

**BLIND SPOT DETECTION SYSTEM RESEARCH TEST
NCAP-DRI-BSD-20-02**

2020 Audi Q5 45 TFSI quattro

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Final Report

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16. Abstract These tests were conducted on the subject 2020 Audi Q5 45 TFSI quattro in accordance with the specifications of the National Highway 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 did not meet the preliminary requirements for any of the runs for the Straight Lane Converge/Diverge scenario but met the preliminary requirements for 58 out of 58 runs for the Straight Lane Pass-by scenario.			
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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 Audi Q5 45 TFSI quattro

VIN: WA1BNAFY0L200xxxx

Test Date: 7/17/2020

System Setting: System on, brightness at the highest level

	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	<u>0</u>	<u>7</u>	<u>7</u>
45 mph - Right	<u>0</u>	<u>8</u>	<u>8</u>
Overall Test 1:	<u>0</u>	<u>15</u>	<u>15</u>
Test 2 - Straight Lane Pass-by			
POV 50 mph - Left	<u>7</u>	<u>0</u>	<u>7</u>
POV 50 mph - Right	<u>7</u>	<u>0</u>	<u>7</u>
POV 55 mph - Left	<u>7</u>	<u>0</u>	<u>7</u>
POV 55 mph - Right	<u>7</u>	<u>0</u>	<u>7</u>
POV 60 mph - Left	<u>7</u>	<u>0</u>	<u>7</u>
POV 60 mph - Right	<u>7</u>	<u>0</u>	<u>7</u>
POV 65 mph - Left	<u>8</u>	<u>0</u>	<u>8</u>
POV 65 mph - Right	<u>8</u>	<u>0</u>	<u>8</u>
Overall Test 2:	<u>58</u>	<u>0</u>	<u>58</u>
Overall:	58	15	73

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)

2020 Audi Q5 45 TFSI quattro

TEST VEHICLE INFORMATION

VIN: WA1BNAFY0L200xxxx

Body Style: SUV

Color: Monsoon Gray Metallic

Date Received: 5/18/2020

Odometer Reading: 55 mi

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: Audi AG

Date of manufacture: 08/19

Vehicle Type: MPV

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: 255/45R20

Rear: 255/45R20

Recommended cold tire pressure: Front: 230 kPa (33 psi)

Rear: 250 kPa (36 psi)

TIRES

Tire manufacturer and model: Continental Cross Contact LX Sport

Front tire size: 255/45R20 101H

Rear tire size: 255/45R20 101H

Front tire DOT prefix: P512WC1L

Rear tire DOT prefix: P512WC1L

BLIND SPOT DETECTION
DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Audi Q5 45 TFSI quattro

GENERAL INFORMATION

Test date: 7/17/2020

AMBIENT CONDITIONS

Air temperature: 30.0 C (86 F)

Wind speed: 1.5 m/s (3.5 mph)

X Windspeed \leq 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: 230 kPa (33 psi)

Rear: 250 kPa (36 psi)

BLIND SPOT DETECTION
DATA SHEET 3: TEST CONDITIONS

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2020 Audi Q5 45 TFSI quattro

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front: 533.0 kg (1175 lb)

Right Front: 527.1 kg (1162 lb)

Left Rear: 477.2 kg (1052 lb)

Right Rear: 477.2 kg (1052 lb)

Total: 2014.5 kg (4441 lb)

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2020 Audi Q5 45 TFSI quattro

General Information

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

Audi side assist

Side assist is available as part of the optional Driver assistance package on Premium trim and standard on the Premium Plus and Prestige trims.

Type and location of sensors the system uses:

Two medium range radar (MRR) sensors located in the corners of the rear bumper.

System setting used for test (if applicable):

System on, brightness at the highest level

Method(s) by which the driver is alerted

X Visual:

<u>Type</u>	<u>Location</u>	<u>Description</u>
<u> </u> Symbol		
<u> </u> Word		
<u> </u> Graphic		

 Audible – Description:

 Haptic:

<u> </u> Steering Wheel	<u> </u> Seatbelt
<u> </u> Pedals	<u> </u> Steering Torque
<u> </u> Seat	<u> </u> Brake Jerk

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2020 Audi Q5 45 TFSI quattro

Description of alert:

A series of LEDs are located adjacent to the outside mirrors. The display in the left exterior mirror provides assistance when making a lane change to the left, while the display in the right exterior mirror provides assistance when making a lane change to the right.

When the turn signal is activated, and if the system classifies a potential conflict as critical, the LEDs provide a flashing warning that vehicles are approaching or traveling in the same direction as your vehicle within sensor range.

If the turn signal is not activated, the side assist system informs you about vehicles that are detected and classified as critical. In this case the display in the mirror turn on but are dim.

See Figure A14 in Appendix A.

System Function

What is the speed range over which the system operates?

Minimum: 14.4 km/h (9 mph)

Maximum: 248 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 sequence/procedure is needed

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 outside 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.

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2020 Audi Q5 45 TFSI quattro

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?

The system can be switched on/off in the Infotainment system.

The hierarchy is:

Vehicle

Driver assistance

Audi side assist. "Off" switches the system off.

Then whatever setting is selected remains when the ignition is cycled.

If the system is activated, the displays in the exterior mirrors will turn on briefly when the ignition is switched on.

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. This is achieved through the Infotainment system.

The hierarchy is:

Vehicle

Driver assistance

Audi Side Assist. Adjust the virtual rotary knob to the desired brightness.

See Appendix A, Figures A11 through A13.

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

If the system is inoperable then the following messages will occur in the gauge cluster: "Audi side assist: malfunction! Please contact Service"

BLIND SPOT DETECTION

DATA SHEET 4: BLIND SPOT DETECTION SYSTEM OPERATION

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2020 Audi Q5 45 TFSI quattro

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 activity.

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.

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

The area in front of the sensors must not be covered by bike racks, stickers, leaves, snow, heavy rain, or any other objects.

System limitations are described on pages 141 and 142 of the Owner's Manual, shown in Appendix B, pages B-4 and B-5.

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.

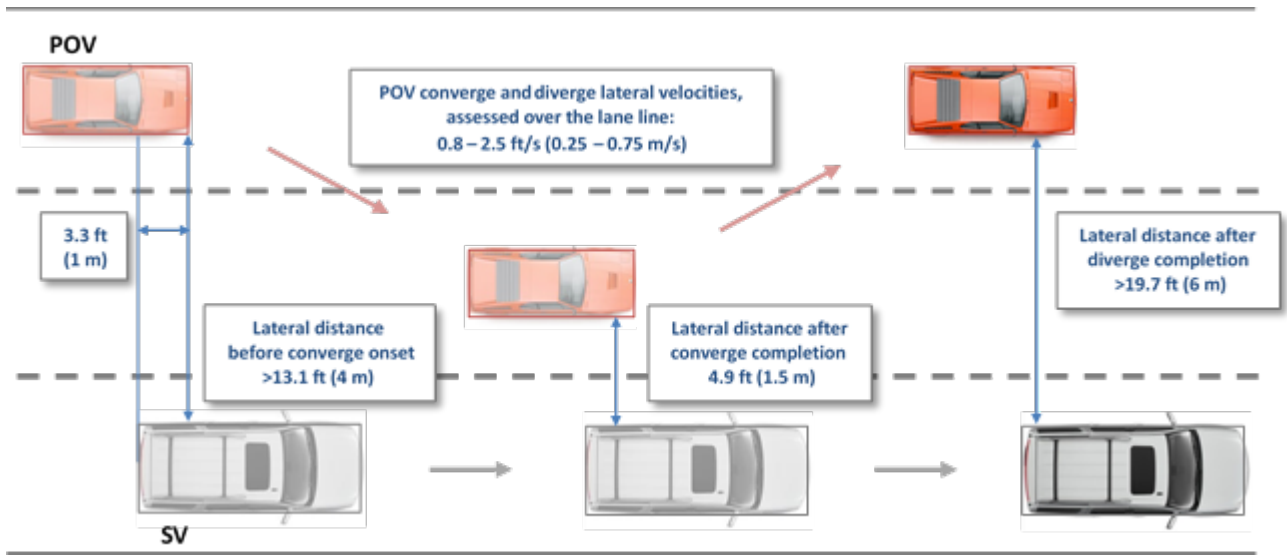


Figure 1. Straight Lane Converge and Diverge Test (POV converge and diverge from the left is shown)

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 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 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.

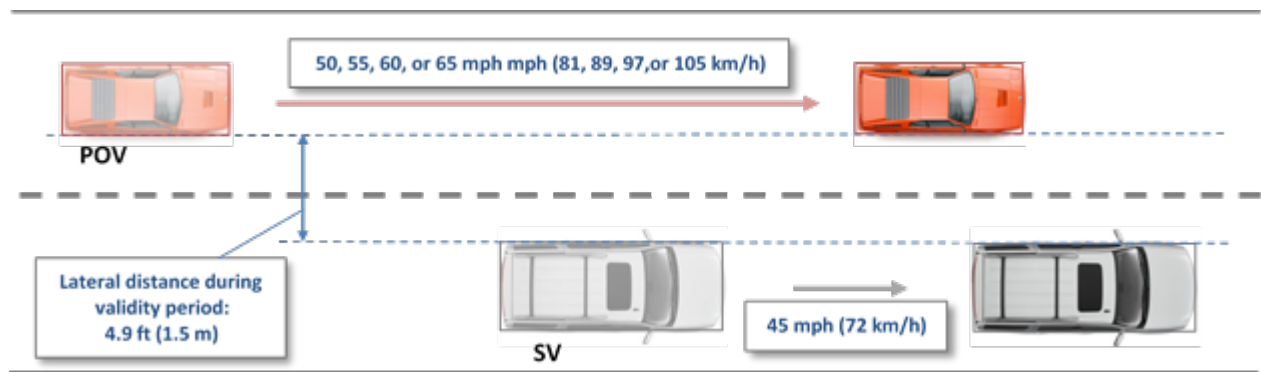


Figure 2. Straight Lane Pass-by Test
(Left-side POV Pass-by is shown)

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)	>29.3ft (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.

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

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.

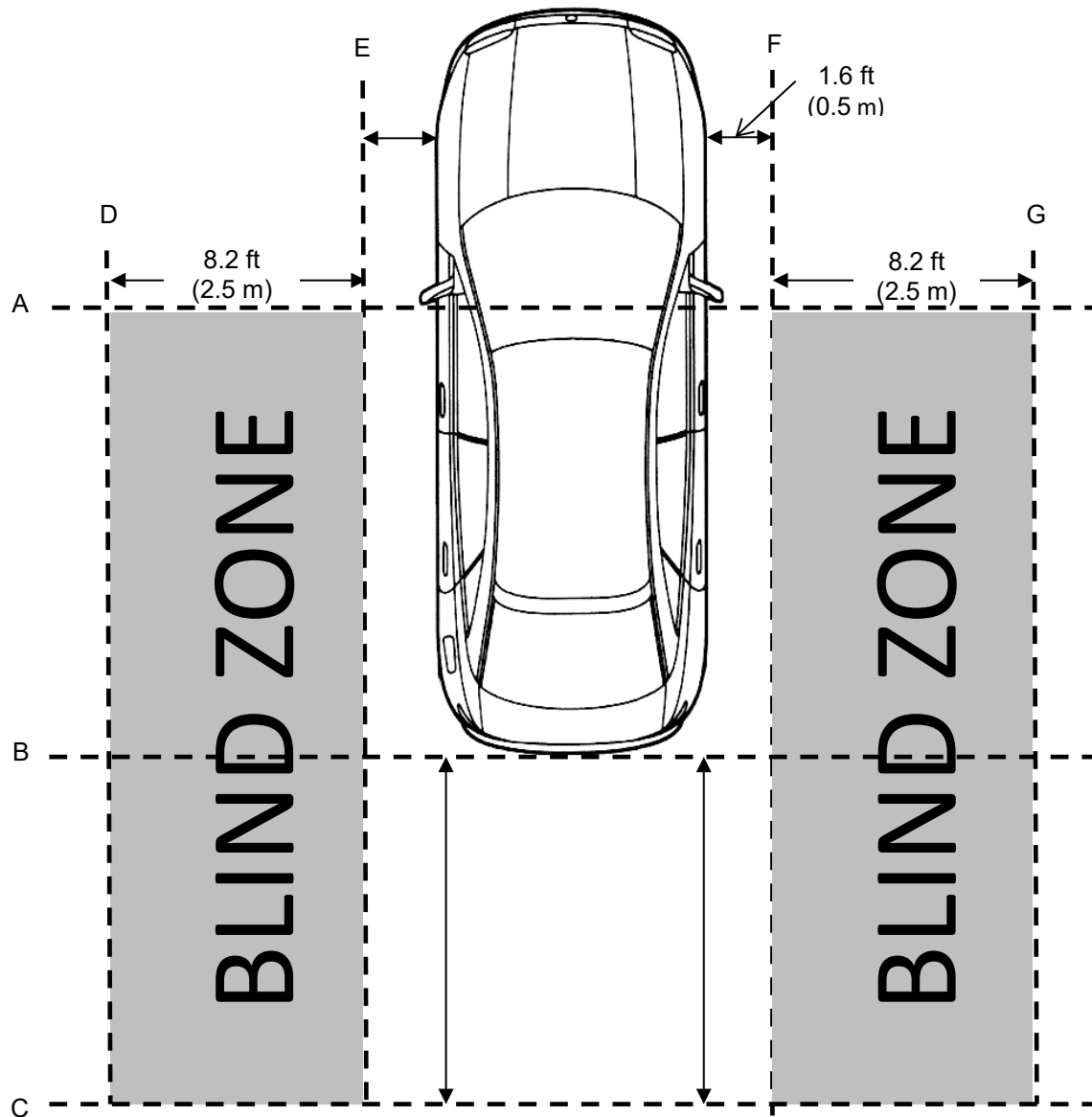


Figure 3. Vehicle Blind Zone Areas

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 $\pm 10g$, 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 +	2258	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: ± 0.02 m/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

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Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle

2020 Audi Q5 45 TFSI quattro



STANDARD EQUIPMENT (unless replaced by options)

TECHNICAL

- 2.0 TFSI® 4 engine
- quattro® all-wheel drive system
- 7-speed S tronic® transmission
- 16" 5-arm-turbine design wheels with all-season tires
- Energy recuperation system with start-stop
- Space-saving spare tire

COMFORT/TECHNOLOGY

- Audi connect® CARE (limited time subscription)
- Audi drive select
- Audi sound system
- Audi xenon plus headlights
- Aluminum high-gloss window surrounds
- Aluminum roof rails with crossbars
- Auto-dimming interior mirror w/ compass
- Garage door opener (HomeLink®)
- Driver information system w/ 7" color display
- Heated front seats
- Heated, power exterior mirrors
- High beam assist
- High-gloss Burl Walnut Wood inlays
- Hill descent control
- Leather seating surfaces
- Power tailgate
- Preparation for mobile phone (Bluetooth®) with audio streaming
- Rear privacy glass
- Sliding 40/20/40 split-folding 2nd row with adjustable recline
- Three-zone automatic climate control with digital rear display
- USB Audi music interface w/ Audi smartphone interface
- 3-spoke multi-function steering wheel w/ shift paddles
- 8-way power front seats, 4-way power lumbar for driver

SAFETY/CONVENIENCE

- Advanced Airbag Protection System with 6 airbags
- Anti-lock Braking System (ABS) w/ Brake Assist
- Audi pre sense basic (preventative occupant protection)
- Child safety locks in rear doors, power
- Child safety locks in rear doors, power
- Electronic Stabilization Control (ESC) w/ Offroad mode
- Electronic vehicle immobilization w/ anti-theft alarm & interior motion sensor
- LED Daytime Running Lights (DRLs) and taillights
- 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
 - 4 Years Roadside Assistance coverage provided by a third party supplier
- *Please refer to the 2020 Audi Warranty and Maintenance Booklet for complete coverage information.

MANUFACTURER'S SUGGESTED RETAIL PRICE

2020 Audi Q5 45 TFSI quattro **\$43,300.00**

PACKAGES / OPTIONS

Monsoon Gray metallic \$595.00
 Black interior Included
 Premium Plus package \$6,650.00

19" 5-spoke-dynamic design wheels with all-season tires
 Auto-dimming, power-folding exterior mirrors with memory
 SiriusXM® All Access service w/3-month trial subscription
 Audi advanced key & memory for driver's seat
 LED headlights
 Panoramic sunroof
 Parking system plus
 Leatherette covered center console and door armrests
 Aluminum front door sill inlays
 Audi side assist with pre sense rear
 MMI® Navigation plus with MMI® all-in-touch
 Audi virtual cockpit
 Audi connect PRIME and PLUS (6 month trial subscription)
 Audi phone box & rear USB charge ports

Driver assistance package \$1,500.00
 Adaptive cruise control with Traffic Jam assist
 Audi active lane assist

Black optic package \$1,300.00
 Titanium black exterior package w/ matte black roof rails

20" 5-arm-offroad design wheels with all-season tires \$950.00
 Bang & Olufsen® sound system with 3D sound \$110.00
 Apple® Lightning® and USB Type-C cables

Destination Charge \$995.00

Subtotal: \$55,400.00

Convenience package plus credit -\$750.00

Convenience package credit -\$1,500.00

Total Price: \$53,150.00

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

MODEL: FYB5NY

VIN: WA1BNAFY0L200

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score ★★★★★

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 ★★★★★
 Passenger ★★★★★

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 ★★★★★
 Rear Seat ★★★★★

Based on the risk of injury in a side impact.

Rollover ★★★★★

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



Fuel Economy and Environment



Gasoline Vehicle

Fuel Economy

24 MPG
 combined city/hwy
 22 city
 28 highway
 4.2 gallons per 100 miles

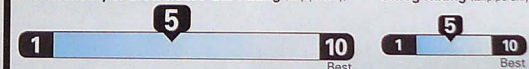
Small Sport Utility Vehicles range from 18 to 120 MPG. The best vehicle rates 136 MPG.

You spend \$2,750

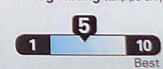
more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost \$2,050

Fuel Economy & Greenhouse Gas Rating (tailpipe only)



Smog Rating (tailpipe only)



This vehicle emits 364 grams of CO₂ per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fuel economy.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 \$7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$3.25 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fuel economy.gov

Calculate personalized estimates and compare vehicles



Smartphone QR Code™



PARTS CONTENT INFORMATION

For Vehicles In This Carline
 U.S./Canadian Parts Content:
 Major Sources Of Foreign
 Parts Content: **MEXICO:**

For This Vehicle:
 Final Assembly Point: **SAN JOSE CHIAPA, MEXICO**
 Country Of Origin: **MEXICO**
ENGINE: MEXICO
TRANSMISSION: GERMANY

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

Figure A3. Window Sticker (Monroney Label)

MFD. BY AUDI AG

0819



Audi

GVWR LBS 5456, KG 2475

GAWR FRONT LBS 2679, KG 1215

FRONT-TIRES 255/45 R20

8JX20 RIMS, AT 230 KPA 33 PSI COLD

GAWR REAR LBS 3042, KG 1380

REAR-TIRES 255/45 R20

8JX20 RIMS, AT 250 KPA 36 PSI COLD


THIS VEHICLE CONFORMS TO ALL APPLICABLE
U.S. FEDERAL MOTOR VEHICLE SAFETY AND
THEFT PREVENTION STANDARDS IN EFFECT ON
THE DATE OF MANUFACTURE SHOWN ABOVE.
MEXICO

WA1BNAFY0L200

TYPE:
MPV




Figure A4. Vehicle Certification Label



TIRE AND LOADING INFORMATION

RENSEIGNEMENTS SUR LES PNEUS ET LE CHARGEMENT



Audi




SEATING CAPACITY NOMBRE DE PLACES	TOTAL	5	FRONT AVANT	2	REAR ARRIERE	3
--------------------------------------	-------	----------	----------------	----------	-----------------	----------

80A 010
502 P

The combined weight of occupants and cargo should never exceed **480** kg or **1058** lbs.
 Le poids total des occupants et du chargement ne doit jamais dépasser **480** kg ou **1058** lb.

TIRE PNEU	SIZE DIMENSIONS	COLD TIRE PRESSURE PRESSION DES PNEUS A FROID	
FRONT AVANT	255/45 R20 101H	230 KPA, 33 PSI	<p style="margin: 0;">SEE OWNER'S MANUAL FOR ADDITIONAL INFORMATION</p> <p style="margin: 0;">VOIR LE MANUEL DU PROPRIETAIRE POUR PLUS DE RENSEIGNEMENTS</p>
REAR ARRIERE	255/45 R20 101H	250 KPA, 36 PSI	
SPARE DE SECOURS	195/75-18	350 KPA, 51 PSI	

RESET

8K0 010 500 D

Figure A5. Tire Placard



Figure A6. Front View of Principal Other Vehicle



Figure A7. Rear View of Principal Other Vehicle

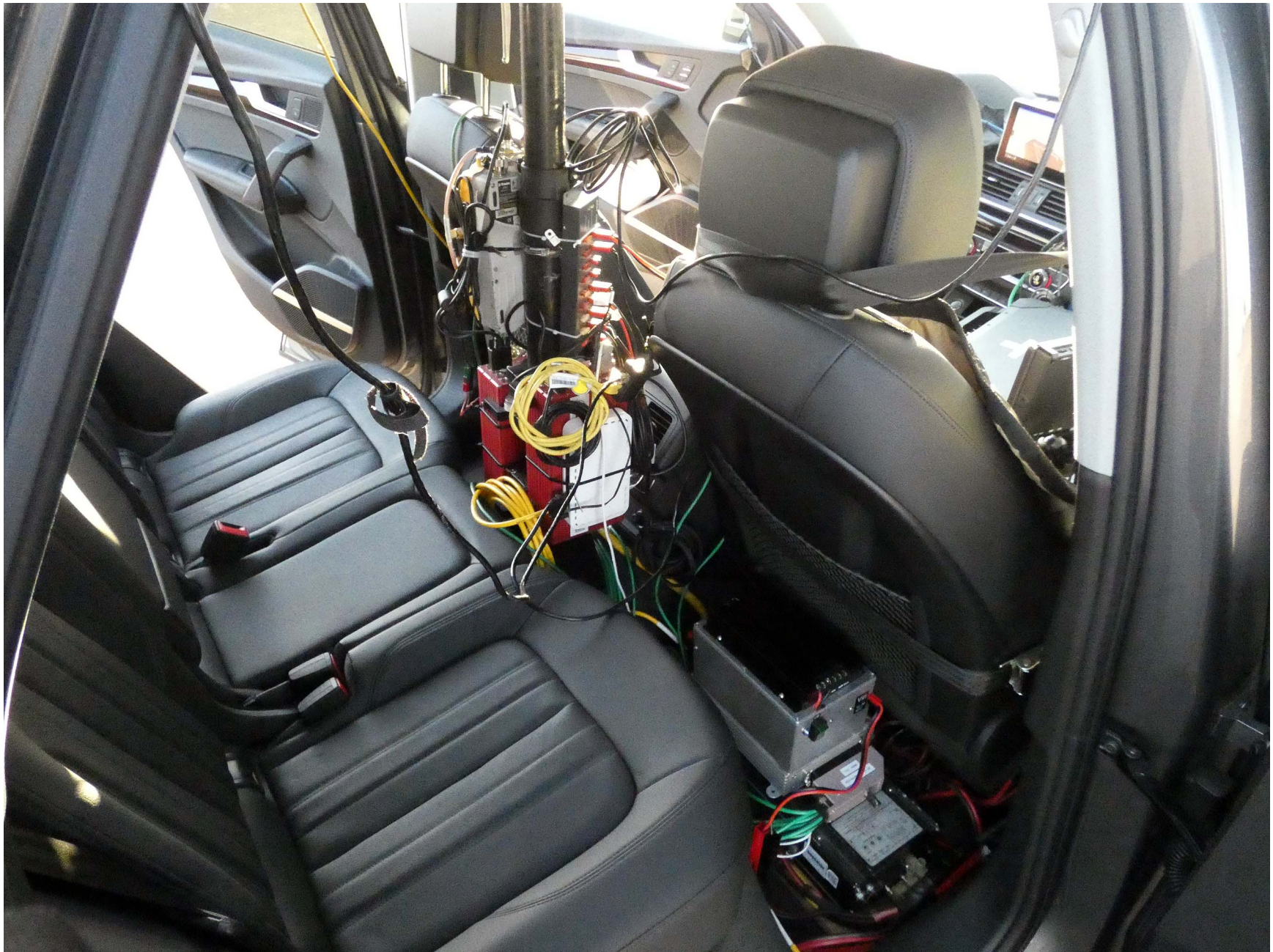


Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle



Figure A9. Sensors for Detecting Visual Alerts



Figure A10. Computer Installed in Subject Vehicle



Figure A11. System Setup Menus (page 1 of 2)

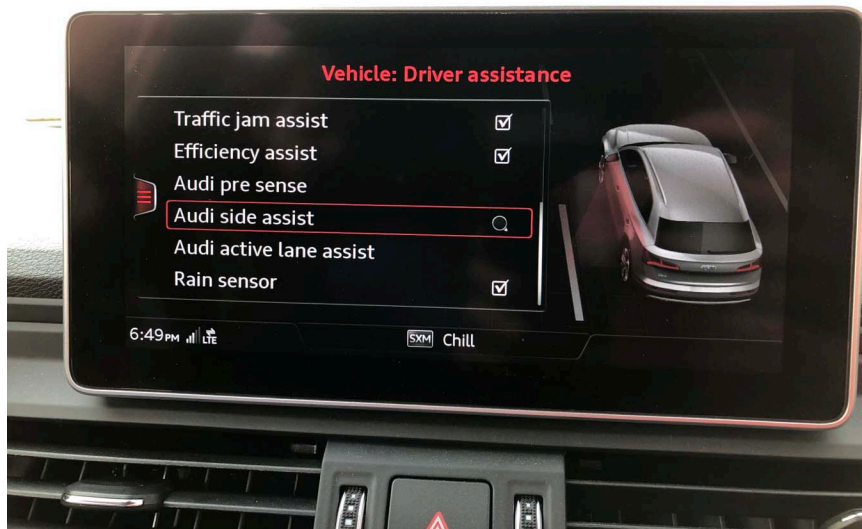


Figure A12. System Setup Menus (page 2 of 2)




Figure A13. Controls for Interacting with System Menus



Figure A14. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

	Drive system ⇒ page 86, ⇒ page 333		Engine oil level (MAX) ⇒ page 330
	Vehicle sound ⇒ page 86		Engine oil sensor ⇒ page 330
	Engine start system ⇒ page 76		Malfunction Indicator Lamp (MIL) ✓ ⇒ page 326
	Keys ⇒ page 76		Engine warm-up request ⇒ page 330
	Electromechanical parking brake ⇒ page 90		Washer fluid level ⇒ page 339
	Brake system ⇒ page 89		Windshield wipers ⇒ page 50
	Electronic Stabilization Control (ESC) ⇒ page 22		Charging system ⇒ page 100
	Electronic Stabilization Control (ESC) ✓ ⇒ page 22		Parking aid ⇒ page 163
	Electronic Stabilization Control (ESC) ⇒ page 165		Tire pressure ⇒ page 359
	Anti-lock braking system (ABS) ✓ ⇒ page 22		Tire pressure ⇒ page 359
	Anti-lock braking system (ABS) ✓ ⇒ page 22		Bulb failure indicator ⇒ page 44
	Steering ⇒ page 166		Headlight range control system ⇒ page 44
	All wheel drive/sport differential ⇒ page 23		Adaptive light ⇒ page 44
	Suspension control ⇒ page 23		Light/rain sensor ⇒ page 44, ⇒ page 50
	Air suspension ⇒ page 23		Driver's door ⇒ page 30
	Engine speed limitation ⇒ page 16		Battery in vehicle key ⇒ page 27
	Tank system ⇒ page 324		Audi side assist ⇒ page 145
	Electrical system ⇒ page 336		Active lane assist ⇒ page 137
	Engine oil level (MIN) ⇒ page 330		Audi pre sense ⇒ page 135
			Emergency call function ⇒ page 217

Audi side assist

Description

Applies to: vehicles with Audi side assist

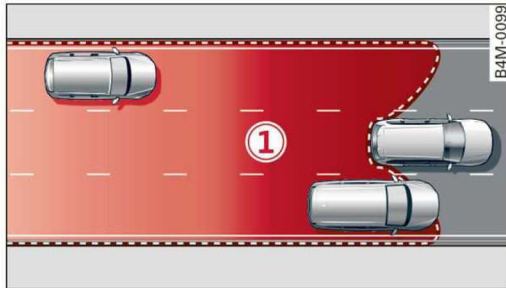


Fig. 128 Sensor detection range



Fig. 129 Indicator on the exterior mirror

Side assist (lane change assist) helps you monitor your blind spot and traffic behind your vehicle. Within the limits of the system, it warns you about vehicles that are approaching or traveling in the same direction as your vehicle within sensor range ① ⇒ *fig. 128*. If a lane change is classified as critical, the display ② in the exterior mirror turns on ⇒ *fig. 129*.

The display in the left exterior mirror provides assistance when making a lane change to the left, while the display in the right exterior mirror provides assistance when making a lane change to the right.

Information stage

As long as you do not activate the turn signal, side assist *informs* you about vehicles that are detected and classified as critical. The display in the mirror turns on, but is dim.

The display remains dim in the information stage so that your view toward the front is not disturbed.

Warning stage

If the display in a mirror blinks brightly when you activate a turn signal, side assist is *warning* you about detected vehicles that it has classified as critical. If this happens, check traffic by glancing in the exterior mirrors and over your shoulder ⇒ ⚠ in *General information on page 141*.

Applies to: vehicles with active lane assist: The display in the mirror can also blink 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, side assist will warn you about detected vehicles that it has classified as critical.

Tips

You can adjust the brightness on of the display on the rearview mirror ⇒ *page 142*.

General information

Applies to: vehicles with Audi side assist

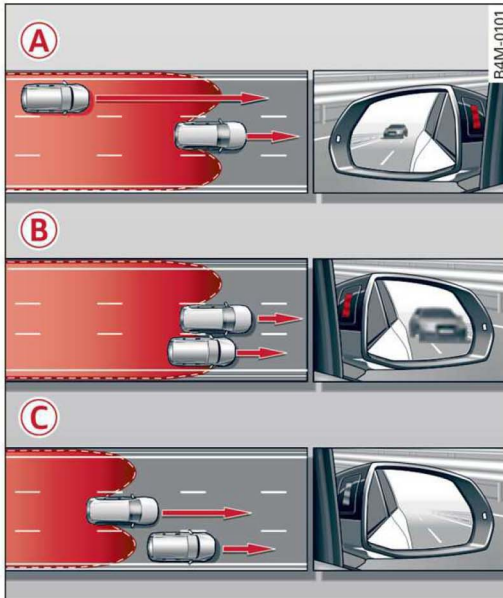


Fig. 130 Driving situations



Fig. 131 Rear of the vehicle: sensor locations

Side assist functions at speeds above approximately 9 mph (15 km/h).

A Vehicles that are approaching

In certain cases, a vehicle will be classified as critical for a lane change even if it is still somewhat far away. The faster a vehicle approaches, the sooner the display in the outside mirror will turn on.

B Vehicles traveling in the same direction as your vehicle

Vehicles traveling in the same direction as your vehicle are indicated in the exterior mirror if they are classified as critical for a lane change. All ve-

hicles detected by side assist are indicated by the time they enter your "blind spot", at the latest.

C Vehicles you are passing

If you slowly pass a vehicle that side assist has detected (the difference in speed between the vehicle and your vehicle is less than approximately 9 mph (15 km/h)), the display in the exterior mirror turns on as soon as the vehicle enters your blind spot.

The display will not turn on if you quickly pass a vehicle that side assist has detected (the difference in speed is greater than approximately 9 mph (15 km/h)).

Functional limitations

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 in the exterior mirror 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).
- In poor weather conditions. The side assist functions are limited.

Do not cover the radar sensors ⇨ *fig. 131* with stickers, deposits, bicycle wheels or other objects, because this will impair the function. For information on cleaning, see ⇨ *page 361*.

! WARNING

- Always pay attention to traffic and to the area around your vehicle. Side assist cannot replace a driver's attention. The driver alone is always responsible for lane changes and similar driving maneuvers.
- In some situations, the system may not function or its function may be limited. For example:

80A01272.1B]

Assist systems

- If vehicles are approaching or being left behind very quickly. The display may not turn on in time.
- In poor weather conditions such as heavy rain, snow or heavy mist.
- On very wide lanes, in tight curves, or if there is a rise in the road surface. Vehicles in the adjacent lane may not be detected because they are outside of the sensor range.

Note

The sensors can be displaced by impacts or damage to the bumper, wheel housing and underbody. This can impair the system. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

Tips

- These systems are not available in trailer towing mode. There is no guarantee the systems will switch off when using a retrofitted trailer hitch. Do not use these functions when towing a trailer.
- 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 390](#).

Switching on and off

Applies to: vehicles with Audi side assist

The system can be switched on/off in the Infotainment system.

- ▶ Select in the Infotainment system: **MENU** button > **Vehicle** > left control button > **Driver assistance** > **Audi side assist**. **Off** switches the system off.

If the system is activated, the displays in the exterior mirrors will turn on briefly when the ignition is switched on.

Tips

When you switch side assist on or off, the exit warning system activates or deactivates [⇒ page 143](#).

Setting the display brightness

Applies to: vehicles with Audi side assist

The display brightness can be adjusted in the Infotainment system.

- ▶ Select in the Infotainment system: **MENU** button > **Vehicle** > left control button > **Driver assistance** > **Audi side assist**.

The display brightness adjusts automatically to the brightness of the surroundings, both in the information and in the warning stage. In very dark or very bright surroundings, the automatic adjustment will set the display to the minimum or maximum level. In such cases, you may notice no change when adjusting the brightness, or the change may only be noticeable once the surroundings change.

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 in the exterior mirror will briefly show the brightness level in the information stage. The brightness of the warning stage is linked to the brightness in the information stage and is adjusted along with the information stage.

Tips

- The side assist functions are not active during the adjustment process.
- The exit warning indicators turn on during the adjustment process.
- Your settings are automatically stored and assigned to the vehicle key being used.

in a critical area, for example when backing into a parking space or maneuvering.

- Once an automatic brake activation occurs, the system cannot brake automatically again for several seconds.
- The rear cross-traffic assist also switches off when you switch off the ESC.
- If there is an acoustic warning signal from the rear cross-traffic assist, then the parking system may not warn you of detected obstacles under certain circumstances.
- The system is not available when the vehicle detects that you are towing a trailer. There is no guarantee the functions will switch off when using a retrofitted trailer hitch. Do not use these functions when towing a trailer.
- For an explanation on conformity with the FCC regulations in the United States and the Industry Canada regulations, see ⇒ *page 390*.


Messages


Applies to: vehicles with Audi side assist

 **Audi side assist: malfunction! Please contact Service**

 **Audi side assist and exit warning: malfunction! Please contact Service**


The system cannot guarantee that it will detect vehicles correctly and it has switched off. The sensors have been moved or are faulty. Have the system checked by an authorized Audi dealer or authorized Audi Service Facility soon.

 **Audi side assist: currently unavailable. Sensor vision restricted due to surroundings. See owner's manual**

 **Audi side assist and exit warning: currently unavailable. Sensor vision restricted due to surroundings**


The radar sensor vision is impaired. The area in front of the sensors must not be covered by bike racks, stickers, leaves, snow or any other objects. Clean the area covering the sensors, if necessary ⇒ *page 141, fig. 131*.

 **Audi side assist: currently unavailable. See owner's manual**


 **Audi side assist and exit warning: currently unavailable. See owner's manual**

Side assist cannot be switched on at this time because there is a malfunction (for example, the battery charge level may be too low).

 **Audi side assist: unavailable in towing mode**

 **Audi side assist and exit warning: currently unavailable. Towing mode**

Side assist switches off automatically when the electrical connector in the factory-installed trailer hitch is connected. There is no guarantee the system will switch off when using a retrofitted trailer hitch. Do not use side assist and the exit warning when towing a trailer.

 **Rear parking aid: obstacle detection restricted**

The rear cross-traffic assist is not available. Either the ESC is switched off, or the radar sensors may be covered by a bike rack, stickers, leaves, snow or other objects. Switch the ESC on, or clean the area in front of the sensors if necessary ⇒ *page 141, fig. 131*. If this message continues to be displayed, drive immediately to an authorized Audi dealer or authorized Audi Service Facility to have the malfunction repaired.

Audi drive select

Introduction

Applies to: vehicles with Audi drive select

Drive select makes it possible to experience different types of vehicle characteristics in one vehicle. With different driving modes, the driver can switch the setting, for example from sporty to comfortable. In the **Individual** mode, the settings can be adjusted to your personal preferences. This makes it possible to combine settings such as a sporty drivetrain setting with comfortable steering.

Description

Applies to: vehicles with Audi drive select

The following systems, among other things, are influenced by drive select: ▶

APPENDIX C

Run Log

Subject Vehicle: **2020 Audi Q5 45 TFSI quattro**

Date: **7/17/2020**

Test Engineer: **J. Robel**

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 Run									
33	Converge/ Diverge	Left	Y			No	No	No	No warning	
34			N							Lateral velocity
35			Y			No	No	No	No	No warning
36			N							Yaw
37			N							Headway, yaw, lateral distance, speed
38			Y			No	No	No	No	No warning
39			N							Lateral velocity
40			N							Lateral velocity
41			N							Ran out of track
42			Y			No	No	No	No	No warning
43			N							Lateral velocity
44			N							Lateral velocity
45			N							SV speed, lateral velocity
46			N							Lateral velocity
47			Y			No	No	No	No	No warning
48			Y			No	No	No	No	No warning

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		
49	Converge/ Diverge (cont'd)	Left	N						Lateral velocity	
50			N						Lateral velocity	
51			N						Ran out of track	
52			N						Lateral velocity	
53			Y				No	No	No	No warning
54	Converge/ Diverge	Right	N						POV did not converge	
55			N							Ran out of track
56			N							Lateral distance, Lateral velocity
57			Y				No	No	No	No warning
58			Y				No	No	No	No warning
59			N							Ran out of track
60			N							Headway
61			Y				No	No	No	No warning
62			N							POV speed
63			N							Lateral velocity, yaw
64			Y				No	No	No	No warning
65			Y				No	No	No	No warning
66			N							Headway, yaw, lateral distance
67			Y				No	No	No	No warning
68			N							Yaw, ran out of track
69	Y				No	No	No	No warning		

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		
70	Converge/ Diverge (cont'd)	Right	N						Lateral velocity	
71			N						Ran out of track	
72			N							Headway, yaw
73			Y			No	No	No	No warning	
2	Straight Lane 45/50	Left	Y	25.6	14.3	Yes	Yes	Yes		
3			N						Lateral distance	
4			Y	24.2	15.1	Yes	Yes	Yes		
5			Y	26.5	14.7	Yes	Yes	Yes		
6			Y	26.9	12.8	Yes	Yes	Yes		
7			Y	27.3	14.6	Yes	Yes	Yes		
8			Y	25.1	14.0	Yes	Yes	Yes		
9			Y	25.9	12.5	Yes	Yes	Yes		
74	Straight Lane 45/50	Right	Y	29.9	13.6	Yes	Yes	Yes		
75			Y	28.9	14.1	Yes	Yes	Yes		
76			Y	24.9	12.8	Yes	Yes	Yes		
77			Y	24.7	13.9	Yes	Yes	Yes		
78			Y	25.6	14.1	Yes	Yes	Yes		
79			Y	26.3	15.0	Yes	Yes	Yes		
80			Y	27.9	14.7	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	
10	Straight Lane 45/55	Left	Y	40.5	17.5	Yes	Yes	Yes	
11			Y	42.7	16.4	Yes	Yes	Yes	
12			Y	44.9	16.4	Yes	Yes	Yes	
13			Y	39.3	17.2	Yes	Yes	Yes	
14			Y	40.8	17.3	Yes	Yes	Yes	
15			Y	38.1	17.9	Yes	Yes	Yes	
16			Y	35.6	18.1	Yes	Yes	Yes	
81	Straight Lane 45/55	Right	Y	36.5	18.7	Yes	Yes	Yes	
82			Y	36.0	17.5	Yes	Yes	Yes	
83			Y	33.5	19.6	Yes	Yes	Yes	
84			Y	33.9	14.9	Yes	Yes	Yes	
85			Y	41.1	17.8	Yes	Yes	Yes	
86			Y	37.7	15.9	Yes	Yes	Yes	
87			Y	36.8	17.7	Yes	Yes	Yes	
17	Straight Lane 45/60	Left	Y	62.0	22.8	Yes	Yes	Yes	
18			Y	53.8	23.3	Yes	Yes	Yes	
19			Y	53.7	22.7	Yes	Yes	Yes	
20			Y	59.6	20.2	Yes	Yes	Yes	
21			Y	54.4	21.5	Yes	Yes	Yes	
22			Y	53.0	20.1	Yes	Yes	Yes	
23			N						

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	Straight Lane 45/60 (cont'd)	Left	Y	60.6	21.3	Yes	Yes	Yes	
88	Straight Lane 45/60	Right	Y	53.3	23.7	Yes	Yes	Yes	
89			Y	50.0	20.9	Yes	Yes	Yes	
90			N						Lateral distance
91			Y	54.9	20.5	Yes	Yes	Yes	
92			Y	56.7	21.8	Yes	Yes	Yes	
93			Y	59.6	18.9	Yes	Yes	Yes	
94			Y	57.8	22.3	Yes	Yes	Yes	
95			Y	55.6	21.3	Yes	Yes	Yes	
25	Straight Lane 45/65	Left	Y	81.5	25.7	Yes	Yes	Yes	
26			Y	79.5	24.5	Yes	Yes	Yes	
27			Y	68.8	25.4	Yes	Yes	Yes	
28			Y	76.1	27.2	Yes	Yes	Yes	
29			Y	93.0	27.2	Yes	Yes	Yes	
30			Y	70.3	25.8	Yes	Yes	Yes	
31			Y	77.0	26.2	Yes	Yes	Yes	
32			Y	74.5	24.8	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	
96	Straight Lane 45/65	Right	Y	81.3	24.3	Yes	Yes	Yes	
97			Y	81.6	24.2	Yes	Yes	Yes	
98			Y	79.5	26.7	Yes	Yes	Yes	
99			Y	74.2	25.8	Yes	Yes	Yes	
100			Y	73.4	24.5	Yes	Yes	Yes	
101			Y	68.6	25.6	Yes	Yes	Yes	
102			Y	81.6	22.6	Yes	Yes	Yes	
103			Y	78.0	23.6	Yes	Yes	Yes	

APPENDIX D

Time History Plots

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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 A¹ 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 distance² 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
 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.

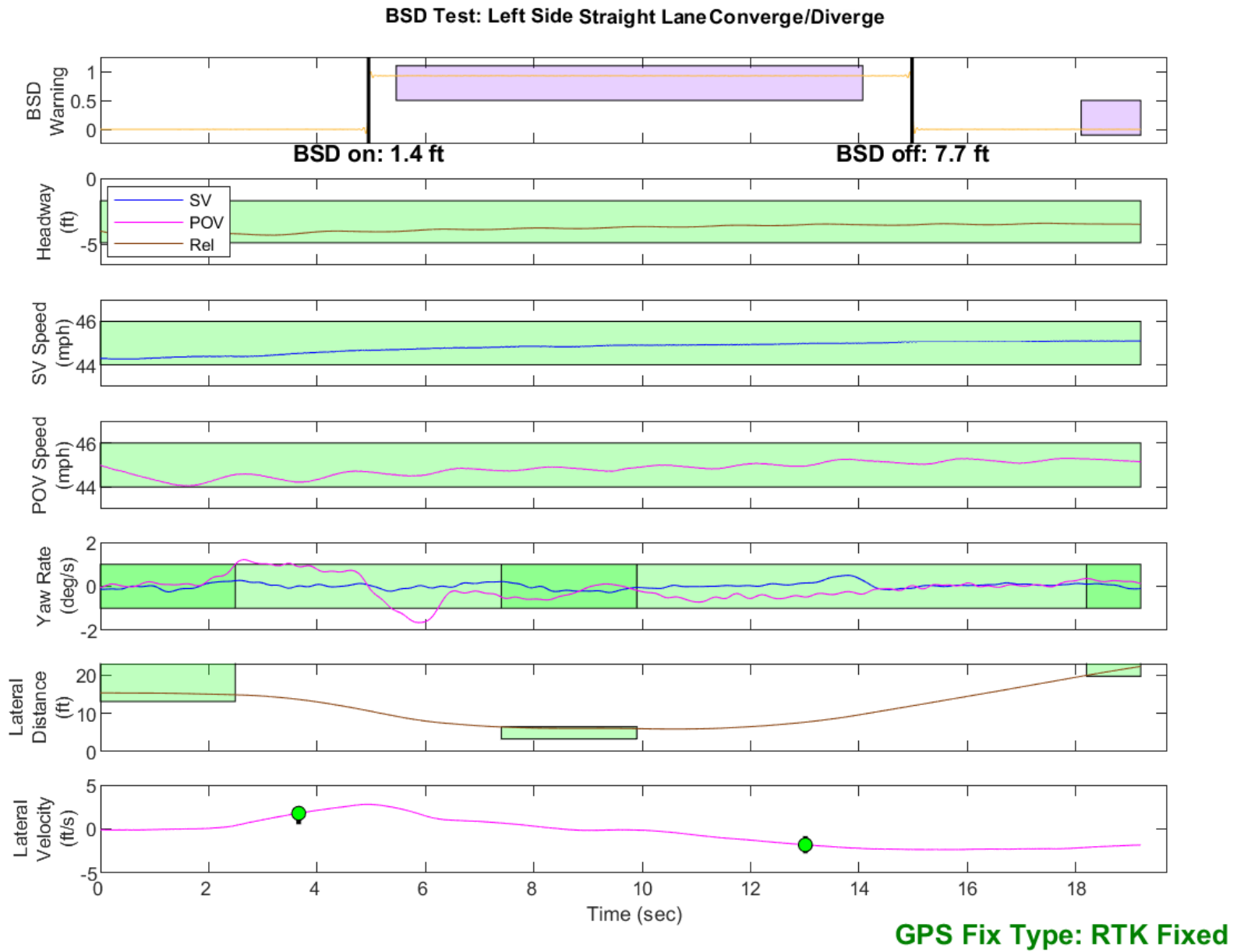


Figure D1. Example Time History for Straight Lane Converge/Diverge Test, Passing

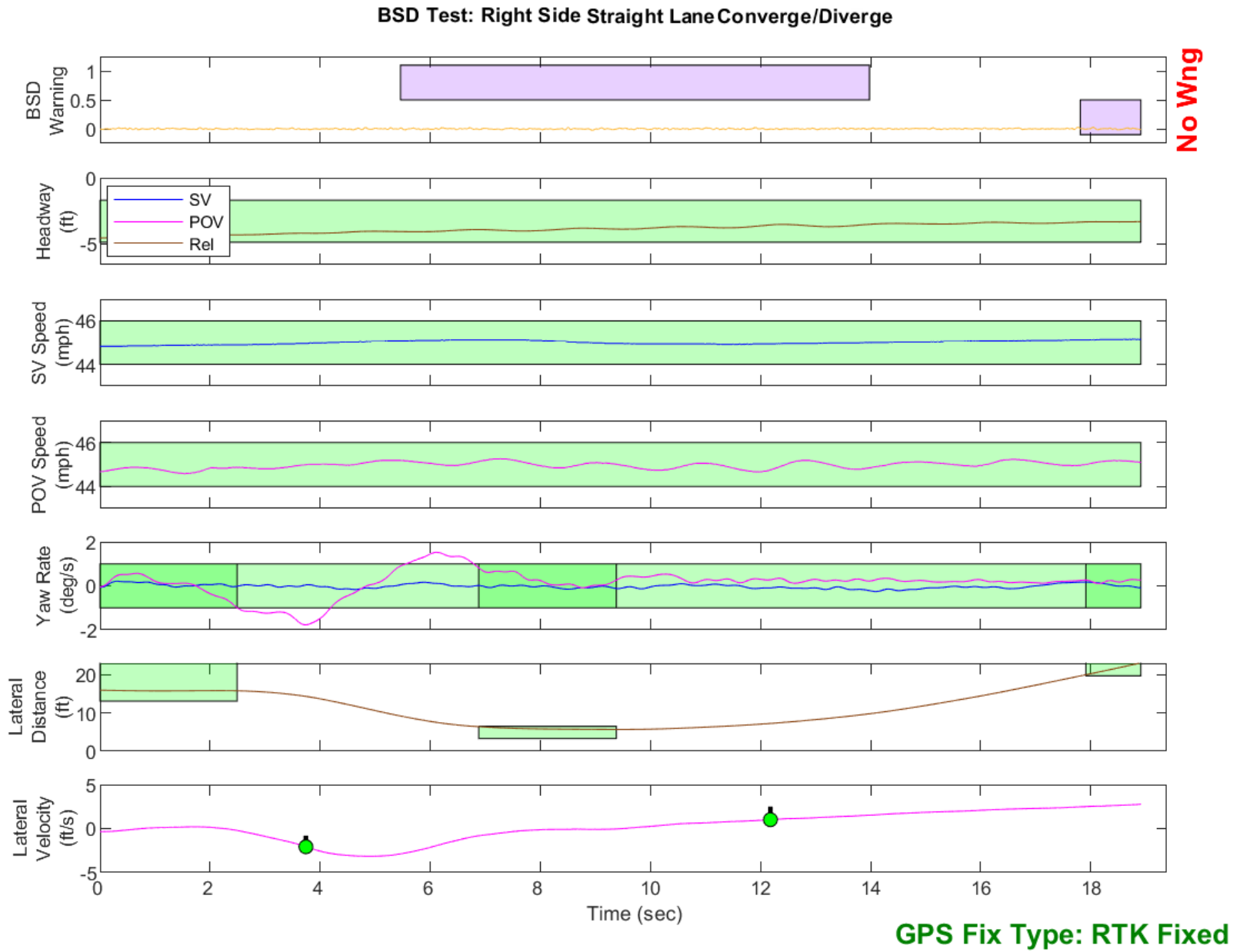


Figure D2. Example Time History for Straight Lane Converge/Diverge Test, Failing

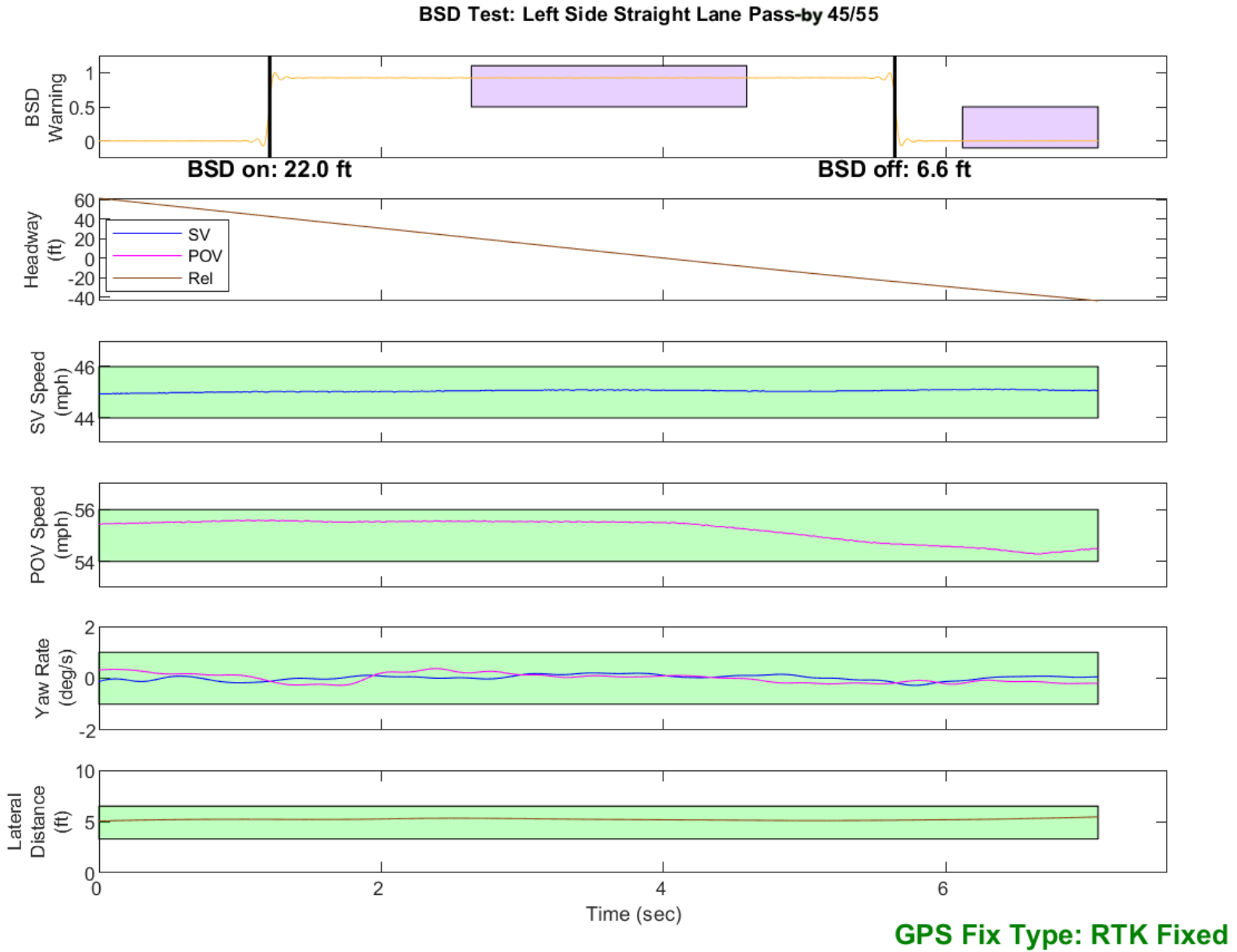


Figure D3. Example Time History for Straight Lane Pass-By Passing

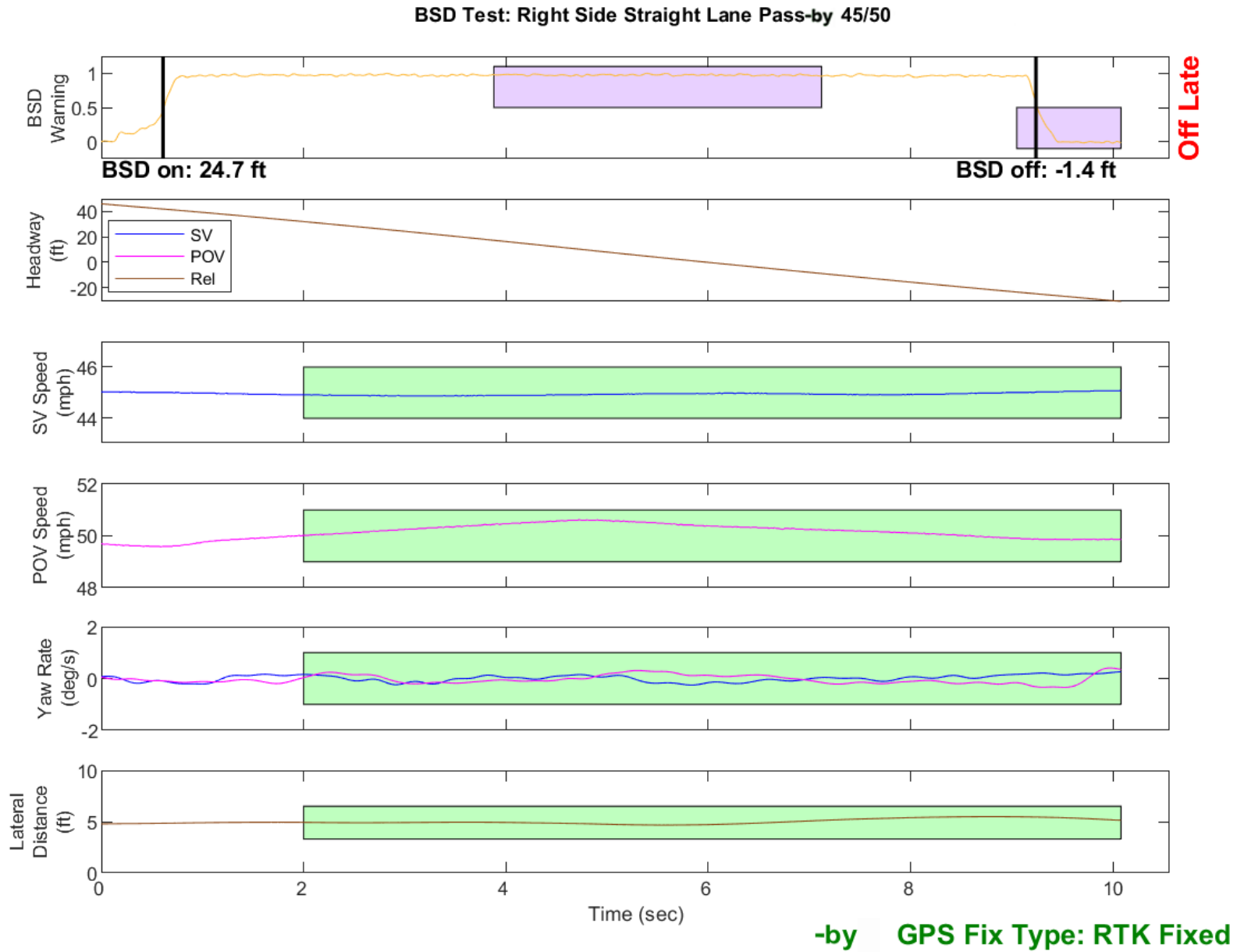


Figure D4. Example Time History for Straight Lane Pass-by Test, Failing

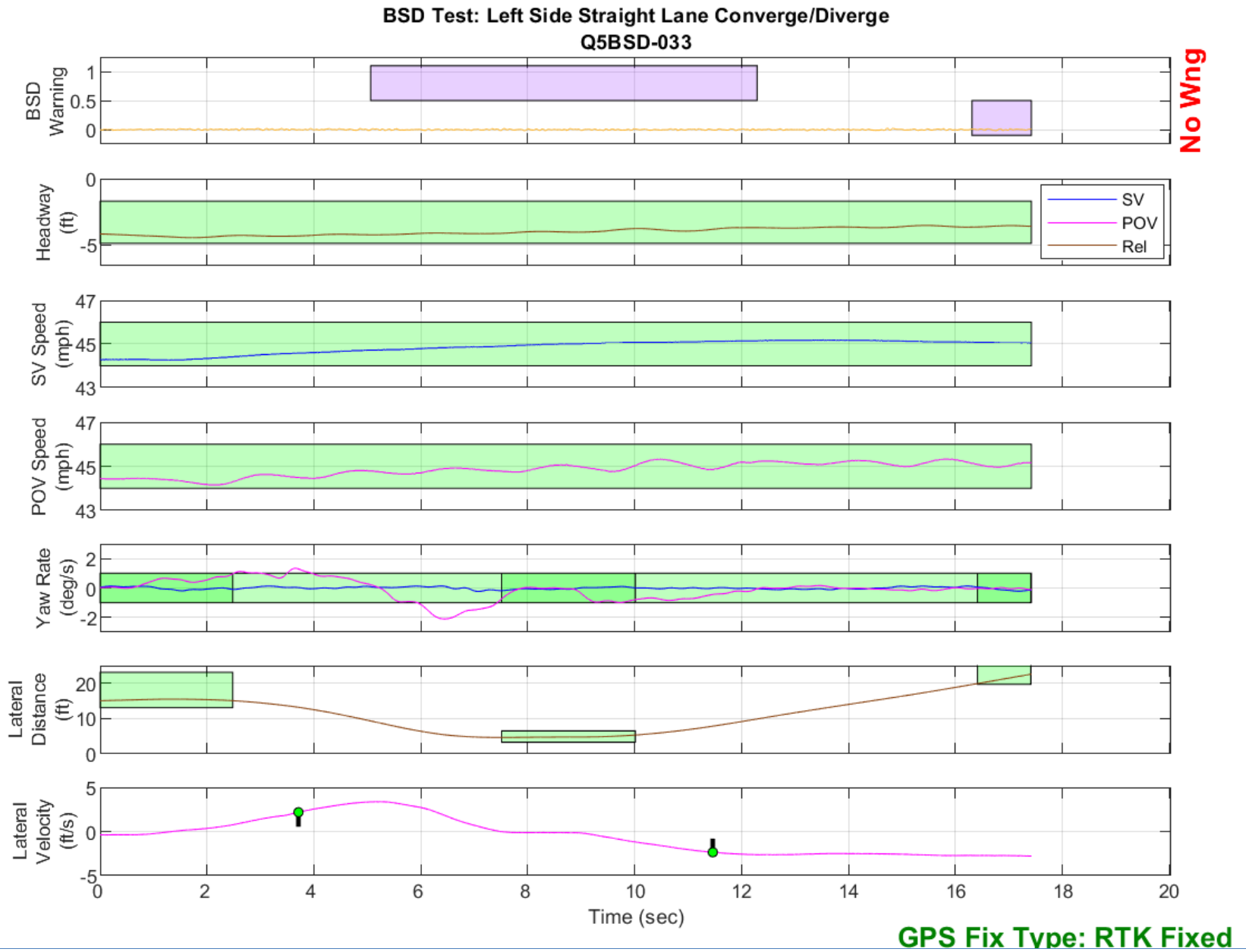


Figure D5. BSD Run 33, Straight Lane Converge/Diverge

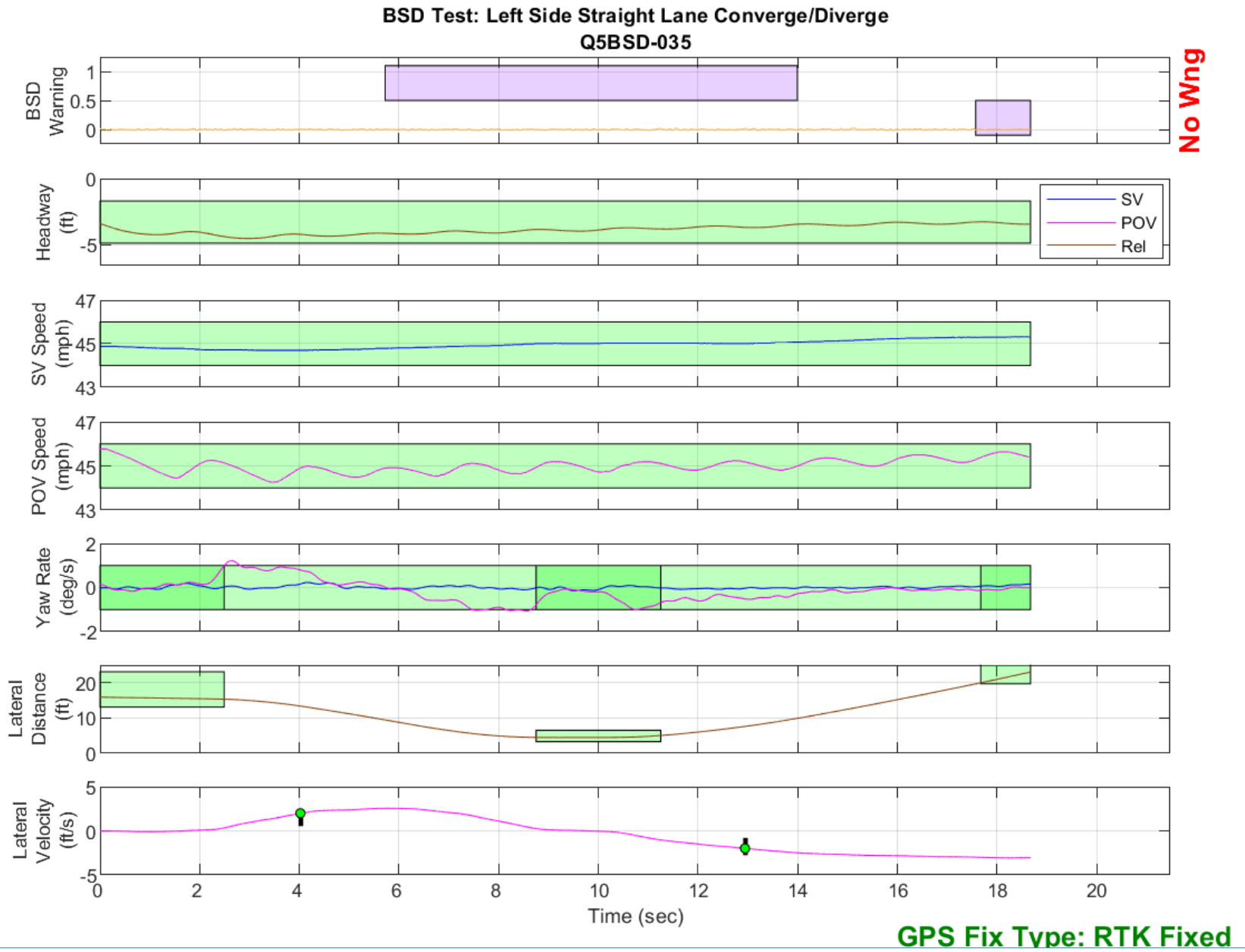


Figure D6. BSD Run 35, Straight Lane Converge/Diverge

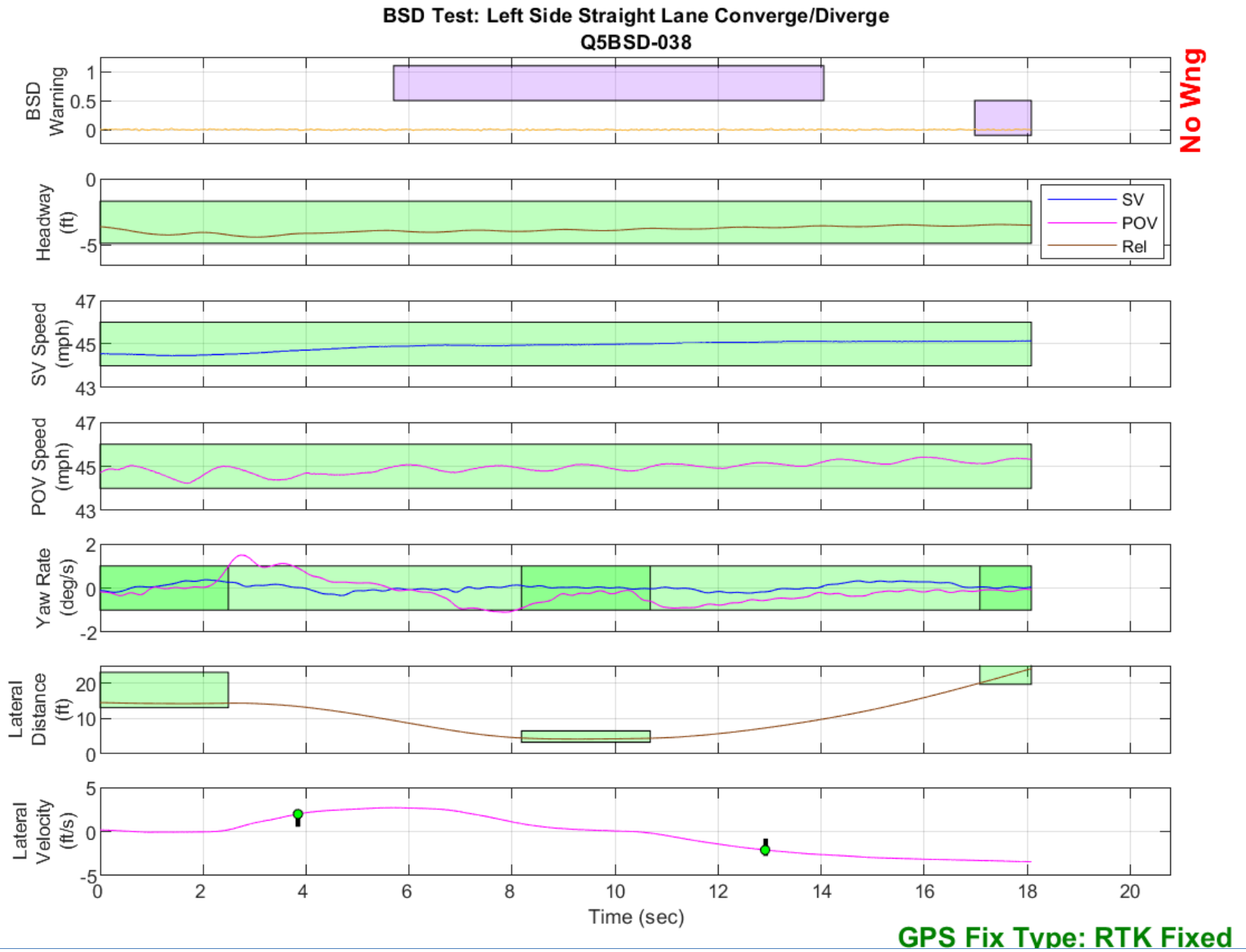


Figure D7. BSD Run 38, Straight Lane Converge/Diverge

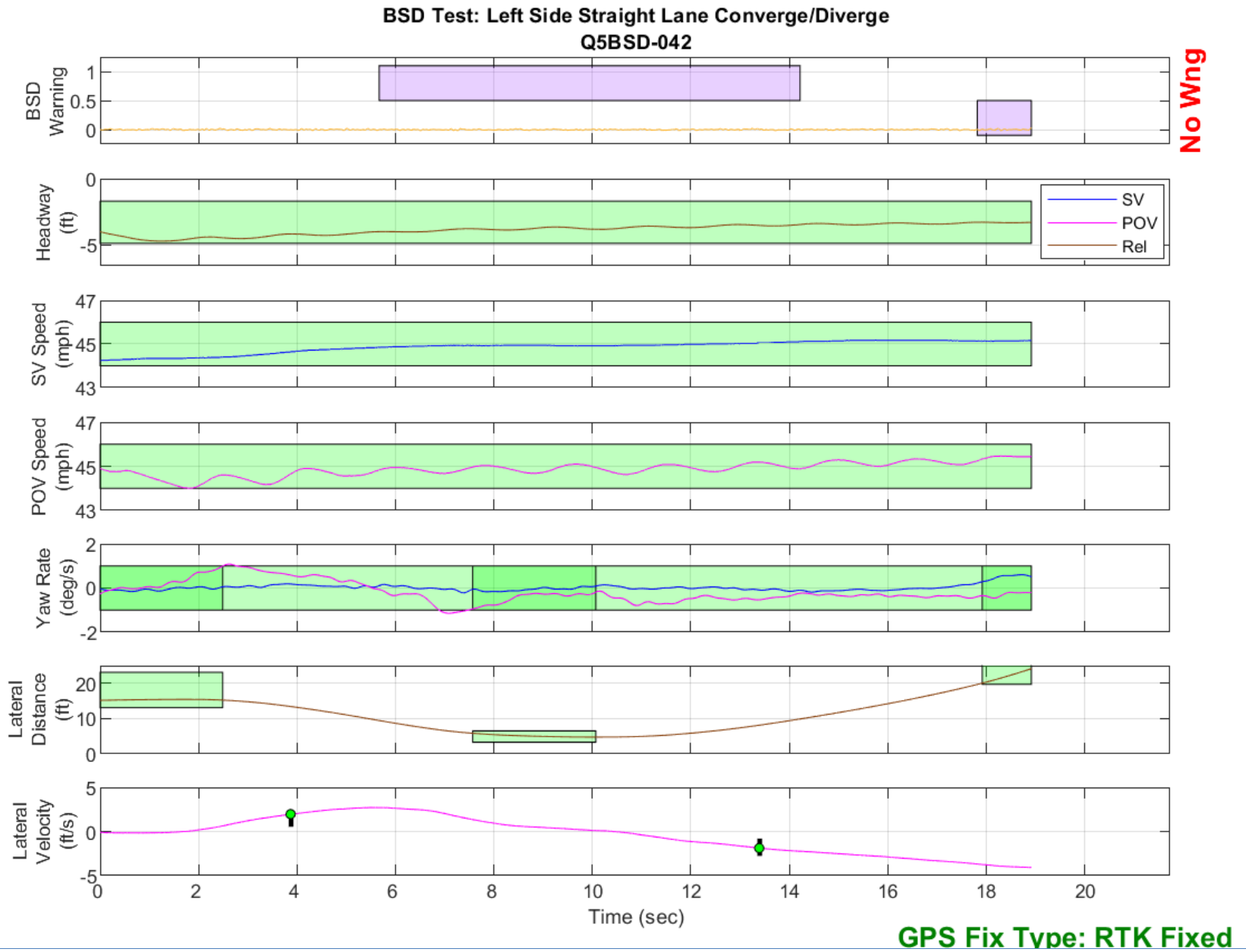


Figure D8. BSD Run 42, Straight Lane Converge/Diverge

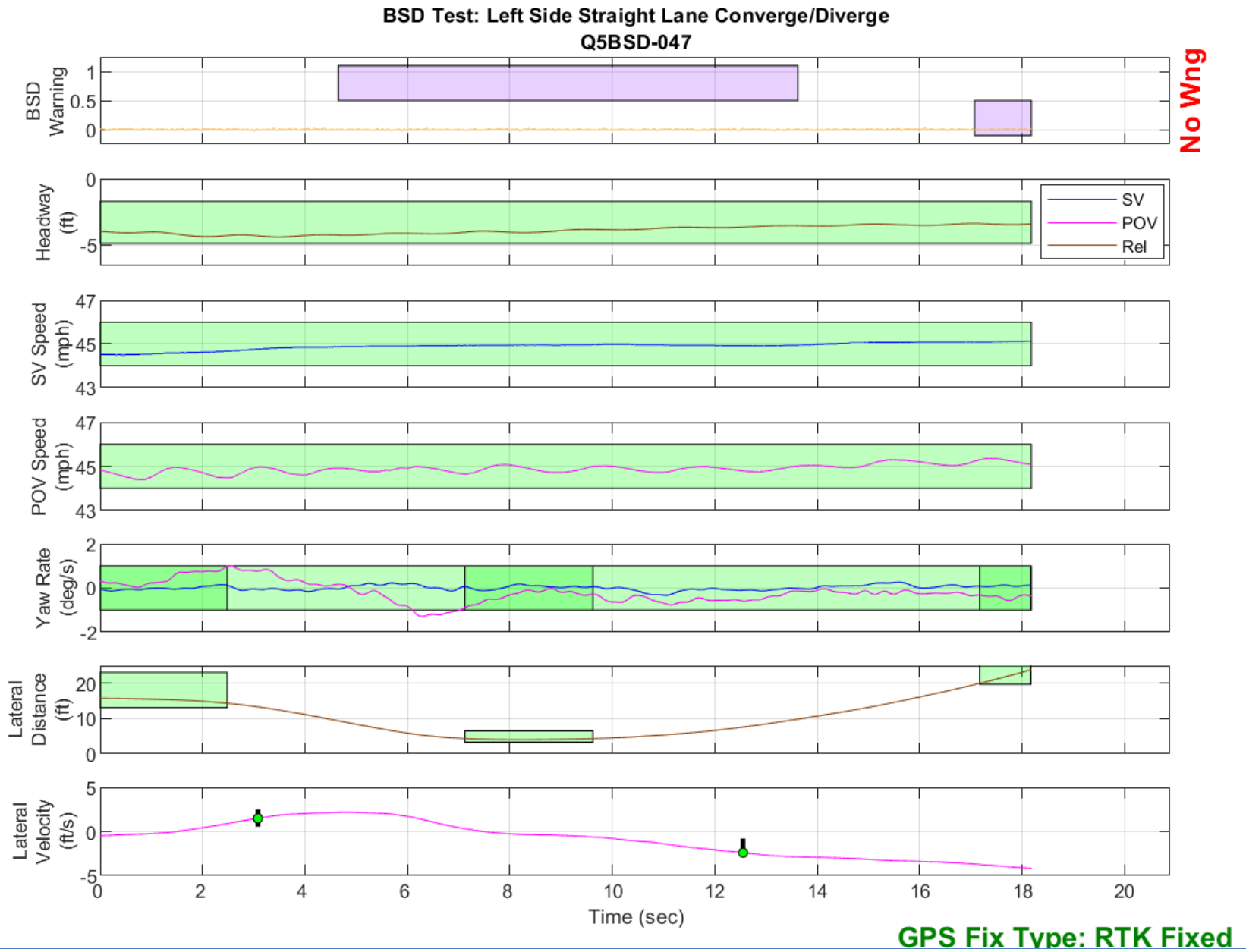


Figure D9. BSD Run 47, Straight Lane Converge/Diverge

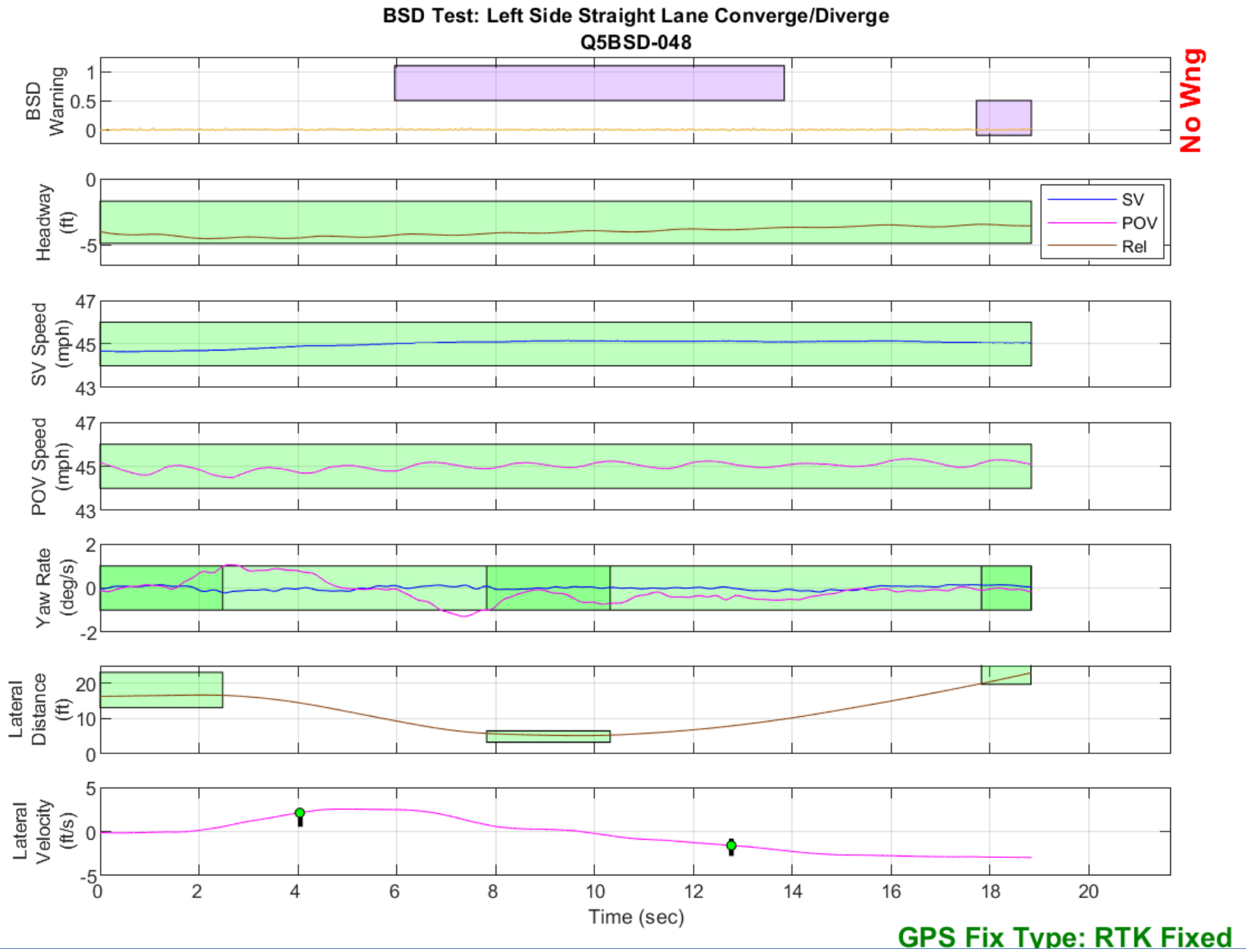


Figure D10. BSD Run 48, Straight Lane Converge/Diverge

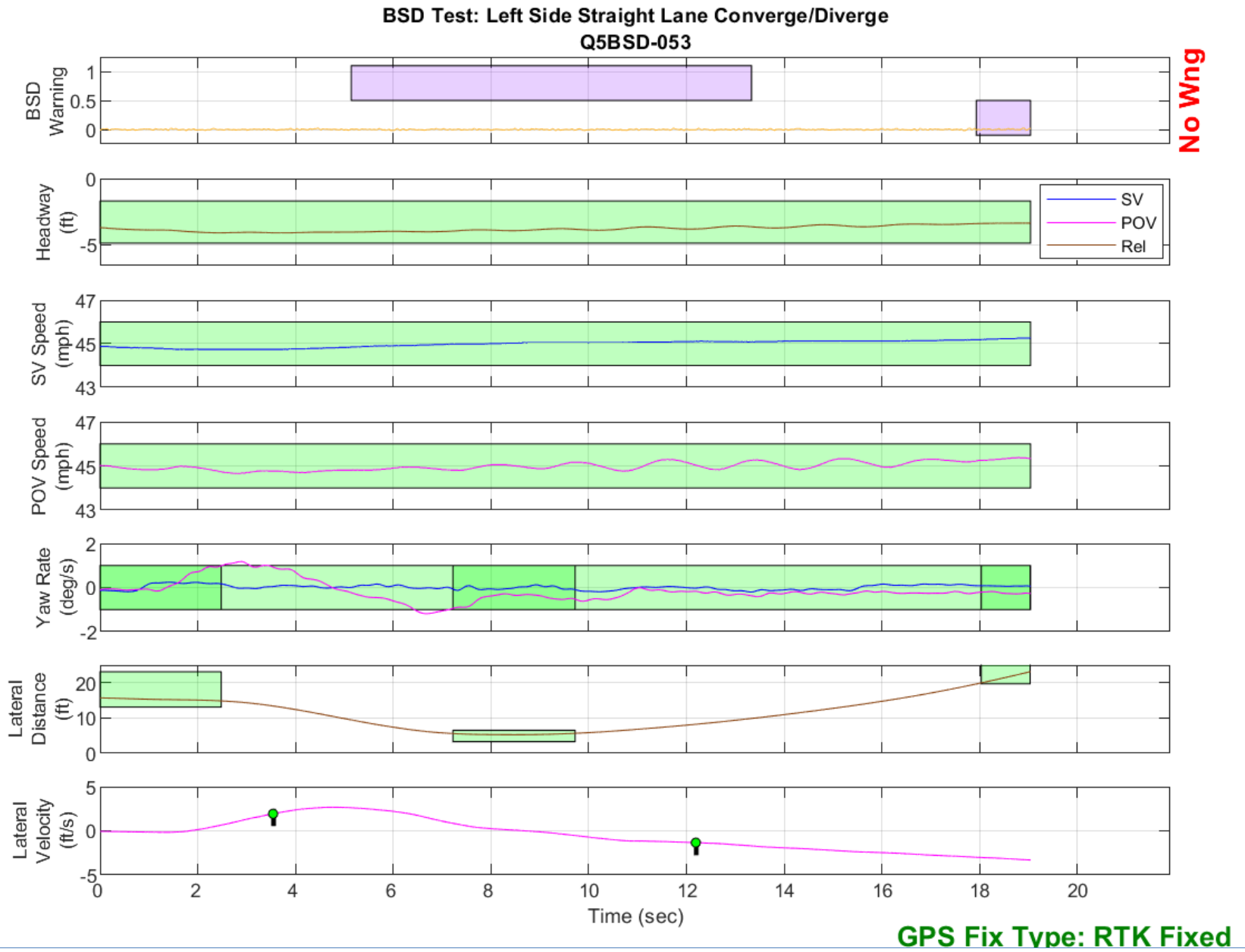


Figure D11. BSD Run 53, Straight Lane Converge/Diverge

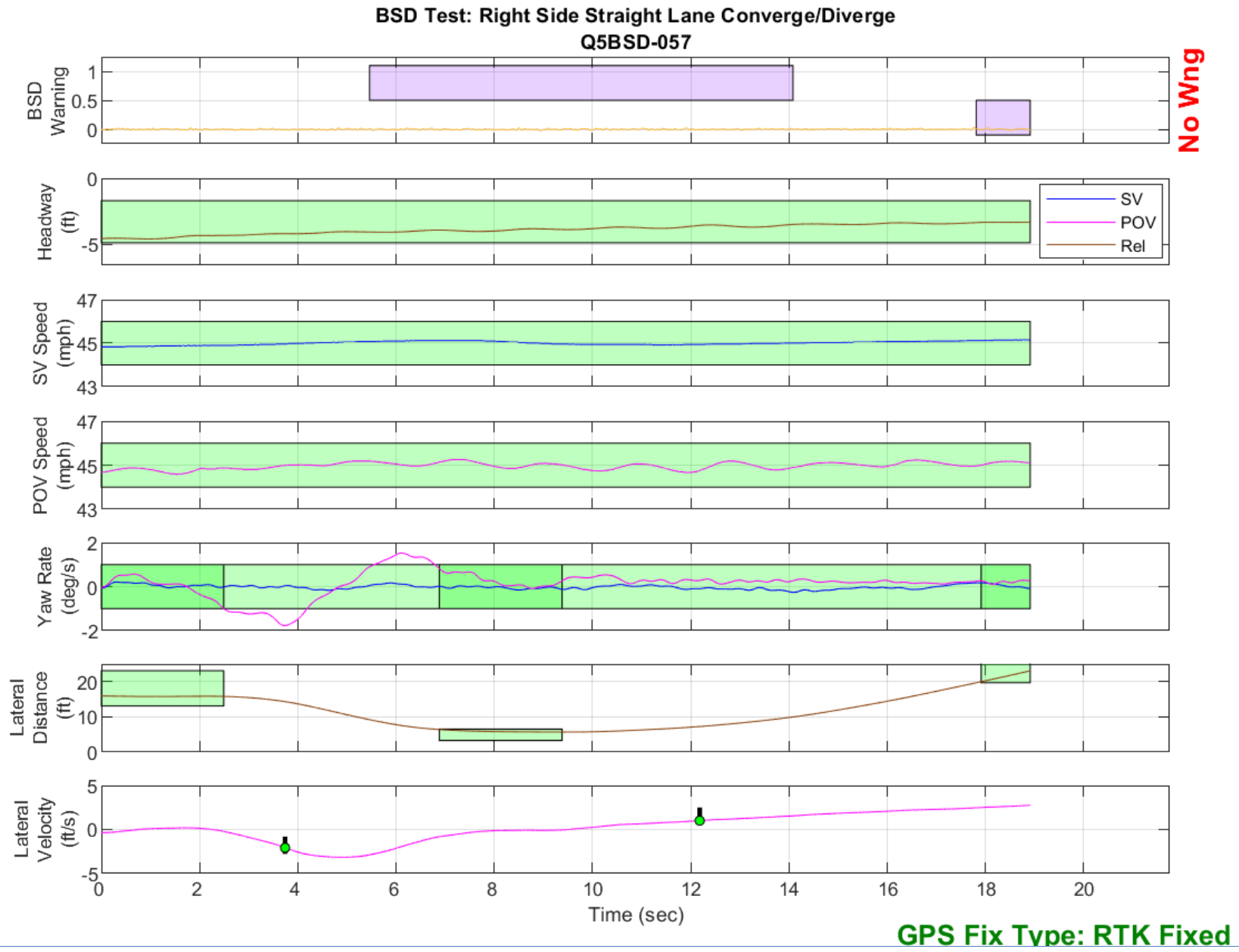


Figure D12. BSD Run 57, Straight Lane Converge/Diverge

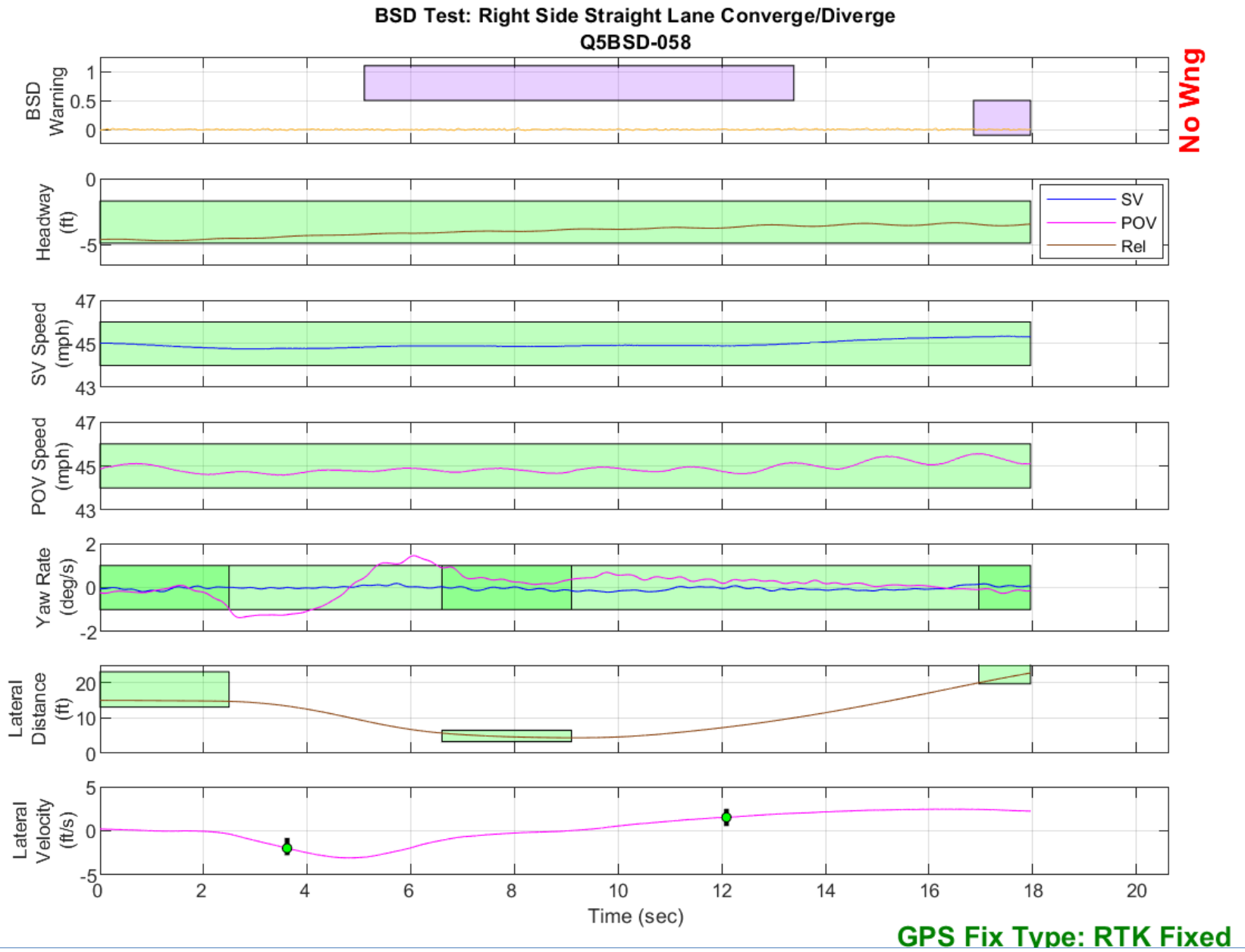


Figure D13. BSD Run 58, Straight Lane Converge/Diverge

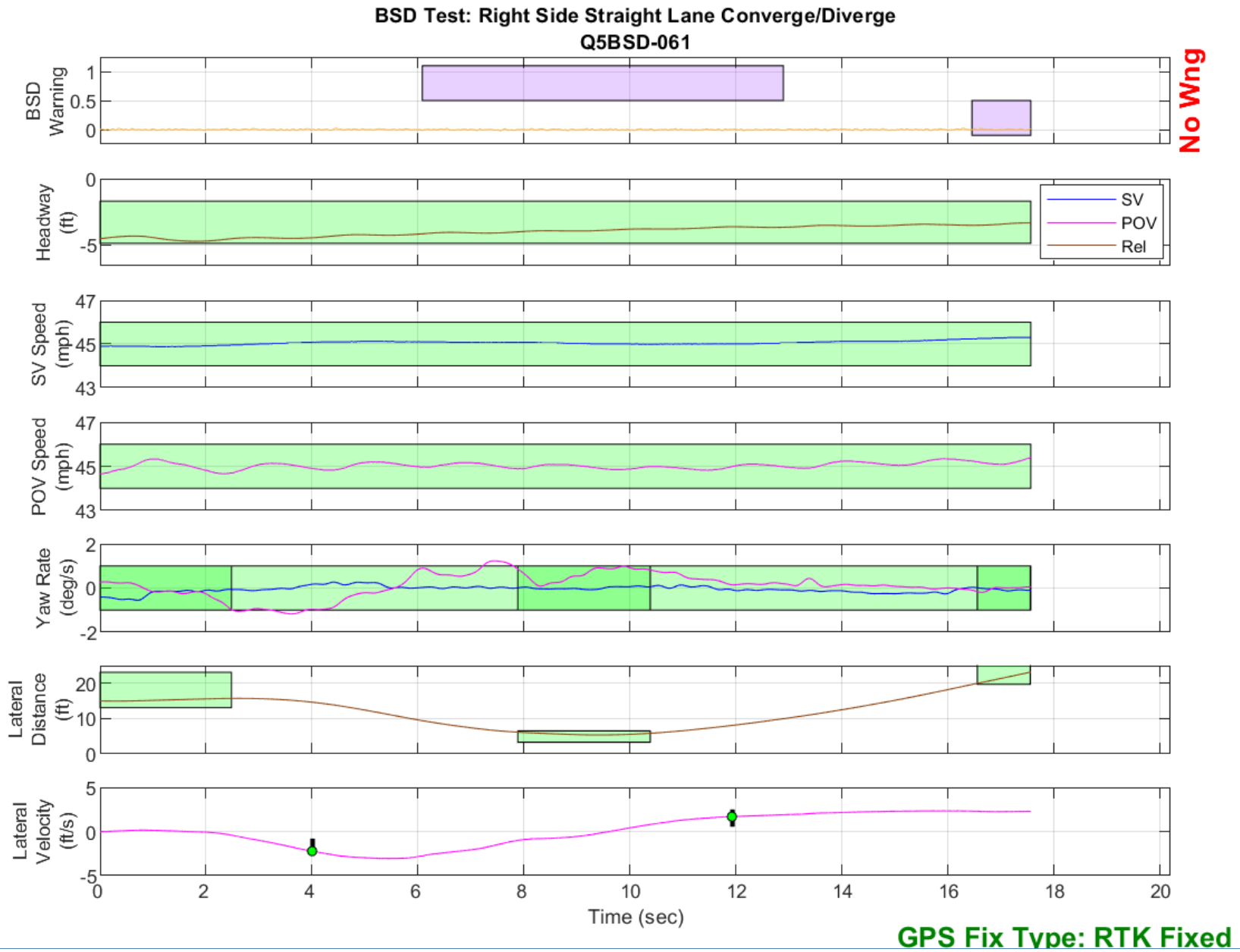


Figure D14. BSD Run 61, Straight Lane Converge/Diverge

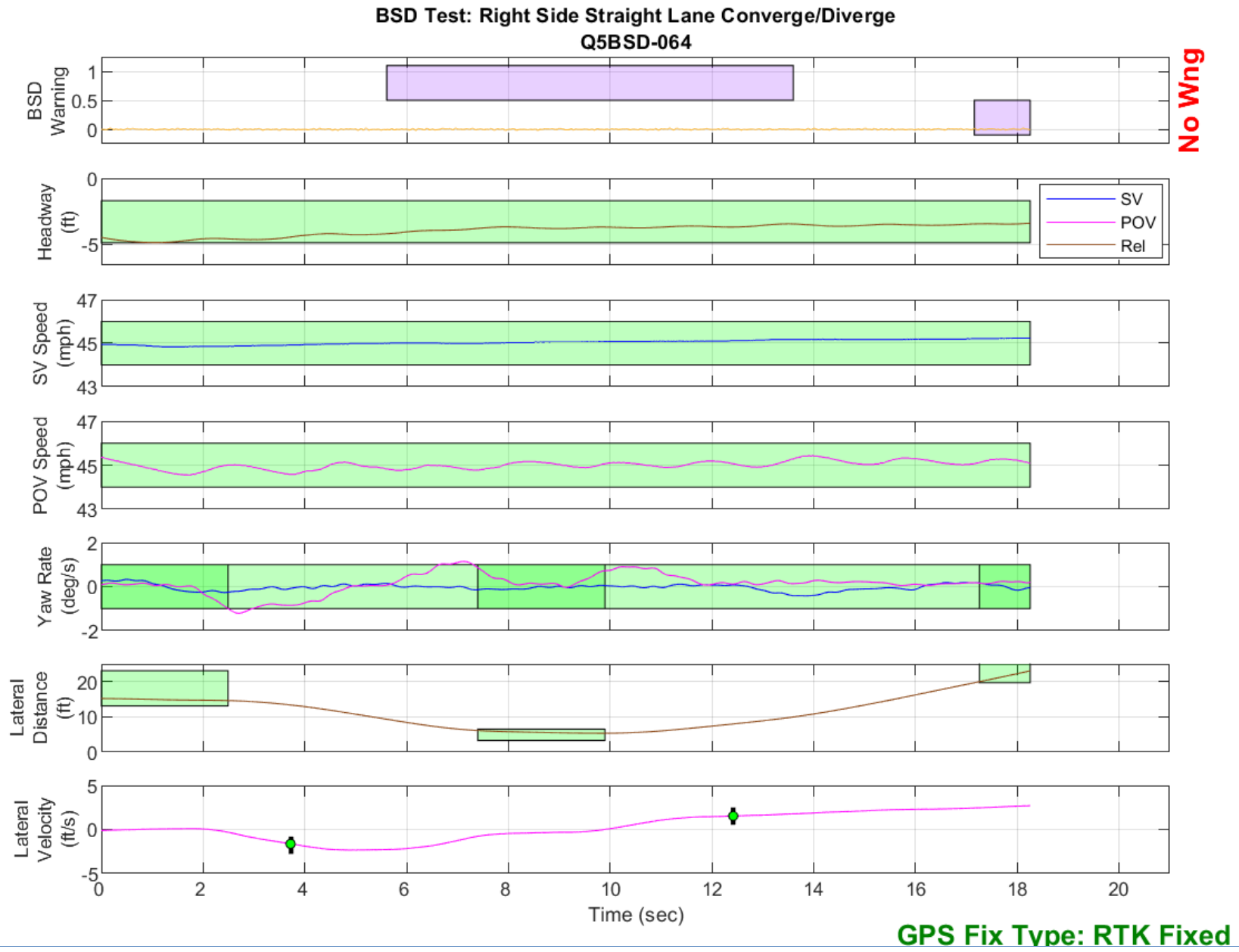


Figure D15. BSD Run 64, Straight Lane Converge/Diverge

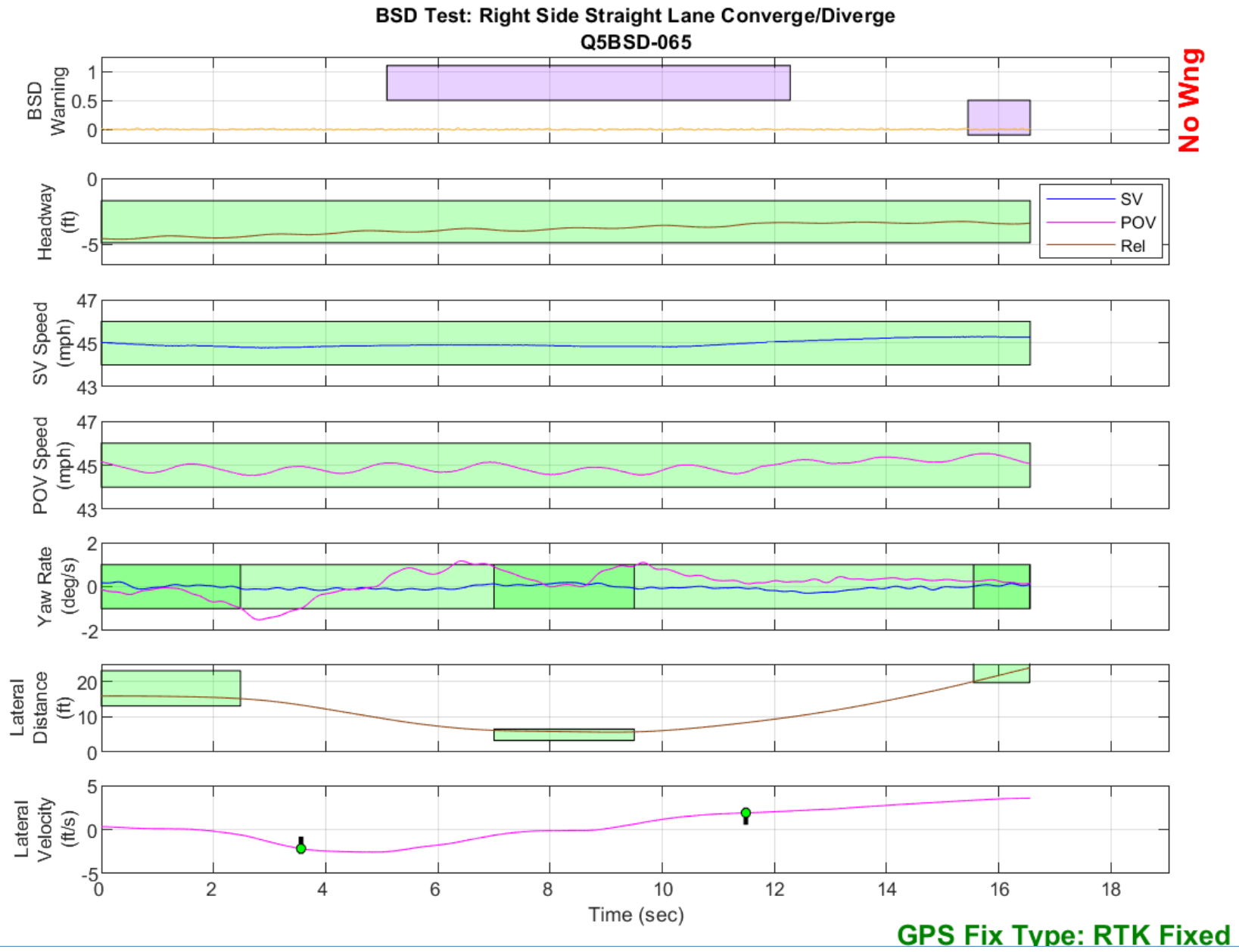


Figure D16. BSD Run 65, Straight Lane Converge/Diverge

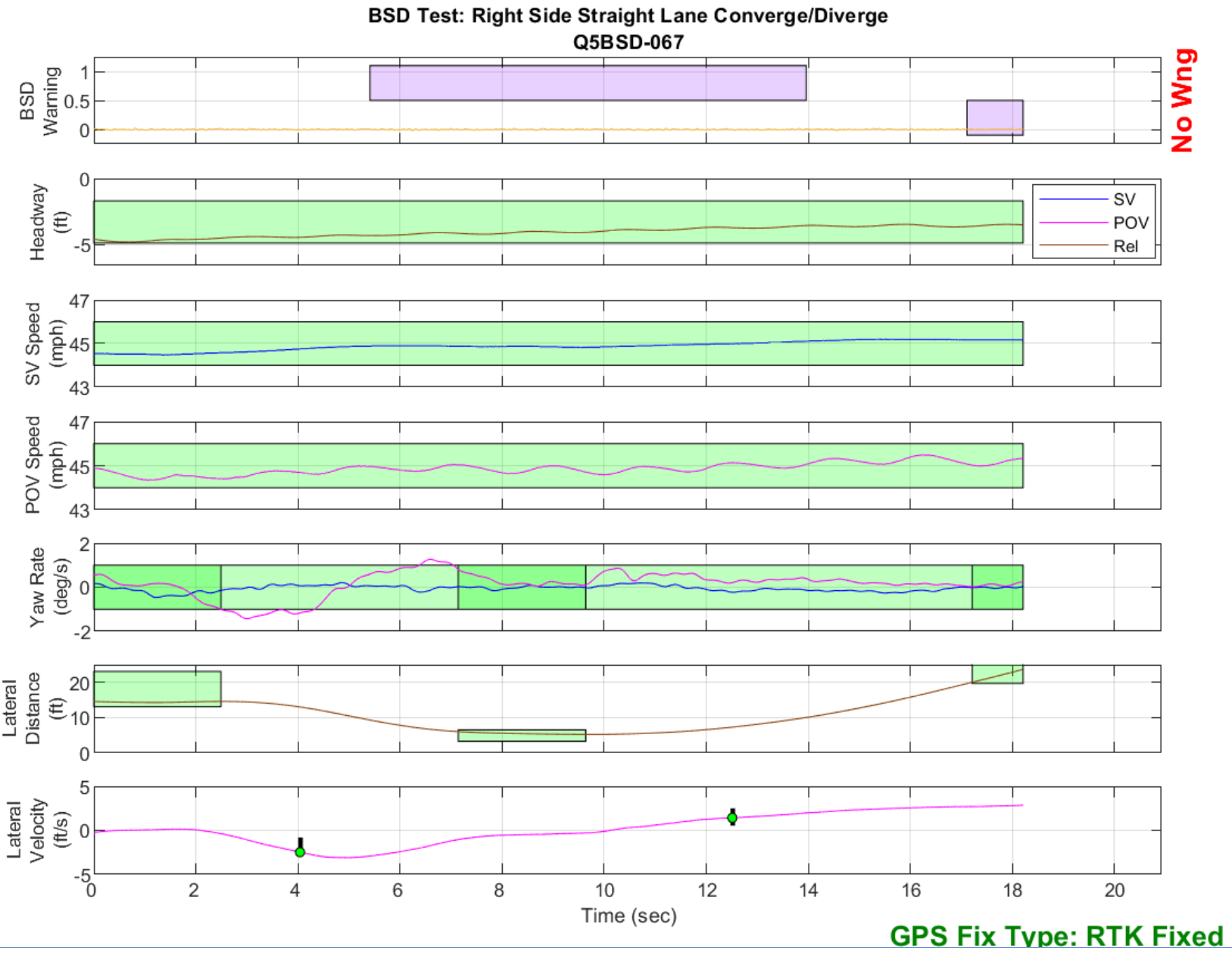


Figure D17. BSD Run 67, Straight Lane Converge/Diverge

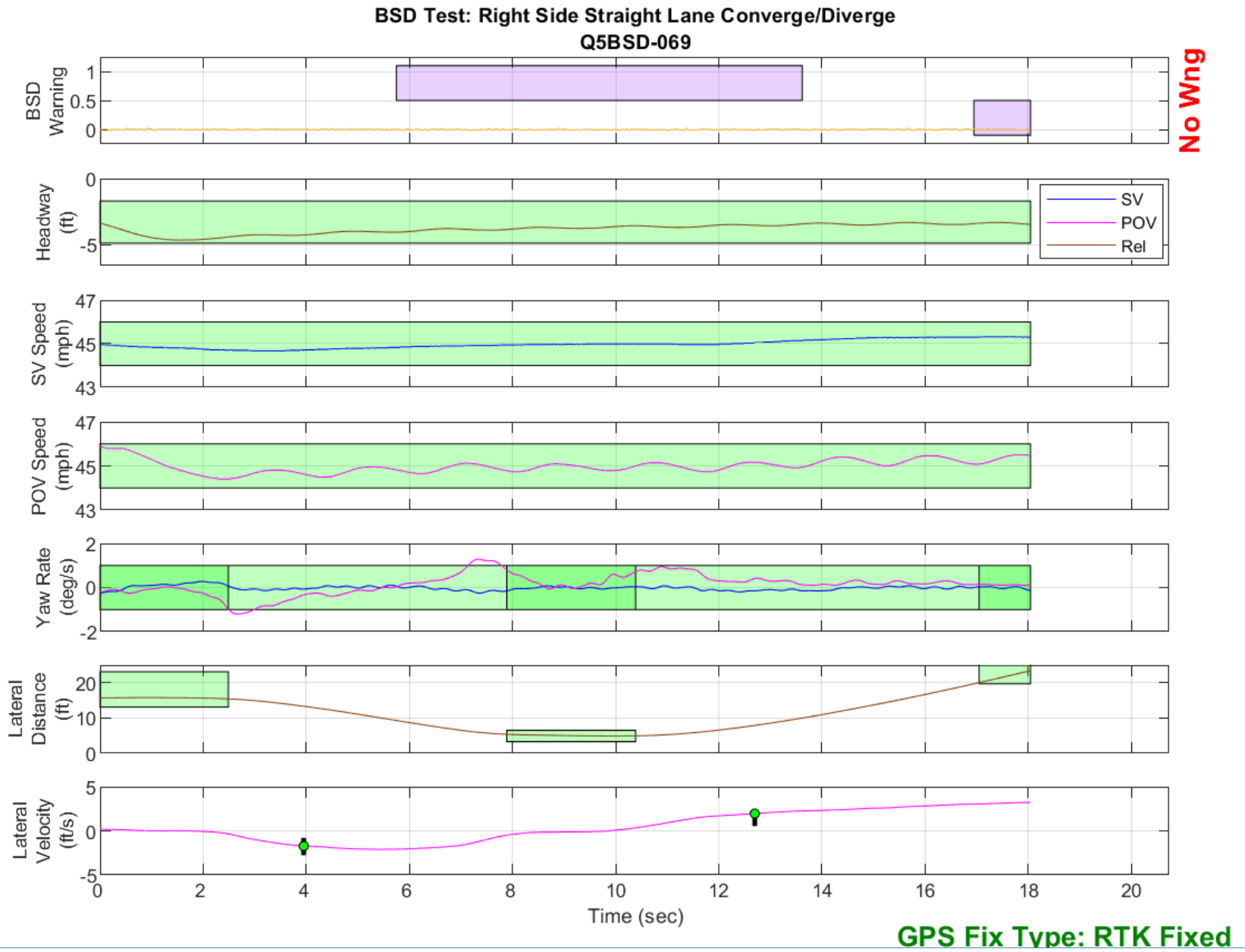


Figure D18. BSD Run 69, Straight Lane Converge/Diverge

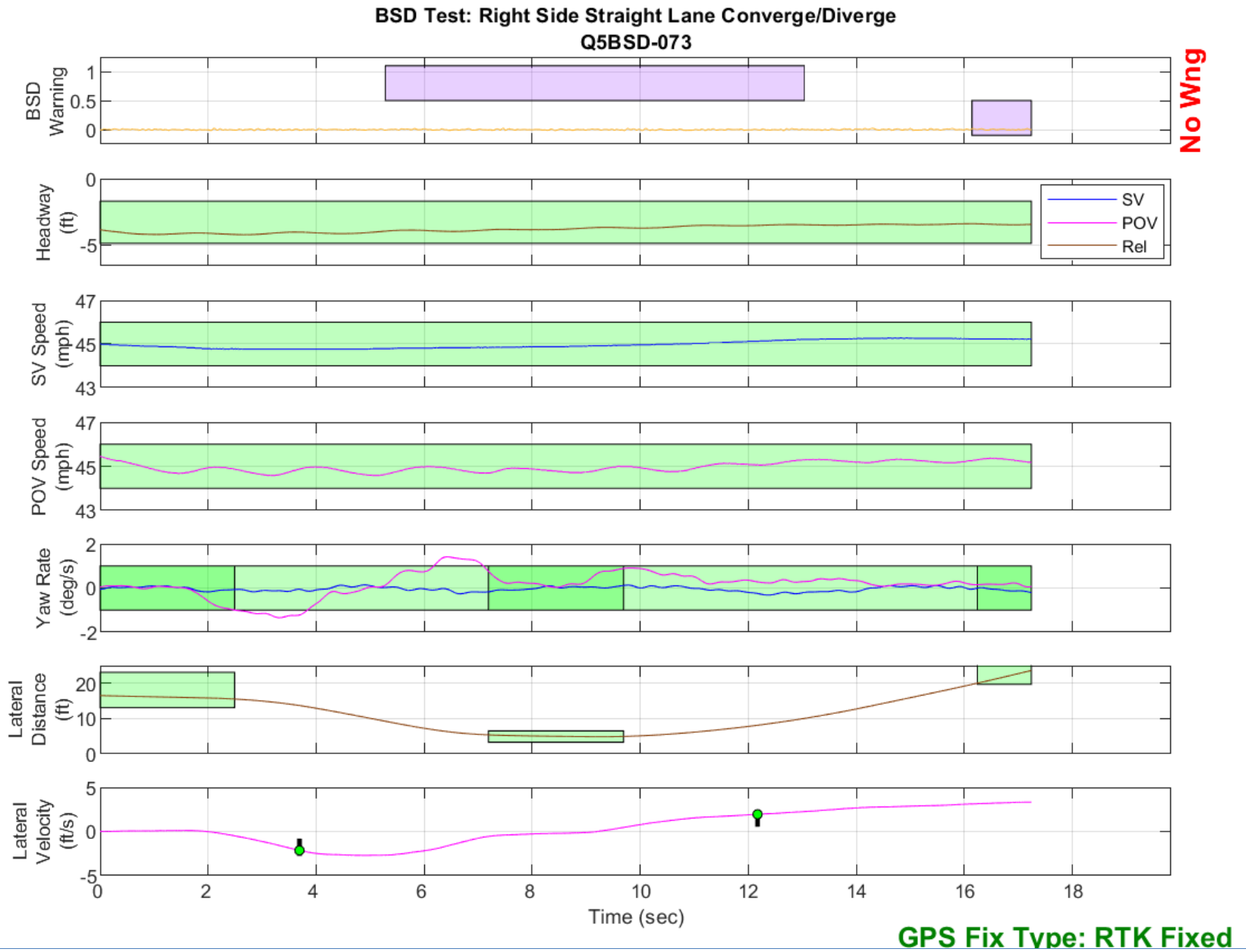
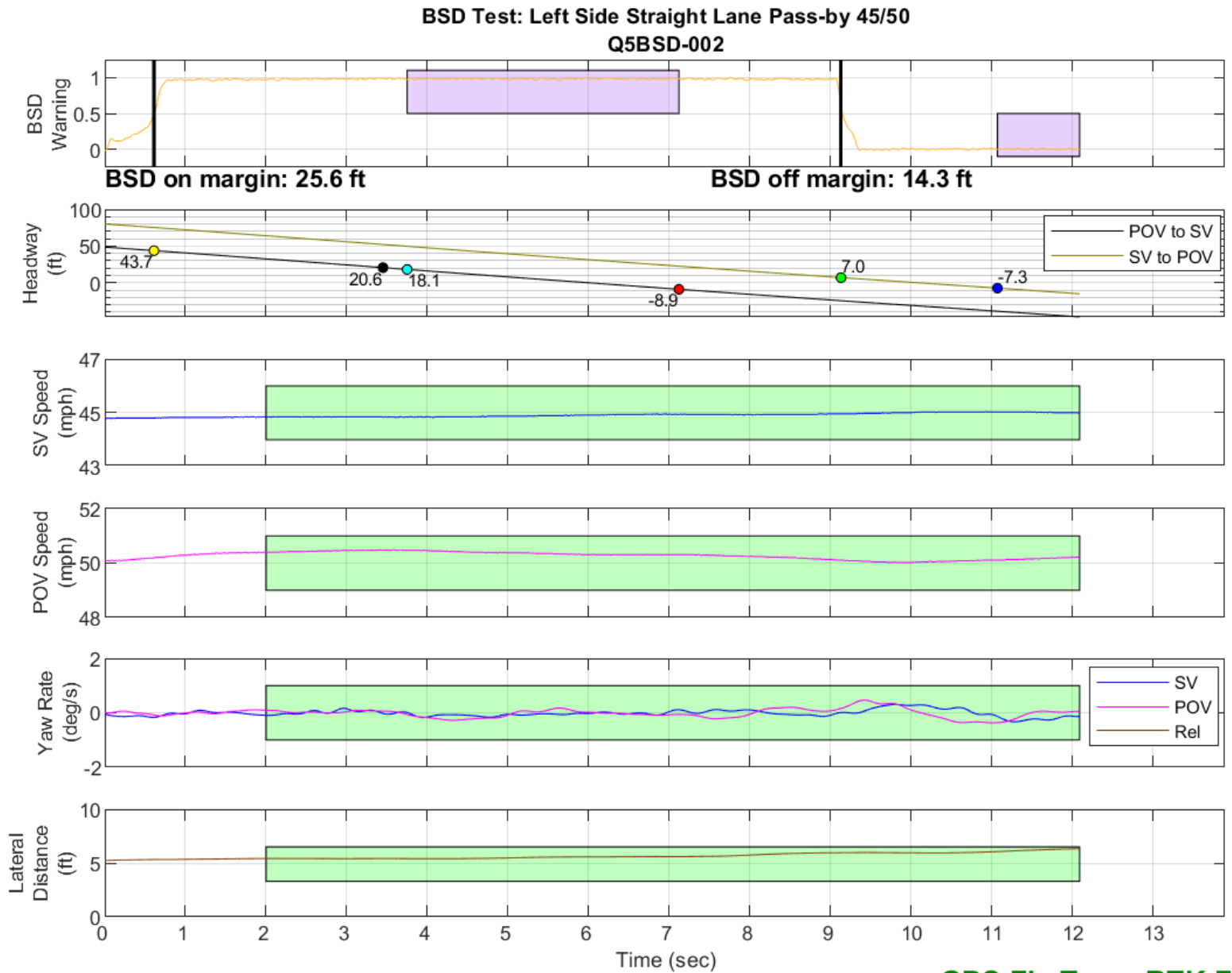


Figure D19. BSD Run 73, Straight Lane Converge/Diverge



GPS Fix Type: RTK Fixed

Figure D20. BSD Run 2, Straight Lane Pass-by, SV 45 mph, POV 50 mph

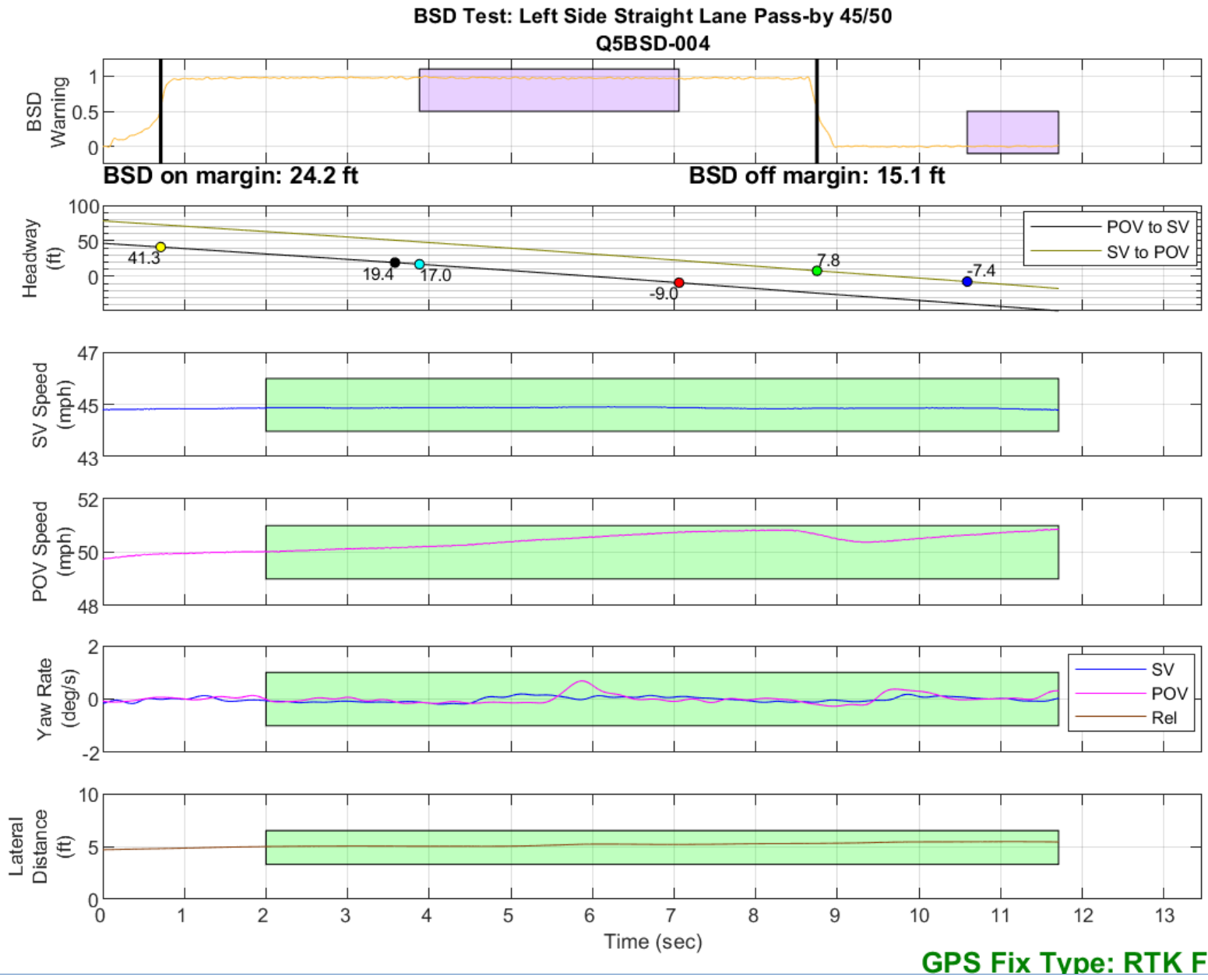


Figure D21. BSD Run 4, Straight Lane Pass-by, SV 45 mph, POV 50 mph

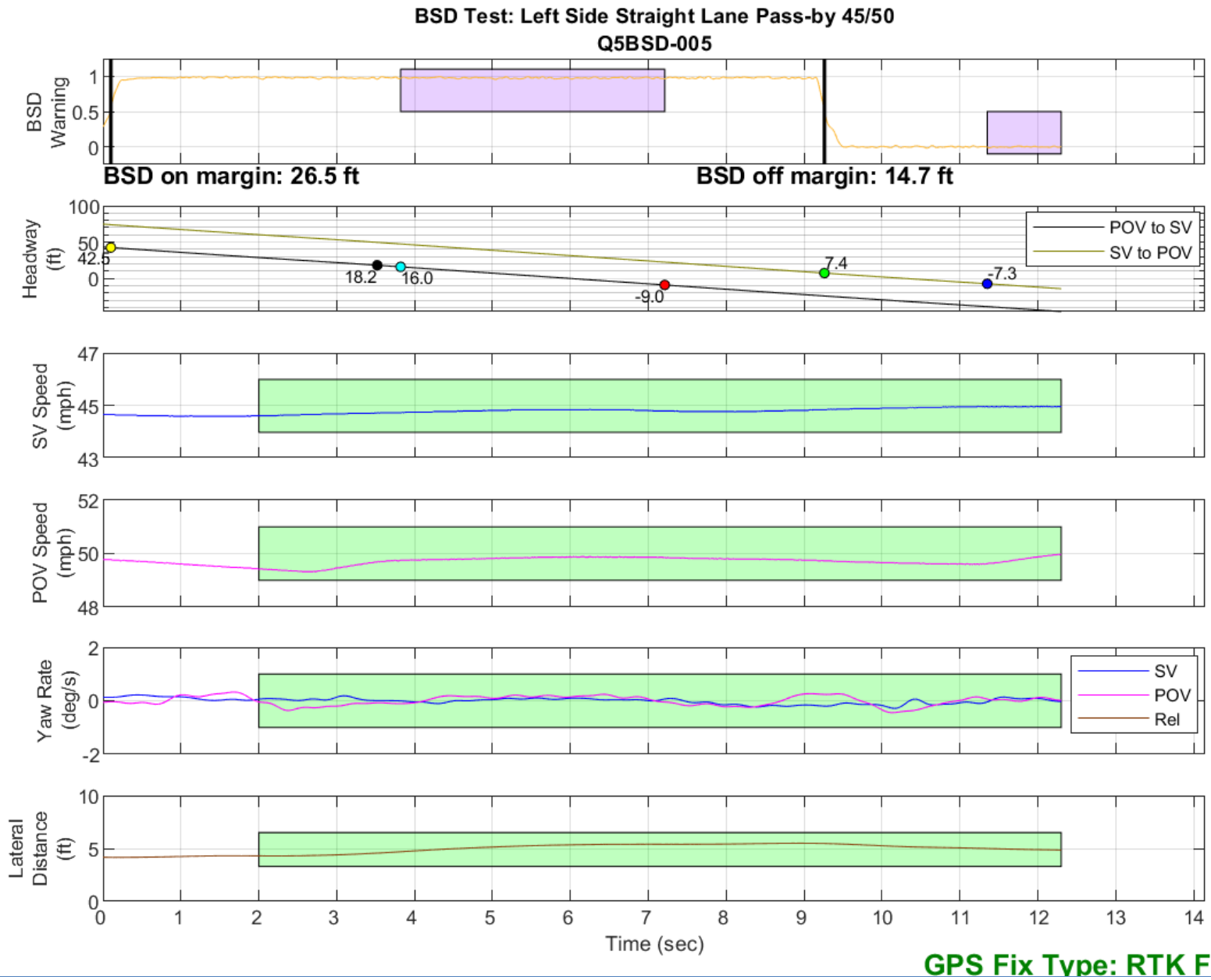
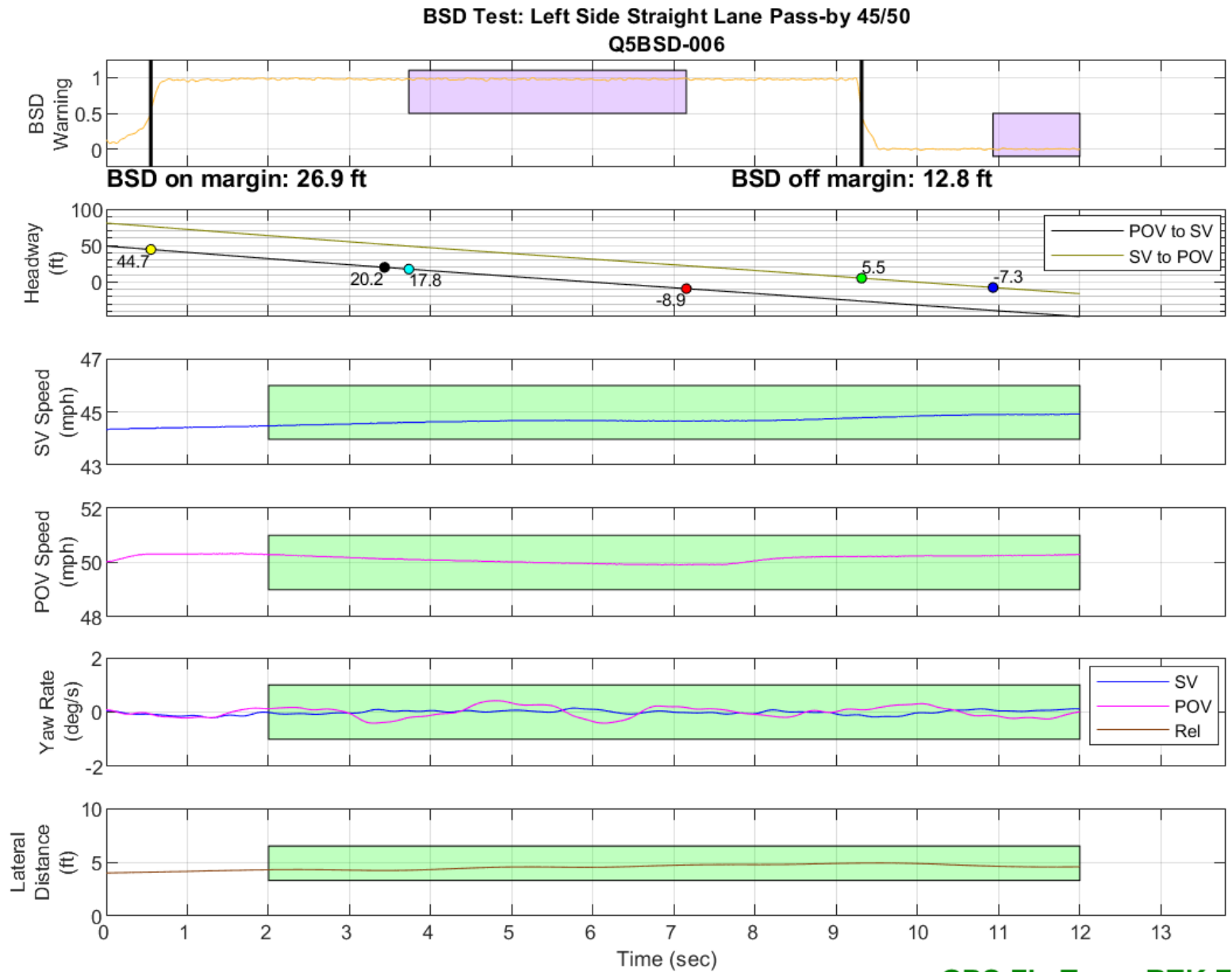


Figure D22. BSD Run 5, Straight Lane Pass-by, SV 45 mph, POV 50 mph



GPS Fix Type: RTK Fixed

Figure D23. BSD Run 6, Straight Lane Pass-by, SV 45 mph, POV 50 mph

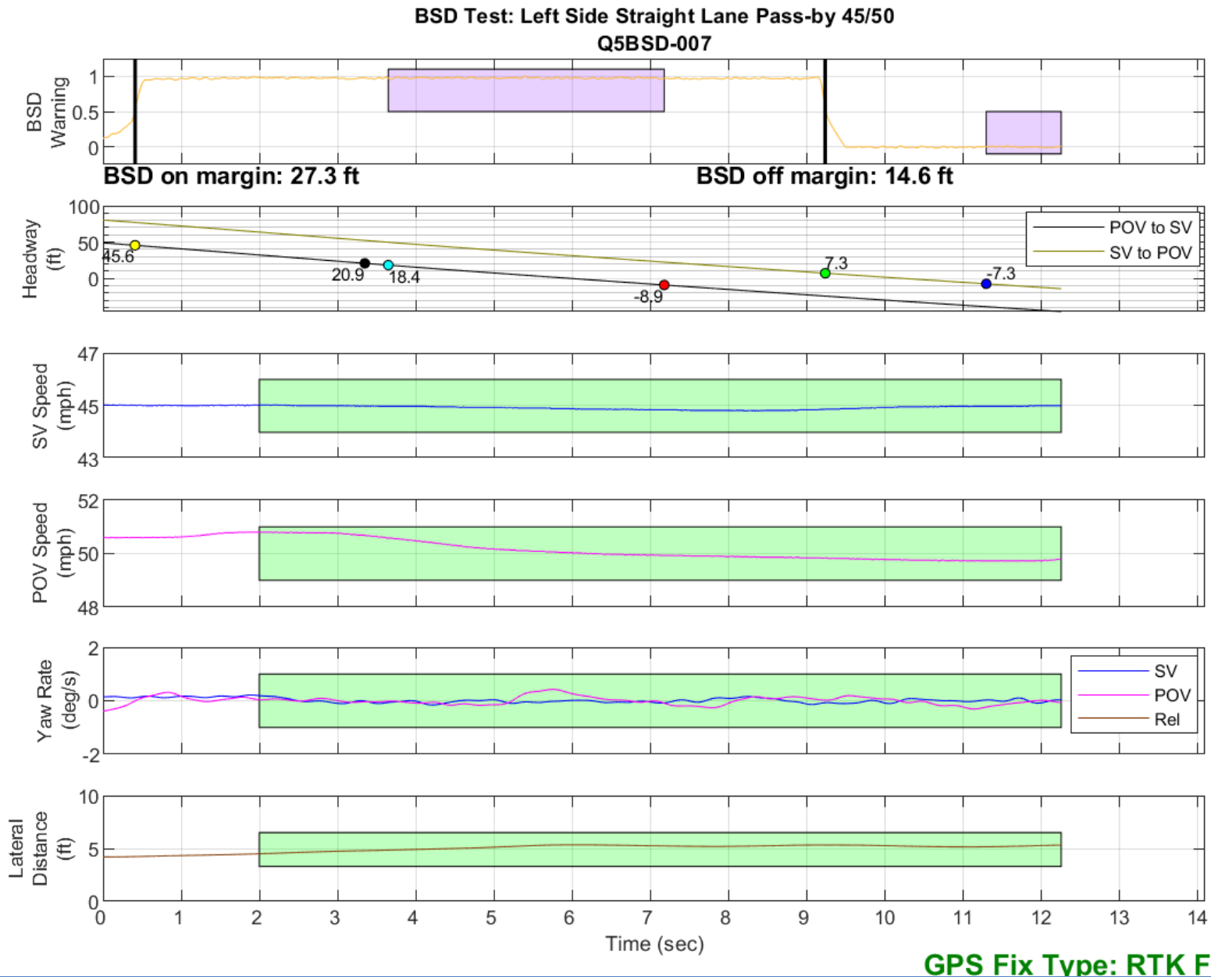
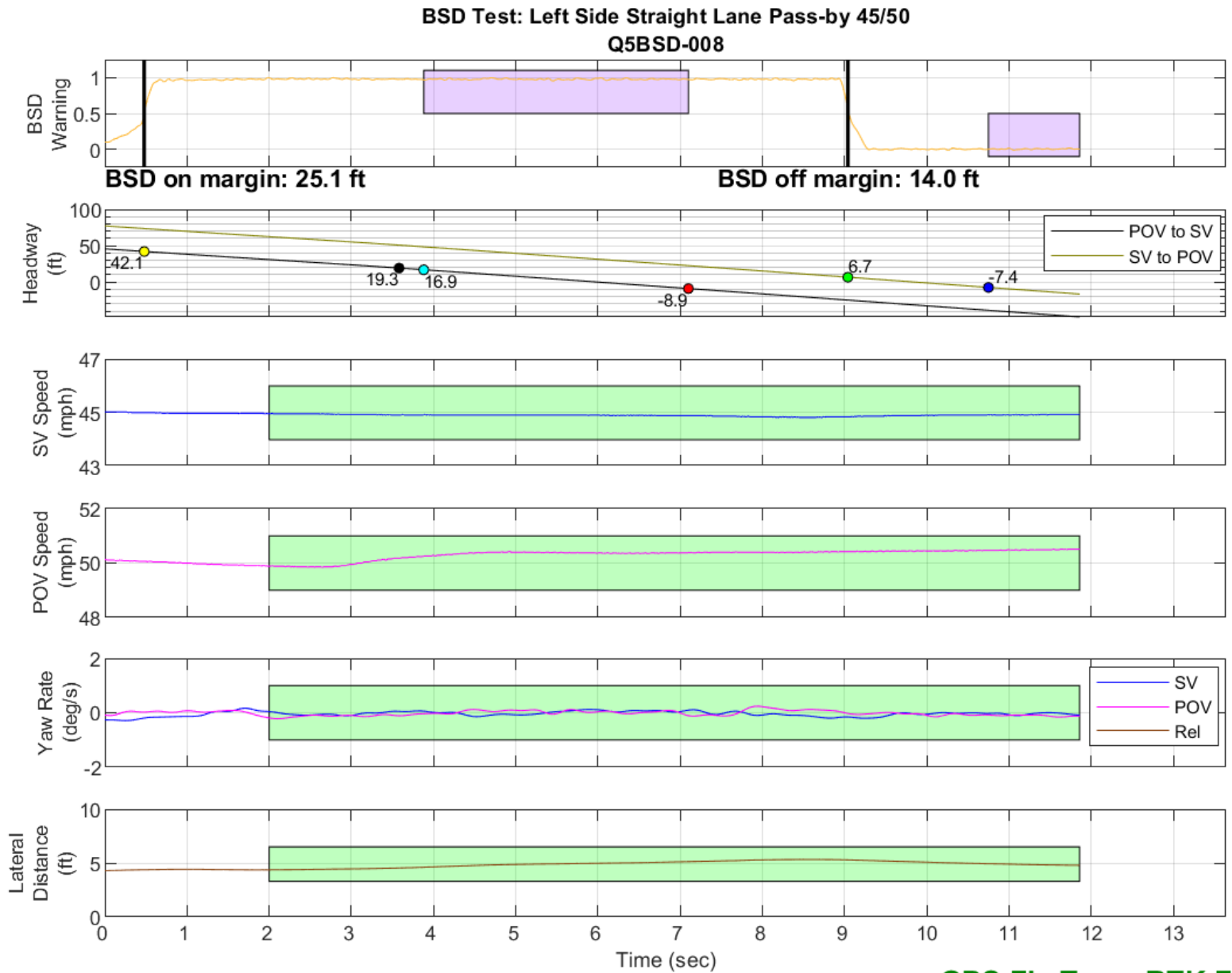


Figure D24. BSD Run 7, Straight Lane Pass-by, SV 45 mph, POV 50 mph



GPS Fix Type: RTK Fixed

Figure D25. BSD Run 8, Straight Lane Pass-by, SV 45 mph, POV 50 mph

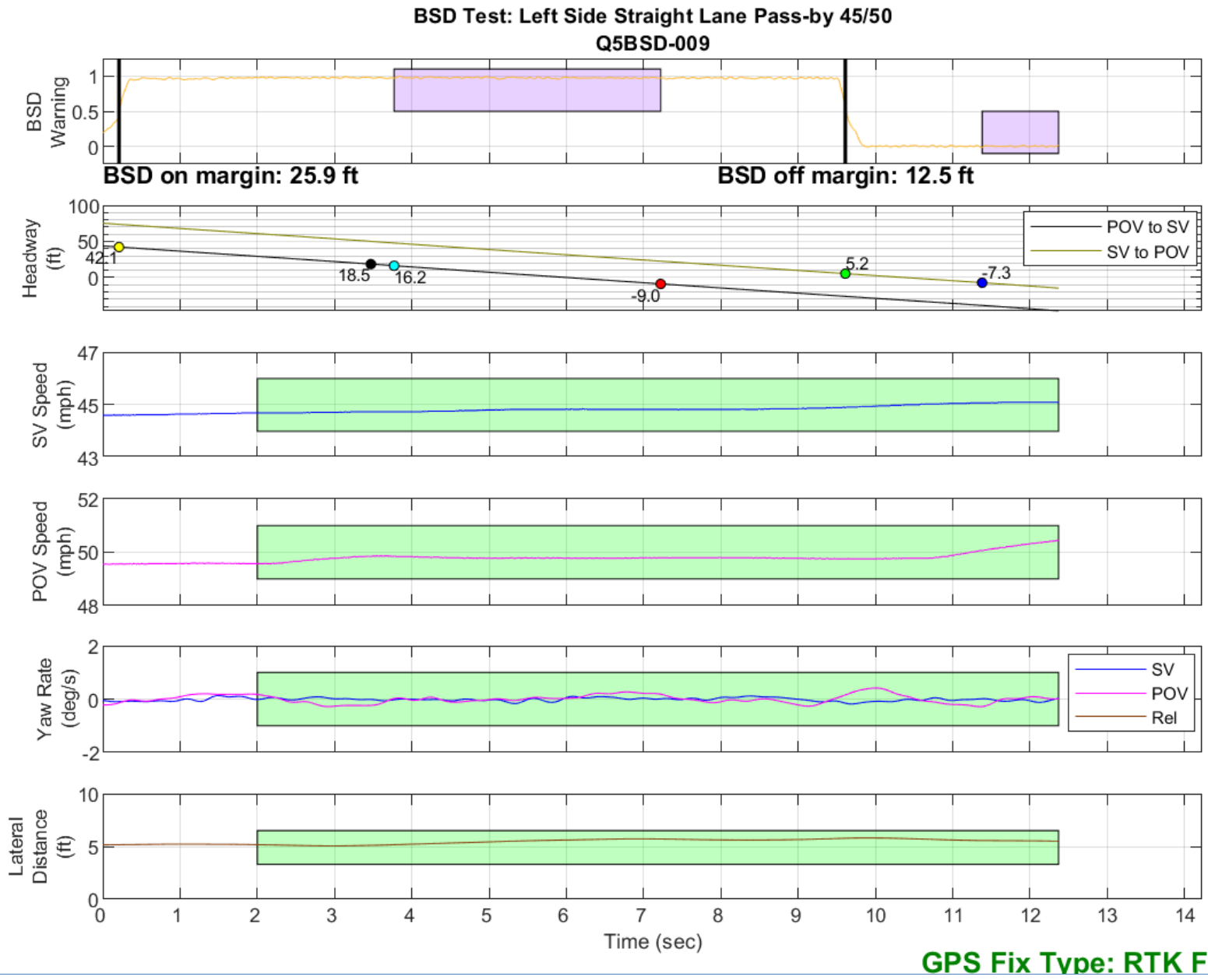


Figure D26. BSD Run 9, Straight Lane Pass-by, SV 45 mph, POV 50 mph

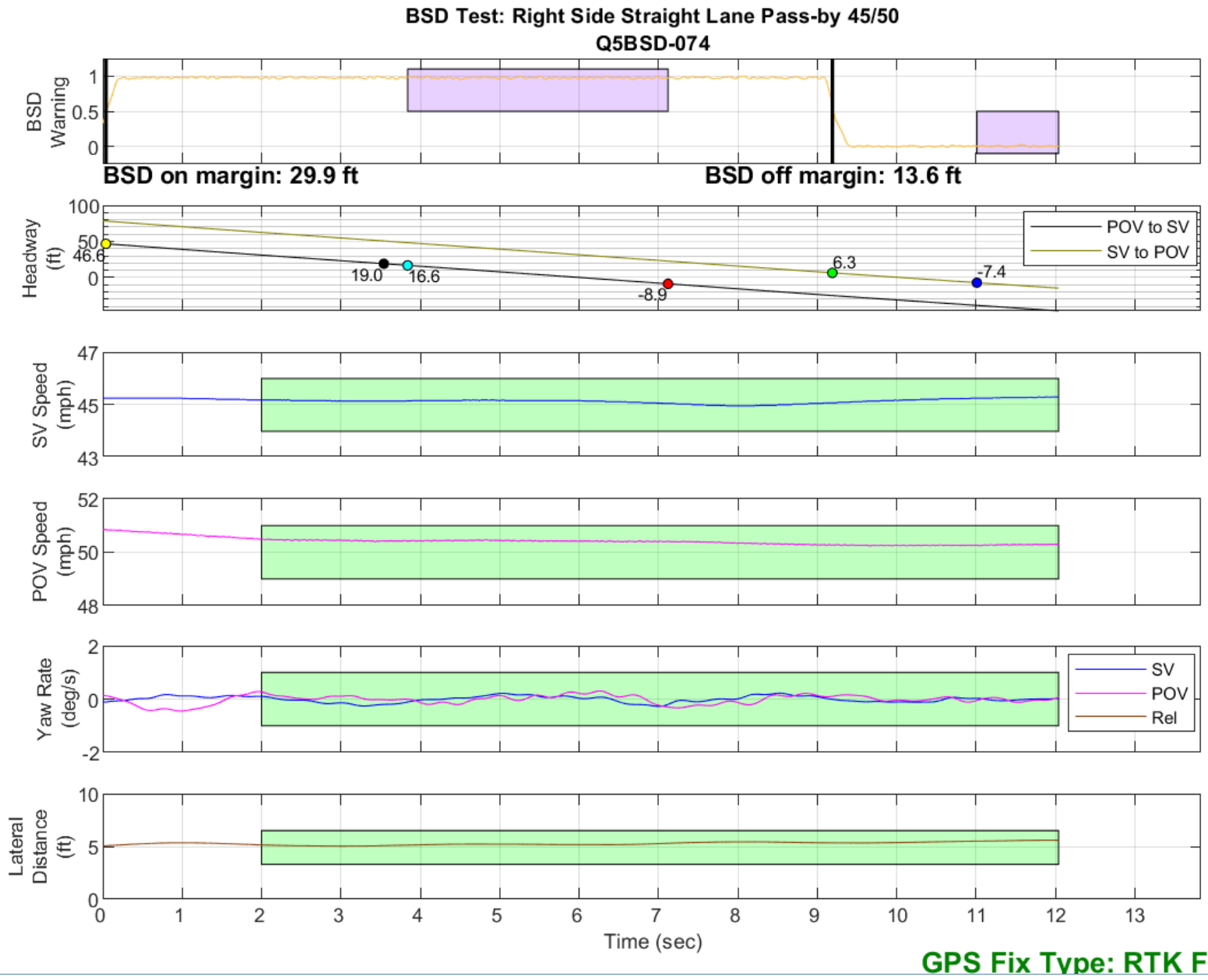
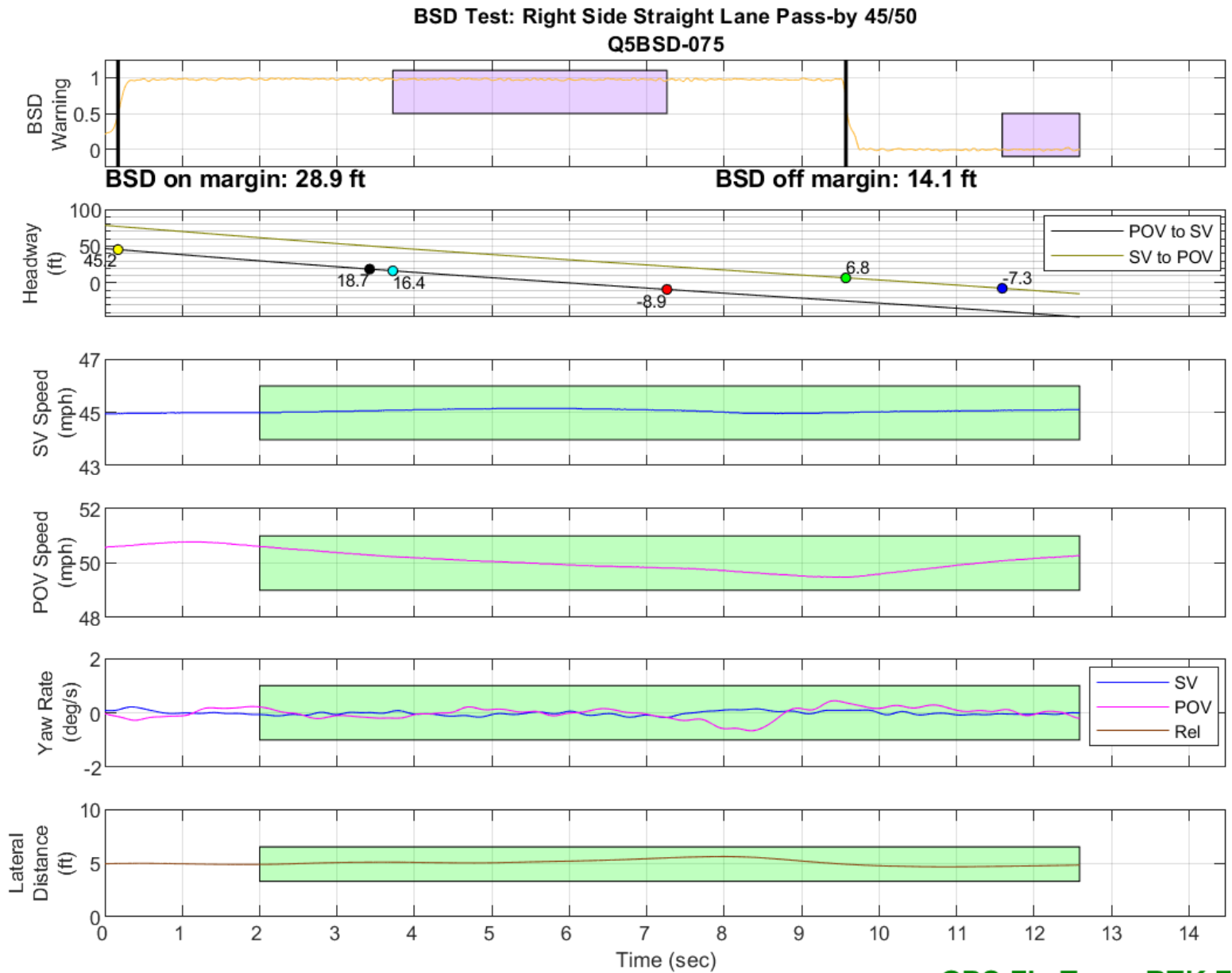
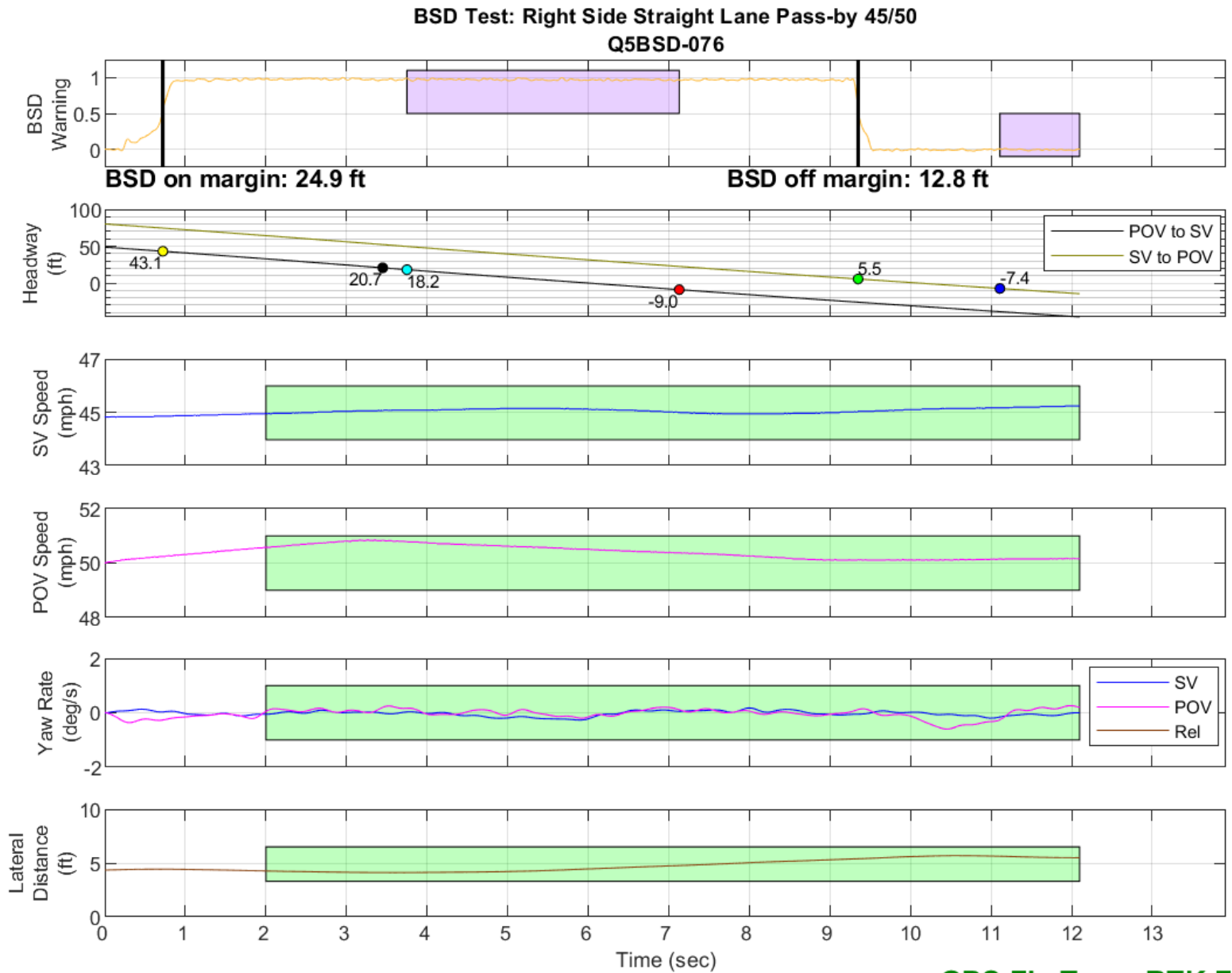


Figure D27. BSD Run 74, Straight Lane Pass-by, SV 45 mph, POV 50 mph



GPS Fix Type: RTK Fixed

Figure D28. BSD Run 75, Straight Lane Pass-by, SV 45 mph, POV 50 mph



GPS Fix Type: RTK Fixed

Figure D29. BSD Run 76, Straight Lane Pass-by, SV 45 mph, POV 50 mph

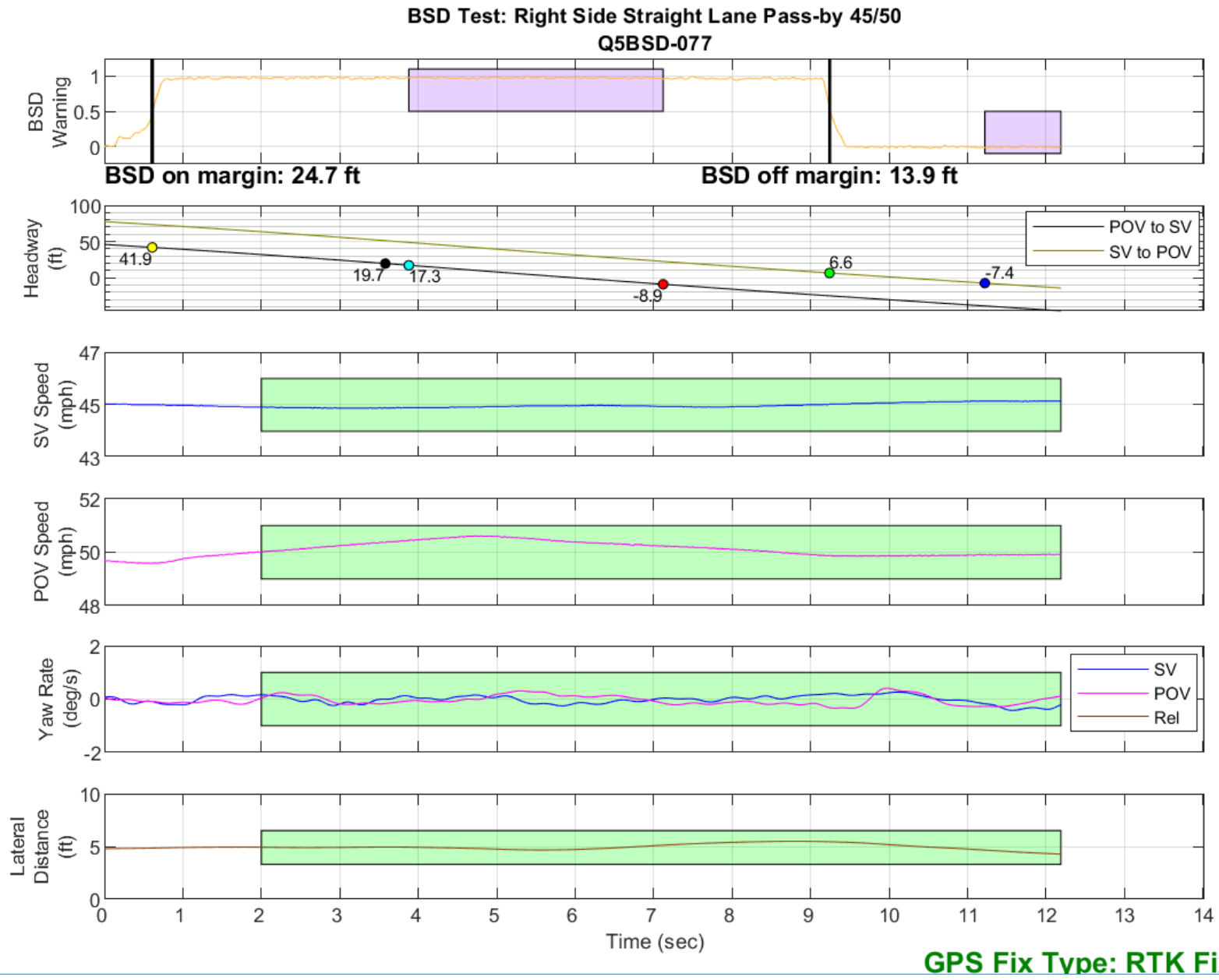
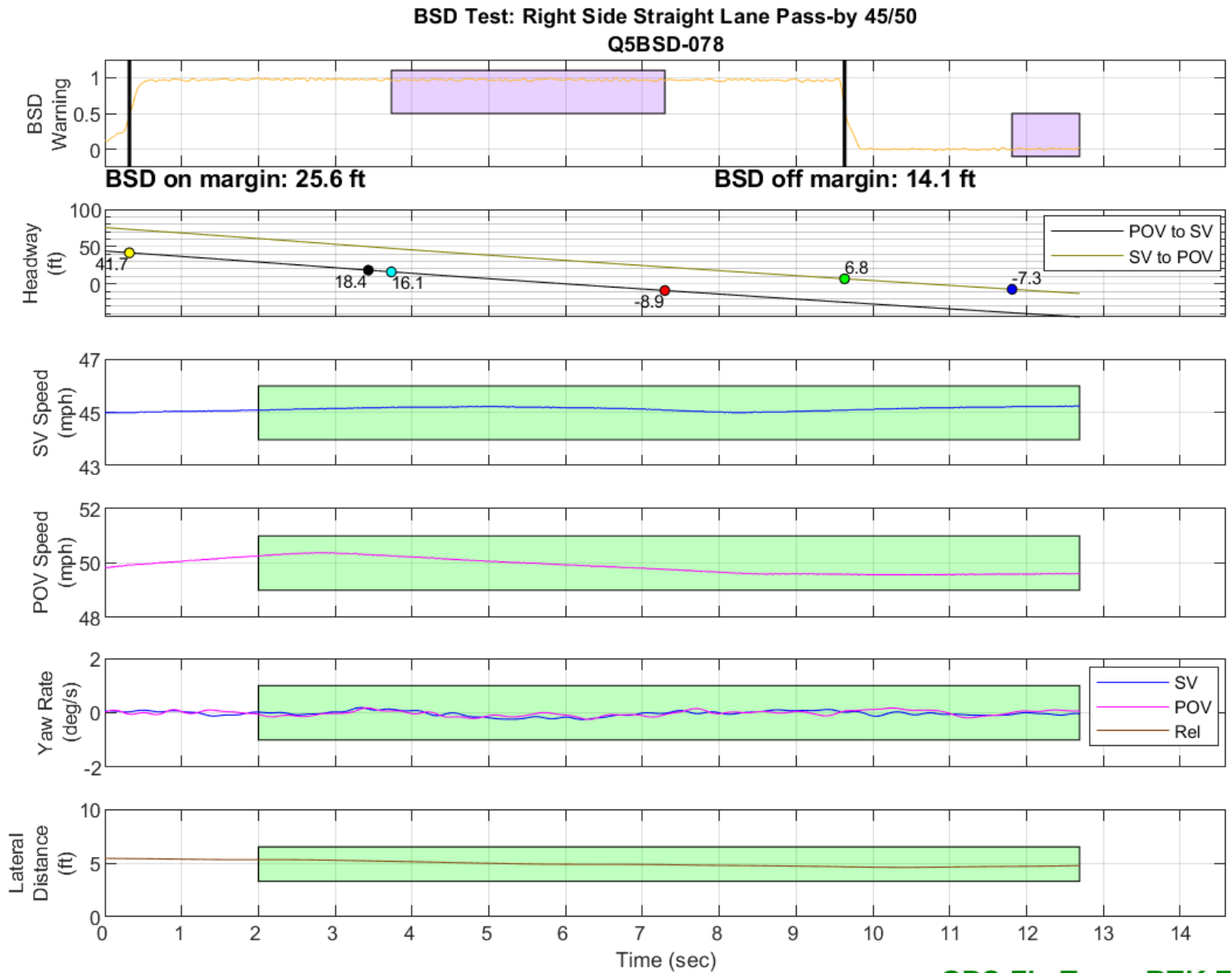
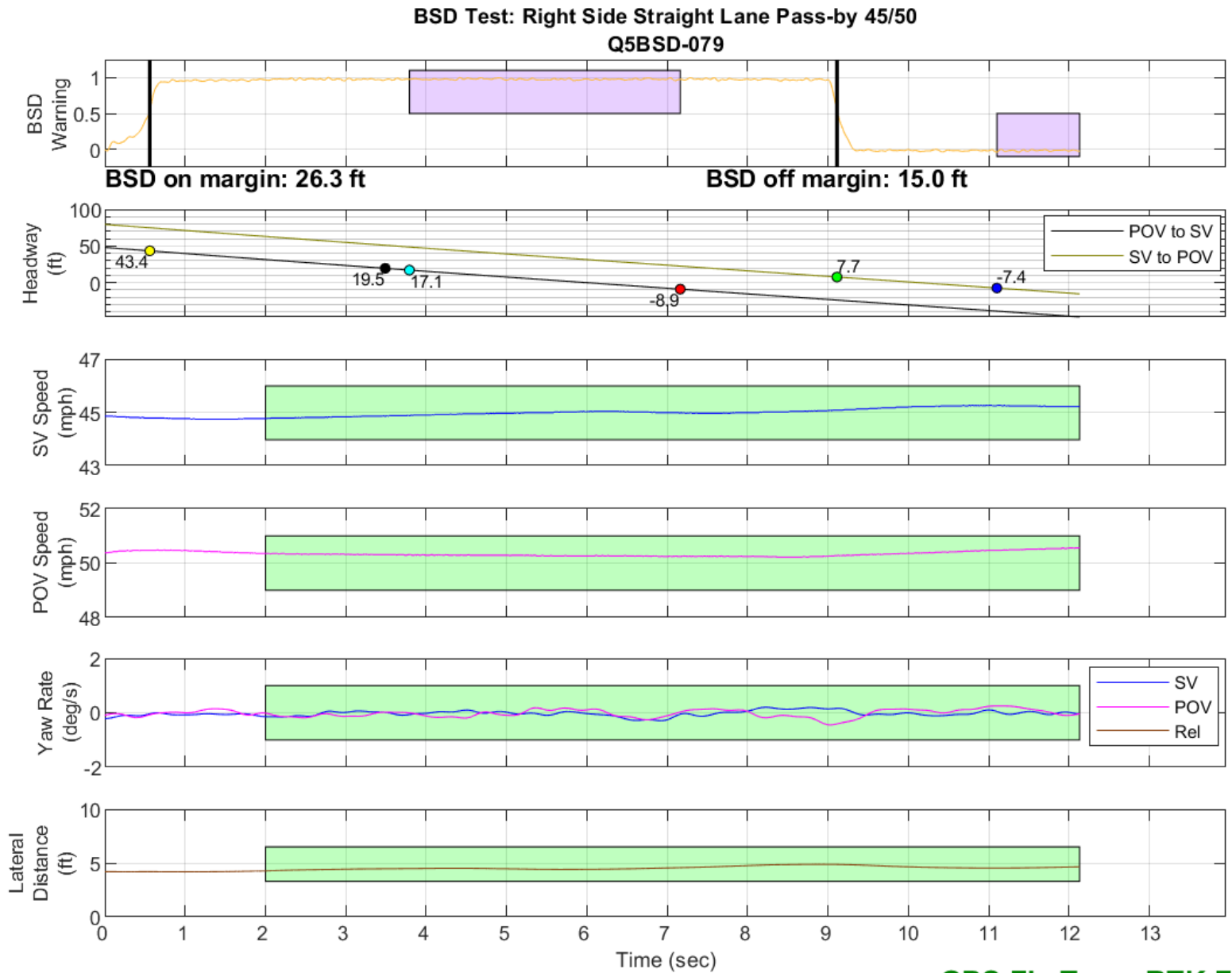


Figure D30. BSD Run 77, Straight Lane Pass-by, SV 45 mph, POV 50 mph



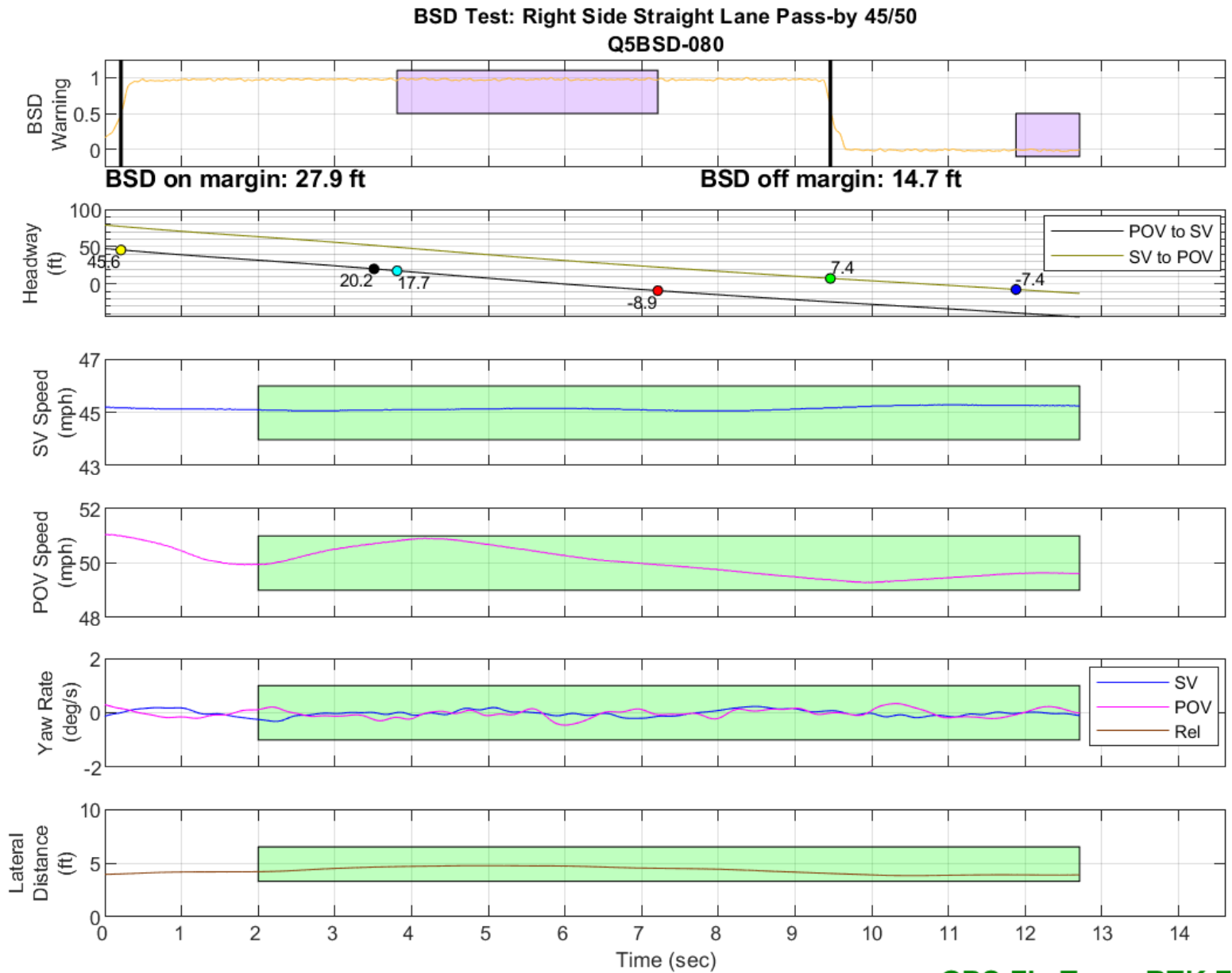
GPS Fix Type: RTK Fixed

Figure D31. BSD Run 78, Straight Lane Pass-by, SV 45 mph, POV 50 mph



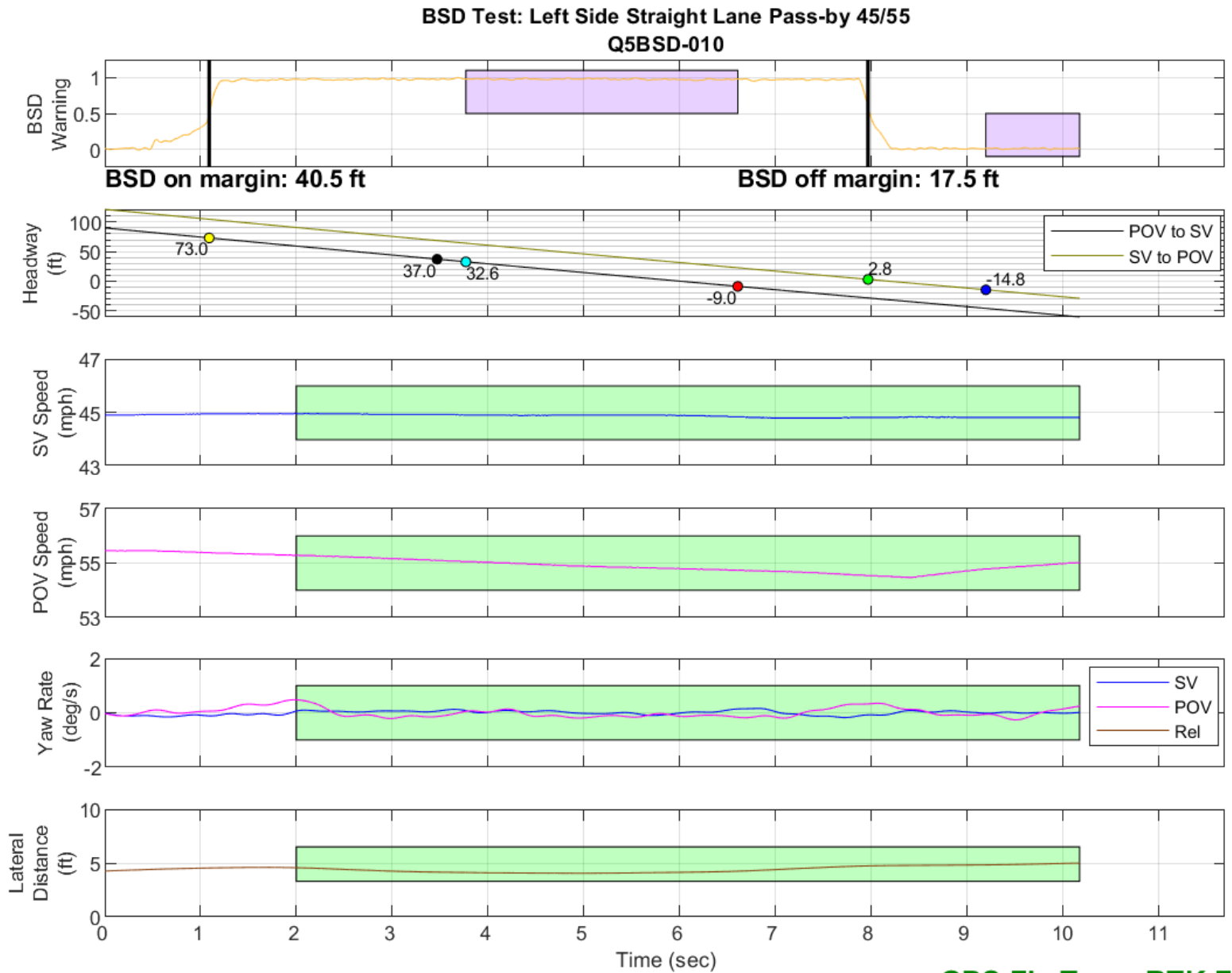
GPS Fix Type: RTK Fixed

Figure D32. BSD Run 79, Straight Lane Pass-by, SV 45 mph, POV 50 mph



GPS Fix Type: RTK Fixed

Figure D33. BSD Run 80, Straight Lane Pass-by, SV 45 mph, POV 50 mph



GPS Fix Type: RTK Fixed

Figure D34. BSD Run 10, Straight Lane Pass-by, SV 45 mph, POV 55 mph

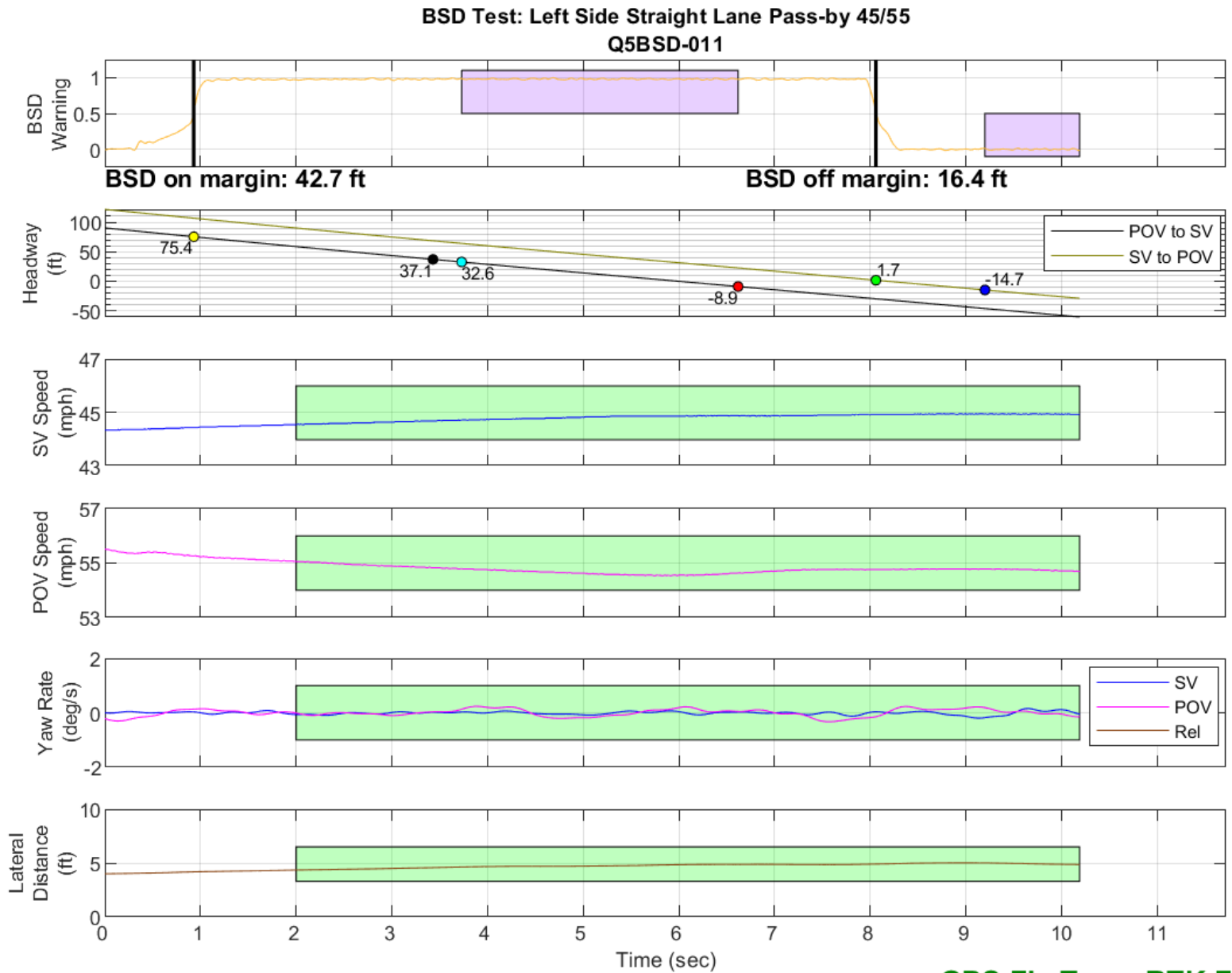


Figure D35. BSD Run 11, Straight Lane Pass-by, SV 45 mph, POV 55 mph

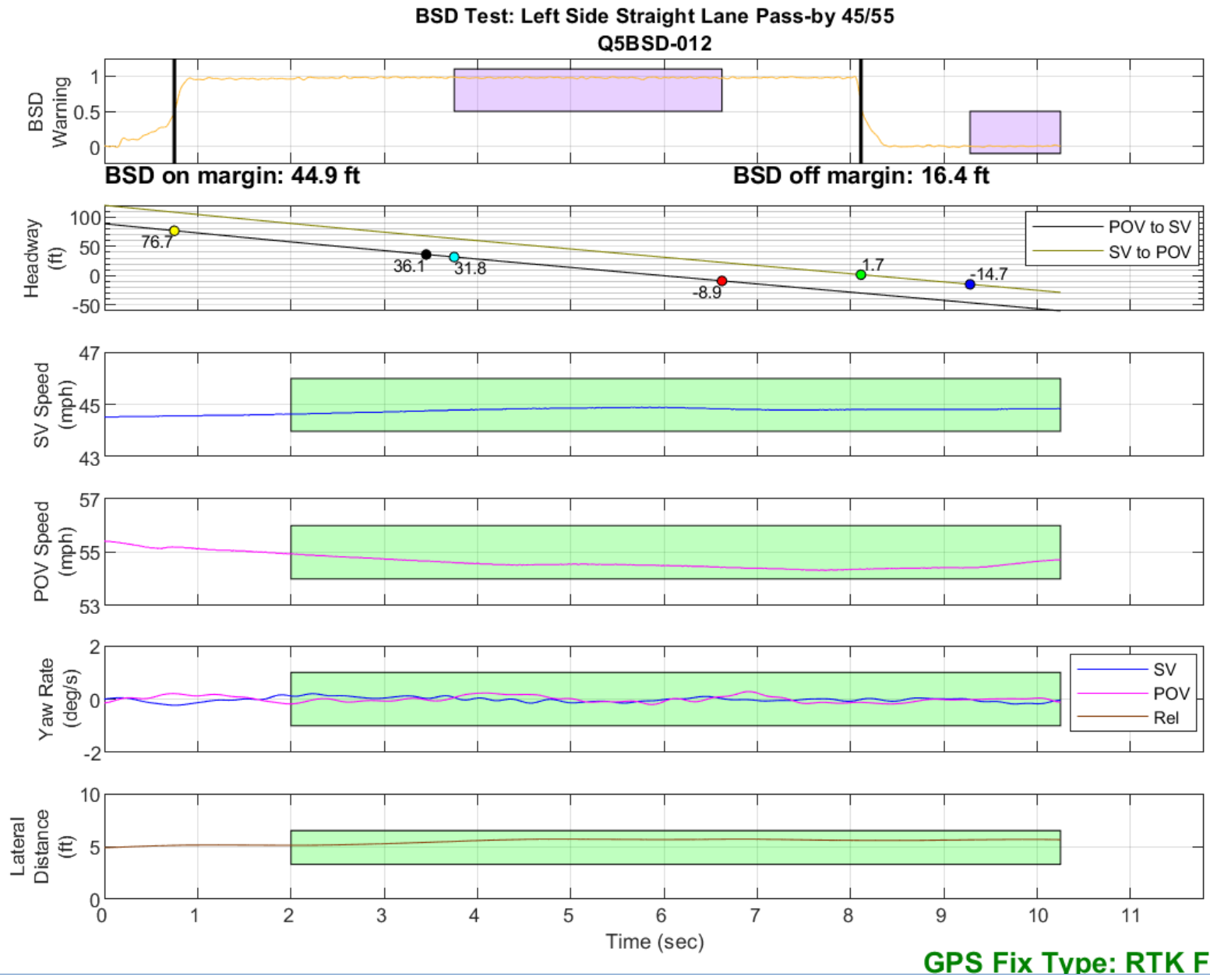
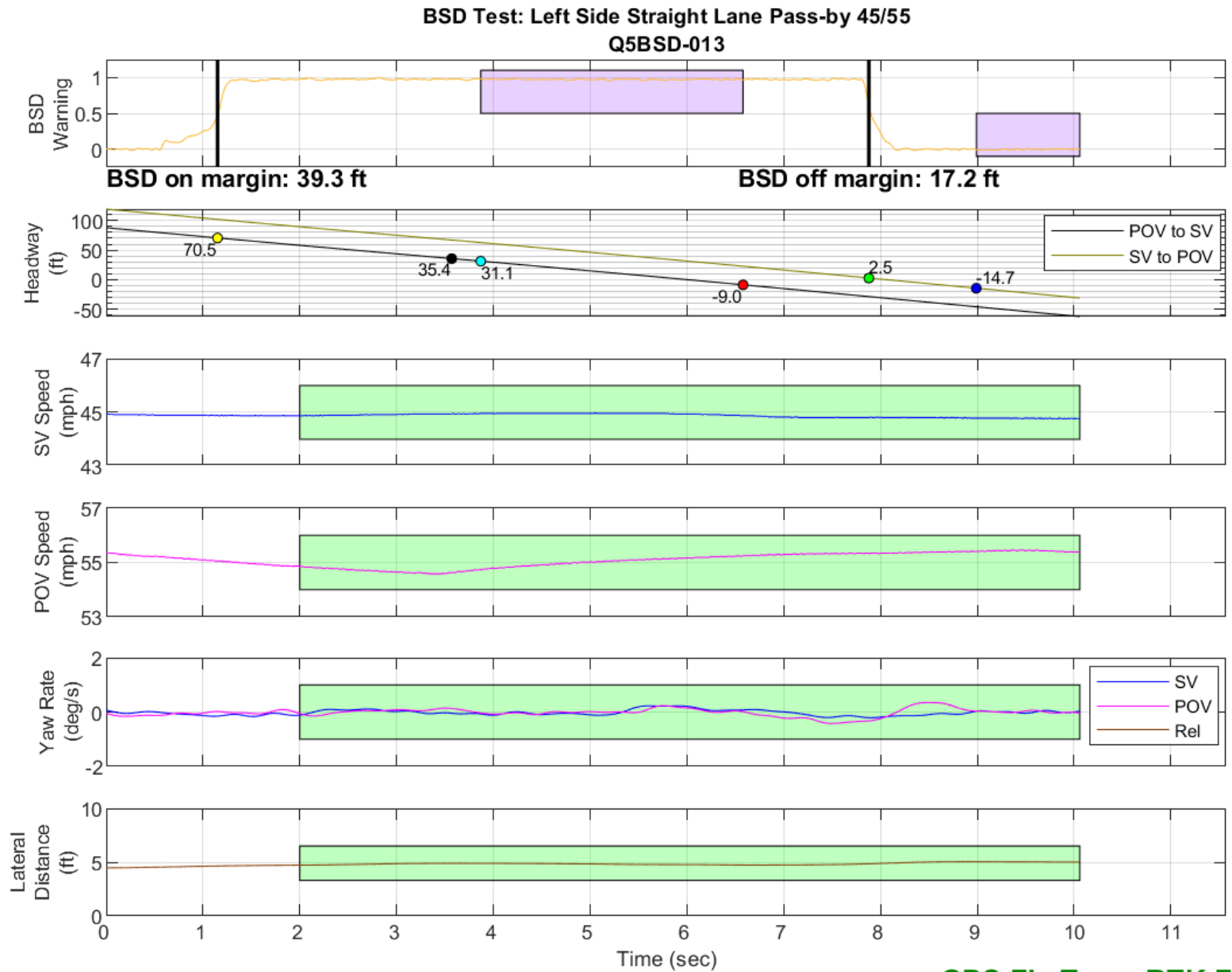
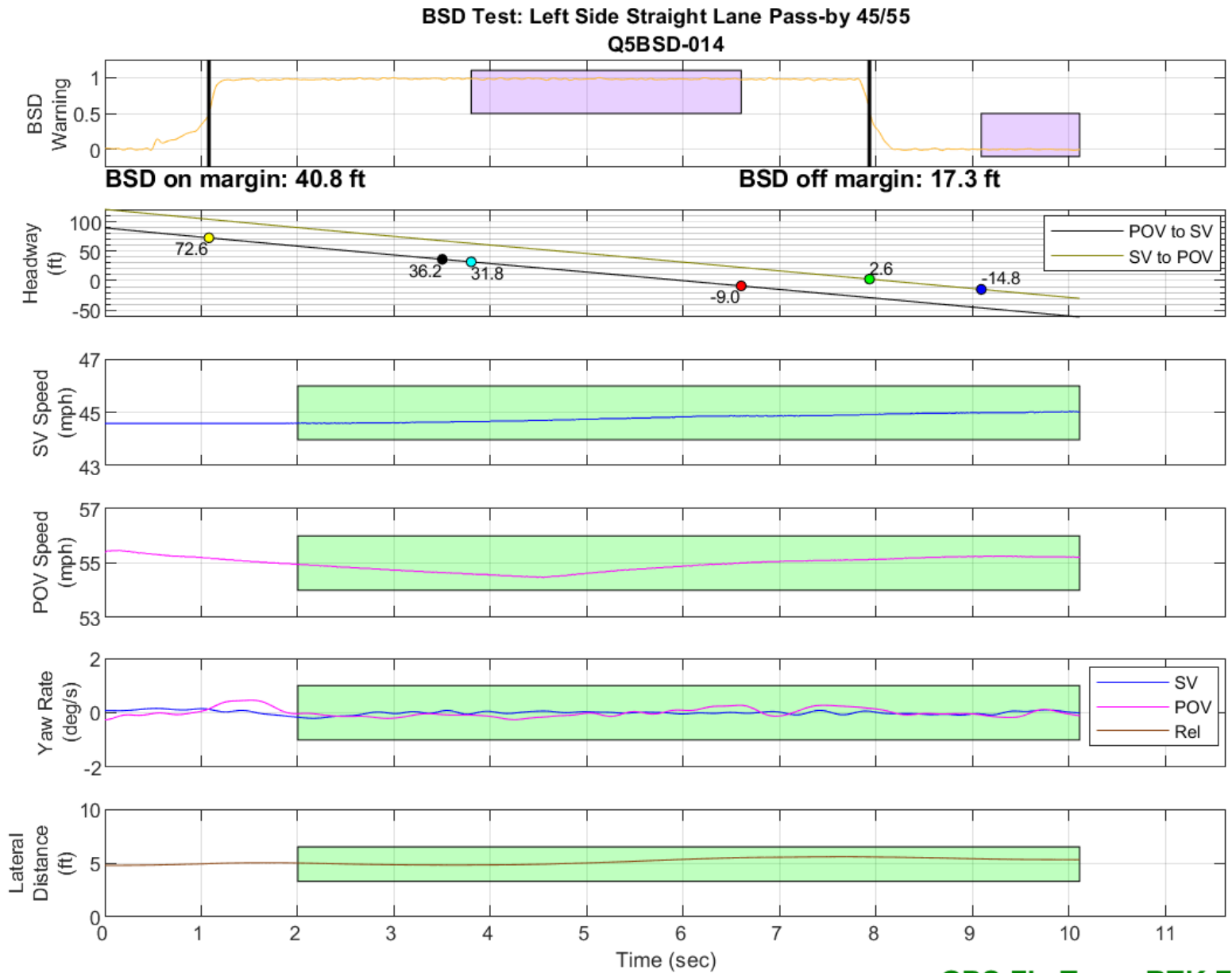


Figure D36. BSD Run 12, Straight Lane Pass-by, SV 45 mph, POV 55 mph



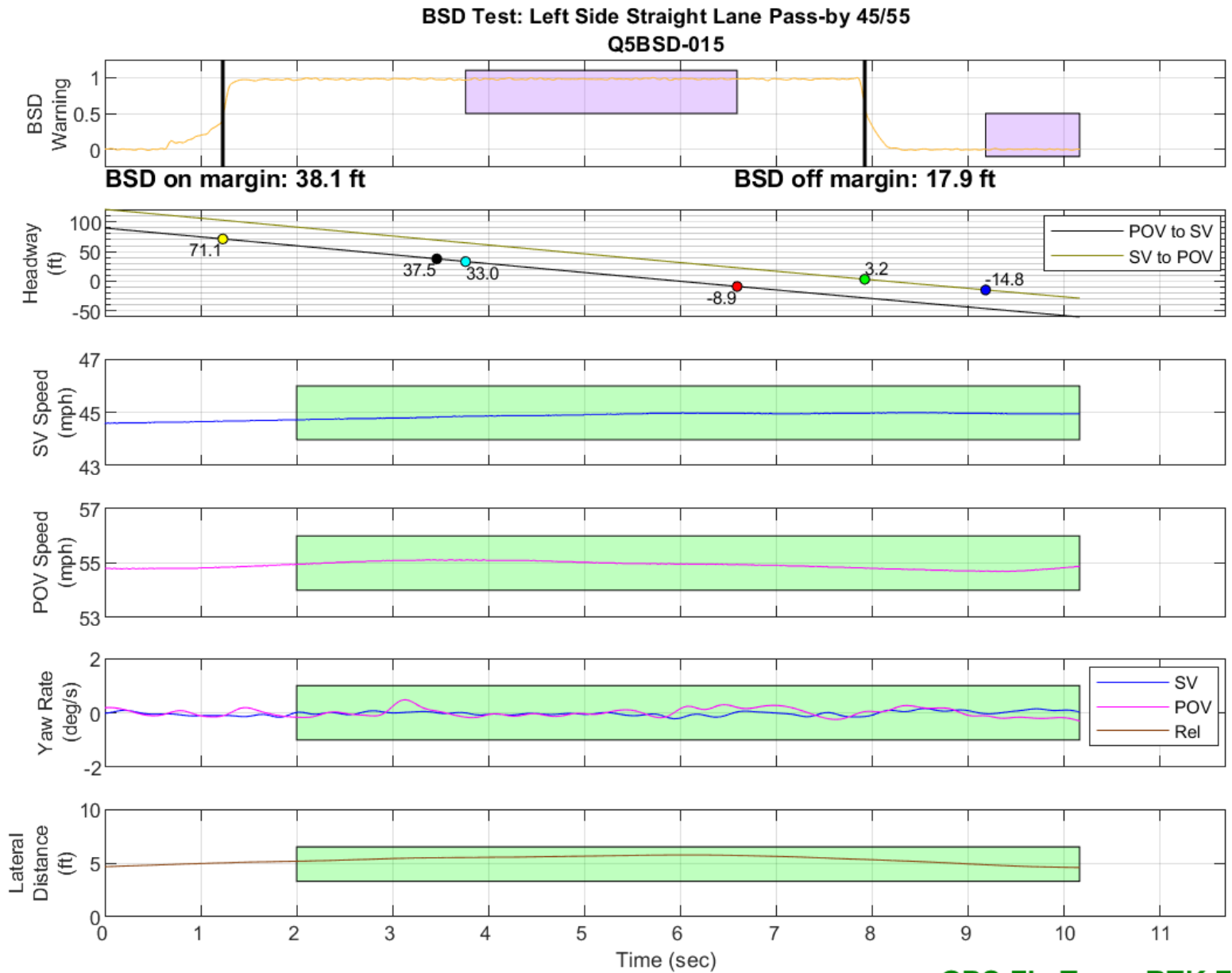
GPS Fix Type: RTK Fixed

Figure D37. BSD Run 13, Straight Lane Pass-by, SV 45 mph, POV 55 mph



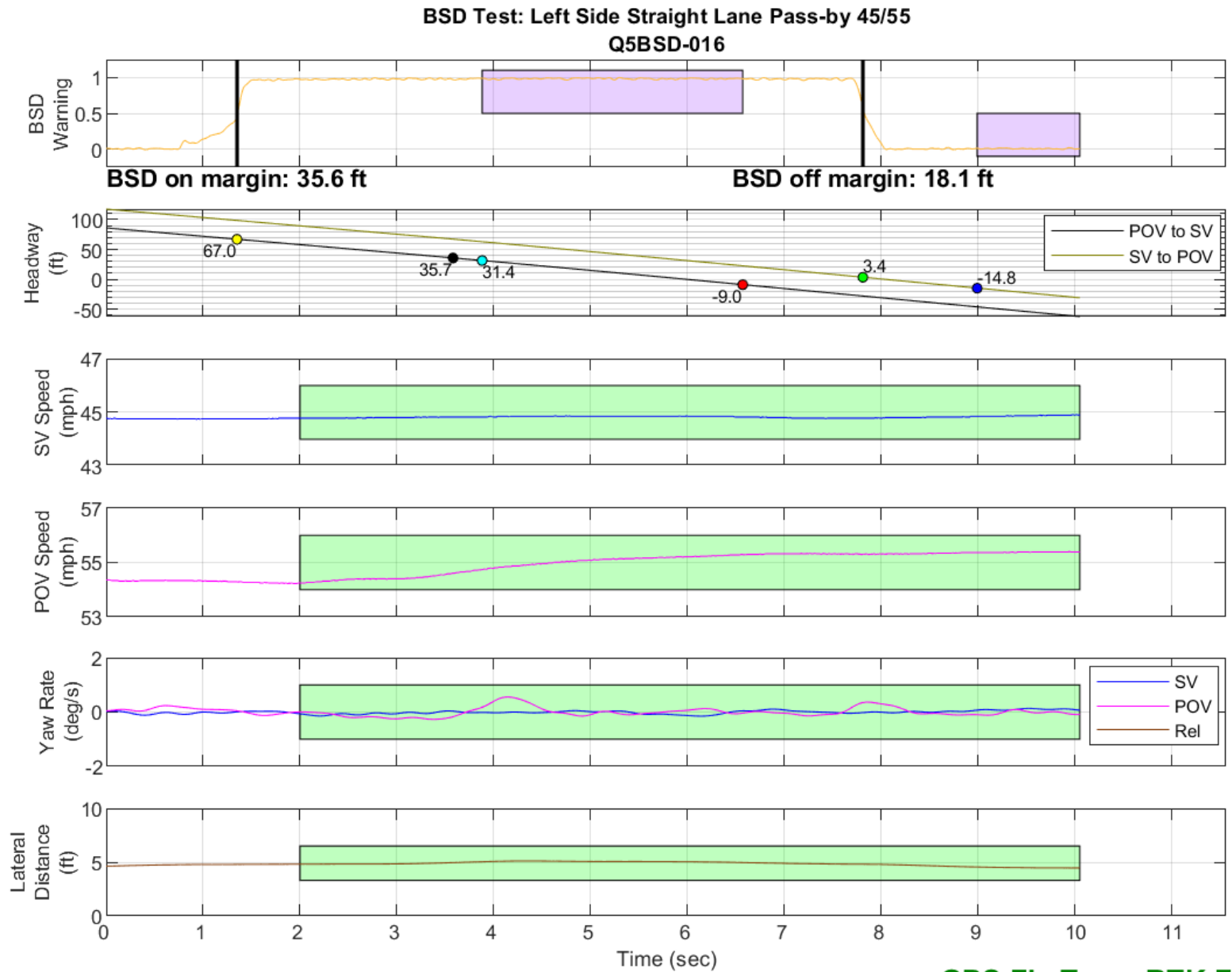
GPS Fix Type: RTK Fixed

Figure D38. BSD Run 14, Straight Lane Pass-by, SV 45 mph, POV 55 mph



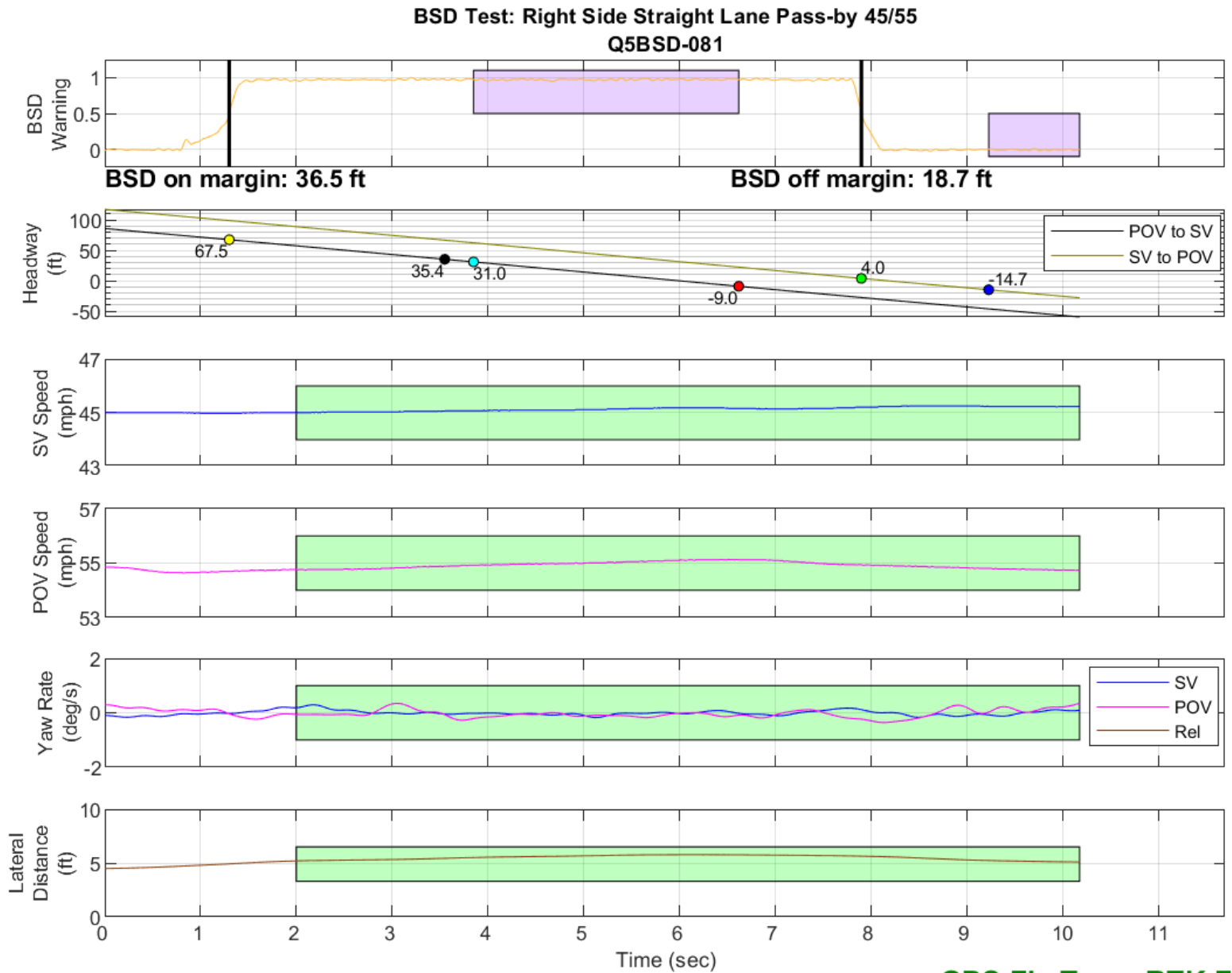
GPS Fix Type: RTK Fixed

Figure D39. BSD Run 15, Straight Lane Pass-by, SV 45 mph, POV 55 mph



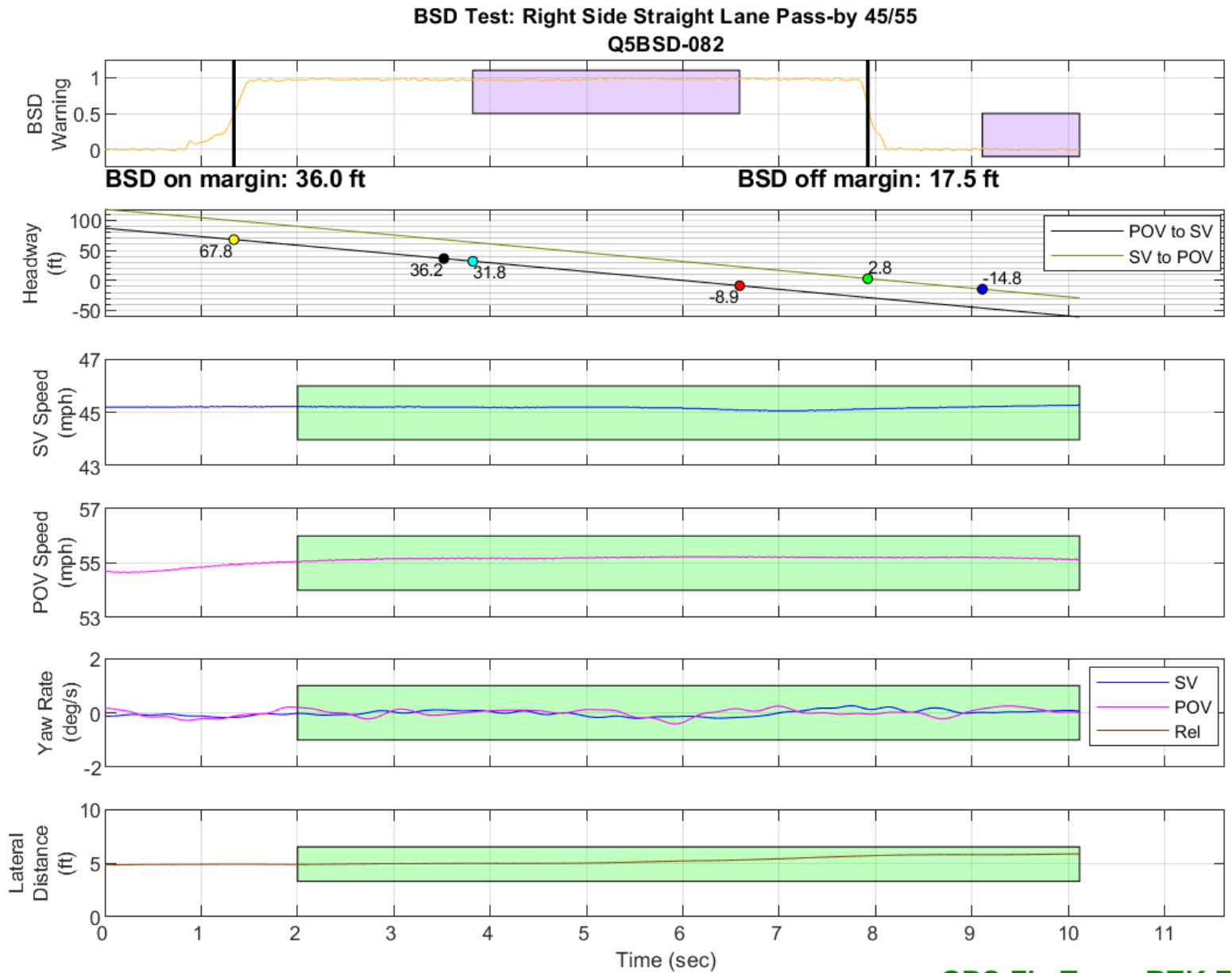
GPS Fix Type: RTK Fixed

Figure D40. BSD Run 16, Straight Lane Pass-by, SV 45 mph, POV 55 mph



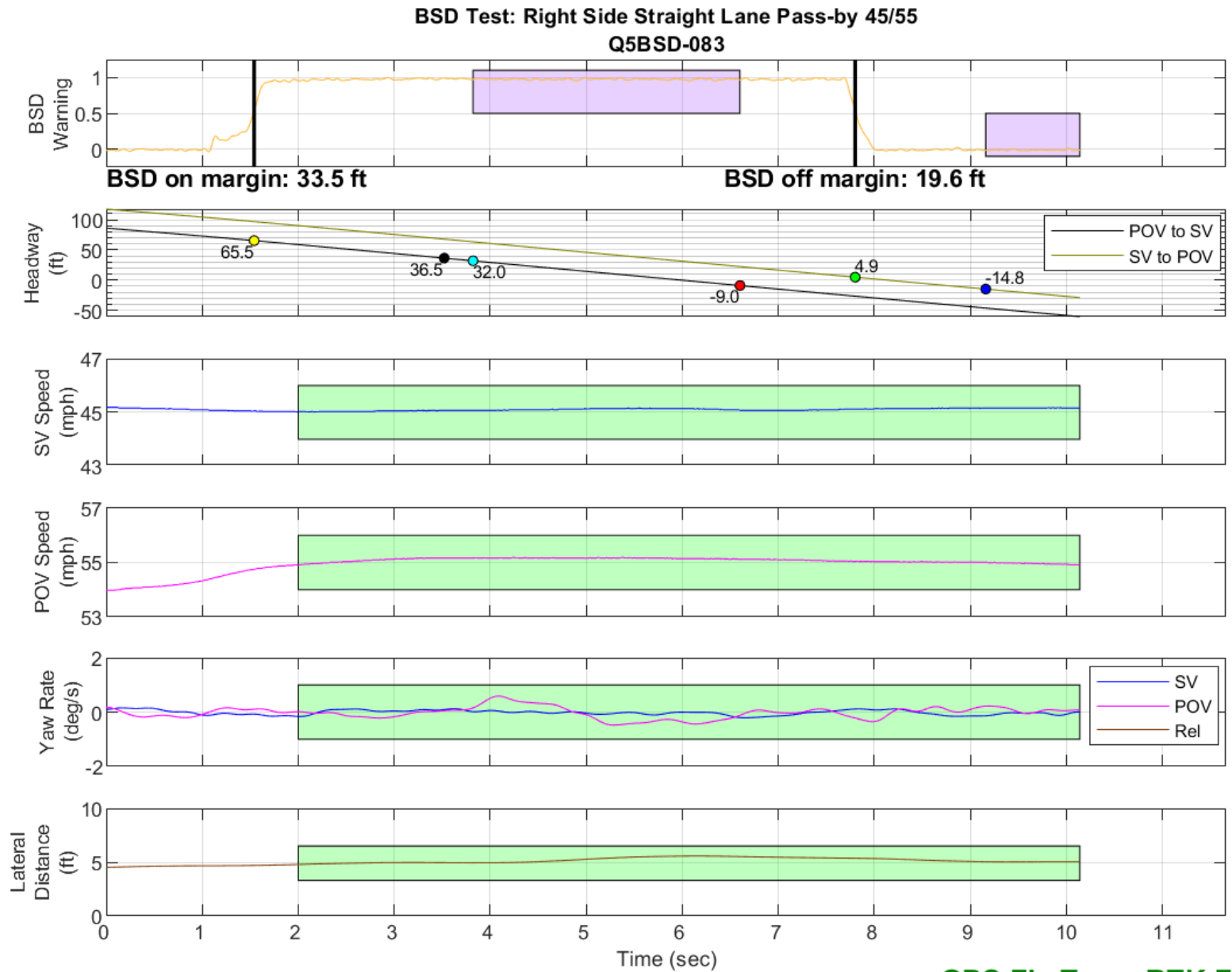
GPS Fix Type: RTK Fixed

Figure D41. BSD Run 81, Straight Lane Pass-by, SV 45 mph, POV 55 mph



GPS Fix Type: RTK Fixed

Figure D42. BSD Run 82, Straight Lane Pass-by, SV 45 mph, POV 55 mph



GPS Fix Type: RTK Fixed

Figure D43. BSD Run 83, Straight Lane Pass-by, SV 45 mph, POV 55 mph

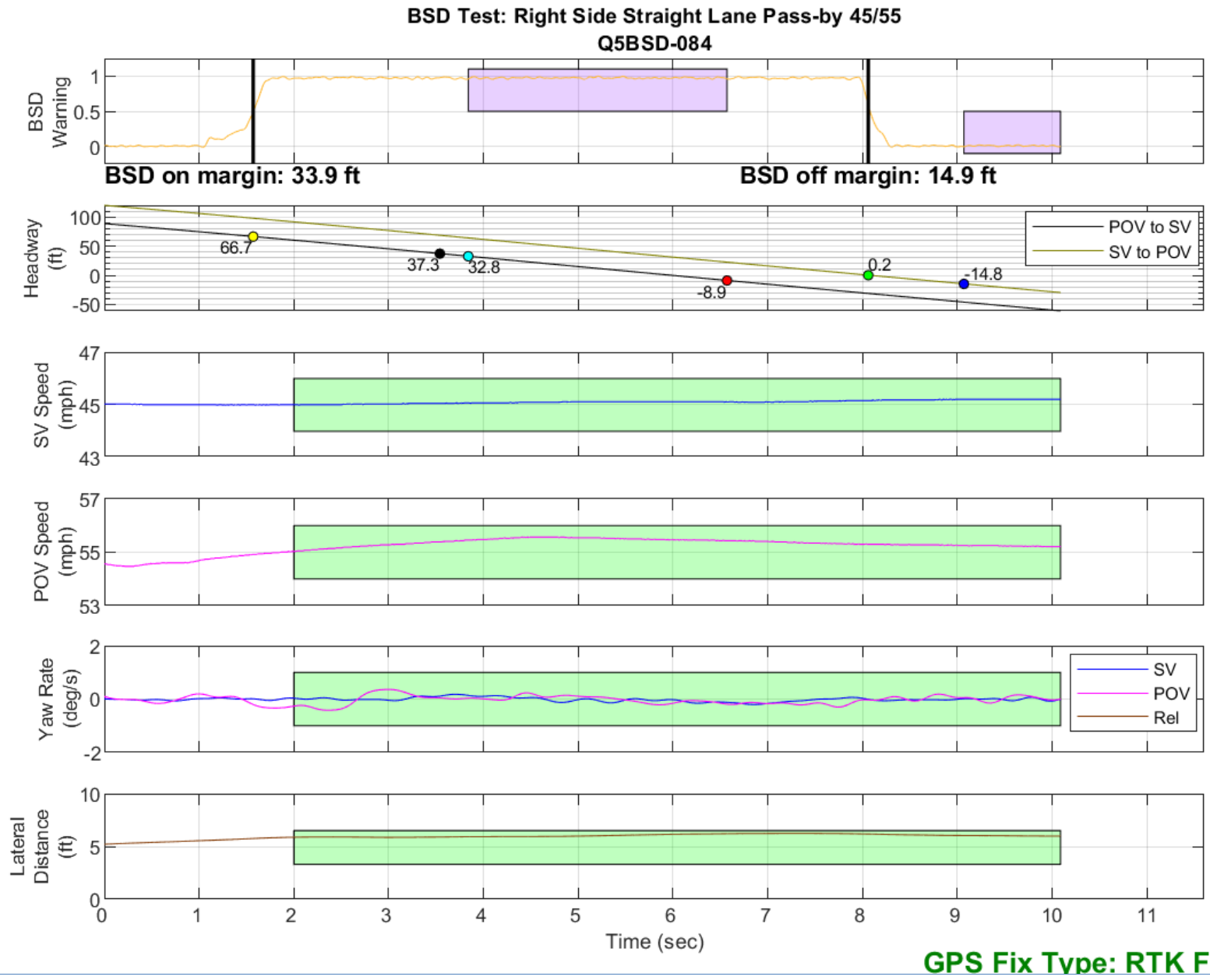
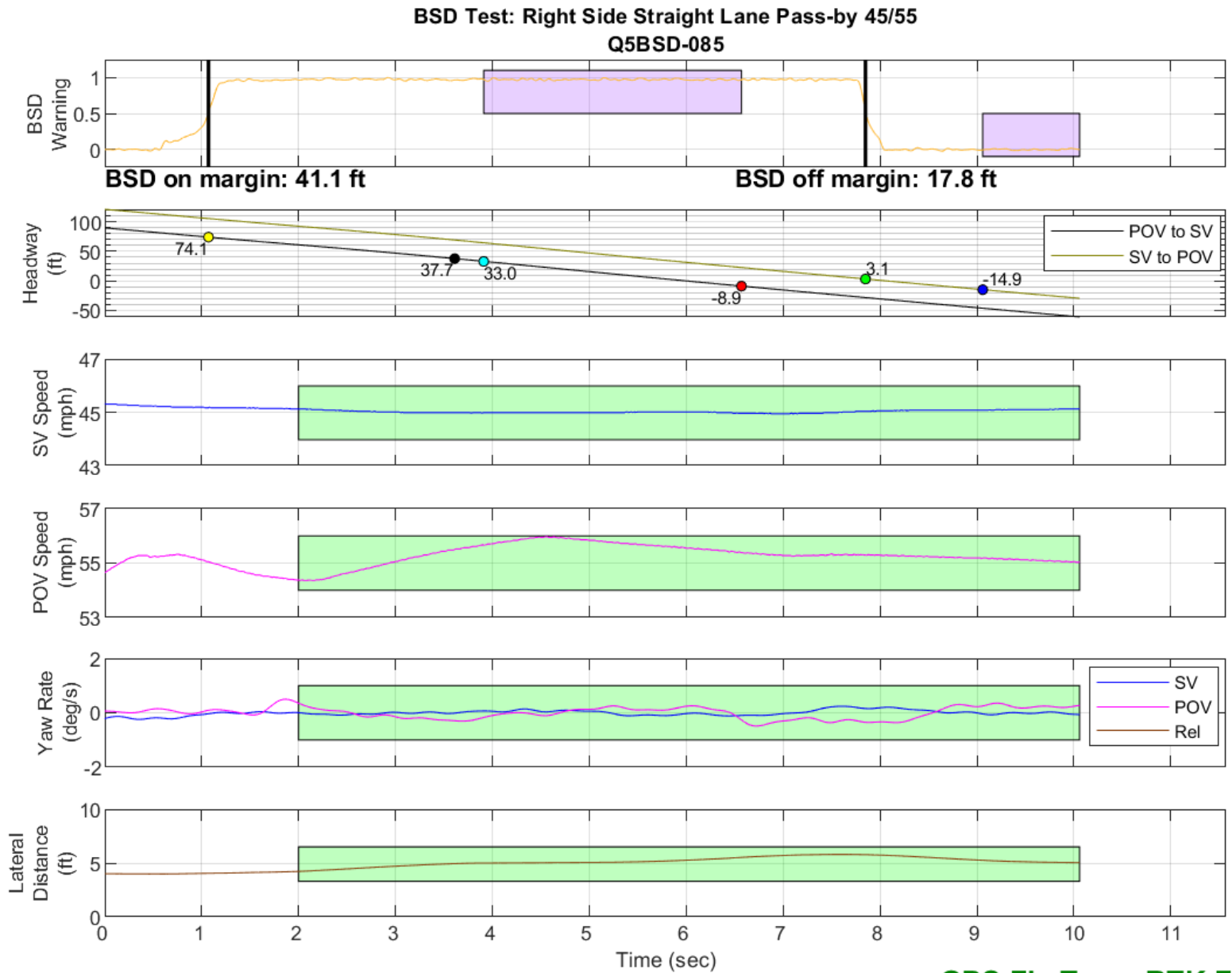
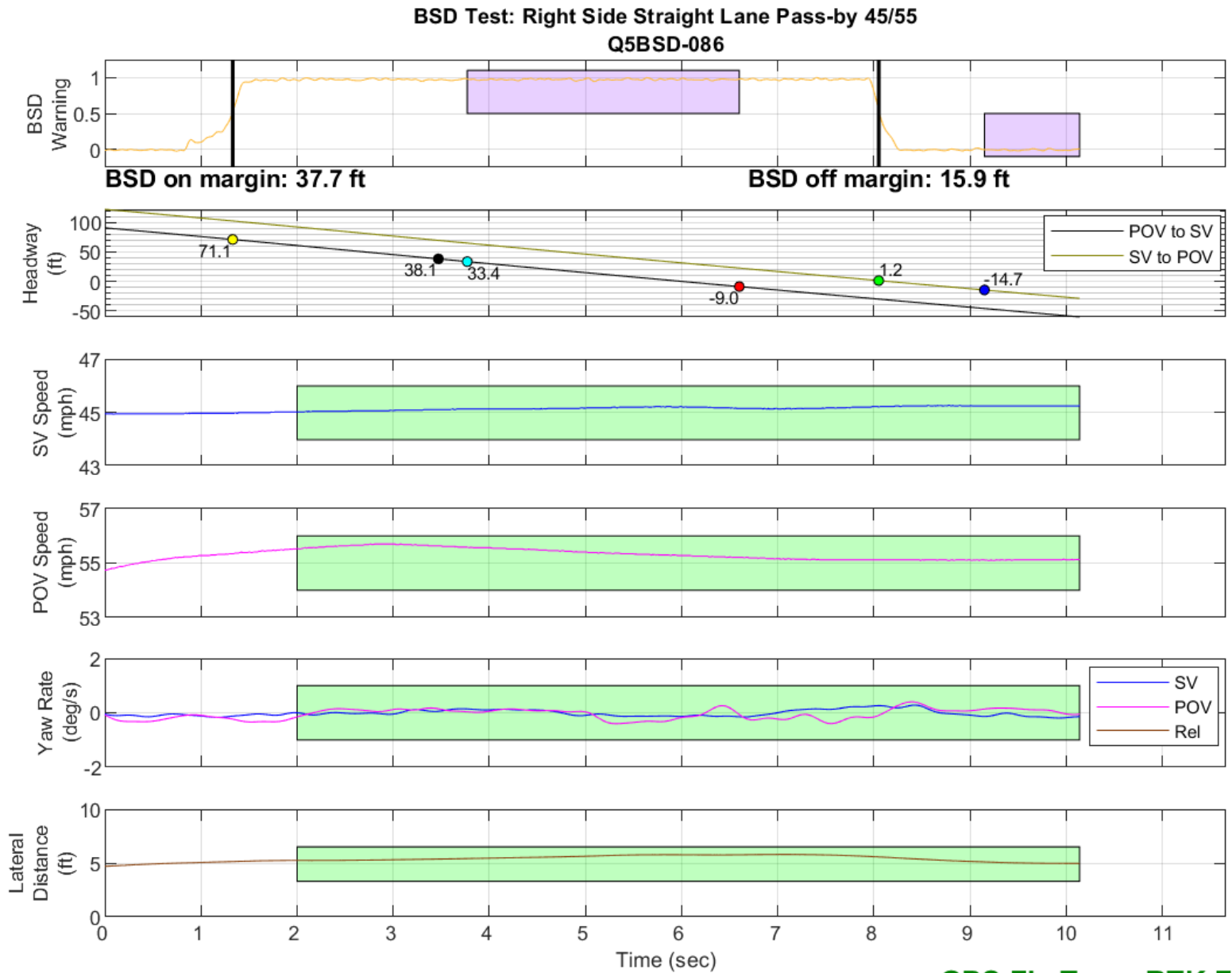


Figure D44. BSD Run 84, Straight Lane Pass-by, SV 45 mph, POV 55 mph



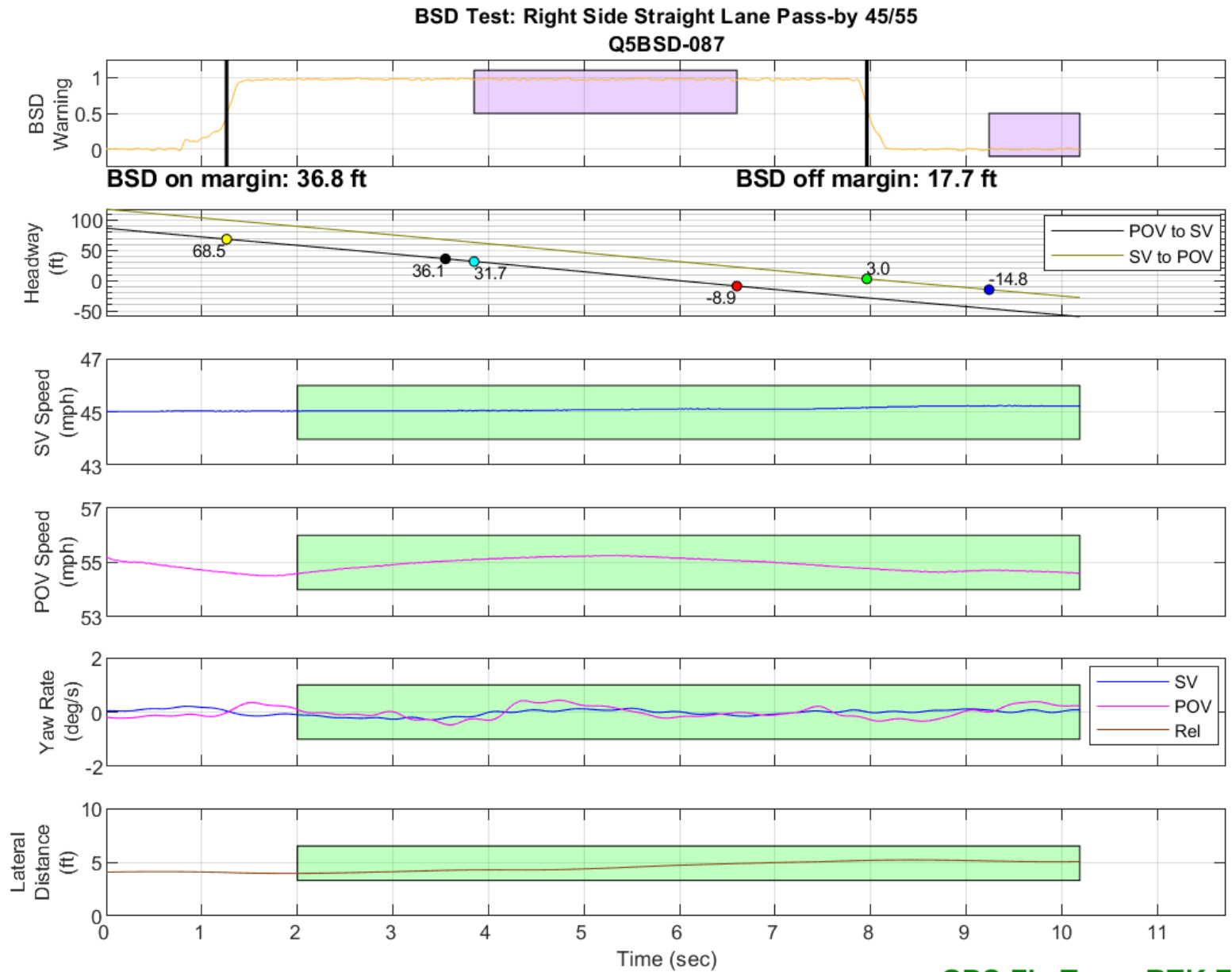
GPS Fix Type: RTK Fixed

Figure D45. BSD Run 85, Straight Lane Pass-by, SV 45 mph, POV 55 mph



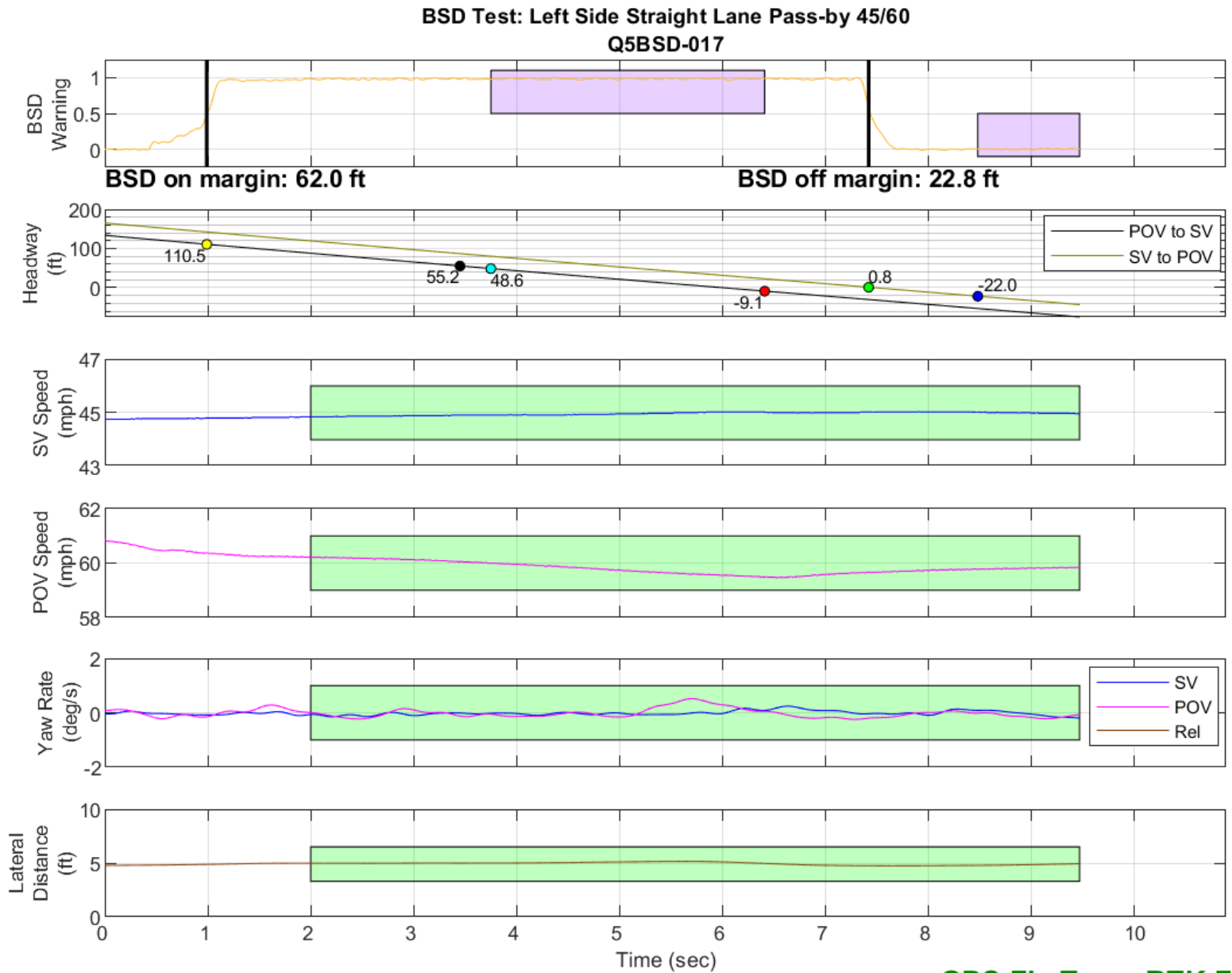
GPS Fix Type: RTK Fixed

Figure D46. BSD Run 86, Straight Lane Pass-by, SV 45 mph, POV 55 mph



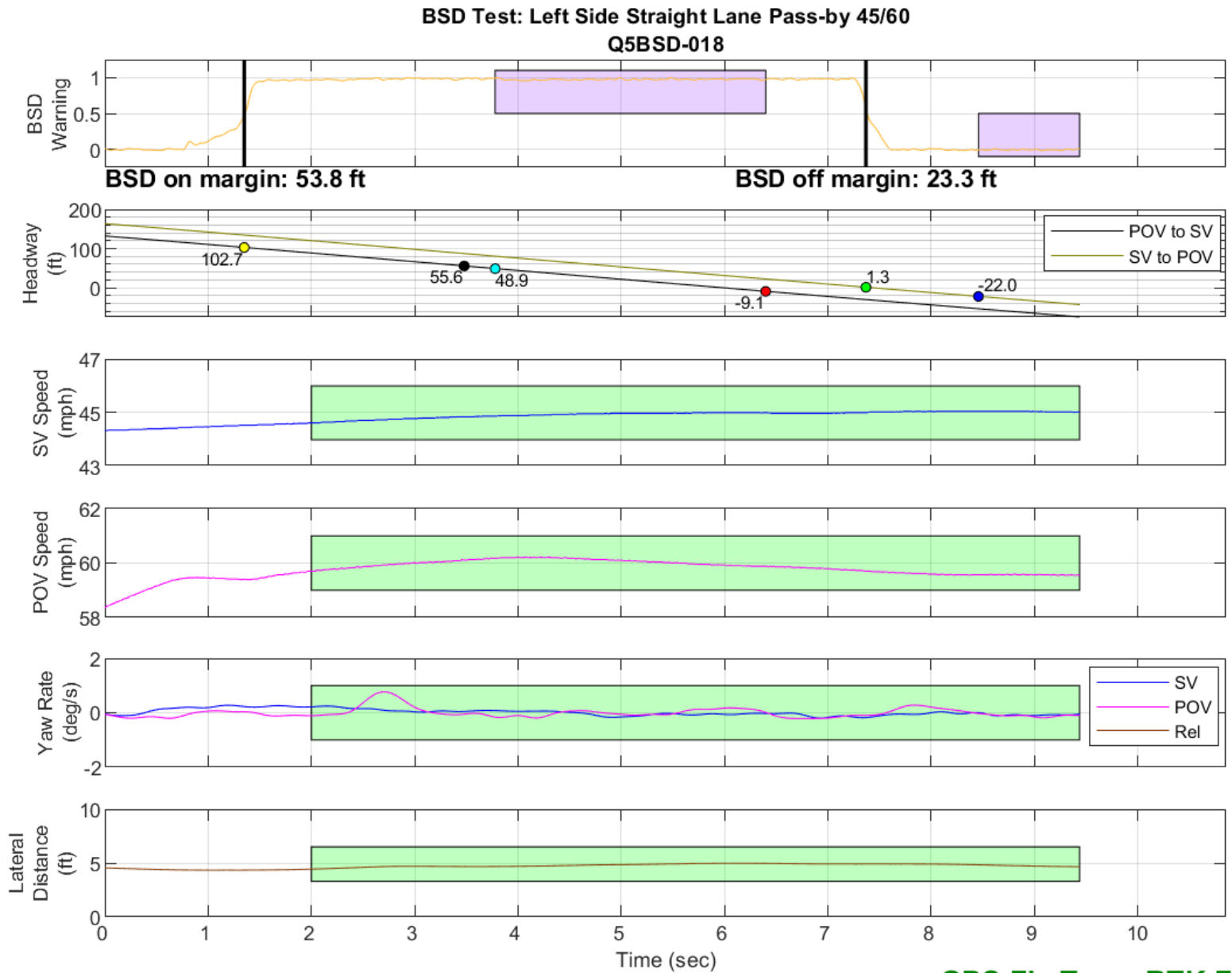
GPS Fix Type: RTK Fixed

Figure D47. BSD Run 87, Straight Lane Pass-by, SV 45 mph, POV 55 mph



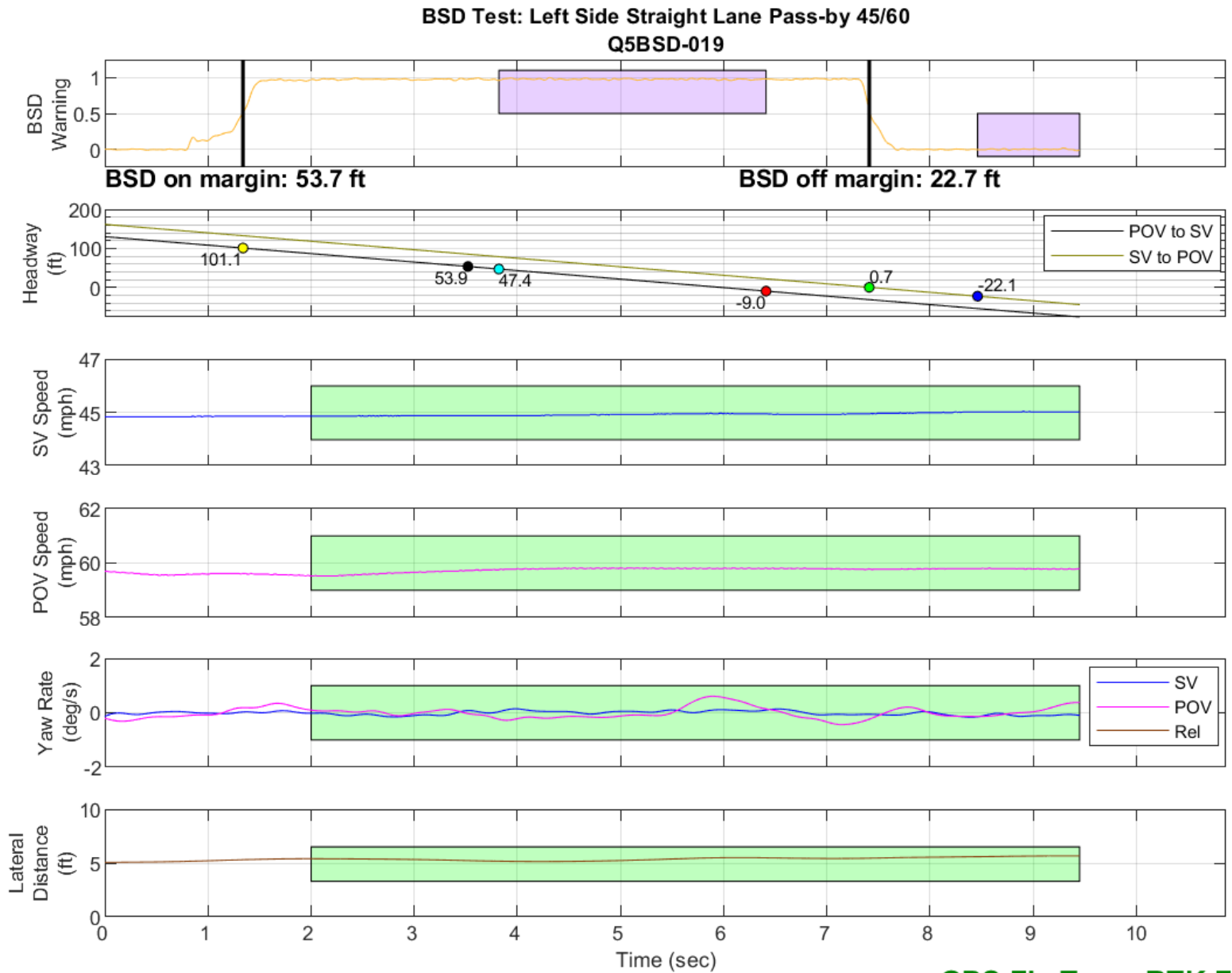
GPS Fix Type: RTK Fixed

Figure D48. BSD Run 17, Straight Lane Pass-by, SV 45 mph, POV 60 mph



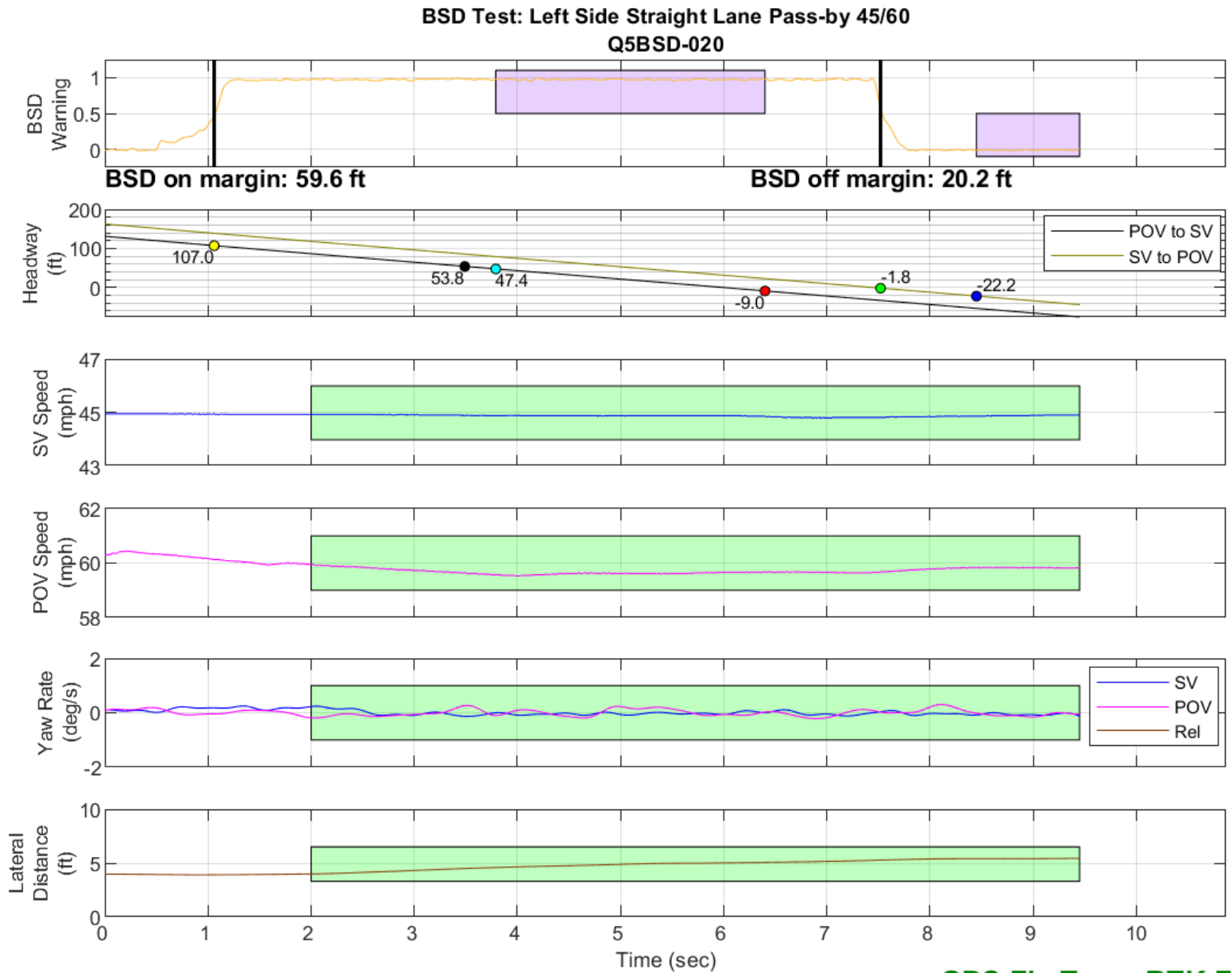
GPS Fix Type: RTK Fixed

Figure D49. BSD Run 18, Straight Lane Pass-by, SV 45 mph, POV 60 mph



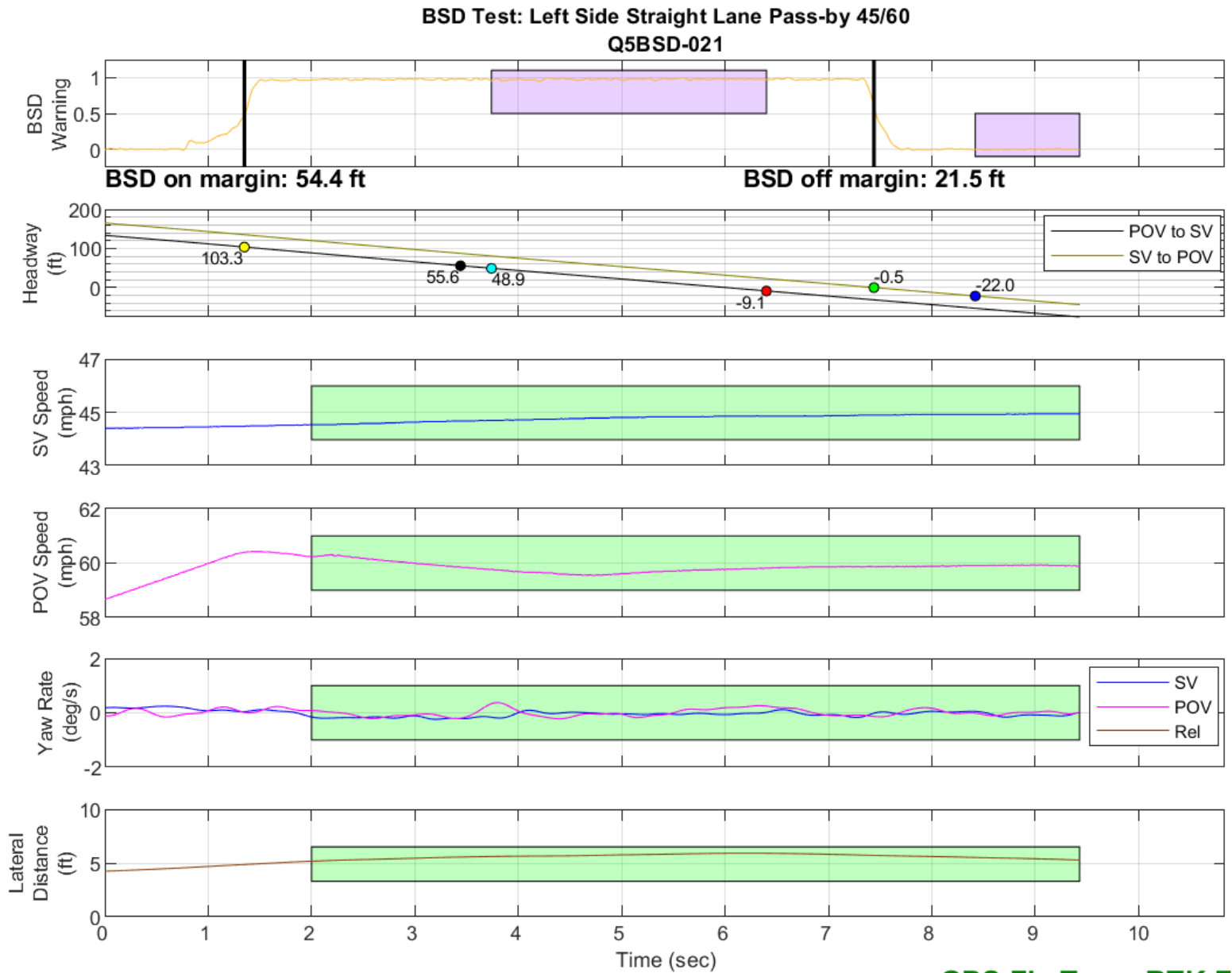
GPS Fix Type: RTK Fixed

Figure D50. BSD Run 19, Straight Lane Pass-by, SV 45 mph, POV 60 mph



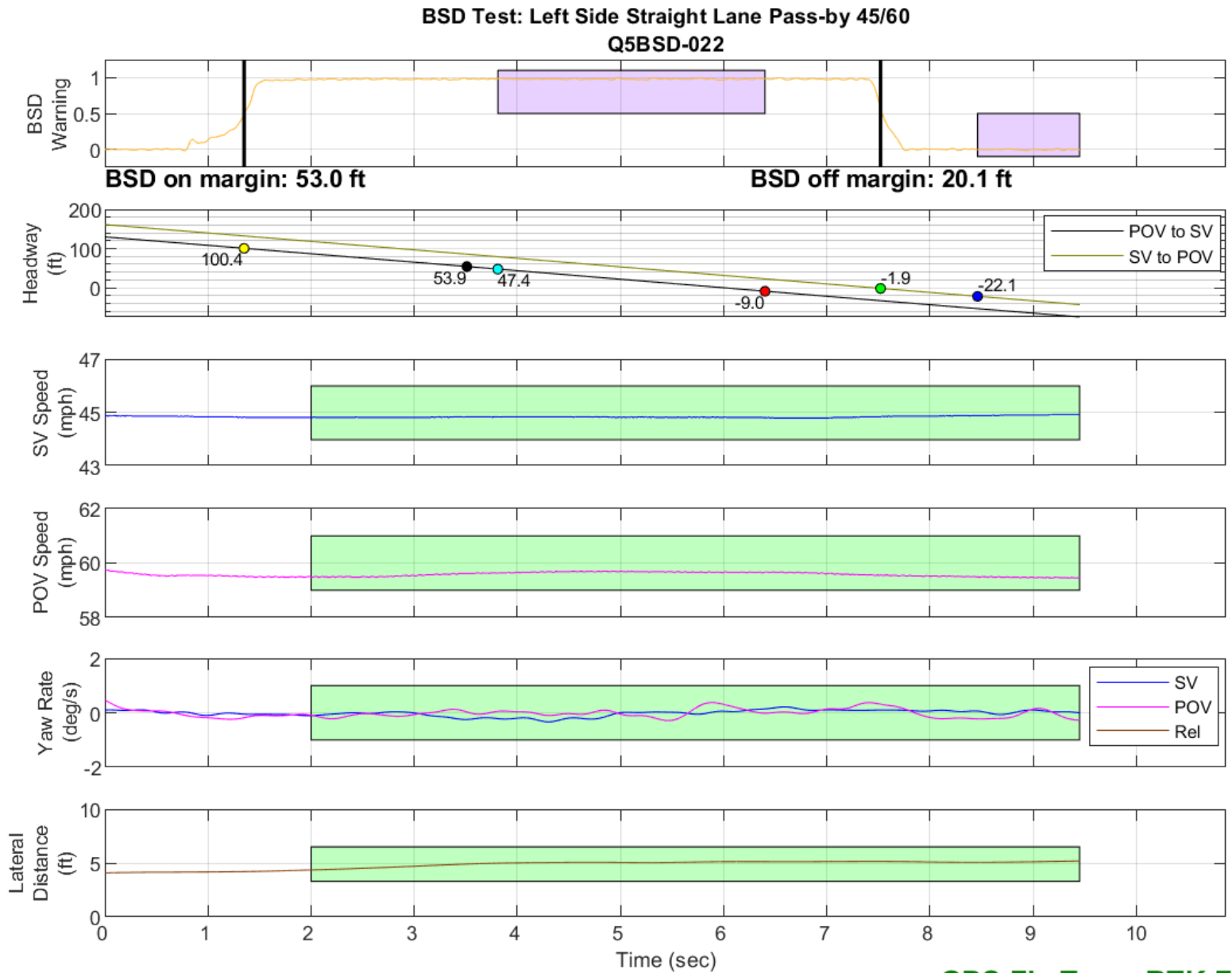
GPS Fix Type: RTK Fixed

Figure D51. BSD Run 20, Straight Lane Pass-by, SV 45 mph, POV 60 mph



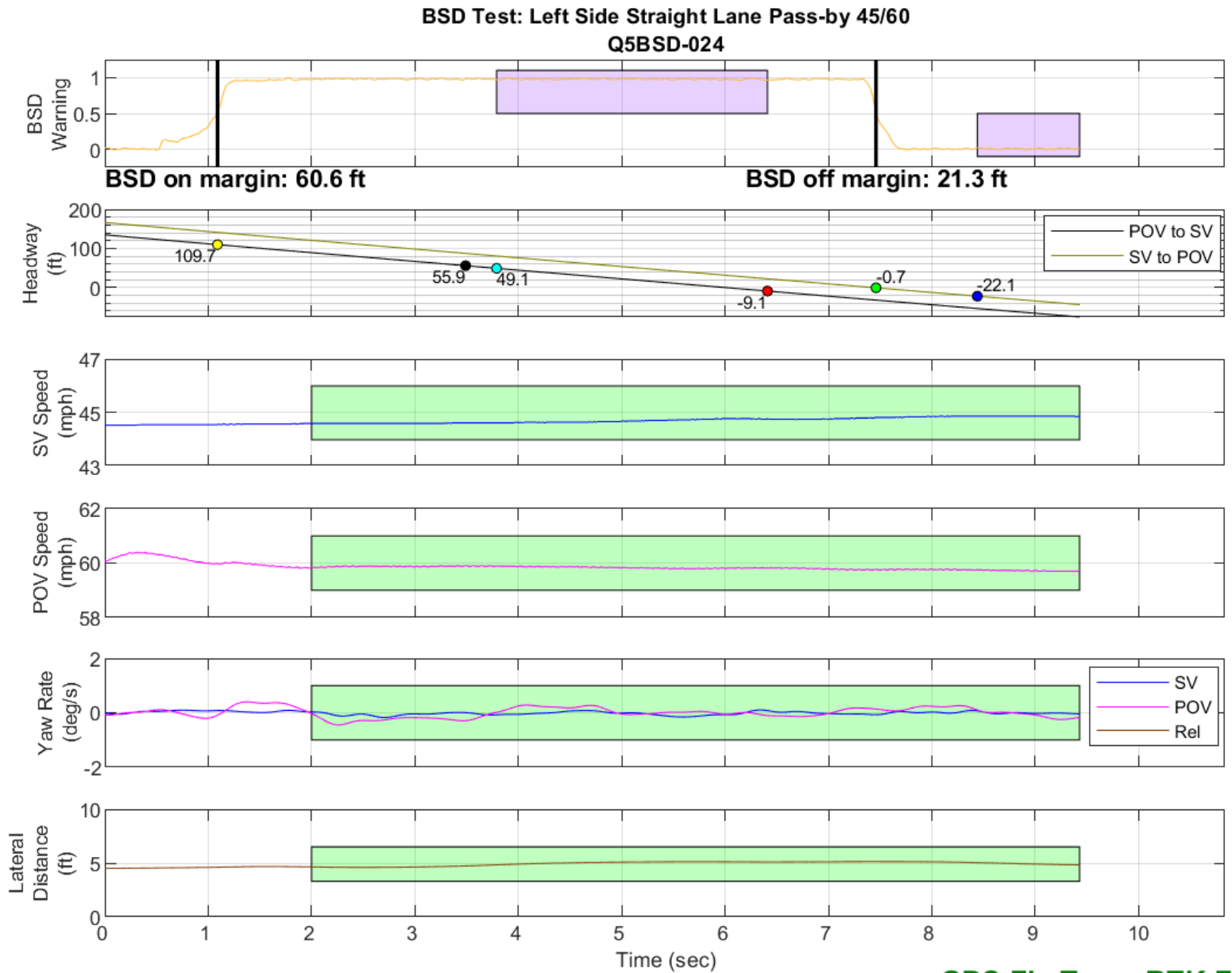
GPS Fix Type: RTK Fixed

Figure D52. BSD Run 21, Straight Lane Pass-by, SV 45 mph, POV 60 mph



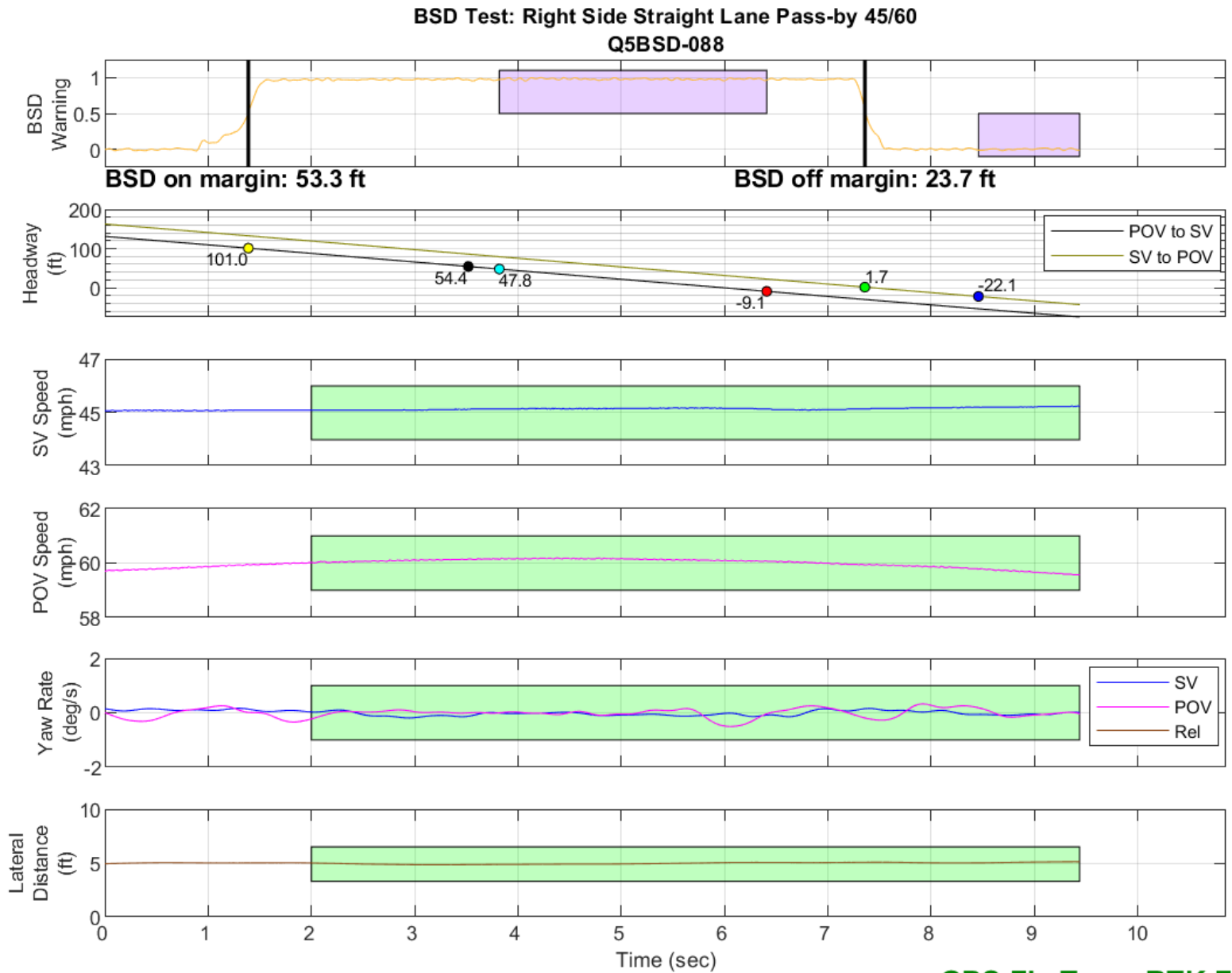
GPS Fix Type: RTK Fixed

Figure D53. BSD Run 22, Straight Lane Pass-by, SV 45 mph, POV 60 mph



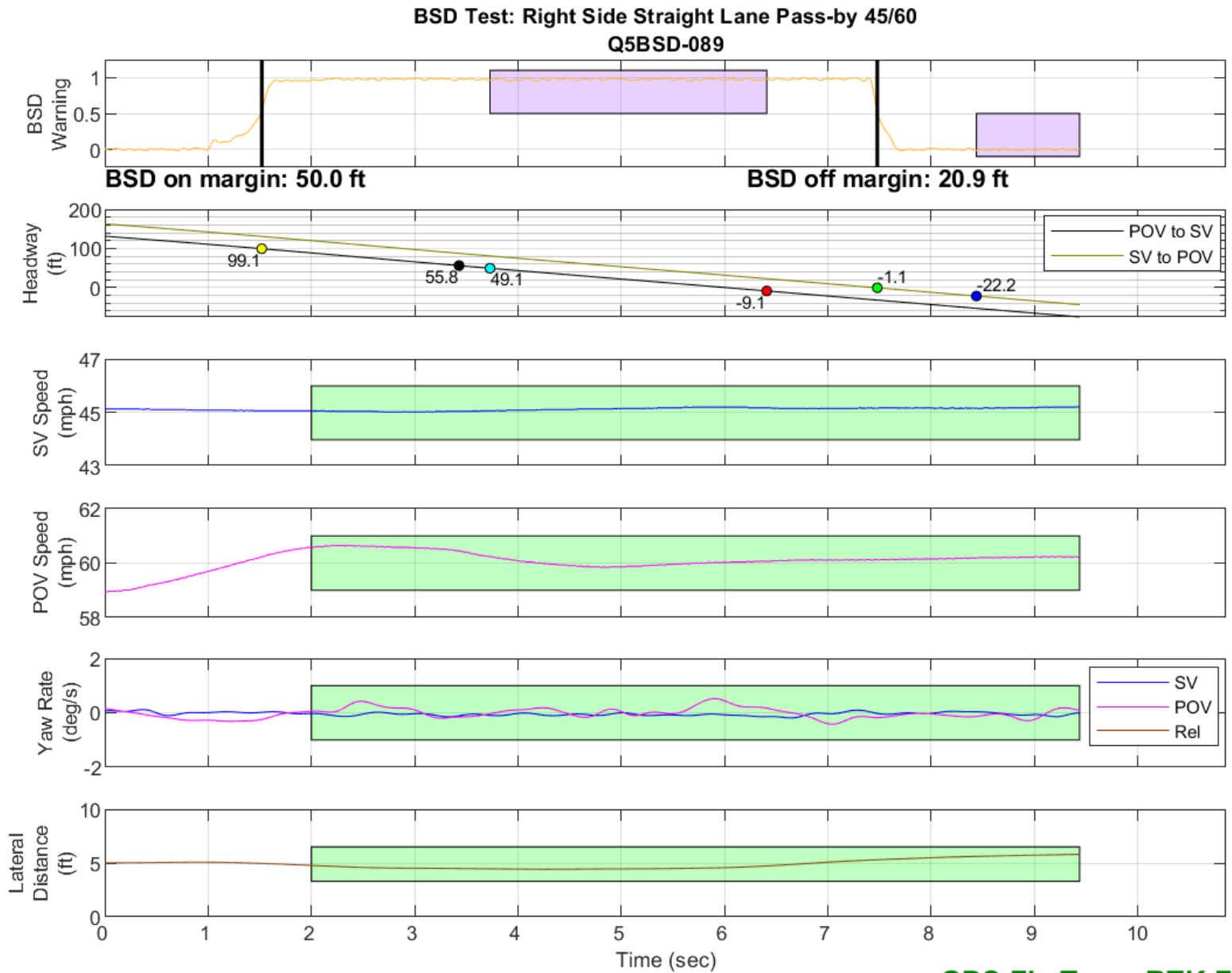
GPS Fix Type: RTK Fixed

Figure D54. BSD Run 24, Straight Lane Pass-by, SV 45 mph, POV 60 mph



GPS Fix Type: RTK Fixed

Figure D55. BSD Run 88, Straight Lane Pass-by, SV 45 mph, POV 60 mph



GPS Fix Type: RTK Fixed

Figure D56. BSD Run 89, Straight Lane Pass-by, SV 45 mph, POV 60 mph

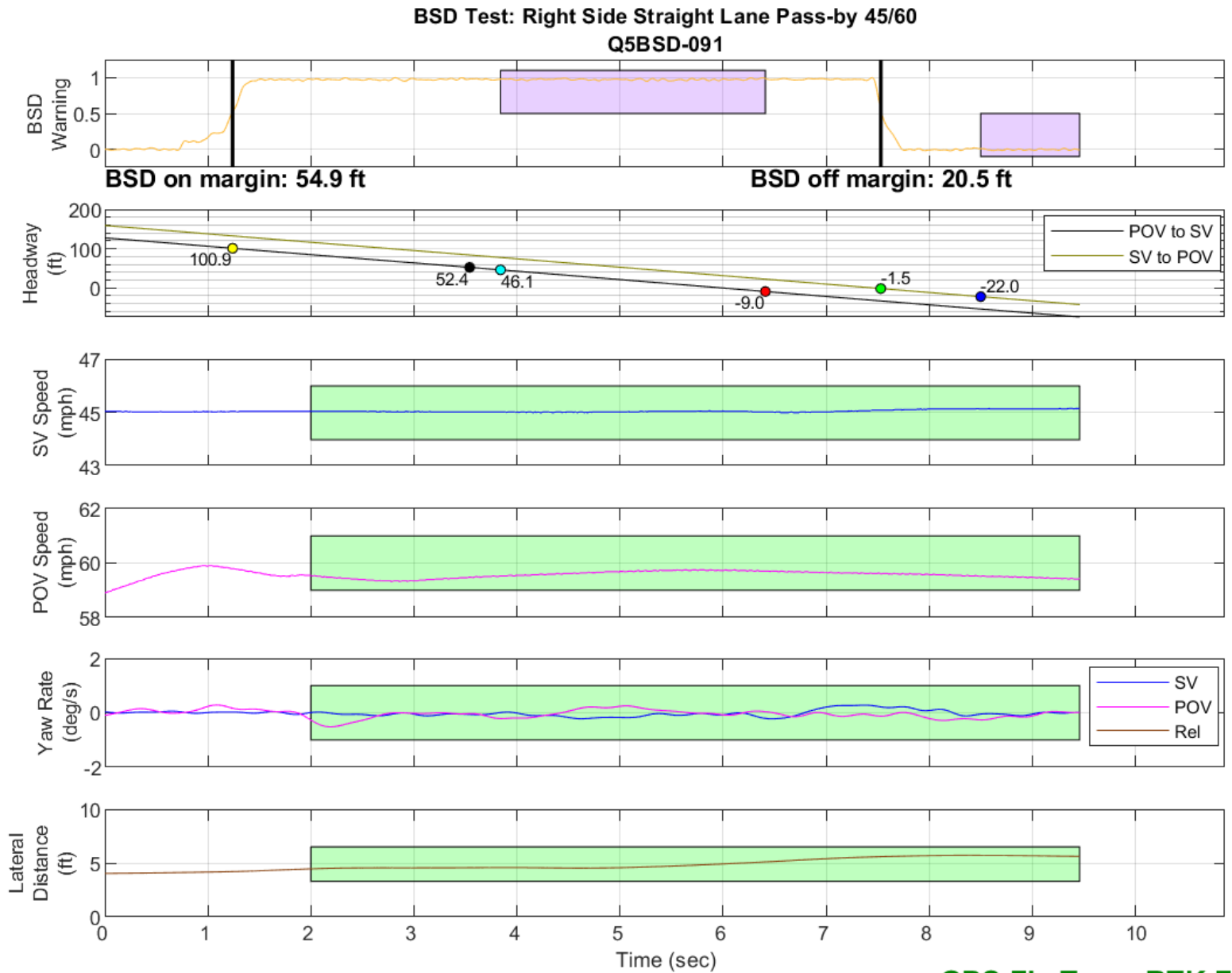
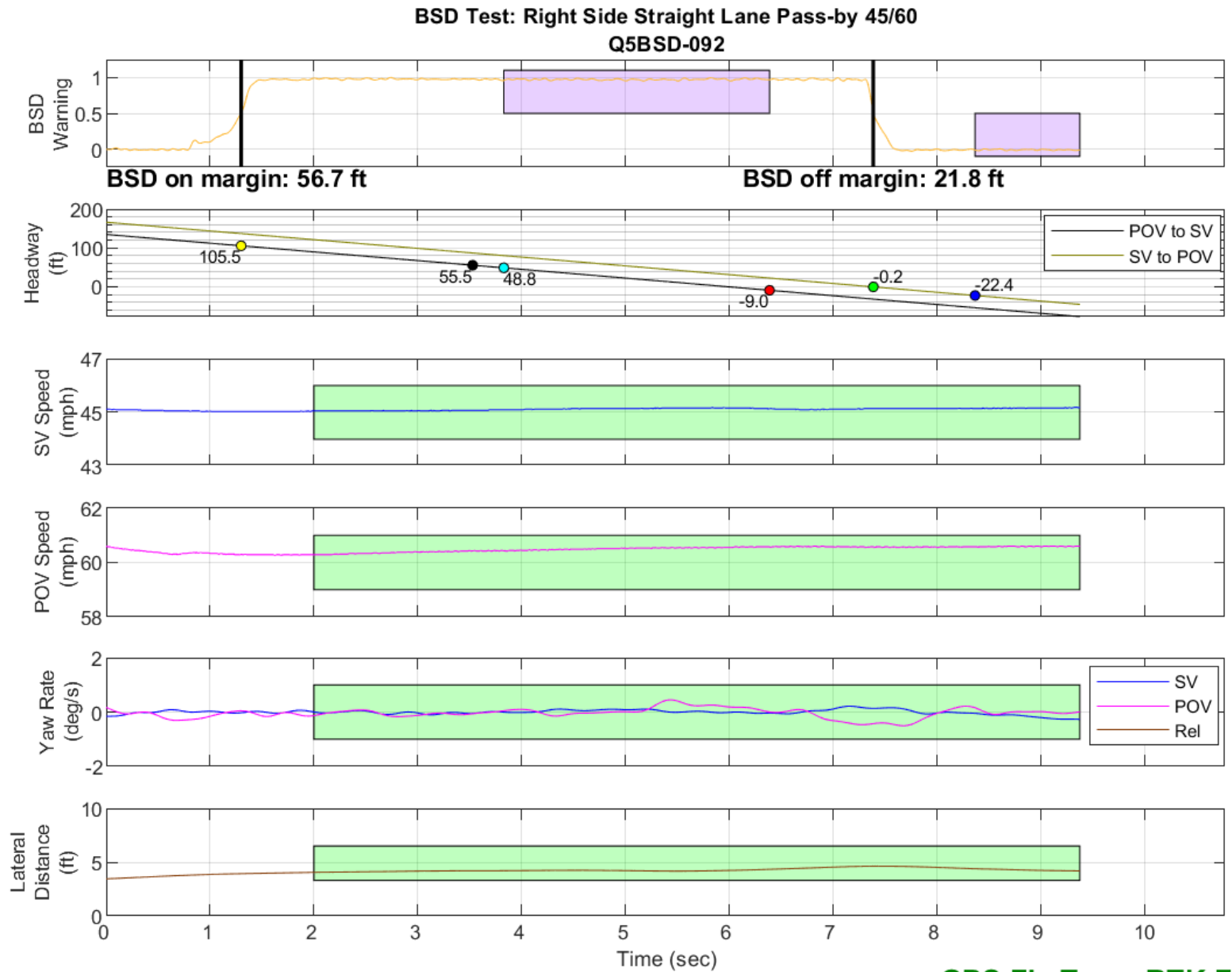
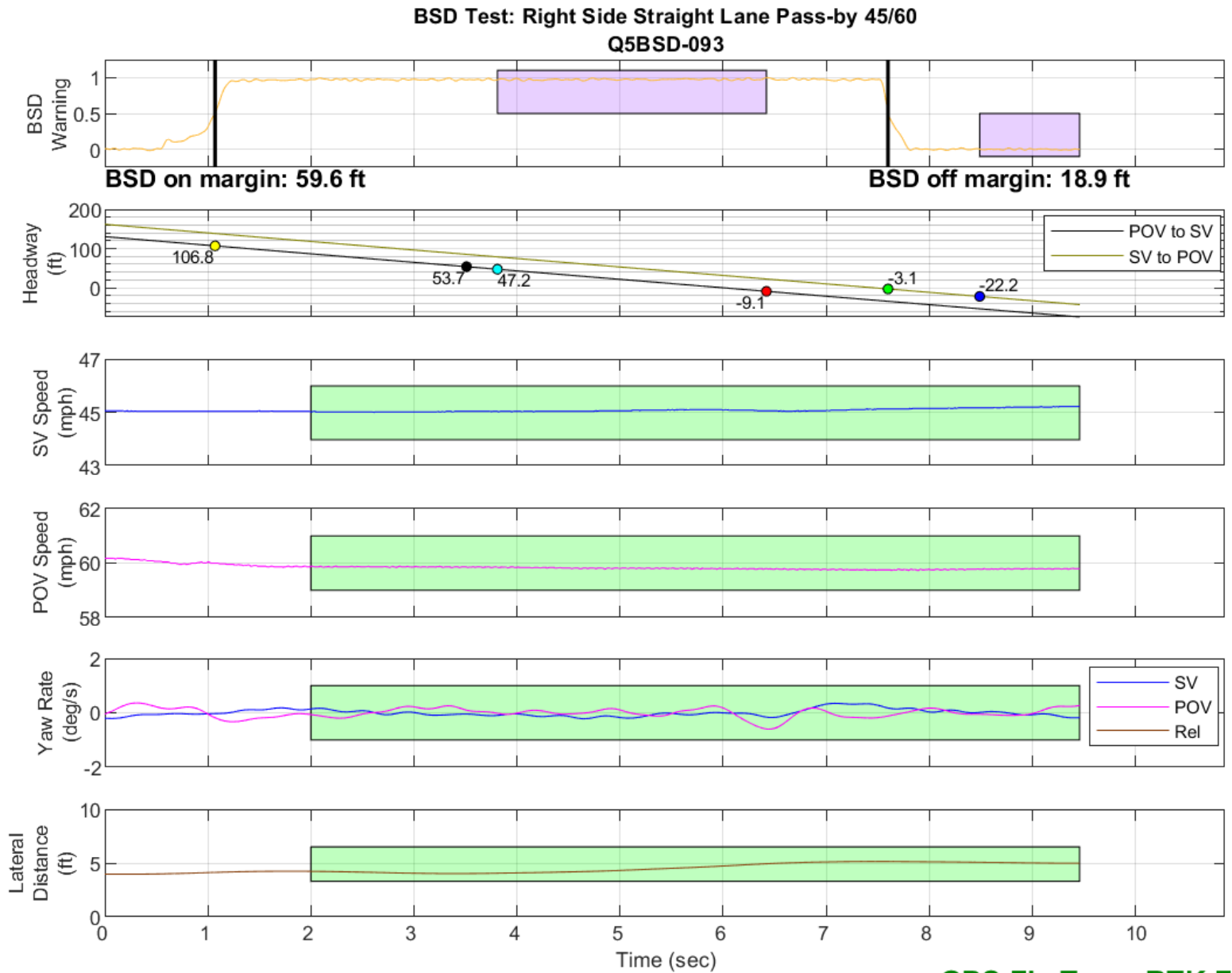


Figure D57. BSD Run 91, Straight Lane Pass-by, SV 45 mph, POV 60 mph



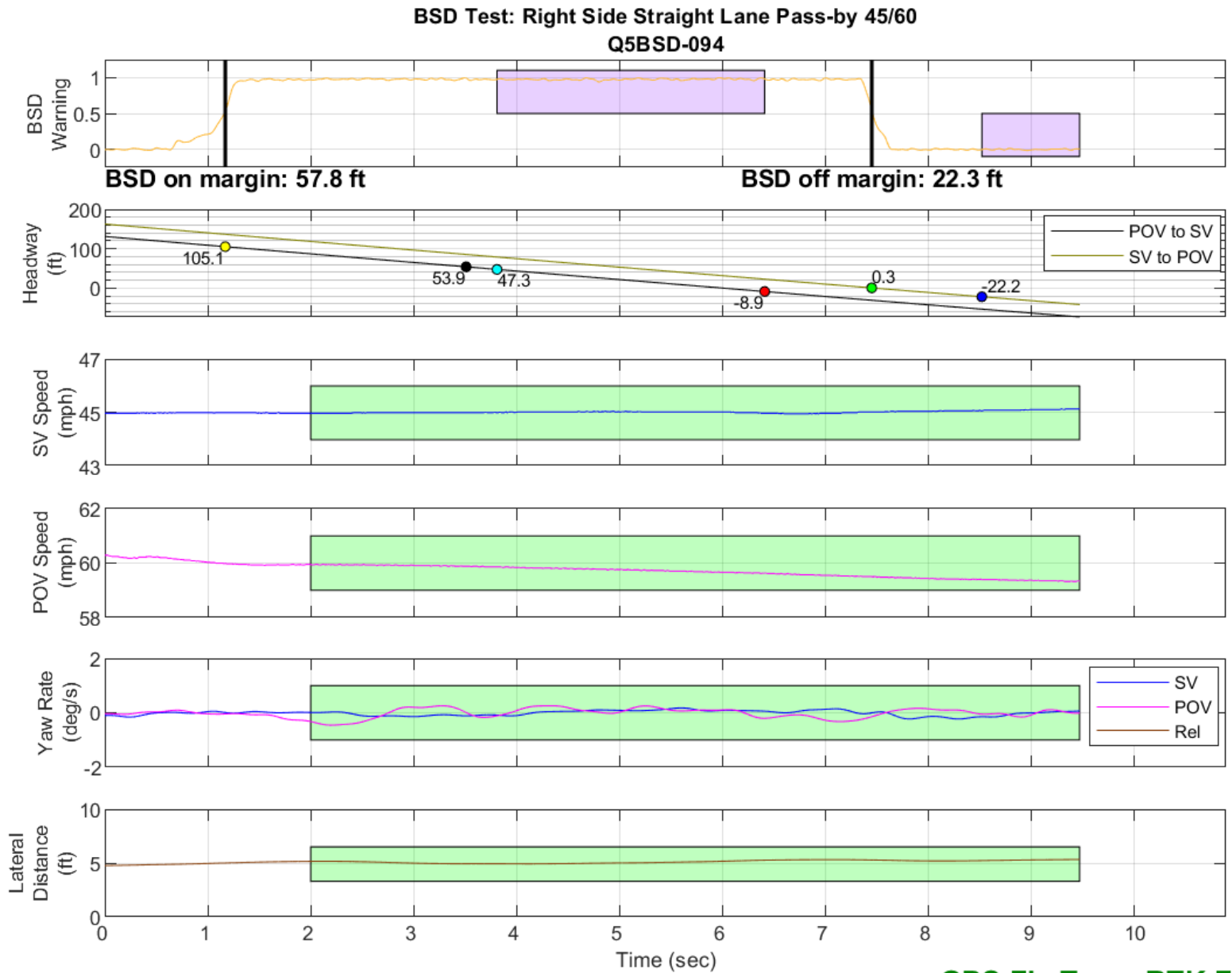
GPS Fix Type: RTK Fixed

Figure D58. BSD Run 92, Straight Lane Pass-by, SV 45 mph, POV 60 mph



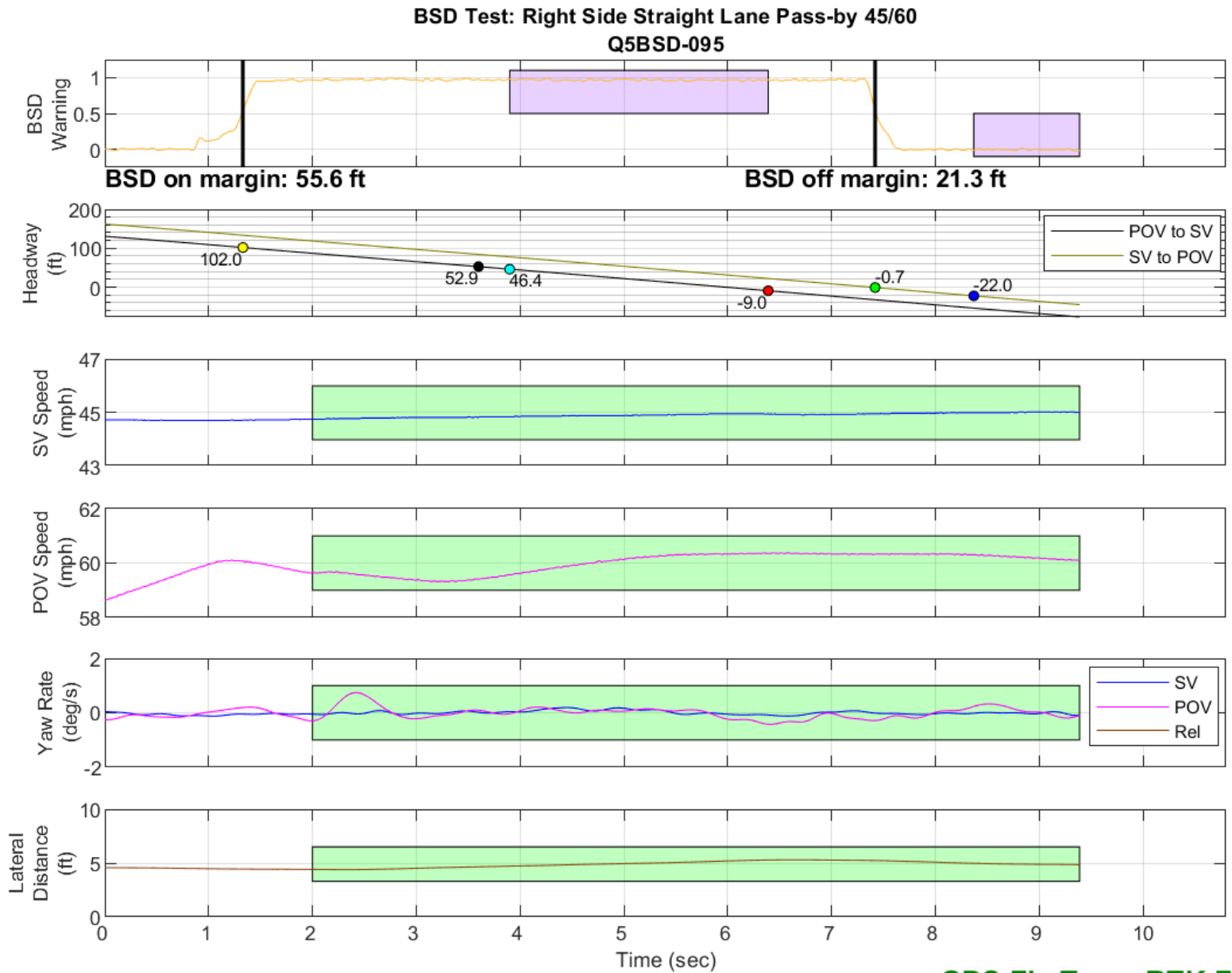
GPS Fix Type: RTK Fixed

Figure D59. BSD Run 93, Straight Lane Pass-by, SV 45 mph, POV 60 mph



GPS Fix Type: RTK Fixed

Figure D60. BSD Run 94, Straight Lane Pass-by, SV 45 mph, POV 60 mph



GPS Fix Type: RTK Fixed

Figure D61. BSD Run 95, Straight Lane Pass-by, SV 45 mph, POV 60 mph

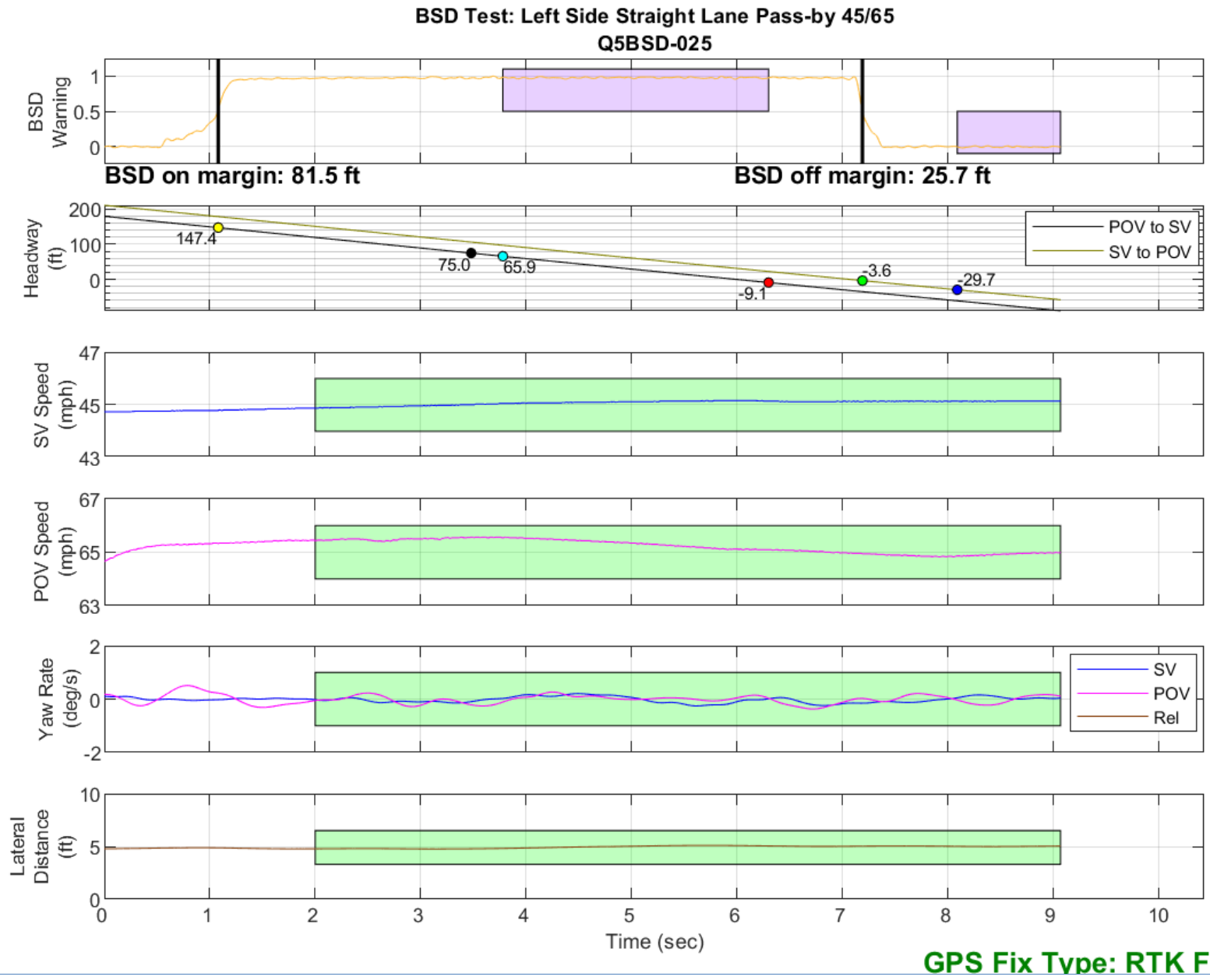
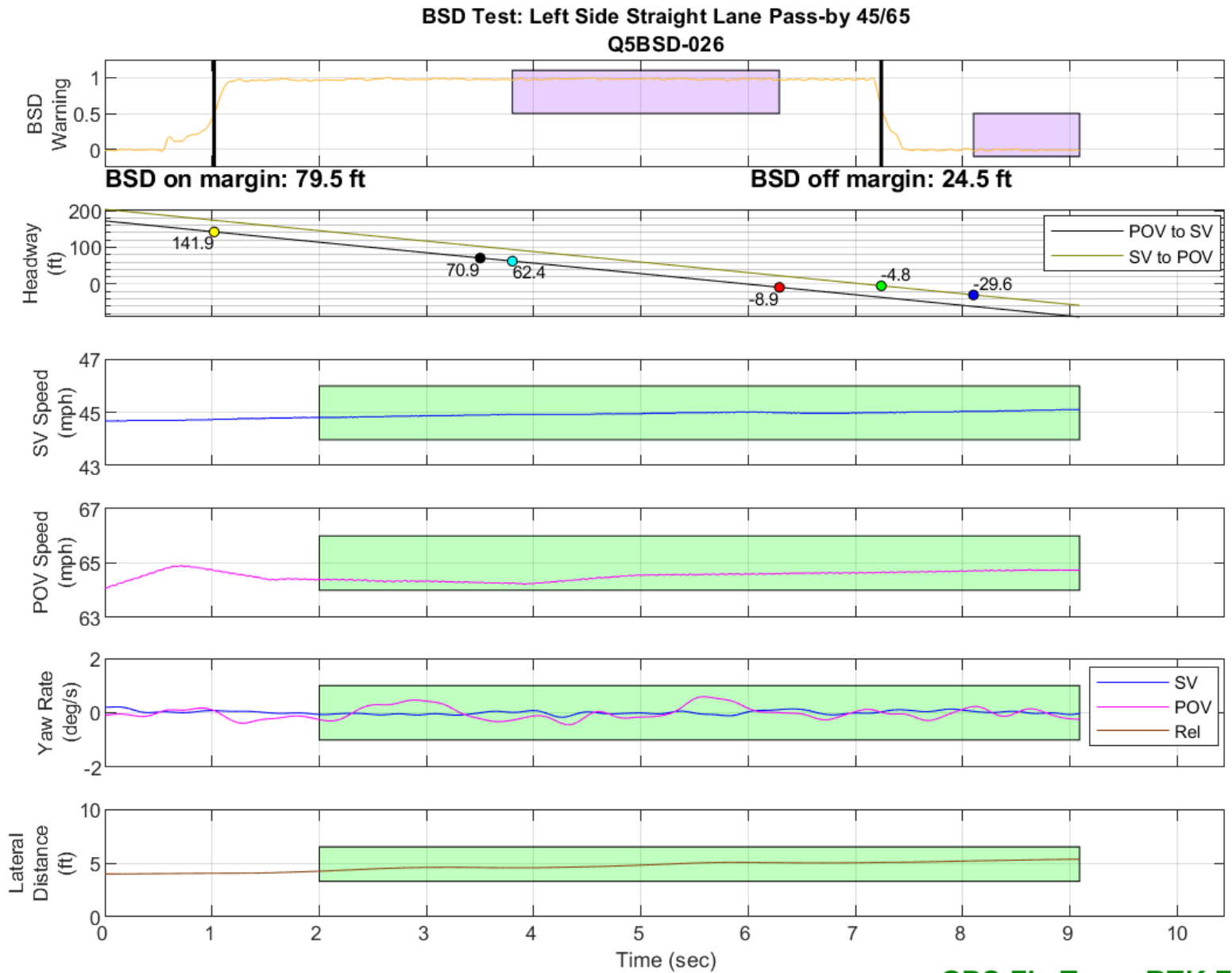
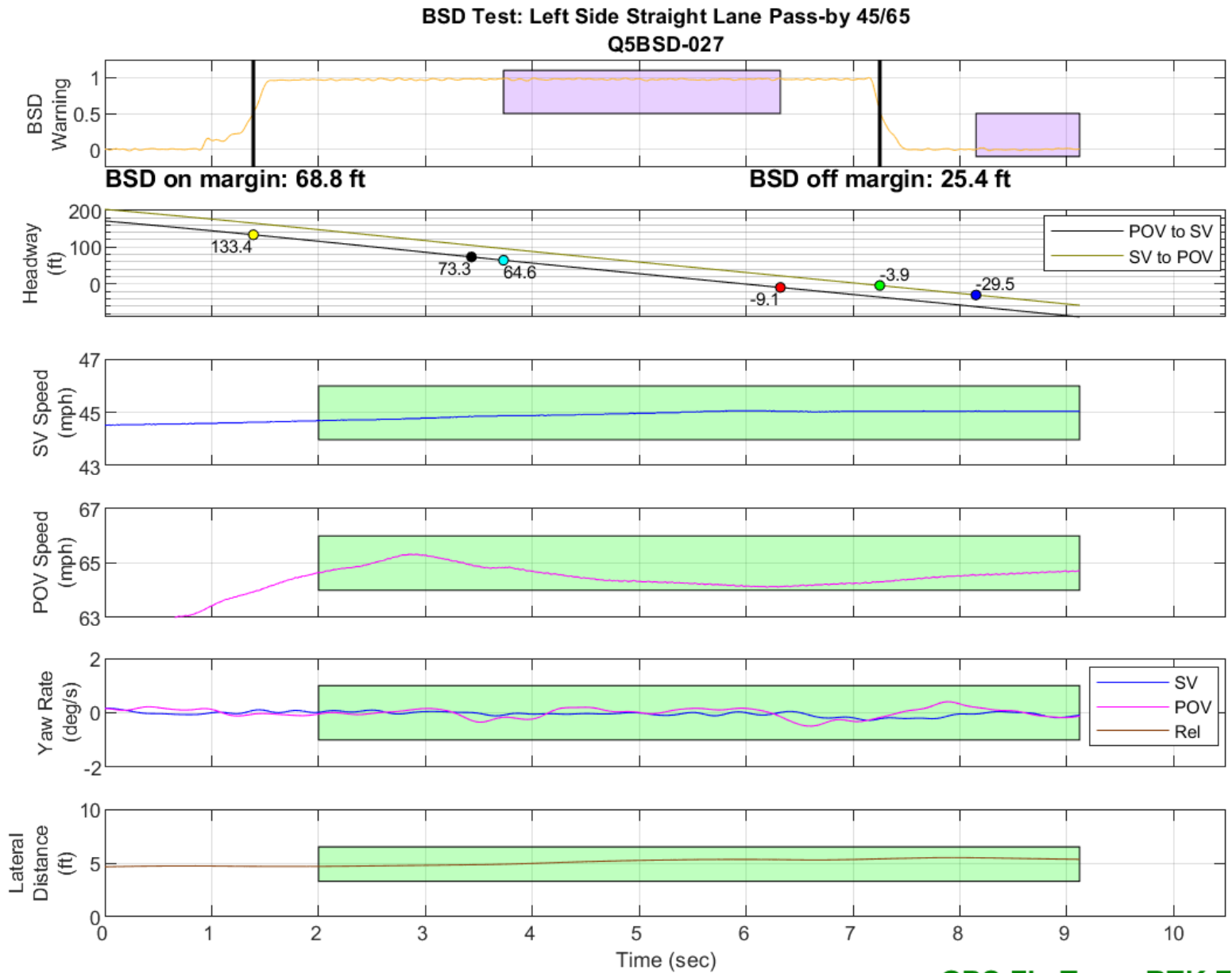


Figure D62. BSD Run 25, Straight Lane Pass-by, SV 45 mph, POV 65 mph



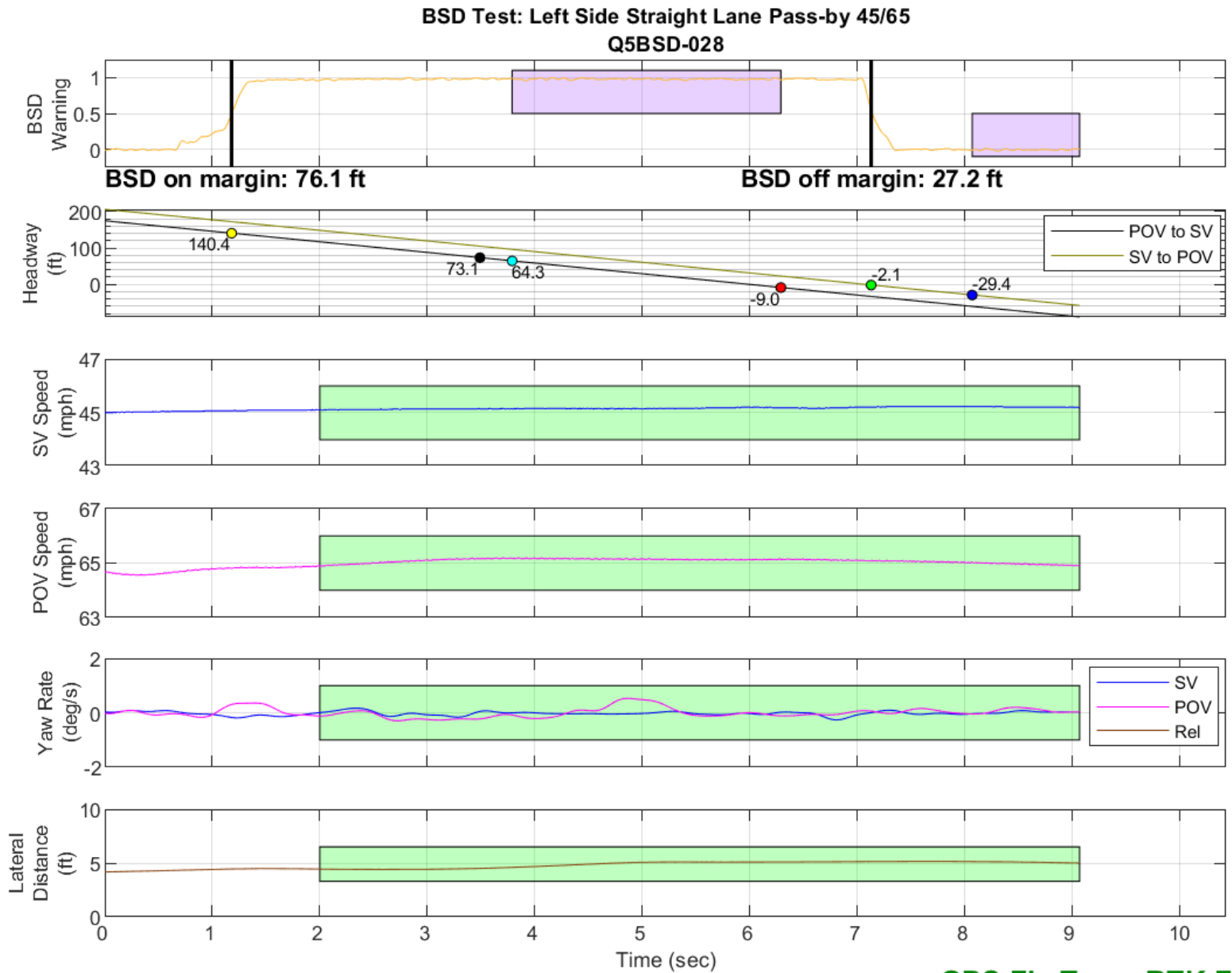
GPS Fix Type: RTK Fixed

Figure D63. BSD Run 26, Straight Lane Pass-by, SV 45 mph, POV 65 mph



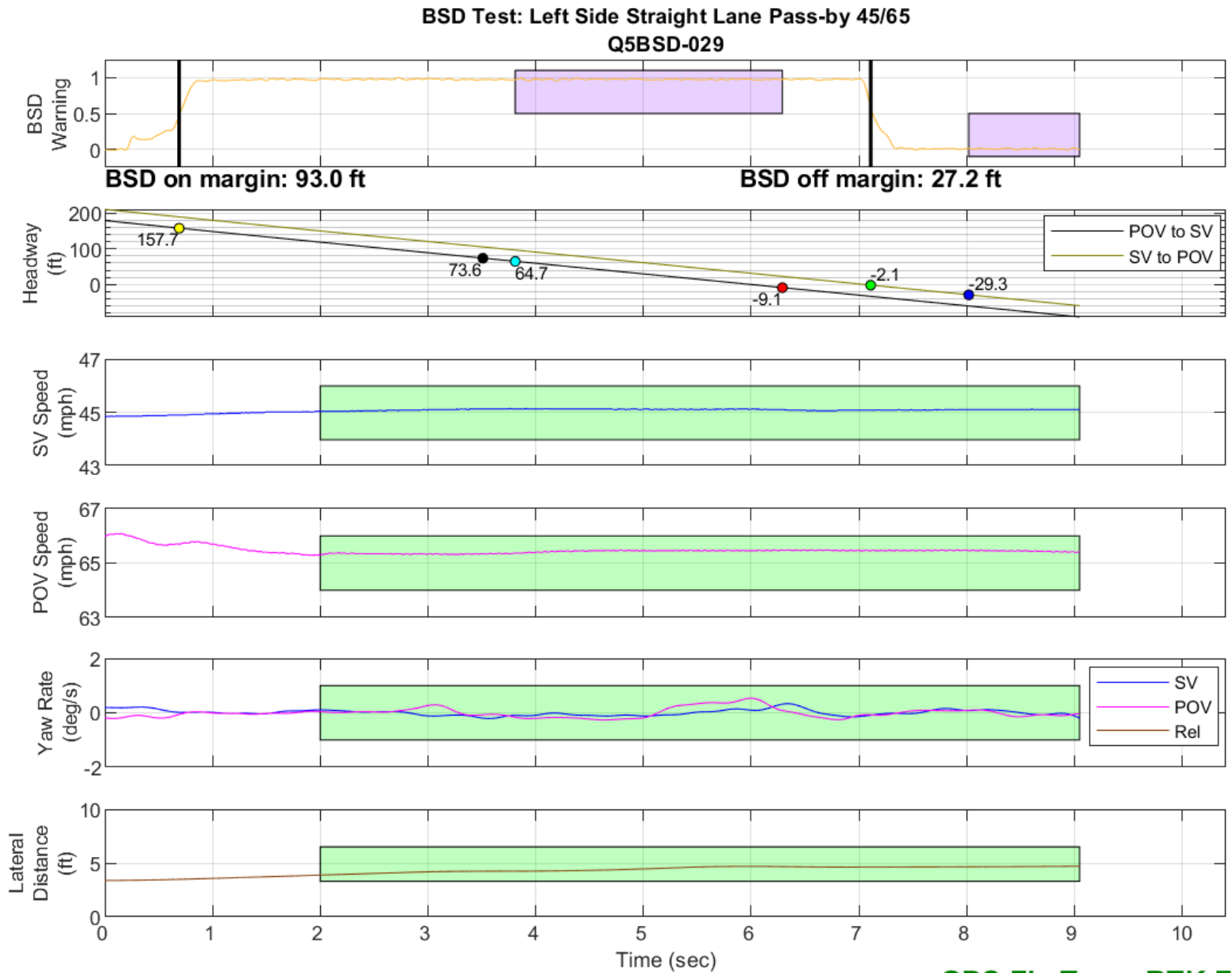
GPS Fix Type: RTK Fixed

Figure D64. BSD Run 27, Straight Lane Pass-by, SV 45 mph, POV 65 mph



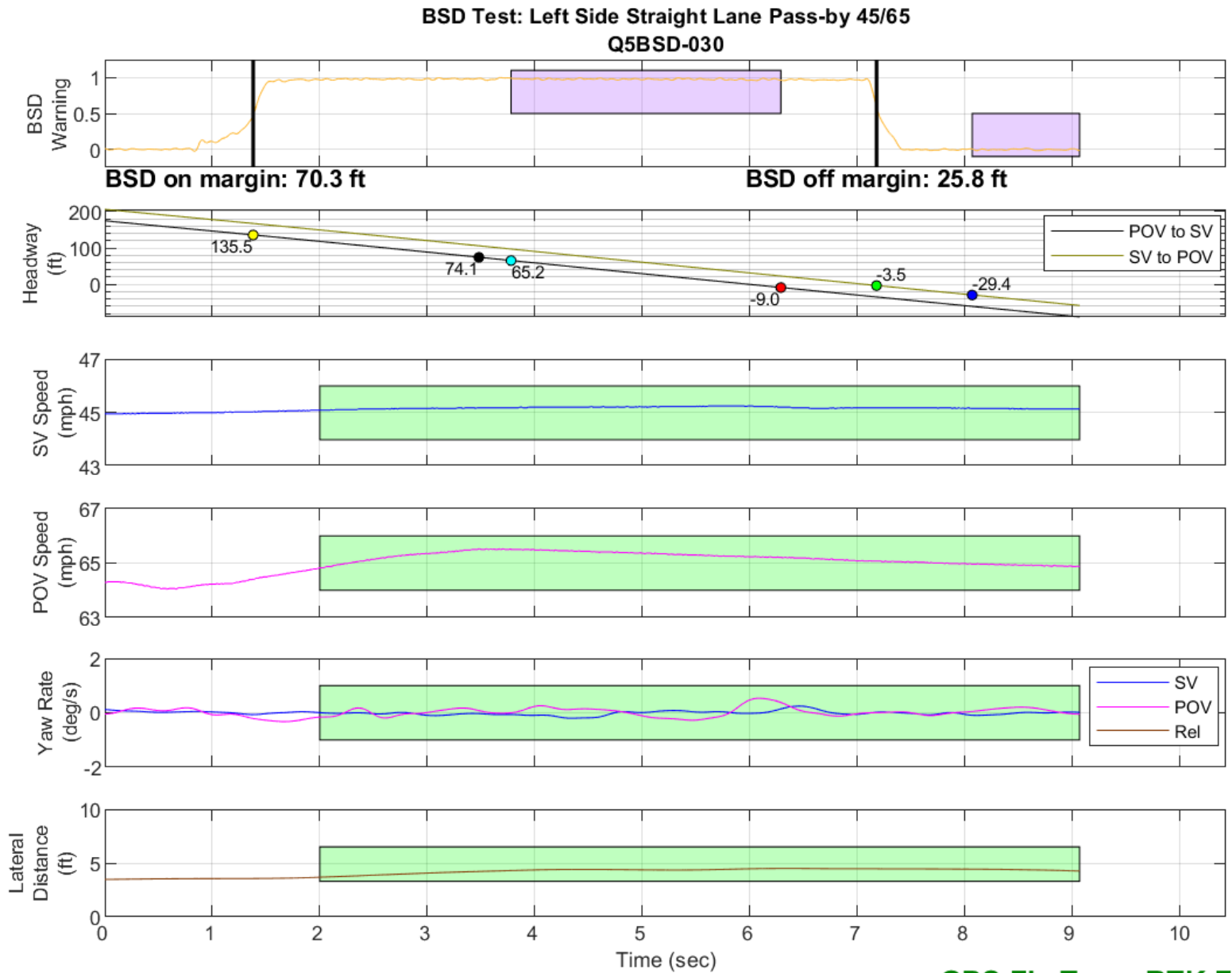
GPS Fix Type: RTK Fixed

Figure D65. BSD Run 28, Straight Lane Pass-by, SV 45 mph, POV 65 mph



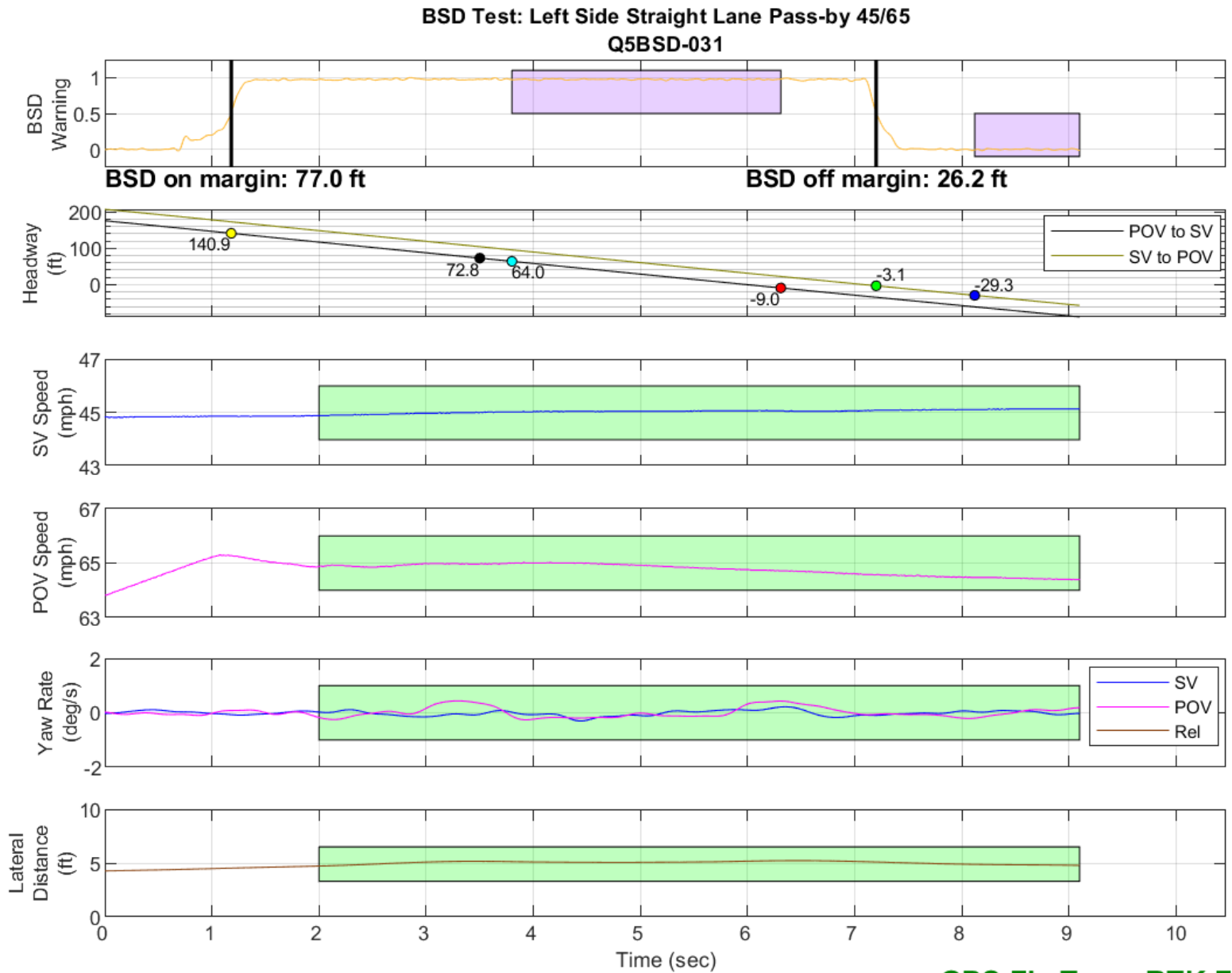
GPS Fix Type: RTK Fixed

Figure D66. BSD Run 29, Straight Lane Pass-by, SV 45 mph, POV 65 mph



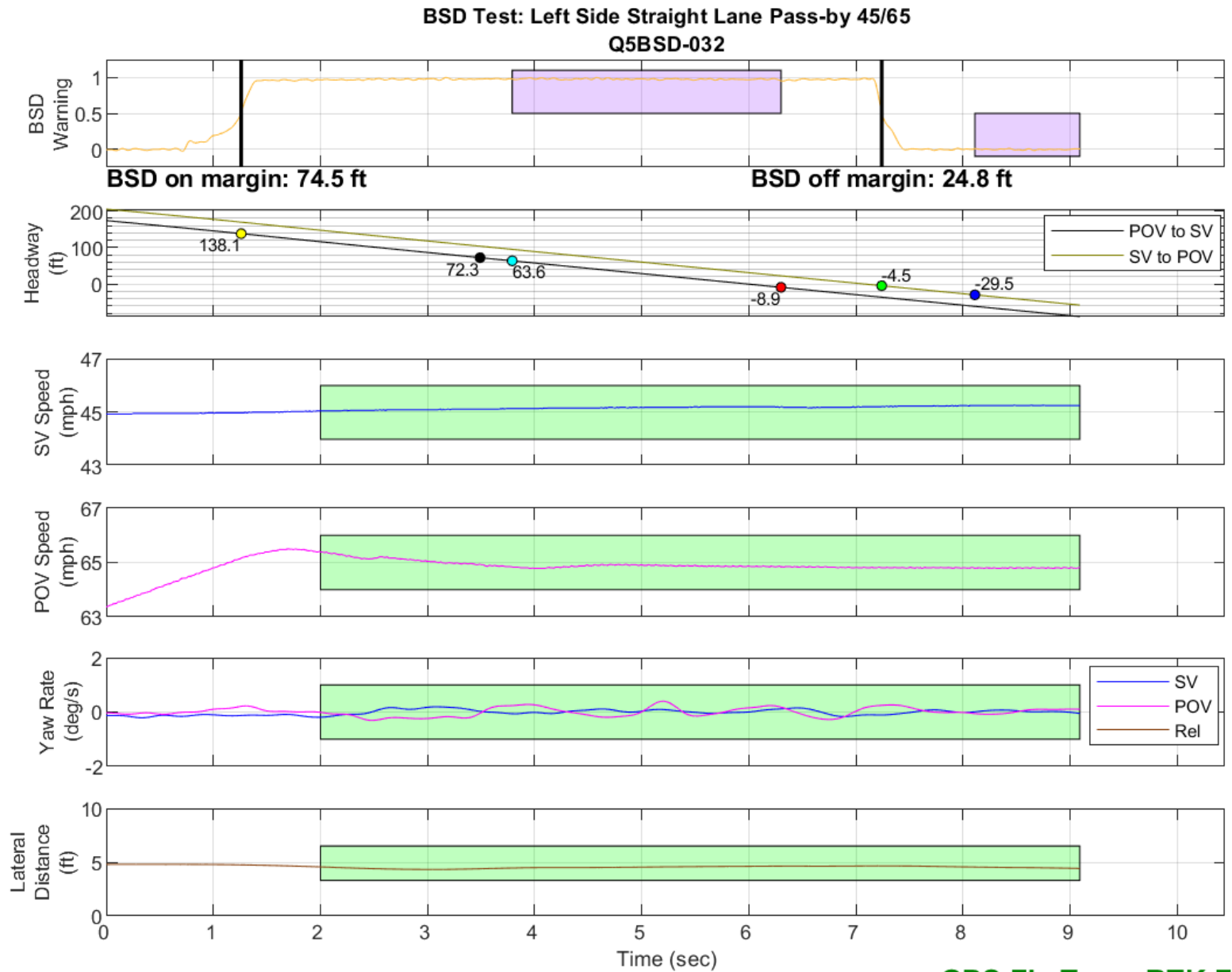
GPS Fix Type: RTK Fixed

Figure D67. BSD Run 30, Straight Lane Pass-by, SV 45 mph, POV 65 mph



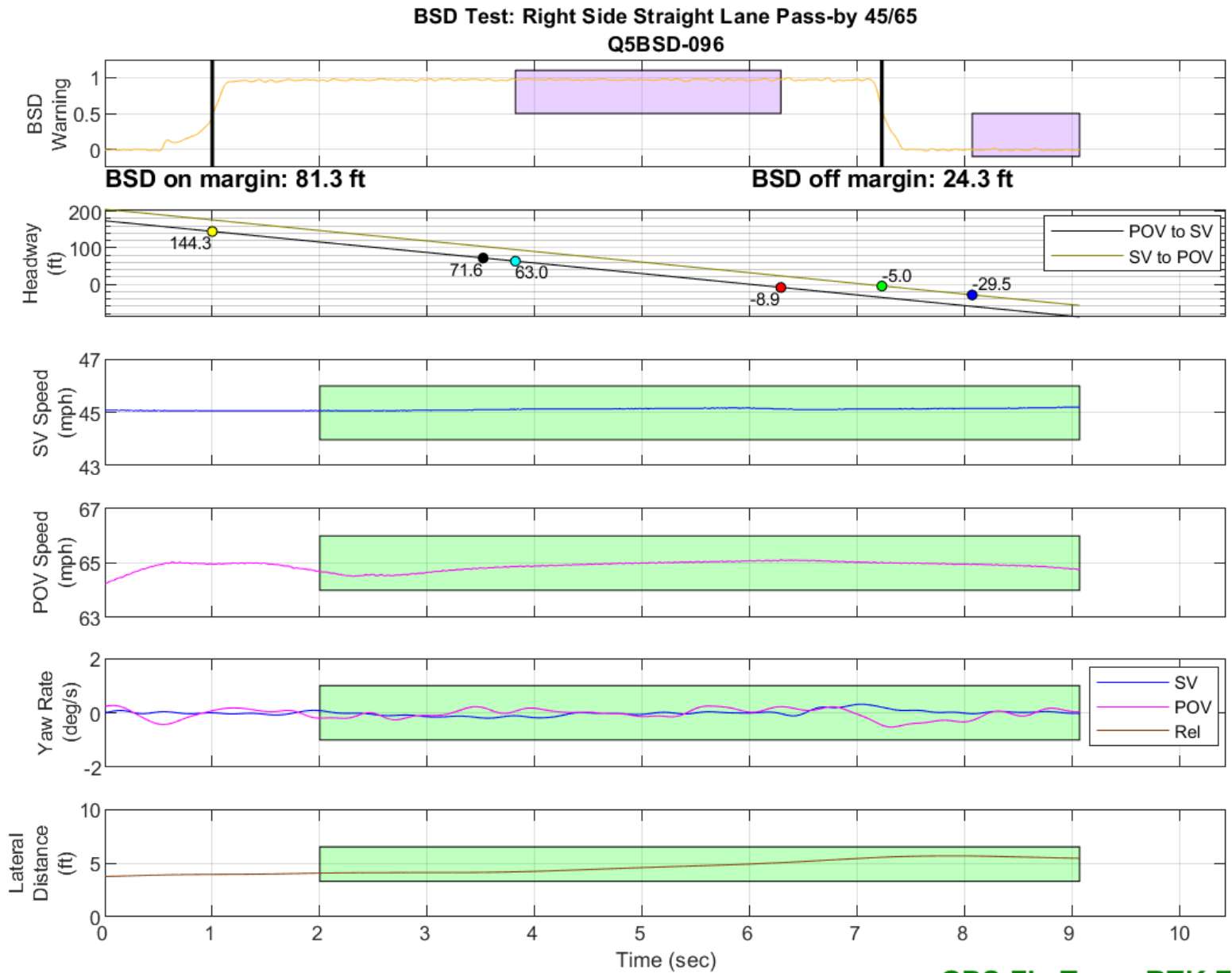
GPS Fix Type: RTK Fixed

Figure D68. BSD Run 31, Straight Lane Pass-by, SV 45 mph, POV 65 mph



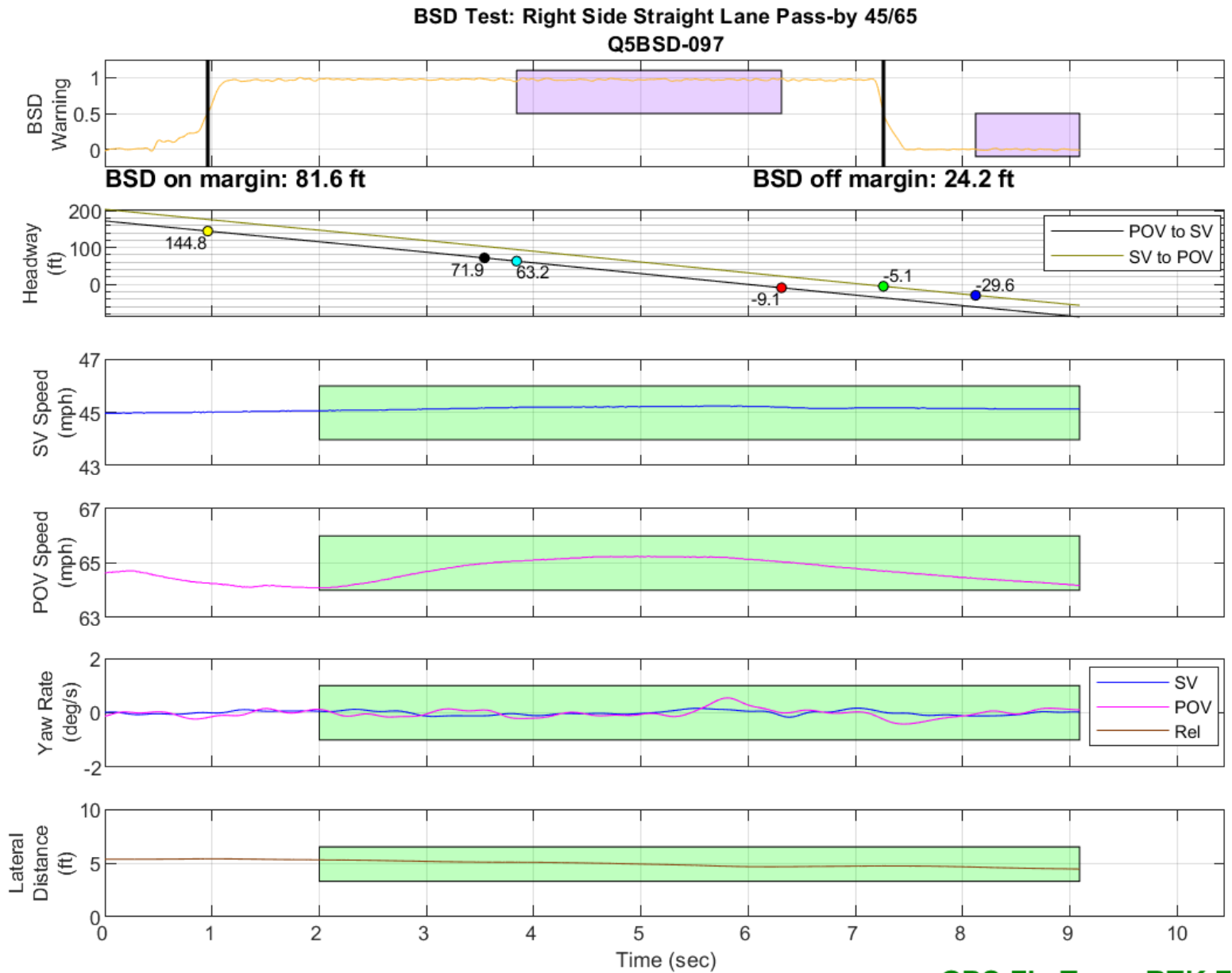
GPS Fix Type: RTK Fixed

Figure D69. BSD Run 32, Straight Lane Pass-by, SV 45 mph, POV 65 mph



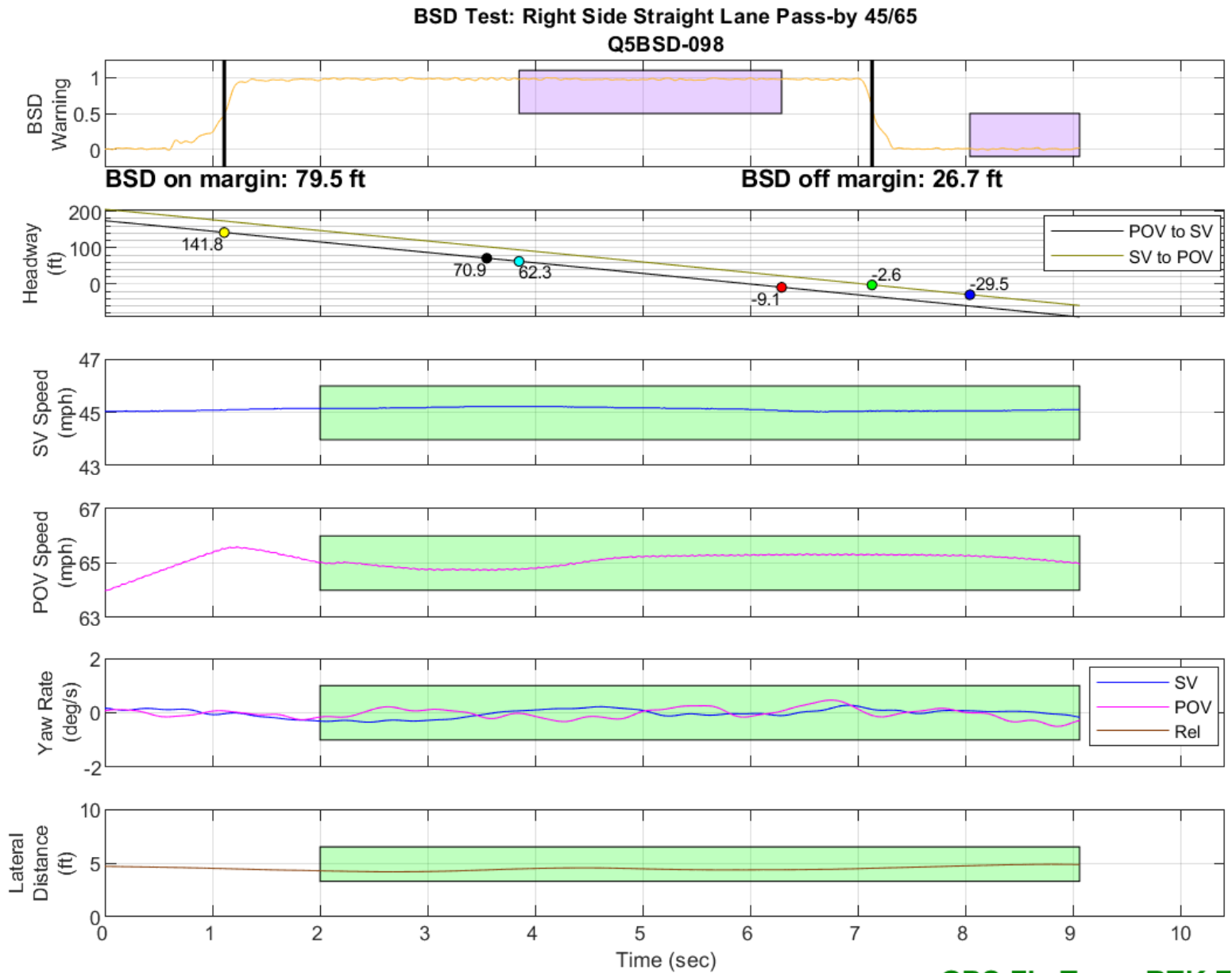
GPS Fix Type: RTK Fixed

Figure D70. BSD Run 96, Straight Lane Pass-by, SV 45 mph, POV 65 mph



GPS Fix Type: RTK Fixed

Figure D71. BSD Run 97, Straight Lane Pass-by, SV 45 mph, POV 65 mph



GPS Fix Type: RTK Fixed

Figure D72. BSD Run 98, Straight Lane Pass-by, SV 45 mph, POV 65 mph

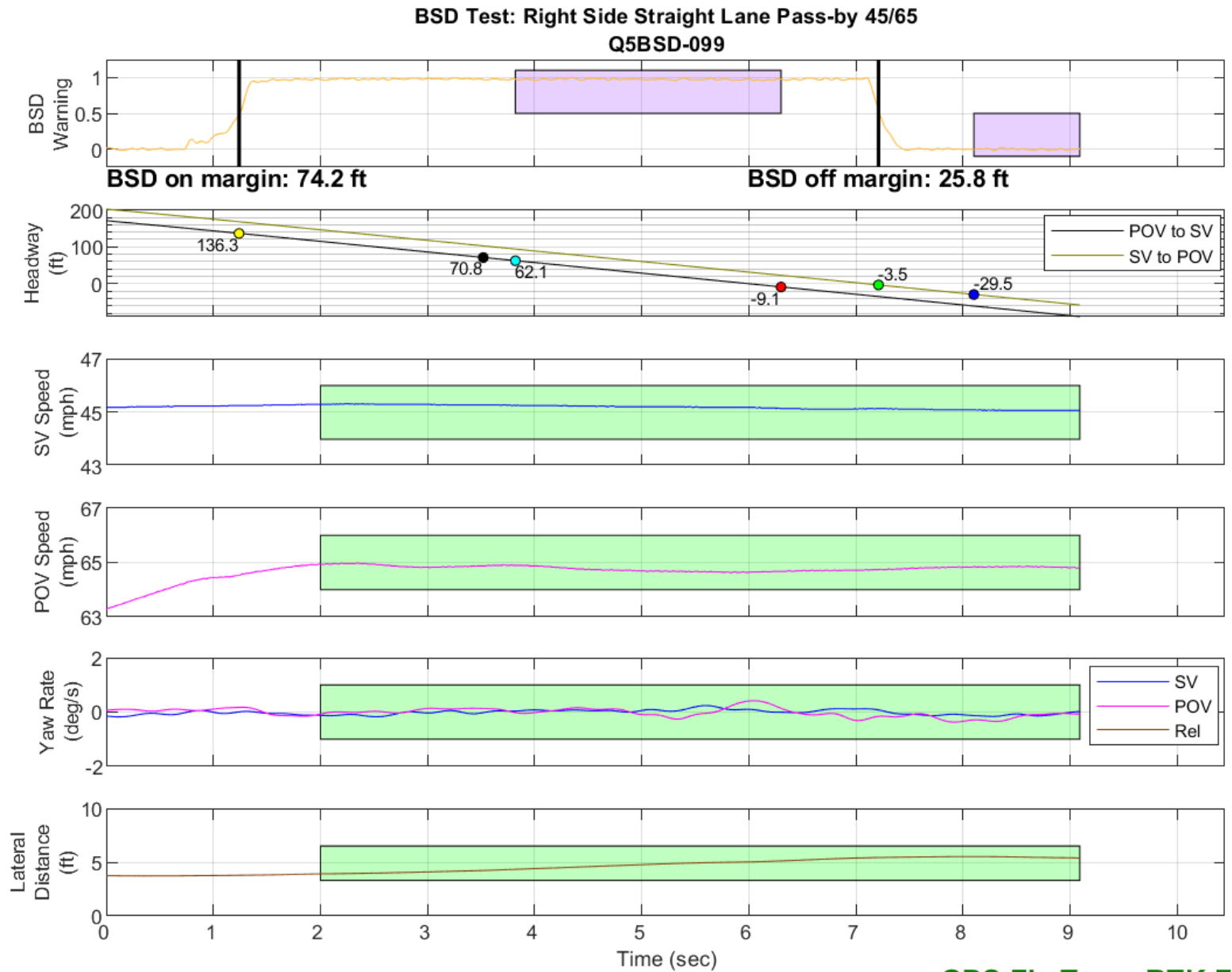


Figure D73. BSD Run 99, Straight Lane Pass-by, SV 45 mph, POV 65 mph

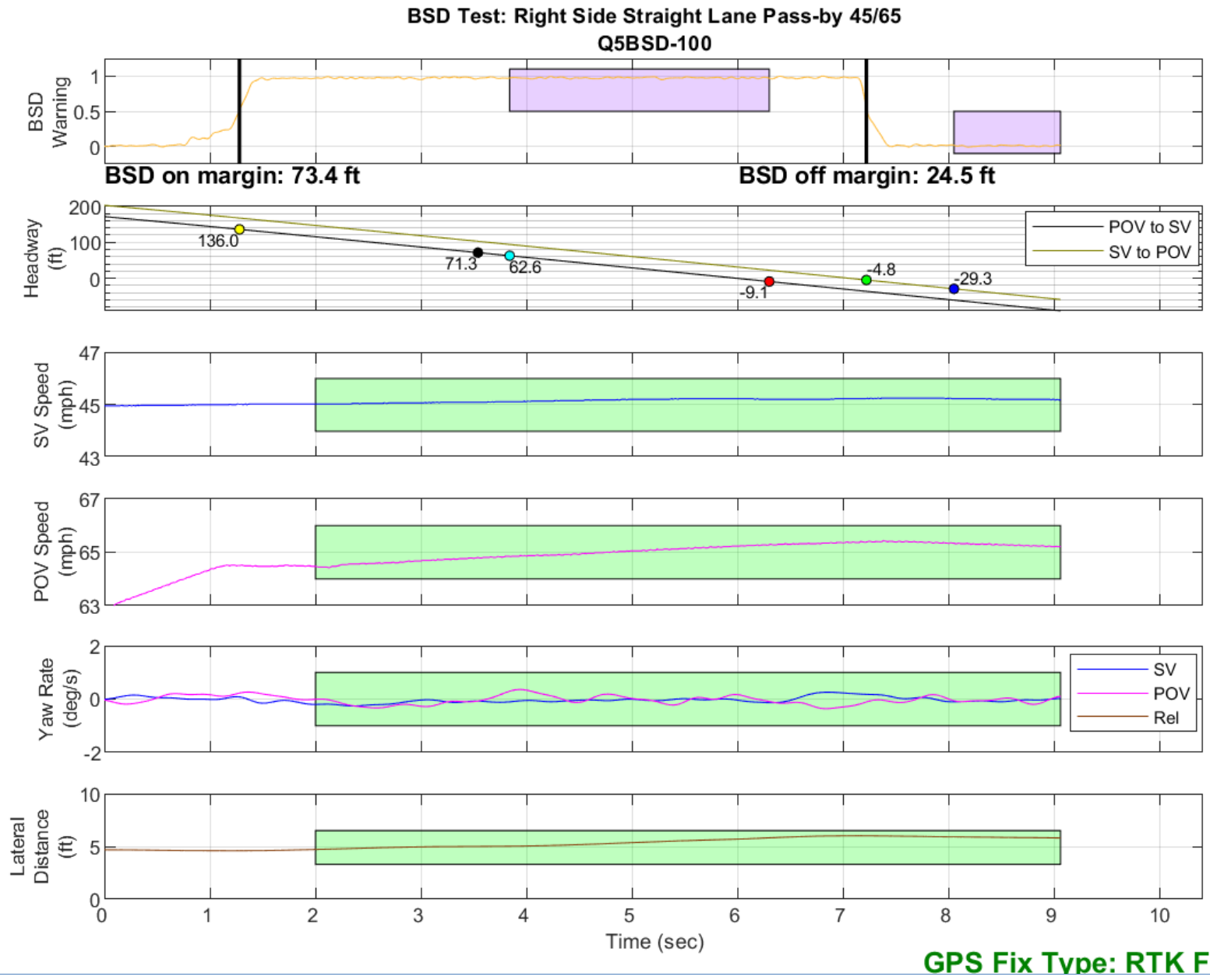
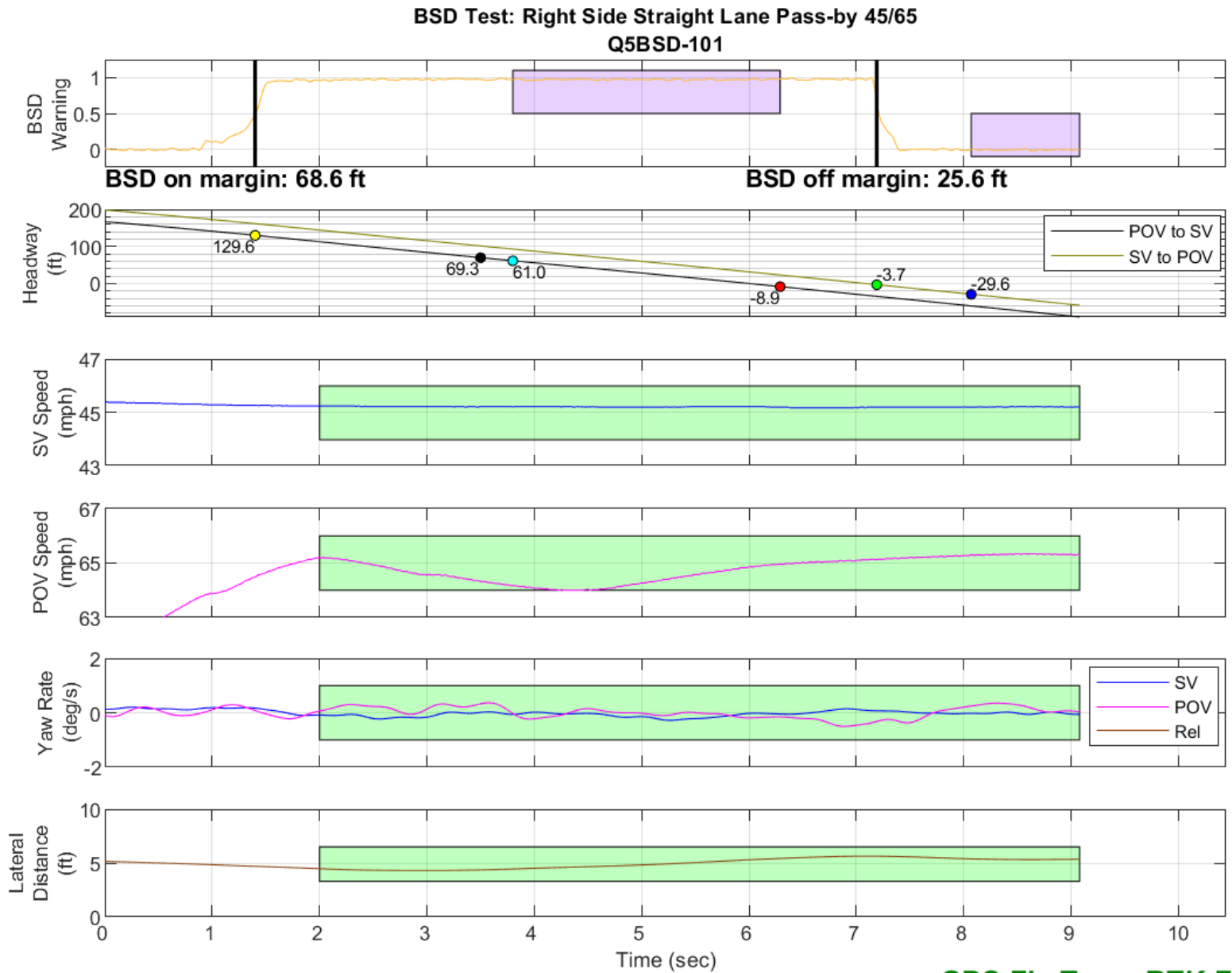
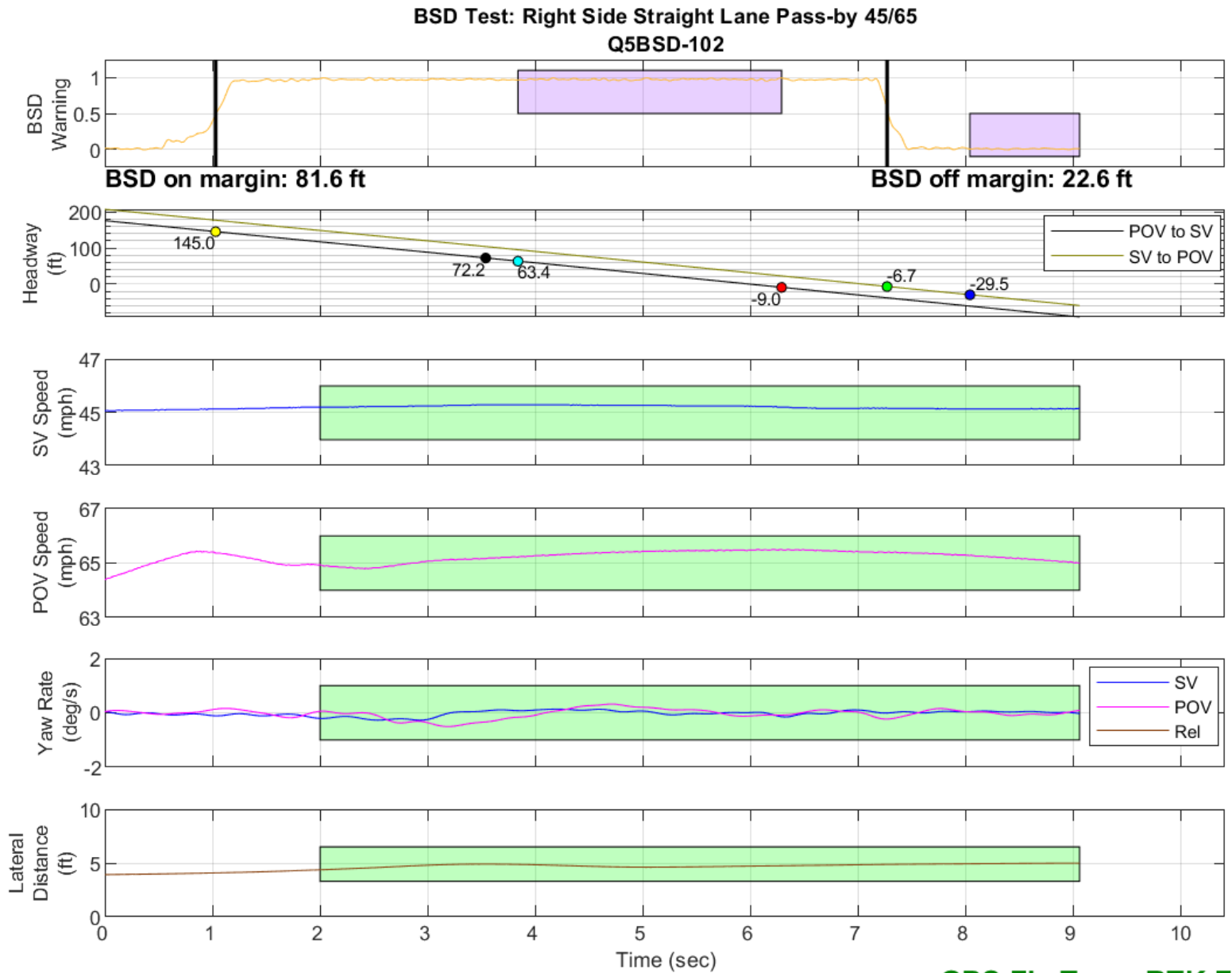


Figure D74. BSD Run 100, Straight Lane Pass-by, SV 45 mph, POV 65 mph



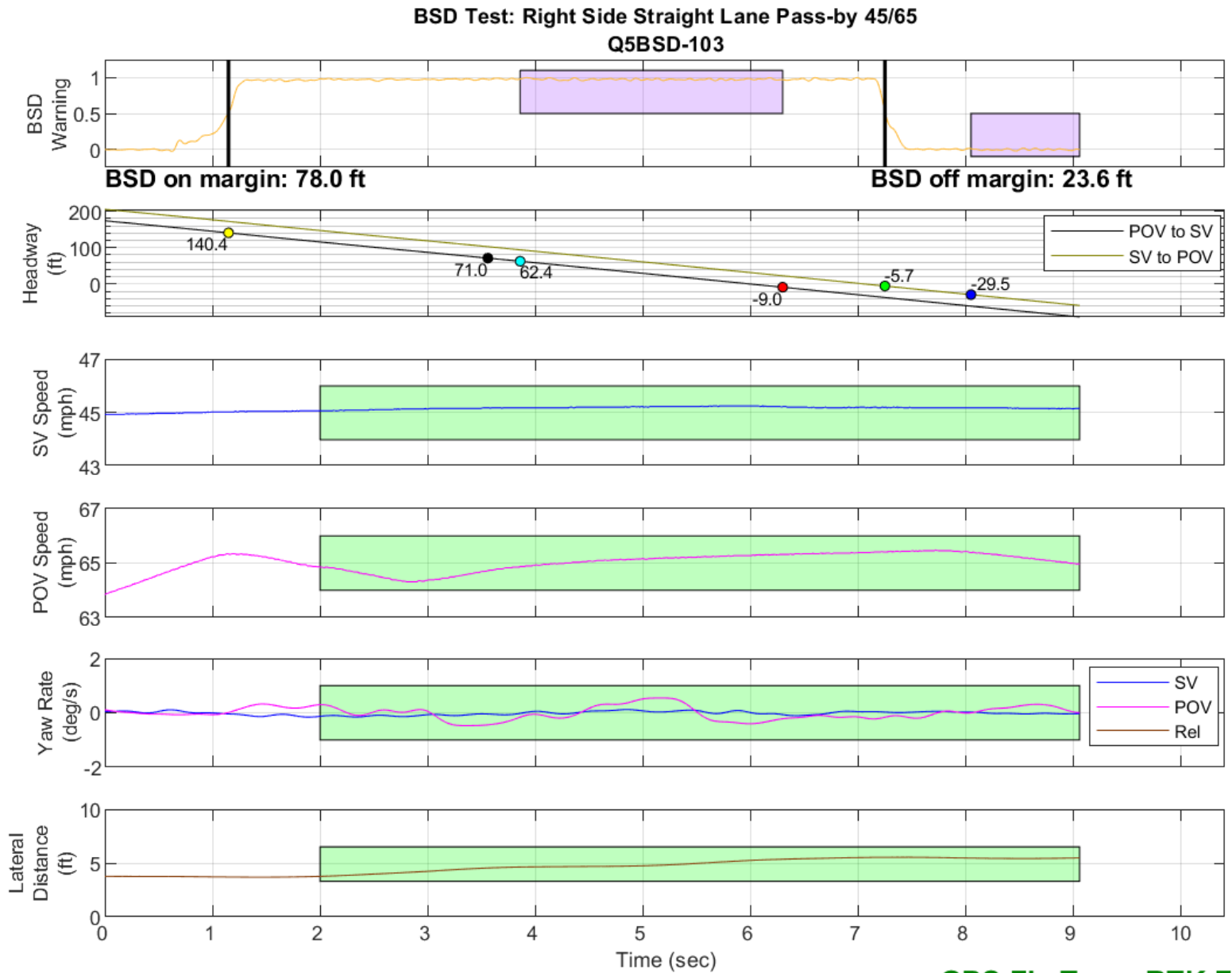
GPS Fix Type: RTK Fixed

Figure D75. BSD Run 101, Straight Lane Pass-by, SV 45 mph, POV 65 mph



GPS Fix Type: RTK Fixed

Figure D76. BSD Run 102, Straight Lane Pass-by, SV 45 mph, POV 65 mph



GPS Fix Type: RTK Fixed

Figure D77. BSD Run 103, Straight Lane Pass-by, SV 45 mph, POV 65 mph