BLIND SPOT INTERVENTION SYSTEM CONFIRMATION TEST
NCAP-DRI-BSI-20-01

2019 Audi A6 55 TFSI (3.0T) quattro

DYNAMIC RESEARCH, INC.
355 Van Ness Avenue, STE 200
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18 January 2021

Final Report

Prepared Under Contract No. DTNH22-14-D-00333

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-110)
Washington, DC 20590

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These tests were conducted on the subject 2019 Audi A6 55 TFSI (3.0T) quattro in accordance with the specifications of the National Highway Traffic Safety Administration's most current Test Procedure in docket NHTSA-2019-0102-0001, BLIND SPOT INTERVENTION SYSTEM CONFIRMATION TEST, to confirm the performance of a Blind Spot Intervention system.</td></tr>
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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

(Page 1 of 1)

2019 Audi A6 55 TFSI (3.0T) quattro

VIN: *WAUL2AF2XKN04xxxx*

Test Date: *10/14/2020*

System Setting(s): *Side Assist on*

	Number of valid test runs for which acceptability[1] criteria were:		
	Met	**Not met**	**Valid trials**
Test 1 - Subject Vehicle Lane Change, Constant Headway	*3*	*0*	*3*
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:	***17***	***0***	***17***

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/No 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)

2019 Audi A6 55 TFSI (3.0T) quattro

TEST VEHICLE INFORMATION

VIN: *WAUL2AF2XKN04xxxx*

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

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

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Audi AG*

Date of manufacture: *11 18*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

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

Rear: *255/40 R20 101 H*

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

Rear: *260 kPa (38 psi)*

TIRES

Tire manufacturer and model: *Michelin Primacy MXM4*

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

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

Front tire DOT prefix: *F3L2 00LX*

Rear tire DOT prefix: *F3L2 00LX*

BLIND SPOT INTERVENTION

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2019 Audi A6 55 TFSI (3.0T) quattro

GENERAL INFORMATION

Test date: *10/14/2020*

AMBIENT CONDITIONS

Air temperature: *31.1 C (88 F)*

Wind speed: *2.7 m/s (6.0 mph)*

X Windspeed ≤ 10 m/s (22 mph)

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

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *250 kPa (36 psi)*

Rear: *260 kPa (38 psi)*

2019 Audi A6 55 TFSI (3.0T) quattro

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*566.1 kg (1248 lb)*	Right Front:	*568.4 kg (1253 lb)*
Left Rear:	*479.0 kg (1056 lb)*	Right Rear:	*487.2 kg (1074 lb)*
		Total:	*2100.7 kg (4631 lb)*

General Information

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

Audi Side assist is an available option as part of the Convenience package on the Premium trim and is standard on the Premium Plus and Prestige trims. There is no specific distinction for Blind Spot Intervention.

Type and location of sensors the system uses:

A forward-looking camera mounted near the inside rearview mirror and 2 Medium Range Radar sensors are mounted in the corners of the rear bumper.

System setting used for test (if applicable):

Side Assist on

Method(s) by which the driver is alerted

X Visual

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

____ Audible - Description

____ Haptic

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

Description of alert:

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

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 Lane Departure Warning 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 is required.*

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

> *If the turn signal is activated while Lane Departure Warning 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 in 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?

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

Vehicle

Driver Assistance – select driver profile:

Individual

Side Assist – select or deselect

Side assist will not reactivate upon each ignition cycle.
Note that the Diver Assistance menu level can be accessed directly by pressing the button located on the center console.
See Appendix A, Figures A11 and A12.

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

Only the brightness of the LEDs can be adjusted.

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

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

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

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

If the system deactivates due to repeated 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 interventions.

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

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

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

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

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

General system limitations are described in the Owner's Manual, pages 118 – 122, shown in Appendix B, Pages B-4 through B-8.

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).

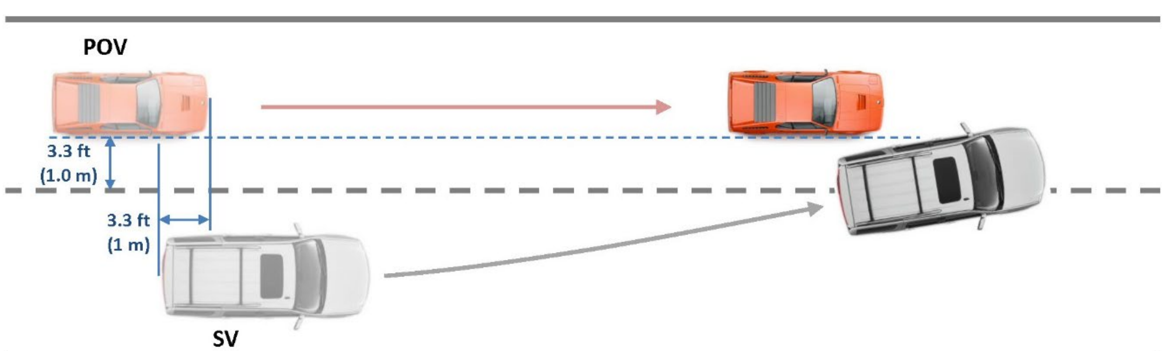

Figure 1. SV Lane Change with Constant Headway Test Scenario

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).

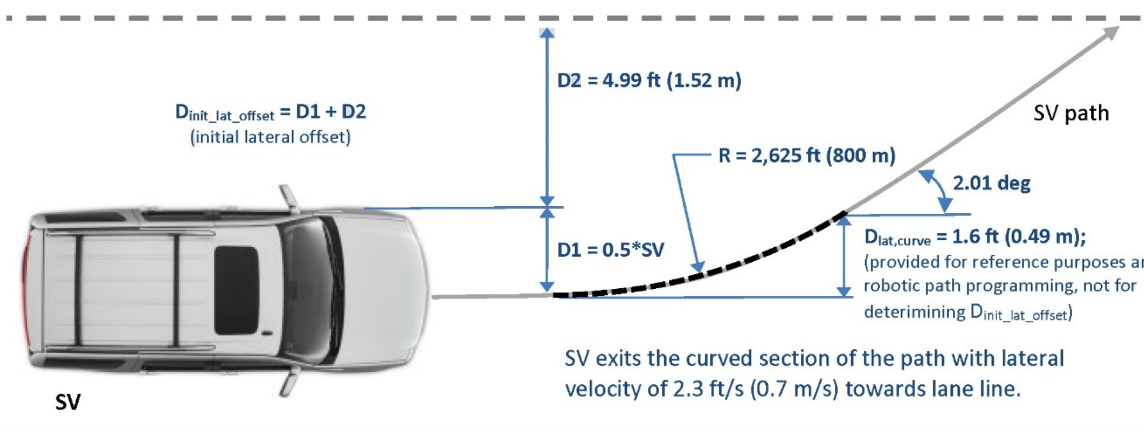

Figure 2. Input Parameters Used to Define the SV Path During the SV Level 0 and 1 Lane Change with Constant Headway Scenario

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.

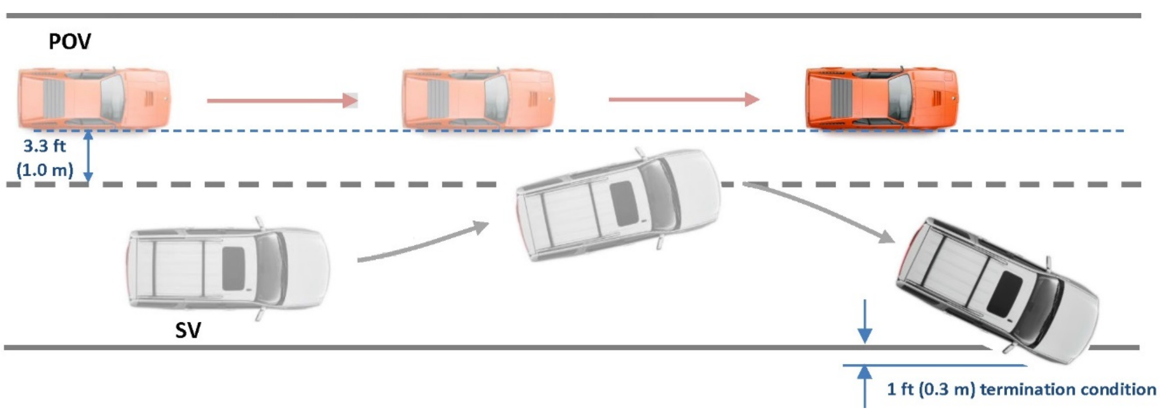

Figure 3. Valid SV Lane Change Intervention Test Interval End Condition 3

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 criteria 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)	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
ACC on, LCC off (Level 1)	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

2. <u>TEST 2 – SV LANE CHANGE WITH CLOSING HEADWAY</u>

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).

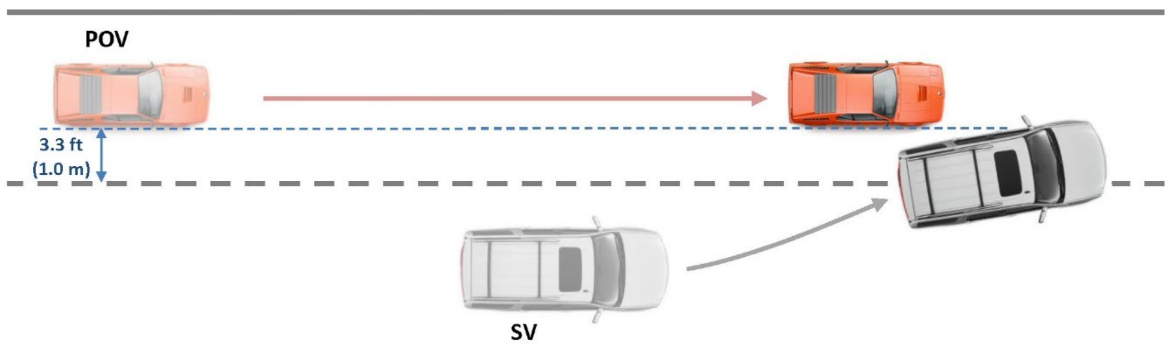

Figure 4. SV Lane Change with Closing Headway Test Scenario

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 criteria 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

<table>
<tr><th rowspan="2">SV Automation Condition</th><th colspan="2">Initial Speed</th><th colspan="2">Lateral Lane Position</th><th rowspan="2">SV-to-POV Longitudinal Orientation</th><th rowspan="2">SV Left Turn Signal Activation</th><th colspan="3">SV Lane Change</th><th rowspan="2">SV Path Tolerance</th><th rowspan="2">Number of Trials</th></tr>
<tr><th>SV</th><th>POV</th><th>SV</th><th>POV</th><th>Initiation Timing</th><th>Steering Release Timing</th><th>Lateral Velocity</th></tr>
<tr><td>Manual speed control, LCC off (Level 0)</td><td rowspan="3">45 ± 1 mph (72.4±1.6 km/h)</td><td rowspan="3">50 ± 1 mph (80.5±1.6 km/h)</td><td rowspan="3">Manually offset within travel lane, then manual lane change towards left adjacent lane</td><td rowspan="3">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</td><td rowspan="3">POV approaches the rear of the SV with a constant 5 mph (8.1 km/h) relative velocity</td><td rowspan="3">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</td><td rowspan="3">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</td><td rowspan="3">Within 250 ms after exiting the 2,625 ft (800 m) radius curve during the lane change</td><td rowspan="3">2.3±0.3 ft/s (0.7±0.1 m/s)</td><td rowspan="3">±0.8 ft (±0.25 m) until SV steering wheel is released</td><td>7</td></tr>
<tr><td>Cruise control, LCC off (Level 0)</td><td>7</td></tr>
<tr><td>ACC on, LCC off (Level 1)</td><td>7</td></tr>
</table>

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.

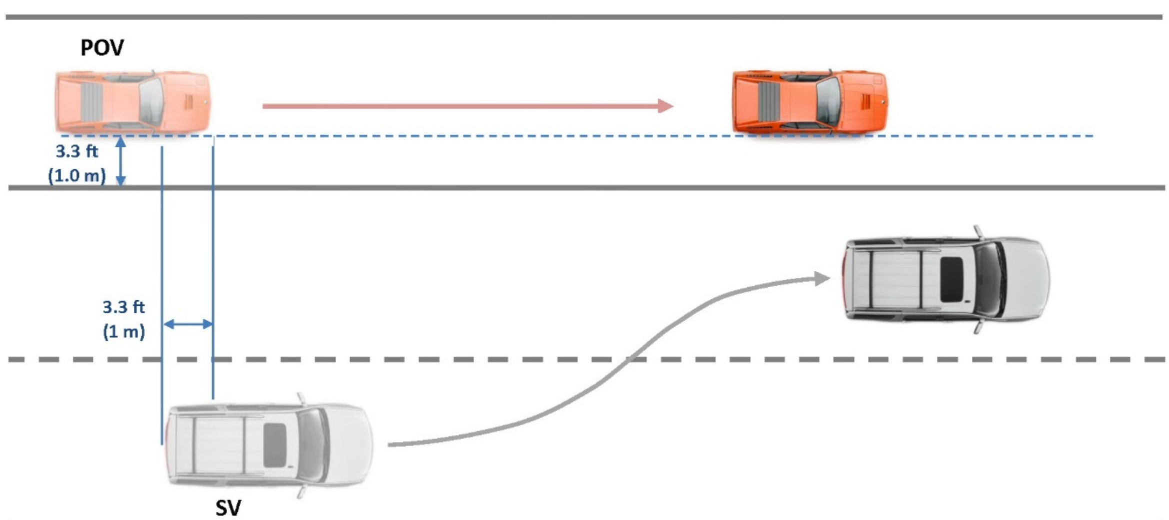

Figure 5. Lane Change with Constant Headway, False Positive Test Scenario

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-to-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.

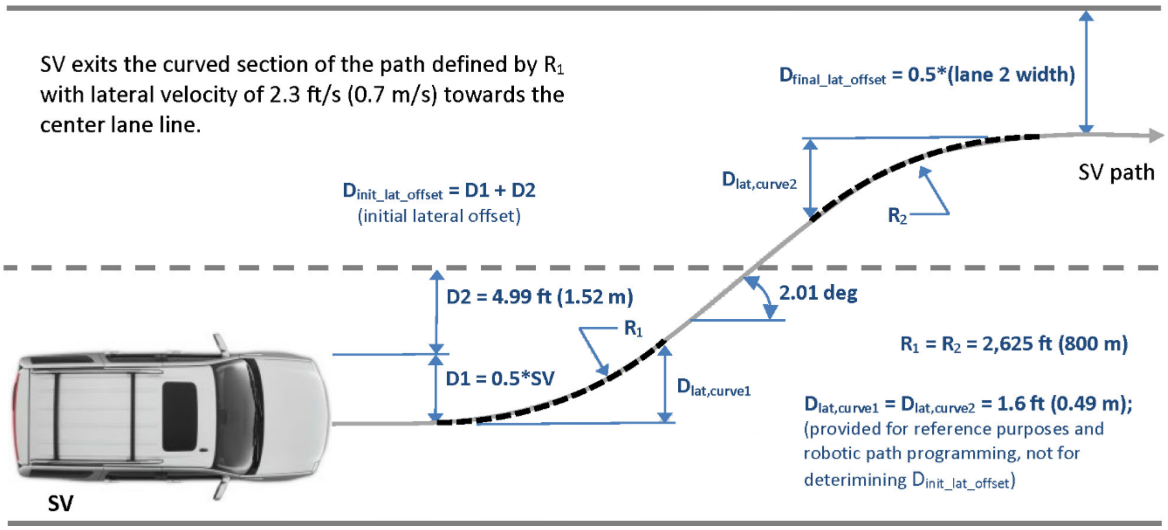

Figure 6. Input Parameters used to define the SV path during the SV Lane Change with Constant Headway, False Positive Scenario

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.

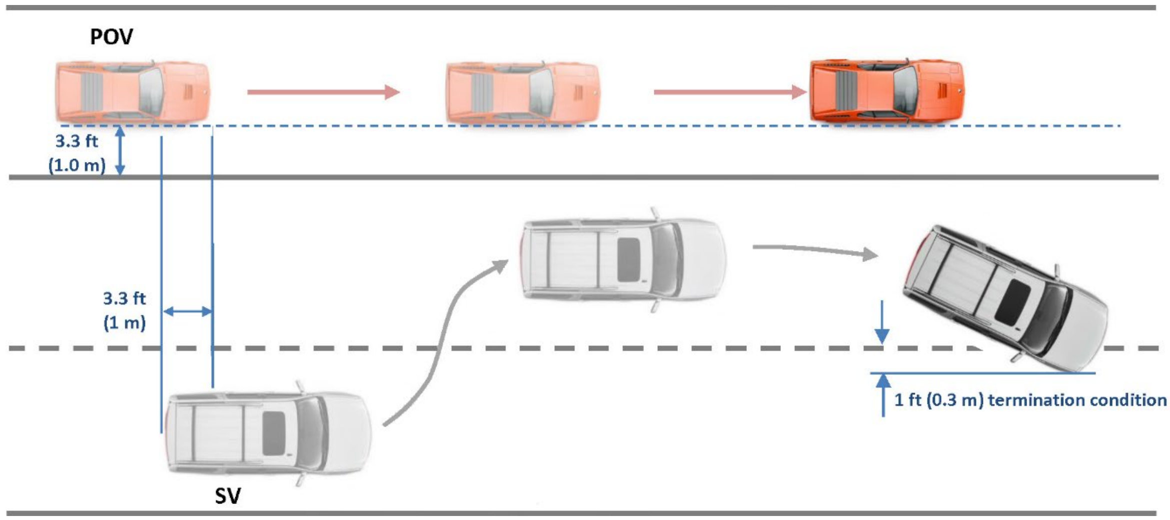

Figure 7. Valid SV Lane Change False Positive Test Interval End Condition 3

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.

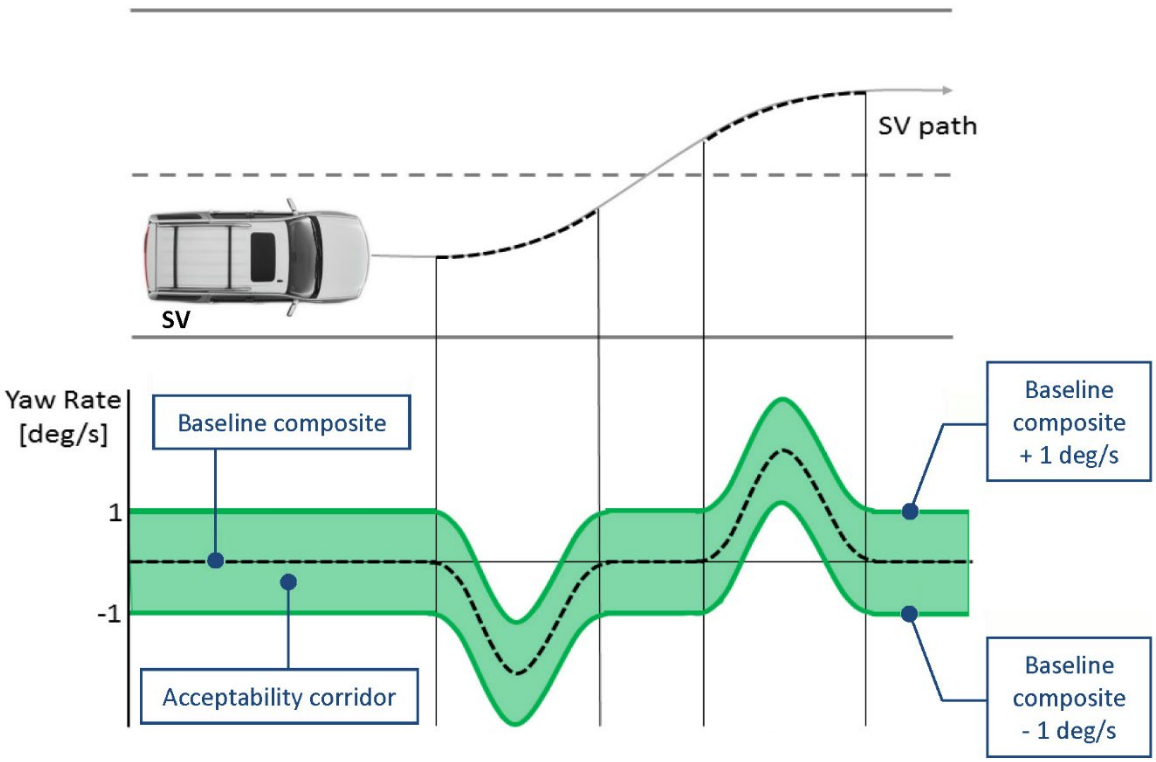

Figure 8. Definition of a Yaw Rate Acceptability Corridor

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.

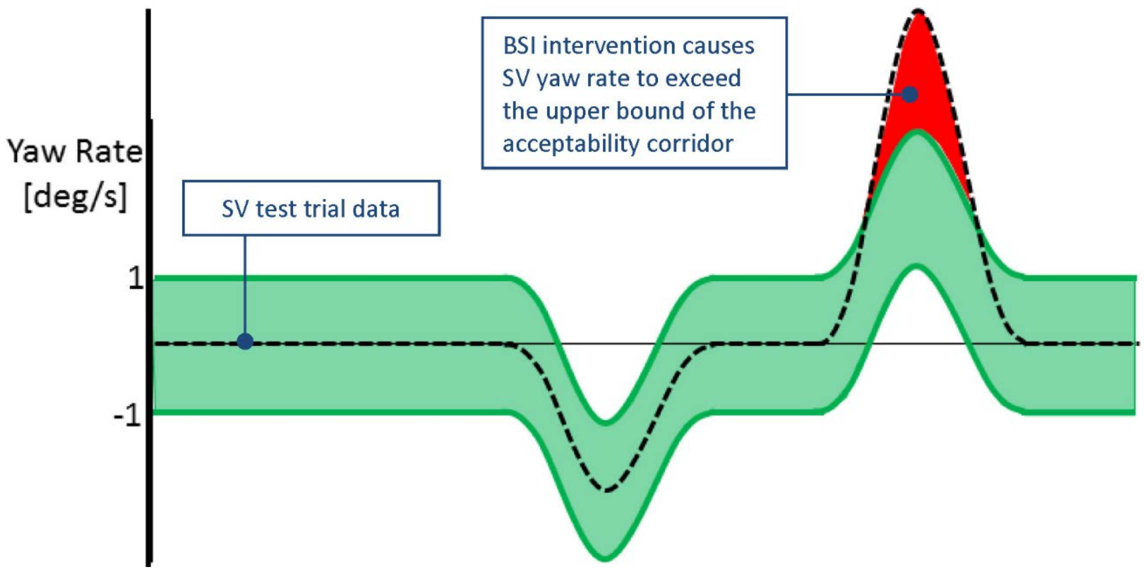

Figure 9. BSI False Positive Example

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)

<table>
<tr><th rowspan="2">SV Automation Condition</th><th colspan="2">Initial Speed</th><th colspan="2">Lateral Lane Position</th><th rowspan="2">SV-to-POV Longitudinal Orientation</th><th rowspan="2">SV Left Turn Signal Activation</th><th colspan="3">SV Lane Change</th><th rowspan="2">SV Path Tolerance</th><th rowspan="2">Number of Trials</th></tr>
<tr><th>SV</th><th>POV</th><th>SV</th><th>POV</th><th>Initiation Timing</th><th>Steering Release Timing</th><th>Lateral Velocity</th></tr>
<tr><td>Manual speed control, LCC off (Level 0)</td><td rowspan="3">45 ± 1 mph (72.4±1.6 km/h)</td><td rowspan="3">45 ± 1 mph (72.4±1.6 km/h)</td><td rowspan="3">Manually offset within travel lane, then manual lane change into a lane left and adjacent to that of the SV</td><td rowspan="3">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.</td><td rowspan="3">Constant; POV front located 3.3 ± 1.6 ft (1 ± 0.5 m) ahead of the SV rear</td><td rowspan="3">At least 3 seconds after all pre-SV lane change test validity criteria have been satisfied</td><td rowspan="3">1.0 ± 0.5 s after the SV turn signal is activated</td><td rowspan="3">N/A (SV driver does not release the steering wheel)</td><td rowspan="3">2.3 ± 0.3 ft/s (0.7 ± 0.1 m/s)</td><td rowspan="3">± 0.8 ft (± 0.25 m) unless a BSI intervention occurs</td><td>7</td></tr>
<tr><td>Cruise control, LCC off (Level 0)</td><td>7</td></tr>
<tr><td>ACC on, LCC off (Level 1)</td><td>7</td></tr>
</table>

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 Oxford Inertial +	2258	Date: 5/3/2019 Due: 5/3/2021
				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

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

VIN: WAUL2AF2XKN04
Interior: Black Interior

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

2019 Audi A6 55 TFSI (3.0T) quattro

STANDARD EQUIPMENT (unless replaced by options)

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

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

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

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

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

MANUFACTURER'S SUGGESTED RETAIL PRICE

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

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

MODEL: 4A2B2Y
VIN: WAUL2AF2XKN04
DEALER:
SHIP TO:

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score		**Not Rated**
Based on the combined ratings of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.		
Frontal Crash	Driver	**Not Rated**
	Passenger	**Not Rated**
Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.		
Side Crash	Front Seat	**Not Rated**
	Rear Seat	**Not Rated**
Based on the risk of injury in a side impact.		
Rollover		**Not Rated**
Based on the risk of rollover in a single-vehicle crash.		

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

EPA DOT Fuel Economy and Environment — Gasoline Vehicle

Fuel Economy
25 MPG combined city/hwy — 22 city — 29 highway
4 gallons per 100 miles

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

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

Annual fuel **cost $1,800**

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

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

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

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

fueleconomy.gov
Calculate personalized estimates and compare vehicles

Smartphone QR Code™

PARTS CONTENT INFORMATION

FOR VEHICLES IN THIS CARLINE:	FOR THIS VEHICLE:
U.S./CANADIAN PARTS CONTENT: 1%	FINAL ASSEMBLY POINT: NECKARSULM, GERMANY
MAJOR SOURCES OF FOREIGN PARTS CONTENT: GERMANY: 53%	COUNTRY OF ORIGIN: ENGINE: HUNGARY
HUNGARY: 21%	TRANSMISSION: GERMANY

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

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

Figure A3. Window Sticker (Monroney Label)

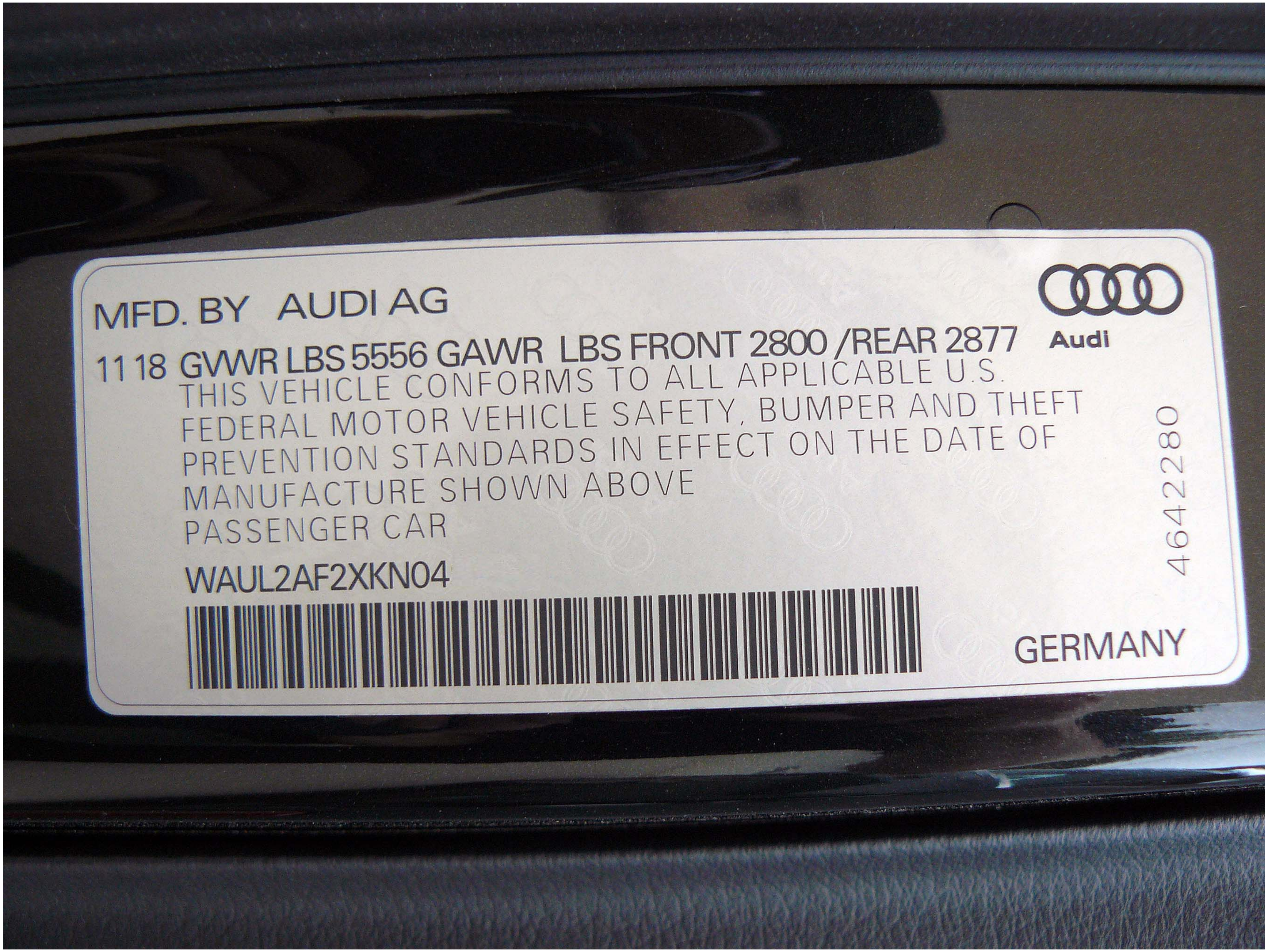

Figure A4. Vehicle Certification Label

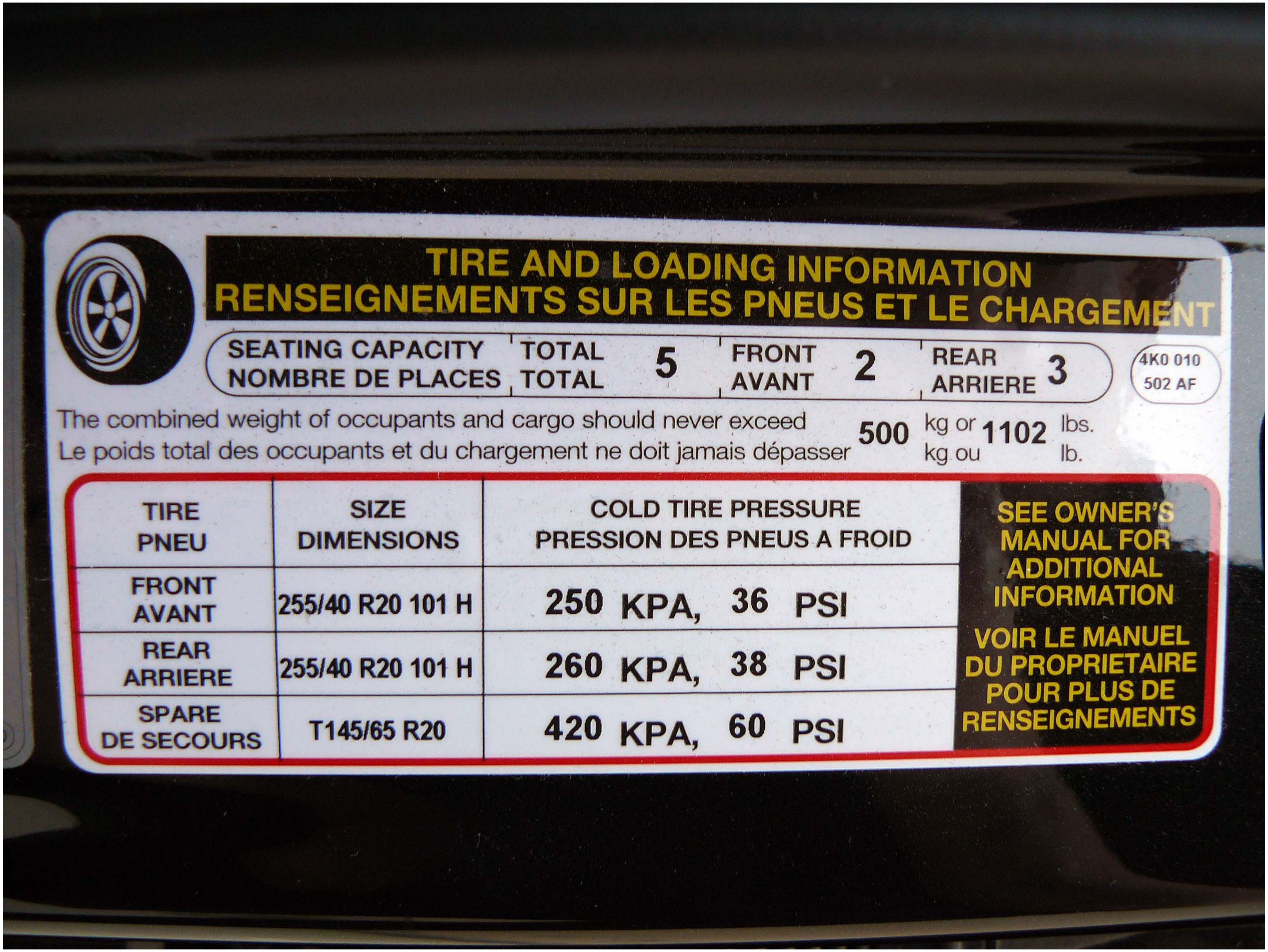

Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle - 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

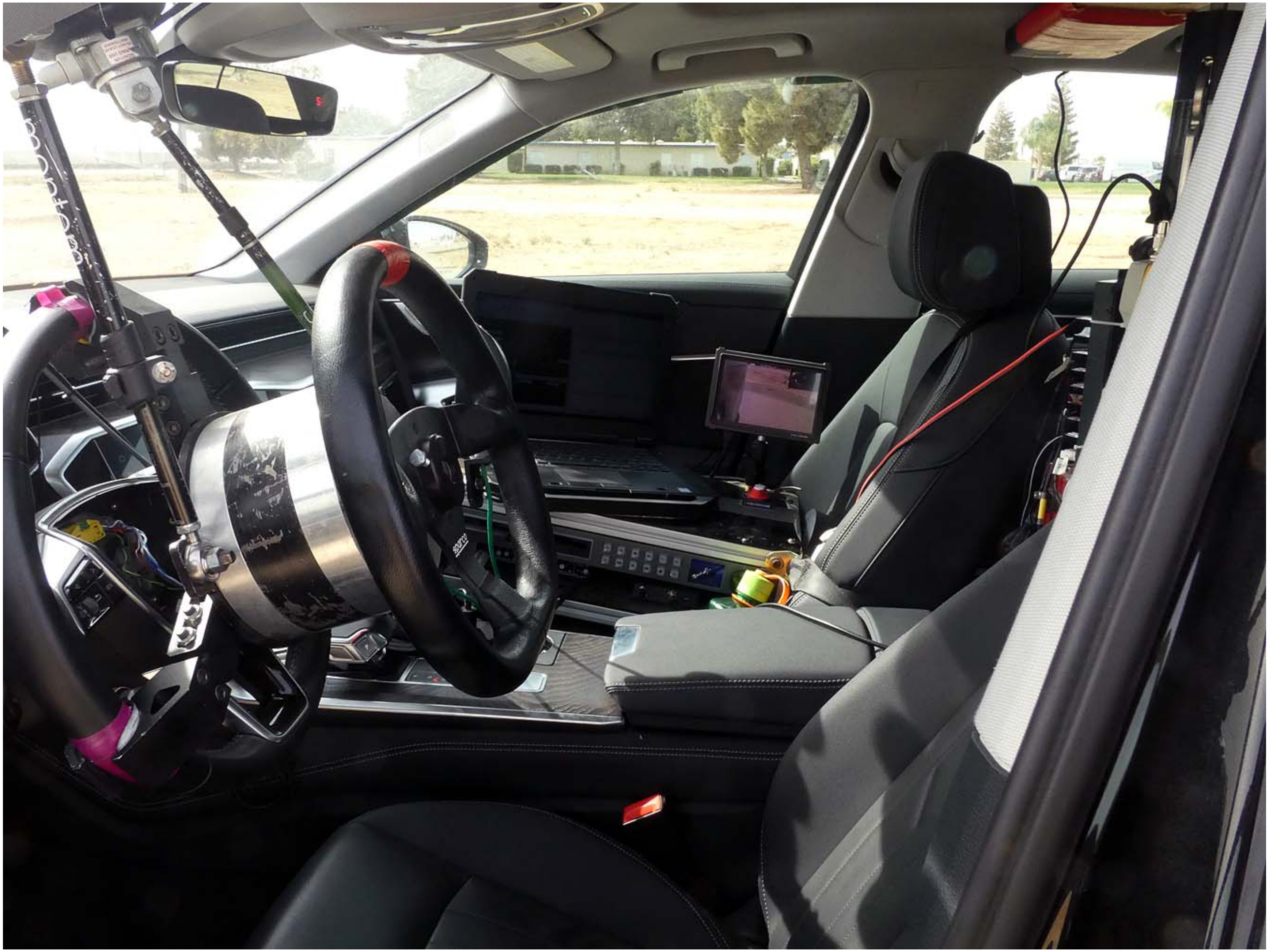

Figure A12. Computer and Steering Controller Installed in Subject Vehicle

Figure A13. System Setup Menus

Figure A14. Button for Directly Accessing Driver Assistance Settings Menus

Figure A15. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

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

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

Other indicator lights

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

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	Efficiency assist ⇨ *page 131*
	Efficiency assist ⇨ *page 131*
	Efficiency assist ⇨ *page 131*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Adaptive cruise assist ⇨ *page 136*
	Lane guidance for adaptive cruise assist ⇨ *page 136*
	Lane departure warning ⇨ *page 144*
	High beams ⇨ *page 50*
AUTO	High beam assistant ⇨ *page 50*
	Rear safety belt ⇨ *page 67*
	Rear safety belt ⇨ *page 67*
	Transmission ⇨ *page 99*
	Convenience key ⇨ *page 94*
PARK BRAKE	Electromechanical parking brake ⇨ *page 105*
(P)	Electromechanical parking brake ⇨ *page 105*
	Hill descent assist ⇨ *page 107*
	Steering ⇨ *page 110*
	Air suspension ⇨ *page 110*
AUTO	High beam assistant ⇨ *page 50*
	Door lock ⇨ *page 34*
	Child safety lock ⇨ *page 43*
MPH	Speed warning system ⇨ *page 123*
Km/h	Speed warning system ⇨ *page 123*
	Camera-based traffic sign recognition ⇨ *page 124*
	Night vision assist ⇨ *page 129*
CRUISE	Cruise control system ⇨ *page 130*
	Cruise control system ⇨ *page 130*
	Intersection assistant ⇨ *page 153*
	Side assist ⇨ *page 151*
	Distance warning ⇨ *page 143*
	Rear cross-traffic assist ⇨ *page 162*
	Adaptive cruise assist ⇨ *page 142*, Efficiency assist ⇨ *page 134*
	Adaptive cruise assist ⇨ *page 139*
	Lane guidance for adaptive cruise assist ⇨ *page 136*
	Lane departure warning ⇨ *page 144*

Assist systems

General information

Safety precautions

WARNING

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

Tips

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

System limitations

WARNING

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

Tips

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

Surrounding area detection

Sensor and camera coverage areas

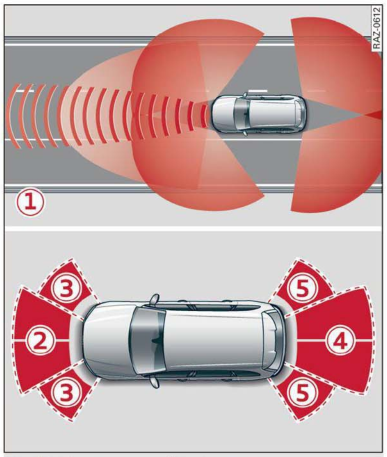

Fig. 91 Diagram: sensor detection areas

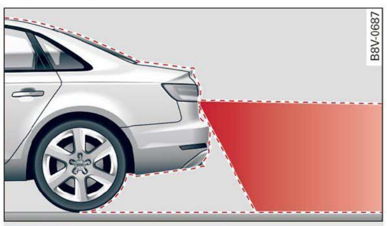

Fig. 92 Diagram: coverage area of the rearview camera

The assist systems analyze the data from various sensors and cameras installed in the vehicle. Do not use any assist systems if there is damage to the vehicle in an area where sensors and cameras are located or on the vehicle underbody, or if the vehicle was involved in a collision. The functionality of the sensors and cameras could be impaired, or they could malfunction. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

Radar sensors

Depending on the vehicle equipment, the area surrounding the entire vehicle may be detected ⇨ *fig. 91* ①.

The wheel sensors on the rear corners of the vehicle are positioned so that the adjacent lanes to the left and right are detected on roads with a normal lane width.

Ultrasonic sensors

Depending on vehicle equipment, various areas may be displayed in the MMI using the ultrasonic sensors ⇨ *fig. 91*.

The range of the displays depends on the location of the ultrasonic sensors:

② Approximately 4 ft (1.20 m)
③ Approximately 3 ft (0.90 m)
④ Approximately 5.2 ft (1.60 m)
⑤ Approximately 3 ft (0.90 m)

Cameras

Use the camera image on the display to assist you only if it shows a good, clear picture. Keep in mind that the image in the display is enlarged and distorted. Under certain circumstances, objects may appear different and unclear on the display.

The rearview camera can only detect the area marked in red ⇨ *fig. 92*. Only this area is displayed on the upper display ⇨ ⚠.

> ⚠ **WARNING**
>
> Sensors and cameras have spots in which the surrounding area cannot be detected. Objects, animals, and people may only be detected with limitations may not be detected at all. Always monitor the traffic and the vehicle's surroundings directly and do not become distracted.

> ! **Note**
>
> – Obstacles may disappear from the measurement range when approaching them, even if they were already detected.

▶

- In some situations, the ability of the sensors and cameras to detect and display certain objects may be limited.
  - Objects located above the coverage area, such as bumpers on parked cars, garage doors that are partially open, or objects that are hanging
  - Low obstacles
  - Narrow objects, such as barrier chains, foliage, poles, or fences
  - Projecting objects, such as trailer draw bars
  - Objects with certain surfaces and structures, such as fabric

Tips

- The sensors and cameras and the areas around them must not be obstructed because this can impair the function of the systems that depend on them. Make sure that the sensors and cameras are free of snow, ice, and other deposits. Do not use any accessories, stickers, or other objects that extend into the range of the sensors and cameras.
- On vehicles that have factory-installed license plate brackets on the front of the vehicle, the brackets may only be replaced with ones that are the same size and made of the same material. Do not install any license plate brackets on the front of vehicles that do not have factory-installed brackets. Otherwise, the function of the system could be impaired.
- The function of the sensors and cameras may be limited when light and visibility conditions are poor, for example when driving into a tunnel, when there is glare, or when there are reflective objects.
- External ultrasonic sensors, such as those in other vehicles, can interfere with the sensors.
- The coverage areas of the sensors ⇨ *fig. 91* are diagrams and do not represent a true-to-scale image of the sensor ranges.
- For an explanation on conformity with the FCC regulations in the United States and the Industry Canada regulations, see ⇨ *page 296*.

Locations of the sensors and cameras

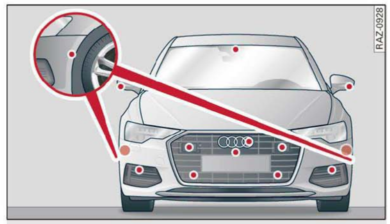

Fig. 93 Front area: sensors and cameras

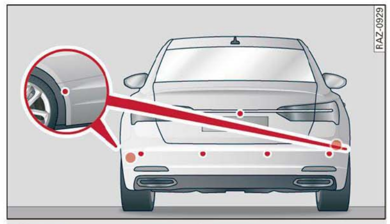

Fig. 94 Rear area: sensors and cameras

Front area

Depending on the vehicle equipment, the following sensors and cameras may be installed:

- Laser scanner in the front in the radiator grille ⇨ ⚠
- Camera behind the windshield
- Peripheral cameras on the exterior mirrors
- Front peripheral camera in the radiator grille
- Night vision camera in the radiator grille
- Front ultrasonic sensors
- Radar sensors at the front corners of the vehicle
- Radar sensor in the front in the radiator grille

Rear area

Depending on the vehicle equipment, the following sensors and cameras may be installed:

- Rearview camera in the luggage compartment lid
- Radar sensors at the rear corners of the vehicle
- Rear ultrasonic sensors ▶

⚠ WARNING

Applies to: vehicles with laser scanner

– The surface of the laser scanner can become hot during operation, which increases the risk of burns.
– The laser scanner contains a class 1 laser in accordance with IEC 60825-1:2014. When used according to regulations, the laser is not dangerous. Opening the laser module and removing covers is not permitted. Doing so could cause permanent injuries to the eyes.
– Any repair work on the laser module must be performed by an authorized Audi dealer or authorized Audi Service Facility; otherwise the vehicle's operating license may be voided. Incorrect repairs may cause limited functionality and eye damage.

ⓘ Tips

Applies to: vehicles with laser scanner

– The possible emissions are below the threshold for class 1 lasers.
– Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.

ⓘ Tips

– The locations of the sensors may differ slightly depending on vehicle equipment.
– Some sensors are installed under vehicle components and cannot be seen from the outside.
– For an explanation on conformity with the FCC regulations in the United States and the Industry Canada regulations, see ⇨ *page 296*.

Switching the systems on and off

Fig. 95 Center console: driver assistance systems button

Description

You can switch some assist systems on and off in the MMI. Depending on the equipment, it may be in the **standard display** or the **profile selection**.

► Press the button, or
► Applies to: MMI: Select on the home screen: **VEHICLE** > **Driver assistance**.

Standard display

Applies to: vehicles with standard display

► To switch a system on or off, press for the desired system.
► To show the brief description of a system, press ⓘ for the desired system.

Profile selection

Applies to: vehicles with profile selection

► To select a profile, press the profile name on the upper display or press the button repeatedly until the profile is active.
► To list systems included in a profile, select on the upper display.
► To show the brief description of a system, select ⓘ for the desired system.
► To switch individual systems on and off in the **Individual** profile, select and for the desired systems.

The following profiles can be selected:

– **Maximum** – All available systems are switched on in this profile.
– **Individual** – You can switch the systems on and off individually in this profile. ▶

– **Basic** or **All off** – Only the basic systems are switched on in this profile. If no basic system is available, the profile is **All off**.

WARNING

Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 118*.

Tips

Certain settings are stored automatically in the active personal profile.

Side assist

Description

Applies to: vehicles with side assist

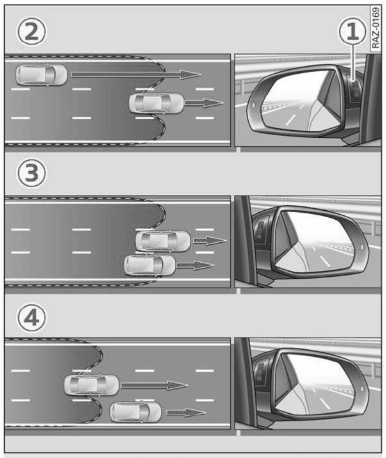

Fig. 116 Diagram: driving situations and displays in the exterior mirror (example)

General information

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

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

Driving situations

The system can provide warnings about the following risks:

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

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

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

Information stage

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

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

Warning stage

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

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

Detection range

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

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

⚠ WARNING

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

ⓘ Tips

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

Adjusting side assist

Applies to: vehicles with side assist

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

Adjusting the brightness

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

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

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

Messages

Applies to: vehicles with side assist

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

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

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

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APPENDIX C

Run Log

Subject Vehicle: **2019 Audi A6 55 TFSI (3.0T) quattro** Date: **10/14/2020**

Test Engineer: **S. Judy**

Run	Test Type	Valid Run	Minimum Distance to POV (ft)[4]	Minimum Distance to Left Lane Edge (ft)	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria [5]	Notes
39	Static Run - GST							
40	**SV Lane Change Constant Headway**	N						Test run
41		N						Headway, POV speed
42		Y	3.92	0.86	Y	N	Yes	Intervention causes SV to diverge from lane of travel
43		N						Headway, POV speed
44		N						Headway, POV speed
45		Y	4.38	1.11	Y	N	Yes	
46		N						SV speed
47		N						Headway, POV speed
48		N						SV path deviation
49		N						POV speed, SV path deviation
50		N						GPS fix type
51		N						GPS fix type
52		N						GPS fix type
53		Y	4.23	0.67	Y	N	Yes	
54		N						GPS fix type

[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/No 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)[4]	Minimum Distance to Left Lane Edge (ft)	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria [5]	Notes
55	**SV Lane Change Constant Headway**	N						GPS fix type
56		N						GPS fix type
57		N						Headway, speed, POV lane line
58		N						POV distance to lane line
59		N						POV distance to lane line
60		N						POV speed
61		N						POV speed
62		N						Headway
63		Y	3.99	1.05	Y	Y	No	
64		N						POV distance to lane line
65		N						Headway
66		N						POV speed
67		Y	4.07	1.00	Y	Y	No	
68		Y	4.31	0.91	Y	Y	No	
69		Y	4.22	1.05	Y	Y	No	Check post processor
70	**SV Lane Change Closing Headway**	N						Turn signal
71		N						POV distance to lane line
72		N						POV distance to lane line
73		N						POV distance to lane line
74		N						Ran out of track
75		Y	2.59	-0.93	Y	N	Yes	
76		Y	2.46	-0.99	Y	N	Yes	

Run	Test Type	Valid Run	Minimum Distance to POV (ft)[4]	Minimum Distance to Left Lane Edge (ft)	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria [5]	Notes
77	SV Lane Change Closing Headway	N						GPS
78		N						Distance to lane line POV, speed, GPS
79								Test run
80		N						POV speed, POV distance lane line
81		N						Distance to lane line
82		N						SV, POV speed, distance to lane line POV
83		N						SV, POV speed, distance to lane line POV
84		N						POV speed
85		N						GPS fix type
86		N						GPS fix type
87		N						POV speed
88		N						POV distance to lane line, turn signal
89		N						Lane late, turn signal
90		N						POV speed, distance to lane, lane late
91		N						GPS fix type
92		Y	3.99	0.70	Y	N	Yes	
93		N						SV path dev, lane late
94		N						POV distance to lane line

Run	Test Type	Valid Run	Minimum Distance to POV (ft)[4]	Minimum Distance to Left Lane Edge (ft)	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria [5]	Notes
95	SV Lane Change Closing Headway	N						GPS fix type
96		N						GPS, POV speed
97		N						GPS fix type
98		N						GPS fix type
99		N						GPS fix type
100		N						GPS fix type
101		N						GPS fix type
102		N						GPS fix type
103		N						GPS fix type
104		Y	3.75	1.00	Y	N	Yes	
105		Y	3.48	0.96	Y	N	Yes	
106		N						POV speed, lane early
107		N						POV speed, distance to lane line
108		N						POV distance to lane line
109		N						Distance to lane line
110		N						Post processor
111		Y	4.13	0.95	Y	N	Yes	
112		Y	4.60	0.97	Y	N	Yes	

Run	Test Type	Valid Run	Minimum Distance to POV (ft)[4]	Minimum Distance to Left Lane Edge (ft)	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria [5]	Notes
1	SV Lane Change Constant Headway False Positive Baseline	N						Wrong gain
2		N						Wrong gain
3		Y						
4		Y						
5		Y						
6		Y						
7		Y						
8		Y						
9		Y						
								-
10	SV Lane Change Constant Headway False Positive Assessment	Y					Yes	
11		N						POV distance to lane line
12		N						POV distance to lane line
13		N						POV distance to lane line
14		N						POV distance to lane line
15		N						POV distance to lane line
16		Y					Yes	
17		N						POV distance to lane line
18		N						POV distance to lane line
19		Y					Yes	
20		N						POV distance to lane line
21		N						POV distance to lane line
22		Y					Yes	

Run	Test Type	Valid Run	Minimum Distance to POV (ft)[4]	Minimum Distance to Left Lane Edge (ft)	BSI Activated (Y/N)	Contact (Y/N)	Meets Criteria [5]	Notes
23	SV Lane Change Constant Headway False Positive Assessment	N						POV distance to lane line
24		Y					Yes	
25		Y					Yes	
26		N						POV distance to lane line
27		N						POV distance to lane line
28		N						POV distance to lane line
29		N						POV distance to lane line
30		N						Test
31		N						POV distance to lane line
32		N						POV distance to lane line
33		N						POV distance to lane line
34		N						POV distance to lane line
35		N						POV distance to lane line
36		N						POV distance to lane line
37		N						POV distance to lane line
38		Y					Yes	POV distance to lane line

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) (Vehicles for which the BSI system operates using a brake intervention.) – Displays the SV lateral acceleration. A vertical bold line marked “BSI Onset” indicates the time at which BSI intervention first occurred.

- SV SWA (deg) (Vehicles for which the BSI system operates using a steering intervention.) – Displays the SV steer wheel angle as measured by a steer wheel encoder. 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.

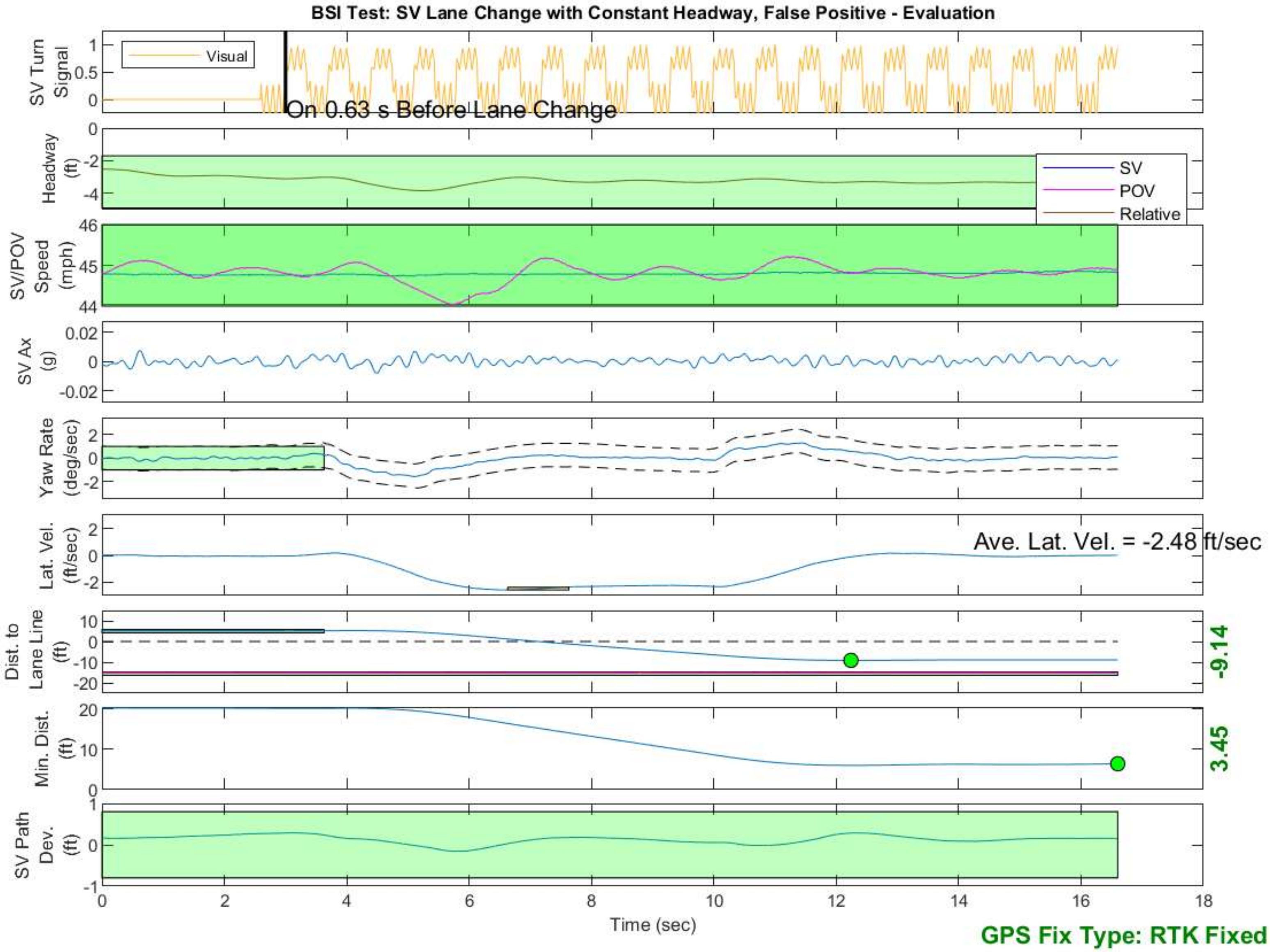

Figure D1. Example Time History for False Positive Evaluation, Passing

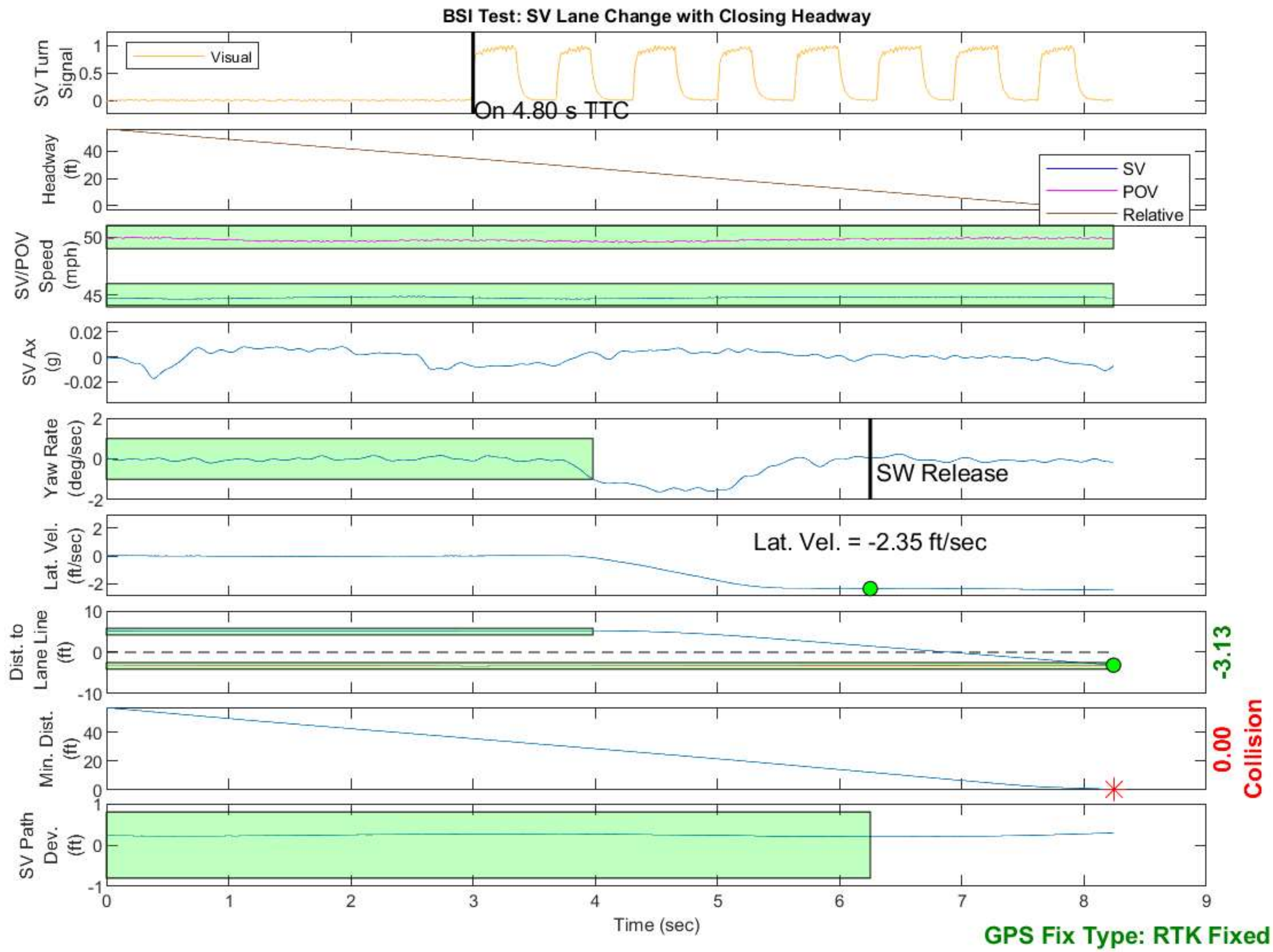

Figure D2. Example Time History for Subject Vehicle with Closing Headway Test, Failing

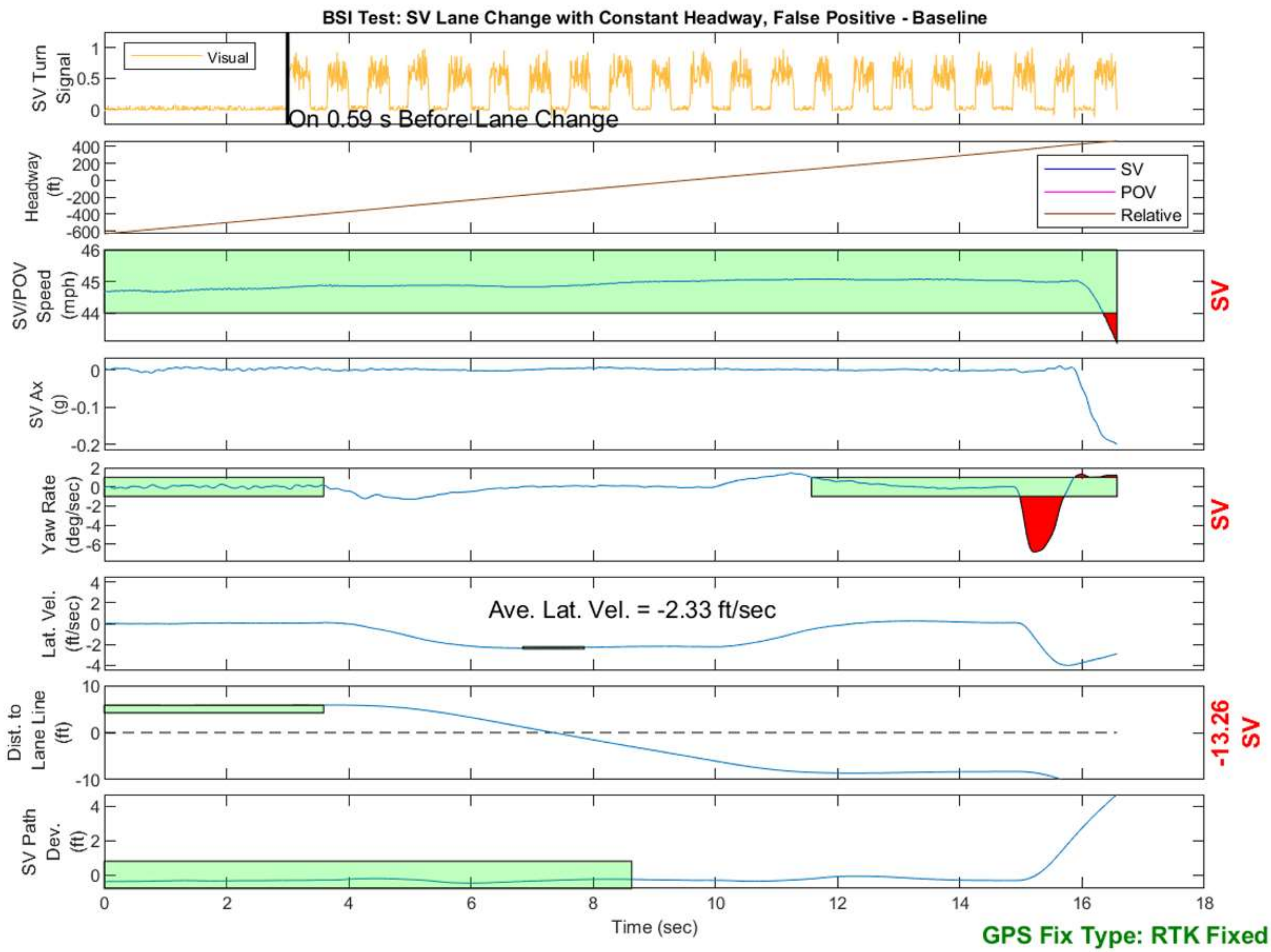

Figure D3. Example Time History for Subject Vehicle with Constant Headway Test, Invalid POV Speed Criteria

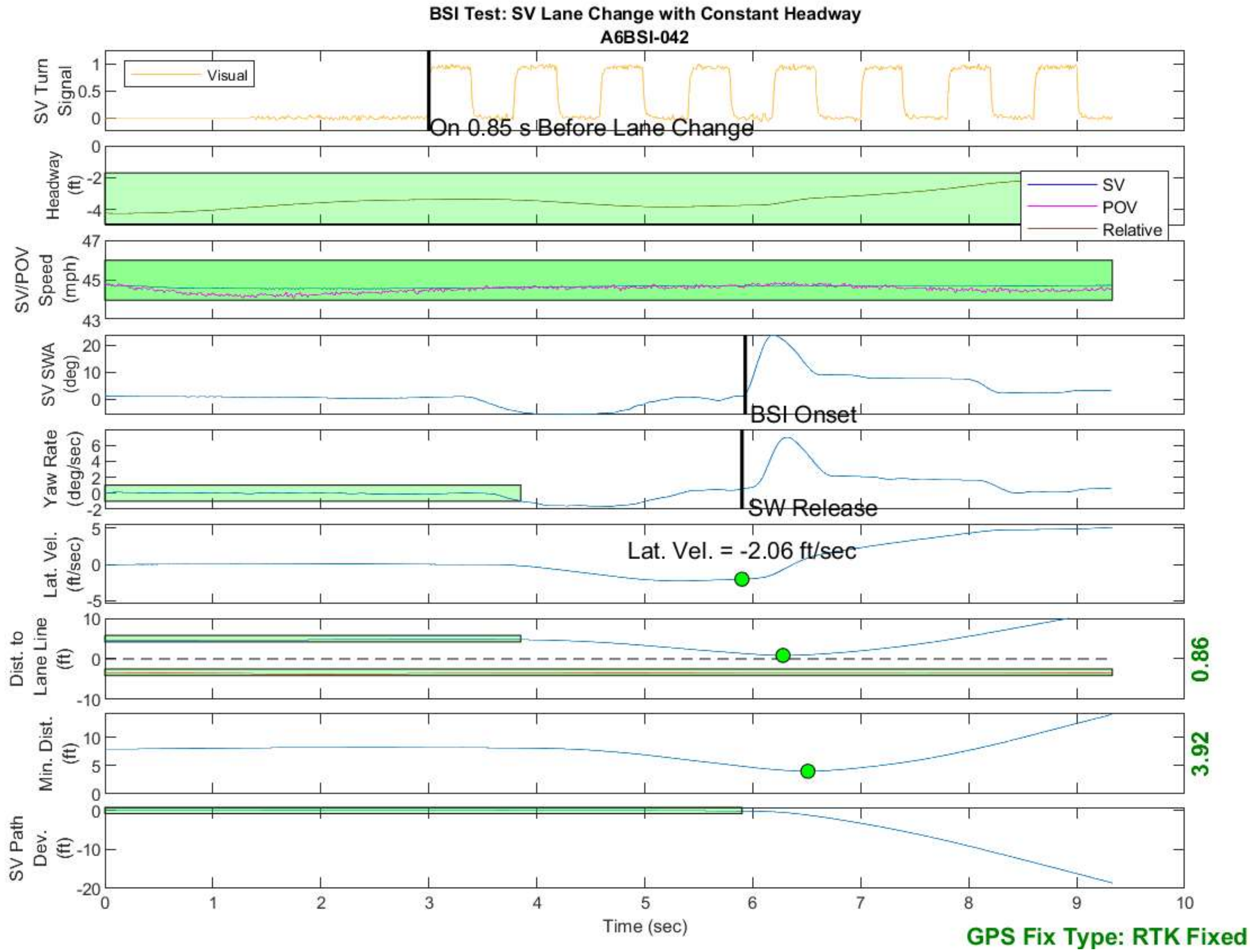

Figure D4. BSI Run 42, Subject Vehicle Lane Change with Constant Headway

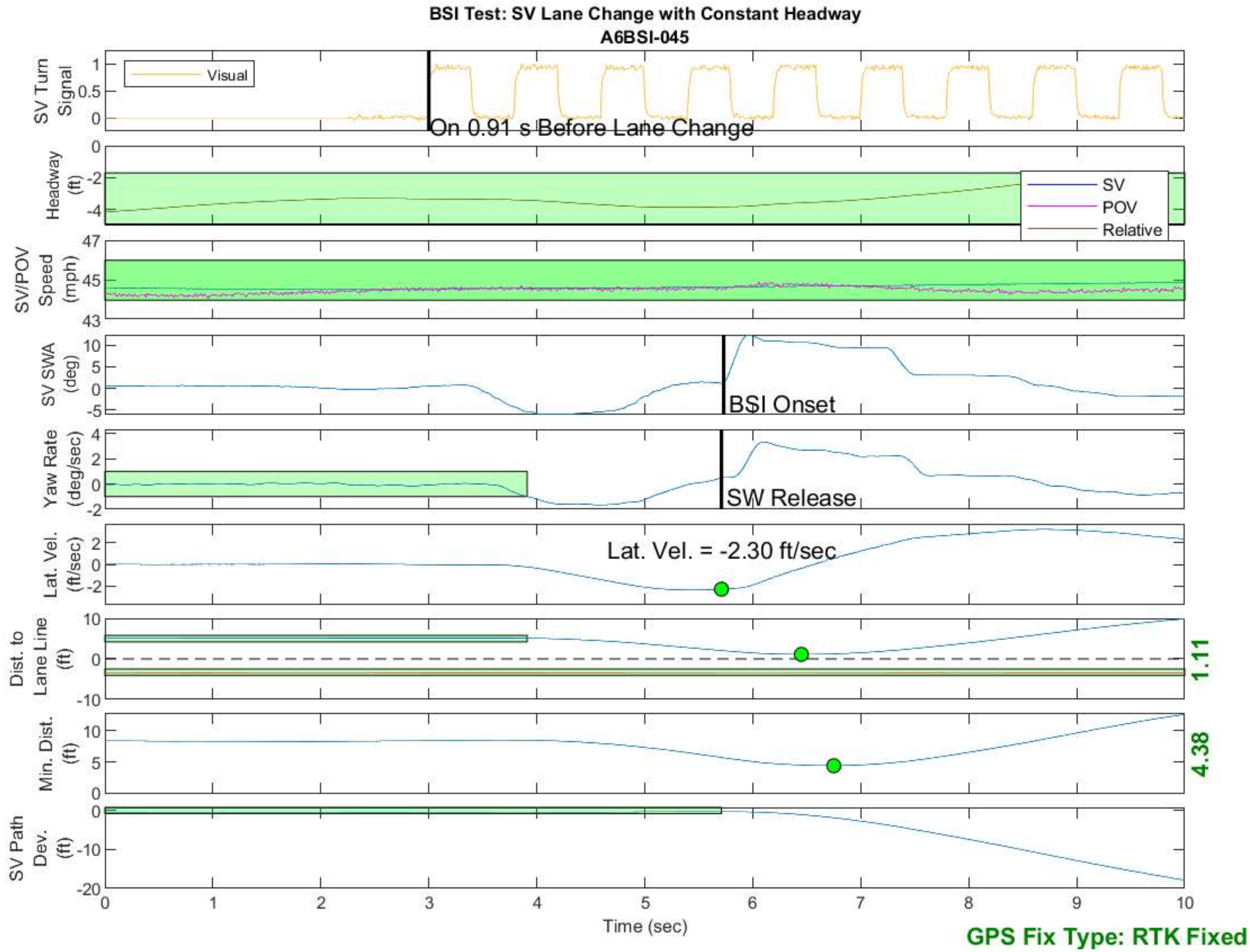

Figure D5. BSI Run 45, Subject Vehicle Lane Change with Constant Headway

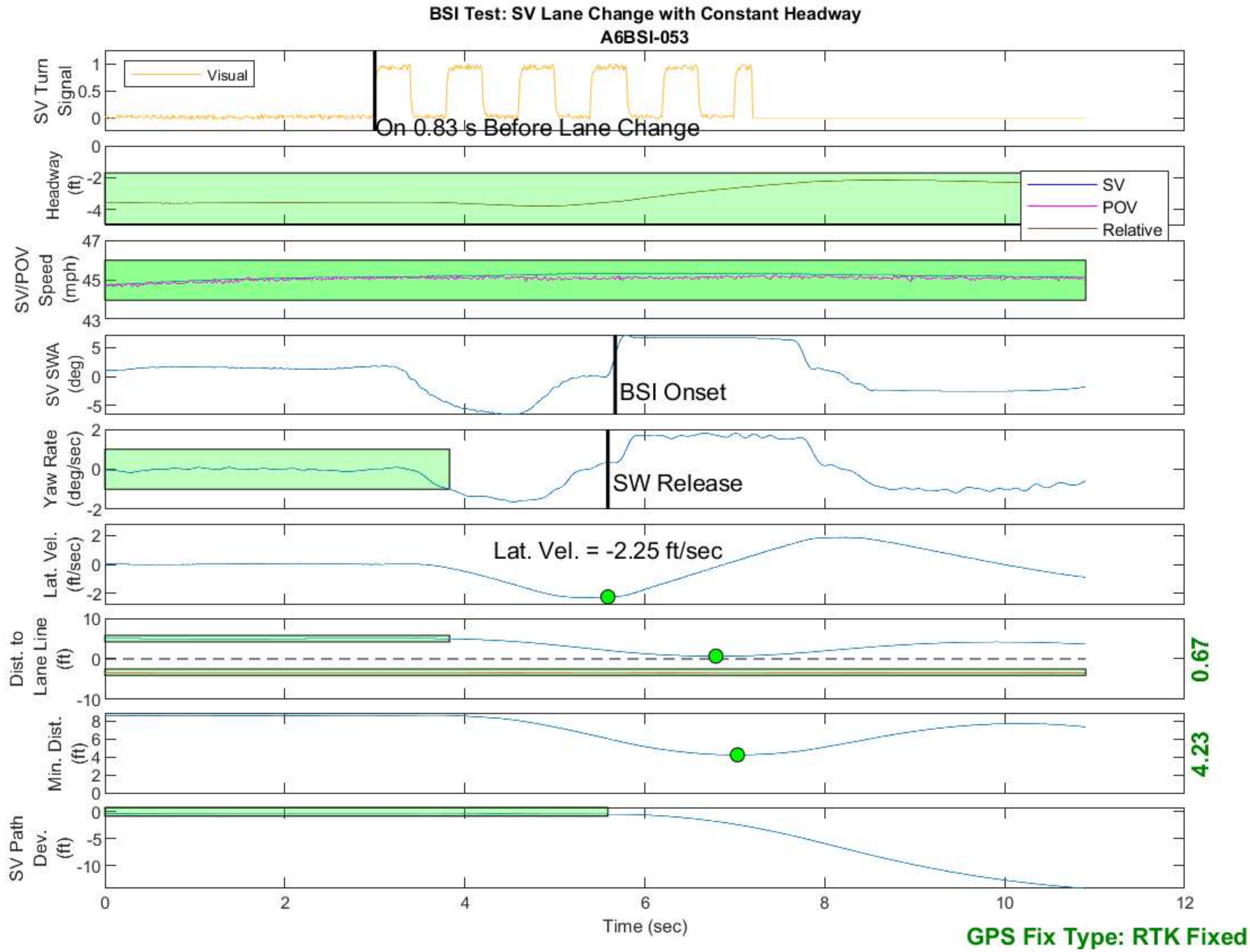

Figure D6. BSI Run 53, Subject Vehicle Lane Change with Constant Headway

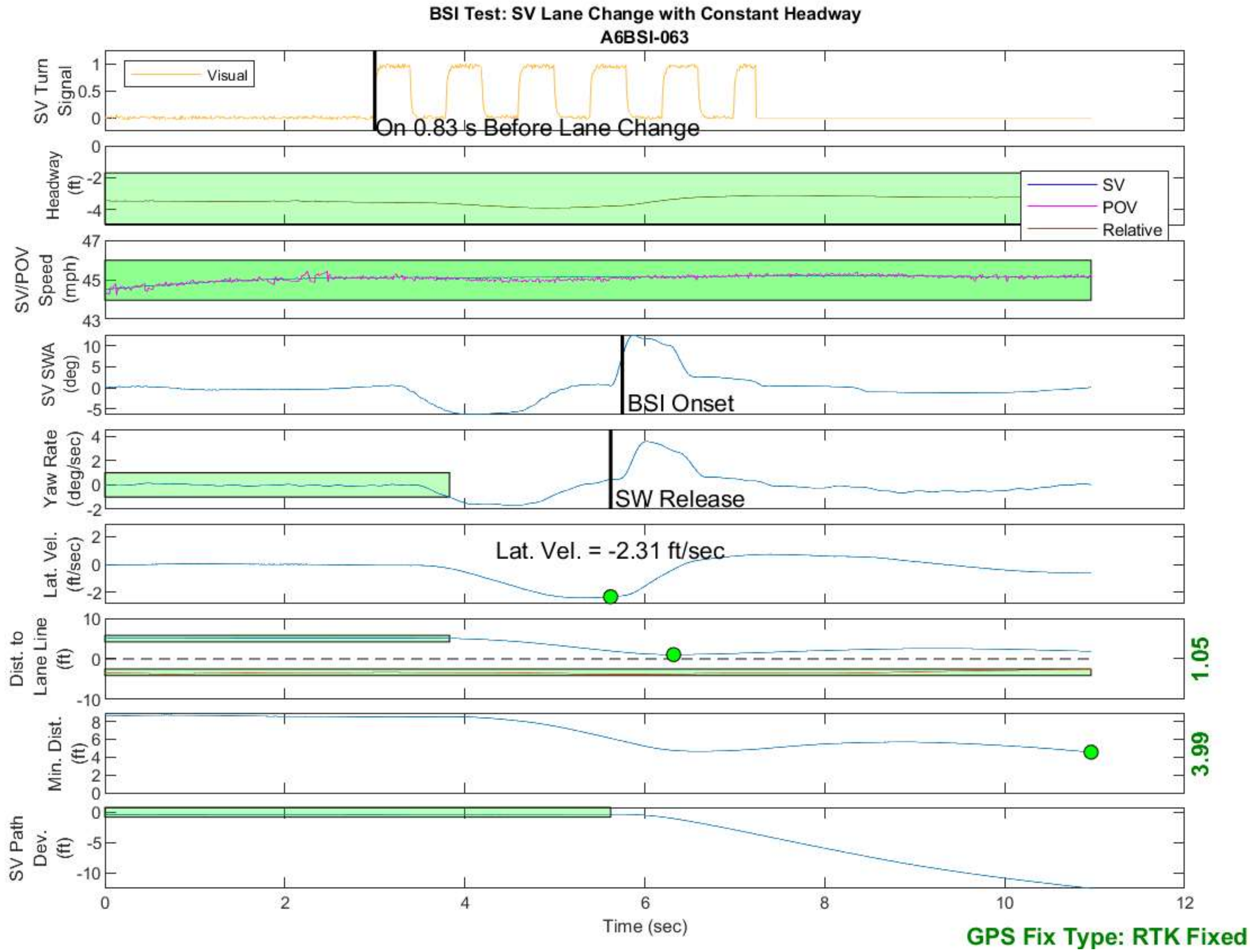

Figure D7. BSI Run 63, Subject Vehicle Lane Change with Constant Headway

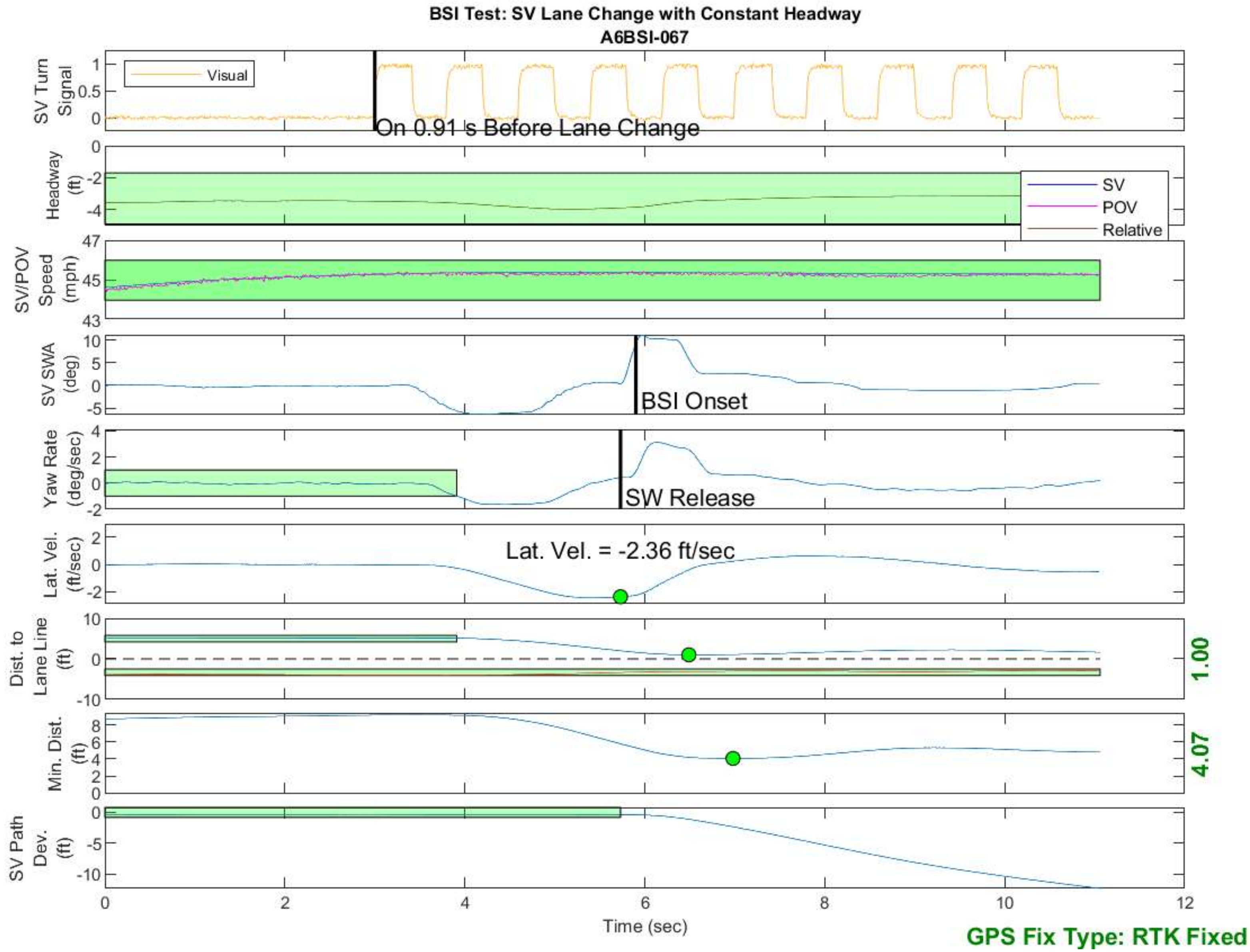

Figure D8. BSI Run 67, Subject Vehicle Lane Change with Constant Headway

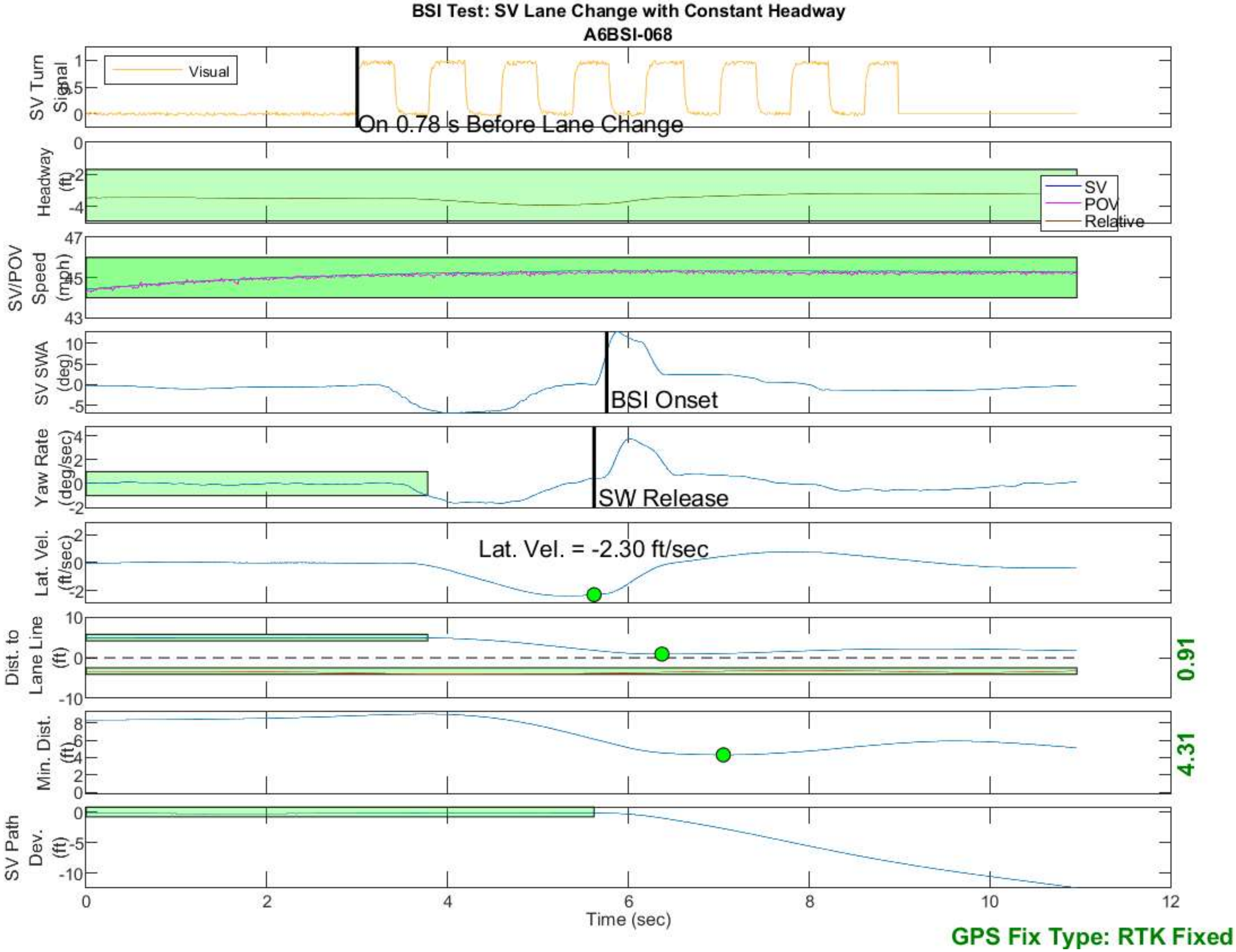

Figure D9. BSI Run 68, Subject Vehicle Lane Change with Constant Headway

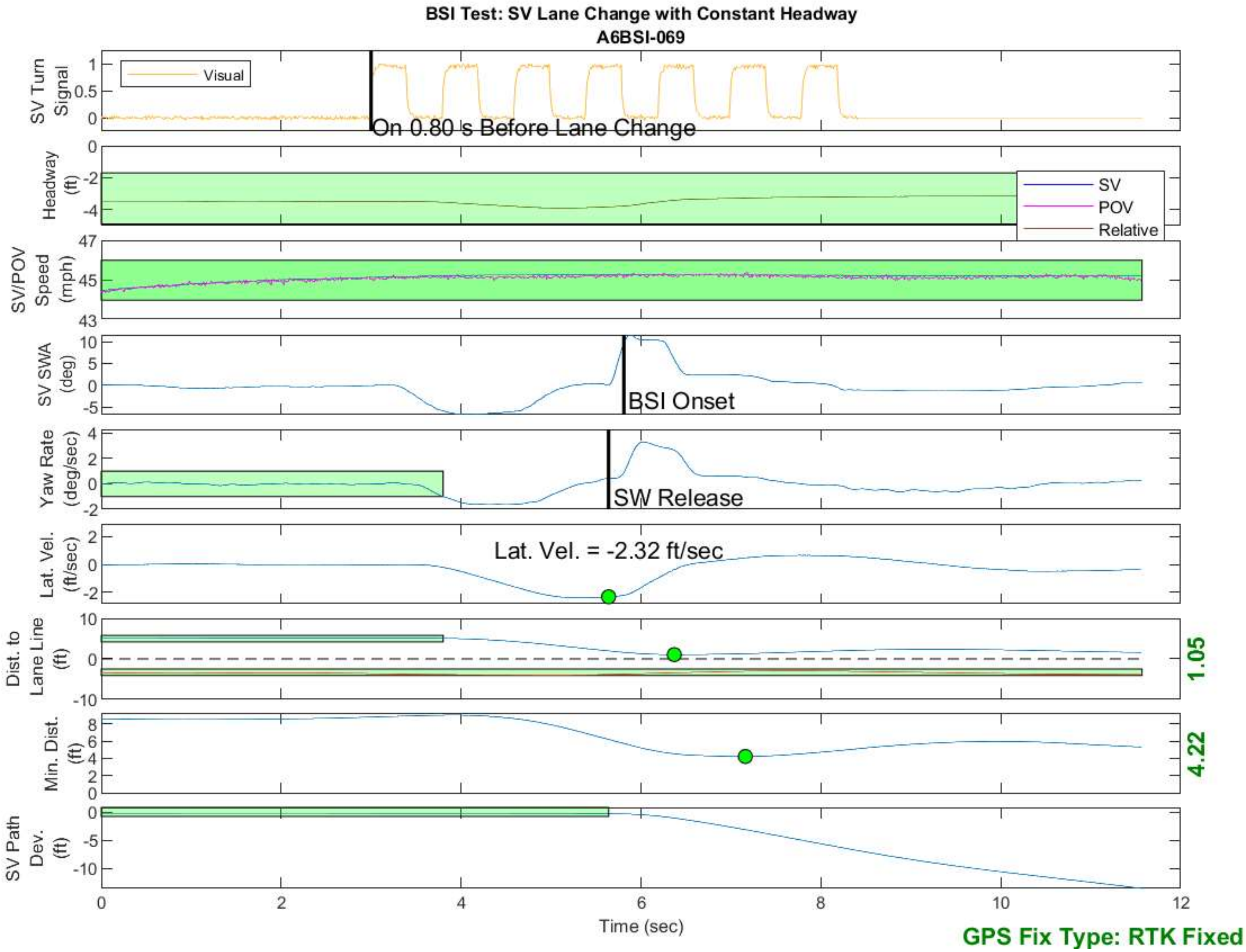

Figure D10. BSI Run 69, Subject Vehicle Lane Change with Constant Headway

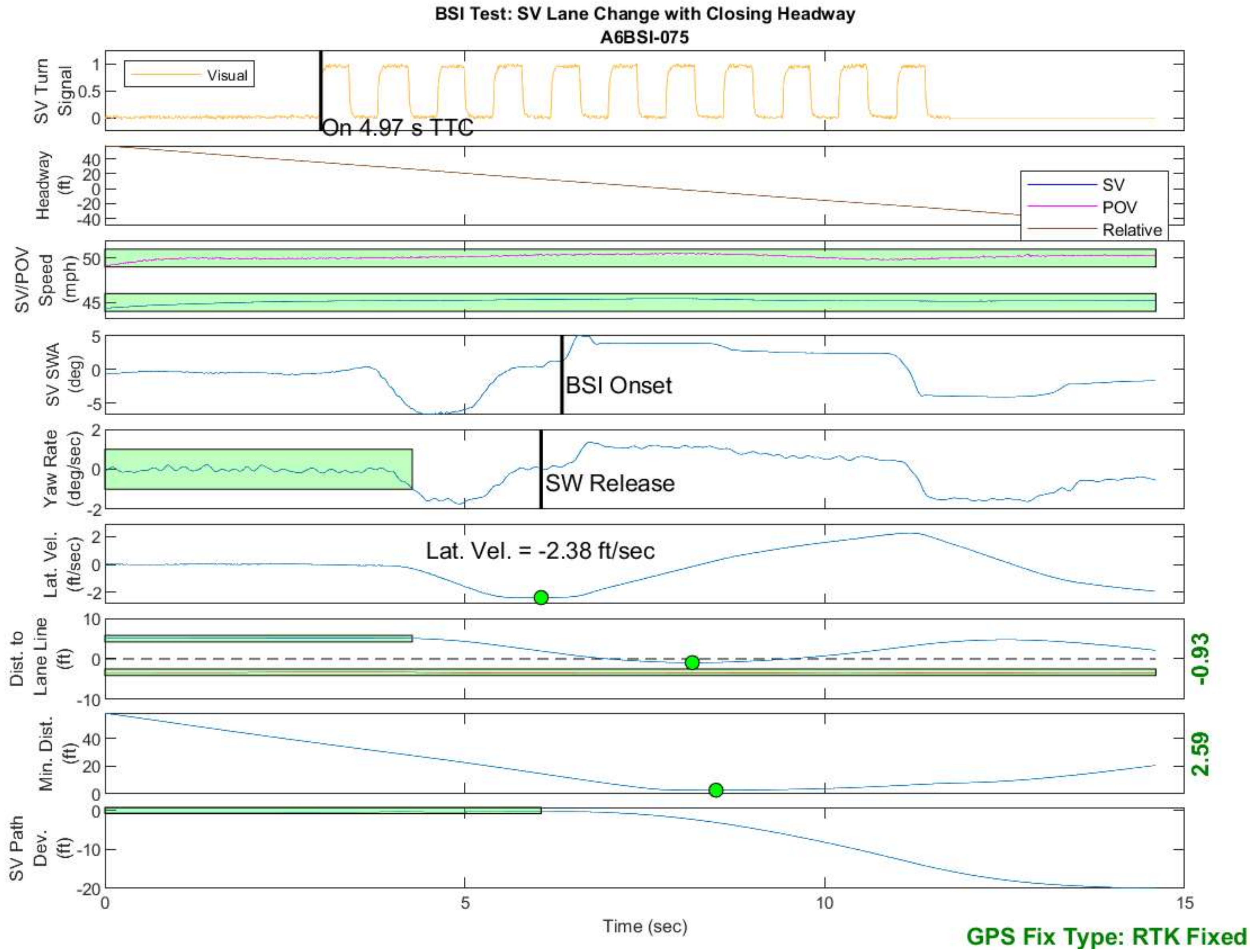

Figure D11. BSI Run 75, Subject Vehicle Lane Change with Closing Headway

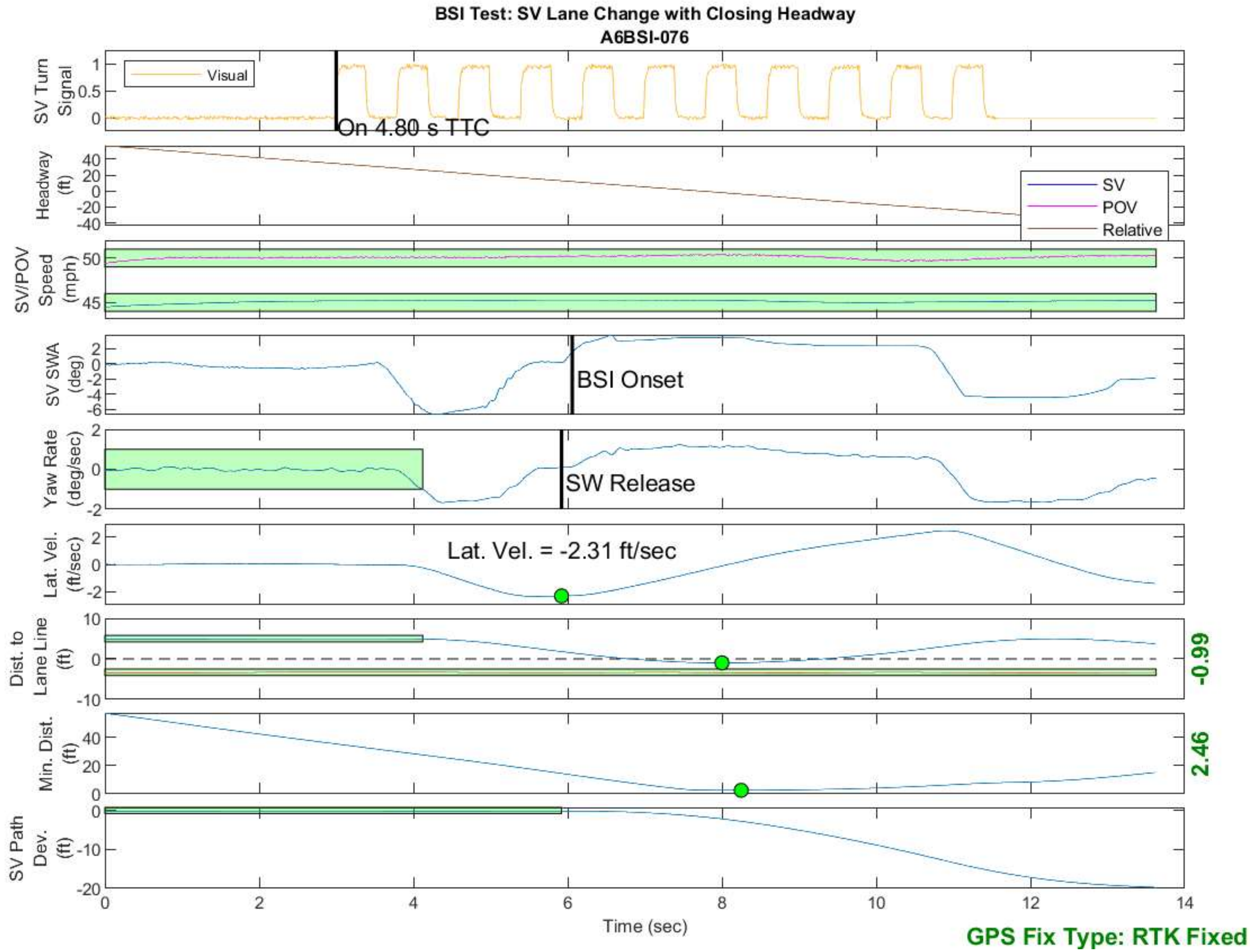

Figure D12. BSI Run 76, Subject Vehicle Lane Change with Closing Headway

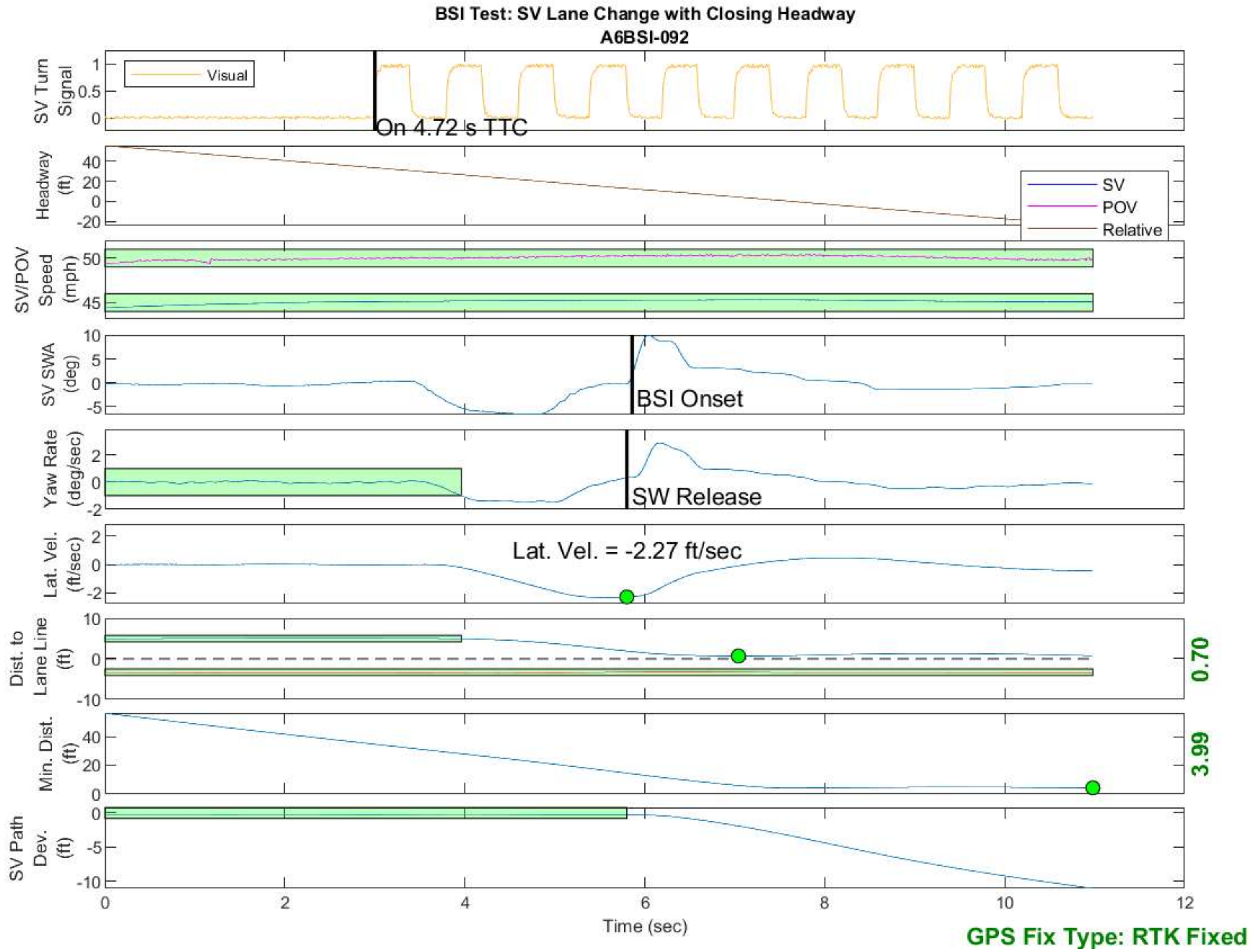

Figure D13. BSI Run 92, Subject Vehicle Lane Change with Closing Headway

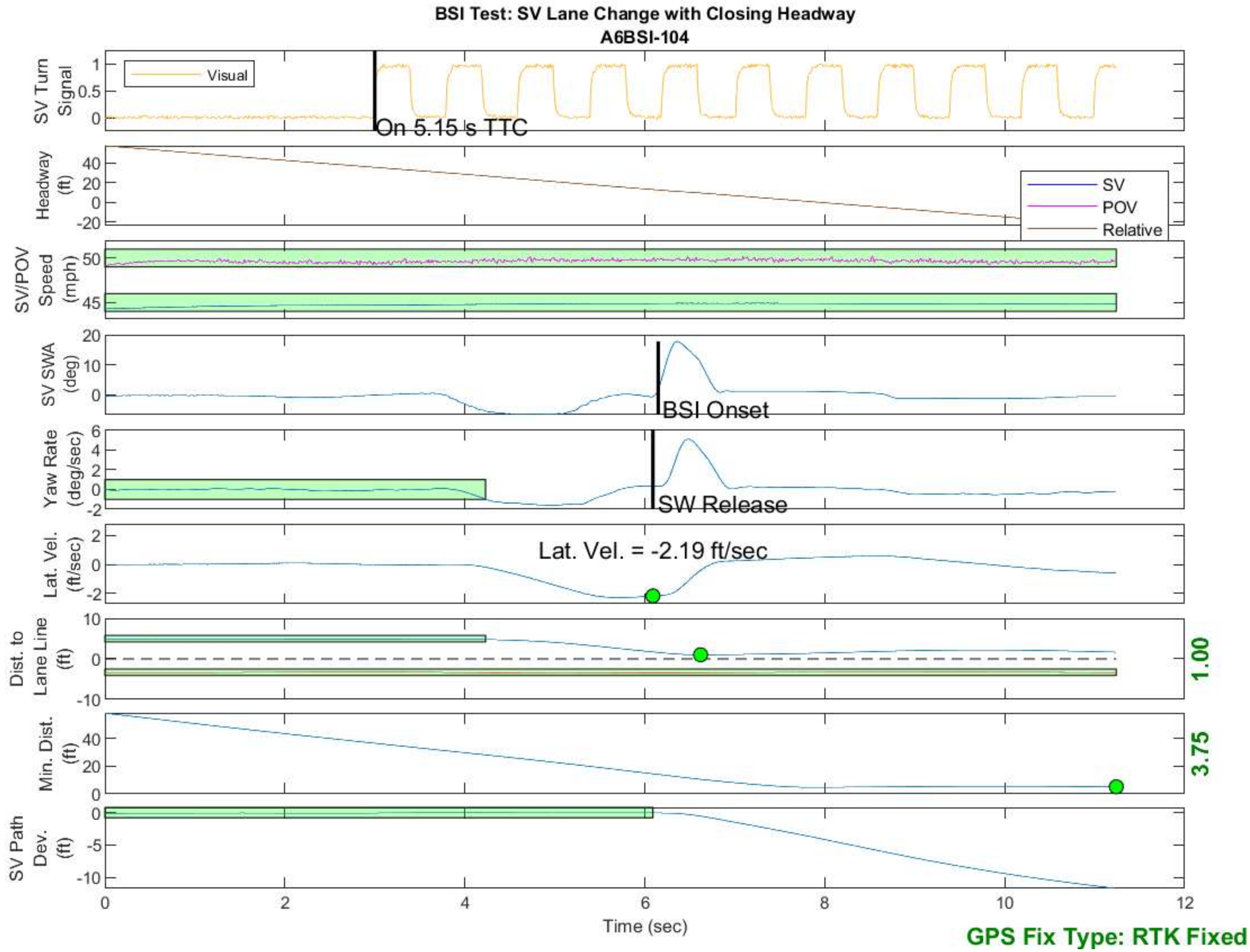

Figure D14. BSI Run 104, Subject Vehicle Lane Change with Closing Headway

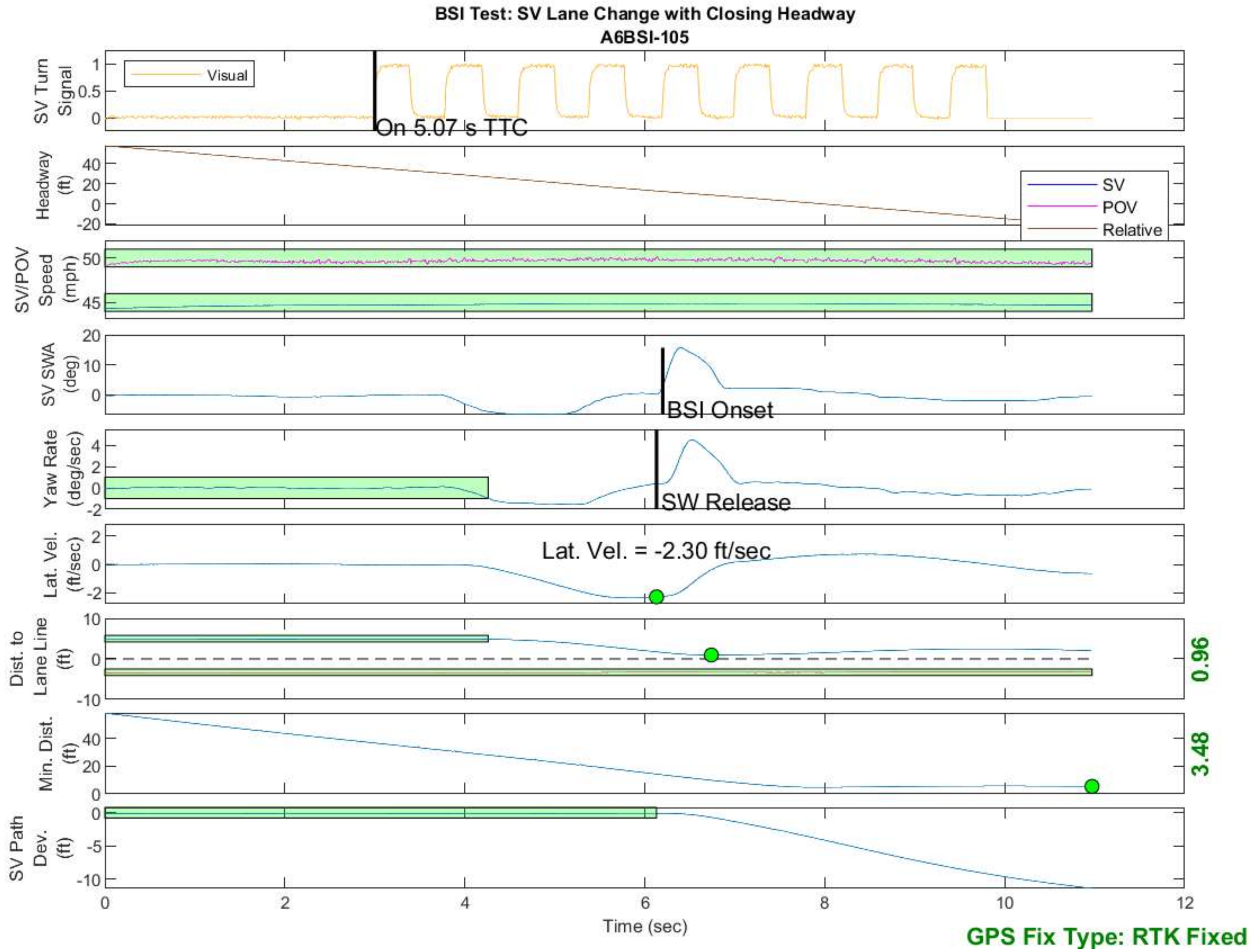

Figure D15. BSI Run 105, Subject Vehicle Lane Change with Closing Headway

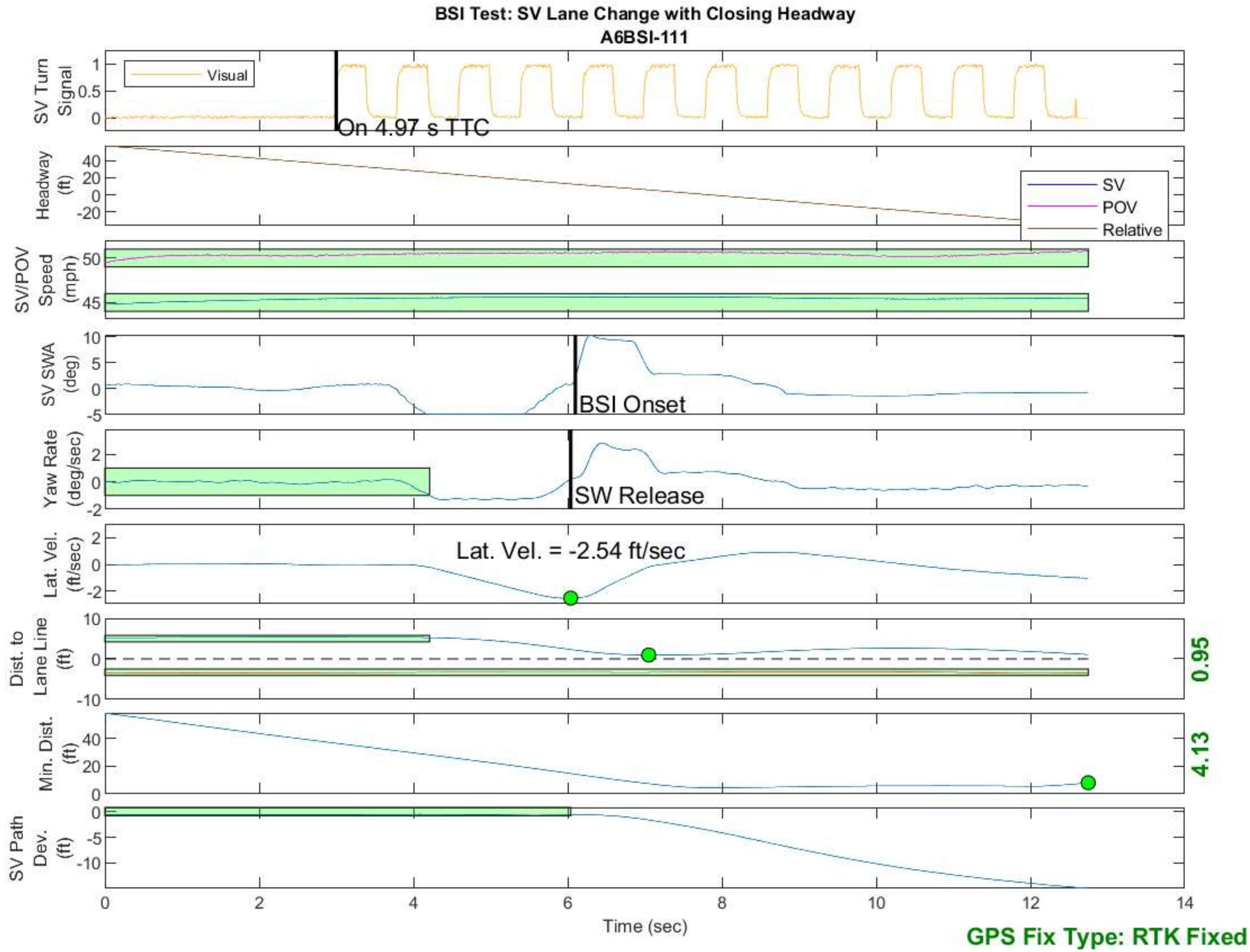

Figure D16. BSI Run 111, Subject Vehicle Lane Change with Closing Headway

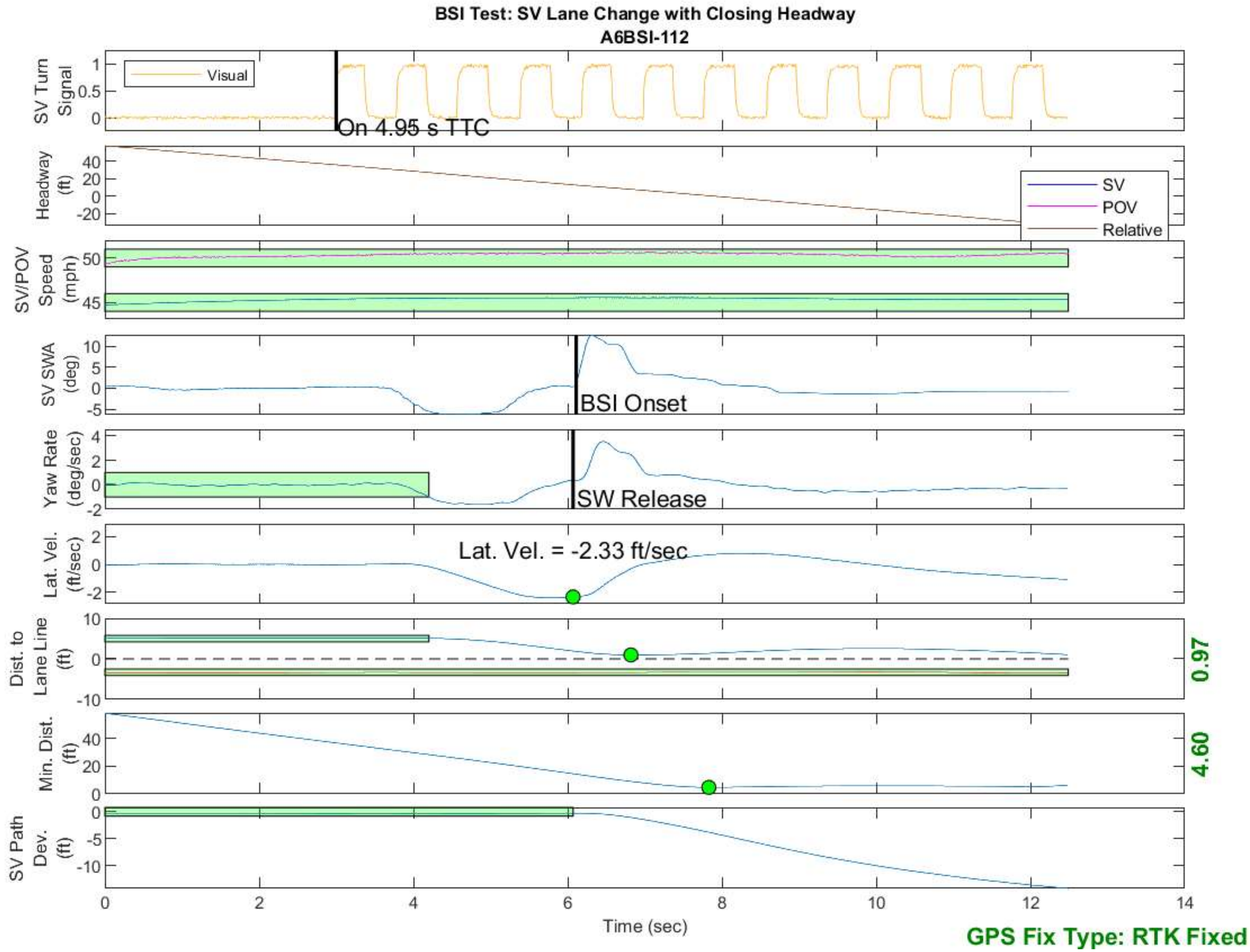

Figure D17. BSI Run 112, Subject Vehicle Lane Change with Closing Headway

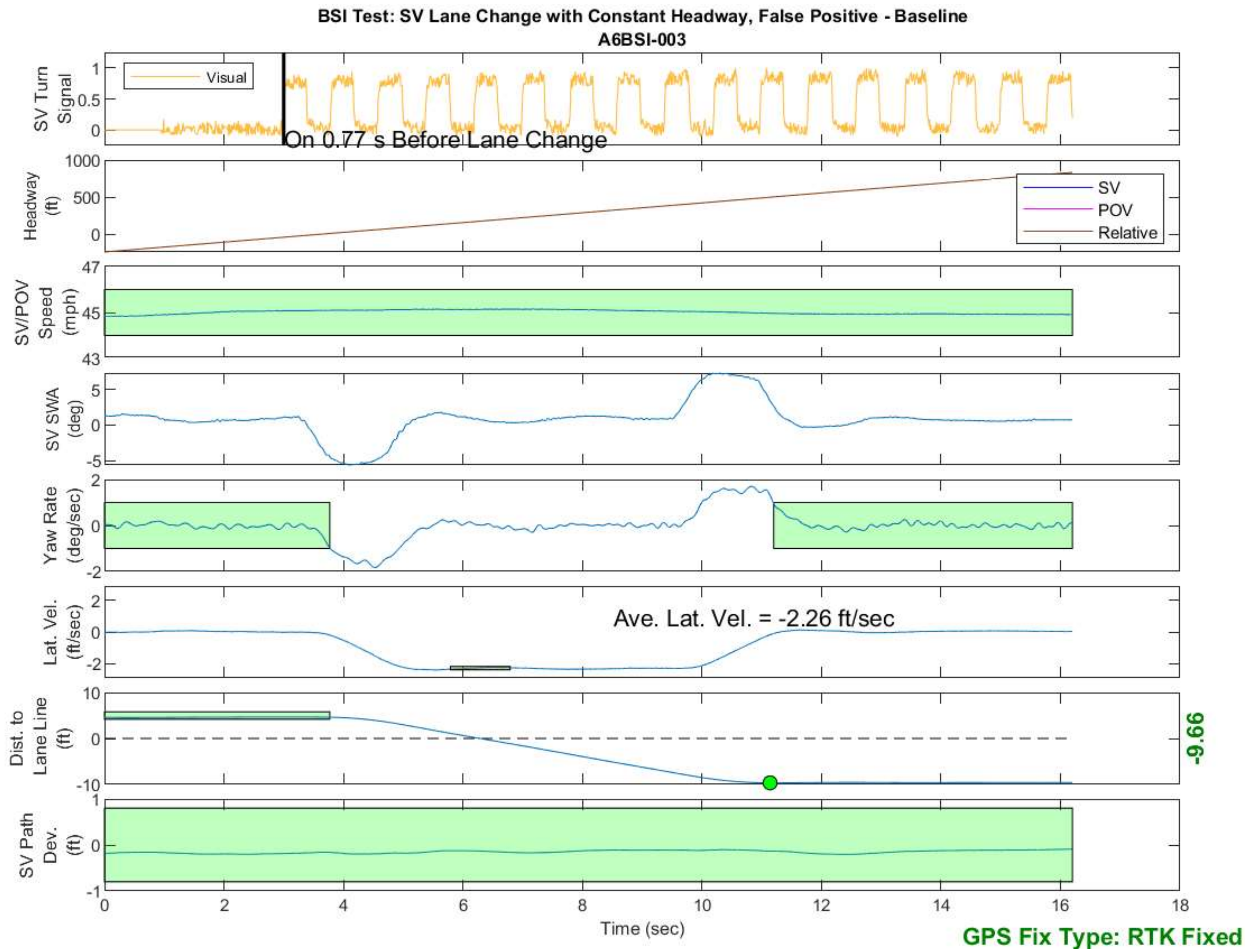

Figure D18. BSI Run 3, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

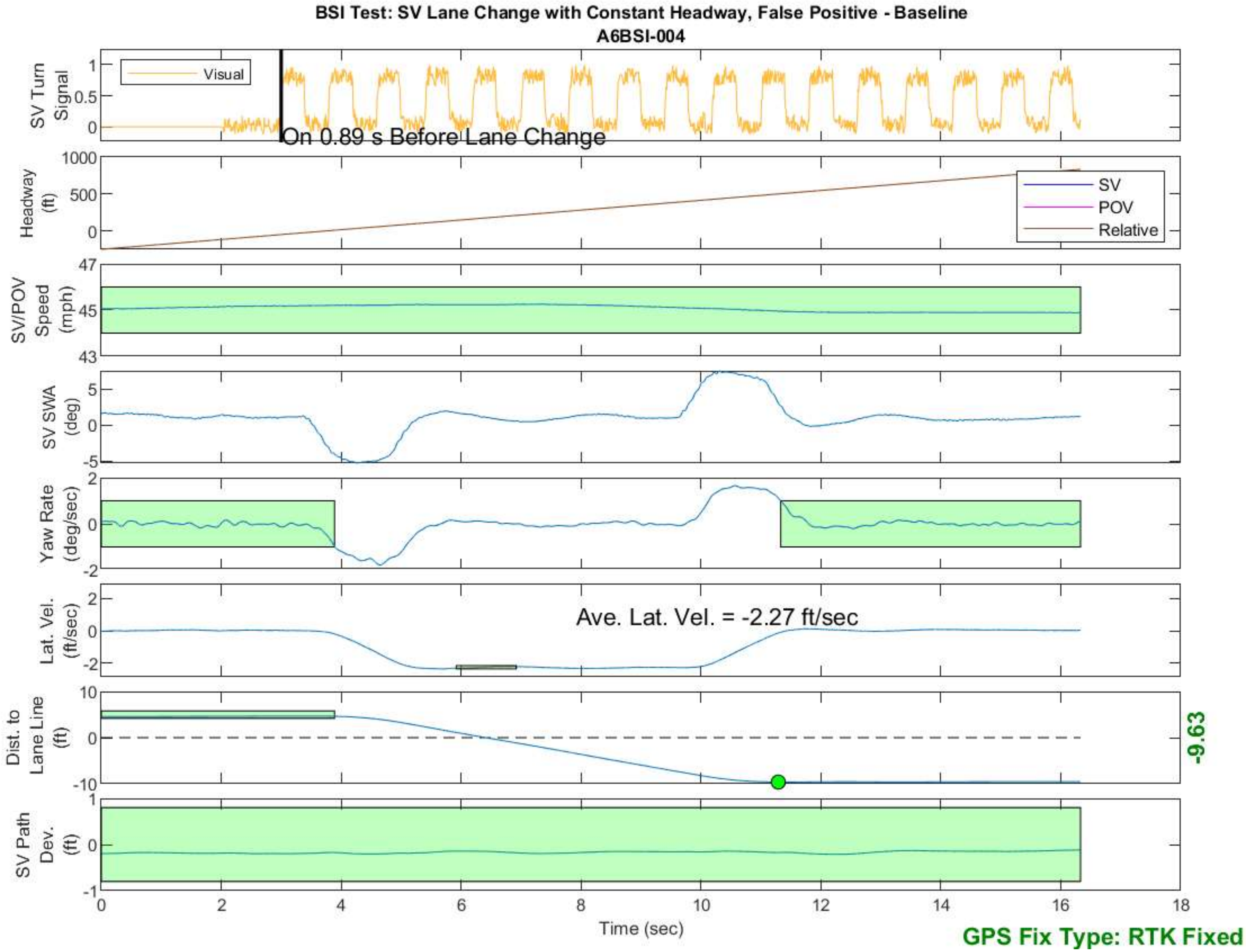

Figure D19. BSI Run 4, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

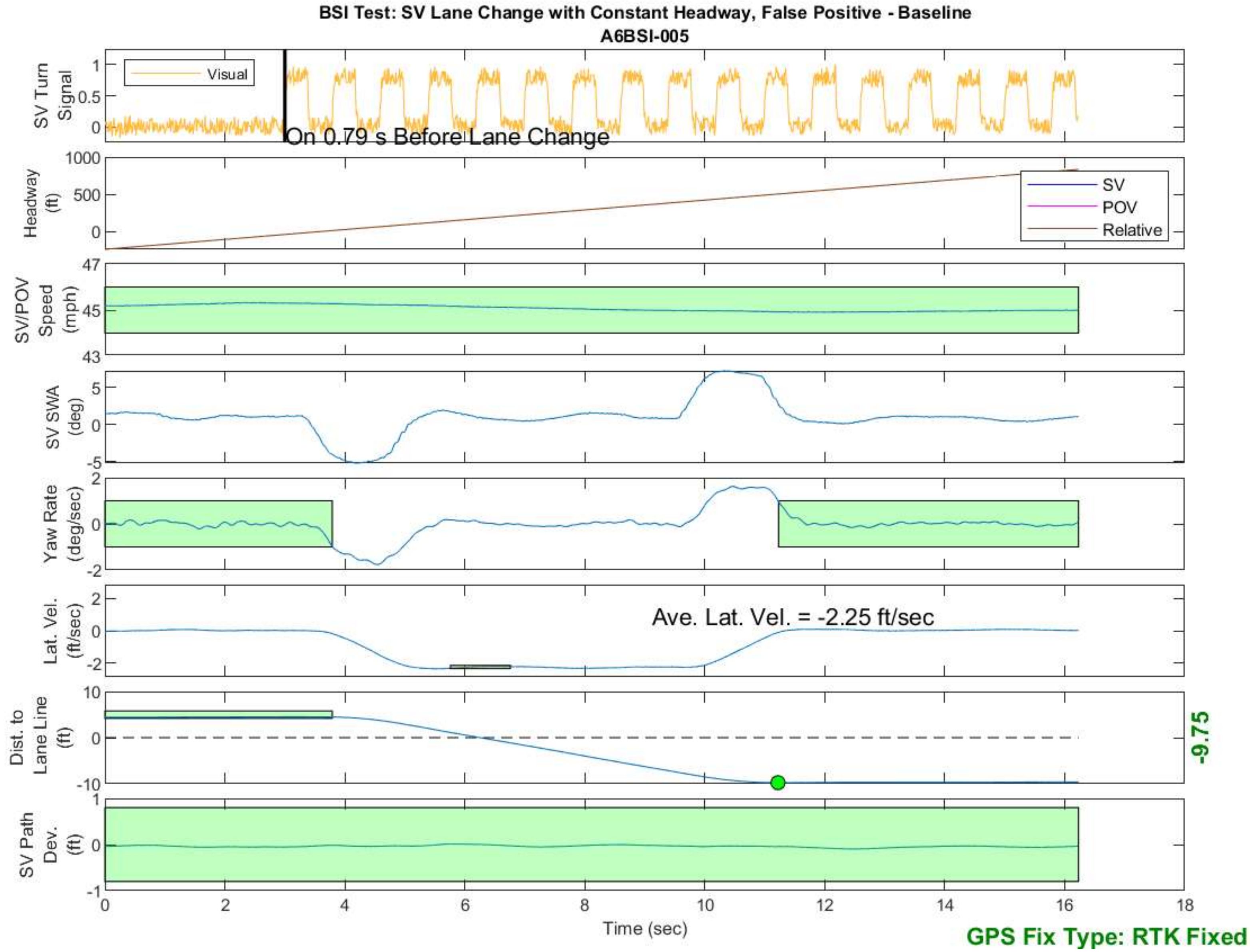

Figure D20. BSI Run 5, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

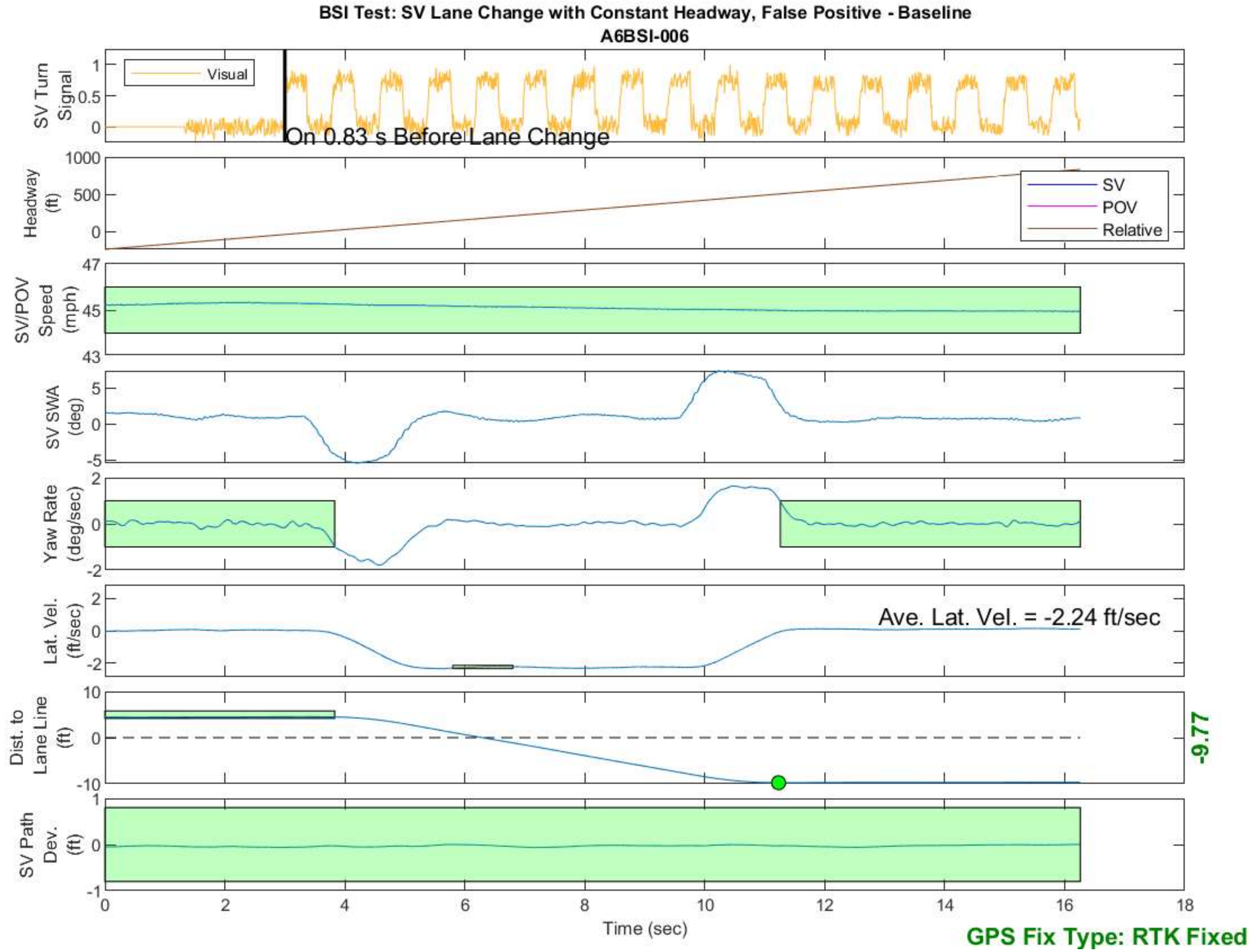

Figure D21. BSI Run 6, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

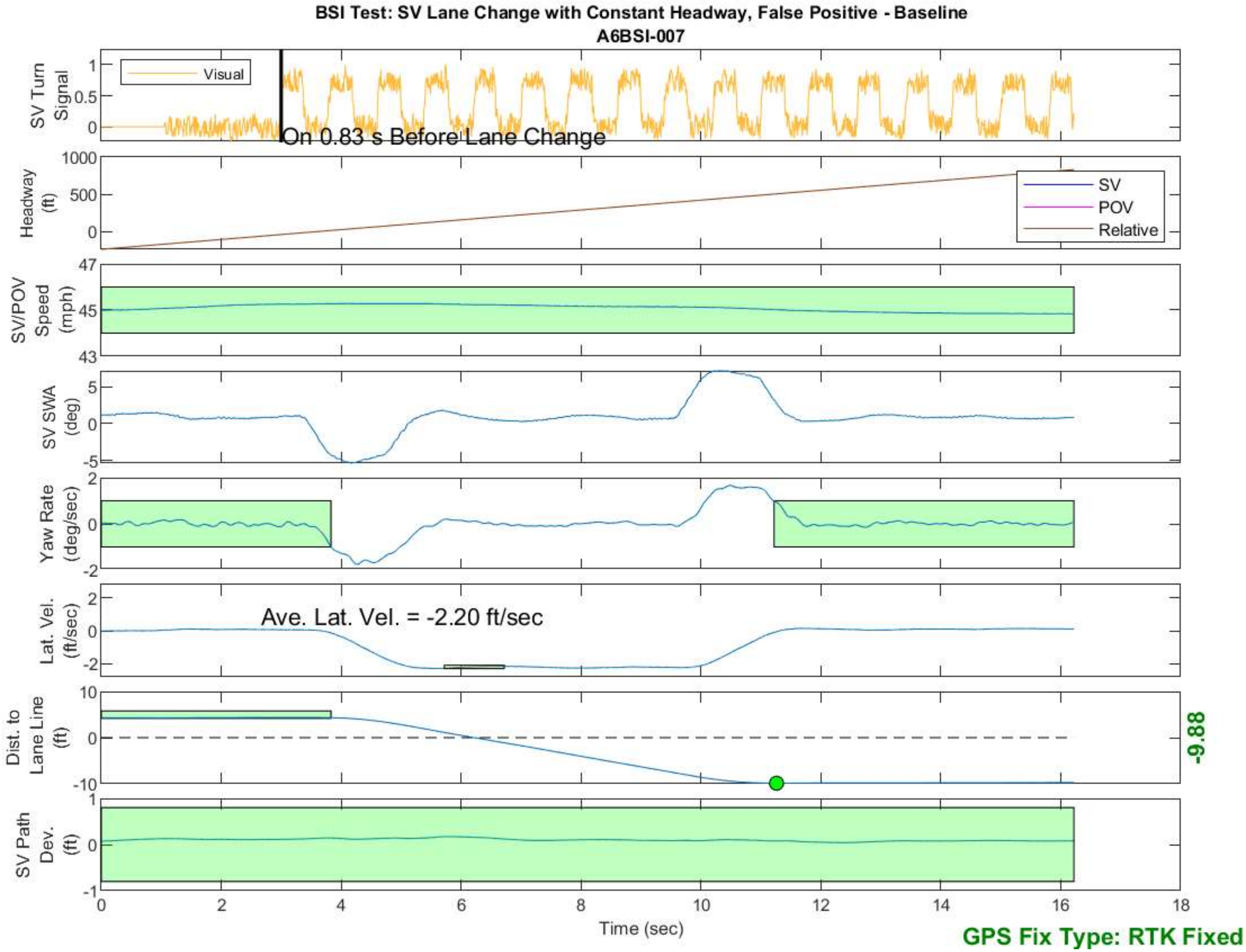

Figure D22. BSI Run 7, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

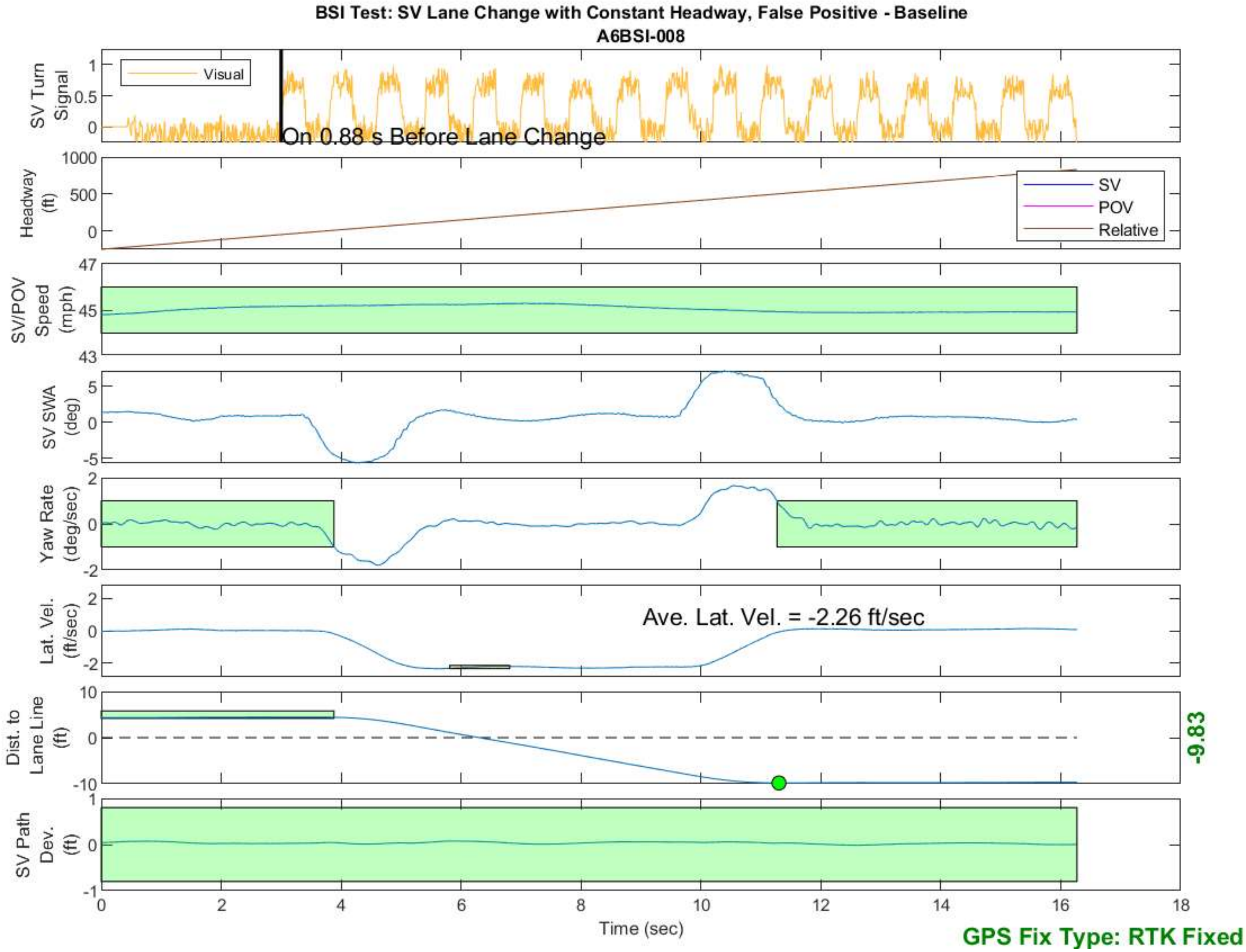

Figure D23. BSI Run 8, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

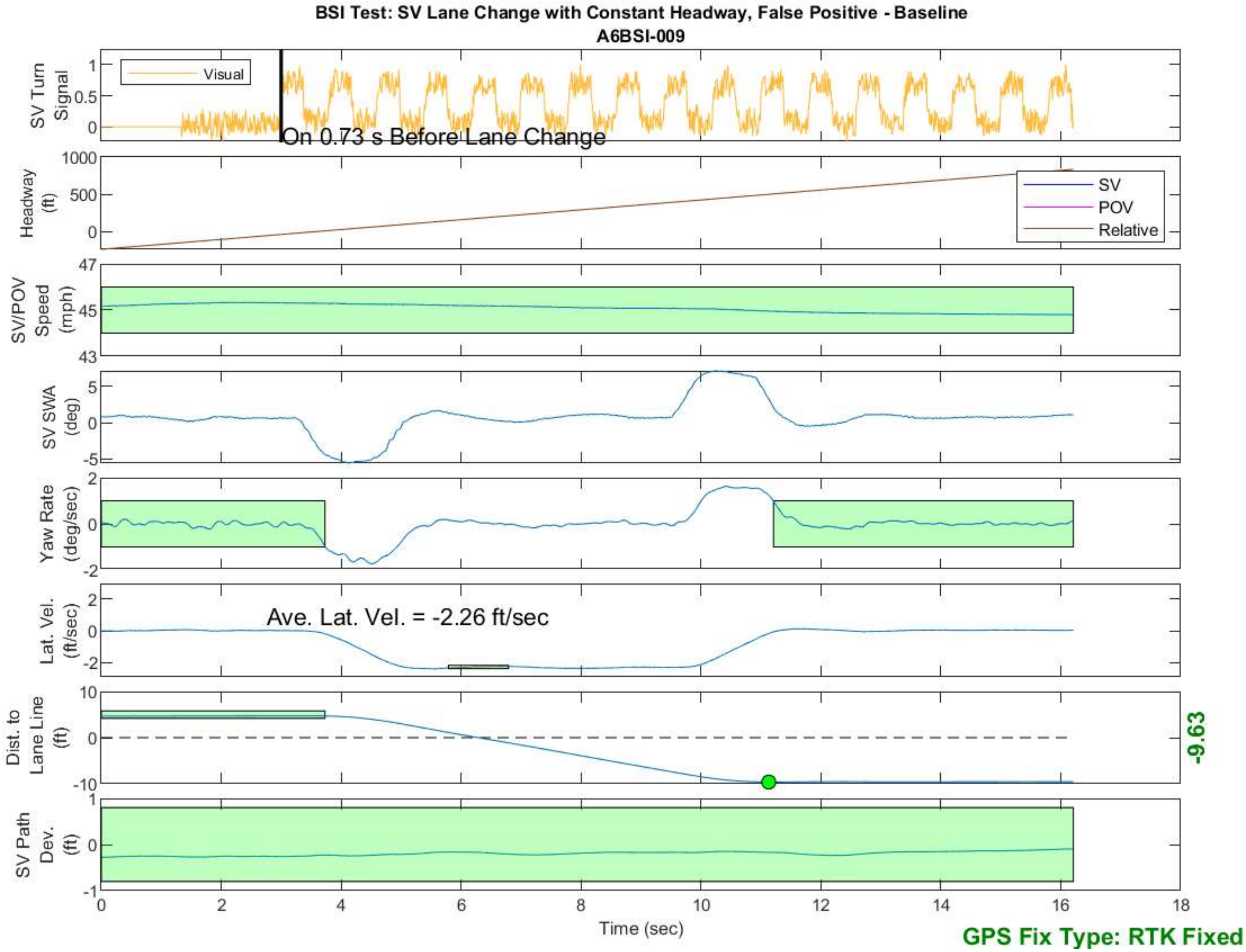

Figure D24. BSI Run 9, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Baseline

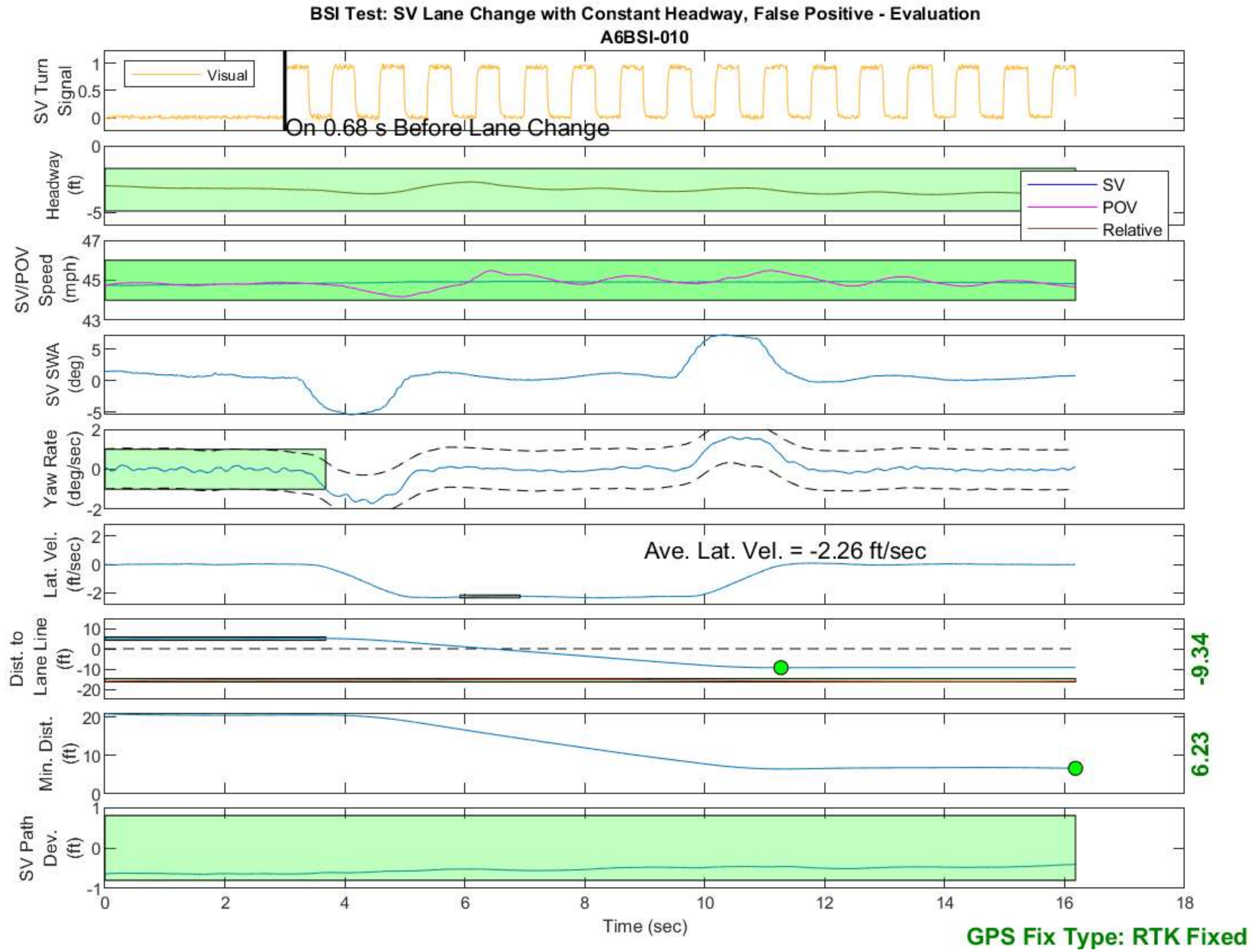

Figure D25. BSI Run 10, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

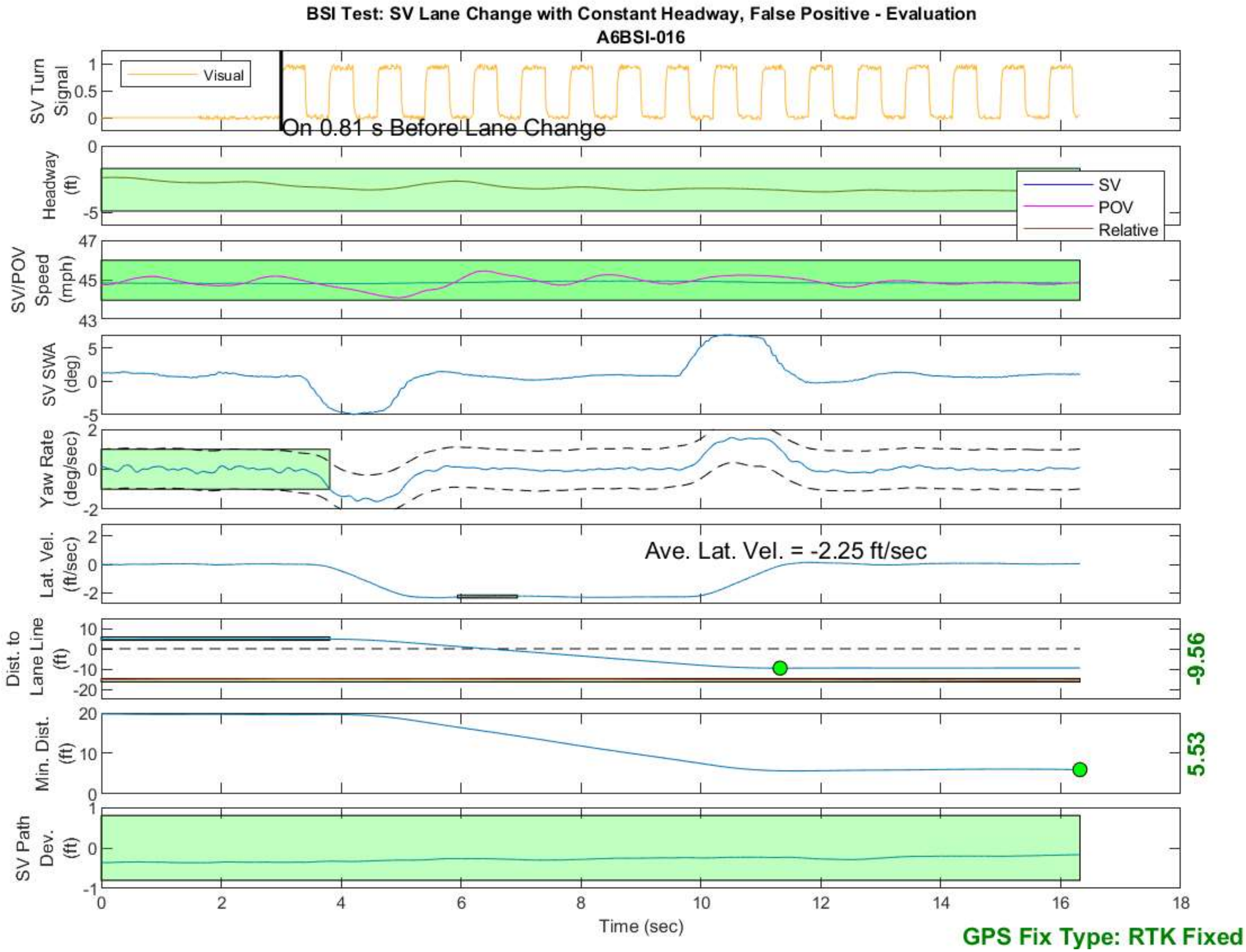

Figure D26. BSI Run 16, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

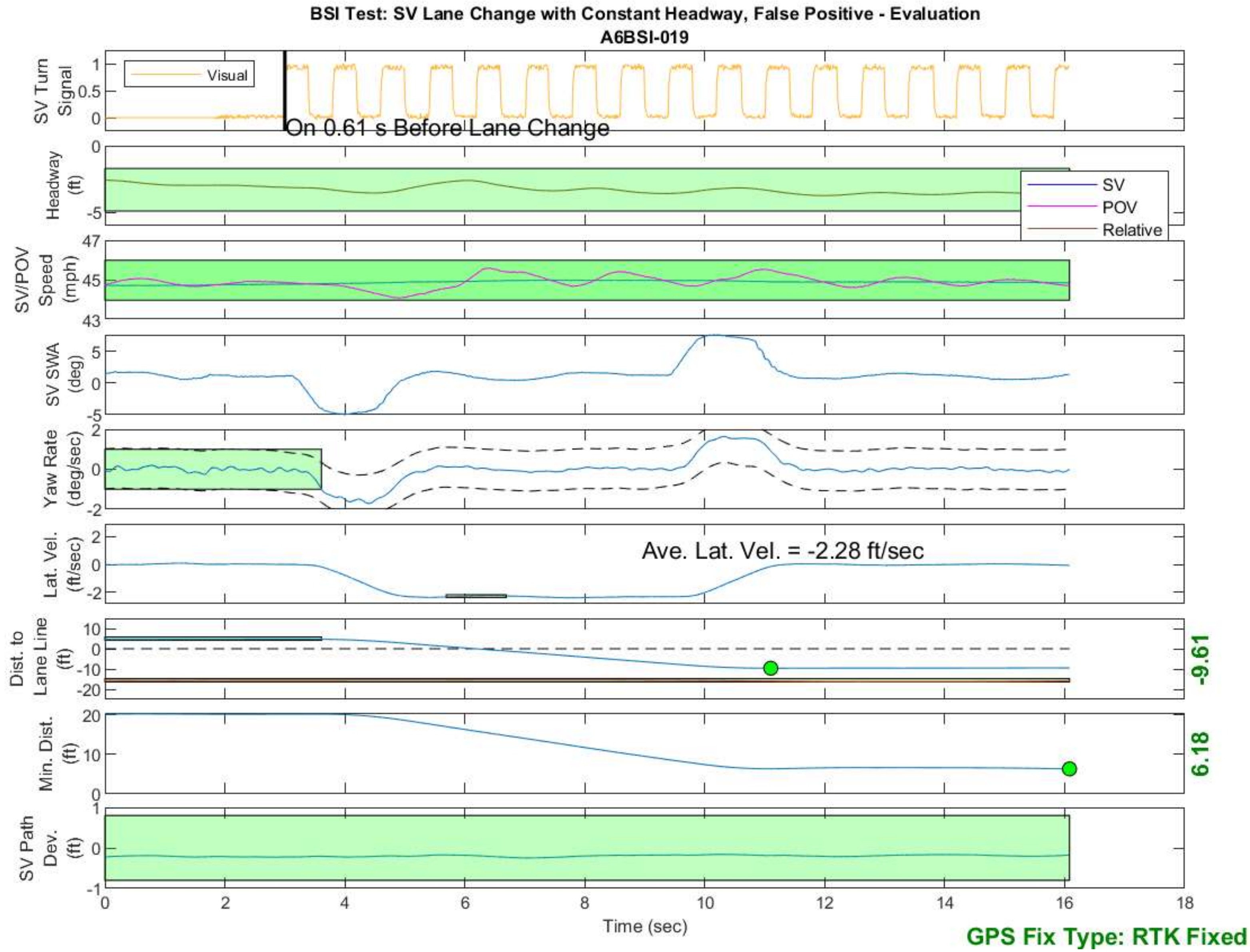

Figure D27. BSI Run 19, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

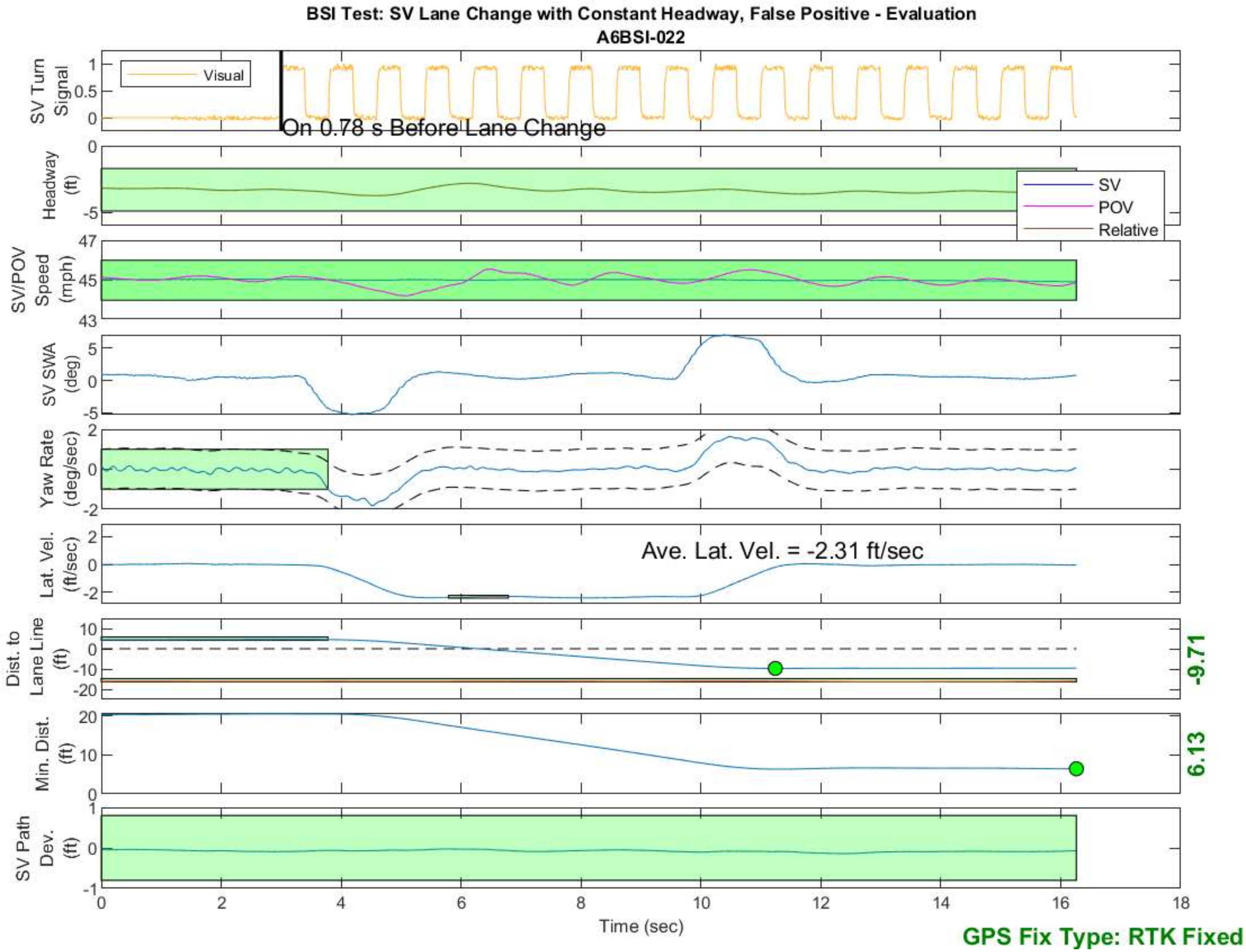

Figure D28. BSI Run 22, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

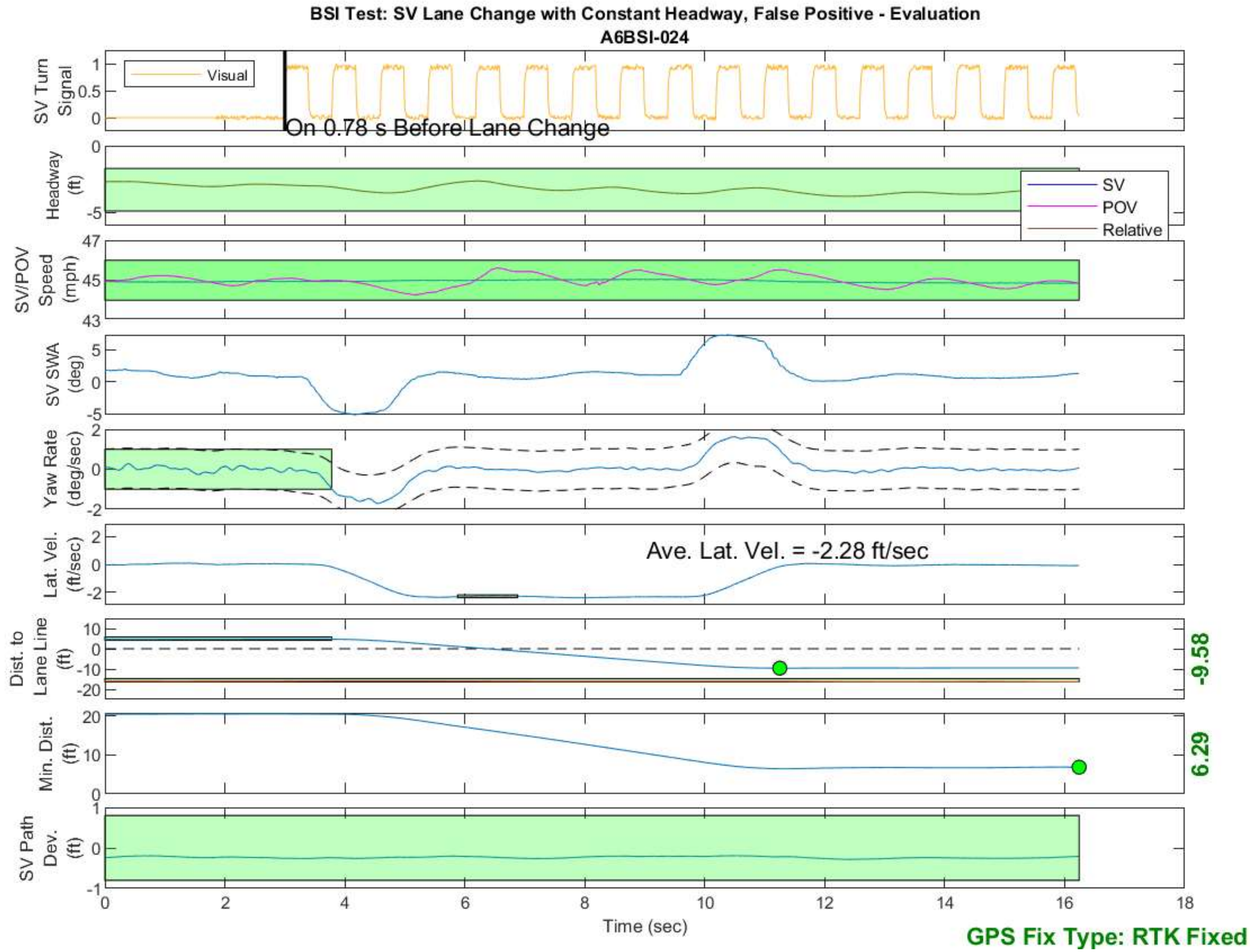

Figure D29. BSI Run 24, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

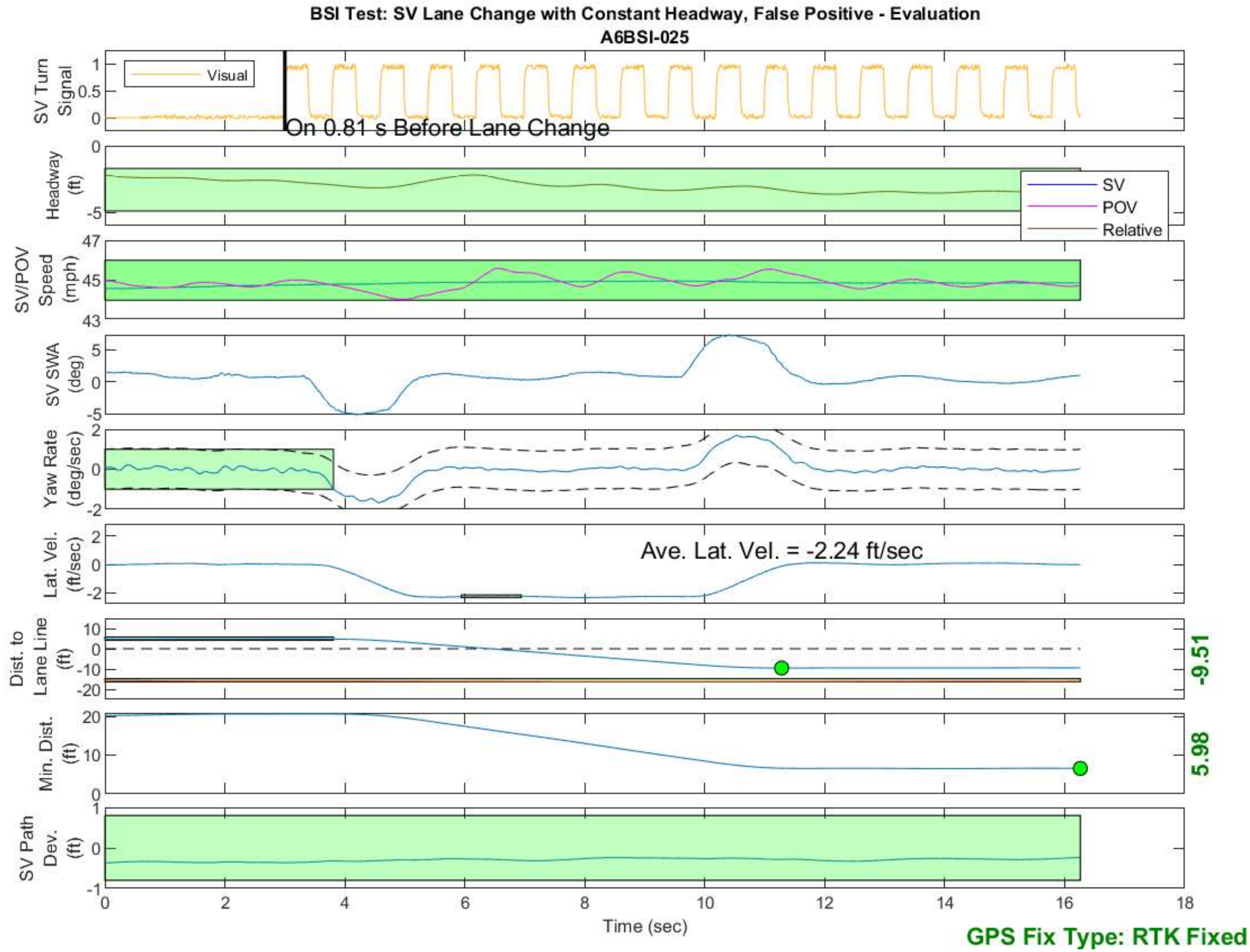

Figure D30. BSI Run 25, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation

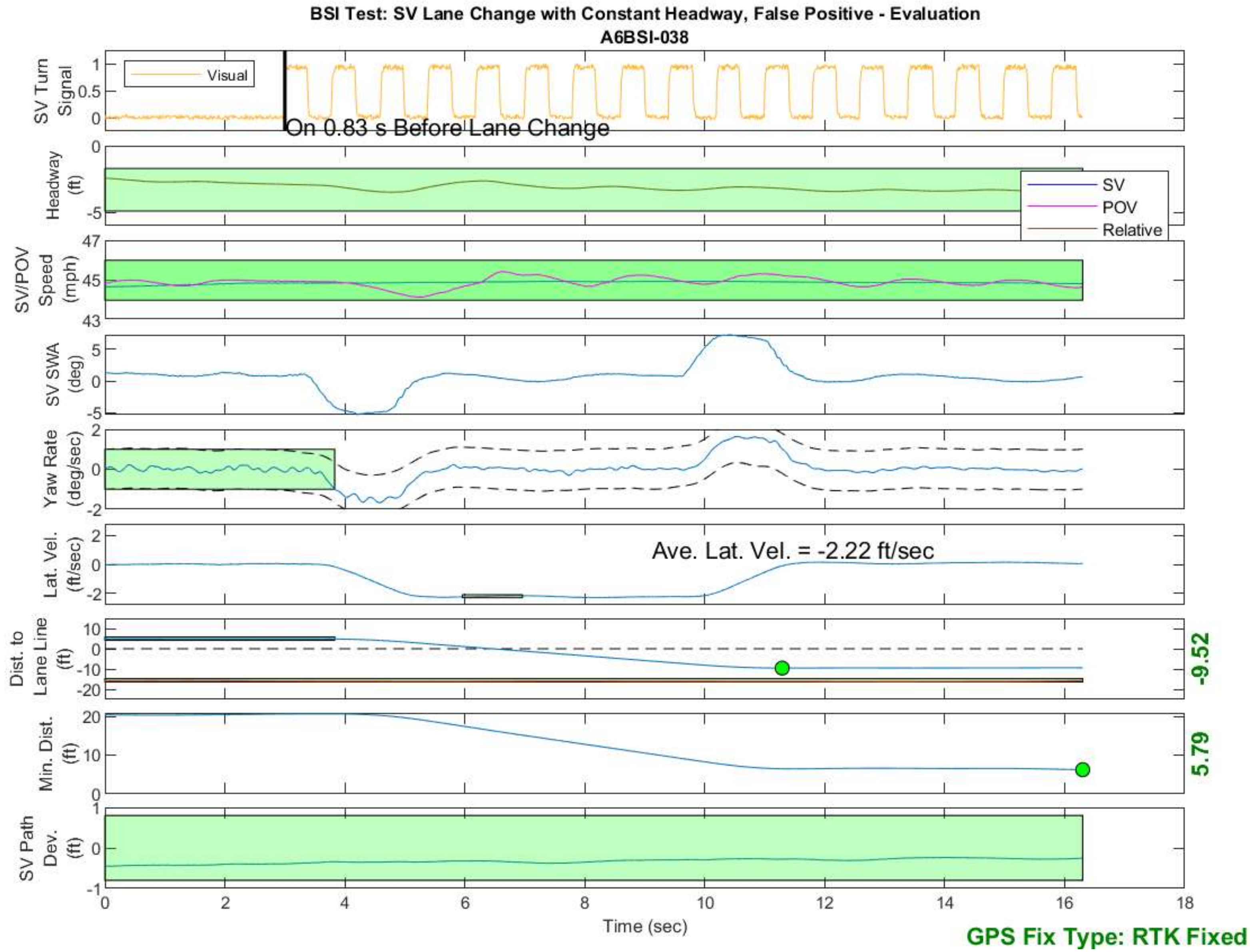

Figure D31. BSI Run 38, Subject Vehicle Lane Change with Constant Headway, False Positive Assessment - Evaluation