BLIND SPOT DETECTION SYSTEM RESEARCH TEST
NCAP-DRI-BSD-20-01

2019 Audi A6 55 TFSI (3.0T) quattro

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18 December 2020

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 2019 Audi A6 55 TFSI (3.0T) quattro 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 preliminary BSD requirements were met for 55 out of 64 valid trials.			
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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's (SV's) 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) a 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's 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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2019 Audi A6 55 TFSI (3.0T) quattro

VIN: *WAUL2AF2XKN04xxxx*

Test Date: *10/12/2020*

System Setting: *Side Assist 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	*5*	*2*	*7*
45 mph - Right	*0*	*7*	*7*
Overall Test 1:	*5*	*9*	*14*
Test 2 - Straight Lane Pass-by			
POV 50 mph - Left	*7*	*0*	*7*
POV 50 mph - Right	*7*	*0*	*7*
POV 55 mph - Left	*6*	*0*	*6*
POV 55 mph - Right	*6*	*0*	*6*
POV 60 mph - Left	*7*	*0*	*7*
POV 60 mph - Right	*7*	*0*	*7*
POV 65 mph - Left	*3*	*0*	*3*
POV 65 mph - Right	*7*	*0*	*7*
Overall Test 2:	*50*	*0*	*50*
Overall:	***55***	***9***	***64***

[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

(Page 1 of 1)

2019 Audi A6 55 TFSI (3.0T) quattro

TEST VEHICLE INFORMATION

VIN: *WAUL2AF2XKN04xxxx*

Body Style: *Sedan* Color: *Vesuvius Gray Metallic*

Date Received: *8/24/2020* Odometer Reading: *2143 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Audi AG*

Date of manufacture: *11 18*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *255/40 R20 101 H*

Rear: *255/40 R20 101 H*

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

Rear: *260 kPa (38 psi)*

TIRES

Tire manufacturer and model: *Michelin Primacy MXM4*

Front tire size: *255/40 R20 101H*

Rear tire size: *255/40 R20 101H*

Front tire DOT prefix: *F3L2 00LX*

Rear tire DOT prefix: *F3L2 00LX*

BLIND SPOT DETECTION

DATA SHEET 3: TEST CONDITIONS

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2019 Audi A6 55 TFSI (3.0T) quattro

GENERAL INFORMATION

Test date: *10/12/2020*

AMBIENT CONDITIONS

Air temperature: *27.8 C (82 F)*

Wind speed: *2.7 m/s (6.0 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: *260 kPa (38 psi)*

BLIND SPOT DETECTION

DATA SHEET 3: TEST CONDITIONS

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2019 Audi A6 55 TFSI (3.0T) quattro

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*556.6 kg (1227 lb)*	Right Front:	*562.5 kg (1240 lb)*
Left Rear:	*477.2 kg (1052 lb)*	Right Rear:	*479.9 kg (1058 lb)*
		Total:	*2076.2 kg (4577 lb)*

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2019 Audi A6 55 TFSI (3.0T) quattro

General Information

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

Audi Side Assist is an available option as part of the Convenience package on the Premium trim and is standard on the Premium Plus and Prestige trims.

Type and location of sensors the system uses:

Medium Range Radar sensors (2) are mounted in the corners of the rear bumper.

System setting used for test (if applicable):

Side Assist on

Method(s) by which the driver is alerted

X Visual:

	Type	Location	Description
X	Symbol	*Housings of outside mirrors*	*Amber light*
	Word		
	Graphic		

____ Audible – Description:

____ Haptic:

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

Description of alert:

If a vehicle is travelling alongside or approaching in the adjacent lane and the turn signal is not activated, the yellow LED in the mirror housing will remain constantly on and dim while the adjacent vehicle is detected. If the turn signal is activated, the LED will flash bright yellow to indicate a critical situation.

System Function

What is the speed range over which the system operates?

Minimum: *10 km/h (6 mph)*

Maximum: *250 km/h (155 mph)*

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

No initialization is required.

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

If a vehicle is detected in the blind spot and the turn signal is not activated, the yellow LED in the mirror housing will remain constantly on and dim while the adjacent vehicle is detected. If the turn signal is activated, the LED will flash bright yellow to indicate a critical situation.

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 provided in the Multi Media Interface touchscreen to activate/deactivate Side assist. The hierarchy is:

Vehicle

Driver Assistance – select driver profile:

Individual

Side Assist – select or deselect

Side assist will not reactivate upon each ignition cycle.

Note that the Diver Assistance menu level can be accessed directly by pressing the button located on the center console.
See Appendix A, Figures A11 and A12.

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.

Only the brightness of the LEDs can be adjusted.

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

If the system is inoperable than the following messages will occur in the gauge cluster:

"Audi side assist: malfunction! Please contact Service" or

"Audi pre sense: currently limited. Sensor view limited due to surroundings."

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?

The system will not deactivate due to repeated BSD interventions.

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?

The system will not deactivate due to periods of inactivity, but if the radar sensors detect blockage, a message is sent to the driver. The system will reactivate automatically as soon as the sensors are no longer blind due to the blockage.

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

In some situations, the display may turn on even though there is no vehicle located in the area that is critical for a lane change.

For example:

- *If the lanes are narrow or if you are driving on the edge of your lane. If this is the case, the system may have detected a vehicle in another lane that is not adjacent to your current lane.*
- *If you are driving through a curve. Side assist may react to a vehicle that is in the same lane or one lane over from the adjacent lane.*
- *If side assist reacts to other objects (such as roadside structures like guard rails).*

See also the Owner's Manual page 118 given 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.

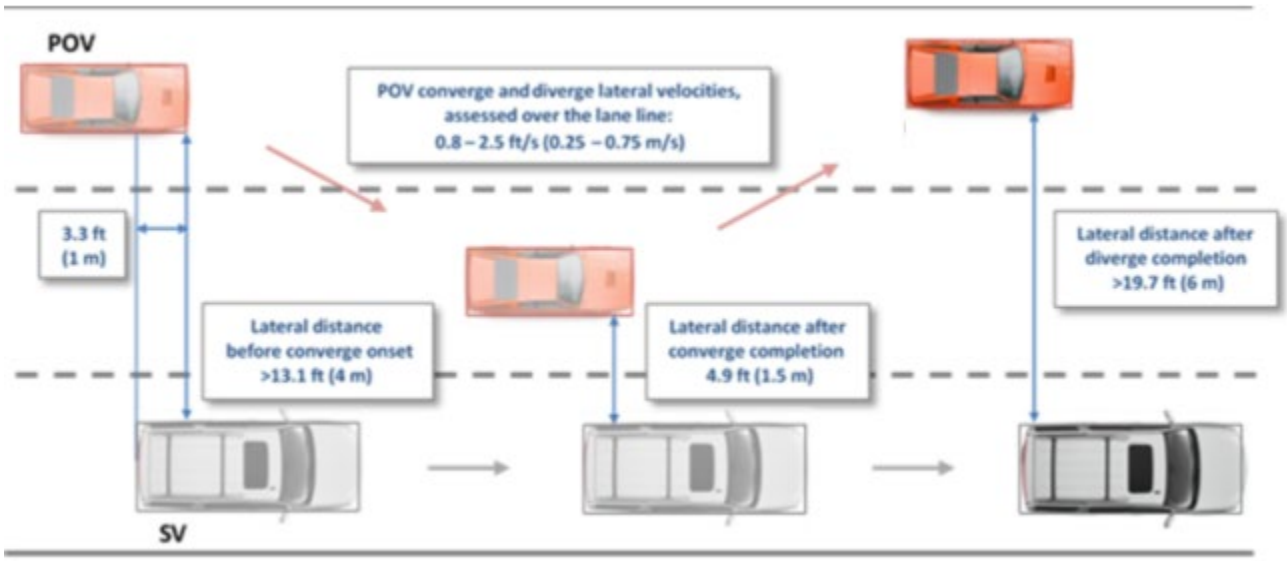

Figure 1. Straight Lane Converge and Diverge Test
(POV converge and diverge from the left is shown)

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.

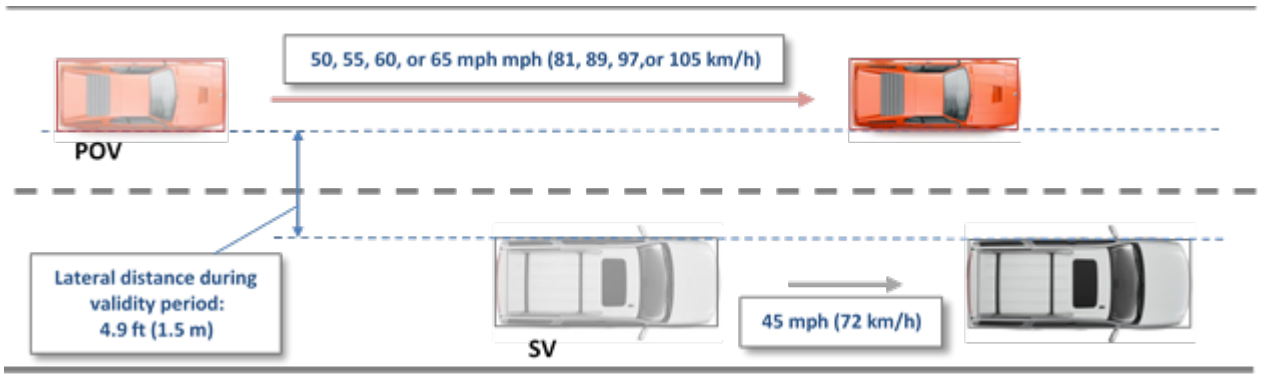

Figure 2. Straight Lane Pass-by Test
(Left-side POV Pass-by is shown)

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 (72.4 ± 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)	>29.3 ft (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.

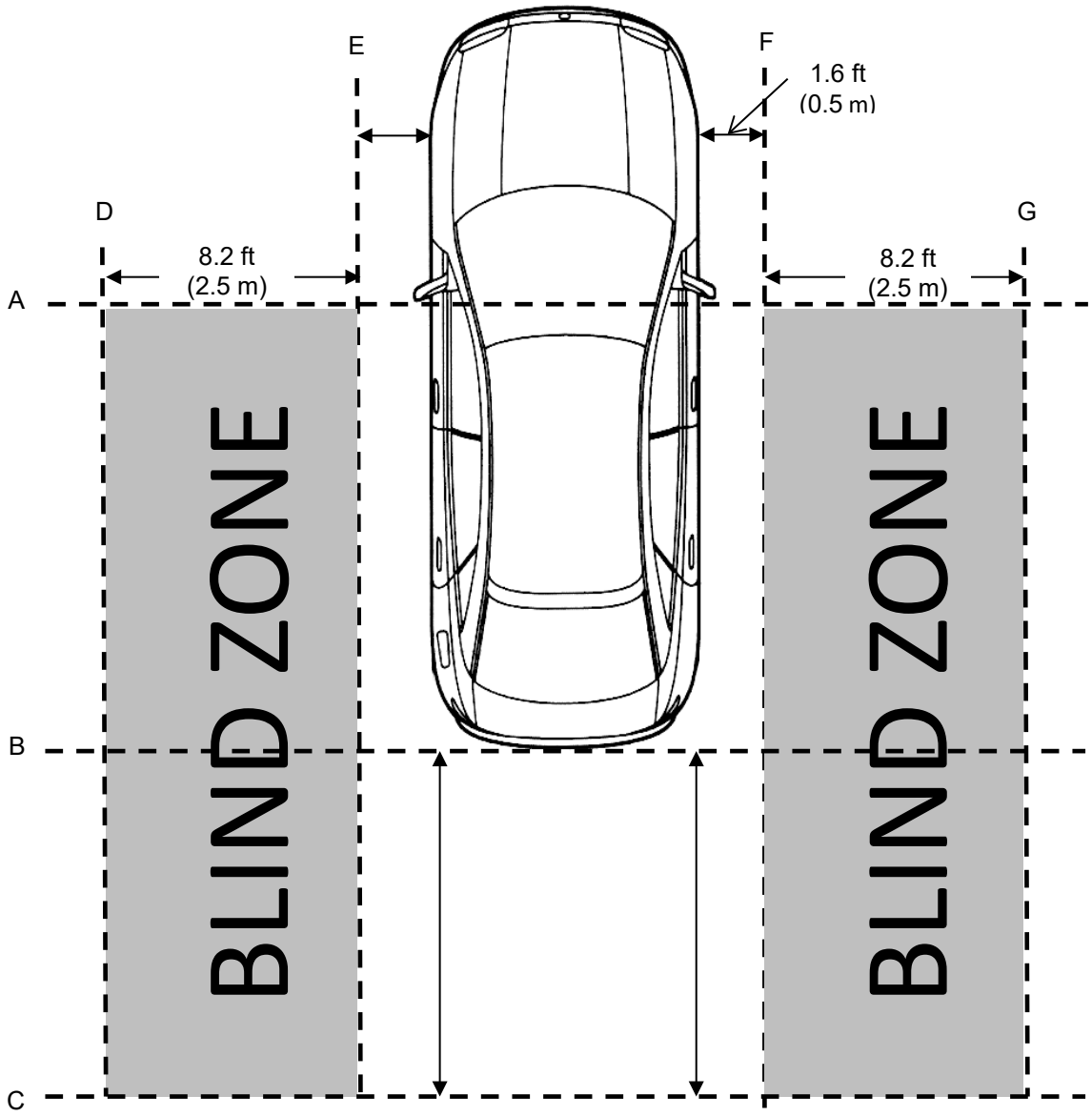

Figure 3. Vehicle Blind Zone Areas

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	N/A
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 +	2176	Date: 6/26/2020 Due: 6/26/2022
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	N/A
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	N/A	N/A

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	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
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	N/A

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

LOC: PR * Dealer Stock Status: SOLD
Exterior: Vesuvius Gray Metallic

VIN: WAUL2AF2XKN04
Interior: Black Interior

MODEL: 4A2B2Y-2019 Audi A6 55 TFSI (3.0T) quattro
2018345-ORIGINAL

2019 Audi A6 55 TFSI (3.0T) quattro

STANDARD EQUIPMENT (unless replaced by options)

TECHNICAL
- 3.0 TFSI® V6 engine
- quattro® all-wheel drive system
- 7-speed S tronic® transmission
- 19" 5-double-spoke bi color wheels, 245/45 all-season tires
- Energy recuperation with start-stop system
- Space-saving spare tire

COMFORT/TECHNOLOGY
- Audi connect® CARE (limited time subscription)
- Audi connect® PRIME & PLUS (6 month trial)
- Audi MMI Navigation w/ MMI touch response and traffic information online
- Audi smartphone interface
- Audi sound system
- Dark Brown Walnut wood inlays
- Garage door opener (HomeLink®)
- Heated, auto-dimming, exterior mirrors, w/ memory
- Heated, 8-way power front seats w/ driver memory and 4-way lumbar adjustment
- Leather seating surfaces
- LED headlights
- Parking system plus
- Preparation for mobile phone (Bluetooth®)
- Power adjustable steering column with memory
- Power sunroof
- S line exterior
- Split-folding rear seat back with pass-through (40/20/40)
- Three-zone automatic climate control
- 3-spoke multi-function steering wheel w/ shift paddles

SAFETY/CONVENIENCE
- Advanced Airbag Protection System with 8 airbags
- Anti-lock Braking System (ABS) w/ Brake Assist
- Audi pre sense basic (preventative occupant protection)
- Audi pre sense front (low speed collision assist)
- Child safety locks in rear doors, power
- Electronic Stabilization Control (ESC) w/ Sport mode
- Electronic vehicle immobilization w/ anti-theft alarm
- LED Daytime Running Lights (DRLs)
- LED taillights w/ dynamic turn signals
- Lower Anchors and Tethers for CHildren (LATCH)
- Rearview camera
- Tire Pressure Monitoring System (TPMS)

WARRANTY/MAINTENANCE
- 4 Year/50,000 mile (whichever occurs first) New Vehicle Limited Warranty*
- 12 Year Limited Warranty Against Corrosion Perforation
- 1 Year/10,000 mile (whichever occurs first) First Scheduled Maintenance Service FREE OF CHARGE
- 4 Years Roadside Assistance coverage provided by a third party supplier

*Please refer to the 2019 Audi Warranty and Maintenance Booklet for complete coverage information.

MANUFACTURER'S SUGGESTED RETAIL PRICE

2019 Audi A6 55 TFSI (3.0T) quattro	**$58,900.00**
PACKAGES / OPTIONS	
Vesuvius Gray metallic	$595.00
Black interior	Included
Premium Plus package	$3,800.00
Audi MMI Navigation w/touch response, 10.1" screen	
Audi virtual cockpit	
Bang & Olufsen® Premium 3D sound system	
Audi phone box w/wireless charging and antenna booster	
Audi advanced key	
Audi side assist, rear cross traffic,Audi pre sense rear	
Power-folding exterior mirrors	
Matrix design LED headlights	
Highbeam assist, Headlight washer system	
Top view camera system	
Driver Assistance package	$2,750.00
20" Sport package	$1,050.00
20" 5-V-spoke bi-color wheels, 255/40 all-season tires	
Sport suspension	
Cold Weather package	$600.00
Heated steering wheel	
Heated rear seats	
Audi Beam - Rings	$450.00
Interior Protection Package	$210.00
Gray/Brown Fine Grain Ash natural wood inlays	Included
Destination Charge	$995.00
Total Price:	**$69,350.00**

Fuel, license, title fees, taxes and dealer-installed accessories are not included.

MODEL: 4A2B2Y

VIN: WAUL2AF2XKN04

DEALER:

SHIP TO:

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score **Not Rated**
Based on the combined ratings of frontal, side and rollover.
Should ONLY be compared to other vehicles of similar size and weight.

Frontal Crash	Driver	**Not Rated**
	Passenger	**Not Rated**

Based on the risk of injury in a frontal impact.
Should ONLY be compared to other vehicles of similar size and weight.

Side Crash	Front Seat	**Not Rated**
	Rear Seat	**Not Rated**

Based on the risk of injury in a side impact.

Rollover **Not Rated**
Based on the risk of rollover in a single-vehicle crash.

Star ratings range from 1 to 5 stars (★★★★★) with 5 being the highest.
Source: National Highway Traffic Safety Administration (NHTSA).
www.safercar.gov or 1-888-327-4236

EPA DOT Fuel Economy and Environment

Gasoline Vehicle

Fuel Economy
25 MPG
combined city/hwy

22 city

29 highway

4 gallons per 100 miles

Mid-Size Cars range from 14 to 136 MPG.
The best vehicle rates 136 MPGe.

You **spend $2,000** more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel **cost** **$1,800**

Fuel Economy & Greenhouse Gas Rating (tailpipe only): 5 (1 – 10, Best)

Smog Rating (tailpipe only): 5 (1 – 10, Best)

This vehicle emits 360 grams of CO_2 per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fueleconomy.gov.

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs $7,000 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at $3.00 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fueleconomy.gov
Calculate personalized estimates and compare vehicles

Smartphone QR Code™

PARTS CONTENT INFORMATION

FOR VEHICLES IN THIS CARLINE: U.S./CANADIAN PARTS CONTENT: 1%
MAJOR SOURCES OF FOREIGN PARTS CONTENT: GERMANY: 53% HUNGARY: 21%

FOR THIS VEHICLE: FINAL ASSEMBLY POINT: NECKARSULM, GERMANY
COUNTRY OF ORIGIN: ENGINE: HUNGARY TRANSMISSION: GERMANY

NOTE: PARTS CONTENT DOES NOT INCLUDE FINAL ASSEMBLY, DISTRIBUTION OR OTHER NON-PARTS COSTS.

Disclaimer: The Monroney describes the vehicle features when the vehicle was first sold/leased to the customer and that as of the present day the actual features on the vehicle might differ from the ones listed on the Monroney label. The Monroney label is for view only purposes and must not be used to paste on the vehicle as a Monroney sticker for resale.

Figure A3. Window Sticker (Monroney Label)

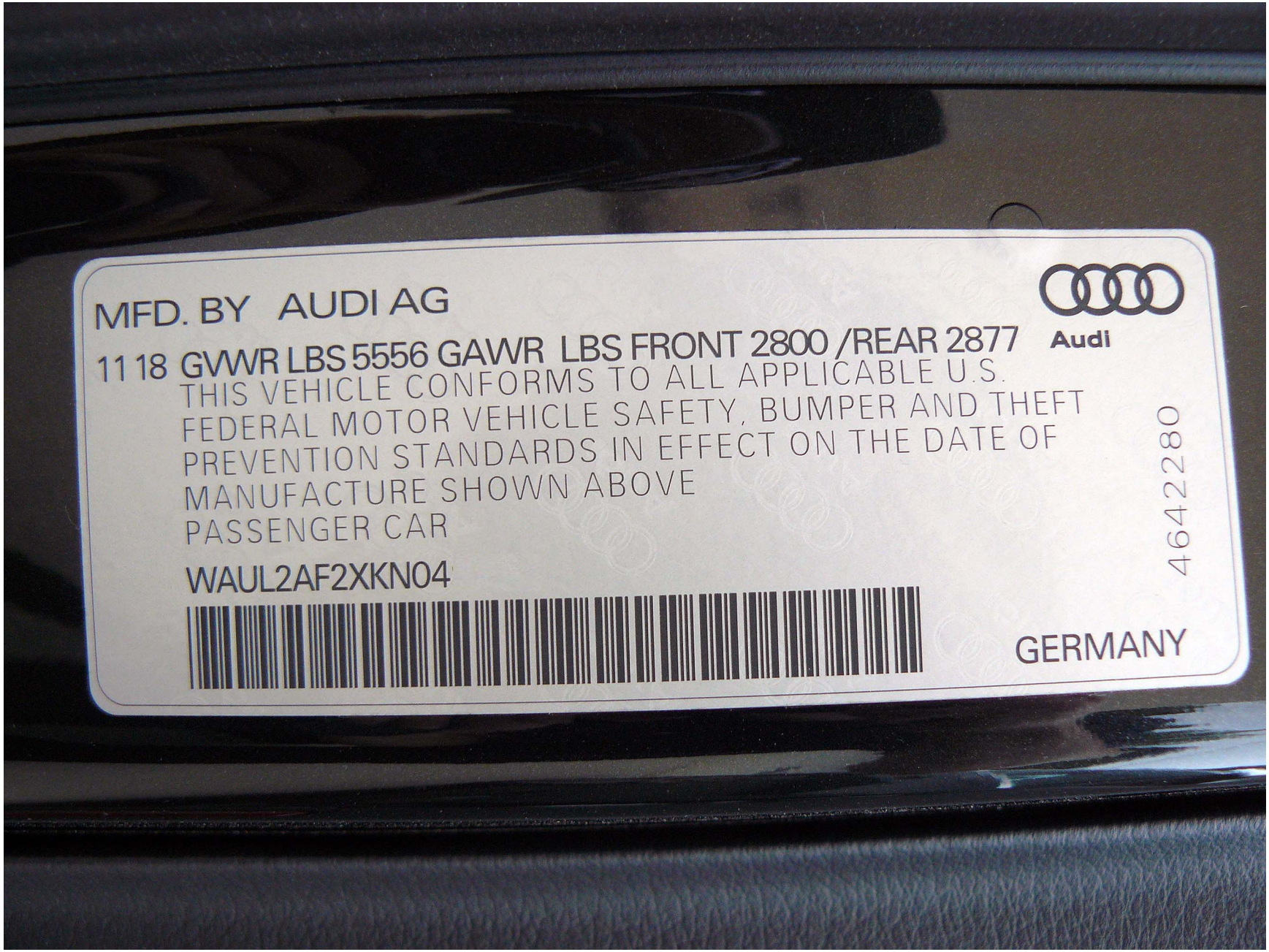

Figure A4. Vehicle Certification Label

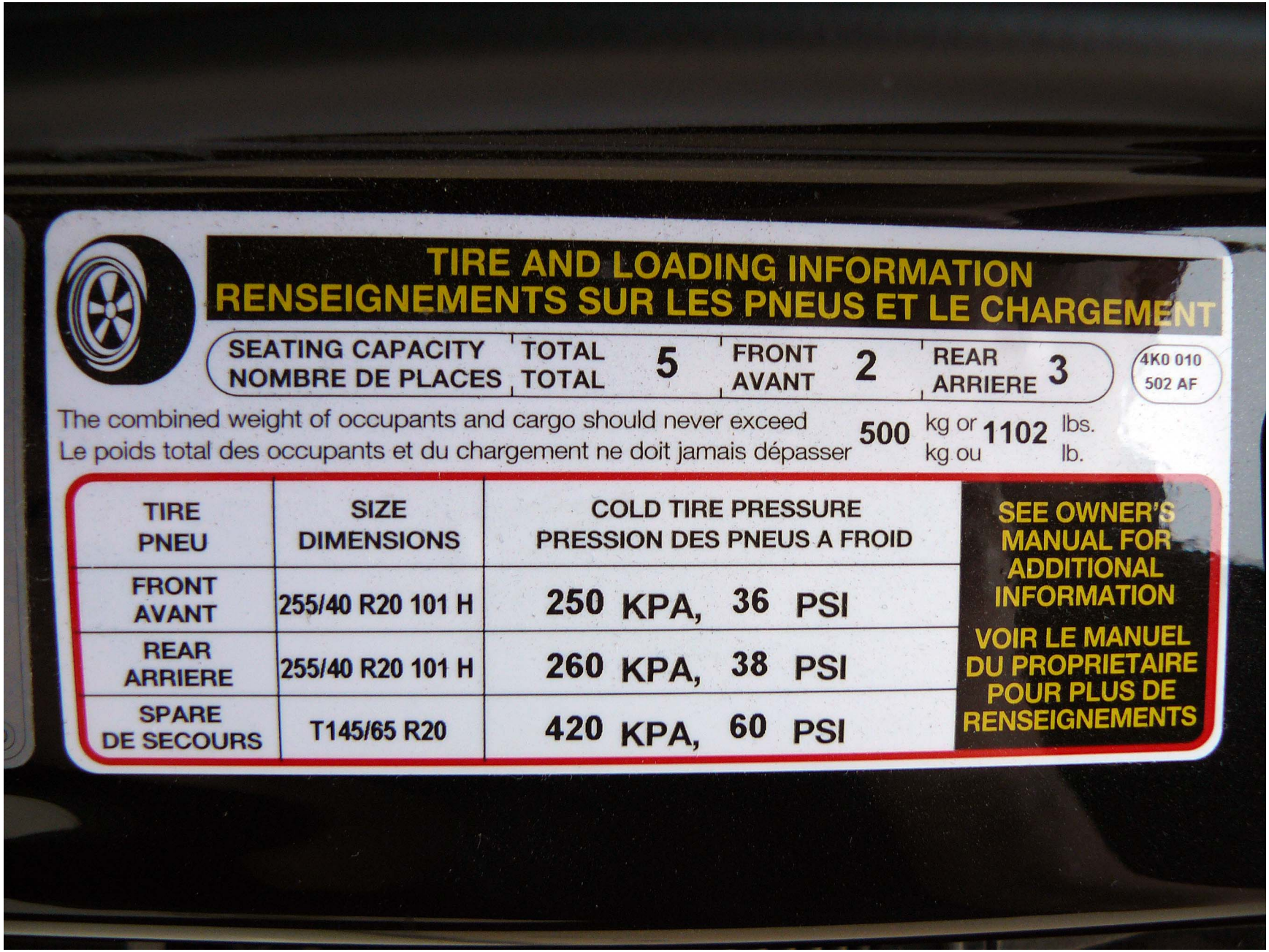

Figure A5. Tire Placard

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. Sensor for Detecting Visual Alerts

Figure A10. Computer Installed in Subject Vehicle

Figure A11. System Setup Menus

Figure A12. Button for Directly Accessing Driver Assistance Settings Menus

Figure A13. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

	Engine oil level (MIN) ⇨ *page 235*
	Engine oil level (MAX) ⇨ *page 235*
	Engine oil sensor ⇨ *page 235*
	Malfunction Indicator Lamp (MIL) ⇨ *page 231*
	Engine warm-up request ⇨ *page 235*
	Washer fluid level ⇨ *page 243*
	Windshield wipers ⇨ *page 58*
	Parking system plus ⇨ *page 157*
TPMS	Tire pressure ⇨ *page 263*
	Tire pressure ⇨ *page 263*
	Loose wheel warning ⇨ *page 260*
	Bulb failure indicator ⇨ *page 52*
	Adaptive light ⇨ *page 52*
	Light/rain sensor ⇨ *page 52*, ⇨ *page 58*
	Door lock ⇨ *page 34*
	Battery in vehicle key ⇨ *page 38*
	Night vision assist ⇨ *page 129*
	Intersection assistant ⇨ *page 153*
	Side assist ⇨ *page 151*; Exit warning ⇨ *page 152*
	Rear cross-traffic assist ⇨ *page 162*

	Adaptive cruise assist ⇨ *page 142*
	Steering intervention request ⇨ *page 139*, ⇨ *page 145*
	Lane departure warning ⇨ *page 145*
	Distance warning ⇨ *page 143*
	Audi pre sense ⇨ *page 149*
SOS	Emergency assist ⇨ *page 154*
SOS	Emergency call function ⇨ *page 184*

Other indicator lights

	Rear safety belt ⇨ *page 67*
	Start/Stop system ⇨ *page 101*
	Hill descent assist ⇨ *page 107*
	Low beam headlight ⇨ *page 49*
	Parking light ⇨ *page 49*
	Turn signals ⇨ *page 50*, ⇨ *page 51*
CRUISE	Cruise control system ⇨ *page 130*
	Cruise control system ⇨ *page 130*
	Efficiency assist ⇨ *page 131*
	Efficiency assist ⇨ *page 131*
50	Efficiency assist ⇨ *page 131*
km/h	Efficiency assist ⇨ *page 131*
MPH	Efficiency assist ⇨ *page 131*

▶

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	Efficiency assist ⇨ *page 131*
	Efficiency assist ⇨ *page 131*
	Efficiency assist ⇨ *page 131*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Lane guidance for adaptive cruise assist ⇨ *page 136*
	Lane departure warning ⇨ *page 144*
	High beams ⇨ *page 50*
	High beam assistant ⇨ *page 50*
	Rear safety belt ⇨ *page 67*
	Rear safety belt ⇨ *page 67*
	Transmission ⇨ *page 99*
	Convenience key ⇨ *page 94*
	Electromechanical parking brake ⇨ *page 105*
	Electromechanical parking brake ⇨ *page 105*
	Hill descent assist ⇨ *page 107*
	Steering ⇨ *page 110*

	Air suspension ⇨ *page 110*
	High beam assistant ⇨ *page 50*
	Door lock ⇨ *page 34*
	Child safety lock ⇨ *page 43*
	Speed warning system ⇨ *page 123*
	Speed warning system ⇨ *page 123*
	Camera-based traffic sign recognition ⇨ *page 124*
	Night vision assist ⇨ *page 129*
	Cruise control system ⇨ *page 130*
	Cruise control system ⇨ *page 130*
	Intersection assistant ⇨ *page 153*
	Side assist ⇨ *page 151*
	Distance warning ⇨ *page 143*
	Rear cross-traffic assist ⇨ *page 162*
	Adaptive cruise assist ⇨ *page 142*, Efficiency assist ⇨ *page 134*
	Adaptive cruise assist ⇨ *page 139*
	Lane guidance for adaptive cruise assist ⇨ *page 136*
	Lane departure warning ⇨ *page 144*

Assist systems

General information

Safety precautions

WARNING

– As the driver, you are always completely responsible for all driving tasks. The assist systems cannot replace the driver's attention. Give your full attention to driving the vehicle, and be ready to intervene in the traffic situation at all times.
– Activate the assist systems only if the surrounding conditions permit it. Always adapt your driving style to the current visual, weather, road, and traffic conditions.
– Loose objects can be thrown around the vehicle interior during sudden driving or braking maneuvers, which increases the risk of an accident. Store objects securely while driving.
– For the assist systems to be able to react correctly, the function of the sensors and cameras must not be restricted. Note the information on sensors and cameras ⇨ *page 119*.

Tips

– Pay attention to applicable local regulations relating to driving tasks, leaving space for emergency vehicles, vehicle distance, speed, parking location, wheel placement, etc. The driver is always responsible for following the laws that are applicable in the location where the vehicle is being operated.
– You can cancel a steering or braking intervention by the system, by braking or accelerating noticeably, steering, or deactivating the respective assist system.
– Always check the assist systems settings before driving. The settings could have been changed, for example, by other drivers or if another personal profile was used.

System limitations

WARNING

– The use of an assist system cannot overcome the natural laws of physics. A collision cannot be prevented in certain circumstances.
– Warnings, messages, or indicator lights may not be displayed or initiated on time or correctly, for example, if vehicles are approaching very fast.
– Corrective interventions by the assist systems, such as steering or braking interventions, may not be sufficient or they may not occur. Always be ready to intervene.

Tips

– Due to the system limitations when detecting the surrounding area, the systems may warn or intervene unexpectedly or too late in certain situations. The assist systems may also interpret a driving maneuver incorrectly and then warn the driver unexpectedly.
– The systems may not function as expected in unusual driving situations, such as driving offroad, on unpaved roads, on loose ground, on inclines, or on grooves in the road.
– The systems may not function correctly in unclear traffic situations, such as turning lanes, exit ramps, construction zones, rises or dips that obstruct visibility, intersections, toll stations, or city traffic.
– The detection of the surrounding area can be limited, for example by vehicles driving ahead or by rain, snow, heavy spray, or light shining into the camera.
– If accessories have been mounted on the steering wheel, the ability for the steering systems to react may be limited.

Side assist

Description

Applies to: vehicles with side assist

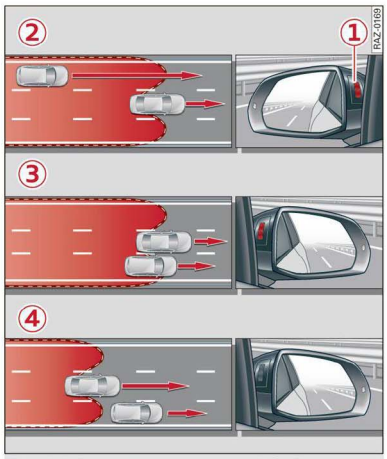

Fig. 116 Diagram: driving situations and displays in the exterior mirror (example)

General information

Side assist monitors the blind spot and traffic in the adjacent lanes behind the vehicle. Within system limits, side assist can detect traffic that is approaching from behind and provide a warning when you are changing lanes and turning. The system uses the data from the radar sensors at the rear corners of the vehicle.

The side assist is active at walking speeds and higher. If an object that is classified as critical is approaching, the display in the exterior mirror ① on the corresponding side of the vehicle will light up.

Driving situations

The system can provide warnings about the following risks:

② **Approaching vehicles**: a vehicle may be classified as critical in some cases, even if it is farther away. The faster a vehicle approaches, the sooner the display will turn on.

③ **Vehicles traveling in the same direction**: the display will turn on if vehicles traveling in the same direction as your vehicle are classified as critical. The side assist warns you of all detected vehicles when they are in the "blind spot" or before they reach that point.

④ **Vehicles you are passing**: the display only turns on if you slowly pass a detected vehicle (difference in speed between the two vehicles is less than 9 mph (15 km/h)). There is no display if you pass a vehicle more quickly.

Information stage

At the information level, the side assist informs you of detected objects that are classified as critical. This is even possible when your vehicle is stationary and the turn signal is turned on, so that the system can also assist you when turning. From speeds of approximately 6 mph (10 km/h) and higher, the system will warn you of detected objects that are classified as critical, even if the turn signal is not turned on.

The display remains dim in the information stage so that you are not distracted while looking forward.

Warning stage

If you activate a turn signal and the display flashes brightly, side assist is warning about objects that have been classified as critical.

Depending on the vehicle equipment and other driver assistance systems, the display may also flash if you have not activated a turn signal. If you are approaching a detected lane marker line and it appears you will be leaving the lane, the display will warn you about detected vehicles that are classified as critical. You can also be warned with corrective steering ⇨ *page 144, Lane departure warning*.

Detection range

The radar sensors are designed to detect the left and right adjacent lanes when the road lanes are the normal width. In some situations, the display may turn on even though there is no vehicle located in the area that is critical for a lane change. For example: ▶

– If the lanes are narrow or if you are driving on the edge of your lane. If this is the case, the system may have detected a vehicle in another lane that is *not* adjacent to your current lane.
– If you are driving through a curve. Side assist may react to a vehicle that is in the same lane or one lane over from the adjacent lane.
– If side assist reacts to other objects (such as roadside structures like guard rails).

WARNING

– Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 118*.
– The display may not appear on time when vehicles are approaching or being passed very quickly.

Tips

– If the window glass in the driver's door or front passenger's door has been tinted, the display in the exterior mirror may be incorrect.
– For an explanation on conformity with the FCC regulations in the United States and the Industry Canada regulations, see ⇨ *page 296*.

Adjusting side assist

Applies to: vehicles with side assist

The system can be switched on and off in the MMI ⇨ *page 121*. If the system is activated, the displays will turn on briefly when the ignition is switched on.

Adjusting the brightness

You can adjust the brightness of the display in the exterior mirror. The settings depend on the vehicle equipment.

▸ Applies to: MMI: Select on the home screen: **VEHICLE** > **Driver assistance** > (⚙) > **Side assist** > **Brightness**.

The display brightness is automatically adapted to the ambient light. If the automatic adaptation has already reached the upper or lower limit, no change will be apparent when the setting is changed, or it will only become visible when the ambient light changes. Adjust the brightness to a level where the display in the information stage will not disrupt your view ahead. If you change the brightness, the display will briefly show the brightness level in the information stage.

Messages

Applies to: vehicles with side assist

If  or  is displayed when there is a malfunction, the side assist and exit warning system functions may be unavailable or may be limited.

A message that indicates the cause and possible solution may appear with some displays. The weather conditions may be too poor or a sensor may be covered. Clean the sensor area in the vehicle rear and try to turn the systems on again later.

If the malfunction remains, drive to an authorized Audi dealer or authorized Audi Service Facility immediately to have the malfunction corrected.

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APPENDIX C

Run Log

Subject Vehicle: **2019 Audi A6 55 TFSI (3.0T) quattro** Date: **10/12/2020**

Test Engineer: **S. Judy**

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	
36	Converge/ Diverge	Left	N						Checkout test run
37			N						POV yaw rate
38			N						POV lateral velocity
39			Y	-0.2	4.8	No	Yes	No	BSD indicator turns off and back on during validity window
40			N						POV lateral velocity
41			N						POV lateral velocity
42			Y	1.0	4.1	Yes	Yes	Yes	
43			Y	1.9	3.6	Yes	Yes	Yes	
44			N						POV yaw rate
45			N						POV lateral velocity
46			N						POV lateral velocity
47			N						POV lateral velocity
48			N						POV lateral velocity
49			N						POV lateral velocity
50			Y	-0.6	4.2	No	Yes	No	

[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	
51			Y	1.4	3.9	Yes	Yes	Yes	
52			N						POV lateral velocity
53			Y	0.2	4.6	Yes	Yes	Yes	
54			Y	5.0	4.1	Yes	Yes	Yes	Alert turned on, off, then on again
55	**Converge/ Diverge**	**Right**	N						POV lateral velocity
56			N						POV lateral distance
57			Y	-1.6	5.7	No	Yes	No	
58			N						POV lateral distance
59			N						POV yaw rate
60			N						POV lateral velocity
61			Y	-2.1	4.6	No	Yes	No	
62			Y	-1.7	4.8	No	Yes	No	
63			Y	-2.3	5.8	No	Yes	No	
64			Y	-2.0	6.3	No	Yes	No	
65			N						POV lateral velocity
66			N						POV speed
67			N						POV lateral velocity
68			N						POV lateral velocity
69			N						POV lateral velocity
70			N						POV lateral velocity
71			N						Post processor error
72			Y	-1.9	4.6	No	Yes	No	

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	
73			Y	-2.3	6.0	No	Yes	No	
1	**Static Run**								
2	**Straight Lane 45/50**	**Left**	Y	18.1	15.0	Yes	Yes	Yes	
3			N						POV lateral distance
4			N						POV lateral distance
5			Y	15.3	14.8	Yes	Yes	Yes	
6			Y	16.0	15.7	Yes	Yes	Yes	
7			Y	16.0	15.0	Yes	Yes	Yes	
8			Y	23.3	15.1	Yes	Yes	Yes	
9			Y	30.3	15.2	Yes	Yes	Yes	
10			Y	21.6	15.1	Yes	Yes	Yes	
74	**Straight Lane 45/50**	**Right**	N						Lateral distance
75			Y	14.9	15.0	Yes	Yes	Yes	
76			Y	19.6	15.4	Yes	Yes	Yes	
77			Y	19.8	15.7	Yes	Yes	Yes	Video may have cut
78			Y	17.9	15.4	Yes	Yes	Yes	
79			Y	14.3	15.2	Yes	Yes	Yes	
80			Y	19.5	15.6	Yes	Yes	Yes	
81			Y	23.0	16.2	Yes	Yes	Yes	
11	**Straight Lane 45/55**	**Left**	Y	34.6	20.2	Yes	Yes	Yes	
12			Y	28.5	19.1	Yes	Yes	Yes	
13			Y	44.0	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	
14			Y	43.0	19.0	Yes	Yes	Yes	
15			Y	40.8	19.1	Yes	Yes	Yes	
16			N						SV speed
17			N						Lateral distance
18			Y	37.8	20.6	Yes	Yes	Yes	
82	**Straight Lane 45/55**	**Right**	Y	41.7	18.6	Yes	Yes	Yes	
83			Y	37.7	19.5	Yes	Yes	Yes	
84			Y	42.1	19.7	Yes	Yes	Yes	
85			Y	35.2	21.3	Yes	Yes	Yes	
86			Y	38.0	20.6	Yes	Yes	Yes	
87			Y	35.8	20.4	Yes	Yes	Yes	
88			Y	35.6	21.8	Yes	Yes	Yes	
19	**Straight Lane 45/60**	**Left**	Y	43.3	25.7	Yes	Yes	Yes	
20			Y	50.6	24.5	Yes	Yes	Yes	
21			Y	58.7	24.6	Yes	Yes	Yes	
22			N						POV lateral distance
23			N						Light sensor error
24			Y	43.9	24.6	Yes	Yes	Yes	
25			N						POV speed
26			Y	59.7	23.7	Yes	Yes	Yes	
27			Y	57.0	23.6	Yes	Yes	Yes	
28			Y	60.2	23.3	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	
89	**Straight Lane 45/60**	**Right**	N						Speed invalid
90			Y	45.1	25.4	Yes	Yes	Yes	
91			Y	55.5	27.0	Yes	Yes	Yes	
92			Y	46.1	26.7	Yes	Yes	Yes	
93			N						POV speed
94			Y	62.7	25.9	Yes	Yes	Yes	
95			Y	59.5	26.5	Yes	Yes	Yes	
96			Y	62.8	25.7	Yes	Yes	Yes	
29	**Straight Lane 45/65**	**Left**	Y	81.0	26.7	Yes	Yes	Yes	
30			Y	75.8	27.0	Yes	Yes	Yes	
31			N						POV speed
32			N						POV speed
33			Y	84.1	27.6	Yes	Yes	Yes	
34			N						POV speed
35			N						POV speed
97	**Straight Lane 45/65**	**Right**	N						POV speed
98			Y	72.6	30.8	Yes	Yes	Yes	
99			Y	69.7	30.3	Yes	Yes	Yes	
100			N						POV speed
101			N						POV speed
102			Y	73.1	31.2	Yes	Yes	Yes	
103			Y	64.8	31.2	Yes	Yes	Yes	
104			Y	72.5	31.9	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	
105			Y	77.4	30.7	Yes	Yes	Yes	
106			Y	78.6	30.3	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.

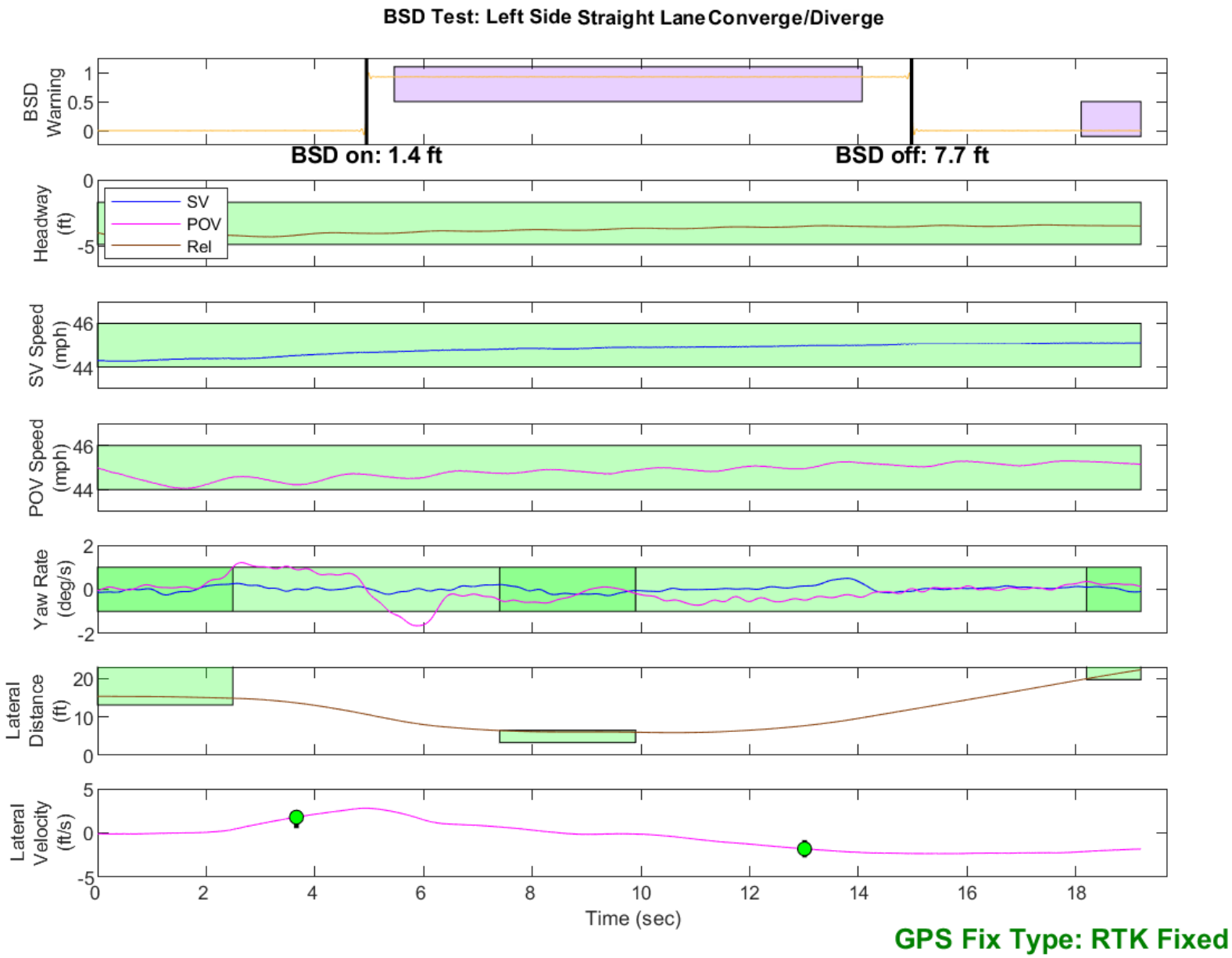

Figure D1. Example Time History for Straight Lane Converge/Diverge Test, Passing

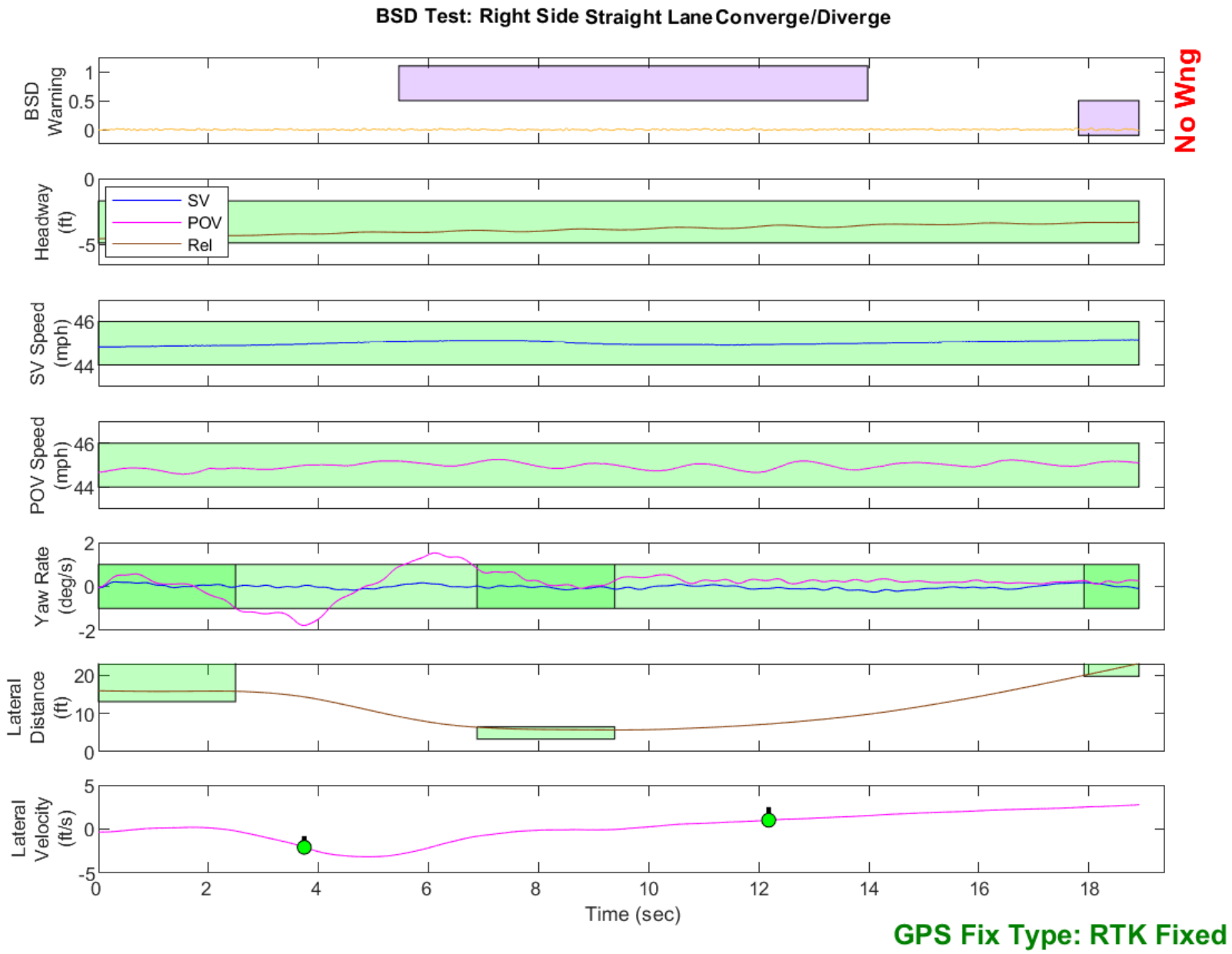

Figure D2. Example Time History for Straight Lane Converge/Diverge Test, Failing

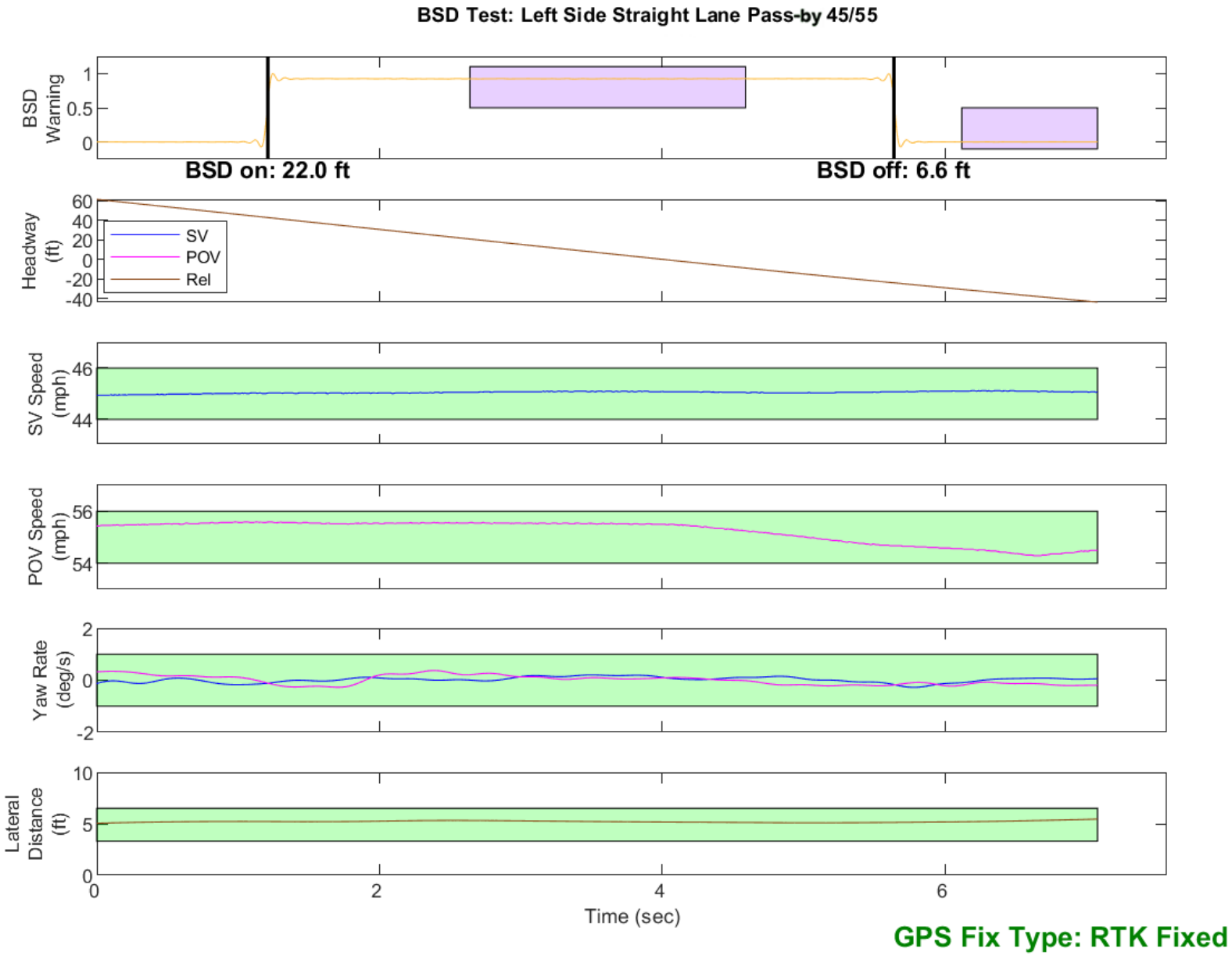

Figure D3. Example Time History for Straight Lane Pass-By Passing

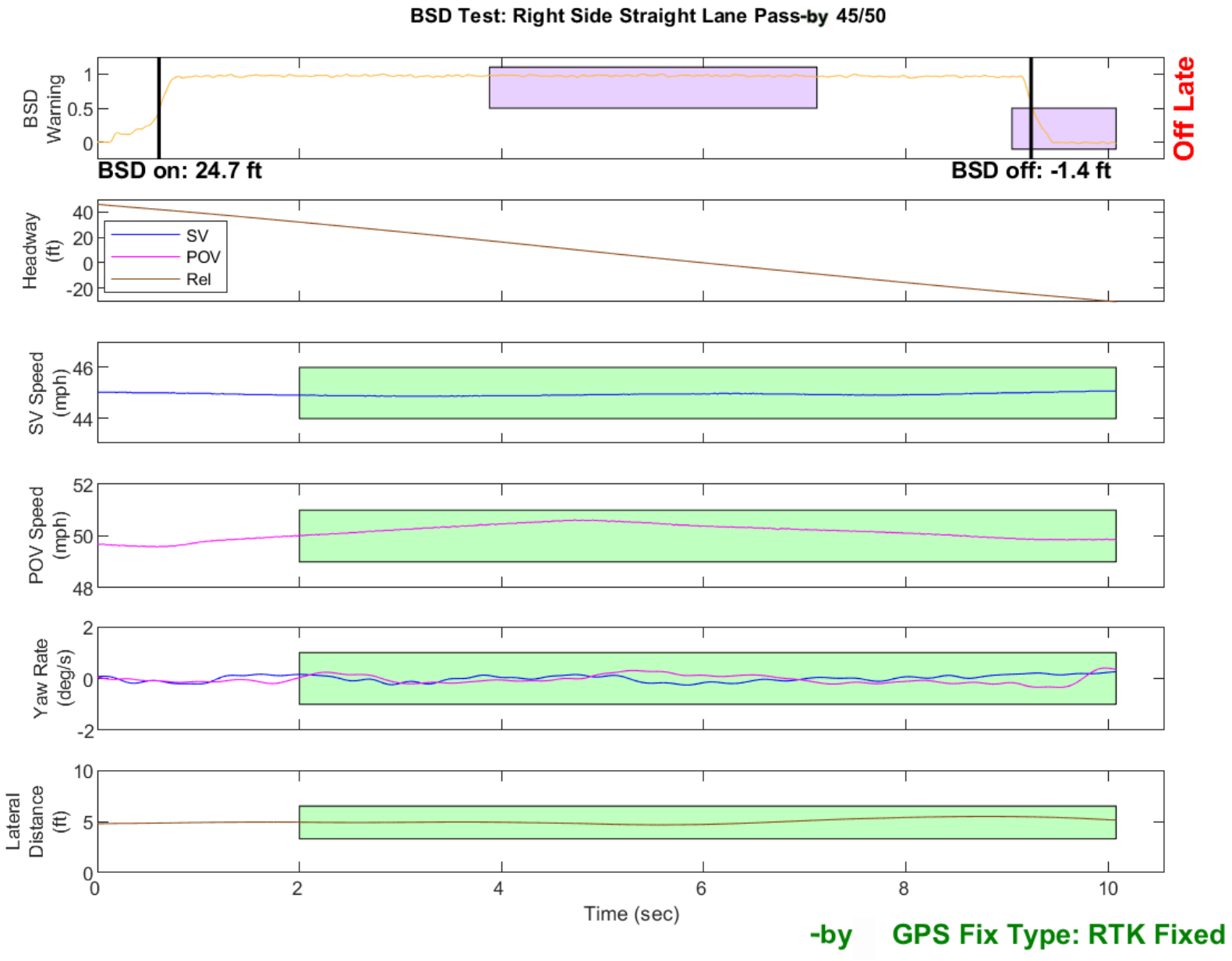

Figure D4. Example Time History for Straight Lane Pass-by Test, Failing

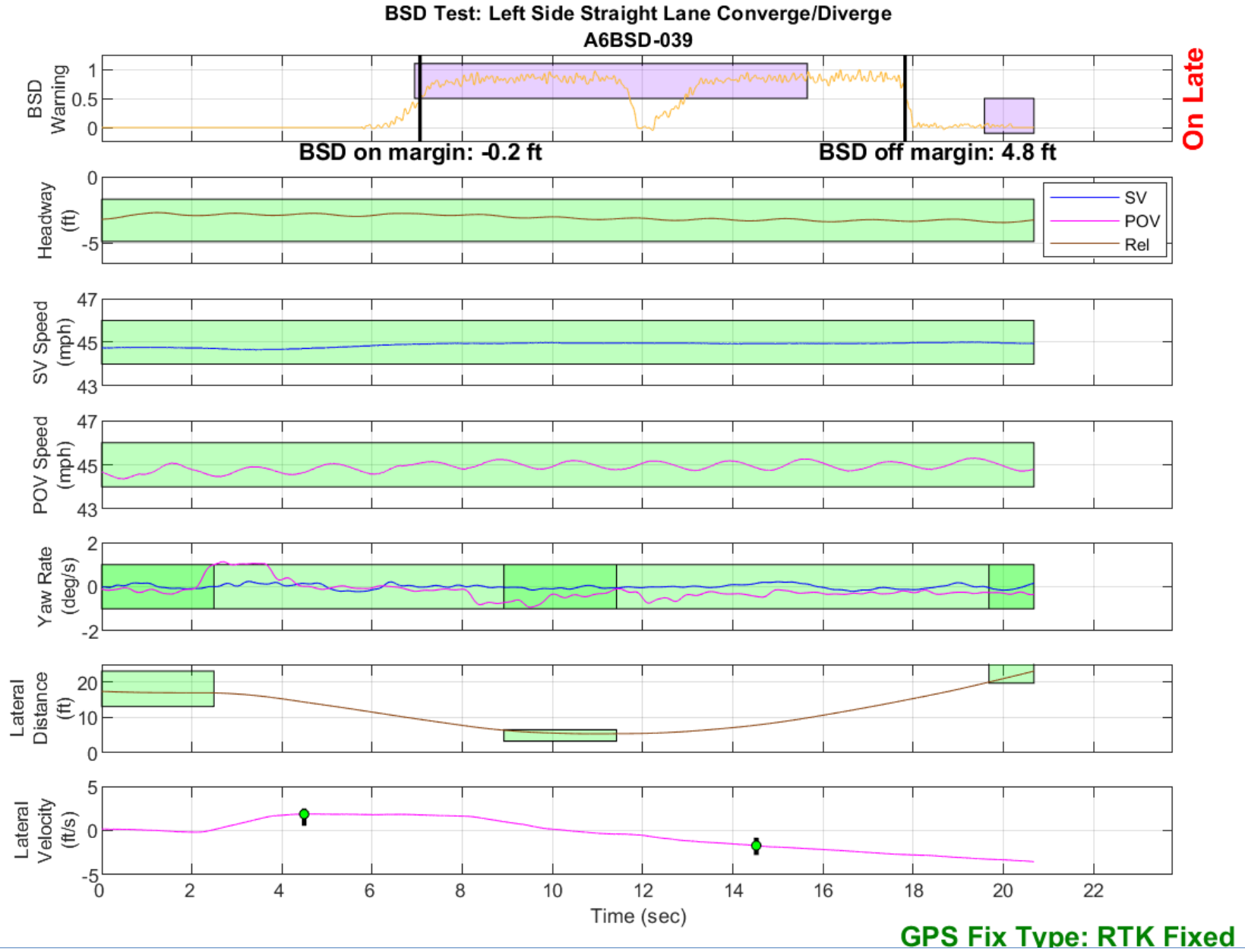

Figure D5. BSD Run 39, Straight Lane Converge/Diverge

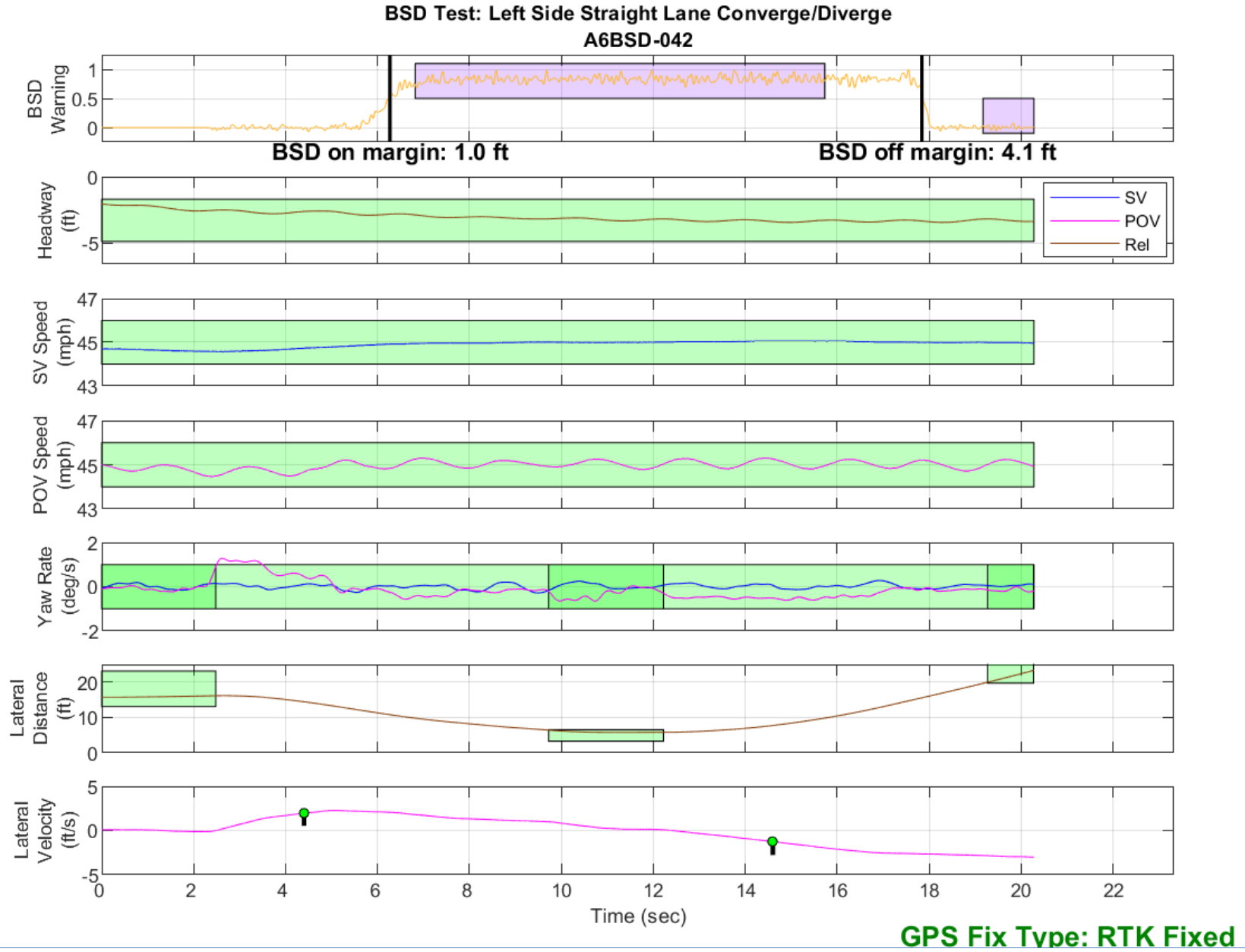

Figure D6. BSD Run 42, Straight Lane Converge/Diverge

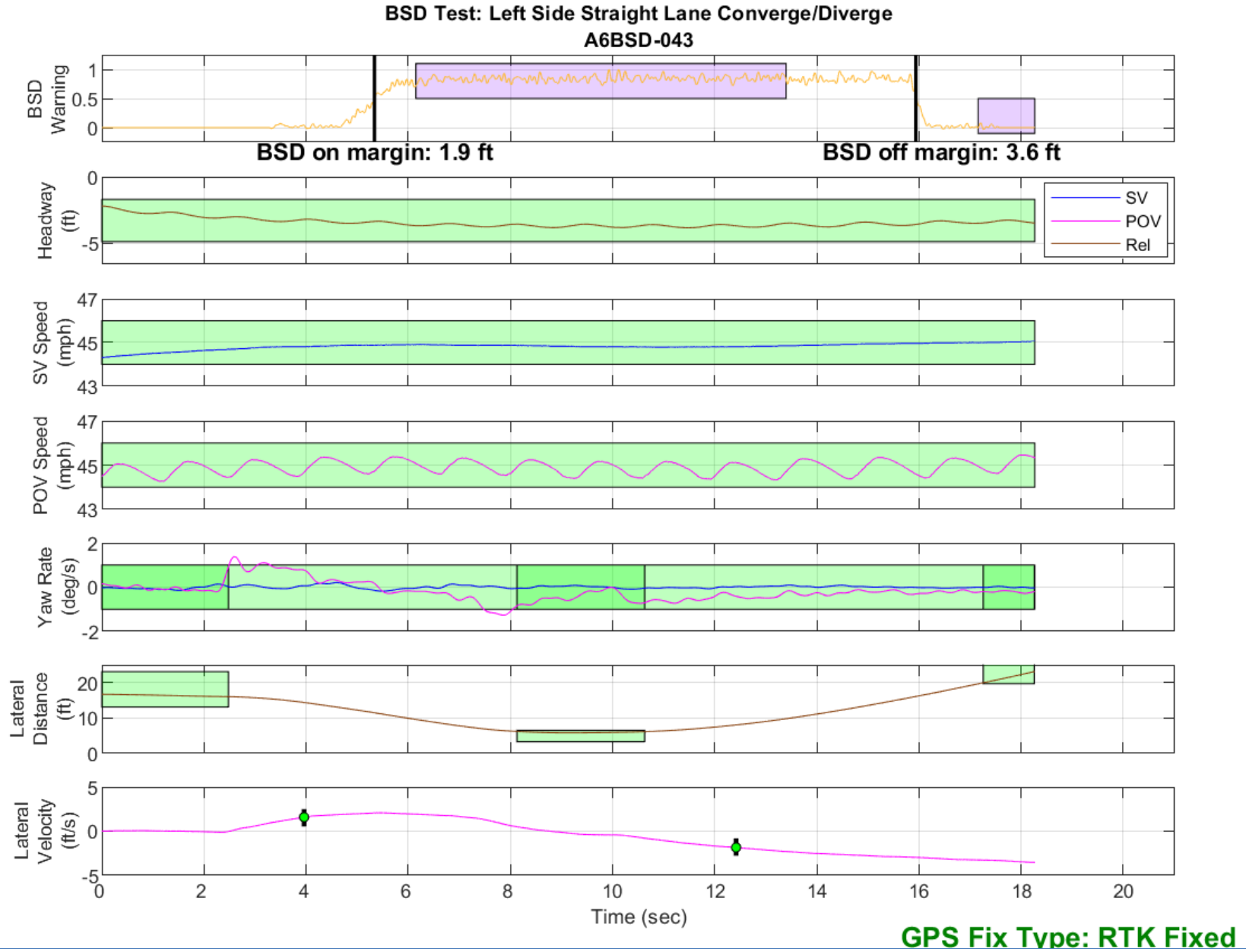

Figure D7. BSD Run 43, Straight Lane Converge/Diverge

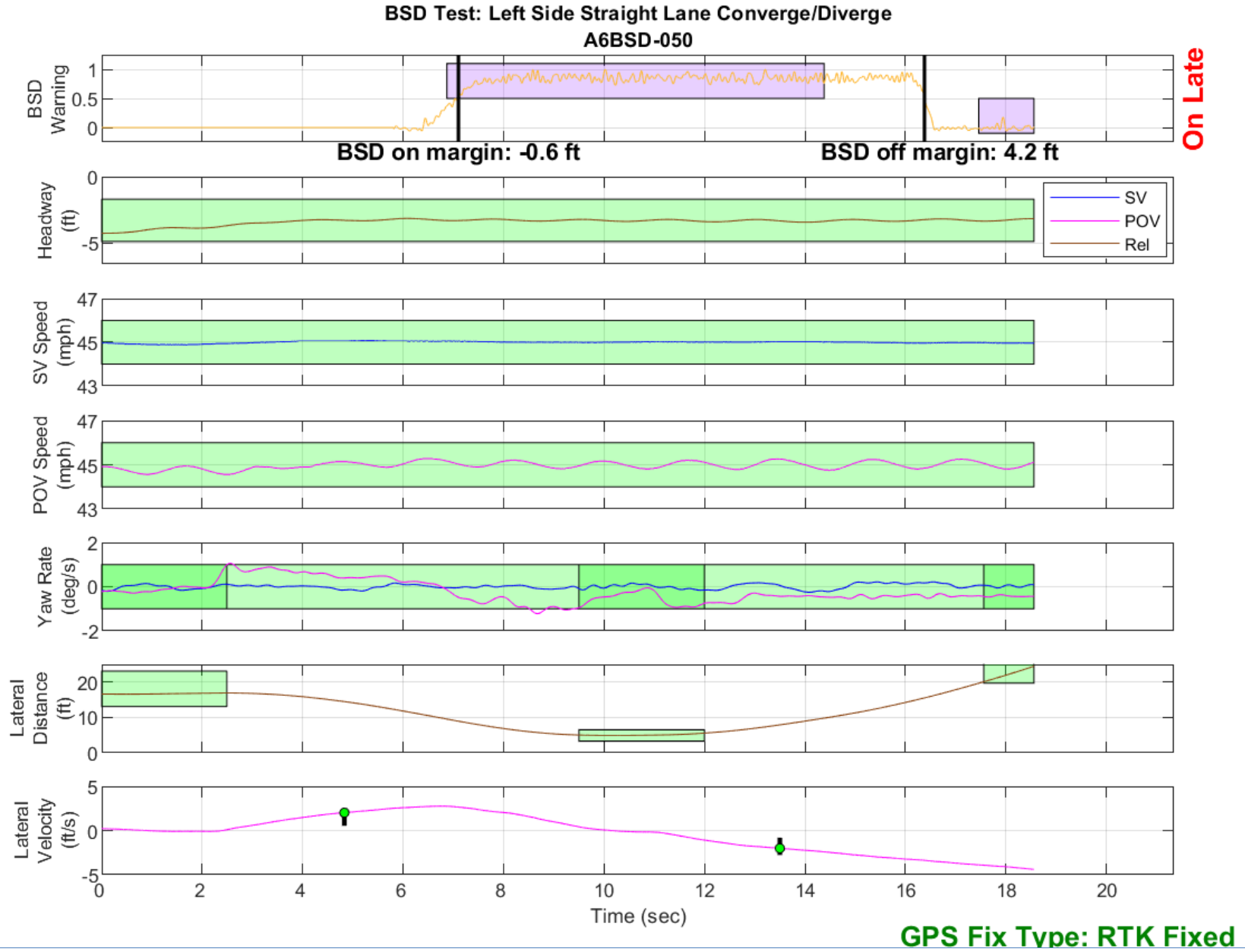

Figure D8. BSD Run 50, Straight Lane Converge/Diverge

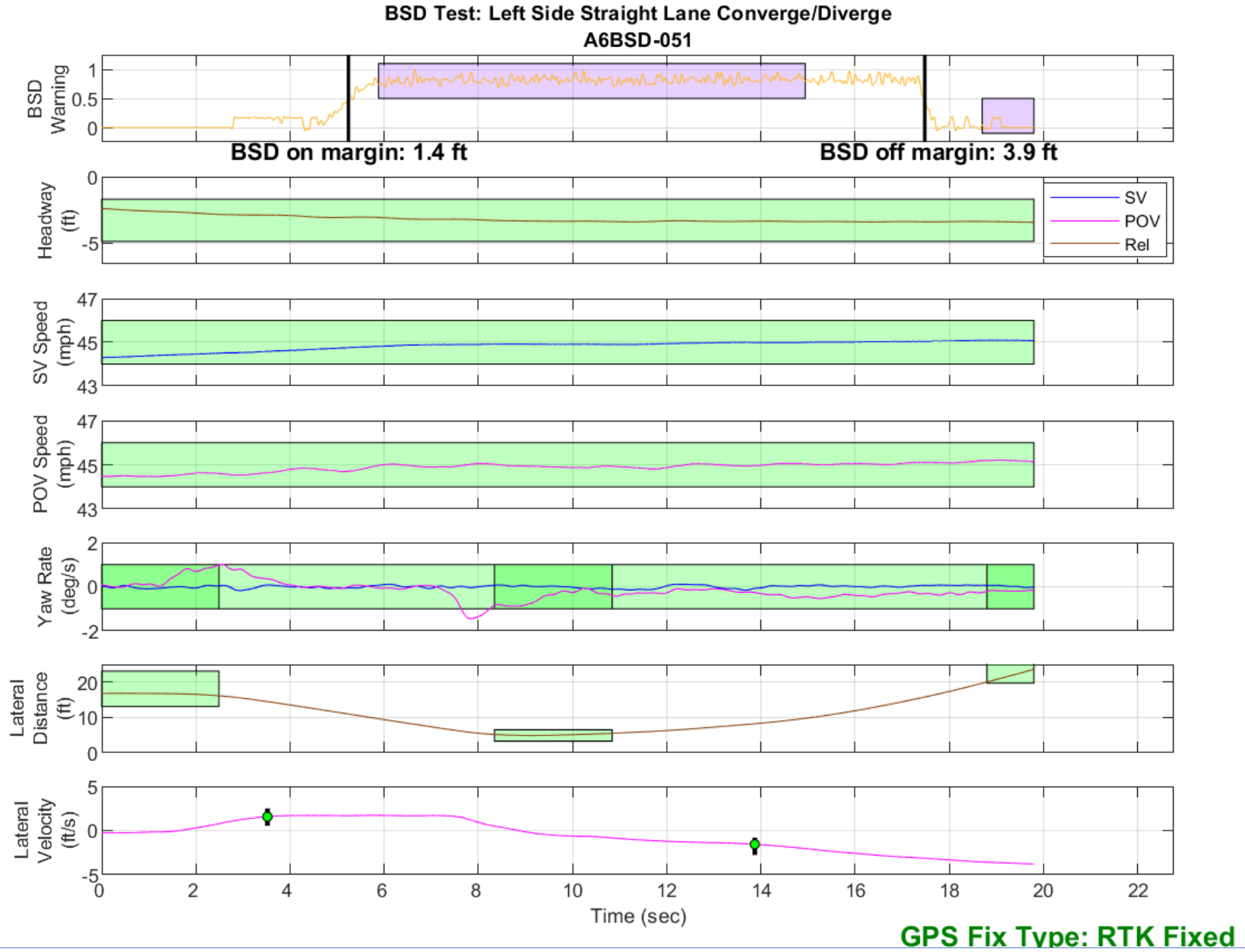

Figure D9. BSD Run 51, Straight Lane Converge/Diverge

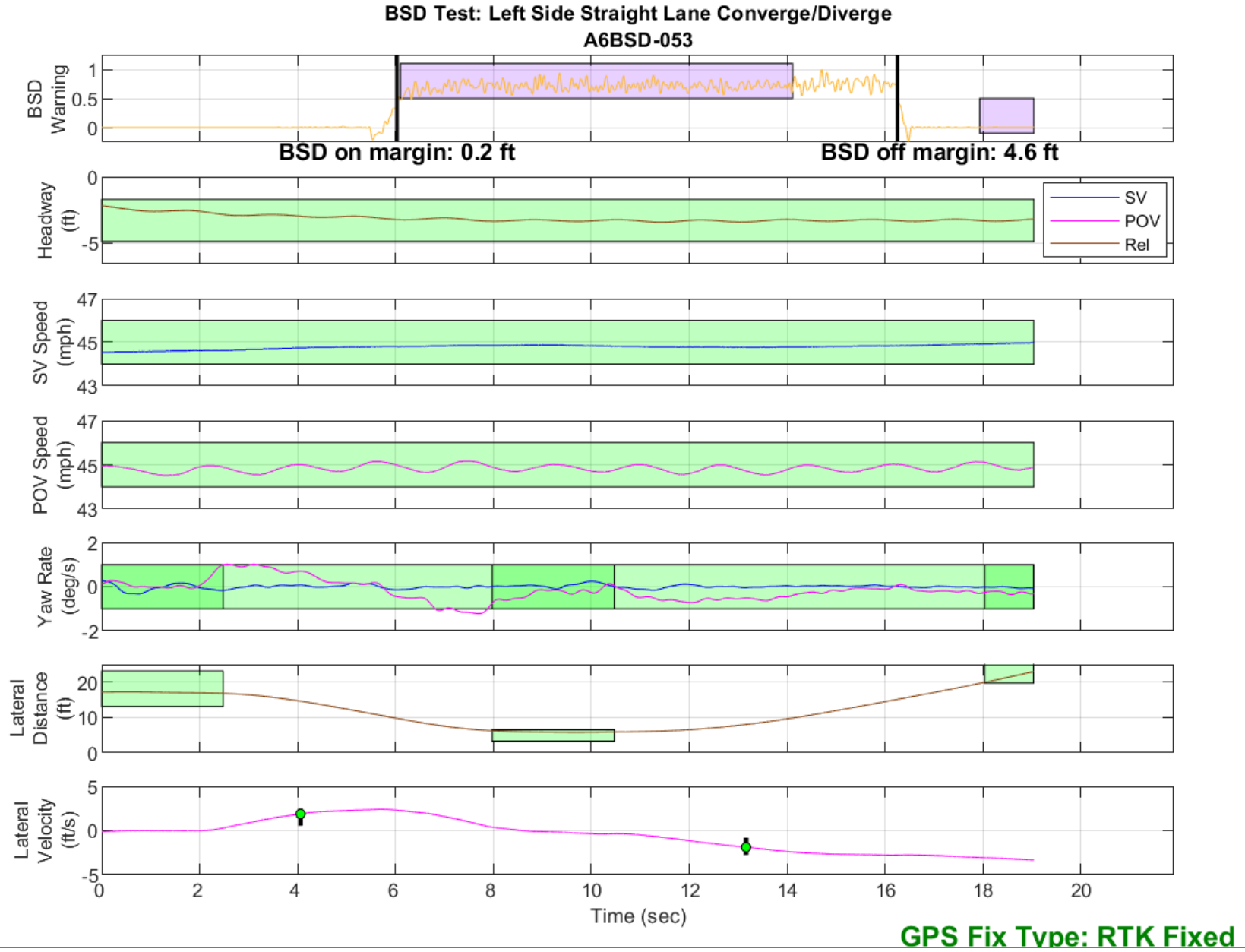

Figure D10. BSD Run 53, Straight Lane Converge/Diverge

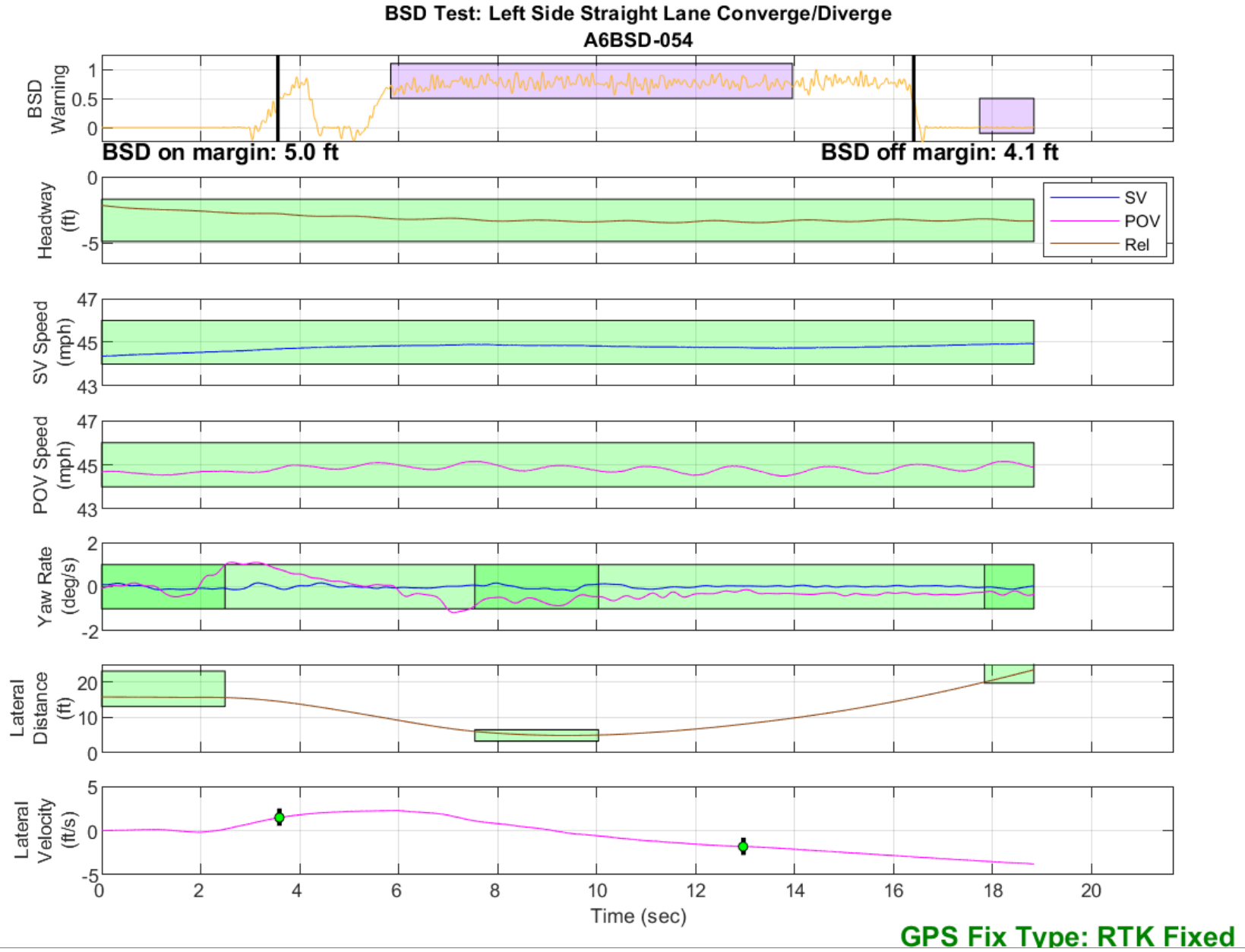

Figure D11. BSD Run 54, Straight Lane Converge/Diverge

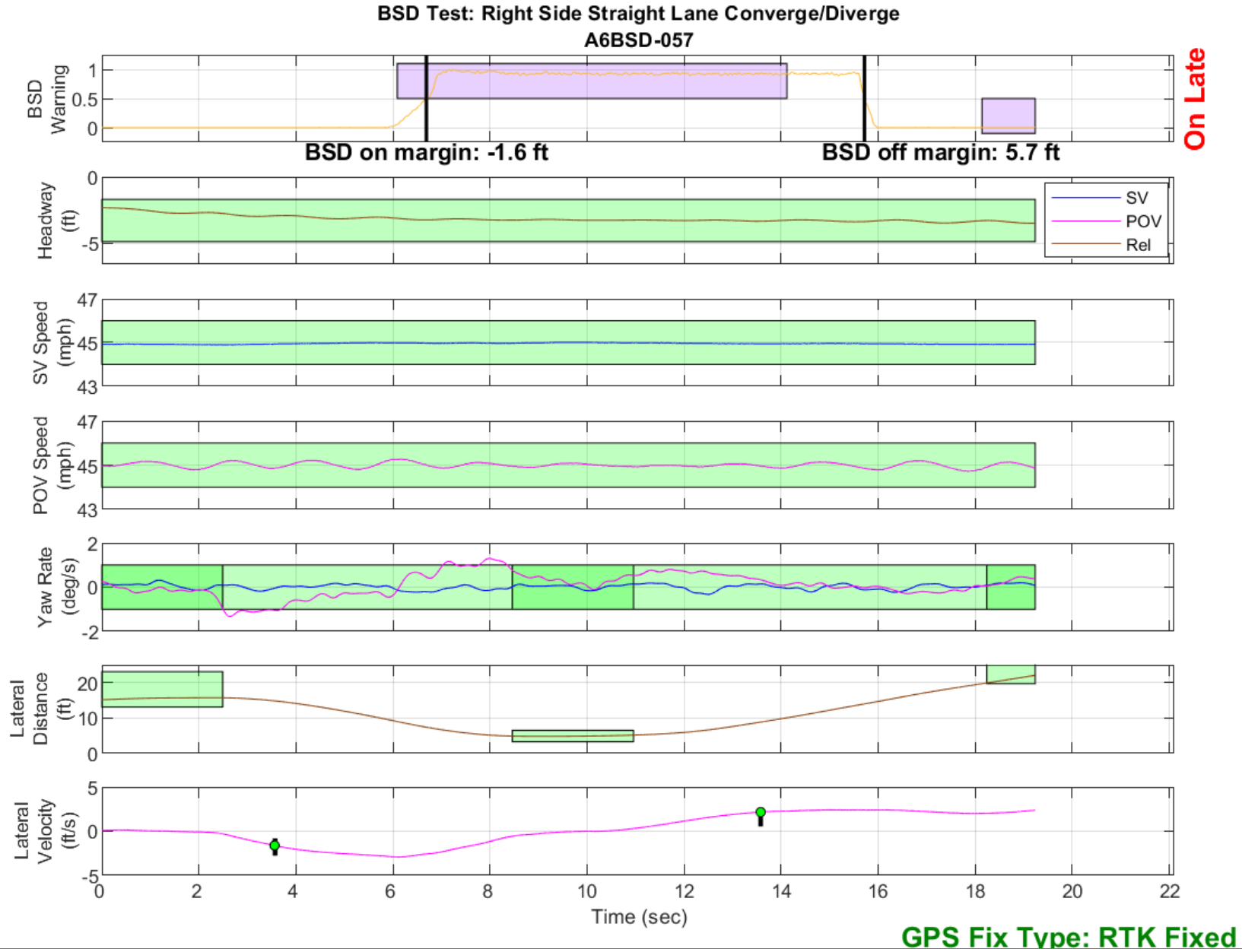

Figure D12. BSD Run 57, Straight Lane Converge/Diverge

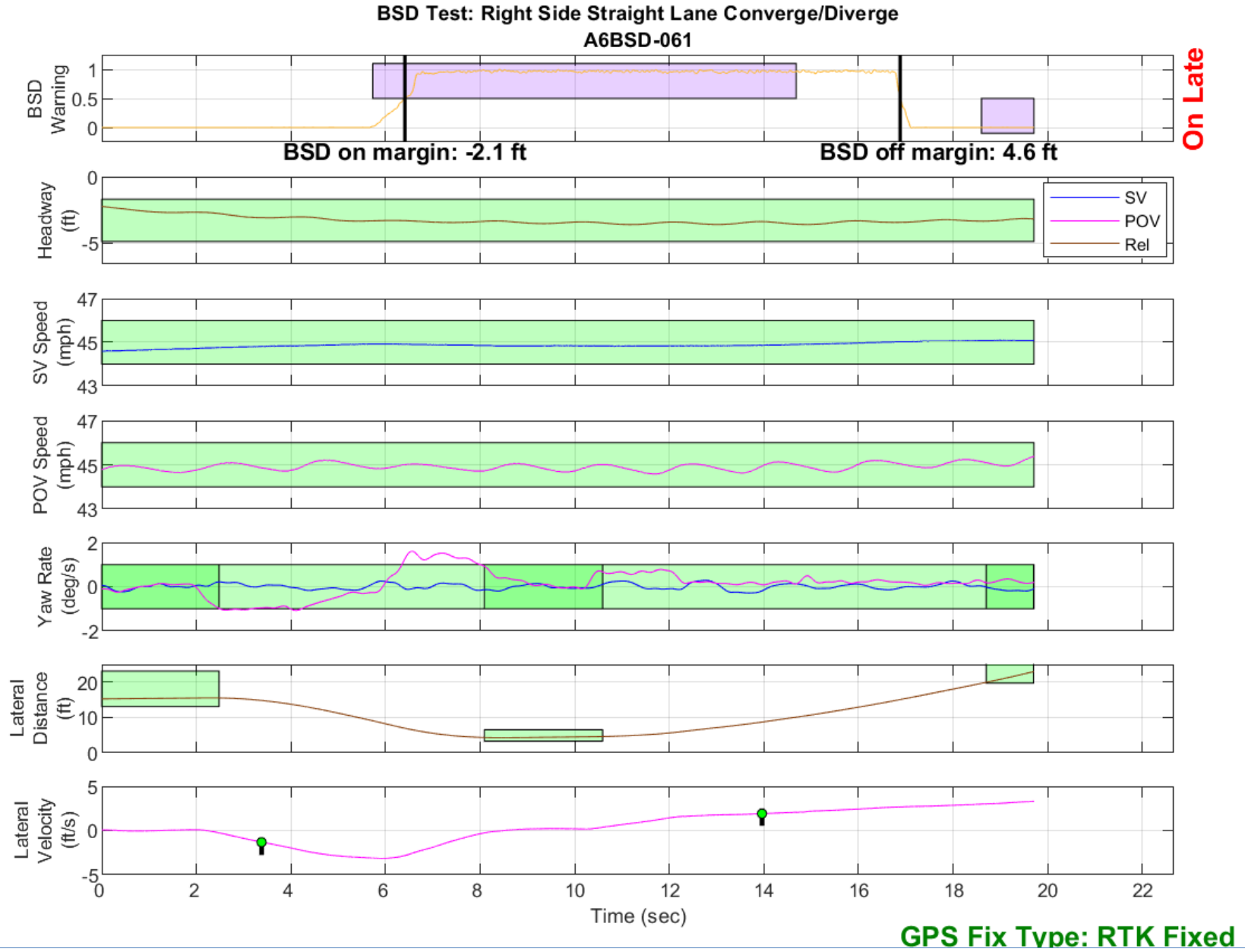

Figure D13. BSD Run 61, Straight Lane Converge/Diverge

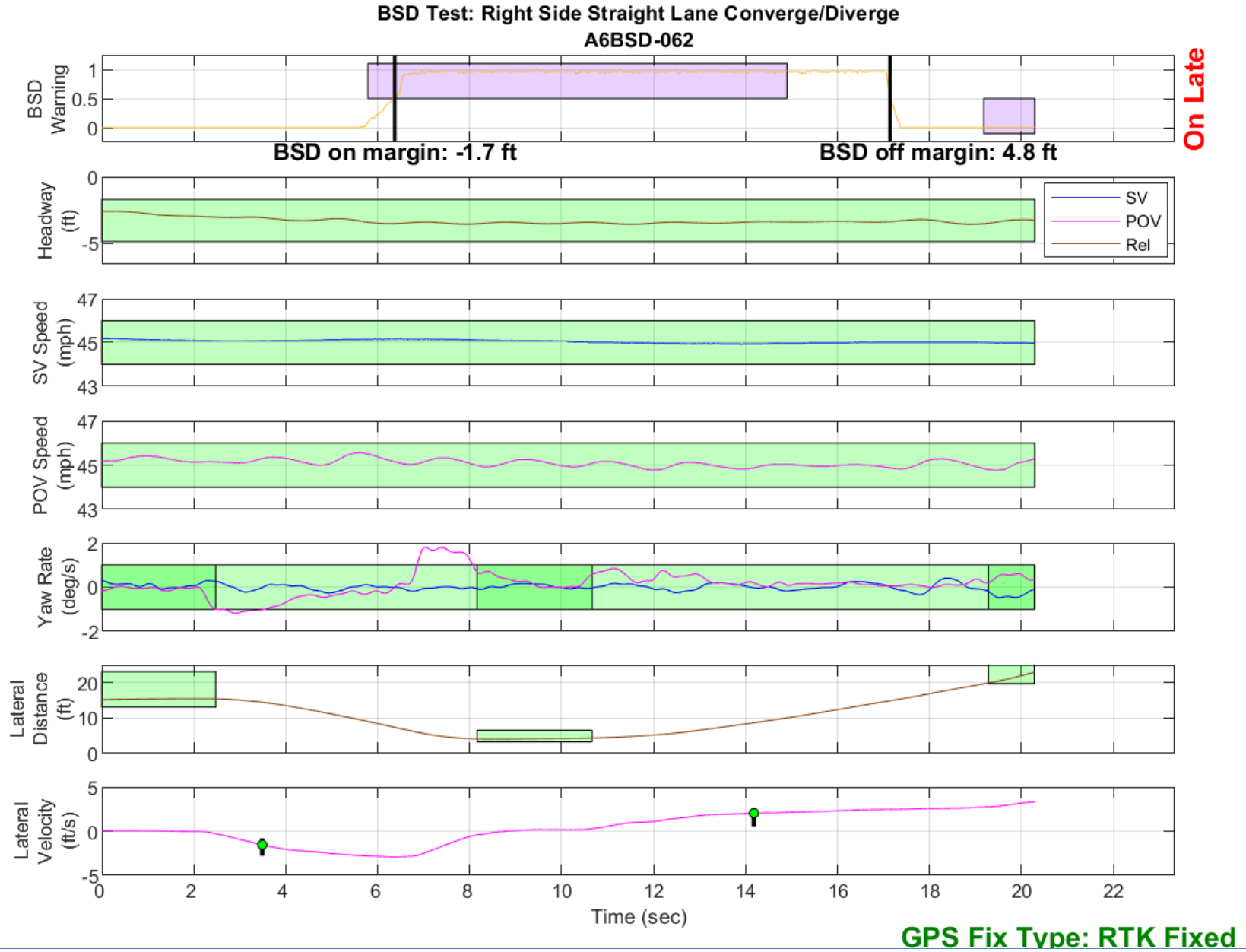

Figure D14. BSD Run 62, Straight Lane Converge/Diverge

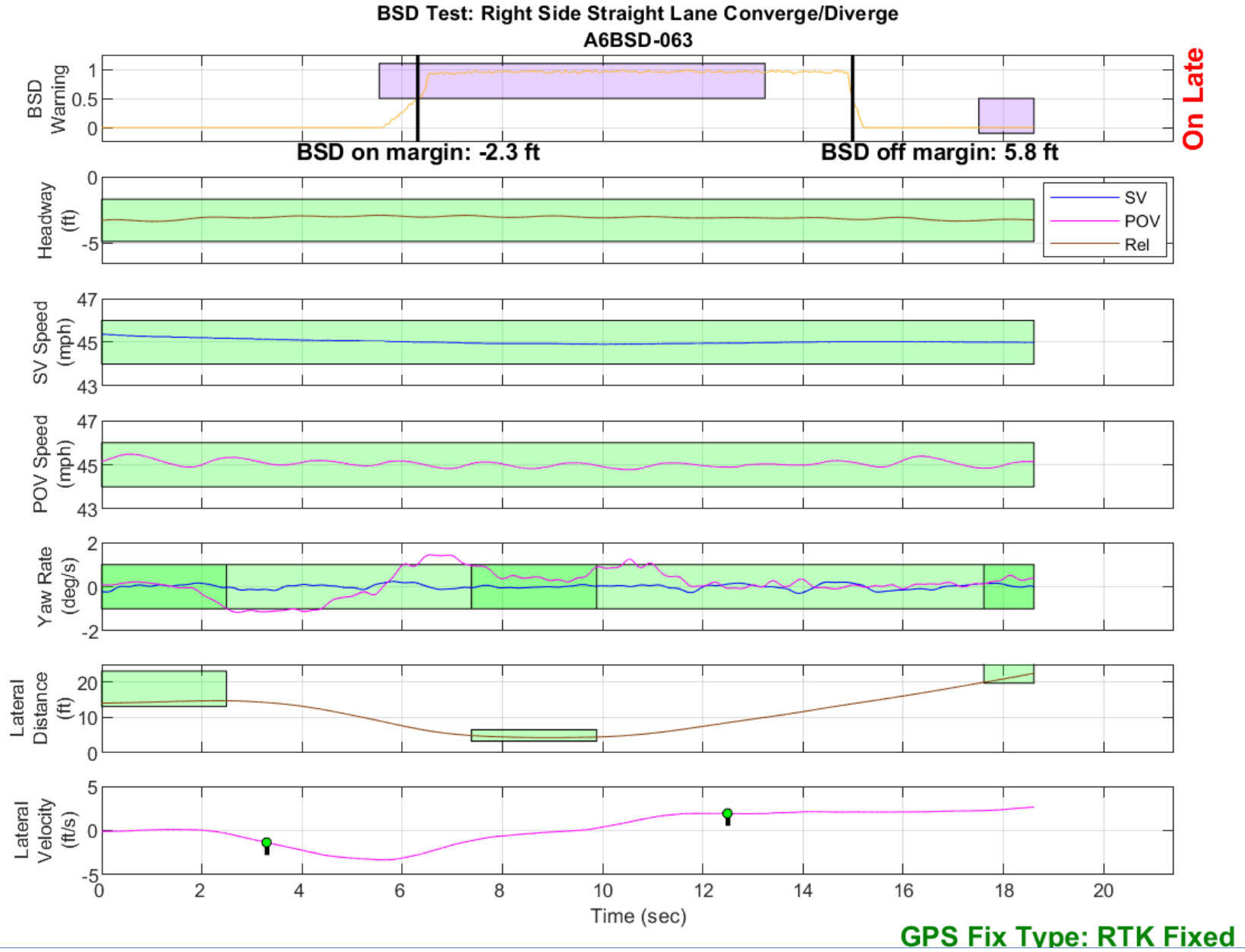

Figure D15. BSD Run 63, Straight Lane Converge/Diverge

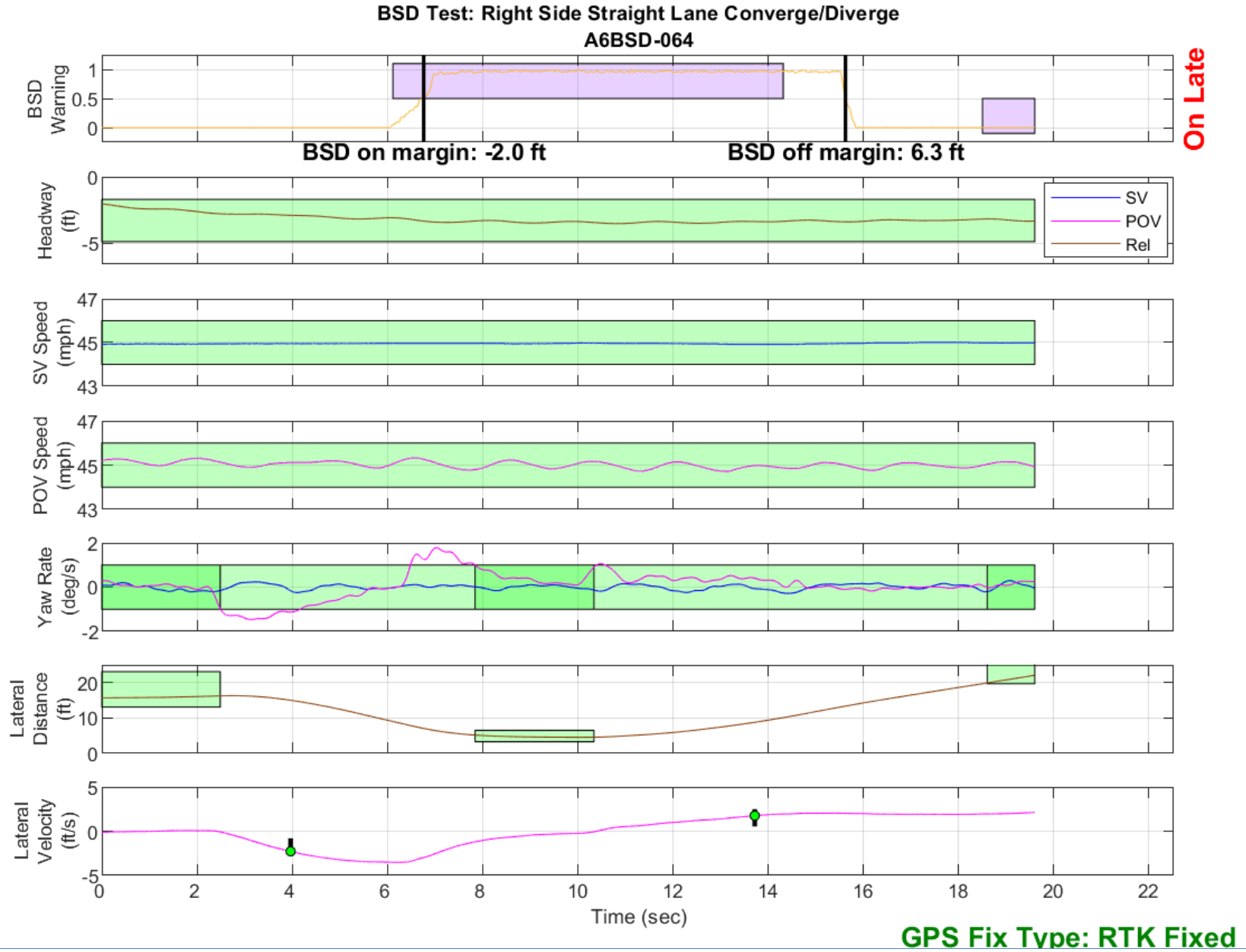

Figure D16. BSD Run 64, Straight Lane Converge/Diverge

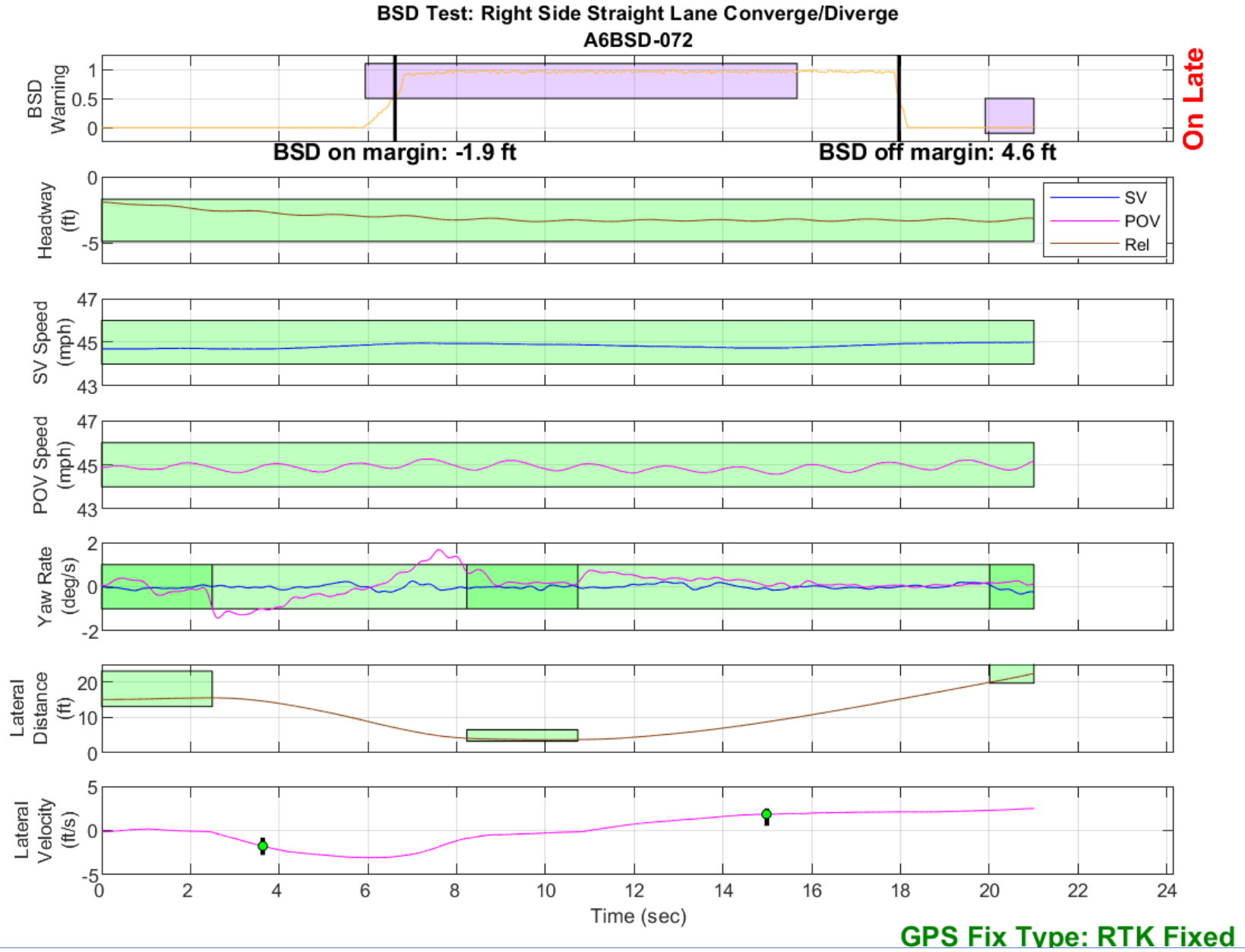

Figure D17. BSD Run 72, Straight Lane Converge/Diverge

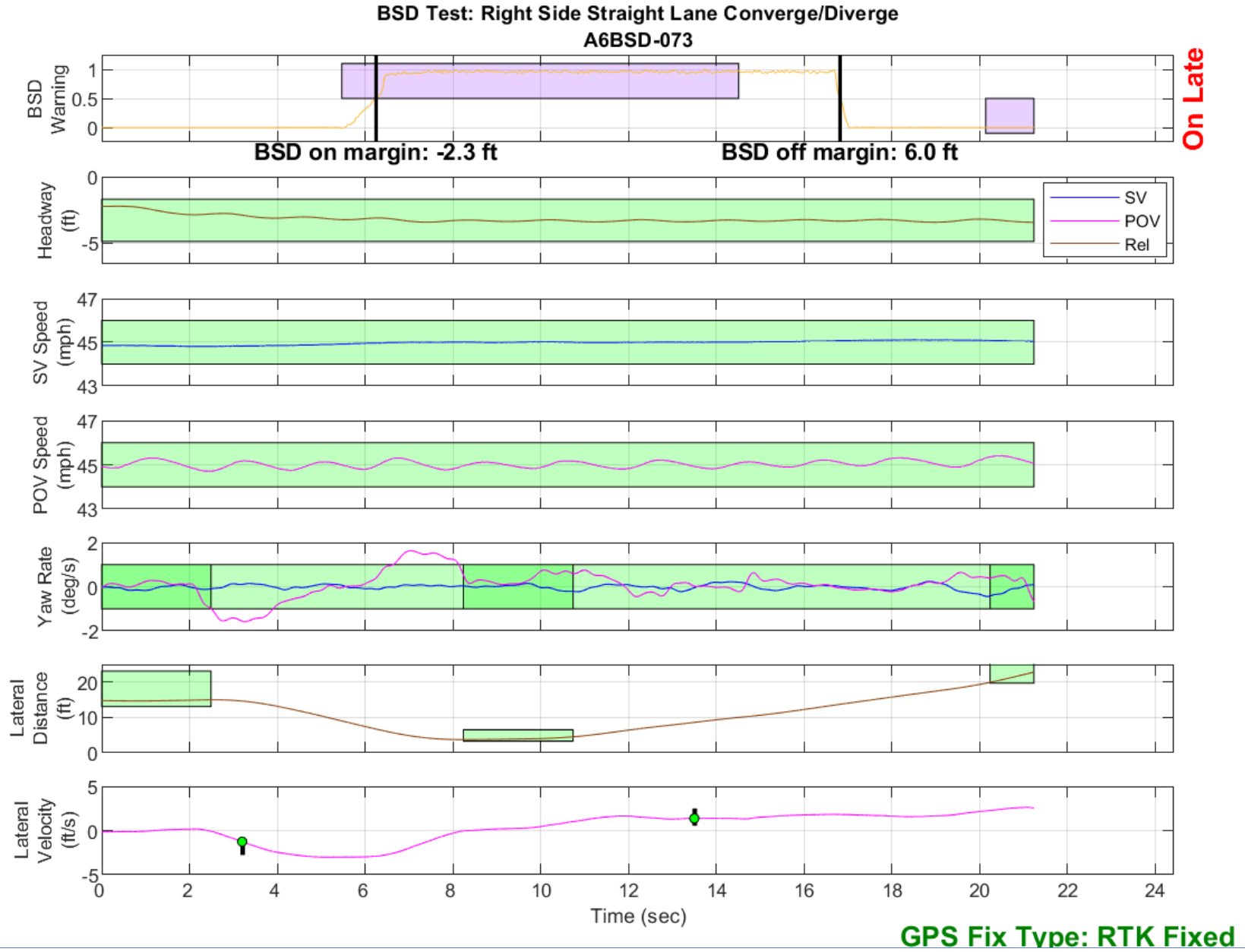

Figure D18. BSD Run 73, Straight Lane Converge/Diverge

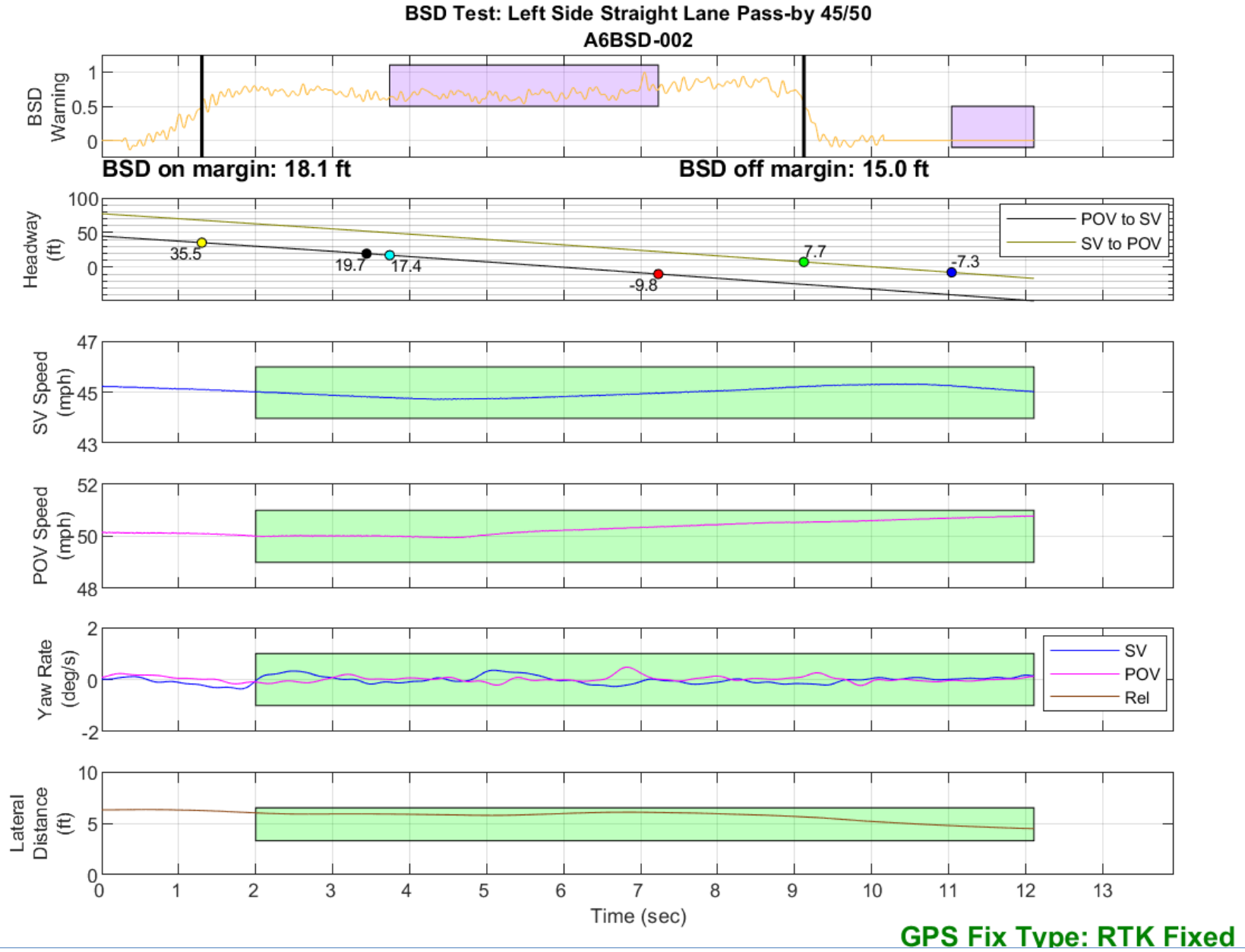

Figure D19. BSD Run 2, Straight Lane Pass-by, SV 45 mph, POV 50 mph

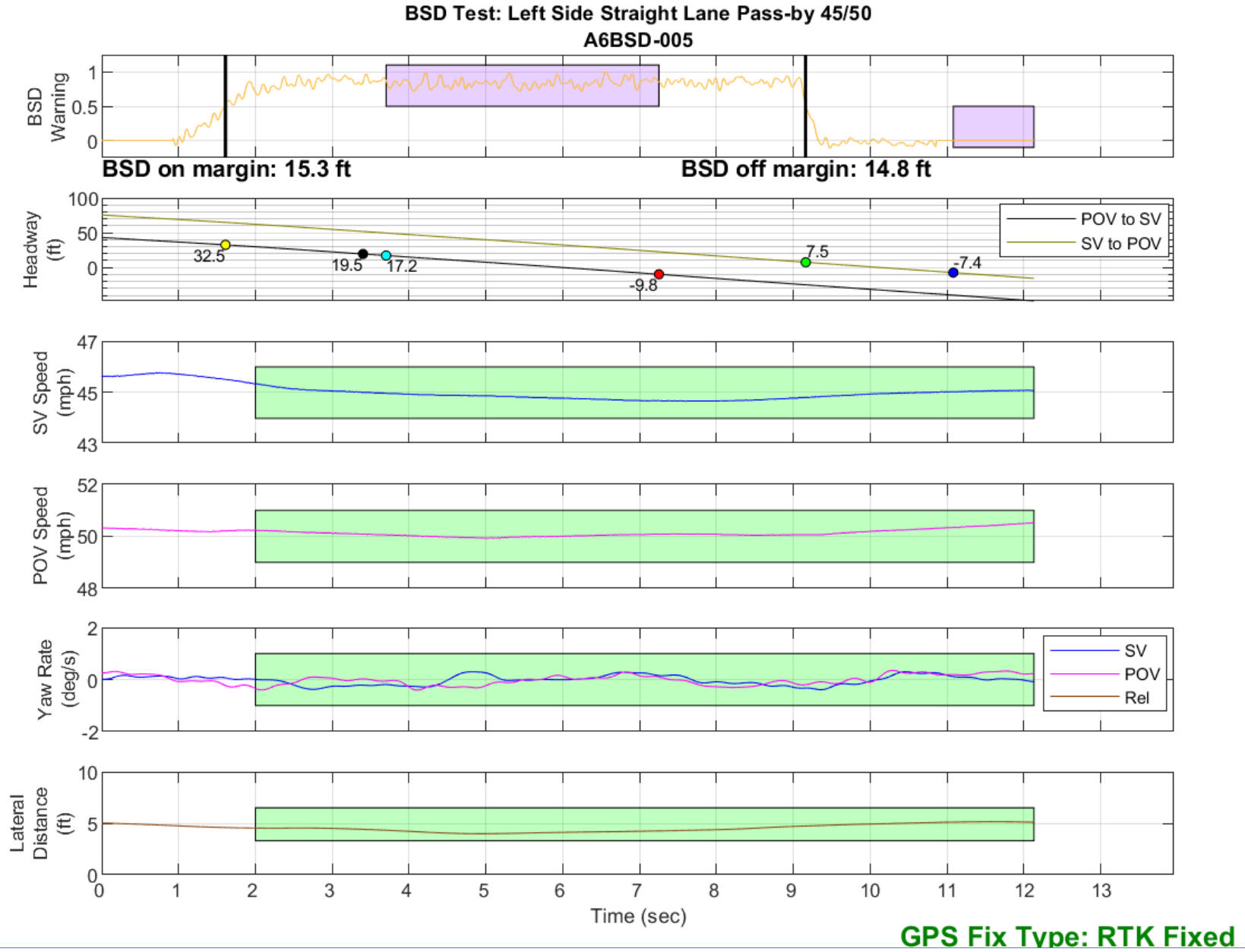

Figure D20. BSD Run 5, Straight Lane Pass-by, SV 45 mph, POV 50 mph

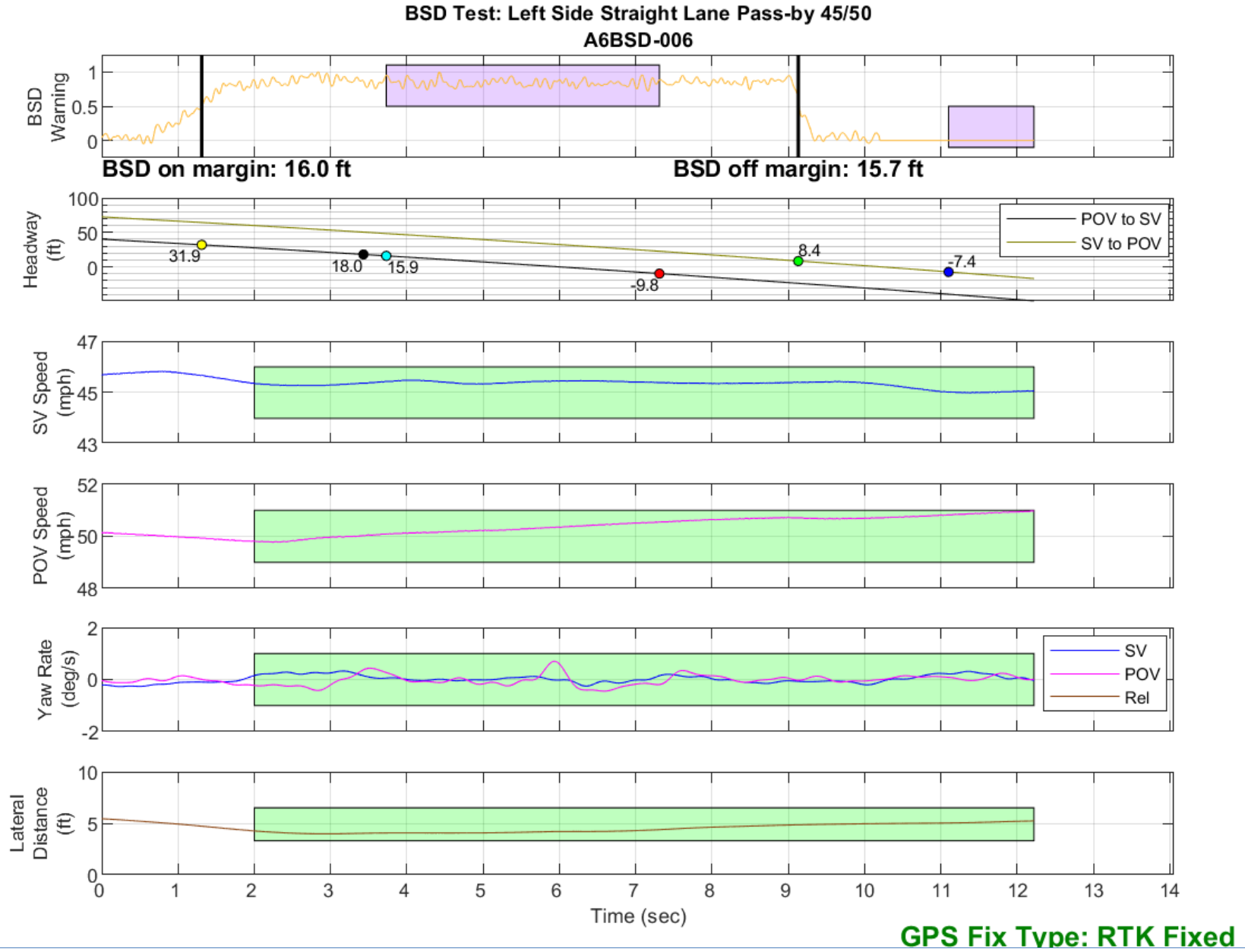

Figure D21. BSD Run 6, Straight Lane Pass-by, SV 45 mph, POV 50 mph

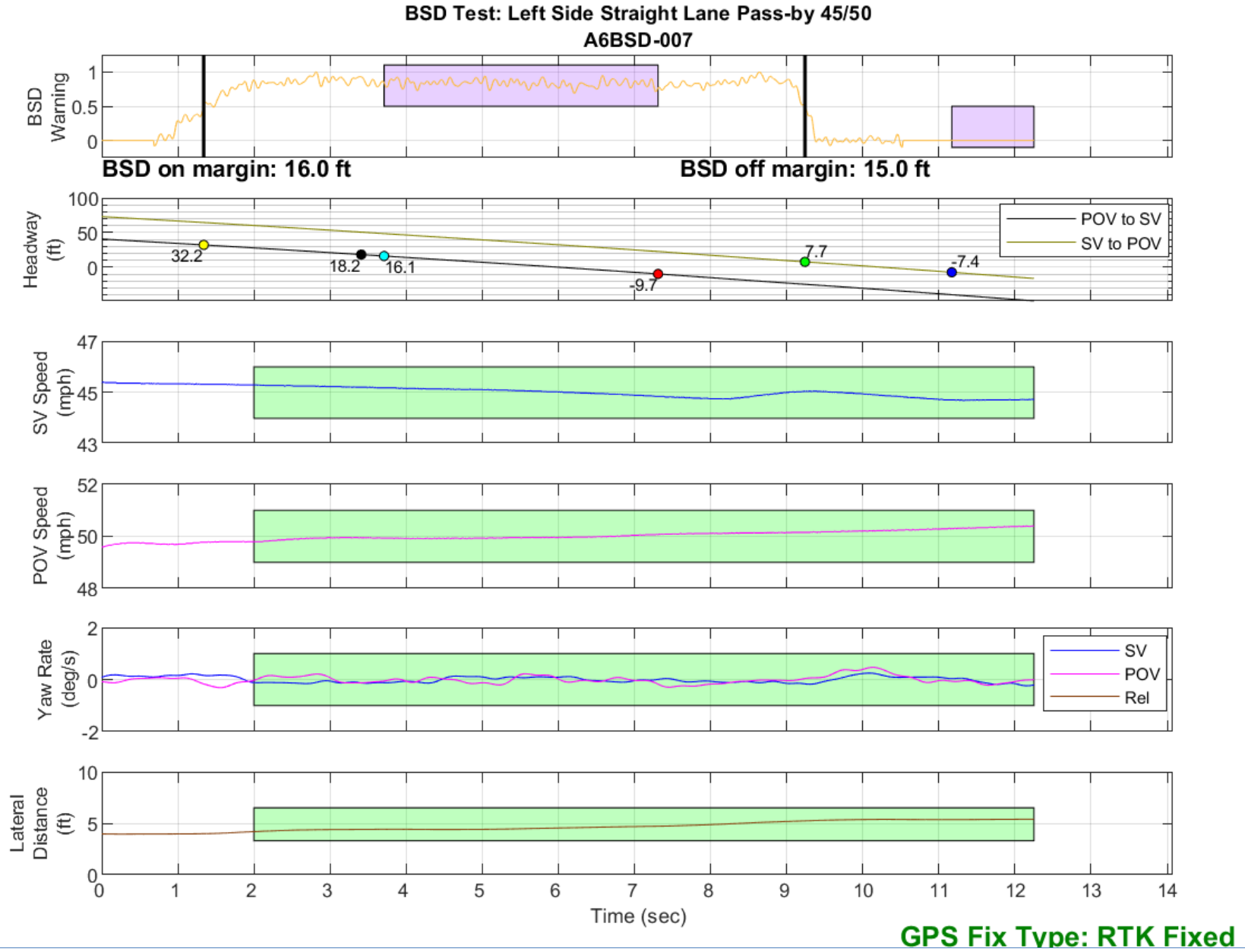

Figure D22. BSD Run 7, Straight Lane Pass-by, SV 45 mph, POV 50 mph

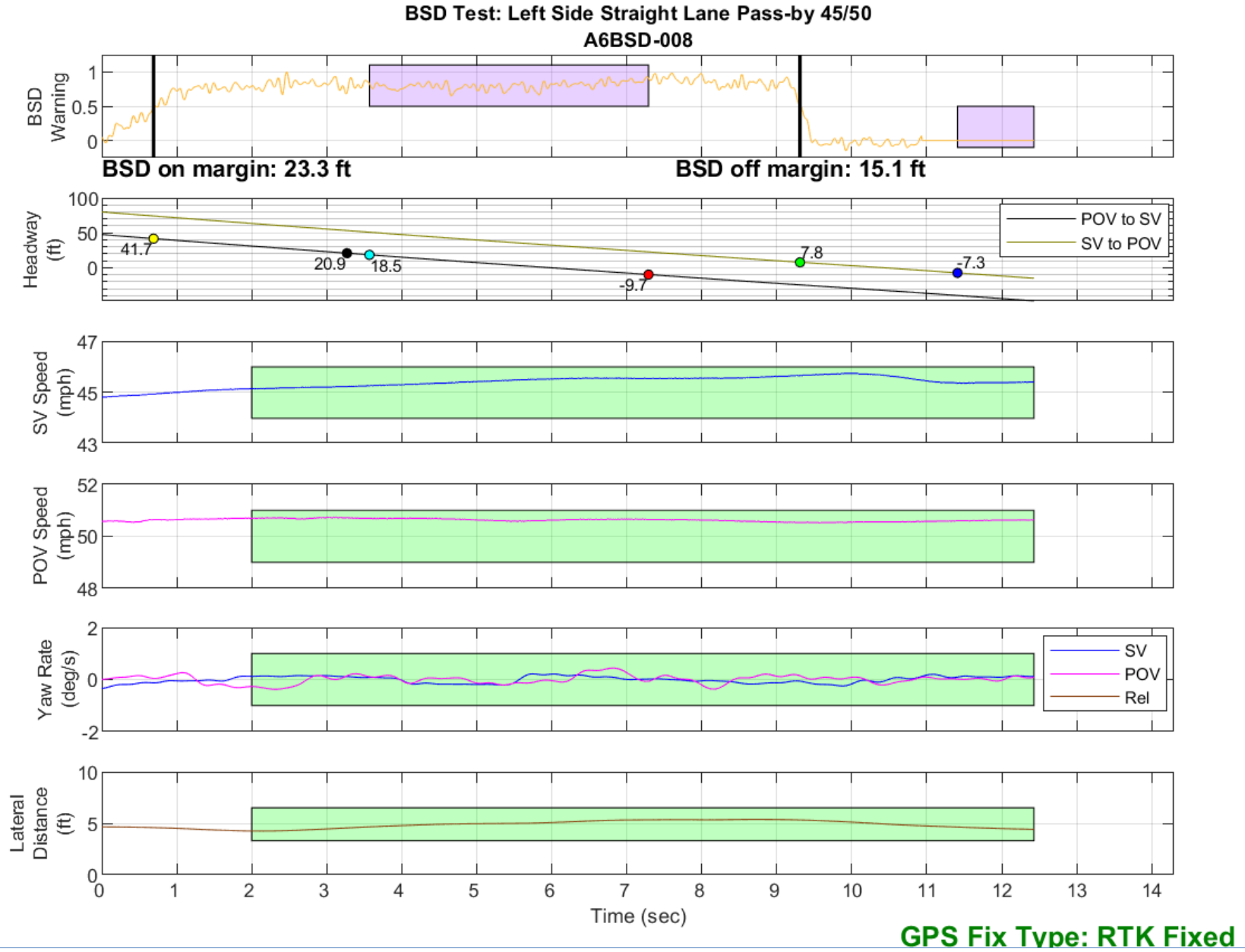

Figure D23. BSD Run 8, Straight Lane Pass-by, SV 45 mph, POV 50 mph

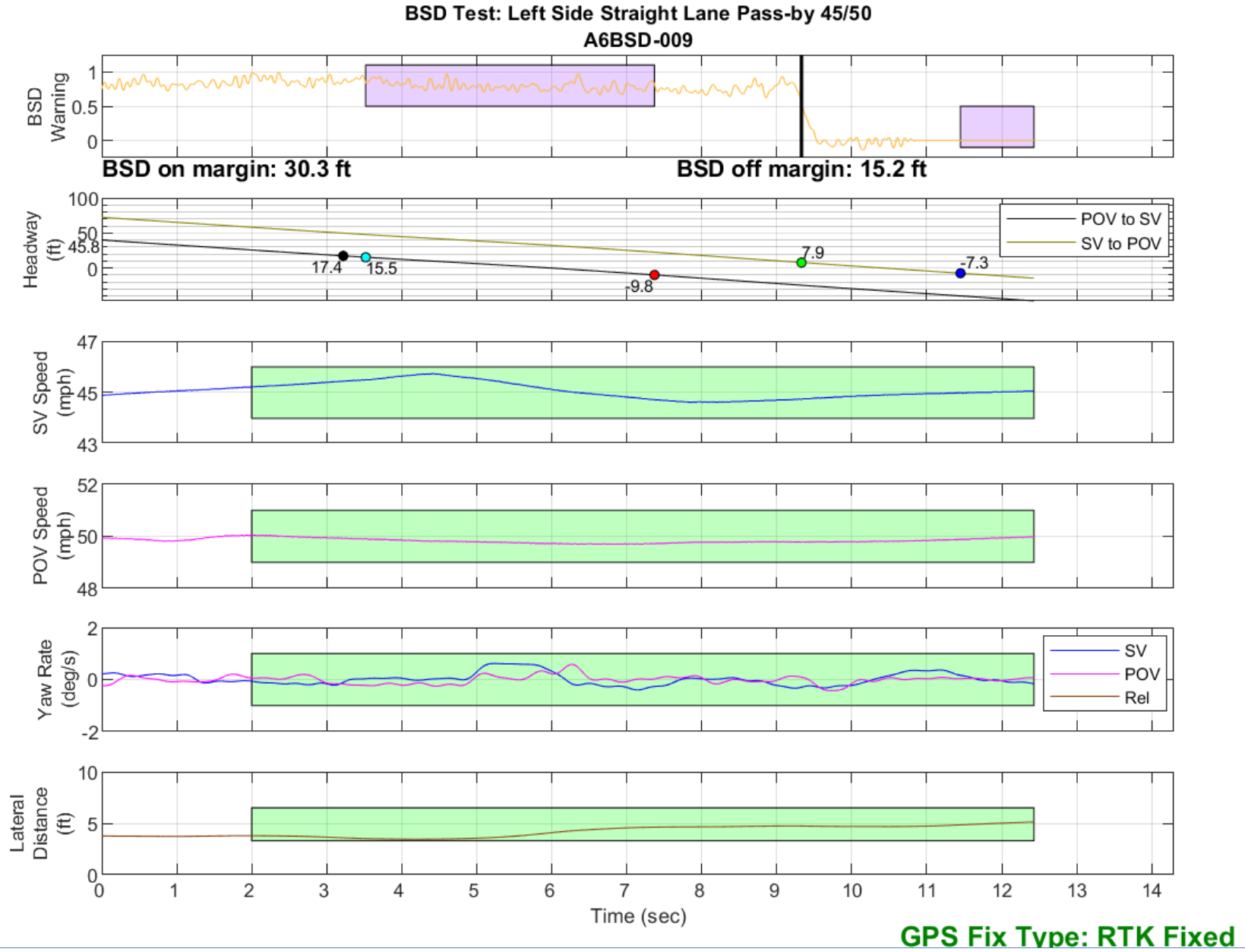

Figure D24. BSD Run 9, Straight Lane Pass-by, SV 45 mph, POV 50 mph

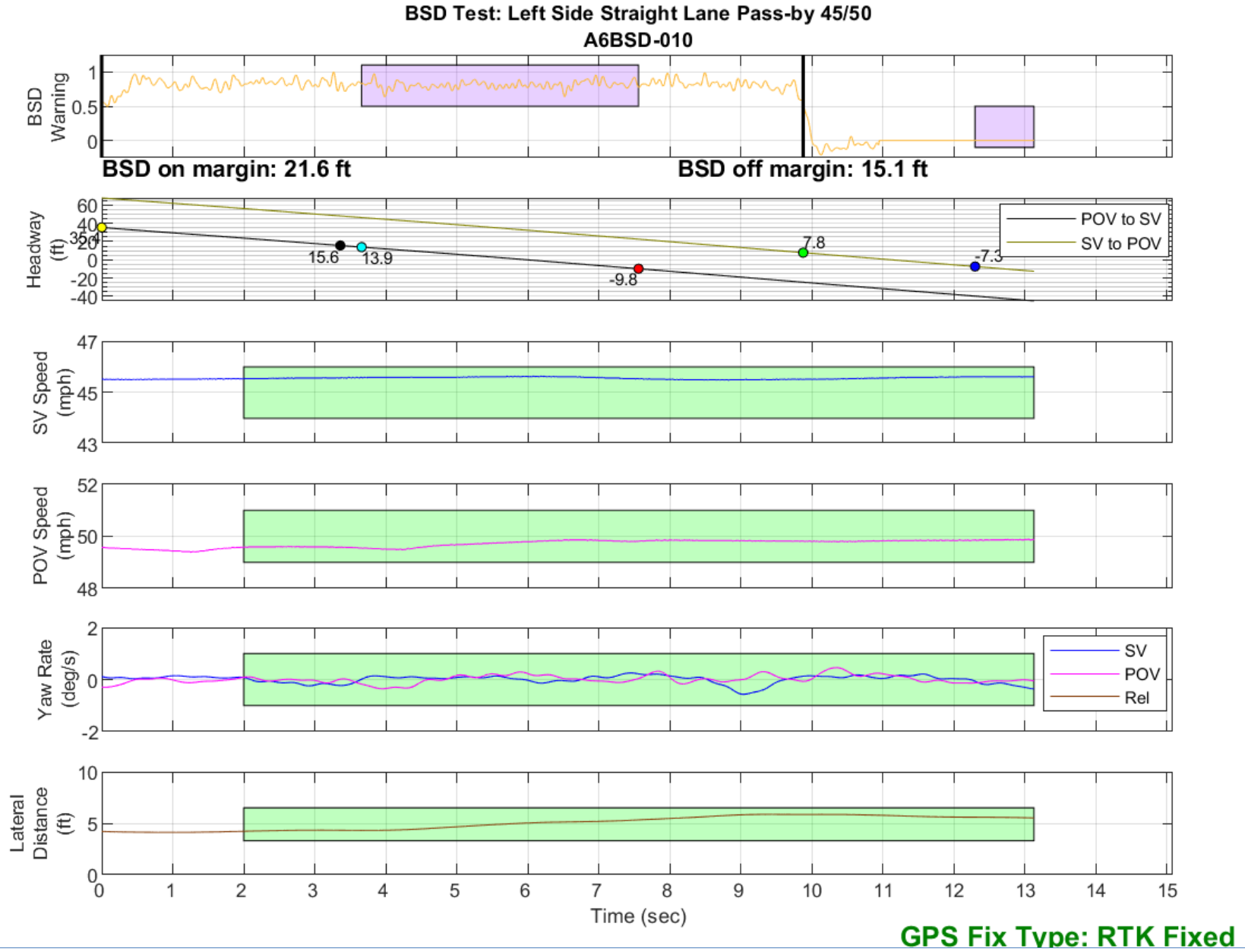

Figure D25. BSD Run 10, Straight Lane Pass-by, SV 45 mph, POV 50 mph

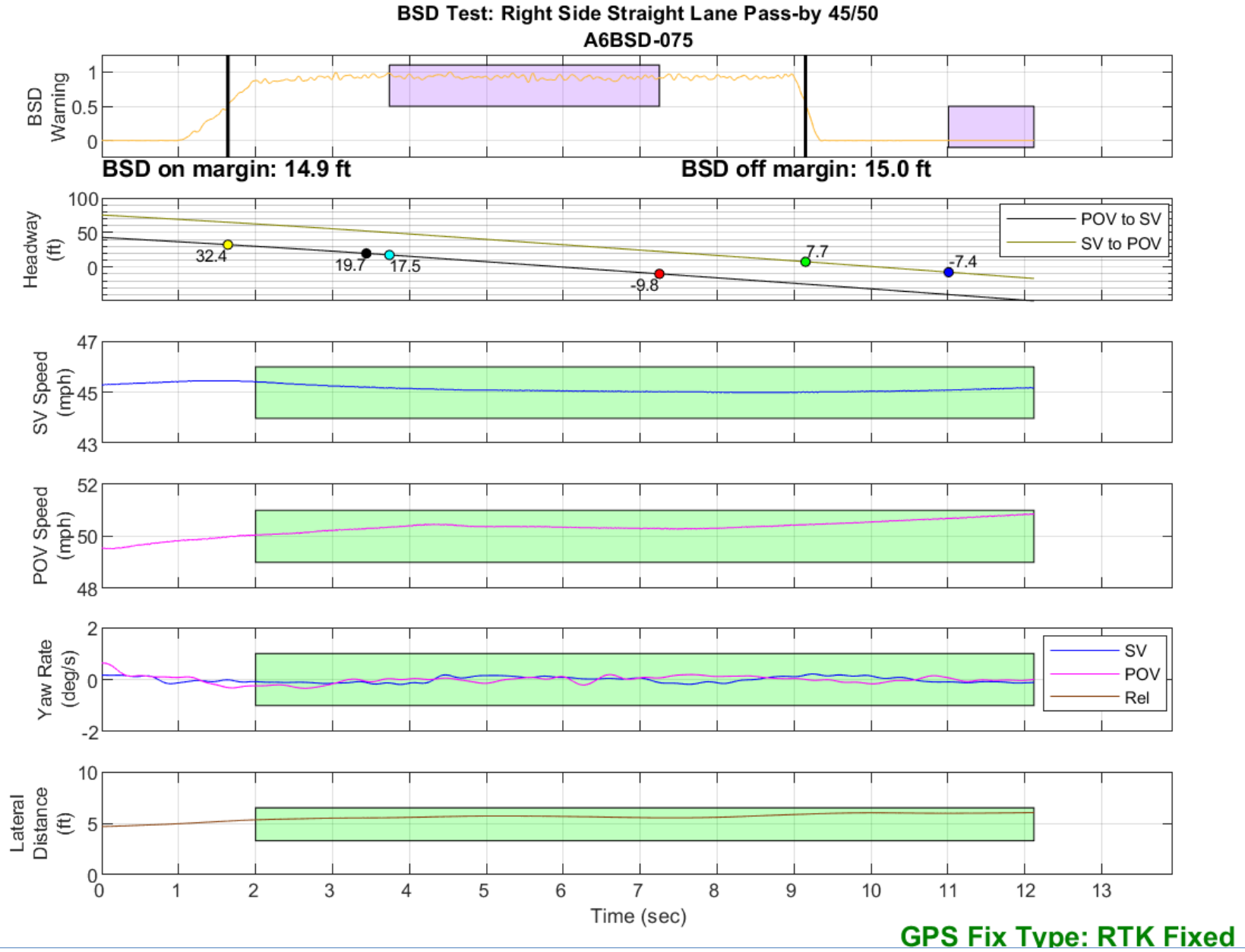

Figure D26. BSD Run 75, Straight Lane Pass-by, SV 45 mph, POV 50 mph

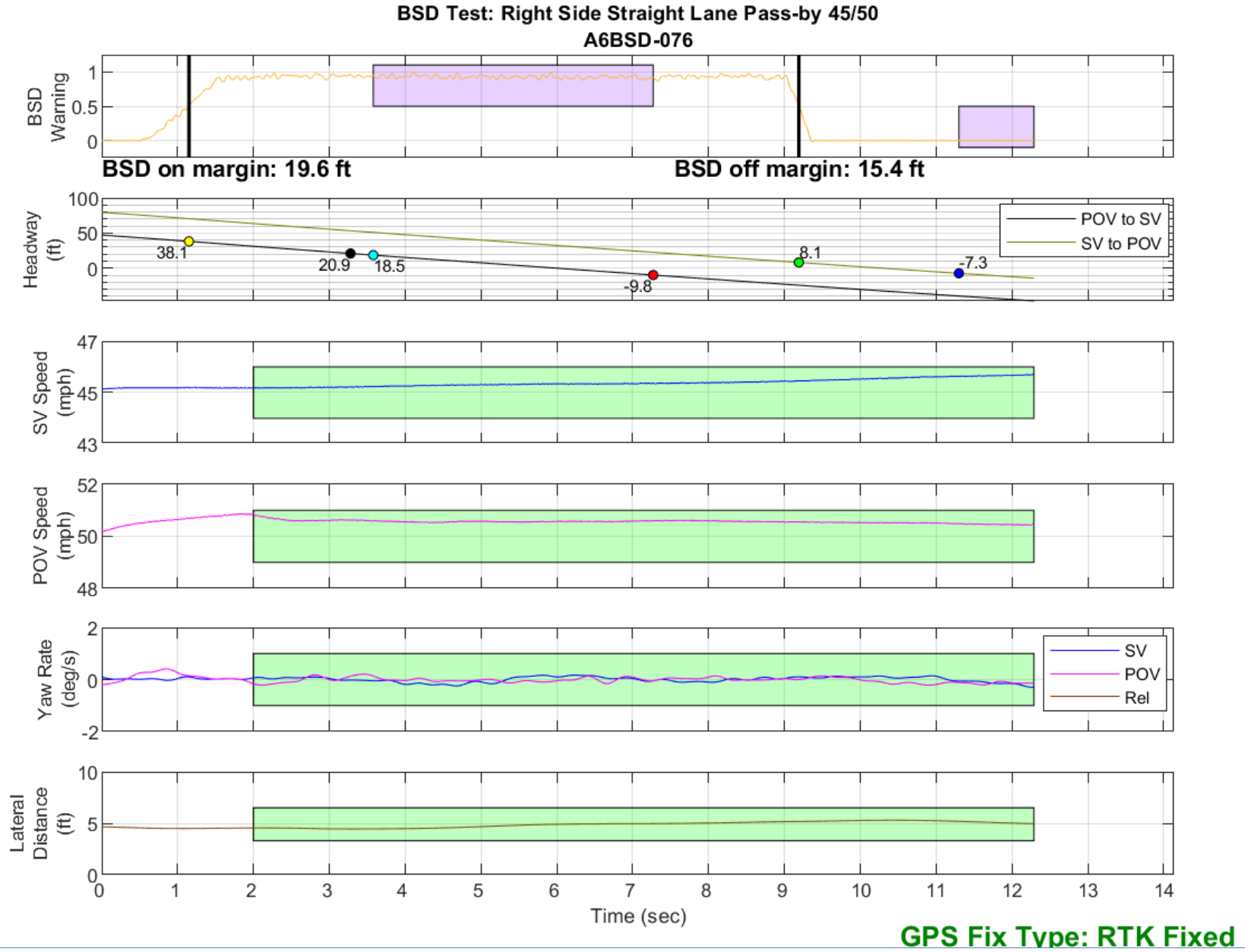

Figure D27. BSD Run 76, Straight Lane Pass-by, SV 45 mph, POV 50 mph

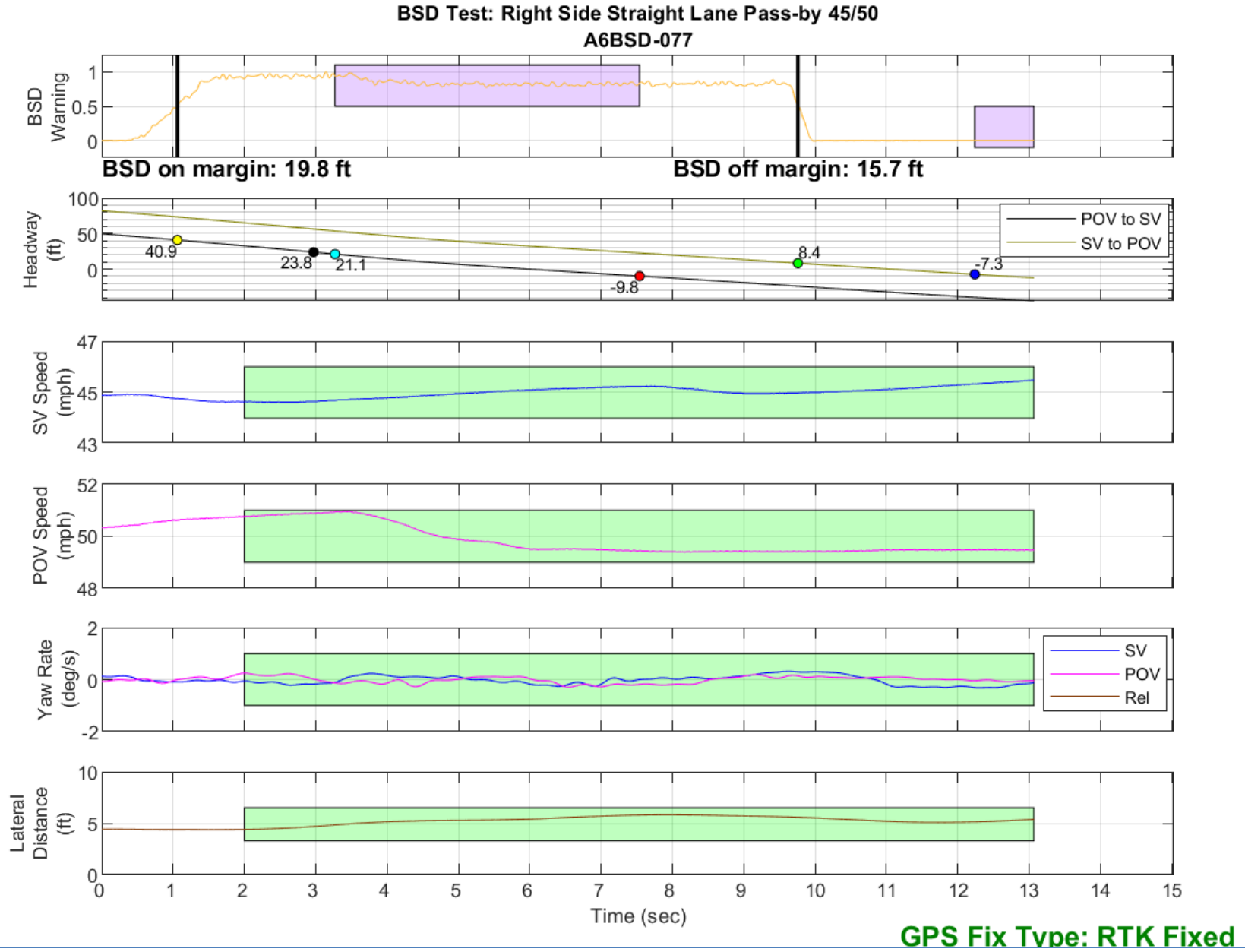

Figure D28. BSD Run 77, Straight Lane Pass-by, SV 45 mph, POV 50 mph

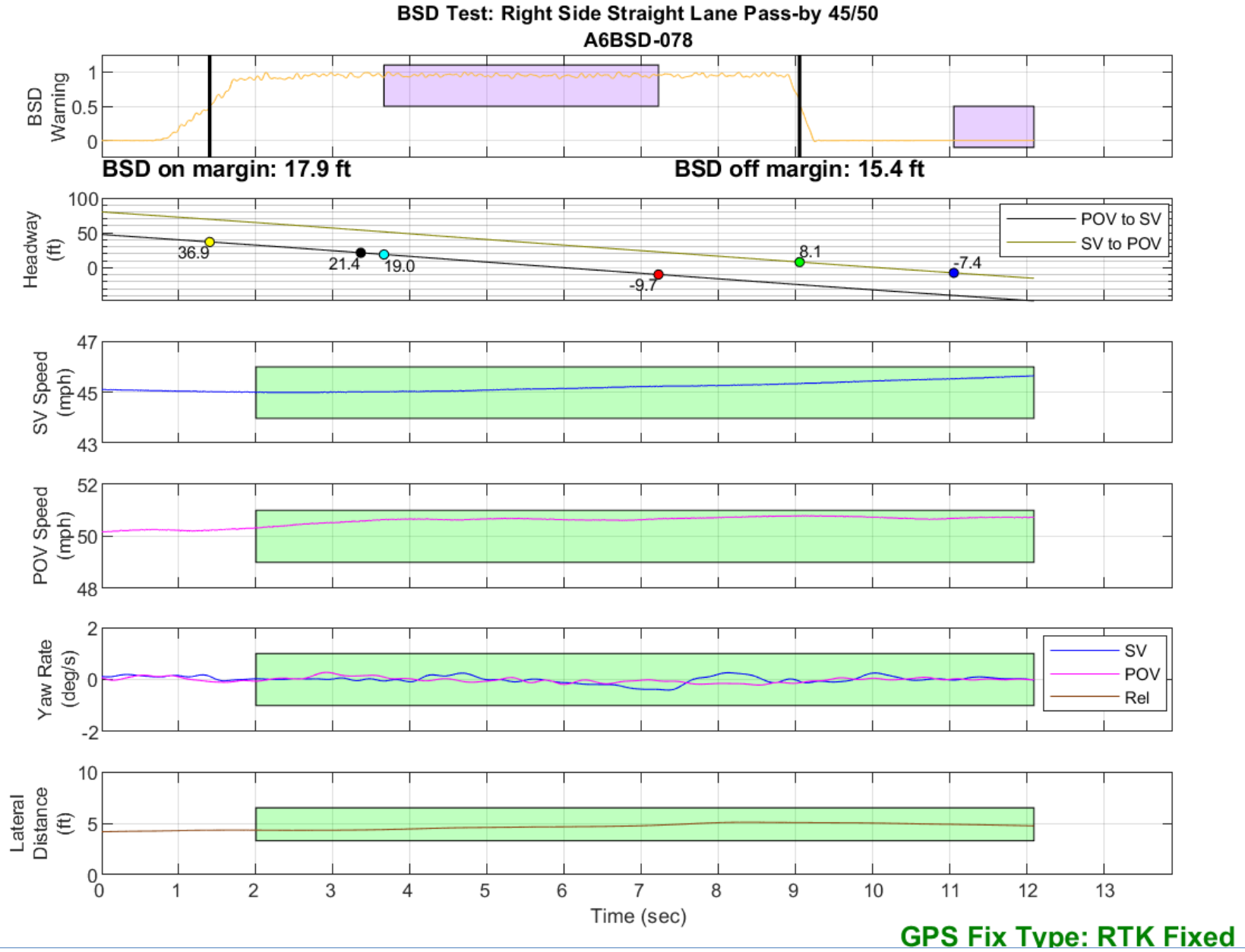

Figure D29. BSD Run 78, Straight Lane Pass-by, SV 45 mph, POV 50 mph

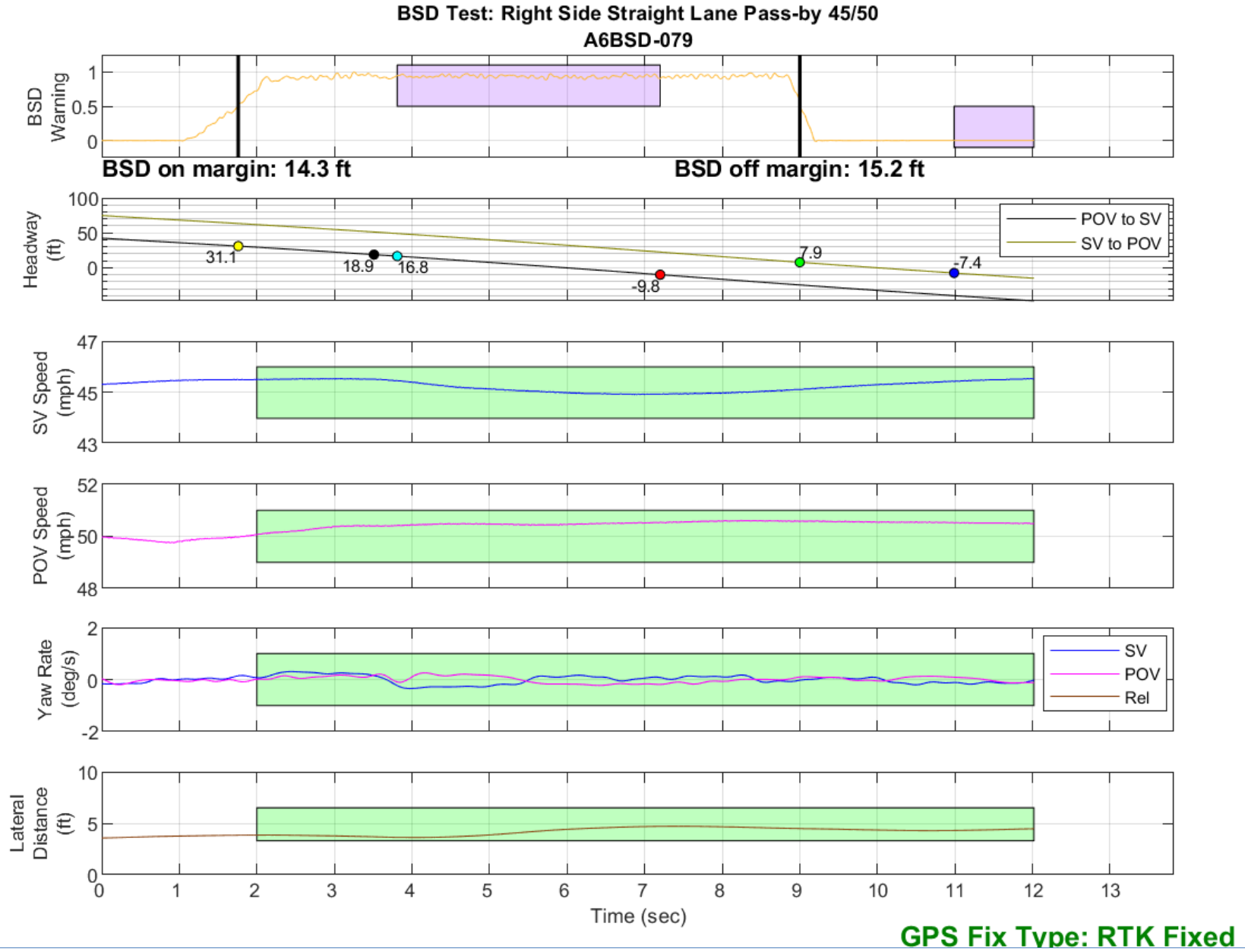

Figure D30. BSD Run 79, Straight Lane Pass-by, SV 45 mph, POV 50 mph

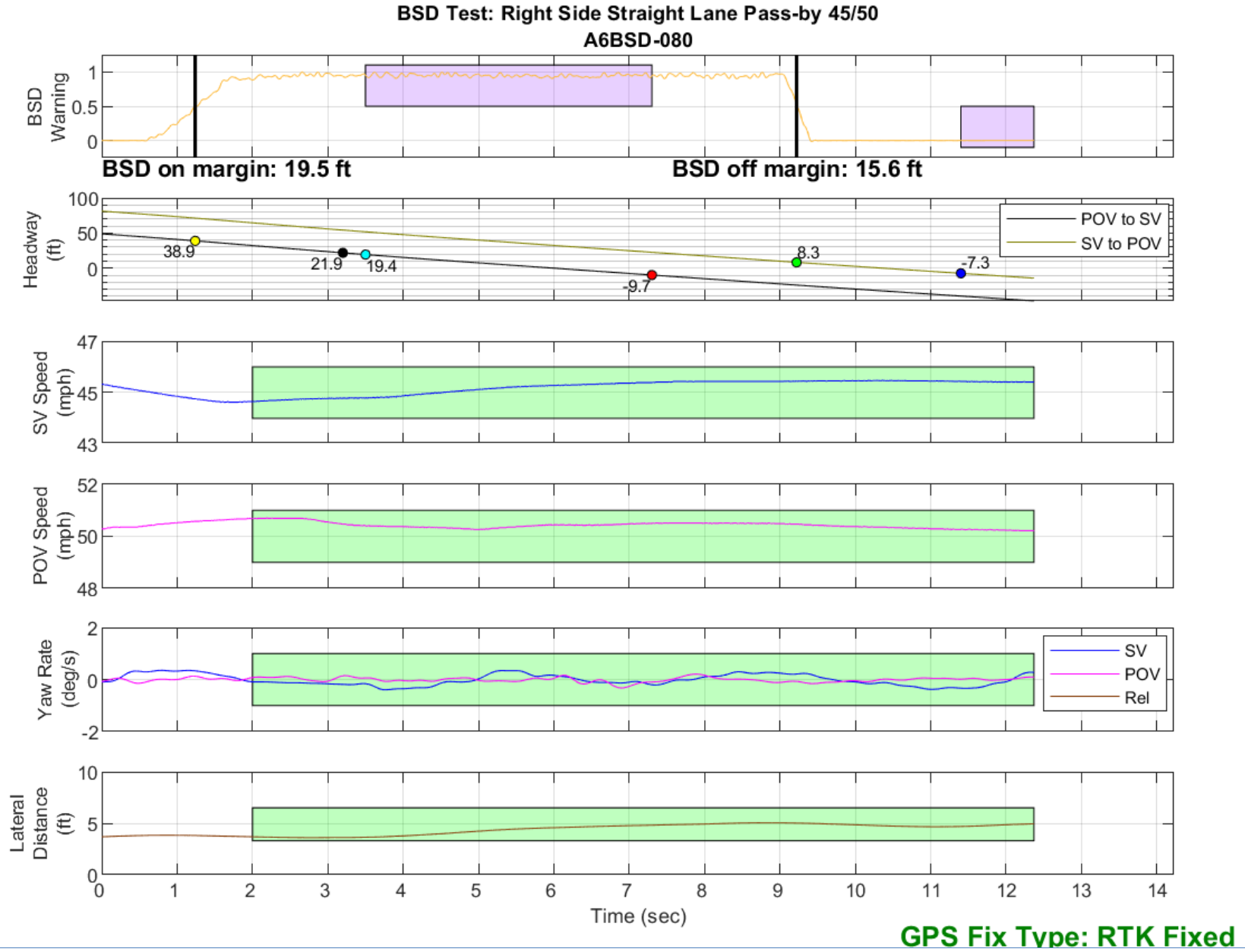

Figure D31. BSD Run 80, Straight Lane Pass-by, SV 45 mph, POV 50 mph

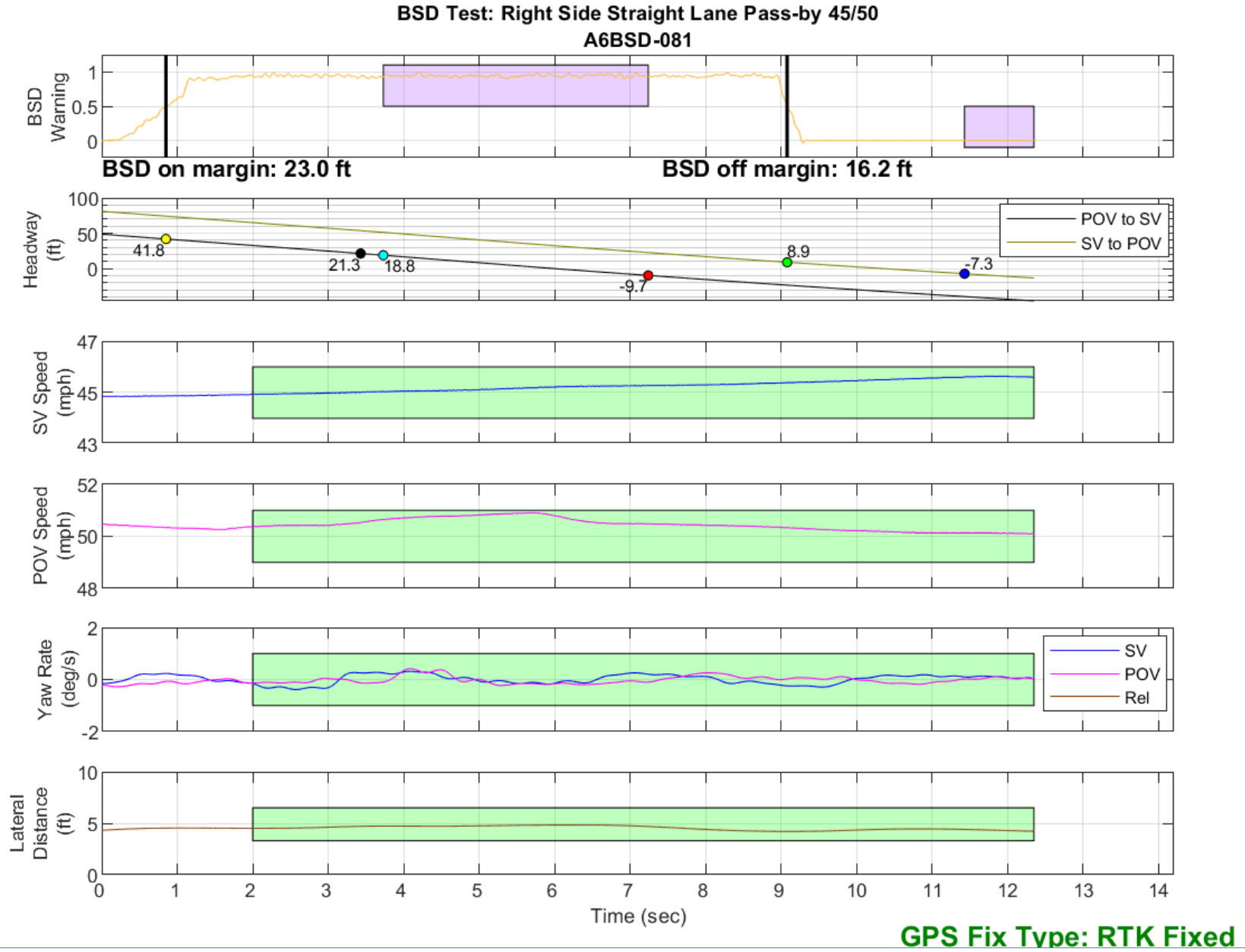

Figure D32. BSD Run 81, Straight Lane Pass-by, SV 45 mph, POV 50 mph

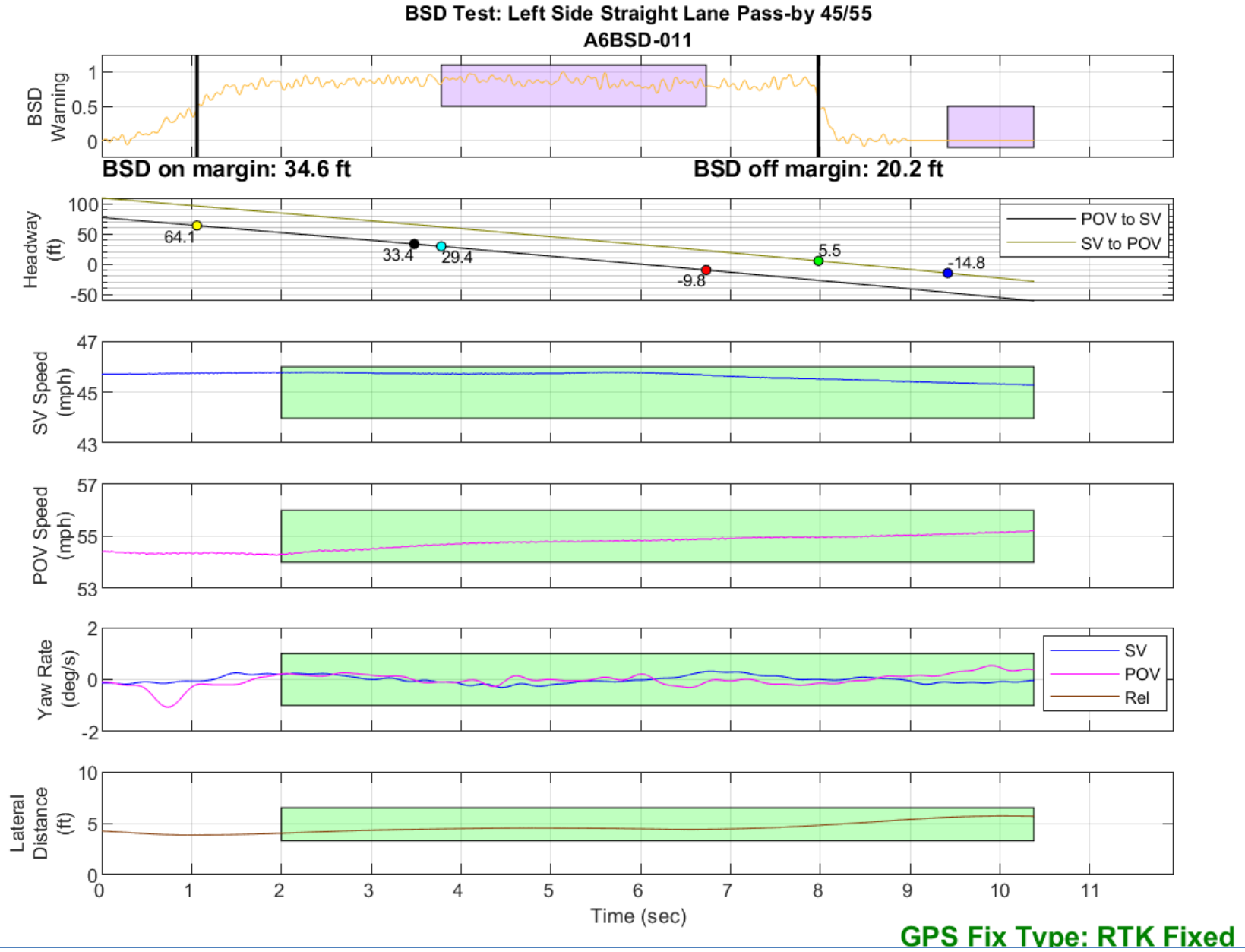

Figure D33. BSD Run 11, Straight Lane Pass-by, SV 45 mph, POV 55 mph

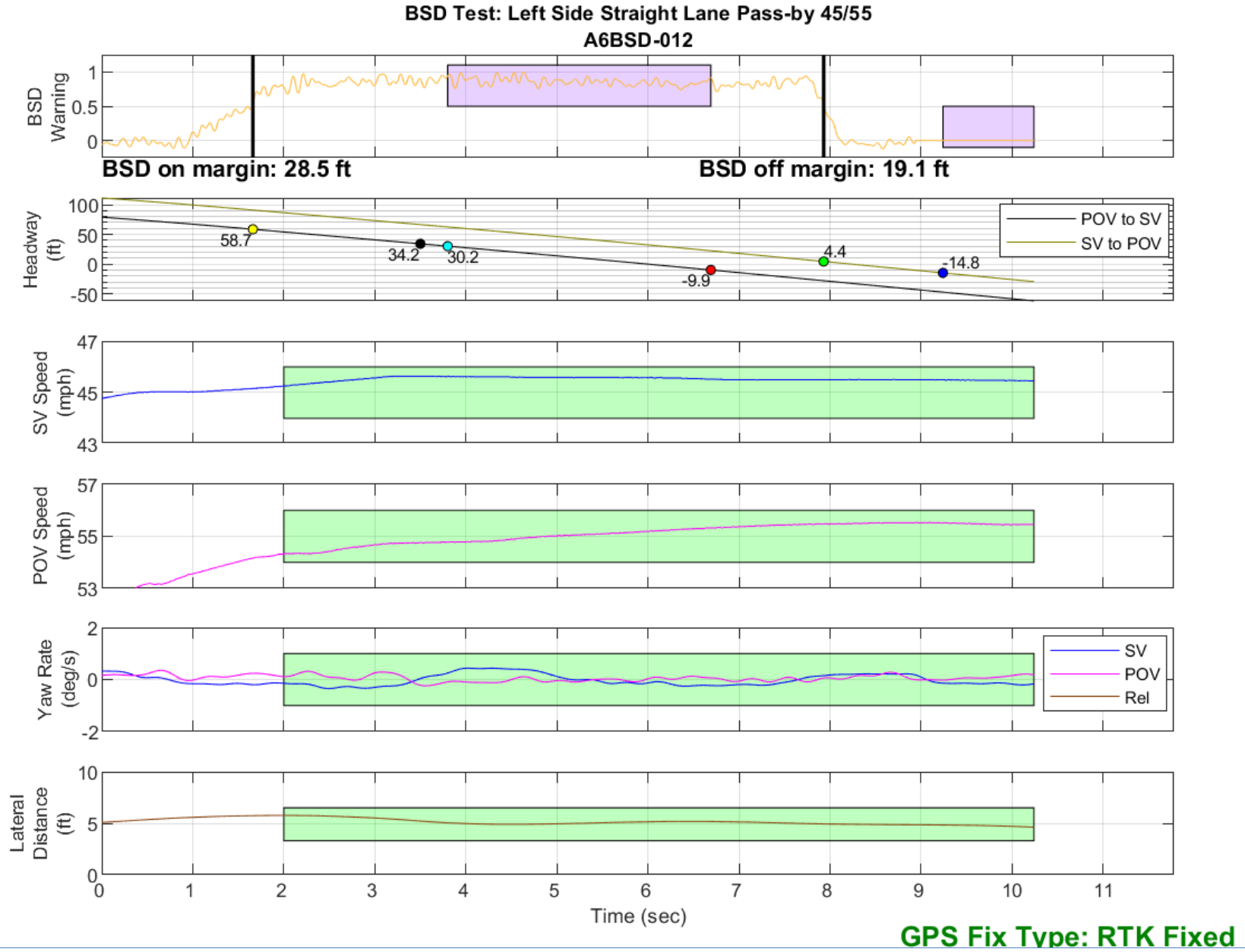

Figure D34. BSD Run 12, Straight Lane Pass-by, SV 45 mph, POV 55 mph

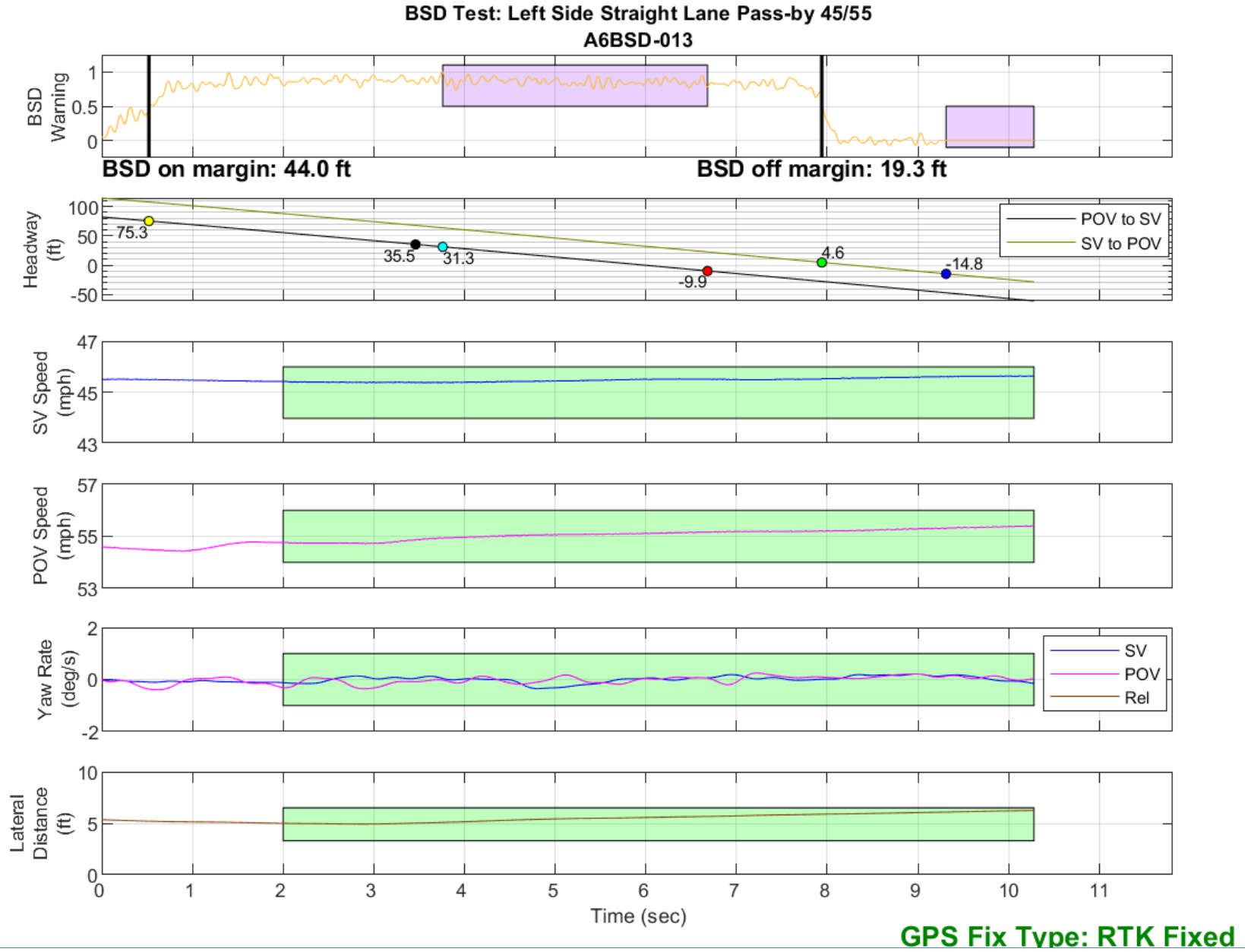

Figure D35. BSD Run 13, Straight Lane Pass-by, SV 45 mph, POV 55 mph

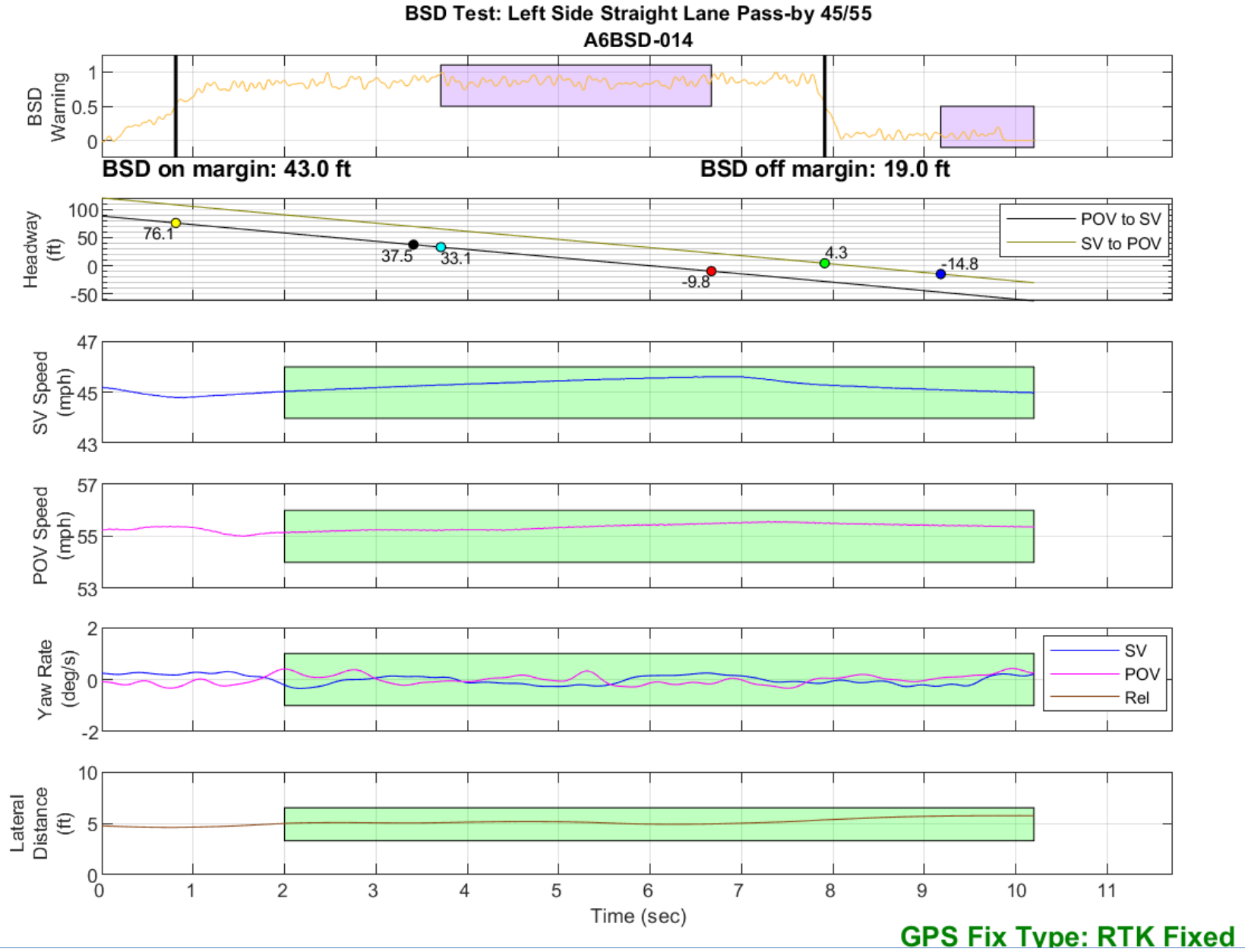

Figure D36. BSD Run 14, Straight Lane Pass-by, SV 45 mph, POV 55 mph

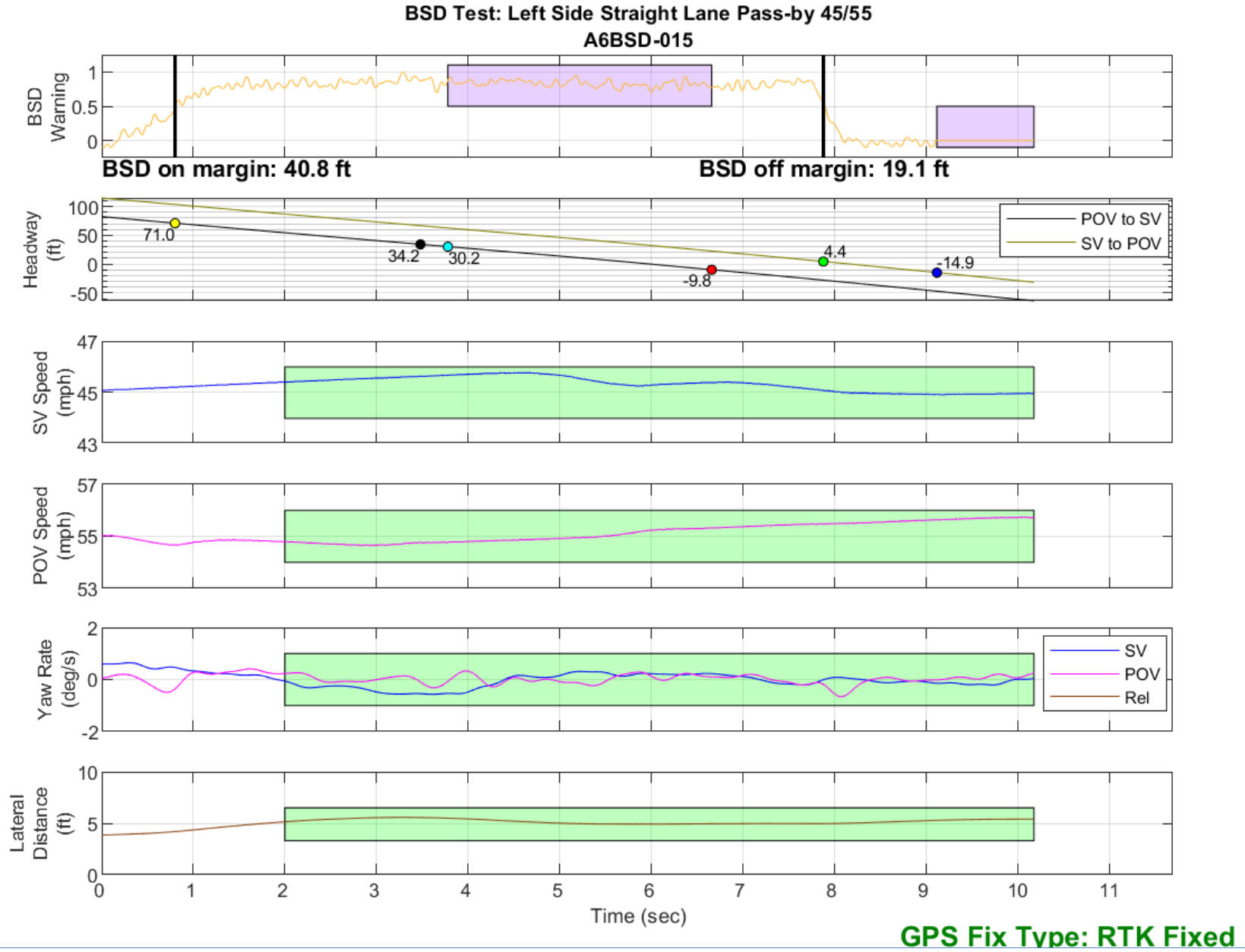

Figure D37. BSD Run 15, Straight Lane Pass-by, SV 45 mph, POV 55 mph

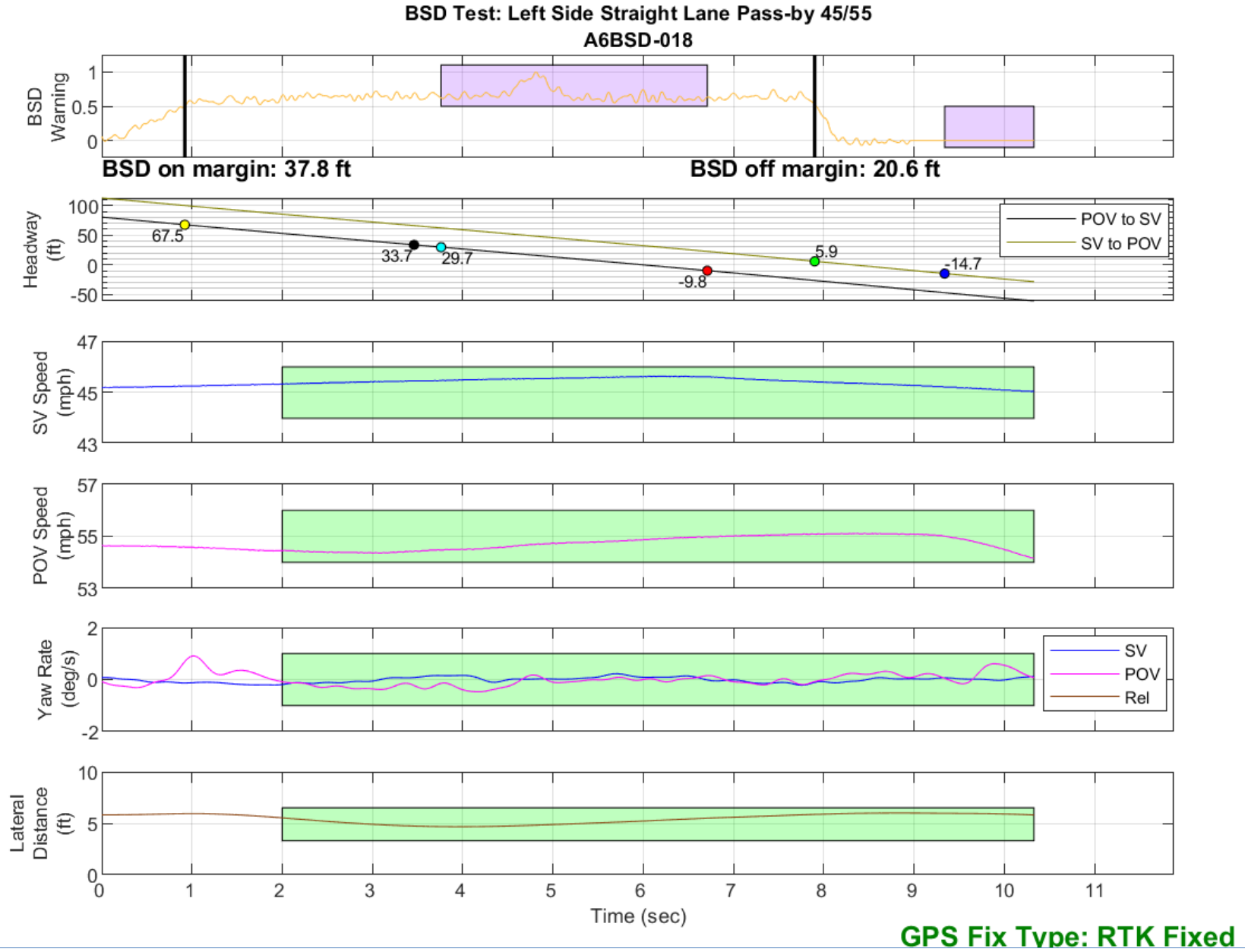

Figure D38. BSD Run 18, Straight Lane Pass-by, SV 45 mph, POV 55 mph

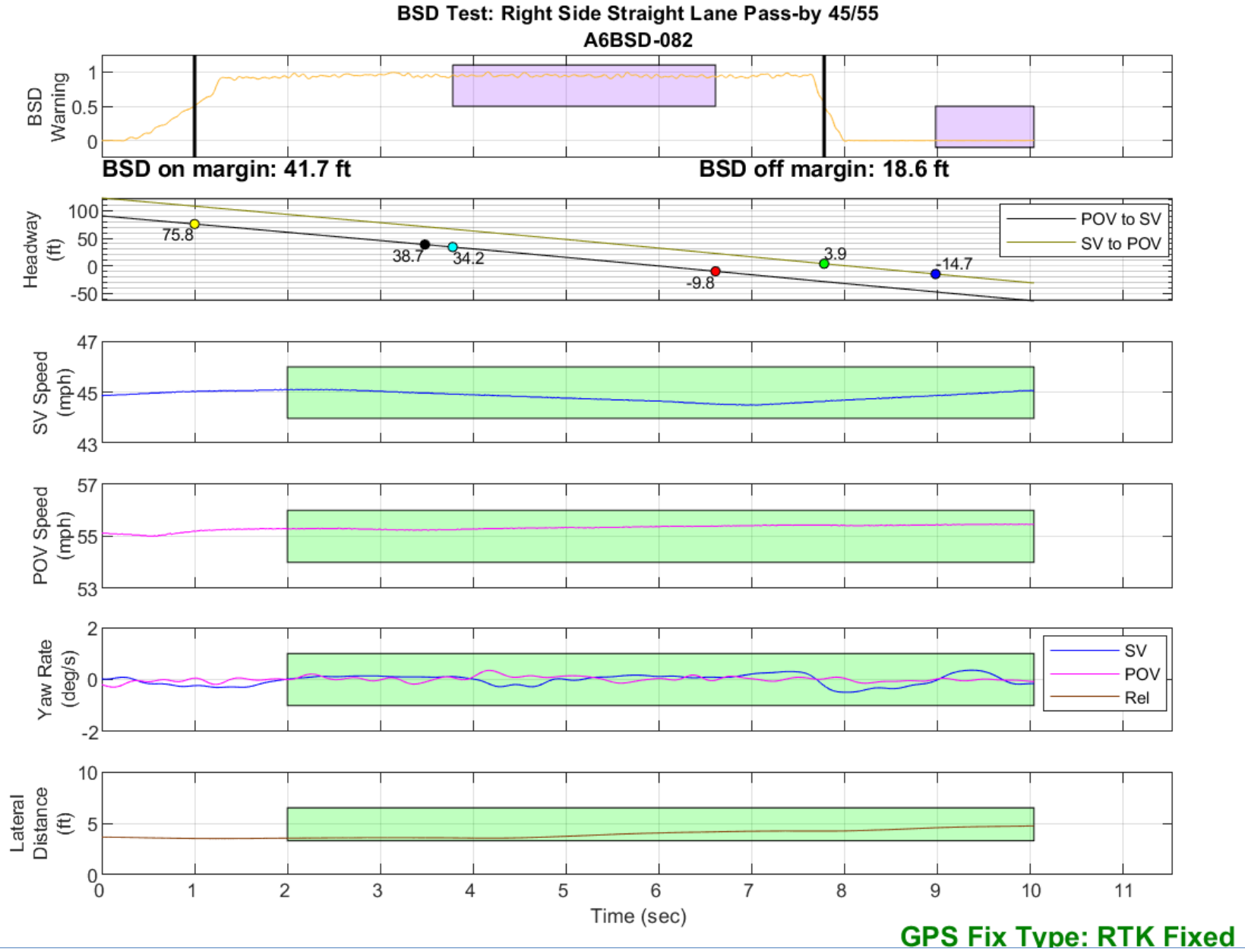

Figure D39. BSD Run 82, Straight Lane Pass-by, SV 45 mph, POV 55 mph

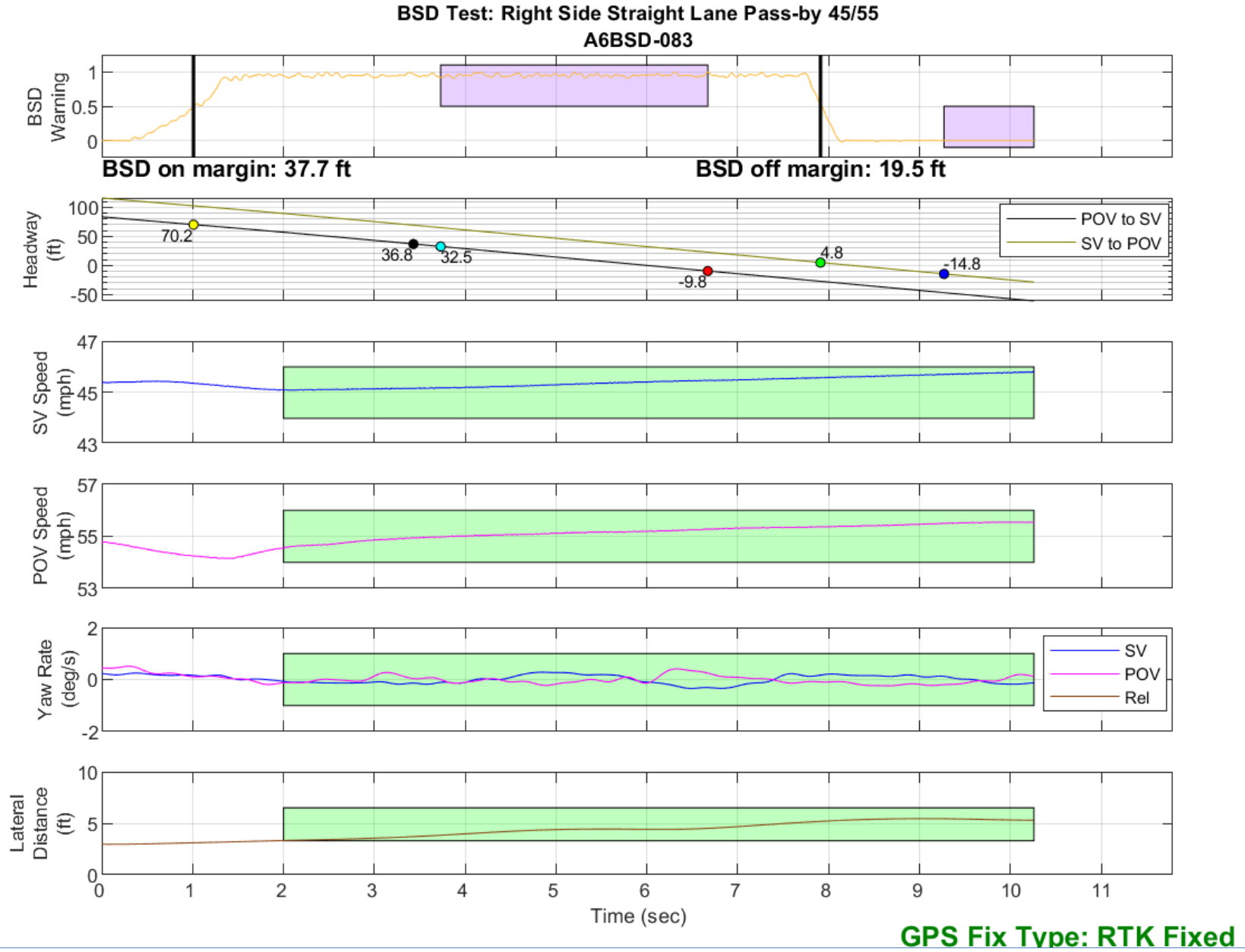

Figure D40. BSD Run 83, Straight Lane Pass-by, SV 45 mph, POV 55 mph

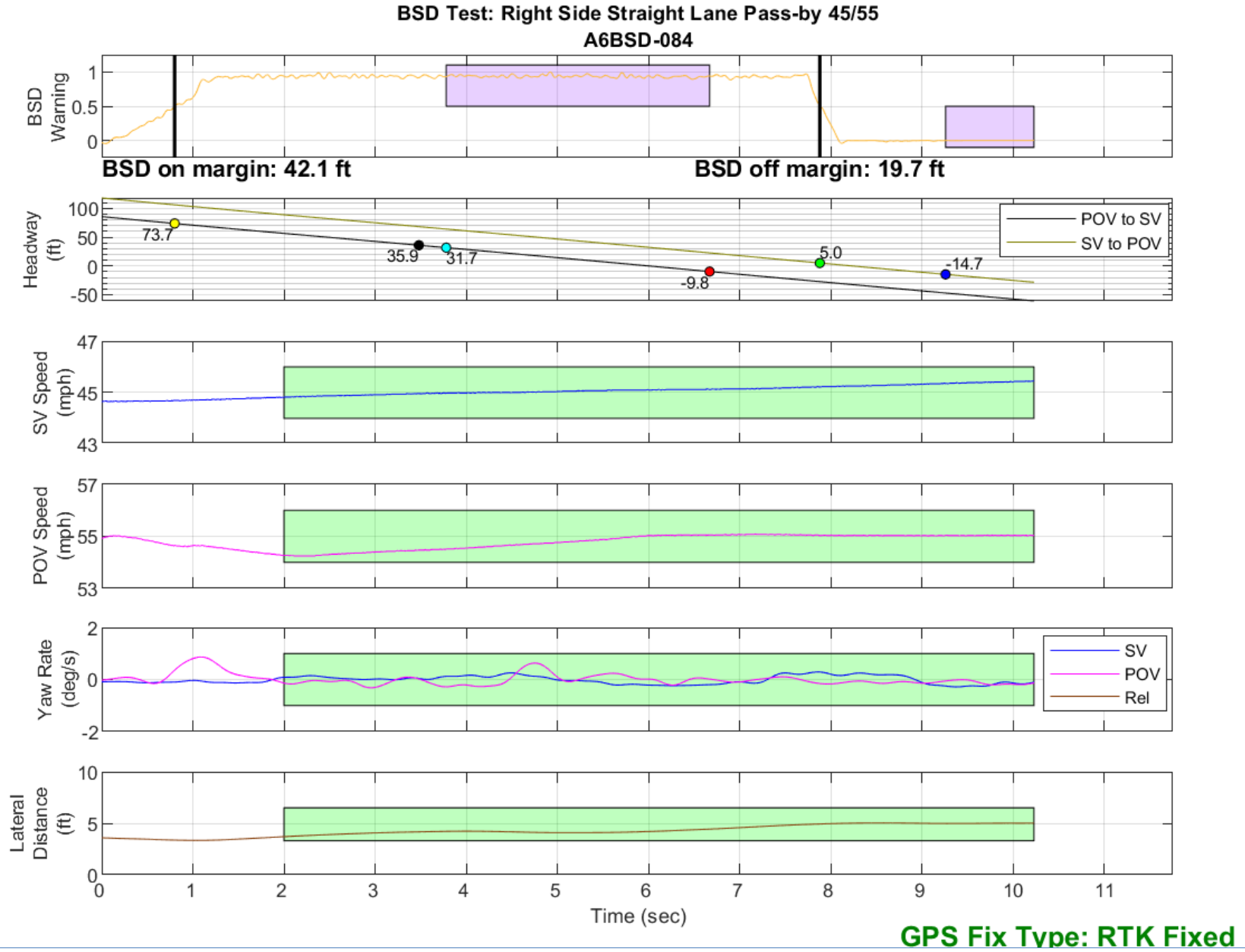

Figure D41. BSD Run 84, Straight Lane Pass-by, SV 45 mph, POV 55 mph

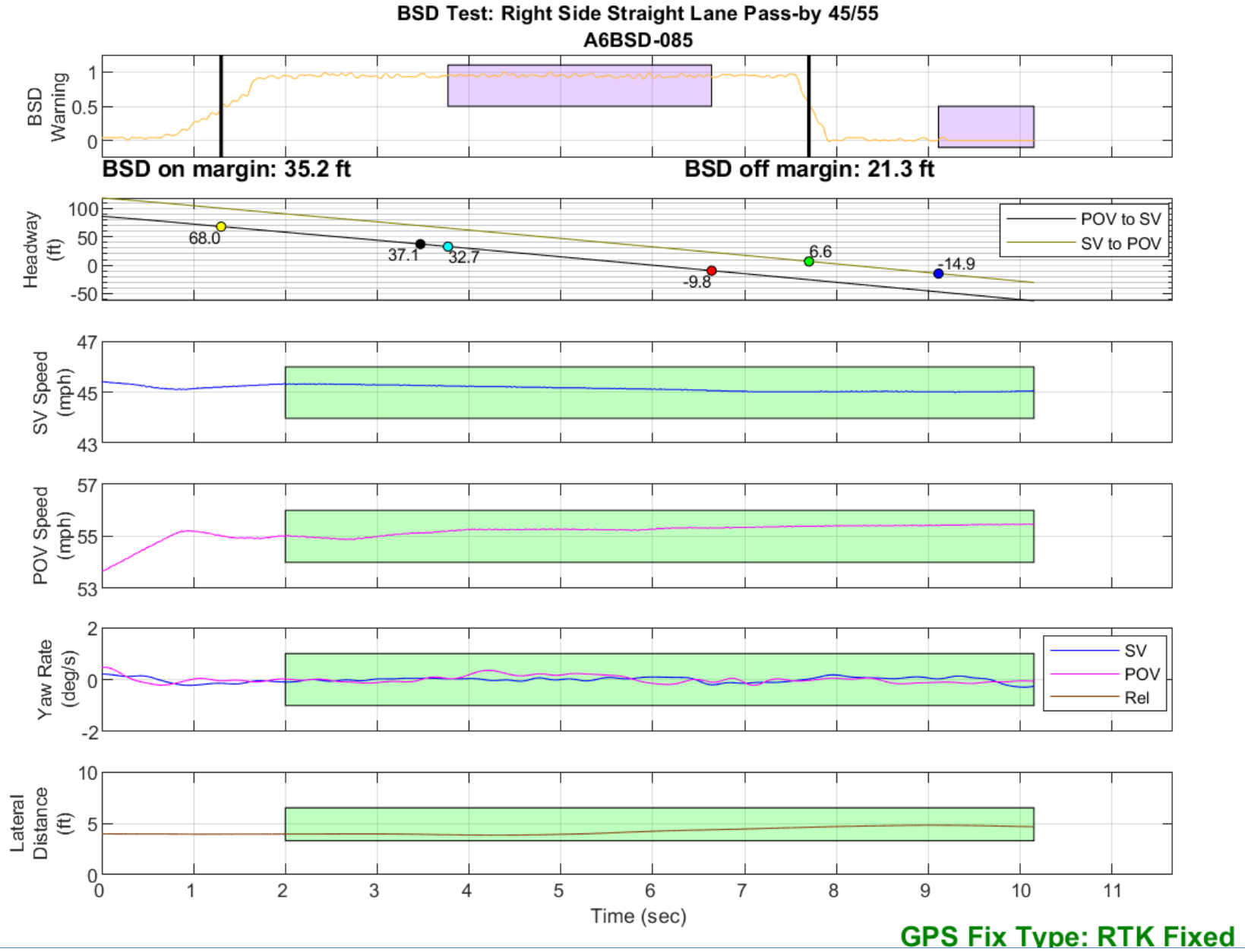

Figure D42. BSD Run 85, Straight Lane Pass-by, SV 45 mph, POV 55 mph

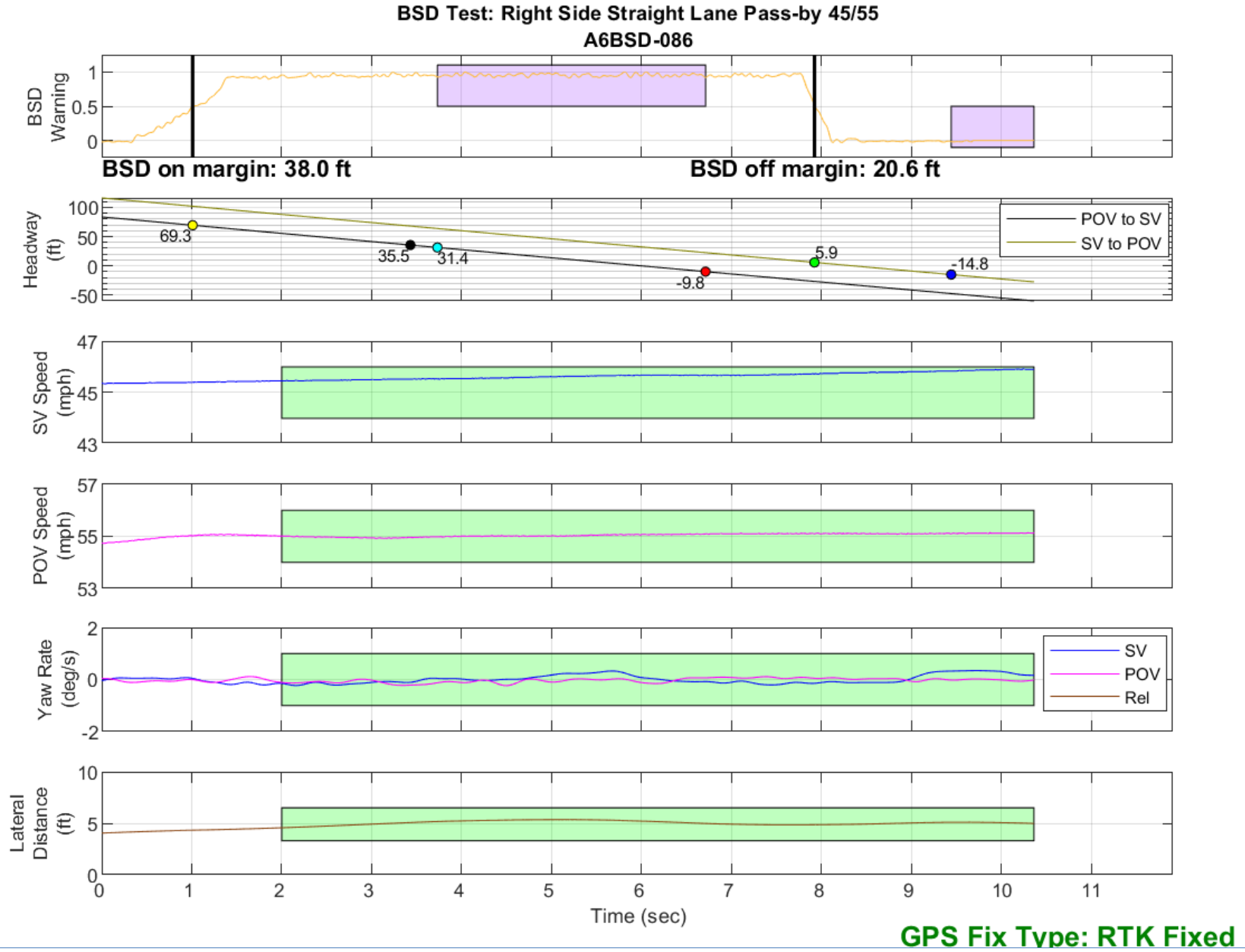

Figure D43. BSD Run 86, Straight Lane Pass-by, SV 45 mph, POV 55 mph

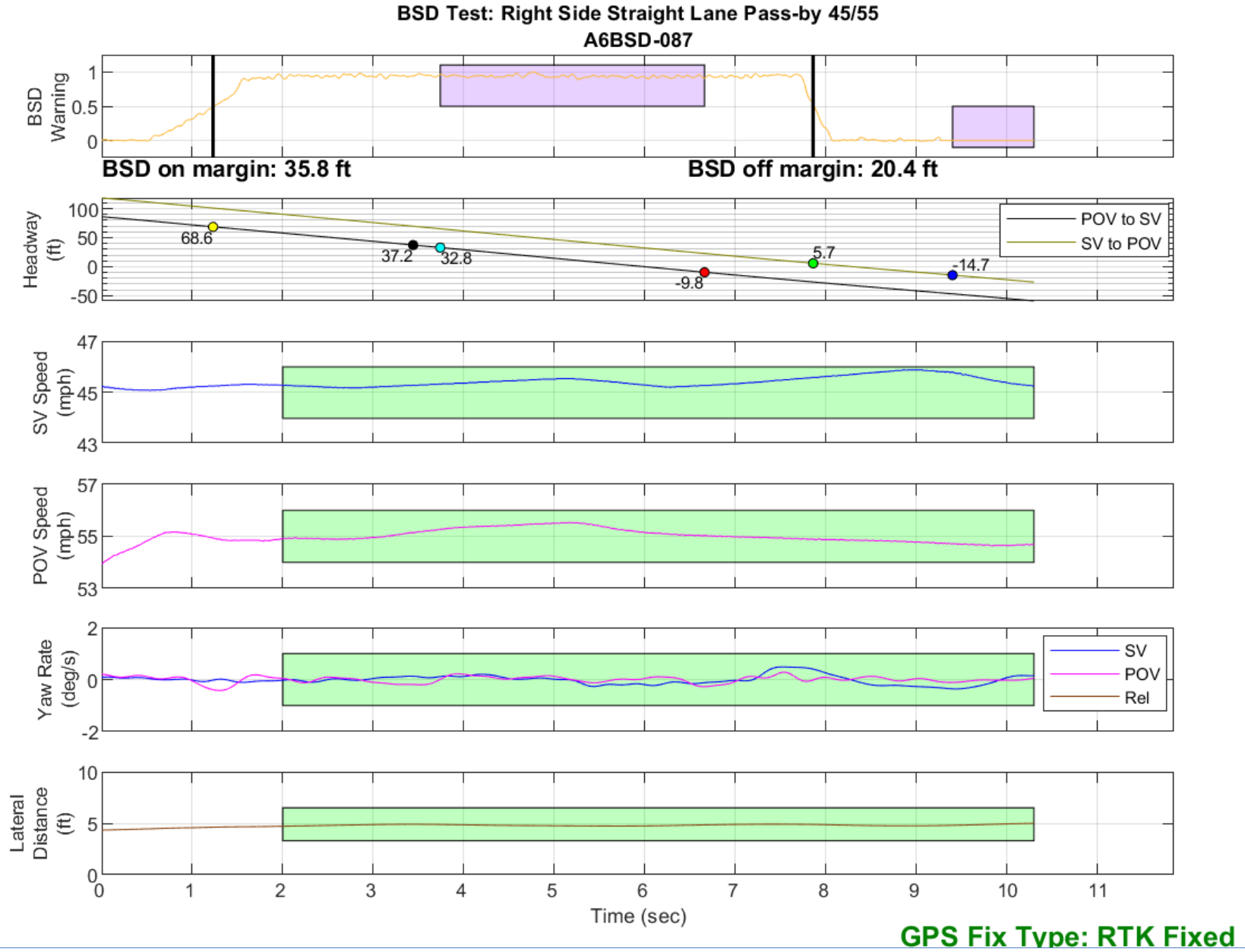

Figure D44. BSD Run 87, Straight Lane Pass-by, SV 45 mph, POV 55 mph

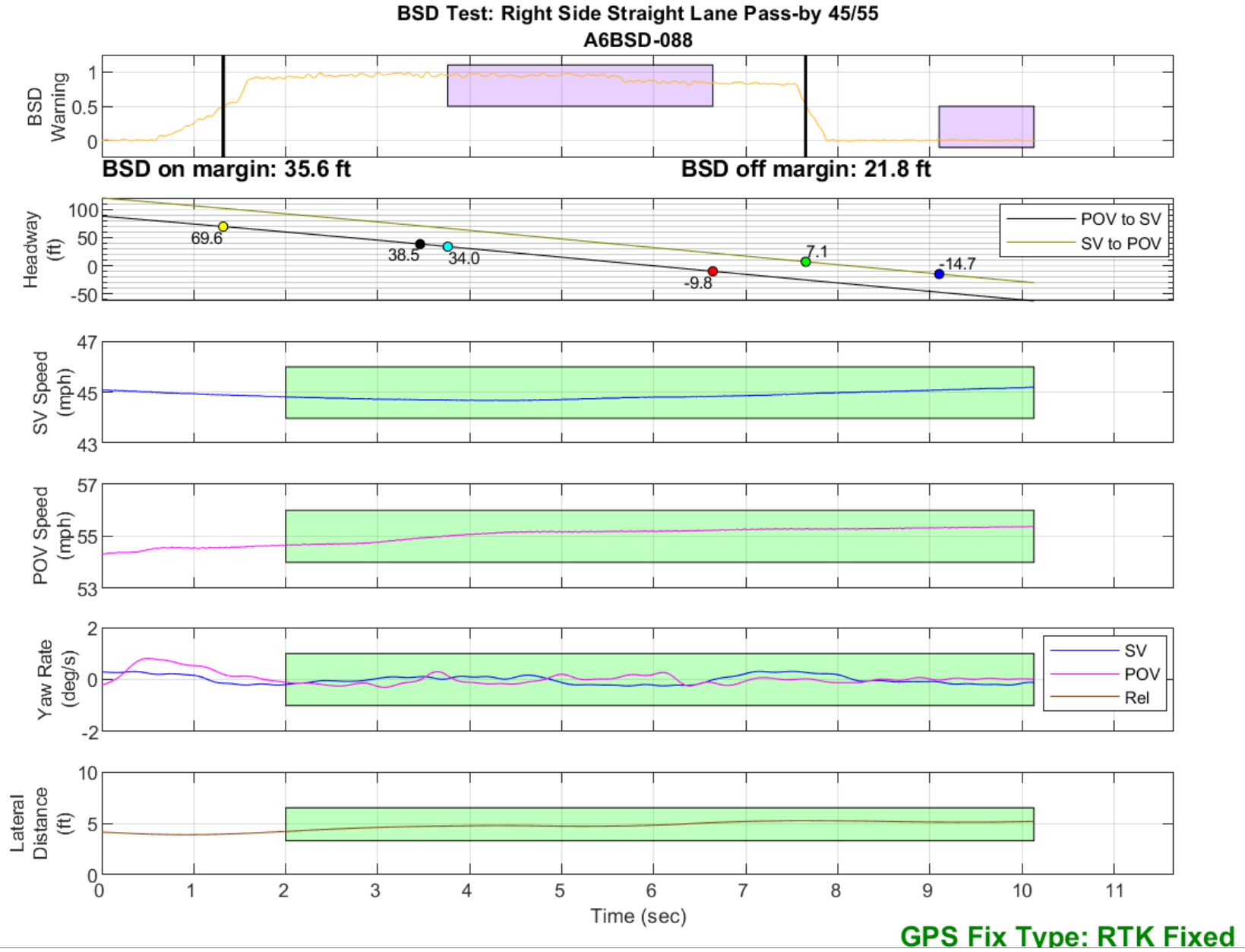

Figure D45. BSD Run 88, Straight Lane Pass-by, SV 45 mph, POV 55 mph

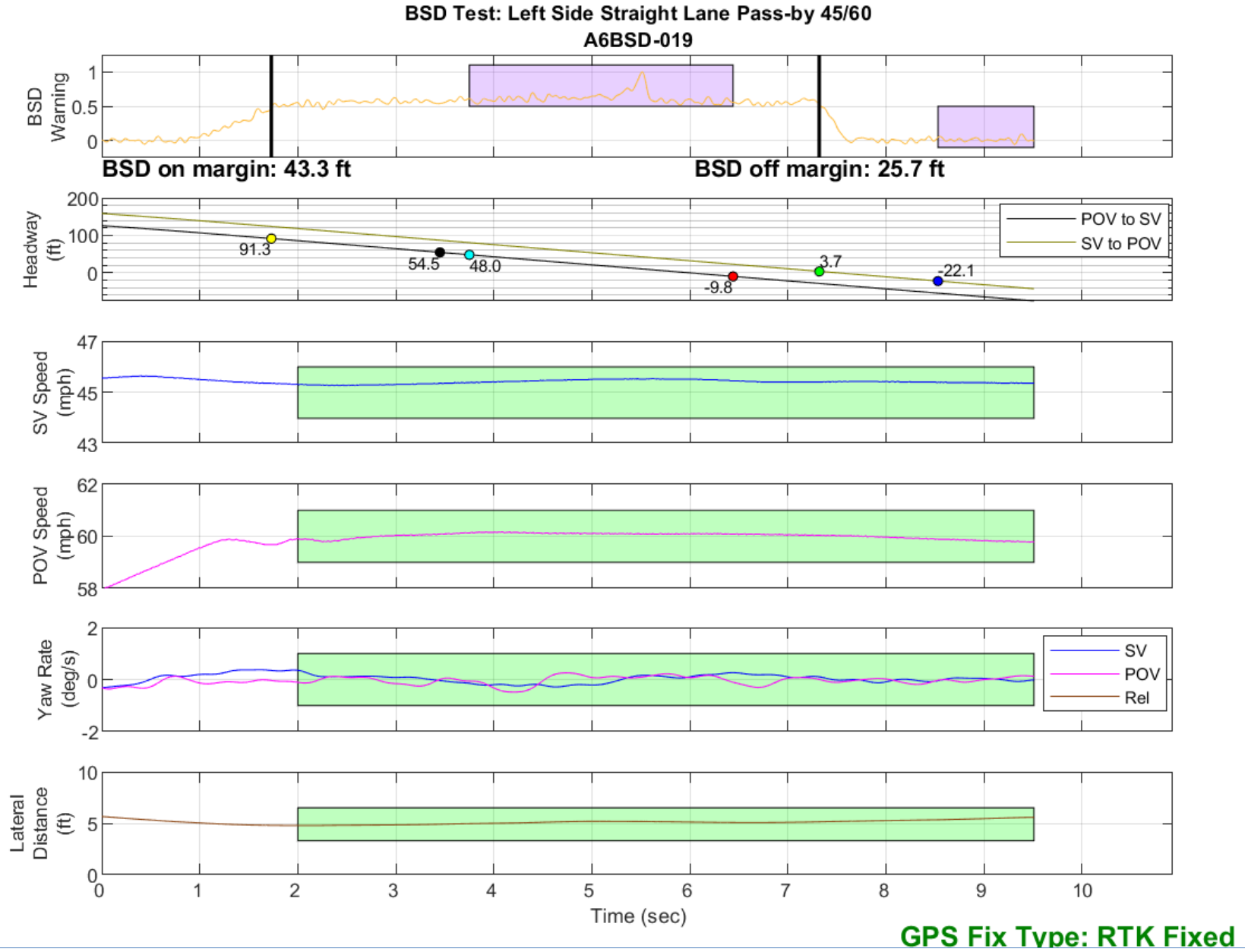

Figure D46. BSD Run 19, Straight Lane Pass-by, SV 45 mph, POV 60 mph

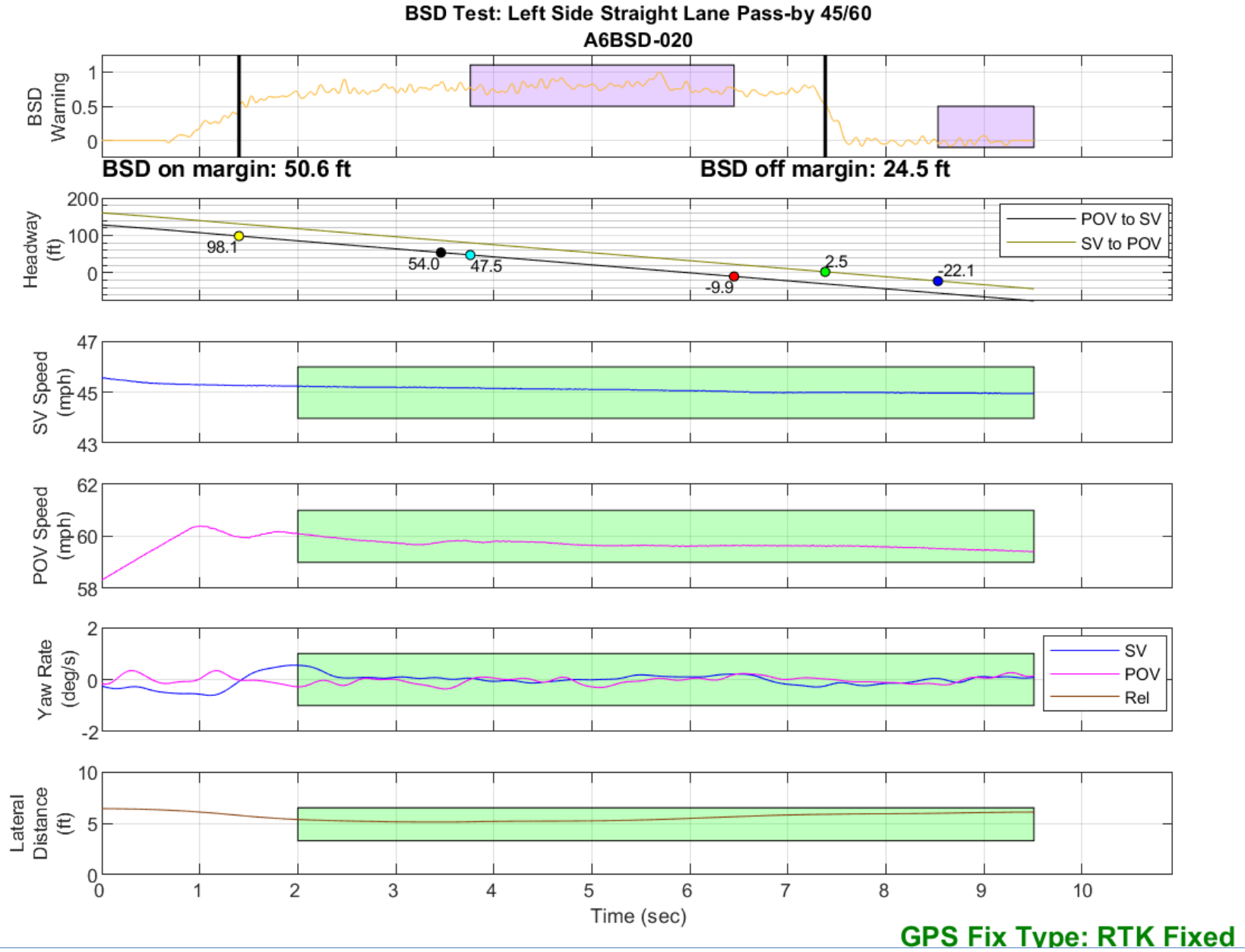

Figure D47. BSD Run 20, Straight Lane Pass-by, SV 45 mph, POV 60 mph

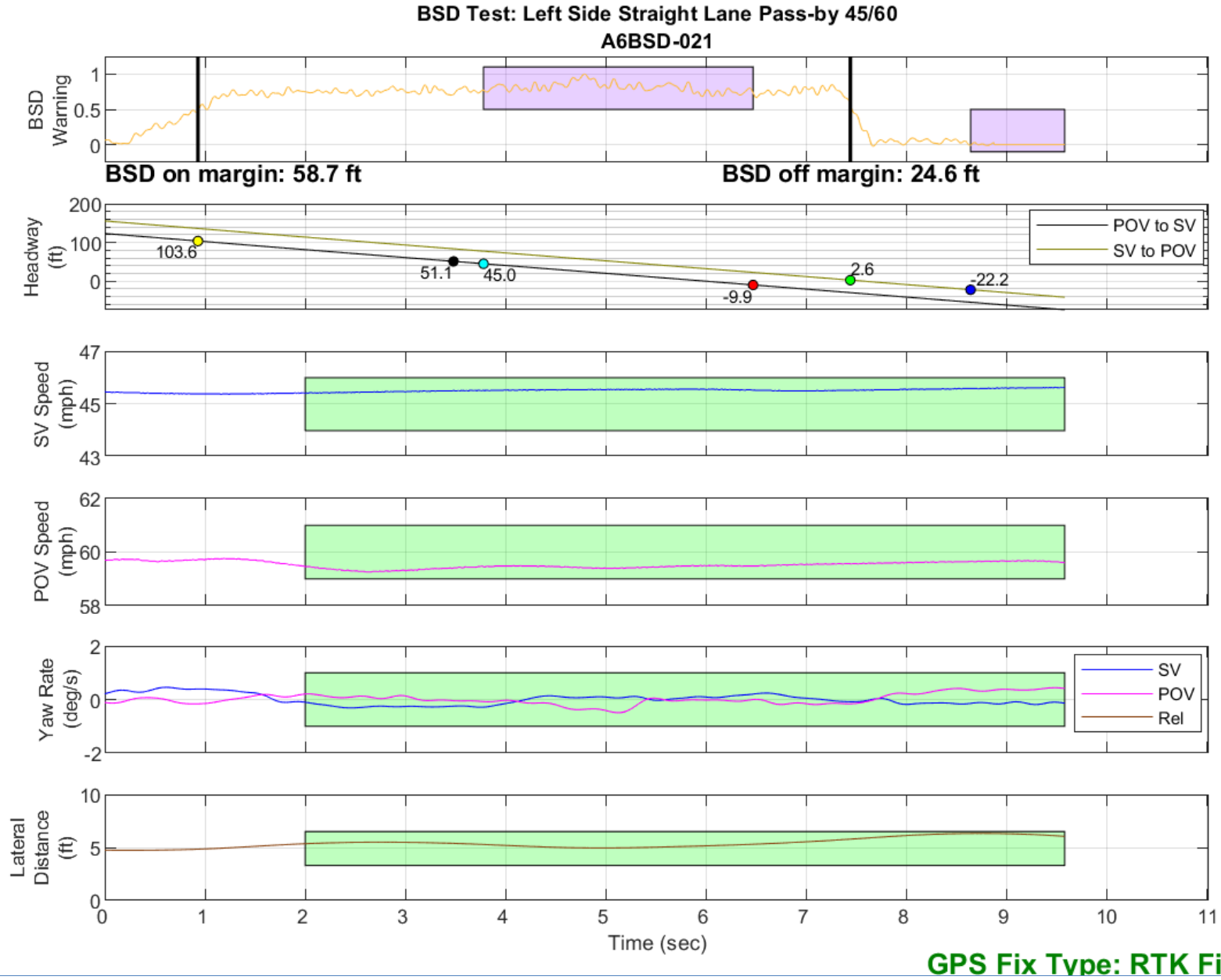

Figure D48. BSD Run 21, Straight Lane Pass-by, SV 45 mph, POV 60 mph

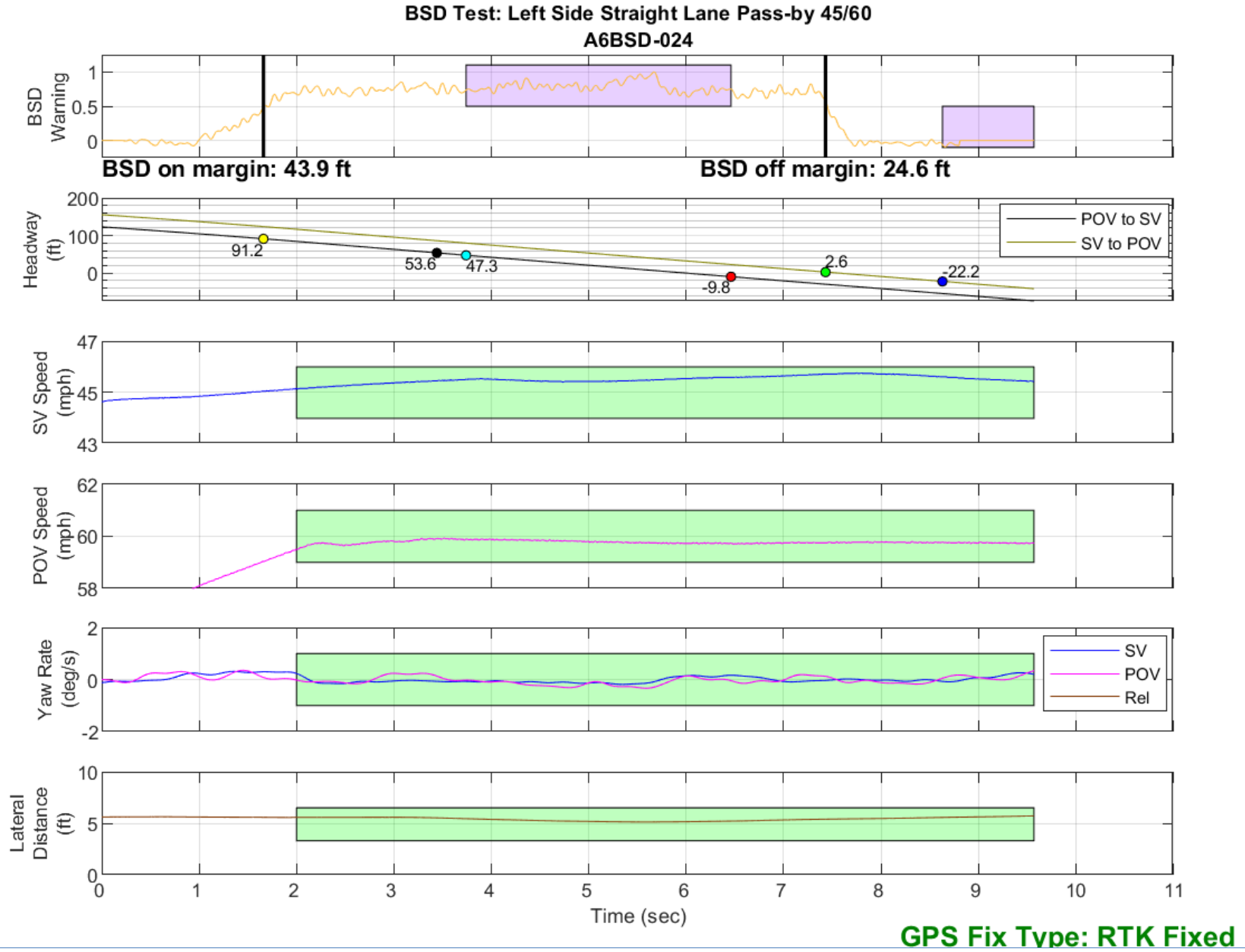

Figure D49. BSD Run 24, Straight Lane Pass-by, SV 45 mph, POV 60 mph

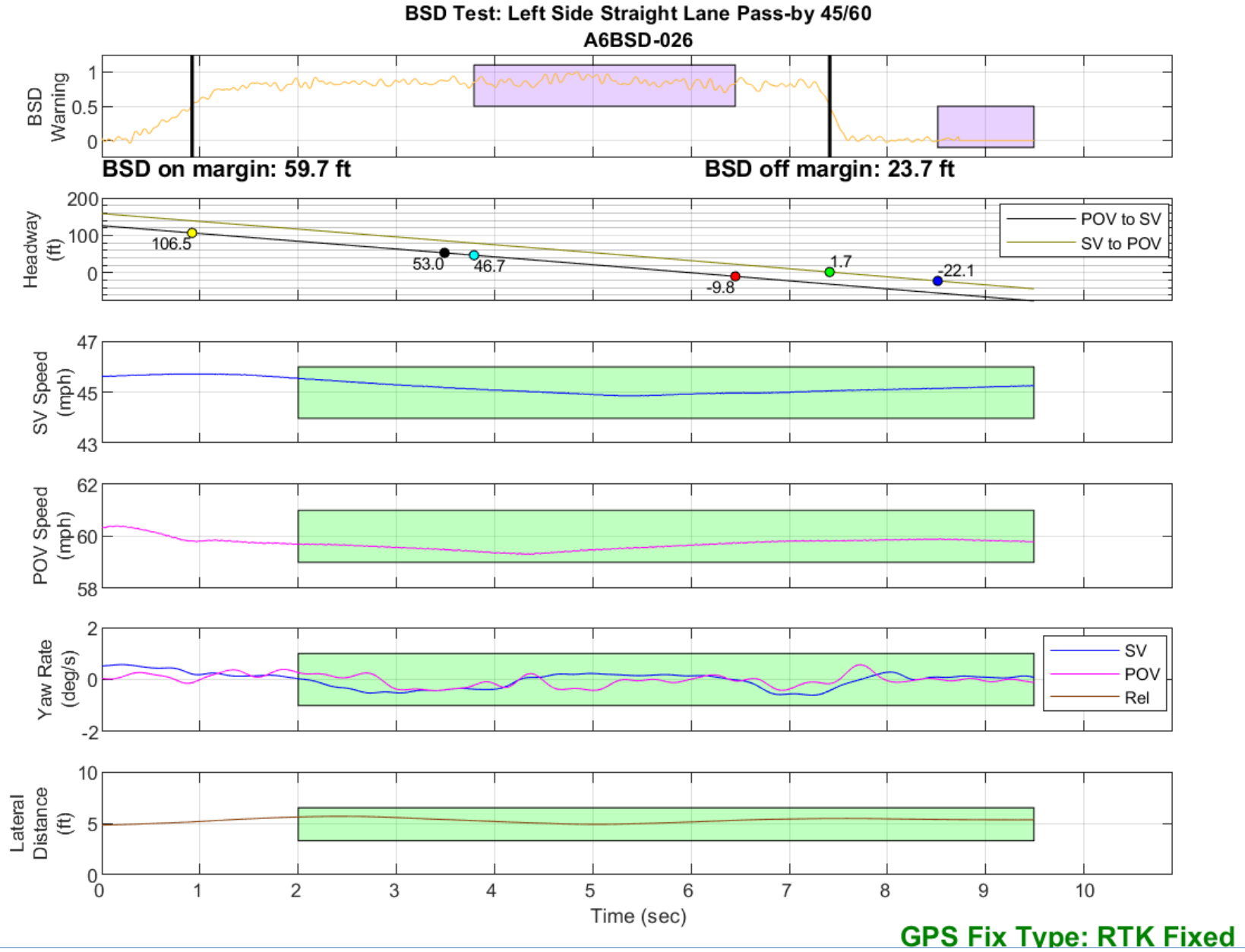

Figure D50. BSD Run 26, Straight Lane Pass-by, SV 45 mph, POV 60 mph

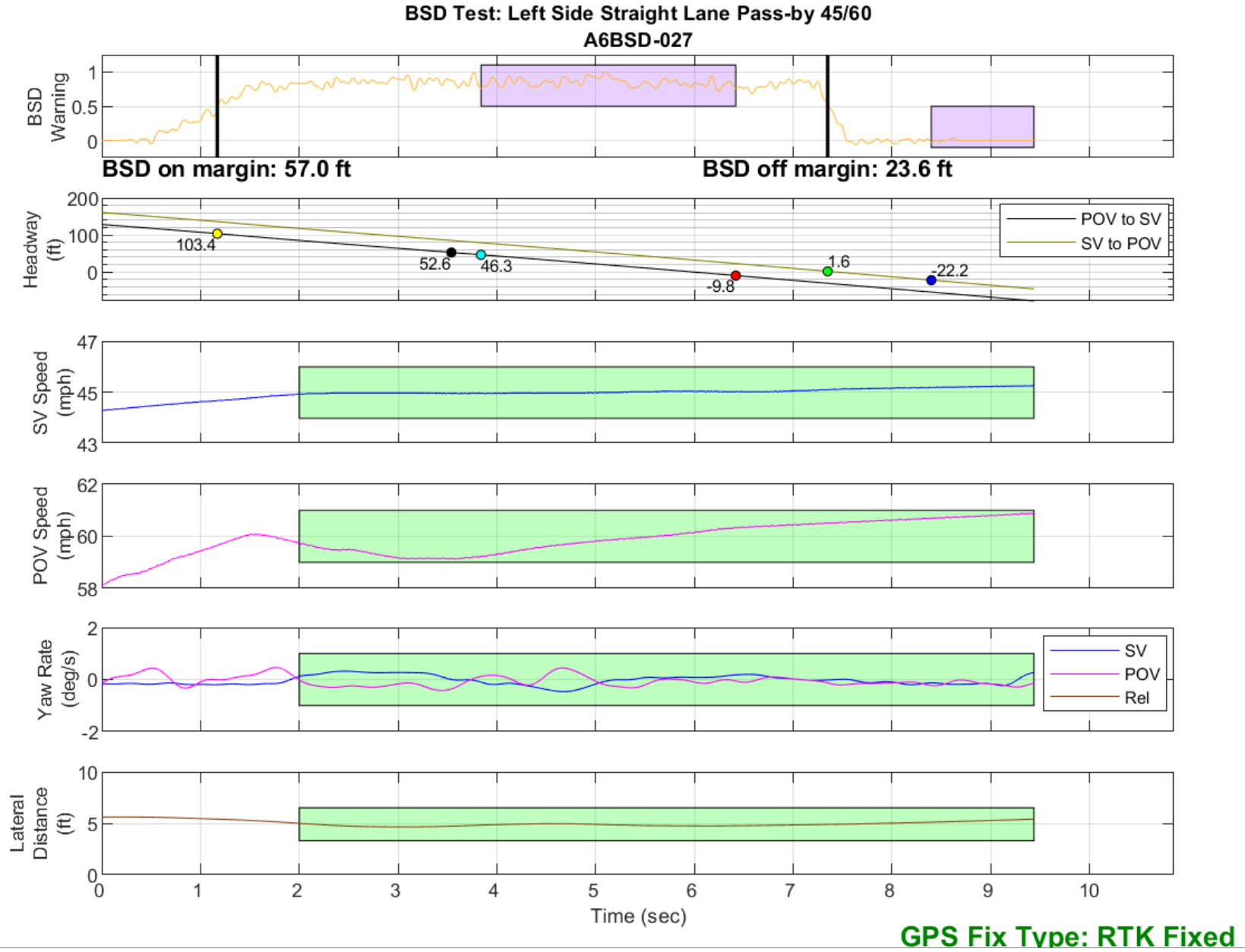

Figure D51. BSD Run 27, Straight Lane Pass-by, SV 45 mph, POV 60 mph

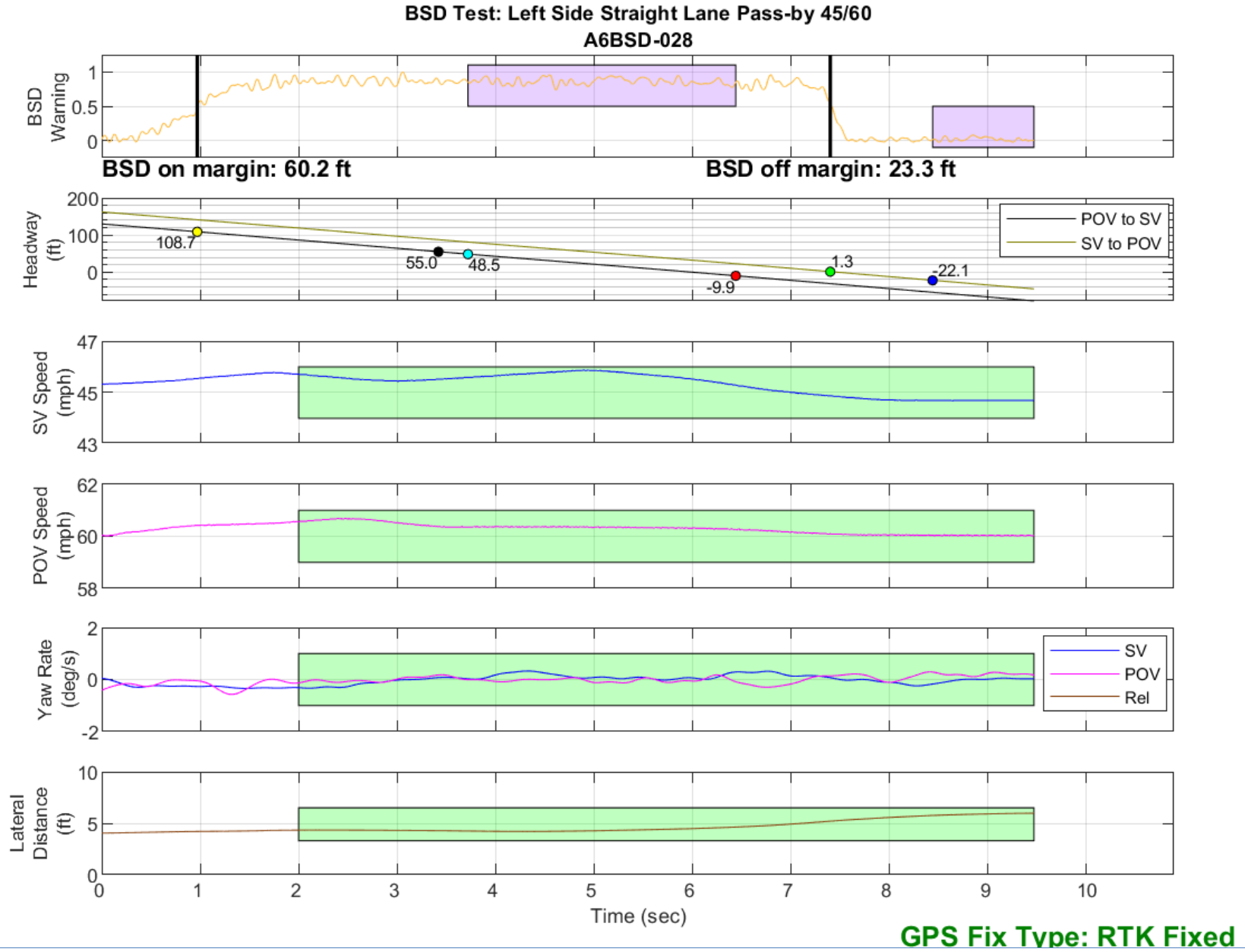

Figure D52. BSD Run 28, Straight Lane Pass-by, SV 45 mph, POV 60 mph

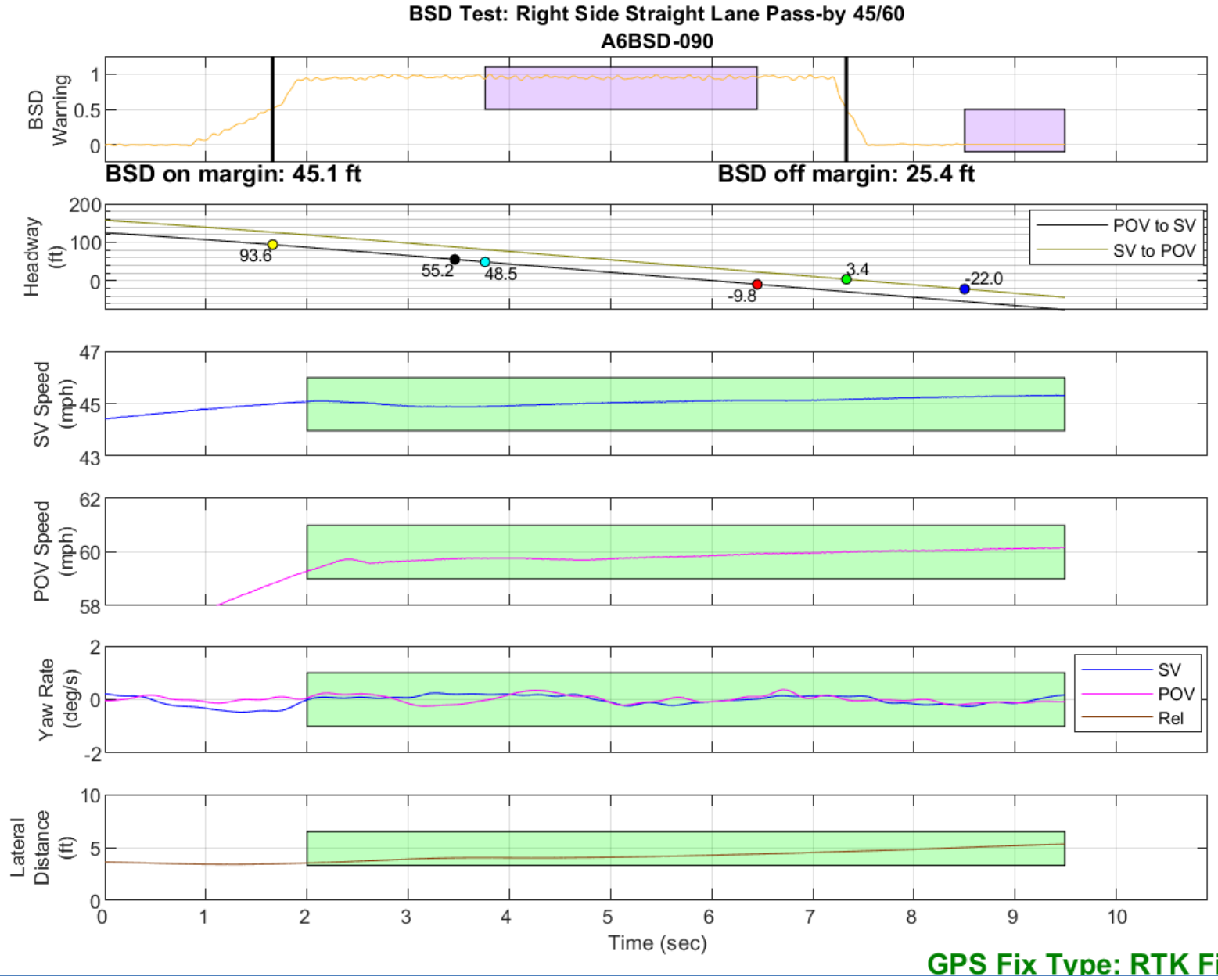

Figure D53. BSD Run 90, Straight Lane Pass-by, SV 45 mph, POV 60 mph

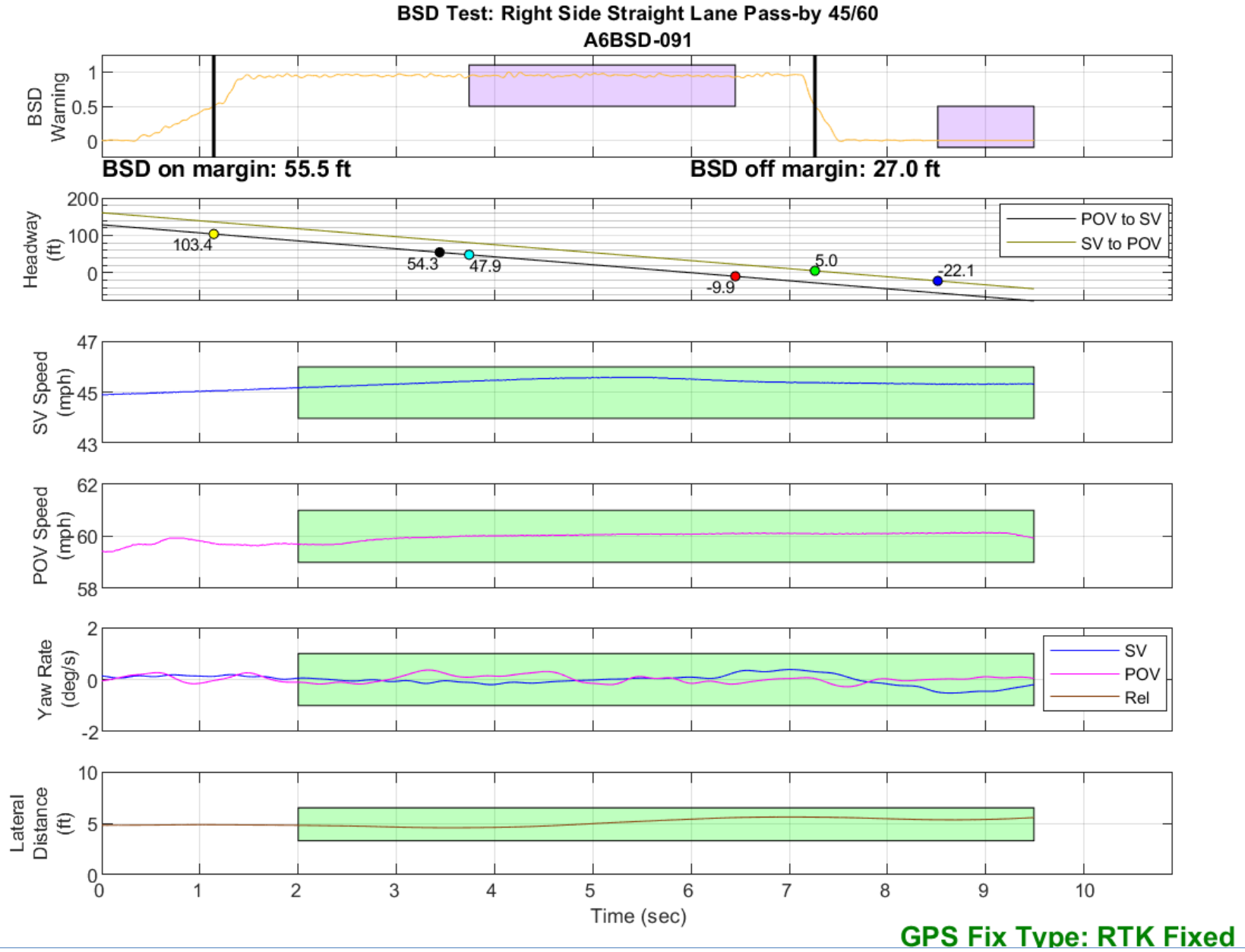

Figure D54. BSD Run 91, Straight Lane Pass-by, SV 45 mph, POV 60 mph

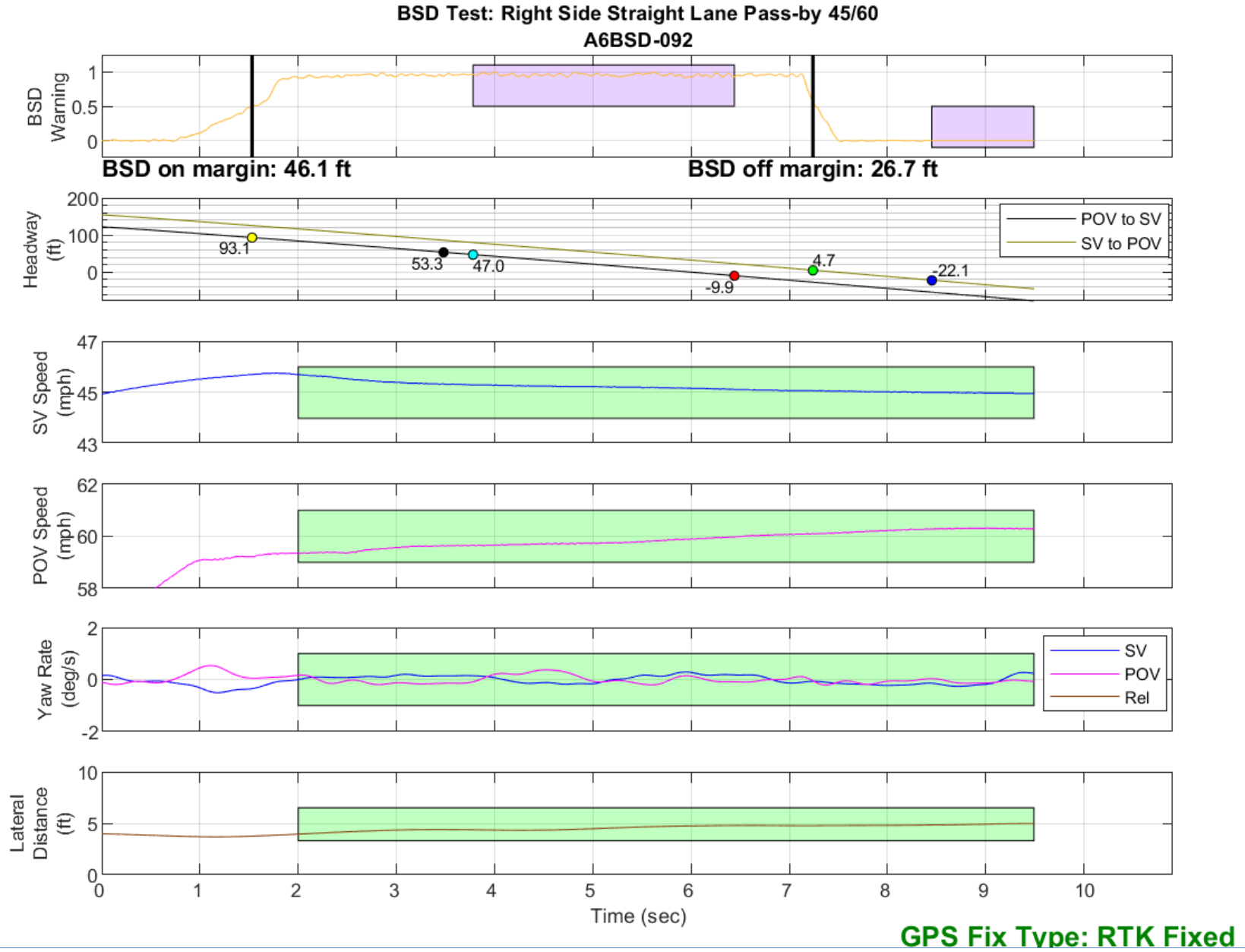

Figure D55. BSD Run 92, Straight Lane Pass-by, SV 45 mph, POV 60 mph

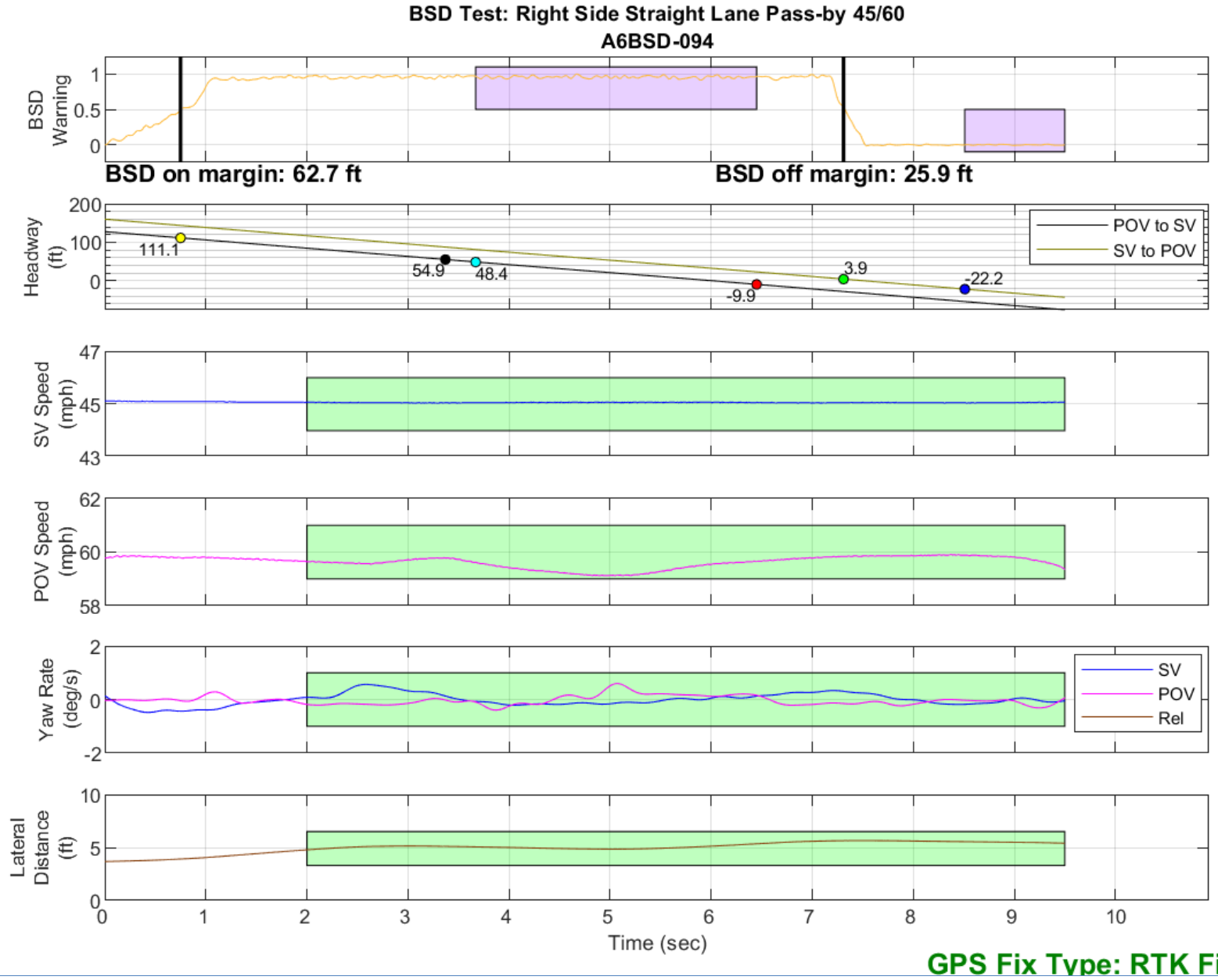

Figure D56. BSD Run 94, Straight Lane Pass-by, SV 45 mph, POV 60 mph

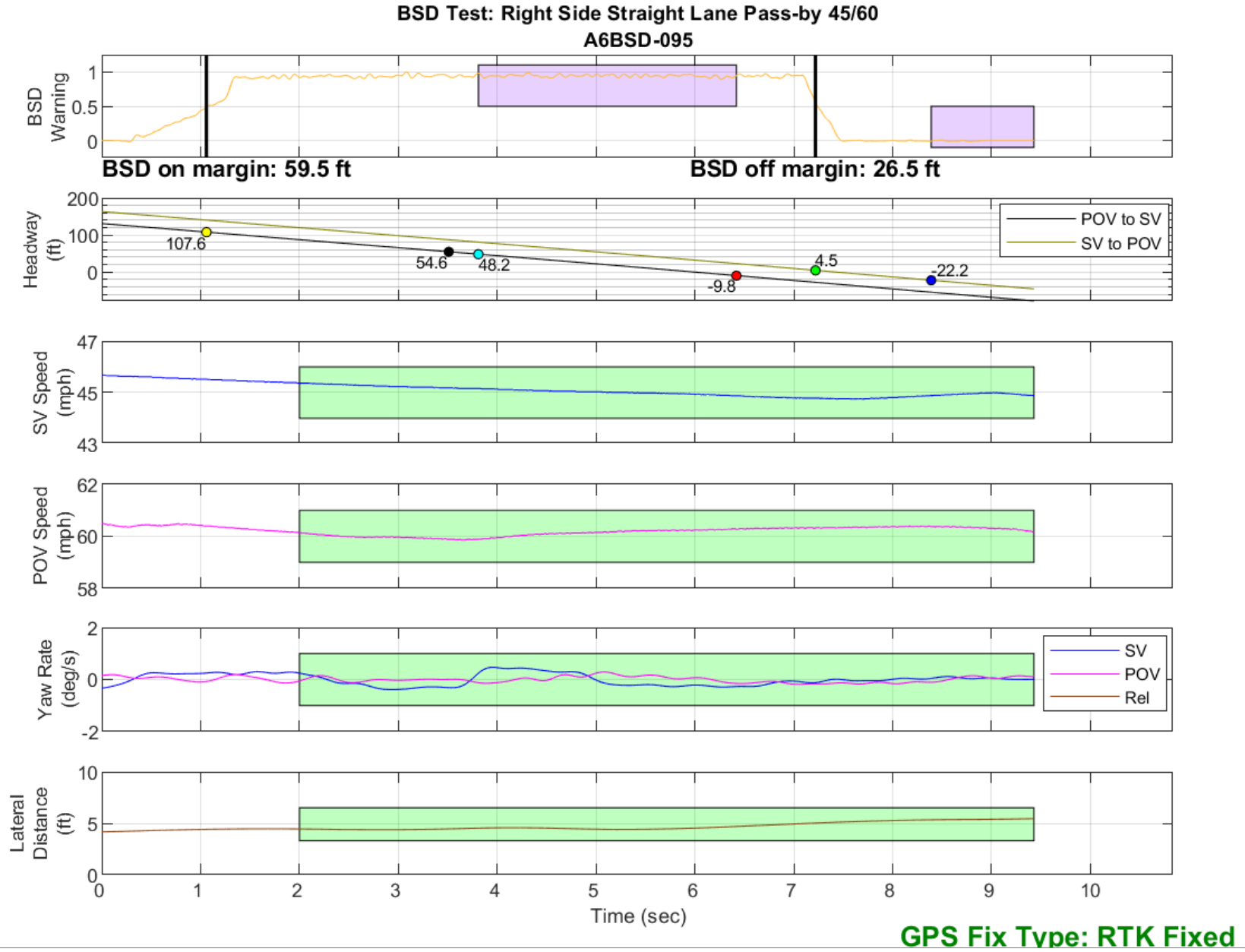

Figure D57. BSD Run 95, Straight Lane Pass-by, SV 45 mph, POV 60 mph

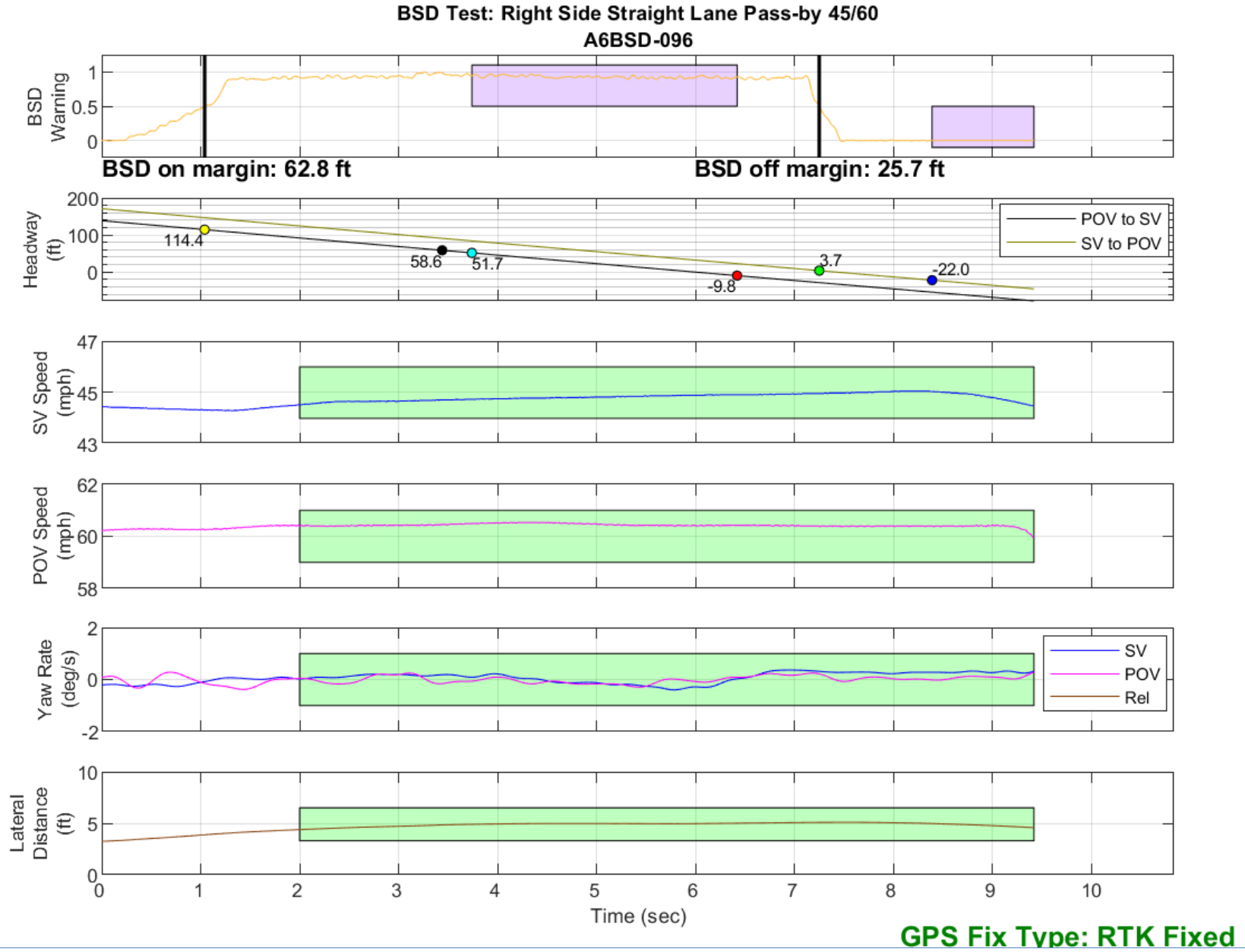

Figure D58. BSD Run 96, Straight Lane Pass-by, SV 45 mph, POV 60 mph

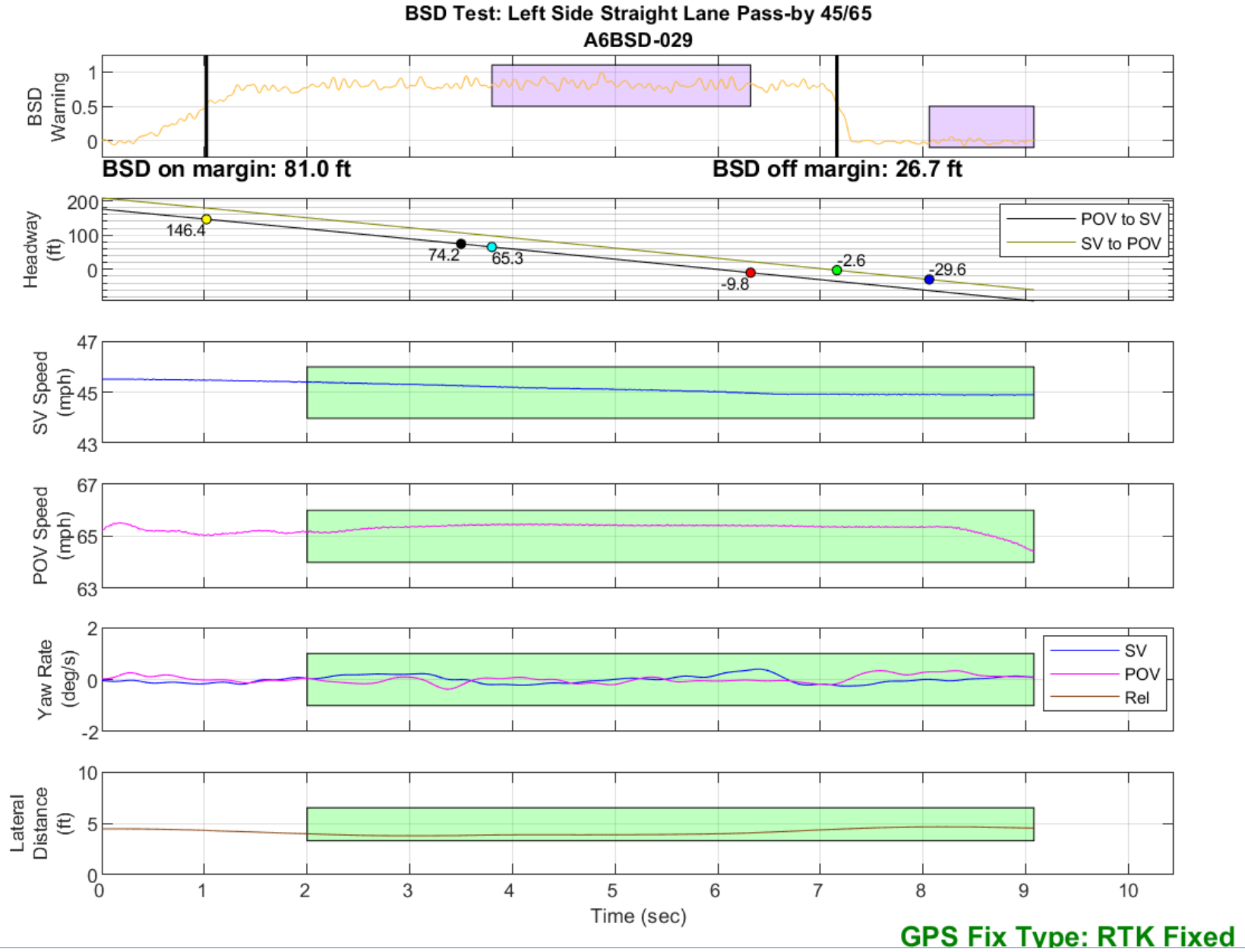

Figure D59. BSD Run 29, Straight Lane Pass-by, SV 45 mph, POV 65 mph

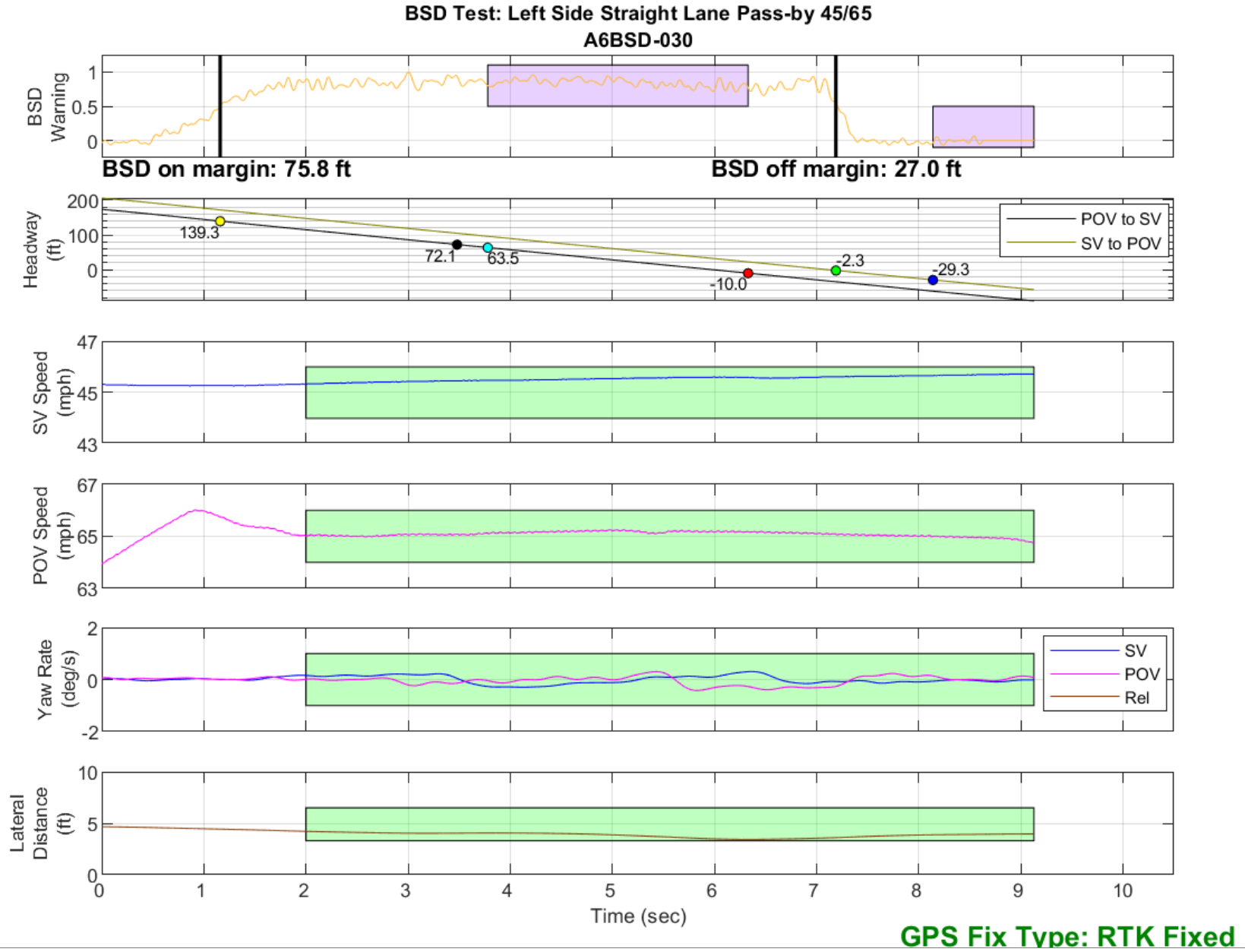

Figure D60. BSD Run 30, Straight Lane Pass-by, SV 45 mph, POV 65 mph

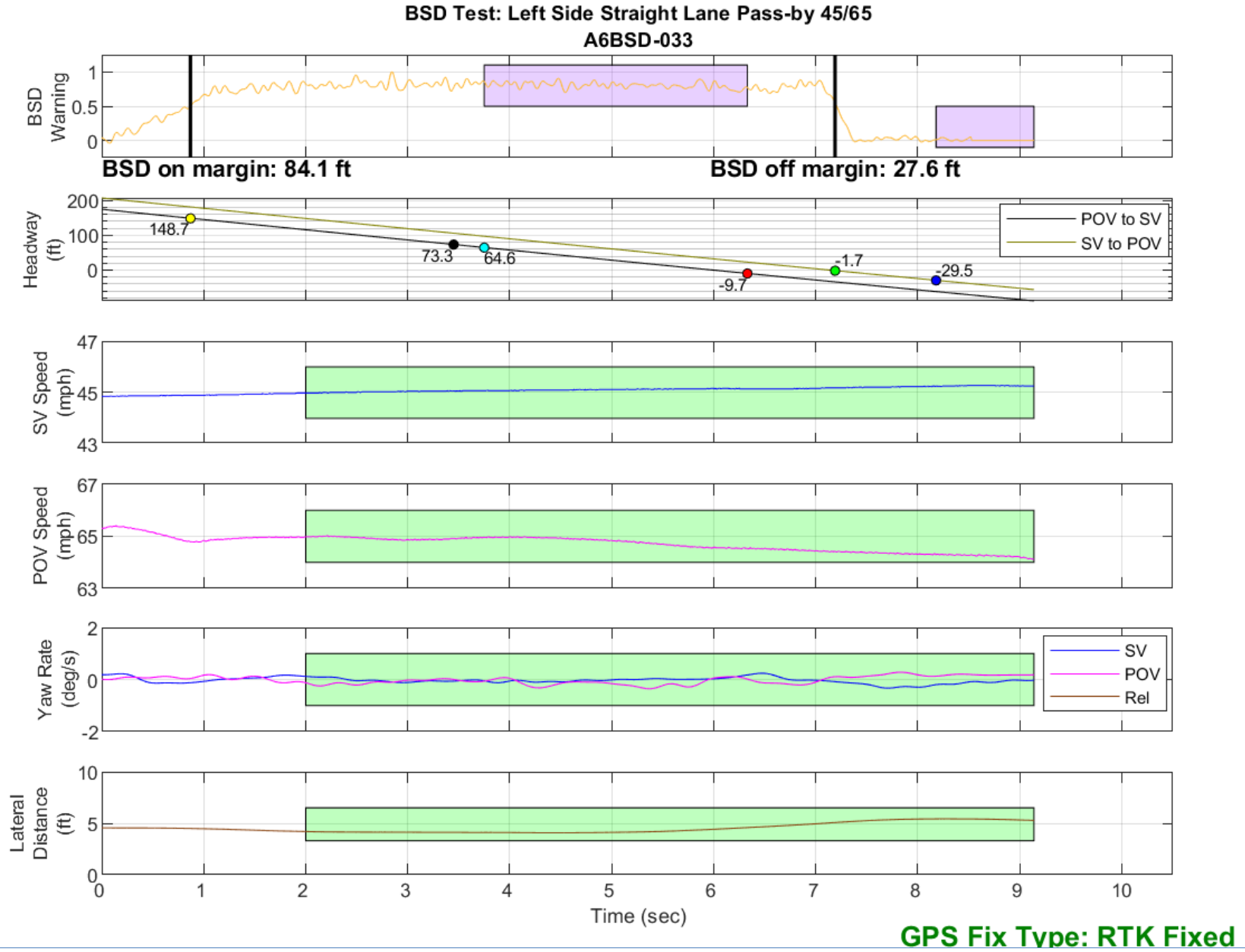

Figure D61. BSD Run 33, Straight Lane Pass-by, SV 45 mph, POV 65 mph

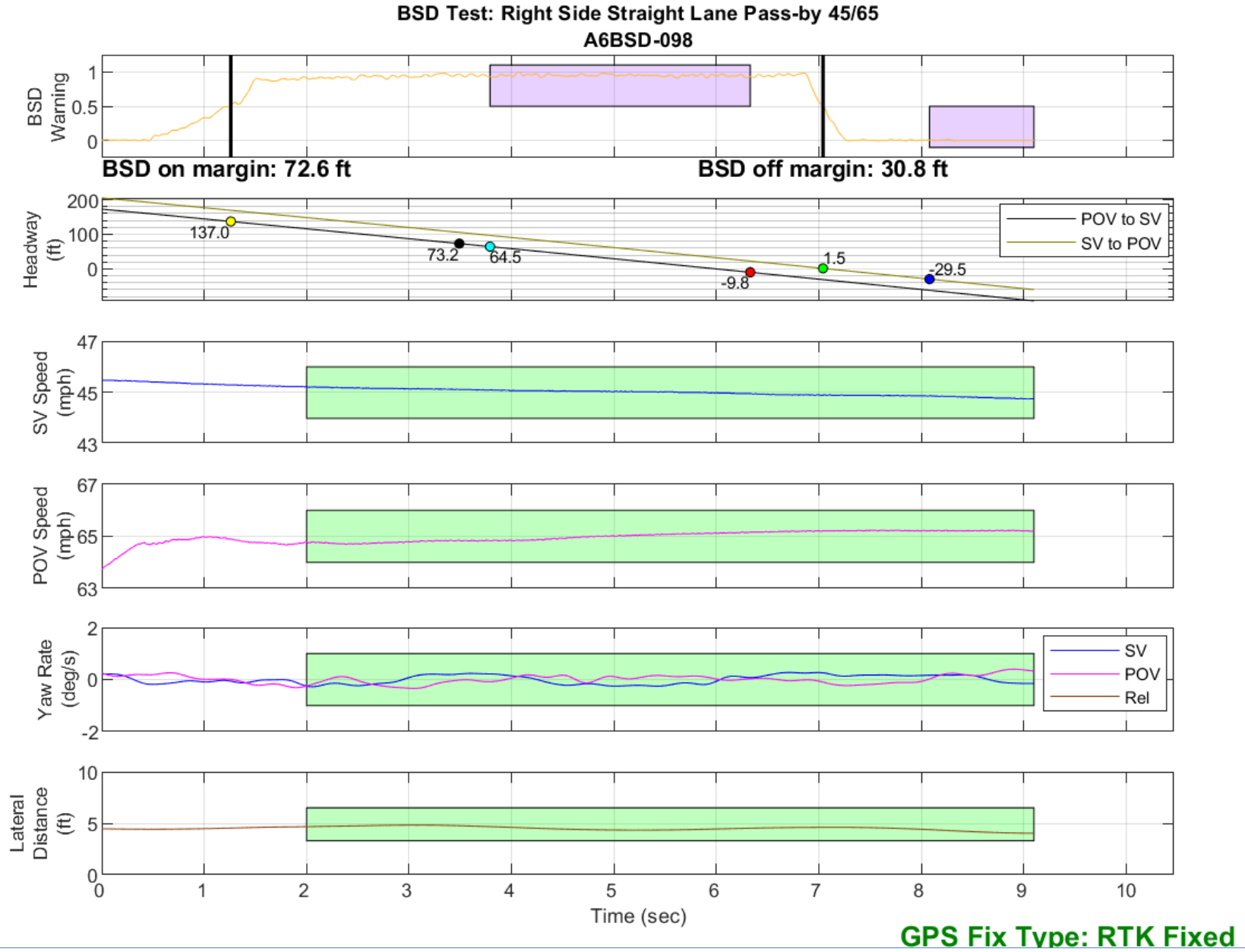

Figure D62. BSD Run 98, Straight Lane Pass-by, SV 45 mph, POV 65 mph

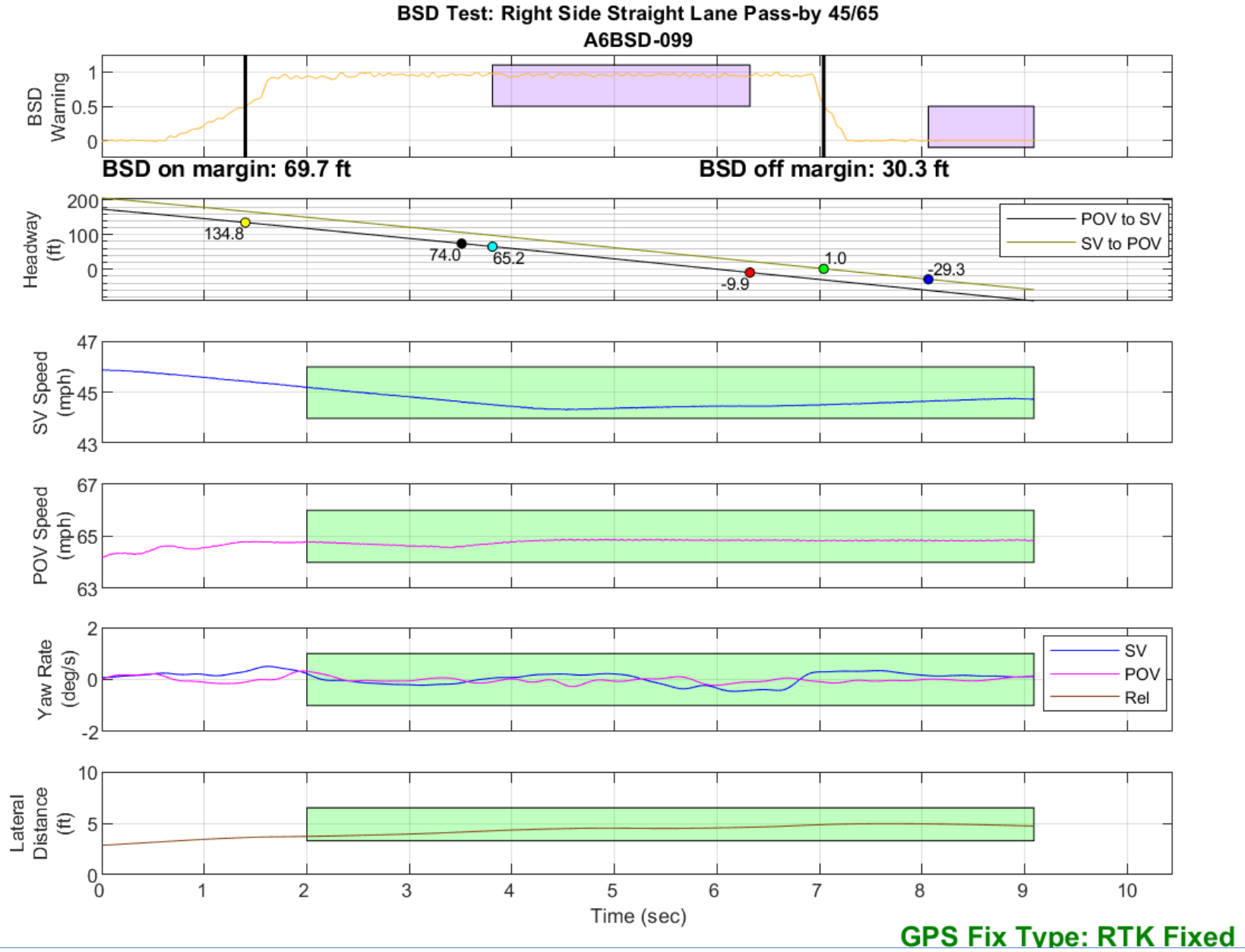

Figure D63. BSD Run 99, Straight Lane Pass-by, SV 45 mph, POV 65 mph

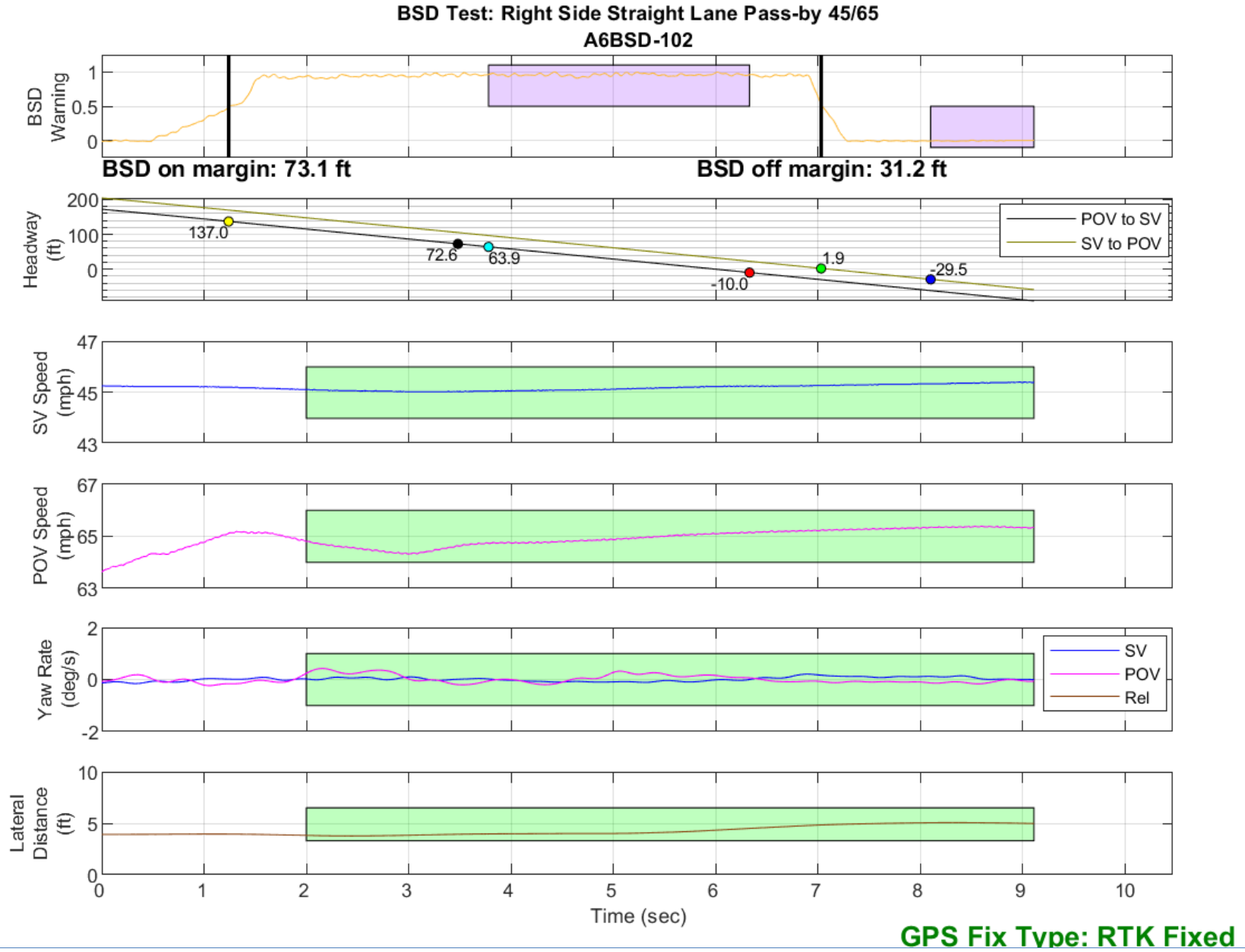

Figure D64. BSD Run 102, Straight Lane Pass-by, SV 45 mph, POV 65 mph

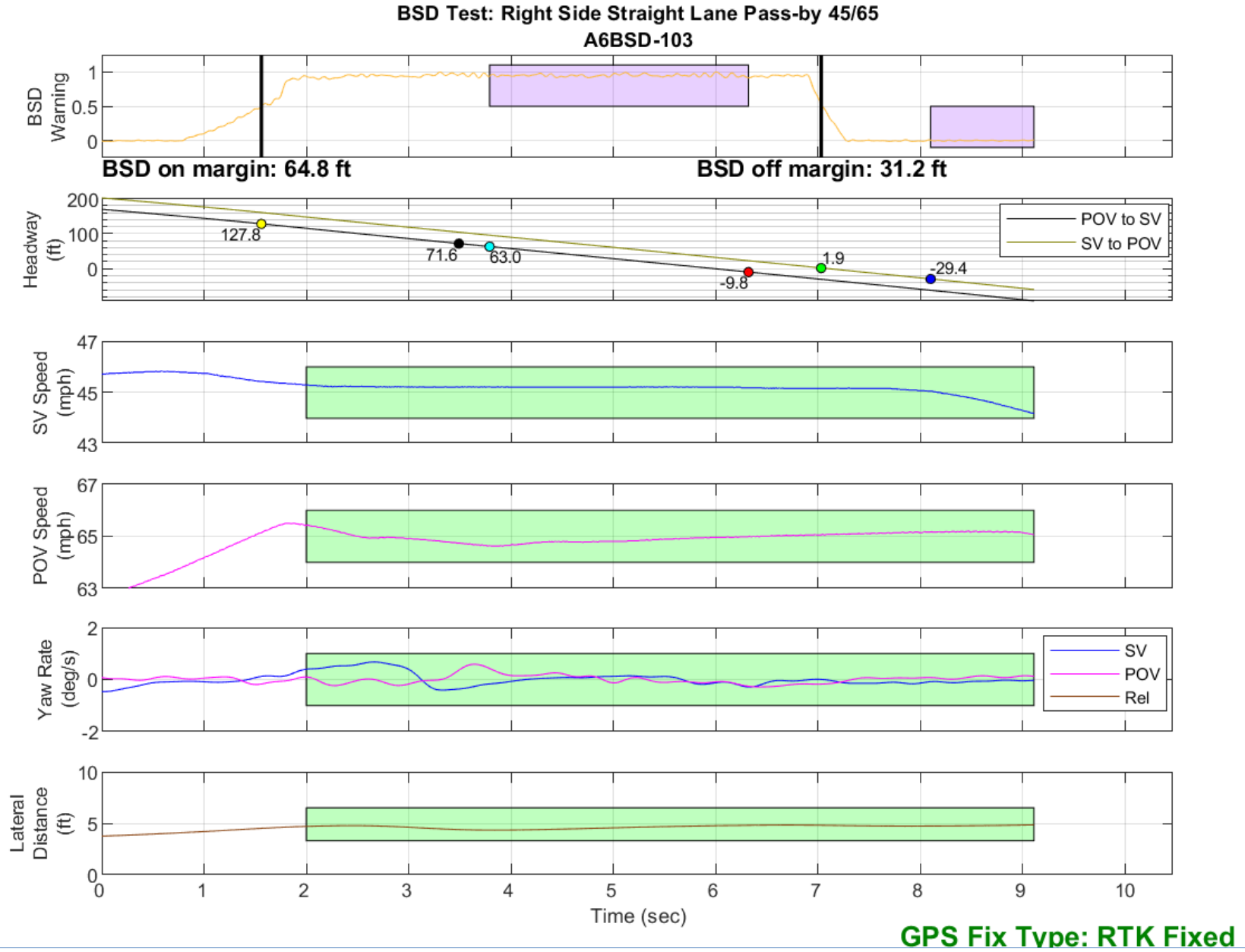

Figure D65. BSD Run 103, Straight Lane Pass-by, SV 45 mph, POV 65 mph

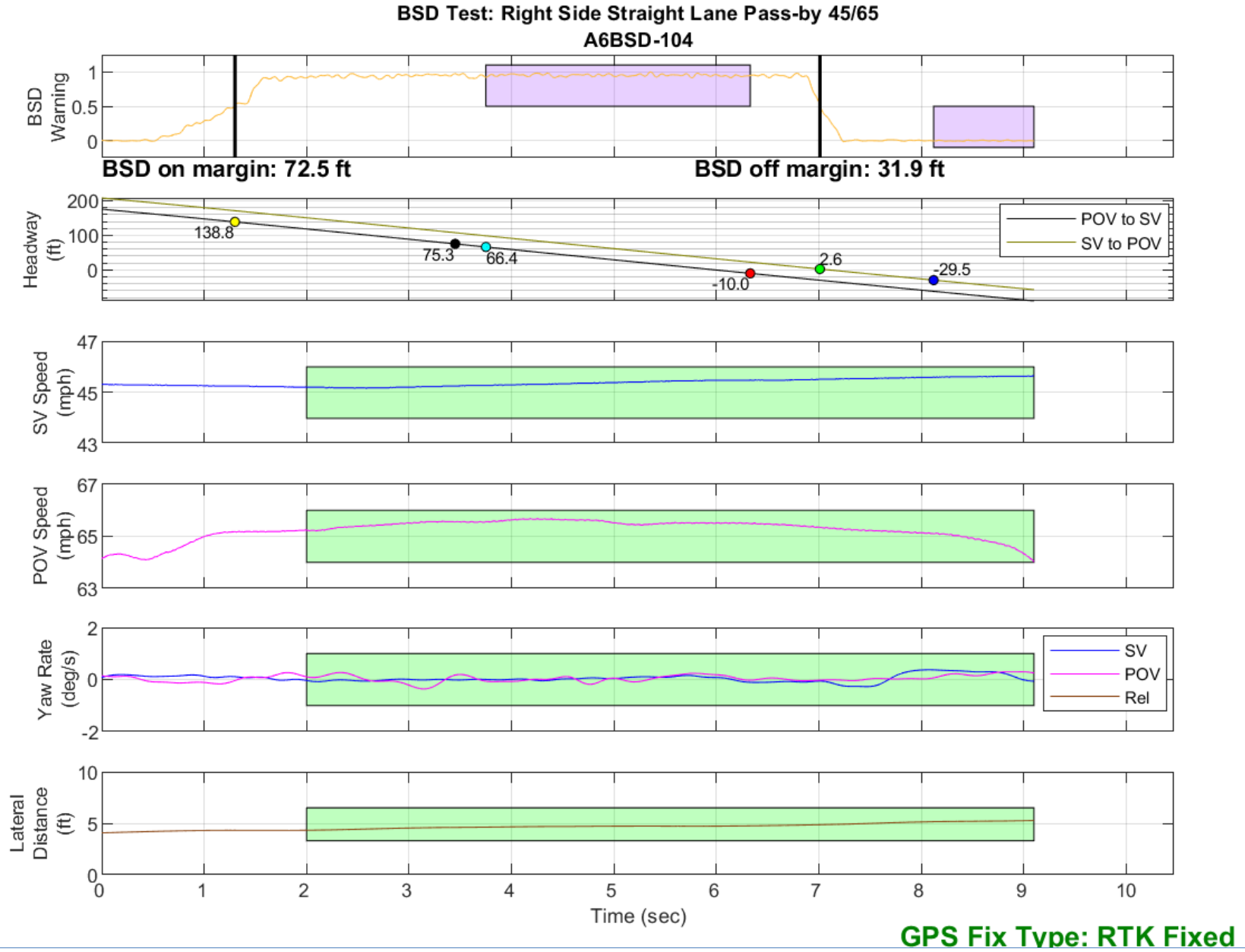

Figure D66. BSD Run 104, Straight Lane Pass-by, SV 45 mph, POV 65 mph

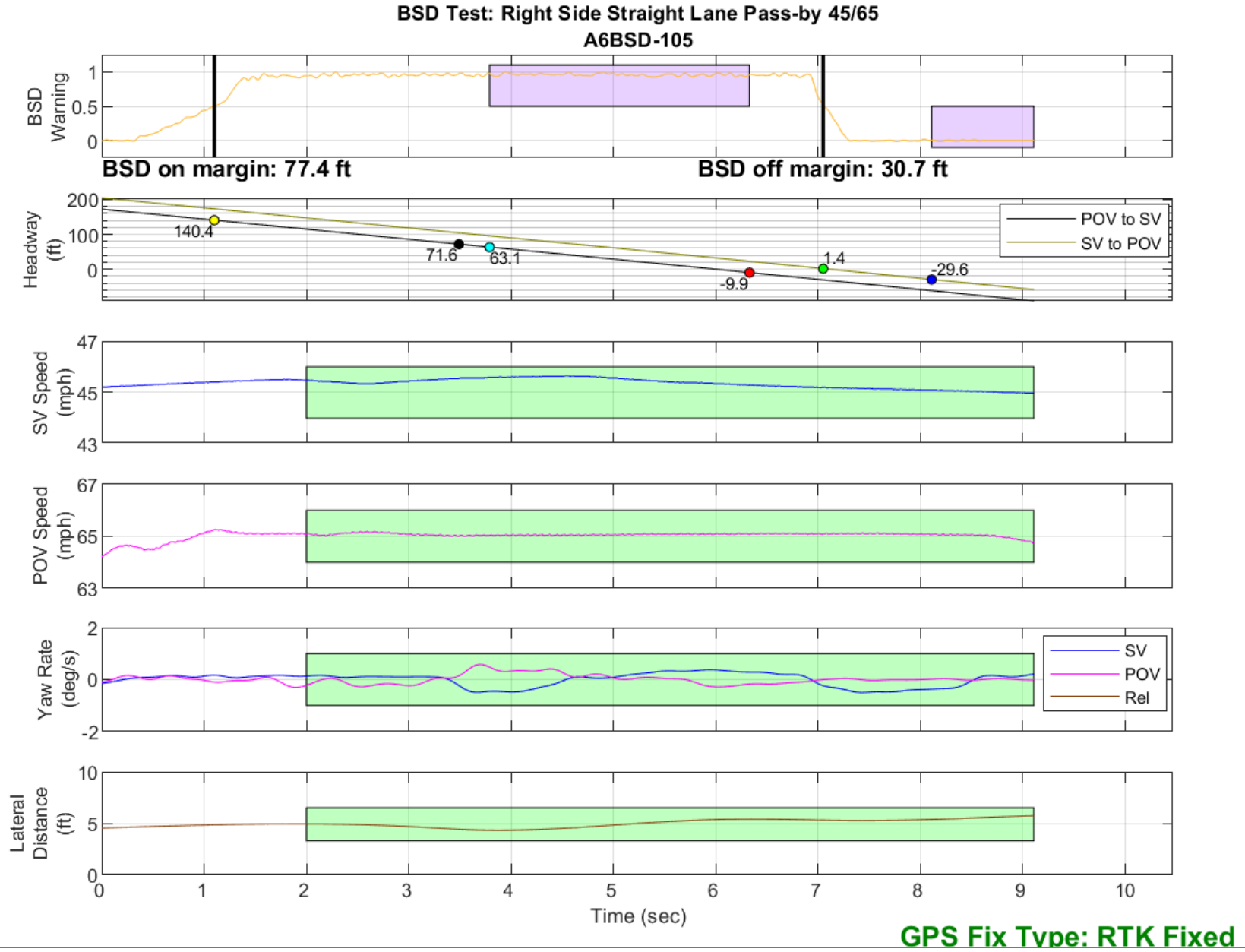

Figure D67. BSD Run 105, Straight Lane Pass-by, SV 45 mph, POV 65 mph

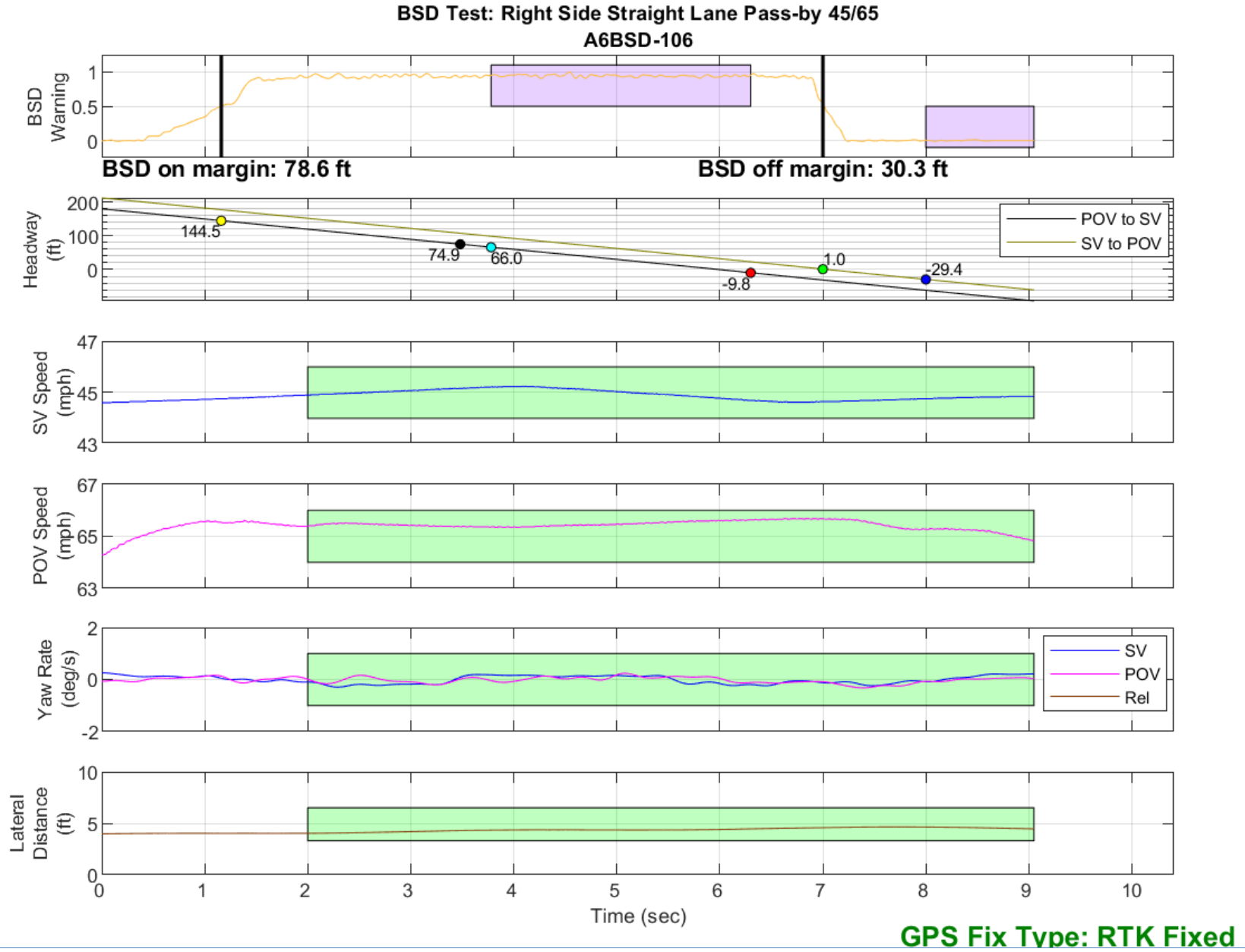

Figure D68. BSD Run 106, Straight Lane Pass-by, SV 45 mph, POV 65 mph