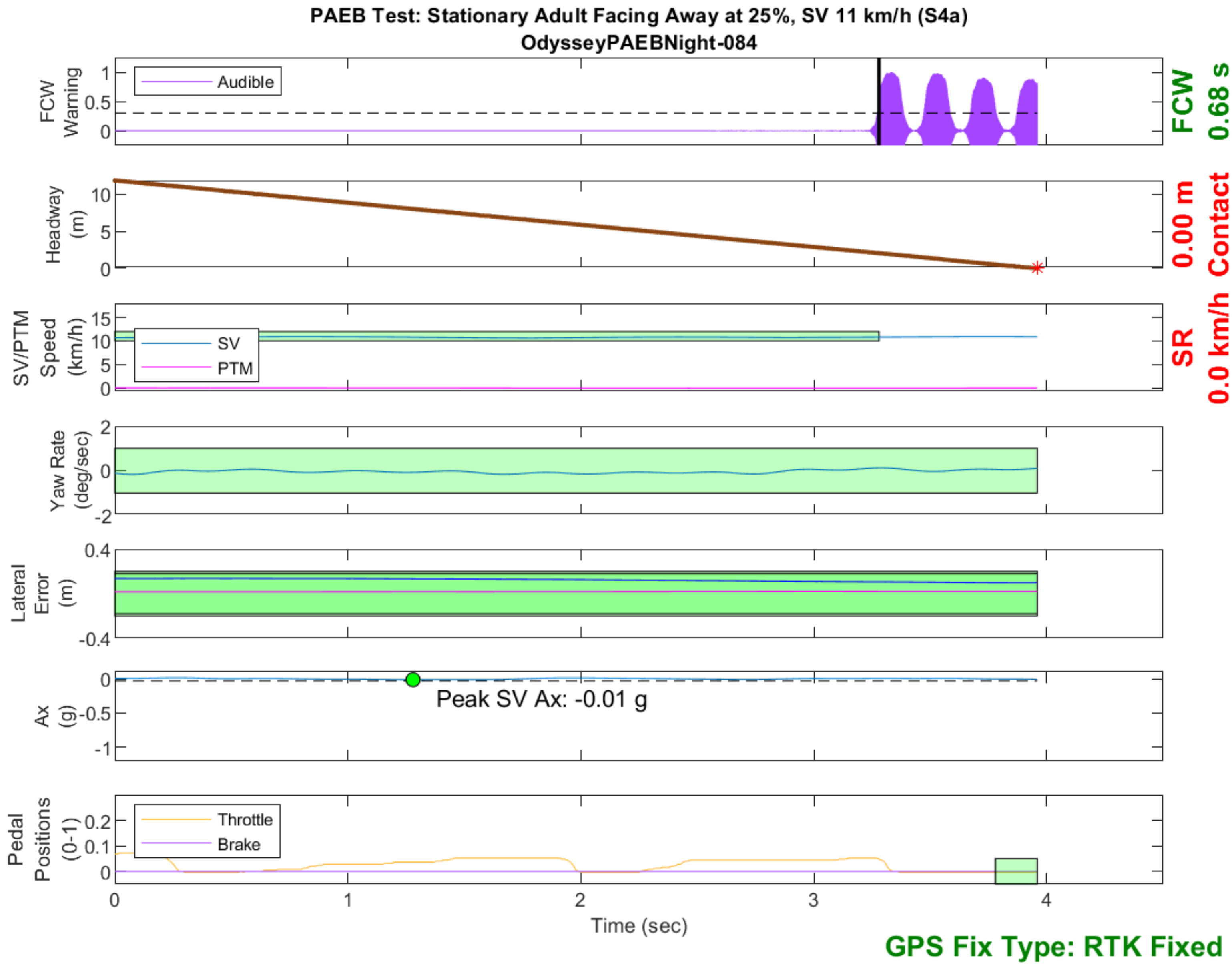


Figure D166. Time History for PAEB Run 84, S4a, Night, Low Beam, 11 km/h

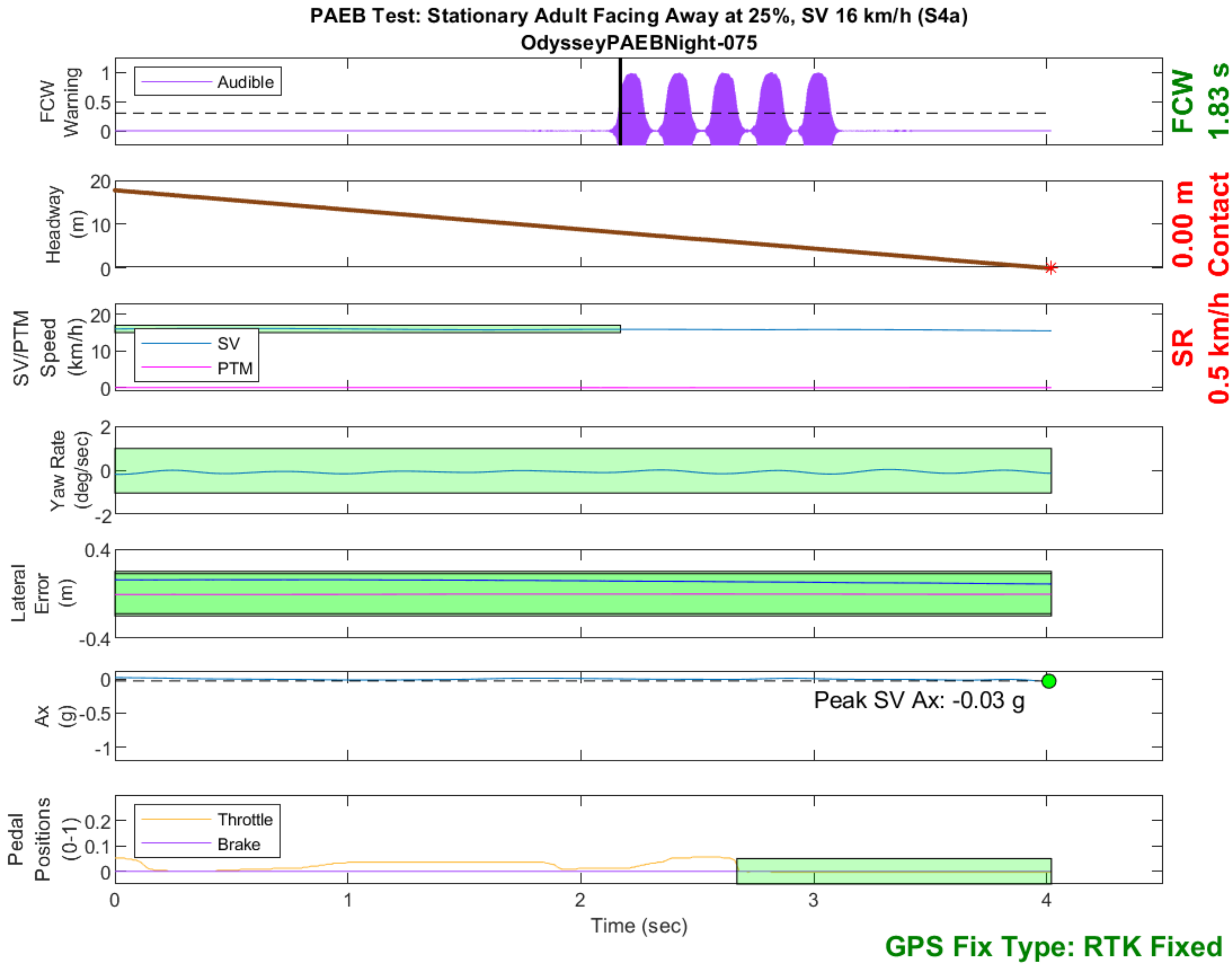


Figure D167. Time History for PAEB Run 75, S4a, Night, Low Beam, 16 km/h

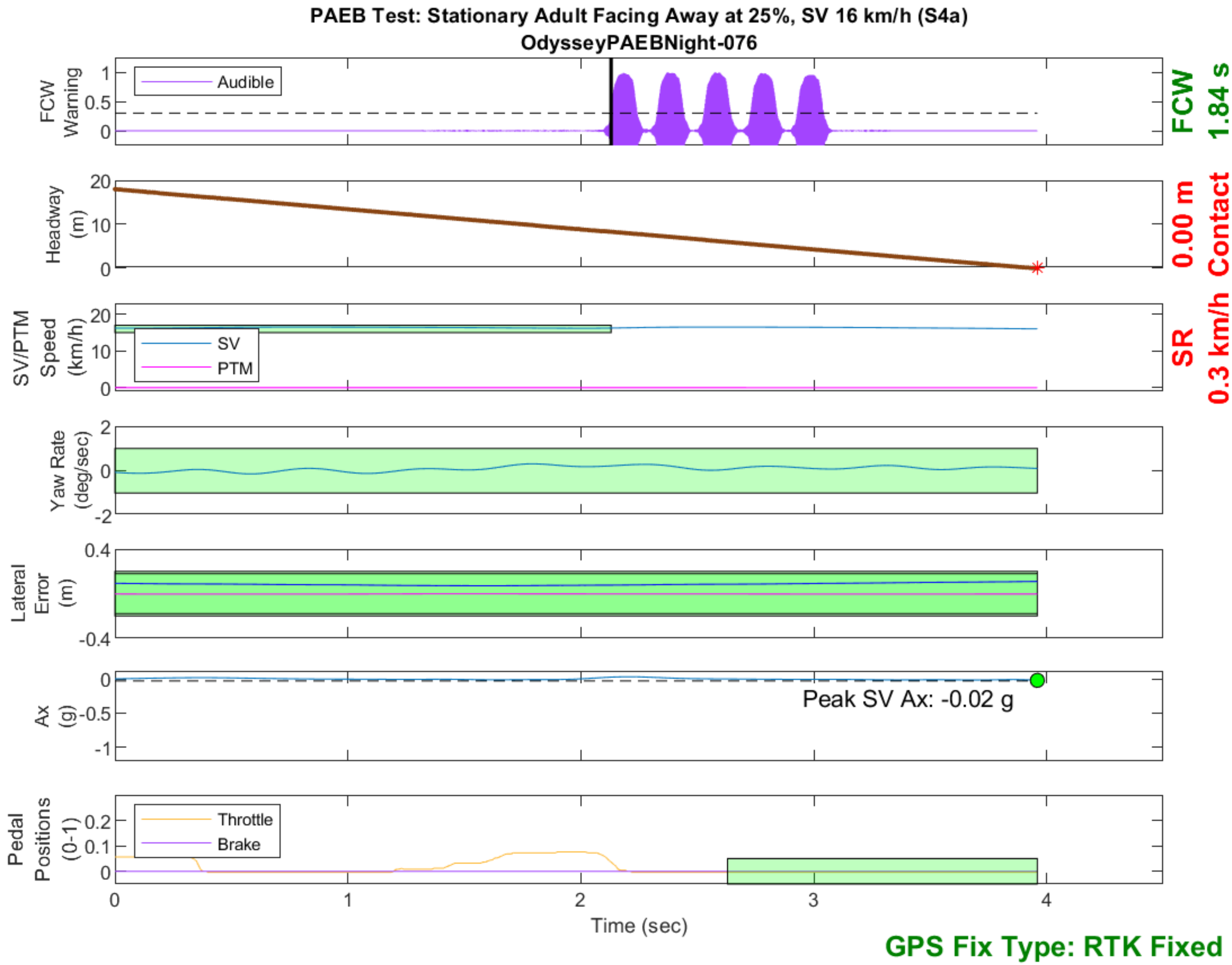


Figure D168. Time History for PAEB Run 76, S4a, Night, Low Beam, 16 km/h

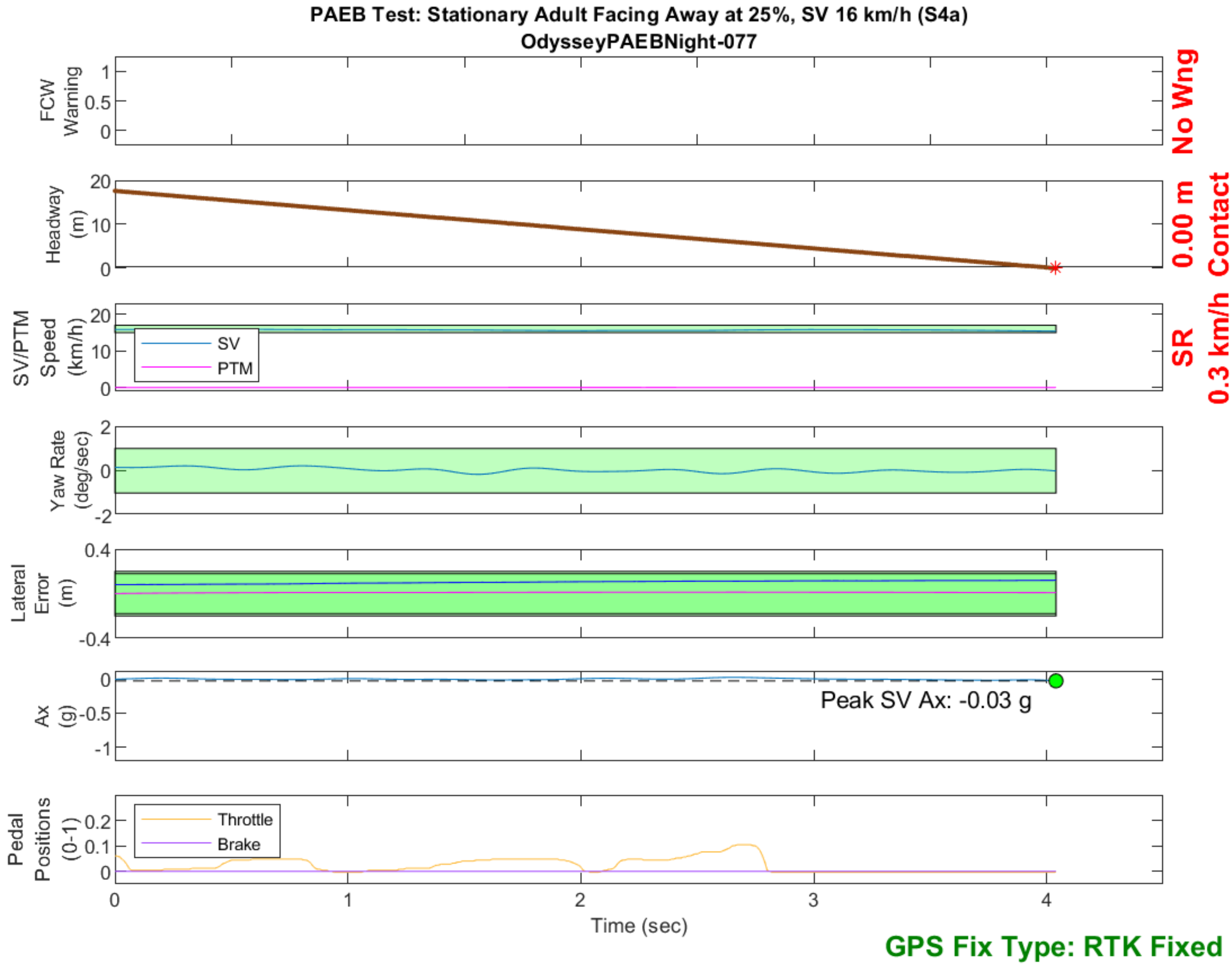


Figure D169. Time History for PAEB Run 77, S4a, Night, Low Beam, 16 km/h

Figure D170. Time History for PAEB Run 78, S4a, Night, Low Beam, 16 km/h

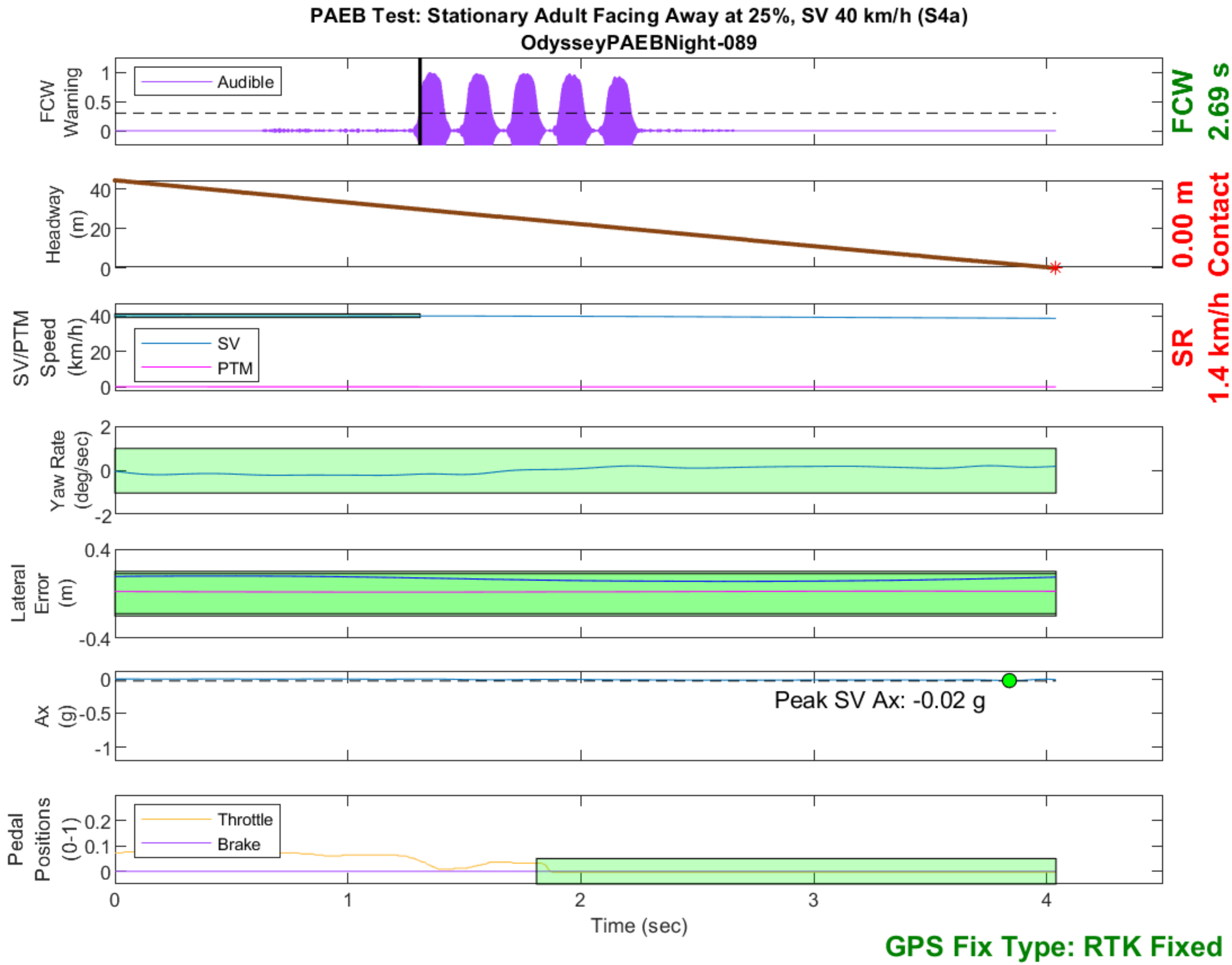


Figure D171. Time History for PAEB Run 89, S4a, Night, Low Beam, 40 km/h

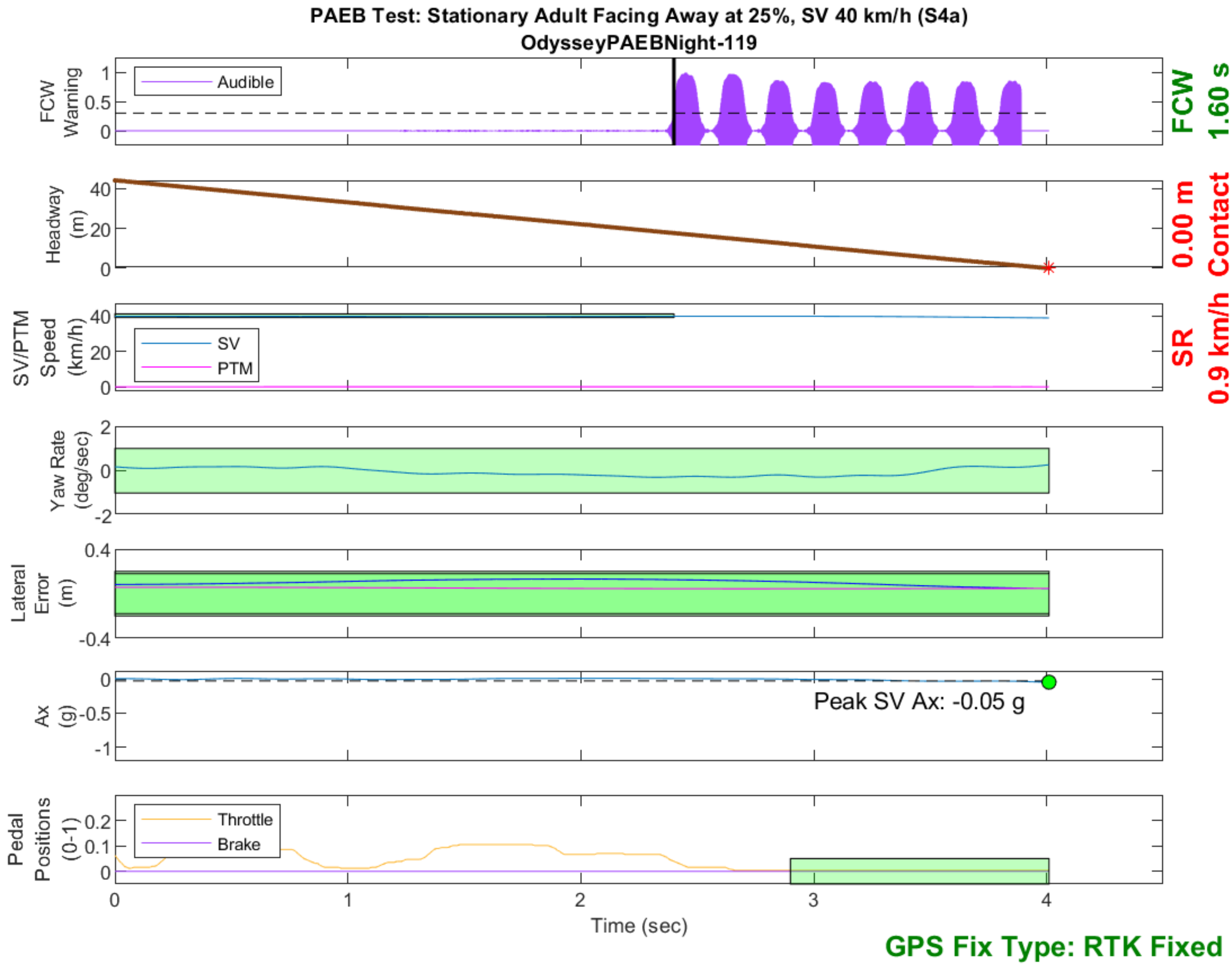


Figure D172. Time History for PAEB Run 119, S4a, Night, Low Beam, 40 km/h

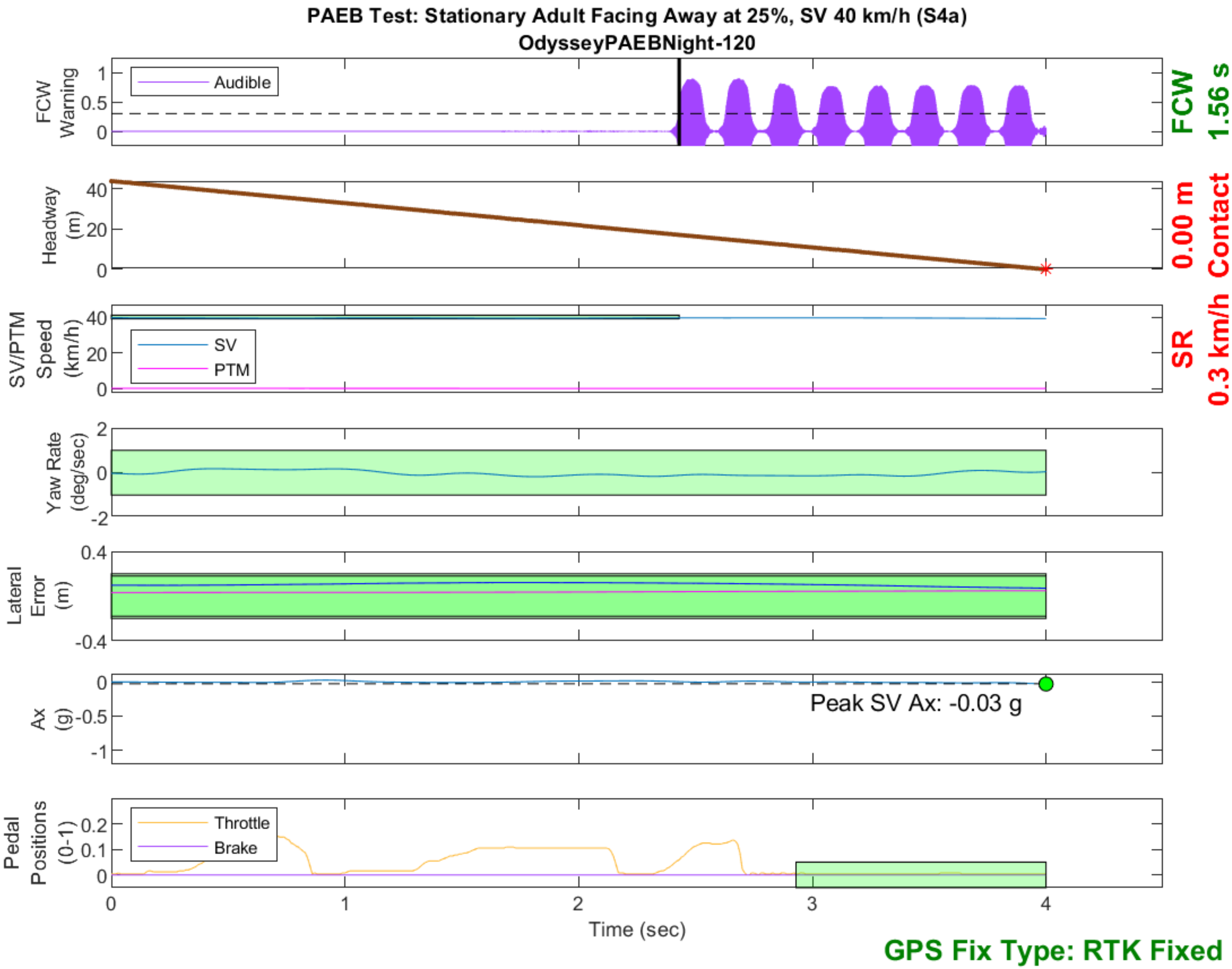


Figure D173. Time History for PAEB Run 120, S4a, Night, Low Beam, 40 km/h

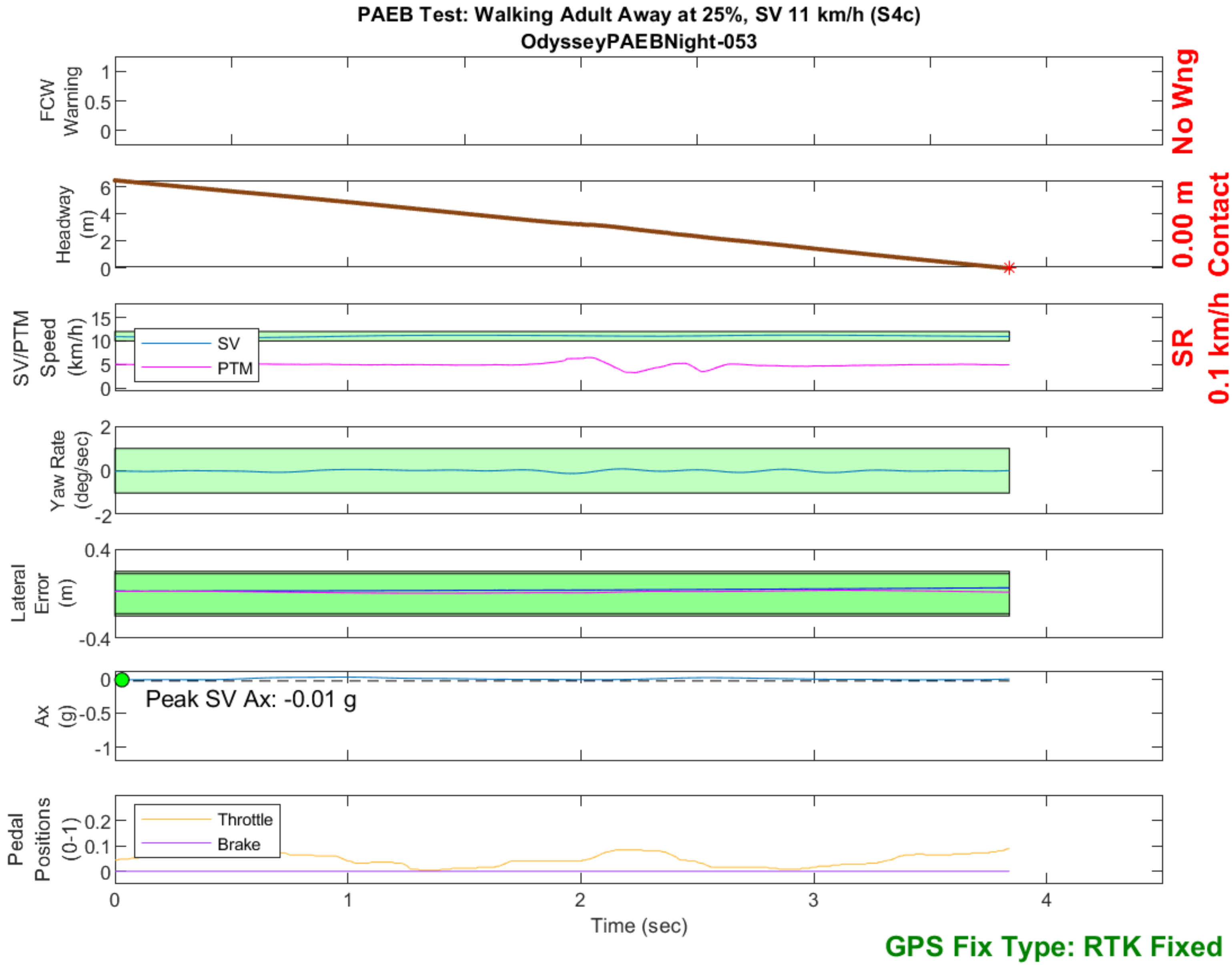


Figure D174. Time History for PAEB Run 53, S4c, Night, Low Beam, 11 km/h

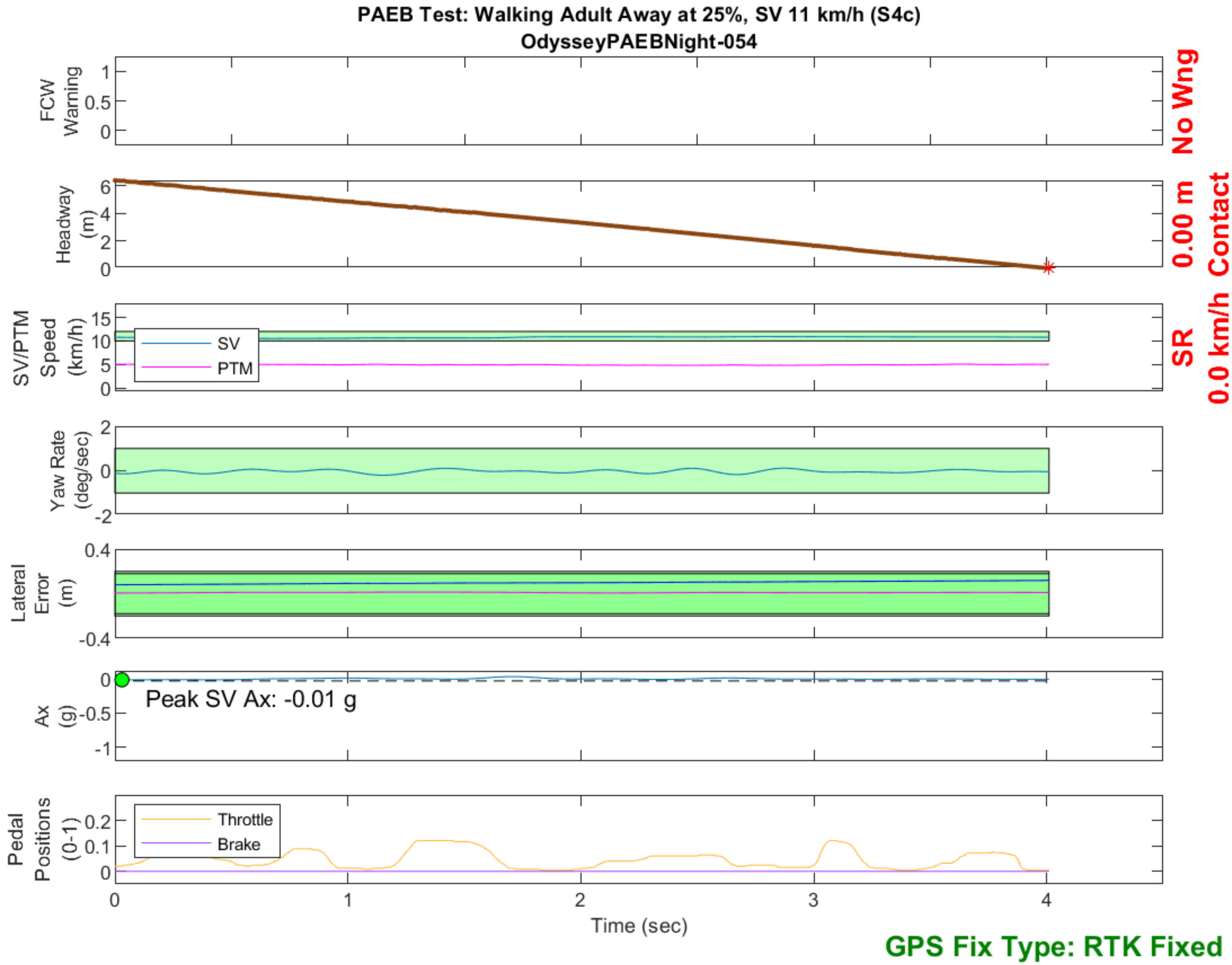


Figure D175. Time History for PAEB Run 54, S4c, Night, Low Beam, 11 km/h

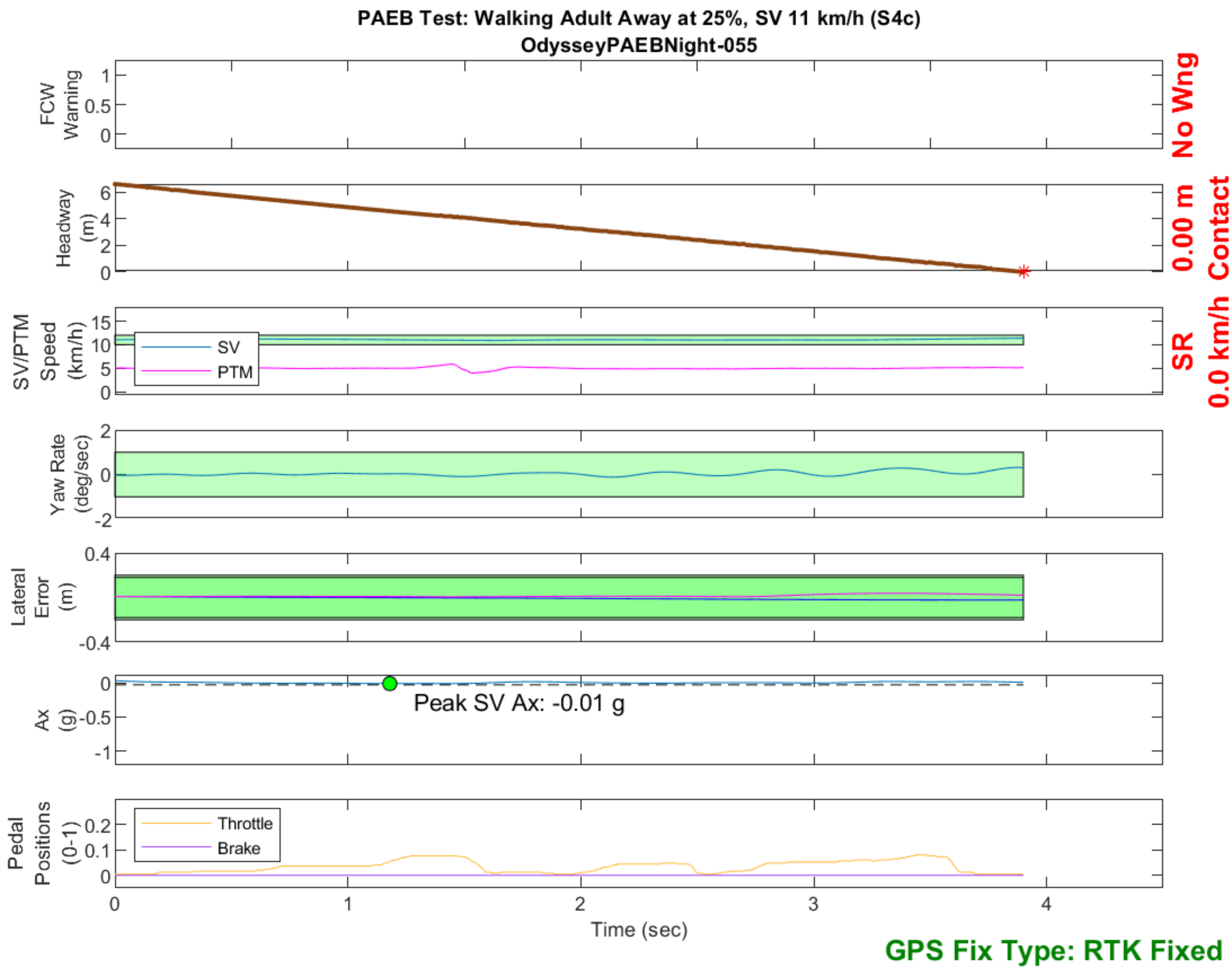


Figure D176. Time History for PAEB Run 55, S4c, Night, Low Beam, 11 km/h

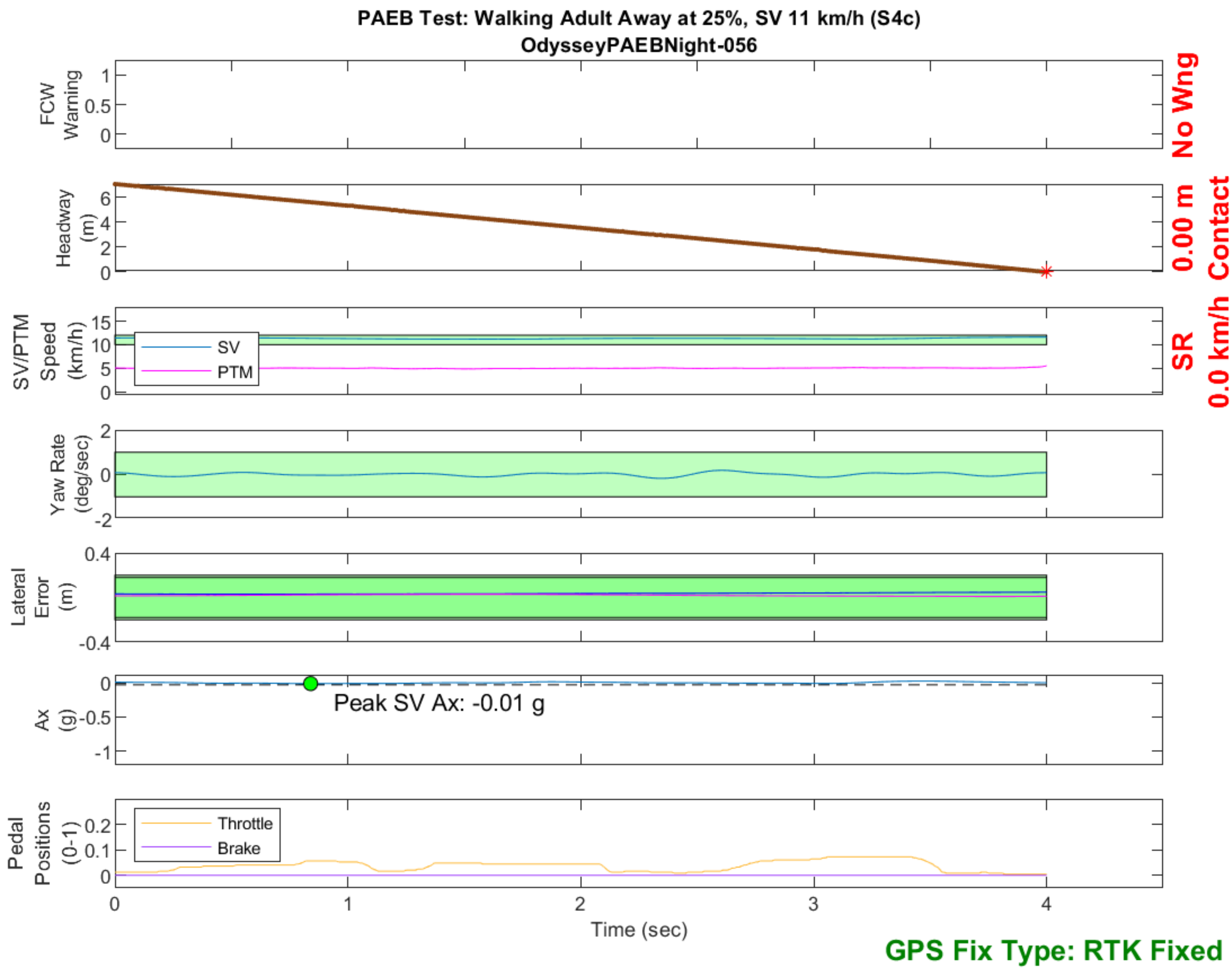


Figure D177. Time History for PAEB Run 56, S4c, Night, Low Beam, 11 km/h

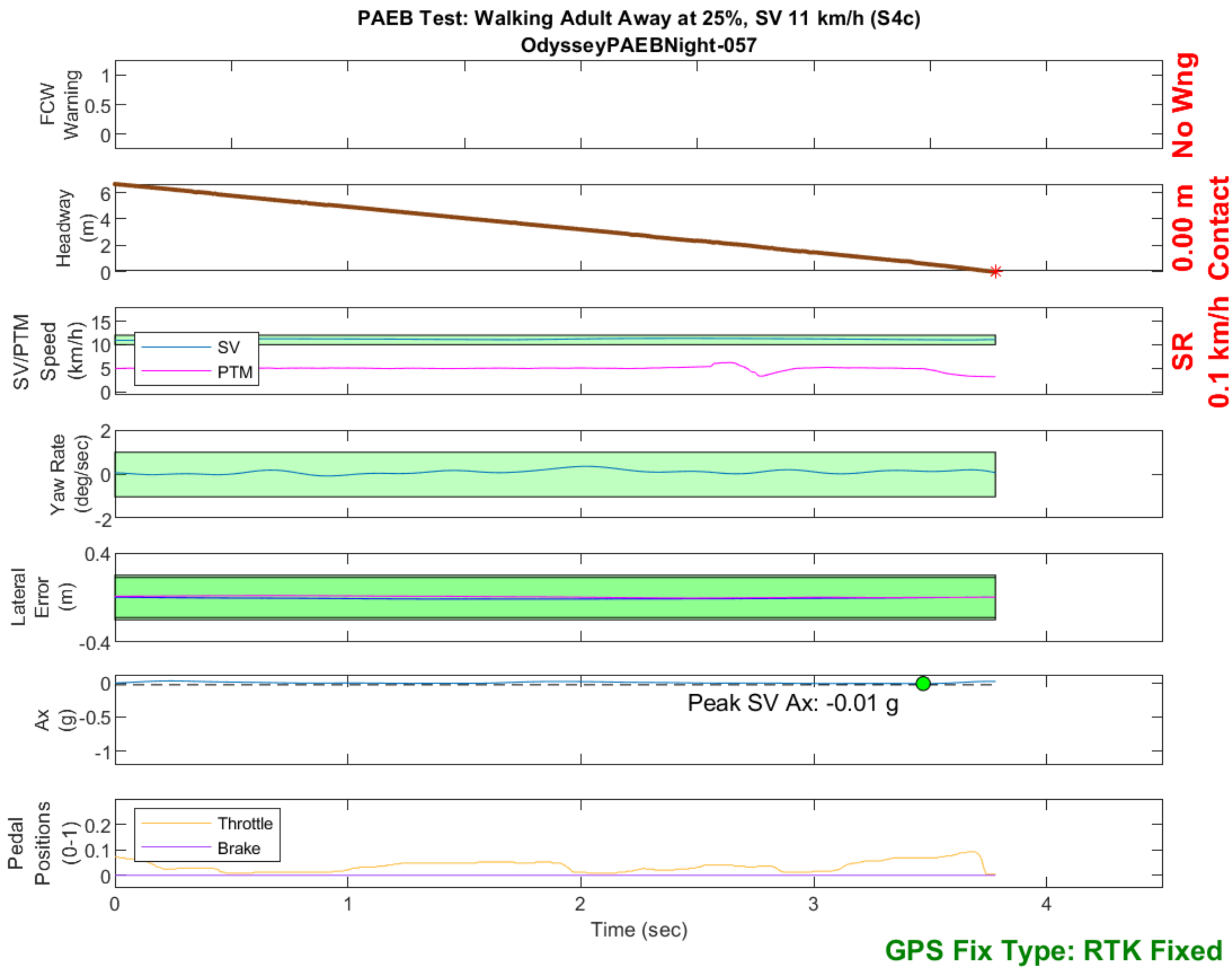


Figure D178. Time History for PAEB Run 57, S4c, Night, Low Beam, 11 km/h

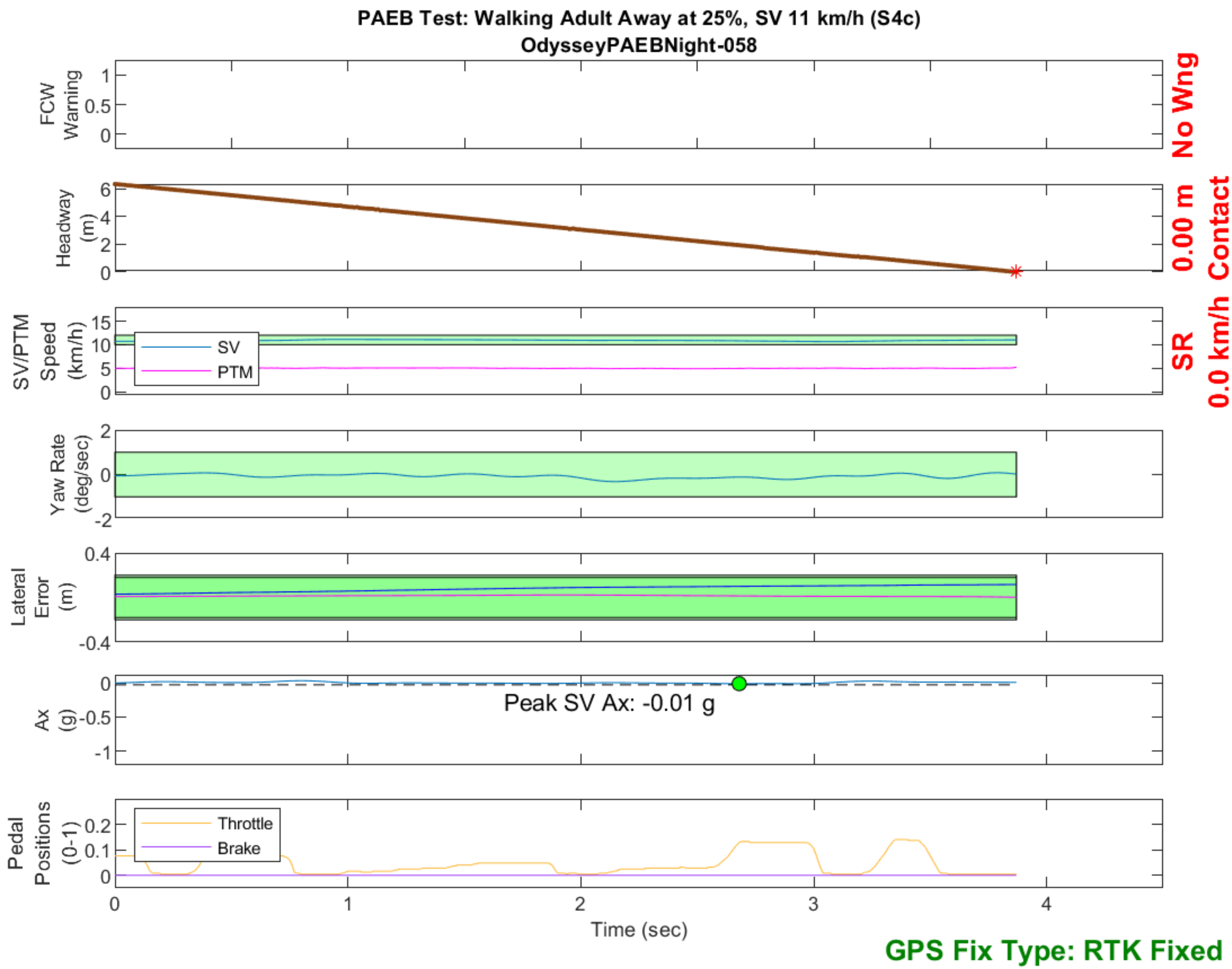


Figure D179. Time History for PAEB Run 58, S4c, Night, Low Beam, 11 km/h

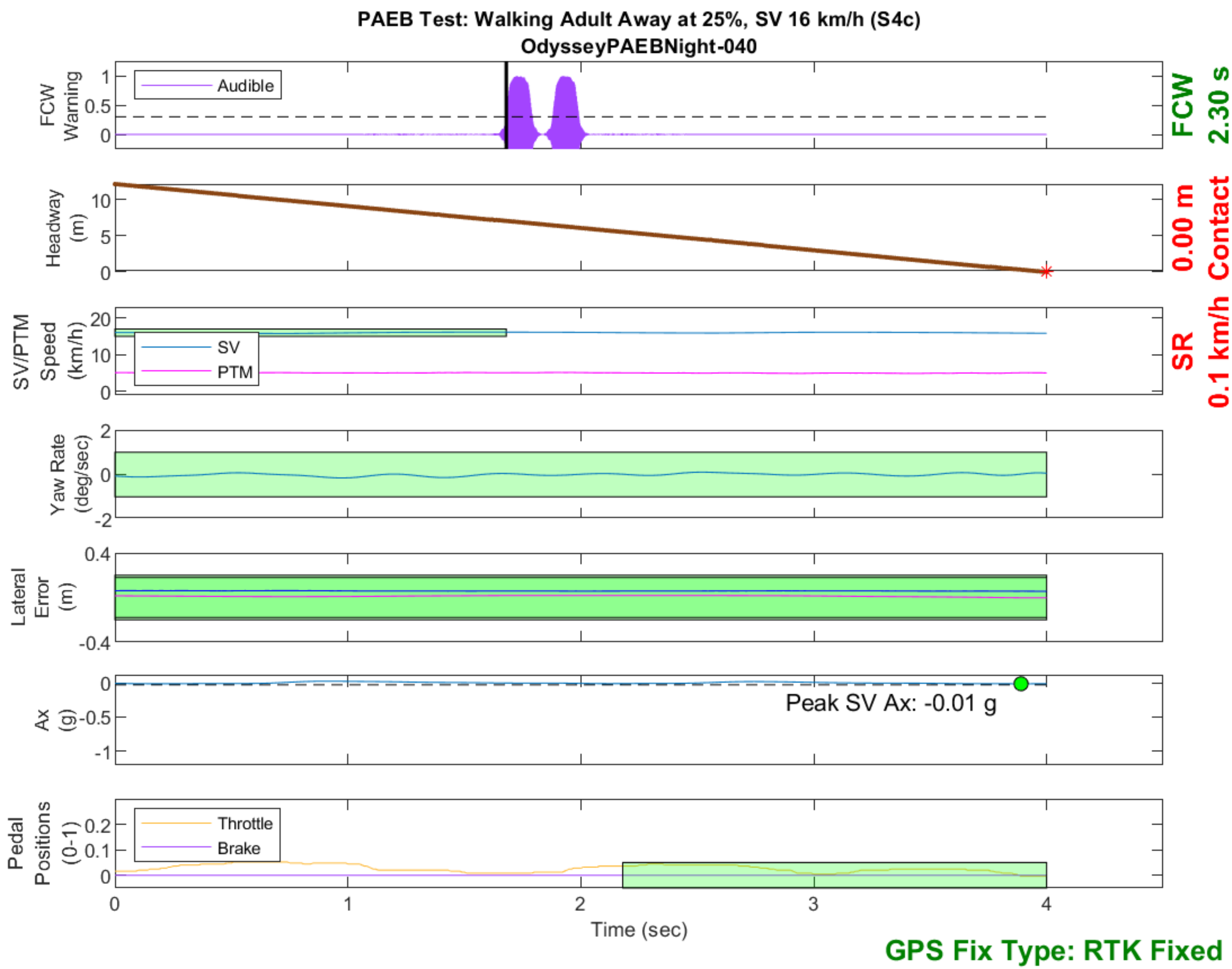


Figure D180. Time History for PAEB Run 40, S4c, Night, Low Beam, 16 km/h

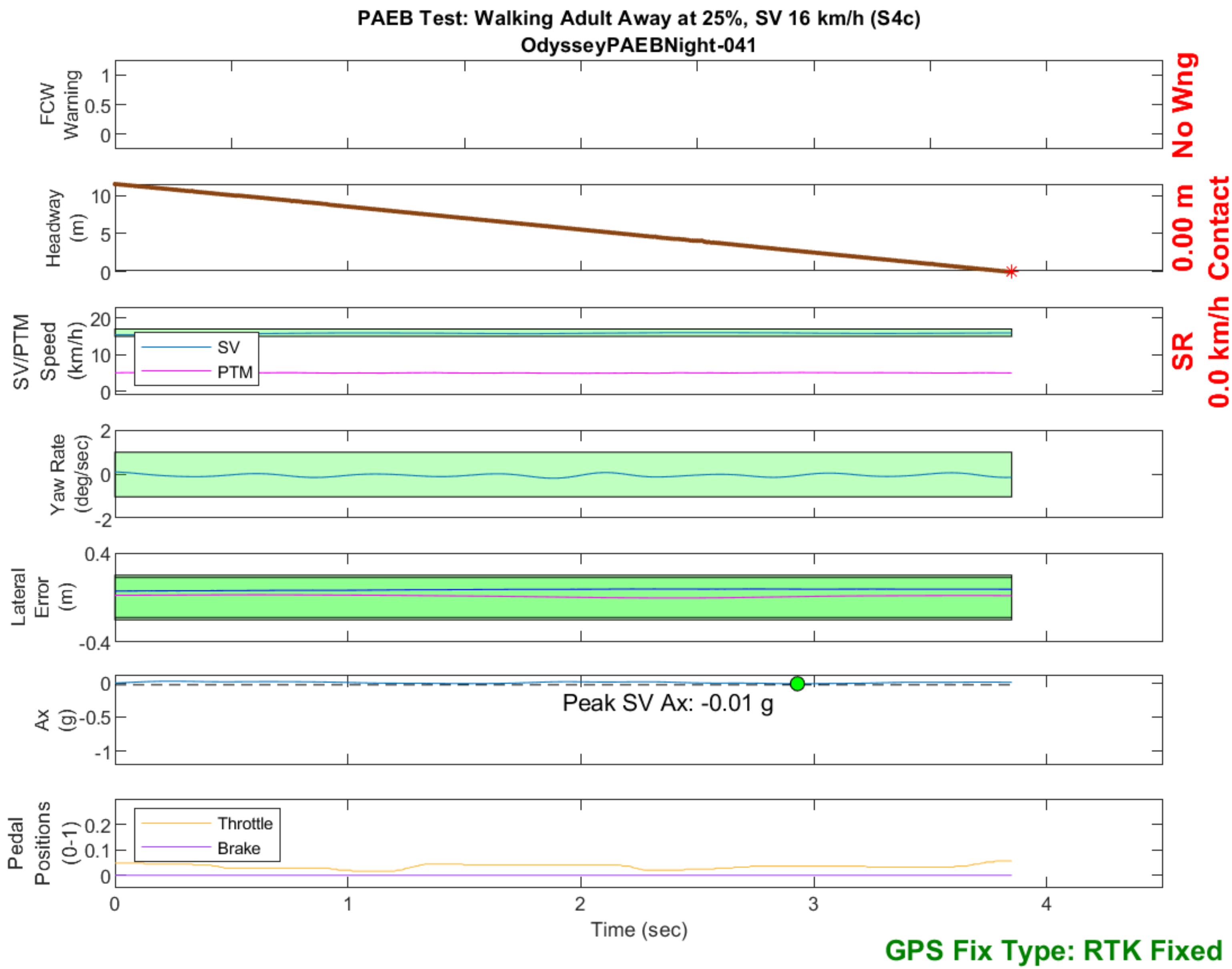


Figure D181. Time History for PAEB Run 41, S4c, Night, Low Beam, 16 km/h

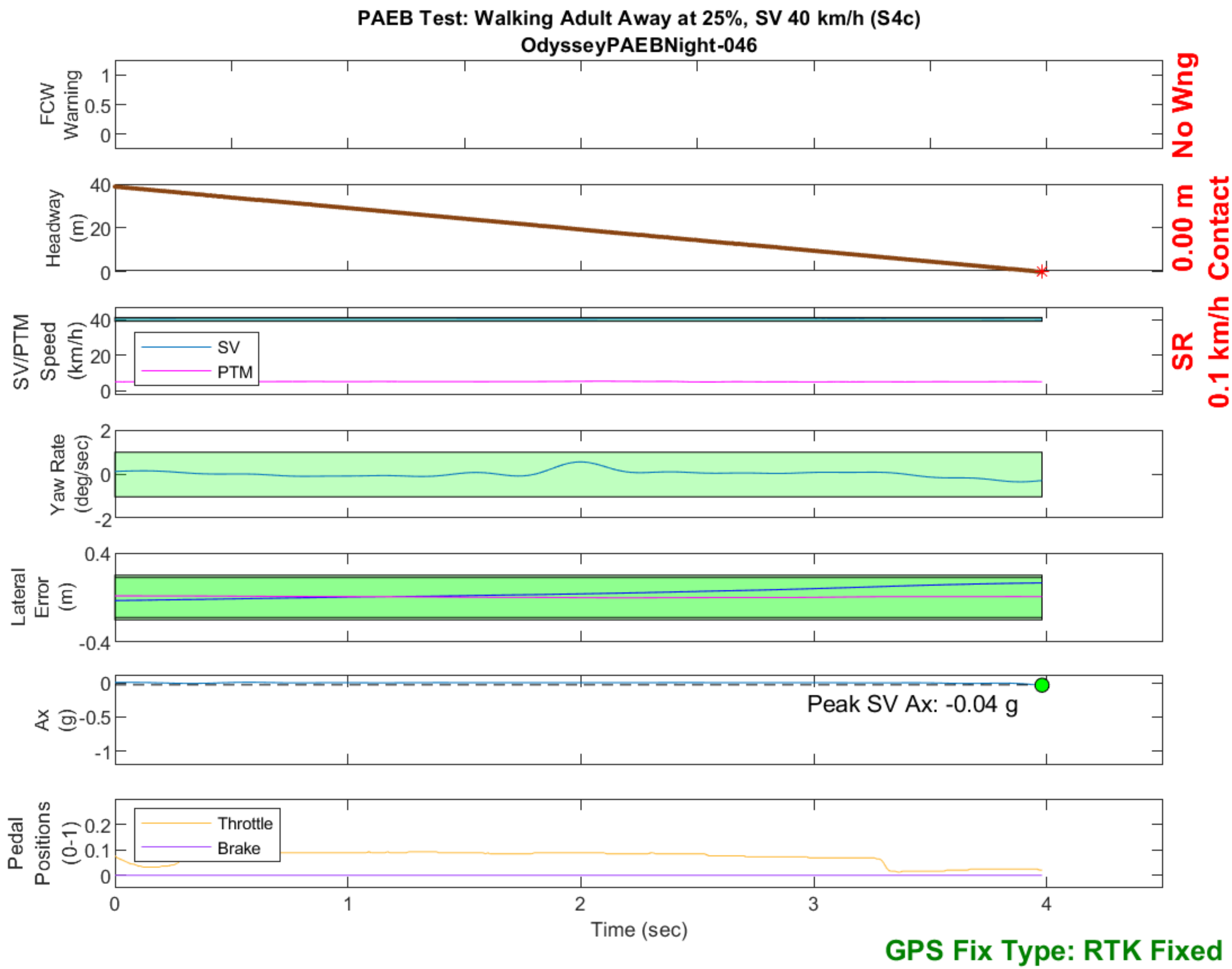


Figure D182. Time History for PAEB Run 46, S4c, Night, Low Beam, 40 km/h

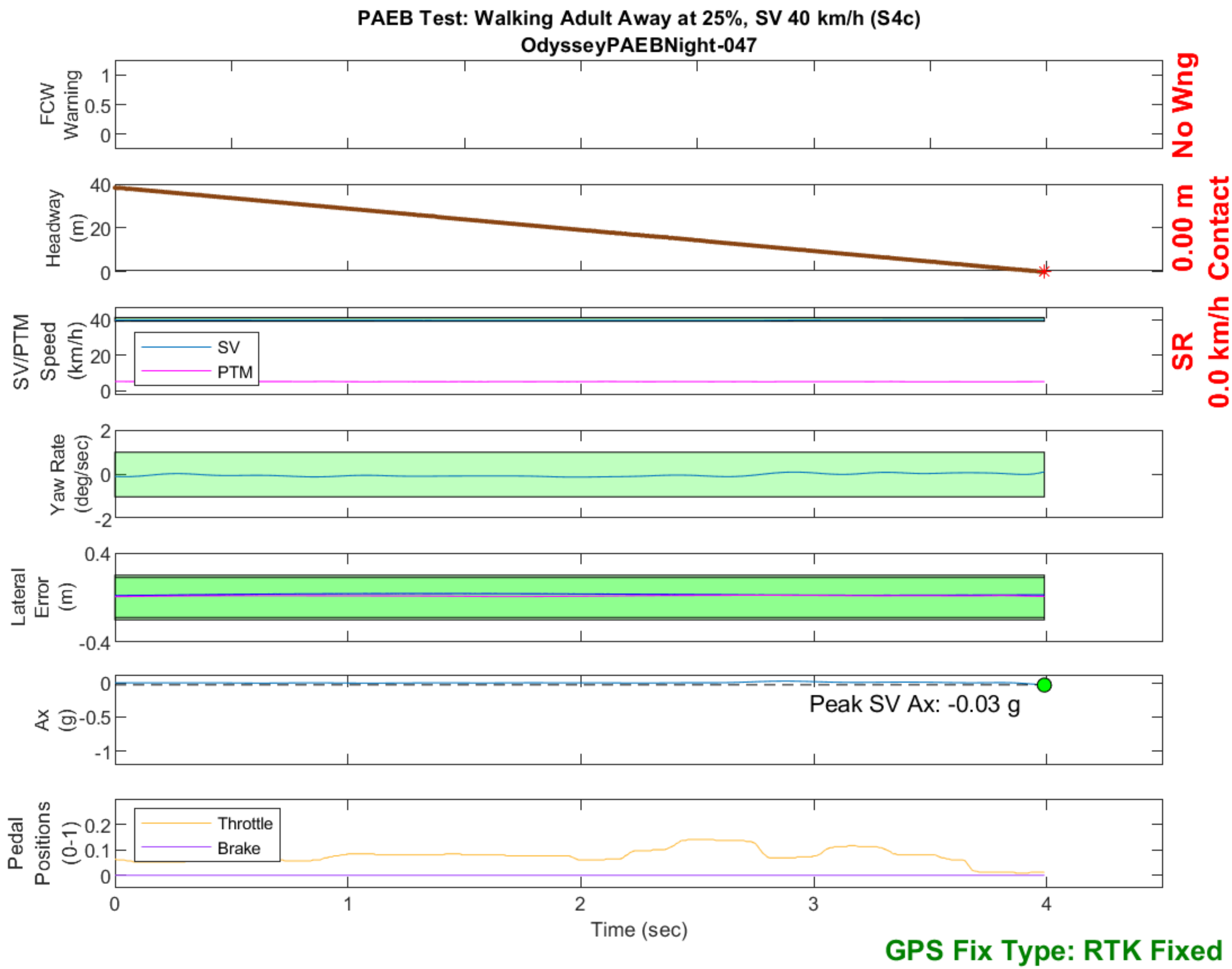


Figure D183. Time History for PAEB Run 47, S4c, Night, Low Beam, 40 km/h

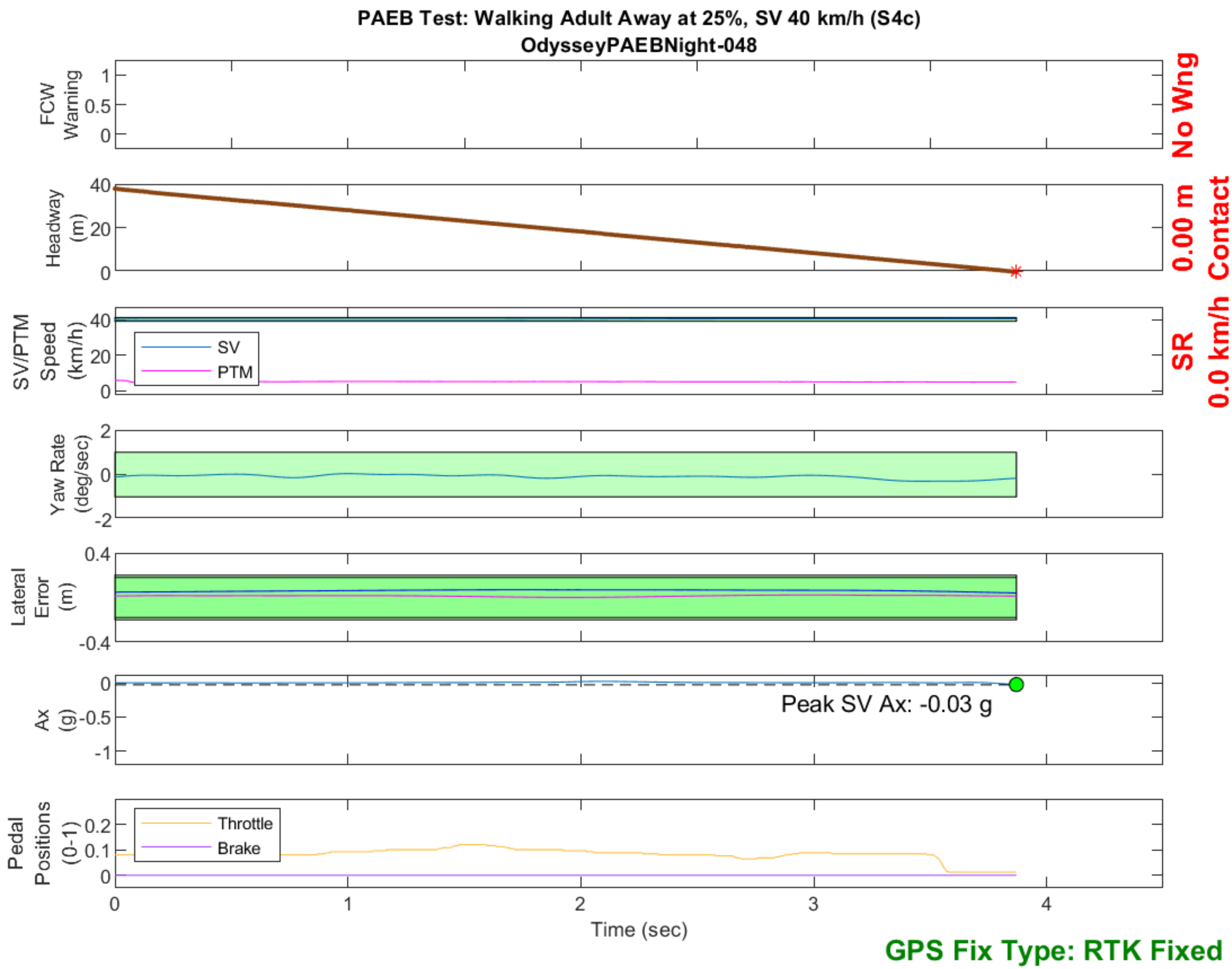


Figure D184. Time History for PAEB Run 48, S4c, Night, Low Beam, 40 km/h

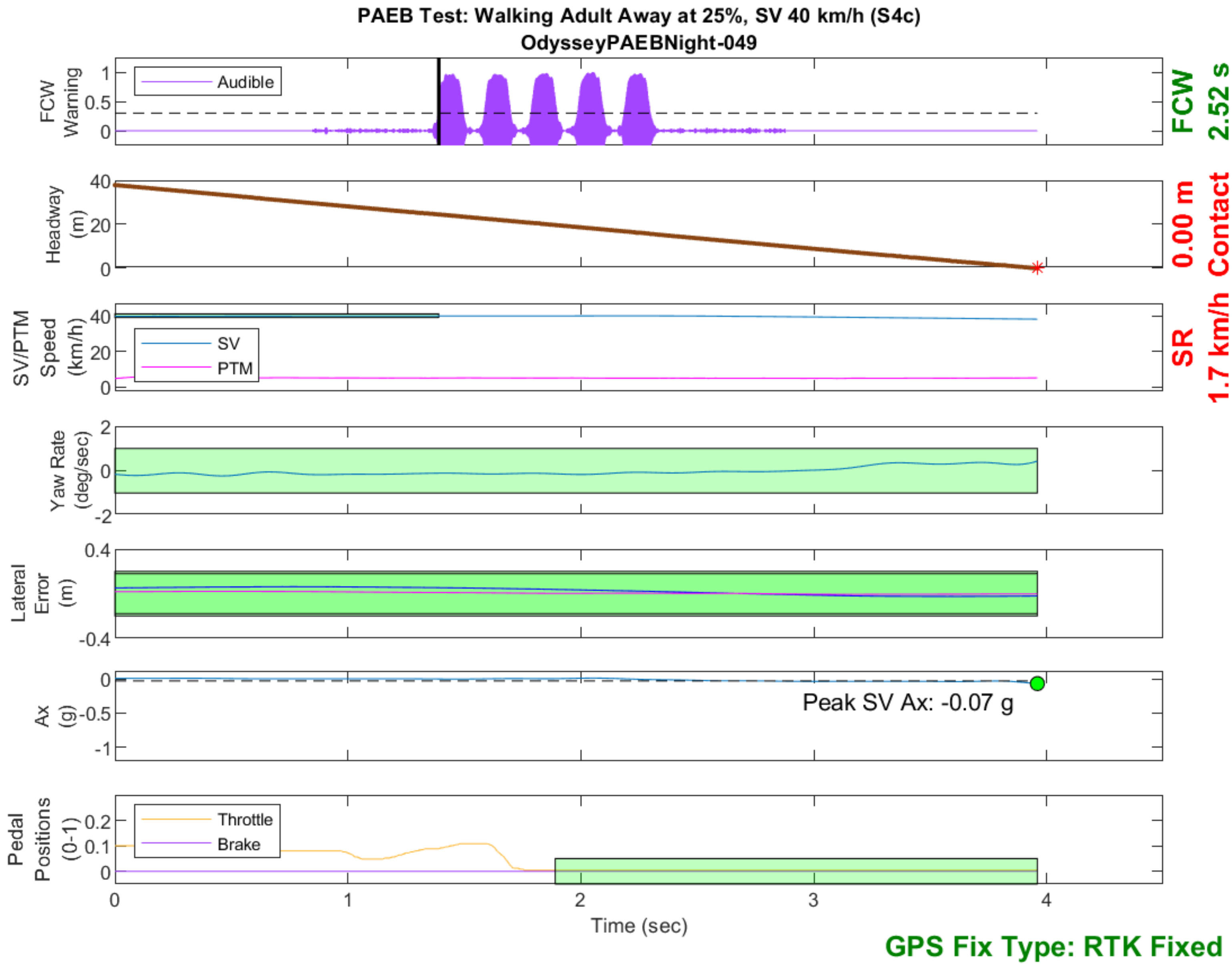


Figure D185. Time History for PAEB Run 49, S4c, Night, Low Beam, 40 km/h