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Semiautomatic Headlamp Beam Switching Device Confirmation Test – Test Procedure Assessment

DISCLAIMER

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16. Abstract

This report summarizes evaluation of a draft test procedure for confirming the presence of a semiautomatic headlamp beam switching device. For the presence of a semiautomatic headlamp beam switching device to be confirmed, the vehicle had to be observed automatically engaging the upper beam headlamps upon reaching the system activation travel speed, then switching to lower beam after the stimulus vehicle's lamps were revealed, and finally returning to upper beam after passing the stimulus vehicle.

Three vehicles were subjected to multiple repetitions of the oncoming and preceding test scenarios. Two met these performance requirements in all conducted test trials. A third vehicle consistently engaged the upper beam headlamps and then switched to lower beam in response to the stimulus vehicle's illuminated lamps, but in some cases failed to switch back to upper beam headlamps after passing the stimulus vehicle. Specifically, the system did not re-engage the upper beam headlamps in 1 of 8 (12%) oncoming trials and 2 of 8 (25%) adjacent-lane preceding trials. Overall, the semiautomatic beam switching performance observed in this testing demonstrated that consistent and appropriate switching performance is achievable.

This effort identified some minor but helpful recommendations. These included specifying a minimum travel speed that is somewhat above the minimum activation speed to help ensure that conditions for semiautomatic beam switching are consistently met. The use of cruise control or other speed-maintenance aids to maintain the test vehicle's travel speed safely above the minimum speed for semiautomatic beam switching is beneficial. Objective measures were also implemented that illustrated and quantitatively documented the device performance. Overall, the testing demonstrated that repeatability is achievable for this test.

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1.0 INTRODUCTION

Current semiautomatic headlamp beam switching technology consists of a sensor-based system that detects an oncoming or preceding vehicle's headlamps or taillamps and automatically switches the vehicle headlighting from upper beam to lower beam. This report summarizes an effort to assess a draft test procedure for confirming the operational existence of a semiautomatic headlamp beam switching device on a passenger or light truck vehicle with a gross vehicle weight rating (GVWR) of under 10,000 pounds. The test consists of static vehicle measurements and two dynamic maneuver scenarios involving an oncoming or preceding other vehicle used to elicit the beam switching response and confirm beam switching control. Headlamp beam switching device operational existence is evaluated through observation and video documentation of the device's response to the other vehicle's illuminated lamps.

This test differs from the equipment-based Federal Motor Vehicle Safety Standard (FMVSS) No.108 [1] in that it confirms the operational existence of a semiautomatic headlamp beam switching device as installed on the vehicle. This test series is not intended to verify compliance with the requirements specified in FMVSS No. 108. Additionally, these dynamic maneuver test scenarios do not imply any performance capability other than operational existence for a semiautomatic headlamp beam switching device.

2.0 METHOD

Testing was performed to evaluate the draft test procedure for confirming the presence of a semiautomatic headlamp beam switching device. In this test procedure, the response of the semiautomatic headlamp beam switching device in specified scenarios is observed and documented using video cameras. Minor adjustments and additions to the draft test procedure were made for the purposes of this evaluation. A summary of the procedure and additions specific to this effort is provided below.

2.1 Test Scenarios

The draft test procedure specifies two test scenarios in which a test vehicle equipped with a semiautomatic headlamp beam switching device is driven toward a stationary “stimulus” vehicle located in an adjacent lane. The first scenario has the stimulus vehicle positioned in an oncoming orientation and the second has it in a preceding, or same direction, orientation. For evaluation purposes, this effort also included a third scenario in which the stimulus vehicle in a preceding orientation was positioned in the same lane as the test vehicle.

2.2 Stimulus Vehicle

The test procedure involves use of a stimulus vehicle to provide the other vehicle lights that elicit the semiautomatic headlamp beam switching response. During test trials, the stimulus vehicle is stationary with both the engine running and the lower beam headlamps on. The stimulus vehicle’s illuminated headlamps or taillamps are initially concealed and later revealed when the test vehicle is a set distance away.

For this testing, a 2012 Mercedes-Benz S400 Hybrid was used as a stimulus vehicle. The vehicle owner’s manual described the headlighting system as having "active bi-xenon headlamps.” The vehicle was purchased in the United States and was certified to FMVSS as stated on the vehicle label. For this effort, the stimulus vehicle also housed the instrumentation described in the following sections.

2.3 Video Camera Equipment

As per the draft test procedure, video cameras were located both on the course aft of the stimulus vehicle to capture the beam switching and inside the test vehicle focused on the instrument panel to capture the illumination of the upper beam telltale.

2.4 Weather Measurement Equipment

Ambient temperature, humidity, and wind speed information was obtained both from the test facility’s official conditions measurement data and from portable weather stations mounted in or on the stimulus and test vehicles.

2.5 Additional Auxiliary Instrumentation

This effort to evaluate a draft confirmation test procedure for semiautomatic headlamp beam switching devices used instrumentation to obtain objective data helpful for documenting the evaluation of the test procedure, as well as the consistency of test vehicle and test procedure repeatability. The additional instrumentation is described in the following sub-sections.

2.5.1 Illuminance Measurement Equipment

In addition to the required video cameras, an illuminance meter was used to record light levels at the stimulus vehicle to permit a quantitative determination of the occurrence of beam switching. A Konica Minolta T-10A illuminance meter was used to measure the amount of light emitted by the test vehicle that reached the receptor heads mounted on the stimulus vehicle. The T-10A is a multi-function digital illuminance meter with detachable receptor head. The unit was configured with multiple receptor heads to permit the measurement of multiple, separate illuminance values. The separate illuminance data channels were recorded at a frequency of 200 Hz. The T-10A had an operating temperature range of 14 to 104 degrees Fahrenheit (-10 to 40 degrees Celsius) and specified operating conditions of 85 percent or less (at 35°C/95°F) relative humidity with no condensation.

Illuminance receptor head locations and orientations are depicted in the following figure. An additional illuminance receptor head not shown in Figure 1 was mounted on a tripod located on the test course next to the video camera position aft of the stimulus vehicle. The purpose of this sensor was to capture illuminance data documenting the test vehicle's headlighting system returning to upper beam.

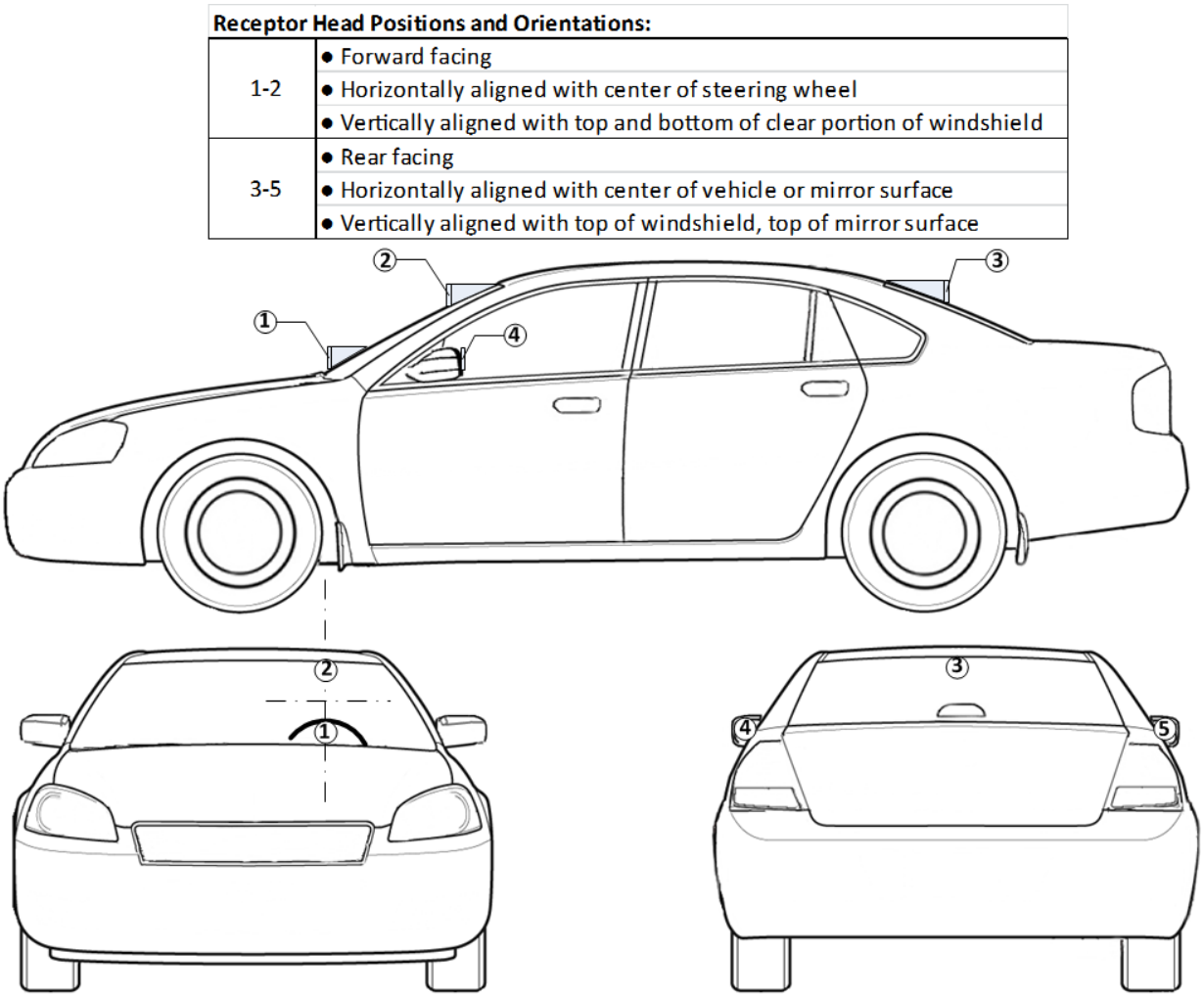

Figure 1. Illuminance Receptor Head Locations and Orientations

2.5.2 Distance Measurement Equipment

Vehicle position and speed data were obtained using RT-Range systems installed in the test vehicles and the stimulus vehicle. The test vehicle's distance to the stimulus vehicle's fixed location was detected and recorded. In the stimulus vehicle, the RT-range system hardware consisted of a RT-Range Target (Oxford Technical Solutions [OXTS]) differential GPS unit coupled with a RT3002 inertial measurement unit [IMU] and a FreeWave (FreeWave Technologies, Inc.) wireless data transceiver. In the test vehicles, the hardware consisted of a RT-Range Hunter (RT3000) differential GPS unit coupled with a RT3002 IMU and a FreeWave wireless data transceiver.

2.5.3 Data Acquisition System

A United Electronic Industries Cube (UEIPAC 600) data acquisition system was used to synchronize and record data from the illuminance meter and RT-Range system.

2.6 Conceal/Reveal System for Stimulus Vehicle Lamps

The test procedure required that the stimulus vehicle's illuminated lamps be concealed at the beginning of a test trial and then unveiled when the approaching test vehicle was approximately 340 feet away. Having the stimulus vehicle's headlamps illuminated for a short time before each test trial was desirable to avoid lamp intensity variations during initialization that may have influenced the outcomes of the test. A system was designed to conceal the stimulus vehicle's illuminated head or taillamps until the approaching test vehicle triggered the mechanism to reveal the stimulus vehicle's illuminated lamps.

Components included two blackout curtains attached to a length of PVC pipe that served as a curtain rod. The curtain rod was curved at each end to allow it to wrap around the corners of the stimulus vehicle to ensure that its lamps were fully concealed. The curtain rod had a steel disk attached to each end to allow the rod to be suspended using tripod-mounted electromagnets. The electromagnets were wired to a relay and an 8-foot long ribbon/tape switch designed for vehicle sensing. The ribbon/tape switch component of the conceal/reveal system was positioned 375 feet before the stimulus vehicle to ensure that the stimulus lamps would be fully revealed by the time the test vehicle left the speed measurement zone located 340 feet (longitudinally) from the stimulus vehicle. Activation of the ribbon switch caused the relay to open, which cut power to the electromagnets thereby releasing the curtain rod and curtain which dropped to the ground. Power was provided by a vehicle "Jump Starter and Portable Power Unit."

The following figures show the conceal/reveal system in position for an oncoming scenario test trial. Additional details about this apparatus are presented in Appendix A.

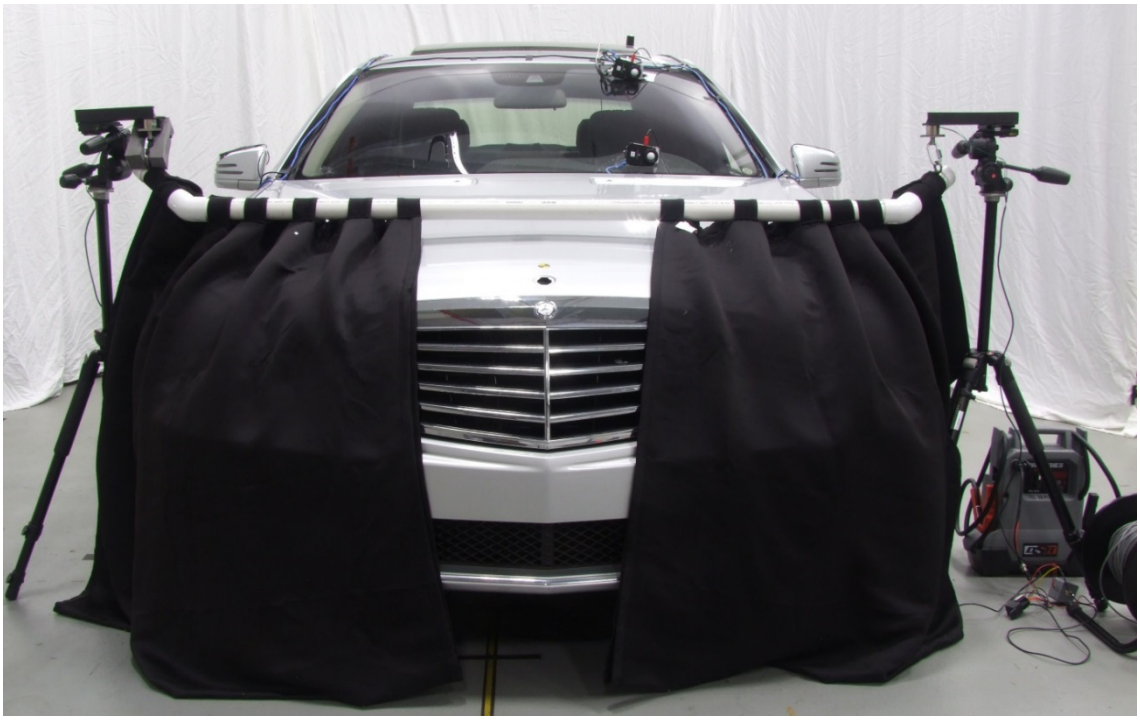

Figure 2. Photo of the Stimulus Vehicle With the Conceal/Reveal System Positioned for an Oncoming Scenario Trial

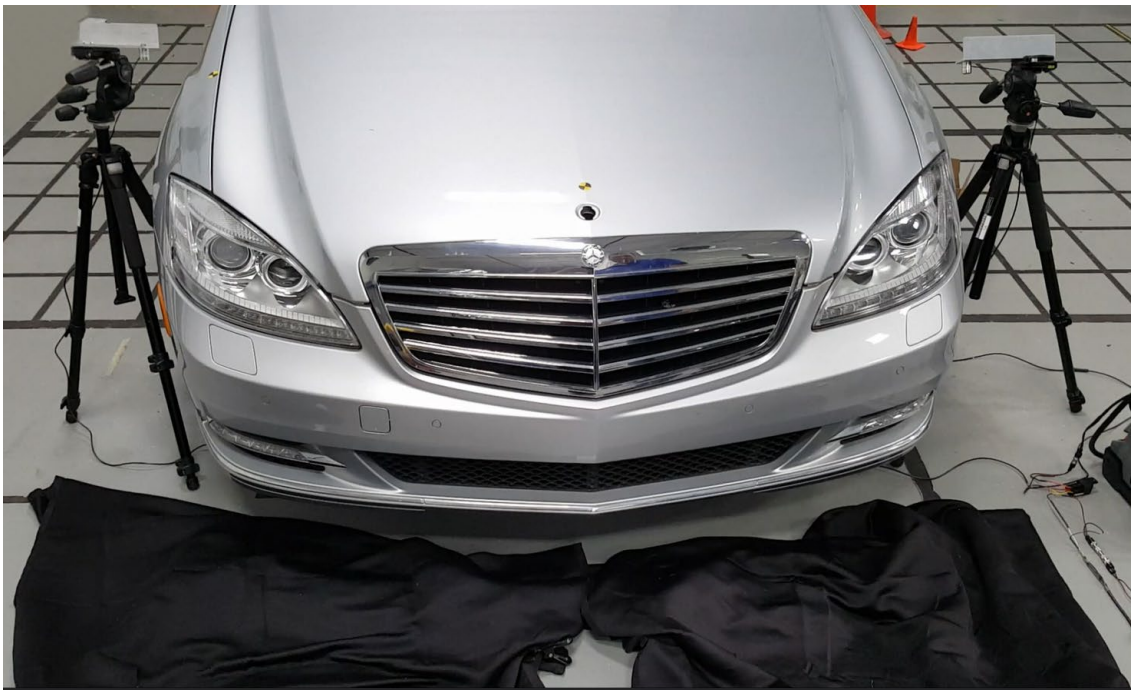

Figure 3. Photo of the Stimulus Vehicle with the Conceal/Reveal System After the Curtain Has Been Released

2.7 Photographic Documentation

Still, color photographs were taken of each vehicle tested including the following views.

- Vehicle exterior, front
- Vehicle exterior, rear
- Vehicle exterior, four three-quarter pictures
- Vehicle interior, driver side with the door open
- Vehicle interior, headlighting control device

Photographs for the vehicles tested in this effort are included in the Results section of this report. A photo of the stimulus vehicle's headlighting system projection pattern was also obtained.

2.8 Test Vehicle Preparation

As per the draft test procedure, each vehicle was prepared for testing by ensuring that the vehicle's hood, trunk, and all doors were closed. The test vehicle's windshield was thoroughly cleaned, particularly in front of the camera beam switching systems. Both the stimulus vehicle and test vehicle's tires were set to the vehicle manufacturer recommended cold inflation pressures. The vehicle fuel tanks were filled. Battery voltage levels were confirmed to be within the nominal operating range on each vehicle.

2.9 Method

Testing was conducted on the Skid Pad facility of the Transportation Research Center [2]. This course has a concrete, broomed surface and five smooth, delineated lanes that are each 14 feet wide. Two of the five 3,600-foot lanes were used for this testing.

2.9.1 Draft Test Procedure

Per the draft test procedure, the following steps were carried out for the dynamic device confirmation test.

1. Confirm ambient conditions to be within the ranges of all relevant test equipment.
2. Initiate video data recording.
3. Accelerate the subject vehicle (SV) to the minimum activation speed identified in the vehicle owner's manual, and maintain this constant speed throughout the test. If no activation speed is identified, then the test speed shall be 35 mph.
4. When the SV enters or passes the speed measurement area, unveil the stimulus lamps.
5. When the SV passes the digital recording device, stop video data recording.
6. Bring SV to a full stop. End of test trial.
7. Repeat Steps 1 to 6 with the stimulus vehicle's taillamps.

When possible, cruise control was used to maintain a consistent test vehicle travel speed during test trials.

Three iterations of each test scenario were performed on each of three separate test nights (i.e., test sets) to provide information on system performance consistency and test repeatability.

2.9.2 Test Setup

In addition, some minor modifications to the scenario and instrumentation layout were made. Figure 3 depicts the layout of the oncoming scenario as tested for this effort. The ribbon/tape switch component of the conceal/reveal system was positioned 375 feet before the stimulus vehicle to ensure that the stimulus lamps would be fully revealed by the time the test vehicle left the speed measurement zone located 340 feet before the test vehicle. The tripod-mounted video camera and illuminance receptor positioned aft of the stimulus vehicle were moved from 115 feet to 130 feet to compensate for minor fluctuations in test vehicle speed and ensure that the system's return to upper beam occurred before the test vehicle passed the tripod location.

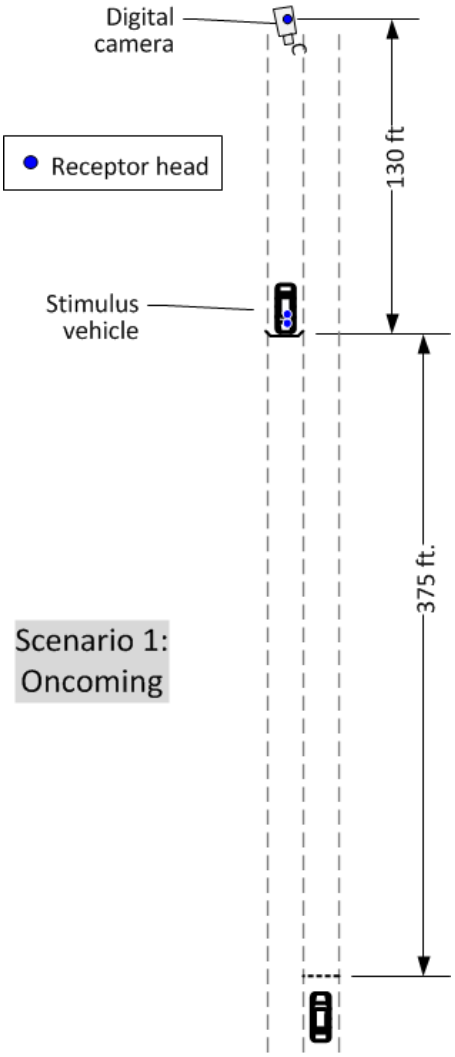

Figure 4. Oncoming Scenario Diagram

In addition to the prescribed oncoming and preceding adjacent lane scenarios, this effort included a same-lane version of the preceding vehicle scenario. In the same-lane preceding scenario, the test vehicle would drive toward the stationary stimulus vehicle and change lanes to go around it after the headlamp had switched from upper to lower beam.

2.9.3 Performance Requirements

For the presence of a semiautomatic headlamp beam switching device to be confirmed, the vehicle had to be observed automatically engaging the upper beam headlamps upon reaching the activation speed, then switching to lower beam after the stimulus vehicle's lamps were revealed, and finally returning to upper beam after passing the stimulus vehicle. The following figure illustrates this performance using objective data. Circled letters on the plot highlight various events of interest illustrated by the data. Descriptions of those events are as follows:

A. At the start of the test run, the vehicle is initially stationary and then accelerates to a target speed somewhat above the system's minimum speed for automatic beam switching operation. Upon reaching that speed, the vehicle's headlamps automatically switch from lower to upper beam.

B. The vehicle's upper beam headlamps are on and illuminance at the stimulus vehicle increases as the test vehicle approaches the stimulus vehicle.

C. Illuminance at the stimulus vehicle drops as the test vehicle's headlamps switch from upper to lower beam upon detecting the stimulus vehicle's lower beam headlamp illumination.

D. Range/distance between the test vehicle and stimulus vehicle decreases as the test vehicle approaches the stimulus vehicle.

E. Illuminance at the stimulus vehicle increases as the test vehicle approaches the stimulus vehicle.

F. Illuminance for the vehicle-mounted receptor heads decreases once the test vehicle passes the stimulus vehicle.

G. Illuminance level as measured at a receptor head 40 m beyond the stimulus vehicle increases as the system switches automatically from lower to upper beam headlamps. Some plots display a coordinate value for test vehicle speed at approximately 2 seconds after the test vehicle passes the stimulus vehicle to highlight whether or not the speed was high enough for semiautomatic beam switching.

H. The test vehicle passes the location of the receptor head located 40 m beyond the stimulus vehicle's longitudinal headlamp location.

I. Illuminance decreases as the test vehicle passes the location of the receptor head beyond the stimulus vehicle.

Some plots display a coordinate value following the "G" label. The y-value of this coordinate indicates test vehicle travel speed. The value is displayed to highlight whether the vehicle was or was not traveling at a speed that would permit semiautomatic beam switching operation.

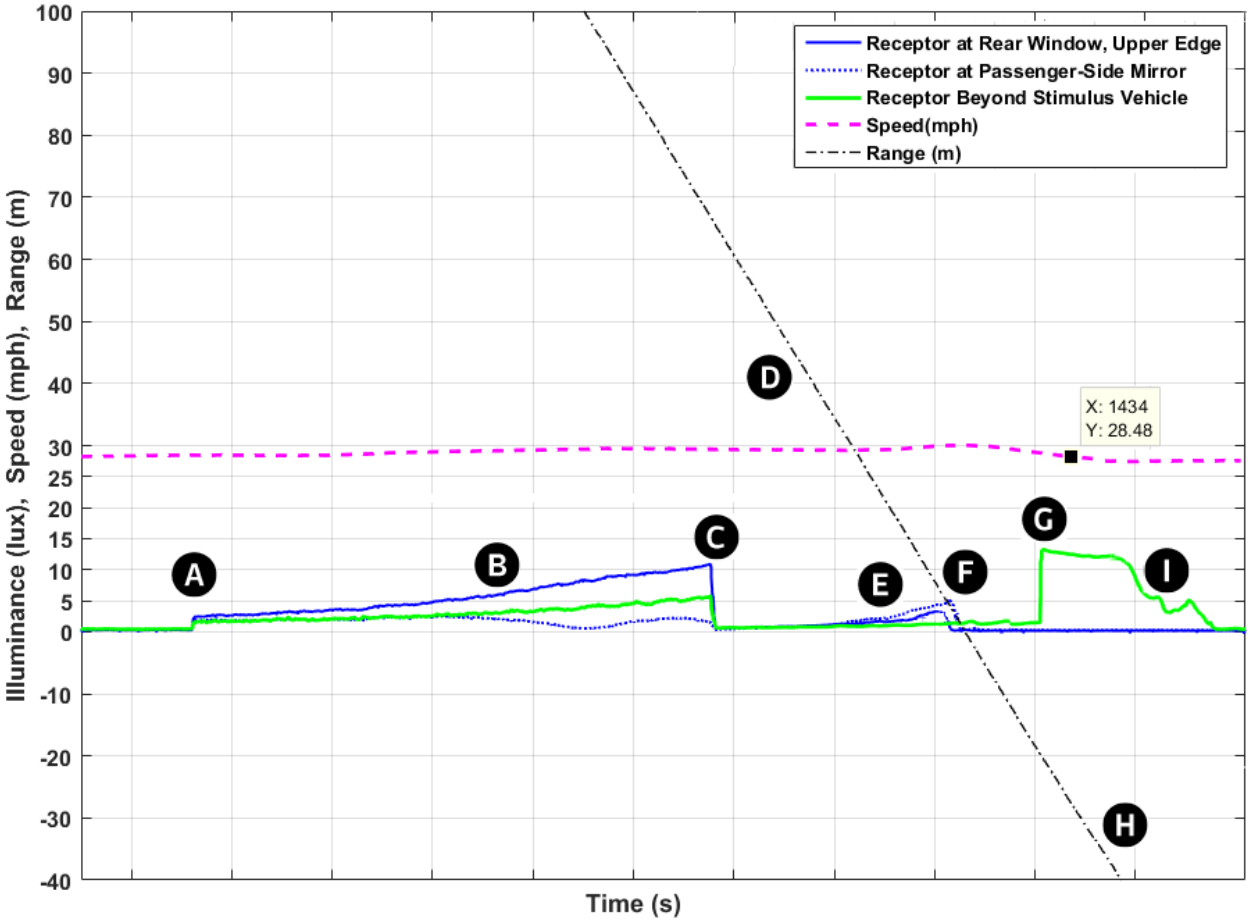

Figure 5. Annotated Example Preceding Scenario Trial Plot Illustrating Headlamp Beam Switching and Other Data Elements

3.0 RESULTS

The following sections present the results of testing conducted in support of the evaluation of the draft semiautomatic headlamp beam switching device confirmation test procedure.

Vehicles examined in this effort are listed in the following table.

Table 1. Vehicles Examined

	Vehicle Model Info	Mileage	Technology Type	System Name	Min. Activation Speed (mph)	Deactivation Speed (mph)
1	2015 Lexus LS460L	2,083	LED	"Intelligent High-Beams"	>21	<17
2	2015 Mercedes-Benz C300	4,185	LED	"Adaptive Highbeam Assist"	>19	<16
3	2016 Volvo XC90 T6	2,117	LED	"Active High Beams"	Not specified	Not specified
Stimulus Vehicle:	2012 Mercedes-Benz S400 Hybrid		HID	"Active bi-xenon headlamps"		

For the presence of a semiautomatic headlamp beam switching device to be confirmed, the vehicle had to be observed automatically engaging the upper beam headlamps upon reaching the system activation travel speed, then switching to lower beam after the stimulus vehicle's lamps were revealed, and finally returning to upper beam after passing the stimulus vehicle.

The following sections contain photographic and objective plotted data documenting testing of the three test vehicles per the draft test procedure. Some plots do not contain speed and range data due to instrumentation issues, but still show beam switching activity through the illuminance data channels presented.

3.1 2015 Lexus LS460L Sedan

3.1.1 Vehicle Photos

Still, color photographs of the measured 2015 Lexus LS460L Sedan are presented in the following figures.

Figure 6. 2015 Lexus LS460L Sedan – Front

Figure 7. 2015 Lexus LS460L Sedan - Rear

Figure 8. 2015 Lexus LS460L Sedan - Four Three-Quarter Pictures

Figure 9. 2015 Lexus LS460L Sedan - Headlighting System Control

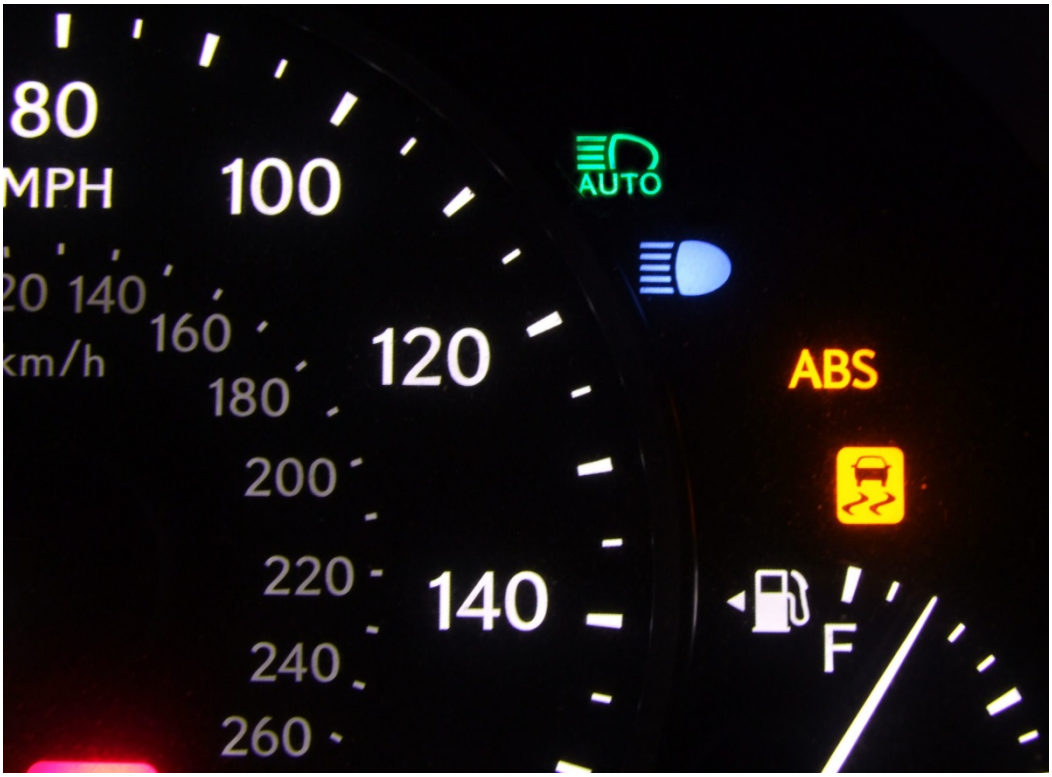

Figure 10. 2015 Lexus LS460L Sedan - Headlighting System Instrument Panel Icons

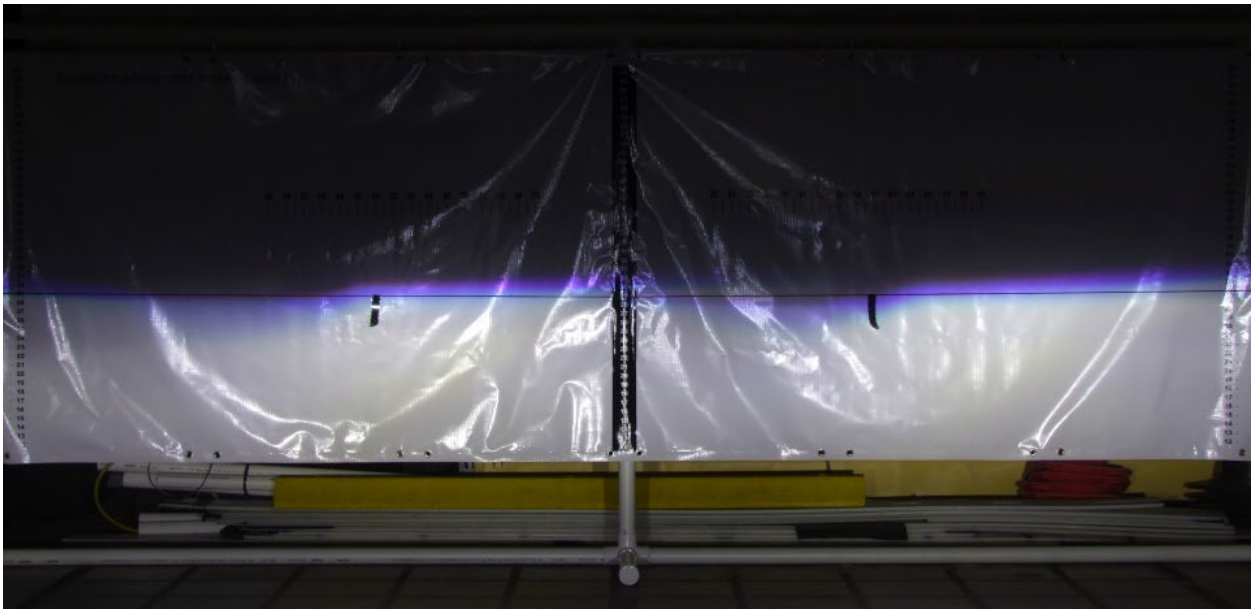

Figure 11. 2015 Lexus LS460L - Headlamp Projection Pattern (Aimed)

3.1.2 Results

In all attempted test trials, the 2015 Lexus LS460L Sedan was observed to engage the upper beam headlamps upon reaching the activation speed for automatic beam control and then switch to lower beam in response to the stimulus vehicle's illuminated lamps being revealed. However, in some cases this vehicle did not successfully switch back to upper beam headlamps after passing the stimulus vehicle. The system did not re-engage the upper beam headlamps in 89 percent of oncoming trials and in 78 percent of both adjacent-lane and same-lane preceding trials. A summary of results for the 2015 Lexus LS460L are provided in the following table.

Table 2. Summary of 2015 Lexus LS460L Headlamp Switching Behavior as Observed in Test Scenarios

Scenario	Set	Trial	File	Vehicle Automatically Switched Upper Beam Headlamps ('A' in Fig. 5)	Illuminance Data Show Switch From Upper to Lower Beam ('C' in Fig. 5)	Illuminance Data Show Return to Upper Beam ('G' in Fig. 5)	1 = Device Presence Confirmed * = Invalid Trial	% Confirmed for 3 Trials	% Confirmed Over All Trials
Oncoming	1	1	8	Y	Y	Y	1	100% (2/2)	88% (7/8)
		2	9	Y	Y	N	*		
		3	10	Y	Y	Y	1		
	2	1	256	Y	Y	Y	1	100% (3/3)	
		2	257	Y	Y	Y	1		
		3	258	Y	Y	Y	1		
	3	1	309	Y	Y	Y	1	67% (2/3)	
		2	310	Y	Y	Y	1		
		3	311	Y	Y	Y	0		
Preceding Adjacent Lane	1	1	116	Y	Y	Y	1	100% (2/2)	75% (6/8)
		2	117	Y	Y	Y	*		
		3	118	Y	Y	Y	1		
	2	1	209	Y	Y	N	0	33% (1/3)	
		2	210	Y	Y	N	0		
		3	211	Y	Y	Y	1		
	3	1	313	Y	Y	Y	1	100% (3/3)	
		2	314	Y	Y	Y	1		
		3	315	Y	Y	Y	1		
Preceding Same Lane	1	1	111	Y	Y	Y	1	100% (3/3)	100% (8/8)
		2	112	Y	Y	N	1		
		3	113	Y	Y	Y	1		
	2	1	213	Y	Y	Y	1	100% (2/2)	
		2	214	Y	Y	N	*		
		3	215	Y	Y	Y	1		
	3	1	317	Y	Y	Y	1	100% (3/3)	
		2	318	Y	Y	Y	1		
		3	319	Y	Y	Y	1		

*Note: Trials with asterisks were invalid trials due to test vehicle travel speed dropped below the minimum speed for semiautomatic beam switching. These trials were excluded from the analysis.

Figures 12 to 14 present the objective data for the 2015 Lexus LS460L in oncoming scenario trial sets 1 to 3, respectively.

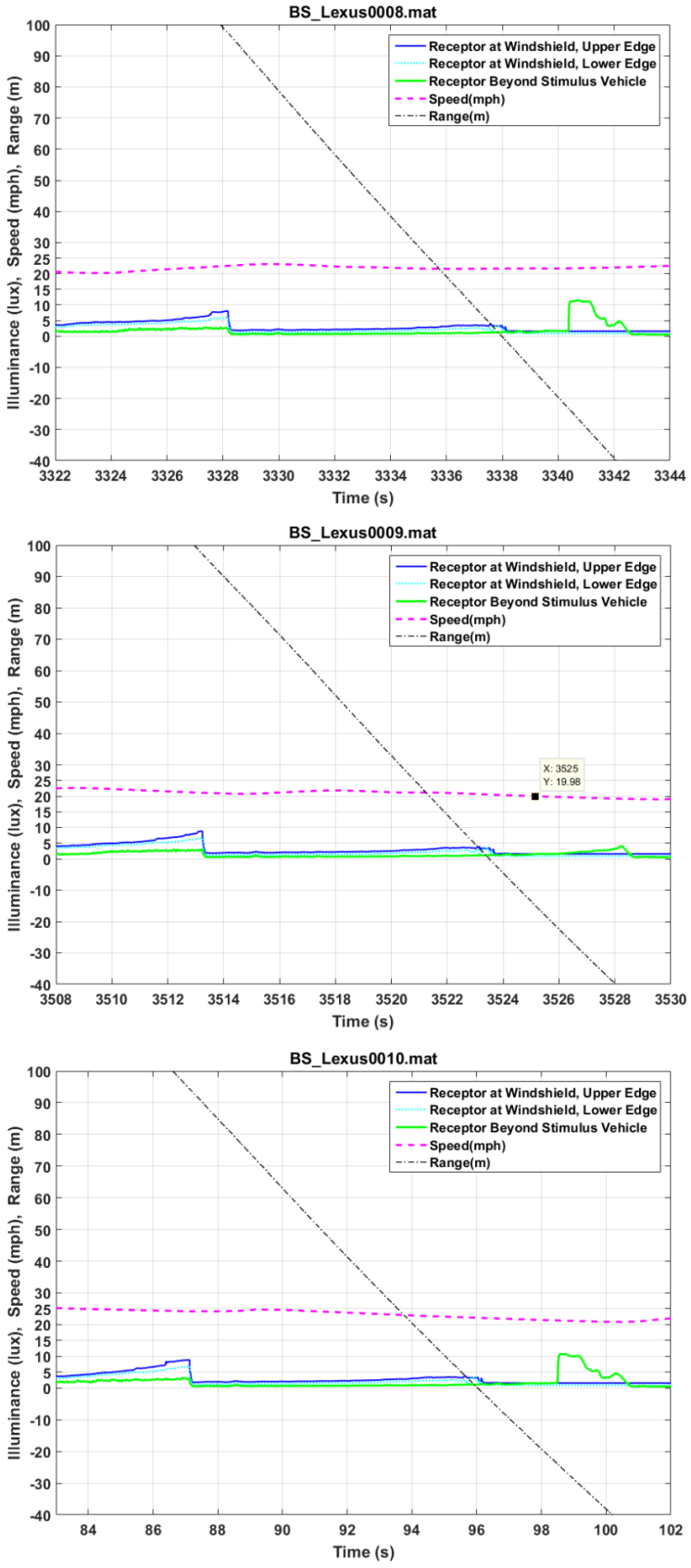

Figure 12. 2015 Lexus LS460L Oncoming Scenario Trial Set 1 Plot

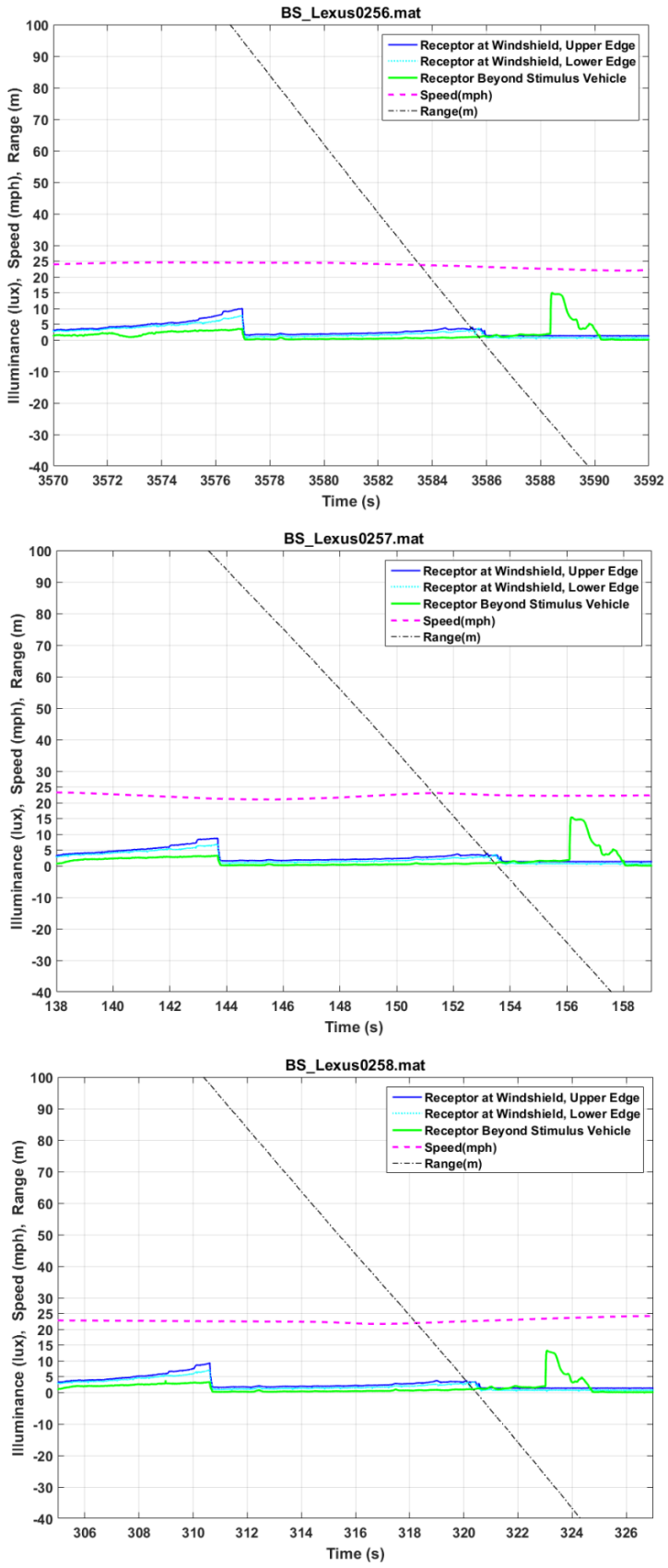

Figure 13. 2015 Lexus LS460L Oncoming Scenario Trial Set 2 Plot

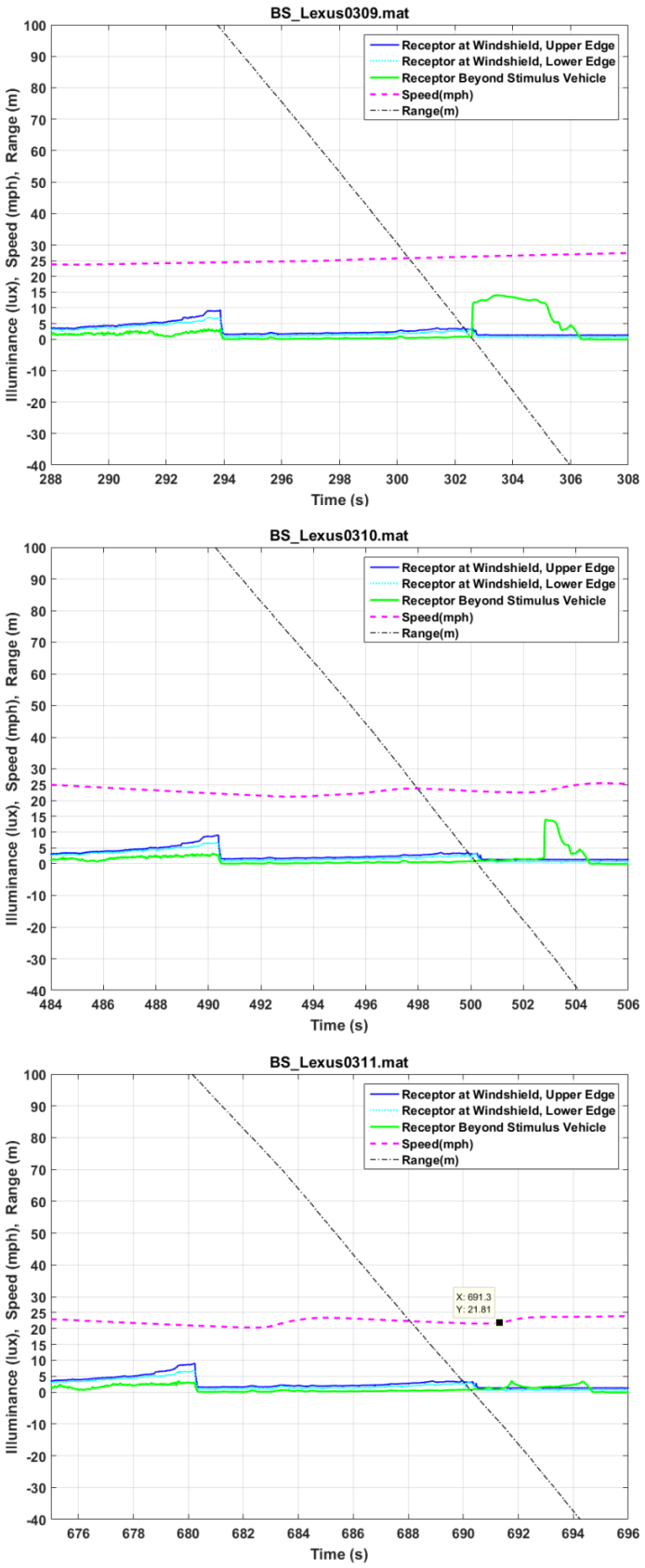

Figure 14. 2015 Lexus LS460L Oncoming Scenario Trial Set 3 Plot

Figures 15 to 17 present the objective data for the 2015 Lexus LS460L in preceding adjacent lane scenario trial sets 1 to 3, respectively.

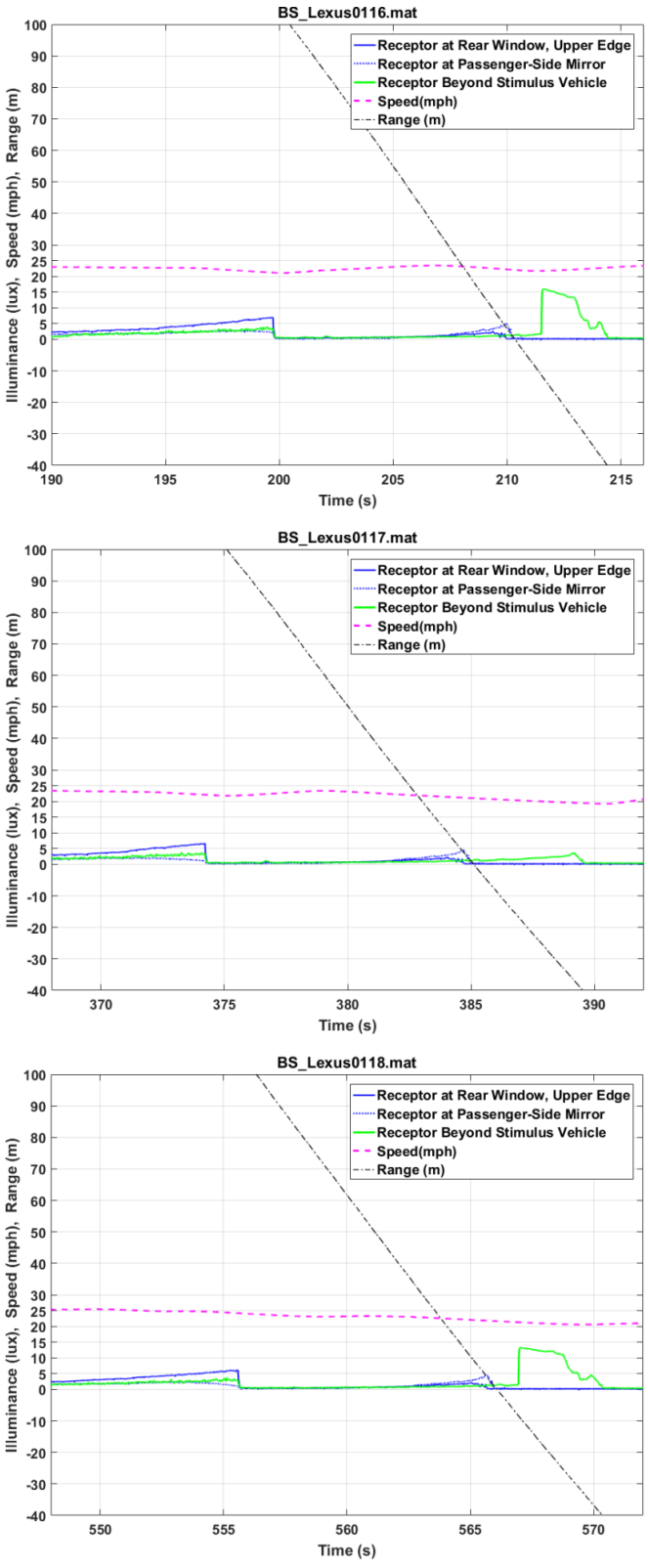

Figure 15. 2015 Lexus LS460L Preceding Adjacent Lane Scenario Trial Set 1 Plot

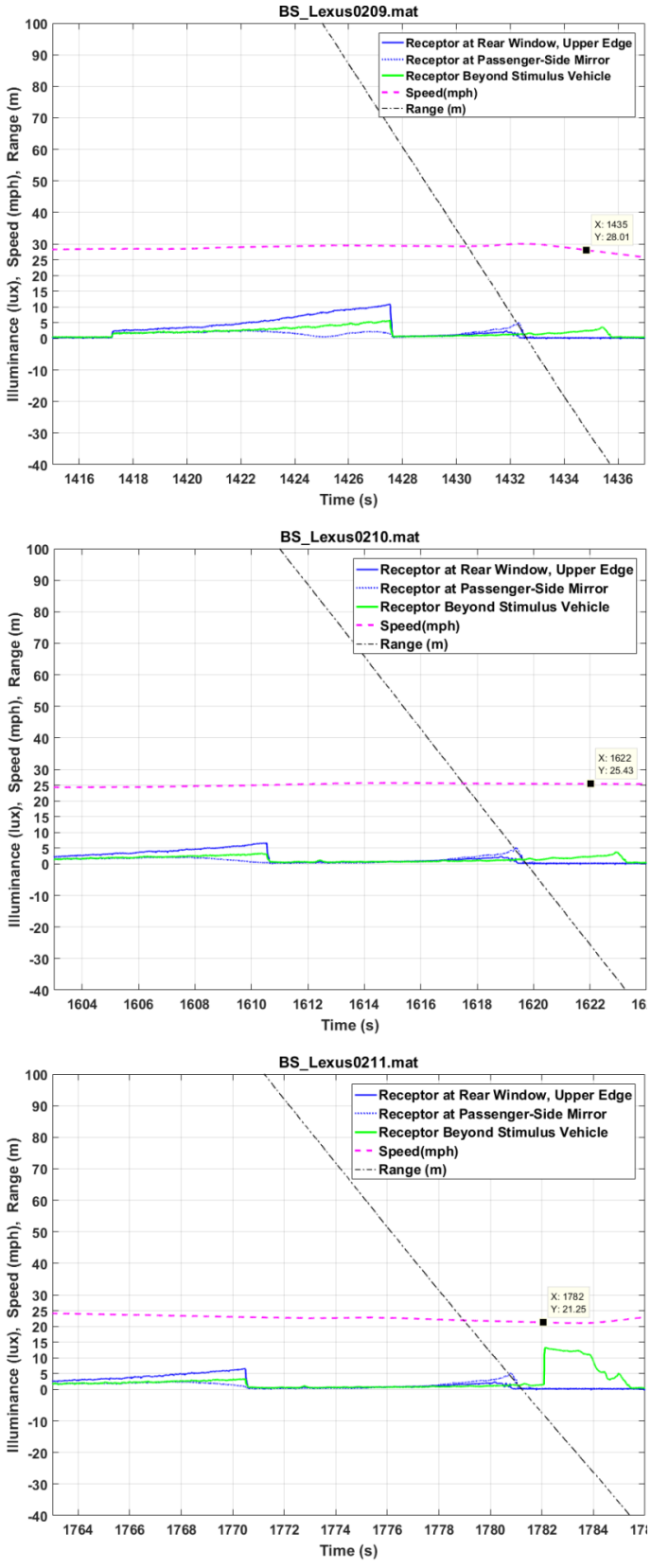

Figure 16. 2015 Lexus LS460L Preceding Adjacent Lane Scenario Trial Set 2 Plot

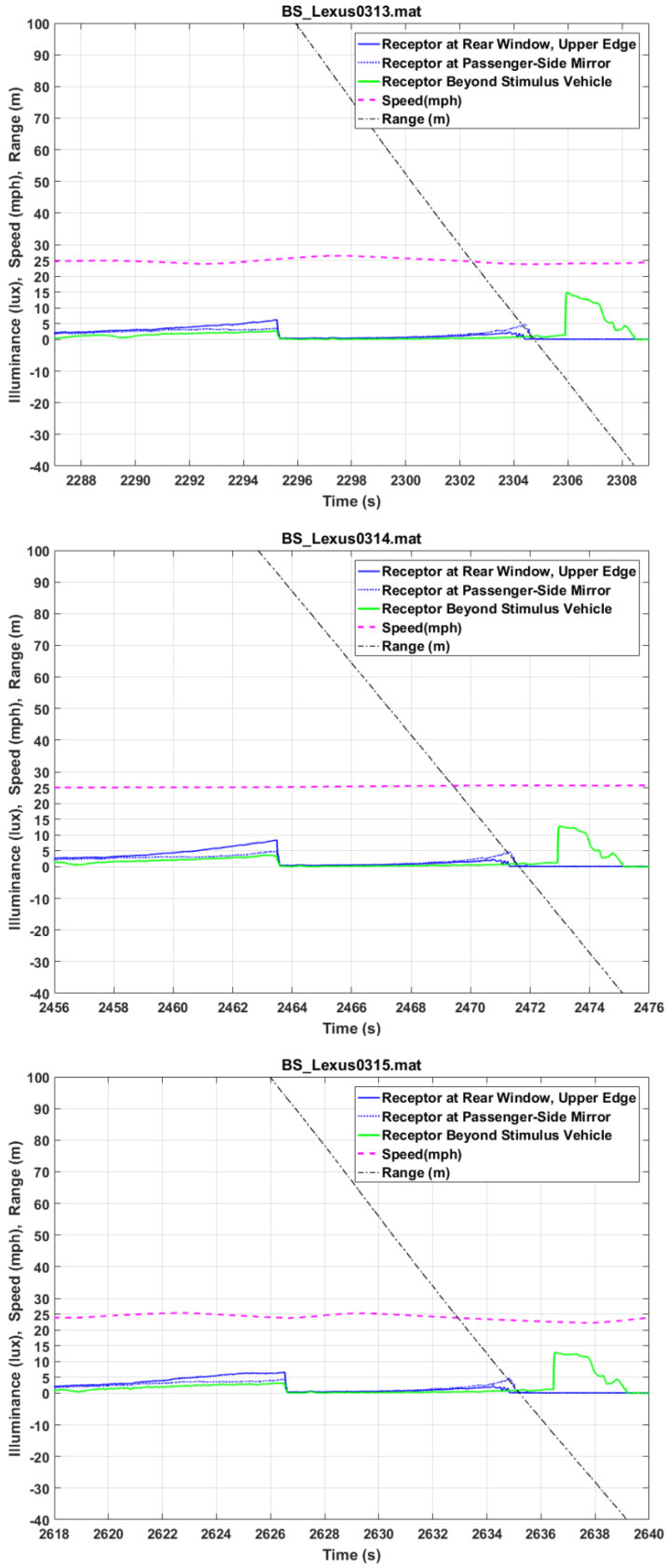

Figure 17. 2015 Lexus LS460L Preceding Adjacent Lane Scenario Trial Set 3 Plot

Figures 18 to 20 present the objective data for the 2015 Lexus LS460L in preceding same lane scenario trial sets 1 to 3, respectively.

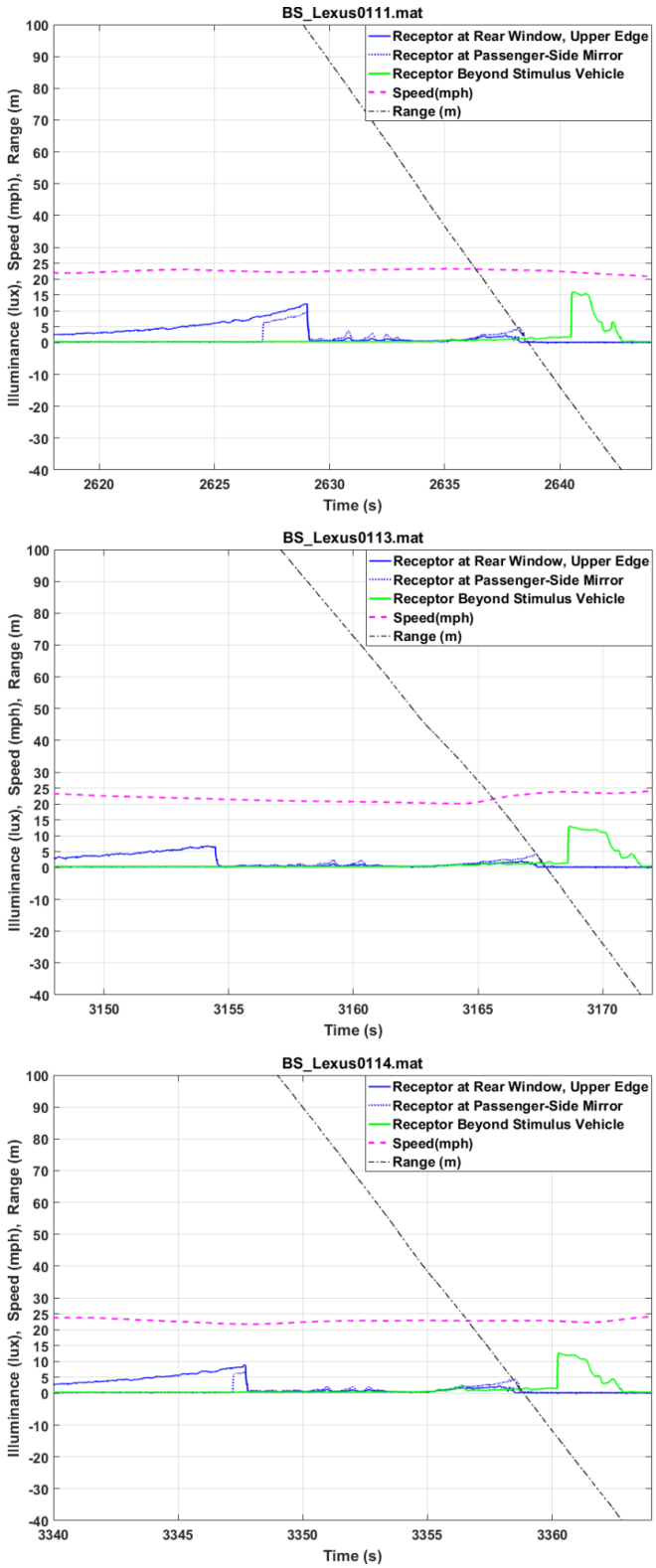

Figure 18. 2015 Lexus LS460L Preceding Same Lane Scenario Trial Set 1 Plot

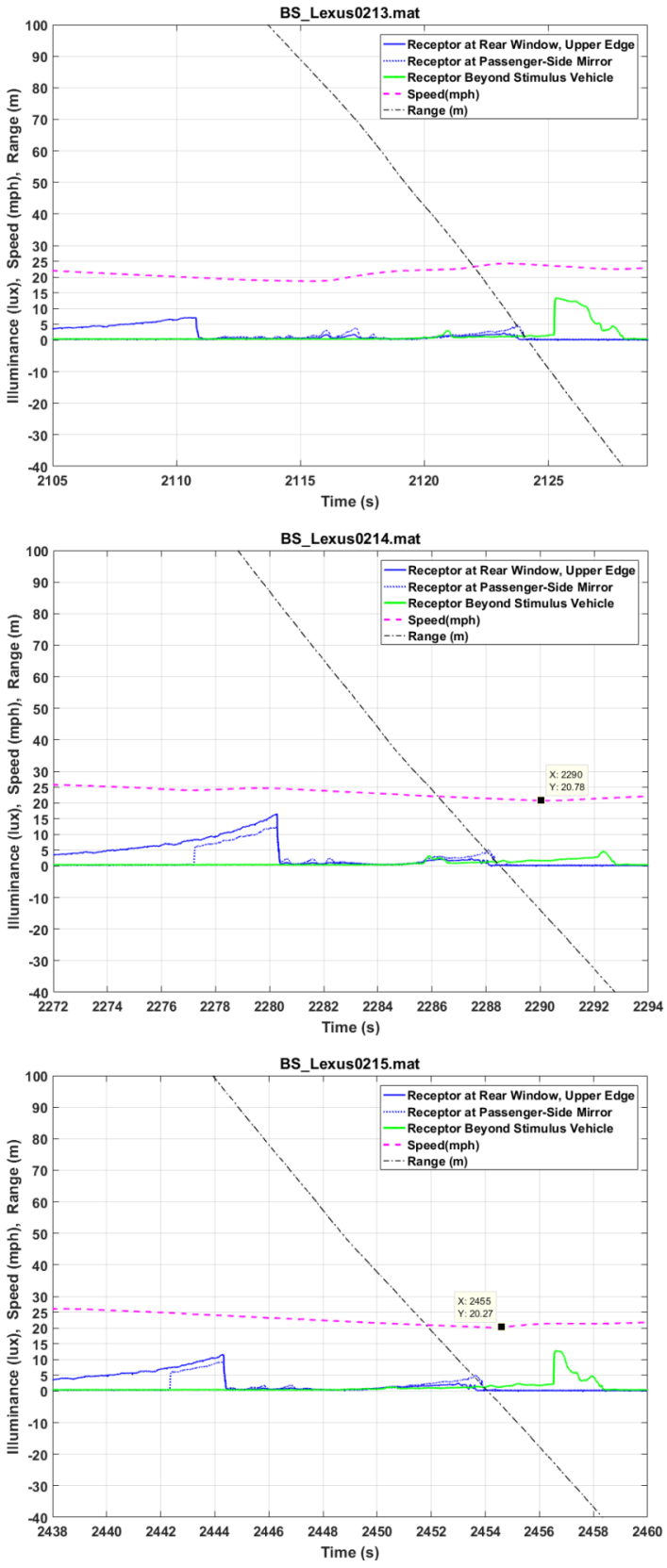

Figure 19. 2015 Lexus LS460L Preceding Same Lane Scenario Trial Set 2 Plot

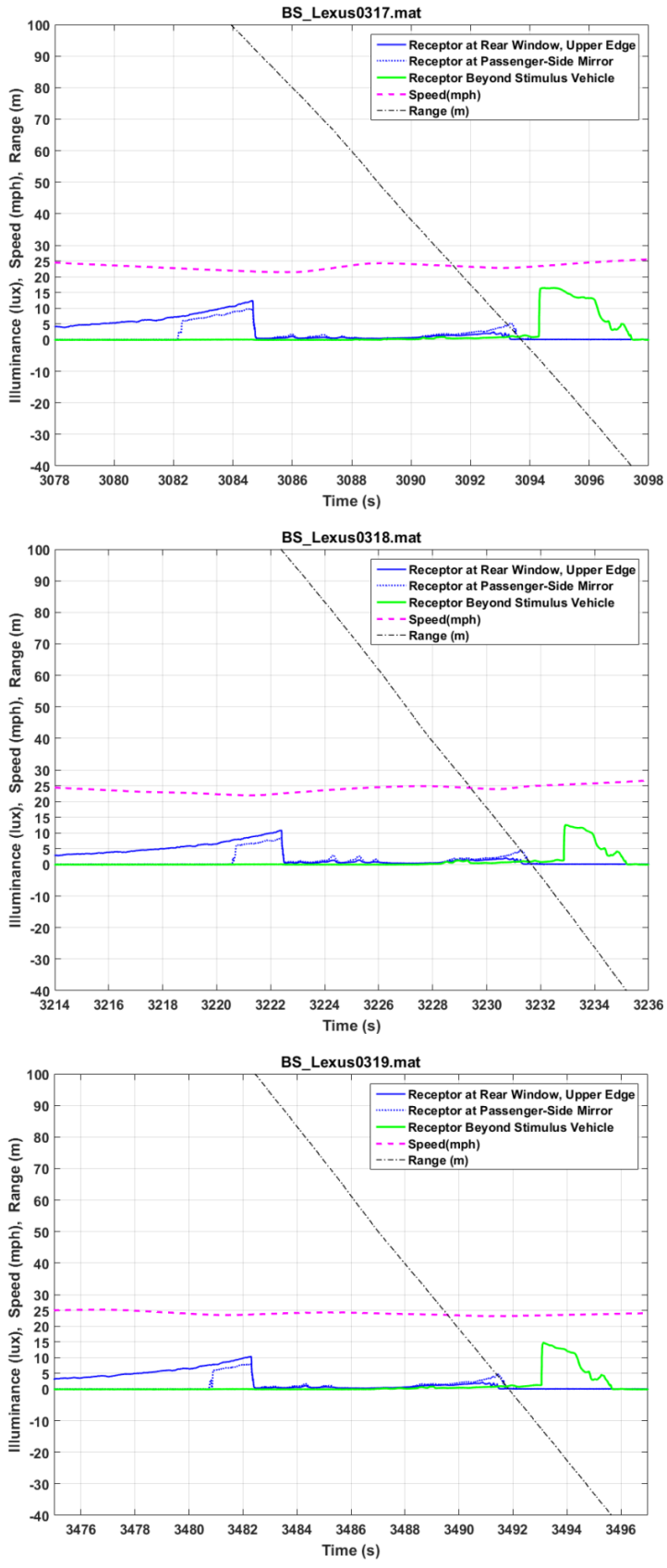

Figure 20. 2015 Lexus LS460L Preceding Same Lane Scenario Trial Set 3 Plot

3.2 2015 Mercedes-Benz C300

3.2.1 Vehicle Photos

Still, color photographs of the measured 2015 Mercedes-Benz C300 are presented in the following figures.

Figure 21. 2015 Mercedes-Benz C300 - Front

Figure 22. 2015 Mercedes-Benz C300 - Rear

Figure 23. 2015 Mercedes-Benz C300 - Four Three-Quarter Pictures

Figure 24. 2015 Mercedes-Benz C300 - Headlighting System Control

Figure 25. 2015 Mercedes-Benz C300 - Headlighting System Upper Beam Activation Control

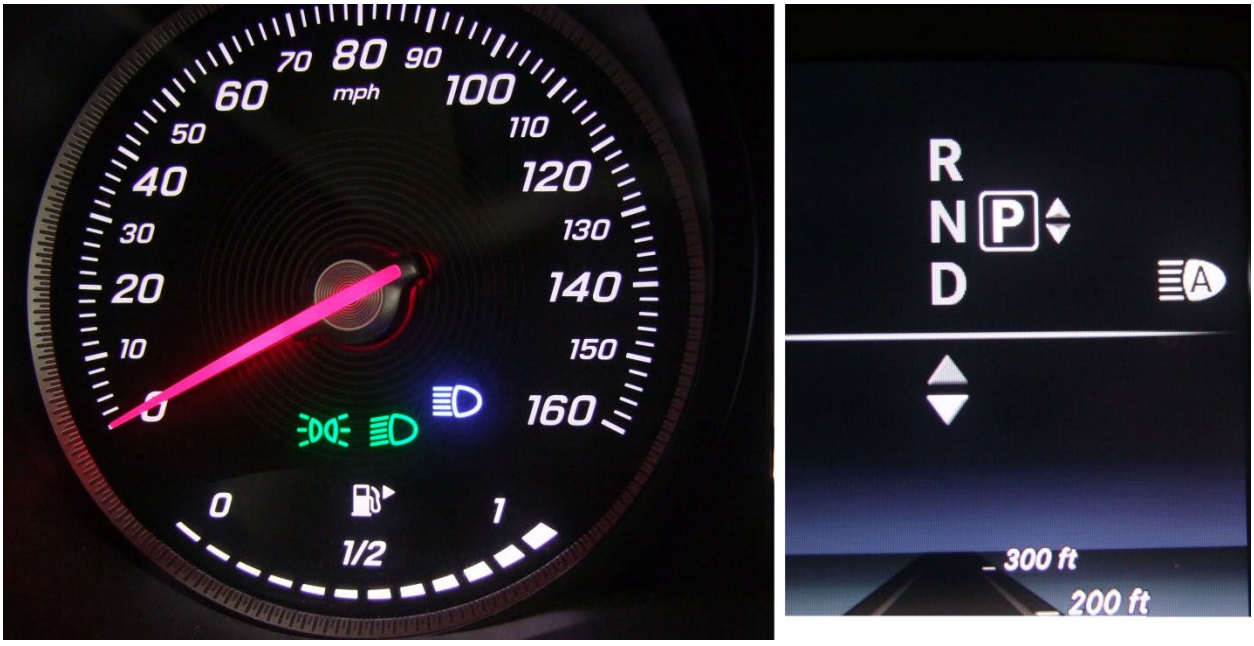

Figure 26. 2015 Mercedes-Benz C300 - Headlighting System Instrument Panel Icons

Figure 27. 2015 Mercedes-Benz C300 - Sensor for Beam Switching Control

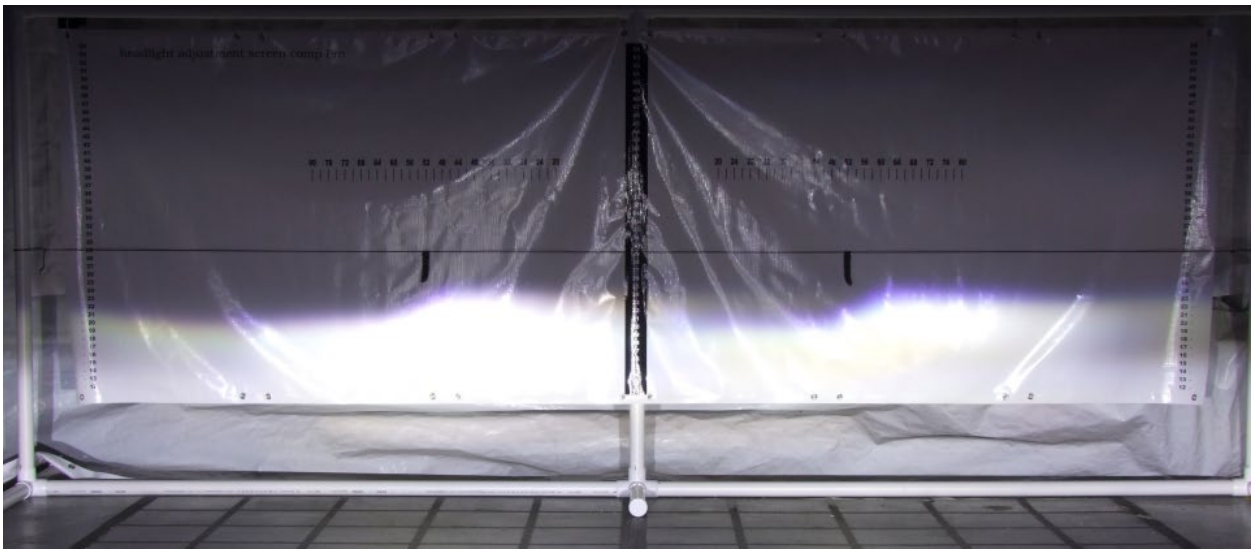

Figure 28. 2015 Mercedes-Benz C300 - Headlamp Projection Pattern (Not Aimed)

3.2.2 Results

In all attempted test trials, the 2015 Mercedes-Benz C300 was observed to engage the upper beam headlamps upon reaching the activation speed for automatic beam control and then switch to lower beam in response to the stimulus vehicle's illuminated lamps being revealed. This vehicle also successfully switched back to upper beam headlamps after passing the stimulus vehicle in 100 percent of trials.

A summary of results for the 2015 Mercedes-Benz C300 by scenario, set, and trial are provided in the following table.

Table 3. Summary of 2015 Mercedes-Benz C300 Headlamp Switching Behavior as Observed in Test Scenarios

Scenario	Set	Trial	File	Vehicle Automatically Switched Upper Beam Headlamps ('A' in Fig. 5)	Illuminance Data Show Switch From Upper to Lower Beam ('C' in Fig. 5)	Illuminance Data Show Return to Upper Beam ('G' in Fig. 5)	1 = Device Presence Confirmed * = Invalid Trial	% Confirmed for 3 Trials	% Confirmed Over All Trials
Oncoming	1	1	3	Y	Y	Y	1	100%	100%
		2	4	Y	Y	Y	1		
		3	5	Y	Y	Y	1		
	2	1	260	Y	Y	Y	1	100%	
		2	261	Y	Y	Y	1		
		3	262	Y	Y	Y	1		
	3	1	301	Y	Y	Y	1	100%	
		2	302	Y	Y	Y	1		
		3	303	Y	Y	Y	1		
Preceding Adjacent Lane	1	1	120	Y	Y	Y	1	100%	100%
		2	121	Y	Y	Y	1		
		3	122	Y	Y	Y	1		
	2	1	205	Y	Y	Y	1	100%	
		2	206	Y	Y	Y	1		
		3	207	Y	Y	Y	1		
	3	1	325	Y	Y	Y	1	100%	
		2	326	Y	Y	Y	1		
		3	327	Y	Y	Y	1		
Preceding Same Lane	1	1	124	Y	Y	Y	1	100%	100%
		2	125	Y	Y	Y	1		
		3	126	Y	Y	Y	1		
	2	1	201	Y	Y	Y	1	100%	
		2	202	Y	Y	Y	1		
		3	203	Y	Y	Y	1		
	3	1	321	Y	Y	Y	1	100%	
		2	322	Y	Y	Y	1		
		3	323	Y	Y	Y	1		

Figures 29 to 31 present the objective data for the 2015 Mercedes-Benz C300 in oncoming scenario trial sets 1 to 3, respectively.

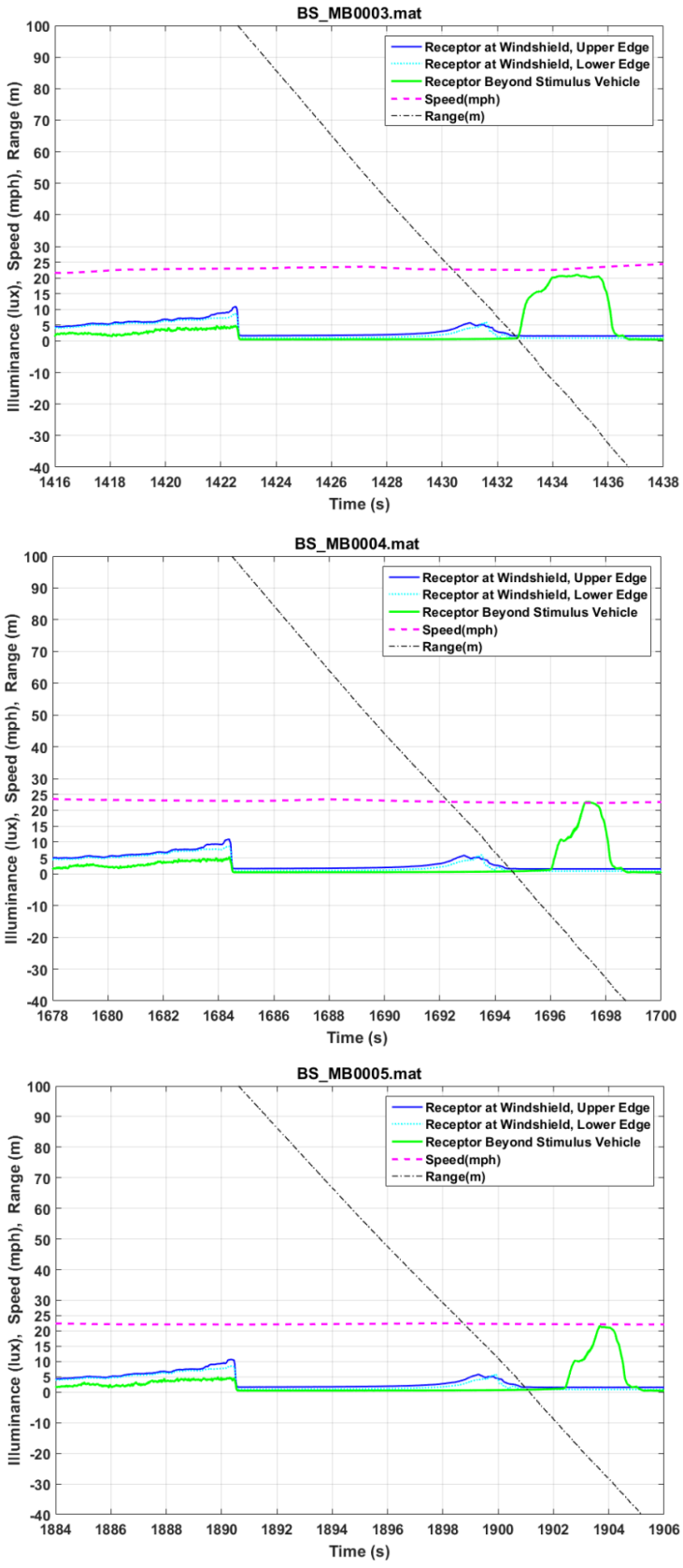

Figure 29. 2015 Mercedes-Benz C300 Oncoming Scenario Trial Set 1 Plot

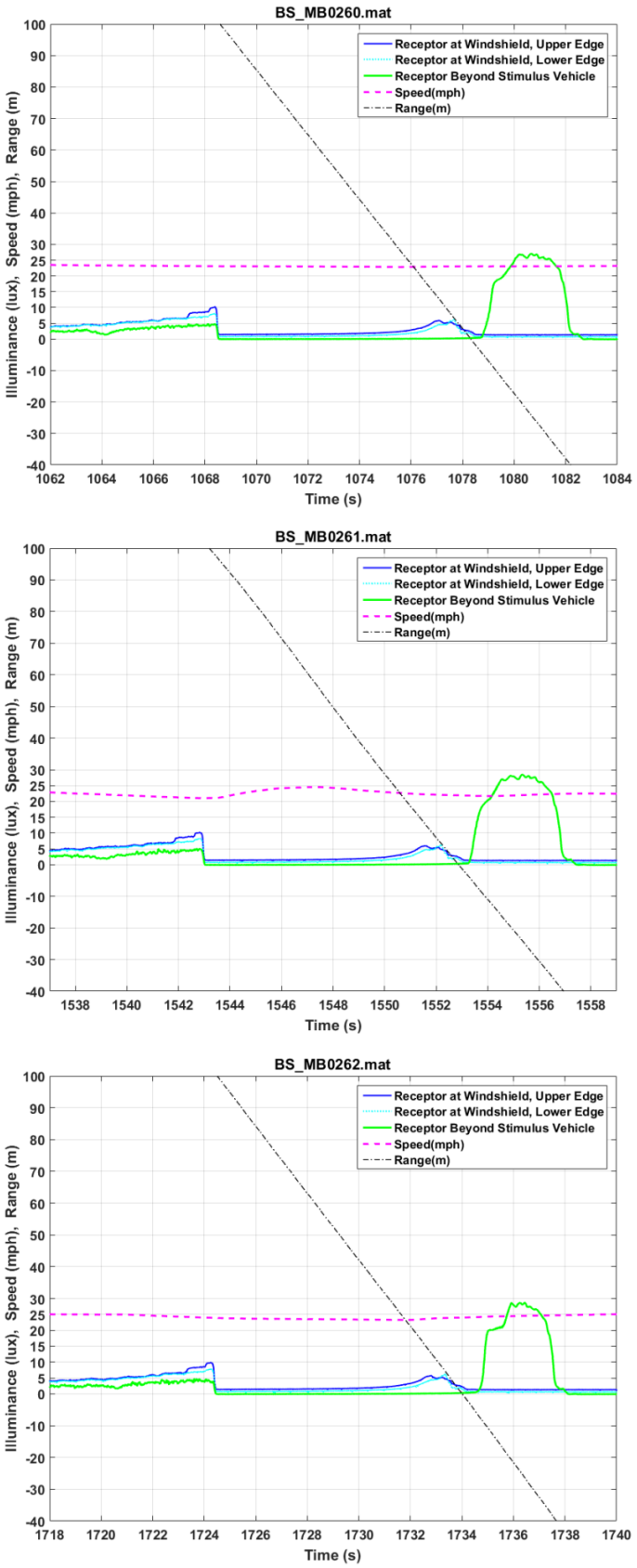

Figure 30. 2015 Mercedes-Benz C300 Oncoming Scenario Trial Set 2 Plot

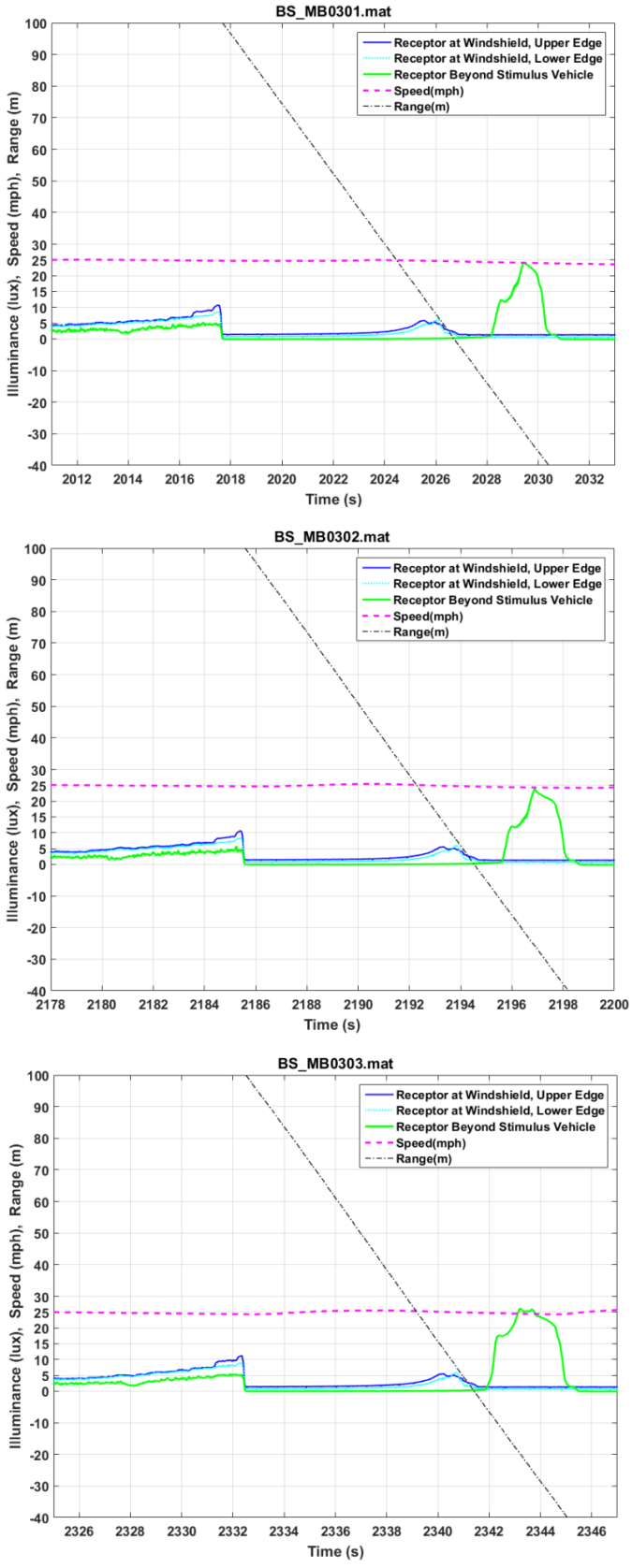

Figure 31. 2015 Mercedes-Benz C300 Oncoming Scenario Trial Set 3 Plot

Figures 32 to 34 present the objective data for the 2015 Mercedes-Benz C300 in preceding adjacent lane scenario trial sets 1 to 3, respectively.

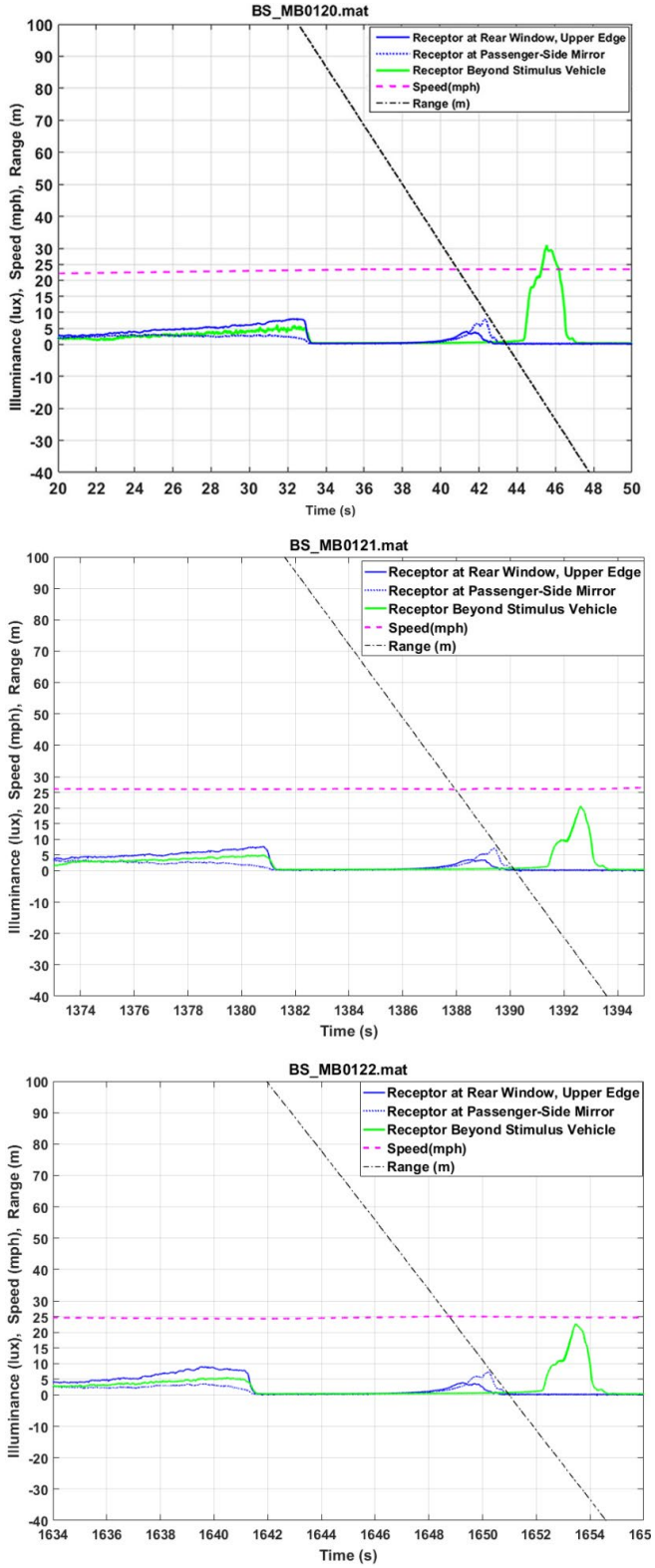

Figure 32. 2015 Mercedes-Benz C300 Preceding Adjacent Lane Scenario Trial Set 1 Plot

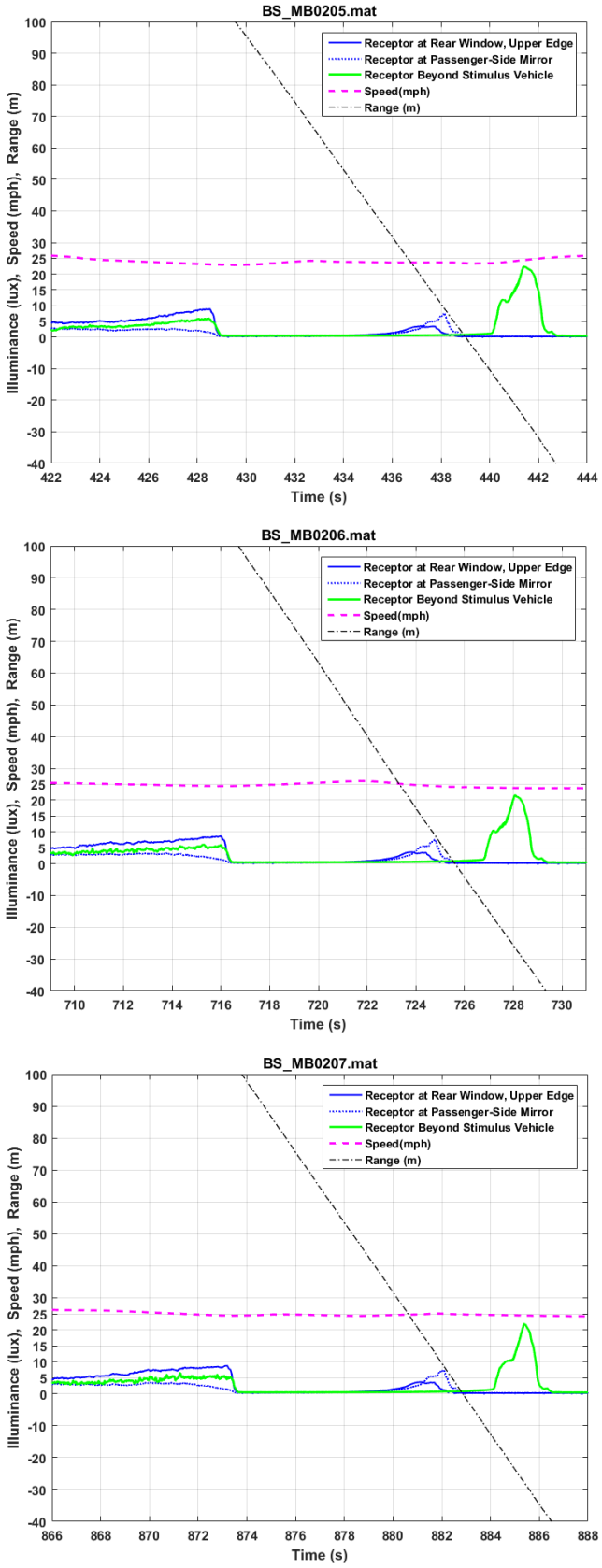

Figure 33. 2015 Mercedes-Benz C300 Preceding Adjacent Lane Scenario Trial Set 2 Plot

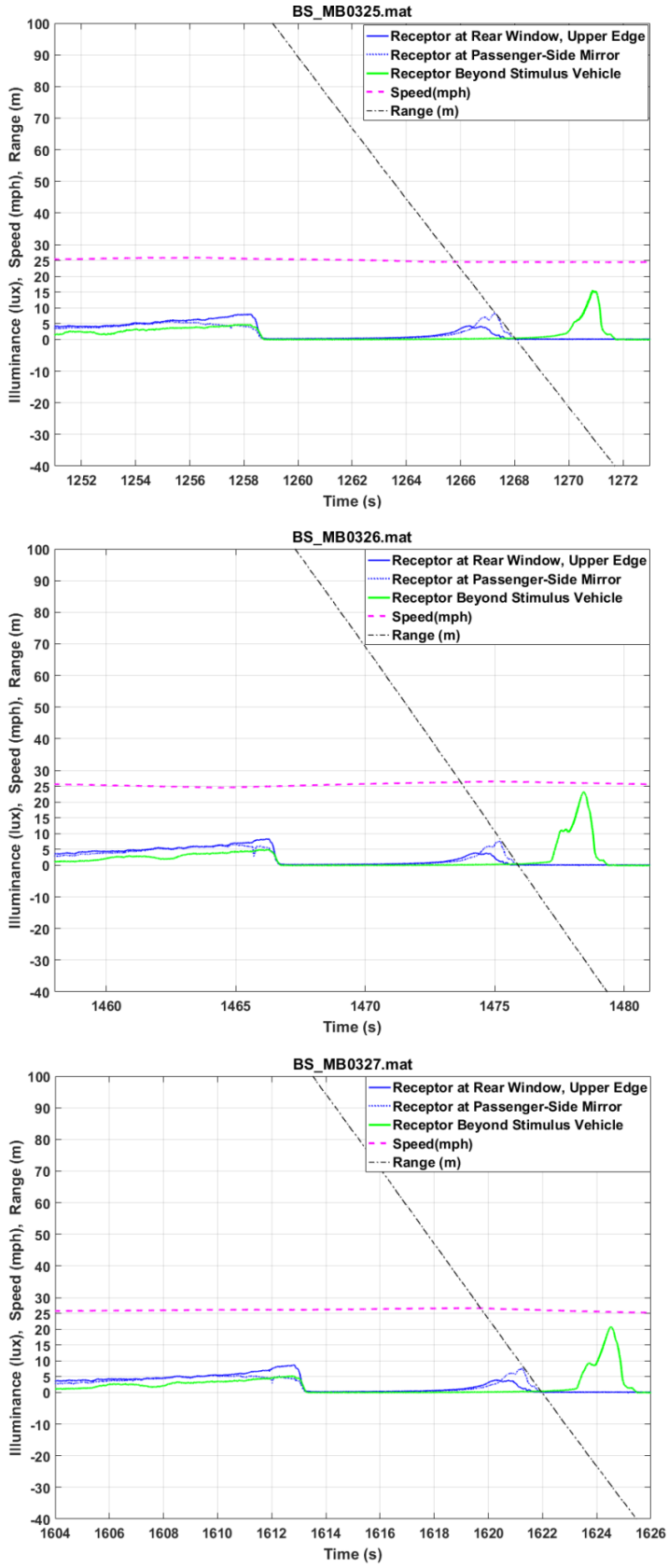

Figure 34. 2015 Mercedes-Benz C300 Preceding Adjacent Lane Scenario Trial Set 3 Plot

Figures 35 to 37 present the objective data for the 2015 Mercedes-Benz C300 in preceding same lane scenario trial sets 1 to 3, respectively.

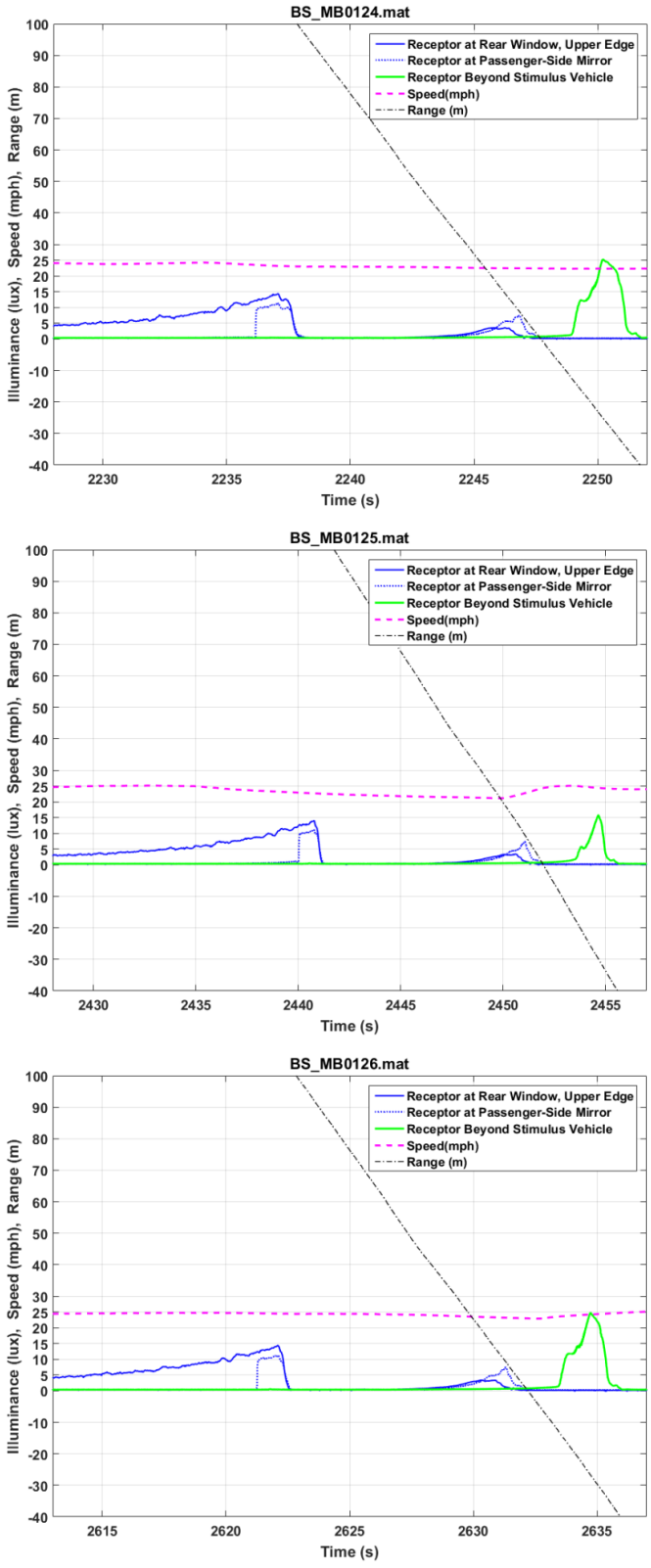

Figure 35. 2015 Mercedes-Benz C300 Preceding Same Lane Scenario Trial Set 1 Plot

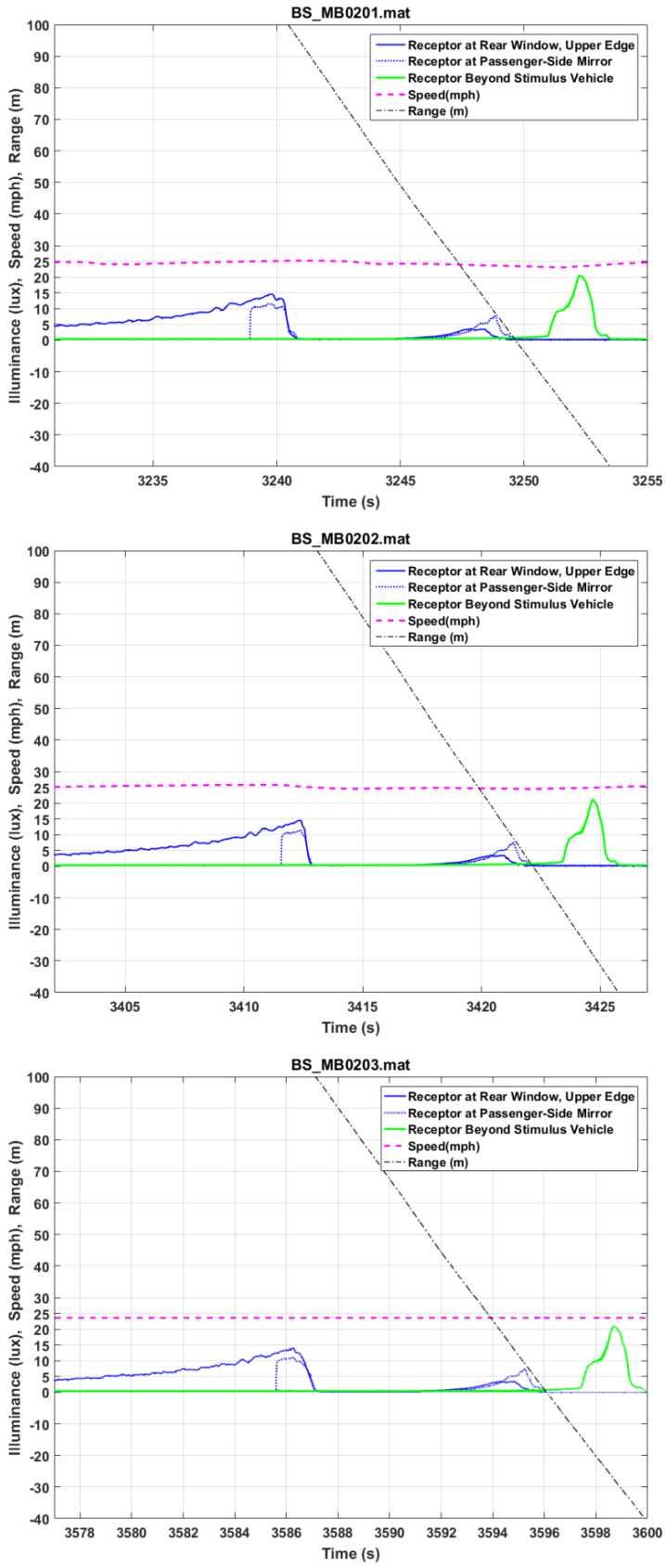

Figure 36. 2015 Mercedes-Benz C300 Preceding Same Lane Scenario Trial Set 2 Plot

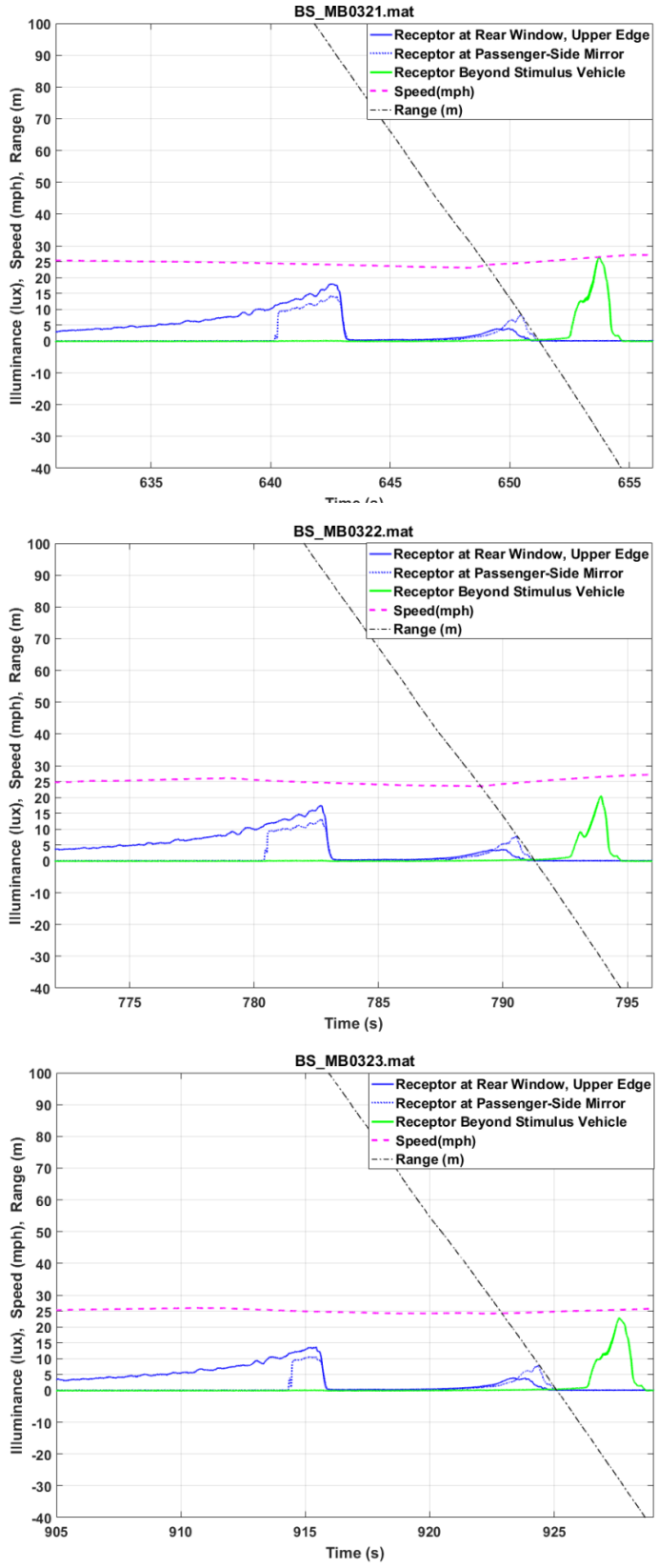

Figure 37. 2015 Mercedes-Benz C300 Preceding Same Lane Scenario Trial Set 3 Plot

3.3 2016 Volvo XC90 T6

3.3.1 Vehicle Photos

Still, color photographs of the measured 2016 Volvo XC90 T6 are presented in the following figures.

Figure 38. 2016 Volvo XC90 T6 - Front

Figure 39. 2016 Volvo XC90 T6 - Rear

Figure 40. 2016 Volvo XC90 T6 - Four Three-Quarter Pictures

Figure 41. 2016 Volvo XC90 T6 - Headlighting System Control

Figure 42. 2016 Volvo XC90 T6 - Headlighting System Instrument Panel Icons

Figure 43. 2016 Volvo XC90 T6 - Sensor for Beam Switching Control

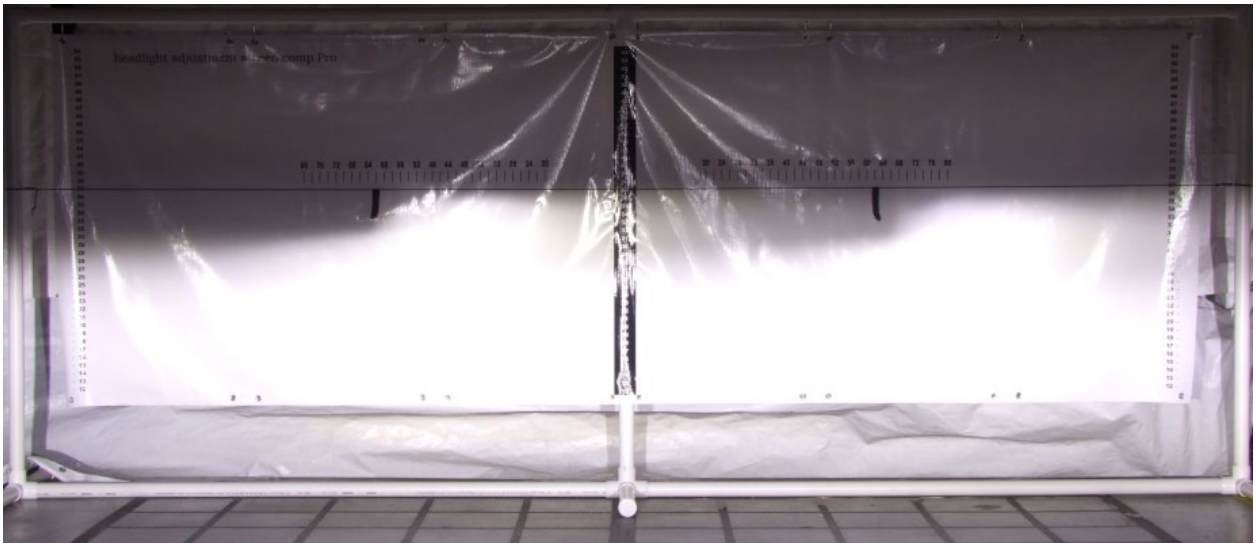

Figure 44. 2016 Volvo XC90 T6 - Headlamp Projection Pattern (Aimed)

3.3.2 Results

In all attempted test trials, the 2016 Volvo XC90 T6 was observed to engage the upper beam headlamps upon reaching the activation speed for automatic beam control and then switch to lower beam in response to the stimulus vehicle's illuminated lamps being revealed. This vehicle also successfully switched back to upper beam headlamps after passing the stimulus vehicle in 100 percent of trials.

A summary of results for the 2016 Volvo XC90 T6 by scenario, set, and trial are provided in the following table.

Table 4. Summary of 2016 Volvo XC90 T6 Headlamp Switching Behavior as Observed in Test Scenarios

Scenario	Set	Trial	File	Vehicle Automatically Switched Upper Beam Headlamps ('A' in Fig. 5)	Illuminance Data Show Switch From Upper to Lower Beam ('C' in Fig. 5)	Illuminance Data Show Return to Upper Beam ('G' in Fig. 5)	1 = Device Presence Confirmed * = Invalid Trial	% Confirmed for 3 Trials	% Confirmed Over All Trials
Oncoming	1	1	12	Y	Y	Y	1	100%	100%
		2	13	Y	Y	Y	1		
		3	14	Y	Y	Y	1		
	2	1	251	Y	Y	Y	1	100%	
		2	253	Y	Y	Y	1		
		3	254	Y	Y	Y	1		
	3	1	305	Y	Y	Y	1	100%	
		2	306	Y	Y	Y	1		
		3	307	Y	Y	Y	1		
Preceding Adjacent Lane	1	1	102	Y	Y	Y	1	100%	100%
		2	103	Y	Y	Y	1		
		3	104	Y	Y	Y	1		
	2	1	221	Y	Y	Y	1	100%	
		2	222	Y	Y	Y	1		
		3	224	Y	Y	Y	1		
	3	1	329	Y	Y	Y	1	100%	
		2	331	Y	Y	Y	1		
		3	332	Y	Y	Y	1		
Preceding Same Lane	1	1	106	Y	Y	Y	1	100%	100%
		2	107	Y	Y	Y	1		
		3	108	Y	Y	Y	1		
	2	1	217	Y	Y	Y	1	100%	
		2	218	Y	Y	Y	1		
		3	219	Y	Y	Y	1		
	3	1	334	Y	Y	Y	1	100%	
		2	335	Y	Y	Y	1		
		3	336	Y	Y	Y	1		

Figures 45 to 47 present the objective data for the 2016 Volvo XC90 T6 in oncoming scenario trial sets 1 to 3, respectively.

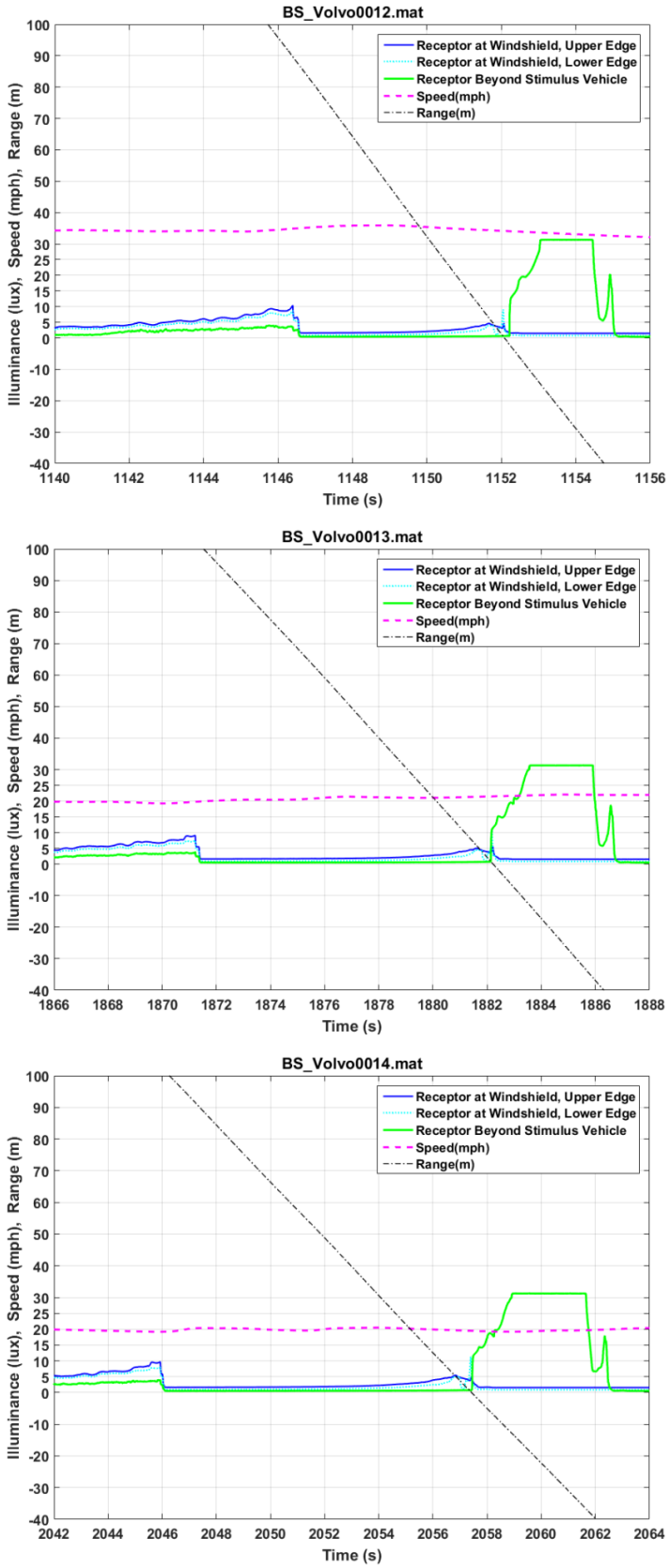

Figure 45. 2016 Volvo XC90 T6 Oncoming Scenario Trial Set 1 Plot

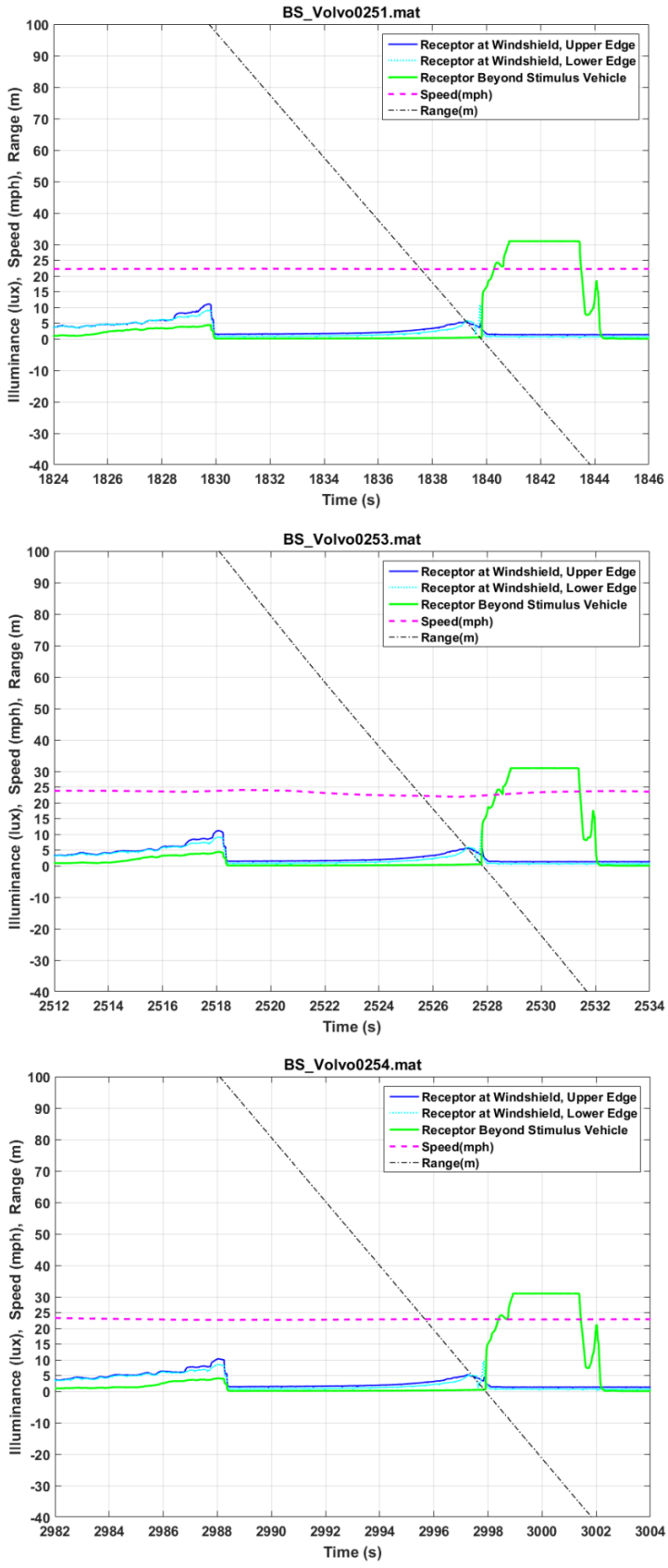

Figure 46. 2016 Volvo XC90 T6 Oncoming Scenario Trial Set 2 Plot

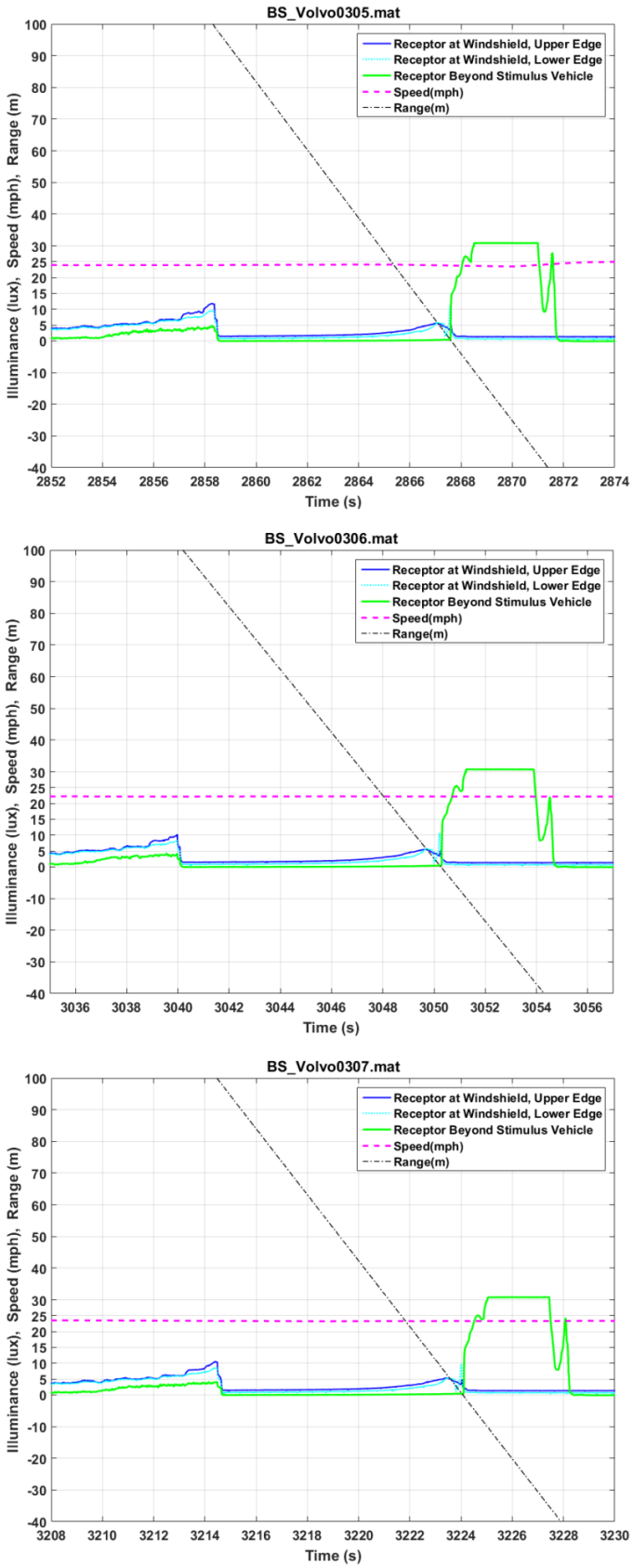

Figure 47. 2016 Volvo XC90 T6 Oncoming Scenario Trial Set 3 Plot

Figures 48 to 50 present the objective data for the 2016 Volvo XC90 T6 in preceding adjacent lane scenario trial sets 1 to 3, respectively.

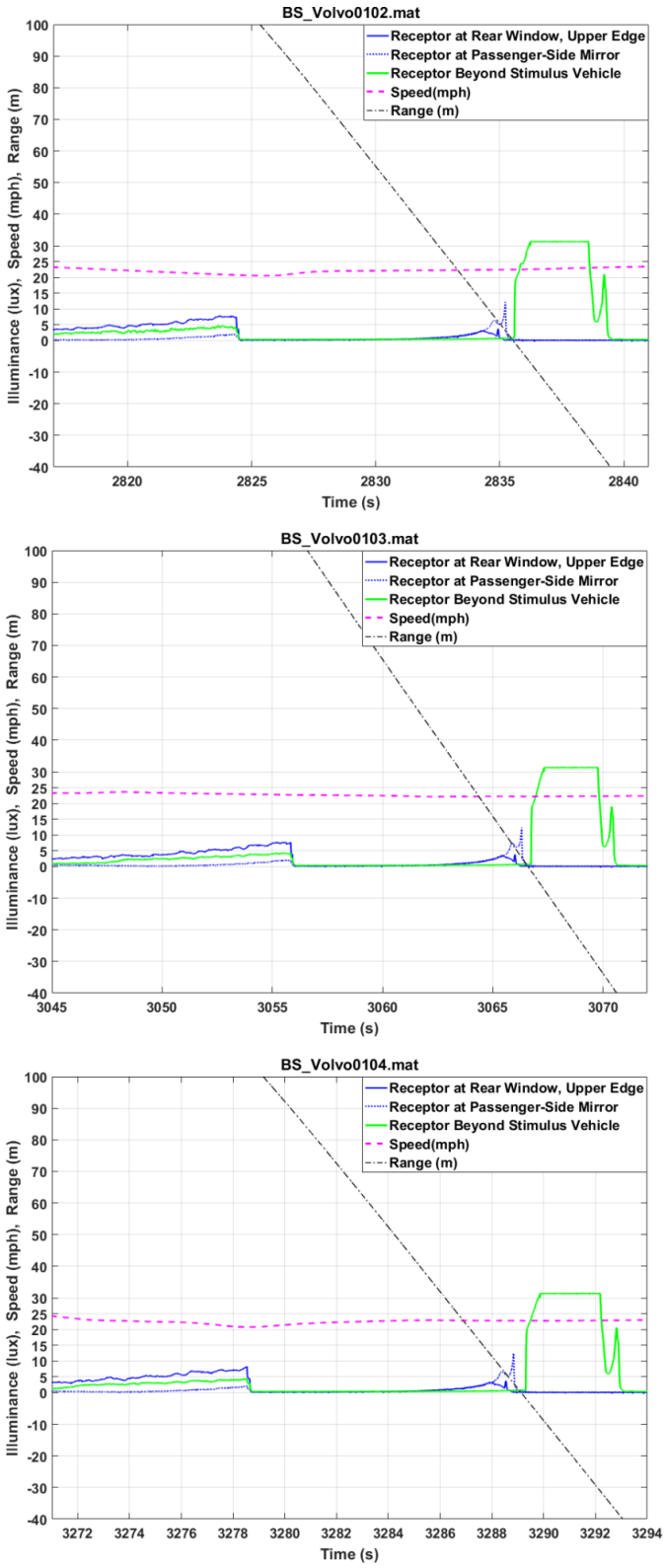

Figure 48. 2016 Volvo XC90 T6 Preceding Adjacent Lane Scenario Trial Set 1 Plot

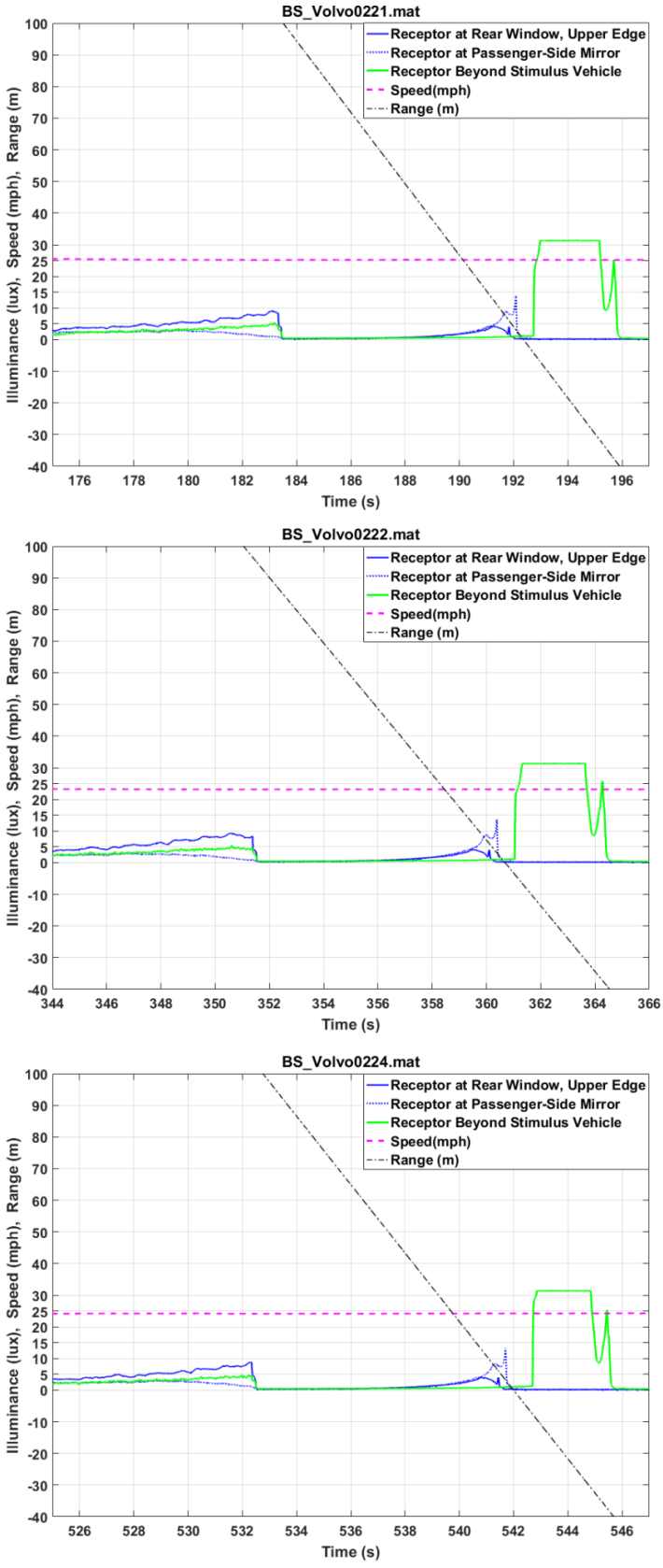

Figure 49. 2016 Volvo XC90 T6 Preceding Adjacent Lane Scenario Trial Set 2 Plot

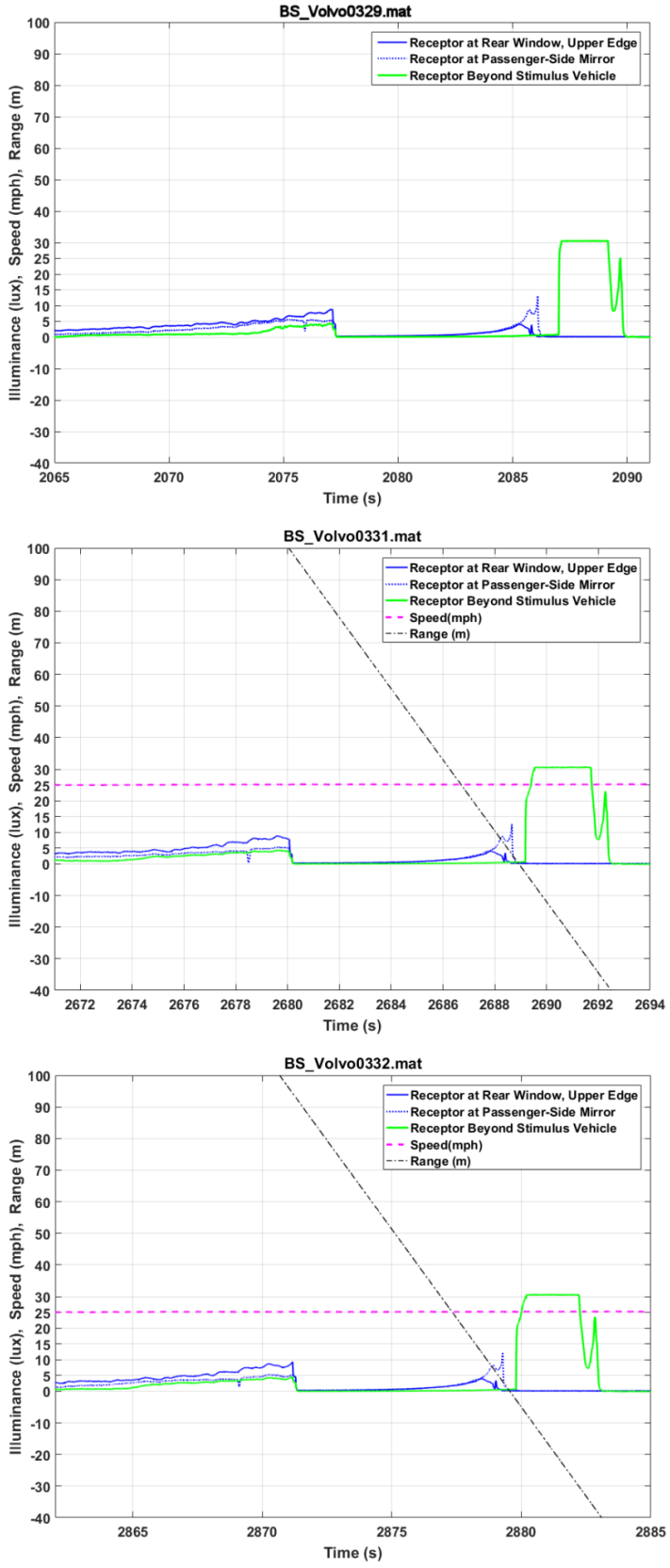

Figure 50. 2016 Volvo XC90 T6 Preceding Adjacent Lane Scenario Trial Set 3 Plot

Figures 51 to 53 present the objective data for the 2016 Volvo XC90 T6 in preceding same lane scenario trial sets 1 to 3, respectively.

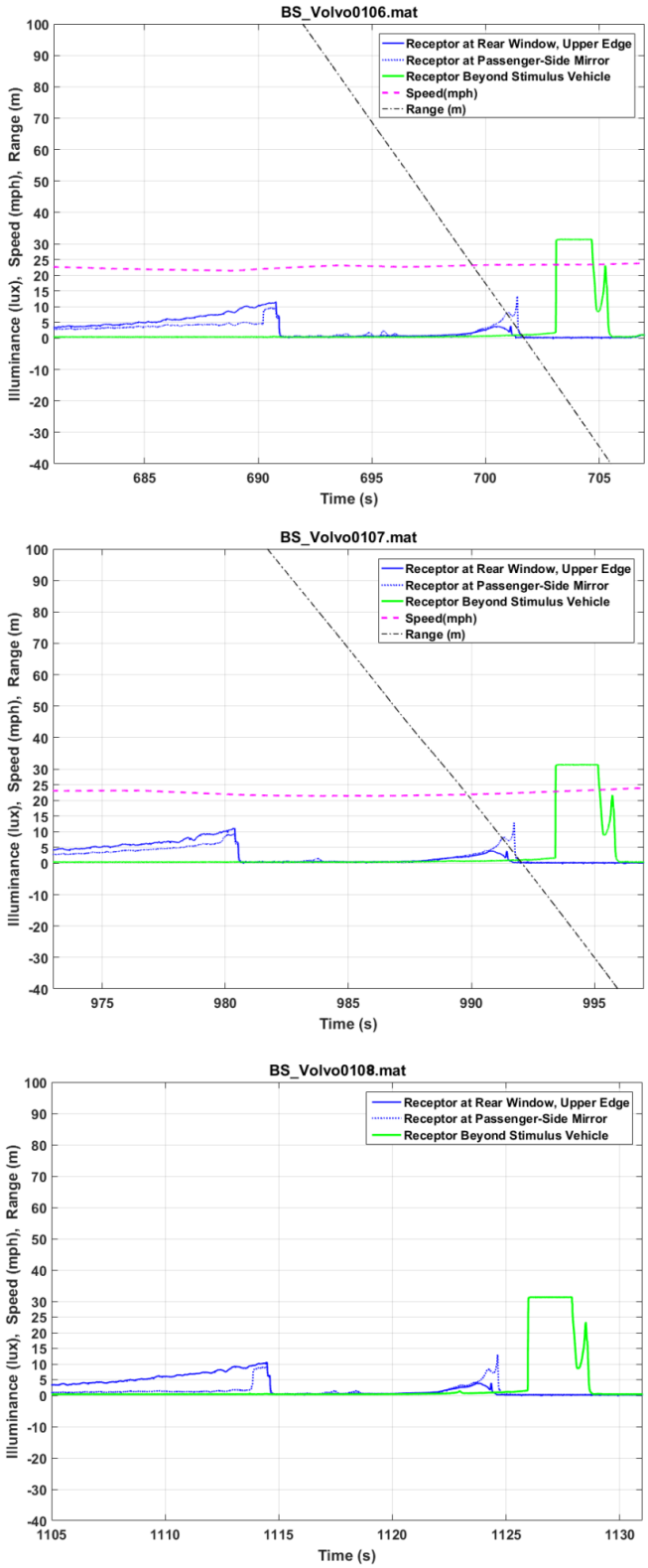

Figure 51. 2016 Volvo XC90 T6 Preceding Same Lane Scenario Trial Set 1 Plot

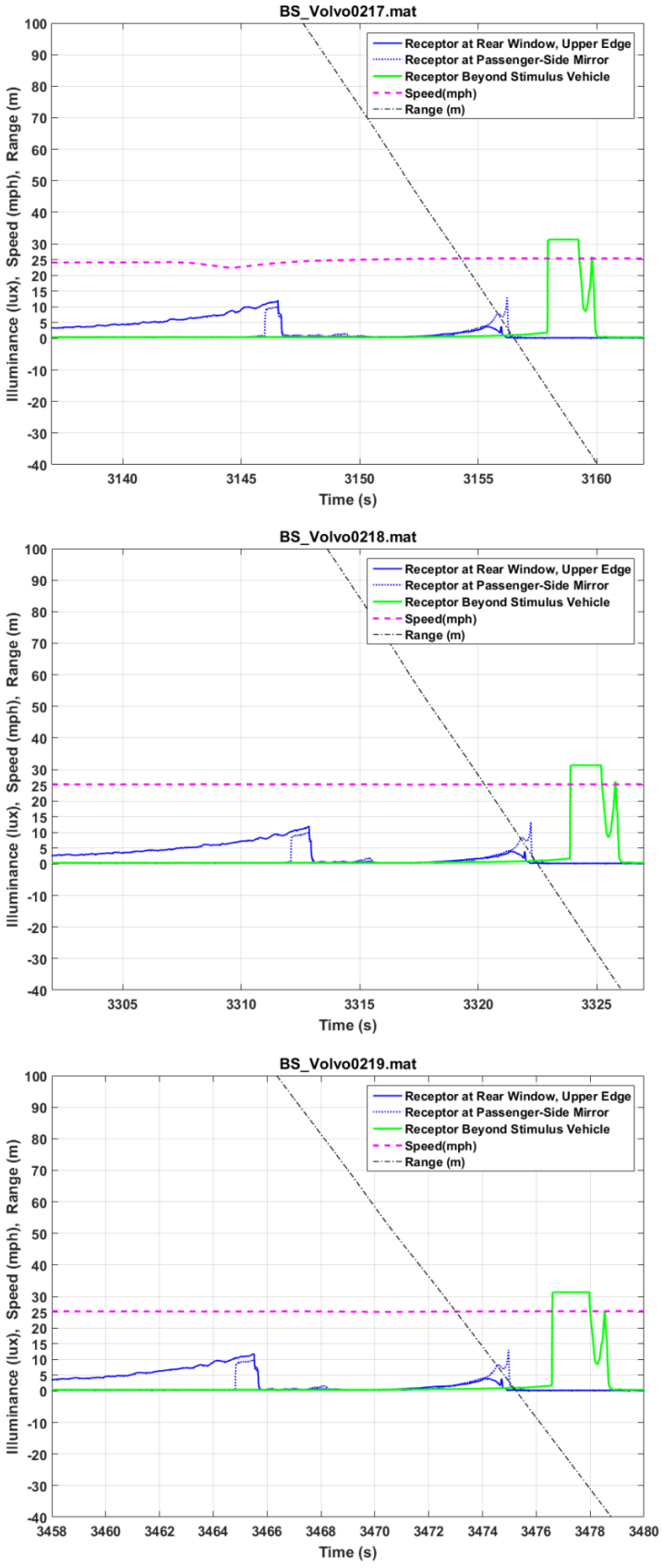

Figure 52. 2016 Volvo XC90 T6 Preceding Same Lane Scenario Trial Set 2 Plot

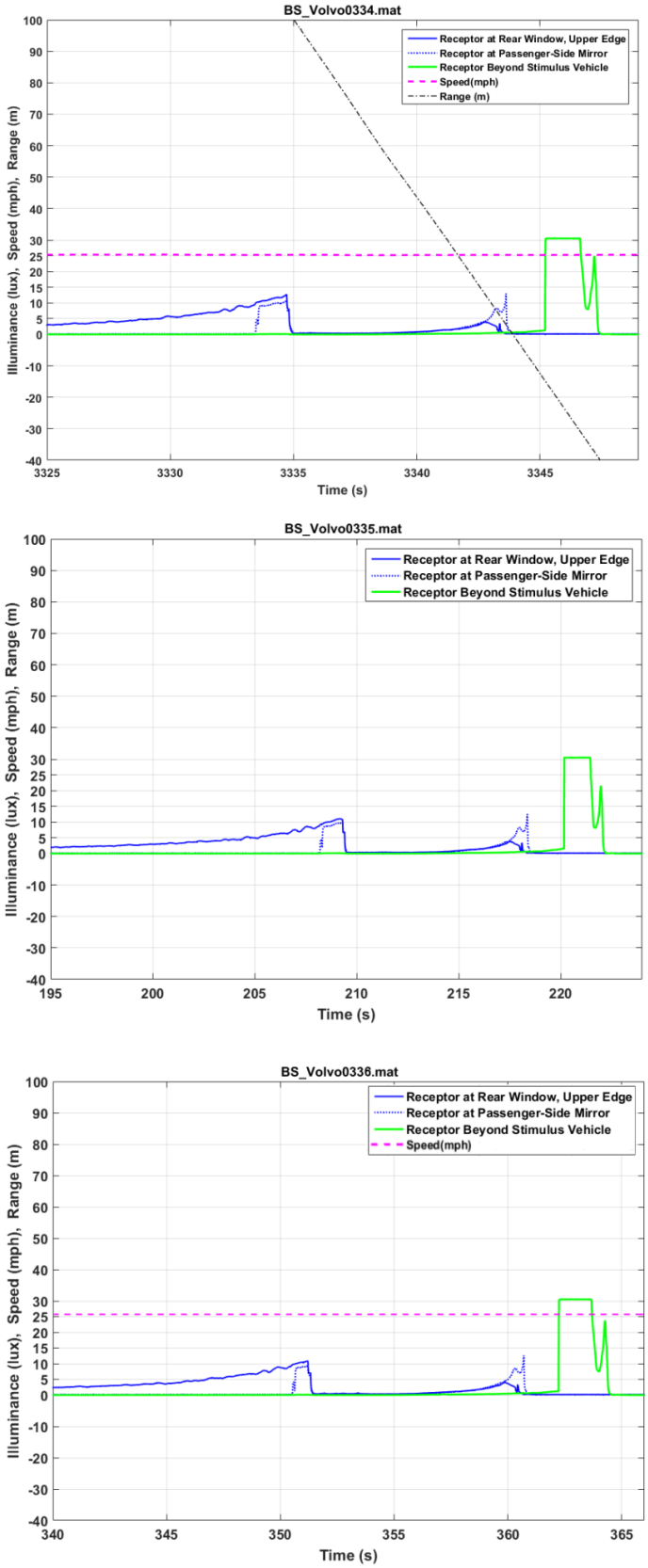

Figure 53. 2016 Volvo XC90 T6 Preceding Same Lane Scenario Trial Set 3 Plot

4.0 DISCUSSION

4.1 Draft Test Procedures

This effort identified minor but helpful revisions to the draft test procedure. While not specified in the test procedure, instrumentation and objective measures implemented in this test effort provided a means to illustrate and quantitatively document semiautomatic beam switching performance. The availability of illuminance and distance data allowed for data to be plotted providing visual quantitative evidence of test outcomes, as opposed to subjective, text-based "pass/fail" indications. The data system provided test vehicle travel speed, the distance between the test and stimulus vehicles, illuminance levels at and beyond the stimulus vehicle, and video data. Speed data allowed for confirmation of whether the test vehicle was being driven at sufficient speed for semiautomatic beam switching to occur. In a few cases, speed data revealed that manual speed control issues likely led to a vehicle's system not returning to upper beam after passing the stimulus vehicle. As a result, the authors recommend that cruise control or other speed control methods be used to help ensure the test vehicle is operated consistently at sufficient speed for semiautomatic beam switching to occur.

It is also suggested that the test procedure specify a minimum travel speed that is somewhat above the minimum activation speed for semiautomatic beam switching for a particular vehicle. This would help to ensure that conditions for semiautomatic beam switching to occur are consistently met and decrease the likelihood that a test trial would need to be repeated.

Lastly, increasing the distance between the stimulus vehicle and the video camera beyond it would help to ensure that the device's return to upper beam would be captured by the camera data. The position of the camera beyond the stimulus vehicle is not critical as long as it is far enough past the stimulus vehicle that it can capture the return to upper beam. A longer distance should be less necessary in cases where the test vehicle speed is controlled automatically as recommended above.

4.2 Performance of Systems Tested

Three late-model vehicles were subjected to multiple repetitions of the oncoming and preceding test scenarios. Two of the three tested vehicles met performance requirements in all conducted test trials. A third vehicle was observed to consistently engage the upper beam headlamps and then switch to lower beam in response to the stimulus vehicle's illuminated lamps. However, in some cases this vehicle did not successfully switch back to upper beam headlamps after passing the stimulus vehicle. Specifically, failure to return to upper beam was observed in 1 of 8 (12%) oncoming trials and 2 of 8 (25%) adjacent-lane preceding trials for that vehicle. In three other trials for that same vehicle, data review revealed that the test vehicle travel speed dropped below the stated minimum speed for semiautomatic beam switching operation. These trials were not removed from the analysis but were not replaced because the speed issue was not identified until after all testing was completed.

Overall, the testing demonstrated that repeatability is achievable both for the test procedure and semiautomatic beam switching operation.

5.0 SUMMARY

This report summarizes an effort to evaluate a draft test procedure for semiautomatic headlamp beam switching device confirmation. For the presence of a semiautomatic headlamp beam switching device to be confirmed, the vehicle had to be observed automatically engaging the upper beam headlamps upon reaching the system activation travel speed, then switching to lower beam after the stimulus vehicle's lamps were revealed, and finally returning to upper beam after passing the stimulus vehicle.

Three late-model vehicles were subjected to multiple repetitions of the oncoming and preceding test scenarios. Two of the three tested vehicles met performance requirements in all conducted test trials. A third vehicle was observed to consistently engage the upper beam headlamps and then switch to lower beam in response to the stimulus vehicle's illuminated lamps, but in a few cases failed to switch back to upper beam headlamps after passing the stimulus vehicle. Overall, the semiautomatic beam switching performance observed in this testing demonstrated that consistent and appropriate switching performance is achievable.

Minor suggested improvements to the draft test procedure were identified that included specifying a minimum travel speed that is somewhat above the minimum activation speed, which would help to ensure that conditions for semiautomatic beam switching are consistently met. The use of cruise control to maintain the test vehicle's travel speed safely above the minimum speed for semiautomatic beam switching is also recommended. In addition, increasing the distance between the stimulus vehicle and the video camera beyond it would help to ensure that the device's return to upper beam would be captured by the camera data. Objective measures were also implemented in this effort that provided a means to illustrate and quantitatively document the device performance. Overall, the testing demonstrated that repeatability is achievable for this test.

6.0 REFERENCES

1. 49 CFR Sec. 571.108, Standard No. 108; Lamps, reflective devices, and associated equipment.

2. Transportation Research Center Skid Pad information, http://www.trcpg.com/facility-tour/skid-pad.aspx

Appendix A. Conceal/Reveal Mechanism Design Information

A system was designed to conceal the stimulus vehicle's illuminated headlamps or taillamps until the approaching test vehicle triggered the mechanism to reveal the stimulus vehicle's illuminated lamps.

Components included two blackout curtains attached to a length of PVC pipe that served as a curtain rod. Having two curtains rather than one very wide curtain allowed for a space in the middle to accommodate air flow through the vehicle's grill. The curtain rod was curved at each end to allow it to wrap around the corners of the stimulus vehicle to ensure that its lamps were fully concealed. The curtain rod had a steel disk attached to each end to allow the rod to be suspended using tripod-mounted electromagnets. The disks were attached with eye bolts. Foam was used around the disks to prevent damage to the vehicle when the curtain dropped. The electromagnets were wired to a relay and an 8-foot long ribbon/tape switch designed for vehicle sensing. The tape switch was positioned in the test vehicle's lane of travel and 375 feet away (longitudinally) from the stimulus vehicle. Activation of the ribbon switch caused the relay to open, which cut power to the electromagnets causing the curtain to drop. Power was provided by a vehicle "Jump Starter and Portable Power Unit." A toggle switch was used to reset the system after each completed test trial.

The following table summarizes the components of the system.

Table 5. Conceal/Reveal System Parts List and Function Description

Item/Part	Function	Quantity	Manufacturer	Model number	Size
Blackout curtains	Conceal illuminated headlights or taillamps	2	Ellery Homestyles	Eclipse Fresno Blackout Window Curtain Panel	52 in. x 95 in., Black
8Ft PVC pipe	Curtain rod	1	N/A	N/A	1.5 in. inner diameter
45-degree PVC elbows	Curtain rod	2	N/A	N/A	1.5 in. inner diameter
PVC end caps	Curtain rod	2	N/A	N/A	1.5 in. inner diameter
Steel disks with attachment tab	Attach curtain to electromagnet	2	N/A	N/A	2.2 in. diameter 0.95 in. height
12v 22lb electromagnet	Hold curtain until reveal is triggered	2	Uxcell	XRN-XP30x22	
Adjustable head	Adjust curtain position	2	Manfrotto	808RC4	
Tripod with quick-detach camera mounts	Hold electromagnets in place	2	Manfrotto	055XPROB	
Jump Starter and Portable Power Unit	Power supply	1	Schumacher	PSJ-3612	12 V 3600 Amp
Ribbon switch	Trigger release	1	Tapeswitch.com	171-IS	8 ft. length
Relay	Switch power to electromagnets	1	Magnadyne	AIA984H-12VDC	
Toggle switch	Reset relay	1	N/A		

The following figures are photos of the conceal/reveal mechanism. The tripod height was adjusted to ensure that the stimulus vehicle's lamps were fully concealed prior to the triggered reveal.

Figure 54. Conceal/Reveal Mechanism

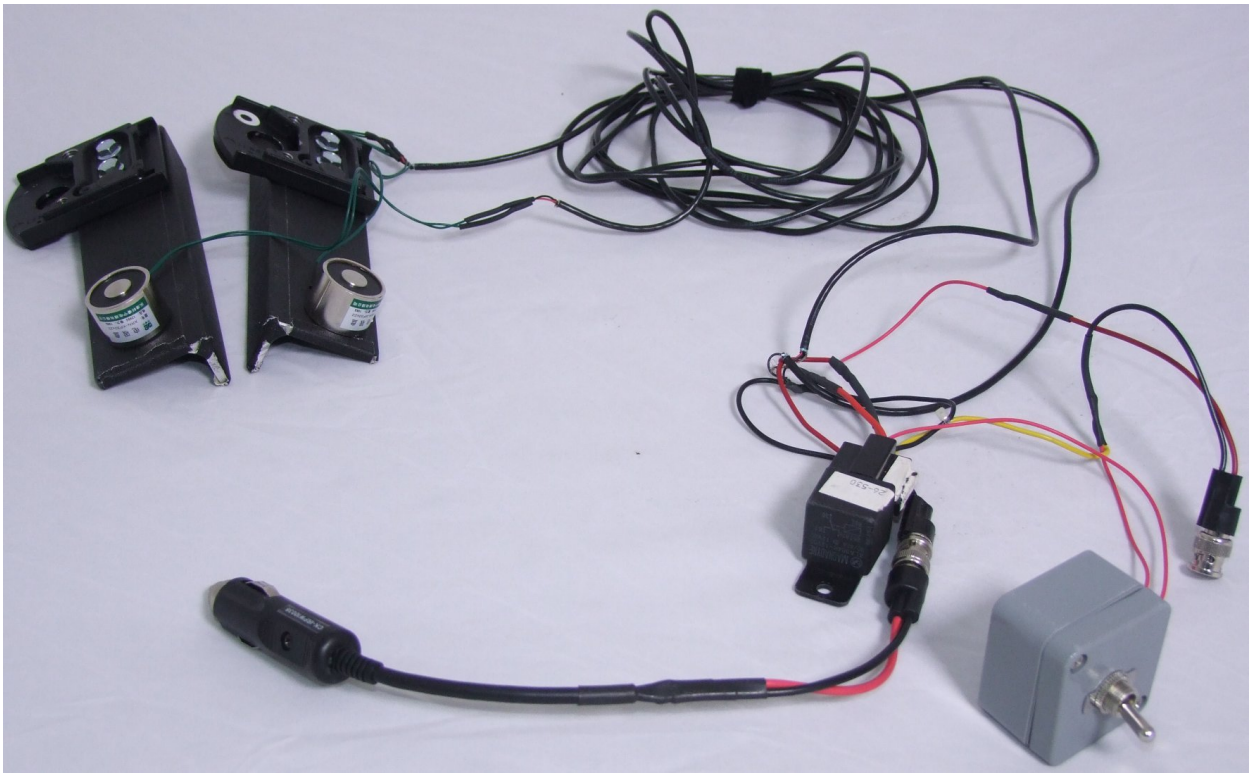

Figure 55. Conceal/Reveal System Electrical Components

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