BLIND SPOT DETECTION SYSTEM RESEARCH TEST
NCAP-DRI-BSD-20-10

2020 Volvo S60 T6 AWD Momentum

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Final Report

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U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
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16. Abstract These tests were conducted on the subject 2020 Volvo S60 T6 AWD Momentum in accordance with the specifications of the National Highway Traffic Safety Administration's most current Test Procedure in docket NHTSA-2019-0102-0010, BLIND SPOT DETECTION SYSTEM CONFIRMATION TEST, to confirm the performance of a Blind Spot Detection system. The vehicle met the requirements of the test for all conditions and speeds.			
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Section I

INTRODUCTION

This test evaluates Blind Spot Detection (BSD) systems on light vehicles with gross vehicle weight ratings (GVWR) of under 10,000 pounds as specified in the National Highway Traffic Safety Administration's (NHTSA's) "Blind Spot Detection System Confirmation Test", dated June 2019. BSD technology uses sensors to detect the presence of other vehicles in the equipped vehicle's left and right blind zone. The procedures described herein emulate two straight-road, real-world scenarios in which the Subject Vehicle (SV) blind zone is breached by a single Principal Other Vehicle (POV). Although it is impossible to predict what technologies could be used by future BSD systems, it is believed that minor modifications to these procedures, when deemed appropriate, could be used to accommodate the evaluation of alternative or more advanced BSD systems.

The BSD system tests described in this document and prescribed by NHTSA involve two different test scenarios: 1) straight lane converge and diverge maneuvers and 2) straight lane pass-by. In the first scenario, the POV is driven at the same speed as the SV, at a constant headway. After a brief period of steady-state driving, the POV enters, then exits the SV blind zone from the side of the vehicle. In the second scenario, the POV is driven by the SV in an adjacent lane at a speed greater than the SV. During this pass-by, the POV enters, then exits the SV blind zone. In both scenarios, BSD performance is assessed by comparing the proximity of the POV to the SV at the time of the BSD alert to the SV blind zone. The test scenarios are conducted at multiple speeds, and on both sides of the vehicle, to the left and right, as indicated in the specific test methodologies.

Section II

DATA SHEETS

BLIND SPOT DETECTION

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Volvo S60 T6 AWD Momentum

VIN: *7JRA22TK5LG06xxxx*

Test Date: *7/29/2020*

System Setting: *BLIS on*

	Number of valid test runs for which acceptability criteria[1] were:		
	Met	**Not met**	**Valid trials**
Test 1 - Straight Lane Converge and Diverge			
45 mph - Left	*7*	*0*	*7*
45 mph - Right	*7*	*0*	*7*
Overall Test 1:	*14*	*0*	*14*
Test 2 - Straight Lane Pass-by			
POV 50 mph - Left	*6*	*0*	*6*
POV 50 mph - Right	*7*	*0*	*7*
POV 55 mph - Left	*8*	*0*	*8*
POV 55 mph - Right	*7*	*0*	*7*
POV 60 mph - Left	*7*	*0*	*7*
POV 60 mph - Right	*7*	*0*	*7*
POV 65 mph - Left	*7*	*0*	*7*
POV 65 mph - Right	*6*	*0*	*6*
Overall Test 2:	*55*	*0*	*55*
Overall:	***69***	***0***	***69***

[1] The acceptability criteria listed herein are used only as a guide to gauge system performance, and are identical to the Pass/Fail criteria given in NHTSA's most current Test Procedure in docket NHTSA-2019-0102-0010, BLIND SPOT DETECTION SYSTEM CONFIRMATION TEST.

BLIND SPOT DETECTION

DATA SHEET 2: VEHICLE DATA

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2020 Volvo S60 T6 AWD Momentum

TEST VEHICLE INFORMATION

VIN: *7JRA22TK5LG06xxxx*

Body Style: *Sedan* Color: *Fusion Red Metallic*

Date Received: *7/13/2020* Odometer Reading: *17 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *VOLVO CAR CORPORATION*

Date of manufacture: *02/20*

Vehicle Type: *PC (Passenger Car)*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/40 R19*

Rear: *235/40 R19*

Recommended cold tire pressure: Front: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

TIRES

Tire manufacturer and model: *Pirelli P Zero*

Front tire size: *235/40 R19 96V*

Rear tire size: *235/40 R19 96V*

Front tire DOT prefix: *1UN FC507K*

Rear tire DOT prefix: *1UN FC507K*

BLIND SPOT DETECTION

DATA SHEET 3: TEST CONDITIONS

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2020 Volvo S60 T6 AWD Momentum

GENERAL INFORMATION

Test date: *7/29/2020*

AMBIENT CONDITIONS

Air temperature: *36.7 C (98 F)*

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

X Windspeed ≤ 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.

All tests were also conducted such that there were no overhead signs, bridges, or other significant structures over, or near, the testing site. Except for the POV, each trial shall be conducted with no vehicles, obstructions, or stationary objects within one lane width of either side the SV path.

VEHICLE PREPARATION

Verify the following:

All non-consumable fluids at 100% capacity: **X**

Fuel tank is full: **X**

Tire pressures are set to manufacturer's recommended cold tire pressure: **X**

Front: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

BLIND SPOT DETECTION

DATA SHEET 3: TEST CONDITIONS

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2020 Volvo S60 T6 AWD Momentum

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*552.9 kg (1219 lb)*	Right Front:	*521.2 kg (1149 lb)*
Left Rear:	*436.4 kg (962 lb)*	Right Rear:	*423.2 kg (933 lb)*
		Total:	*1933.7 kg (4263 lb)*

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2020 Volvo S60 T6 AWD Momentum

General Information

Name of the BSD option, option package, etc., as shown on the Monroney label:

Blind Spot Information System with Steer Assist (BLIS); included in the Premium Package which is optionally available on all trims.

Type and location of sensors the system uses:

Radar sensors (2) located in the left and right side of the rear bumper.

System setting used for test (if applicable):

BLIS on

Method(s) by which the driver is alerted

X Visual:

	Type	Location	Description
X	Symbol	*Top corners of outside mirrors*	*Orange symbol*
	Word		
	Graphic		

____ Audible – Description:

____ Haptic:

____	Steering Wheel	____	Seatbelt
____	Pedals	____	Steering Torque
____	Seat	____	Brake Jerk

Description of alert:

Visual indicators are located in the upper-outside corners of the outside mirrors. When a vehicle is in the blind spot and the driver has not activated the turn signal, these indicators will light steady orange. If the driver turns on the turn signal and a vehicle is present in the blind spot the alert flashes orange. See Figure A12 in Appendix A.

System Function

What is the speed range over which the system operates?

Minimum: *10 km/h (6.3 mph)*

Maximum: *200 km/h (125 mph)*

If the system requires an initialization sequence/procedure, please provide a description of the process required to initialize the system.

Initialization is not required.

If the system requires the driver to operate their turn signal indicator during lane change in order to activate, please provide a description.

The system does not require the turn signal to be activated, but if the driver turns on the turn signal and a vehicle is present in the blind spot the visual alert flashes orange.

If the vehicle is equipped with a method to activate/deactivate the system(s) please provide a description of how this is accomplished. If the system is deactivated by this method, does it reactivate upon each ignition cycle?

Menus are presented on the vehicle's center display. Swiping across the screen changes the top-level views. From the Function view, the BLIS can be activated or deactivated. See Appendix B, page B-3 (Owner's Manual, page 322) and Appendix A, Figure A11.

The system does not automatically reactivate upon each ignition cycle.

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2020 Volvo S60 T6 AWD Momentum

If the vehicle is equipped with a method to adjust the range setting/sensitivity or otherwise influence the operation of BSD, please provide a description.

No range/sensitivity adjustments are provided.

If the system deactivates due to damage to the sensors, how is this indicated to the driver?

Warning messages are described on page 324 of the Owner's Manual, shown in Appendix B, Page B-5.

If the system deactivates due to repeated BSD activations:

- How is this indicated to the driver?
- Can deactivation be avoided (e.g., by cycling the ignition after each BSD activation)?
- How can the system be reactivated?

No, the system remains operational.

If the system deactivates or its effectiveness is reduced due to periods of inactivity:

- How is this indicated to the driver?
- Can deactivation be avoided?
- How can the system be reactivated?

Warning messages are described on page 324 of the Owner's Manual, shown in Appendix B, Page B-5.

If there are other driving modes or conditions (such as weather) that render the system inoperable or reduce its effectiveness please provide a description.

Potential system limitations are described in the Owner's manual on page 323 shown in Appendix B, page B-4.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Two test scenarios were used, as follows:

Test 1. Straight Lane Converge and Diverge
Test 2. Straight Lane Pass-by

An overview of each of the test procedures follows.

For the purposes of this document, headway is defined as the longitudinal distance from the front-most point of the POV to the rear-most point of the SV, regardless of the relative lateral (lane) positions of the SV and POV. When the front-most part of the POV is ahead of the rear-most point on the SV, the headway is negative.

1. TEST 1 – STRAIGHT LANE CONVERGE AND DIVERGE

The Straight Lane Converge and Diverge Test evaluates the ability of the Blind Spot Detection (BSD) system to detect and respond to a vehicle that enters and exits the blind zone from a lane outside of the blind zone area. This test scenario is depicted in Figure 1. In this scenario, the test begins with the POV two lanes away from the SV. After both vehicles have reached their designated speeds and headway overlap, the POV begins a single lane change maneuver so that it is travelling in the lane next to the SV and holds this relative position for at least 2.5 seconds. The POV then begins a lane change maneuver back to its original lane, moving outside of the SV's blind zone.

This test was performed with the POV on both the left- and right-hand sides of the SV. The SV and POV turn signals were not active during any of the tests.

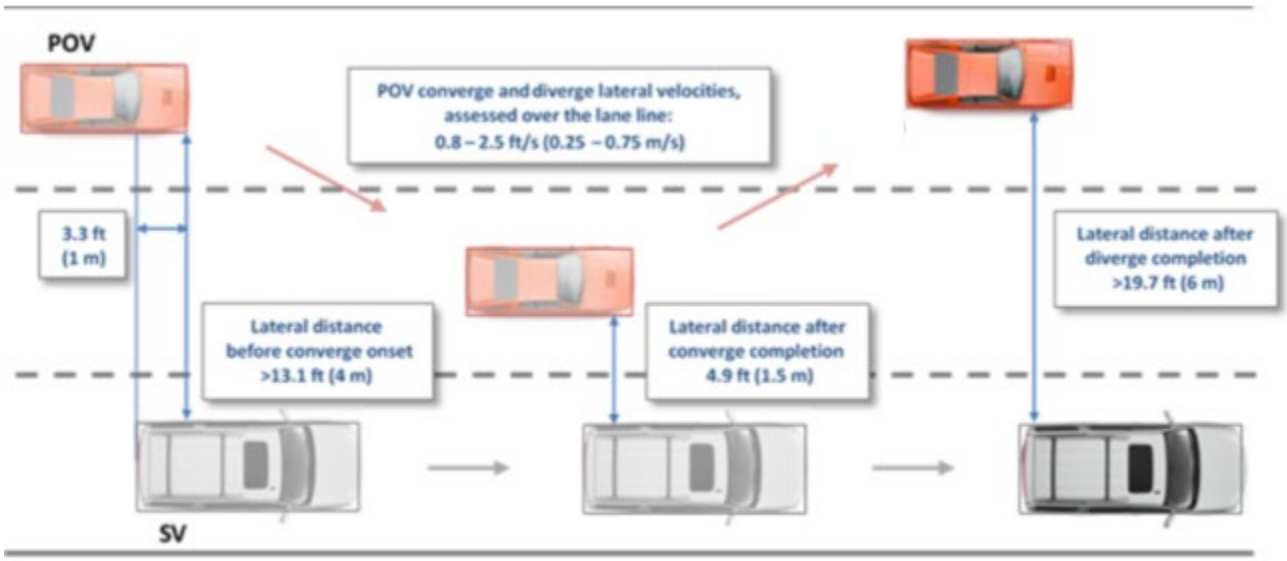


Figure 1. Straight Lane Converge and Diverge Test
(POV converge and diverge from the left is shown)

a. Procedure

The SV began in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge. The POV began two lanes away from the SV, with its longitudinal axis oriented parallel to the roadway edge. Both vehicles then accelerated to a nominal speed of 45 mph (72.4 km/h). The nominal speed and specified headway overlap between the front bumper of the POV and the rear bumper of SV was maintained, within tolerance, throughout the test. As shown in Figure 1, the specified headway for this test was -3.3 ft (-1.0 m) resulting in a longitudinal overlap. The specified speed for both the SV and POV was 45 mph (72.4 km/h).

Once the specified speed and headway were stabilized and maintained for at least 2.5 seconds, the POV performed a “converge” lane change into the lane adjacent to the SV using a lateral velocity between 0.8 ft/s and 2.5 ft/s (0.25 to 0.75 m/s).

Once the lane change was completed, the POV continued in a straight line for at least 2.5 seconds, and then performed a “diverge” lane change back into its original lane using a lateral velocity between 0.8 ft/s and 2.5 ft/s (0.25 to 0.75 m/s).

The test concluded once the POV was back in its original lane and had been driving straight for at least 1.0 second.

The validity period for this test started 2.5 seconds prior to initiating the first POV lane change and ended 1.0 second after completion of the final POV lane change. For an individual test trial to be valid, the following requirements must have been met throughout the validity period:

- The SV and POV speeds could not deviate from the specified speed by more

than 1.0 mph (1.6 km/h) during the entire test trial interval.

- The SV yaw rate could not exceed ±1 deg/s for the entire test interval.
- The POV yaw rate could not exceed ±1 deg/s when not performing a lane change maneuver.
- The POV lateral velocity during a lane change maneuver must have been 0.8 to 2.5 ft/s (0.25 to 0.75 m/s), assessed at the instant the vehicle first crossed the lane line separating the initial and adjacent travel lanes.
- The headway overlap from the front of the POV to the rear of the SV bumper must have been within 3.3 ± 1.6 ft (1.0 ± 0.5 m) for the entire test interval.
- The lateral offset between the widest point of the SV (not including side mirrors) and the widest point of the POV (not including side mirrors) must have been
    - greater than 13.1 ft (4 m) before the POV begins the converge lane change,
    - within 4.9 ± 1.6 ft (1.5 ± 0.5 m) when the POV is in the lane adjacent to the SV, and
    - greater than 19.7 ft (6 m) after the POV completes the diverge lane change.

After the test validity period ended, the SV driver manually applied force to the brake pedal, bringing the vehicle to a stop, and placed the transmission in park. The POV was also braked to a stop, and the test trial was complete.

b. Number of Test Trials

Seven valid trials per POV approach direction were performed for the Straight Lane Converge and Diverge Test scenario, for a total of 14 tests overall. If the test conductor performed more than 7 trials per approach direction within this scenario, the first 7 trials satisfying all test tolerances per approach direction were used to assess the SV performance.

c. Evaluation Criteria

The performance requirement for this series of tests is that the BSD system must be presented by a time no later than 300 ms after any part of the POV enters the SV blind zone defined by the intersections of lines A, C, D, and E for left side tests and of lines A, C, F, and G for right side tests (as shown in Figure 3), and shall remain on while any part of the POV resides within the SV blind zone. During the diverge portion of the test scenario, the BSD alert may remain active when the lateral distance between the SV and the POV is greater than 9.8 ft (3 m) but less than or equal to 19.7 ft (6 m). The BSD shall not be active once the lateral distance between the SV and the POV is greater than 19.7 ft (6 m).

2. TEST 2 – STRAIGHT LANE PASS-BY

This test evaluates the ability of the BSD system to detect and respond to a vehicle which approaches and then passes by the SV in an adjacent lane. This test scenario, depicted in Figure 2, was performed with the POV on both the left- and right-hand side of the SV, with four different POV speed configurations on each side: 50 mph, 55 mph, 60 mph, and 65 mph.

The SV and POV turn signals were not active during any of the tests.

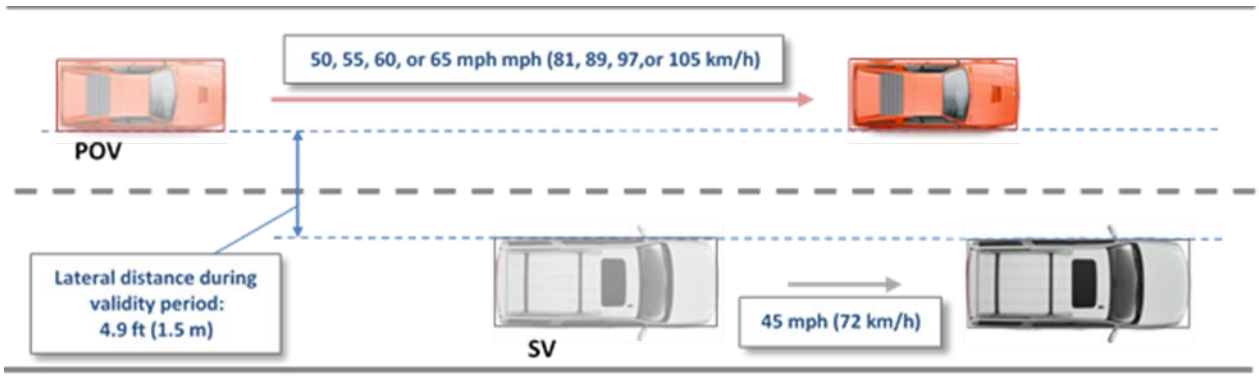


Figure 2. Straight Lane Pass-by Test
(Left-side POV Pass-by is shown)

a. Procedure

The SV is started in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge. The POV is started in an adjacent lane on either the left or right side of the SV, with its longitudinal axis oriented parallel to the roadway edge, and behind the SV blind zone area.

The SV is then accelerated to a nominal speed of 45 mph (72.4 km/h) and the POV is accelerated to a nominal speed of either 50 mph (80.5 km/h), 55 mph (88.5 km/h), 60 mph (96.6 km/h), or 65 mph (104.6 km/h) depending on the test configuration. Both vehicles continue straight in their respective lanes.

The Straight Lane Pass-by Test parameters are defined in Table 1. The test validity period begins 4.0 seconds before the front-most part of the POV passes beyond a plane defined by the rear-most part of the SV perpendicular to the SV centerline. The test validity period ends 2.0 seconds after the rear-most point of the POV passes beyond a plane defined by the front-most point of the SV perpendicular to the SV centerline.

Table 1. Straight Lane Pass-by Test Scenarios

Parameter	Test Scenario			
	Straight Lane 45/50	Straight Lane 45/55	Straight Lane 45/60	Straight Lane 45/65
SV Speed	45 ± 1 mph (72.4 ± 1.6 km/h)	45 ± 1 mph (72.4 ± 1.6 km/h)	45 ± 1 mph (72.4 ± 1.6 km/h)	45 ± 1 mph (72.4 ± 1.6 km/h)
POV Speed	50 ± 1 mph (80.5 ± 1.6 km/h)	55 ± 1 mph (88.5 ± 1.6 km/h)	60 ± 1 mph (96.6 ± 1.6 km/h)	65 ± 1 mph (104.6 ± 1.6 km/h)
Differential Speed	5 ± 1 mph (8.0 ± 1.6 km/h)	10 ± 1 mph (16.1± 1.6 km/h)	15 ± 1 mph (24.1 ± 1.6 km/h)	20 ± 1 mph (32.2 ± 1.6 km/h)
Starting Headway Distance (nominally a 4 second gap) at validity period onset	29.3 ft (8.9 m)	58.7 ft (17.9 m)	88.0 ft (26.8 m)	117.3 ft (35.8 m)

For an individual test trial to be valid, the following requirements must have been met throughout the validity period:

- The SV speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during the entire test interval.
- The POV speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during the entire test interval.
- The SV yaw rate could not exceed ±1 deg/s for the entire test interval.
- The POV yaw rate could not exceed ±1 deg/s for the entire test interval.
- The lateral offset between the widest point of the SV (not including side mirrors) and the widest point of the POV (not including side mirrors) must have been within 4.9 ± 1.6 ft (1.5 ± 0.5 m) for the entire test interval.

After the test validity period ended, the SV driver manually applied force to the brake pedal, bringing the vehicle to a stop, and placed the transmission in park. The POV was also braked to a stop, and the test trial was complete.

b. Number of Test Trials

Seven valid trials for each POV pass-by side and speed were performed for the Straight Lane Pass-by Test scenario, for a total of 56 test trials overall. If the test conductor performed more than 7 trials per approach direction within this scenario, the first 7 trials satisfying all test tolerances per test condition were used to assess the SV performance.

c. Evaluation Criteria

The performance requirement for this series of tests is that the BSD alert must be presented by a time no later than 300 ms after the front-most part of the POV enters the blind zone defined by the intersections of lines A, C, D, and E for left side tests and of lines A, C, F, and G for right side tests, and shall remain on while the front-most point of the POV lies behind line A. The BSD alert shall not be active once the longitudinal distance between the front-most part of the SV and the rear-most part of the POV exceeds the BSD termination distances specified in Table 2.

Table 2. Straight Lane Pass-by BSD Evaluation Criteria

SV Speed	POV Speed	BSD Onset Headway[1] (SV ahead of POV)	BSD Termination Distance[2] (POV ahead of SV)
45 ± 1 mph (72 ± 1.6 km/h)	50 ± 1 mph (80.5 ± 1.6 km/h)	Within 300 ms after $\overline{BC}$ = 18.3 ft (5.6 m)	>7.3 ft (2.2 m)
	55 ± 1 mph (88.5 ± 1.6 km/h)	Within 300 ms after $\overline{BC}$ = 36.7 ft (11.2 m)	>14.7 ft (4.5 m)
	60 ± 1 mph (96.6 ± 1.6 km/h)	Within 300 ms after $\overline{BC}$ = 55.0 ft (16.8 m)	>22.0 ft (6.7 m)
	65 ± 1 mph (104.6 ± 1.6 km/h)	Within 300 ms after $\overline{BC}$ = 73.3 ft (22.4 m)	>29.3ft (8.9 m)

[1] The BSD onset headway is the longitudinal distance when the rear-most part of the SV is ahead of the front-most part of the POV. The BSD onset headway criteria nominally corresponds to 2.5 seconds before the front-most part of the POV passes by the rear-most part of the SV.

[2] The BSD termination distance is the longitudinal distance when the rear-most part of the POV is ahead of the front-most part of the SV. The BSD termination distance criteria nominally corresponds to 1 second after the rear-most part of the POV passes by the front-most part of the SV.

B. Pre-Test Initialization and Calibration

A zero calibration was performed to align the lateral and longitudinal zero for the vehicles immediately before and after testing. The “zero position” was determined by positioning the SV and POV such that the centerline of the front-most location of the POV was aligned with the centerline of the rear-most location of the SV. Longitudinally, the front-most point of the front bumper of the POV was placed at the rear-most point of the rear bumper of the SV.

Static calibrations were then performed by placing the SV and POV transmissions in park, where applicable. Data were then collected for approximately 10 seconds using data from at least six GPS satellites. If the pre-test and post-test zero-positions reported by the data acquisition system differed by more than ±2 in (±5 cm) then the tests performed between the pre-test and post-test static calibrations were repeated.

C. Vehicle’s Blind Zone

The SV blind zones, for the purpose of this test, are defined by two rectangular regions adjacent to the sides of the SV, as shown in Figure 3.

The width of each rectangle is 8.2 ft (2.5 m) and is represented by lines parallel to the longitudinal centerline of the vehicle. The width of the rectangle begins 1.6 ft (0.5 m) from the outermost edge of the SV’s body, excluding the side view mirrors.

The length of the rectangle starts at the rear-most portion of the SV’s side view mirrors, perpendicular to the longitudinal centerline of the vehicle, and continues to a distance dependent on the differential speed between the SV and POV or SOV. To calculate the distance for the length of the rectangle that extends beyond the rear bumper of the SV, the following equation is used and corresponds to the length from point B to point C in Figure 3.

$$\overline{BC} = 2.5\Delta v\ (ft/s\ to\ ft)$$

where,

> Δv is the differential speed between the POV and the SV. A positive Δv indicates that the POV is travelling faster than the SV.

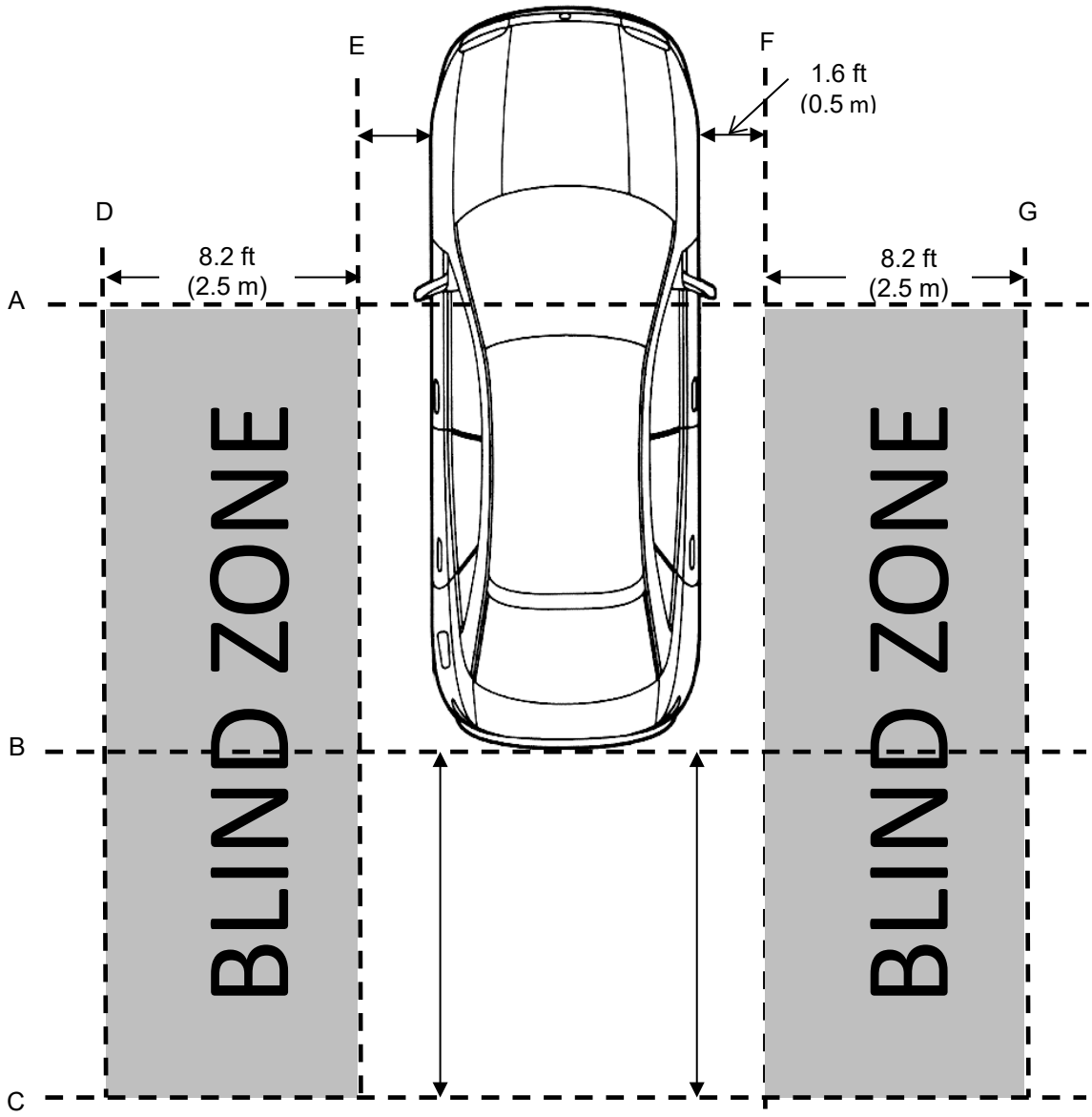


Figure 3. Vehicle Blind Zone Areas

Table 3 details the difference in length from point B to point C of the blind zone for the different speeds used in the tests.

Table 3. B to C Blind Zone Distance

SV-to-POV Differential Speed	B to C Distance (Nominal TTC = 2.5s)
5 ± 1 mph (8.0 ± 1.6 km/h)	18.3 ft (5.6 m)
10 ± 1 mph (16.1 ± 1.6 km/h)	36.7 ft (11.2 m)
15 ± 1 mph (24.1 ± 1.6 km/h)	55.0 ft (16.8 m)
20 ± 1 mph (32.2 ± 1.6 km/h)	73.3 ft (22.4 m)

For the Straight Lane Converge and Diverge Test scenario where there is no speed differential between the SV and POV, the B to C distance is given as 9.8 ft (3 m).

D. Principal Other Vehicle

The vehicle used as the Principal Other Vehicle (POV) was a 2006 Acura RL. This vehicle met the test requirements that the POV be a high-production mid-sized passenger car from 175 to 197 in (445 to 500 cm) long, and 70 to 76 in (178 to 193 cm) wide, measured at the widest part of the vehicle, exclusive of signal lamps, marker lamps, outside rearview mirrors, flexible fender extensions, and mud flaps, determined with doors and windows closed and the wheels in the straight-ahead position. Vehicle loading consisted of the driver plus equipment and instrumentation.

E. Throttle Controller

The POV was equipped with a programmable throttle controller which was used during the Straight Lane Converge and Diverge Test scenarios to modulate both speed and headway overlap between the SV and the POV. The throttle controller system consisted of the following components:

- Electronically controlled servo motor, mounted on an aluminum rail system and installed in the vehicle
- Real time computer (Arduino)

- Laptop computer, used to program and enable the throttle controller

F. Instrumentation

Table 4 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

Table 4. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +	2258	By: Oxford Technical Solutions Date: 5/3/2019 Due: 5/3/2021
				Oxford Inertial +	2182	Date: 9/16/2019 Due: 9/16/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA
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

Table 4. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
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
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi	< 1% error between 20 and 100 psi	Omega DPG8001	18111410000	By: DRI Date: 5/4/2020 Due: 5/4/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
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

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
Throttle Controller	Arduino based, servo actuated controller for managing POV speed	DRI developed	NA

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

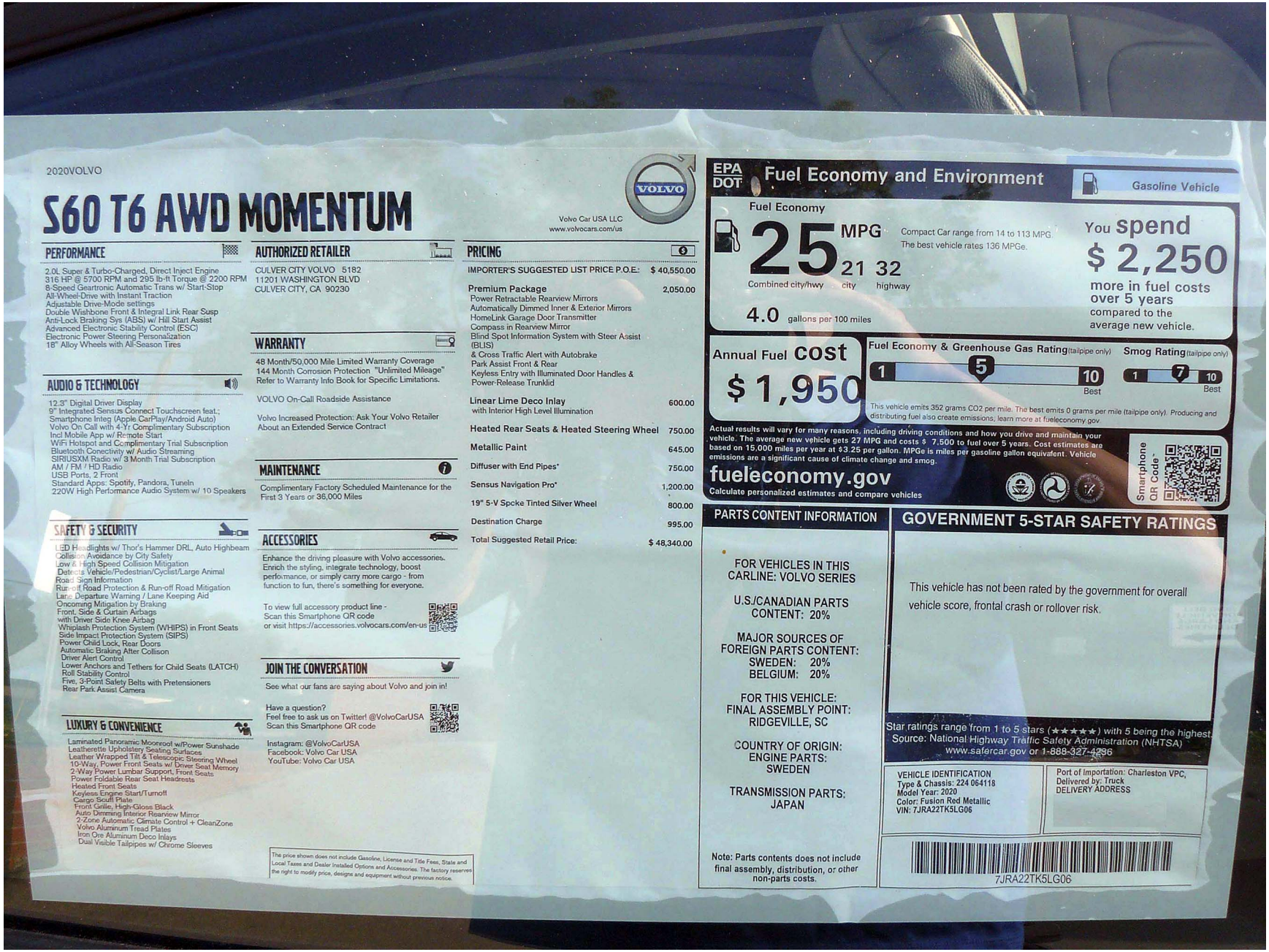


Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle

Figure A7. Rear View of Principal Other Vehicle

Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

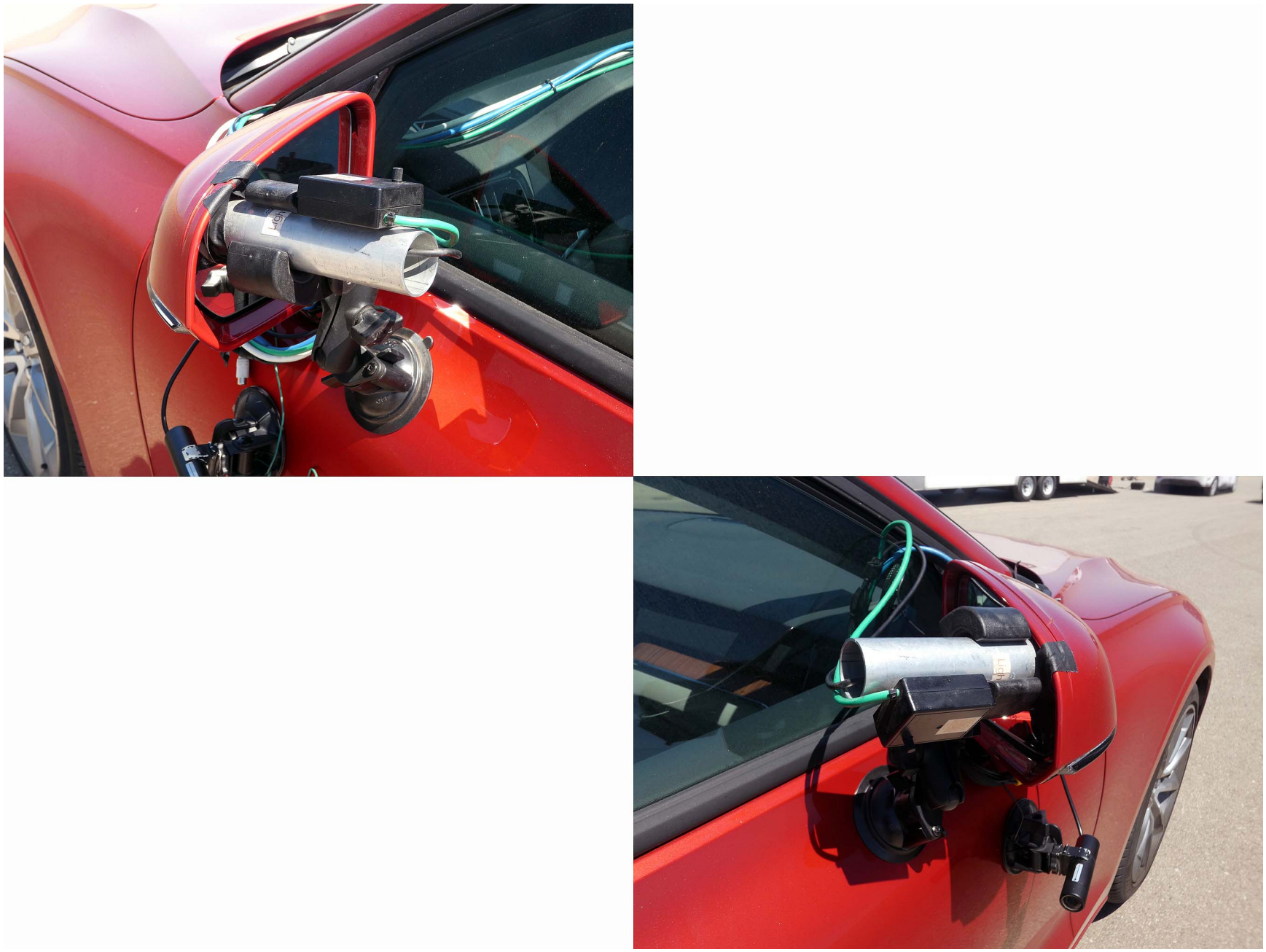


Figure A9. Sensors for Detecting Visual Alerts

Figure A10. Computer Installed in Subject Vehicle

Figure A11. System Setup Menu

Figure A12. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

NOTE

The warning with direction indicators for Rear Collision Warning* is deactivated if the collision warning distance in the City Safety function is set to the lowest level "**Late**".

The seat belt tensioning and braking functions remain active.

NOTE

The function uses the vehicle's camera and radar sensor, which has certain general limitations.

Related information

- Rear Collision Warning* (p. 320)
- Setting a warning distance for City Safety (p. 309)
- Camera/radar sensor limitations (p. 301)

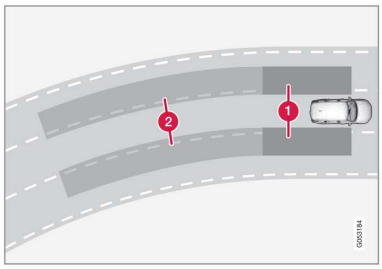
BLIS*

The BLIS[65] function is designed to help provide assistance in heavy traffic with several lanes moving in the same direction by helping the driver to detect the presence of vehicles in the "blind spot" area behind and to the side of the vehicle.

Location of BLIS indicator light.

BLIS is a driver support system designed to alert the driver of:

- vehicles in your "blind spot"
- vehicles approaching rapidly in adjacent lanes.



BLIS overview

1. Blind spot zone
2. Rapidly approaching vehicle zone.

The system is designed to react to:

- vehicles passing your vehicle
- vehicles that are rapidly approaching your vehicle from behind.

When BLIS detects a vehicle in zone 1 or a rapidly approaching vehicle in zone 2, an indicator light will illuminate in the relevant rear-view mirror and glow steadily. If the driver then uses the turn signal on the side in which the warning has been given, the indicator light will become brighter and begin flashing.

BLIS is active when your vehicle is traveling at a speed over 10 km/h (6 mph).

65 Blind Spot Information

If a passing vehicle's speed is more than 15 km/h (9 mph) faster than your vehicle, BLIS will not react.

NOTE

The light illuminates on the side of the vehicle where the system has detected the vehicle. If the vehicle is passed on both sides simultaneously, both lights come on.

WARNING

- The function is supplementary driver support intended to facilitate driving and help make it safer – it cannot handle all situations in all traffic, weather and road conditions.
- The driver is advised to read all sections in the Owner's Manual about this function to learn of its limitations, which the driver must be aware of before using the function.
- Driver support functions are not a substitute for the driver's attention and judgment. The driver is always responsible for ensuring the vehicle is driven in a safe manner, at the appropriate speed, with an appropriate distance to other vehicles, and in accordance with current traffic rules and regulations.

[66] Blind Spot Information

Related information

- Driver support systems (p. 260)
- Activating or deactivating BLIS (p. 322)
- BLIS limitations (p. 323)
- BLIS messages (p. 324)

Activating or deactivating BLIS

The BLIS[66] function can be activated or deactivated.

Activate or deactivate the function using this button in the center display's Function view.

- GREEN button indicator light – the function is activated.
- GRAY button indicator light – the function is deactivated.

If BLIS is activated when the engine is started, the indicator lights in the rearview mirrors will flash once.

If BLIS is deactivated when the engine is turned off, it will remain off the next time the engine is started and the indicator lights will not illuminate.

Related information

- BLIS* (p. 321)
- BLIS limitations (p. 323)

* Option/accessory.

BLIS limitations

BLIS[67] functionality may be reduced in certain situations.

Keep the marked area clean (on both the left and right sides of the vehicle)[68].

Examples of limitations:

- Dirt, ice and snow covering the sensors may reduce functionality and prevent the system from providing warnings.
- The BLIS function is automatically deactivated if a trailer, bicycle holder or similar is connected to the vehicle's electrical system.
- For BLIS to function effectively, bicycle holders, luggage racks or similar should not be mounted on the vehicle's towbar.

WARNING

- BLIS does not work in sharp curves.
- BLIS does not work when the vehicle is being reversed.

NOTE

The function uses the vehicle's camera and radar sensor, which has certain general limitations.

Related information

- BLIS* (p. 321)
- Camera/radar sensor limitations (p. 301)

[67] Blind Spot Information
[68] Note: This illustration is general and details may vary depending on model.

BLIS messages

A number of messages related to BLIS[69] may be displayed in the instrument panel. Several examples are provided below.

Message	Meaning
Blind spot sensor **Service required**	The system is not functioning as intended. Contact a workshop[A].
Blind spot system off **Trailer attached**	BLIS and CTA [B] have been deactivated because a trailer has been connected to the vehicle's electrical system.

[A] An authorized Volvo workshop is recommended.
[B] Cross Traffic Alert*

A text message can be erased by briefly pressing the ○ button in the center of the right-side steering wheel keypad.

If a message cannot be erased, contact a workshop[A].

Related information

- BLIS* (p. 321)
- Cross Traffic Alert* (p. 325)

[69] Blind Spot Information

APPENDIX C

Run Log

Subject Vehicle: **2020 Volvo S60 T6 AWD Momentum** Date: **7/29/2020**

Test Engineer: **S. Rhim**

Run	Test Type	BSD Side (L/R)	Valid Run?	BSD On (ft)	BSD Off (ft)	Acceptability Criteria met[1]			Notes
						BSD On	BSD Off	Overall	
1	Static								
2	**Converge/ Diverge**	**Left**	N						No warning
3			Y	2.0	1.8	Yes	Yes	Yes	
4			Y	1.7	1.6	Yes	Yes	Yes	
5			N						POV speed
6			N						Yaw rate
7			Y	1.7	1.9	Yes	Yes	Yes	
8			N						POV speed, lateral velocity
9			N						Lateral velocity
10			Y	1.5	2.1	Yes	Yes	Yes	
11			Y	2.3	1.1	Yes	Yes	Yes	
12			Y	2.3	1.6	Yes	Yes	Yes	
13			N						Lateral velocity
14			Y	1.9	2.0	Yes	Yes	Yes	

[1] The acceptability criteria listed herein are used only as a guide to gauge system performance, and are identical to the Pass/Fail criteria given in NHTSA's most current Test Procedure in docket NHTSA-2019-0102-0010, BLIND SPOT DETECTION SYSTEM CONFIRMATION TEST.

Run	Test Type	BSD Side (L/R)	Valid Run?	BSD On (ft)	BSD Off (ft)	Acceptability Criteria met[1]			Notes
						BSD On	BSD Off	Overall	
47	Converge/ Diverge	Right	N						Ran out of track
48			N						SV speed
49			Y	1.9	4.4	Yes	Yes	Yes	
50			Y	1.6	3.2	Yes	Yes	Yes	
51			Y	1.9	3.0	Yes	Yes	Yes	
52			N						Lateral velocity
53			Y	1.8	2.4	Yes	Yes	Yes	
54			N						Lateral velocity
55			Y	2.0	2.9	Yes	Yes	Yes	
56			Y	2.1	2.4	Yes	Yes	Yes	
57			N						Lateral velocity
58			Y	1.7	3.3	Yes	Yes	Yes	
15	Straight Lane 45/50	Left	N						Control desk error
16			N						Control desk error
17			N						POV speed, lateral distance
18			Y	14.7	18.0	Yes	Yes	Yes	
19			Y	15.7	19.5	Yes	Yes	Yes	
20			N						Yaw
21			Y	11.5	19.6	Yes	Yes	Yes	
22			Y	14.0	19.2	Yes	Yes	Yes	
23			Y	13.8	19.3	Yes	Yes	Yes	

Run	Test Type	BSD Side (L/R)	Valid Run?	BSD On (ft)	BSD Off (ft)	Acceptability Criteria met[1]			Notes
						BSD On	BSD Off	Overall	
24			Y	12.1	19.0	Yes	Yes	Yes	
59	**Straight Lane 45/50**	**Right**	N						SV speed, yaw
60			Y	15.5	19.8	Yes	Yes	Yes	
61			Y	15.5	20.3	Yes	Yes	Yes	
62			Y	15.5	20.9	Yes	Yes	Yes	
63			Y	16.2	20.1	Yes	Yes	Yes	
64			Y	14.9	19.9	Yes	Yes	Yes	
65			Y	15.7	19.8	Yes	Yes	Yes	
66			Y	15.6	20.0	Yes	Yes	Yes	
25	**Straight Lane 45/55**	**Left**	Y	16.5	23.9	Yes	Yes	Yes	
26			Y	15.6	23.4	Yes	Yes	Yes	
27			Y	17.4	24.1	Yes	Yes	Yes	
28			Y	14.8	23.2	Yes	Yes	Yes	
29			Y	15.3	23.7	Yes	Yes	Yes	
30			Y	18.5	23.8	Yes	Yes	Yes	
31			Y	15.4	23.8	Yes	Yes	Yes	
32			Y	16.1	23.9	Yes	Yes	Yes	

Run	Test Type	BSD Side (L/R)	Valid Run?	BSD On (ft)	BSD Off (ft)	Acceptability Criteria met[1]			Notes
						BSD On	BSD Off	Overall	
67	**Straight Lane 45/55**	**Right**	Y	17.3	24.9	Yes	Yes	Yes	
68			Y	15.1	25.1	Yes	Yes	Yes	
69			Y	16.4	25.8	Yes	Yes	Yes	
70			Y	16.6	25.4	Yes	Yes	Yes	
71			Y	15.9	25.1	Yes	Yes	Yes	
72			Y	15.2	25.1	Yes	Yes	Yes	
73			Y	14.6	25.0	Yes	Yes	Yes	
33	**Straight Lane 45/60**	**Left**	Y	25.1	29.0	Yes	Yes	Yes	
34			Y	22.4	29.6	Yes	Yes	Yes	
35			Y	24.2	28.6	Yes	Yes	Yes	
36			Y	24.4	28.6	Yes	Yes	Yes	
37			Y	23.8	28.0	Yes	Yes	Yes	
38			Y	22.5	28.7	Yes	Yes	Yes	
39			Y	23.7	28.8	Yes	Yes	Yes	
74	**Straight Lane 45/60**	**Right**	Y	25.3	29.3	Yes	Yes	Yes	
75			Y	23.9	30.1	Yes	Yes	Yes	
76			Y	24.0	30.0	Yes	Yes	Yes	
77			N						Lateral distance
78			N						POV speed
79			N						Lateral distance
80			Y	26.0	29.0	Yes	Yes	Yes	

Run	Test Type	BSD Side (L/R)	Valid Run?	BSD On (ft)	BSD Off (ft)	Acceptability Criteria met[1]			Notes
						BSD On	BSD Off	Overall	
81			Y	24.8	30.5	Yes	Yes	Yes	
82			Y	23.7	30.7	Yes	Yes	Yes	
83			Y	25.6	30.8	Yes	Yes	Yes	
40	**Straight Lane 45/65**	**Left**	Y	33.2	34.5	Yes	Yes	Yes	
41			Y	31.1	32.5	Yes	Yes	Yes	
42			Y	34.5	32.9	Yes	Yes	Yes	
43			Y	30.6	32.9	Yes	Yes	Yes	
44			Y	31.0	32.3	Yes	Yes	Yes	
45			Y	33.4	33.7	Yes	Yes	Yes	
46			Y	31.9	33.8	Yes	Yes	Yes	
84	**Straight Lane 45/65**	**Right**	Y	34.5	36.4	Yes	Yes	Yes	
85			Y	37.5	34.1	Yes	Yes	Yes	
86			Y	35.3	37.2	Yes	Yes	Yes	
87			N						POV speed
88			Y	33.3	35.1	Yes	Yes	Yes	
89			N						POV speed
90			Y	32.7	36.4	Yes	Yes	Yes	
91			Y	35.6	37.3	Yes	Yes	Yes	

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

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 Principal Other Vehicle (POV) with overlaid pass/fail and validity envelopes and thresholds.

Several of the plots include green envelopes (boxes) that are provided to verify test validity. For plots with green envelopes, the test is valid if the time-varying data is completely within the envelope boundaries.

Plots shown herein are grouped by test type and are presented sequentially within a given test type. Each time history plot consists of data relevant to the test type under consideration, and therefore the data channels plotted vary according to test type. The test types (shown in the plot titles) include:

- Straight Lane Converge/Diverge
- Straight Lane Pass-by (SV at 45 mph, POV at 50 mph)
- Straight Lane Pass-by (SV at 45 mph, POV at 55 mph)
- Straight Lane Pass-by (SV at 45 mph, POV at 60 mph)
- Straight Lane Pass-by (SV at 45 mph, POV at 65 mph)

Sub-plots

Time history figures include the following sub-plots:

- BSD Warning – displays the Blind Spot Detection alert (which can be audible, visual, or haptic). Depending on the type of BSD alert or instrumentation used to measure the alert, this can be any of the following:

    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (i.e., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Normalized light sensor signal. The vertical scale is 0 to 1.

    The magenta envelopes indicate pass/fail criteria. For a test to meet the BSD-on criterion, the trace must be greater than a threshold of 0.5 and completely within the first envelope. The envelope begins 300 ms after the POV enters the SV Blind Zone and ends when the POV is no longer in the SV Blind Zone for

Converge/Diverge tests and when the front-most part of the POV is in front of line A[1] for Straight Lane Pass-by test.

For a test to meet the BSD-off criterion, the trace must be less than a threshold of 0.5 and completely within the second envelope. The envelope begins when the lateral distance between the POV and SV is greater than 6 m (19.7 ft) for Converge/Diverge Tests and when the longitudinal distance between the rear-most part of the POV and the front-most part of the SV exceeds the BSD termination headway specified in Table 4 of the test procedure. The envelope ends at the end of the test.

The bold black vertical lines indicate BSD-on and BSD-off. The value shown for BSD-on represents the distance[2] between the POV and 300 ms into SV's Blind Zone. A negative value means the BSD warning activated after 300 ms of the POV entering the SV's blind zone and the warning was late. The value shown for BSD-off for Converge/Diverge tests represents the lateral distance between the POV and SV relative to the 6 m (19.7 ft) BSD-off requirement. The value shown for BSD-off for Pass-by tests represents the longitudinal distance between the POV and SV relative to the BSD termination headway for a given test speed. A negative value means the BSD warning deactivated after the lateral distance between the POV and SV was greater than 6 m (19.7 ft) for Converge/Diverge tests or the longitudinal distance between the POV and SB was greater than the BSD termination headway for Pass-by tests and the warning was late.

- Headway (ft) – for Converge/Diverge tests, this is the longitudinal distance from the front of the POV to the rear of the SV. A negative value for headway indicates that the front of the POV is forward relative to the rear of the SV. For Straight Lane Pass-by tests, two headway traces are shown. The distance from the front of the POV to the rear of the SV is shown in *black* and the distance from the front of the SV to the rear of the POV is shown in *green*. Additionally, there are colored markers with values to indicate critical events.
    - Yellow Marker – BSD warning activates
    - Black Marker – POV enters the SV Blind Zone
    - Cyan Marker – 300 ms after the POV enters the SV Blind Zone
    - Red Marker – POV exits the SV Blind Zone
    - Green Marker – BSD warning deactivates
    - Blue Marker – BSD termination headway

[1] Line A is defined as the line that connects the rearmost part of the SV side mirror housings and runs perpendicular to the SV's longitudinal centerline
[2] Lateral distance for Converge and Diverge Scenarios and longitudinal distance for Pass-by Scenarios

- SV Speed (mph) – speed of the SV.
- POV Speed (mph) – speed of the POV.
- Yaw Rate (deg/sec) – yaw rate of the SV and POV. Overlapping validity envelopes are shown for the Converge/Diverge tests. The darker green indicates the validity envelope for the POV.
- Lateral Distance (ft) – lateral distance from the widest point (not including side mirrors) on the side of the SV to the widest point (not including side mirrors) on the side of the POV.
- Lateral Velocity (ft/s) – lateral velocity of the POV for Converge/Diverge tests only. Bold vertical black lines are provided to indicate the allowable lateral velocity range. A green dot indicates a valid value.

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
2. Pass/Fail envelopes, validation envelopes and thresholds
3. Individual data points
4. Text

1. Time-varying data color codes:
   - Blue = Subject Vehicle data
   - Magenta = Principal Other Vehicle data
   - Brown = Relative data between SV and POV (i.e., TTC, lateral distance and headway distance)

2. Pass/Fail envelopes, validation envelopes and threshold color codes:
   - Magenta envelope = time varying data must be within the envelope at all times for a passing run
   - Green envelope = time varying data must be within the envelope at all times in order to be valid

- Black threshold (Solid) = time varying data must cross this threshold in the time period shown in order to be valid

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

- No Wng – No warning was detected.
- On Late – Indicates that the BSD warning activated after the allowable criteria.
- Off Early – Indicates that the BSD warning deactivated before the allowable criteria.
- Off Late – Indicates that the BSD warning deactivated after the allowable criteria.
- POV – Indicates that the value for the Principal Other Vehicle was out of bounds.
- SV – Indicates that the value for the Subject Vehicle was out of bounds.

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 the Straight Lane Converge/Diverge and Straight Lane Pass-by are shown in Figures D1 through D4. These show examples of passing and failing runs for both test types. Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure D5.

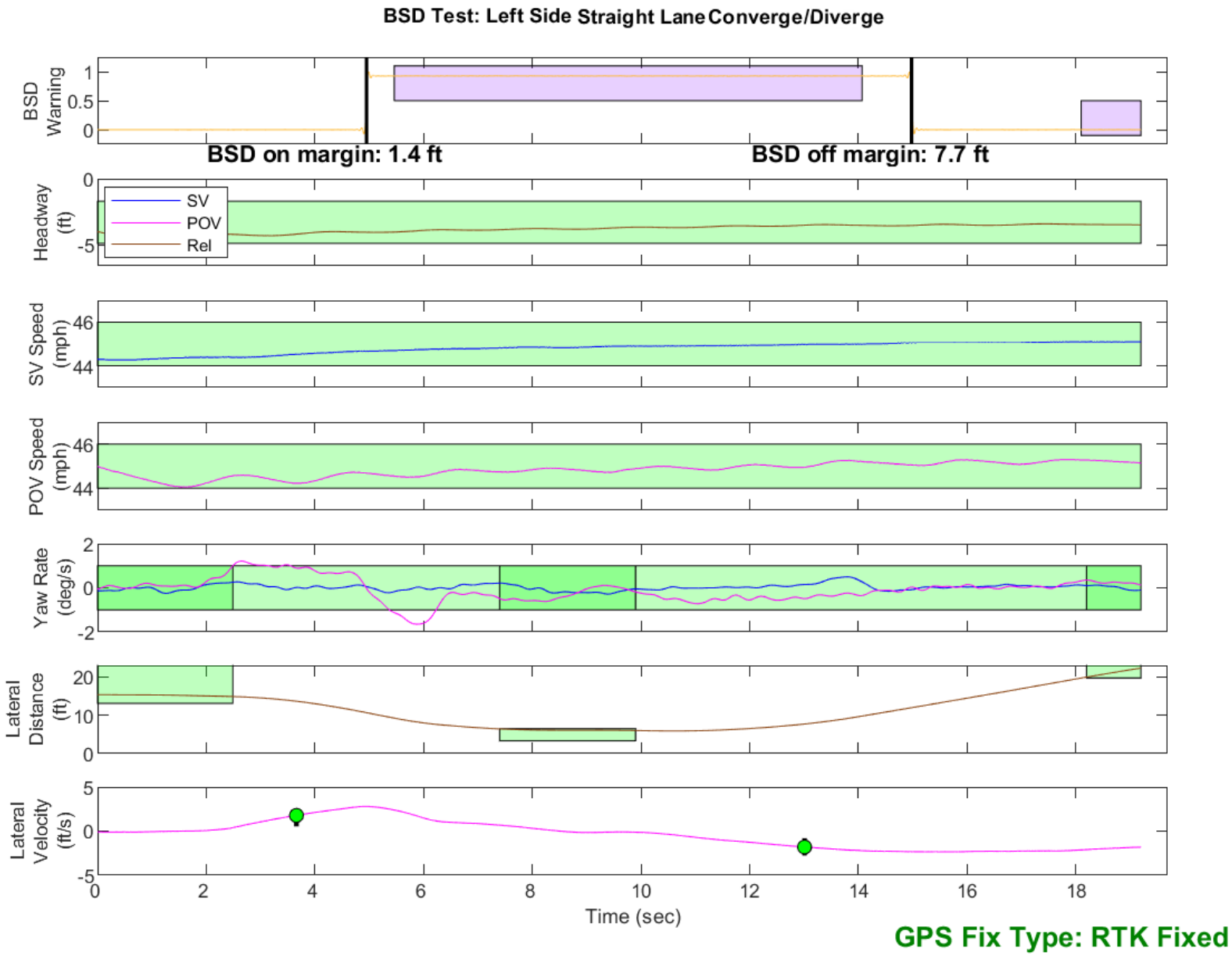


Figure D1. Example Time History for Straight Lane Converge/Diverge Test, Passing

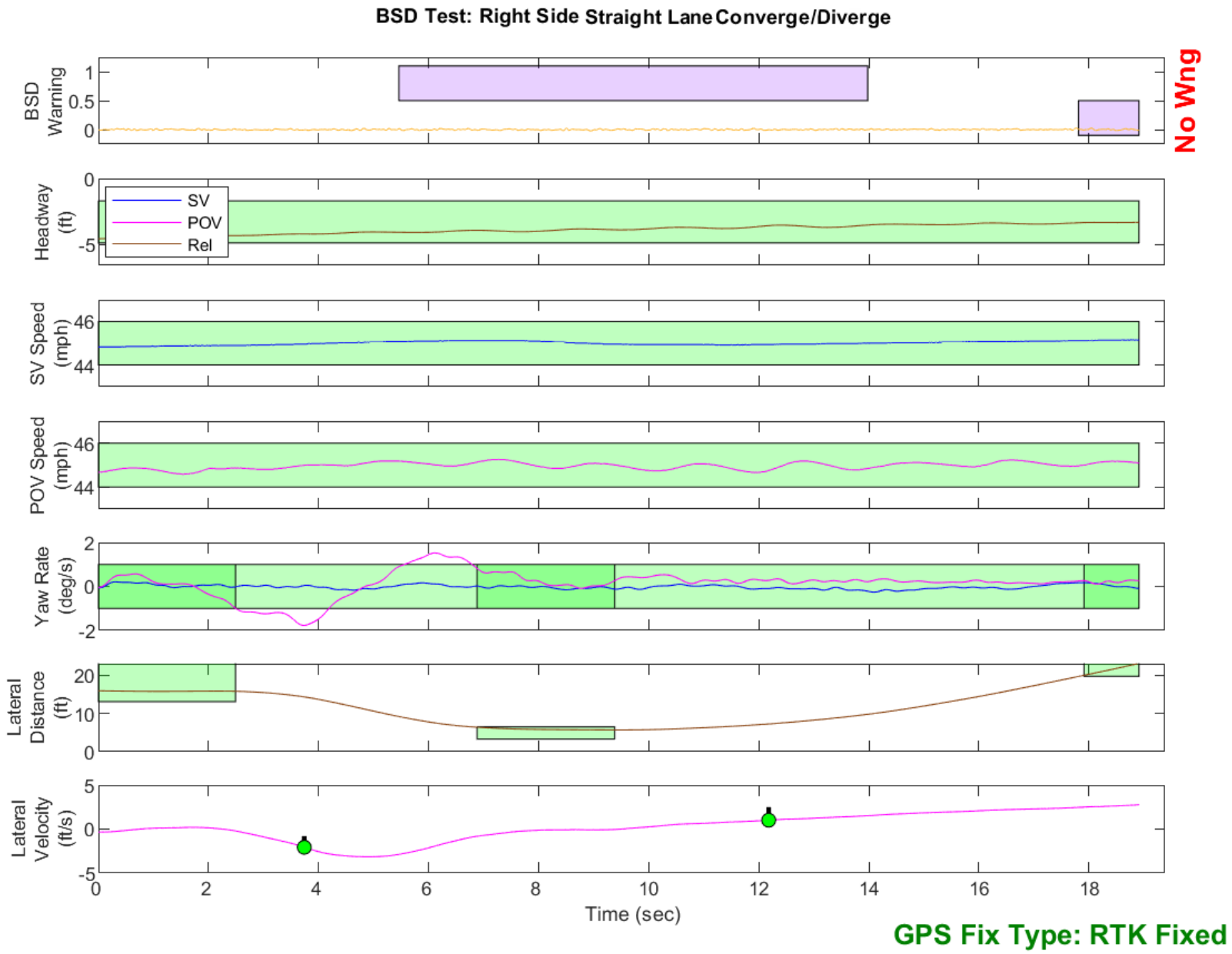


Figure D2. Example Time History for Straight Lane Converge/Diverge Test, Failing

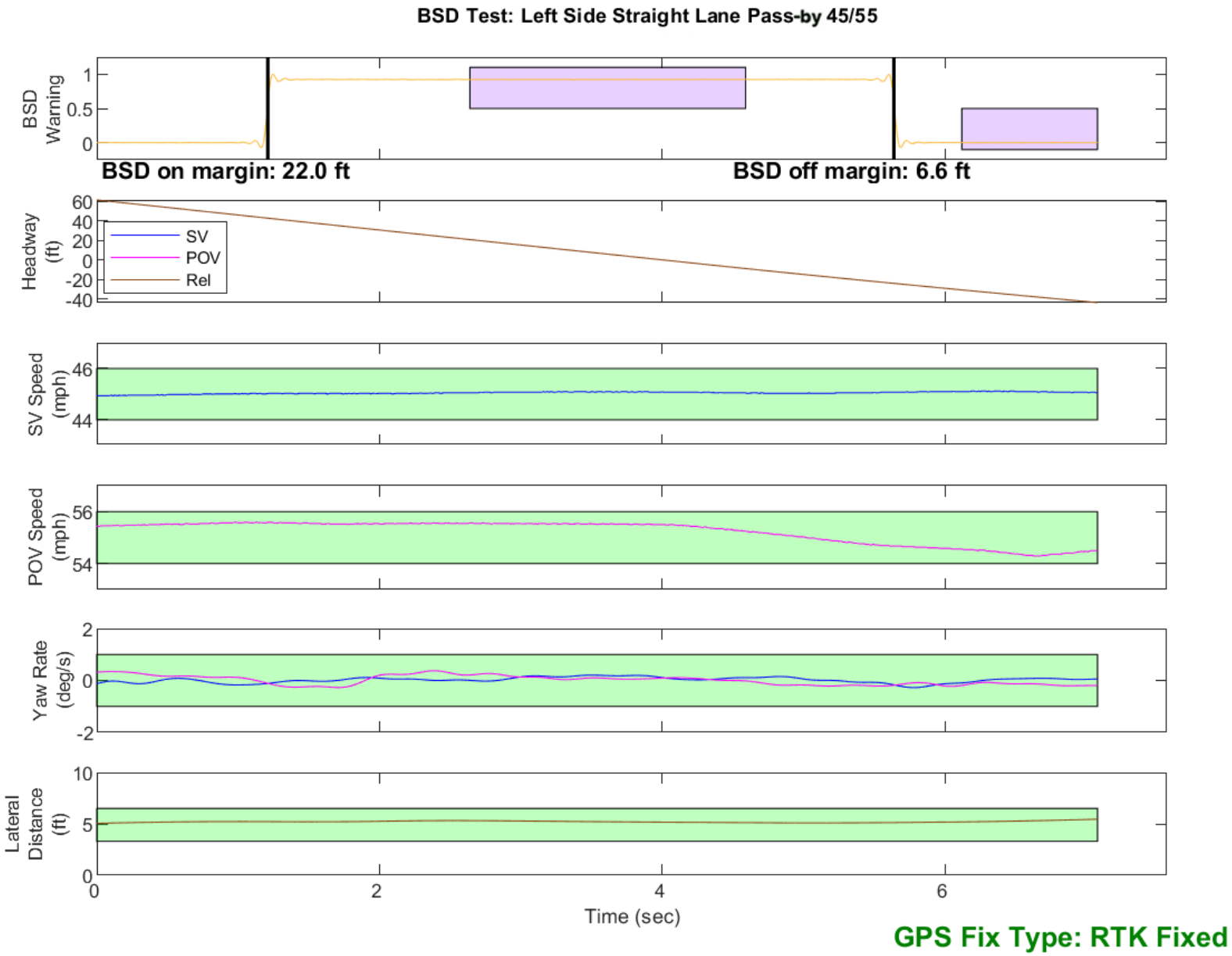


Figure D3. Example Time History for Straight Lane Pass-By Passing

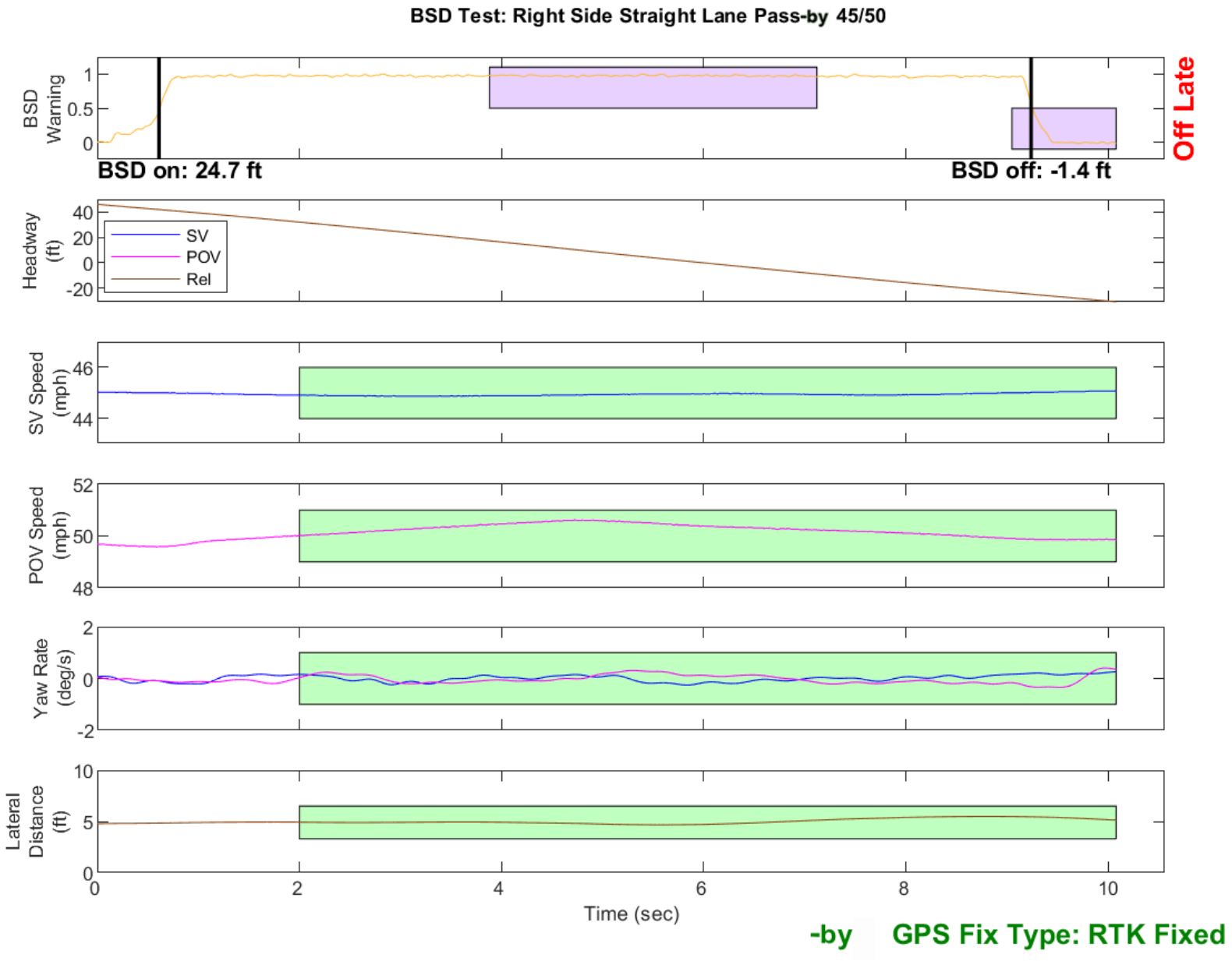


Figure D4. Example Time History for Straight Lane Pass-by Test, Failing

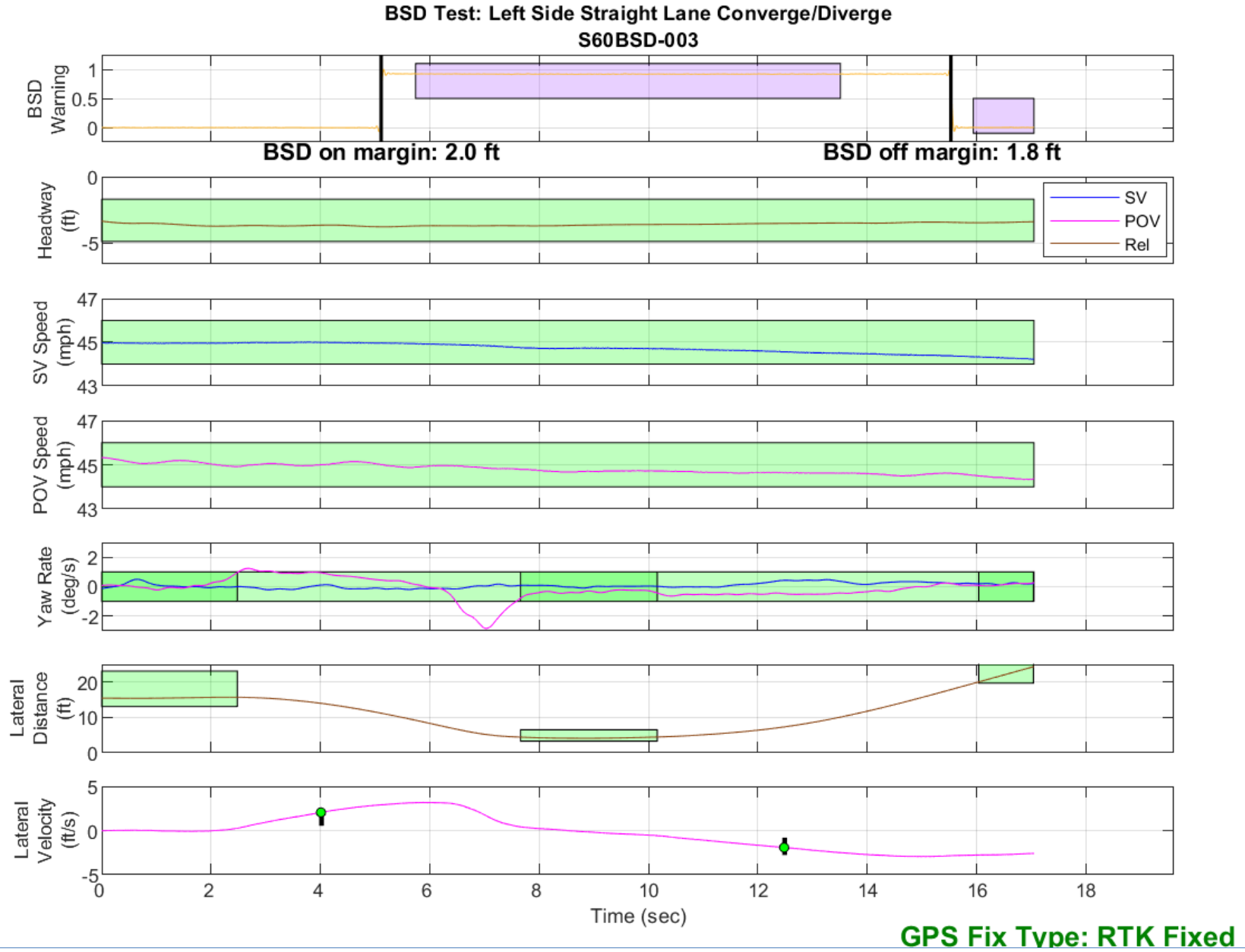


Figure D5. BSD Run 3, Straight Lane Converge/Diverge

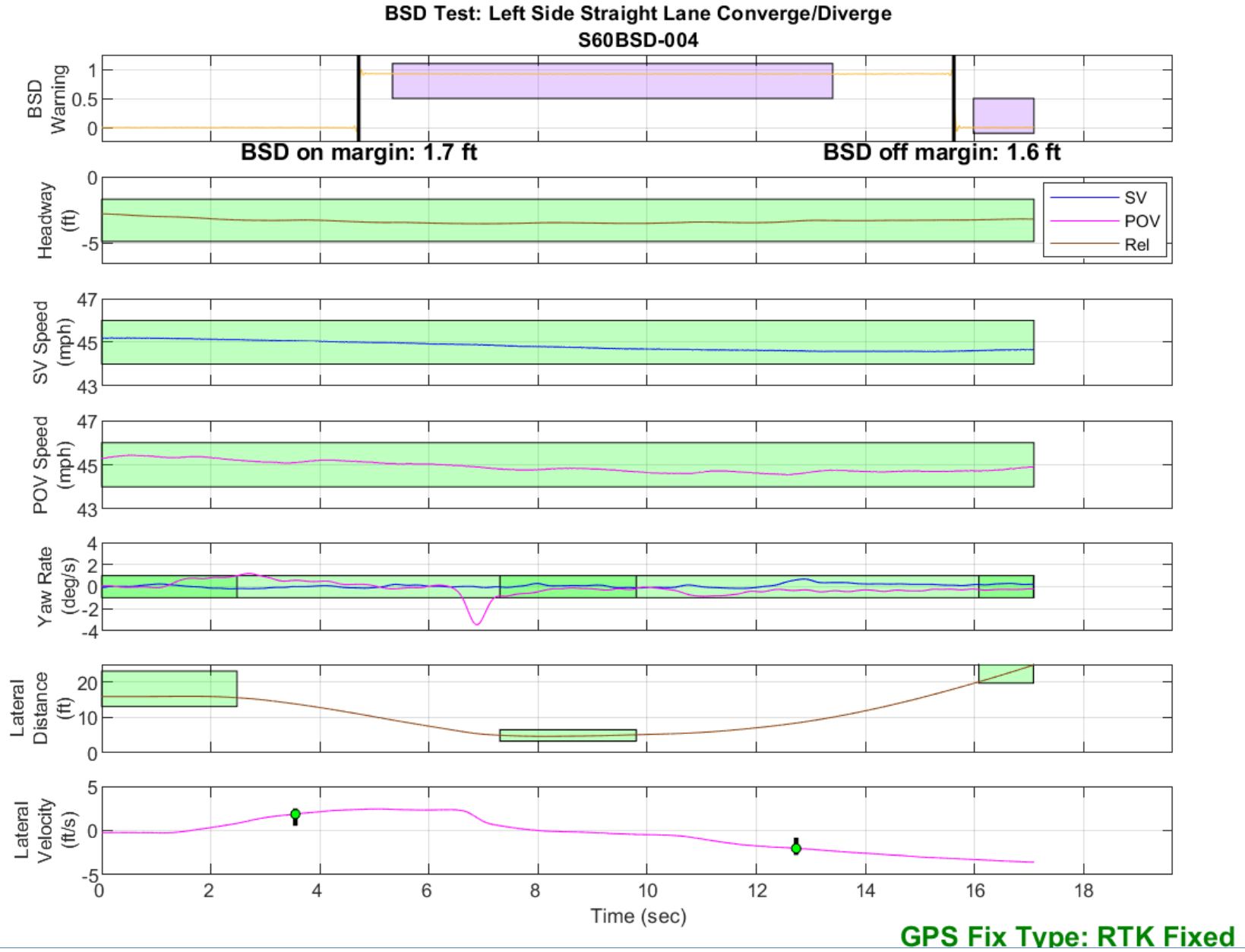


Figure D6. BSD Run 4, Straight Lane Converge/Diverge

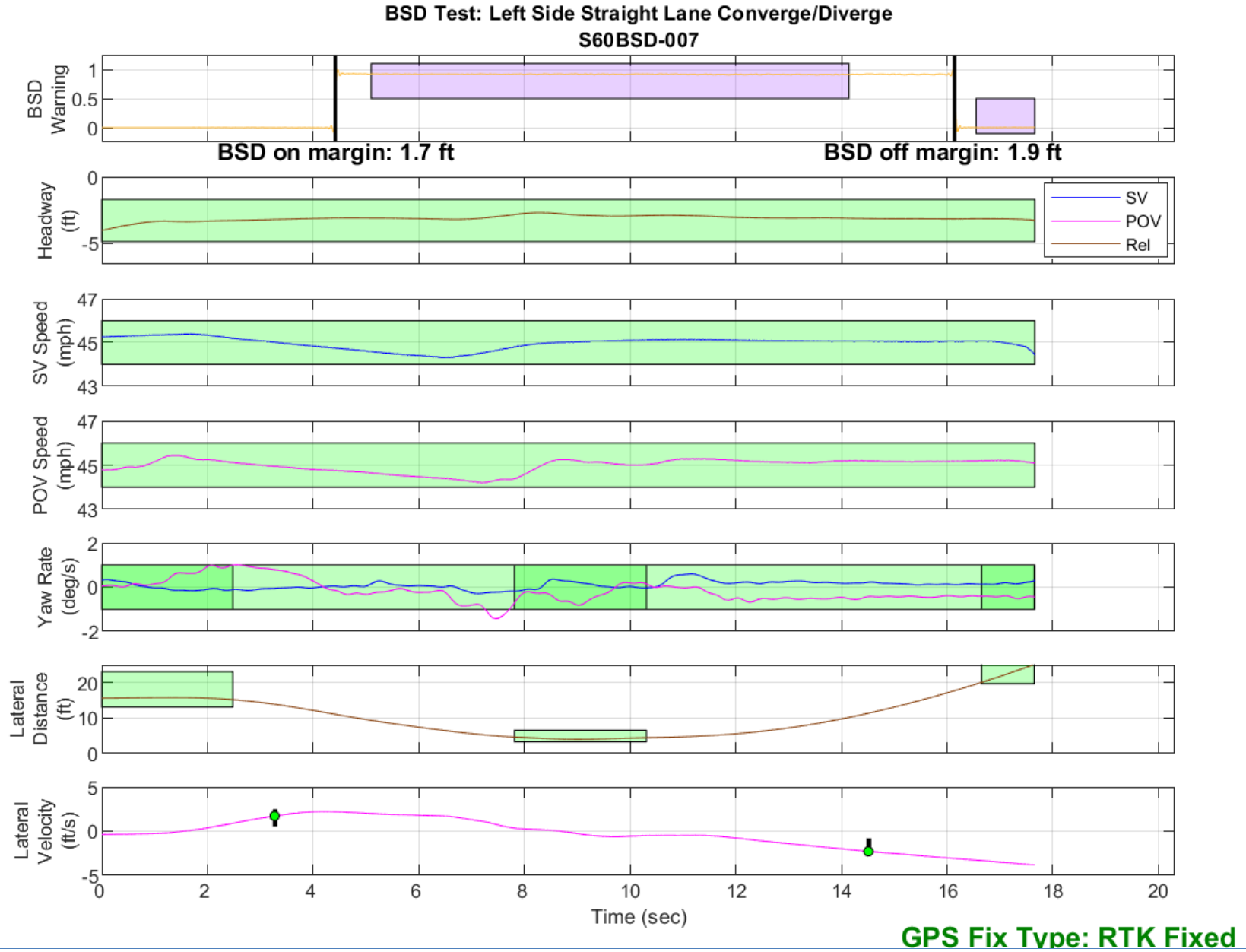


Figure D7. BSD Run 7, Straight Lane Converge/Diverge

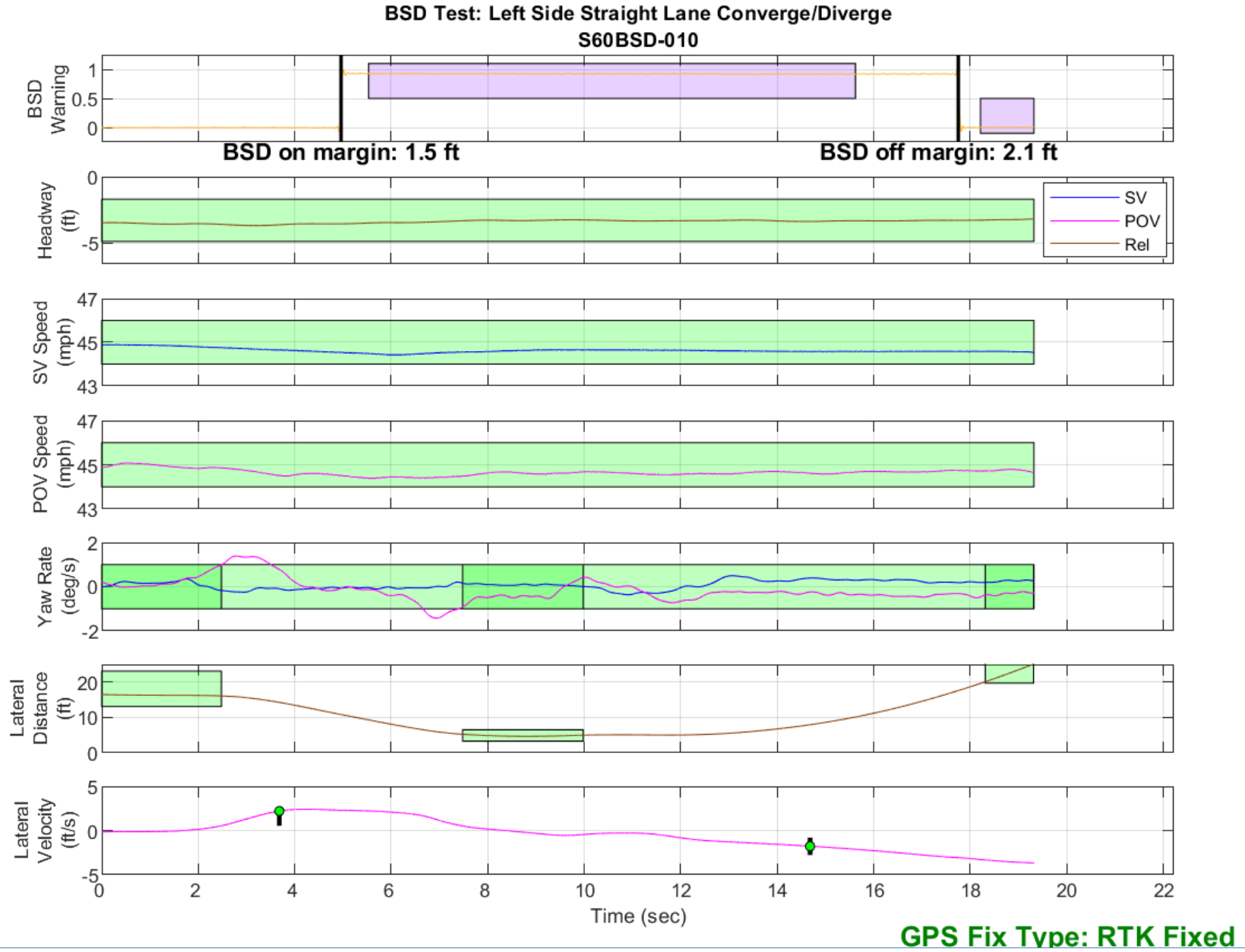


Figure D8. BSD Run 10, Straight Lane Converge/Diverge

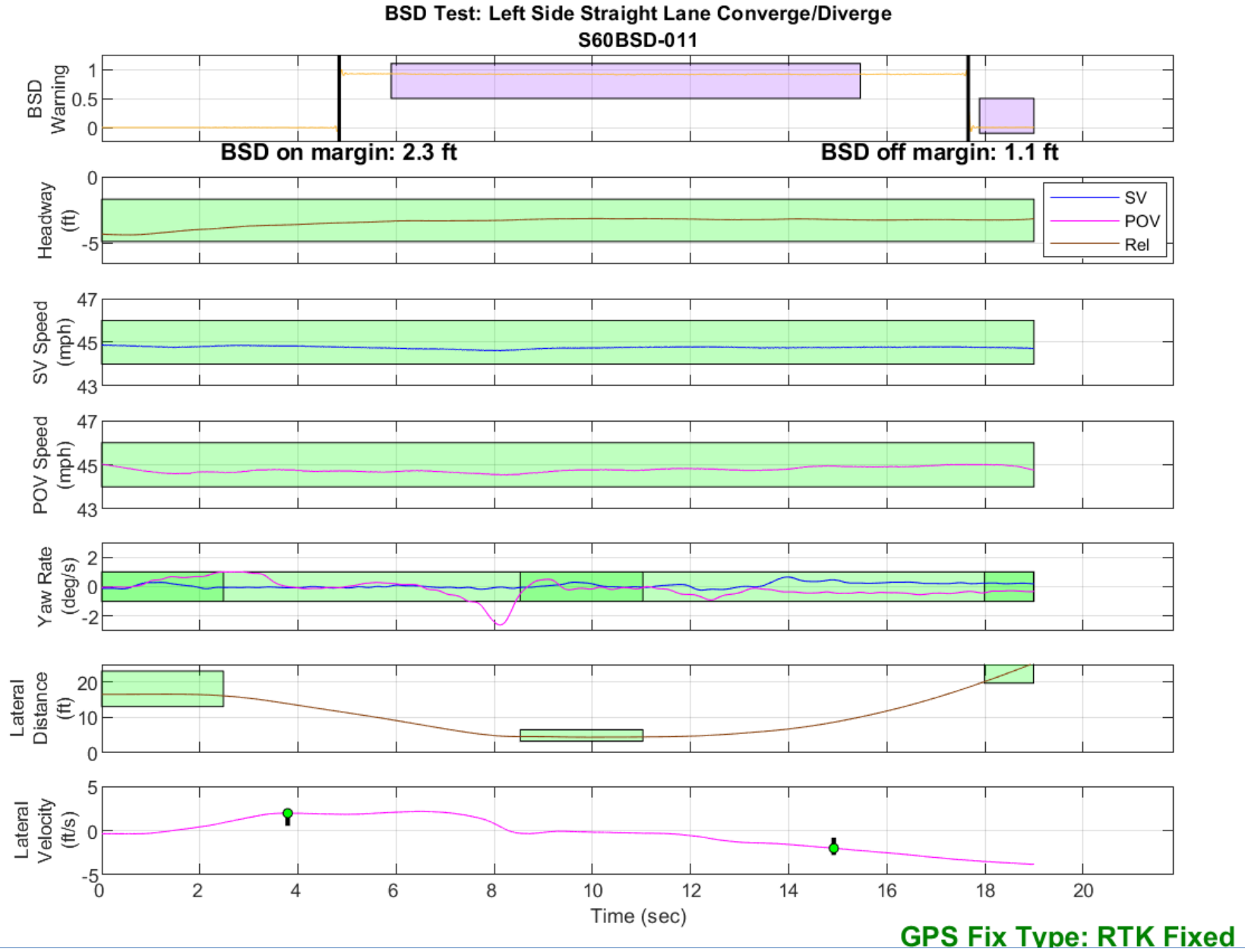


Figure D9. BSD Run 11, Straight Lane Converge/Diverge

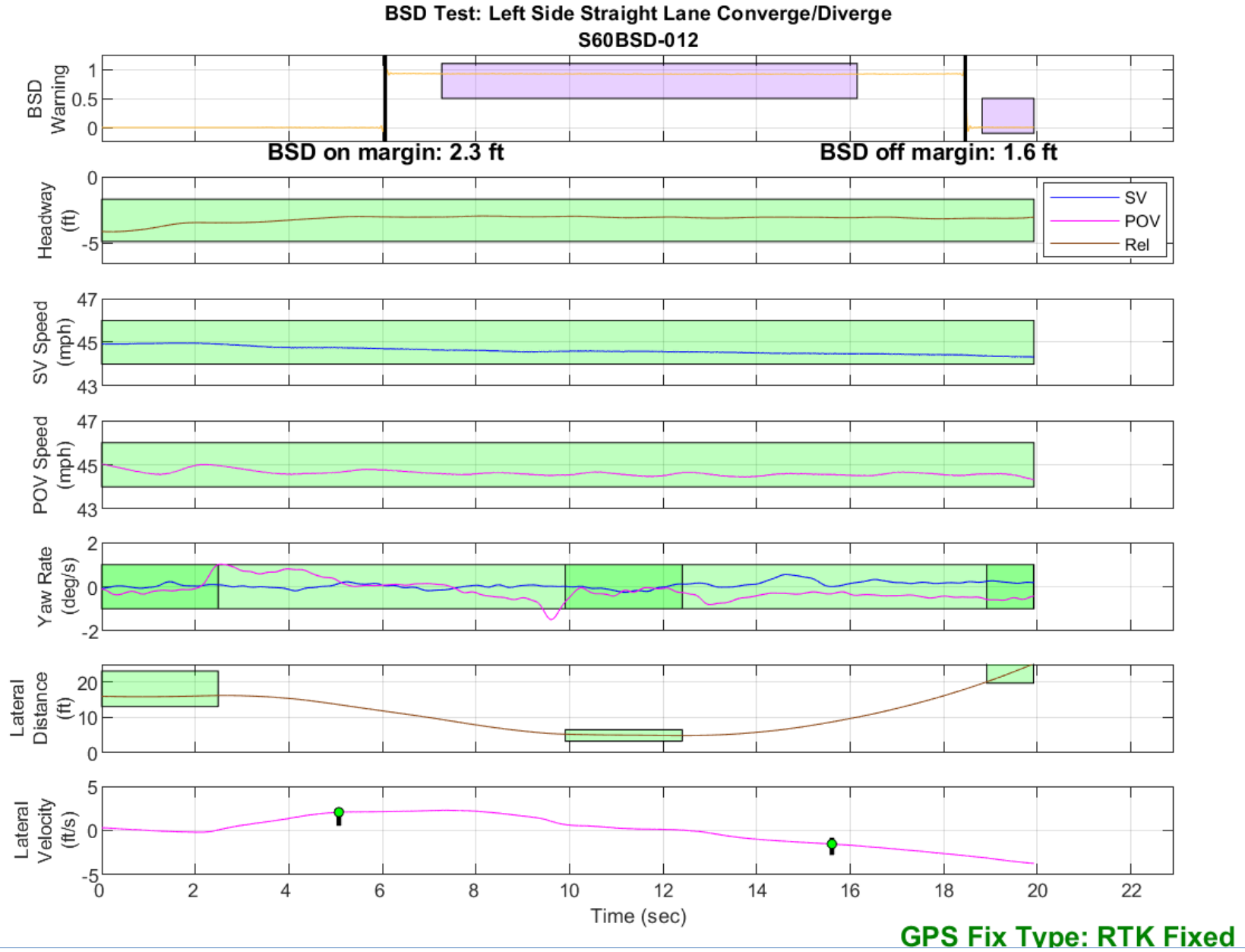


Figure D10. BSD Run 12, Straight Lane Converge/Diverge

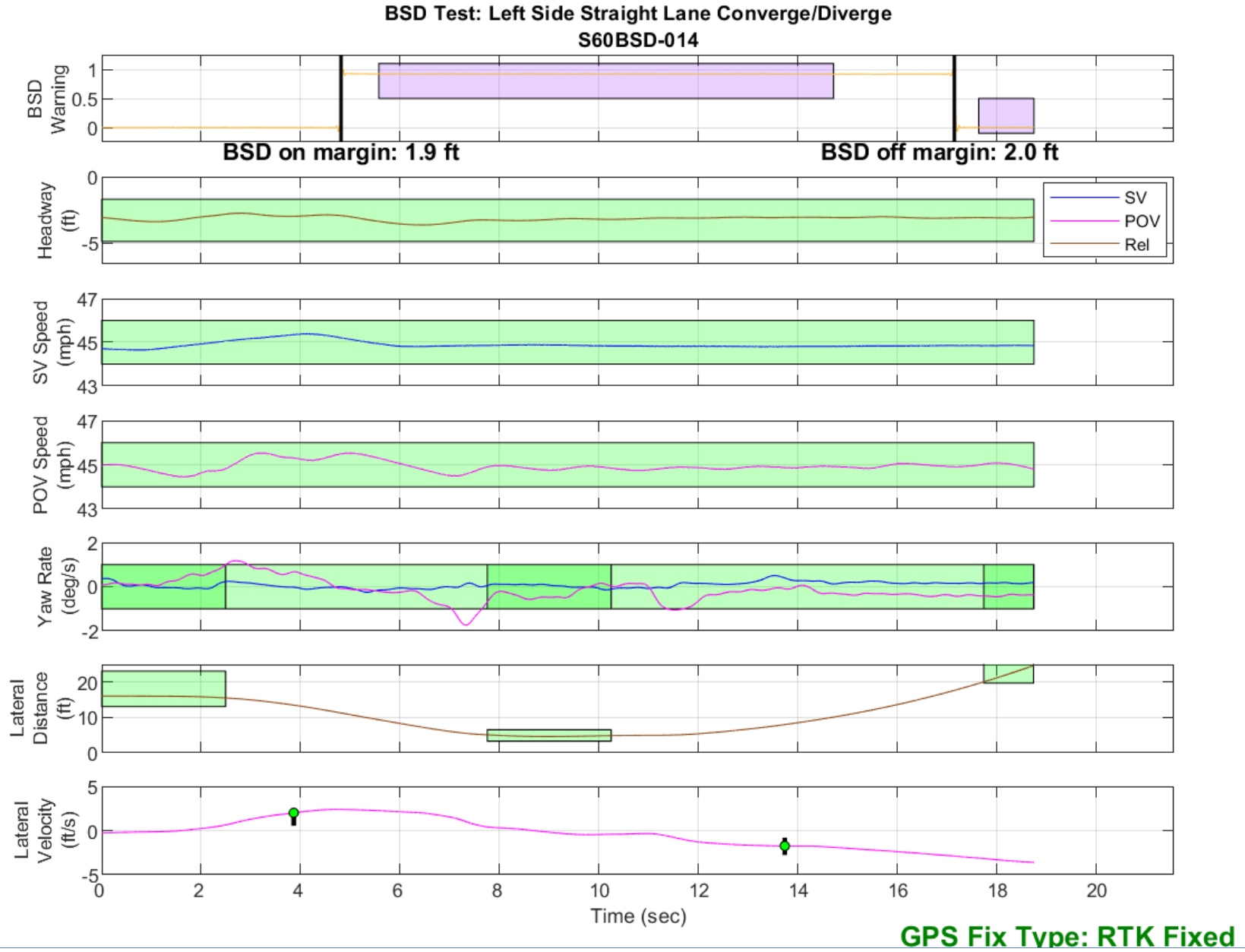


Figure D11. BSD Run 14, Straight Lane Converge/Diverge

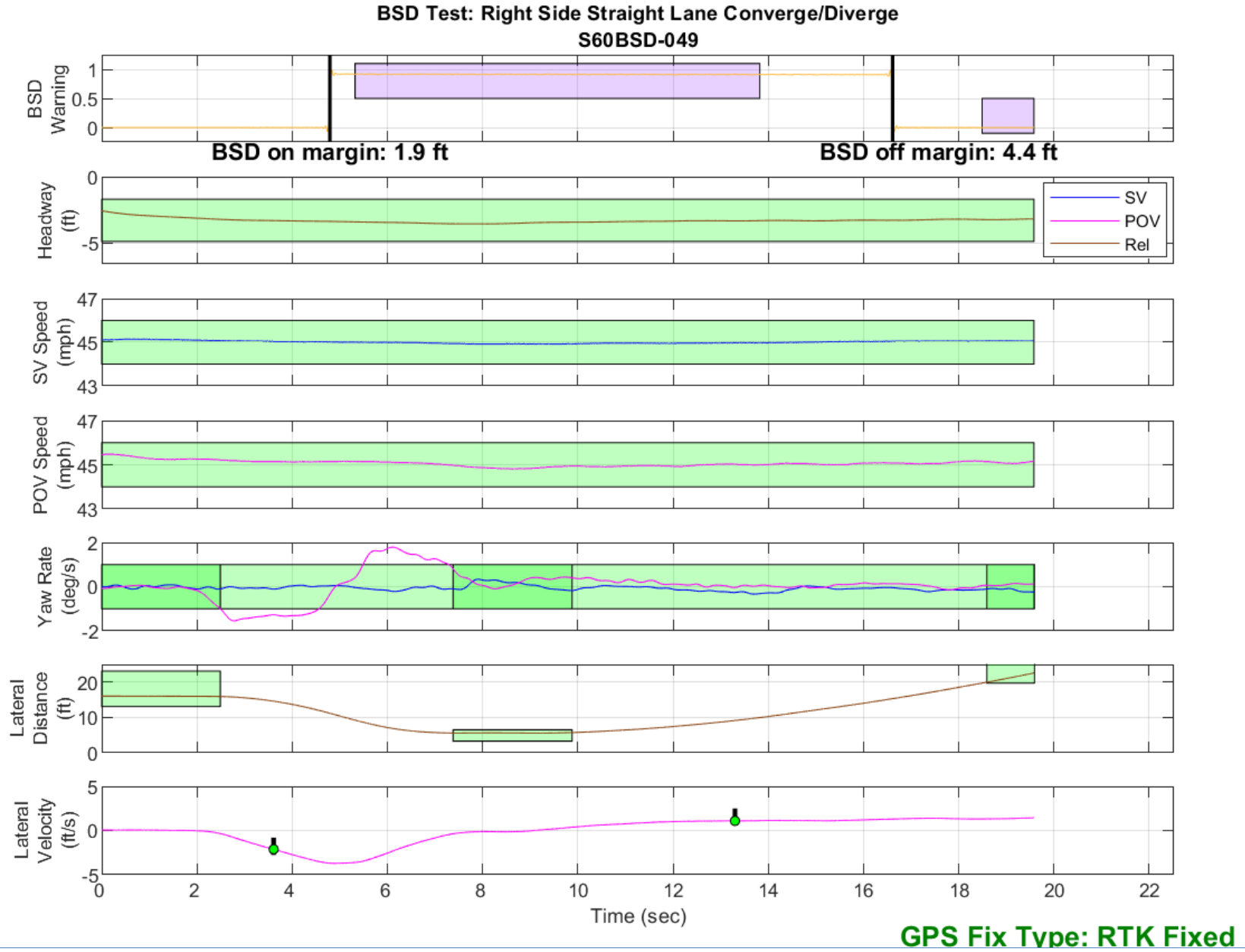


Figure D12. BSD Run 49, Straight Lane Converge/Diverge

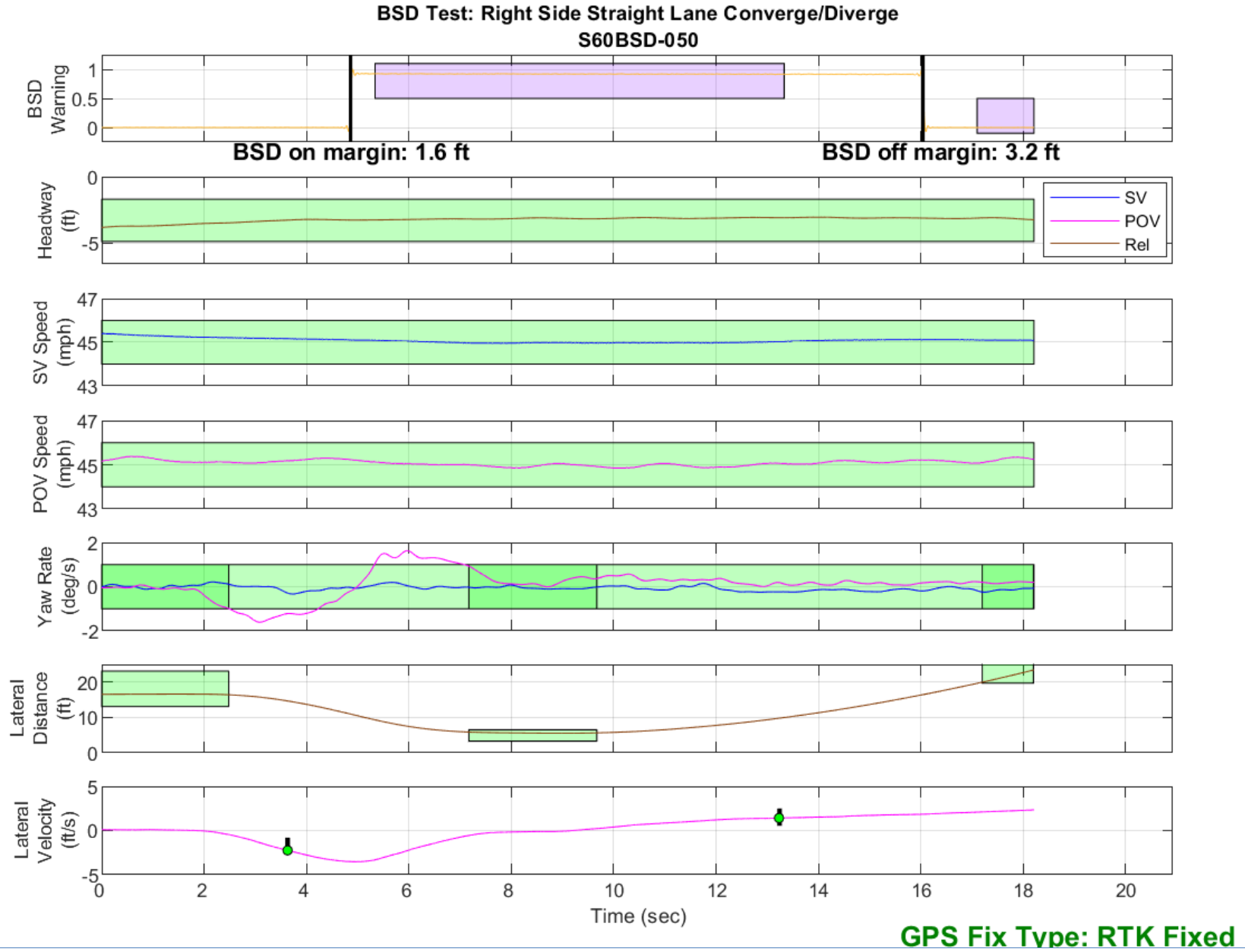


Figure D13. BSD Run 50, Straight Lane Converge/Diverge

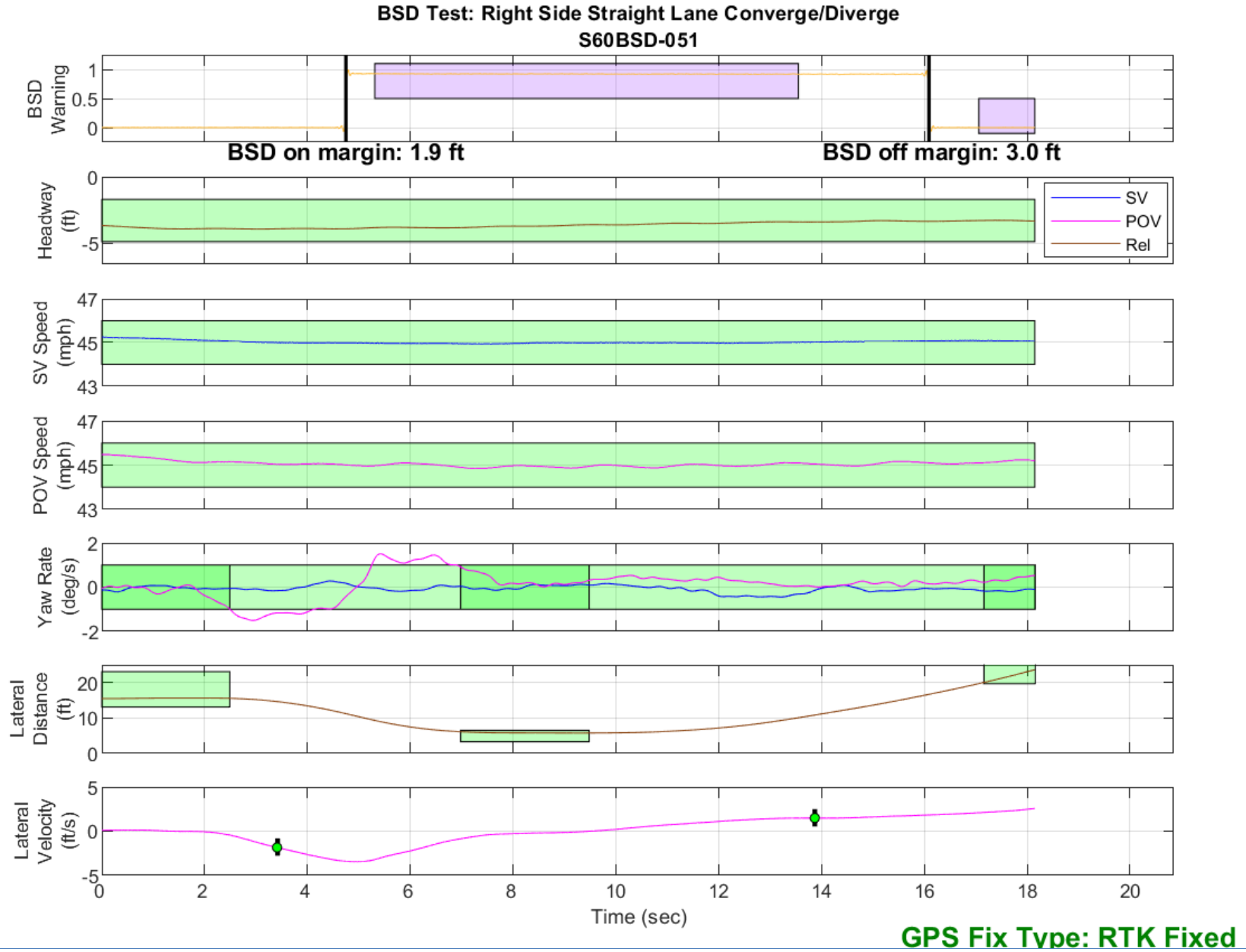


Figure D14. BSD Run 51, Straight Lane Converge/Diverge

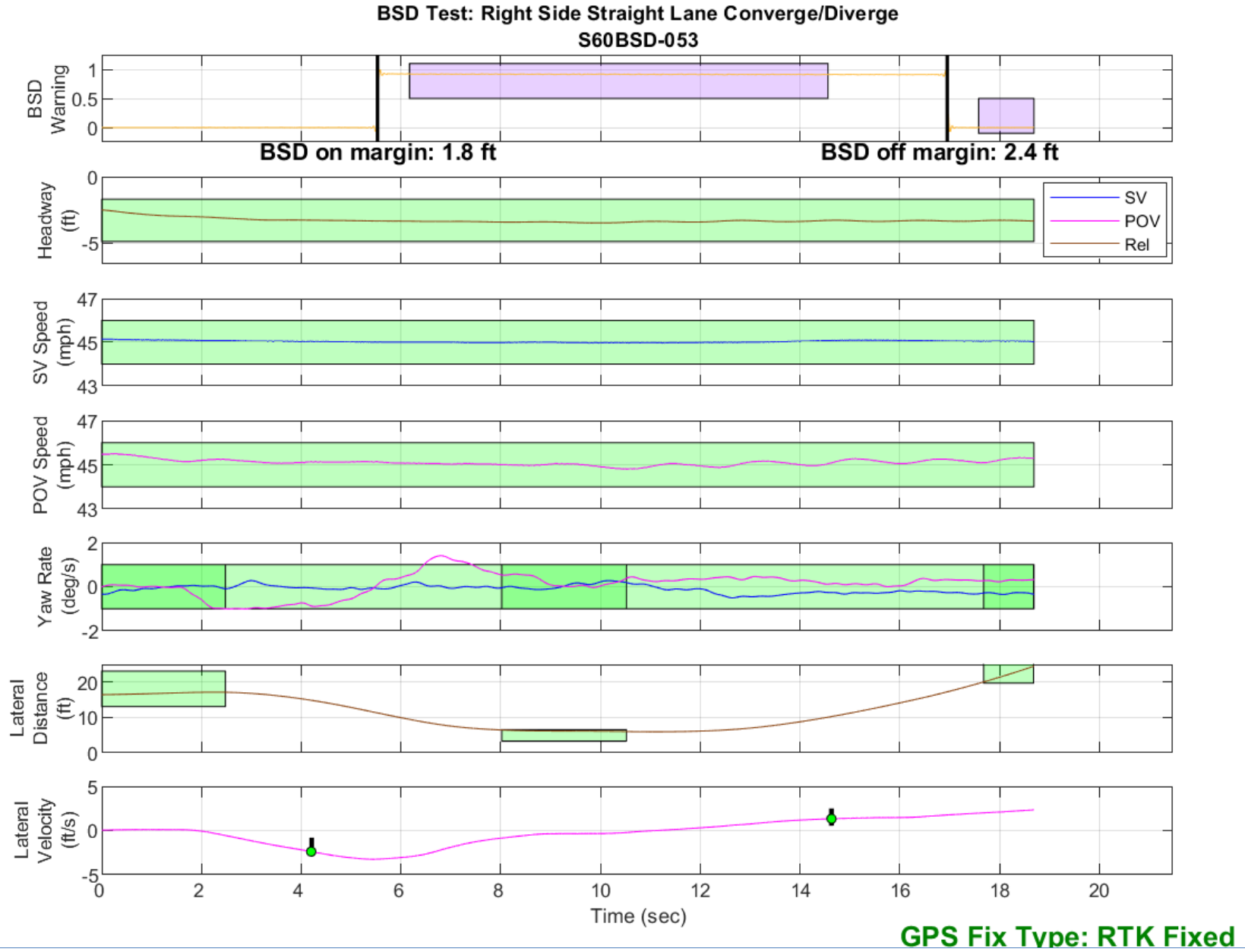


Figure D15. BSD Run 53, Straight Lane Converge/Diverge

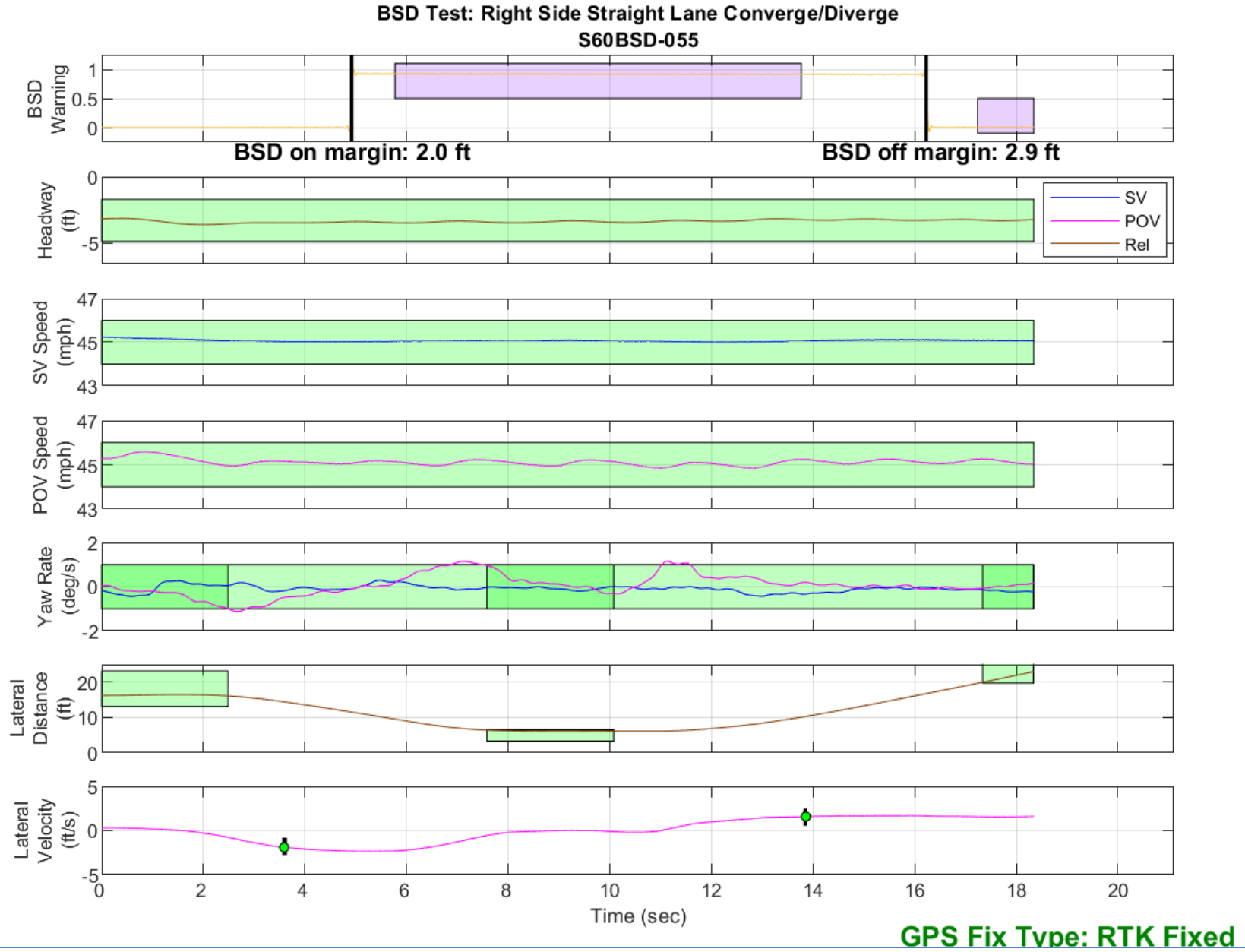


Figure D16. BSD Run 55, Straight Lane Converge/Diverge

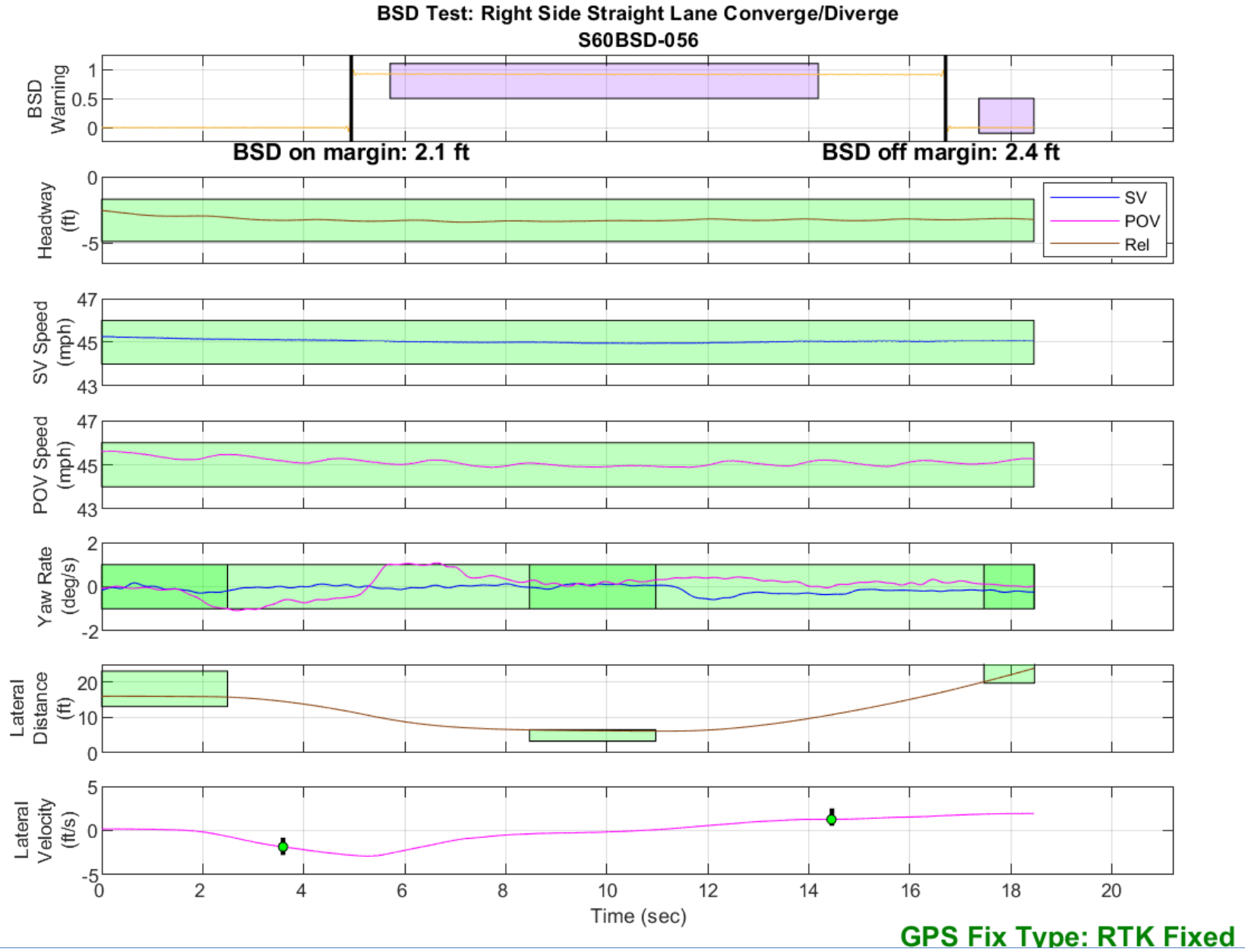


Figure D17. BSD Run 56, Straight Lane Converge/Diverge

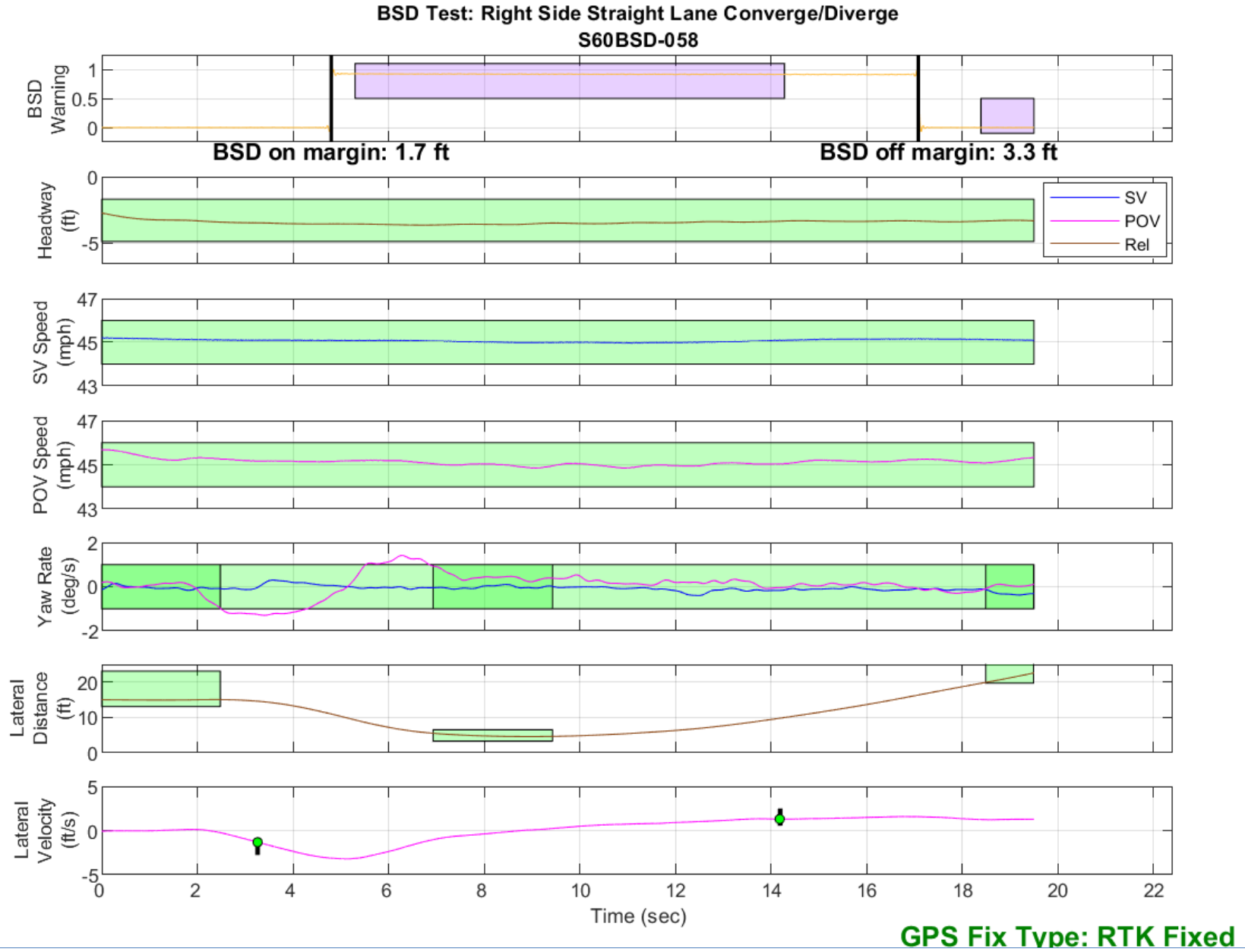


Figure D18. BSD Run 58, Straight Lane Converge/Diverge

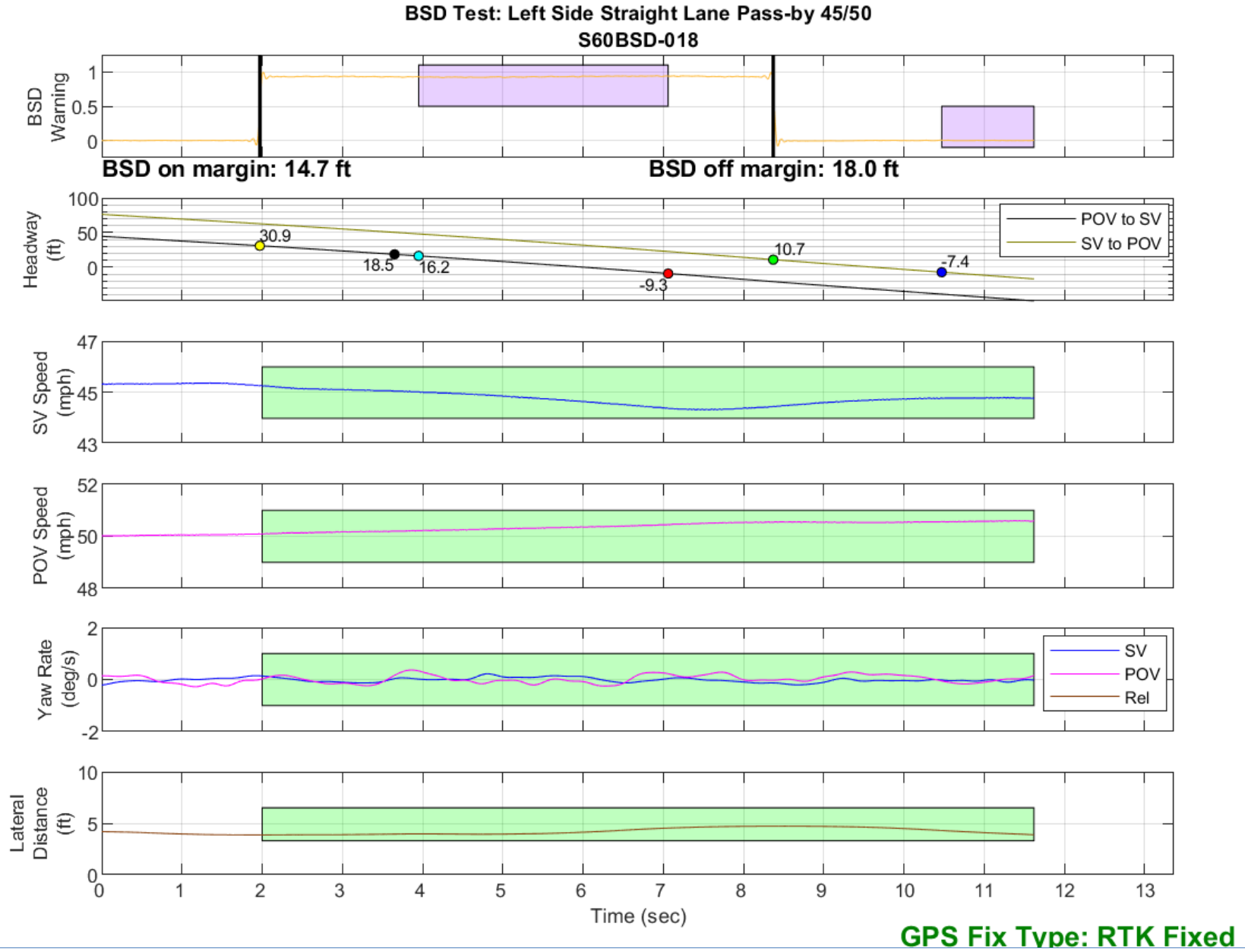


Figure D19. BSD Run 18, Straight Lane Pass-by, SV 45 mph, POV 50 mph

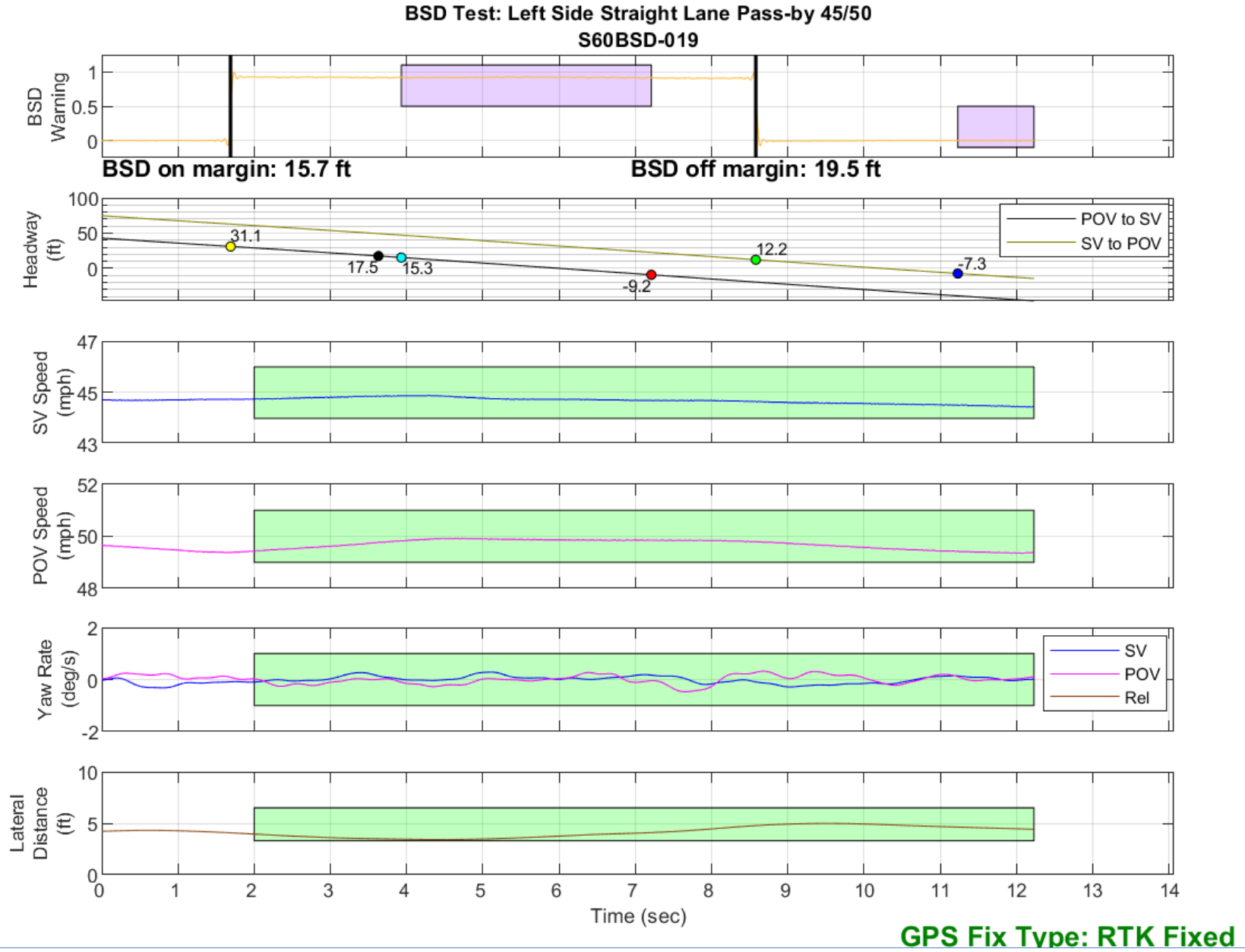


Figure D20. BSD Run 19, Straight Lane Pass-by, SV 45 mph, POV 50 mph

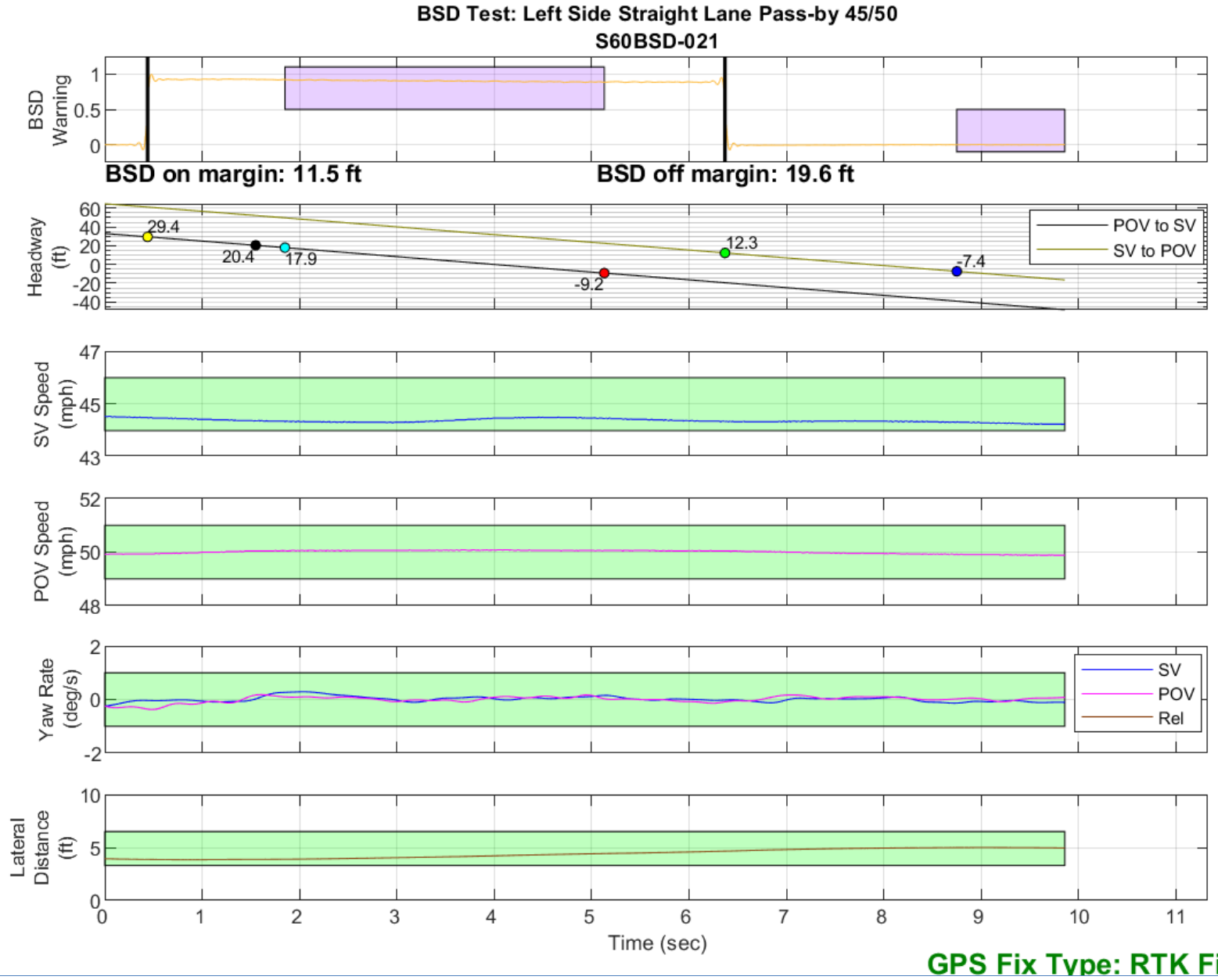


Figure D21. BSD Run 21, Straight Lane Pass-by, SV 45 mph, POV 50 mph

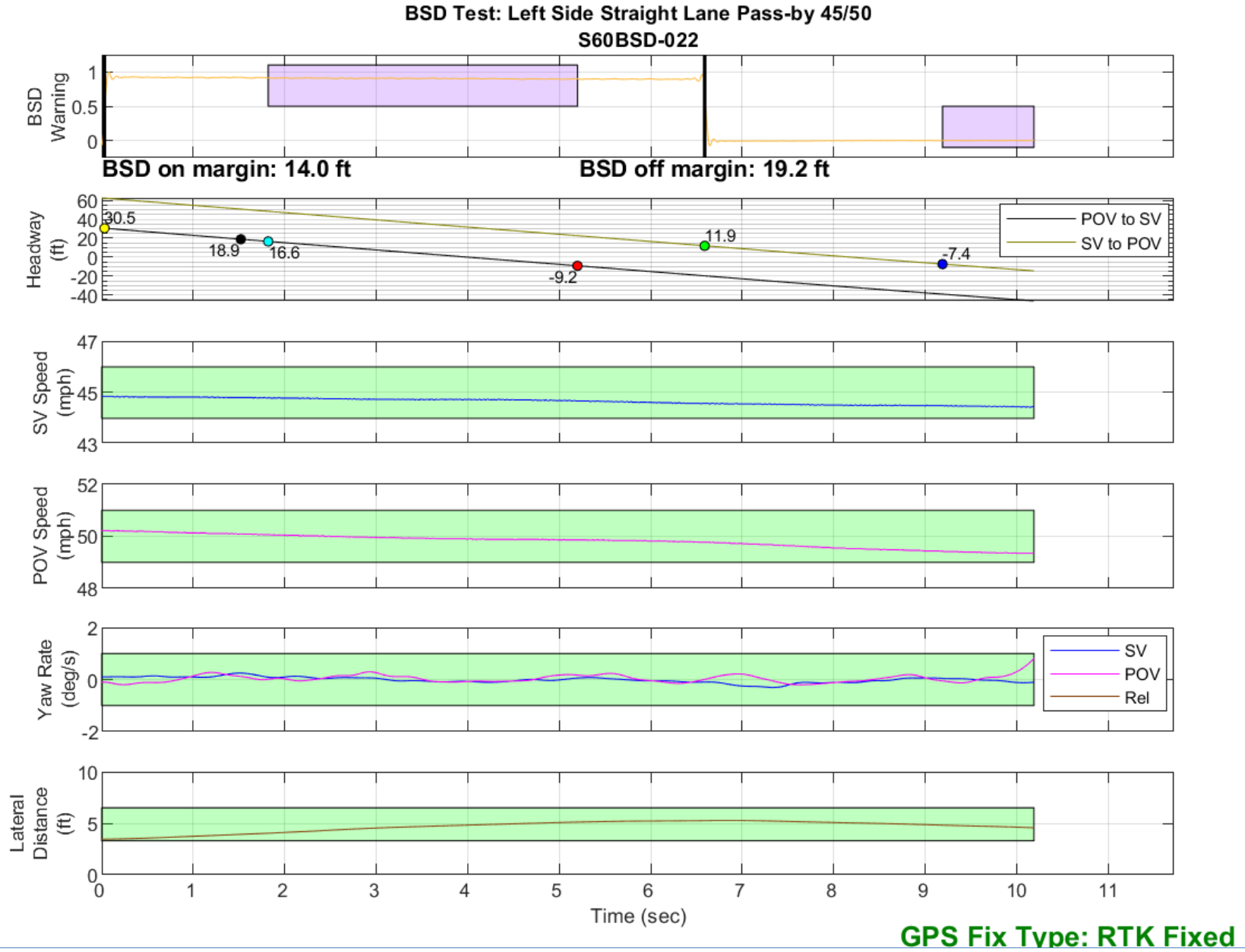


Figure D22. BSD Run 22, Straight Lane Pass-by, SV 45 mph, POV 50 mph

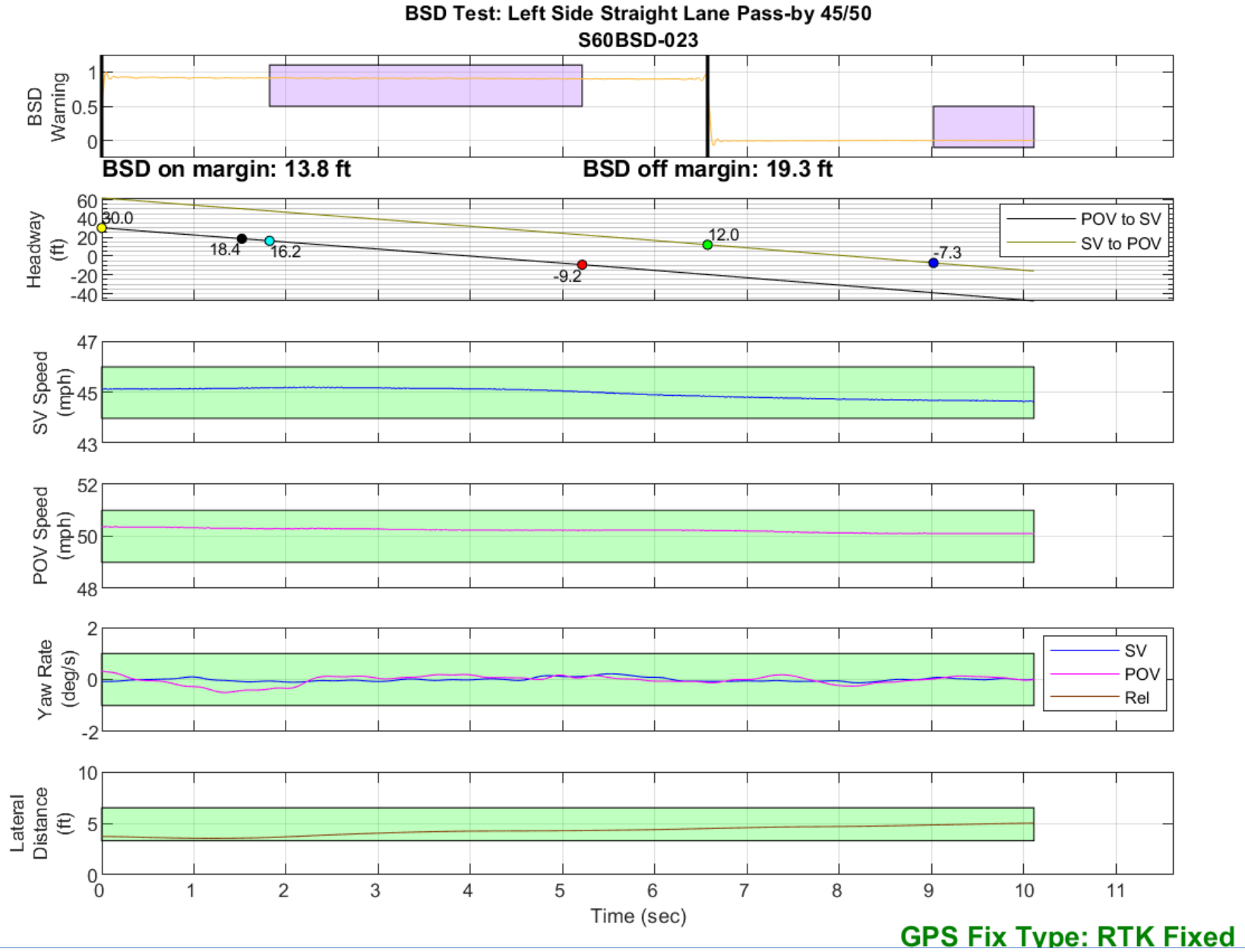


Figure D23. BSD Run 23, Straight Lane Pass-by, SV 45 mph, POV 50 mph

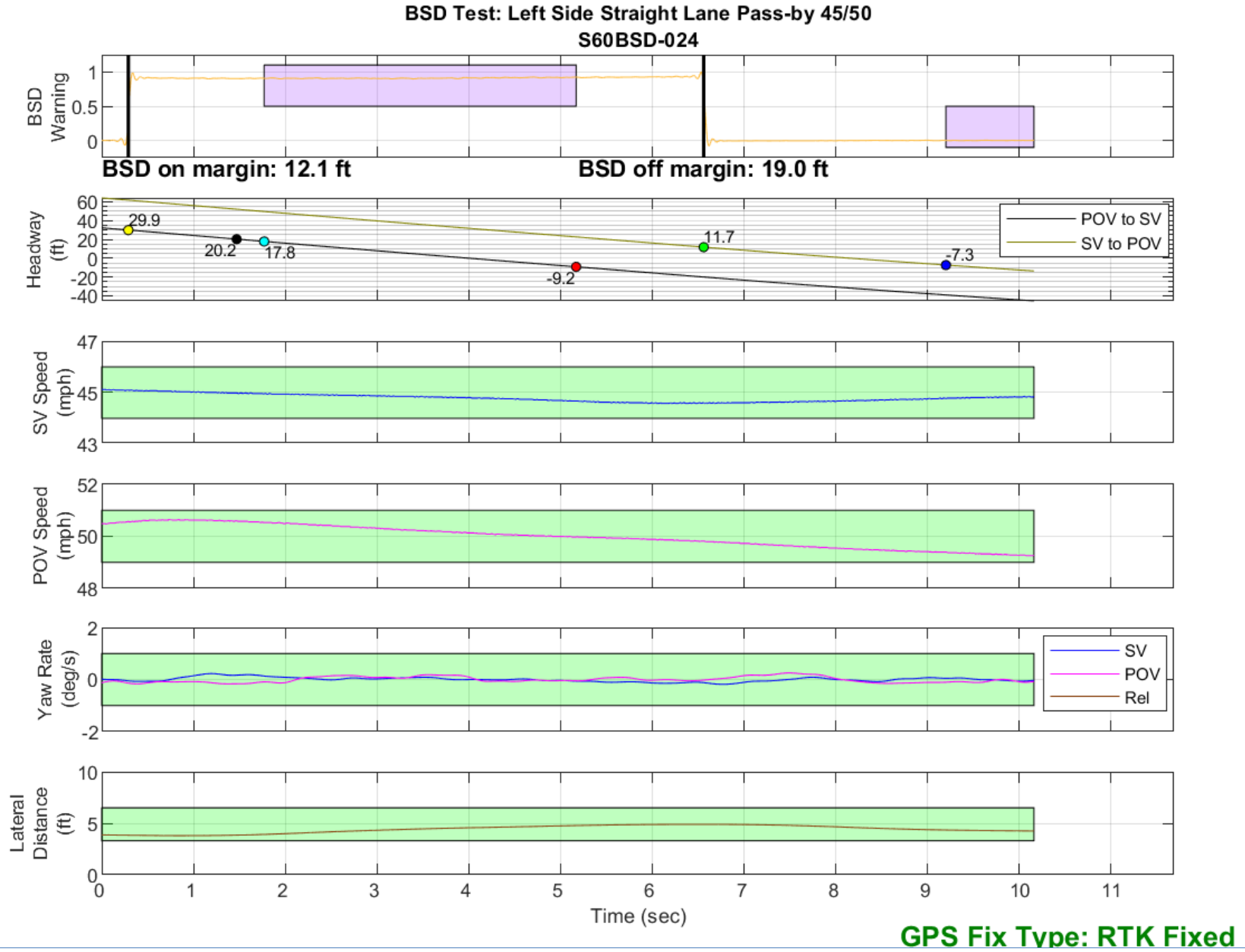


Figure D24. BSD Run 24, Straight Lane Pass-by, SV 45 mph, POV 50 mph

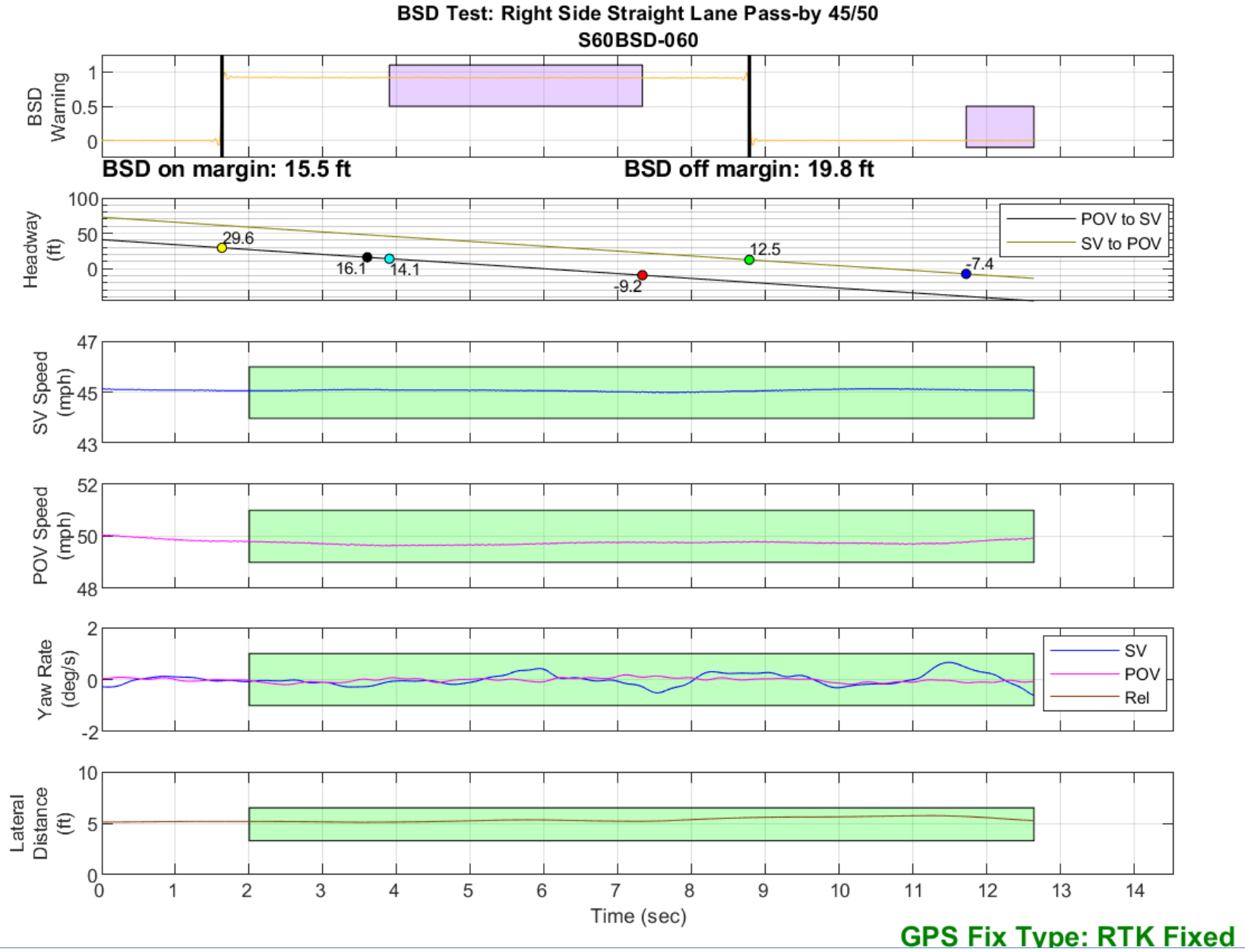


Figure D25. BSD Run 60, Straight Lane Pass-by, SV 45 mph, POV 50 mph

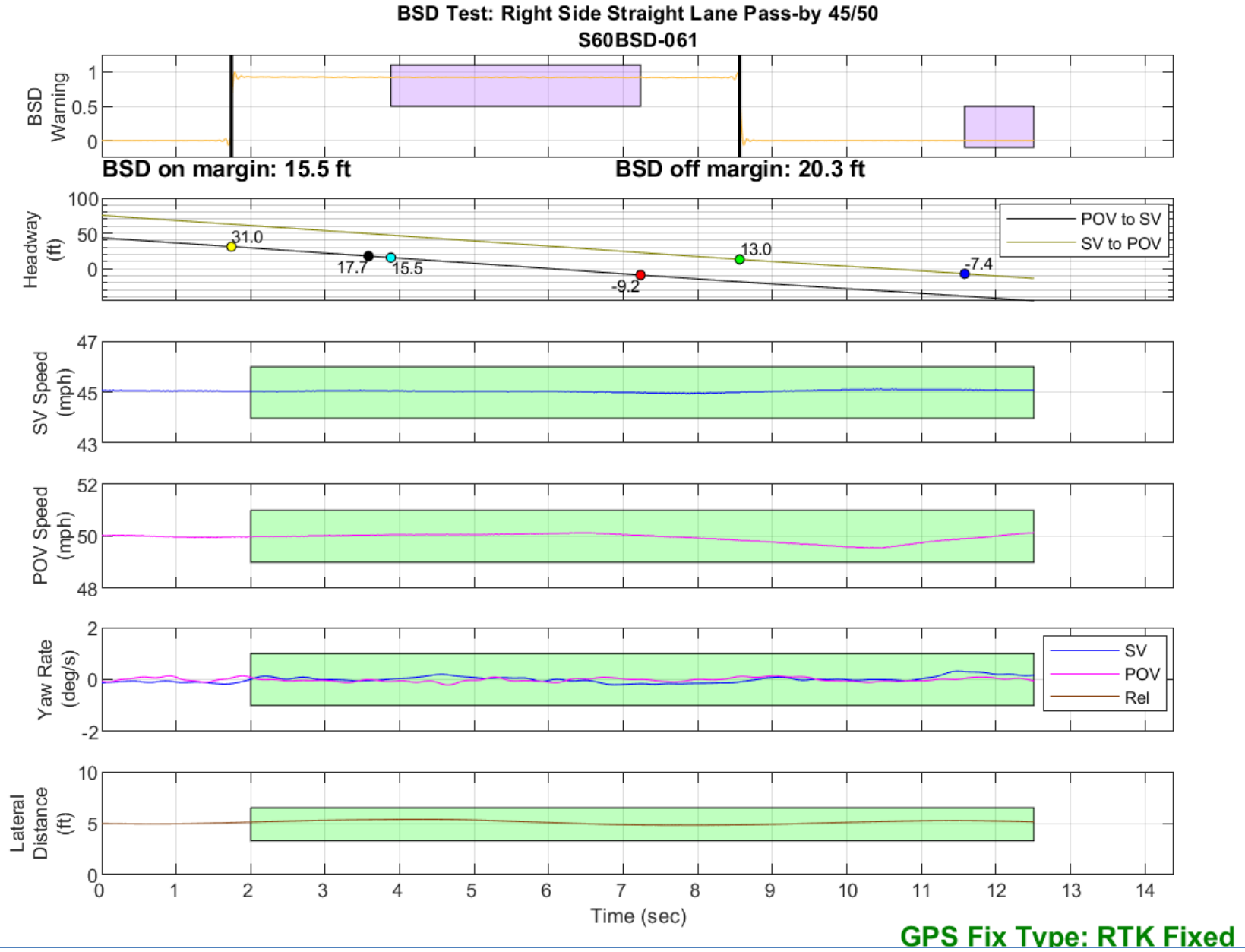


Figure D26. BSD Run 61, Straight Lane Pass-by, SV 45 mph, POV 50 mph

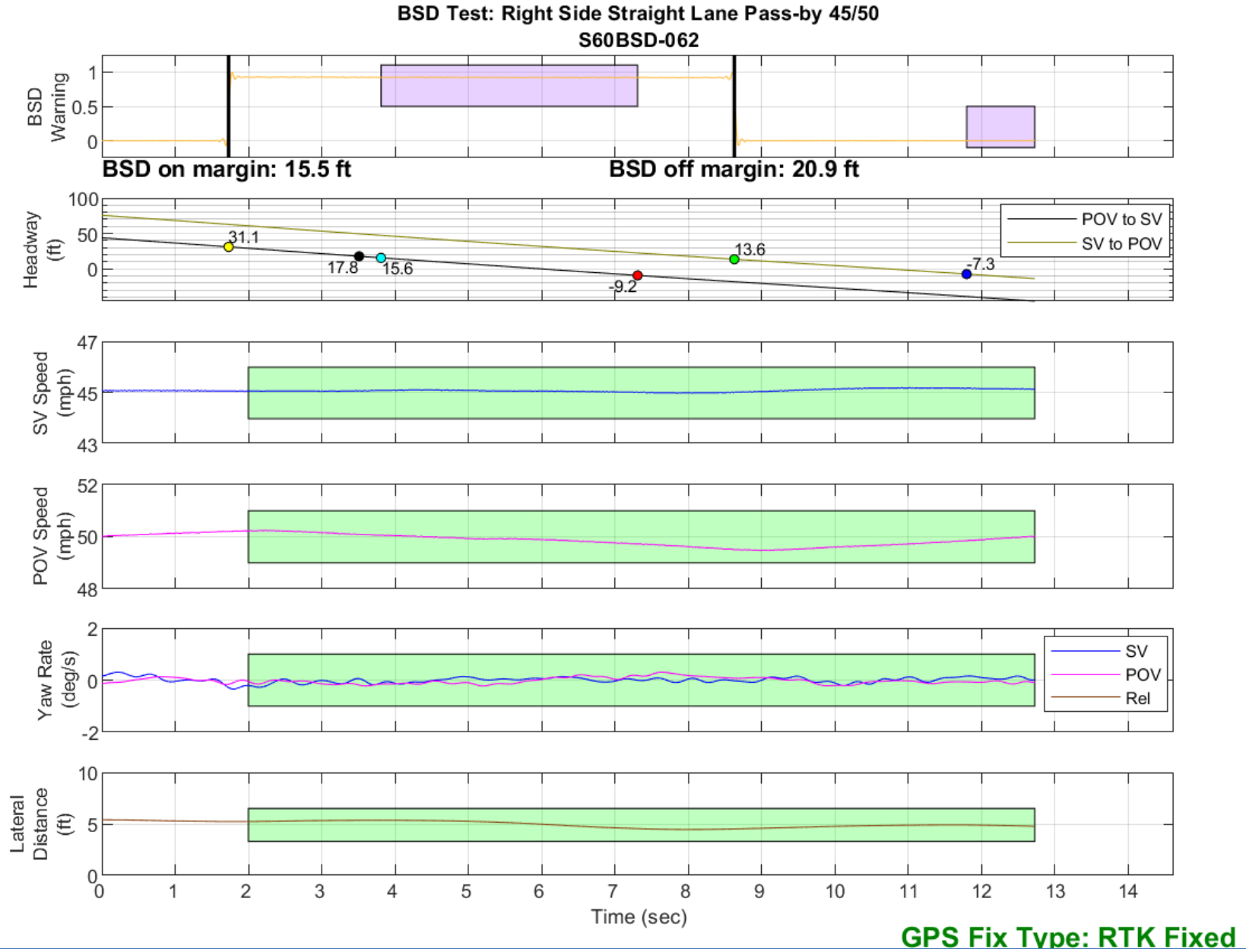


Figure D27. BSD Run 62, Straight Lane Pass-by, SV 45 mph, POV 50 mph

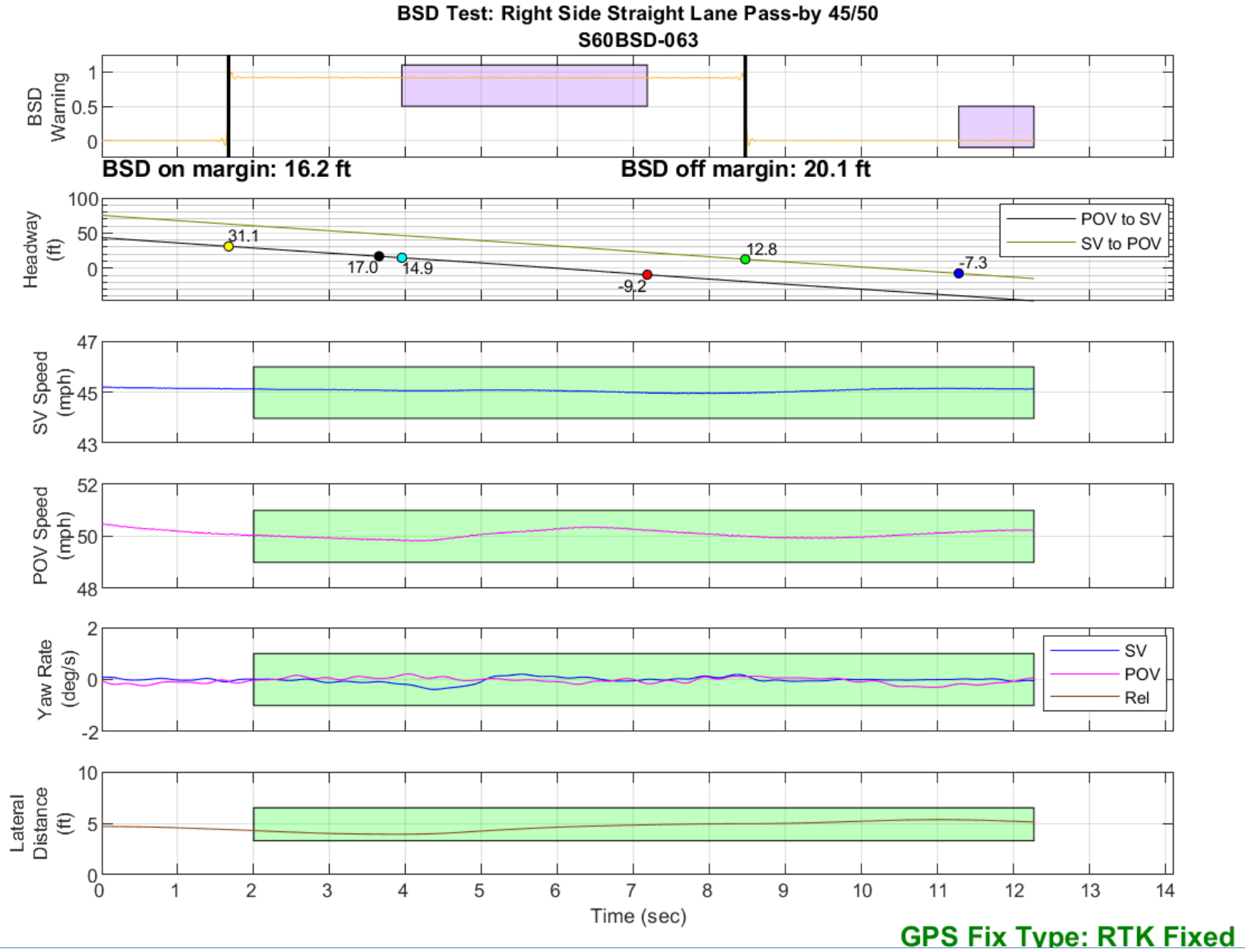


Figure D28. BSD Run 63, Straight Lane Pass-by, SV 45 mph, POV 50 mph

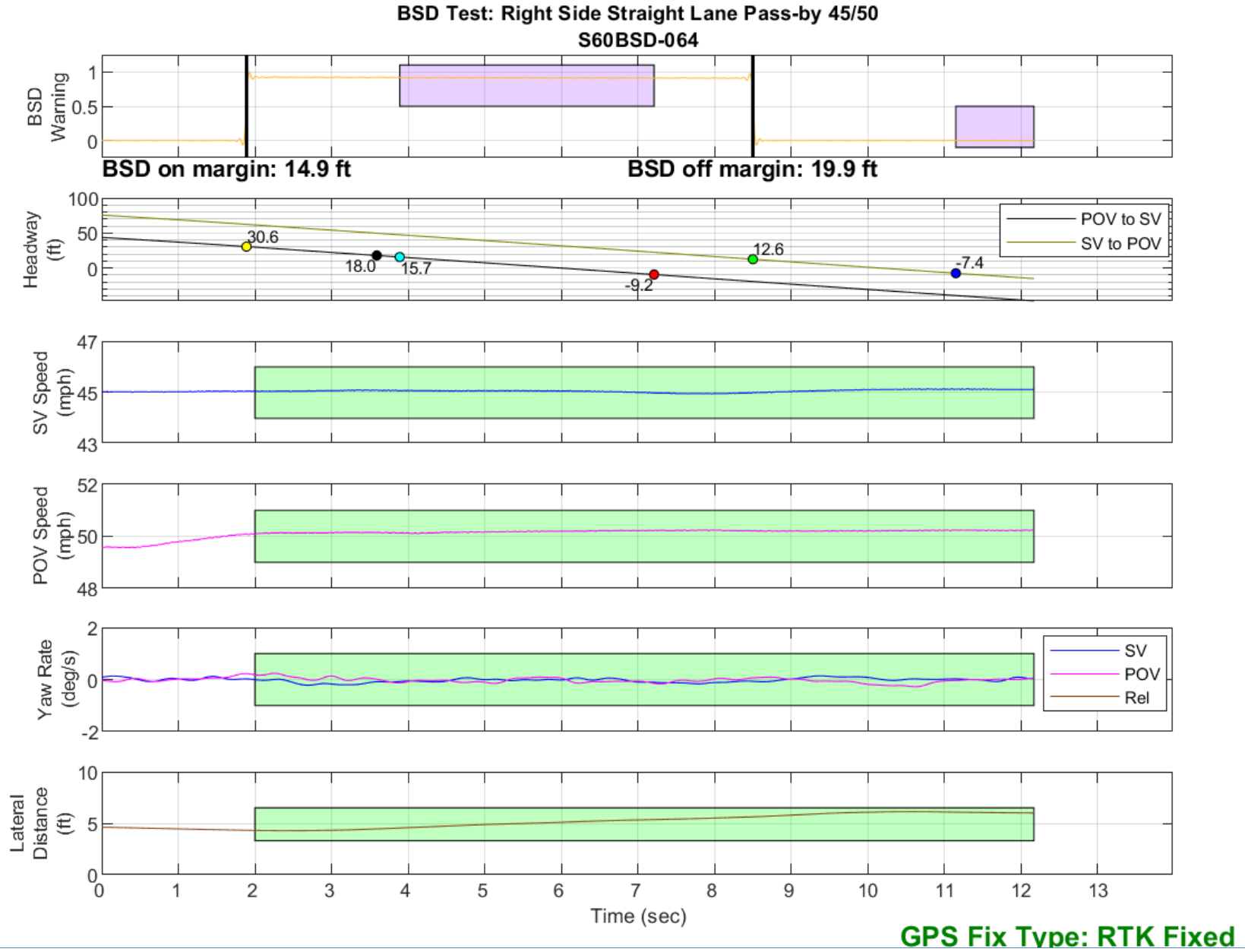


Figure D29. BSD Run 64, Straight Lane Pass-by, SV 45 mph, POV 50 mph

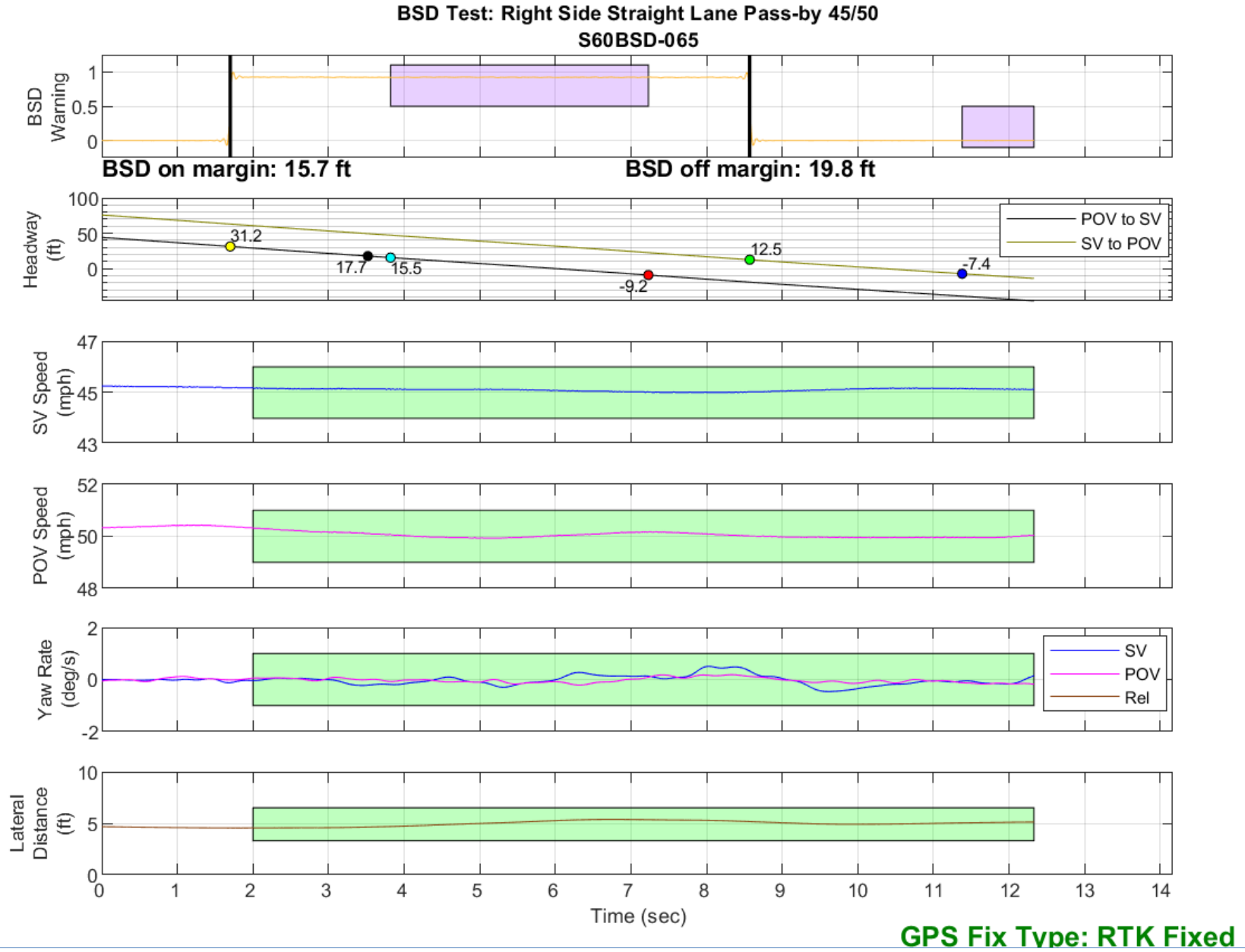


Figure D30. BSD Run 65, Straight Lane Pass-by, SV 45 mph, POV 50 mph

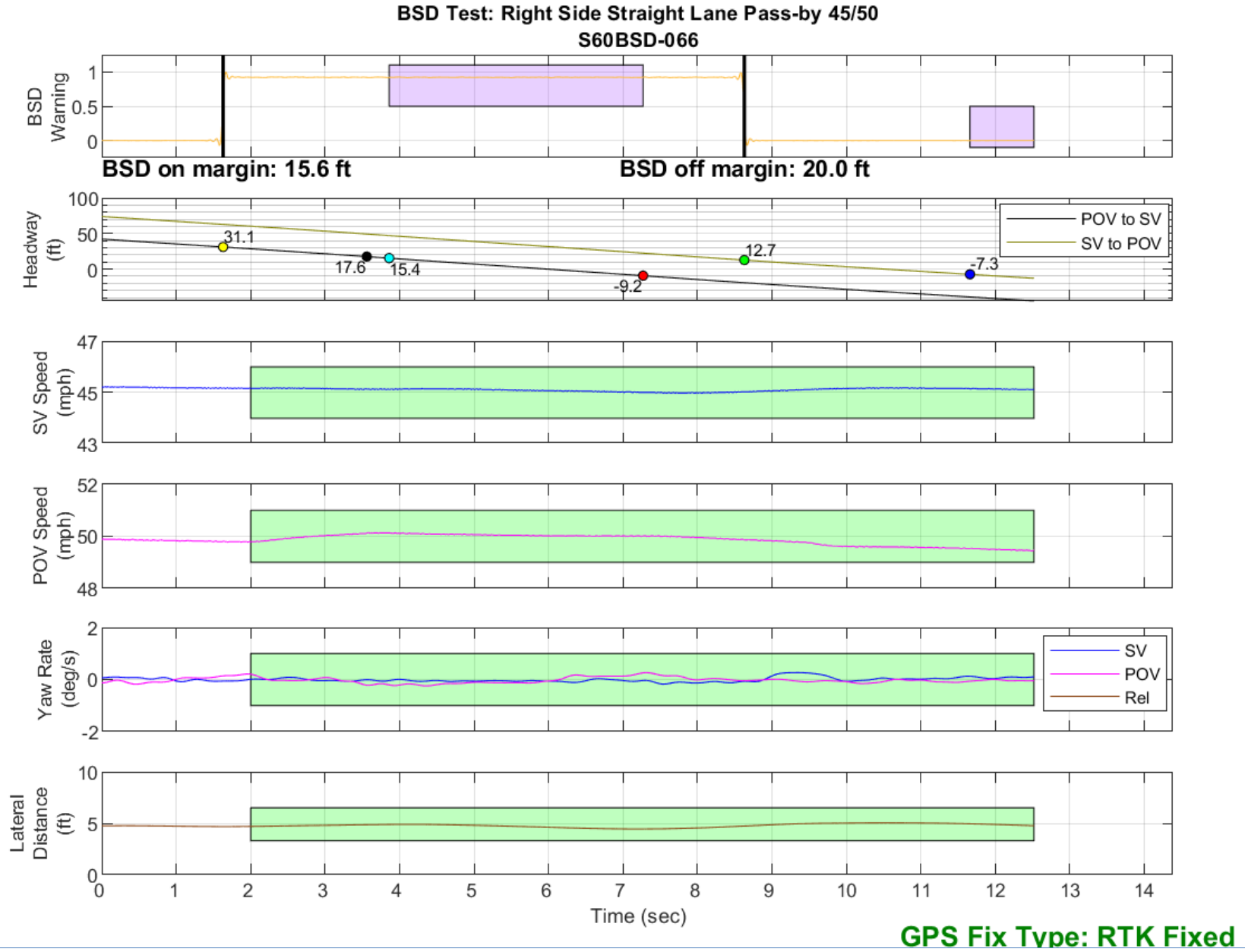


Figure D31. BSD Run 66, Straight Lane Pass-by, SV 45 mph, POV 50 mph

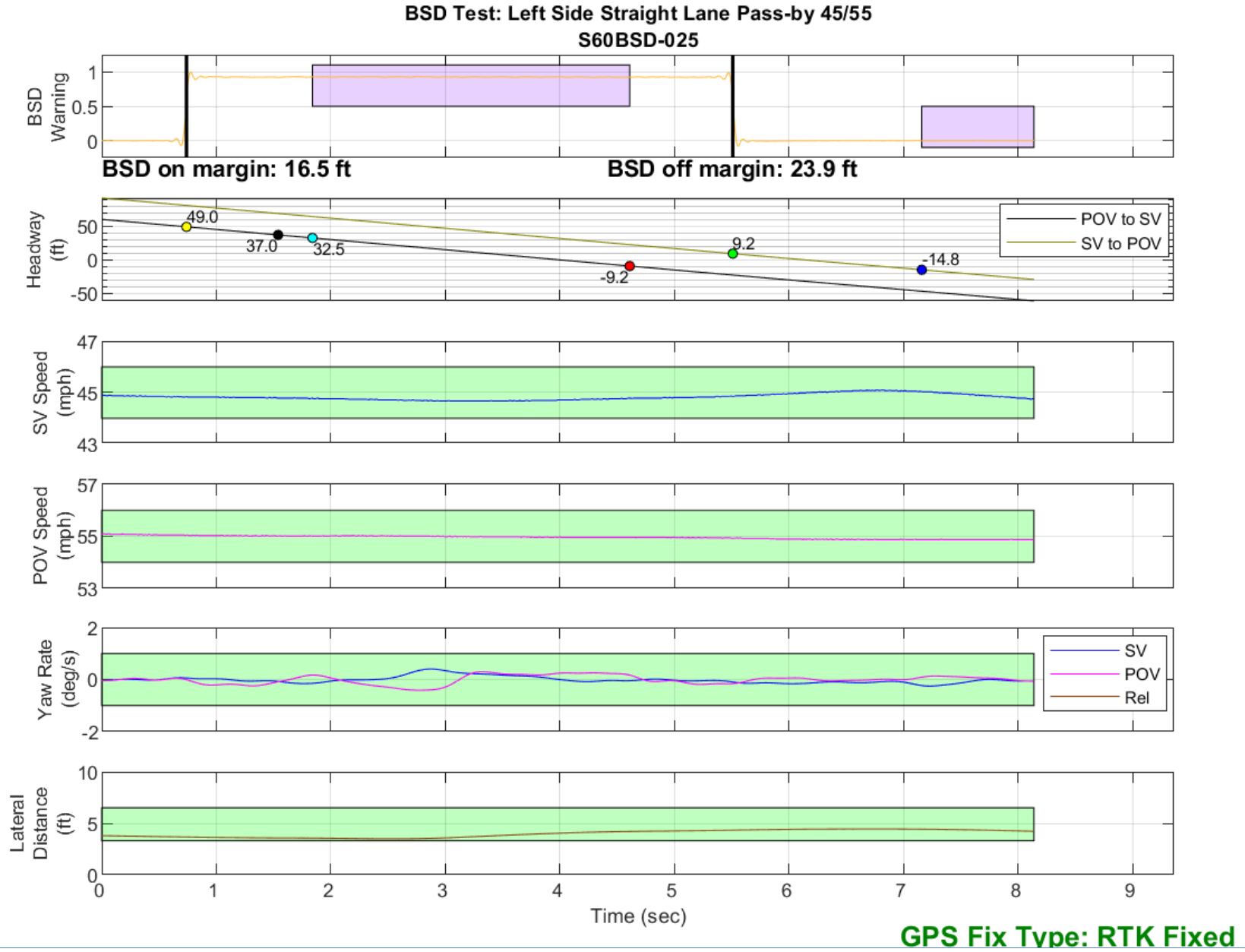


Figure D32. BSD Run 25, Straight Lane Pass-by, SV 45 mph, POV 55 mph

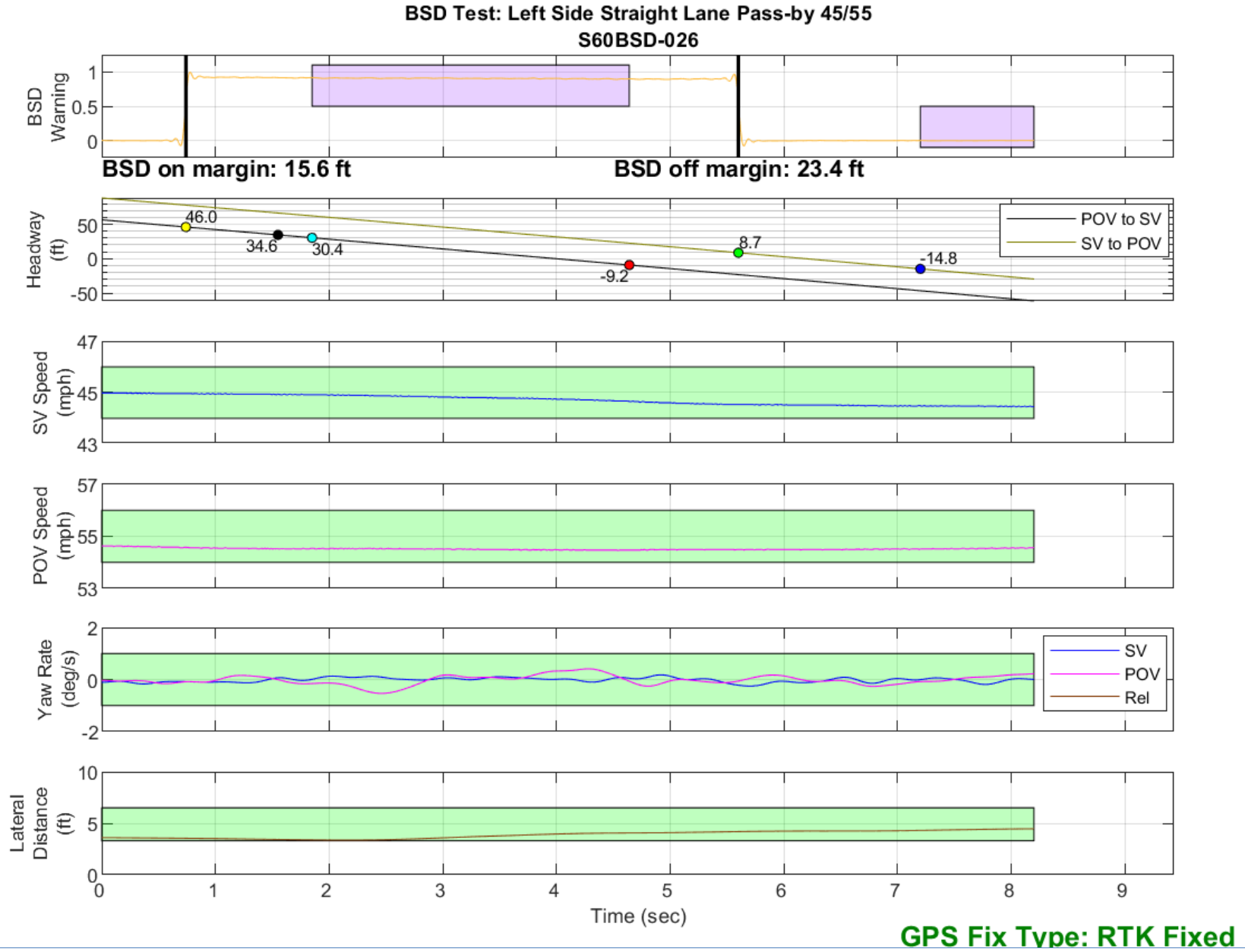


Figure D33. BSD Run 26, Straight Lane Pass-by, SV 45 mph, POV 55 mph

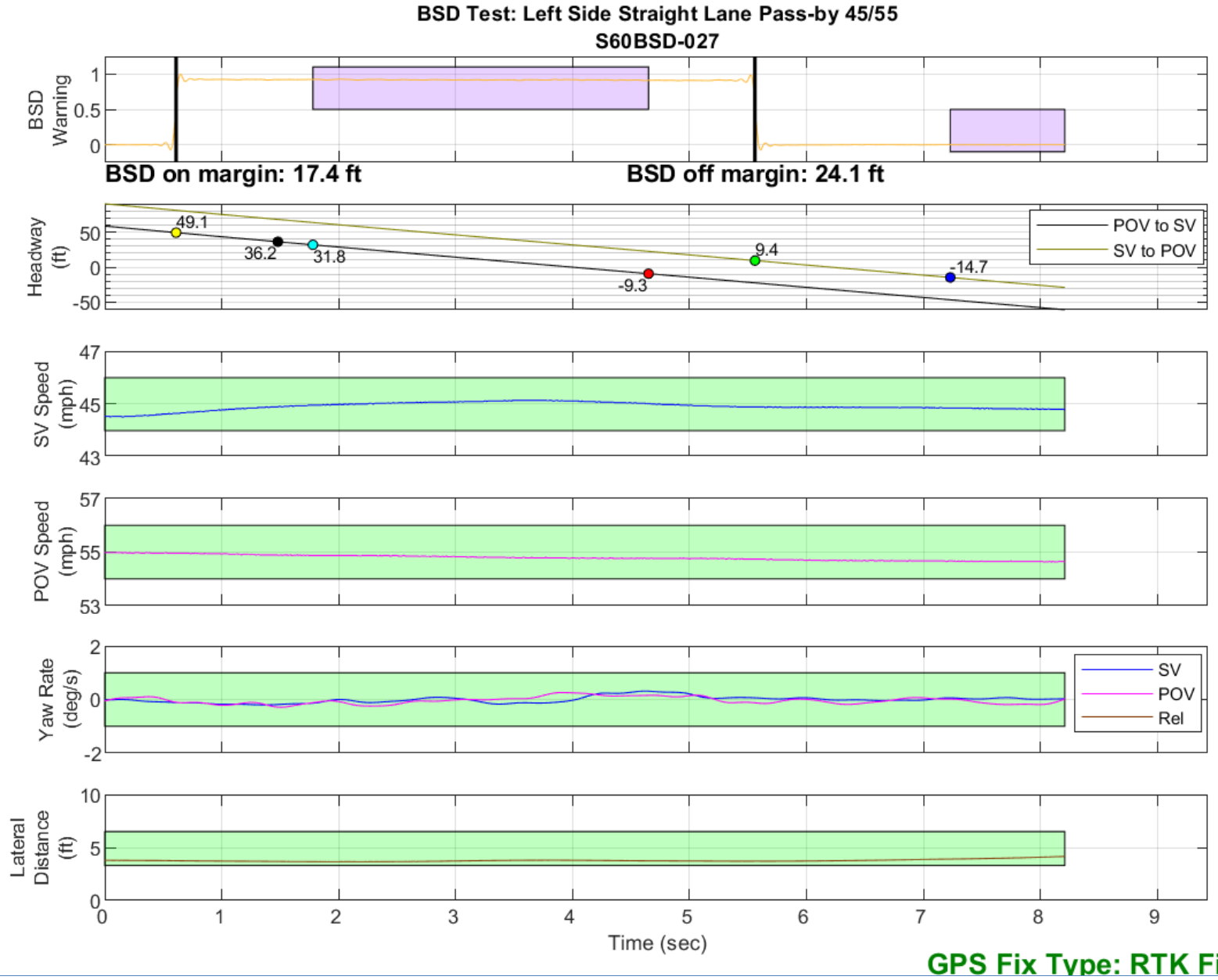


Figure D34. BSD Run 27, Straight Lane Pass-by, SV 45 mph, POV 55 mph

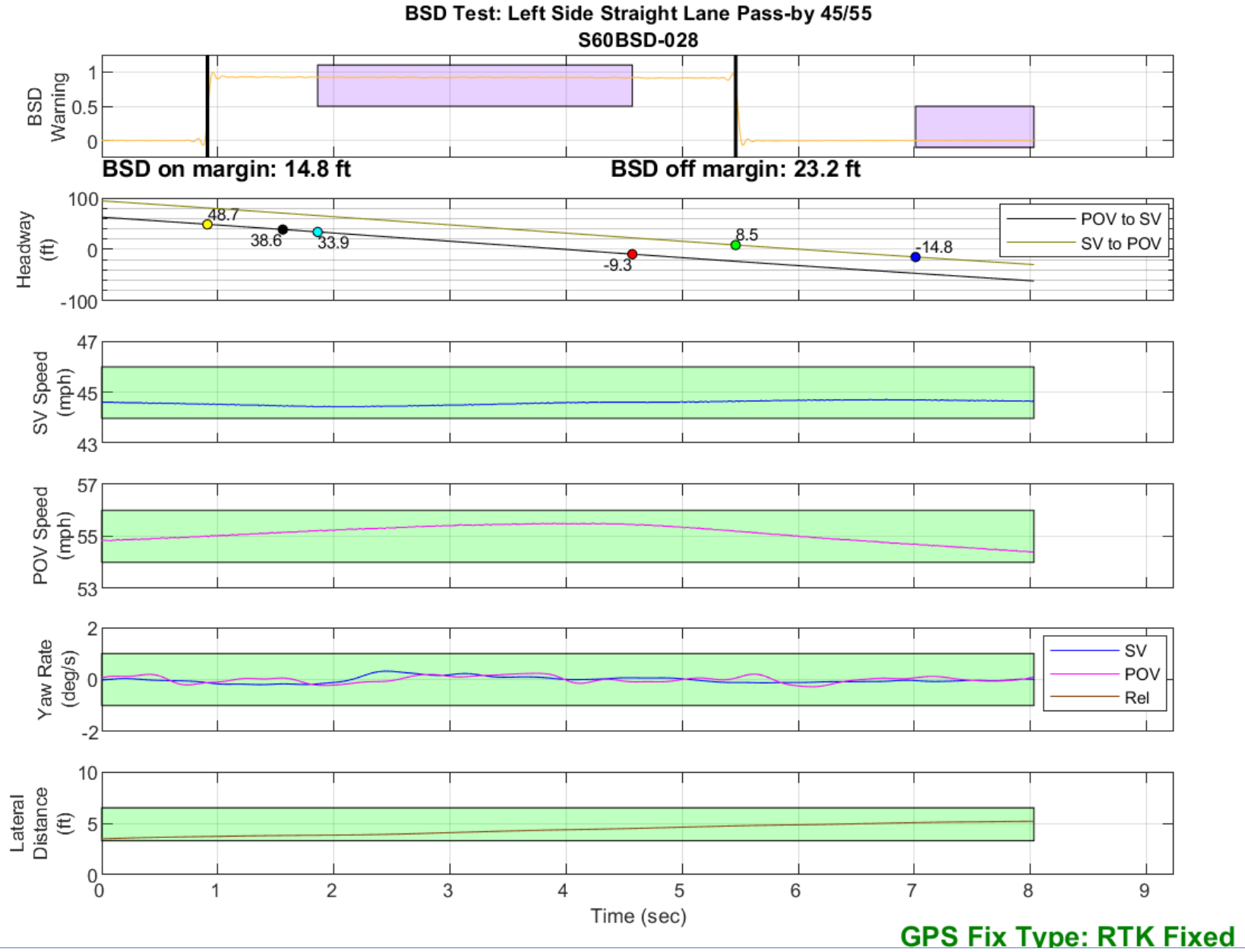


Figure D35. BSD Run 28, Straight Lane Pass-by, SV 45 mph, POV 55 mph

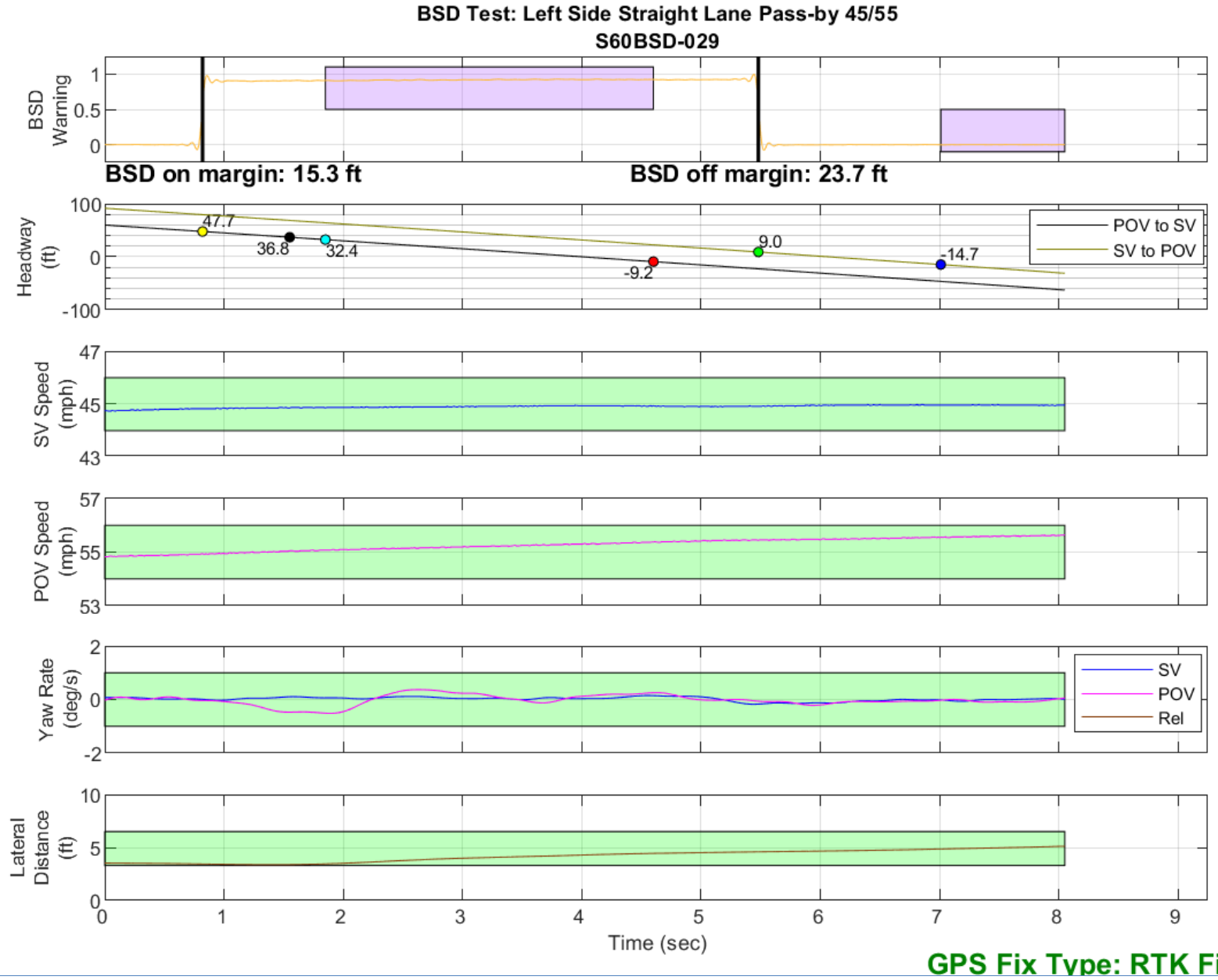


Figure D36. BSD Run 29, Straight Lane Pass-by, SV 45 mph, POV 55 mph

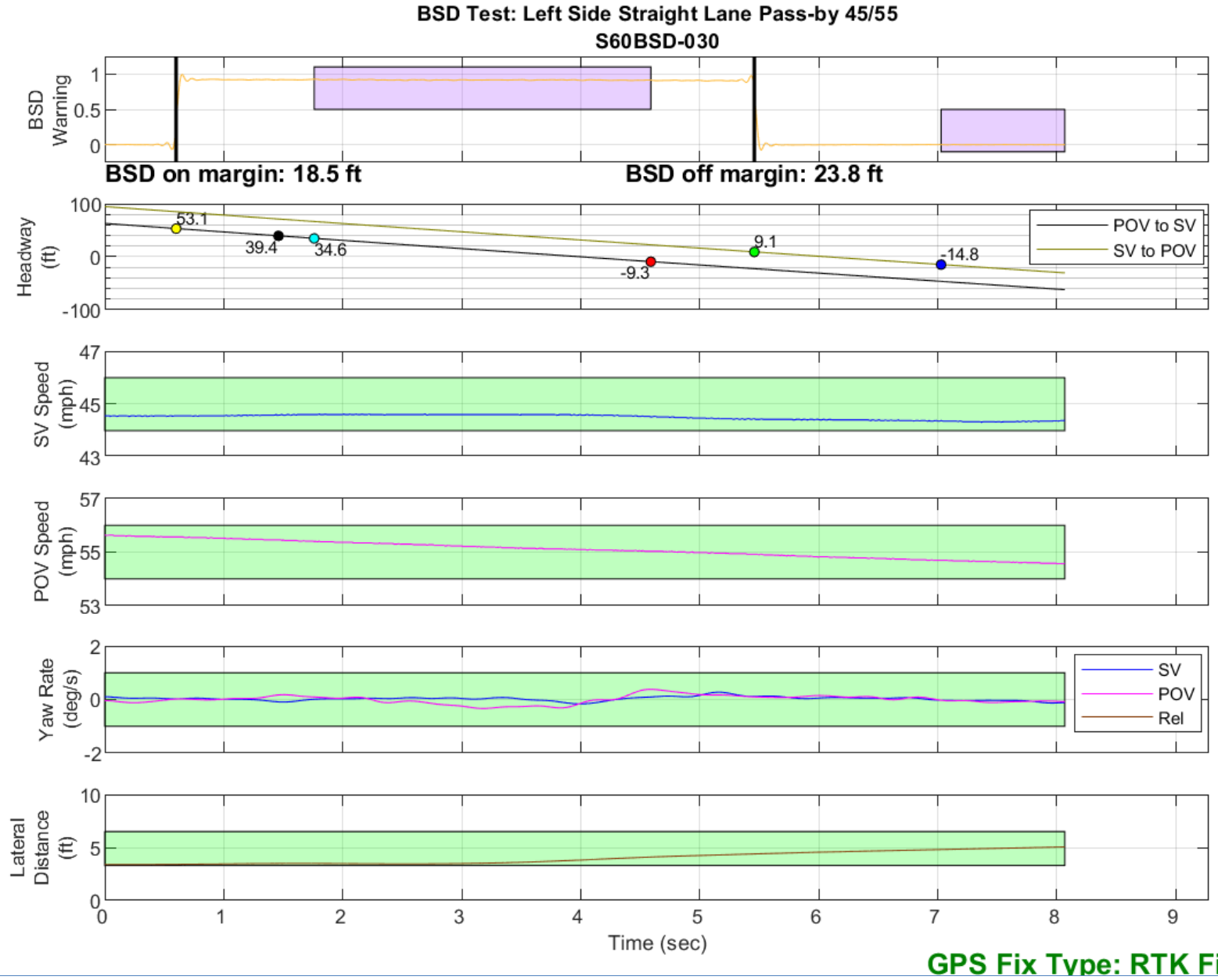


Figure D37. BSD Run 30, Straight Lane Pass-by, SV 45 mph, POV 55 mph

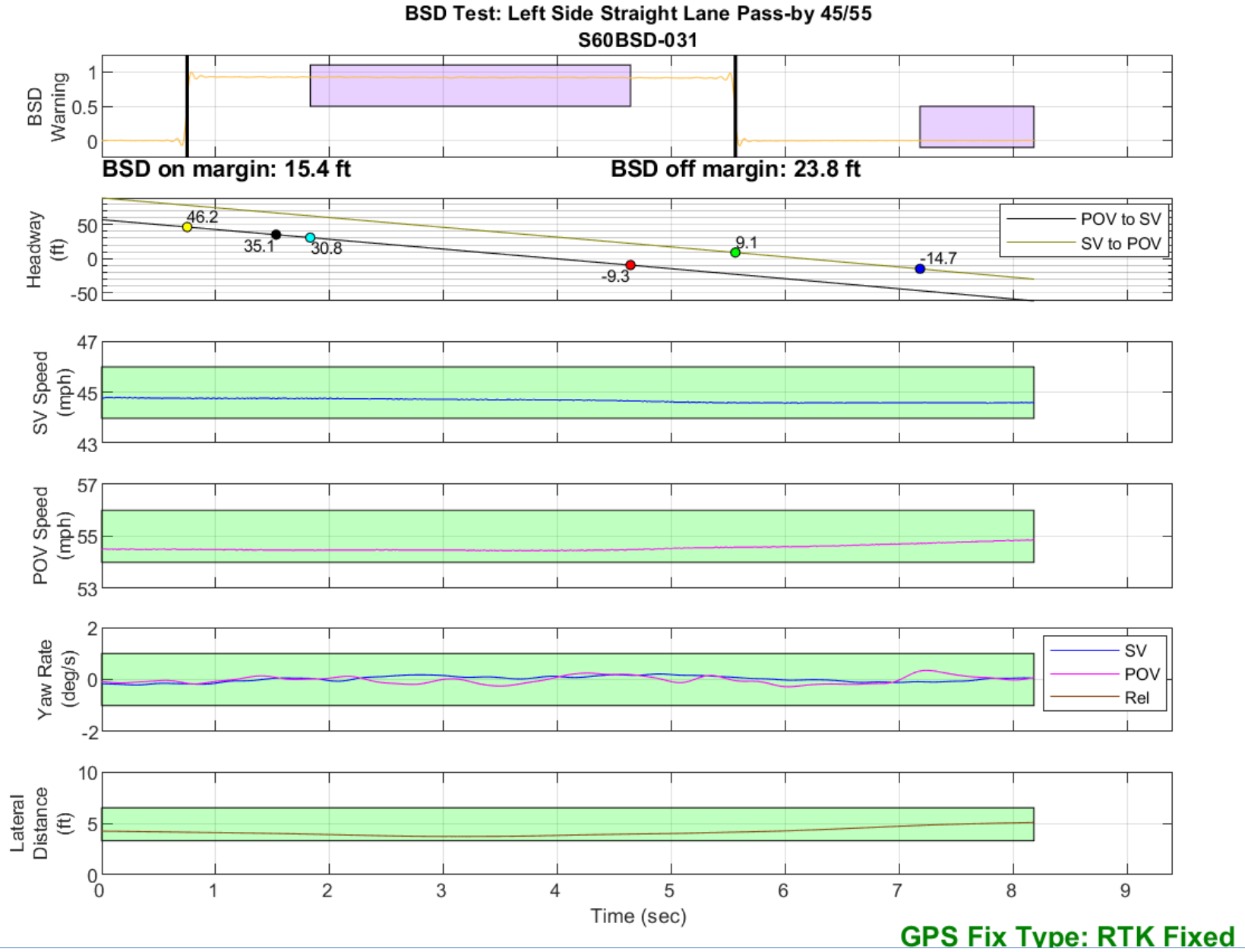


Figure D38. BSD Run 31, Straight Lane Pass-by, SV 45 mph, POV 55 mph

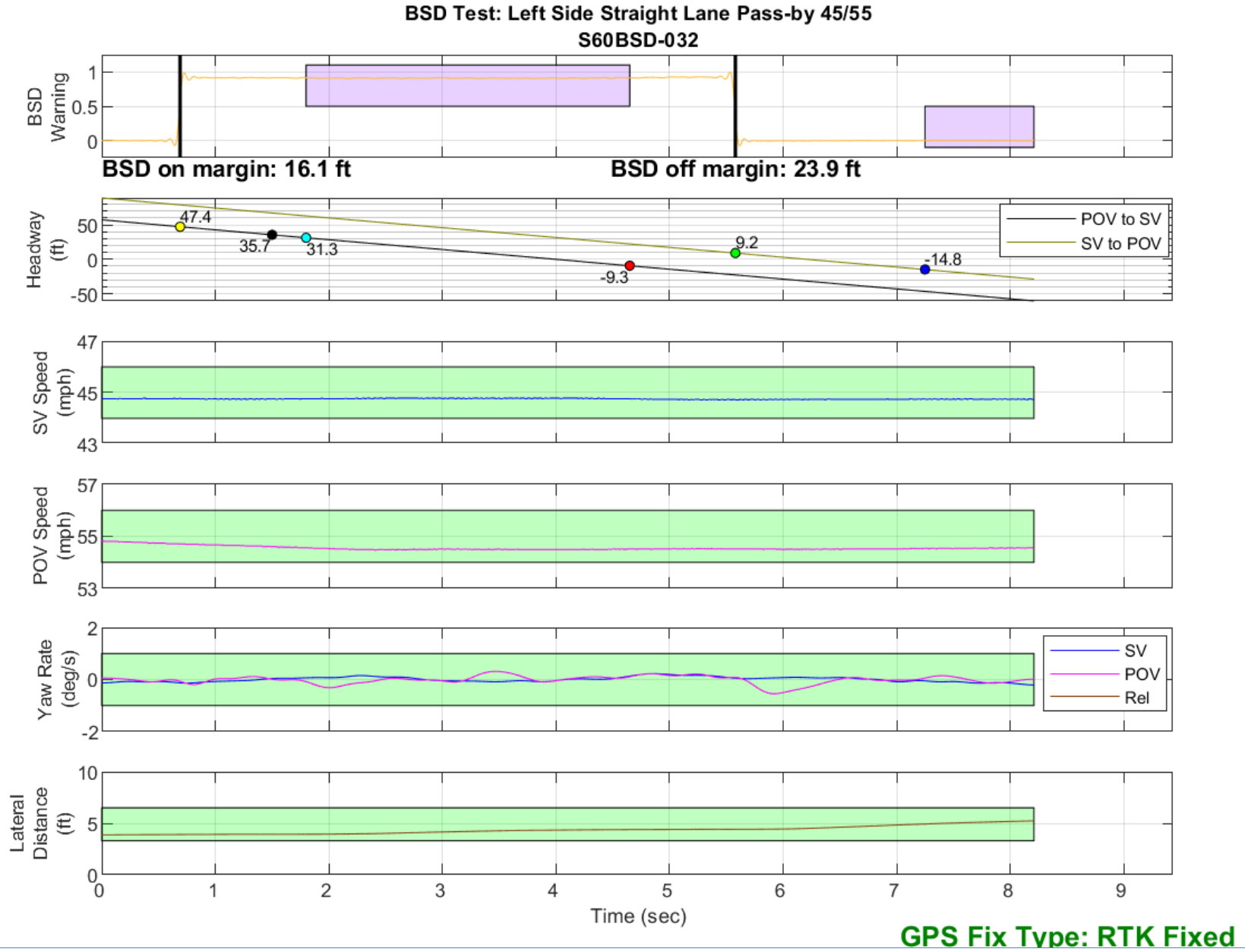


Figure D39. BSD Run 32, Straight Lane Pass-by, SV 45 mph, POV 55 mph

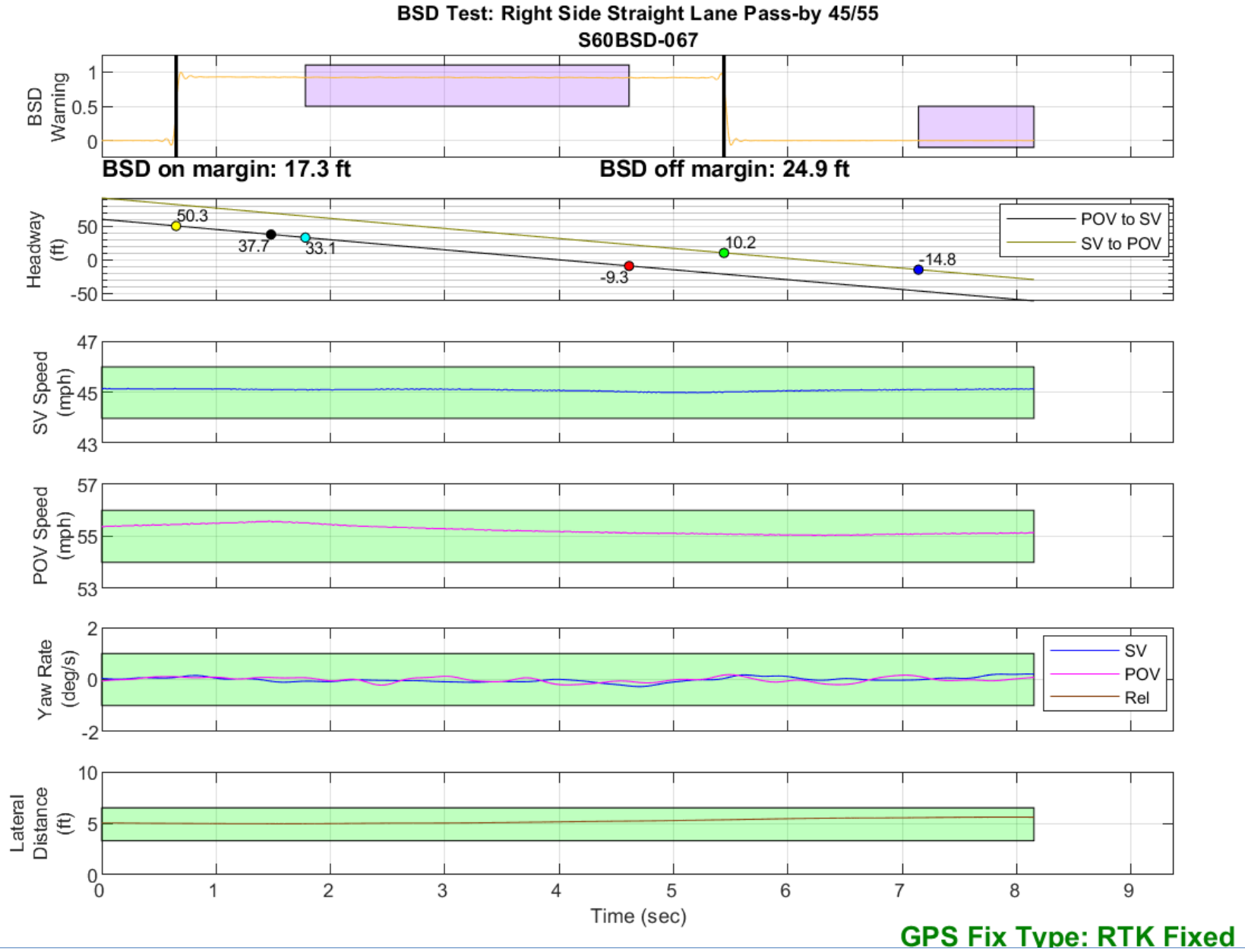


Figure D40. BSD Run 67, Straight Lane Pass-by, SV 45 mph, POV 55 mph

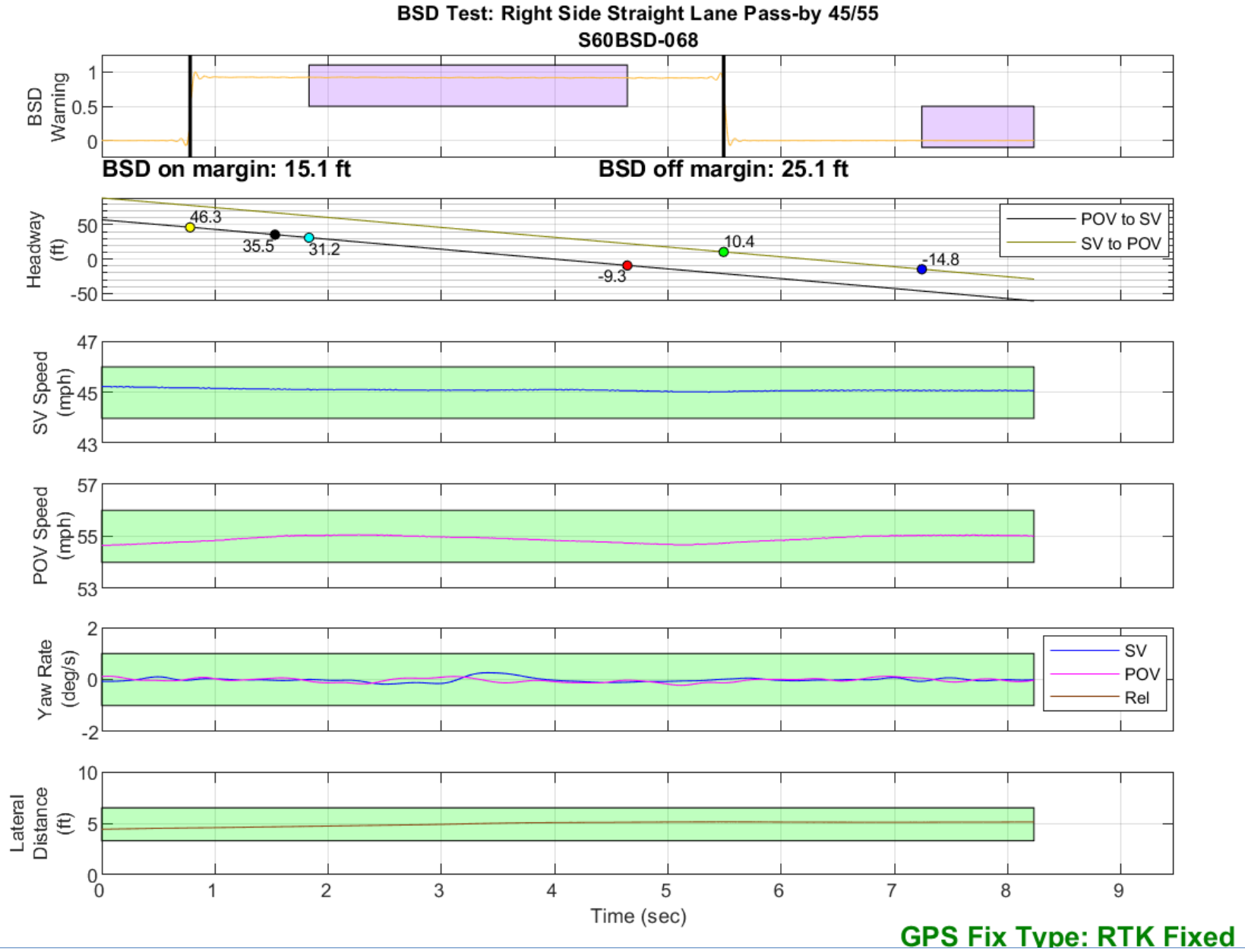


Figure D41. BSD Run 68, Straight Lane Pass-by, SV 45 mph, POV 55 mph

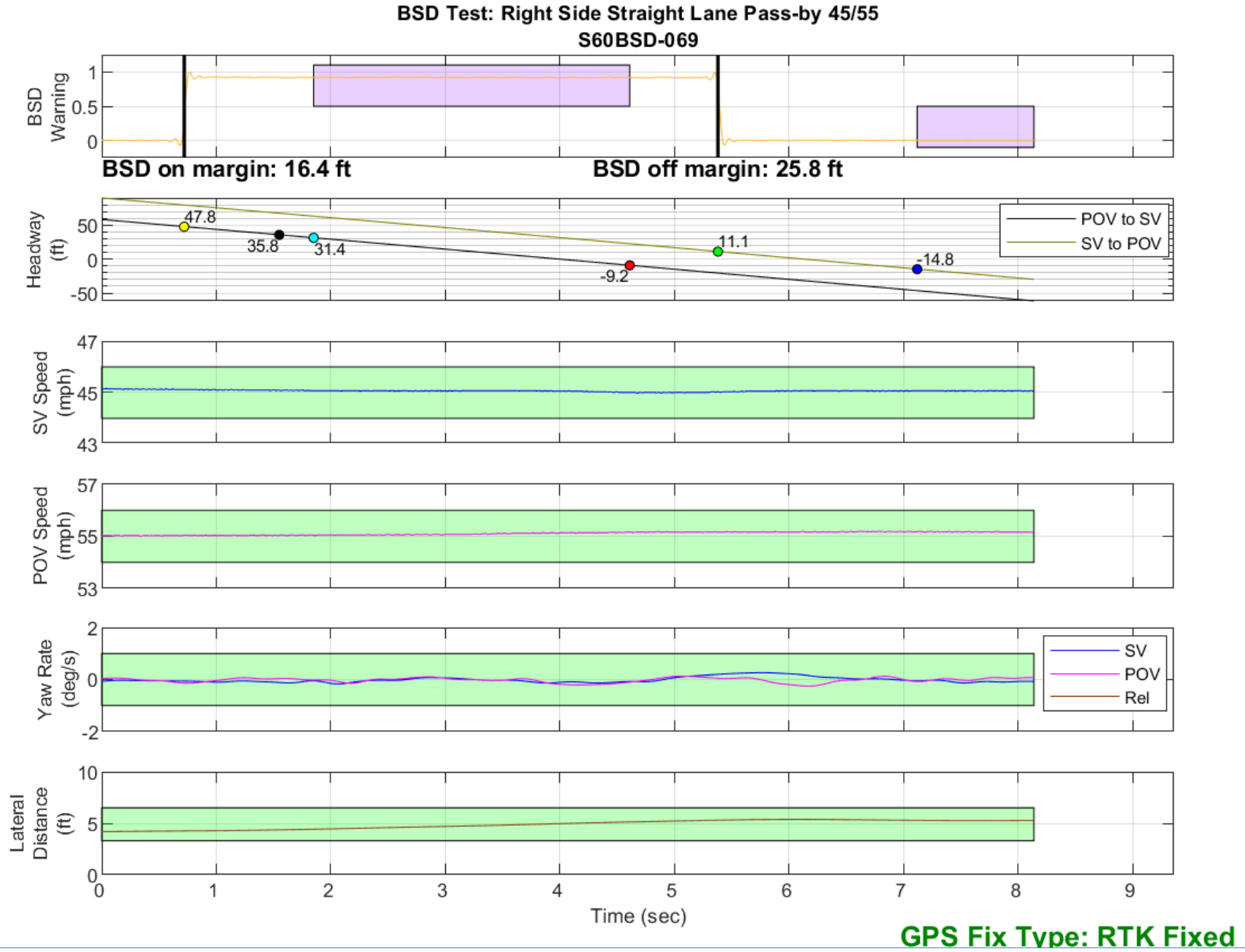


Figure D42. BSD Run 69, Straight Lane Pass-by, SV 45 mph, POV 55 mph

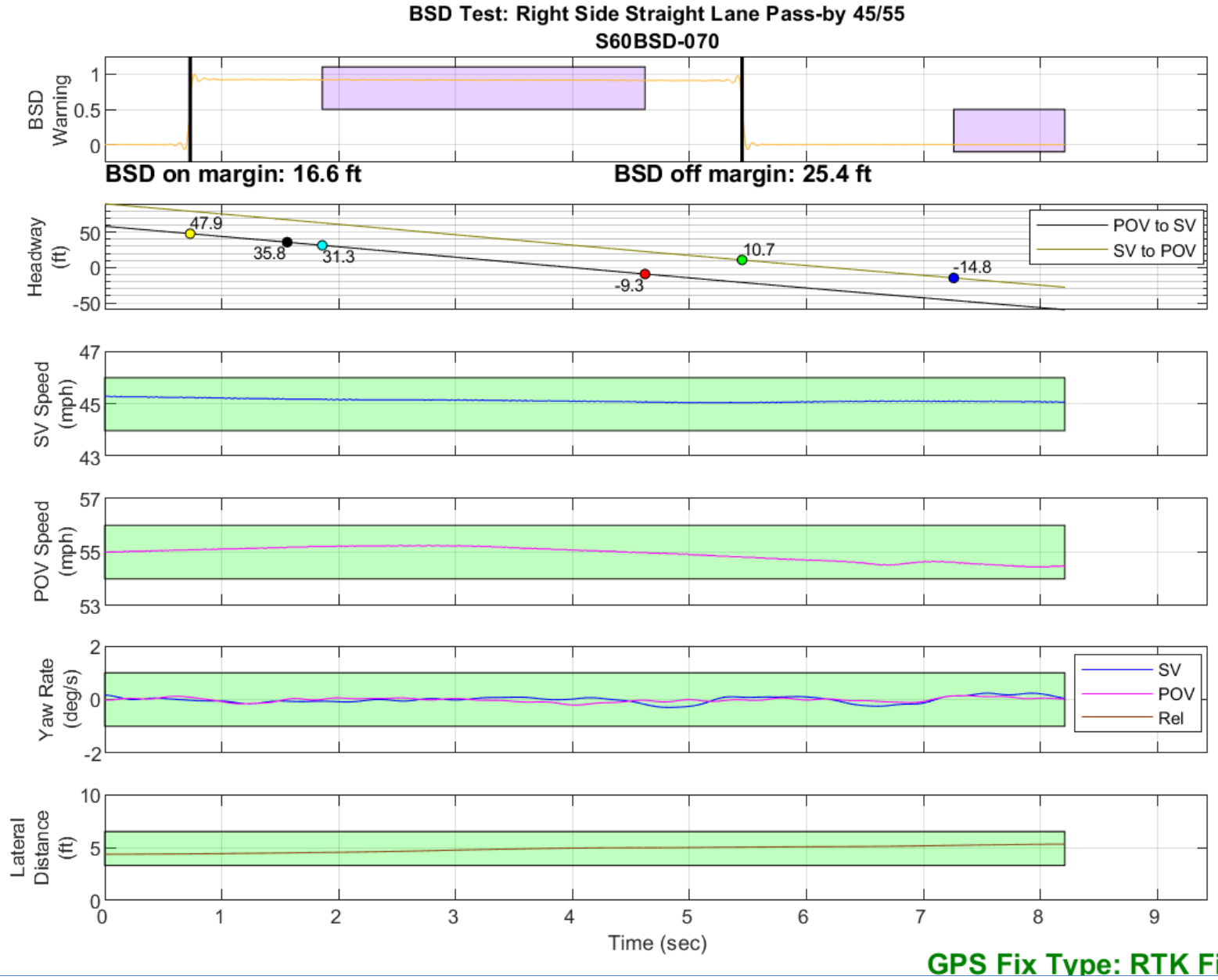


Figure D43. BSD Run 70, Straight Lane Pass-by, SV 45 mph, POV 55 mph

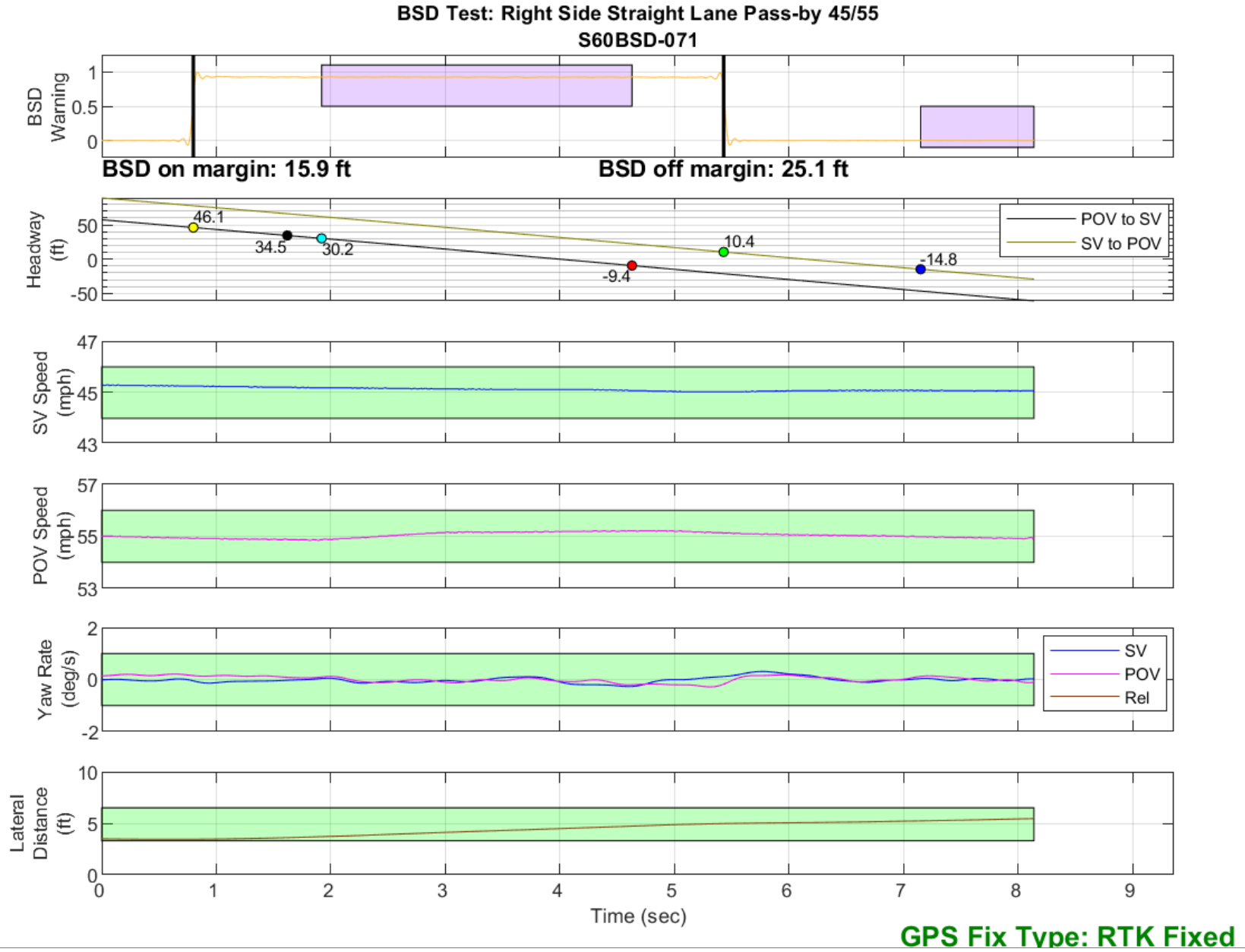


Figure D44. BSD Run 71, Straight Lane Pass-by, SV 45 mph, POV 55 mph

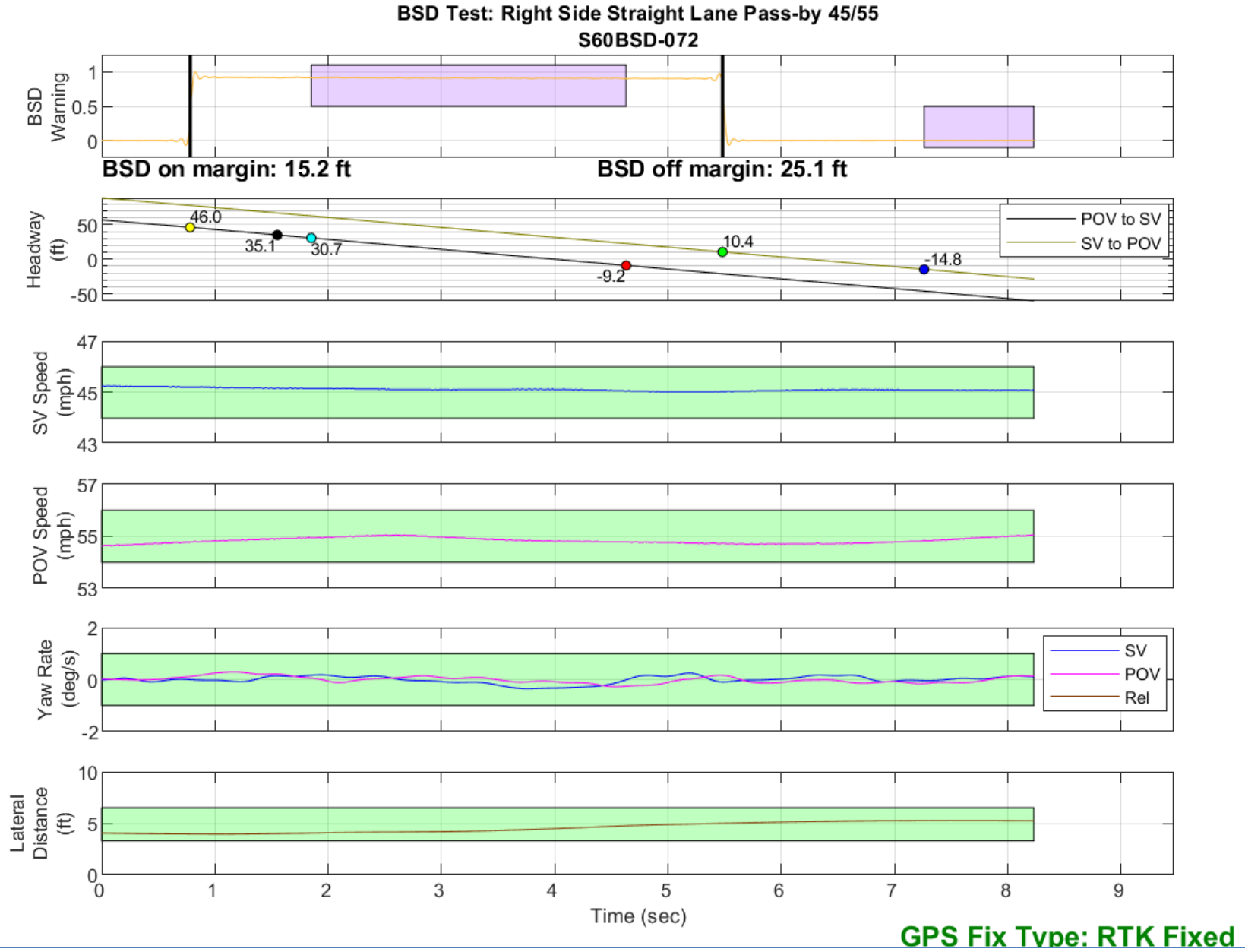


Figure D45. BSD Run 72, Straight Lane Pass-by, SV 45 mph, POV 55 mph

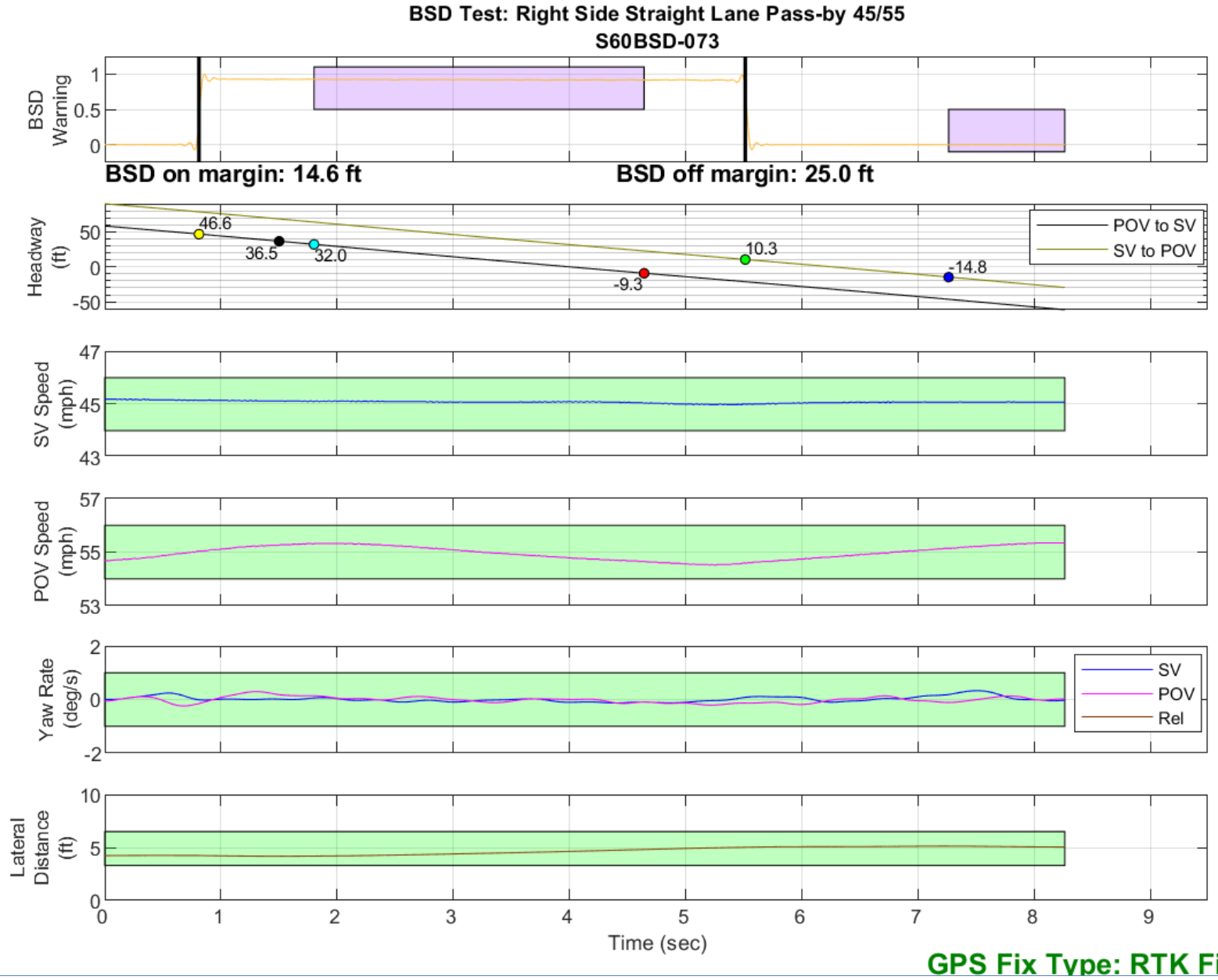


Figure D46. BSD Run 73, Straight Lane Pass-by, SV 45 mph, POV 55 mph

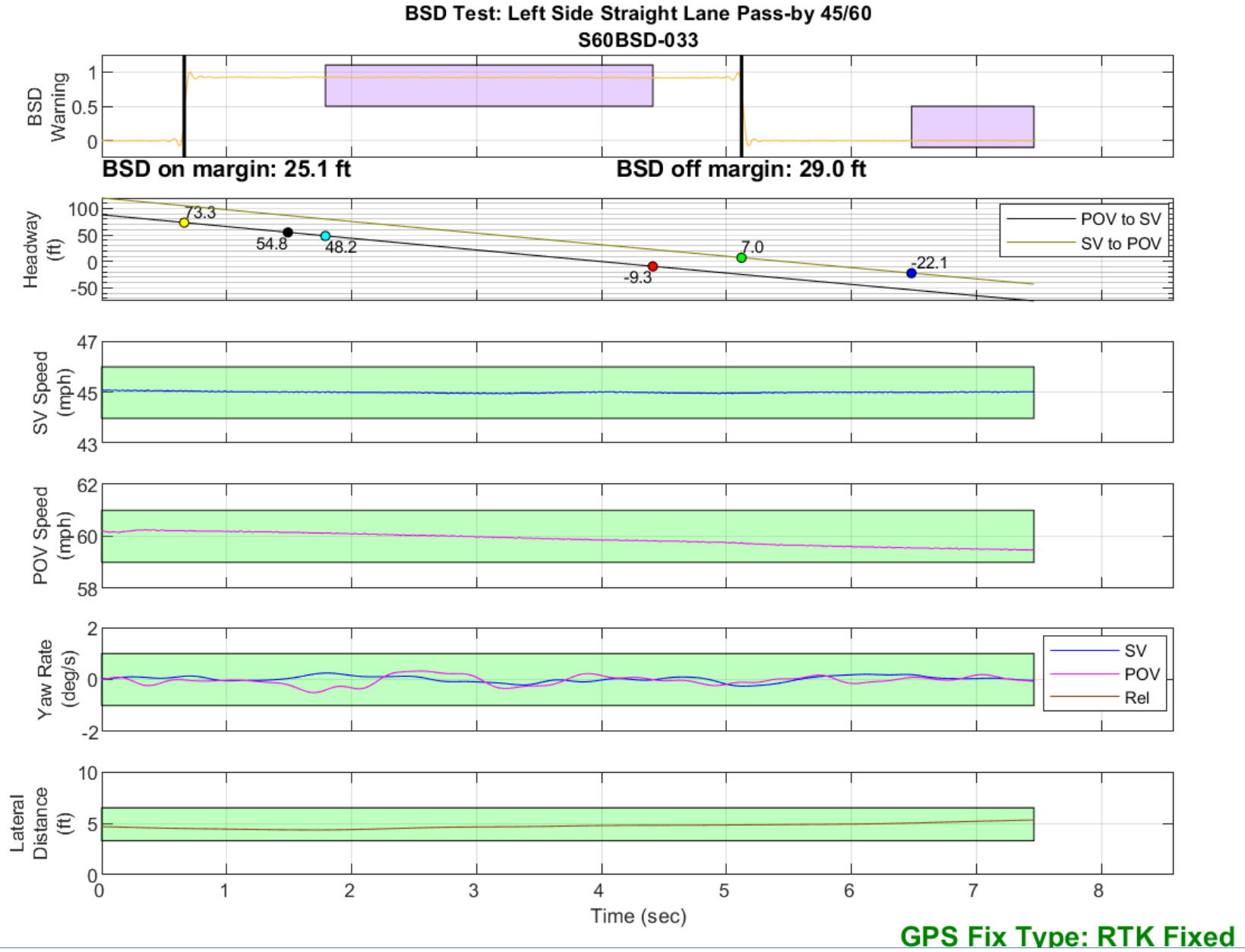


Figure D47. BSD Run 33, Straight Lane Pass-by, SV 45 mph, POV 60 mph

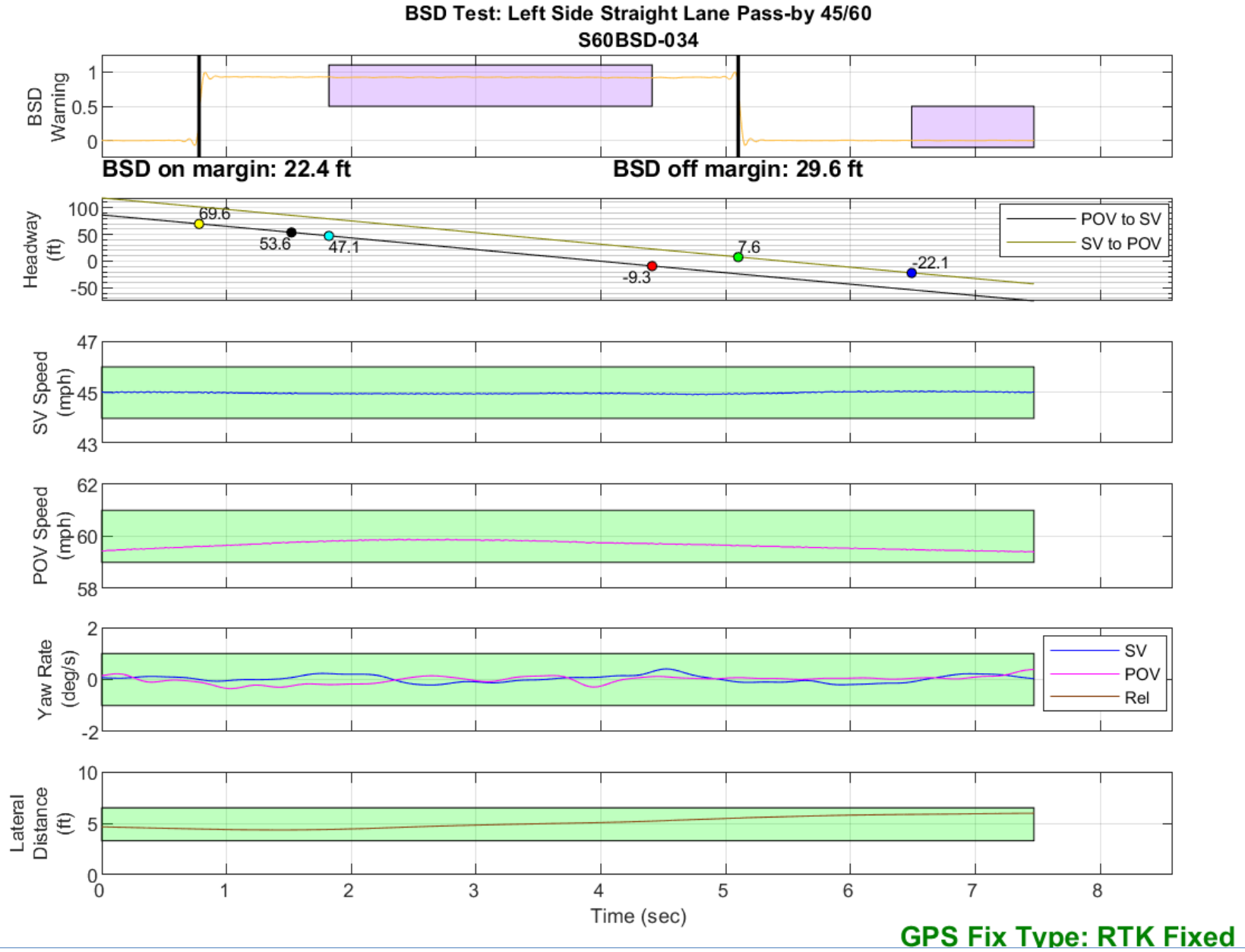


Figure D48. BSD Run 34, Straight Lane Pass-by, SV 45 mph, POV 60 mph

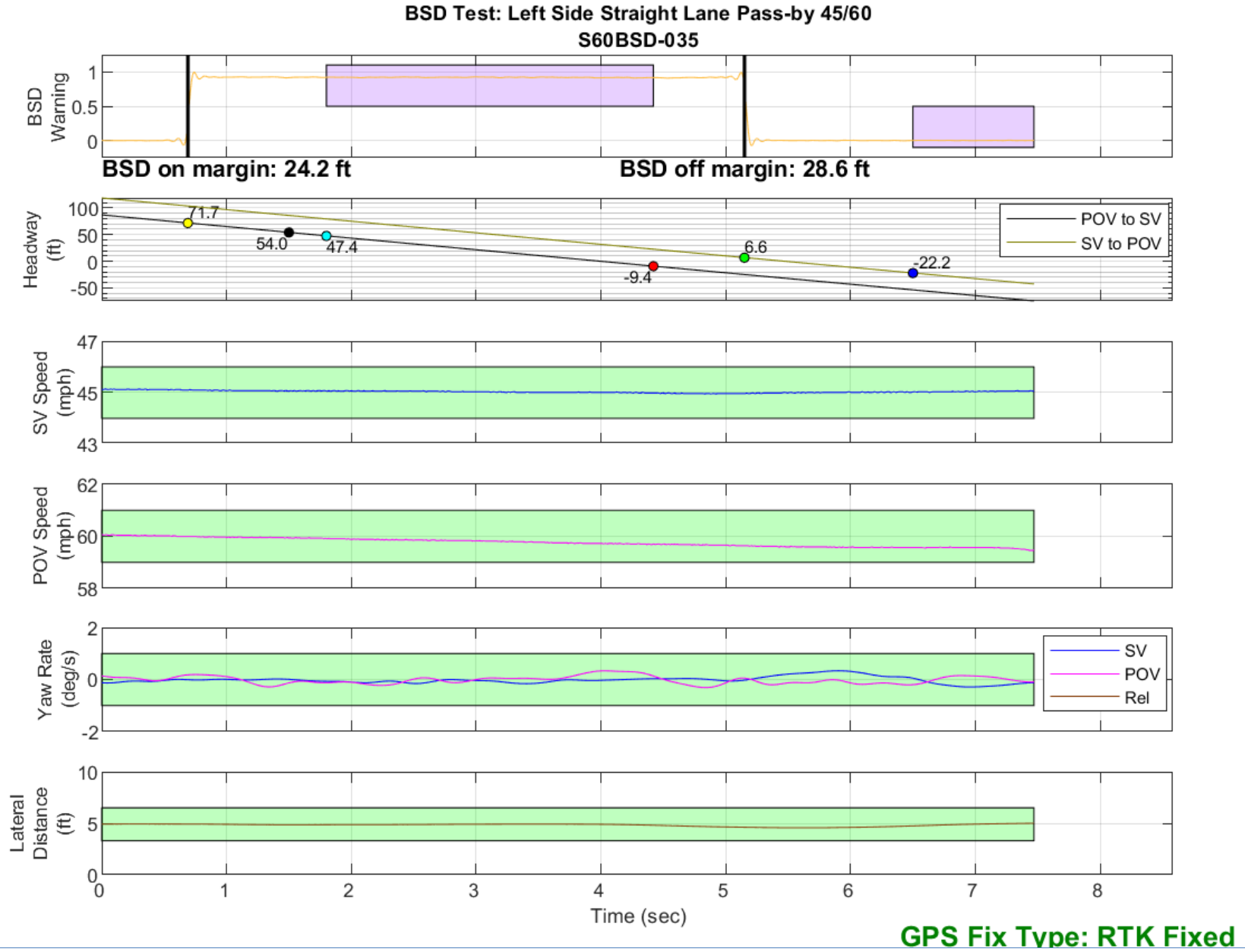


Figure D49. BSD Run 35, Straight Lane Pass-by, SV 45 mph, POV 60 mph

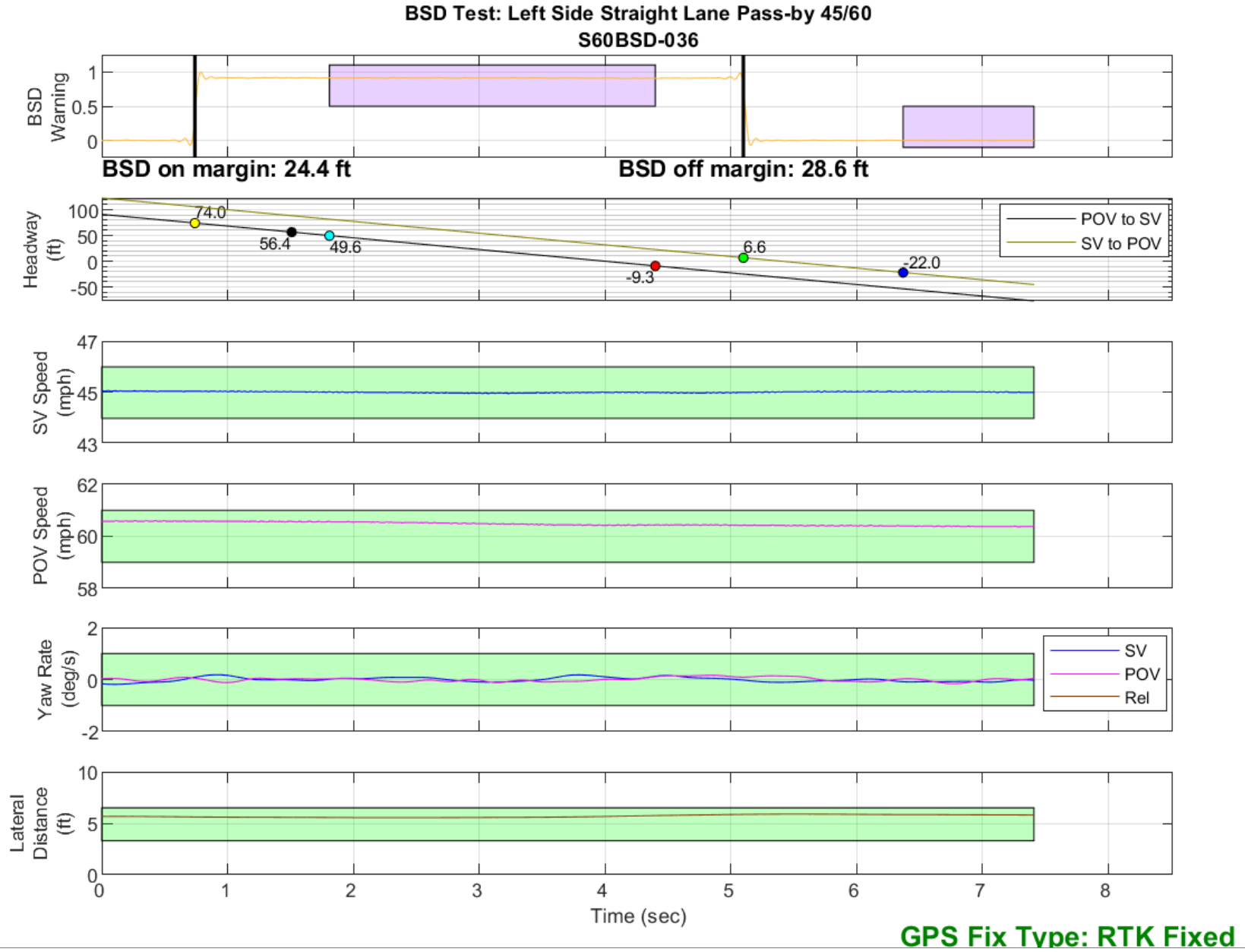


Figure D50. BSD Run 36, Straight Lane Pass-by, SV 45 mph, POV 60 mph

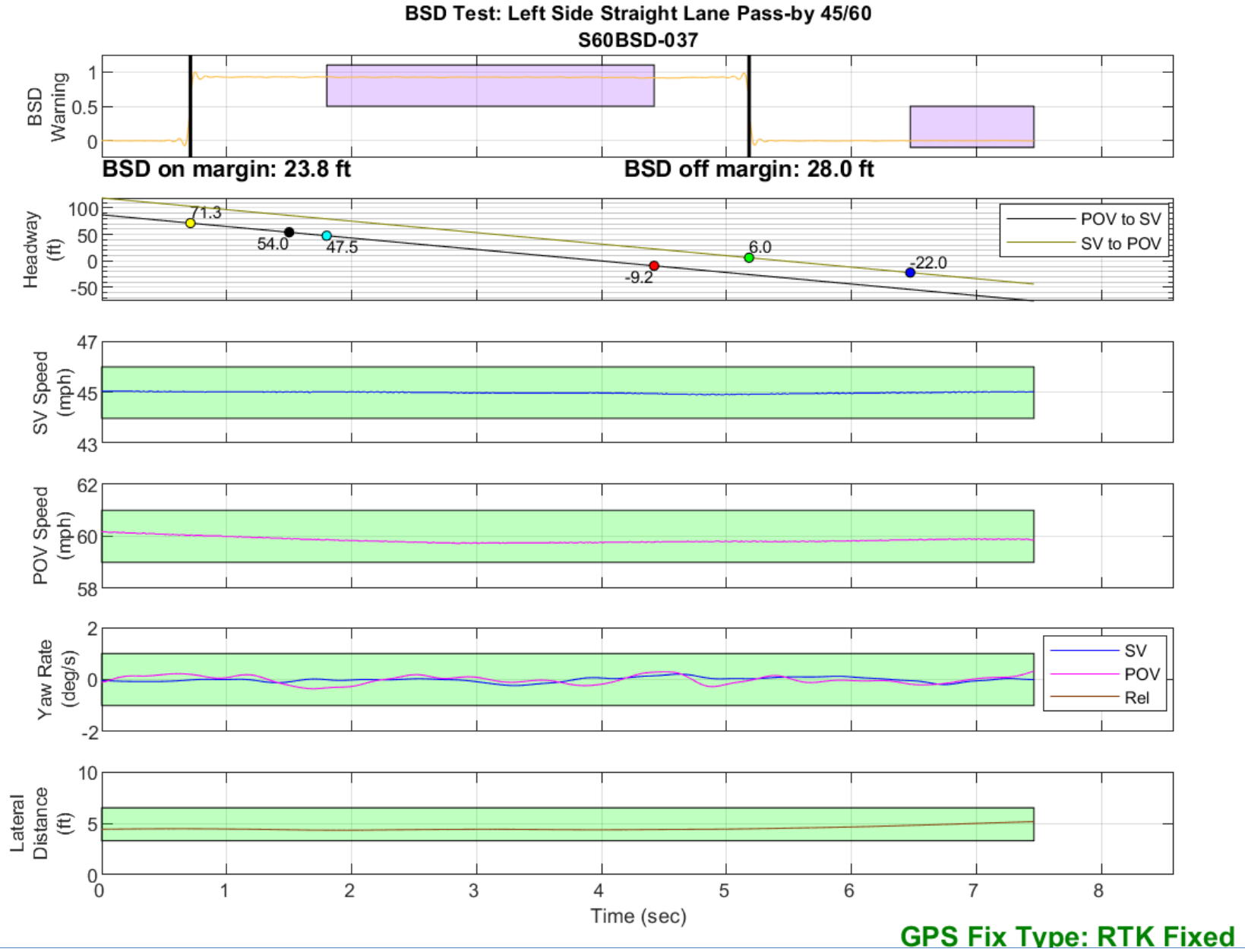


Figure D51. BSD Run 37, Straight Lane Pass-by, SV 45 mph, POV 60 mph

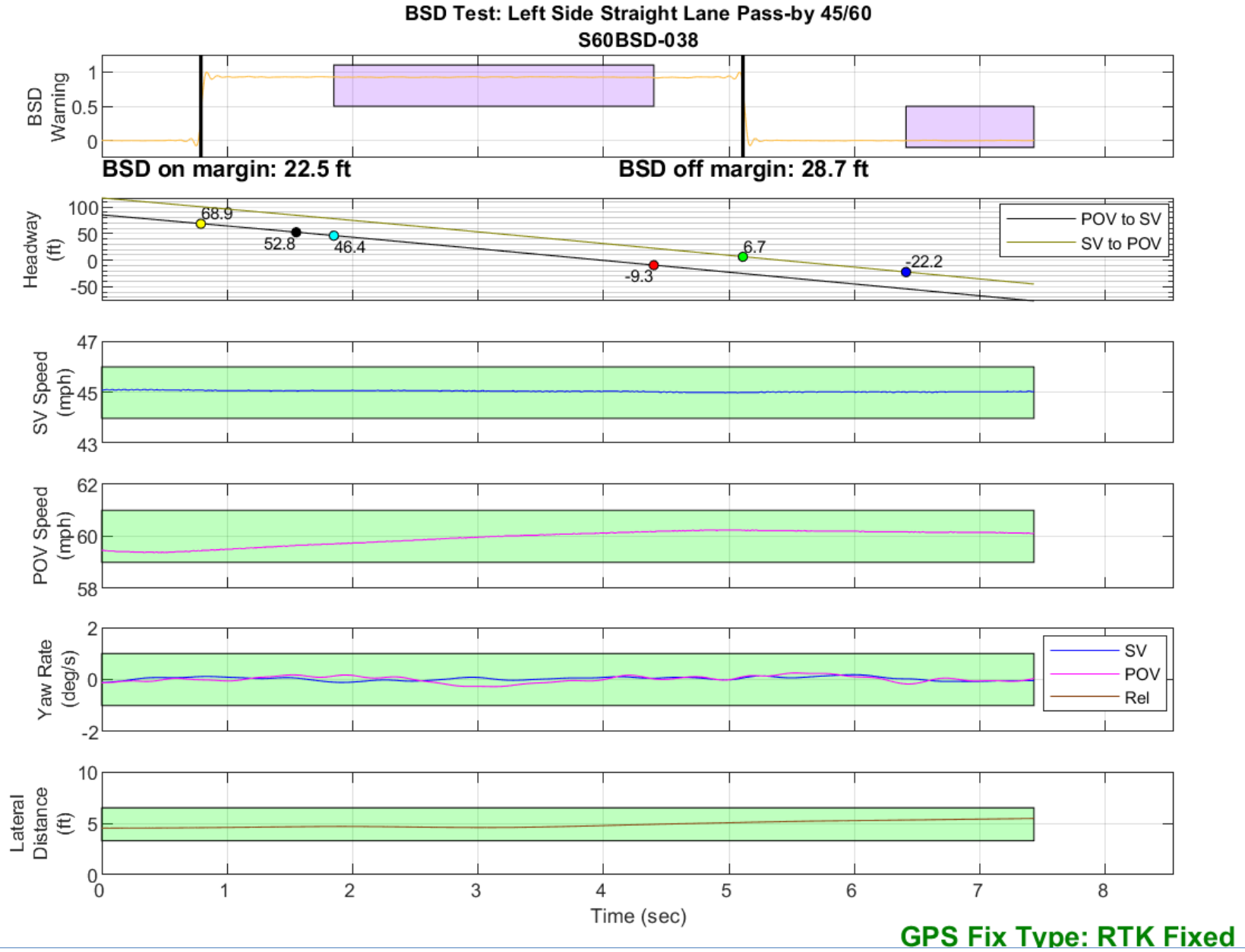


Figure D52. BSD Run 38, Straight Lane Pass-by, SV 45 mph, POV 60 mph

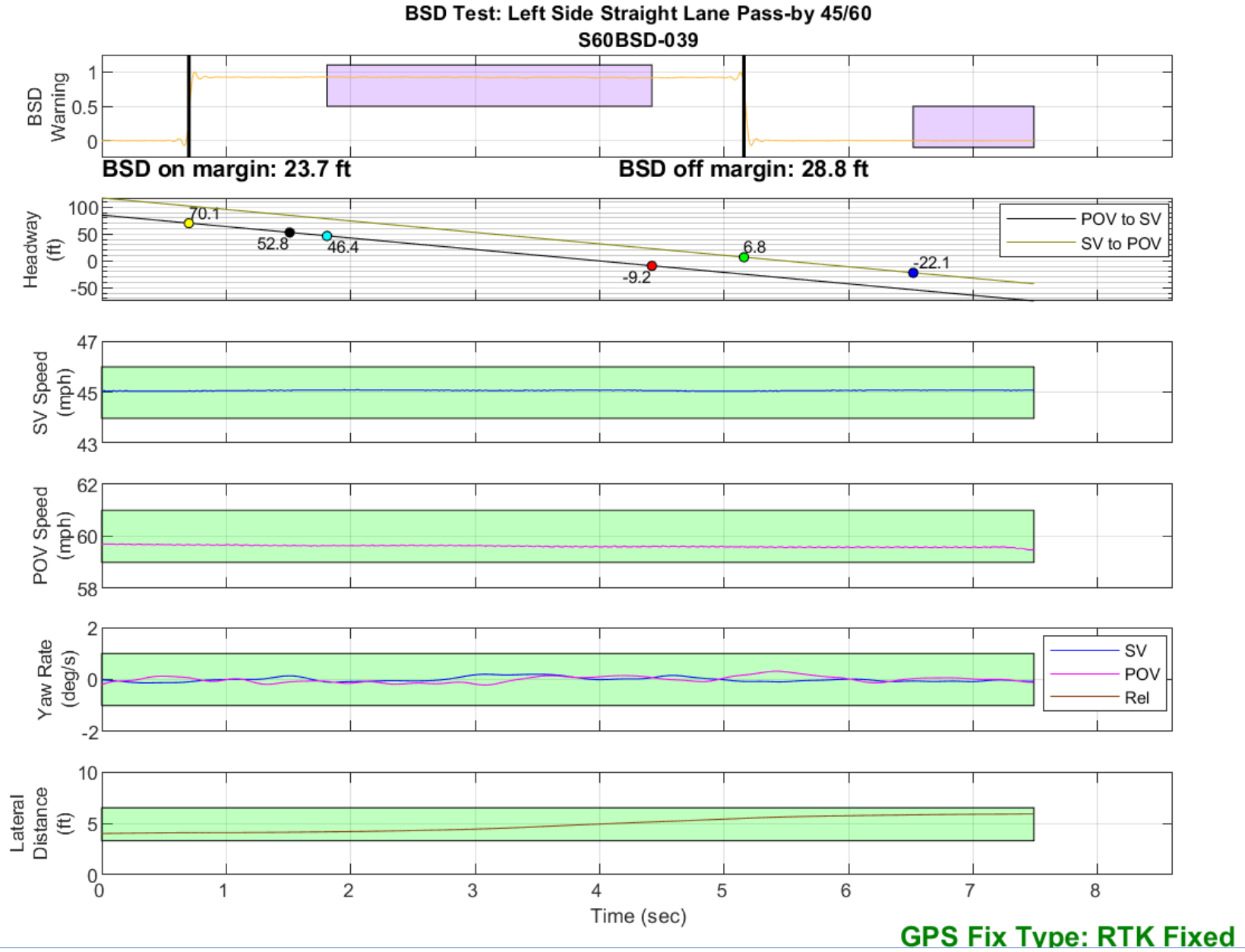


Figure D53. BSD Run 39, Straight Lane Pass-by, SV 45 mph, POV 60 mph

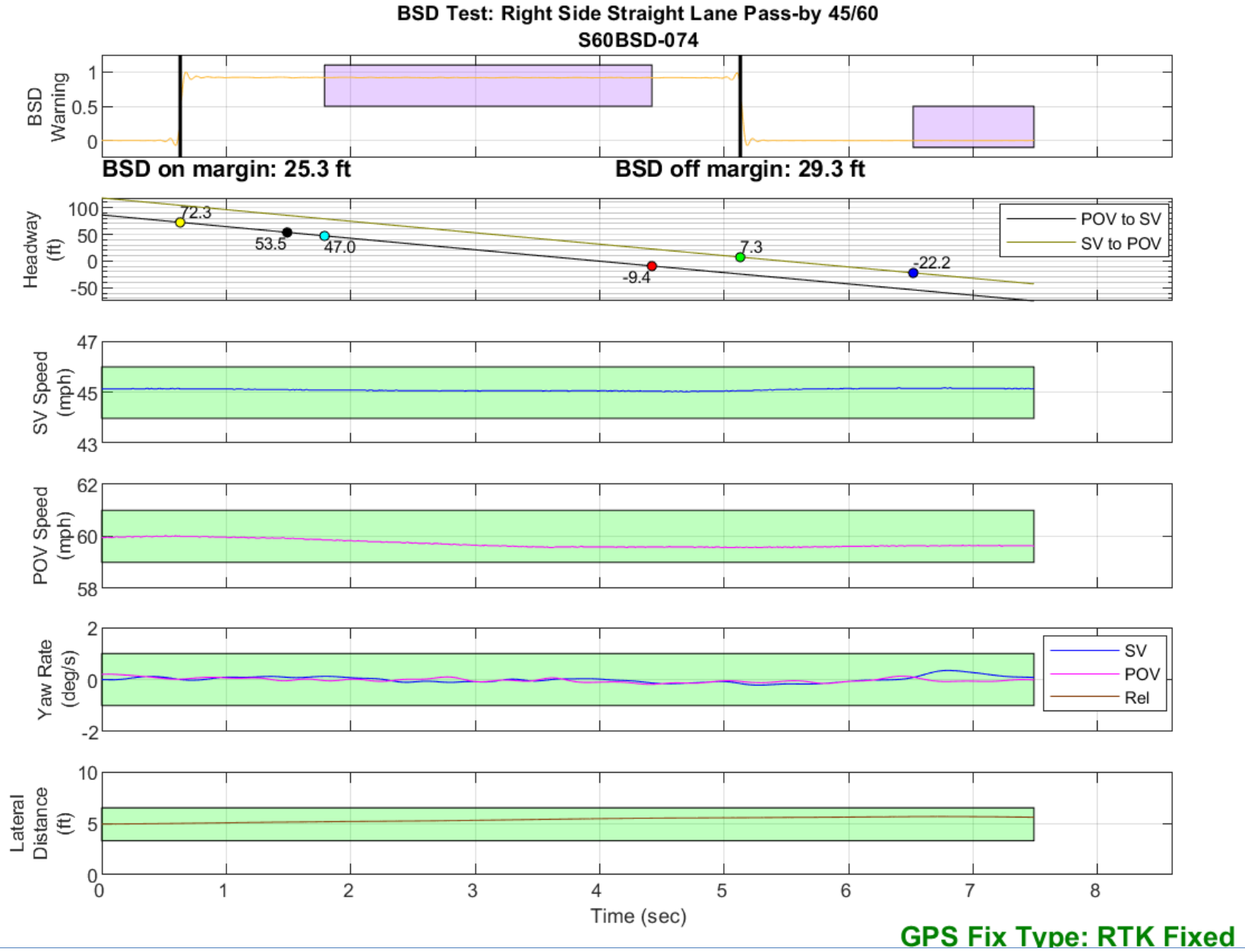


Figure D54. BSD Run 74, Straight Lane Pass-by, SV 45 mph, POV 60 mph

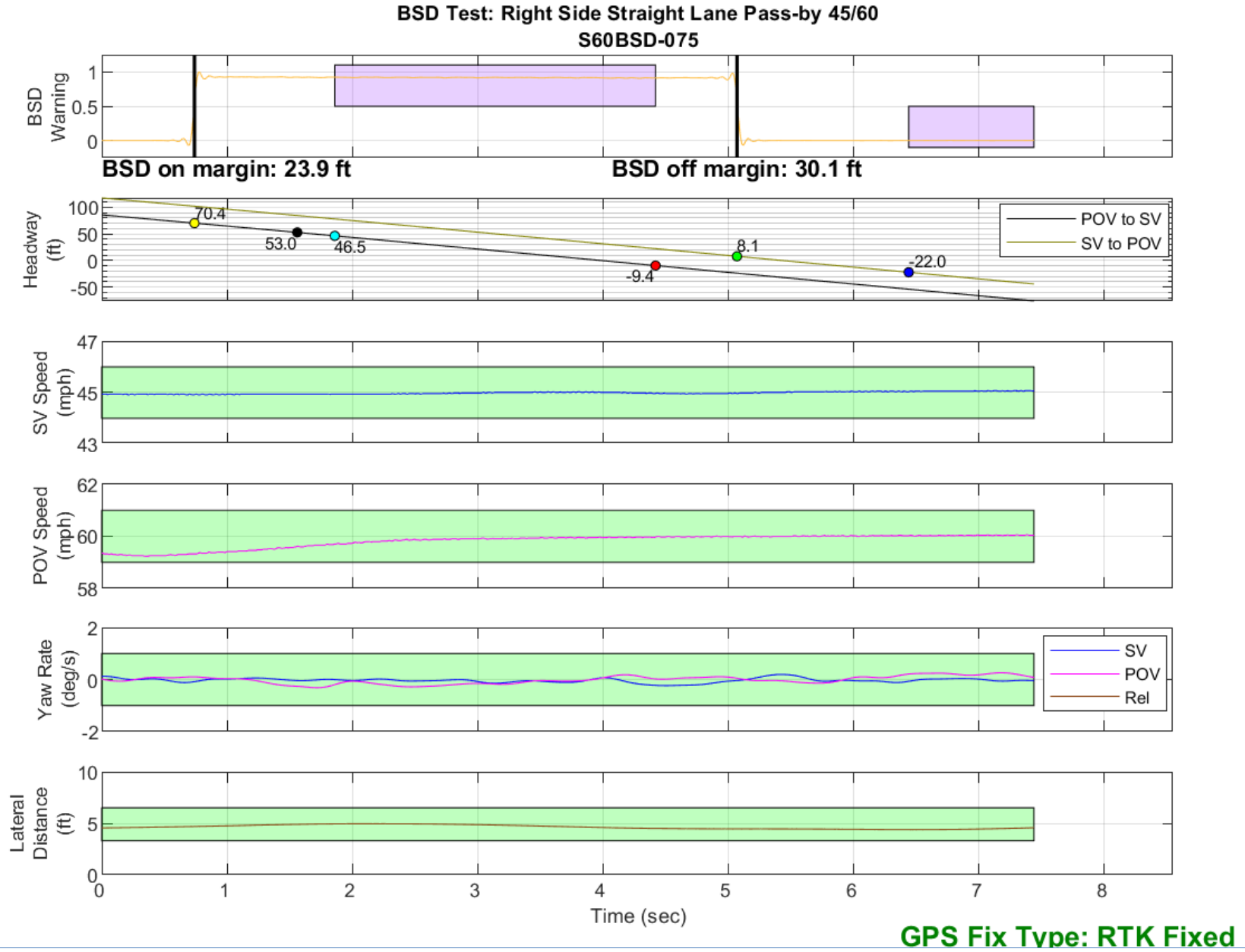


Figure D55. BSD Run 75, Straight Lane Pass-by, SV 45 mph, POV 60 mph

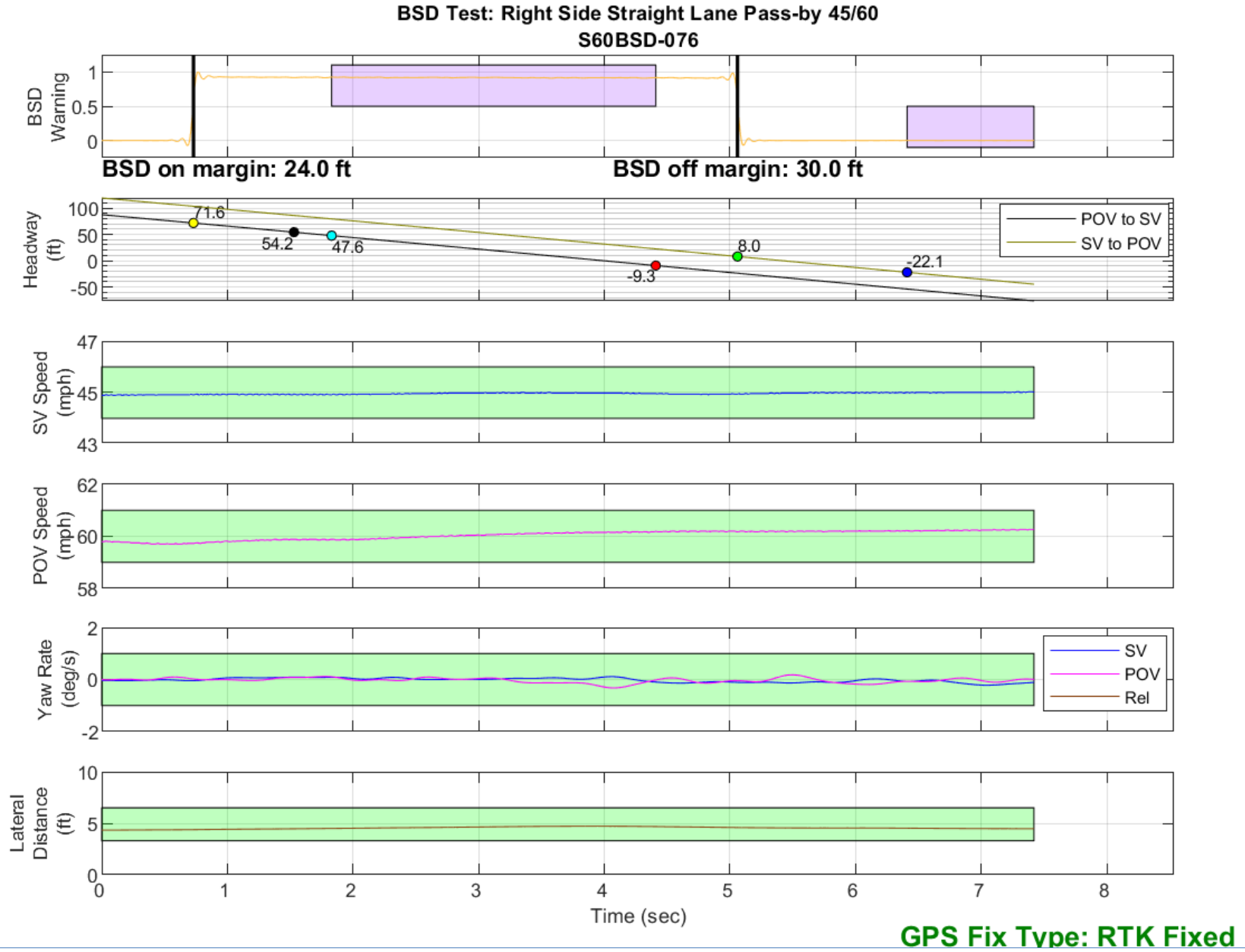


Figure D56. BSD Run 76, Straight Lane Pass-by, SV 45 mph, POV 60 mph

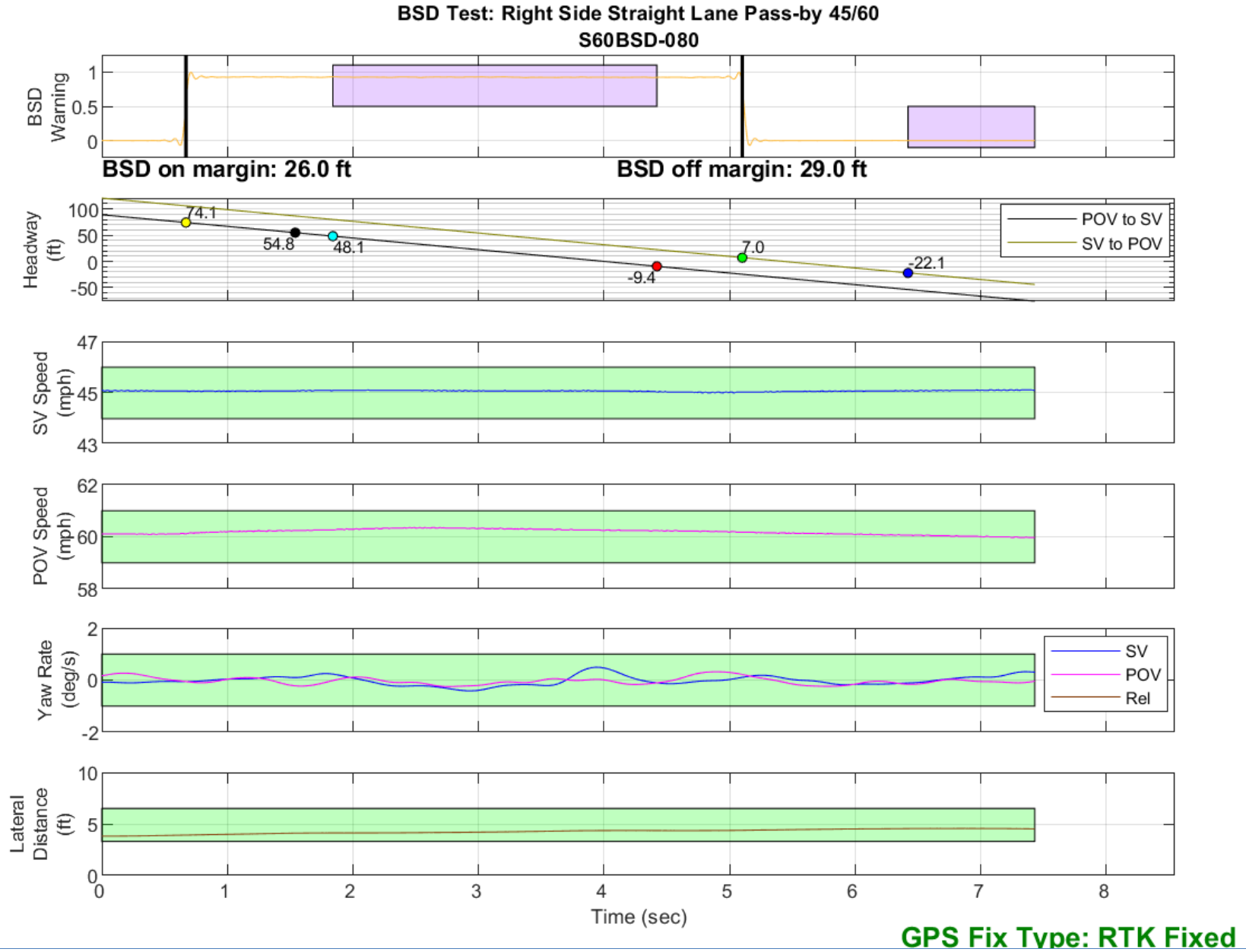


Figure D57. BSD Run 80, Straight Lane Pass-by, SV 45 mph, POV 60 mph

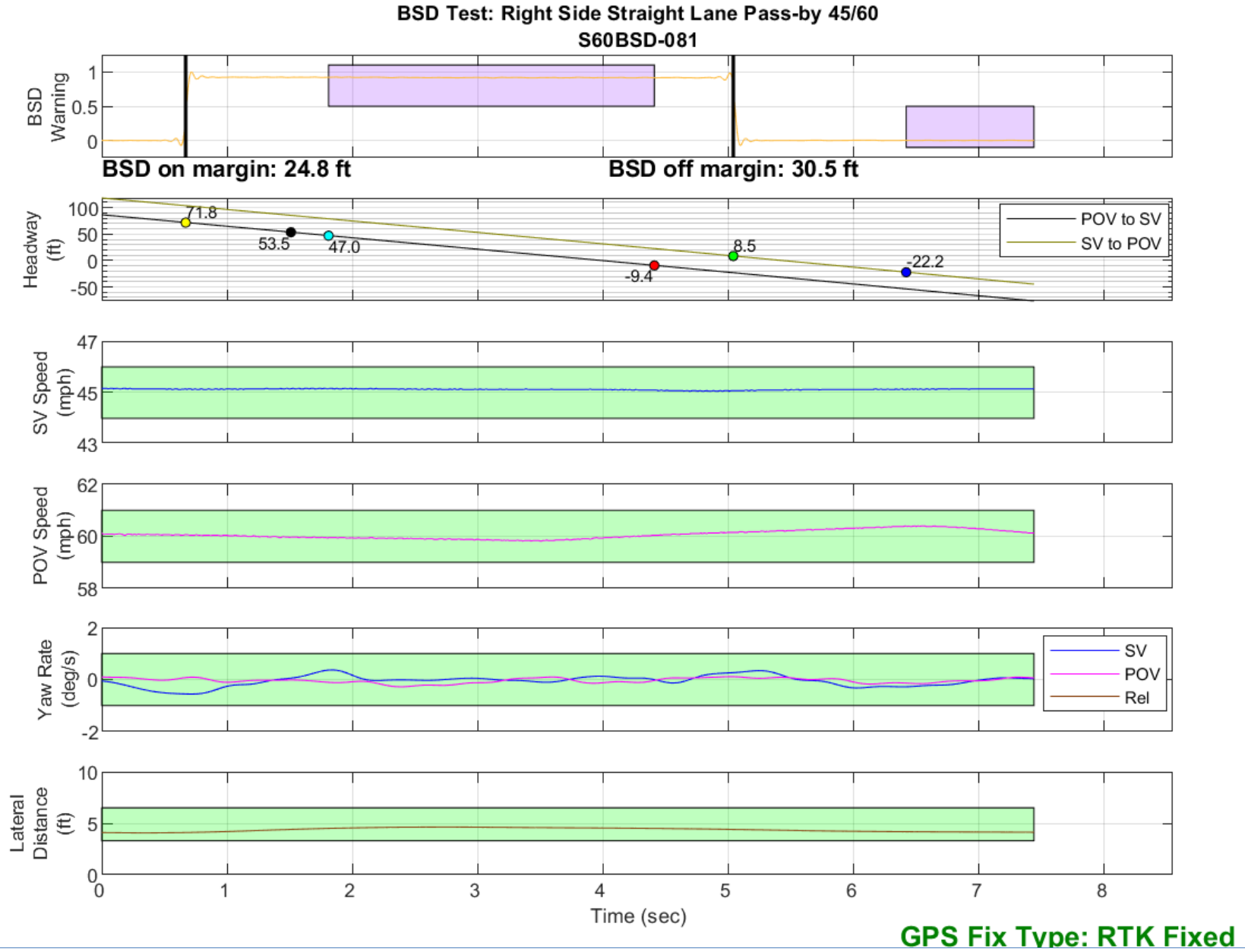


Figure D58. BSD Run 81, Straight Lane Pass-by, SV 45 mph, POV 60 mph

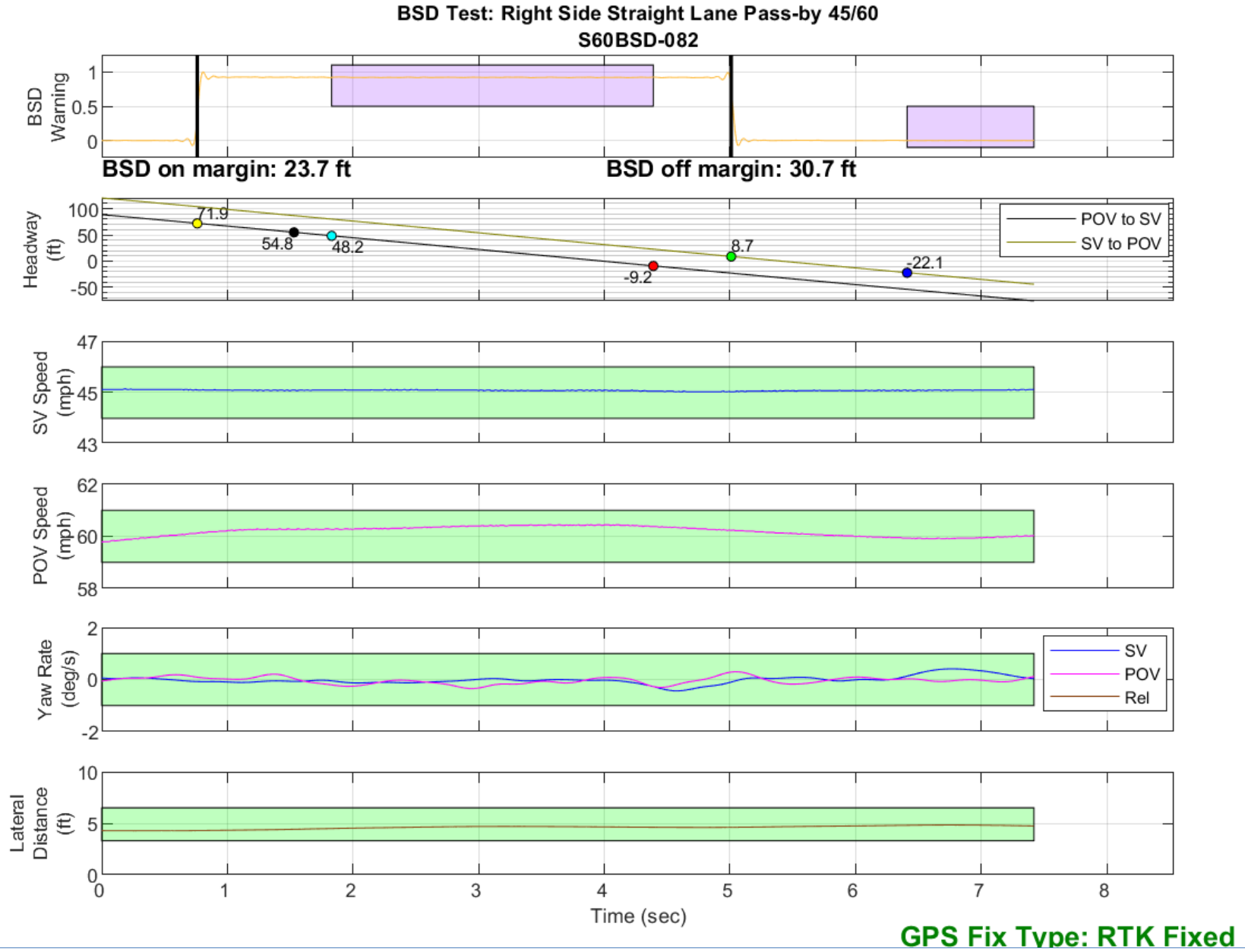


Figure D59. BSD Run 82, Straight Lane Pass-by, SV 45 mph, POV 60 mph

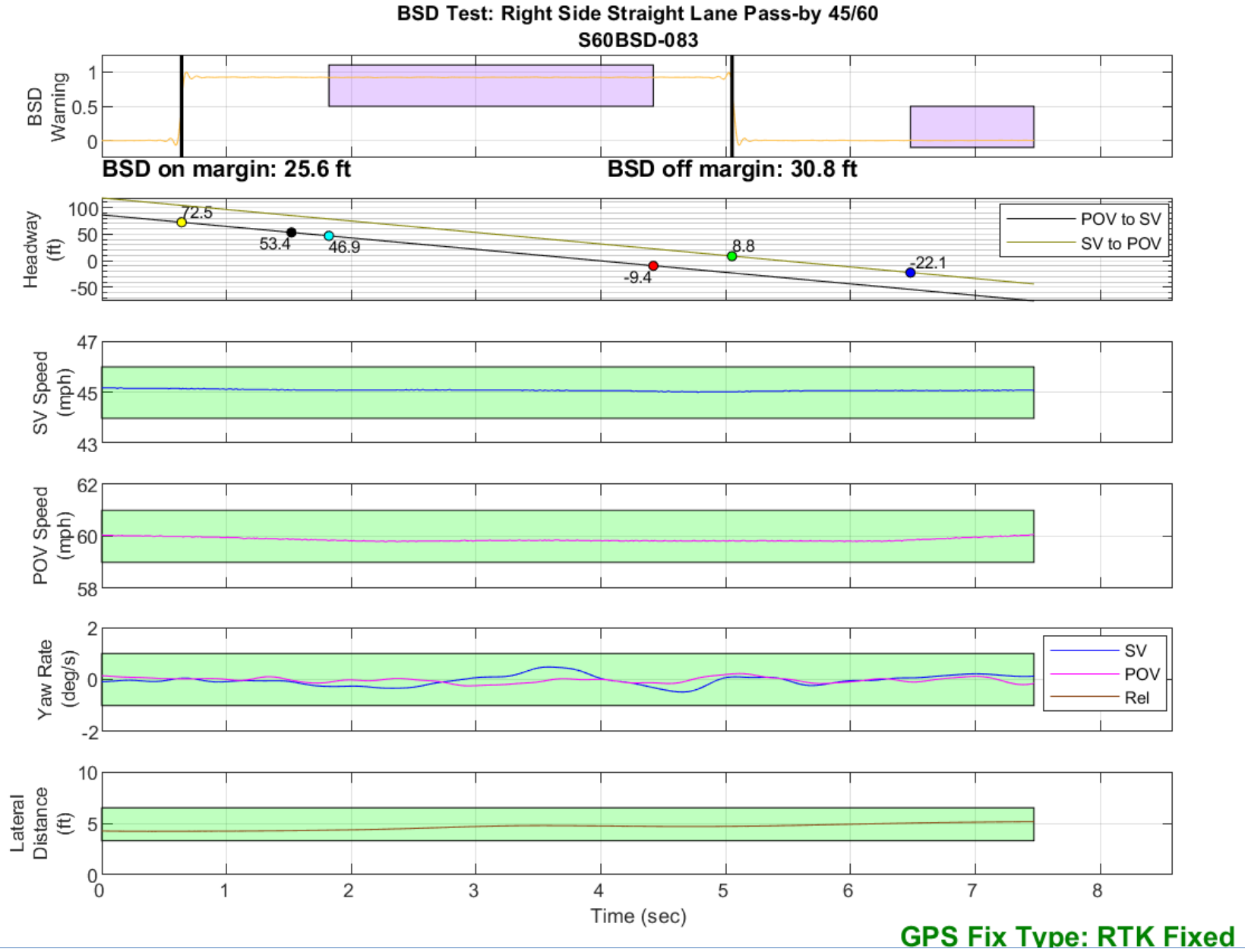


Figure D60. BSD Run 83, Straight Lane Pass-by, SV 45 mph, POV 60 mph

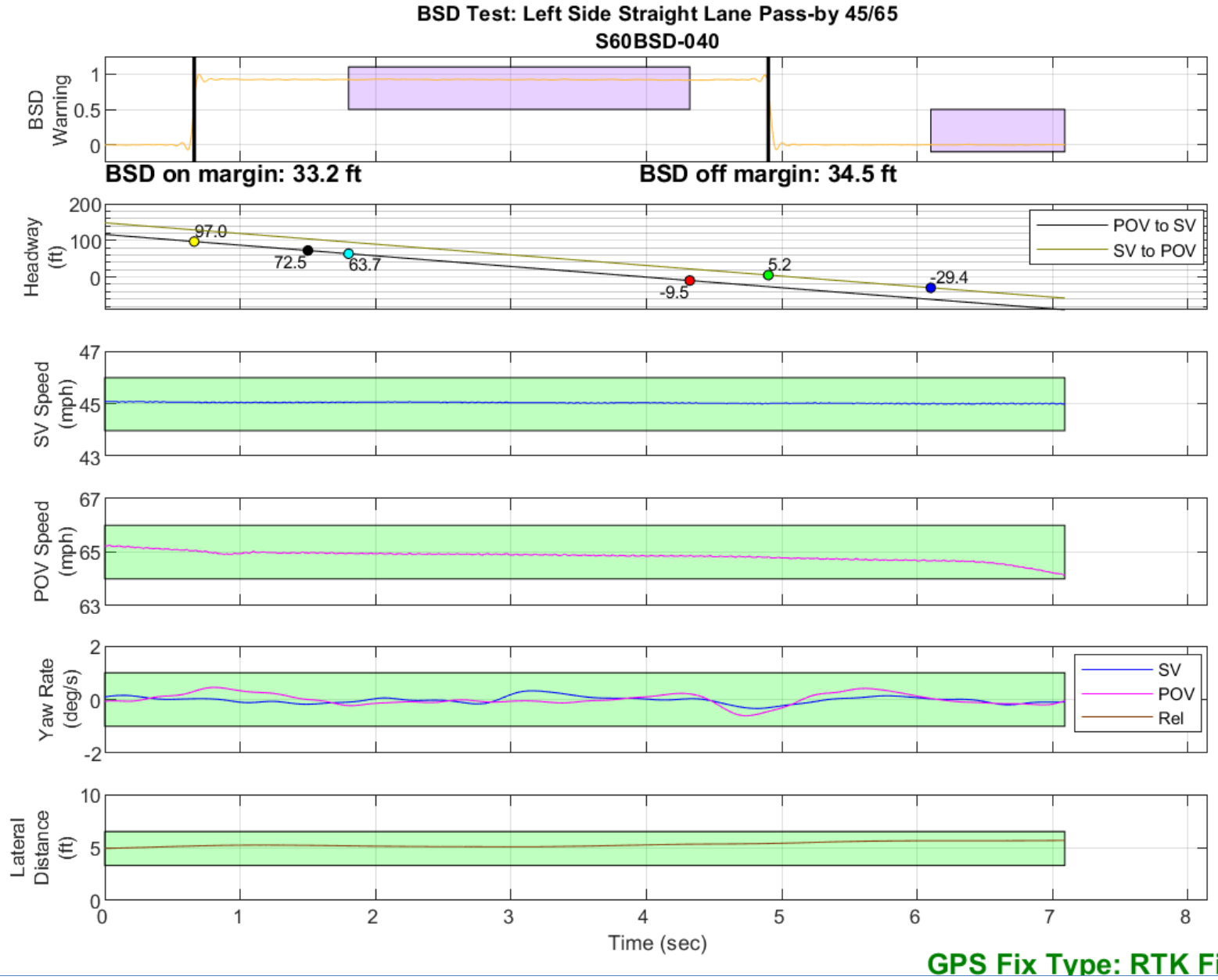


Figure D61. BSD Run 40, Straight Lane Pass-by, SV 45 mph, POV 65 mph

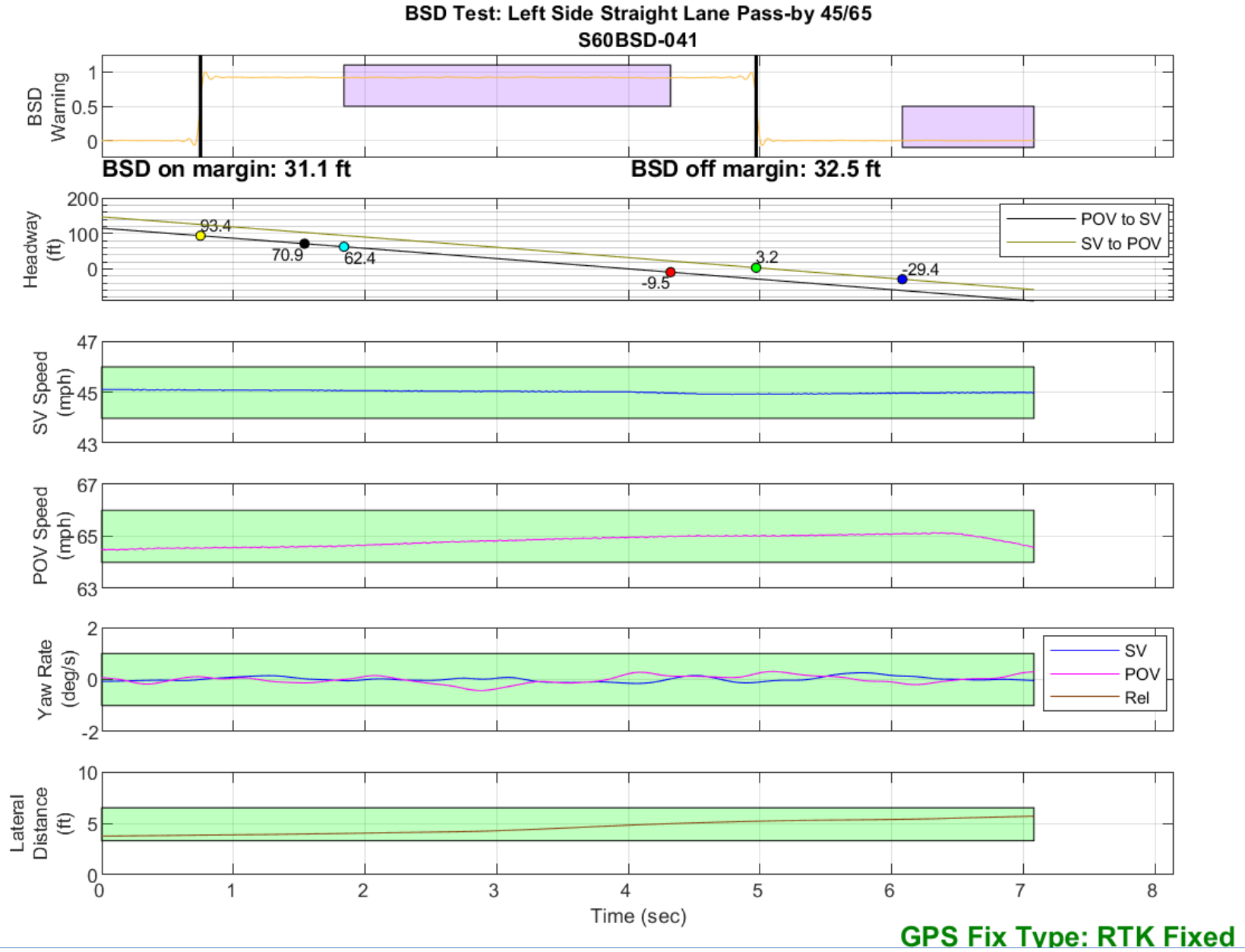


Figure D62. BSD Run 41, Straight Lane Pass-by, SV 45 mph, POV 65 mph

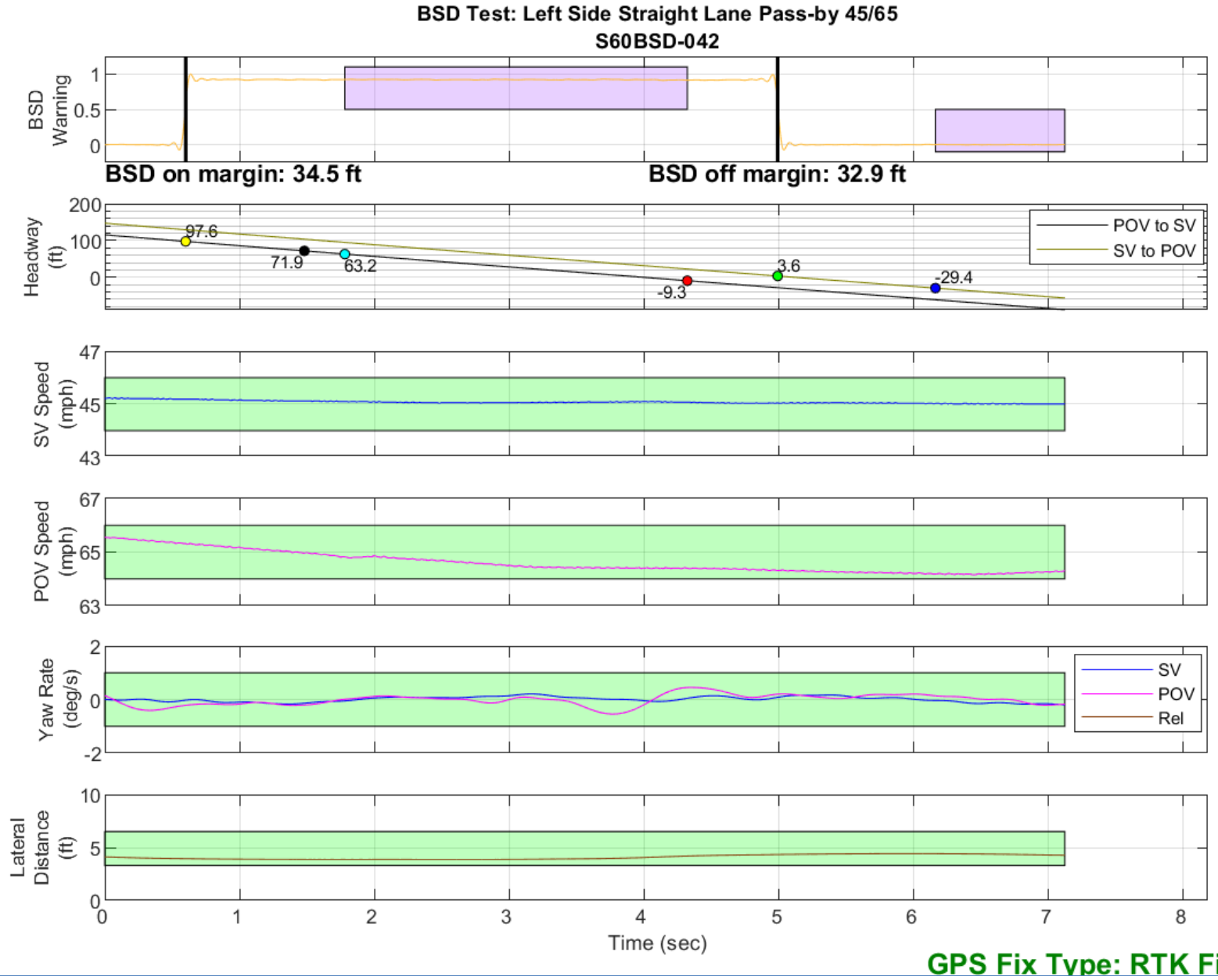


Figure D63. BSD Run 42, Straight Lane Pass-by, SV 45 mph, POV 65 mph

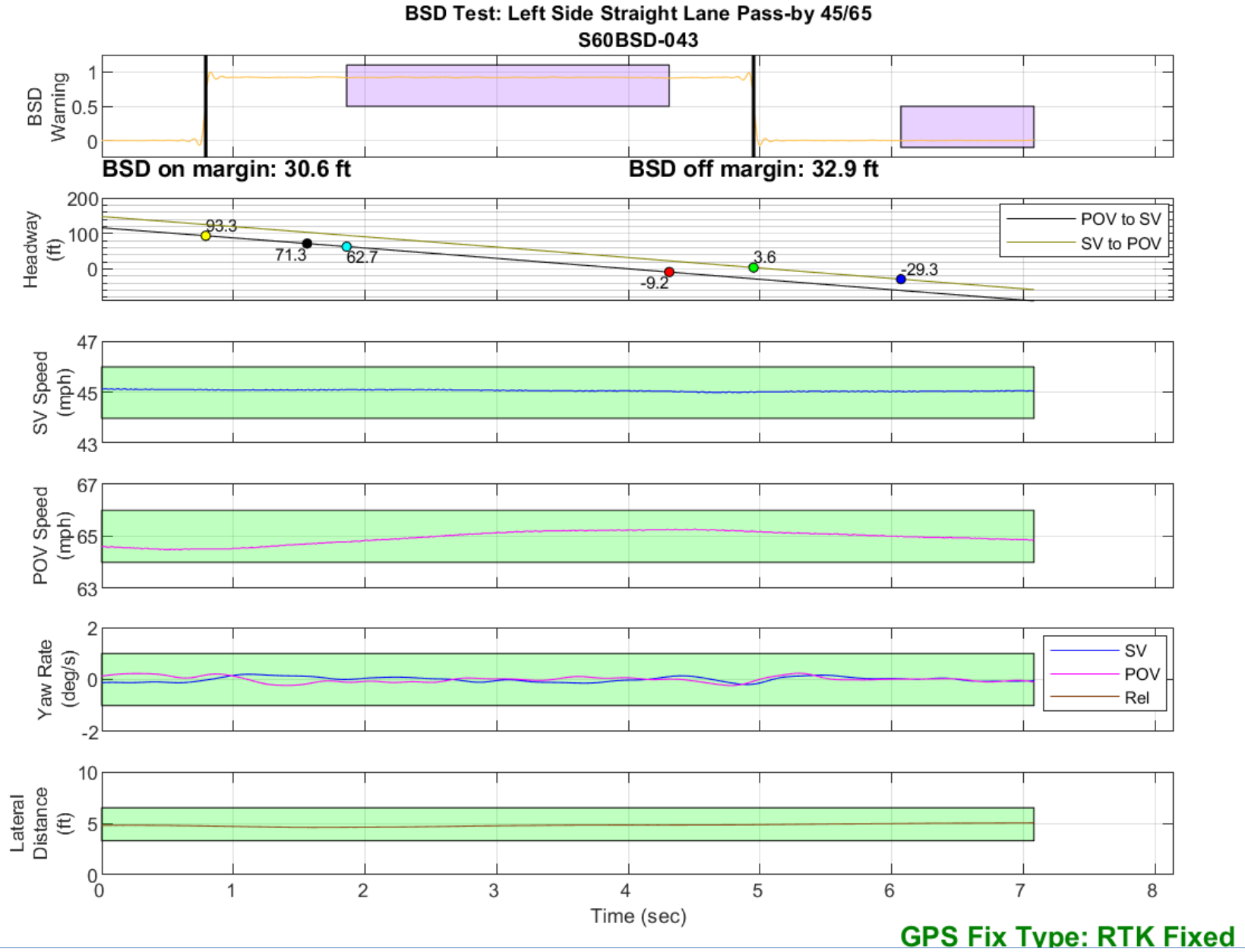


Figure D64. BSD Run 43, Straight Lane Pass-by, SV 45 mph, POV 65 mph

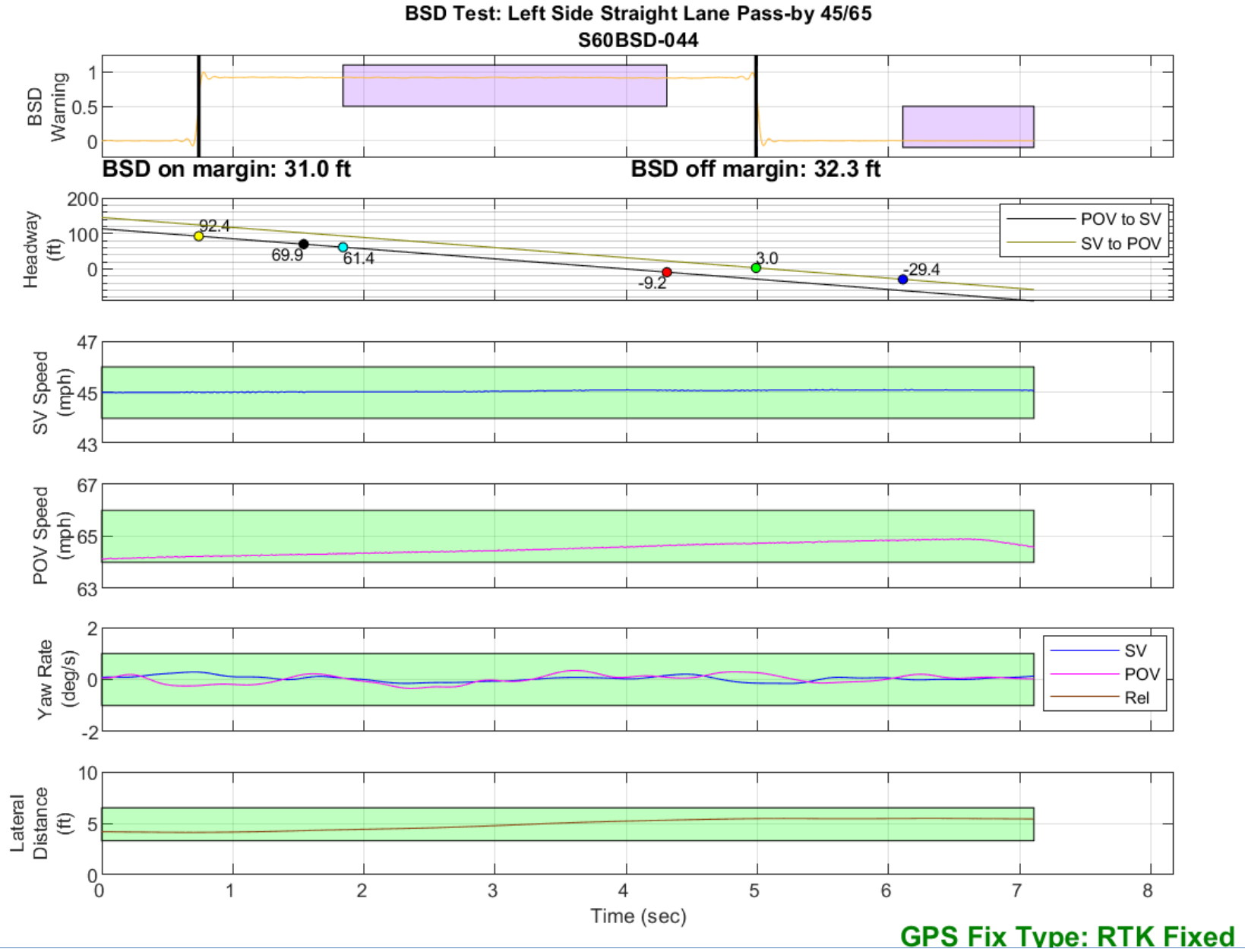


Figure D65. BSD Run 44, Straight Lane Pass-by, SV 45 mph, POV 65 mph

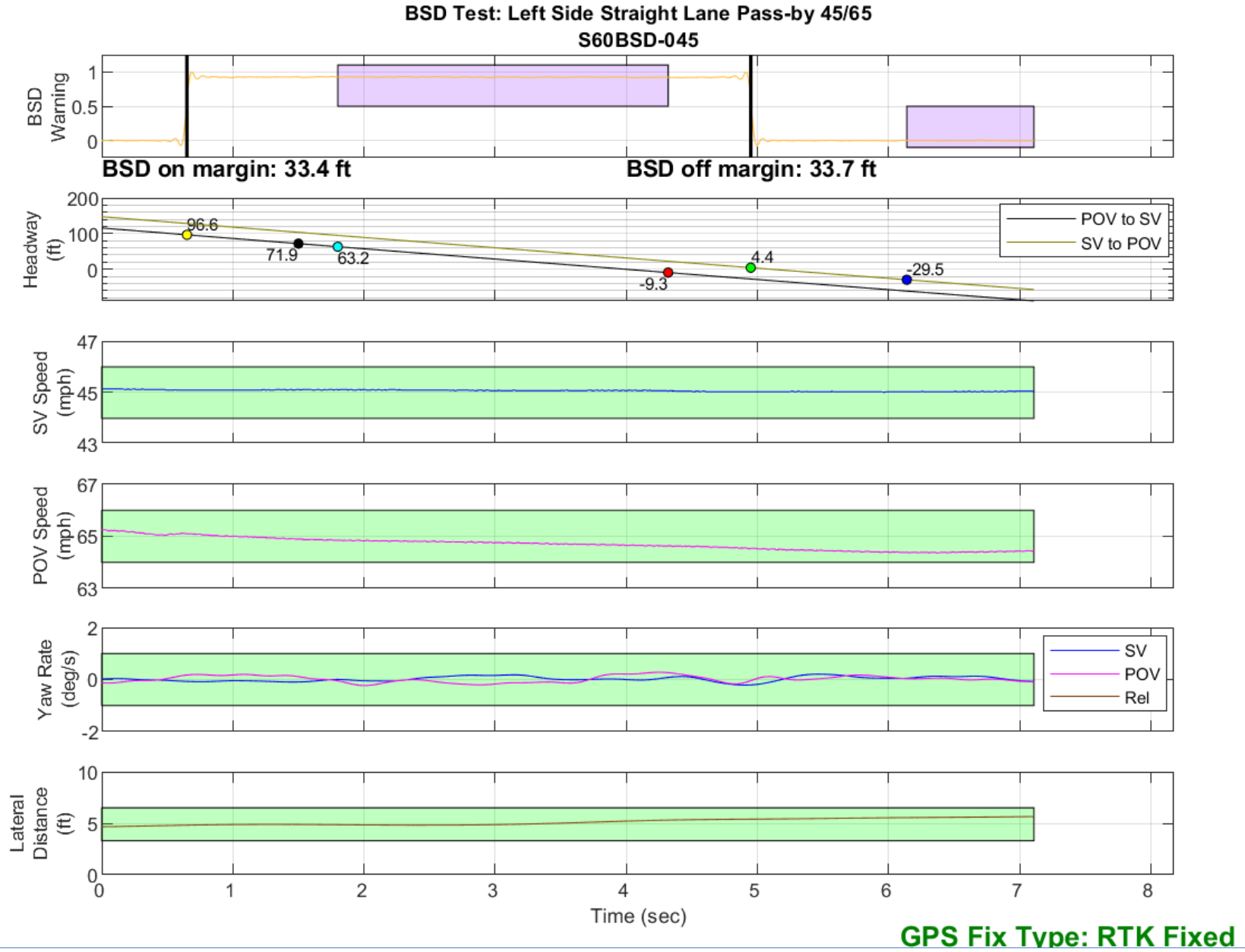


Figure D66. BSD Run 45, Straight Lane Pass-by, SV 45 mph, POV 65 mph

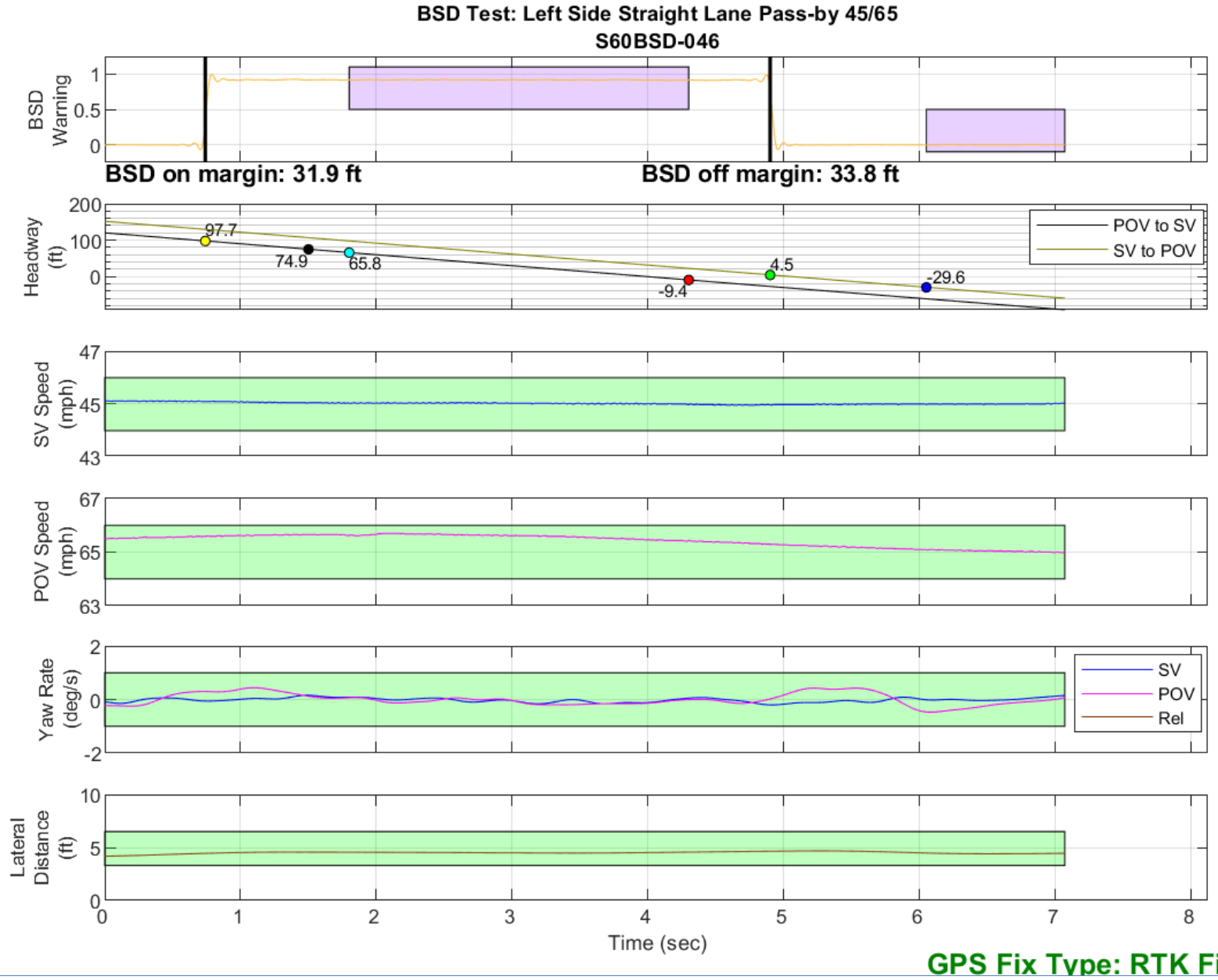


Figure D67. BSD Run 46, Straight Lane Pass-by, SV 45 mph, POV 65 mph

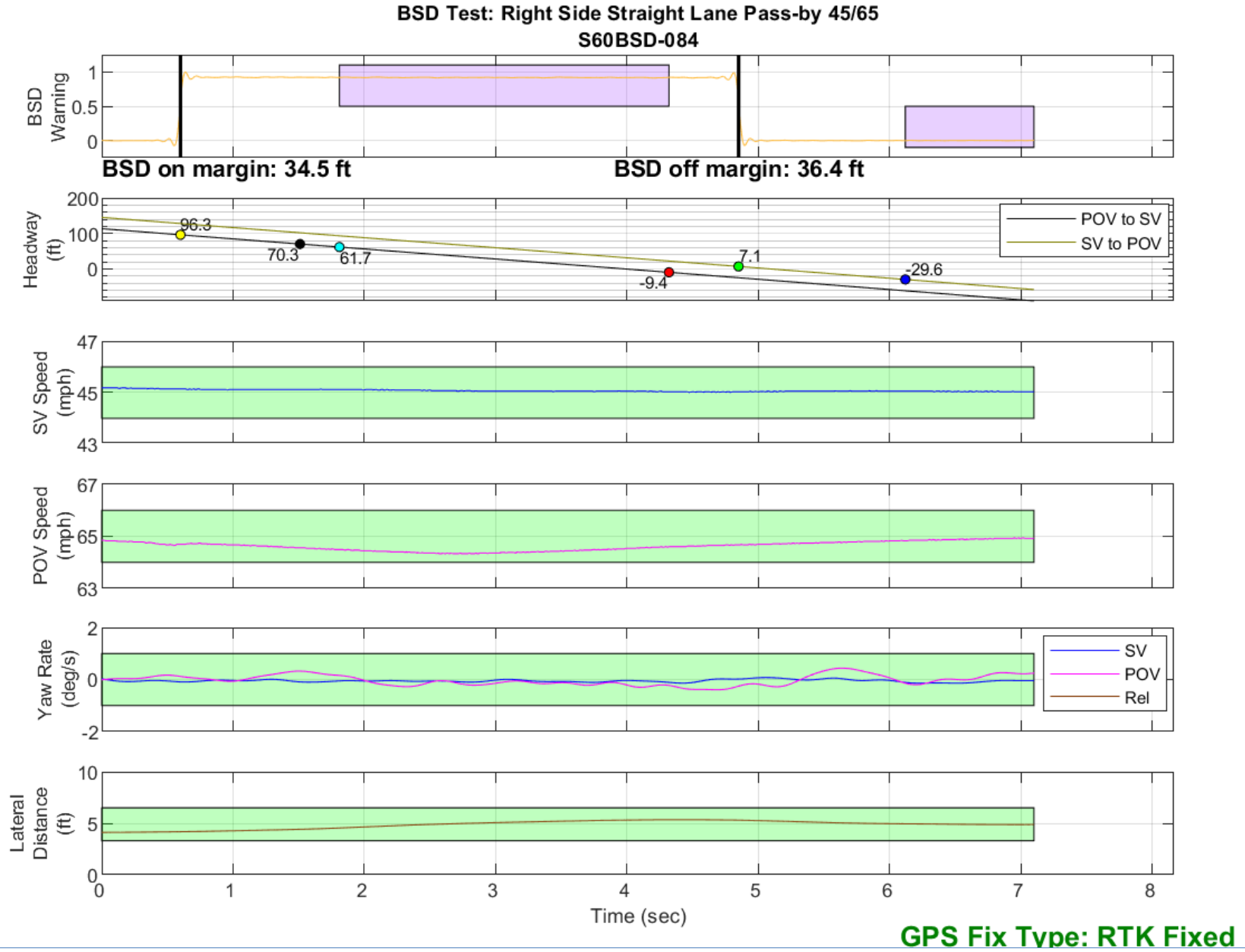


Figure D68. BSD Run 84, Straight Lane Pass-by, SV 45 mph, POV 65 mph

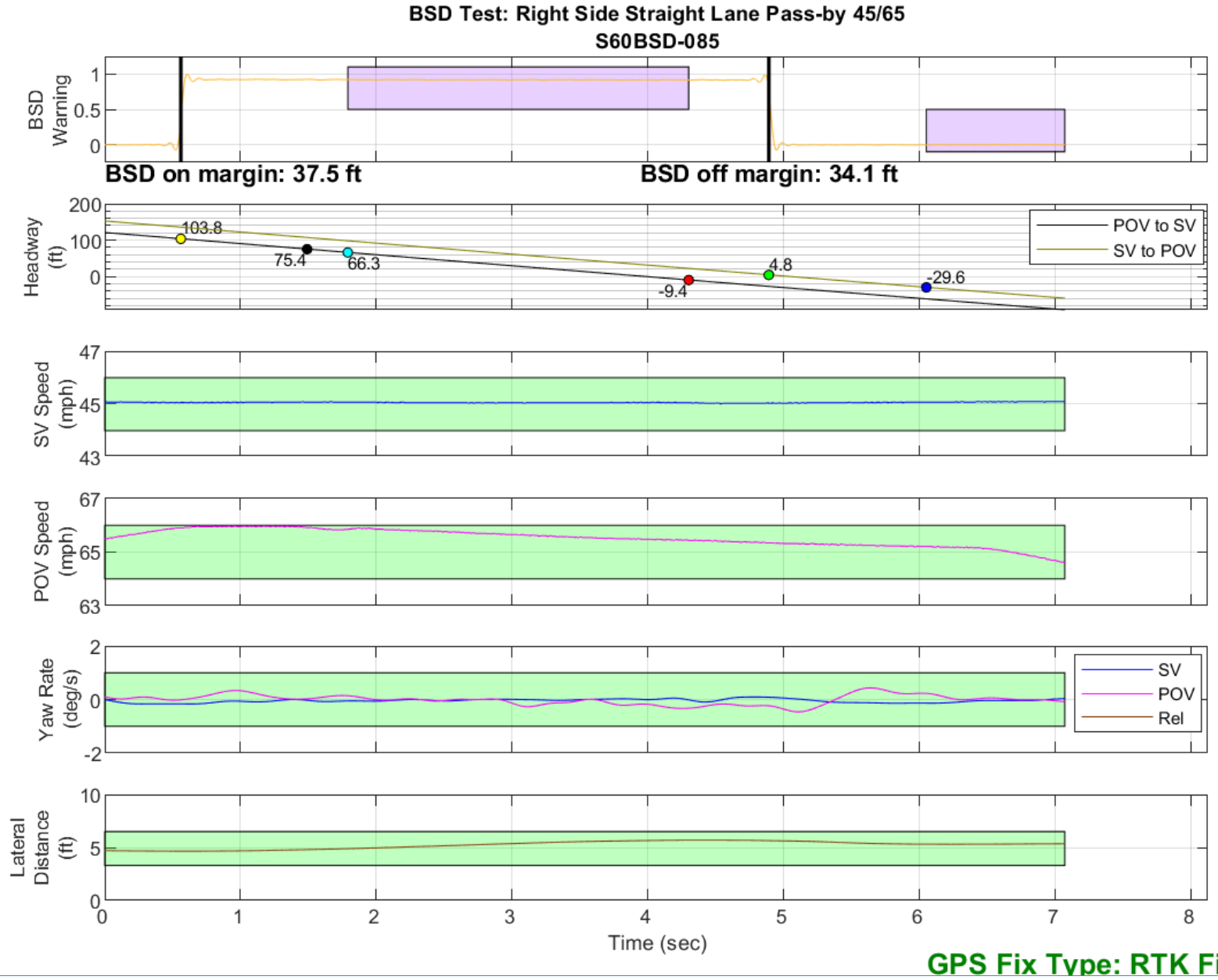


Figure D69. BSD Run 85, Straight Lane Pass-by, SV 45 mph, POV 65 mph

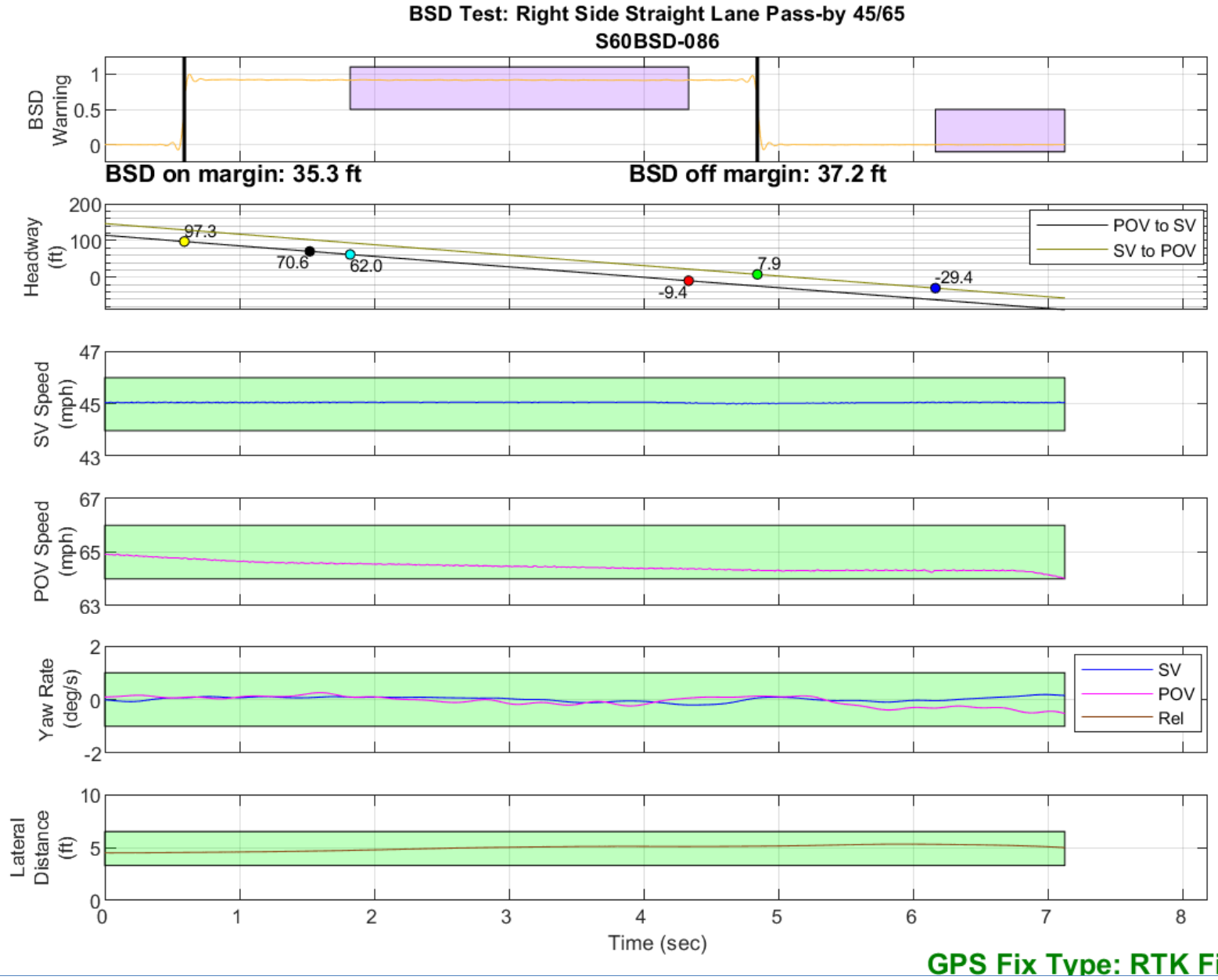


Figure D70. BSD Run 86, Straight Lane Pass-by, SV 45 mph, POV 65 mph

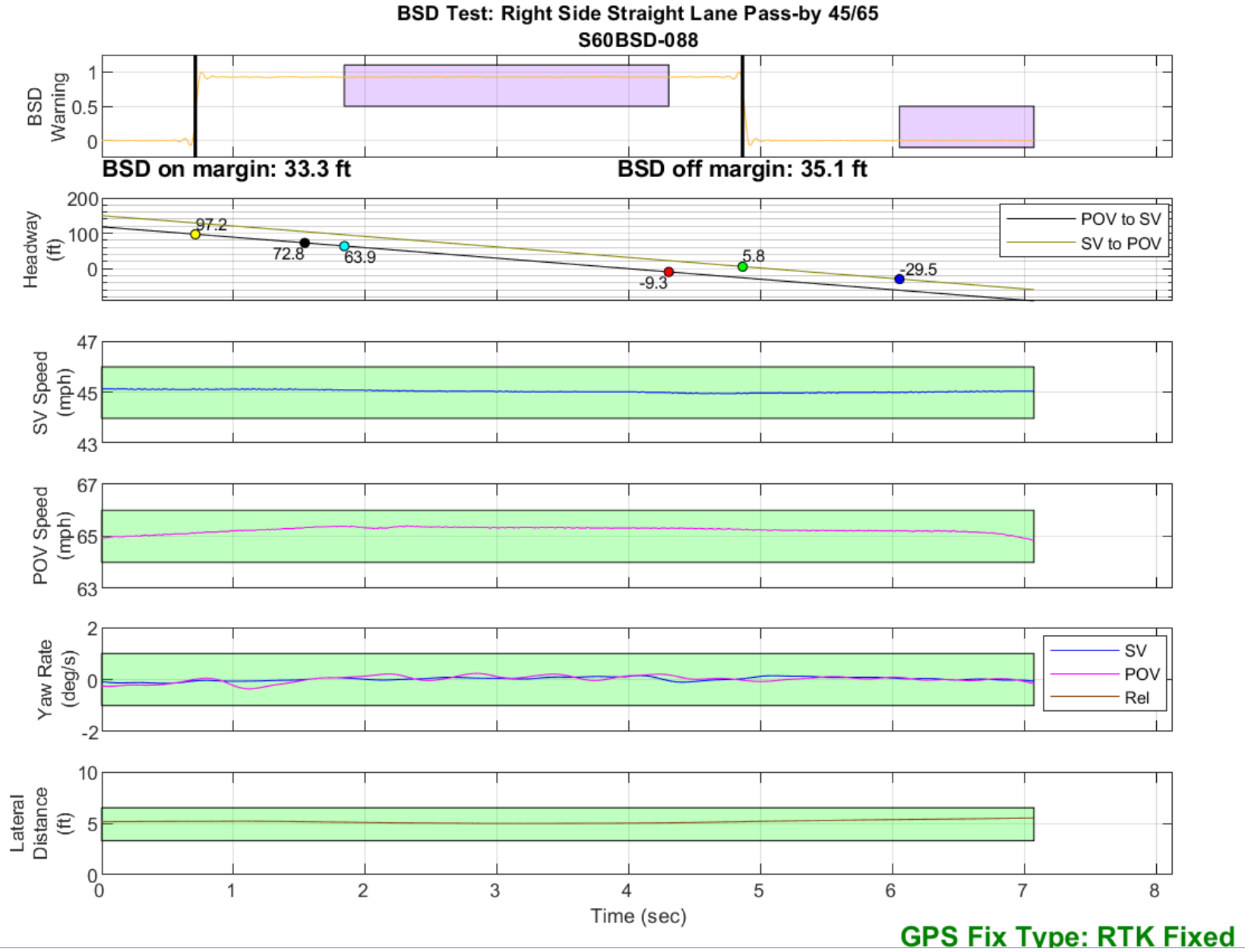


Figure D71. BSD Run 88, Straight Lane Pass-by, SV 45 mph, POV 65 mph

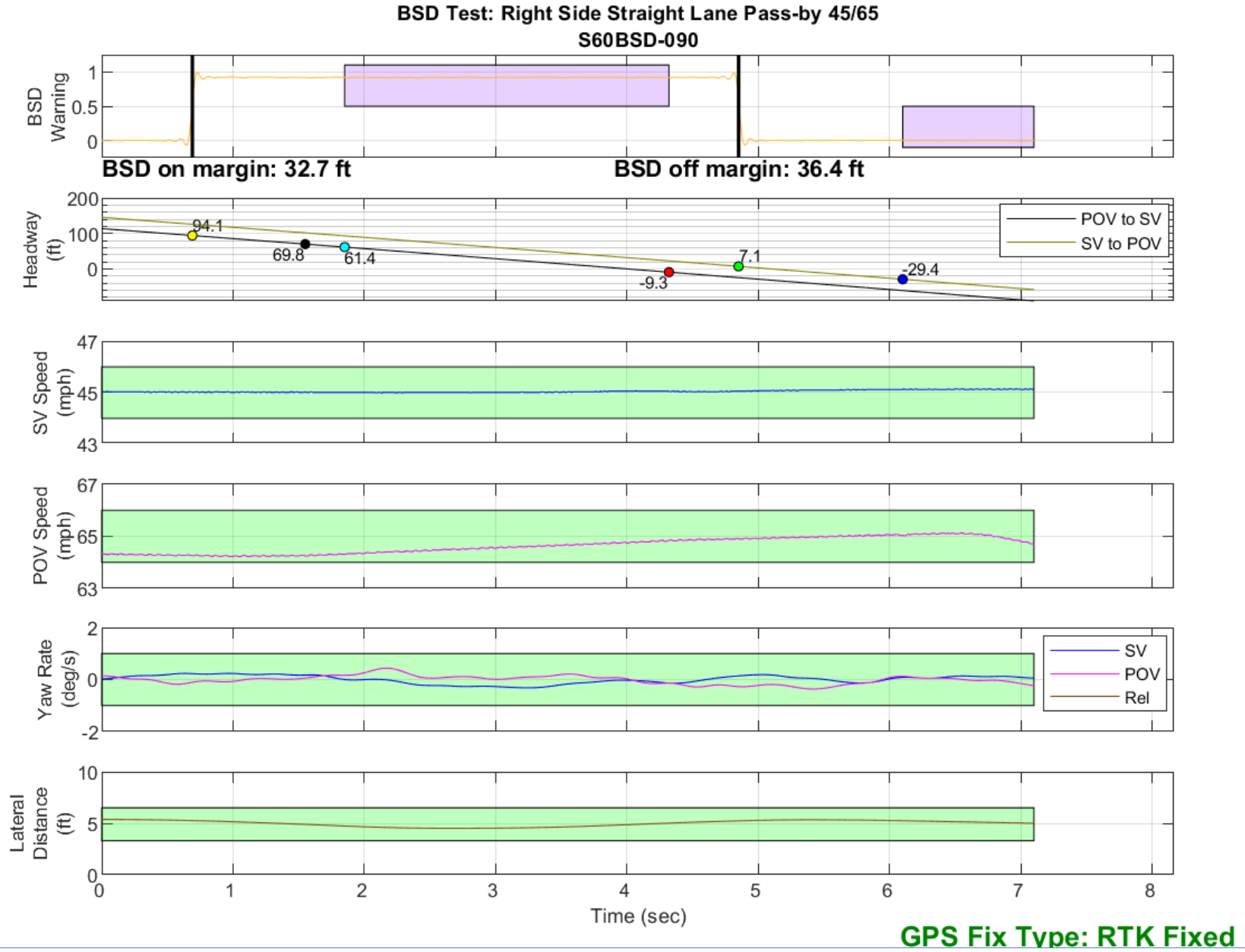


Figure D72. BSD Run 90, Straight Lane Pass-by, SV 45 mph, POV 65 mph

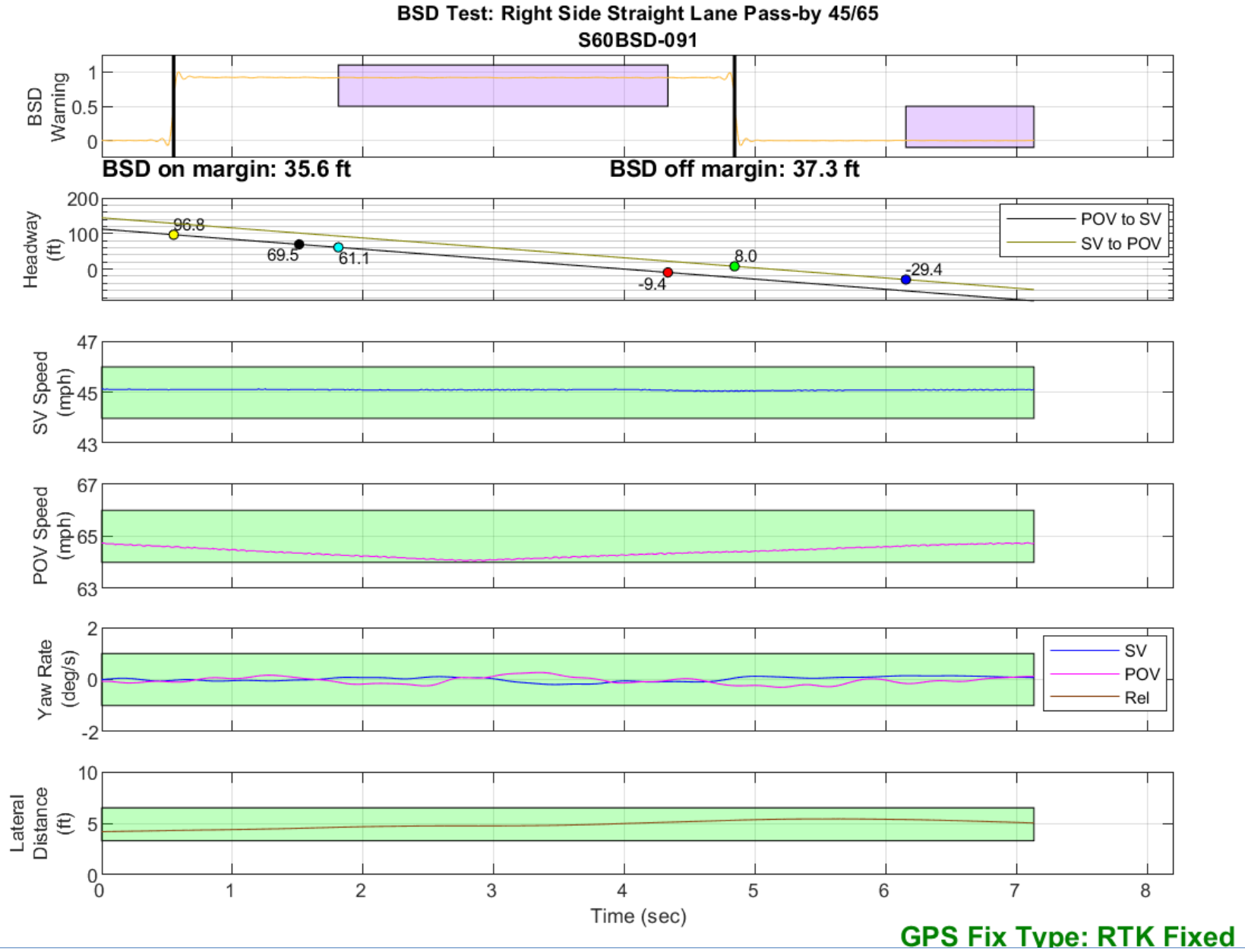


Figure D73. BSD Run 91, Straight Lane Pass-by, SV 45 mph, POV 65 mph