BLIND SPOT INTERVENTION SYSTEM CONFIRMATION TEST
NCAP-DRI-BSI-20-02

2020 Audi Q5 45 TFSI quattro

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4 January 2021

Final Report

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National Highway Traffic Safety Administration
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15. Supplementary Notes

16. Abstract

These tests were conducted on the subject 2020 Audi Q5 45 TFSI quattro in accordance with the specifications of the National Highway Traffic Safety Administration's most current Test Procedure in docket NHTSA-2019-0102-0001, BLIND SPOT INTERVENTION SYSTEM CONFIRMATION TEST, to confirm the performance of a Blind Spot Intervention system. The vehicle met the preliminary BSI requirements for 16 out of 21 valid trials.

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Section I

INTRODUCTION

There are presently two commercially available crash avoidance technologies designed to directly address the “changing lanes/same direction” pre-crash scenario: Blind Spot Detection (BSD) and Blind Spot Intervention (BSI). BSD is a warning-based passive technology designed to help the driver recognize that another vehicle is approaching, or being operated within, the blind spot of their vehicle in an adjacent lane. Should the driver initiate a lane change towards this other vehicle, the BSD presents an alert before a collision is expected to occur. BSI systems are designed to actively help the driver avoid a collision with another vehicle that is approaching, or being operated within, the blind spot of their vehicle in an adjacent lane.

This research test evaluates BSI systems on light vehicles with SAE automation levels 0, 1, 2, or 3, as specified in the National Highway Traffic Safety Administration’s “Blind Spot Intervention System Confirmation Test”, July 2019. The subject light vehicles have gross vehicle weight ratings (GVWR) under 10,000 pounds. BSI technology uses sensors to detect the presence of other vehicles in the equipped vehicle’s left and right blind spot and then intervene to avoid a collision. The procedures described herein emulate three straight-road, real-world scenarios in which the Subject Vehicle (SV) operating under SAE automation levels 0, 1, 2, or 3 attempts to perform a lane change. The adjacent destination lane is occupied by a single Principal Other Vehicle (POV) in the first two scenarios, and not in the third. Although it is impossible to predict what technologies could be used by future BSI 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 BSI systems.

Section II

DATA SHEETS

BLIND SPOT INTERVENTION

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Audi Q5 45 TFSI quattro

VIN: *WA1BNAFY0L200xxxx*

Test Date: *11/13/2020*

System Setting(s): *Early*

	Number of valid test runs for which acceptability[1] criteria were: Met	Not met	Valid trials
Test 1 - Subject Vehicle Lane Change, Constant Headway	*2*	*5*	*7*
Test 2 - Subject Vehicle Lane Change, Closing Headway	*7*	*0*	*7*
Test 3 - Subject Vehicle Lane Change, Constant Headway, False Positive	*7*	*0*	*7*
Overall:	***16***	***5***	***21***

Notes: *All tests were performed at Level 0 automation.*

[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-2019-0102-0001, BLIND SPOT INTERVENTION SYSTEM CONFIRMATION TEST.

BLIND SPOT INTERVENTION

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: *0819*

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 INTERVENTION

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Audi Q5 45 TFSI quattro

GENERAL INFORMATION

Test date: *11/13/2020*

AMBIENT CONDITIONS

Air temperature: *16.7 C (62 F)*

Wind speed: *0.5 m/s (1.2 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: *230 kPa (33 psi)*

Rear: *250 kPa (36 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*571.5 kg (1260 lb)*	Right Front:	*503.9 kg (1111 lb)*
Left Rear:	*449.1 kg (990 lb)*	Right Rear:	*512.6 kg (1130 lb)*
		Total:	*2037.1 kg (4491 lb)*

BLIND SPOT INTERVENTION

DATA SHEET 4: BLIND SPOT INTERVENTION SYSTEM OPERATION

2020 Audi Q5 45 TFSI quattro

General Information

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

No specific name is assigned to the Blind Spot Intervention system.

The vehicle must be equipped with both Active Lane Assist and Side Assist. Both are included as part of the optional 'Driver Assistance' package and are standard with Premium trim.

Type and location of sensors the system uses:

Two medium range radar sensors; located in the corners of the rear bumper.

Mono camera located in the top center of the windshield.

System setting used for test (if applicable):

Early

Method(s) by which the driver is alerted

X Visual

Type	Location	Description
X Symbol		
___ Word		
___ Graphic		

___ Audible - Description

X Haptic

___ Steering Wheel	___ Seatbelt
___ Pedals	X Steering Torque
___ Seat	___ Brake Jerk

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 displays in the mirror turn on but are dim.

The steering wheel will also provide a vibration if Active Lane Assist detects the vehicle leaving its traveling lane.

See Figure A16 in Appendix A.

Please describe the method of intervention for the BSI system. For example, if the intervention is turning of the steering wheel, application of braking to one or more wheels of the vehicle, or a combination. If the intervention has different phases, please describe and provide information for each of these.

If the turn signal is activated while Active Lane Assist is detecting lane markers and Side Assist is actively detecting vehicles travelling alongside or approaching in the adjacent lane, the system will provide corrective steering if you attempt to leave your lane.

System Function

What is the speed range over which the system operates?

Minimum: *64 km/h (40 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 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 the turn signal is activated while Active Lane Assist is detecting lane markers and Side Assist is actively detecting vehicles travelling alongside or approaching in the adjacent lane, the system will provide corrective steering if you attempt to leave your lane. No intervention occurs if the turn signal is not activated.

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.

See Appendix A, Figures A13 through A15.

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

The steering correction timing can be adjusted. This is achieved through the Infotainment system.

The hierarchy is:

- *Vehicle*
  - *Driver assistance*
    - *Audi active lane assist*
      - *Steering Correction – Select*
        - *Early or Late*

See Appendix A, Figures A13 through A15.

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"*

If the system deactivates due to repeated BSI activations:

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

> *The system will not deactivate due to repeated BSI 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

Three test scenarios were used, as follows:

Test 1.	SV Lane Change with Constant Headway
Test 2.	SV Lane Change with Closing Headway
Test 3.	SV Lane Change with Constant Headway, False Positive

An overview of each of the test procedures follows.

1. TEST 1 – SV LANE CHANGE WITH CONSTANT HEADWAY

The SV Lane Change with Constant Headway (SVLC_Constant_HW) test evaluates the ability of the BSI system to detect and respond to a POV in an adjacent lane blind spot by preventing the SV from changing lanes or colliding with the POV. For this scenario, the POV resides in the SV blind spot with a constant headway. This test scenario is depicted in Figure 1.

The test begins with the POV in the left lane adjacent to the SV. After both vehicles have reached their designated speeds and headway overlap, the SV driver engages the left turn signal indicator and initiates a single lane change maneuver into the lane occupied by the POV. Specific details of the lane change method depended on the automation level as summarized in Table 1. The BSI system was then expected to intervene and prevent the SV from contacting the POV.

This test scenario was performed with the highest available SV automation level (0, 1, 2, or 3).

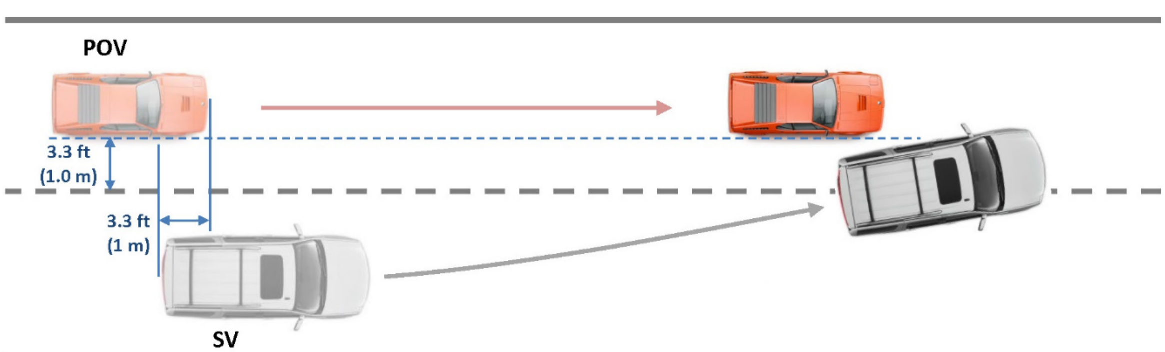

Figure 1. SV Lane Change with Constant Headway Test Scenario

a. Procedure for Automated Vehicle Level 0 or 1 Operation

The tests with SV automated vehicle level 0 or 1 were performed with manual steering input from a robotic steering controller. The SV and POV began in their respective travel lanes with their longitudinal axes oriented parallel to the roadway edge. The initial SV path was offset in the lane as shown in Figure 2 . Both vehicles then accelerated to an initial speed of 45 mph (72.4 km/h). This speed and specified headway overlap between the front-most point of the POV and the rear-most point of the SV were maintained throughout the test. The headway overlap is specified with the front bumper of the POV located 1.0 ± 0.5 m (3.3 ±1.6 ft) ahead of the rear of the SV (therefore the specified headway distance is a negative value indicating longitudinal overlap).

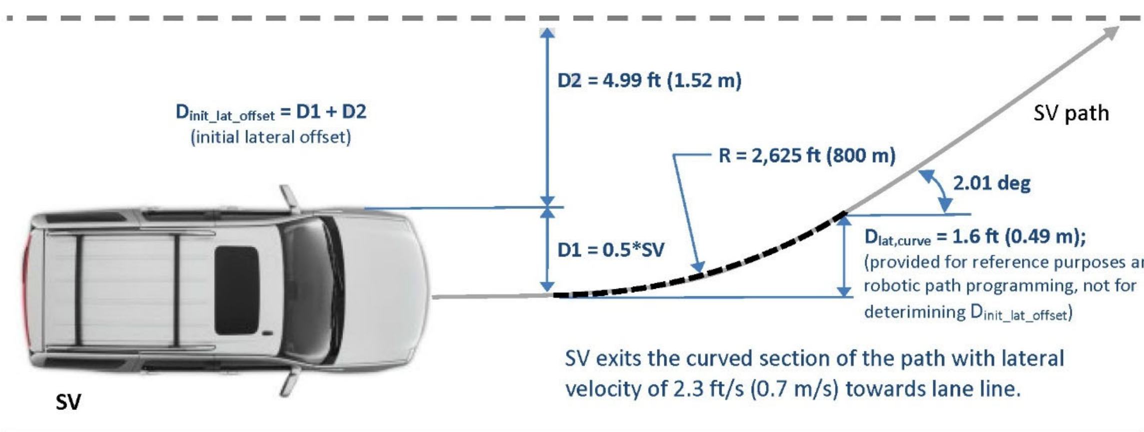

Figure 2. Input Parameters Used to Define the SV Path During the SV Level 0 and 1 Lane Change with Constant Headway Scenario

Once the speeds of both vehicles and the specified headway overlap were stabilized, the vehicles held this formation from the beginning of the test validity period until the SV lane change was initiated, as follows. After at least 3 seconds from the onset of the validity period, the SV driver activated the left turn signal indicator. Then within 1 ± 0.5 seconds after the turn signal was activated, the SV robotic steering controller began the lane change shown in Figure 2. The steer torque applied by the SV robotic steering controller stopped[2] within 250 ms of achieving the desired SV heading angle after the SV exited the 2,625 ft (800 m) radius curve during the lane change. The POV used open loop control to maintain the initial speed indicated in Table 1 (i.e., 45 mph).

[2] To emulate the situation where a human driver is operating the vehicle with their hands removed from the steering wheel.

b. Validity Period

The valid test interval began 3 seconds before the SV driver activated the left turn signal indicator.

For trials where the BSI system intervened, the valid test interval ended when one of the following conditions occurred:

- The SV impacted the POV; or
- five seconds after the SV had established a heading away from the POV and was completely within its original travel lane; or
- one second after the SV traveled ≥ 1 ft (0.3 m) beyond the inboard edge of the lane line separating the SV travel lane from the lane adjacent and to the right of it, as shown in Figure 3.

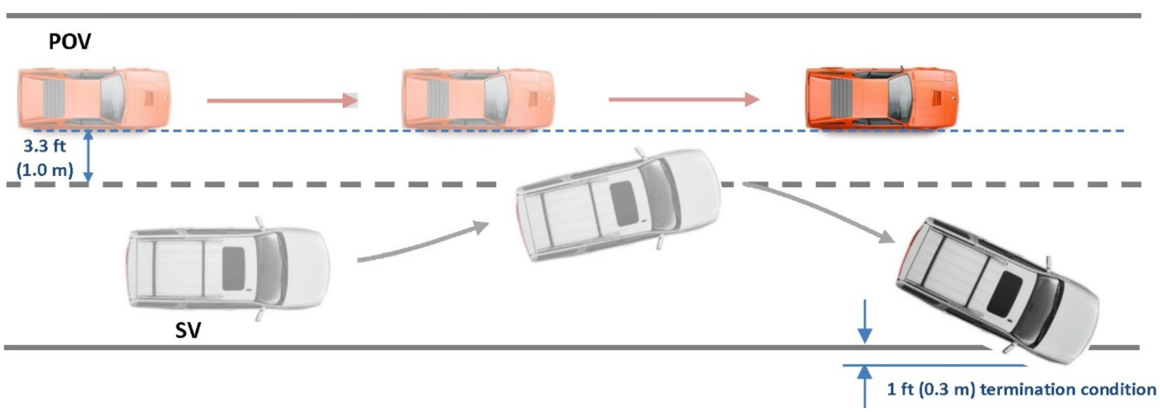

Figure 3. Valid SV Lane Change Intervention Test Interval End Condition 3

For trials where the BSI did not intervene, the valid test interval ended when the SV impacted the POV.

In addition to the procedure and timing described above, for an individual test trial to be valid, the following was required throughout the test:

- The general test validity criterial specified in Section III.B.1 were satisfied.
- The test parameters specified in Table 1 were within the allowable limits specified in Table 1 during the entire test interval or the epoch indicated.
- After initiation of the SV lane change, the POV used open loop control to maintain the constant speed specified in Table 1.

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 also braked to a stop, and the SVLC_Constant_HW test trial was complete.

c. Number of Test Trials

Seven valid SVLC_Constant_HW test trials were performed for the SV automation condition listed in Data Sheet 1.

If no intervention was detected on the first three of the seven valid trials, testing was stopped after three trials in order to mitigate damage to both the POV and SV.

d. Evaluation Criteria

The BSI system performance requirements for the SVLC_Constant_HW tests depended on the level of automation the SV was operating in during that trial. Passing BSI test criteria were:

- The SV did not impact the POV during any valid test performed in automation level 0 or 1 (i.e., those performed with the timing and inputs described in Section III.A.1.a), or

- the SV did not initiate the lane change commanded by the turn signal indicator during any valid test performed with automation level 2 or 3 (i.e., those described in Section III.A.1.b), and

- the SV BSI intervention did not cause the SV to travel ≥ 1 ft (0.3 m) beyond the inboard edge of the lane line separating the SV travel lane from one adjacent and to the right of it within the validity period defined in Section III.A.1.b during any valid test (i.e., with automation level 1, 2, or 3).

Table 1. SV Lane Change with Constant Headway Test Specifications

SV Automation Condition	Initial Speed		Lateral Lane Position		SV-to-POV Longitudinal Orientation	SV Left Turn Signal Activation	SV Lane Change			SV Path Tolerance	Number of Trials
	SV	POV	SV	POV			Initiation Timing	Steering Release Timing	Lateral Velocity		
Manual speed control, LCC off (Level 0)	45 ± 1 mph (72.4±1.6 km/h)	45 ± 1 mph (72.4±1.6 km/h)	Manually offset within travel lane, then manual lane change towards left adjacent lane	Constant; 3.3 ± 0.8 ft (1 ± 0.25 m) from the right side of the POV to the inboard edge of the lane line immediately to its right	Constant; front-most point of the POV 3.3 ± 1.6 ft (1 ± 0.5 m) ahead of the rear-most point of the SV	At least 3 seconds after all pre-SV lane change test validity criteria have been satisfied	1.0 ± 0.5 s after the SV turn signal is activated	Within 250 ms of achieving desired SV heading angle after exiting the 2,625 ft (800 m) radius curve during the lane change	2.3±0.3 ft/s (0.7±0.1 m/s)	±0.8 ft (±0.25 m) until SV steering wheel is released	7
Cruise control, LCC off (Level 0)											7
ACC on, LCC off (Level 1)											7

2. TEST 2 – SV LANE CHANGE WITH CLOSING HEADWAY

The SV Lane Change with Closing Headway (SVLC_Closing_HW) test evaluates the ability of the BSI system to detect a POV approaching a blind spot in an adjacent lane and prevent the SV from changing lanes and colliding with it. The POV is approaching the SV blind spot from the rear, as depicted in Figure 4. In this scenario, the test begins with the POV in the left lane adjacent to the SV. After both vehicles have reached their designated speeds, the SV driver engages the left turn signal indicator and initiates a single lane change maneuver into the lane occupied by the POV. Specific details of the lane change method depended on the automation level as summarized in Table 2. The BSI system was then expected to intervene and prevent the SV from contacting the POV.

This test scenario was performed with the highest available SV automation level (0, 1, 2, and 3).

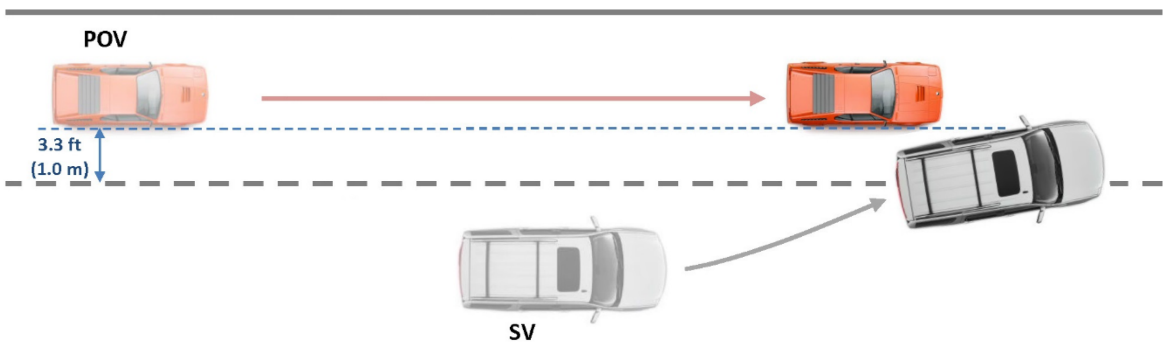

Figure 4. SV Lane Change with Closing Headway Test Scenario

a. Procedure for Automated Vehicle Level 0 or 1 operation

The tests with SV automated vehicle level 0 or 1 were performed with manual steering input from a robotic steering controller. The SV and POV began in their respective travel lanes with their longitudinal axes oriented parallel to the roadway edge, with the POV behind the SV as shown in Figure 4. The initial SV path was offset in the lane as shown in Figure 2 . The SV then accelerated to an initial speed of 45 mph (72.4 km/h) while the POV accelerated to an initial speed of 50 mph (80.5 km/h). These speeds were then maintained throughout the test.

The SV driver then activated the left SV turn signal indicator when the front of the POV was 4.9 ± 0.5 seconds from a vertical plane defined by the rear of the SV and perpendicular to the SV travel lane. This event nominally occurs when the longitudinal SV-to-POV headway is 35.6 ft (10.8 m) if the speed differential is 5 mph (8 km/h).

Then, when the POV is 3.9 ± 0.5 seconds from a vertical plane defined by the rear of the SV and perpendicular to the SV travel lane, the SV robotic steering controller began the lane change shown in Figure 2. This event nominally occurs when the longitudinal SV-to-POV headway is 28.2 ft (8.6 m) if the speed differential is 5 mph (8 km/h). The steer torque applied by the SV robotic steering controller stopped within 250 ms of achieving the desired SV heading angle after the SV exited the 2,625 ft (800 m) radius curve during the lane change. The POV used open loop control to maintain the initial speed indicated in Table 2 (i.e., 50 mph).

b. Validity Period

The valid test interval began 3 seconds before the SV driver activated the left turn signal indicator.

For trials where the BSI system intervened, the valid test interval ended when one of the following conditions occurred:

- The SV impacted the POV; or
- five seconds after the SV had established a heading away from the POV and was completely within its original travel lane; or
- one second after the SV traveled ≥ 1 ft (0.3 m) beyond the inboard edge of the lane line separating the SV travel lane from the lane adjacent and to the right of it, as shown in Figure 3.

For trials where the BSI did not intervene, the valid test interval ended when the SV impacted the POV.

In addition to the procedure and timing described above, for an individual test trial to be valid, the following was required throughout the test:

- The general test validity criterial specified in Section III.B.1 were satisfied.
- 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 SVLC_Closing_HW test trial was complete.

c. Number of Test Trials

Seven valid SVLC_ Closing _HW test trial were performed for the SV automation condition listed in Data Sheet 1.

If no intervention was detected on the first three of the seven valid trials, testing was stopped after three trials in order to mitigate damage to both the POV and SV.

d. Evaluation Criteria

The BSI system performance requirements for the SVLC_Closing_HW tests depended on the level of automation the SV was operating in during that trial. Passing BSI test criteria were:

- The SV did not impact the POV during any valid test performed in automation level 0 or 1 (i.e., those performed with the timing and inputs described in Section III.A.2.a), or
- the SV did not initiate the lane change commanded by the turn signal indicator during any valid test performed with automation level 2 or 3 (i.e., those described in Section III.A.2.b), and
- the SV BSI intervention did not cause the SV to travel ≥ 1 ft (0.3 m) beyond the inboard edge of the lane line separating the SV travel lane from one adjacent and to the right of it within the validity period defined in III.A.2.b during any valid test (i.e., with automation level 1, 2, or 3).

Table 2. SV Lane Change with Closing Headway Test Specifications

SV Automation Condition	Initial Speed		Lateral Lane Position		SV-to-POV Longitudinal Orientation	SV Left Turn Signal Activation	SV Lane Change			SV Path Tolerance	Number of Trials
	SV	POV	SV	POV			Initiation Timing	Steering Release Timing	Lateral Velocity		
Manual speed control, LCC off (Level 0)	45 ± 1 mph (72.4±1.6 km/h)	50 ± 1 mph (80.5±1.6 km/h)	Manually offset within travel lane, then manual lane change towards left adjacent lane	Constant; 3.3 ± 0.8 ft (1 ± 0.25 m) from the right side of the POV to the inboard edge of the lane line immediately to its right	POV approaches the rear of the SV with a constant 5 mph (8.1 km/h) relative velocity	When the front-most point of the POV is 4.9 ± 0.5 seconds from a vertical plane defined by the rear-most point of the SV and perpendicular to the SV travel lane	When the front-most point of the POV is 3.9 ± 0.5 seconds from a vertical plane defined by the rear-most point of the SV and perpendicular to the SV travel lane	Within 250 ms after exiting the 2,625 ft (800 m) radius curve during the lane change	2.3±0.3 ft/s (0.7±0.1 m/s)	±0.8 ft (±0.25 m) until SV steering wheel is released	7
Cruise control, LCC off (Level 0)											7
ACC on, LCC off (Level 1)											7

Note: Columns 3, 6, 7, and 8 in Table 2 are different from Table 1.

3. <u>TEST 3 – SV LANE CHANGE WITH CONSTANT HEADWAY, FALSE POSITIVE ASSESSMENT</u>

The SV Lane Change with Constant Headway, False Positive (SVLC_Constant_HW_FP) test assesses whether or not a BSI system detects and responds to a non-threatening POV during a single lane change. In this scenario, the POV is two lanes away from the SV, adjacent to the SV blind spot, and traveling with constant headway. This test scenario is depicted in Figure 5. In this scenario the test begins with the POV in the second lane to the left of the SV After both vehicles have reached their designated speeds and headway overlap, the SV driver engages the left turn signal indicator and initiates a single lane change maneuver into the lane between the initial SV and POV travel lanes. Specific details of the lane change method depended on the automation level as summarized in Table 3a and 3b.

This test scenario was performed in two parts comprised of "baseline" and "evaluation" trials, with SV automation level 0, 1, 2, or 3 depending on the highest SAE automation level available on the SV. The main difference between the baseline and evaluation trials is that evaluation trials were performed with the POV present and the baseline trials were performed without the POV. The BSI system was expected to not respond any differently to the presence of the POV compared to a similar baseline test trial without the POV.

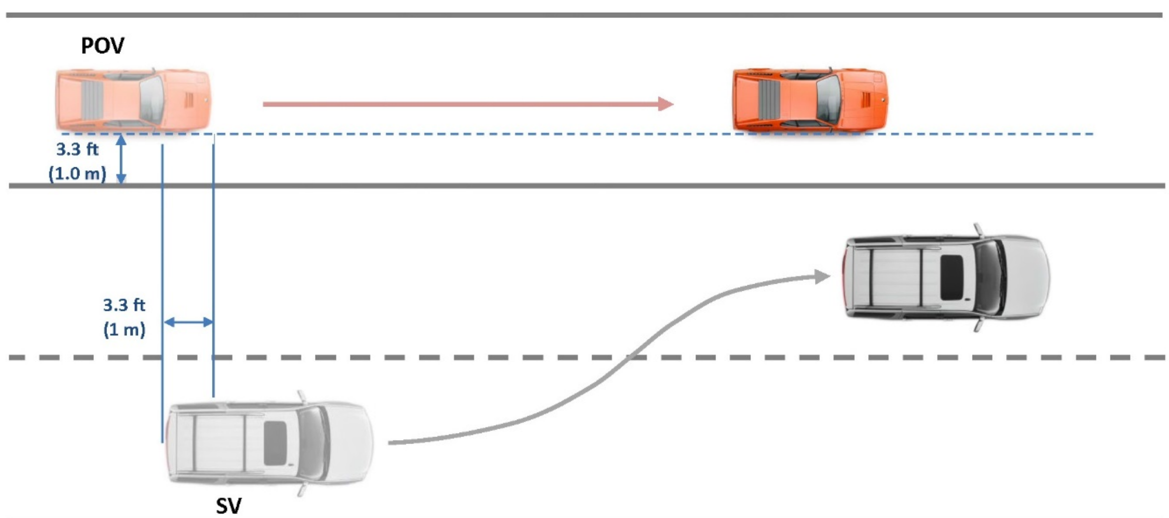

Figure 5. Lane Change with Constant Headway, False Positive Test Scenario

a. Procedure for Automated Vehicle Level 0 or 1 Operation

The SVLC_Constant_HW_FP tests with level 0 and 1 operation were performed in a similar manner as the SVLC_Constant_HW tests described in Section III.A.1.a with the following exceptions:

- The initial SV and POV lanes of travel were separated by a lane of travel in between them as shown in Figure 5.
- The SV driver did not release the steering wheel (or robotic steering control equivalent) at any time during the baseline test trial.
- The SV driver did not release the steering wheel (or robotic steering control equivalent) at any time during the evaluation test trial unless system intervention was detected.
- The manual steer input included a lane change completion phase as shown in Figure 6.
- The tests were conducted both with and without the POV present.
- There were 3 baseline trials without the POV, as specified in Table 3a. The SV was driven at the initial speed of 45 mph (72.4 km/h) either manually or using the cruise control after it was enabled and initialized. After maintaining this initial speed (there was no initial SV-POV vehicle formation as depicted in Figure 5 during the trial because the POV was not present), the SV driver engaged the left turn signal indicator and initiated the single lane change into the left adjacent lane. No BSI system interventions were expected in the baseline trials because no POV was present.
- There were 7 evaluation trials with the POV, as specified in Table 3b. The SV and POV were both driven at the initial speed of 45 mph (72.4 km/h) and established the initial longitudinal and lateral formation shown in Figure 5. The SV speed was achieved either manually or with the cruise control enabled and initialized. After maintaining the initial formation shown in Figure 5 for 3 seconds, the SV driver engaged the left turn signal indicator and initiated the single lane change into the left adjacent lane. No BSI system interventions were expected in the evaluation trial because a single lane change should not result in a collision with the POV.
- The validity period is defined in Section III.A.3.b.

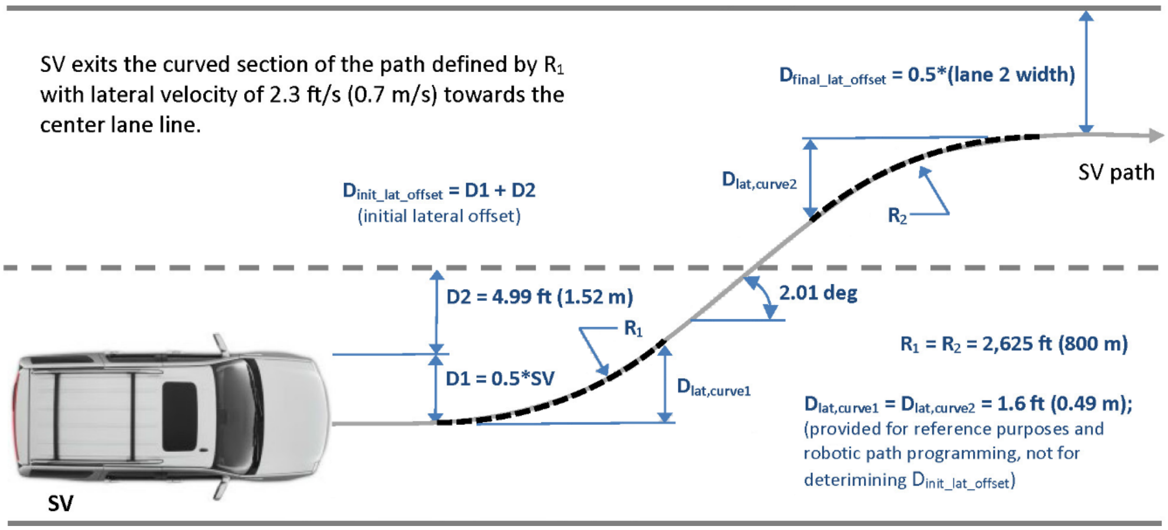

Figure 6. Input Parameters used to define the SV path during the SV Lane Change with Constant Headway, False Positive Scenario

b. Validity Period

The valid test interval began 3 seconds before the SV driver activated the left turn signal indicator.

The valid test interval ended when one of the following conditions occurred:

1. The SV impacted the POV; or
2. Five seconds after the SV had completed the single lane change into the left lane adjacent to the SV's original travel lane without a BSI intervention; or
3. One second after a BSI intervention caused the SV to travel ≥ 1 ft (0.3 m) beyond the inboard edge of the lane line separating the post lane change SV travel lane and the lane adjacent and to the right of it, as shown in Figure 7.

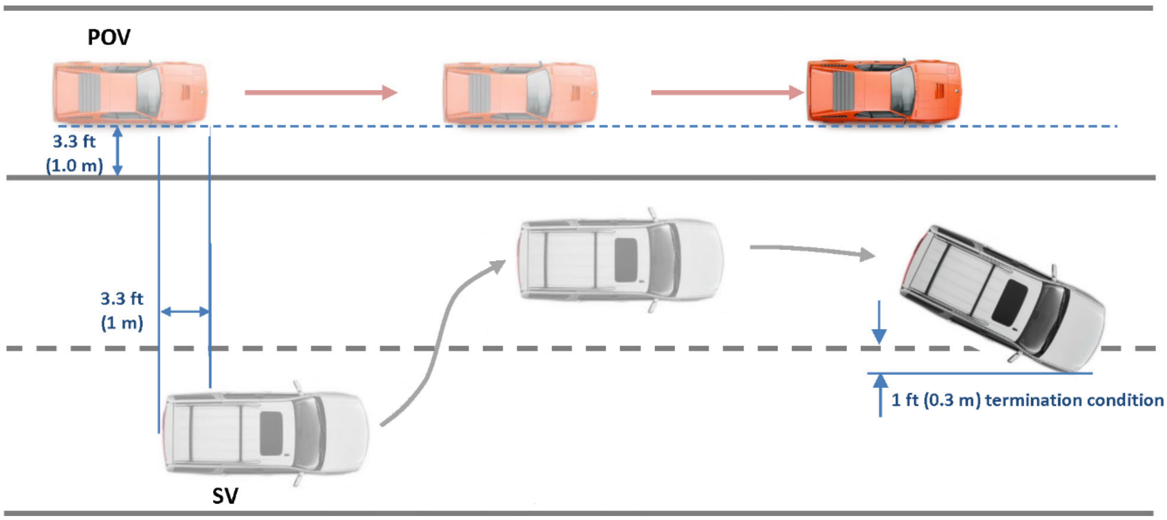

Figure 7. Valid SV Lane Change False Positive Test Interval End Condition 3

In addition to the procedure and timing described above, for an individual test trial to be valid, the following was required throughout the test:

- The general test validity criteria specified in Section III.B.1 were satisfied.
- The test parameters specified in Table 3a and 3b were within the allowable limits specified in Table 3a and 3b during the entire test interval or the epoch indicated.
- For evaluation trials, after initiation of the SV lane change, the POV used open-loop control to maintain the constant speed specified in Table 3b.

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 for evaluation trials. The SVLC_Constant_HW_FP test trial was then complete.

c. Evaluation Method and Criteria

Determination of whether a false positive BSI intervention occurred during a SVLC_Closing_HW_FP evaluation required the comparison of the SV yaw rate data collected during the evaluation trial with the acceptability corridor defined by the corresponding composite data from the baseline trials. This was accomplished in two steps.

The first step was to determine an acceptable yaw rate time history corridor for each SV automation condition, as illustrated by the hypothetical example in Figure 8. The yaw rate time histories for the 3 baseline trials were first synchronized in time so that the onsets of the respective lane changes occurred within 20 ms of each other.

The baseline composite yaw rate was then calculated by averaging the yaw rates from the 3 baseline trials, at each time point in the synchronized time history. The acceptability corridor was then the baseline composite yaw rate value ± 1 deg/s.

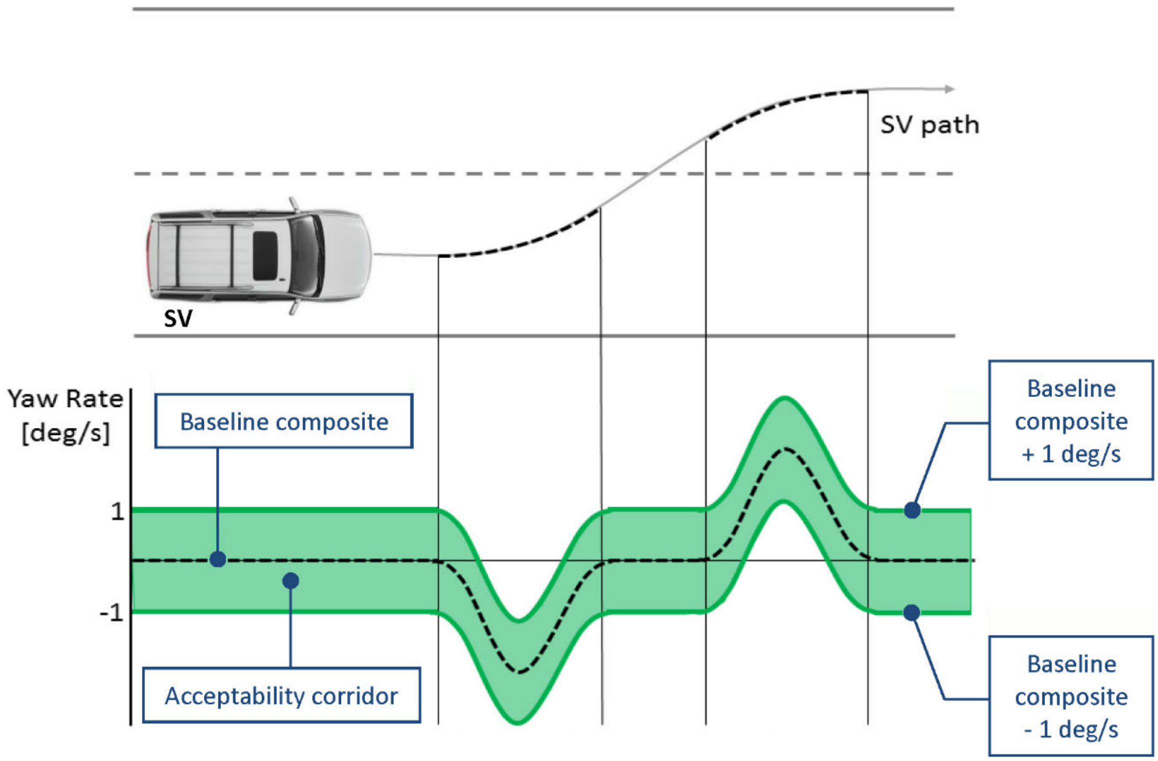

Figure 8. Definition of a Yaw Rate Acceptability Corridor

The second step was to compare the SV yaw rate from each evaluation trial to the acceptable yaw rate time history corridor, as illustrated by the hypothetical example in Figure 9. If, after data synchronization, the SV yaw rate exceeded the acceptability corridor any time during the test validity period defined in Section III.A.3.b, then a false positive intervention test result was determined to have occurred.

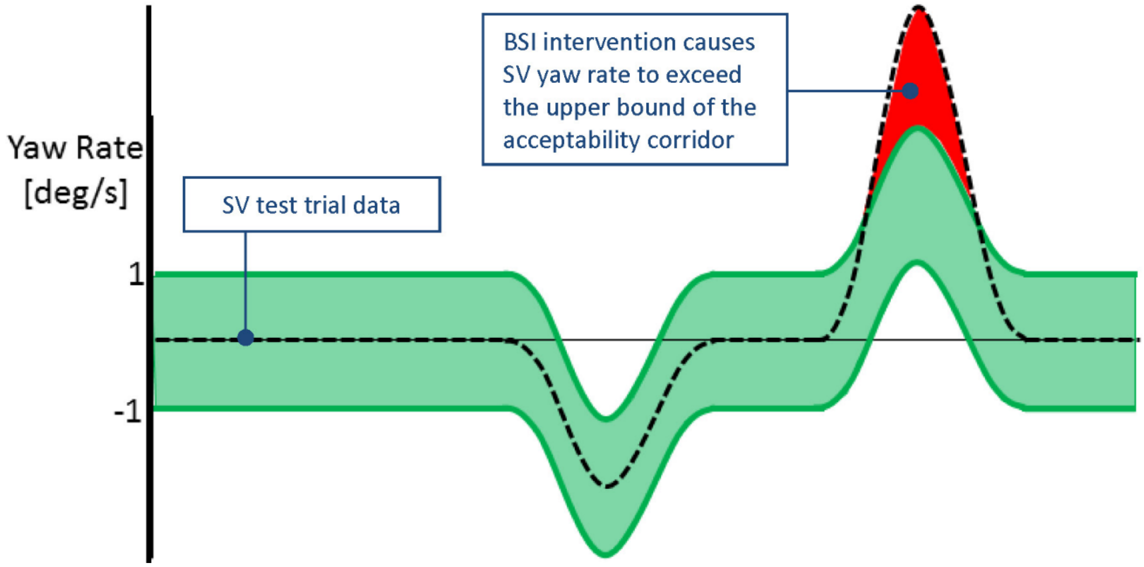

Figure 9. BSI False Positive Example

Table 3a. SV Lane Change with Constant Headway, False Positive Test Specifications (Baseline Trials)

SV Automation Condition	Initial Speed		Lateral Lane Position		SV-to-POV Longitudinal Orientation	SV Left Turn Signal Activation	SV Lane Change			SV Path Tolerance	Number of Trials
	SV	POV	SV	POV			Initiation Timing	Steering Release Timing	Lateral Velocity		
Manual speed control, LCC off (Level 0)	45 ± 1 mph (72.4±1.6 km/h)	N/A	Manually offset within travel lane, then manual lane change into a lane left and adjacent to that of the SV	N/A	N/A	At least 3 seconds after all pre-SV lane change test validity criteria have been satisfied	1.0±0.5 s after the SV turn signal is activated	N/A (the SV driver does not release the steering wheel)	2.3±0.3 ft/s (0.7±0.1 m/s)	±0.8 ft (±0.25 m)	3
Cruise control, LCC off (Level 0)											3
ACC on, LCC off (Level 1)											3

Table 3b. SV Lane Change with Constant Headway, False Positive Test Specifications (Evaluation Trials)

SV Automation Condition	Initial Speed		Lateral Lane Position		SV-to-POV Longitudinal Orientation	SV Left Turn Signal Activation	SV Lane Change			SV Path Tolerance	Number of Trials
	SV	POV	SV	POV			Initiation Timing	Steering Release Timing	Lateral Velocity		
Manual speed control, LCC off (Level 0)	45 ± 1 mph (72.4±1.6 km/h)	45 ± 1 mph (72.4±1.6 km/h)	Manually offset within travel lane, then manual lane change into a lane left and adjacent to that of the SV	Constant; 3.3 ± 0.8 ft (1.0±0.25 m) from the right side of the POV to the inboard edge of the lane line immediately to its right Note: the POV travel lane is two lanes to the left of the initial SV travel lane.	Constant; POV front located 3.3 ± 1.6 ft (1 ± 0.5 m) ahead of the SV rear	At least 3 seconds after all pre-SV lane change test validity criteria have been satisfied	1.0 ± 0.5 s after the SV turn signal is activated	N/A (SV driver does not release the steering wheel)	2.3 ± 0.3 ft/s (0.7 ± 0.1 m/s)	± 0.8 ft (± 0.25 m) unless a BSI intervention occurs	7
Cruise control, LCC off (Level 0)											7
ACC on, LCC off (Level 1)											7

B. General Information

1. GENERAL VALIDITY CRITERIA

In addition to any validity criteria described above for the individual test scenarios, for an individual trial to be valid, it must have met the following criteria throughout the test:

- The SV driver seatbelt was latched.
- If any load had been placed on the SV front passenger seat (e.g., for instrumentation), the vehicle's front passenger seatbelt was latched.
- When operating the SV in automation level 0 within the validity period, SV speed was maintained by (1) the SV driver manually modulating the SV accelerator pedal, or (2) use of conventional cruise control unless the SV BSI system automatically terminated its operation.
- Operating the SV in automation level 1 required the SV ACC (i.e., not the vehicle's lane centering system) to be enabled and in operation unless the SV BSI system automatically terminated its operation.
- Operating the SV in automation level 2 or 3 required the SV ACC and lane centering systems both be enabled and in operation.
- The SV driver did not provide manual inputs to the SV accelerator or brake pedals while the SV was being operated in automation level 1 (i.e., while ACC was actively modulating the SV speed), 2, or 3.
- The POV was driven at constant speed.
- The lateral distance between the right side of the POV and the inboard edge of the lane line immediately to its right was 3.3 ± 0.8 ft (1.0 ± 0.25 m).
- When the SV was being operated in automation level 0 or 1, the SV yaw rate did not exceed ± 1.0 deg/s from the onset of the validity period until the initiation of the SV lane change.

2. 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 is aligned with the centerline of the rear-most location of the SV. Longitudinally, the front of the front bumper of the POV was placed at the rear of the rear bumper of the SV.

Static calibrations were then performed by placing the SV and POV transmissions in park, or with the system brake enabled, where applicable. Data were then collected for approximately 10 seconds using data from at least six GPS satellites.

C. Principal Other Vehicle

For tests in which a vehicle-to-vehicle collision will not occur, such as the False Positive tests, a high production, mid-sized passenger car was used as the POV. The tests reported herein made use of a 2006 Acura RL.

For tests in which a collision may occur, BSI testing requires a POV that realistically represents typical vehicles, does not suffer damage or cause damage to a test vehicle in the event of collision, and can be accurately positioned and moved during the tests. The tests reported herein made use of the Global Vehicle Target (GVT) secured to a low-profile robotic vehicle (LPRV).

This GVT system was designed for a wide range of pre-crash scenarios including scenarios which BSI systems address. The key components of the GVT system are:

- A soft GVT, which is visually and dimensionally similar to a 2013 Ford Fiesta hatchback. It is designed to appear realistic to the sensors used by automotive safety systems and automated vehicles: radar, camera, and lidar. Appropriate radar characteristics are achieved by using a combination of radar-reflective and radar-absorbing material enclosed within the GVT's vinyl covers. Internally, the GVT consists of a vinyl-covered foam structure. If a test vehicle impacts the GVT at low speeds, it is designed to separate, and is typically pushed off and away from the supporting LPRV platform. At higher impact speeds, the GVT breaks apart as the SV essentially drives through it. The GVT can be repeatedly struck from any approach angle without harm to those performing the tests or the vehicles being evaluated. Reassembly of the GVT occurs on top of the robotic platform and takes a team of 3 to 5 people approximately 7 to 10 minutes to complete.
- An LPRV platform that supports the GVT and provides for precisely controlled GVT motion. The LPRV contains the batteries, drive motors, GPS receiver, and the control electronics for the system. It has a top speed of 50 mph (80 km/h); a maximum longitudinal acceleration and deceleration of 0.12 g (1.18 m/s^2) and 0.8 g (7.8 m/s^2), respectively; and a maximum lateral acceleration of 0.5 g (4.9 m/s^2). The LPRV is preprogrammed and allows the GVT's movement to be accurately and repeatedly choreographed with the test vehicle and/or other test equipment required by a pre-crash scenario using closed-loop control. The LPRV is designed to be safely driven over by the SV without damage if the GVT is struck by the SV.

The key requirements of the POV element are to:

- Provide an accurate representation of a real vehicle to BSI and BSD sensors, including cameras and radar.
- Be resistant to damage and inflict little or no damage to the SV as a result of repeated SV-to-POV impacts.

The key requirements of the POV delivery system are to:

- Accurately control the nominal POV speed up to 50 mph (80 km/h).
- Accurately control the lateral position of the POV within the travel lane.
- Allow the POV to move away from the SV after an impact occurs.

Operationally, the GVT body is attached to LPRV using Velcro hook and loop fasteners. The GVT and LPRV are designed to separate if the GVT is struck by the SV. The GVT/LPRV system is shown in Figures A6 and A7 in Appendix A and a detailed description can be found in the NHTSA report: “A Test Track Comparison of the Global Vehicle Target (GVT) and NHTSA’s Strikeable Surrogate Vehicle (SSV)”.[3]

D. Throttle Controller

The actual vehicle POV was equipped with a programmable throttle controller, which was used for the False Positive Assessment test scenario to modulate the speed and headway overlap. 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).

E. Instrumentation

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

[3] Snyder, A.C., Forkenbrock, G.J., Davis, I.J., O’Harra, B.C., and Schnelle, S.C., A Test Track Comparison of the Global Vehicle Target (GVT) and NHTSA’s Strikeable Surrogate Vehicle (SSV), DOT HS 812 698, Vehicle Research and Test Center, National Highway Traffic Safety Administration, Washington, DC, July 2019.

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			By: Oxford Technical Solutions
				SV IMU#1 Oxford Inertial +	2258	Date: 5/3/2019 Due: 5/3/2021
				SV IMU#2 Oxford xNAV 550	015386	Date: 8/8/2019 Due: 8/8/2021
				POV IMU Oxford Inertial +	2182	Date: 9/16/2019 Due: 9/16/2021
				LPRV IMU Oxford RT3000 v3	40213	Date: 3/23/2020 Due: 3/23/2022
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

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
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
Light Sensor	Light intensity (visual alert)	Spectral Bandwidth: 440 - 800 nm	Rise Time < 10 ms	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	< 1% error between 20 and 100 psi	Omega DPG8001	18111410000	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	Date: 4/20/2020 Due: 4/20/2021
Coordinate Measurement Machine	Point x,y,z location	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	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.	dSPACE Micro-Autobox II 1401/1513	
		Base Board	549068
		I/O Board	588523
Steering Controller	Precise controlled steering is accomplished using a steering machine designed and constructed by DRI. DRI has used its Automated Vehicle Controller (AVC) steering machine for many vehicle tests including FMVSS 126 tests. It can provide up to 65 ft-lb torque and rates over 1300 deg/sec. The integrated angle encoder has an unlimited range with a resolution of 0.045 degrees and an accuracy of ±0.045 degrees. The steering motor is controlled by a MicroAutoBox II from dSPACE, which also acts as the data acquisition system.	DRI developed	N/A
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

Figure A3. Window Sticker (Monroney Label)

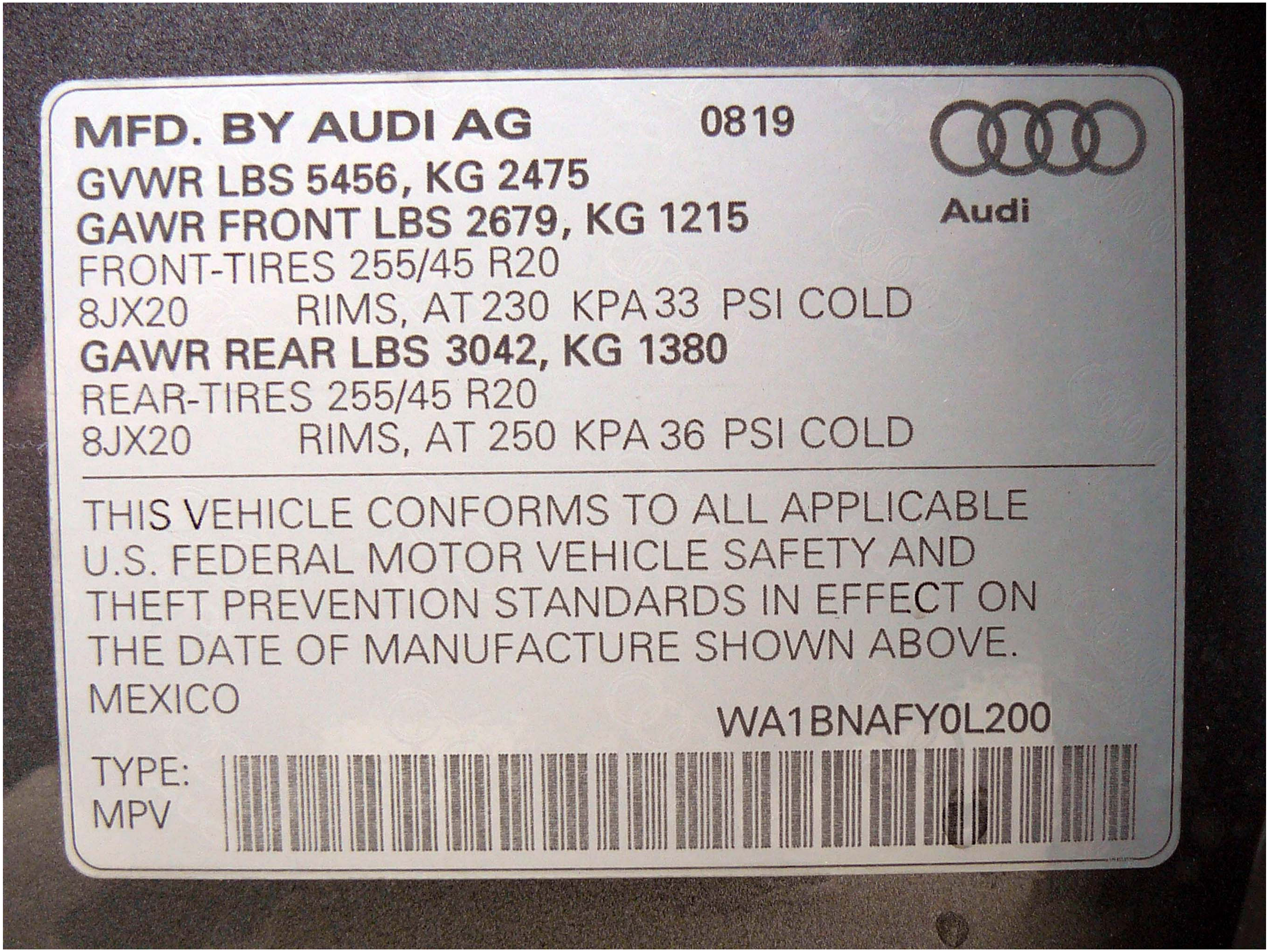

Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle - GVT (Tests 1 and 2)

Figure A7. Rear View of Principal Other Vehicle - GVT (Tests 1 and 2)

Figure A8. Front View of Principal Other Vehicle (Test 3)

Figure A9. Rear View of Principal Other Vehicle (Test 3)

Figure A10. Sensor for Detecting Visual Alerts

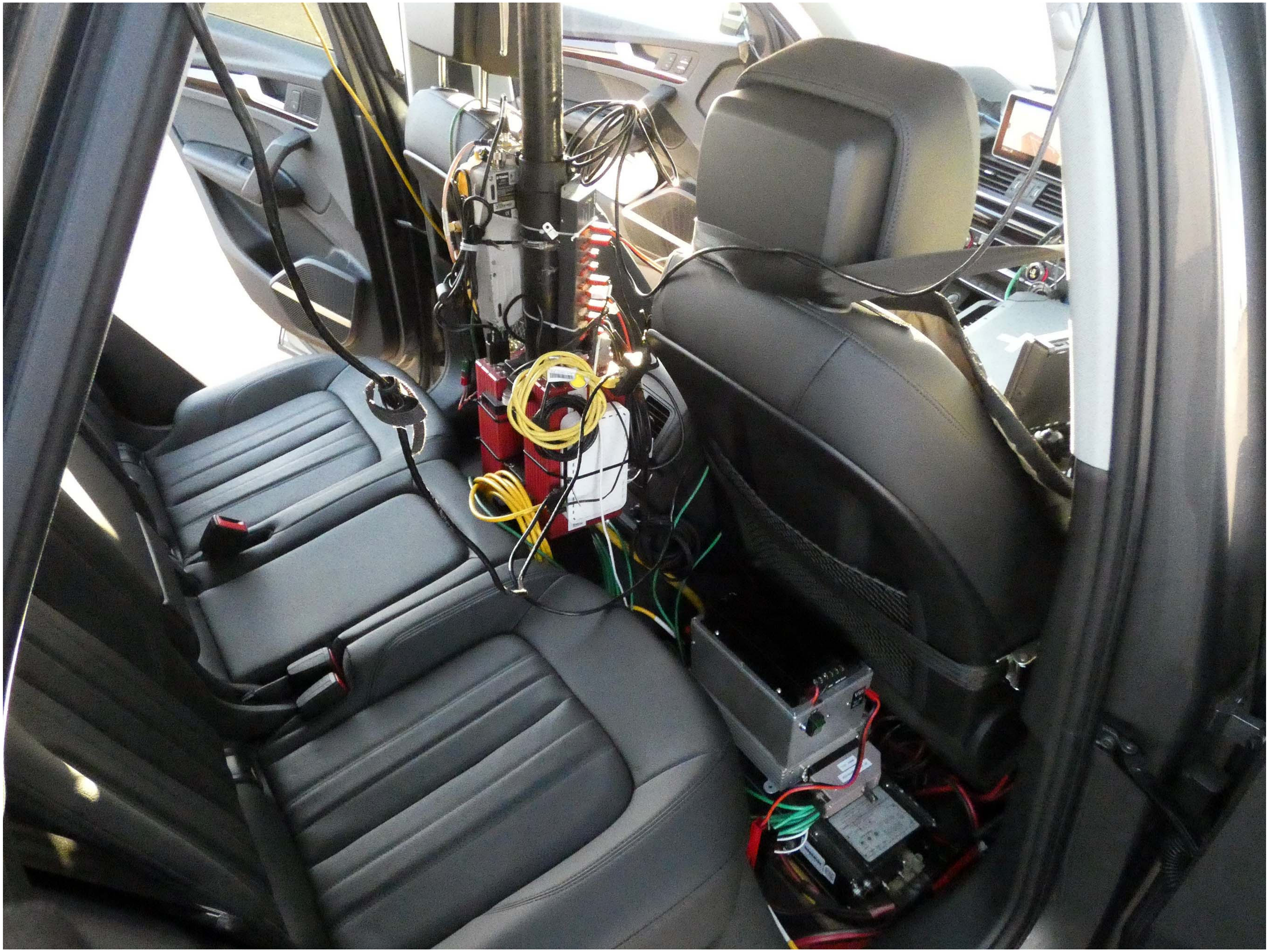

Figure A11. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A12. Computer and Steering Controller Installed in Subject Vehicle

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

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

Figure A15. Controls for Accessing Driver Assistance Settings Menus

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

	Drive system ⇨ page 86, ⇨ page 333
	Vehicle sound ⇨ page 86
	Engine start system ⇨ page 76
	Keys ⇨ page 76
	Electromechanical parking brake ⇨ page 90
	Brake system ⇨ page 89
	Electronic Stabilization Control (ESC) ⇨ page 22
OFF	Electronic Stabilization Control (ESC) ✓ ⇨ page 22
ESC OFF	Electronic Stabilization Control (ESC) ⇨ page 165
ABS	Anti-lock braking system (ABS) ✓ ⇨ page 22
ABS	Anti-lock braking system (ABS) ✓ ⇨ page 22
	Steering ⇨ page 166

	All wheel drive/sport differential ⇨ page 23
	Suspension control ⇨ page 23
	Air suspension ⇨ page 23
	Engine speed limitation ⇨ page 16
	Tank system ⇨ page 324
	Electrical system ⇨ page 336
MIN	Engine oil level (MIN) ⇨ page 330

MAX	Engine oil level (MAX) ⇨ page 330
SENSOR	Engine oil sensor ⇨ page 330
	Malfunction Indicator Lamp (MIL) ✓ ⇨ page 326
	Engine warm-up request ⇨ page 330
	Washer fluid level ⇨ page 339
	Windshield wipers ⇨ page 50
AC	Charging system ⇨ page 100
P	Parking aid ⇨ page 163
	Tire pressure ⇨ page 359
TPMS	Tire pressure ⇨ page 359
	Bulb failure indicator ⇨ page 44
	Headlight range control system ⇨ page 44
	Adaptive light ⇨ page 44
	Light/rain sensor ⇨ page 44, ⇨ page 50
	Driver's door ⇨ page 30
	Battery in vehicle key ⇨ page 27
	Audi side assist ⇨ page 145
	Active lane assist ⇨ page 137
	Audi pre sense ⇨ page 135
SOS	Emergency call function ⇨ page 217

▶

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Audi side assist

Description

Applies to: vehicles with Audi side assist

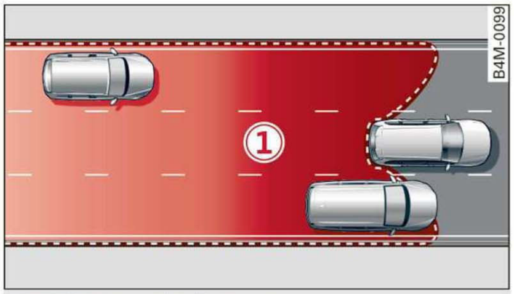

Fig. 128 Sensor detection range

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

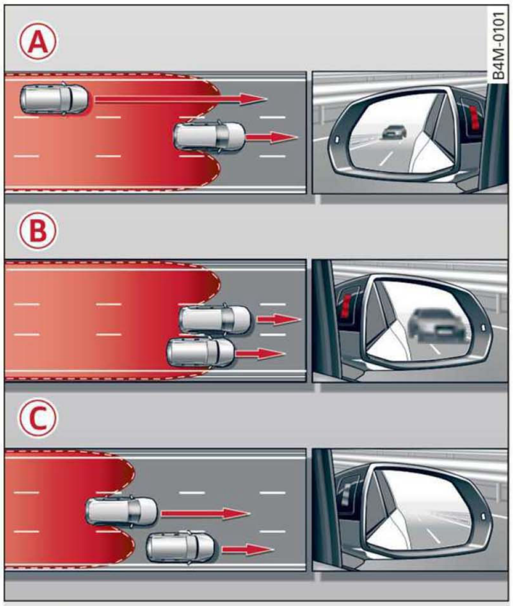

Fig. 130 Driving situations

Fig. 131 Rear of the vehicle: sensor locations

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

Ⓐ 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.

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

Ⓒ 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:

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- 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: **11/13/2020**

Test Engineer: **N. Watanabe**

Run	Test Type	Valid Run	Minimum Distance to POV (ft)	Minimum Distance to Left Lane Edge (ft)[4]	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria[5]	Notes
11	Static Run - GST							
12	**SV Lane Change Constant Headway**	N						POV lateral error
13		Y	3.65	-1.32	Yes	No	Yes	Ran out of tarmac, but several seconds after minimum separation
14		N						POV speed, headway
15		Y	0.00	-3.39	No	Yes	No	
16		Y	0.00	-2.72	No	Yes	No	
17		N						POV speed
18		Y	0.96	-2.38	Yes	No	Yes	
19		N						POV lateral error
20		N						POV speed, headway
21		Y	0.00	-3.92	No	Yes	No	
22		Y	0.00	-3.18	No	Yes	No	
23		Y	0.00	-2.66	No	Yes	No	

[4] Negative values indicate the vehicle has crossed the lane line.

[5] 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-2019-0102-0001, BLIND SPOT INTERVENTION SYSTEM CONFIRMATION TEST.

Run	Test Type	Valid Run	Minimum Distance to POV (ft)	Minimum Distance to Left Lane Edge (ft)[4]	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria[5]	Notes
24	SV Lane Change Closing Headway	N						GST out of position
25		N						POV speed
26		N						Lane early, POV speed, TTC for turn signal
27		N						POV speed
28		N						POV speed
29		N						POV speed
30		N						POV speed
31		N						POV speed
32		N						POV speed
33		N						POV speed
34		N						POV speed
35		N						POV speed
36		N						POV speed
37		N						POV speed
38		N						POV speed
39		N						POV speed
40		Y	2.95	-0.52	Yes	No	Yes	
41		N						POV speed
42		N						GPS fix type
43		N						Post Processor not working
44		N						GPS fix type

Run	Test Type	Valid Run	Minimum Distance to POV (ft)	Minimum Distance to Left Lane Edge (ft)[4]	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria[5]	Notes
45		N						SV, POV speed
46	SV Lane Change Closing Headway	N						POV speed
47		N						POV speed
48		N						POV speed
49		N						POV speed
50		N						POV speed
51		N						POV speed
52		N						POV speed
53		N						Post Processor not working
54		N						POV speed
55		N						POV speed
56		N						POV speed
57		N						POV speed
58		N						POV speed
59		N						No light signal
60		N						SV distance to lane line
61		Y	4.44	0.43	Yes	No	Yes	Ran out of track
62		Y	4.09	0.45	Yes	No	Yes	
63		N						SV distance to lane line
64		Y	3.34	0.56	Yes	No	Yes	
65		N						POV distance to lane line
66		Y	3.79	-0.22	Yes	No	Yes	Ran out of track
67		Y	3.46	0.10	Yes	No	Yes	Ran out of track

Run	Test Type	Valid Run	Minimum Distance to POV (ft)	Minimum Distance to Left Lane Edge (ft)[4]	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria[5]	Notes
68		Y	3.51	0.16	Yes	No	Yes	Ran out of track
1	**SV Lane Change Constant Headway False Positive Baseline**	Y						
2		Y						
3		Y						
4	**SV Lane Change Constant Headway False Positive Assessment**	Y					Yes	
5		Y					Yes	
6		Y					Yes	
7		Y					Yes	
8		Y					Yes	
9		Y					Yes	
10		Y					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), as well as pass/fail envelopes and thresholds. Plots shown herein are grouped by test type and are presented sequentially within a given test type. The following is a description of data types shown in the time history plots, as well as a description of the color code indicating to which vehicle the data pertain.

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:

SV Lane Change with Constant Headway
SV Lane Change with Closing Headway
SV Lane Change with Constant Headway, False Positive Assessment – Baseline
SV Lane Change with Constant Headway, False Positive Assessment – Evaluation

Time history figures include the following sub-plots:

- SV Turn Signal – Displays the cycling of the SV turn signal indicator. The bold vertical line indicates the time at which the turn signal is activated.

- Headway (ft) – Longitudinal separation between the rear of the SV and the front of the POV. A negative value for headway indicates that the front-most point of the POV is forward relative to the rear-most point of the SV.

- SV/POV Speed (mph) – Indicates the speed of the SV and POV.

- SV Ax (g) (For vehicles with braking intervention) – SV longitudinal acceleration. If the BSI system operates using a brake intervention, a vertical bold line marked “BSI Onset” indicates the time at which BSI intervention first occurred.

- SWA (deg) (For vehicles with steering intervention) – Subject vehicle steer wheel angle as measured by a steer wheel encoder. If the BSI system operates using a steering intervention, a vertical bold line marked “BSI Onset” indicates the time at which the BSI intervention first occurred.

- Yaw Rate (deg/sec) – Yaw rate of the SV. A vertical bold line marked “SW Release” indicates the point at which the control of the steering wheel by the robotic controller is released allowing for free response of the vehicle. If the BSI system operates using a steering wheel input, a vertical bold line marked “BSI Onset” indicates the time at which BSI intervention first occurred.

- Lateral Velocity (ft/s) – Lateral velocity of the SV. For the False Positive scenario, the average lateral velocity calculated from half a second before the lane line crossing to half a second after the lane line crossing is noted. For the other scenarios, the lateral velocity at the time of steering wheel release is noted.

- Distance to Lane Line (ft) – For both the SV and POV, the distance from the outer-most (not including side mirrors) part of the vehicle to the edge of the lane line. The minimum distance from the left side of the SV to the adjacent left side lane is shown. A negative value indicates that the SV has crossed over the left side lane line.

- Minimum Distance (ft) – Distance between the outer-most (not including side mirrors) parts of the SV and POV. The minimum distance between the SV and POV is shown on the right of the plot. Note that this is not shown for False Positive Baseline cases.

- SV Path Deviation (ft) – The SV deviation from its intended path.

Envelopes and Thresholds

Some of the time history plot figures contain either green or yellow envelopes and/or black threshold lines. These envelopes and thresholds are used to programmatically and visually determine the validity of a given test run. Envelope and threshold exceedances are indicated with either red shading or red asterisks, and red text is placed to the right side of the plot indicating the type of exceedance. Such exceedances indicate either that the test was invalid or that the requirements of the test were not met (i.e., failure of the BSI system).

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

For plots with yellow envelopes, the yellow envelope is used to signify an area of interest over which the data is being averaged. The data may exceed the envelope at any point during this envelope with no impact on the test validity.

For SV Lane Change with Constant Headway, False Positive – Evaluation tests only, a dashed boundary line is shown on the yaw rate plot. This dashed boundary line indicates the allowable yaw rate threshold used to determine the presence of a BSI intervention as defined in the test procedure. Exceedances of this boundary will display red text to the right of the plot.

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. 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. Validation envelope and threshold color codes:
   - Green envelope = time varying data must be within the envelope at all times in order to be valid
   - Black threshold (Solid) = define points of interest during the run (i.e., steering wheel release, BSI onset, etc.)

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

- NG – Indicates that the value for that variable was outside of bounds and therefore "No Good".
- 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.
- Lane Early – Indicates that the lane change was initiated too early relative to the timing criteria listed for the scenario.
- Lane Late – Indicates that the lane change was initiated too late relative to the timing criteria listed for the scenario.
- Collision – Indicates that the SV and POV collided.

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

Examples of time history plots for each test type (including passing, failing, and invalid runs) are shown in Figures D1 through D3. Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure D4.

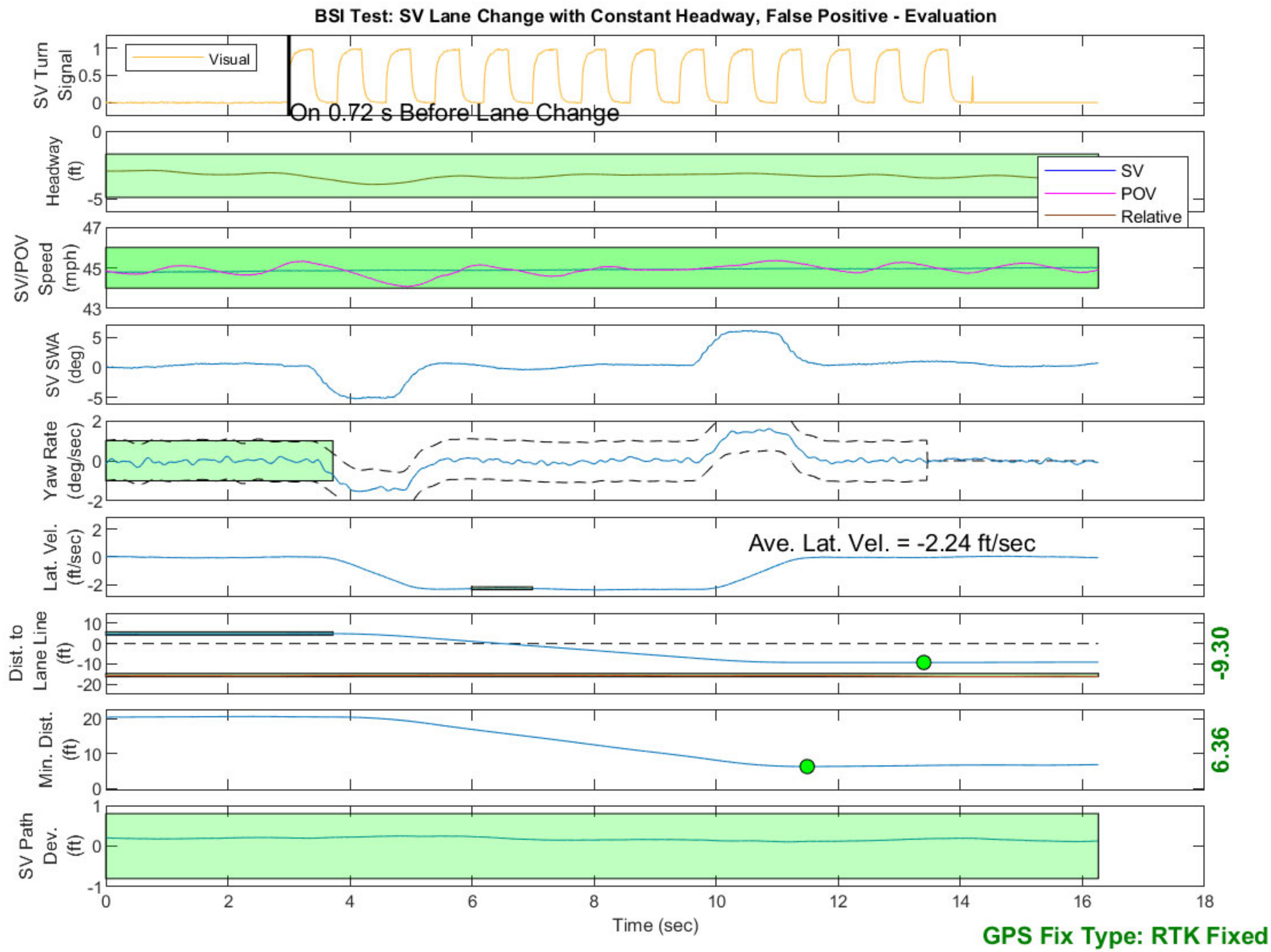

Figure D1. Example Time History for False Positive Evaluation, Passing

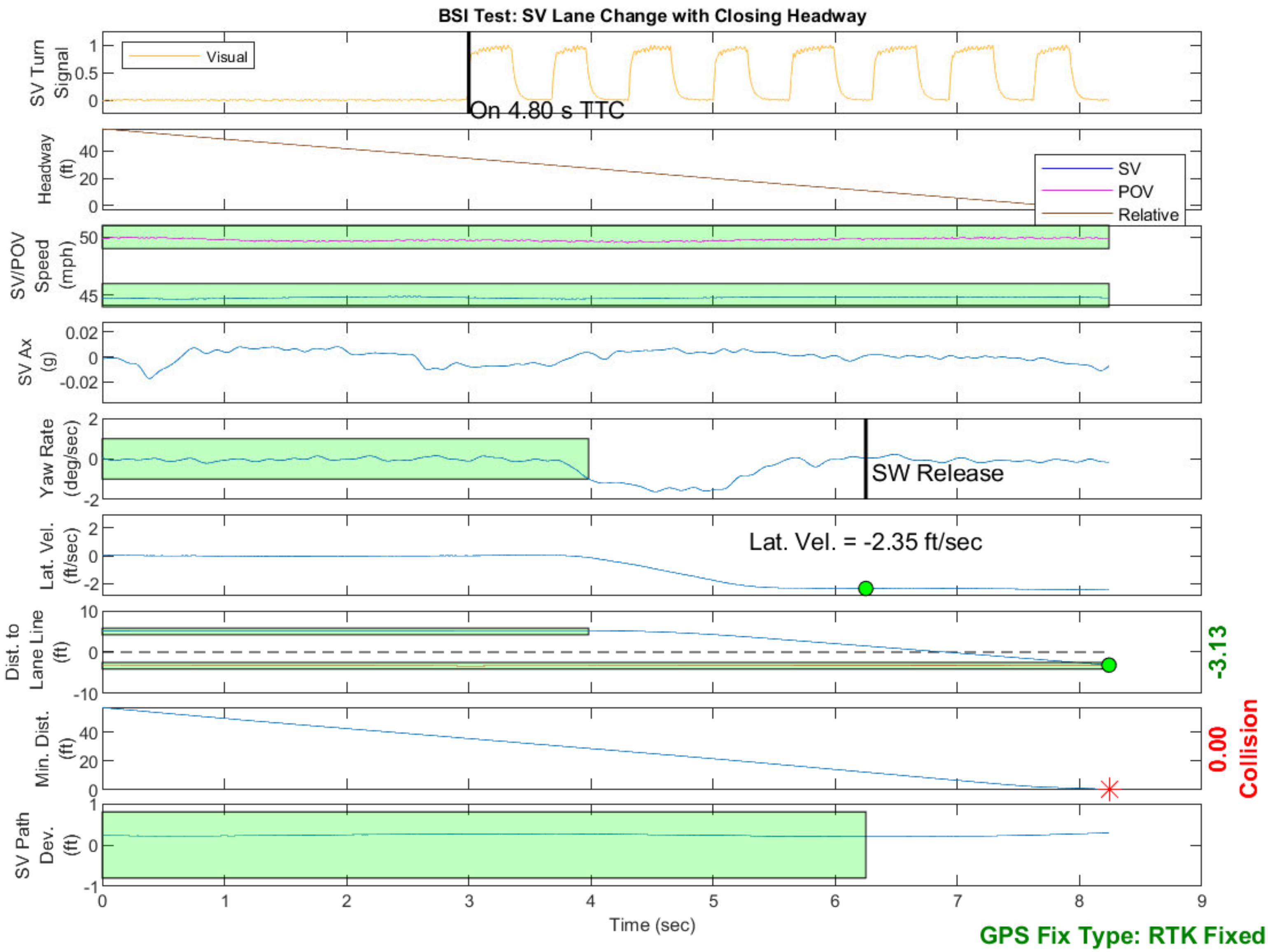

Figure D2. Example Time History for Subject Vehicle with Closing Headway Test, Failing

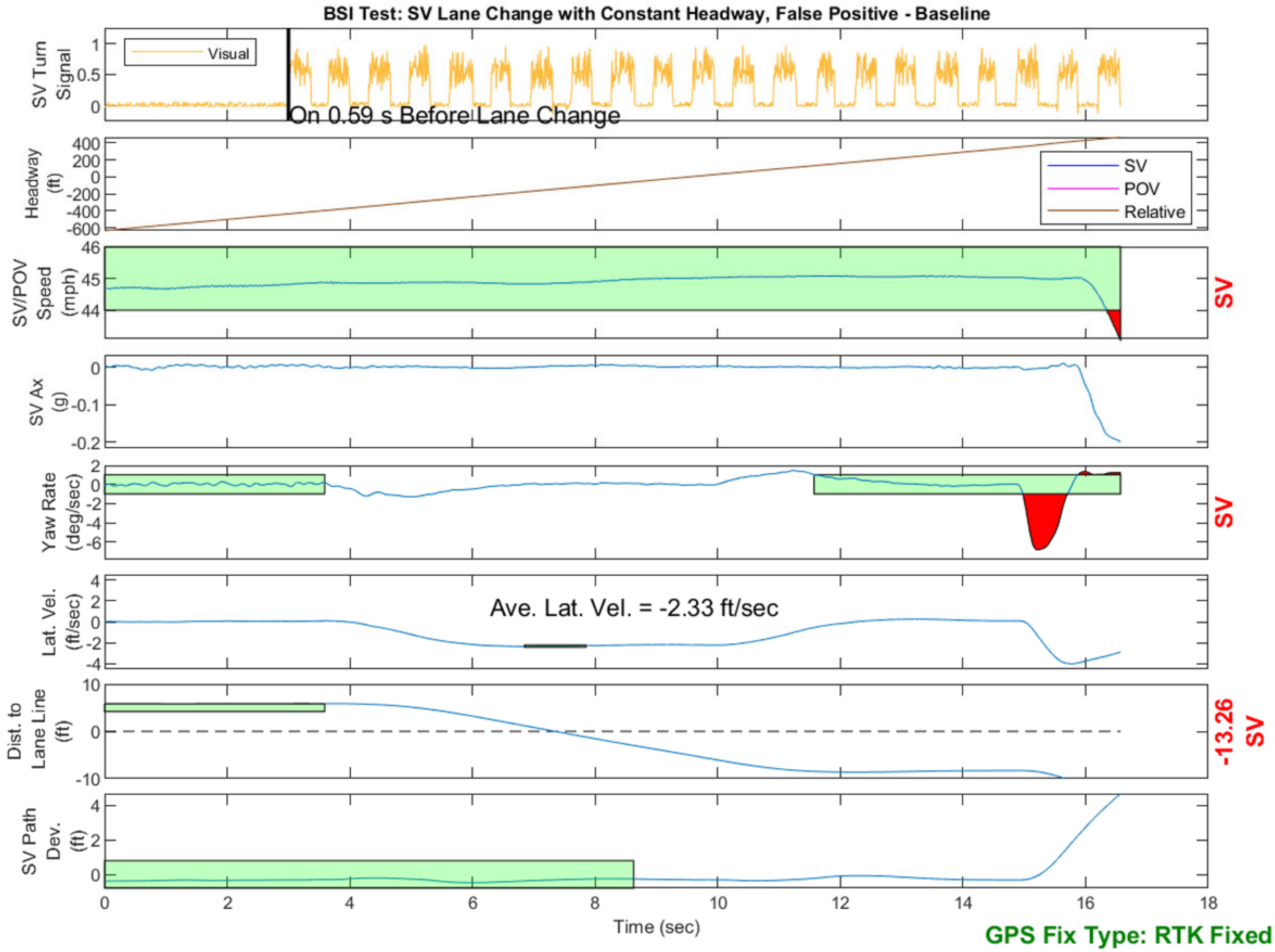

Figure D3. Example Time History for Subject Vehicle with Constant Headway Test, Invalid POV Speed Criteria

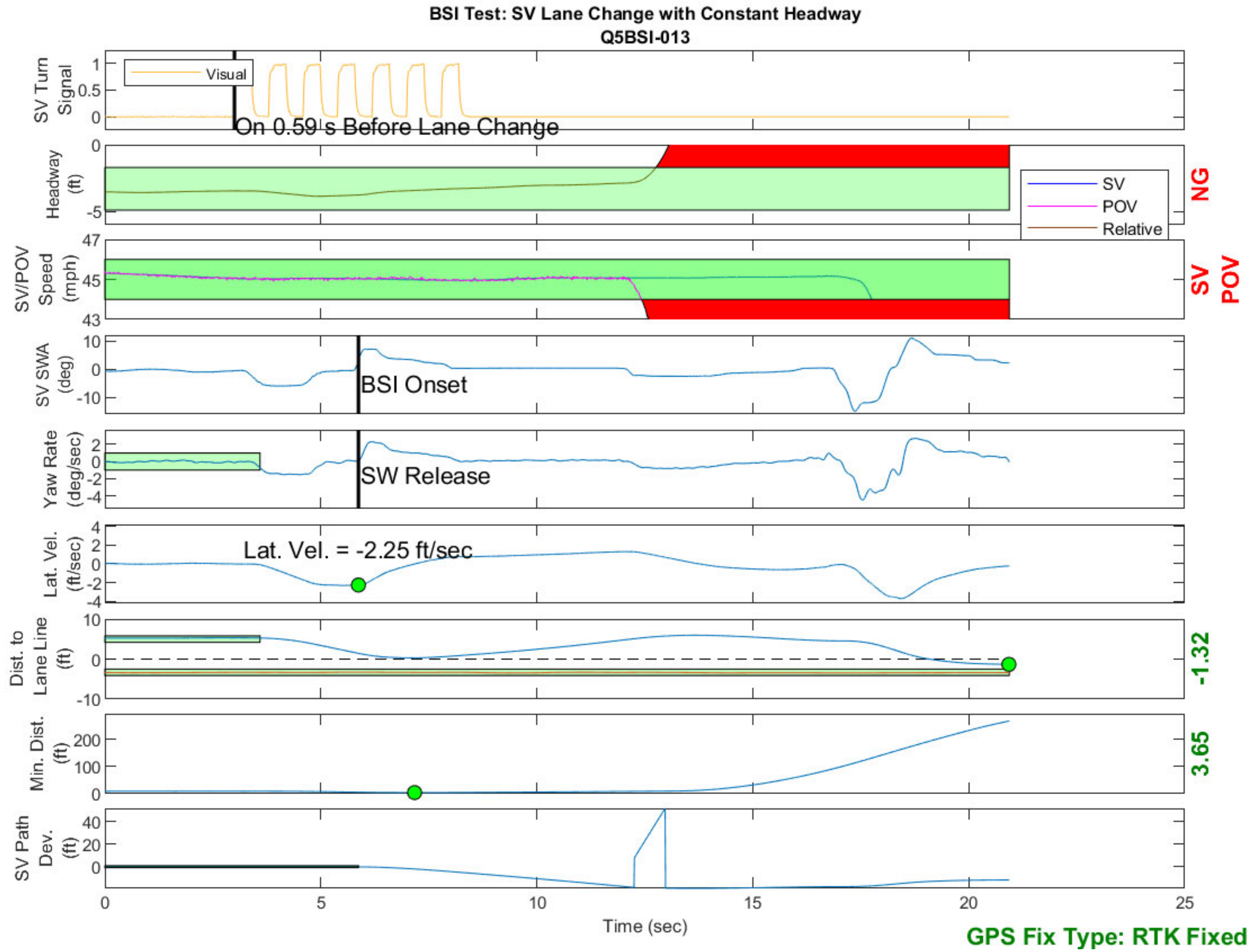

Figure D4. BSI Run 13, Subject Vehicle Lane Change with Constant Headway

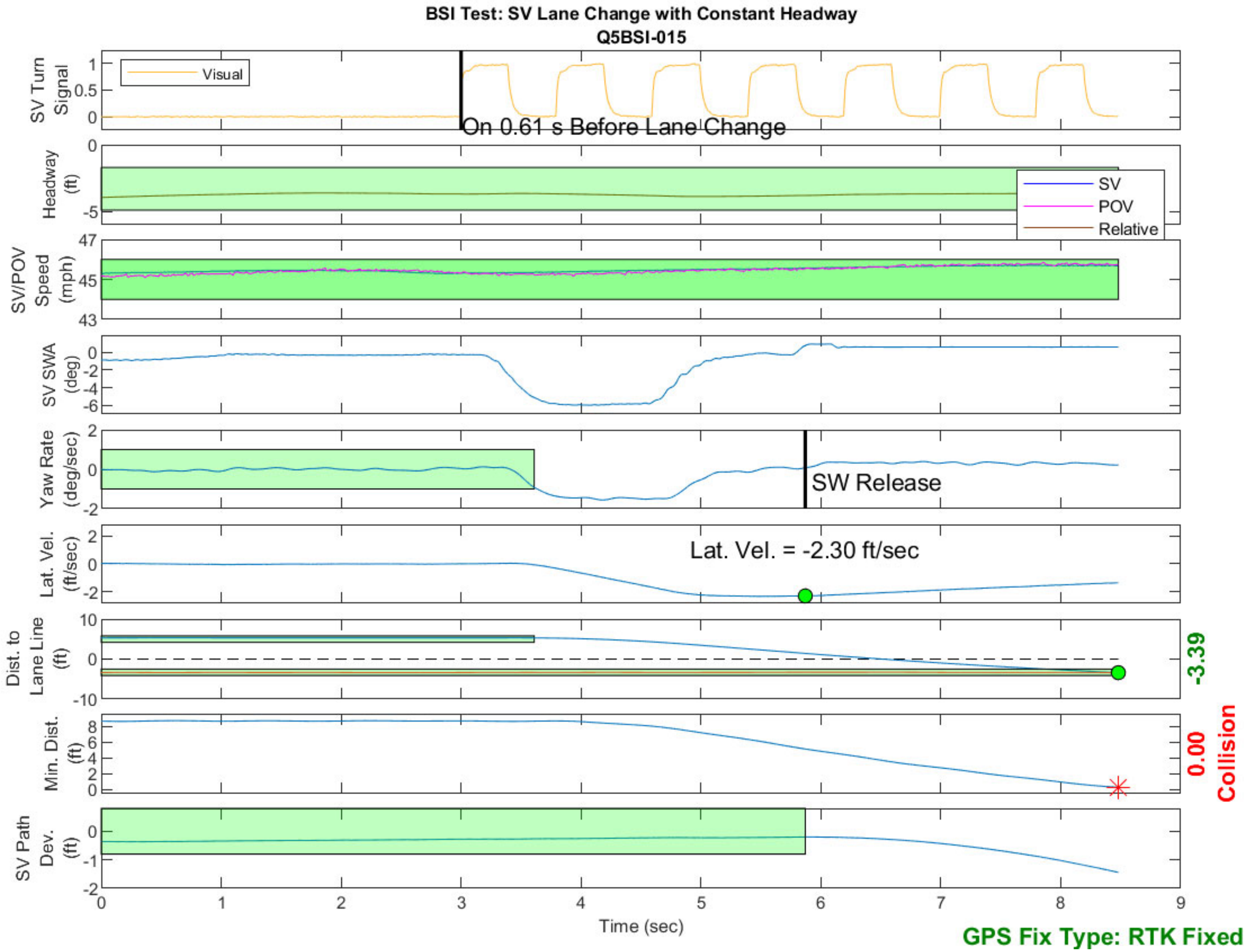

Figure D5. BSI Run 15, Subject Vehicle Lane Change with Constant Headway

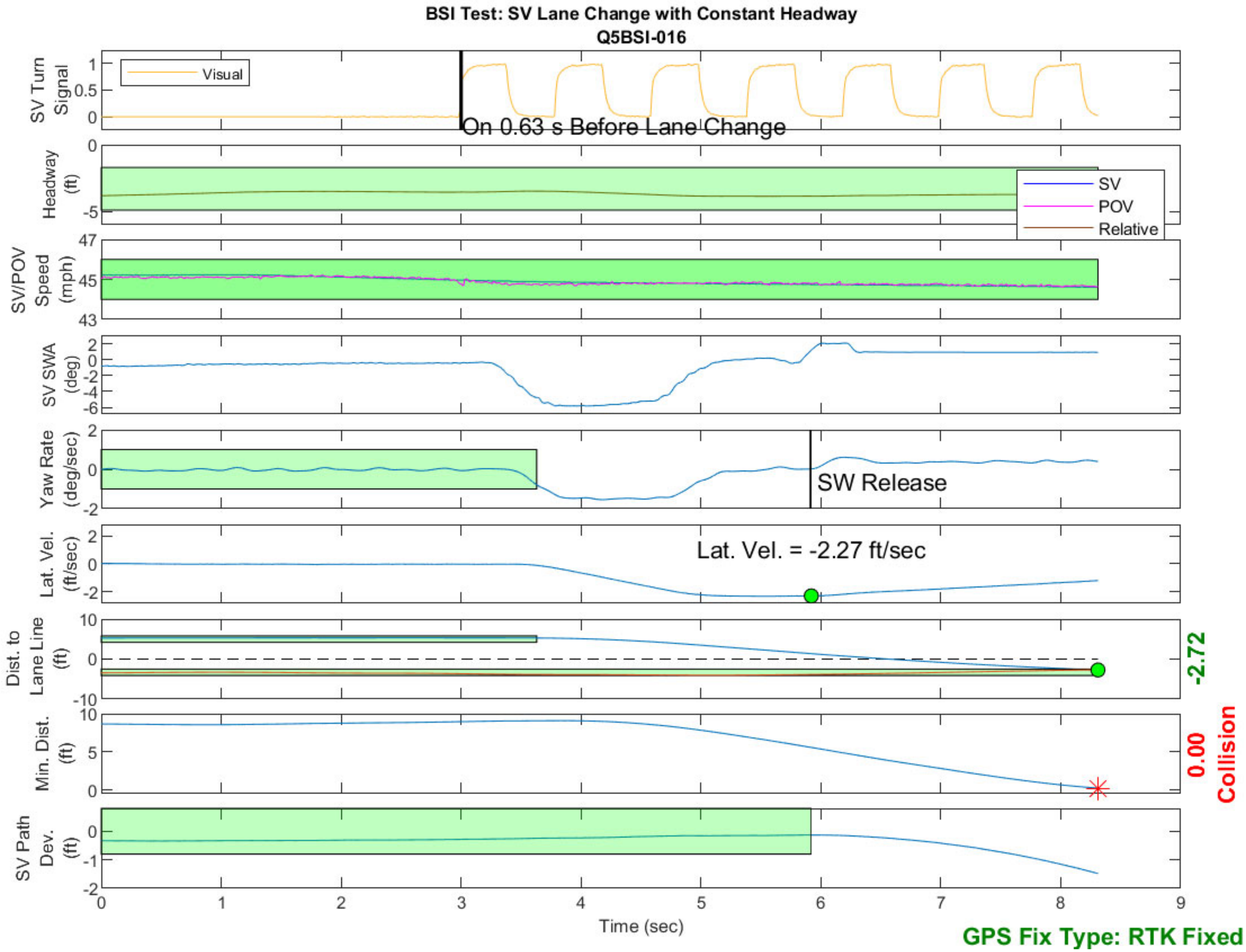

Figure D6. BSI Run 16, Subject Vehicle Lane Change with Constant Headway

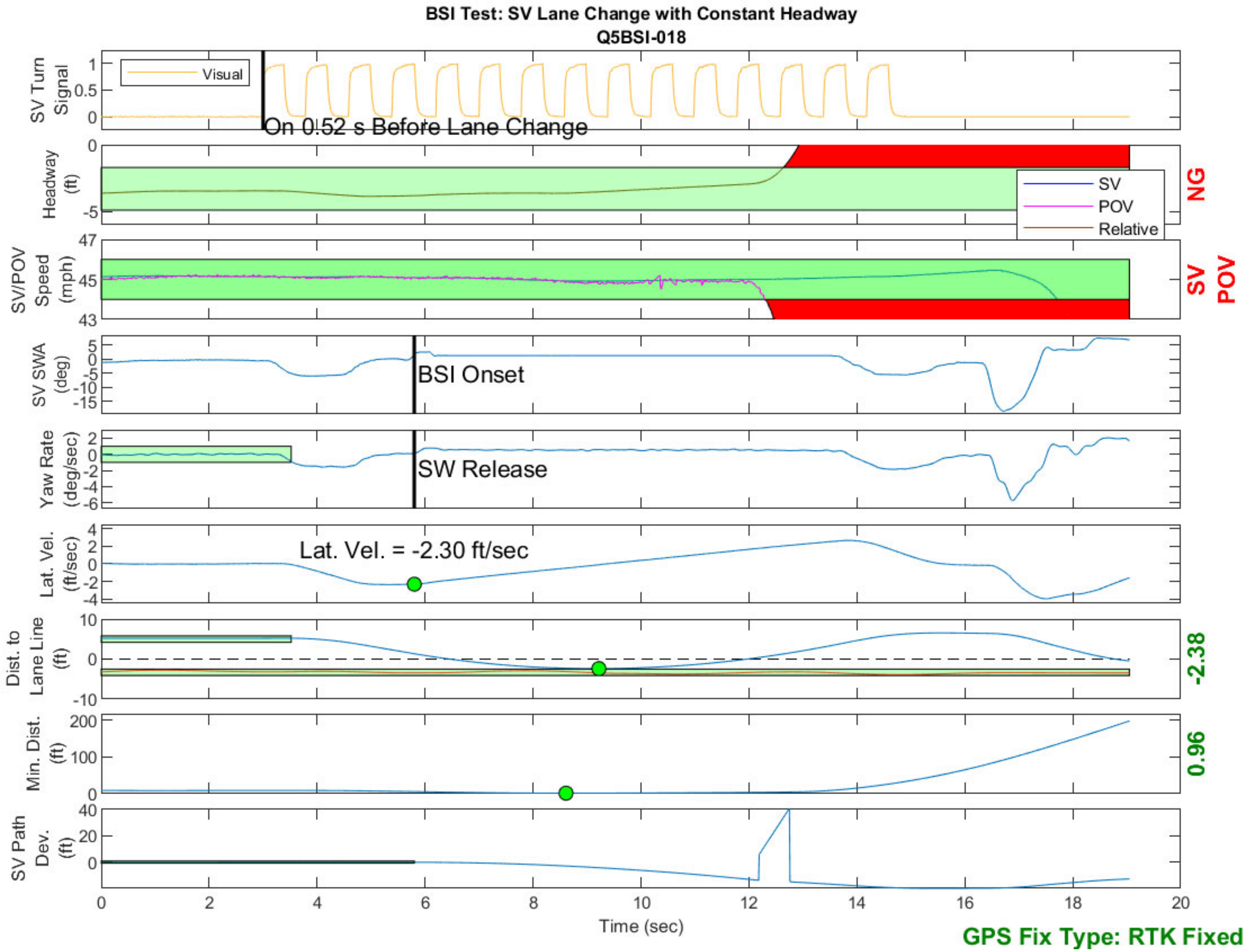

Figure D7. BSI Run 18, Subject Vehicle Lane Change with Constant Headway

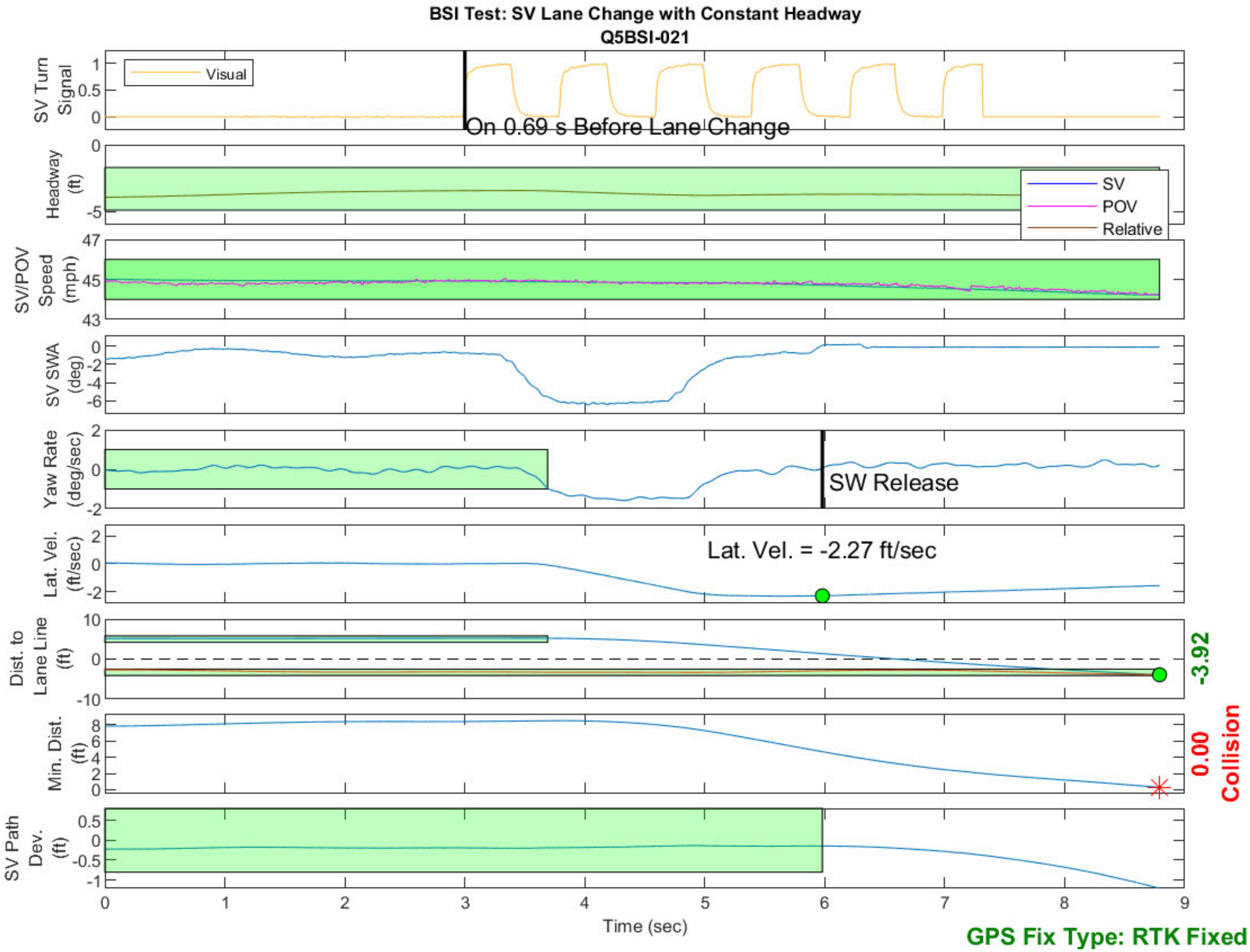

Figure D8. BSI Run 21, Subject Vehicle Lane Change with Constant Headway

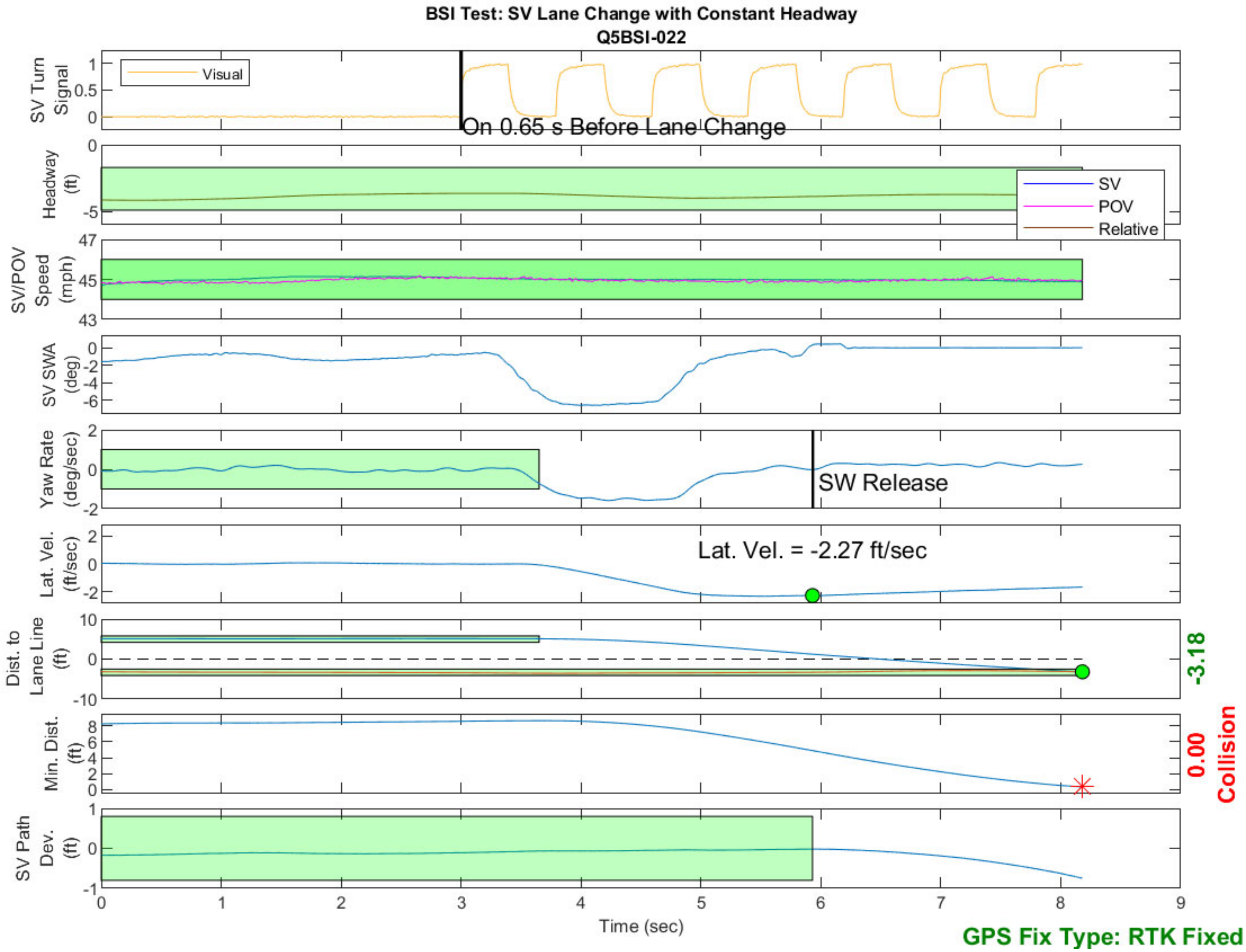

Figure D9. BSI Run 22, Subject Vehicle Lane Change with Constant Headway

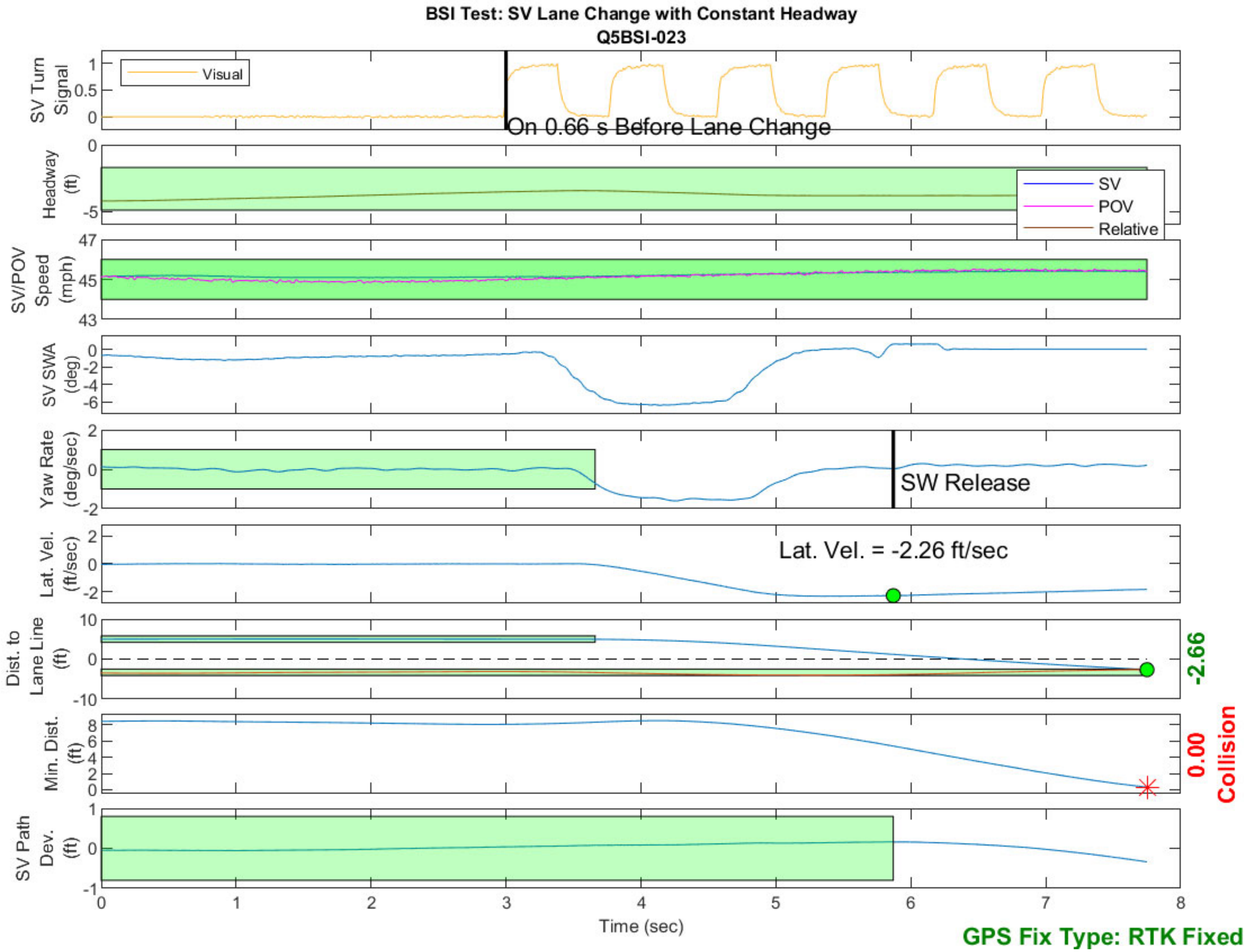

Figure D10. BSI Run 23, Subject Vehicle Lane Change with Constant Headway

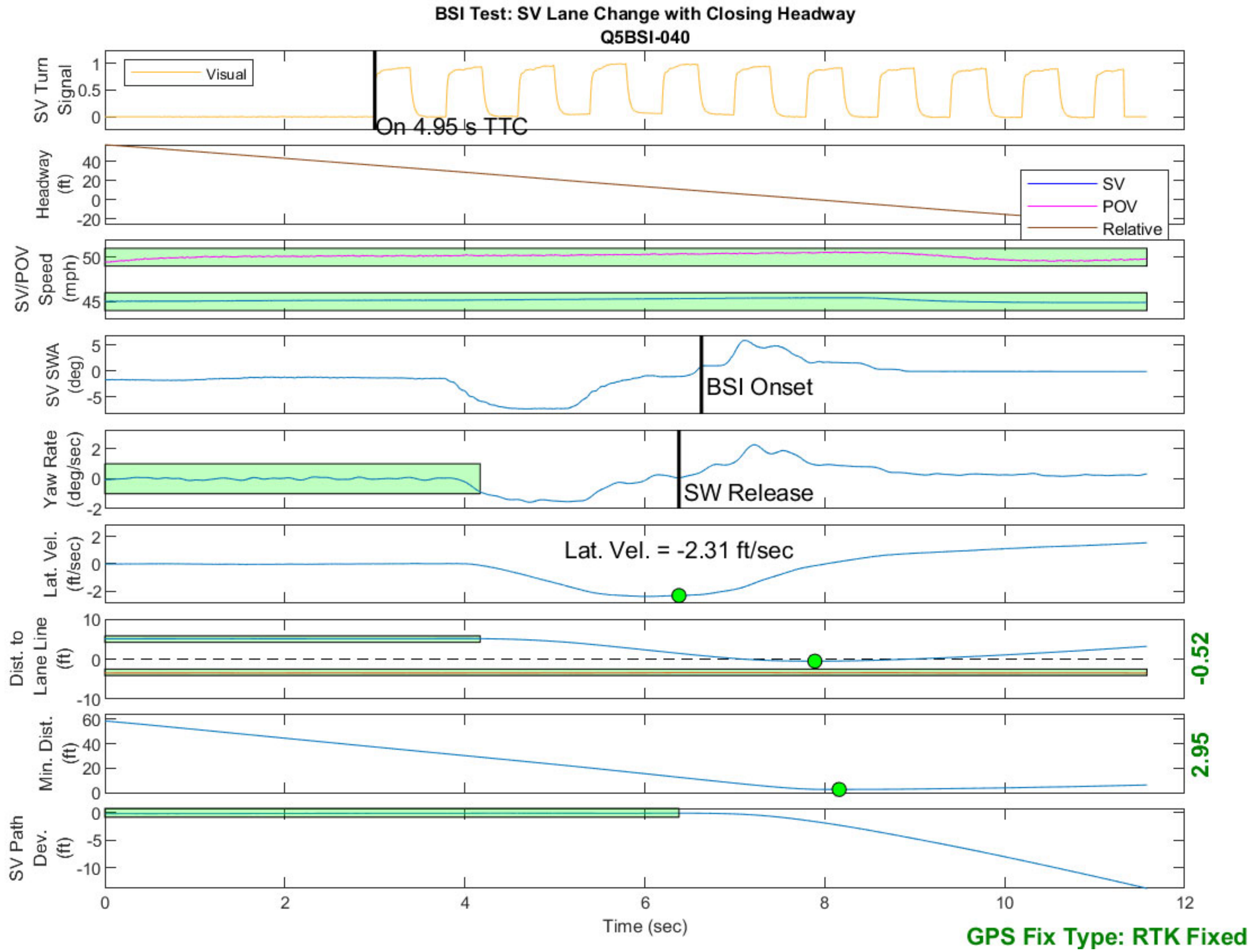

Figure D11. BSI Run 40, Subject Vehicle Lane Change with Closing Headway

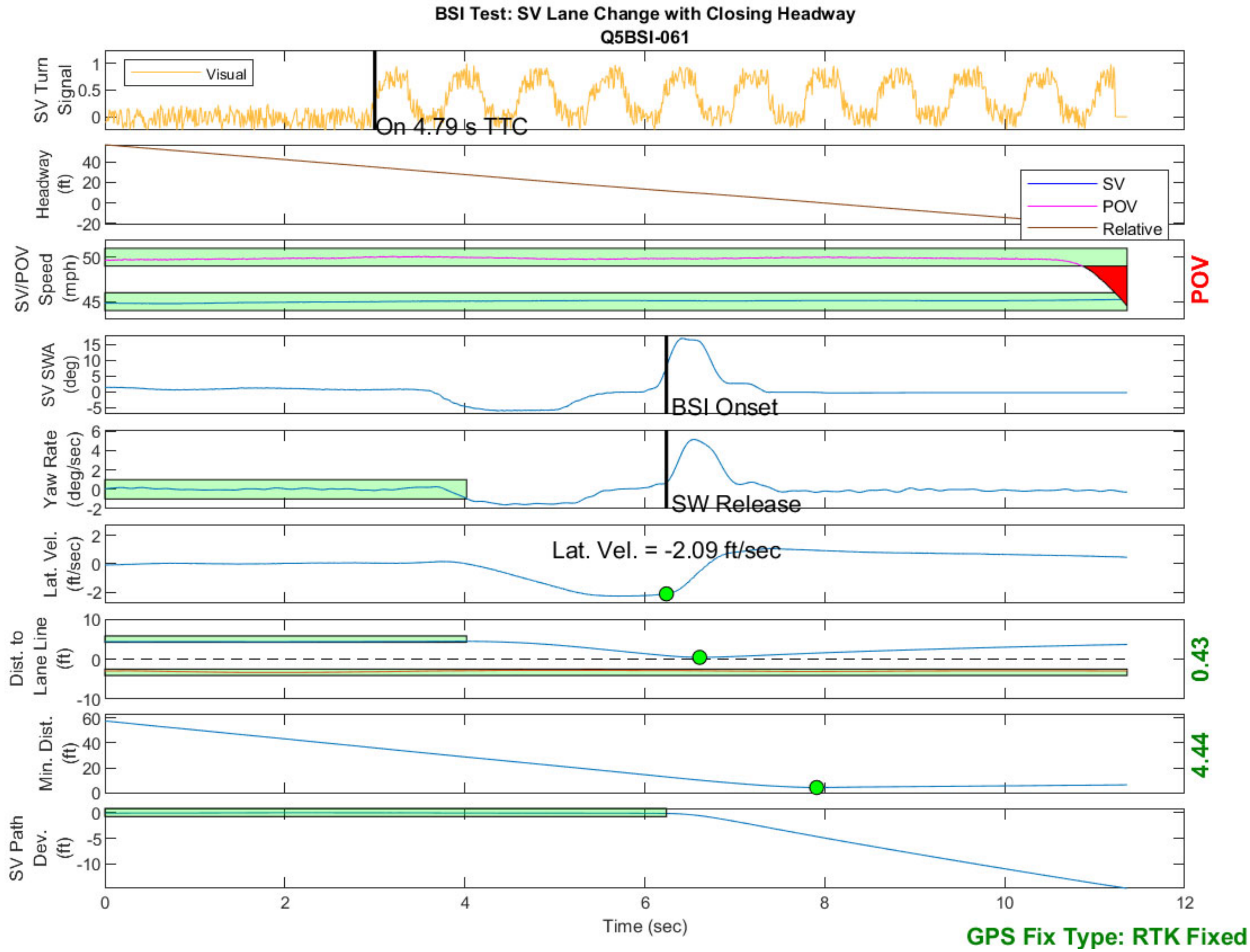

Figure D12. BSI Run 61, Subject Vehicle Lane Change with Closing Headway

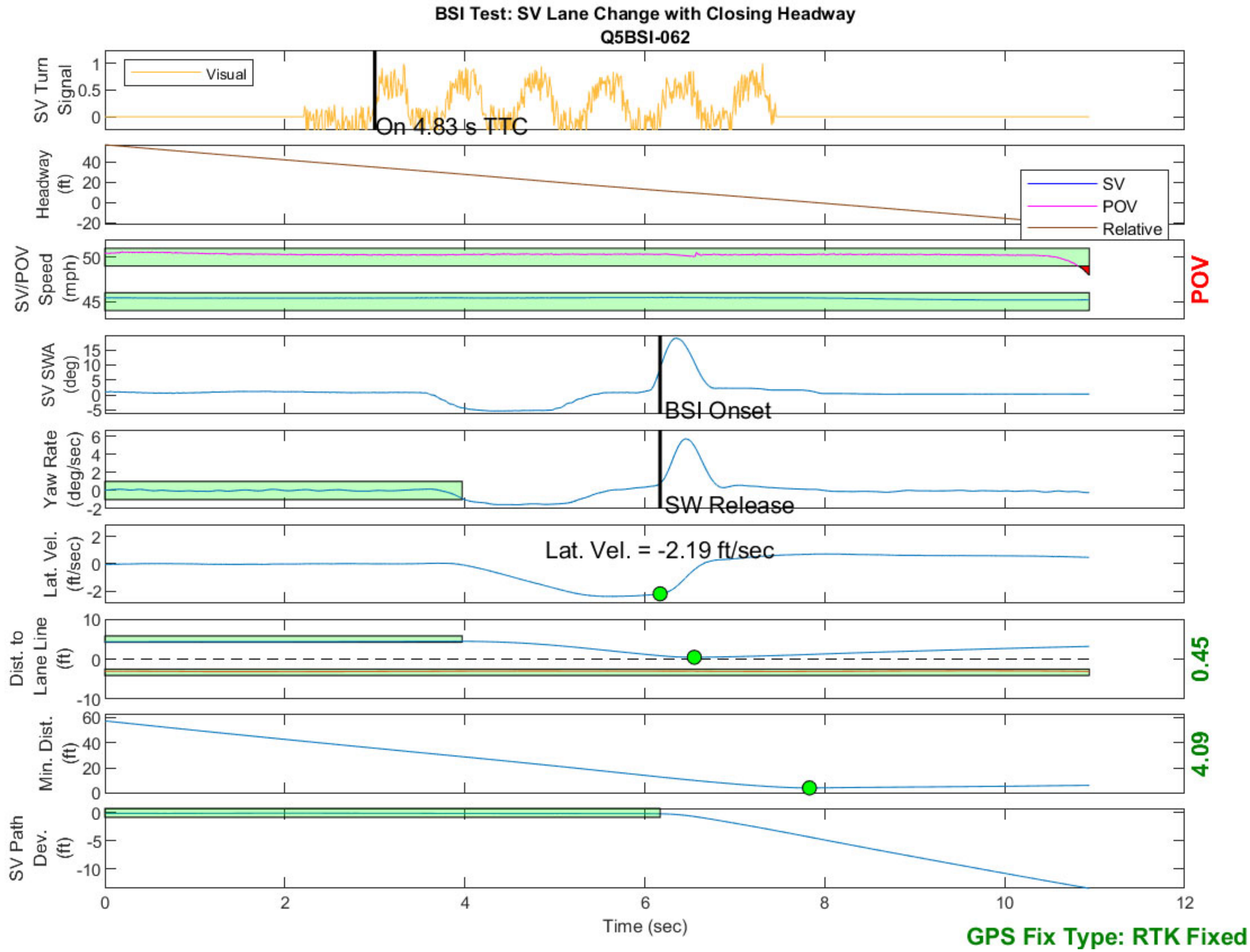

Figure D13. BSI Run 62, Subject Vehicle Lane Change with Closing Headway

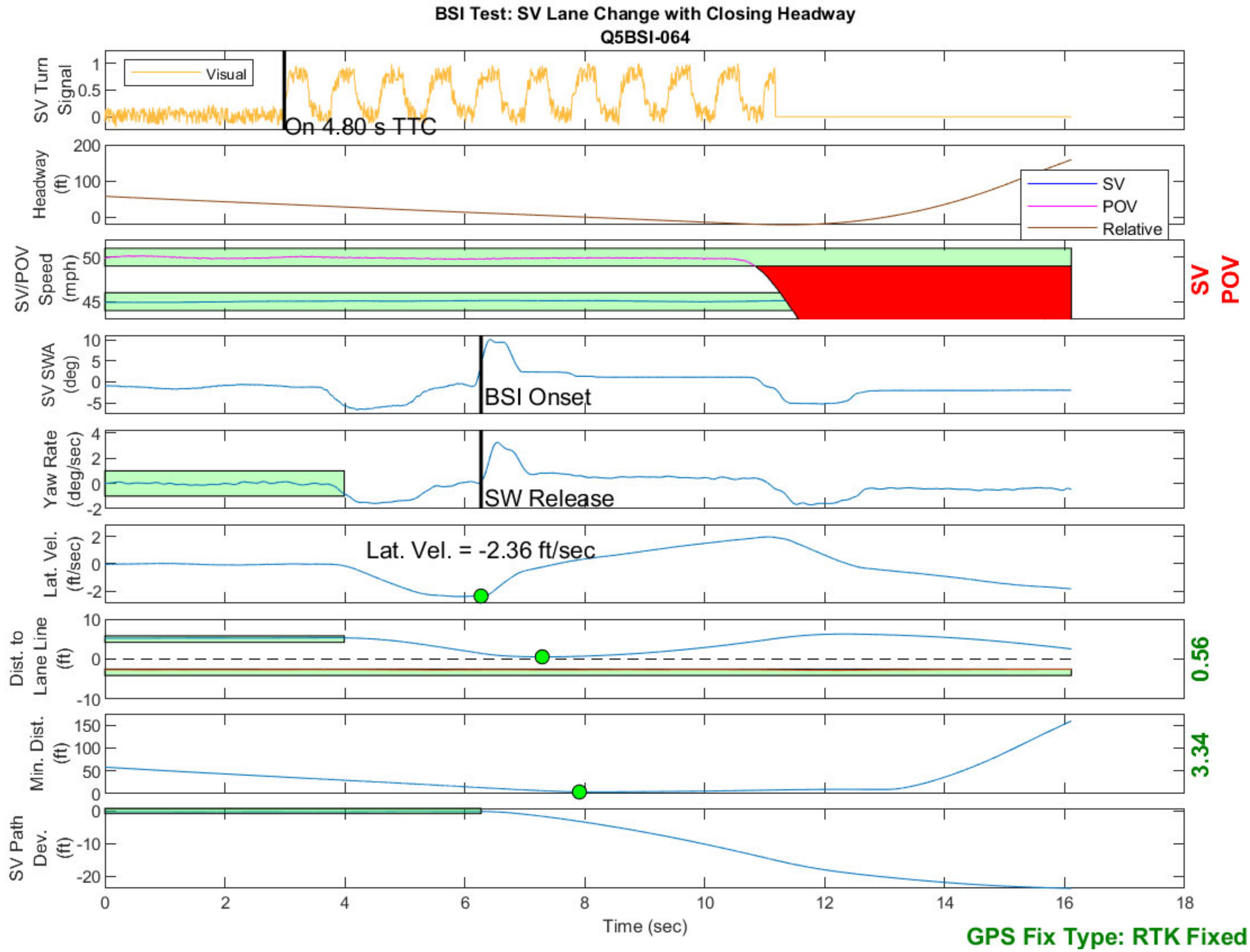

Figure D14. BSI Run 64, Subject Vehicle Lane Change with Closing Headway

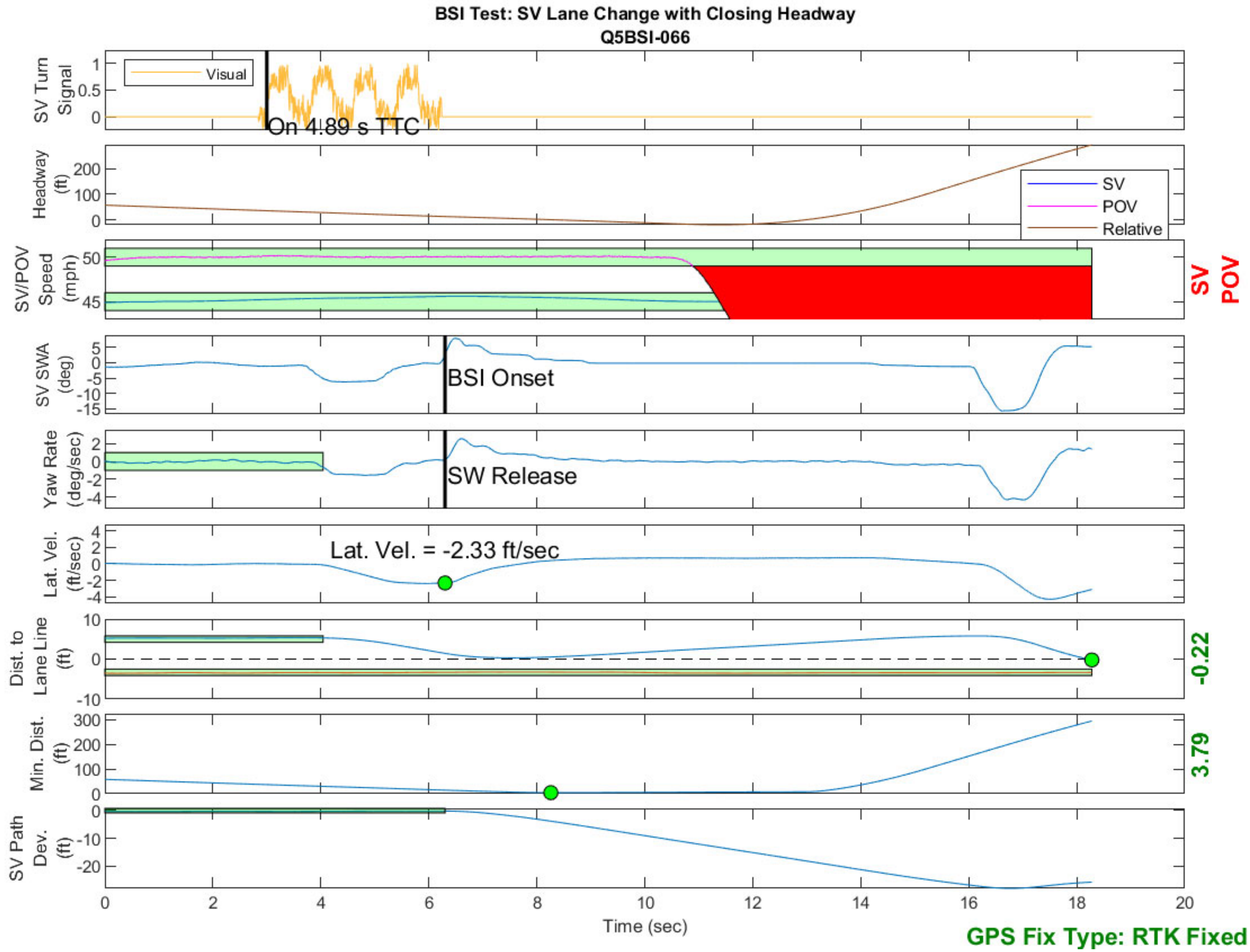

Figure D15. BSI Run 66, Subject Vehicle Lane Change with Closing Headway

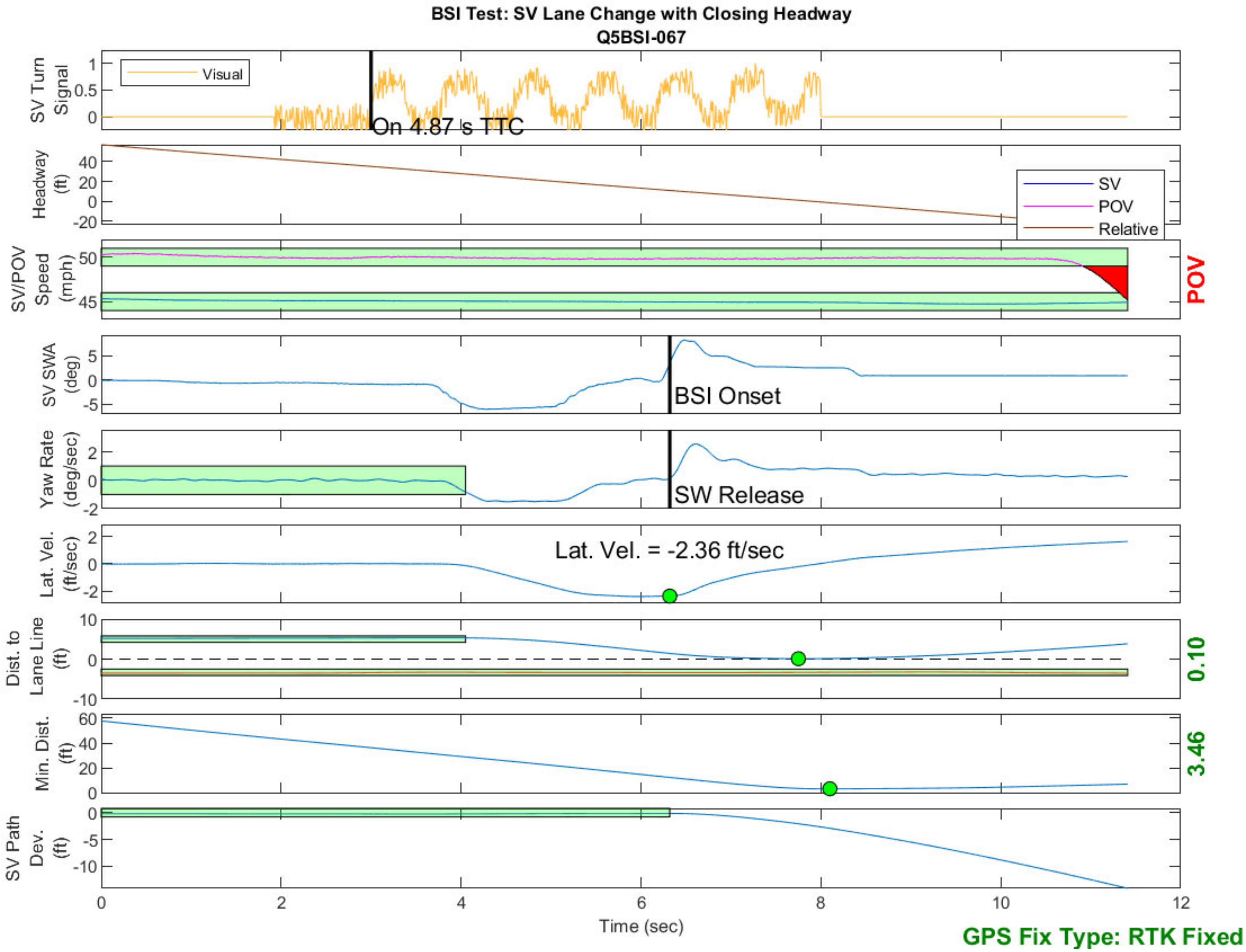

Figure D16. BSI Run 67, Subject Vehicle Lane Change with Closing Headway

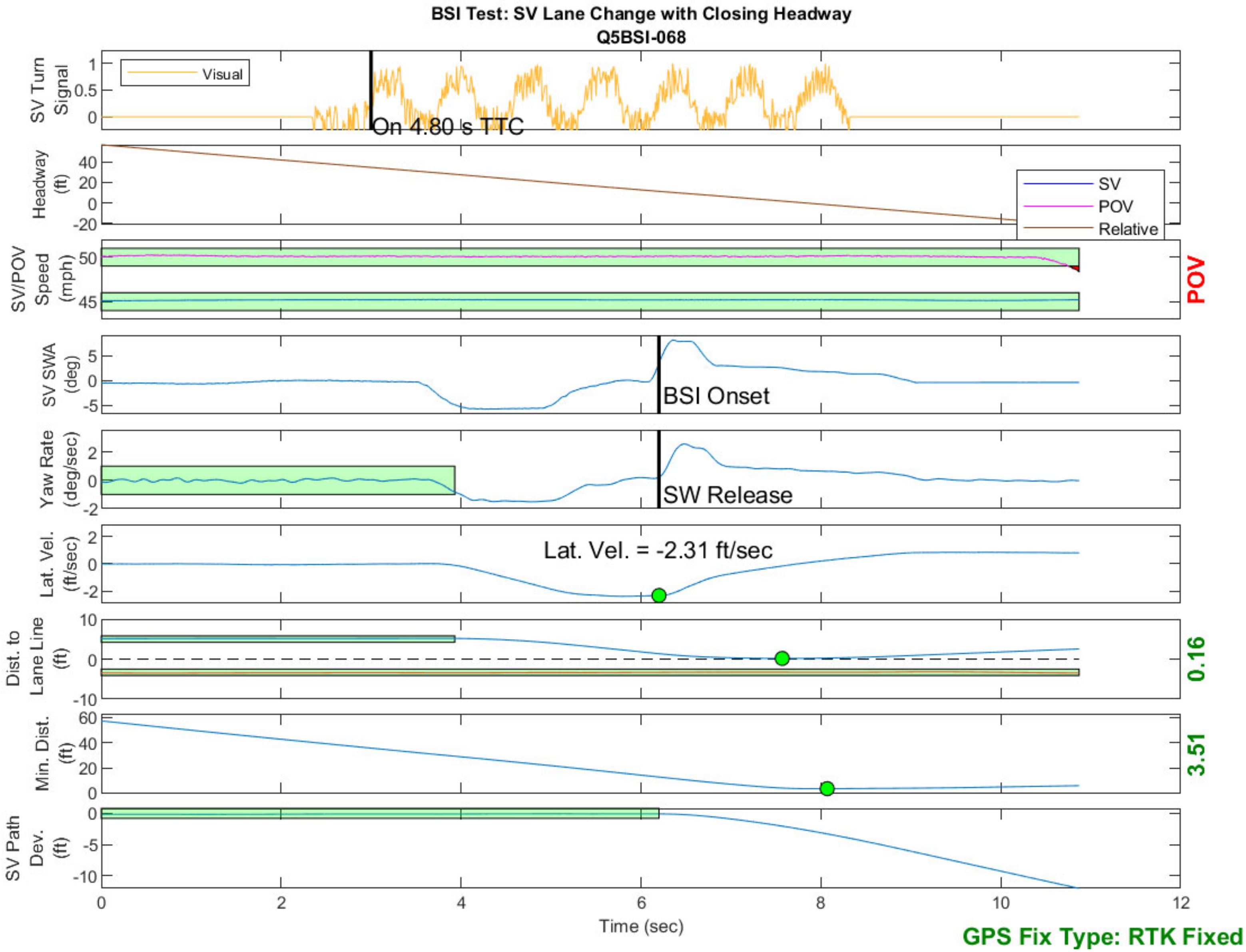

Figure D17. BSI Run 68, Subject Vehicle Lane Change with Closing Headway

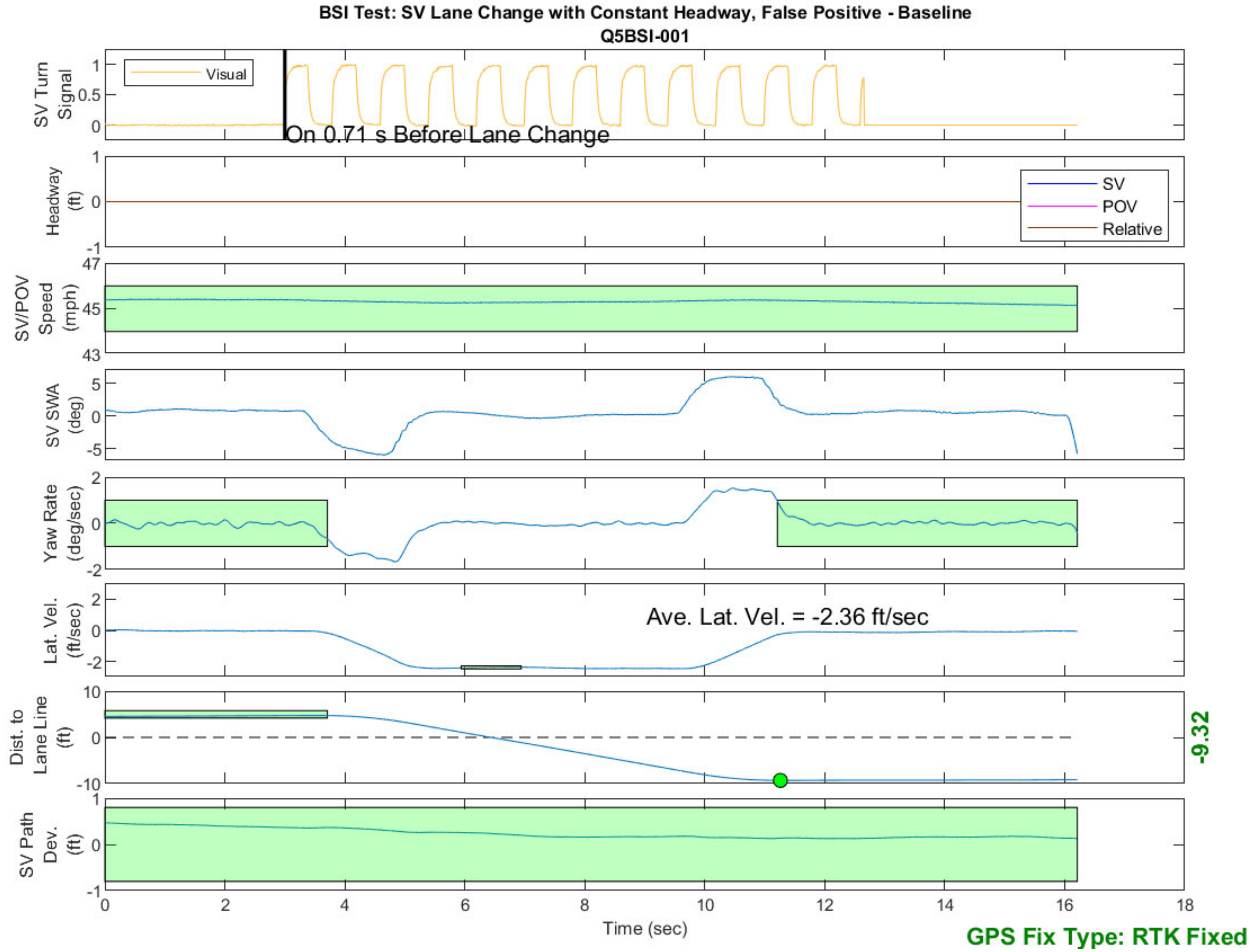

Figure D18. BSI Run 1, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

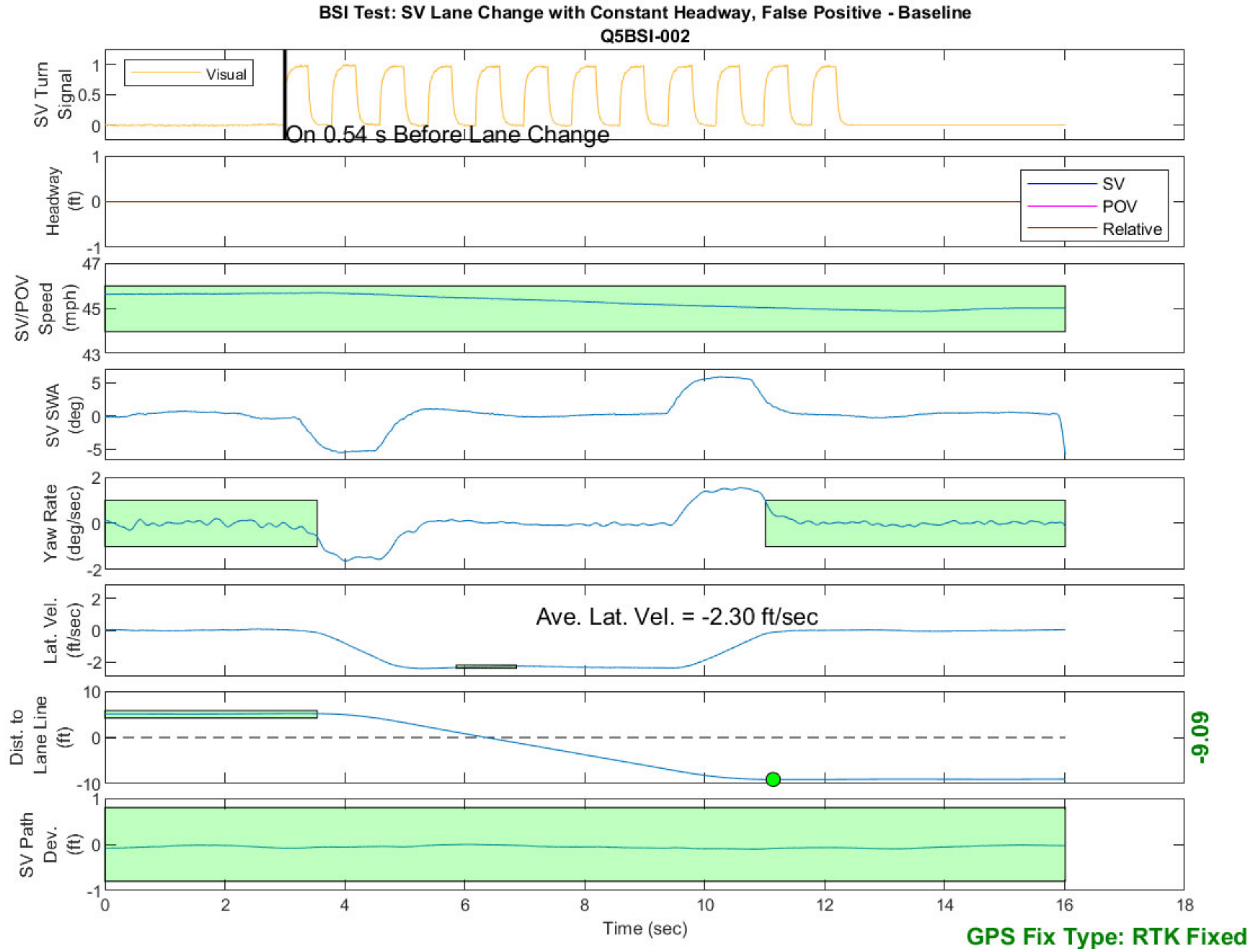

Figure D19. BSI Run 2, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

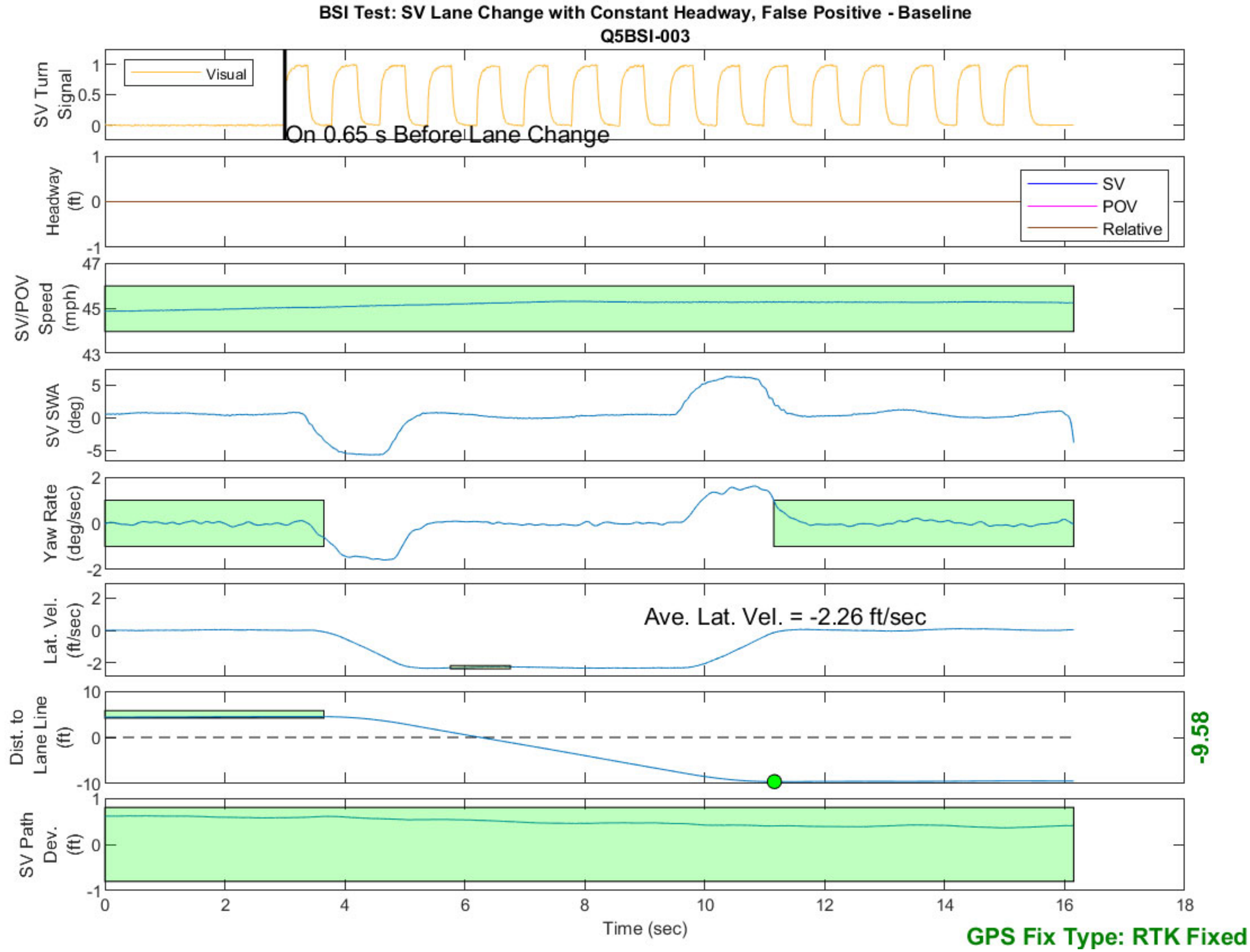

Figure D20. BSI Run 3, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

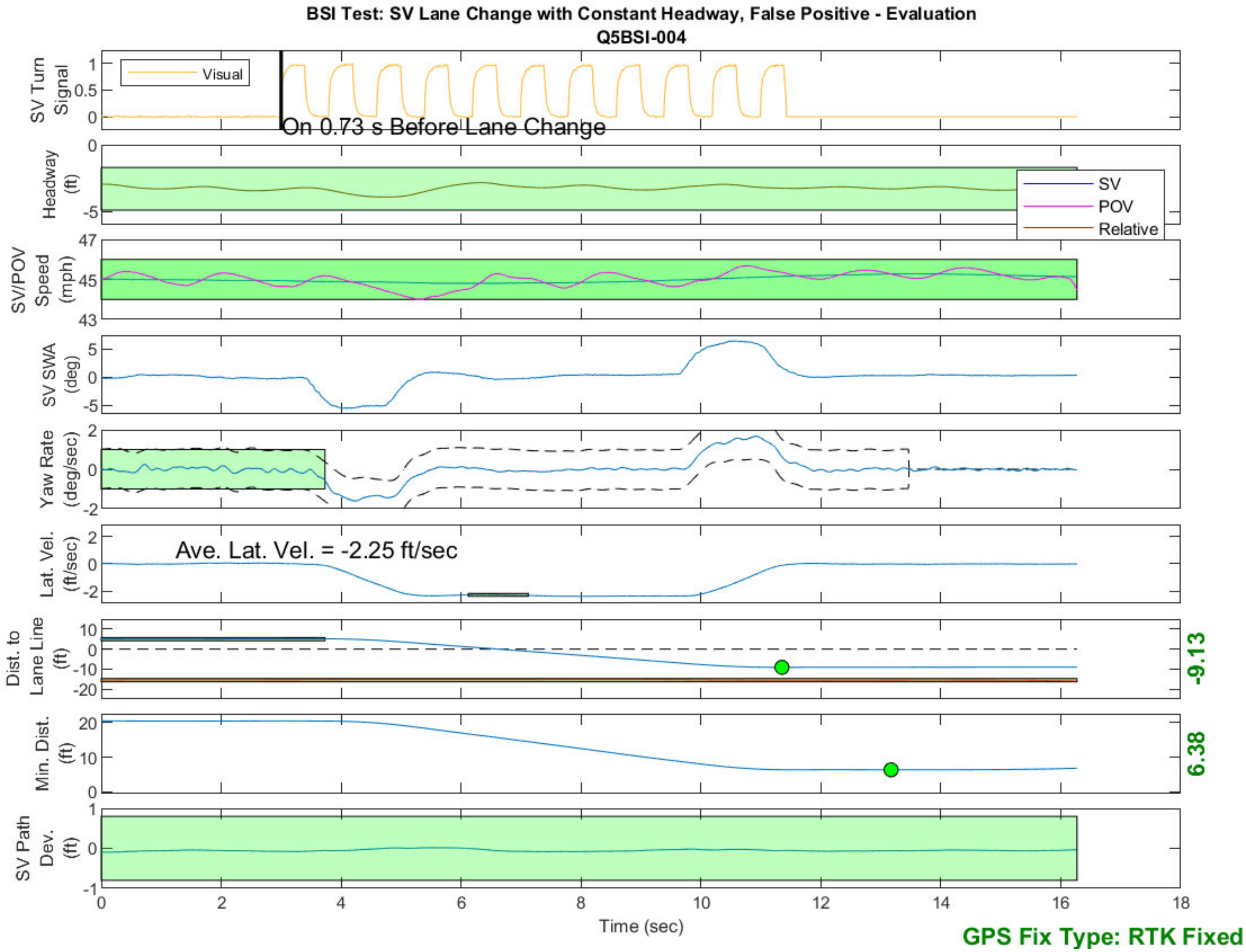

Figure D21. BSI Run 4, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

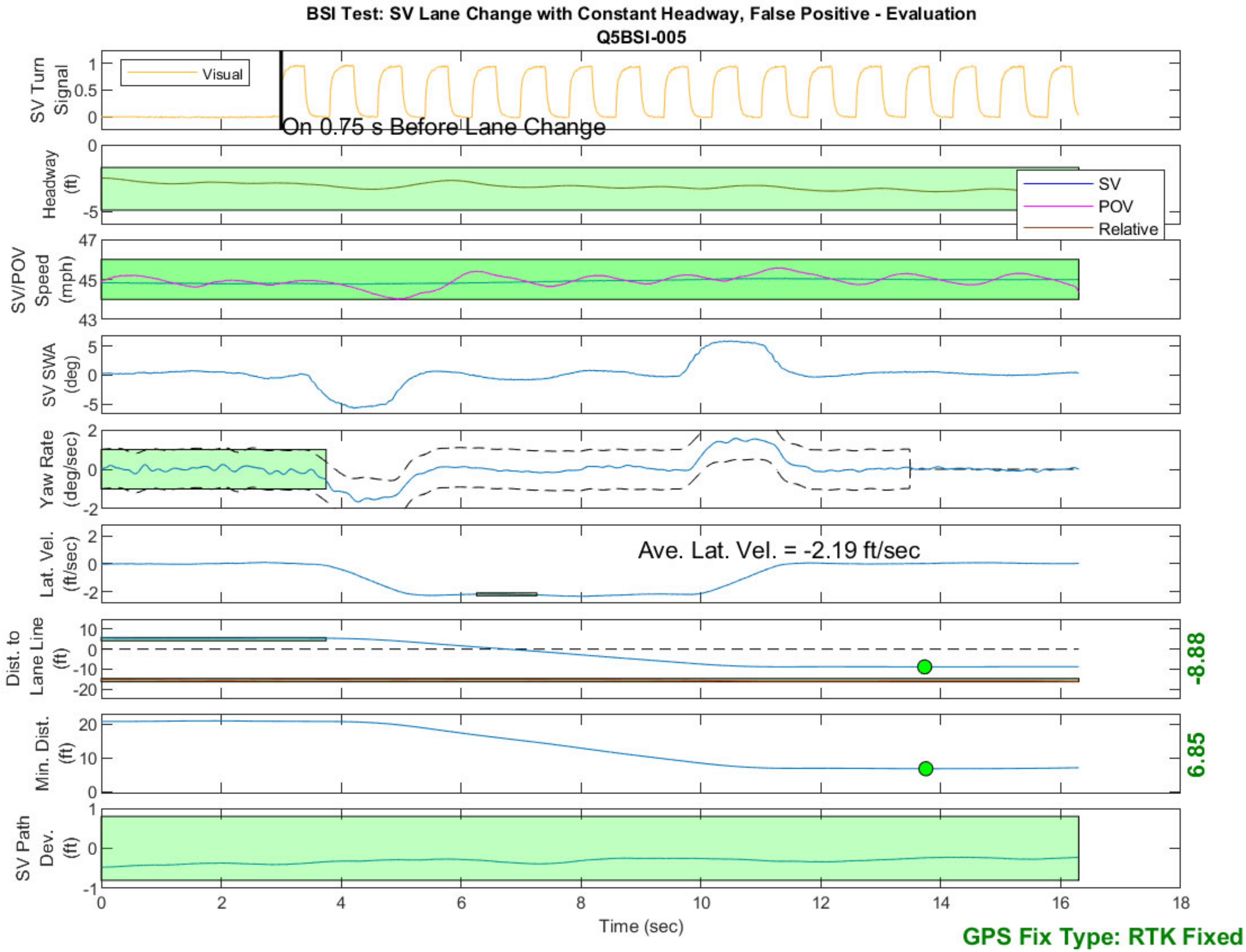

Figure D22. BSI Run 5, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

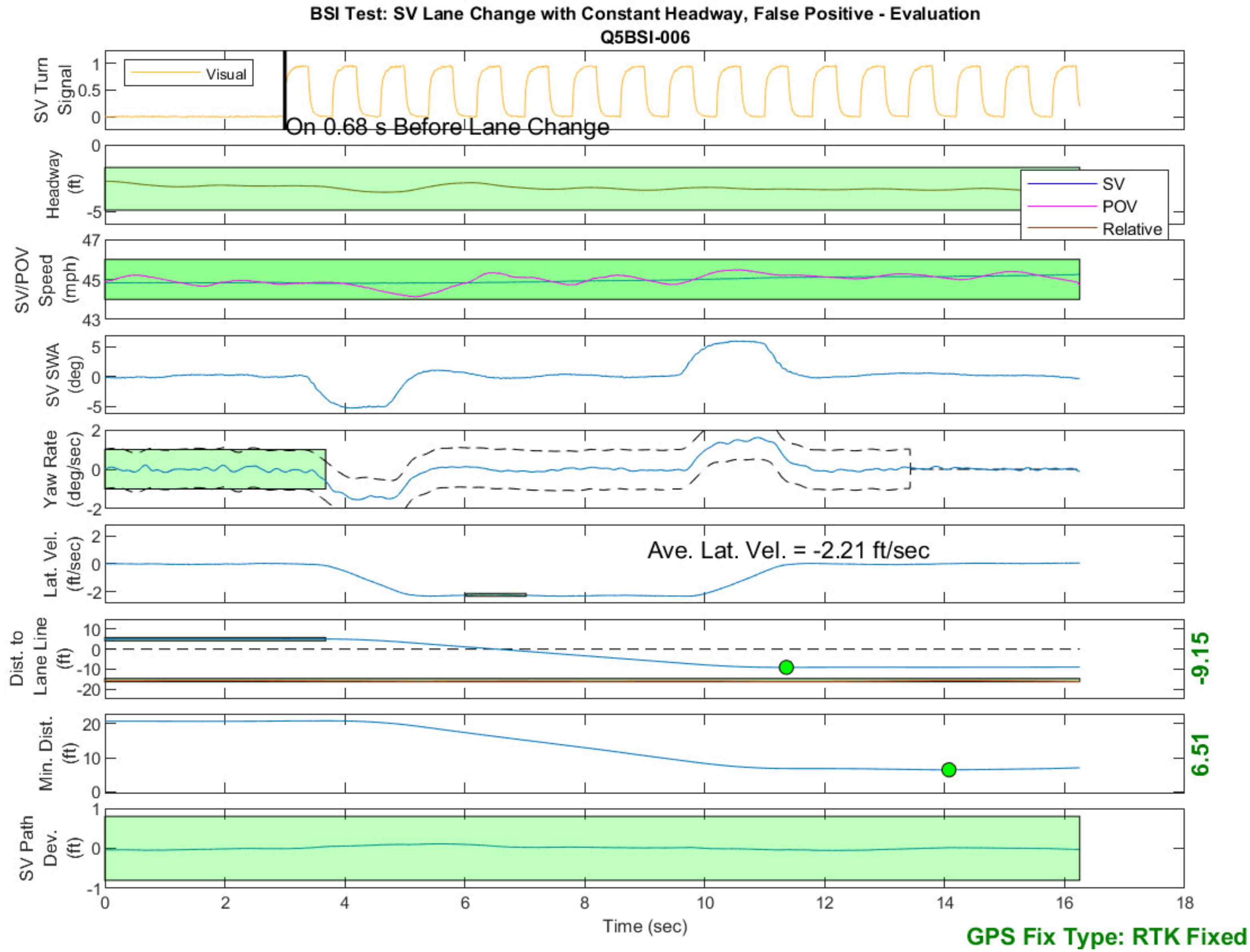

Figure D23. BSI Run 6, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

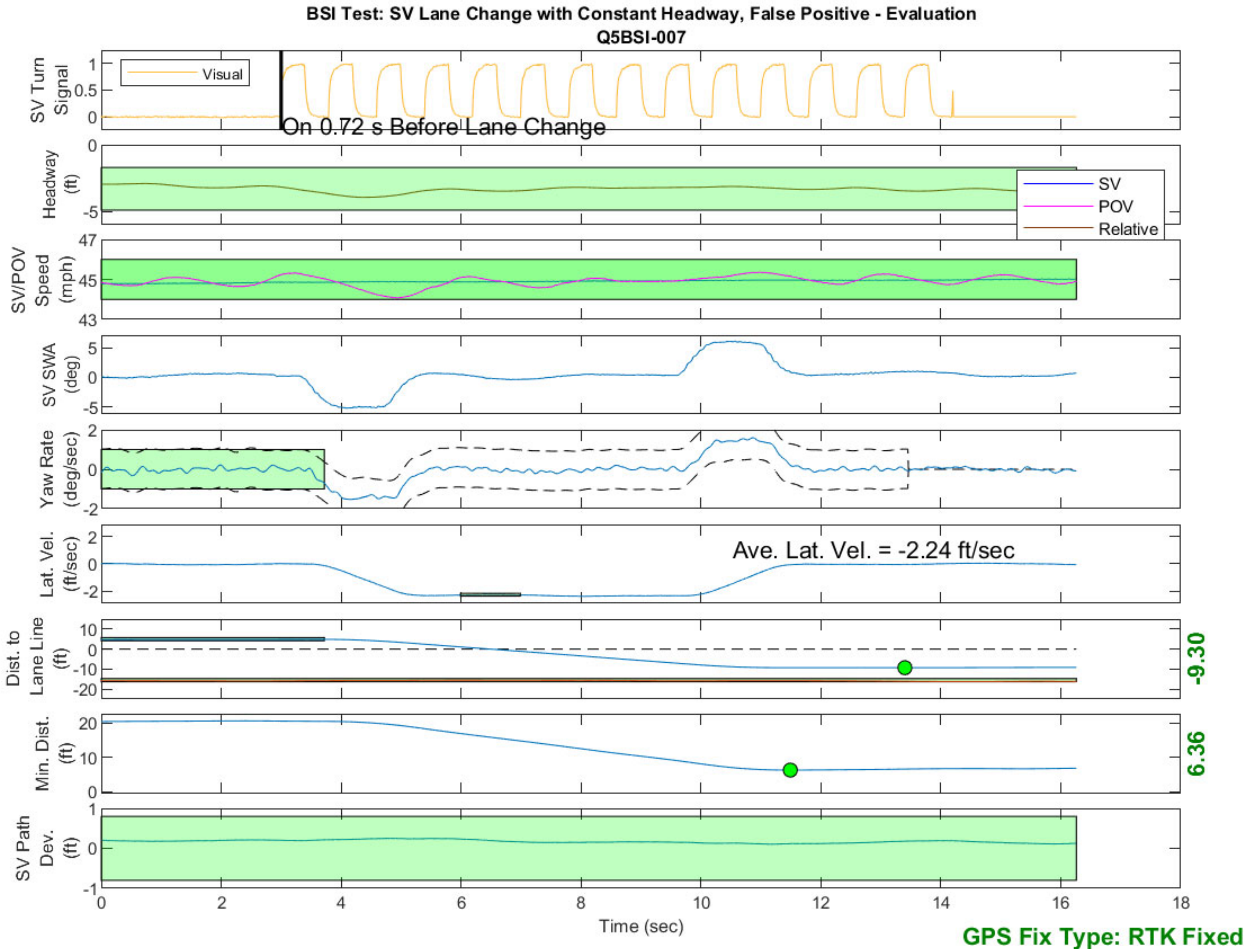

Figure D24. BSI Run 7, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

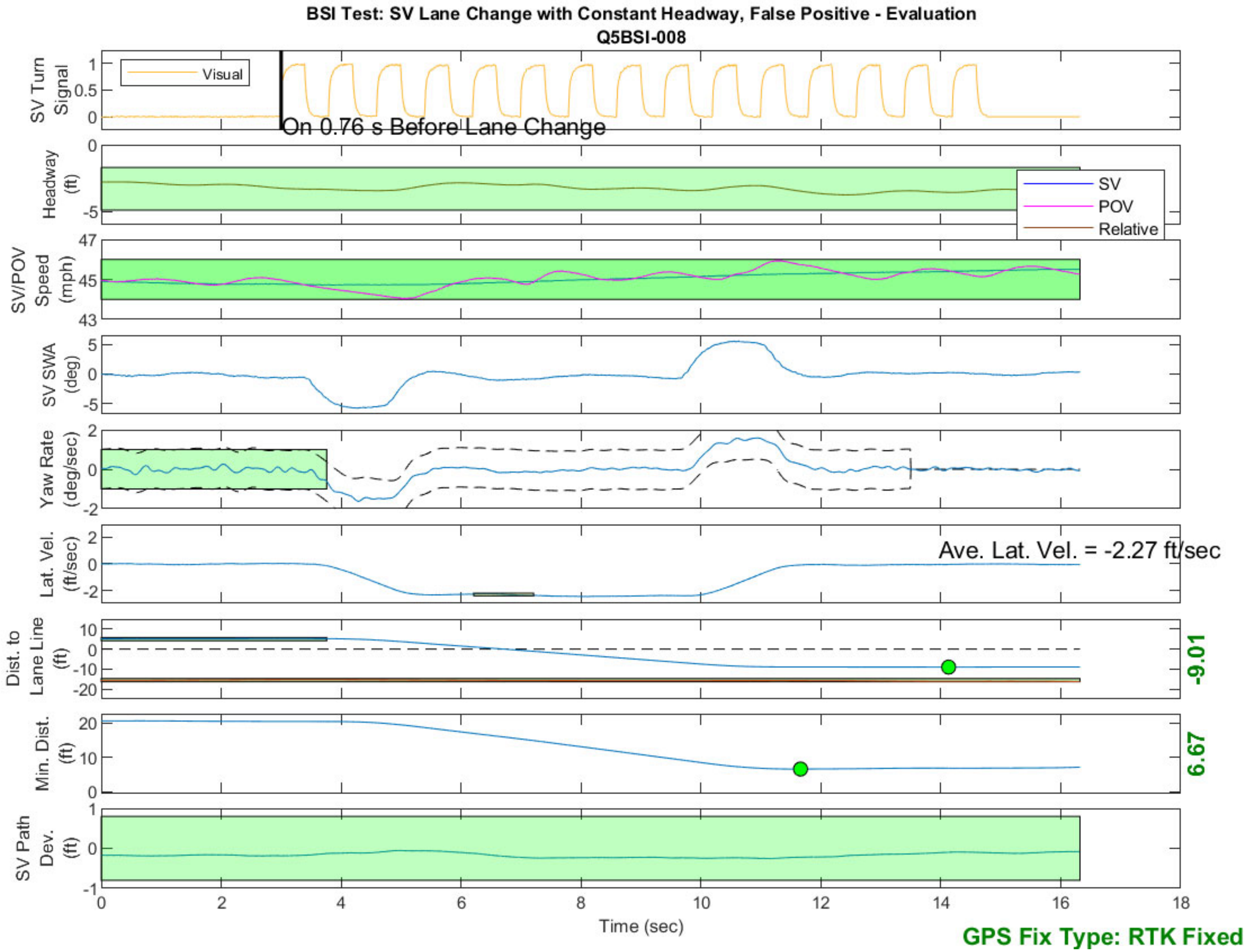

Figure D25. BSI Run 8, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

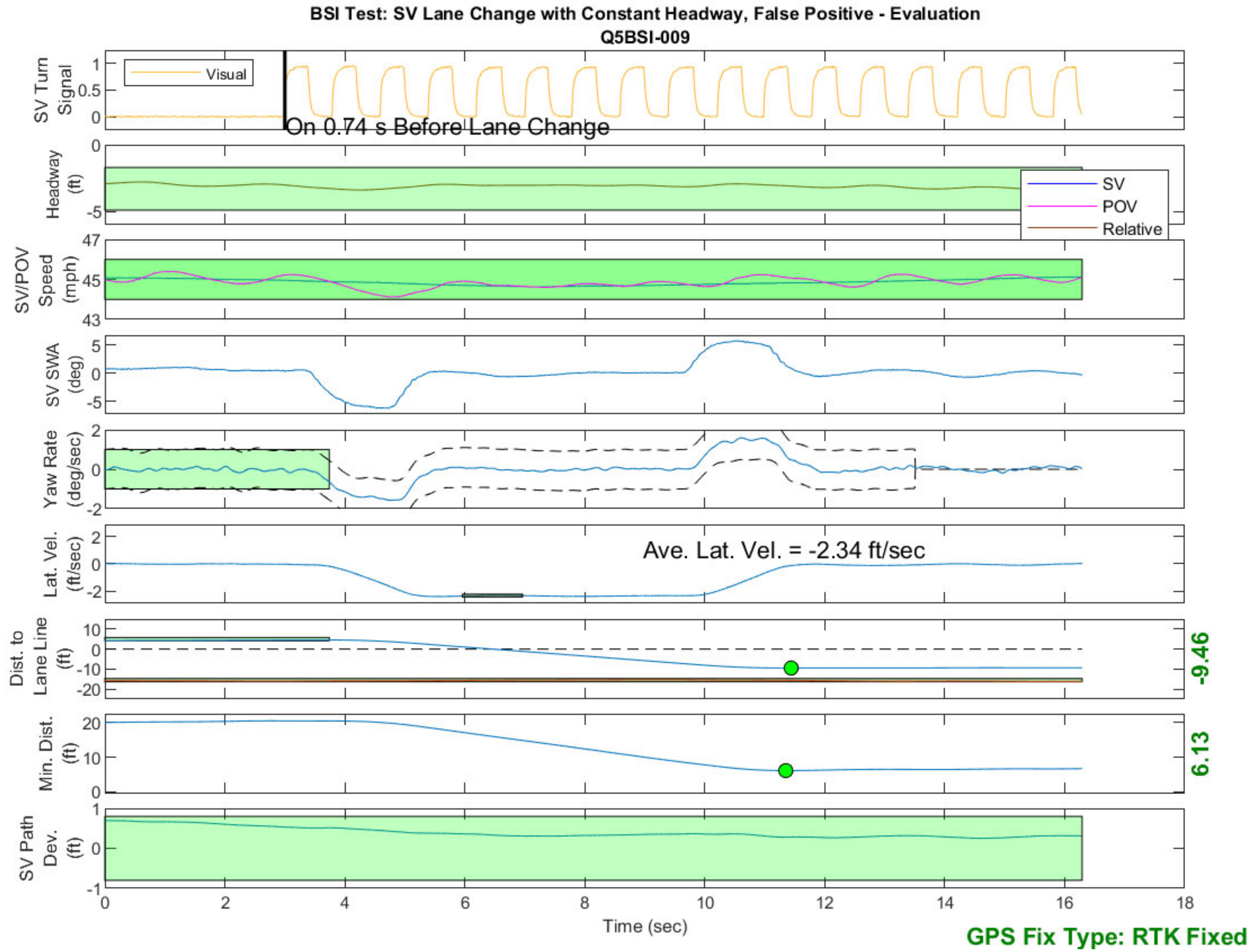

Figure D26. BSI Run 9, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

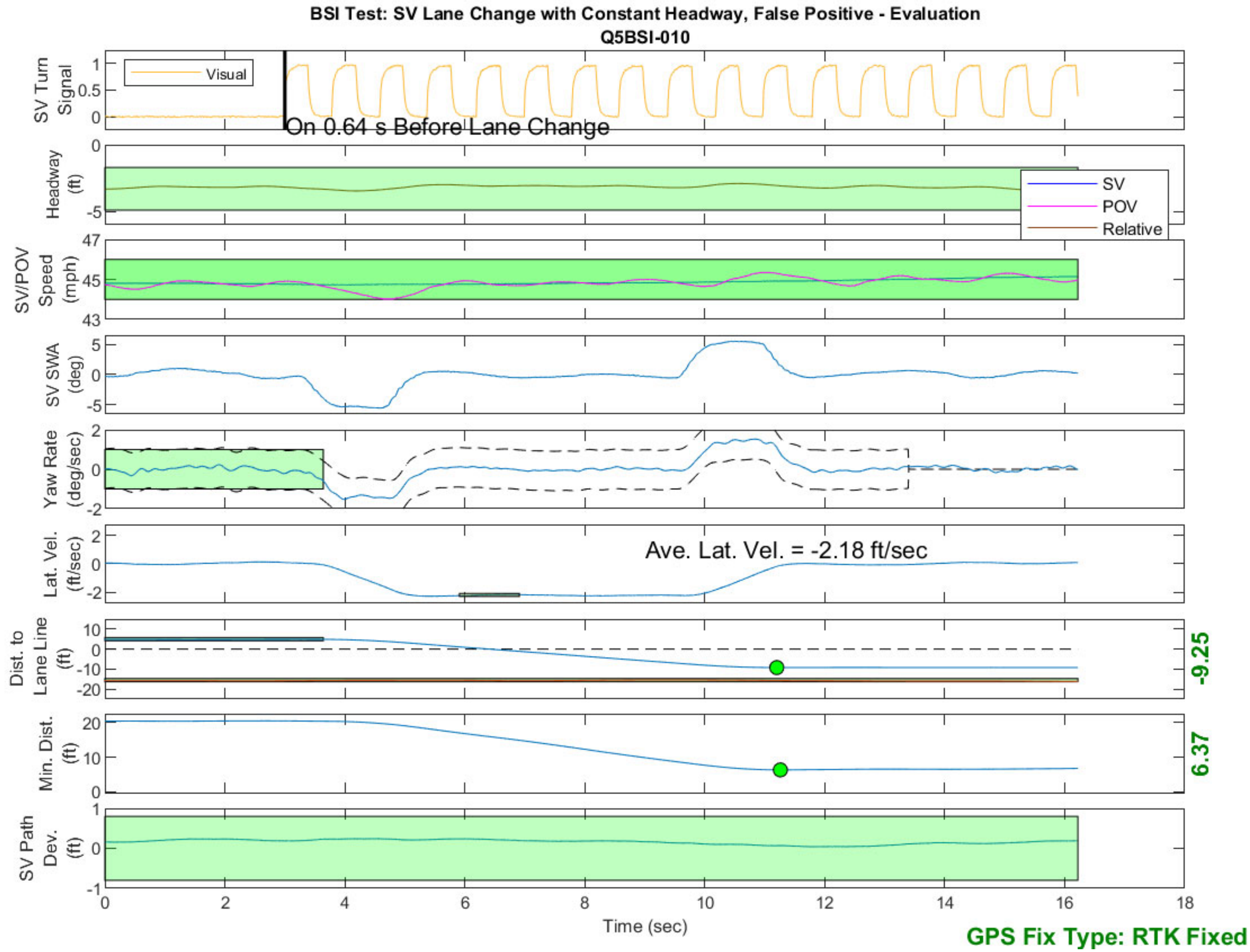

Figure D27. BSI Run 10, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation