ALLIANCE
FOR AUTOMOTIVE
INNOVATION

SUBMITTED ELECTRONICALLY VIA REGULATIONS.GOV

Mr. James Owens
Deputy Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue S.E., West Building Washington D.C. 20590-0001

July 31, 2020

Re: NHTSA Notice of Proposed Rulemaking to Amend FMVSS No. 108 to Permit Adaptive Driving Beams, NHTSA Docket No. 2018-0090, 83 Fed. Reg. 51766 (October 12, 2018)

Dear Mr. Owens:

The Alliance for Automotive Innovation ("Auto Innovators") appreciates this opportunity to provide supplemental comments to the National Highway Traffic Safety Administration's ("NHTSA" or "Agency") notice of proposed rulemaking ("NPRM") for Federal Motor Vehicle Safety Standard ("FMVSS") 108, Lamps, Reflective Devices, and Associated Equipment, to permit the certification of Adaptive Driving Beam ("ADB") headlighting systems. Auto Innovators is the leading advocacy group for the auto industry, representing 37 innovative manufacturers and value chain partners who together produce nearly 99 percent of all light-duty vehicles sold in the United States.[1] The newly established organization, in part, a combination of the Association of Global Automakers and the Alliance of Automobile Manufacturers, is directly involved in regulatory and policy matters impacting the light-duty vehicle market across the country. Members include motor vehicle manufacturers, original equipment suppliers, technology and other automotive-related companies and trade associations.

Prior to the newly established organization, the Alliance of Automobile Manufacturers, in its December 2018 submission to the Agency, expressed intent to conduct testing to thoroughly assess the proposal's feasibility, and to inform future supplemental comments. Auto Innovators believed that simulating NHTSA's dynamic test procedure would provide information and data needed to competently address certain technical areas in the NPRM, and demonstrate concerns outlined in our previous comments. The test protocol, outlined in more detail below, was completed in late 2019. While our comments do not address NHTSA's proposed equipment-level laboratory testing requirements, we request that, should NHTSA conduct compliance testing, allowance be made for the contracted test laboratory to conduct

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[1] The members of Auto Innovators include (alphabetically) Aptiv PLC, Aston Martin, Robert Bosch LLC, BMW Group, Byton, Cruise LLC, DENSO, Fiat Chrysler Automobiles, Ferrari S.p.A., Ford Motor Company, General Motors Company, Harman International, Honda Motor Company, Hyundai Motor America, Intel Corporation, Isuzu Motors Ltd., Jaguar Land Rover, Karma Automotive, Kia Motors, Local Motors, Maserati, Mazda Motor Corporation, McLaren Automotive, Mercedes-Benz USA, Mitsubishi Motors, Nissan Motor Company, NXP Semiconductors, Panasonic Corporation, Porsche, PSA North America, SiriusXM, Subaru, Suzuki, Texas Instruments, Toyota Motor Company, Volkswagen Group of America, and Volvo Car USA.

calibration of any sensors required for ADB system performance prior to that testing, if requested by the vehicle manufacturer. Additionally, we wholly support the inclusion of a transition zone for equipment level laboratory testing as specified in SAE International Lighting System Group's comments[2] to the Agency in response to its NPRM.

We appreciate that NHTSA's proposal was developed with the intent that ADB systems operate safely by providing adequate visibility while mitigating glare upon other motorists. As a result of our testing, we have greater understanding of the Agency's proposed track test requirements and test procedures to evaluate ADB performance. Moreover, our assessment allowed us to develop meaningful feedback and recommendations to address both technical and feasibility concerns with the NPRM. Specifically, to improve practicability of the proposal, we recommend that NHTSA modifies certain portions of its test procedure to limit the number of test scenarios and scope of stimulus vehicles to evaluate ADB performance. We continue to emphasize from our prior comments that the variety (i.e., road geometry, vehicle speeds, and vehicle orientation) of scenarios selected by the Agency is excessive and unduly complicated to appropriately address the abilities of ADB systems.

The application of the Agency's derived glare limits is overly stringent and not based on modern headlight systems. NHTSA's application is also misguided towards preventing momentary discomfort glare at the expense of overall driver visibility. To incorporate more flexibility into the dynamic portions of the test protocol, while still ensuring that ADB systems increase visibility without introducing excessive glare, Auto Innovators recommends that the Agency consider an approach that relaxes the stringent glare limits for evaluating ADB performance, allows glare exceedance for more than one-tenth of a second, and provides required passage of a percentage of all test scenarios to achieve compliance. Other areas that we request the Agency's consideration include use of a static stimulus, standard stimulus lighting, and the allowance of horizontal aim. The rationale for each of these recommendations is presented in this comment submission.

Should the Agency foresee a final rule beyond the bounds set by 49 Code of Federal Regulations ("CFR") Part 555, we additionally encourage expeditious response to any outstanding petitions for temporary exemption of adaptive driving beam headlighting systems that it has received. BMW[3] and Volkswagen[4] have submitted petitions under 49 CFR Part 555 for their ADB systems in order to facilitate the field evaluation of these systems in the United States ("U.S."). We reiterate that ADB systems offer important safety benefits to the traveling public by incorporating the advantages of upper beams, thereby enhancing visibility, while avoiding their disadvantages by adjusting the light distribution and intensity to eliminate discomfort glare for other road users. We strongly support these petitions, and encourage the Agency to expedite their approval, in addition to any subsequent petitions NHTSA may receive from our members and other vehicle manufacturers.

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[2] *See* NHTSA Docket No. 2018-0090-0167 (October 12, 2018).
[3] *See* 83 FR 12650 (Mar. 22, 2018).
[4] *See* NHTSA Docket No. NHTSA-2017-0018 (September 11, 2017).

I. Auto Innovators Execution of NHTSA's Proposed Test Protocol

Following an extensive search for test facilities capable and equipped to replicate the Agency's proposal as accurately and efficiently as possible, Auto Innovators selected FT Techno of America, LLC ("FTTA") as its third-party vendor to conduct testing to evaluate the dynamic portions of NHTSA's proposed test procedure for FMVSS 108. FTTA specializes in vehicle dynamics, active safety, and Insurance Institute for Highway Safety ("IIHS") headlamp evaluations with their proving grounds located in Fowlerville, Michigan ("FPG"). A summary of the test protocol, observations, and example results are provided in this section.

A. Adaptive Driving Beam Test Protocol

The scope of our test protocol was limited to four test vehicles and four stimulus vehicles. The test vehicles were comprised of a small passenger car, a midsize sedan, a midsize sport utility vehicle ("SUV") and a large SUV. The small passenger car and midsize sedan were equipped with headlamps designed to the United Nations Economic Commission for Europe ("UNECE") R123[5] ADB requirements, the midsize SUV to SAE J3069™ but otherwise fully FMVSS 108 compliant, and the large SUV was fully FMVSS 108 compliant and then modified to mimic the UNECE R123 ADB function. For each test vehicle, tire pressures were set to vehicle specification and headlamp aims were unchanged from their received state or set to manufacturer specification. Stimulus vehicles were rented locally and selected according to the NPRM's Table XXI and S14.9.3.12.1, representing each vehicle type and from within five model years prior to the model year of the corresponding test vehicle. They were comprised of the following headlamp types: light-emitting diode ("LED") projector, LED reflector, halogen reflector and halogen projector, with their aim adjusted per manufacturer specification. Additional details for our stimulus vehicles can be found in Appendix A.

FTTA's equipment setup was similar to that described in the NPRM. FTTA utilized the same model illuminance (lux) sensors, high accuracy global positioning systems, vehicle-to-vehicle communication, and recording rate equipment (see Appendix B). Lux sensor count was limited to a critical number (e.g., driver forward, left rearview, right rearview, and center rearview when applicable). Data was collected by an acquisition unit aboard the stimulus vehicle, which in scenarios other than the motorcycle testing, was controlled by a passenger.

Unlike the NPRM, to measure lux sensor distance, FTTA utilized an optional multi-point live measurement feature of the OxTS equipment. The measurement was limited to 200 meters maximum, and most applicable for rear-facing sensors with critical measurements less than 120 meters. Forward-facing distance was determined with a live math channel resultant and offset from the Stimulus RT unit. In the NPRM, lux sensor distances were determined with a math offset post-test, in relation to true test

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[5] UN Regulation No. 123 – Uniform provisions concerning the approval of adaptive front-lighting systems (AFS) for motor vehicles.

measurement (between GPS antenna points). However, we believe that this change should not yield a difference in results.

FTTA determined that four lux sensors were adequate for this test, especially when placed in driver's glare zones. A center rearview sensor was not used for the heavy truck or motorcycle. On the light truck and passenger car, a center rearview sensor was positioned in line with the interior rearview mirror. All sensors were placed on the vehicle exterior to eliminate distortion or blockage potentially caused by glass.

Longitudinal lane international roughness index ("IRI") measurements remained within the NPRM's 1.5 meter per kilometer ("m/km") specification maximum, averaging near 0.475 m/km. Atypical IRI measurements across transverse lanes (east/west) are unknown and may have relevance for those test scenarios which include curves. Radius specifications and an overview of the test track layout can be found in Appendix C.

Modifications to curvature radii and superelevation specified in the NPRM were necessary to accommodate the track lengths at the FPG facility. In addition, changes were necessary to certain track geometries of the proposal to address safety concerns, specifically when testing mid radius preceding scenarios with the motorcycle stimulus vehicle at higher speeds. Similarly, FTTA operators also noted safety risks when conducting oncoming scenarios with each stimulus vehicle at speeds above 55 mph. FTTA also altered certain track and speed parameters from those proposed to account for differences in acceleration for each stimulus vehicle. This included adjusting two of three curve radii, along with three speed ranges, to conduct all test scenarios specified in the NPRM at the FPG facility. Had these adjustments not been made, distance requirements for certain test scenarios could not be met. Based on our experience, we believe that manufacturers will be unable to locate test facilities that are equipped to conduct all test scenarios proposed without modifications.

Approximately three to four hours were needed to complete testing for one vehicle set (i.e., one stimulus vs. one vehicle under test ("VUT")), with additional time needed for equipment validation and initialization. Although NHTSA did not address the number of test runs per scenario in the NPRM, Auto Innovators recommends an allowance of three or more runs for averaging and recognizing data anomalies. However, our testing was limited to two runs per scenario in the interest of total test time. Vehicles were refueled approximately half-way through the testing for each vehicle set to maintain above seventy-five percent fuel capacity. Synching path distance and speed timing were done by trial and error, with constant communication and feedback between vehicle operators. The stimulus vehicle maintained a second operator for real-time data verification of speeds, distance ranges, and equipment errors. For motorcycle testing, an operator rode in the VUT, conducting the same verifications through remote connection.

Lane position efforts were made by operators, despite a large tolerance when considering the 10'-12' maximum lane width for two lanes and two vehicles. Further, instances of roll angle and resulting lamp height variation were likely introduced while adjusting to maintain lane position.

B. Test Observations

Figure 1 below shows each test scenario and the corresponding speeds for the stimulus and VUT as outlined in the NPRM. This data also indicates the modifications made to test speeds and curve radii in certain scenarios. The curve radii specified in the NPRM were classified into three categories: small, mid, and large. In the mid radius scenario, with an actual 815'R curve, limited track length at the FPG facility necessitated modifications. Certain cases of slower paired vehicles showed difficulty reaching and maintaining specified speed in the finite length of the 815'R curve. When selecting the highest allowable delta between vehicles, it was still necessary to modify some speeds for length of test track within a curve.

The oncoming scenarios required adjustment for slower accelerating vehicles (i.e., no run-up on one curve end). In preceding scenarios, different speeds were needed to close or fill gaps to satisfy required test track lengths. In the large radius "preceding (same lane)" scenario, with an actual 1015'R curve, adjustment was also needed to meet the NPRM's requisite test track length.

		Oncoming			Preceding (Same Lane)			Preceding (VUT Passing on Left)			Preceding (Stimulus Passing on Left)			
		15-220m			30-119.9m			15-119.9m			30-119.9m			
		#	Stimulus	VUT	#	Stimulus	VUT	#	Stimulus	VUT	#	Stimulus	VUT	
Road D (Actual 1015'R)	Large Radius (1100-1300') RIGHT		50mph	50		50	60[1]							x2 runs = 8
												55	40	
									40	55				
	Large Radius (1100-1300') LEFT		50mph	50		50	60[1]							x2 runs = 8
												55	40	
									40	55				
Road C (Actual 815'R)	Mid Radius (730-790') RIGHT		45mph	45		30[2]	45							x2 runs = 12
			0	45					0	45				
									30	45				
												50[3]	25[4]	
	Mid Radius (730-790') LEFT		45mph	45		30[2]	45							x2 runs = 12
			0	45					0	45				
									30	45				
												50[3]	25[4]	
Road C (Actual 328'R)	Small Radius (320-380') RIGHT		30mph	30		25	30							x2 runs = 8
			0	30					0	30				
	Small Radius (320-380') LEFT		30mph	30		25	30							x2 runs = 8
			0	30					0	30				
Road D West Straight	Straightaway		70mph	70		60	70							x2 runs = 12
			0	70					0	70				
									40	70				
												70	40	

[1] Speed increased to from 55mph to 60mph. Original delta created difficulty catching stimulus in curve length.

[2] Speed decreased from 40mph to 30mph in order to cover test length.

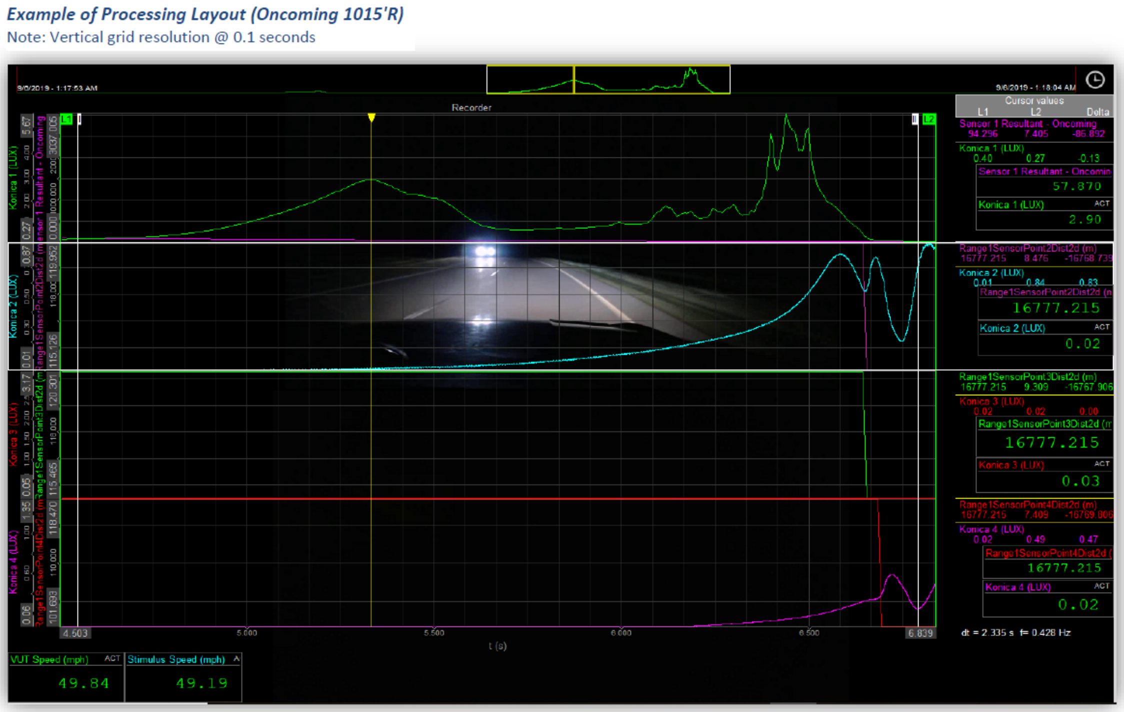
[3] Speed Increased from 45mph to 50mph.

[4] Speed decreased from 30mph to 25mph. The oncoming scenario U-Haul stimulus was also reduced to 40mph.

Figure 1. ADB Headlight Test Matrix

C. Test Data

Figure 2 below shows an example of the data processing layout. The processing was done using a manual method of scroll bar channel overlays to find each maximum lux value. A formulated excel template or automated script could help expedite processing and ensure consistency.



Example of Processing Layout (Oncoming 1015'R)

Note: Vertical grid resolution @ 0.1 seconds

Cursor values

L1	L2	Delta
Sensor 1 Resultant - Oncoming		
94.296	7.405	-86.892
Konica 1 (LUX)		
0.40	0.27	-0.13
Range1SensorPoint2Dist2d (m)		
16777.215	8.476	-16768.739
Konica 2 (LUX)		
0.01	0.84	0.83
Range1SensorPoint3Dist2d (m)		
16777.215	9.309	-16767.906
Konica 3 (LUX)		
0.02	0.02	0.00
Range1SensorPoint4Dist2d (m)		
16777.215	7.409	-16769.806
Konica 4 (LUX)		
0.02	0.49	0.47

Sensor 1 Resultant - Oncomin 57.870

Konica 1 (LUX) ACT 2.90

Range1SensorPoint2Dist2d (m 16777.215

Konica 2 (LUX) ACT 0.02

Range1SensorPoint3Dist2d (m 16777.215

Konica 3 (LUX) ACT 0.03

Range1SensorPoint4Dist2d (16777.215

Konica 4 (LUX) ACT 0.02

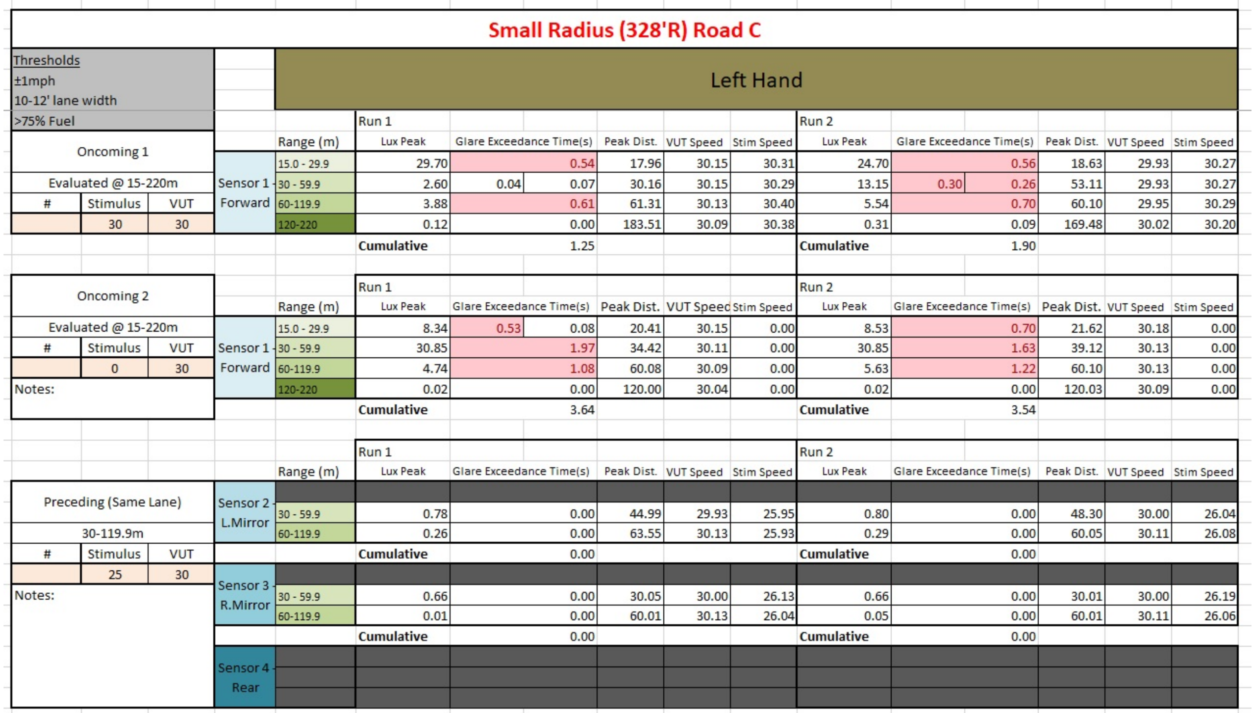
dt = 2.335 s f= 0.428 Hz

VUT Speed (mph) ACT 49.84

Stimulus Speed (mph) 49.19

Figure 2. Example of Processing Layout (Oncoming 1015'R)

Figure 3 below shows an example of a data processing matrix. The final test results consist of Excel workbooks for each test vehicle. Each Excel workbook contains 16 tabs for the various stimulus vehicles and roadway geometries. The data contains values for peak lux along with the distance and speed of both the VUT and stimulus ("Stim") vehicle at peak lux. Speed values are shown in miles per hour (mph) and distance values in meters (m). If the lux value exceeded the NPRM glare limit, a value greater than zero is included under Glare Exceedance Time. Glare exceedance times greater than 0.1 seconds are highlighted in red. A cumulative value of all glare exceedance times in a given run is also included. In some cases, there were more than one glare exceedance per sensor and range, so multiple glare exceedance times are shown. Sensors or ranges that were not applicable are grayed out in the data processing matrix.



Small Radius (328'R) Road C																
Thresholds ±1mph 10-12' lane width				Left Hand												
>75% Fuel					Run 1						Run 2					
Oncoming 1				Range (m)	Lux Peak	Glare Exceedance Time(s)		Peak Dist.	VUT Speed	Stim Speed	Lux Peak	Glare Exceedance Time(s)		Peak Dist.	VUT Speed	Stim Speed
				15.0 - 29.9	29.70		0.54	17.96	30.15	30.31	24.70		0.56	18.63	29.93	30.27
Evaluated @ 15-220m			Sensor 1 Forward	30 - 59.9	2.60	0.04	0.07	30.16	30.15	30.29	13.15	0.30	0.26	53.11	29.93	30.27
#	Stimulus	VUT		60-119.9	3.88		0.61	61.31	30.13	30.40	5.54		0.70	60.10	29.95	30.29
	30	30		120-220	0.12		0.00	183.51	30.09	30.38	0.31		0.09	169.48	30.02	30.20
					Cumulative		1.25				Cumulative		1.90			
					Run 1						Run 2					
Oncoming 2				Range (m)	Lux Peak	Glare Exceedance Time(s)		Peak Dist.	VUT Speed	Stim Speed	Lux Peak	Glare Exceedance Time(s)		Peak Dist.	VUT Speed	Stim Speed
Evaluated @ 15-220m				15.0 - 29.9	8.34	0.53	0.08	20.41	30.15	0.00	8.53		0.70	21.62	30.18	0.00
#	Stimulus	VUT	Sensor 1 Forward	30 - 59.9	30.85		1.97	34.42	30.11	0.00	30.85		1.63	39.12	30.13	0.00
	0	30		60-119.9	4.74		1.08	60.08	30.09	0.00	5.63		1.22	60.10	30.13	0.00
Notes:				120-220	0.02		0.00	120.00	30.04	0.00	0.02		0.00	120.03	30.09	0.00
					Cumulative		3.64				Cumulative		3.54			
					Run 1						Run 2					
				Range (m)	Lux Peak	Glare Exceedance Time(s)		Peak Dist.	VUT Speed	Stim Speed	Lux Peak	Glare Exceedance Time(s)		Peak Dist.	VUT Speed	Stim Speed
Preceding (Same Lane)			Sensor 2 L.Mirror													
				30 - 59.9	0.78		0.00	44.99	29.93	25.95	0.80		0.00	48.30	30.00	26.04
30-119.9m				60-119.9	0.26		0.00	63.55	30.13	25.93	0.29		0.00	60.05	30.11	26.08
#	Stimulus	VUT			Cumulative		0.00				Cumulative		0.00			
	25	30	Sensor 3 R.Mirror													
Notes:				30 - 59.9	0.66		0.00	30.05	30.00	26.13	0.66		0.00	30.01	30.00	26.19
				60-119.9	0.01		0.00	60.01	30.13	26.04	0.05		0.00	60.01	30.11	26.06
					Cumulative		0.00				Cumulative		0.00			
			Sensor 4 Rear													

Figure 3. Example of Data Processing Matrix from the Small Passenger Car and Motorcycle on Small Radius, Left Hand Curve.

II. Glare, Visibility, and Pedestrian Safety

In its proposed amendment, NHTSA largely focuses on glare. The Agency notes that it is particularly concerned about ensuring, to a reasonable degree, that ADB systems do not glare other motorists, as glare is a negative externality that might not be sufficiently mitigated by market forces alone.[6] While we understand that discomfort glare is a concern for the Agency when evaluating ADB systems, we believe that this proposal minimizes the significant safety benefits of increased visibility that ADB brings, and its potential to reduce crash risk between vehicles and with pedestrians and other vulnerable road users. NHTSA's own research indicates that it is difficult to determine glare as a direct cause to crashes or fatalities.[7] While the Agency's evaluation has shown that an average of 0.3% of nighttime fatal crashes list glare as a contributing factor,[8] alternatively data shows that over 70% of pedestrian fatalities have occurred at night.[9] IIHS found that between 2009 and 2016, pedestrian deaths in dark conditions increased 56%.[10] The Government Accountability Office ("GAO") in its recent report cited that the number of pedestrians killed annually in motor vehicle crashes in the United States has

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[6] NPRM at 51799.

[7] *See* Nighttime Glare and Driving Performance, Report to Congress, National Highway Traffic Safety Administration, Department of Transportation (2007).

[8] National Highway Traffic Safety Administration. 2014. Traffic Safety Facts 2012 Data: Pedestrians, DOT HS 811 888. Washington, DC: National Highway Traffic Safety Administration.

[9] National Highway Traffic Safety Administration. 2018 (Revised). Traffic Safety Facts 2016 Data: Pedestrians, DOT HS 812 493. Washington, DC: National Highway Traffic Safety Administration.

[10] https://www.iihs.org/iihs/sr/statusreport/article/53/3/1.

increased from about 4,400 in 2008 to almost 6,300 in 2018—a roughly 43 percent increase.[11] GAO recommended that NHTSA take additional action to address pedestrian safety.

While there are many factors that can be attributed to pedestrian fatalities and injuries, improved visibility benefits of ADB systems can help to decrease fatalities and injuries associated with these crashes. The increased illumination from ADB systems can contribute to considerably improving a driver's ability to identify obstacles or pedestrians on and off the roadway. Yet, NHTSA has chosen to focus more in this NPRM on discomfort glare rather than the safety benefits of ADB systems. We strongly encourage the Agency to not diminish the visibility improvements an ADB system can provide to disproportionately protect against discomfort glare.

A. IIHS Glare Limits

NHTSA proposes a set of glare limits from a 2011 University of Michigan Research Institute ("UMTRI") Feasibility Study ("Feasibility Study"), which is derived from reported median photometry of headlamps from 1997 model year U.S. vehicles.[12] Since 1997, headlight technologies that comply with FMVSS 108 have advanced drastically, including in the form of LED or high-intensity discharge ("HID") lighting that can provide greater levels of visibility without producing excessive glare. In addition to advancements in lighting hardware, in 2016 the IIHS introduced its Headlight Rating ("IIHS Headlight Rating") which has incentivized U.S. automakers to provide high levels of visibility without sacrificing glare performance.[13]

Regarding angle of incidence, the Feasibility Study rightfully notes that "[t]he disabling effects of glare (e.g., Vos, 2003) and the discomforting effects of glare (e.g., Schmidt-Clausen & Bindels, 1974) both fall off strongly as the angle between the glare source and the center of a person's field of view increase." The study notes that when separation distances between two vehicles are greater than 60 meters, glare illuminance values should be smaller; and when separation distances are shorter than 30 meters, glare illuminance values should be greater. However, the study is unable to compensate for these glare illuminance values because they "do not exactly fit the standard models of glare effects by angle."

As indicated in the rationale for the IIHS Headlight Rating, the IIHS takes a similar approach to the 2011 UMTRI Feasibility Study for establishing illuminance requirements.[14] In both studies, the illuminance of U.S. vehicle lower beam headlamp patterns compliant to FMVSS 108 are measured and extrapolated to establish illuminance criteria at different distances. However, the IIHS study departs

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[11] Government Accountability Office. (2020, April). *NHTSA Needs to Decide Whether to Include Pedestrian Safety Tests in Its New Car Assessment Program.* (Publication No. GAO-20-419). Retrieved from https://www.gao.gov/assets/710/706348.pdf.

[12] Michael J. Flannagan & John M. Sullivan. 2011. Feasibility of New Approaches for the Regulation of Motor Vehicle Lighting Performance. Washington, DC: National Highway Traffic Safety Administration.

[13] Insurance Institute for Highway Safety. (2018, July). *Headlight Test and Rating Protocol (Version III)*.

[14] Insurance Institute for Highway Safety. (2015, August). *Rationale and Supporting Work for Headlight Test and Rating Protocol.*

from the Feasibility Study in three significant ways. First, the Feasibility Study uses “lamps typical of the 1997 model year”, whereas the IIHS study uses lamps that are representative of headlamps on U.S. roads today.[15] Figures 4 and 5 below demonstrate the respective difference between the lower beam headlamp patterns used in the Feasibility Study and the IIHS study. Second, the IIHS study accounts for prior research that indicates that glare effects should consider both peak illuminance and overall “dosage” of glare exposure. This is the basis for the IIHS glare threshold that assesses illuminance in terms of overall exposure distance.

Third, the IIHS study accounts for glare effects due to incidence angle whereas the Feasibility Study does not. This is the basis for allowing 10 lux of glare illuminance for all approaches at distances between 5 and 10 meters, noting that “[a]t these smaller distances, drivers are less likely to be focused on the oncoming vehicle headlamps, and greater angular distances from the light sources are associated with less discomfort glare (Schmidt-Clausen and Bindels 1974).” Our test data shows that the least amount of failures occurred at the 15-29.9 meter distance range for both the oncoming and preceding scenarios. Additionally, the glare exceedance times for all the test failures in this range were 1.0 seconds or less. Based on these results, we believe that it is less critical to test the performance of ADB systems at this distance range. Accordingly, Auto Innovators recommends that NHTSA eliminate the 15-29.9 meter distance requirement for each oncoming and preceding test scenario.

From a technical design perspective, ADB systems that utilize a swiveling beam (as opposed to a matrix-style LED array) and that dip to a lower beam in the presence of other vehicles, operate by swiveling the dipped beam as far as possible outboard during passing scenarios at short distances. For example, as a stimulus vehicle passes an ADB vehicle on its left side, the ADB left hand lamp swivels, reaching its maximum swivel angle and the stimulus vehicle passes through the full lower beam pattern at the extremes. Due to the “kink” in the lower beam pattern necessitated under FMVSS 108 requirements, this creates an area of higher intensity light just to the right of the H-V point (see Figures below) that must pass over the stimulus vehicle as the ADB vehicle returns the swiveling lamp to center. This increased area of intensity may explain some of the exceedances at short distances in NHTSA’s previous testing and similarly within the FTTA data. While this explanation is only relevant for swiveling beam ADB systems, Auto Innovators believes that any safety standard should remain

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[15] Prior to the allowance of visual/optical headlamp aim, which was generally effective for the 1999 model year, including those used in the UMTRI study, headlamps were aimed by use of external mechanical aimers or by vehicle headlamp aiming devices (VHADs). Generally, all headlamps installed as original equipment on current light vehicles use visual/optical aim, and incorporate the characteristic sharp optical gradient used in visual/optical aim.

technology neutral. Also, the increased intensity resulting from any such situation would not functionally differ from any vehicle with traditional lower beams with a vehicle passing on its left side.

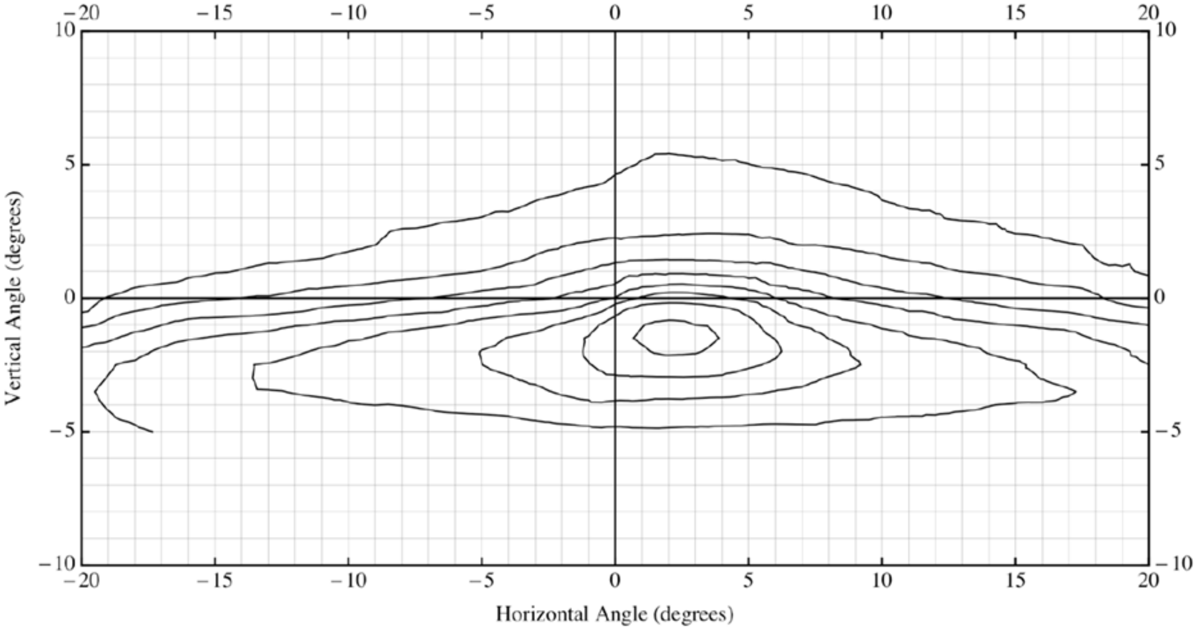

Figure 4. Low-Beam Headlamp Intensity Pattern from NHTSA Feasibility Study

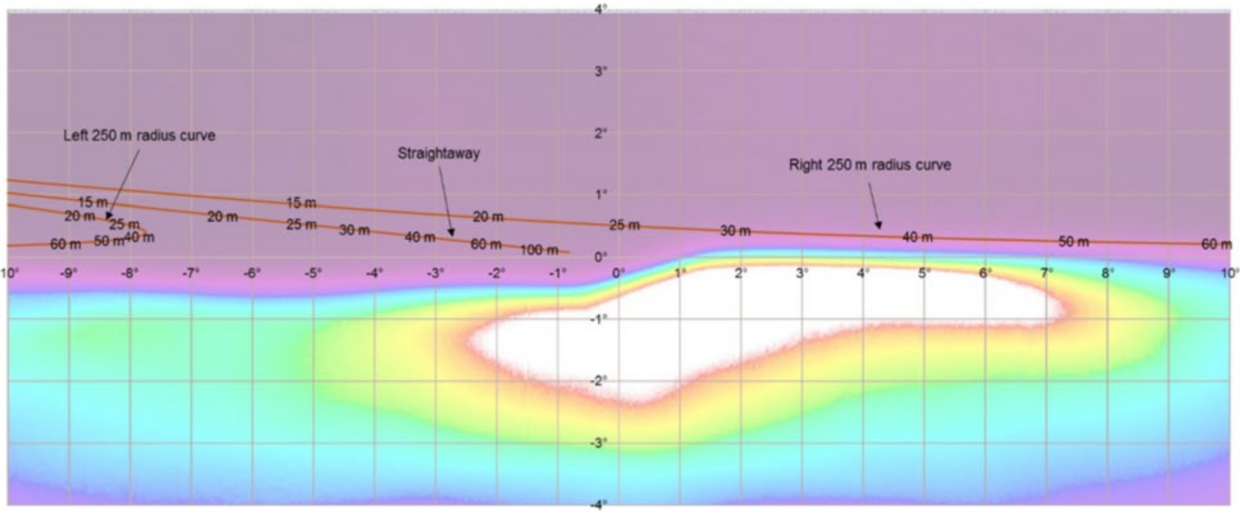

Figure 5. Low-Beam Headlight Intensity Pattern from IIHS Headlight Rating

Additionally, IIHS has studied headlamp performance and real world implications in order to add headlamp performance ratings into their test protocols and overall safety rating scheme. IIHS found that, “The lower beams of many headlight systems with poor ratings don't provide enough light for a driver going 55 mph on a straight road to stop in time after spotting an obstacle in his or her lane. They provide even less illumination on the left side of a straight road and when driving on a curve."[16] IIHS indicates that upper beams are underused and that the use of high beam assist or ADB could increase the use of upper beams, thus improving visibility. The IIHS test protocol accounts for both visibility and glare. It attempts to limit discomfort glare, while not imposing disabling glare, underscoring NHTSA's focus on glare to road users.

B. IIHS Top Safety Pick Criteria

The IIHS Top Safety Pick criteria for headlamps has driven the industry to the current state of the art in increasing the need for visibility with simultaneous reductions in glare. IIHS "GOOD" rated headlamps serve to influence consumers' purchasing decisions through these ratings. When comparing the glare results of the model year ("MY") 2020 Top Safety Pick Plus ("TSP+") award winners having GOOD rated headlamps to the glare limit values provided in the present NPRM, it is clear that the glare limit values for ADB lamps are unreasonably stringent. The graph below presents the glare illuminance values from each of the 32 GOOD rated headlamps, and subsequent TSP+ vehicles, which are overlaid with the glare illuminance limits cited in the NPRM.

As evidenced in Figure 6, nine of the 32 GOOD rated headlamps (~28%) in the *low beam* configuration would fail the oncoming glare limits provided for in the NPRM. Because the highest IIHS rated lower beam headlamps would struggle to even meet the glare criteria requirements to which ADB lighting is being held, Auto Innovators believes that a relaxation of the glare limit values is appropriate. To align with IIHS consumer messaging for what constitutes a "good" headlamp, we recommend also aligning closer to the glare limits specified in the IIHS Headlight Evaluation.

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[16] https://www.iihs.org/topics/headlights#headlight-performance.

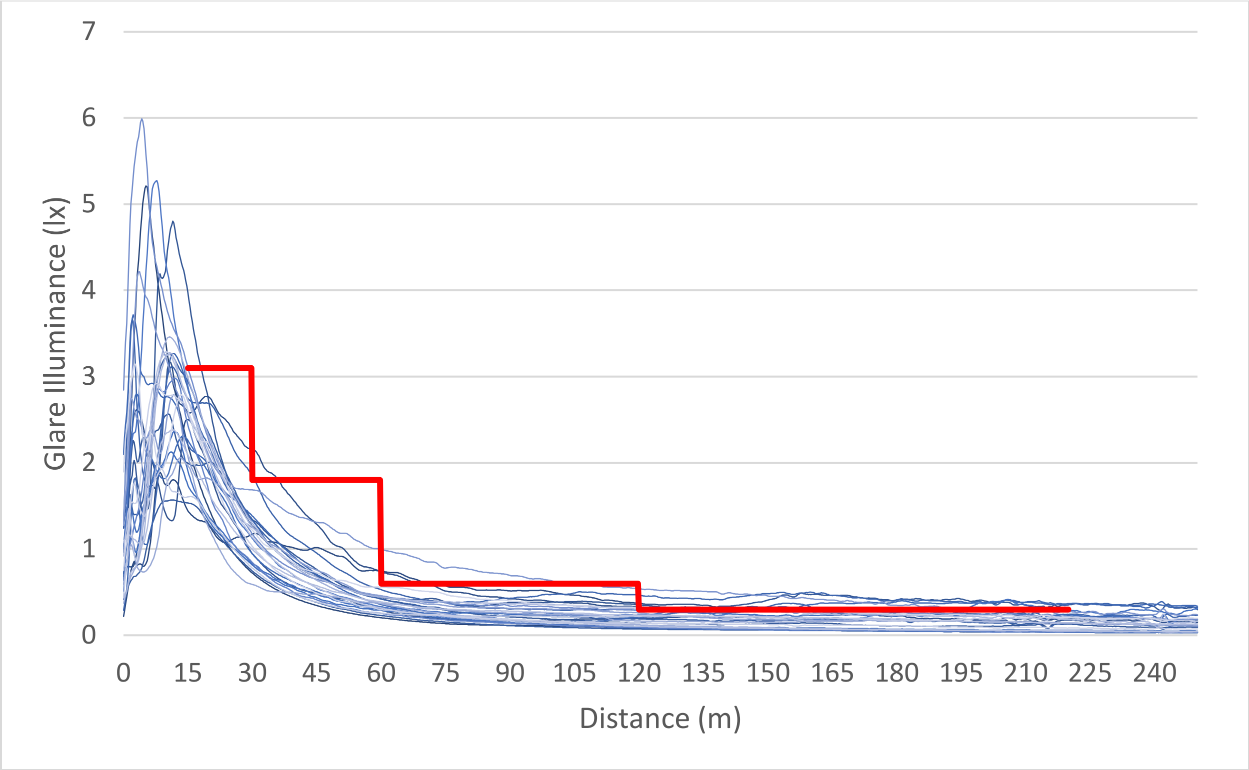

Figure 6. Glare illuminance versus distance of 32 IIHS GOOD rated MY2020 vehicles (blue) overlaid with NHTSA ADB NPRM glare limit values (red)

C. NHTSA Should Adopt IIHS Glare Limits

Auto Innovators believes that the glare limits presented in the IIHS test protocol, which examines visibility and glare from a real world perspective, reflect the performance bar set by modern headlights more accurately than the overly restrictive limits proposed in the NPRM. We recommend that the Agency adopts the glare limits utilized in the IIHS Headlight Evaluation as outlined below.

While IIHS provides glare exposure criteria for both a right curve and a straight/left curve scenario, we believe the right curve glare limits are more appropriate for application to the present rulemaking for all oncoming scenarios. Specifically, IIHS allows exceedances in the form of cumulative exposures as opposed to hard pass/fail limits. These cumulative glare exceedances result in a series of demerits for which it is possible for a vehicle to achieve a GOOD rating while still offering small amounts of glare. Auto Innovators recommends that the Agency adopts a similar method for establishing an allowable time exceedance for each test range. The IIHS model uses the percentage over the limit to determine glare demerits, an approach that should also be considered by NHTSA. We additionally note that the NPRM does not specify left or right curves, and request that NHTSA clarify whether which or both were contemplated for the ADB test procedure.

Secondly, the IIHS glare limits are intended to provide a relative assessment to consumers of headlamp performance rather than a strict compliance metric by which manufacturers will be held under this rulemaking. In other words, it is still possible for a vehicle to drastically exceed the glare criteria in the

IIHS test, earn a POOR rating, and still be fully FMVSS 108 compliant. For these reasons, we believe adopting the higher glare metric of the IIHS right curve scenario to apply to all oncoming scenarios offers sufficient balance between the need for limiting glare exposure while allowing for the benefits of ADB. Although IIHS provides a gradient of glare exposure limits, we recommend that NHTSA's proposed stepwise glare illuminance limits correlate to the IIHS curve at each step's shortest distance. Specifically, Auto Innovators offers the following modified glare limit criteria for the Agency's consideration:

Distance (m)	Lux Limit (lx)
30 to 59.9	6
60 to 119.9	3.4
120 to 220	1

Table 1. Modified Glare Limit Criteria Based on IIHS Glare Limits

III. Additional Recommendations to NHTSA

The recommendations that follow are substantiated by our ADB testing and data analysis. Auto Innovators believes that they will not diminish the Agency's objectives to develop performance requirements that demonstrate an ADB system is capable of providing increased visibility for the driver, while correctly detecting and mitigating glare to oncoming and preceding vehicles.

A. Modify Certain Portions of Test Procedure to Facilitate Practicability

1. Limit Dynamic Test Scenarios

The Agency states that the centerpiece of its proposal is a dynamic road test to evaluate the performance of ADB systems in a select number of driving scenarios and road configurations.[17] NHTSA selected a variety of different types of interactions with either an oncoming or preceding vehicle, different scenarios that vary the road geometry (straight or curved), vehicle speed (from 0 to 70 mph), and vehicle orientation. The Agency tentatively concluded that a dynamic road test was necessary to ensure that an ADB system meets minimum safety requirements for the prevention of glare. With respect to the track test, NHTSA's intent was to maintain a practical and efficient test while also reflecting real world conditions to which an ADB system would need to adapt to perform adequately.[18]

However, our experience simulating NHTSA's proposed scenarios did not amount to a practical nor efficient test. The rigor and specificity for the test tracks present not only the disparity to real world ADB performance, but also the challenge of vehicle self-certification and repeatable results. To further evaluate testing variability, one Auto Innovator member repeated a test series using a vehicle that was tested by FTTA and cited in the NPRM. The full test series was repeated under the same conditions using comparable measurement equipment. Despite careful attention to test setup and test conditions,

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[17] NPRM at page 51767.

[18] NPRM at page 51781.

the results varied from those obtained by FTTA. The magnitude of the variation was sufficient to alter the compliance status of the vehicle.

Additionally, the number of tests and maneuvers in the NPRM require multiple sensor readings resulting in an extensive amount of data. The proposed track test includes 15 test modes and 34 tests per vehicle set. Each test has 3 or 4 sensor readings, resulting in 102 or 136 data elements per vehicle set. Testing four stimulus vehicles required analysis of 476 data elements. This is excessive and incompatible with many proving grounds, creating unassailable burdens for vehicle manufacturers. FTTA noted that it had underestimated the amount of time needed for data collection and processing. Test engineers used a manual method of scroll bar channel overlays to find the maximum lux value for each given range. As expected, this approach was very time consuming. Auto Innovators recommends that NHTSA develop software or other compliance tool to expedite processing the ADB test data. Overall, we conclude that the track testing proposed in the NPRM is overly complicated, not practicable, and does not reasonably address the abilities of ADB systems.

In consideration of the FTTA test results, Auto Innovators notes that certain test scenarios provided no additional benefit in determining whether an ADB system would provide undue glare to other road users. For example, the Preceding (Same Lane) test scenario resulted in only 5 failures out of 109 valid test runs (4.6%) across all stimulus and subject test vehicles. Therefore, we suggest that the Preceding (Same Lane) test scenario be eliminated because conformable performance in these scenarios will be accounted for by default. Further, Auto Innovators believes that by adopting the most stringent test scenarios at the extremes of the testing range, the intermediate tests will thereby be obviated. Measuring system performance at the extremes allows inference of system performance at points between those extremes. Specifically, the small radius curve was determined to be the most stringent test with 46 failures out of 127 valid test runs (36.2% failure rate). The failure rates for the straight, mid, and large radius test scenarios were 26.6%, 26.7%, and 22.4%, respectively. Therefore, by only requiring the straight and small radius test scenarios, an accurate assessment of overall system performance can be achieved.

Moreover, we recommend that NHTSA decrease the maximum test speed from 70 mph to 55mph. Since camera detection would be indifferent to the change in speed, we do not believe that testing to 70 mph is necessary to evaluate ADB performance. IIHS noted in its ADB testing rationale, that the majority of fatal nighttime passenger vehicle crashes on curves occur at speeds of 55 mph or less.[19] In addition, this change will help address safety concerns when testing on certain track geometries at higher speeds. High speed differentials pose an unreasonable safety risk for test operators, and certain vehicles such as the U-Haul (large truck), have difficulty reaching the specified test speeds in short times and/or distances allowed by a test facility. Limiting the test speed to 55 mph for all vehicles will still allow NHTSA to strike a reasonable balance between safety and practicability in its proposed test scenarios.

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[19] Insurance Institute for Highway Safety. (2015, August). *Rationale and Supporting Work for Headlight Test and Rating Protocol*.

Lastly, with regards to the stimulus vehicle selection, the test results showed that for all, but one valid test run for the light truck stimulus, each failure was mirrored by a failure with the Mustang stimulus for the same scenario. In other words, for all but one run using the light truck as the stimulus that exceeded the prescribed limits, a failure was also recorded for the same scenario using the Mustang as the stimulus. As the Mustang provided additional exceedance failures beyond the light truck, the Mustang clearly provided a more stringent stimulus. As the headlamp configurations for the Mustang (LED projectors) were similar to the light truck (HID projectors), i.e., similar color temperature, projector lens, and luminous intensity, the difference in performance is judged to be attributed to the geometries of both the headlamp mounting as well as the sensor mounting locations. As the bounds for the light truck presented in Table XXI are between the passenger car and the heavy truck, Auto Innovators believe that the need for an intermediate stimulus vehicle geometry is unwarranted along the same logic provided in the previous argument. Therefore, we recommend the elimination of the light truck as a required stimulus vehicle.

2. Allow a Static Stimulus in the ADB Test Procedure

A static stimulus can be used to represent preceding and opposing subject vehicles, such as a car, truck or a motorcycle as described in SAE J3069™.[20] The Agency decided not to use a static stimulus in this NPRM, citing its concern that a static stimulus is not realistic and may encourage ADB systems to be designed to ensure identification of a static stimulus rather than actual vehicles. To address NHTSA's concern, SAE International is considering a revision of its recommended practice to include that a static stimulus can appear like the vehicle it represents in 3-dimensions.[21]

The NPRM noted that a static stimulus has the advantage of relative simplicity and ease of testing. It also helps to reduce test variability, such as lateral variation, differences in vehicle speeds or changing ambient lighting. Ultimately, a static stimulus can enable repeatability while minimizing test burden. In addition, Auto Innovators' experience on the test track revealed potential safety issues with two vehicles driving at high speed in close proximity during nighttime test scenarios. A static stimulus, which would replace the subject stimulus vehicle, would help increase safety during testing.

Auto Innovators supports SAE International's position that a static stimulus is considered the most challenging scenario since some camera systems utilize opposing or preceding vehicles' movement within a scene to identify them as vehicles instead of other road objects, such as reflectors on the side of the road. We also support SAE International's position that a "standardized" stimulus lighting device, standard in illuminance, color and illuminated area, is intended to represent the minimum for each allowed in FMVSS 108. Since a static stimulus with minimum stimulus illuminance, color and illuminated area is the most challenging test scenario, it can be considered the worst case for the ADB system to differentiate a vehicle from other objects. Using static stimuli and/or standardized stimulus lighting devices not only provides each manufacturer with repeatable and objective criteria to which to test, but also affords the same to the Agency and/or to the third parties contracted to carryout compliance

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[20] SAE J3069™ (JUN 2016), pages 11-13.

[21] SAE International's proposed revision will be voted on in late Summer or Fall 2020.

testing on the Agency's behalf. For these reasons, we recommend that NHTSA reconsiders the use of a static stimulus, such as a static test fixture or actual vehicle, and/or standardized stimulus lighting devices in this NPRM.

Allowing standardized headlamps and tail lamps for the stimuli is an obvious mitigating tactic. Auto Innovators also points out that standardized lighting device stimuli need not be restricted to static evaluations, i.e., they could be mounted to vehicle 'mules' in various locations as needed, and tested dynamically. Either way, the approach is a more repeatable, objective, and orderly means for demonstrating compliance than the proposed use of publicly available vehicles.

Vehicle designs have certain variability, simply by the complexity of the product alone, but there are also the unfortunate instances where designs are found to later be not compliant, or not to design intent, forcing manufacturers to make in-cycle design changes or actions. These changes will not always be known at the time a manufacturer of the ADB vehicle conducts self-certification testing nor to a third-party conducting compliance testing for the Agency. Such changes will not amend model name, model year, trim series, or vehicle identification number. Auto Innovators believes this presents an unforeseeable incertitude to the compliance process with potential for chaos in the industry. If a stimulus vehicle used for compliance testing later conducted a recall on its headlighting or tail lighting, or even to a non-lighting component that affected its driving dynamics, pitch or ride height, and the remedy involved a change in design, what, if any, repercussions would there be for the ADB manufacturer and its already achieved compliance to the ADB requirements? Other potential unknowns for vehicles acquired 'in the field,' vehicles that will have been handled and driven by many prior to being used as a stimulus, are additionally disconcerting.

3. Limit Stimulus Vehicle Five Year Prior Model Year Requirement

The NPRM is unclear as to the number of stimulus vehicles that will be used in the Agency's evaluation of ADB systems, and how audit testing will be conducted. Auto Innovators requests that the Agency provide clarification on these issues. While we continue to view the static stimulus as the best path forward for practicably evaluating ADB systems under the most challenging scenarios, if the Agency moves forward with the usage of dynamic stimulus vehicles and intends that automakers should certify with stimulus vehicles in every classification, we urge the Agency to consider greater objectivity in this process. We propose that NHTSA limit the extensive list of proposed stimulus vehicles to a practical and manageable list which includes a specific stimulus vehicle from each of the following FMVSS classifications identified in Table XXI of the NPRM: passenger vehicle; light truck, bus, or multi-purpose passenger vehicle ("MPV")[22]; heavy truck, bus, or MPV; and motorcycle. We recognize that the proposal to limit the list to one stimulus vehicle from each of the classifications presents challenges with respect to the appropriate determination of which vehicle to utilize and may raise concerns that this

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[22] In section II.A.1. above, we propose eliminating the light truck stimulus vehicle from the list of stimulus vehicles for testing.

process is subject to gaming. To address such concerns, we propose that the single stimulus vehicle from each vehicle classification shall be selected by the Agency, using a criteria that is transparent and self-executing, to the greatest extent possible.

We specifically recommend that the Agency select a single set of stimulus vehicles every 5 years, based on the best-selling make and model within each vehicle classification for a single model year. This stimulus vehicle set would remain in effect for 10 years, and be updated every 5 years. This means that after the initial 5 year period for the first set of stimulus vehicles, there would be two overlapping stimulus vehicle sets at any moment in time, and would continue ad infinitum. This overlap would provide regulatory certainty for variations in vehicle development lifecycles. To demonstrate this proposal, we offer the following example.

Assuming this rulemaking begins to allow compliance for 2021 MY ADB vehicles, the following set of stimulus vehicles would be selected from the prior 2020 model year based on the makes and models with the highest sales volume in each classification[23]:

- Passenger Cars: 2020 MY Toyota Camry
- Trucks, buses, MPVs (light): 2020 MY Ford F-150, should the agency not accept our suggestion to eliminate the light truck as a stimulus
- Trucks, buses, MPVs (heavy): 2020 MY Ford E-450
- Motorcycles: 2020 MY Harley-Davidson Iron 1200

This initial list of stimulus vehicles would be used for certifying the compliance of 2021 to 2030 MY ADB vehicles. Five years later at 2026 MY timing, the Agency would provide a second list, again based upon sales volume in each vehicle classification in the prior model year, in this case 2025 MY. This subsequent list of stimulus vehicles would be used for certifying 2026 to 2036 MY ADB vehicles, in addition to the previous list with an expiration of 2030 MY. This selection process would continue to repeat every 5 years. Because headlight and/or tail light designs can vary within a given vehicle make and model line, we propose that the Agency select a specific headlight and tail light design for the stimulus vehicles selected for the list.

We believe that this transparent self-executing update to the stimulus vehicle strikes an appropriate balance between burden and practicability, while also addressing concerns with gaming. This allows manufacturers and NHTSA test facilities to maintain a limited set of stimulus vehicles and conduct certification testing within a finite amount of time. The 10-year phase out also provides manufacturers with sufficient lead time and regulatory certainty that is needed at the beginning of any vehicle development cycle, and currently provided in other FMVSSs. With respect to gaming, we believe that this approach addresses potential concerns e.g., lack of accounting for stimulus vehicles that may have a

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[23] In light of the current production impact due to COVID-19, and general potential for sales fluctuation due to model lineup changes, we further recommend that the Agency consider aggregating the sales volume for the prior 5 model years, and not necessarily just the prior model year. In the case of the example, these 2020 MY vehicles could also be selected based on combined sales volume leaders during the entire period of 2016 to 2020 MY.

unique headlamp design, lack of incentivization to manufacturers to test for a variety of stimulus vehicles, or that this requirement does not cover the entire range of possible stimulus vehicles in several ways. First, the selection of these stimulus vehicles is completely out of the control of the manufacturers. This unbiased selection process requires that manufacturers ensure that ADB systems recognize actual vehicle headlamp types on our roads today, and continue to do so as headlamps systems evolve. Second, this approach indeed requires that ADB systems recognize a wide variety of stimulus vehicles by maintaining the proposed requirement to certify against a variety of stimulus vehicle classifications. Third, the selection of the stimulus vehicle based on greatest total sales volume ensures that the selected headlight and tail light stimuli are the most appropriate representation possible within each classification. To reiterate, if it is the Agency's intent that automakers should certify with stimulus vehicles in every classification, we request consideration be made for this alternate proposal.

We agree with NHTSA that an ADB system should be able to identify a wide range of different vehicle types, just as camera-based auto high beam ("AHB") systems (i.e., semiautomatic headlamp beam switching devices) have been doing since 2004. We estimate more than seventeen million vehicles, greater than 50% of some automakers' sales, are equipped with camera-controlled AHB systems. These systems currently use similar or identical forward vision camera and vehicle identification algorithms as today's ADB systems in countries outside of the United States. Automobile manufacturer members of Auto Innovators agree that their AHB systems, which were designed without the type of rigorous examination laid out in the NPRM, have not resulted in increased discomfort glare complaints. This longstanding precedence should serve as an undoubting indicator that future ADB systems, using similar control hardware and algorithms, will provide superior visibility performance while protecting against discomfort glare, similar to AHB systems.[24]

Further, having an ADB system recognize any vehicle in every segment is a contrary approach compared to other FMVSS' test protocols which account for real world variations under objective and repeatable conditions. For example, FMVSS 208 accounts for the population of all possible drivers by testing with just 5th percentile female, 50th percentile male, and 95th percentile male crash test dummies. It additionally uses a NHTSA-defined fixed barrier,[25] one specified range of vehicle test speeds, and adjustments of components like seats, steering wheels, seat belt anchorages and head restraints are specified and limited.

The proposed requirement for selecting random stimulus vehicles from within the preceding five model years does not strike a reasonable balance between the need for safety and practicability. Other standards are based, in the case of FMVSS 208, on one crash "partner" intended to represent a much greater crash population, e.g., crash barrier, crash speed, anthropomorphic test device ("ATD"), surrogate subject vehicle ("SSV"), pedestrian dummy, etc. However, in this ADB NPRM, we are being asked to recognize every "partner", in every "partner" segment from the last five model years. Our proposal still allows for an ADB system to test to a broad range of stimulus vehicles that are

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[24] Michael J. Flannagan & John M. Sullivan. 2011. Preliminary Assessment of The Potential Benefits of Adaptive Driving Beams, UMTRI–2011–37. University of Michigan, Transportation Research Institute.

[25] Part 571 Subpart A General definitions.

representative of the current vehicle population, and to reiterate, will use similar operating parameters as AHB, a feature with proven precedence in the field. It is unnecessary to test practically every vehicle on the road to demonstrate compliance when vehicles within a category are substantially similar.

Checking representative vehicles through the track test and better defining those representative vehicles will make the standard practicable without limiting the safety benefits. Also, this approach addresses the Agency's concerns of whether glare prevention can be adequately ensured with a smaller set of stimulus vehicles, limits manufacturer burden in testing, and would encourage repeatability to compare ADB performance between tests.

B. Technical Recommendations

1. Require Passage of a Percentage of Individual Illuminance Readings to Achieve Compliance

Auto Innovators proposes a new approach for determining compliance to the Agency's proposed FMVSS 108 test procedures to evaluate ADB performance. Instead of requiring that an ADB system pass all the test scenarios outlined in the NPRM, we recommend that NHTSA instead require passage of a percentage of individual illuminance readings to achieve compliance. We believe that this approach may be supported by the design to conform provision included in the NPRM. The Agency has proposed to extend the design to conform language that has been part of FMVSS 108 since its inception to the proposed requirements for ADB.[26] With design to conform, NHTSA has stated that it will not consider a lamp to be noncompliant if its failure to meet a test point is random and occasional, and historically, there has never been an absolute requirement that every motor vehicle lighting device meet every single photometric test point to comply with FMVSS 108.[27]

The NPRM includes 34 individual test scenarios with three or four illuminance readings taken for each test for a total of 102 or 136 illuminance readings for a full compliance test for each ADB-equipped vehicle.[28] It would be helpful if the Agency provided guidance as to how the "occasional and random" criteria would apply, since the readings in the proposed ADB test represent the maximum value recorded over a period of time rather than readings historically taken in FMVSS 108 that are at points, along lines, or in zones in a defined two dimensional grid. Since its inception, all photometric testing conducted according to FMVSS 108 has been with the lighting device and the photodetector having a static physical relationship between them. However, the large majority of NHTSA's proposed ADB tests would occur with continuous movement between the device being tested and the photodetector—often time with the relative movement occurring in three planes.

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[26] NPRM at 51786.

[27] *Id.*

[28] FMVSS 108 photometric test requirements include at most 4 individual readings for upper beam headlamp maximum intensity, and 10 individual readings for lower beam headlamp maximum intensity.

Additionally, unlike photometry conducted in dedicated indoor test facilities where the temperature, humidity, and ambient lighting can be strictly controlled, outdoor test conditions cannot be controlled.[29] It would be difficult not to attribute failures of illuminance readings to variances that could appear in the novel and unique aspects of the test procedure, rather than to quality control issues particularly where the time and complexity of the testing preclude conducting it on multiple ADB-equipped vehicles.[30] To further account for the test variations associated with this type of testing, we propose that up to three test runs for each individual test scenario be permitted, and an average of the individual illuminance readings for those runs be used as the reported maximum illuminance reading for that test scenario.

We believe that an appropriate basis for compliance for ADB systems should allow up to 15% of the individual illuminance readings to exceed the glare limits proposed in our comments by no more than 25% in intensity. The precedence for allowing exceeding glare limits by no more than 25% in intensity is described below, while the allowance for up to 15% in quantity comes from FMVSS 108 itself. S14.9.3 of FMVSS 108 requires that 20 flashers chosen from a lot of 50 be subject to a starting time test, a voltage drop test, a flash rate and percent current "on" time test, and a durability test where the performance requirements for these two devices are considered to have been met if 17 of the 20 samples (85%) comply. This amount of performance variation would seem consistent with the previously noted challenges of outdoor dynamic testing where little previous experience exists.

The concept that slight differences in light intensity are generally not perceivable to human observers has been widely supported in various studies including those by NHTSA[31] and UMTRI.[32] These studies have interpreted such slight differences to not exceed 25%. The Agency, in granting an inconsequential noncompliance petition from Hella, confirmed that the 25% criteria applied to situations where the actual lamp intensity was above the stated requirement maximum.[33] Also, NHTSA recently used a similar basis to grant petitions for inconsequential noncompliance from Nissan and Toyota.[34] Auto Innovators recommends that NHTSA consider evaluating whether its test procedure for ADB should allow for compliance of a percentage of all test scenarios based on the Agency's provision of design to conform in FMVSS 108.

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[29] Although the IIHS states that, "a full moon on a cloudless night illuminates the ground below to about 1 lux", its headlight test and rating protocol limits tests to where the ambient light is below 0.3 lux. Insurance Institute for Highway Safety. (2018, July). *Headlight Test and Rating Protocol (Version III).*

[30] NHTSA conducted testing of several ECE compliant vehicles equipped with ADB using modified ECE R48 and R123 vehicle tests. The Agency concluded that, *"Multiple test trials per scenario would serve to compensate for variability in dynamic maneuver scenario performance as well as ADB performance variability. More than three trials per scenario are recommended*. DOT HS 812 174 August 2015, Page 18.

[31] *Driver Perception of Just Noticeable Difference(s) in Signal Lamp Intensities*, DOT HS 808 209, September 1994.

[32] Sayer, J. R., Flannagan, M. J., Sivak, M., Kojima, S., & Flannagan, C. C. (1997). Just Noticeable Differences for Low-Beam Headlamp Intensities (Report No. UMTRI-97-4). Ann Arbor: The University of Michigan Transportation Research Institute.

[33] 55 FR 37601-2, Docket No. NHTSA-1989-09, September 12, 1990.

[34] *See* 85 FR 39678 and 85 FR 39679, Docket No. NHTSA–2019–0079; Notice 2, July 1, 2020.

2. Increase Glare Limit Exceedance Time to Greater Than One-Tenth of a Second

As noted in Section II, Auto Innovators understands the importance of balancing the safety benefits of ADB technology with avoiding discomfort glare to other vehicle motorists. However, the Agency should not diminish the visibility improvements an ADB system can provide to disproportionately protect against discomfort glare. Unfortunately, we believe that the glare limits specified by NHTSA in its test procedure do exactly that. NHTSA is proposing stricter requirements for an advanced system that increases safety with increased visibility; stricter even more than that imposed on AHB systems as discussed above. However, even compliant IIHS top rated lower beam systems today cannot meet the proposed glare requirements.

Our testing demonstrated a need for an illuminance exceedance factor that would allow for some flexibility in system response, yet still account for only a minor portion of time in each test run. For a robust system response that adapts the beams accordingly, it must be allowed time to process and validate the driving environment. To not allow for this can result in false validations or sporadic and frantic adaptations. Such a factor would allow for reliable and repeatable test results despite minor variations in the environment, stimulus vehicles, and system detection and response. An analysis of our test data shows that a majority of exceedances were less than 2.0 seconds. Only a few exceedances were over 2.5 seconds, and these were limited to difficult to detect scenarios, such as testing the stationary motorcycle.

We believe that the Agency intended the 0.1 second momentary spike allowance as only a filter for sensor or environmental noise. Based on our results, we believe that 2.5 seconds is reasonable for an ADB system response. We propose that NHTSA increases the illuminance exceedance time for momentary spikes and the sum of momentary spikes over all test distances (30-220 meters) to a maximum of 2.5 seconds. This glare exceedance limit is allowed in SAE J3069™ and is based on human response time to the sudden appearance of an opposing or preceding vehicle.[35] Advanced ADB headlighting systems will outperform human response. Accordingly, we recommend that NHTSA adopts a glare exceedance limit of 2.5 seconds to align with Canada Motor Vehicle Safety Standard ("CMVSS") 108 and SAE J3069™.

3. Eliminate the Glare Limit Exceedance for Distance

S14.9.3.12.8.1 of the NPRM ignores spikes in the illuminance measurement results over the prescribed limits of 0.1 seconds or 1 meter. Because the testing is conducted at constant speeds, having both a time and distance specification becomes duplicative and does not add any value to the test protocol. For example, in the oncoming scenario with both the VUT and the stimulus vehicle traveling at 70 miles per hour, the vehicles will pass a distance of 1 meter in 0.016 seconds. Because timing holds more

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[35] SAE J3069™ (JUN 2016).

relevance in real world driving (for example, comparing response times of an ADB system to the perception response time of a human driver in dipping to lower beams), Auto Innovators believes that the distance exceedance limit should be eliminated and the Agency should instead focus only on time limited exceedances.

C. Allow Horizontal Aim

As set forth in SAE J3069™ and CMVSS 108, and expressed in the December 2018 submission under the previous organization Alliance of Automobile Manufacturers, ADB systems require horizontal adjustment to properly align the beam pattern to the vehicle's camera. This facilitates proper alignment of the beam's area of reduced intensity to prevent discomfort glare to any oncoming or preceding vehicles. This alignment exists at the system level and continues to be necessary in the field where occasional need for lamp replacement can occur, for example, as a result of collision damage.

Horizontal (and vertical) adjustment serve to minimize the area of reduced intensity by allowing more precise calibration of what is directed towards the stimulus vehicle(s). If provisions for accessibility and adjustment of horizontal aim were not incorporated into the final rule, automakers would be required to compensate for any resulting horizontal vehicle variation into the size of the area of reduced intensity, resulting in greatly increasing this area. An area of reduced intensity larger than necessary would significantly reduce the additional light otherwise provided to a driver by an optimal ADB system if horizontal aim and adjustment were permitted.

FMVSS 108 allows horizontal aim only when a vehicle is equipped with on-vehicle headlamp aiming devices ("VHAD"). With the introduction of visual/optical aim, not to mention that they were fraught with shortcomings, VHADs have become obsolete. FMVSS 108 should allow the horizontal aim adjustment of ADB headlamps similar to UNECE and Canada Motor Vehicle Safety Standard regulations to properly align the beam pattern with the vehicle's camera to obtain the minimum size of the area of reduced intensity necessary, and properly position it to prevent discomfort glare to oncoming or preceding vehicles.

The method to horizontally aim each ADB headlamp can take many forms, depending on the specific execution of the ADB system. Each involves an ADB-specific aim calibration mode which is activated either by a dealer or consumer when the vehicle is parked. This mode would illuminate a horizontal aim feature utilizing one or more of the ADB-illuminated elements which have a sufficient vertical gradient that can be used for horizontal aim, just as one does today with vertical aim. The dealer or consumer would use this vertical gradient to properly calibrate the horizontal aim following instructions specified in the service manual or owner's manual.

We request that, for the reasons cited above, provisions be made in FMVSS 108 to allow horizontal aim and adjustment for headlamps performing ADB function, wherever it currently is prohibited. Additionally, for compliance testing, we request that NHTSA ensures headlight aiming for stimulus vehicles be adjusted per the vehicle manufacturer's specifications prior to testing, and that the Agency considers prescribing performance criteria to ensure that light being emitted by stimulus vehicles does not degrade (e.g., decreased illuminance) over time due to aging.

IV. Conclusion

Auto Innovators requests that NHTSA consider both the feasibility and technical concerns and recommendations outlined above regarding the FMVSS 108 test protocol when drafting the final rule. We do not believe the proposed test protocol is practicable or repeatable, rather it is unnecessarily burdensome for manufacturers. We request that NHTSA reconsiders the proposed test parameters which, as currently written, are overly complicated. Specifically, the Agency should scale back its quantity of dynamic test scenarios and the five-year model year requirement for stimulus vehicle selection.

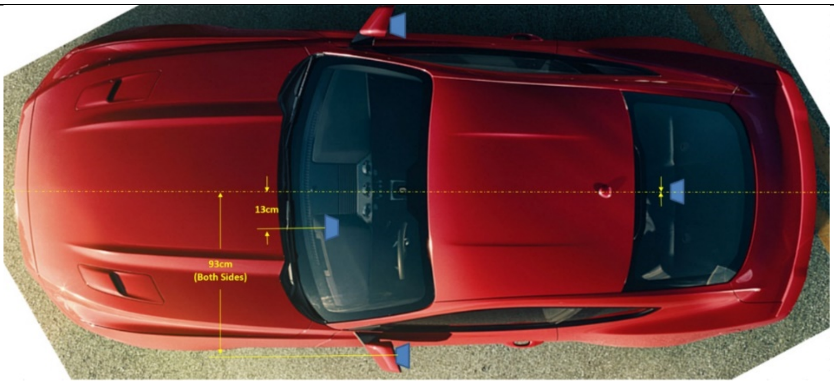
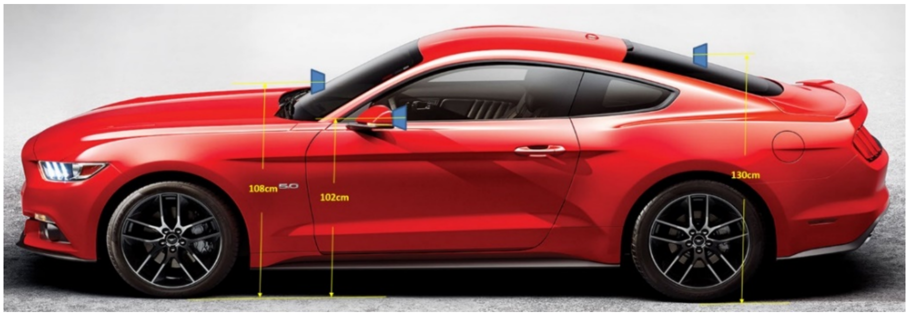
We also recommend that NHTSA increase the glare limit exceedance time to higher than one-tenth of a second. Specifically, we suggest up to 2.5 seconds as recommended by SAE J3069™ and allowed per CMVSS 108. Our data analysis shows that this time limit is more appropriate for the ADB system to adapt to mitigate glare, while at the same time avoid intermittent and haphazard responses. Additionally, NHTSA should incorporate modified glare limits based on IIHS glare limits into the ADB test procedure, and eliminate the glare limit exceedance for distance. Further, we propose that the Agency reconsider the use of a static stimulus and standardized stimulus lighting, require passage of a percentage of individual illuminance readings to achieve compliance, and allow for horizontal aim. For NHTSA's convenience, we have summarized these recommendations in Table 2 in Appendix D.

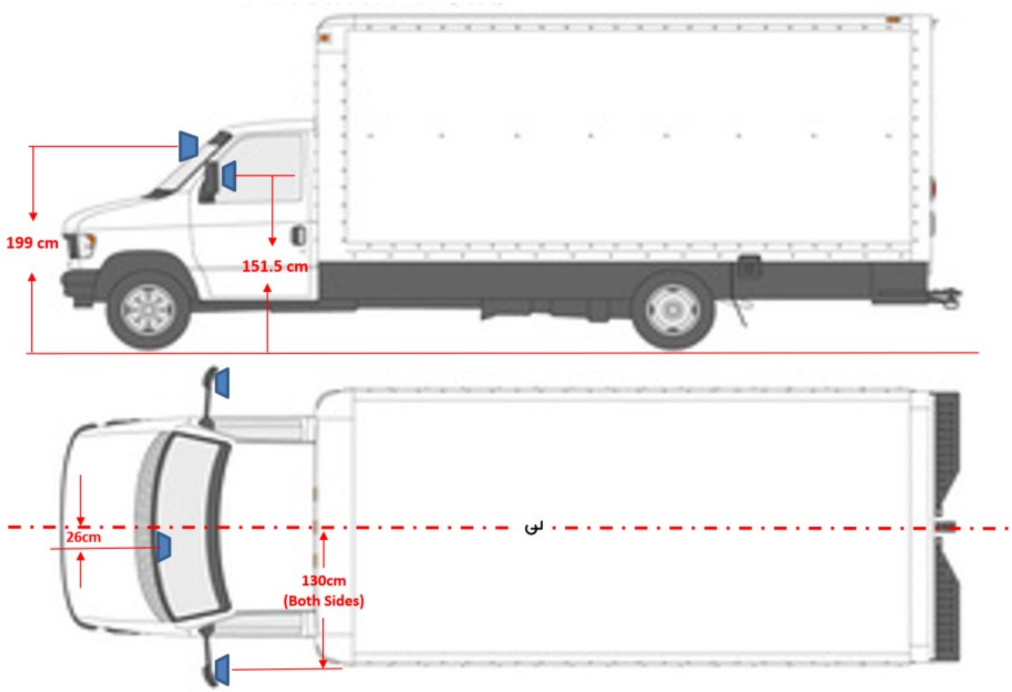
Auto Innovators appreciates this opportunity to provide supplemental comments and hopes that NHTSA grants them their full consideration. We look forward to continuing working closely with the Agency to prioritize safety and innovation and introduce ADB systems in the U.S. vehicle fleet.

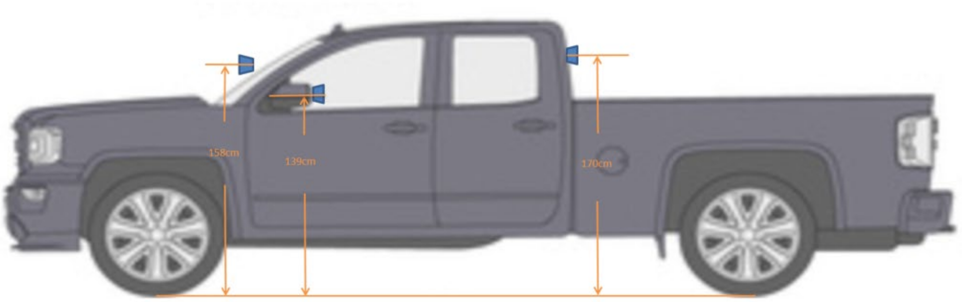
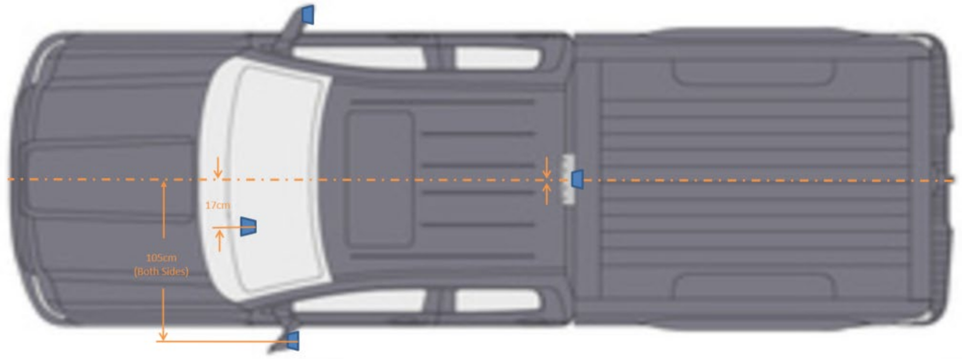
Sincerely,

Scott Schmidt
Senior Director, Safety

APPENDIX A – STIMULUS VEHICLES

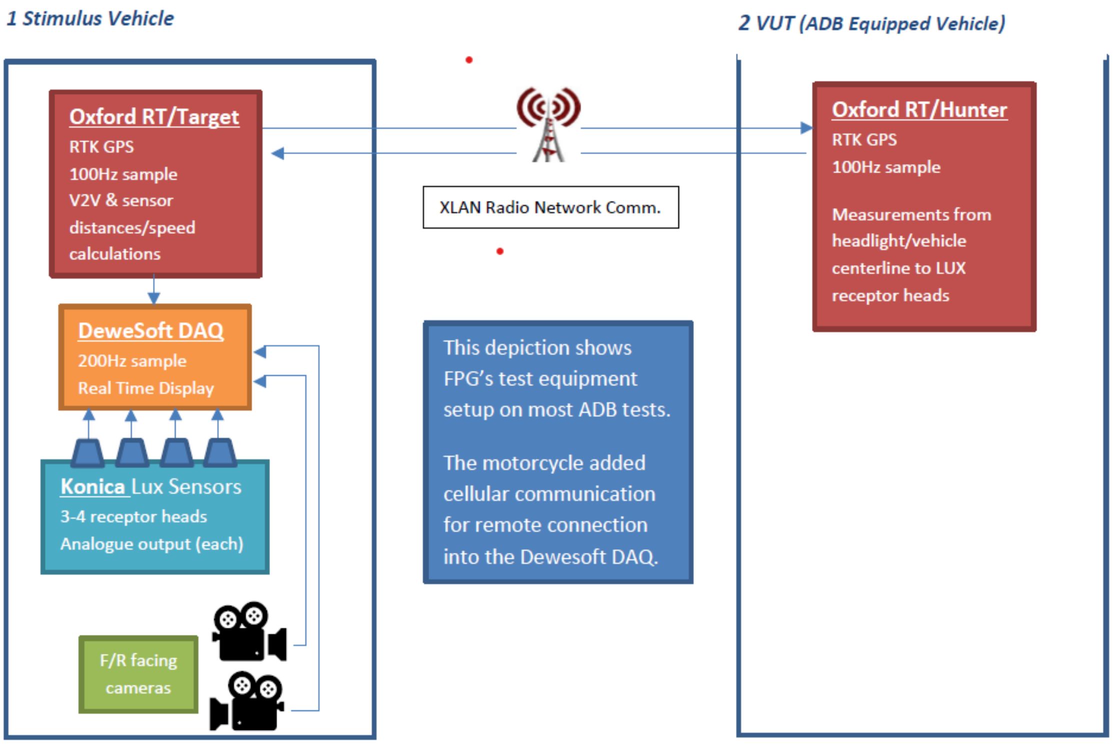
Stimulus Vehicle (Passenger Car)	2018 Ford Mustang GT 
Lamp Type	LED Projector headlamps (low lamp height)
Sensor Placement	 

Stimulus Vehicle (Heavy Truck)	2017 Ford Econoline E-450 (15’ U-Haul) 
Lamp Type	Halogen Reflector headlamps
Sensor Placement	Forward Lux sensor placement fit within the NPRM’s placement boundary but was very close to the lower limit while placed near maximum windshield height. Wide box, extended towing style mirrors, utilized 3 lux sensors. 

Stimulus Vehicle (Light Truck)	2017 GMC Sierra 1500, 4WD Double Cab/ 2016 Chevrolet Silverado 1500, 4WD Double Cab  
Lamp Type	HID Projector headlamps, utilized 4 lux sensors. While three vehicles were tested against the GMC Sierra 1500, one vehicle was tested against a 2016 Chevrolet Silverado 1500 w/ HID Lamps.
Sensor Placement	 

Stimulus Vehicle (Motorcycle)	2018 Harley Davidson Ultra Classic 
Lamp Type	Single LED Projector, forward auxiliary lighting was disabled using only the center source. There was discussion whether to disable the redundant tour pack taillights to create a worst-case scenario for testing. Ultimately, it was decided to keep the taillight array intact, avoiding FMVSS 108 compliance concerns. Also 3 lux sensors were utilized without a sensor placed in the center rearview.
Sensor Placement	Generally, motorcycle windscreens do not extend beyond an operator's line of sight. The NPRM boundaries represent appropriate placement, however, sensor placement on a windscreen within these limits was challenging. The Harley-Davidson motorcycle required placement close to the lower boundary at 1.32 meters, while the rider's sightline position was mid-boundary. Physically lower models of motorcycles may require an elaborate mounting fixture isolated from the windscreen to meet the boundary requirements specified in the NPRM. Further, windscreen mounting can introduce variation when considering frame fixed versus steering fixed (such as our machine).  

APPENDIX B – EQUIPMENT SETUP



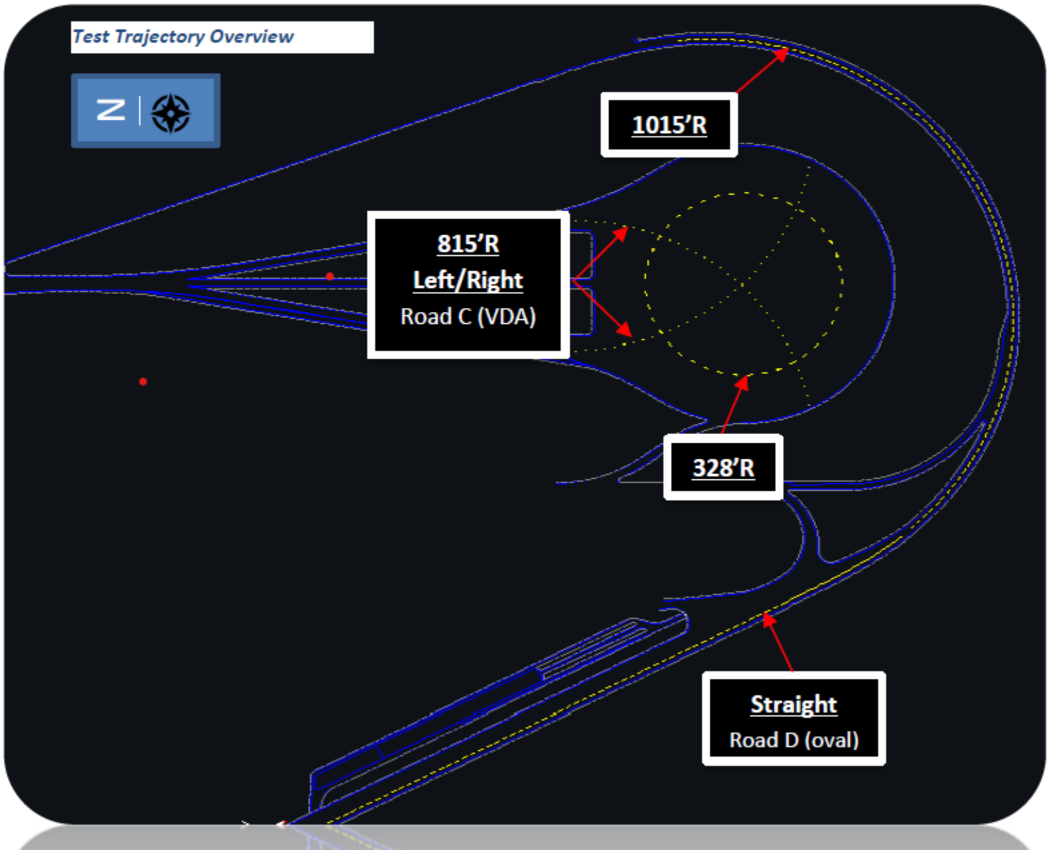
- Oxford Technical Solutions RT3002 (high accuracy GPS), OxTS Range system (Target/Hunter)
- Dewesoft Data Acquisition – customizable hardware, video and data acquisition
- Konica Minolta T-10A LUX receptors – individual analog output recorded by Dewesoft at low gain
- Basic HD USB webcams – forward and rear facing, helpful for visualizing/sorting tests

APPENDIX C – TRACK SETUP

- 1100-1300 ft. Radius Curve (Large) – FTTA selected its oval track (Road D) south curve for this scenario. The actual center line measurement is a 1015 ft radius. Superelevation was at 7%, compared to the 2% specified in the NPRM, and adjacent test lanes were on the same slope. This curve was defined by standard Michigan Department of Transportation (DOT) lane markings (dashed center, solid edge lines, grassy shoulder, partial guard rail).

- 730-790 ft. Radius Curve (Mid) – This test scenario was conducted on FTTA's VDA pad (Road C). Actual centerline radius was 815 ft. between adjacent test lanes. Curvature was defined by short road cones along survey dots, with no edge lines.

- 320-380 ft. Radius Curve (Small) – Also conducted on the VDA pad, with a 328 ft. centerline radius – the only curve in spec of the NPRM. This curvature was defined by DOT specification dashed yellow, but no edge lines. The oncoming 220m "start of test" is not always achievable here, with vehicles only reaching 200m distance (measure by line of sight). Though somewhat irrelevant when vehicles are 180° apart – no oncoming light will be in frame.



APPENDIX D – SUMMARY OF RECOMMENDATIONS

TABLE 2. AFAI SUPPLEMENTAL COMMENTS ADB NPRM REVISION REQUESTS

NPRM PROCEDURE SUBJECT	REQUESTED PROCEDURE REVISION	REVISION BASIS	NPRM & FMVSS No. 108 SECTION(S) AFFECTED
Transition zone between upper beam and lower beam.	Allow transition zone without photometric requirements	Physical and technical impossibility of providing large changes in light levels across small horizontal distances	S9.4.1.6.6 & S9.4.1.6.7
Glare limits	Allow right curve glare limits used in IIHS headlamp evaluation procedure	More typically represents performance of current OEM headlamps and an appropriate balance of visibility and glare	S9.4.1.6.3 & Table XIX-d
Glare exceedance time interval or distance interval	Allow up to 2.5 seconds and remove distance interval	Represents glare tolerance based upon cumulative dosage exposure	S14.9.3.12.8.1
Photometric performance basis of compliance	Allow compliance to be based upon passage of a percentage of total test scenarios	Recognition of variances implicit in novel outdoor dynamic photometry testing and application of design to conform precedent	S14.9.3.12.8 Reference: S14.9.3.3.3, S14.9.3.4.3, S14.9.3.5.3, S14.9.3.6.3, S14.9.3.7.3, S14.9.3.8.3, S14.9.3.9.3 & S14.9.3.10.3
Static stimulus	Allow a static stimulus such as a test fixture or a stimulus vehicle, and standardized stimulus lighting	Observed safety concerns and stimulus identification issues	ADB Test Matrix Reference: S6.4.3, Table V-b, & Table V-c
Horizontal headlamp aim	Allow horizontal headlamp aim adjustment without use of a VHAD	Permit camera and headlamp alignment on each individual vehicle	S10.18.4
Short (15-29.9 m) distance range	Eliminate 15-29.9 m distance range	Observed small amount of test failures	S9.4.1.6.3 & Table XIX-d
Preceding (Same) lane test scenarios	Eliminate preceding (Same) lane test scenarios	Testing showed infrequent failures	S14.9.3.12.5
Mid and large curve radius test scenarios	Eliminate mid and large curve radius test scenarios	Stringency of straight and small radius curve scenarios negates redundancy of results	S14.9.3.12.5

		with mid and large radius curve scenarios	
Test vehicle maximum speed	Reduce from 70 mph to 55 mph	Observed safety concerns and lack of large truck acceleration performance	ADB Test Matrix
Stimulus vehicle category overlap	Eliminate use of light truck stimulus vehicle	Redundancy of results with passenger car	S14.9.3.12.1
Stimulus vehicle selection	Agency selects a single stimulus vehicle from each prior model year of vehicles, based on the best-selling make and model within each vehicle classification.	Imposes practical limits to size of test vehicle fleets	S14.9.3.12.1