DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA–2018–0090]

RIN 2127–AL83

Federal Motor Vehicle Safety Standards; Lamps, Reflective Devices, and Associated Equipment

AGENCY: National Highway Traffic Safety Administration (''NHTSA''), Department of Transportation (''DOT'').

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This document proposes amendments to Federal Motor Vehicle Safety Standard (''FMVSS'') No. 108; *Lamps, reflective devices, and associated equipment,* to permit the certification of adaptive driving beam headlighting systems, if the manufacturer chooses to equip vehicles with these systems. Toyota Motor North America, Inc. (Toyota) petitioned NHTSA for rulemaking to amend FMVSS No. 108 to permit manufacturers the option of equipping vehicles with adaptive driving beam systems. NHTSA has granted Toyota's petition and proposes to establish appropriate performance requirements to ensure the safe introduction of adaptive driving beam headlighting systems if equipped on newly manufactured vehicles.

DATES: You should submit your comments early enough to be received not later than December 11, 2018.

ADDRESSES: You may submit comments to the docket number identified in the heading of this document by any of the following methods:

• *Federal eRulemaking Portal:* Go to *http://www.regulations.gov.* Follow the online instructions for submitting comments.

• *Mail:* Docket Management Facility: U.S. Department of Transportation, 1200 New Jersey Avenue SE, West Building Ground Floor, Room W12–140, Washington, DC 20590–0001.

• *Hand Delivery or Courier:* 1200 New Jersey Avenue SE, West Building Ground Floor, Room W12–140, between 9 a.m. and 5 p.m. ET, Monday through Friday, except Federal holidays.

• *Fax:* 202–493–2251.

Instructions: All submissions must include the agency name and docket number. *Note:* All comments received will be posted without change to *http://www.regulations.gov,* including any personal information provided. Please see the Privacy Act discussion below. We will consider all comments received before the close of business on the comment closing date indicated above. To the extent possible, we will also consider comments filed after the closing date.

Docket: For access to the docket to read background documents or comments received, go to *http://www.regulations.gov* at any time or to 1200 New Jersey Avenue SE, West Building Ground Floor, Room W12–140, Washington, DC 20590, between 9 a.m. and 5 p.m., Monday through Friday, except Federal Holidays. Telephone: 202–366–9826.

Privacy Act: Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (Volume 65, Number 70; Pages 19477–78) or you may visit *http://www.dot.gov/privacy.html*.

Confidential Business Information: If you wish to submit any information under a claim of confidentiality, you should submit three copies of your complete submission, including the information you claim to be confidential business information, to the Chief Counsel, NHTSA, at the address given under **FOR FURTHER INFORMATION CONTACT**. In addition, you should submit two copies, from which you have deleted the claimed confidential business information, to Docket Management at the address given above. When you send a comment containing information claimed to be confidential business information, you should include a cover letter setting forth the information specified in our confidential business information regulation (49 CFR part 512).

FOR FURTHER INFORMATION CONTACT: Please contact Mr. Markus Price, 202–366–0098 or Mr. John Piazza, Office of Chief Counsel, Telephone: 202–366–2992. Facsimile: 202–366–3820. You may send mail to these officials at: The National Highway Traffic Safety Administration, 1200 New Jersey Avenue SE, Washington, DC, 20590.

SUPPLEMENTARY INFORMATION:

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I. Executive Summary

Glare, Visibility, and Adaptive Driving Beam Technology

This proposal is intended to allow an advanced type of headlighting system referred to as adaptive driving beam to be introduced in the United States. Adaptive driving beam (''ADB'') headlamps use advanced technology that actively modifies the headlamp beams to provide more illumination while not glaring other vehicles. The requirements proposed today are intended to amend the existing regulations to permit this technology and ensure that it operates safely.

Vehicle headlamps must satisfy two different safety needs: Visibility and glare prevention. The primary function of headlamps is to provide forward visibility. At the same time, there is a risk that intense headlamp illumination may be directed towards oncoming or preceding vehicles. Such illumination, referred to as glare, can reduce the ability of other drivers to see and cause discomfort. Headlighting has therefore traditionally entailed a trade-off between long-distance visibility and glare. This is reflected in the requirement that headlamp systems have both lower and upper beams. The existing headlight requirements regulate the beam pattern (photometry) of the upper and lower beams; they ensure sufficient visibility by specifying minimum amounts of light in certain areas on and around the road and prevent glare by specifying maximum amounts of light in directions that correspond to where oncoming and preceding vehicles would be.

While the benefits of improved visibility and the harmful effects of glare are difficult to quantify, they are real. For example, a recent study from the Insurance Institute for Highway Safety found that pedestrian deaths in dark conditions increased 56% from 2009 to 2016. The harmful effects of glare are highlighted by the thousands of consumer complaints NHTSA has received from the public over the years, Congressional interest, and the Agency's research. NHTSA received more than 5,000 comments in response to a 2001 Request for Comments on glare from headlamps and other frontal vehicle lamps. Most of these comments concerned nighttime glare. In 2005, Congress directed the Department of Transportation to study the risks of glare. In response to these concerns, NHTSA initiated a multipronged research program to study the risks of, and possible solutions to, glare.

ADB systems are an advanced type of headlamp beam switching technology that provides increased illumination without increasing glare. Headlamp beam switching systems were first introduced in the 1950s, and while not initially widely adopted, have more recently become widely offered as optional equipment. These traditional beam switching systems switch automatically from the upper beam to the lower beam when meeting other vehicles. ADB systems improve on this technology. They utilize advanced equipment, including sensors (such as cameras), data processing software, and headlamp hardware (such as shutters or LED arrays). ADB systems detect oncoming and preceding vehicles and automatically adjust the headlamp beams to provide less light to the occupied roadway and more light to the unoccupied roadway.

ADB technology enhances safety in two ways. First, it provides a variable, enhanced lower beam pattern that is sculpted to traffic on the road, rather than just one static lower beam pattern. It provides more illumination than existing lower beams without glaring other motorists (if operating correctly). Second, it likely will lead to increased upper beam usage. Research has shown that most drivers under-utilize the upper beams. The effects of this increase as speeds increase, because at higher speeds the need for greater seeing distance increases. ADB technology (like traditional beam switching technology) enables the driver to activate the ADB system so that it is always in use and there is no need to switch between lower beams and upper beams. In this way, the upper beam will be more widely used, and used only when there are no other vehicles present. For both these reasons, ADB has the potential to reduce the risk of crashes by increasing visibility without increasing glare. In particular, it offers potentially significant safety benefits in avoiding collisions with pedestrians, cyclists, animals, and roadside objects.

ADB systems are currently available in foreign markets but are not currently offered on vehicles in the United States. ADB systems have been permitted (and regulated) in Europe for several years. ADB systems are not, however, currently offered on vehicles in the United States. NHTSA's lighting standard, Federal Motor Vehicle Safety Standard (''FMVSS'') No. 108, has been viewed as not permitting ADB. In particular, the current lower beam photometry requirements do not appear to allow the enhanced beam that ADB systems provide. In 2013, Toyota petitioned NHTSA for rulemaking to amend FMVSS No. 108 to permit the introduction of ADB. SAE (formerly, the Society of Automotive Engineers) in 2016 published a recommended practice for ADB. And more recently, NHTSA has received multiple exemption petitions for ADB-equipped vehicles. NHTSA has granted Toyota's rulemaking petition and this proposal is our action on that grant.

The Proposed Requirements and Test Procedures

This proposal, if adopted, would amend the lighting standard to allow ADB systems on vehicles in the United States and ensure that they operate safely. ADB, like other headlamp technologies, implicates the twin safety needs of glare prevention and visibility. This proposal does three main things that, taken together, are intended to allow ADB systems and ensure that they meet these safety needs.

First, it would amend FMVSS No. 108 to allow ADB systems. We propose amendments to, among other things, the existing lower beam photometry requirements so that ADB technology is permitted.

Second, it proposes requirements to ensure that ADB systems operate safely and do not glare other motorists. ADB systems provide an enhanced lower beam that provides more illumination than the currently-allowed lower beam. If ADB systems do not accurately detect other vehicles on the road and shade them accordingly, other motorists will be glared. NHTSA is sensitive to concerns about glare due to the numerous complaints from the public that it has received, the 2005 Congressional mandate, and its own research. The proposal addresses this safety need with a combination of vehicle-level track tests and equipment-level laboratory testing requirements.

The centerpiece of the proposal is a vehicle-level track test to evaluate ADB performance in recognizing and not glaring other vehicles. We propose evaluating ADB performance in a variety of different types of interactions with either an oncoming or preceding vehicle (referred to as a ''stimulus'' vehicle because it stimulates a response from the ADB system). The stimulus vehicle would be equipped with sensors near the driver's eyes (or rearview mirrors) to measure the illuminance from the ADB headlights. We propose a variety of different scenarios that vary the road geometry (straight or curved); vehicle speeds (from 0 to 70 mph); and vehicle orientation (whether the stimulus vehicle is oncoming or preceding). The illumination cast on the stimulus vehicle would be measured and recorded throughout the test run. In order to evaluate ADB performance, we are proposing a set of glare limits. These are numeric illuminance values that would be the maximum illuminance the ADB system would be permitted to cast on the stimulus vehicle. The proposed glare limits and test procedures are based on extensive Agency research and testing. NHTSA sponsored a study that developed the glare limits that are the objective performance criteria we are proposing. NHTSA also ran extensive track tests using vehicles equipped with ECE-approved ADB systems (modified to produce U.S.-compliant beams) to develop the test procedures and scenarios. The resulting performance requirements and test procedures are intended to ensure that an ADB system is capable of correctly detecting oncoming and preceding vehicles and not glaring them.

In addition to this track test, we also propose a limited set of equipment-level laboratory-tested performance requirements to regulate glare. We propose to require that the part of the adaptive beam that is cast near other vehicles not exceed the current low beam maxima, and the part of the adaptive beam that is cast onto unoccupied roadway not exceed the current upper beam maxima. These would essentially subject the ADB system to laboratory tests of the beam similar to what are currently required for headlights.

Third, it proposes a limited set of equipment-level laboratory-tested performance requirements to ensure that the ADB system provides sufficient visibility for the driver. The current headlamp requirements include minimum levels of illumination to ensure that the driver has a minimum level of visibility. We propose that these existing laboratory photometry tests be applied to the ADB system to ensure that the ADB beam pattern, although dynamically changing, always provides at least a minimum level of light. We propose requiring that the part of the adaptive beam that is cast near other vehicles comply with the current lower beam minima and that the part of the adaptive beam that is cast onto unoccupied roadway comply with the upper beam minima. These minimum levels of illuminance are in a direction such that they do not glare other motorists.

Regulatory Alternatives Considered: ECE Requirements and SAE J3069

NHTSA has considered a number of alternatives to this proposal. The main alternatives are the European requirements and the SAE recommended practice for ADB published in June 2016 (SAE J3069). This proposal incorporates elements of these standards, but departs from them in significant ways.

ECE Requirements

The Economic Commission for Europe (ECE) has permitted and regulated ADB under its type approval framework for several years. The ECE regulations have a variety of requirements that specifically apply to ADB. Many of these are equipment requirements that are not appropriate for a performance-oriented FMVSS. The ECE requirements also include a vehicle-level road test on public roads. The road test includes a variety of types of roads (*e.g.,* rural, urban) and types of interactions with other vehicles. The performance of the ADB system—with respect to both visibility and glare—is evaluated by the type approval engineer driving the ADB-equipped vehicle. A Federal Motor Vehicle Safety Standard is, however, statutorily required to be objective. The ECE road test is not appropriate for adoption as an FMVSS because it does not provide sufficiently objective performance criteria. The proposed track test scenarios are based, in part, on the ECE scenarios. The proposed glare limits are the objective criteria that we propose using to evaluate the performance of an ADB system as it is put through these maneuvers. In developing the proposal NHTSA tested several ADB-equipped vehicles that were type-approved to the ECE requirements. We believe that these ADB systems would able to meet the proposed requirements and test procedures.

SAE J3069

SAE published this recommended practice in June 2016, while NHTSA was developing this proposal, but after NHTSA had concluded the testing on which the proposal is based. The SAE standard is based, in part, on NHTSA's testing and research. SAE J3069 includes vehicle-level track testing as well as equipment-level laboratory testing requirements, although they differ from the proposal in important ways.

SAE J3069 sets out requirements and test procedures to evaluate ADB performance in recognizing and not glaring other vehicles. The major component of these is a vehicle-level track test for glare. The track test uses glare limits similar to (and based on) the ones developed by NHTSA. The track test, however, differs significantly from the proposed track test. The SAE test does not use actual vehicles to stimulate the ADB system, but instead uses test fixtures fitted with lamps that are intended to simulate oncoming and preceding vehicles. It also specifies a much smaller range of scenarios (for example, it only tests on straight roadway, not curves) and measures ADB illuminance only at a small number of specified distance intervals.

To test for glare SAE J3069 also includes, in addition to this track test, an equipment-level laboratory test requirement that the part of the adaptive beam directed towards an oncoming or preceding vehicle not exceed the lower beam photometric maxima. We propose a requirement very similar to this, but we also propose to require that the part of the adaptive beam directed towards unoccupied roadway not exceed the current upper beam maxima. Although this is not included in the SAE standard, we believe it is important to maintain the upper beam maxima because they too play a role in glare prevention.

To test for adequate visibility, SAE J3069 includes an equipment-level laboratory test requirement that the part of the adaptive beam directed towards unoccupied roadway comply with the lower beam minima. The proposed requirements are more stringent. They would require that this part of the adaptive beam comply with the current upper beam minima, not the lower beam minima. We believe this additional light is important. The proposal would also require that the part of the adaptive beam directed towards an oncoming or preceding vehicle meet the current lower beam minima. We believe this minimum level of illumination will ensure a minimum level of visibility (as explained above, we would also subject the dimmed portion of the adaptive beam to the lower beam maxima to ensure that the level of light is not so high as to glare other motorists).

II. Background and Safety Need

This proposal is intended to facilitate the introduction of an advanced headlighting technology referred to as adaptive driving beam (''ADB'') into vehicles sold in the United States. ADB technology is an advanced type of semiautomatic headlamp beam switching technology. More rudimentary beam switching technology was first introduced in the 1950s and was limited simply to switching between upper and lower beams. Adaptive driving beam technology is more advanced. It uses advanced sensors and computing technology that more accurately and precisely detect the presence and location of other vehicles and shape the headlamp beams to provide enhanced illumination of unoccupied portions of the road and avoid glaring other vehicles.

This proposal would amend the Federal safety standard for lighting to permit the certification of this advanced technology and specify performance requirements and compliance test procedures for these optional systems. The proposed requirements are intended to ensure that ADB systems operate safely by providing adequate visibility while not glaring oncoming or preceding vehicles. To understand what the new technology does and the proposed regulatory adjustments, it will be helpful first to provide some background on headlamp technology and NHTSA's headlamp regulations.

The Twin Safety Needs of Glare Prevention and Visibility

Vehicle headlamps must satisfy two different safety needs: Visibility and glare prevention. Headlamps provide forward visibility (and also work in conjunction with parking lamps on passenger cars and other narrow vehicles to provide conspicuity). They also have the potential to glare other motorists and road users. For this reason, headlighting systems include a lower beam and an upper beam. Lower beams (also referred to as passing beams or dipped beams) illuminate the road and its environs close ahead of the vehicle and are intended for use during low speed driving or when meeting or closely following another vehicle. Upper beams (also referred to as high beams, main beams, or driving beams) are intended primarily for distance illumination and for use when not meeting or closely following another vehicle. The lower beam pattern is designed to produce relatively high levels of light only in the close-in forward visibility region; the upper beam is designed to produce high light levels in close-in and longer distance regions. Thus, headlighting has traditionally entailed a trade-off between forward longer-distance visibility for the driver and glare to other road users.

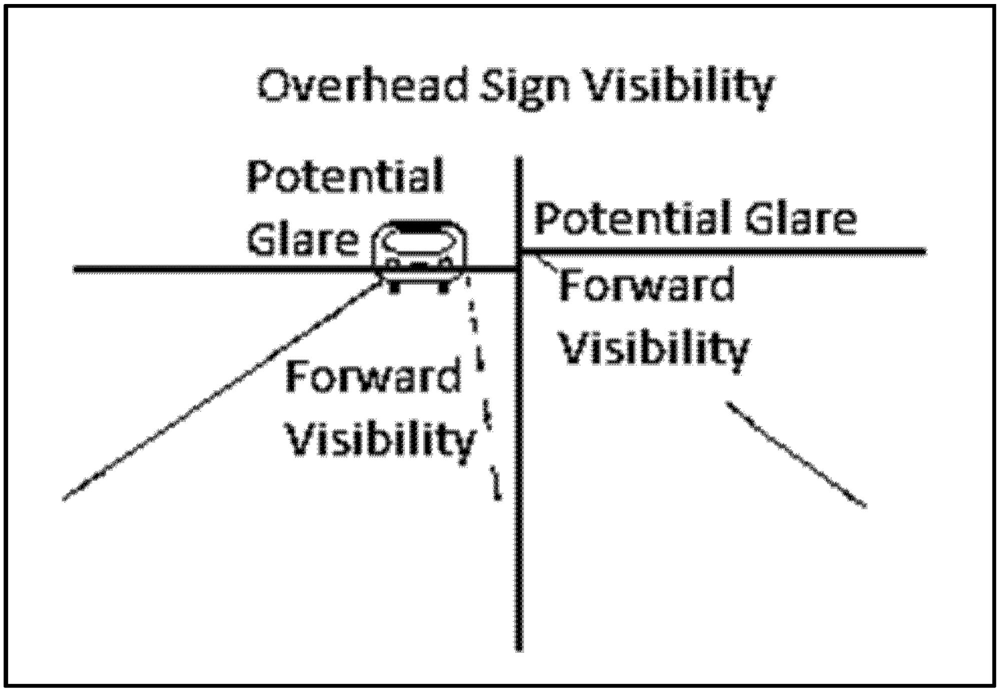

Figure 1.

Regions where one's own headlamps are likely to contribute to visibility and to glare to oncoming drivers.

Visibility and glare are both related to motor vehicle safety. Visibility has an obvious, intuitive relation to safety: The better a driver can see the road, the better he or she can react to road conditions and obstacles and avoid crashes. Although the qualitative connection to safety is intuitive, quantifying the effect of visibility on crash risk is difficult because of many confounding factors (for example, was the late-night crash because of diminished visibility or driver fatigue?). Glare, again intuitively, is related to safety because it degrades a driver's ability to see the forward roadway and any unexpected obstacles. Glare is a sensation caused by bright light in an observer's field of view. It reduces the ability to see and/or causes discomfort. Headlamp glare is the reduction in visibility and discomfort caused by viewing headlamps of oncoming or trailing vehicles (via the rearview or side mirrors).[1] Empirical evidence suggests that headlamp glare degrades important aspects of driving performance, such as decreasing the distance at which an object in or near the roadway can be seen, increasing driver reaction times, and reducing the probability a driver will detect an object.[2] It is difficult, however, to quantify the effect of glare on crash risk. Unlike drug or alcohol use, there is usually no way to determine precisely the amount of glare present in a crash. Nevertheless, some police crash reports mention glare as a potential cause, and it is reasonable to expect that reductions in visibility caused by headlamp glare increase crash risk.[3] Discomfort might also indirectly affect crash risk; for example, if a driver reacts to glare by changing her direction of gaze.[4] In addition to influencing safety, discomfort caused by glare may induce some drivers, particularly older drivers,

[1] *See generally* Nighttime Glare and Driving Performance, Report to Congress, p. ii (2007), National Highway Traffic Safety Administration, Department of Transportation [hereinafter ''2007 Report to Congress''].

[2] 2007 Report to Congress, pp. iv, 11–14. *See also, e.g.,* John D. Bullough *et al.* 2003. An Investigation of Headlamp Glare: Intensity, Spectrum and Size, DOT HS 809 672. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration [hereinafter ''Investigation of Headlamp Glare''], p. 1 (''It is almost always the case that headlamp glare reduces visual performance under driving conditions relative to the level of performance achievable without glare.'').

[3] John D. Bullough *et al.* 2008. Nighttime Glare and Driving Performance: Research Findings, DOT HS 811 043. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, p. I–4.

[4] *Id.,* p. 33. *But see* Investigation of Headlamp Glare, p. 3 (''Very few studies have probed the interactions between discomfort and disability glare, or indeed any driving-performance related factors . . . .'').

to avoid driving at night or simply increase annoyance.[5]

The potential problems associated with glare are highlighted by the thousands of complaints NHTSA has received from the public on the issue. The introduction of halogen headlamp technology in the late 1970s and high-intensity discharge and auxiliary headlamps in the 1990s was accompanied by a marked upswing in the number of glare complaints to NHTSA. In response to increased consumer complaints about glare in the late 1990s, NHTSA published a Request for Comments in 2001 on issues related to glare from headlamps, fog lamps, driving lamps, and auxiliary headlamps.[6] NHTSA received more than 5,000 comments, most of which concerned nighttime glare from front-mounted lamps.[7]

This proposal is intended to enable the adoption of ADB and help ensure that ADB systems meet these twin safety needs of glare prevention and visibility.

Headlamp Photometric Requirements

NHTSA is authorized to issue FMVSS that set performance requirements for new motor vehicles and new items of motor vehicle equipment. Each FMVSS specifies performance requirements and test procedures the Agency will use to conduct compliance testing to confirm performance requirements are met. Motor vehicle and equipment manufacturers are required to self-certify that their products conform to all applicable FMVSS. FMVSS No. 108 specifies performance and equipment requirements for vehicle lighting, including headlamps. The standard requires, among other things, that vehicles be equipped with lower and upper beams as well as a means for switching between the two. Three aspects of these requirements are especially relevant to this proposal.

First, the standard sets out requirements for the beam performance (beam pattern) of the lower and upper beam. These requirements, referred to as photometric requirements, consist of sets of test points and corresponding criterion values. Each test point is defined with respect to an angular coordinate system relative to the headlamp. (As discussed in more detail below, these requirements are for an individual headlamp, not for an entire headlighting system as installed on a vehicle.) For each test point, the standard specifies the minimum amount of photometric intensity the headlamp must provide in the direction of that test point or the maximum level of intensity the headlamp may provide toward the test point, or both. There are different photometric requirements for lower beams and upper beams.[8]

Different test points regulate different aspects of headlamp performance. With respect to the lower beam, some test points ensure the beam is providing enough visibility of the roadway; other test points ensure the beam does not glare oncoming or preceding drivers; and other test points ensure there is illumination of overhead signs. The upper beam photometric test points primarily (but not exclusively) consist of minima, and ensure sufficient light is cast far down the road. The lower beam test points consist of both minima and maxima, resulting in a beam pattern providing more illumination to the right of the vehicle centerline and less illumination to the left side of the vehicle centerline and much less light above the horizon (roughly in the area of the beam pattern an oncoming vehicle would be exposed to). The lower beam test points controlling the amount of light cast on other vehicles are test points regulating glare. This rulemaking is related to and based on the current lower and upper beam photometric test points, especially the lower beam photometric test points limiting glare to oncoming and preceding drivers.

Second, the photometric requirements, and the requirements in FMVSS No. 108 generally, are requirements for equipment, not for vehicles. There are two basic types of Federal Motor Vehicle Safety Standards: Those establishing minimum performance levels for motor vehicles, and those establishing levels for individual items of motor vehicle equipment. An example of the former is Standard No. 208, Occupant Crash Protection. That standard requires that vehicles be equipped with specific occupant protection equipment (such as seat belts or air bags) and certified as being able to pass specified whole-vehicle tests (such as a frontal crash test). FMVSS No. 108, on the other hand, is largely an equipment standard. It uses a two-step process to regulate vehicle lighting. It requires vehicle lighting equipment be manufactured to conform to its requirements (such as the headlamp photometry requirements), whether used as original or replacement equipment. These requirements are, for the most part, independent of the vehicle; they regulate lamps as individual components, not as installed on a vehicle. It also requires lamps be placed within designated bounds on a motor vehicle. Thus, except for the type, number, activation, and location of lighting, FMVSS No. 108 primarily regulates lighting as equipment independent of the vehicle. The proposed glare limits and vehicle-level track test to evaluate ADB performance in recognizing and not glaring oncoming and preceding vehicles differ from the existing photometry requirements because they are vehicle-level—not equipment-level—requirements.

Third, compliance testing for conformance to the current photometry requirements is, for the most part, conducted in a laboratory. Photometry testing is performed under strictly controlled conditions in a darkened laboratory using highly accurate light measurement sensors. The headlamp being tested is placed in a specialized fixture, and the light sensor is used to measure the amount of light at each of the photometric test points to determine whether the headlamp complies with the photometric requirement(s) for that test point. The proposed vehicle-level track test to evaluate ADB performance differs from this traditional testing because it is track-based, not laboratory-based.

Regulatory History and Research Efforts Related to Glare

FMVSS No. 108 has included photometry requirements since the inception of the standard in 1967. The standard initially adopted SAE[9] photometry requirements.[10] Since then, NHTSA has made some adjustments to the photometry requirements. For example, the requirements were amended to permit brighter upper beams[11] and to include photometric test points for overhead retroreflective signs.[12] In addition, in the mid and late 1980s, NHTSA began to explore the possibility of making FMVSS No. 108 more of a vehicle standard.[13] NHTSA began developing vehicle-level headlamp photometric specifications based on the geometry of roadways, an analysis of crash data, and the driver's ability to see.[14] The Agency then issued an NPRM to amend the headlamp

[5] 2007 Report to Congress, p. iv.

[6] 66 FR 49594 (Sept. 28, 2001).

[7] 69 FR 54255 (Sept. 8, 2004).

[8] The upper beam photometric requirements are set out in Table XVIII; the lower beam photometric requirements are set out in Table XIX.

[9] The Society of Automotive Engineers (now SAE International). SAE is an organization that develops technical standards based on best practices.

[10] *See* 54 FR 20066 (May 9, 1989) (explaining history of photometric requirements).

[11] 43 FR 32416 (July 27, 1978).

[12] 58 FR 3856 (Jan. 12, 1993).

[13] 50 FR 42735 (Oct. 22, 1985) (Request for Comments).

[14] 52 FR 30393 (Aug. 14, 1987) (Request for Comments).

requirements to make them more performance-oriented.[15] That rulemaking was terminated several years later because the technical complexities proved too difficult to surmount at that time.

NHTSA has also, at various times, taken steps to address problems and consumer complaints related to glare.[16] In the 1970s, NHTSA began research in response to consumer suggestions that vehicles should have a lower-intensity third beam for driving in well-lit areas. In the 1990s, NHTSA issued a final rule to address headlamp misaim, which is an important factor in the cause of glare.[17] In 2001, NHTSA published a Request for Comments concerning issues related to glare from headlamps, fog lamps, driving lamps, and auxiliary headlamps.[18] We observed that ''auxiliary lamps are now becoming a source of complaint for glare. Often described as another set of headlamps, sometimes mounted lower, the public reports that these lamps seem to be used all the time at night. This documented misuse of fog lamps in particular helps substantiate the complaints that NHTSA has been receiving. NHTSA has received complaints about fog lamp use for a while, but never so many as recently.'' [19] NHTSA received more than 5,000 comments in response to the 2001 notice, most of which expressed concerns about glare. In 2005 Congress directed the Department of Transportation to conduct a study of the risks associated with glare to oncoming vehicles.[20] NHTSA also issued a variety of interpretation letters concerning the permissibility of various frontal lighting concepts. Generally, NHTSA allowed low-illuminance supplementary frontal lighting such as fog lamps, but found, in at least some instances, that higher-power frontal lamps were not permitted. These interpretations are discussed in detail in Section VI below which sets out NHTSA's tentative interpretation of how FMVSS No. 108 applies to ADB.

In response to the many complaints from the public about glare and the Congressional mandate to study the risks of glare, NHTSA initiated a multipronged research program to examine the reasons for the complaints as well as possible solutions. This effort culminated in several detailed Agency reports. For example, to better understand the complaints, NHTSA conducted a survey of U.S. drivers.[21] The results showed that while, for a majority of respondents (about 54%) glare was ''noticeable but acceptable,'' a sizeable number of drivers (about 30%) rated glare as ''disturbing.'' In 2003 NHTSA published a request for comments to learn more about advanced headlighting systems that can actively change the intensity and duration of headlamp illumination (these systems were precursors of ADB technology) to evaluate whether such systems would contribute to glare.[22] In 2007, NHTSA submitted a report on glare to Congress.[23] In addition, NHTSA conducted multiple studies, using field measurements, laboratory tests, computer analyses, and vehicle tests to examine the effects of different headlamp factors on driver performance.[24]

After these efforts concluded, NHTSA has continued in recent years to study the possibilities offered by advanced frontal lighting, including its potential to reduce glare. Two recent NHTSA research studies form the basis for this proposal. In 2012, the Agency published a study (''Feasibility Study'') [25] exploring the feasibility of new approaches to regulating vehicle lighting performance, including headlamp photometry. Among other things, the study presented vehicle-based headlamp photometry requirements derived from the current requirements in Tables XVIII (upper beam) and XIX (lower beam). This included vehicle-based photometry requirements to ensure that other vehicles are not glared. NHTSA built on this effort by developing a vehicle-level track test to evaluate whether an ADB system complies with the derived photometry requirements for glare prevention (''ADB Test Report'').[26] This research was necessary because, among other things, the current photometry requirements are equipment-based requirements that involve laboratory testing, not vehicle-based requirements tested on a track. Both of these research efforts are discussed in more detail in Section IV below.

Adaptive Driving Beam Technology, Toyota Petition for Rulemaking, and SAE J3069

The last several years have seen the development of ADB headlamps in other parts of the world, including Europe. Adaptive driving beam is a ''long-range forward visibility light beam[ ] that adapts to the presence of opposing and preceding vehicles by modifying portions of the projected light in order to reduce glare to the drivers/riders of opposing and preceding vehicles.'' [27] It therefore has the potential to improve long-range visibility for the driver without glaring other road users.

ADB systems utilize advanced equipment, including sensors (such as cameras), data processing software, and headlamp hardware (such as shutters or LED arrays). ADB systems detect and identify illumination from the headlamps of oncoming vehicles and the taillamps of preceding vehicles. The system uses this information to automatically adjust the headlamp beams to provide less light to areas of the roadway occupied by other vehicles and more light to unoccupied portions of the road. ADB systems typically use the existing front headlamps with modifications that either implement a mechanical shade rotating in front of the headlamp beam to block part of the beam, or extinguish individual LEDs in headlamps using arrays of light source systems (*e.g.,* LED matrix systems). The portion of the beam directed to portions of the roadway occupied by other vehicles is at or even below levels of a traditional lower beam.[28] The portion of the beam directed at unoccupied portions of the road is typically equivalent to existing upper beams. The ADB systems NHTSA tested required that the driver manually select ADB mode using the headlighting system control and were designed to activate only at speeds above typical city driving speeds (about 20 mph).

ADB systems may be viewed as an advanced type of semiautomatic headlamp beam switching device (which is explicitly permitted as a compliance option in FMVSS No.

[15] 54 FR 20084 (May 9, 1989).

[16] *See generally* 66 FR 49594, 49596 (Sept. 28, 2001).

[17] 62 FR 10710 (Mar. 10, 1997).

[18] 66 FR 49594.

[19] 66 FR 49601.

[20] Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, Public Law 109–59, Sec. 2015 (2005).

[21] Perel & Singh. 2004. Drivers' Perceptions of Headlamp Glare from Oncoming and Following Vehicles, DOT HS 809 669. Washington, DC: National Highway Traffic Safety Administration.

[22] 68 FR 7101 (Feb. 12, 2003); 70 FR 40974 (July 15, 2005) (withdrawn).

[23] *See supra,* note 1.

[24] *See generally* Summary of Headlamp Research at NHTSA, DOT HS 811 006. Washington, DC: National Highway Traffic Safety Administration (2008).

[25] 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. *See also* 77 FR 40843 (July 11, 2012) (request for comments on the report).

[26] Elizabeth Mazzae, G.H. Scott Baldwin, Adam Andrella, & Larry A. Smith. 2015. Adaptive Driving Beam Headlighting System Glare Assessment, DOT HS 812 174. Washington, DC: National Highway Traffic Safety Administration.

[27] SAE J3069 JUN2016, Sec. 3.1.

[28] SAE J3069JUN 2016, pp. 1–2.

108 [29]). Semiautomatic beam switching was first introduced in vehicles in the 1950s, and while not initially widely adopted, in recent years it has become widely offered as optional equipment. Traditional semiautomatic beam switching headlamps switch automatically from upper beam to lower beam when meeting other vehicles. Unlike ADB, however, traditional semiautomatic beam switching headlamps are not able to vary the lower beam pattern to fit the traffic on the road; they are only able to produce a single lower beam pattern.

ADB technology enhances safety in two ways. First, it provides a variable, enhanced lower beam pattern that is sculpted to traffic on the road, rather than just the one static lower beam pattern. It is thus able to provide more illumination than existing lower beams. And it does this, if operating correctly, without glaring other motorists. Second, it likely will lead to increased, appropriate, upper beam usage (in situations where other vehicles will not be glared). Research has shown that most drivers under-utilize the upper beams. ''[A]bundant evidence suggests that most drivers use lower beams primarily, if not exclusively.'' [30] Unfortunately, ''driving with lower-beam headlamps can result in insufficient visibility for a number of driving situations,'' [31] particularly at higher speeds, because at higher speeds the need for greater seeing distance increases.[32] ADB technology (like traditional beam switching technology) enables the driver to activate the ADB system so that it is always in use, obviating the need to switch between lower and upper beams. In this way, the upper beam will be more widely used, and used only when there are no other vehicles present. For both these reasons, ADB has the potential to reduce the risk of crashes by increasing visibility without increasing glare. Although isolating the effect of visibility on nighttime crash risk is difficult because of many confounding factors, there is evidence suggesting diminished visibility likely increases the risk of crashes, particularly the risk of pedestrian crashes at higher speeds, as well as crashes involving animals, trains, and parked cars.[33]

ADB was first permitted in Europe by an amendment to R48 and R123 of the Economic Commission for Europe (''ECE''). Since then vehicle manufacturers have provided ADB systems in select vehicle lines sold in Europe. For instance, the 2017 Volkswagen Passat was available in Europe equipped with an ADB system. Audi has been installing ADB on a variety of Audi models and has sold (as of the end of 2016) approximately 123,000 vehicles with ADB across 55 different markets outside the United States.[34] Additional world regions adopting ECE regulations also permit ADB.

ECE lighting requirements permit adaptive driving beam systems under the umbrella of adaptive front lighting systems, including lighting devices type-approved according to ECE R123. These systems provide beams with differing characteristics for automatic adaptation to varying conditions of use of dipped-beam (lower beam) and if it applies, the main-beam (upper beam). ECE installation requirements for ADB systems take advantage of the type-approval framework used throughout ECE standards to test whole vehicles within traffic to verify performance. The system is evaluated subjectively through observations made by the type-approval technician during a test drive consisting of various driving situations.

The automotive industry has also recently developed a recommended practice for ADB technology. In June 2016, SAE adopted SAE J3069 JUN2016, Surface Vehicle Recommended Practice; Adaptive Driving Beam (''SAE J3069''). The standard, which is based, in part, on NHTSA's Feasibility Study, specifies a track test to evaluate the performance of ADB, as well as a variety of other requirements.

Although ADB has been deployed in Europe on a limited basis, it has not yet been deployed in the United States. This is largely because of industry uncertainty about whether FMVSS No. 108 allows ADB systems.[35] NHTSA has not, until this NPRM, issued an interpretation of whether and how FMVSS No. 108 applies to ADB. In 2013, Toyota petitioned NHTSA for rulemaking to amend FMVSS No. 108 to permit manufacturers the option of equipping vehicles with ADB systems.[36] In its petition, Toyota described how its system works, identified the potential safety benefits of the system, and discussed its view of how ADB should be treated under the Agency's regulations. In this NPRM, NHTSA sets out its tentative interpretation that the existing FMVSS No. 108 prohibits ADB, while, at the same time, granting and acting on Toyota's petition to amend the standard to allow for this technology and ensure that it meets the safety needs of glare prevention and visibility.

III. ECE ADB Regulations

ECE regulations allow ADB systems under the umbrella of adaptive front lighting systems (''AFS'') under Regulation 48.[37] There are a variety of requirements for AFS generally and adaptive lighting in particular. Unlike the FMVSS, which rely on manufacturer self-certification, ECE requirements for ADB systems utilize the type approval framework used throughout the ECE standards. Under the type approval framework, production samples of new model cars must be approved by regulators before being offered for sale. This approval is based, in part, on testing whole vehicles on public roadways to verify performance. The ECE requirements specify that the adaptation of the main-beam not cause any discomfort, distraction or glare to the driver of the ADB-equipped vehicle or to oncoming and preceding vehicles. This is demonstrated through the technical service performing a test drive

[29] S9.4.1.

[30] John D. Bullough, Nicholas P. Skinner, Yukio Akashi, & John Van Derlofske. 2008. Investigation of Safety-Based Advanced Forward-Lighting Concepts to Reduce Glare, DOT HS 811 033. Washington, DC: National Highway Traffic Safety Administration, p. 63. *See also, e.g.,* Mary Lynn Mefford, Michael J. Flannagan & Scott E. Bogard. 2006. Real-World Use of High-Beam Headlamps, UMTRI–2006–11. University of Michigan, Transportation Research Institute, p. 6 (finding that ''high-beam headlamp use is low . . . consistent with previous studies that used different methods'').

[31] Investigation of Safety-Based Advanced Forward-Lighting Concepts to Reduce Glare, DOT HS 811 033, p. 63.

[32] 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, p. 2.

[33] 2007 Report to Congress, p. 6. A recent study by the Insurance Institute for Highway Safety noted that ''[t]wenty-nine percent of all fatalities during 2014 occurred in the dark on unlit roads. Although factors such as alcohol impairment and fatigue contributed to many of these crashes, poor visibility likely also played a role.'' Ian J. Reagan, Matthew L. Brumbelow & Michael J. Flannagan. 2016. The Effects of Rurality, Proximity of Other Traffic, and Roadway Curvature on High Beam Headlamp Use Rates. Insurance Institute for Highway Safety, pp. 2–3 (citations omitted). *See also* Feasibility Study, p. 5 (''The conclusion of our analysis was that pedestrian crashes were by far the most prevalent type of crash that could in principle be addressed by headlighting.''). See Appendix A for an analysis that roughly estimates the target population that could benefit from ADB technology.

[34] Letter from Thomas Zorn, Volkswagen Group of America to Dr. Mark Rosekind, Administrator, NHTSA, Petition for Temporary Exemption from FMVSS 108 (October 10, 2016), pp. 1, 7.

[35] *See, e.g.,* SAE J3069 (''However, in the United States it is unclear how ADB would be treated under the current Federal Motor Vehicle Safety Standard (FMVSS) 108.'').

[36] Letter from Tom Stricker, Toyota Motor North America, Inc. to David Strickland (Mar. 29, 2013).

[37] Regulation 48 defines AFS as ''a lighting device type-approved according to Regulation No. 123, providing beams with differing characteristics for automatic adaptation to varying conditions of use of the dipped-beam (passing-beam) and, if it applies, the main-beam (driving-beam).''

on various types of roads (*e.g.,* urban, multi-lane roads, and country roads), at a variety of speeds, and in a variety of specified traffic conditions.[38] The performance of the ADB system is evaluated based on the subjective observations of the type approval engineer during this test drive.

IV. NHTSA Research Related to ADB

There are two components to NHTSA's ADB-related research—the 2012 Feasibility Study and the 2015 ADB Test report. This research develops objective criteria and test procedures to evaluate whether an ADB system glares oncoming or preceding vehicles.

The Feasibility Study derives vehicle-based photometric requirements to control glare from the current equipment-based photometric test points in FMVSS No. 108. As explained above, the existing lower-beam photometry requirements regulate glare by specifying the maximum intensity of light permitted at certain specified portions of the lower beam that are directed towards oncoming or preceding vehicles. These requirements are set out in Table XIX of FMVSS No. 108. Four of these test points regulate headlamp glare.[39] Two of these test points correspond to locations of oncoming vehicles (*i.e.,* to the left of the lamp and slightly above horizontal),[40] and two correspond to glare to preceding vehicles (*i.e.,* to the right of the lamp and slightly above horizontal).[41] Table XIX specifies the maximum intensity of light that may be emitted in these directions. So, for example, a lower beam may not provide more than 1,000 candela[42] (cd) at 0.5 degrees up, and 1.5 degrees to the left. These photometric requirements are for an individual headlamp (as a piece of equipment, and tested in a laboratory), not for a headlighting system as installed on a vehicle.

The Feasibility Study translates these equipment requirements into vehicle-based photometric requirements for an entire headlighting system by translating them into three-dimensional space around a vehicle (picture a cloud of points in front of the vehicle). It derives groups of test points to control glare to oncoming and preceding drivers. These test points correspond to where an oncoming or preceding vehicle would be on the road in relation to the vehicle. For each of these points there is a maximum illuminance[43] level—a level of light that should not be exceeded. The maximum allowed illuminance level depends on how far in front of the vehicle the test point is. That is, the Feasibility Study derives the maximum amount of light that should be directed toward an oncoming or preceding vehicle, based on how far the oncoming or preceding vehicle is from the ADB-equipped vehicle (''derived glare limits''). Additional details on this derivation can be found in the Feasibility Study.

NHTSA conducted testing and research to develop an objective and repeatable performance test to evaluate whether an ADB system exceeds the derived glare limits. The testing was based on the ECE R48 test drive scenarios and the derived glare limits.

We evaluated and refined a range of test track scenarios based on the ECE test drive specifications. These included a variety of types of roadway geometry (*e.g.,* curved, straight, winding), and maneuver scenarios (*e.g.,* encountering an oncoming vehicle, or passing a preceding vehicle). We ran the tests on a closed test track with three types of ''stimulus'' vehicles (the vehicle that was used to interact with the ADB-equipped vehicle and stimulate the adaptive driving beam): A large stimulus vehicle, a small stimulus vehicle, and a motorcycle. Scenarios varied the speed of both the ADB-equipped vehicle and the stimulus vehicle (anywhere from stationary to 67 mph).

We also developed methods and procedures to objectively assess ADB system performance on these test track drives. As noted above, ADB performance on the ECE test drive is evaluated based on the subjective observations of the type approval engineer. NHTSA's statute requires, however, that an FMVSS be objective. To objectively measure the amount of light cast on oncoming and preceding vehicles by the ADB-equipped vehicle, the stimulus vehicle was equipped with photometers[44] mounted at locations where light from the ADB headlamps could glare the driver of the stimulus vehicle—for example, on an outside rear view mirror, or in front of the windshield near the driver's eyes.[45] The ADB-equipped vehicle and one or more of the stimulus vehicles were then run through the various driving scenarios on closed courses at a vehicle testing facility. During these test runs illuminance data from the photometers was recorded as was position data for vehicles. A variety of adjustments were made to the illuminance and position data (for example, the recorded illuminance values were adjusted to account for ambient light).

To evaluate the performance of the ADB system, NHTSA used simplified versions of the derived glare limits reported in the Feasibility Study. This resulted in two sets of glare limits: One set for glare to oncoming vehicles and one set for glare to preceding vehicles. The glare limits are specified with respect to the distance between the ADB-equipped vehicle and either the oncoming or preceding stimulus vehicle (see Table 1 and Table 2). The specified glare limit is the maximum amount of light that may be cast on an oncoming or preceding vehicle within that distance interval. The recorded illuminance values were compared with the derived glare limit corresponding to the distance at which the illuminance value was recorded. If the recorded illuminance value exceeded the derived glare limit, this was considered a test failure.

TABLE 1—LIMITS FOR GLARE TO ONCOMING VEHICLES

Range from headlamp to photometer (m)	Maximum illuminance (lux)
15.0–29.9	3.1
30.0–59.9	1.8
60.0–119.9	0.6
120.0–239.9	0.3

TABLE 2—LIMITS FOR GLARE TO PRECEDING VEHICLES

Range from headlamp to photometer (m)	Maximum illuminance (lux)
15.0–29.9	18.9
30.0–59.9	18.9
60.0–119.9	4.0
120.0–239.9	4.0

[38] *See* Annex 12 to ECE R48.

[39] More specifically, they regulate glare that comes directly from the headlamps (as opposed to headlamp glare that reflects off of, say, the road surface).

[40] 1U, 1.5L to L (700 cd maximum); 0.5U, 1.5L to L (1,000 cd maximum).

[41] 1.5U, 1R to R (1,400 cd maximum); 0.5U, 1R to 3R (2,700 cd maximum).

[42] Candela is a unit of measurement of luminous intensity. Candela is a measure of the amount of light coming from a source per unit solid angle.

[43] Illuminance is the amount of light falling on a surface. The unit of measurement for illuminance is lux. Lux is a unit measurement of illuminance describing the amount of light falling on a surface, whereas candela is a measure of the luminous intensity produced by a light source in a particular direction per solid angle. A measure of luminous intensity in candela can be converted to a lux equivalent, given a specified distance.

[44] A photometer, or illuminance meter, is an instrument that measures light.

[45] The motorcycle was not fitted with photometers because of time constraints and equipment availability. Illuminance receptors were located on a vehicle positioned adjacent to the motorcycle; this vehicle's lamps remained off to ensure that the ADB-equipped vehicle was responding only to the motorcycle's lamps.

We tested four different ADB-equipped vehicles that were approved and sold in Europe: A MY 2014 Audi A8 equipped with MatrixBeam; a MY 2014 BMW X5 xDrive35i equipped with Adaptive High-Beam Assist; a MY 2014 Lexus LS460 F Sport equipped with Adaptive High-Beam System; and a MY 2014 Mercedes-Benz E350 equipped with Adaptive Highbeam Assist. The beam patterns on the Audi and Mercedes headlamps were FMVSS No. 108-compliant. Activation speeds for these ADB systems ranged from 19 to 43 mph.[46] The Agency analyzed the research in a variety of ways, including assessments for repeatability.

In these tests, ADB appeared to provide noticeable additional roadway illumination. ADB adaptation was more apparent in some vehicles than others. However, in many cases ADB did not succeed in maintaining glare in the location of other vehicles to lower beam levels. Generally, the Agency's testing suggested that when an ADB system has a long preview of another vehicle, ADB can perform well. When an ADB system does not have a long preview of another vehicle, such as in an intersection scenario or when two vehicles are oncoming on a curved road, ADB may not adapt its beam pattern quickly enough. Additionally, some ADB system behaviors that were not expected and uncharacteristic of ADB's stated purpose were observed, such as instances of momentary engagement of the upper beam or interpreting a reflective roadside sign to be another vehicle and suddenly darkening the forward roadway. Because this research evaluated ADB systems installed on MY 2014 vehicles, current ADB systems may be capable of better performance.

The Agency's test report made a number of observations based on its analysis of the testing data. Here, the Agency notes several. First, testing confirmed the validity of the derived glare limits. For example, the illuminance of the lower beams of the ADB systems equipped with an FMVSS No. 108-compliant lower beam was within the glare limits when measured on the test track with the vehicle stationary. Second, the research demonstrated that achieving a valid whole-vehicle test procedure for assessing ADB headlighting system performance with respect to relevant performance criteria is technically feasible. The results showed that making such measurements outdoors in variable ambient illumination conditions can be performed in a valid way, by removing the measured ambient illumination from the recorded headlighting system test trial data. For example, ADB response timing seemed consistent across trials. Scenarios involving the stimulus vehicle and ADB-equipped vehicle driving toward each other showed ADB adaptation occurring at closer range between vehicles than would be seen if the stimulus vehicle is stationary because of the ADB response timing. Third, the testing showed that this whole-vehicle test procedure could be accomplished in a repeatable manner. Specific testing results are discussed in more detail in the docketed test report and data and in subsequent sections of this preamble. Repeatability is discussed in more detail in Section VIII.c.

[46] ADB Test Report, p. 20.

V. SAE J3069

In 2016, SAE published a standard for adaptive driving beam systems, SAE J3069 JUN 2016, Adaptive Driving Beam. The standard specifies a road test to determine whether an ADB system glares oncoming or preceding vehicles. The standard specifies, as performance criteria, glare limits based on and similar but not identical to the glare limits used in the ADB Test Report (See Table 3).

SAE J3069 specifies a straight test track with a single lane 155 m long. On either side of this test lane, the standard specifies the placement of test fixtures simulating an opposing or preceding vehicle. The test fixtures are fitted with lamps having a specified brightness, color, and size similar to the taillamps and headlamps on a typical car, truck, or motorcycle. The standard specifies four test fixtures: An opposing car/truck; an opposing motorcycle; a preceding car/truck; and a preceding motorcycle. In addition to simulated vehicle lighting, the test fixtures are fitted with photometers to measure the illumination from the ADB headlamps.

The standard specifies a total of eighteen different test drive scenarios. The scenarios vary the test fixture used, the placement of the fixture (*i.e.,* to the right or left of the lane in which the ADB-equipped vehicle is travelling), and whether the lamps on the test fixture are illuminated for the entire test drive, or are instead suddenly illuminated when the ADB vehicle is close to the test fixture. During each of these test runs, the illuminance recorded at 30 m, 60 m, 120 m, and 155 m must not exceed the specified glare limits. If there is no recorded illuminance value at any of these distances, interpolation is used to estimate the illuminance at that distance. For sudden appearance tests, the system is given a maximum of 2.5 seconds to react and adjust the beam. If any recorded (or interpolated) illuminance value exceeds the applicable glare limit, the standard provides for an allowance: The same test drive scenario is run, except now only the lower beam is activated. The ADB system can still be deemed to have passed the test as long as any of the ADB exceedances do not exceed 125% of the measured (or interpolated) illuminance value(s) for the lower beam.

TABLE 3—SAE J3069 GLARE LIMITS

Range from headlamp to photometer (m)	Maximum illuminance, oncoming (lux)	Maximum illuminance, preceding (lux)
30	1.8	18.9
60	0.7	8.9
120	0.3	4.0
155	0.3	4.0

In addition to the dynamic track test, the standard contains a number of other system requirements, such as physical test requirements and requirements for the telltale. It also requires the system to comply with certain aspects of existing standards for lower and upper beam photometry as measured statically in a laboratory environment (for example, for the portion of the ADB beam that is directed at areas of the roadway unoccupied by other vehicles, the lower beam minimum values specified in the relevant SAE standard must be met).

In the Proposal and Regulatory Alternatives sections of this document we discuss specific provisions of SAE J3069 in more detail.

VI. Interpretation of How FMVSS No. 108 Applies to ADB

NHTSA has never squarely addressed whether ADB technology is permitted under existing FMSS No. 108 requirements. Here we address this issue and consider requirements in FMVSS No. 108 that could pose regulatory obstacles to the introduction of ADB in the United States. We first consider whether ADB technology would be permissible under FMVSS No. 108 as supplemental lighting and conclude it is not supplemental lighting. We then consider whether an ADB system would comply with the current FMVSS No. 108 requirements for headlights. As we explain below, ADB would likely not comply with at least some of these requirements, particularly the photometry and semiautomatic beam switching device requirements. We tentatively conclude that FMVSS No. 108 currently would not permit the installation of ADB on motor vehicles.

a. ADB Is Not Supplemental Lighting But Is Part of the Required Headlamp System

The threshold issue is whether an ADB system is supplemental or required lighting. FMVSS No. 108 specifies, for each class of vehicle, certain required and optional (if-equipped) lighting elements. The standard sets out various performance requirements for the required and optional lighting elements. The standard also allows vehicles to be equipped with lighting not otherwise regulated as required or optional equipment. This type of lighting equipment is referred to as supplemental or auxiliary lighting. Supplemental lighting is permitted if it does not impair the effectiveness of lighting equipment required by the standard.[47] There are two different but related reasons leading us to tentatively conclude that an ADB system is not supplemental lighting.

First, ADB systems are not supplemental lighting because they fit the definition of ''semiautomatic beam switching device,'' a headlighting device that is specifically regulated by the standard. FMVSS No. 108 requires that vehicles be equipped with a headlamp switching device that provides ''a means of switching between lower and upper beams designed and located so that it may be operated conveniently by a simple movement of the driver's hand or foot.'' [48] As an alternative to this requirement, the standard allows a vehicle to be equipped with a semiautomatic means of switching between the lower and upper beams.[49] The standard defines ''semiautomatic headlamp beam switching device'' as ''one which provides either automatic or manual control of beam switching at the option of the driver. When the control is automatic the headlamps switch from the upper beam to the lower beam when illuminated by the headlamps on an approaching vehicle and switch back to the upper beam when the road ahead is dark. When the control is manual, the driver may obtain either beam manually regardless of the conditions ahead of the vehicle.'' [50]

We have tentatively concluded that an ADB system is a semiautomatic beam switching device under FMVSS No. 108 because an ADB system automatically switches between an upper beam and a lower beam. An upper beam is defined in the standard as ''a beam intended primarily for distance illumination and for use when not meeting or closely following other vehicles.'' [51] A lower beam is defined as ''a beam intended to illuminate the road and its environs ahead of the vehicle when meeting or closely following another vehicle.'' [52] The beam an ADB system emits when there are no preceding or oncoming vehicles is the upper beam; the beam it emits when there are preceding or oncoming vehicles is a lower beam.[53] ADB technology differs from standard headlighting technology in that it can provide a variety of lower beam patterns tailored to fit the particular traffic situation it is confronted with. For ease of reference, we will refer to the ''base'' lower beam as the lower beam pattern produced by the ADB system that is the same as the lower beam the headlighting system would produce if it were not ADB-equipped, and the ''augmented'' lower beam as the enhanced lower beam with which the system illuminates the roadway when at least some portion(s) of the forward roadway is unoccupied by other vehicles. If the forward roadway is sufficiently occupied by other vehicles (either oncoming or preceding) so there is no portion of the roadway that could be illuminated with additional light without glaring other vehicles, the ADB system produces a base lower beam; if the forward roadway is at least partially unoccupied, the system produces an augmented lower beam, in which at least some portions of the beam pattern are brighter than the corresponding portions in the pattern of the base lower beam. An ADB system can provide a variety of different augmented lower beam patterns, depending on the traffic situation. However, each of these augmented beams is, by definition, a lower beam. Because an ADB system provides either automatic or manual control of beam switching at the option of the driver, and, when the control is automatic the headlamps switch between an upper beam and a lower beam, it is a semiautomatic headlamp beam switching device. The standard has specific requirements for semiautomatic beam switching devices (we discuss these requirements in more detail below and in the Proposal section of this document). Because ADB is regulated by these requirements, it is not supplemental lighting.

Second, ADB is not supplemental lighting under NHTSA's interpretation of the term ''supplemental lighting.'' FMVSS No. 108 requires vehicles to be equipped with one of several permissible headlighting systems, whose specifications are set forth in the standard. Headlighting systems are comprised of headlamps and associated hardware. The purpose of headlighting is primarily to provide forward illumination.[54] In determining whether lighting equipment providing forward illumination is supplemental or required, NHTSA looks at several factors: (1) Where the lamp directs its light; (2) whether it uses a headlamp replaceable light source to emit a beam that provides significantly more light flux than supplemental cornering lamps or fog lamps designed to conform to applicable SAE standards; (3) whether the lamp is intended to be used regularly or is limited (as are fog lamps) to more narrow driving conditions and situations; and (4) whether there is a manual on/off switch.[55] For example, in a 2004 interpretation letter, NHTSA used these factors to evaluate a swiveling lamp included as part of a vehicle front lighting system meeting the FMVSS No. 108 requirements without the lamp. The lamp was designed to automatically enhance forward illumination around corners and through curves to improve a driver's ability to see pedestrians, bicycles, and other objects. NHTSA concluded the lamp was part of the required headlighting system, and thus not supplemental lighting, and therefore subject to the headlamp requirements.[56]

Under this analysis, we tentatively conclude an ADB system is part of the required headlighting system and not supplemental lighting. Most importantly, an ADB system, in contrast to supplemental lamps such as cornering lights or fog lamps, provides significantly more light flux forward of the vehicle and is intended to be used regularly.[57] ADB systems function, and

[47] S6.2.1.

[48] S9.4.

[49] S9.4.1.

[50] S4.

[51] *Id.*

[52] *Id.*

[53] This is consistent with SAE J3069 JUN2016, which considers ADB as ''an addition to or equivalent to the lower beam.''

[54] S4 ''*Headlamp* means a lighting device providing an upper and/or a lower beam used for providing illumination forward of the vehicle.'' (formatting in original).

[55] Letter from Jacqueline Glassman, Chief Counsel, to [Redacted] (Jan. 21, 2004) (opining that a ''swiveling lamp'' is a component of the required headlighting system). *See also* Letter from John Womack, Acting Chief Counsel, to M. Guy Dorleans, Valeo Vision (Aug. 31, 1994) (treating an auxiliary driving beam as part of the required headlighting system); Letter from Frank Berndt, Chief Counsel, to I.A. Wuddel, Hueck & Co. (Nov. 18, 1983) (treating an auxiliary driving beam as part of the required headlighting system and alternatively treating it as a supplemental light). All interpretations cited in this document are available at *https://isearch.nhtsa.gov/.*

[56] Letter from Jacqueline Glassman, Chief Counsel, to [Redacted] (Jan. 21, 2004).

[57] *See* Letter from Frank Berndt, Chief Counsel, to Robert Bosch Corp. (Feb. 11, 1977) (finding that fog

Continued

are intended to function, as the primary source of forward illumination for the vehicle when they are activated. This is a safety-critical function affecting not only the ADB-equipped vehicle but also (through glare) other vehicles. The purpose of the headlighting requirements is to ensure headlighting systems attend to both these safety-critical issues and strike an acceptable balance between forward visibility and glare. The entire purpose of ADB technology is to strike this balance more robustly and effectively. It therefore seems appropriate that ADB is considered an element of required lighting and not merely supplemental lighting.

We note that prior to the 2004 interpretation letter, NHTSA had issued several interpretations concerning auxiliary driving beams in which the Agency treated, without directly considering the issue, those lamps as supplemental lighting.[58] If the lamps in question in those earlier interpretations would be considered supplemental lighting under the factors set forth in the 2004 interpretation, they may be consistent with that later interpretation. There is not, however, sufficient information about the lighting systems at issue in those earlier interpretations letters to be able to apply the factors from the 2004 interpretation. In any case, the 2004 interpretation has been, to date, NHTSA's view on the issue. Because of the reasons given above, we tentatively conclude that changing that interpretation is not warranted at this time.

b. ADB Systems Would Not Comply With at Least Some of the Headlamp Requirements

Because we tentatively conclude that an ADB system is part of the required headlamp system, we next consider whether there are any headlamp requirements with which it would not comply. We tentatively conclude that an ADB system would likely not comply with certain of the requirements for lower beam photometry and semiautomatic beam switching devices.

i. Photometry Requirements

An ADB system would have to comply with all applicable photometry requirements. As discussed earlier, there are separate photometry requirements for lower and upper beams. The photometry requirements specify test points, with each test point specifying minimum levels of light (to ensure adequate illumination) and/or maximum levels of light (to limit glare to oncoming or preceding vehicles). When an ADB system is emitting an upper beam, the upper beam must conform to the upper beam photometry requirements, and when it is emitting a lower beam it must conform to the lower beam photometry requirements.[59]

The upper beam of an ADB system would likely be able to comply with the upper beam photometry requirements. This is because the ADB upper beam would, or should, be the same as the upper beam on the non-ADB-equipped version of that vehicle. Accordingly, an ADB system's upper beam presumably would comply with the upper beam photometric requirements.

The ADB system's lower beam, on the other hand, would probably not always comply with the lower beam photometric requirements. An ADB system can produce a variety of lower beams; each lower beam must comply with the applicable lower beam photometric requirements. The base lower beam is designed to conform to the current lower beam photometry requirements. However, the augmented lower beam(s) provide more illumination than the base lower beam would; the purpose of ADB is to produce a lower beam providing more illumination than a current FMVSS No. 108-compliant lower beam. Therefore, it is likely that the augmented lower beam would not always comply with existing lower beam photometry requirements. Toyota appears to allude to this in its petition when it states that ''[w]hile the variable beam pattern mode does occasionally emit asymmetric candlepower that is above the maxima or below the minima at certain FMVSS No. 108 test points, these differences are always designed to be consistent with satisfying the dual goals of minimizing glare to oncoming and preceding drivers and enhancing the forward and sideways illumination for the benefit of the driver in the AHS-equipped vehicle.''[60] Volkswagen, in a recent exemption petition, also notes that ''the Audi Matrix Beam ADB system does not conform to FMVSS 108 photometric requirements at certain test points.''[61]

We also note that in the 2003 Request for Comments regarding advanced headlighting systems mentioned earlier, the Agency considered, among other things, advanced headlighting systems that could actively re-aim the lower beam horizontally (so-called ''bending light''). NHTSA concluded that FMVSS No. 108 does not prohibit bending light headlamps because the standard does not specifically address initial or subsequent headlamp aim (the standard addresses only aimability requirements). Advanced headlighting systems that can actively re-aim the lower beam horizontally are currently available as original and replacement equipment in the U.S.

ii. Semiautomatic Beam Switching Device Requirements

We have tentatively concluded that an ADB system is a semiautomatic beam switching device under FMVSS No. 108. ADB systems could likely meet some, but not all, requirements applicable to these devices.

FMVSS No. 108 sets forth a variety of performance requirements for semiautomatic beam switching devices. ADB systems would likely be able to meet some of the existing semiautomatic beam switching device requirements: Owner's manual operating instructions (S9.4.1.1); manual override (S9.4.1.2); fail safe operation (S9.4.1.3); and automatic dimming indicator (S9.4.1.4). We propose applying these requirements to ADB systems. However, ADB systems likely would not comply with other requirements applicable to semiautomatic beam switching devices. One of the requirements is that semiautomatic headlamp beam switching devices must provide lower and upper beams complying with relevant photometry requirements. As we explain in the section immediately above, an ADB system would not comply with the lower beam

lamp is supplemental lighting); Letter from Erika Z. Jones, Chief Counsel, to M. Iwase, Koito Mfg. Co., Ltd. (March 31, 1986) (same); Letter from Erika Z. Jones, Chief Counsel, to T. Chikada, Stanley Elec. Co. (June 19, 1987) (same); Letter from Erika Z. Jones, Chief Counsel to Byung M. Soh, Target Marketing Sys., Inc. (Sept. 13, 1988) (same); Letter from Erika Z. Jones, Chief Counsel, to Sadato Kadoya, Mazda (North America), Inc. (Nov. 3, 1988) (same); Letter from Philip Recht, Chief Counsel, to Melinda Dresser, Carlin Mfg. (January 9, 1985) (same); Letter from John Womack, Acting Chief Counsel, to Yohsiaki Matsui, Stanley Elec. Co. (Sept. 20, 1995) (same).

[58] *See* Letter from Erika Z. Jones, Chief Counsel, to P. Soardo, Instituto Elettrotecnico Nazionale (May 22, 1987); Letter from S.P. Wood to Subaru of America, Inc. (Oct. 31, 1978); Letter from Erika Z. Jones, Chief Counsel, to Byung M. Soh, Target Marketing Sys., Inc. (Sept. 13, 1988); Letter from Erika Z. Jones, Chief Counsel to George Ziolo (Sept. 12, 1988); Letter from Frank Berndt, Chief Counsel, to I.A. Wuddel, Hueck & Co. (Nov. 18, 1983).

[59] We note it does not appear possible to interpret the standard so the dimmed portion of the ADB beam is subject to the lower beam photometry requirements and the undimmed portion is subject to upper beam photometry requirements because S9.4.1 prohibits simultaneous activation of upper and lower beams (except for signaling or switching, neither of which is applicable here).

[60] Letter from Tom Stricker, Toyota Motor North America, Inc. to David Strickland (Mar. 29, 2013), p. 3.

[61] Letter from Thomas Zorn, Volkswagen Group of America to Dr. Mark Rosekind, Administrator, NHTSA, Petition for Temporary Exemption from FMVSS 108 (October 10, 2016), p. 2.

photometry requirements in all instances. Other requirements include fail safe operation requirements, mounting height limitations, and a series of physical tests, including a sensitivity test. Some of these would be difficult to apply to, or would not sensibly apply to, an ADB system.

c. Tentative Determination

We tentatively conclude that ADB would not be supplemental lighting and would likely not comply with at least some of the lower beam photometric and semiautomatic beam switching device requirements. We therefore tentatively conclude that FMVSS No. 108 would, in its current form, preclude an ADB system as original or replacement equipment.

Although we tentatively conclude that an ADB system is part of the required headlighting system, we briefly consider the status of ADB technology if it were instead considered supplemental equipment. If we were to instead determine that an ADB system is supplemental lighting, it would be permissible provided it did not impair the effectiveness of any of the required lighting (S6.2.1). A vehicle manufacturer must certify that supplemental lighting installed as original equipment complies with S6.2.1 (although, as a practical matter, vehicle manufacturers generally insist that equipment manufacturers provide assurance that their products meet Federal standards). Effectiveness may be impaired if, among other things, supplemental lighting creates a noncompliance in the existing lighting equipment or confusion with the signal sent by another lamp, or functionally interferes with it, or modifies its candlepower to either below the minima or above the maxima permitted by the standard.[62] The judgment of impairment is one made by the person installing the device, although that decision may be questioned by NHTSA if it appears erroneous.

If an ADB system were installed as supplemental equipment, it would impair the effectiveness of the required headlighting system if it did not meet the Table XVIII (upper beam) test points corresponding to unoccupied portions of the road, or if it did not meet the Table XIX (lower beam) test points corresponding to portions of the road on which an oncoming or preceding vehicle was located.[63] It would, however, be difficult for NHTSA to verify this because the Table XVIII and XIX photometric test points are premised on laboratory measurements, whereas whether an ADB system is functioning properly depends on whether it is accurately detecting oncoming and preceding vehicles in actual operation on the road. Accordingly, even if NHTSA were to adopt this alternative interpretation, it still might not obviate the need for this rulemaking.

We seek comment on this tentative interpretation. In addition, we seek comment on whether there are provisions in FMVSS No. 108 we have not identified in this document that might apply to ADB systems and so should be amended.

VII. NHTSA's Statutory Authority

NHTSA is proposing this NPRM pursuant to its authority under the Motor Vehicle Safety Act. Under 49 U.S.C. chapter 301, Motor Vehicle Safety (49 U.S.C. 30101 *et seq.*), the Secretary of Transportation is responsible for prescribing motor vehicle safety standards that are practicable, meet the need for motor vehicle safety, and are stated in objective terms.[64] ''Motor vehicle safety'' is defined in the Motor Vehicle Safety Act as ''the performance of a motor vehicle or motor vehicle equipment in a way that protects the public against unreasonable risk of accidents occurring because of the design, construction, or performance of a motor vehicle, and against unreasonable risk of death or injury in an accident, and includes nonoperational safety of a motor vehicle.''[65] ''Motor vehicle safety standard'' means a minimum performance standard for motor vehicles or motor vehicle equipment.[66] When prescribing such standards, the Secretary must consider all relevant, available motor vehicle safety information.[67] The Secretary must also consider whether a proposed standard is reasonable, practicable, and appropriate for the types of motor vehicles or motor vehicle equipment for which it is prescribed and the extent to which the standard will further the statutory purpose of reducing traffic accidents and associated deaths.[68] The responsibility for promulgation of Federal motor vehicle safety standards is delegated to NHTSA.[69] The Agency carefully considered these statutory requirements in developing this proposal. We evaluate the proposal with respect to these requirements in subsequent sections of this preamble.

VIII. Proposed Requirements and Test Procedures

We propose amending NHTSA's lighting standard to allow ADB systems on vehicles in the United States and ensure that they operate safety with respect to the twin safety needs of glare prevention and visibility.

We have tentatively concluded that because ADB has the potential to provide significant safety benefits, FMVSS No. 108 should be amended in order to permit it. ADB technology has the potential to reduce the risk of crashes by increasing visibility without increasing glare. In particular, it offers potentially significant safety benefits in preventing collisions with pedestrians, cyclists, animals, and roadside objects. We have tentatively concluded, however, that ADB would not comply with FMVSS No. 108 because an ADB system is part of the required headlighting system—not supplemental lighting—and would likely not comply with at least some existing lighting requirements. Accordingly, we propose amending FMVSS No. 108 to permit ADB systems on vehicles in the U.S.

We have also tentatively concluded that in order to ensure that ADB systems operate safely, the standard should be amended to include additional requirements specific to ADB systems. Because ADB uses relatively new, advanced technology to provide an enhanced lower beam and dynamically changes the beam to accommodate the presence of other vehicles, it has the potential—if it does not function properly—to glare other motorists. NHTSA is particularly sensitive to concerns about glare in light of the history of glare complaints from the public, the 2005 Congressional mandate, and the Agency's research. Because the existing headlighting regulations (in particular, the photometry requirements) are based on and intended for the current, static beams, they do not have any requirements or

[62] *See, e.g.,* Letter from Erika Jones, Chief Counsel, to Byung M. Soh, Target Marketing Systems, Inc. (Sept. 13, 1988).

[63] *See* Feasibility Study, p. 36 (Fig. 19) (locations of upper beam test points) and p. 16 (Fig. 5) (locations of lower beam test points). *See also* Letter from Erika Z. Jones, Chief Counsel to George Ziolo (Sept. 12, 1988) (finding that a supplemental headlamp would impair the effectiveness of the headlighting system because it caused the upper beam to exceed the upper beam photometric maxima); Letter from Erika Z. Jones, Chief Counsel, to Byung M. Soh, Target Marketing Sys., Inc. (Sept. 13, 1988) (finding that a supplemental headlamp intensity modulator would impair the effectiveness of the headlighting system because it would not necessarily comply with upper or lower beam photometric requirements).

[64] 49 U.S.C. 30111(a).

[65] 49 U.S.C. 30102(a)(8).

[66] 30102(a)(9).

[67] 30111(b)(1).

[68] 30111(b) (3)–(4).

[69] *See* 49 CFR 1.95.

test procedures to evaluate whether an ADB system is functioning properly as it dynamically changes the beam to accommodate other vehicles. We therefore propose amending FMVSS No. 108 to include requirements and test procedures specifically tailored to ensure that ADB systems do not glare other motorists. NHTSA is also proposing a limited set of requirements to ensure that ADB systems provide adequate visibility at all times.

First, we propose amending FMVSS No. 108 to allow ADB systems. We propose amendments to, among other things, the lower beam photometry requirements so that the enhanced lower beam provided by ADB technology is permitted.

Second, we propose requirements to ensure that ADB systems do not glare other motorists. ADB systems provide an enhanced lower beam that provides more illumination than the currently-allowed lower beam. If ADB systems do not function properly—detect oncoming and preceding vehicles and shade them accordingly—other motorists will be glared. The proposal addresses this safety concern with a combination of vehicle-level track tests and equipment-level laboratory testing requirements.

The centerpiece of the proposal is a vehicle-level track test to evaluate ADB performance in recognizing and not glaring other vehicles. We propose evaluating ADB performance in a variety of different types of interactions with oncoming and preceding vehicles (referred to as ''stimulus'' vehicles because they stimulate a response from the ADB system). The stimulus vehicle would be equipped with sensors to measure the illuminance from the ADB system near the driver's eyes (or rearview mirrors). We propose a variety of different test scenarios. The scenarios vary the road geometry (whether it is straight or curved); vehicle speeds (from 0 to 70 mph); and vehicle orientation (whether the stimulus vehicle is oncoming or preceding). The illumination cast on the stimulus vehicle would be measured and recorded throughout the test run. In order to evaluate ADB performance in these test runs, we are proposing a set of glare limits. These are numeric illuminance values that would be the maximum allowable illuminance the ADB system would be permitted to cast on the stimulus vehicle. The proposed glare limits and test procedures are based on NHTSA's ADB-related research and are intended to ensure that an ADB system is capable of correctly detecting oncoming and preceding vehicles and not glaring them. They differ from the existing photometry requirements because they are vehicle-level requirements tested on a track.

In addition to this track test, we also propose a small set of equipment-level laboratory testing requirements related to glare prevention. We propose to require that the dimmed portion of the adaptive beam (*i.e.,* the light directed towards an oncoming or preceding vehicle) not exceed the current low beam maxima, and that in the undimmed portion of the adaptive beam (*i.e.,* the light directed towards unoccupied roadway) the current upper beam maxima not be exceeded. These tests would be carried out at the component level—on the headlamps (not installed on the vehicle) in a photometric laboratory. These proposed requirements would essentially subject the ADB system to laboratory tests of the beam similar to what are currently required for standard headlights. NHTSA anticipates that manufacturers would be able to certify to these photometry requirements in a typical photometric laboratory using typical test procedures, with the addition of a headlamp beam controller simulating the signal sent to headlamps from the camera/headlamp controller.

Third, we propose a limited set of minimum illumination requirements (as tested in a laboratory) to ensure that the ADB system provides sufficient visibility for the driver. The current headlamp requirements include, in addition to maximum light levels in certain directions, minimum levels of illumination to ensure that the driver has a minimum level of visibility. We propose that these existing laboratory photometry tests be applied to the ADB system to ensure that the ADB beam pattern, although dynamically changing, always provides at least a minimum amount of light. We propose requiring that the dimmed portion of the adaptive beam meet the current lower beam minima and that that in the undimmed portion of the adaptive beam the current upper beam minima be met. These minimum levels of illuminance are in a direction such that they would not glare other motorists. Again, NHTSA anticipates that manufacturers will be able to certify to these photometry requirement in a typical photometric laboratory.

Finally, we propose several other system requirements to ensure that an ADB system operates safely. Some of these requirements, such as manual override, are already part of the existing regulations for semiautomatic beam switching devices, and are being extended to ADB systems. Other requirements such as one that the system notify the driver of a fault or malfunction, would be specific to ADB systems.

a. Requirements

This NPRM proposes to subject ADB-equipped vehicles to a dynamic compliance test to ensure the ADB system does not glare oncoming or preceding vehicles. The performance requirements we propose specify the maximum level of illuminance an ADB system may cast on opposing or preceding vehicles. In addition to these glare limit requirements, we are proposing a set of minimum system requirements to ensure an ADB system performs safely.

i. Baseline Glare Limits

The foundation of this rulemaking is a set of glare limits specifying the amount of light that may be directed towards oncoming or preceding vehicles. The glare limits we propose are the same limits used in the ADB Test Report and presented earlier in this document in Table 1 (oncoming glare limits) and Table 2 (preceding glare limits), except instead of regulating glare out to 239.9 m, we propose to regulate glare out to 220 m. Earlier we explained how these limits were derived. These glare limits would be used to evaluate ADB headlamp illuminance as measured in a dynamic track test. (We explain the proposed test procedures later in this document.) The current photometric test points from which the proposed limits are derived are maxima; therefore, we propose applying the derived glare limits as maxima, so that any measured exceedance of an applicable glare limit would be used to determine compliance (except for momentary spikes above the limits lasting no longer than 0.1 sec. or over a distance range of no longer that 1 m). We are stating the glare limits to a precision of one decimal place, as recommended in the report that developed these glare limits.[70] For purposes of determining compliance with the glare limits, the Agency will, when conducting compliance testing, round measured illuminance values to the nearest 0.1 lux, in accordance with the rounding method of ASTM Practice E29 Using Significant Digits in Test Data to Determine Conformance with Specifications.

SAE J3069 uses glare limits drawing on and similar but not identical to the proposed glare limits. The proposed glare limits deviate from SAE J3069 in two main respects.

First, two of the glare limits differ slightly. At 60 m, SAE J3069 uses glare

[70] Feasibility Study, p. 80.

limits of 0.7 lux (oncoming) and 8.9 lux (preceding) compared to the proposed 0.6 lux and 4.0 lux. The proposed limits are based on the 0.643 lux and 4.041 lux limits derived in the Feasibility Study, rounded to two decimal places.

Second, SAE J3069 applies to a narrower range of distances (30 m–155 m) than the proposed glare limits (15 m–220 m). Our tentative decision to regulate glare down to 15 m differs from SAE J3069, which does not apply to distances less than 30 m. At 15 m, the angle between the oncoming or preceding driver's eyes and the headlamps is small enough to cause the observer to be unable to see objects in the roadway. The 15 m cutoff we propose is consistent with the Feasibility Study and ADB Test Report, which also use glare limits for inter-vehicle distances as small as 15 m.[71] We believe it is reasonable not to regulate glare for distances smaller than 15 m because as the distance between the ADB and the oncoming vehicle decreases, the angle between the two vehicles increases; the effects of glare fall off rapidly as the angle between the glare source and the center of the observer's field of view increase. For preceding vehicles in a passing situation, we tentatively believe this is justified because at this distance the location of the driver's eye likely corresponds to a portion of the beam pattern where less light is typically projected. In addition, at smaller distances it might be difficult to obtain accurate photometry readings.

The proposal to measure and regulate glare out to 220 m is farther than either SAE J3069 (which applies only out to 155 m) or the Feasibility Study (which derived glare limits only out to 120 m) and is slightly less than in the ADB Test Report.[72] We tentatively believe it is necessary to regulate glare further than 120 m or 155 m because the upper beams can glare other roadway users at and beyond those distances. The maximum intensity allowed for each upper beam headlamp is 75,000 cd;[73] this is equivalent to 150,000 cd for a headlighting system. At 120 m, 150,000 cd is equivalent to 10.4 lux; at 155 m, this translates to 6.2 lux. Both values are greater than the 0.3 lux glare limit the Feasibility Study derived for the furthest distance it considered (120 m).

The issue then is to what maximum distance glare should be regulated. We considered regulating glare out to the distance at which the upper beams would be extremely unlikely to glare other motorists, but this would involve measuring glare at very large distances, which would not be practicable for testing purposes.[74] The maximum distance we are proposing (220 m) seems to be roughly consistent with assumptions about allowable glare implicit in state laws governing upper beam use.[75] Requiring an ADB system not exceed 0.3 lux out to 220 m would therefore preclude an ADB system from using the full upper beam once an oncoming vehicle is less than 220 m away.[76]

We believe it is practicable for OEMs to design systems complying with glare limits out to 220 m. We are simply applying the lux limit, 0.3, which was derived for 120 m, out farther, to 220 m. A headlight system able to comply with an illuminance limit of 0.3 lux at 155 m (as required by SAE J3069) should be able to comply with the same 0.3 lux limit at 220 m (because the illuminance decreases as the distance from the light source increases), as long as the ADB system is able to detect oncoming vehicles at that distance. We believe it is reasonable to expect this sort of detection capability from ADB systems; for example, the ECE ADB regulations require ADB cameras to be capable of sensing vehicles out to 400 m.[77]

We have tentatively concluded that the proposed glare limits are appropriate for use in this rulemaking. The proposed glare limits provide objective, numeric criteria to evaluate ADB system performance with respect to glare. They are based on the existing glare limits, which have been part of FMVSS No. 108 since its inception in 1967 (although the current lower beam maxima are slightly higher than the maxima incorporated by reference in the initial FMVSS). SAE has adopted glare limits similar to the proposed limits in SAE J3069. We seek comment on the appropriateness and use of the proposed glare limits. In particular, we request comment on any potential safety difference between adopting the SAE glare limits and the proposed glare limits. In addition, we seek comment on the proposal to consider any exceedance of an applicable glare limit (other than momentary spikes) to be a noncompliance. This does not take into account glare dosage, exposure, or perceptibility. Some studies suggest at least some adverse effects of glare depend on temporal duration. For example, some studies have shown that the time it takes for a driver's visual performance to return to its original state after exposure to glare (referred to as glare recovery) is proportional to the total glare or glare dosage.[78] It may also be possible that light intensities exceeding the glare limits may not be perceptible to an oncoming or preceding driver if the exposure duration is sufficiently small. Should there be a durational element to the glare limits, and if so, what should the duration be? What is the safety-related basis for the duration (*e.g.,* evidence that light intensity at or above a baseline glare limit does not have adverse effects on an oncoming or preceding motorist if the glare lasts for no longer than that duration)? Would the ''any exceedance'' rule potentially mean that an ADB system utilizing pulse width modulated

[71] Feasibility Study, pp. 23–24.

[72] The SAE range of 155 m appears to roughly track state laws regulating upper beam use. Many states allow drivers to use upper beams up to about 152 m (500 ft.) from an oncoming vehicle; inside of 152 m, the driver must use the lower beams. The distance requirements are smaller for preceding vehicles. *See, e.g.,* Va. Code Ann. sec. 46.2–1034 (2017); Cal. Veh. Code sec. 24409 (2017); 7 Tex. Transp. Code Ann. sec. 547.333.

[73] Table XVIII.

[74] The Feasibility Study derived a glare limit of .3 lux at 120 m for oncoming vehicles. For simplicity, and since we do not have derived glare limits for distances greater than 120 m, we apply .3 lux as the glare limit for distances greater than 120 m. (From the standpoint of regulatory stringency this is conservative, because, as the Feasibility Study explains, the allowable illuminance actually decreases as distance increases.) The maximum permissible intensity for an upper beam system is 150,000 cd, and the distance at which this will not glare an oncoming motorist is, approximately, the distance at which this will result in illuminance of .3 lux, which is 700 m. This long of a distance—almost a half mile—is not practicable for testing purposes.

[75] Many states prohibit upper beam use unless oncoming vehicles are more than approximately 155 m away. These state upper beam laws are likely based on older upper beam headlamps that were not as intense as modern headlamps. *See, e.g.,* Cal. Veh. Code sec. 24409 (2017) (requirement that driver use lower beam within 500 ft (152 m) of an oncoming vehicle enacted prior to 1978). Prior to 1978, the maximum allowable upper beam intensity for a headlighting system was 75,000 cd. *See* 61 FR 54981. At 155 m, this is equivalent to 3.1 lux. Thus, under these state laws the illumination to which an oncoming driver would be exposed would not exceed (roughly) 3.1 lux. The current photometry requirements permit a maximum upper beam intensity (for a system) of 150,000 cd. This is equivalent to 3.1 lux at 220 m. Thus, the proposal to regulate glare out to 220 m is consistent with the distance specified by state headlamp beam use laws based on the lower-intensity pre-1978 upper beam, adjusted to account for the higher-intensity upper beam allowed since 1978. That is, the distance we propose exceeds the 155 m found in many state beam use laws because headlamps are now allowed to be brighter than they were previously allowed to be.

[76] Assuming the system's upper beam is designed to produce up the maximum allowable intensity. If the upper beam were designed to produce less than the maximum allowable intensity, then the system potentially could use the full upper beam within 220 m.

[77] ECE R48 6.1.9.3.1.2.

[78] Yukio Akashi, John Van Derlofske, Jennifer Watkinson & Charles Fay. 2005. Assessment of Headlamp Glare and Potential Countermeasures: Survey of Advanced Front Lighting System (AFS). DOT HS 809 973. Washington, DC: National Highway Traffic Safety Administration, pg. 71.

light sources could be noncompliant even though oncoming drivers would not experience glare? If so, how should this be accounted for?

ii. Existing Photometry Requirements That Would Also Apply to ADB Systems

The proposed baseline glare limits are essentially new lower beam photometric requirements with which an ADB system would have to comply when tested under the track-test procedures discussed later in this preamble. In addition to these track-tested glare limits, under this proposal an ADB system would also be subject to some of the existing laboratory-based upper and lower beam photometry requirements. When the ADB system is producing an upper beam (*i.e.* when there are no oncoming or preceding vehicles within 15 m to 220 m) we propose the beam be subject to all of the applicable Table XVIII upper beam requirements. In addition, we propose that in the undimmed portion of the adaptive beam the applicable Table XVIII upper beam maxima and minima be met. Similarly, we propose requiring that the lower beam maxima and minima be complied with within the dimmed portion of the adaptive beam.

This differs from SAE J3069 in some respects. SAE J3069 has somewhat similar provisions relating to lower and upper beam photometry, but those provisions reference the relevant SAE photometric standards; the proposal instead appropriately references the upper and lower beam photometric requirements in Tables XVIII and XIX of FMVSS No. 108. In addition, SAE J3069 only specifies that the lower beam maxima not be exceeded within the dimmed portion of the augmented lower beam, and the lower beam minima be complied with outside the dimmed portion of the augmented lower beam. We do not see any reason an ADB system's upper beam should not be subject to the same requirements as is a standard upper beam, or the dimmed and undimmed portions of the ADB adaptive lower beam should not be subjected to the applicable upper and lower beam maxima and minima. This limited set of laboratory-tested photometric requirements are an extension of the longstanding laboratory-based photometry requirements for standard headlights. The Agency requests comment on this preliminary determination. In particular, can commenters provide information on the safety impact of adopting the proposed standard versus the SAE approach?

If the Agency were to test an ADB system for compliance with these proposed requirements, the testing would be conducted as photometry testing is now tested, *i.e.,* in a laboratory using a goniometer. The Agency anticipates manufacturers will be able to certify to this photometry requirement in a typical photometric laboratory using typical test procedures, with the addition of a headlamp beam controller simulating the signal sent to headlamps from the camera/headlamp controller. For the Agency to conduct such testing, it would need to collect considerable information from the manufacturer as to how to control the headlamps to simulate the dynamic environment. NHTSA anticipates that it would consider the manufacturer's certification valid unless it is clearly erroneous or if the track testing indicates the basic headlamp photometry may be noncompliant with this requirement.

iii. Other System Requirements

We are also proposing several other requirements for ADB systems.

We propose applying some existing semiautomatic beam switching device requirements to ADB systems: Manual override (S9.4.1.2); fail safe operation (S9.4.1.3); and automatic dimming indicator (S9.4.1.4). These are requirements that apply today to semiautomatic beam switches.

We also propose adopting additional operation requirements that do not have analogs in the current semiautomatic beam switching device requirements; most of these are also part of SAE J3069. We propose to require the following:

- The ADB system must be capable of detecting system malfunctions (including but not limited to sensor obstruction).
- The ADB system must notify the driver of a fault or malfunction.
- If the ADB system detects a fault, it must disable the system until the fault is corrected.
- The system must produce a base lower beam at speeds below 25 mph. As the primary purpose of the ADB is to provide additional light down the road at high speed, the system is not needed at lower speeds. For speeds below 25 mph, it may be likely that the potential disbenefits from glare outweigh the potential benefits from the additional headlamp illumination.

Although we propose requiring a telltale informing the driver when the ADB system is activated (the automatic dimming indicator requirement in S9.4.1.4), we have tentatively decided not to require telltales indicating the type of beam (upper or lower) the ADB system is providing. We have tentatively decided not to follow the approach of ECE Regulation 48, which requires the upper beam telltale be used to indicate ADB activation, because we consider the ADB adaptive beam to be a lower beam if there are vehicles on the roadway to which the beam must adapt. We also do not require a telltale indicating an enabled ADB system is projecting an augmented lower beam. We believe providing the driver with a visual indication of the type of beam (upper or lower) an ADB system is providing is not necessary for safe driving and, if present, may result in the driver making unnecessary glances at the instrument panel instead of monitoring the roadway. We also propose revising the existing upper beam indicator requirement in S9.5 to state that the upper beam indicator need not activate when the ADB system is activated (and the ADB telltale is activated). This is consistent with SAE J3069. OEMs would be free to devise supplemental telltales/messages. In all of these, we follow the approach taken in SAE J3069.[79]

We seek comment on these choices. Our intent is to ensure that ADB systems operate robustly, while at the same time not unduly restricting manufacturer design flexibility. We also note that Table I–a of FMVSS No. 108 requires the ''wiring harness or connector assembly of each headlighting system must be designed so that only those light sources intended for meeting lower beam photometrics are energized when the beam selector switch is in the lower beam position, and that only those light sources intended for meeting upper beam photometrics are energized when the beam selector switch is in the upper beam position, except for certain systems listed in Table II.'' This might affect design choices for the headlight and/or ADB controls. It might mean that the headlight and ADB controls could not be designed so the ADB system is activated when the beam selector switch is in the lower beam position—the ADB system might, if no other vehicles are present, be projecting the upper beam, which could mean that upper beam light sources are activated when the beam selector switch is in the lower beam position. We seek comment on the effect of this requirement on ADB systems, and whether it needs to be amended, and if so, how.

We are not proposing to subject the switch controlling the ADB system to any physical test requirements (*e.g.,* vibration requirements, humidity requirement, etc.). We are not extending current device test requirements for

[79] S6.8 and discussion at p. 2.

semiautomatic beam switching devices[80] to ADB systems because those requirements date from the 1960s and do not appear to usefully extend to modern ADB technologies. We also are not proposing any new physical test requirements. We believe market forces will ensure an ADB system's switching device will operate robustly. We are, however, proposing requiring the ADB system to provide malfunction detection and notification and fail-safe operation. We seek comment on whether we should specify physical test or additional device test requirements.

In addition, other requirements in FMVSS No. 108 applying to headlamps will apply to ADB systems. ADB systems, as part of the required lighting system, would be required to comply with, for example, the Table I requirements, such as color (S6.1.2) and the steady-burning requirement (except for signaling purposes, and except for the automatic switching from upper beam to lower beam stimulated by the appearance of an oncoming or preceding vehicle), and any other provisions in FMVSS No. 108 that would apply to ADB systems by virtue of their being part of the required headlighting system (as we have tentatively concluded that they are).[81] We asked for comment in Section VI above for any other regulatory provisions that might affect ADB systems that we should consider amending.

iv. Retention of Existing Requirements for Semiautomatic Headlamp Beam Switching Devices Other Than ADB

The proposal retains the existing semiautomatic beam switching requirements for beam switching devices other than ADB (*i.e.,* beam switching devices that switch only between an upper beam and a single lower beam). These requirements have been in the standard for several decades, and while they might be updated, the focus of this rulemaking is on amending the current requirements to allow the adoption of ADB systems.

b. Test Procedures

i. Introduction

This section explains how we propose to test an ADB system to determine whether it complies with the photometric glare limits we are proposing as a performance requirement. We propose to test the ADB system in a dynamic road test, in a select number of driving scenarios and road configurations.[82] As noted earlier, the existing headlamp photometric requirements, including the requirements that regulate glare, are component-level requirements, and testing for compliance with them is conducted on the headlamp in a laboratory. We tentatively believe a dynamic road test is necessary to ensure, to a reasonable degree of confidence, that an ADB system meets minimum safety requirements for the prevention of glare. Because the ADB system relies on a combination of sensors/cameras, controller units, and headlamps that must all work together, the Agency tentatively concludes a dynamic compliance test is essential for evaluating ADB performance.

Below we discuss the proposed test procedures in detail. The proposed procedures involve equipping an FMVSS-certified vehicle with photometers (a ''stimulus vehicle'') to measure the amount of glare produced by the ADB-equipped vehicle being tested for compliance (''test vehicle''). With respect to the track on which we would test vehicles, we propose specifying relatively broad ranges of conditions, with a limited number of driving scenarios 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. The test track may include straight and curved portions but no intersections. For curved sections, we propose allowable radii of curvature. The ADB systems we tested were unable to prevent glare to any measurable degree better on hilly roads than a typical lower beam headlamp. Accordingly, the longitudinal slope (grade) cannot exceed 2% to maintain useful alignment with headlamps. While we encourage continued development of the technology to reduce glare below the current lower beam on hilly roads, we are not proposing such a requirement today. We are proposing realistic vehicle speeds, appropriate for the radii of curvature we have specified.

ii. Test Vehicle and Stimulus Vehicle

In later sections of this preamble, we discuss proposed maneuvers of the stimulus and ADB test vehicles. Here, we discuss the stimulus vehicles we propose to use in testing.

1. Proposal

We propose to use as a stimulus vehicle any FMVSS-certified vehicle satisfying the following criteria: (1) Of any FMVSS vehicle classification excluding trailers, motor-driven cycles, and low-speed vehicles; (2) of any weight class; (3) of any make or model; (4) from any of the five model years prior to the model year of the test vehicle; and (5) subject to a vehicle height constraint. These criteria, and alternatives we are considering, are discussed in more detail below.

Vehicle Classification

We propose to use vehicles of any FMVSS classification other than trailers, motor-driven cycles, and low-speed vehicles: passenger cars, buses, trucks, multipurpose passenger vehicles, and motorcycles. An ADB system should be able to function so as to not glare a broad range of FMVSS-certified vehicles. We do not believe it would be difficult for an ADB system to identify and shade different vehicle types because the image recognition technology will likely focus on headlight and taillight patterns and locations. While the FMVSS do not regulate vehicle width, FMVSS No. 108 does regulate the range of permissible mounting heights for front and rear lamps, based on the type of vehicle; this should help aid detection.

Weight

We propose using vehicles of any gross vehicle weight rating (GVWR). SAE J3069 similarly uses fixtures based on light and heavy vehicle applications. Again, we see no reason why an acceptable ADB system should not be able to recognize and shade both large and small vehicles as these vehicles will be encountered in the real world.

Make and Model

We propose using any make or model of vehicle (that meets the other criteria). We alternatively considered specifying a list of eligible test vehicles by make and model spanning a range of manufacturers and vehicle types. The list would be included as an appendix in FMVSS No. 108. Vehicles included on the list would comprise a relatively large percentage of vehicles sold in the United States; for example, the list could be based on vehicle and sales data from Ward's Automotive Yearbook. Under this specification, the Agency could use any vehicle on the list from the preceding five model years. We have tentatively decided not to adopt this

[80] FMVSS No. 108 S14.9.3.11.

[81] Other examples include, but are not necessarily limited to, the following: S10 (headlighting system requirements); S12 (headlamp concealment device requirements); S13 (replaceable headlamp lens requirements); and S14.6 (headlamp physical test requirements and procedures).

[82] As with all the FMVSSs, the proposed test procedures are the procedures that NHTSA would use in performing compliance testing. Vehicle or equipment manufacturers would not be required to use these testing procedures to certify their vehicles. They may certify their vehicles using other means as long as they exercise due care in making that certification.

approach because we believe an ADB system should recognize and shade a wide variety of vehicles. However, we seek comment on this alternative approach. Are there certain makes or models an ADB system should not be expected and required to detect? If so, what is the basis for such a determination, and how does it satisfy the need for safety as well as practicability?

Model Year

We believe limiting ourselves to the preceding five model years strikes a reasonable balance between the need for safety and practicability.

Vehicle Height Constraint

While we propose potentially using a relatively broad range of vehicle types, weights, makes, and models, we propose to constrain the set of vehicles eligible as test vehicles by vehicle height. The height constraint is based on the proposed specification for where the photometric receptor head(s) to measure oncoming glare will be placed on the windshield of the stimulus vehicle (see Section VIII.b.ii.3.a below). They may be mounted anywhere within a specified range on the windshield (roughly corresponding to where the driver's eyes would be), subject to a height constraint: The photometer may be placed no higher or lower than a specified height range (measured with respect to the ground). The ranges are based on data and studies of driver eye heights for different types of vehicles. If it is not possible to mount the receptor head(s) within the specified range on a candidate stimulus vehicle, then that vehicle would not be eligible for use as a stimulus vehicle. This photometer receptor head placement constraint effectively acts as a constraint on vehicles that may be used as stimulus vehicles and excludes vehicles that ride unusually high or low. We are proposing this constraint because we recognize it may be difficult or impossible to design a headlighting system accommodating such outlier vehicles. The existing Table XIX lower beam photometry requirements are such that low-to-the-ground vehicles may be subject to glare even by a compliant lower beam. We would also constrain ourselves by not using unusually high vehicles to ease potential testing burdens on manufacturers.

Summary

We tentatively believe this broad range of stimulus vehicles is reasonable to adequately ensure that an ADB system functions robustly and avoids glaring other drivers; we are concerned about a test procedure effectively permitting an ADB system designed to accommodate only a narrow range of oncoming or preceding vehicles. The purpose of the stimulus vehicle is to elicit headlamp beam adaptation by an ADB system and test whether the ADB system recognizes oncoming and preceding vehicles and appropriately limits the amount of light cast on these vehicles to ensure that they are not glared. This requires an ADB system be able to appropriately detect and identify light coming from another vehicle and dynamically shade that vehicle. An ADB system must be able to recognize multiple possible configurations of headlights and taillights, on vehicles of different size and shape (within a reasonable range).

We tentatively believe it would be practicable for a manufacturer to design an ADB system to recognize and shade any vehicle satisfying the proposed selection criteria. Although we are proposing a relatively broad range of eligible stimulus vehicles, the lighting configurations an ADB system would have to recognize are not unbounded. Front and rear lighting designs are limited by the requirements of FMVSS No. 108 and realities of vehicle design. Mounting heights, number, color, and locations of vehicle lighting are constrained by requirements set out in Table I of FMVSS No. 108. For example, headlamps must be white and mounted at the same height symmetrically about the vertical centerline, as far apart as practicable, and mounted at a height of not less than 22 inches nor more than 54 inches. Additionally, while we are proposing a broad array of makes and models as test vehicles, there is a limited, and not exceptionally large, number of makes and models of vehicles offered for sale in the United States every year. For example, in Model Year 2017, approximately 420 makes/models of passenger cars, trucks, vans, and SUVs were offered for sale. The set of vehicles eligible to be used as test vehicles will be further limited by the height constraint we are proposing.

We seek comment on the proposed vehicle selection criteria. Do the criteria define a set of stimulus vehicles that is so large as to be impracticable or unnecessary? If so, in what specific ways would manufacturers find them impracticable, or why are they unnecessary (*i.e.,* how could the Agency be confident that glare prevention could be adequately ensured with a smaller set of possible stimulus vehicles)? Are the alternative criteria mentioned above preferable, and if so, why? Are there other vehicle selection criteria that would result in a smaller set of eligible stimulus vehicles but that would still be sufficient to adequately discriminate between a robust ADB system and a less robust ADB system?

2. Alternative: Test Fixtures

We also considered using test fixtures instead of vehicles for the purpose of eliciting an ADB response as part of a compliance test. SAE J3069 specifies stationary test fixtures (structures intended to simulate the front or rear of an actual vehicle) in place of actual vehicles. It specifies four test fixtures: An opposing car/truck fixture; an opposing motorcycle fixture; a preceding car/truck fixture; and a preceding motorcycle fixture. The fixtures are fitted with lamps simulating headlamps and taillamps. For headlamp representations, it specifies a lamp projecting 300 cd of white light in a specified manner and angle. For the taillamp representations, it specifies lamps emitting no more than 7 cd of red light in a specified manner and angle. The fixtures are fitted with photometers positioned near where a driver's eyes would be to measure the light from the ADB test vehicle.[83] The lamp and photometer locations are based on ''median location values provided by [the University of Michigan Transportation Research Institute].''[84] SAE specifies test fixtures to reduce test variability and because it considers stationary fixtures as a ''worst case 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.''[85] There was also a ''concern that if the actual lower beam headlamps were used on the opposing vehicle test fixture the large gradients present in typical lower beam patterns would cause unnecessary test variability.''[86]

We are not proposing to use test fixtures because we have tentatively concluded they may not be sufficient to ensure that an ADB system operates satisfactorily in actual use. Using stationary test fixtures as opposed to dynamic actual production vehicles has the advantage of relative simplicity and ease of testing. However, the drawback is that it is not realistic. Test fixtures may encourage an ADB system designed to ensure identification of test fixtures rather than actual vehicles. This may not adequately ensure that the system

[83] SAE J3069 5.5.2 and Figures 1 and 2 (opposing vehicle fixture); 5.5.3 and Figures 3 and 4 (preceding vehicle fixture).

[84] SAE J3069, p. 3.

[85] SAE J3069, p. 3.

[86] SAE J3069, p. 4.

performs satisfactorily when faced with a wide range of different vehicles equipped with lighting differing from the test fixtures. In addition, to the extent that test fixtures differ in appearance from actual vehicles, an ADB system would have to be programmed to recognize them, which in practice might make it difficult to tune out non-vehicle objects confronting the system in actual use. Regarding gradients in typical headlamp beam patterns, we tentatively believe this will only affect the repeatability of the test if the reaction by the ADB system changes based on this difference. If this is the case, the ADB system will have this issue in actual use, and this should not be considered variability attributable to the test, but a failing of the ADB system.

We are also not necessarily confident that stationary fixtures with lamps represented as specified in SAE J3069 represent a worst-case scenario. Some ADB systems may have more difficulty detecting moving dim lights or moving lights spaced a certain width apart. The Agency welcomes any data relating to this. In addition, we seek comment on the extent to which narrowly defined lamps can be used to establish performance requirements that reasonably ensure an ADB system will recognize and adapt appropriately to the wide range of lighting configurations permitted under FMVSS No. 108. For instance, the minimum intensity allowed for a taillamp is 2.0 cd at H–V and as low as 0.3 cd at an angle of 20 degrees. These values are considerably lower than the 7.0 cd lamp specified in SAE J3069. Using stationary test fixtures would likely reduce test variability. However, we tentatively believe that the variability attributable to the proposed procedure would be within acceptable limits considering the previously described necessity of vehicle-level testing as demonstrated by NHTSA's research. As discussed below in Section VIII.c, the variability the Agency observed in the test results between a stationary lower beam and a moving test vehicle lower beam (most applicable in the straight approach maneuver) seemed to primarily be caused by the moving test vehicle not the moving stimulus vehicle.

3. Photometer Placement

The photometer measures the amount of light cast by the ADB test vehicle falling on the stimulus vehicle. Our general approach is to place the photometer [87] near where the driver's eyes would be (to measure glare to oncoming vehicles) or near where light would strike an inside or outside rearview mirror (to measure glare to preceding vehicles).

a. Oncoming Vehicles

Here the approach is to measure light cast near where the driver's eyes would be. Below we explain our proposal, as well as several alternatives.

Proposal

We propose to specify the position of photometers with respect to the X, Y, and Z coordinates [88] (*i.e.,* the longitudinal, lateral, and vertical placement of the photometers). With respect to the longitudinal position, we propose to mount the photometer(s) outside the vehicle, forward of the windshield and rearward of the headlamps. Measuring headlight illuminance in front of the windshield is consistent with the proposed glare limits; they are derived from the current glare test points, which apply to light coming from a headlamp and do not take into account effects related to the windshield glass. If the photometer were placed behind the windshield, test results might depend on properties of the windshield, which is undesirable because the purpose of the test is to measure ADB system performance.

With respect to the lateral and vertical positions of the photometer(s), we are proposing specifying a range of permissible positions.

With respect to the lateral position of the photometer, we propose locating the photometer anywhere from the longitudinal centerline of the stimulus vehicle over to and including the driver's side A-pillar.

With respect to the vertical position of the photometer, we propose placing it anywhere from the bottom of the windshield to the top of the windshield, subject to an upper bound and a lower bound. These upper and lower bounds, which differ based on vehicle classification and weight, are set out in the proposed regulatory text and are reproduced in Table 4. If it is not possible to place a photometer on a candidate measurement stimulus vehicle so the photometer was both between the top and bottom of the windshield and within the applicable range in Table 4, then that vehicle would not be eligible for use as a stimulus vehicle.

TABLE 4

Vehicle classification/weight	Mean	Height range (m)	
		Lower bound	Upper bound
Passenger Cars	1.11	1.07	1.15
Trucks, buses, MPVs (light)	1.42	1.26	1.58
Trucks, buses, MPVs (heavy)	2.33	1.99	2.67
Motorcycles	1.43	1.30	1.66

"Light" means vehicles with a GVWR of 10,000 lb. or less. "Heavy" means vehicles with a GVWR of more than 10,000 lb. Heights are measured from the ground.

[87] Or, perhaps more accurately, photometric receptor heads, if, for example, the photometer is configured with multiple receptor heads, as was the case in NHTSA's testing. For ease of exposition, the discussion in this document simply refers to the "photometer" to refer to the test equipment used to detect the light emitted from the ADB system. In addition, we may use multiple photometers or receptor heads simultaneously.

[88] *See* SAE J1100 FEB2001, Motor Vehicle Dimensions.

The ranges for passenger cars and light trucks, buses, and MPVs are from a 1996 University of Michigan Transportation Research Institute (UMTRI) study estimating mean driver's eye heights based on a sample of high-sales volume vehicles and drivers.[89] The range for heavy trucks, buses, and MPVs is from a 1990 study based on a sample of heavy goods vehicles in a 1989 roadside survey in the United Kingdom.[90] The ranges we are proposing are the two standard deviation ranges.[91] These are consistent with the photometer heights specified in SAE J3069 for the opposing vehicle fixtures. SAE J3069 specifies heights of 1.1 m and 2.2 m for the photometers used to measure oncoming glare to drivers of passenger cars and trucks, respectively. While SAE J3069 specifies a point, not a range, the points it specifies for the passenger car and truck driver eye heights are based on the same means we used to construct the height ranges for passenger cars and heavy trucks/buses. (SAE J3069 does not distinguish between heavy and light trucks, and appears to use a mean for truck driver eye height that is a slight downward adjustment of the heavy truck mean reported in the Cobb study).

The height range for motorcycles was determined as follows. The opposing motorcycle test fixture specified in SAE J3069 locates the photometer coincident with the rider's eye point, 1.3 m above the ground. This appears to have been based on the 5th percentile motorcycle rider eye height of 1.35 m reported in a study that examined motorcycle rider eye heights in Malaysia.[92] We propose this as the lower bound for the vertical height of the photometer. For the upper bound, we propose using 1.66 m, which is based on a two-standard deviation range.[93]

We tentatively believe that the proposed specification for the placement of the photometers meets the need for safety and is practicable. It defines a bounded area approximating the location of the driver's (or rider's) eyes. Unlike a specification for an eye ellipse,[94] which defines a smaller area more precisely targeting where the driver's eyes would likely be located, the larger area we specify provides a margin for safety and is easier to locate. Given that ADB is currently designed to shade an entire approaching or preceding vehicle, we believe focusing on a small area such as that of an eye ellipse is not necessary. Instead, "the expectation is that ADB will reduce any glare producing light toward and on the full width of opposing and preceding vehicles, thereby providing benefit to all occupants in the vehicle." [95] However, we propose to subject the vertical placement of the photometer to a lower bound because we recognize it may be difficult to design an ADB system to prevent glaring extremely low-riding vehicles with correspondingly low driver eye heights; we recognize that because of the low height, even an FMVSS No. 108-compliant lower beam might glare such a low-riding driver. We are proposing an upper bound on photometer placement to limit the conceivable test locations; we also do not anticipate ADB systems would produce high levels of illumination at heights above the ranges we are proposing. At the same time, we believe a two-standard deviation range captures enough variation to require the design of robust ADB systems. We also believe specifying these bounds will ensure tests are not unduly stringent. If a candidate stimulus vehicle is such that there is no position between the top and bottom of the windshield that would be within these bounds, then that vehicle would not be eligible for use as a stimulus vehicle.

We seek comment on the proposed specifications for photometer placement. In particular, we seek comment on whether the proposed height range is necessary, and if so, whether the proposed specification is sound.

Alternatives to Proposal

We also considered alternative procedures for determining the lateral and/or vertical position of the photometer(s) to measure oncoming glare. We discuss these below. Note that these are not alternatives for determining the longitudinal position of the photometer. In addition, for all of these alternatives, the vertical position of the photometer(s) would be subject to the upper and lower bounds proposed above.

Alternative 1

We considered specifying the lateral and vertical position of the photometer by using a test procedure based on that currently used to locate the approximate eye position of a 50th percentile male in compliance testing for the FMVSS No. 111 rear visibility field of view and image size requirements. FMVSS No. 111 requires, among other things, a visual display of an image of an area behind the vehicle and specifies certain requirements for the image. The field of view and image size test procedures locate where eyes of a typical driver would be. More specifically, they locate the midpoint of the eyes of a 50th percentile male. The test procedure specifies the eye midpoint by using the H-point as a point of reference. The H-point is used in several other NHTSA standards [96] and represents a specific landmark near the hip of a 50th percentile adult male positioned in a vehicle's driver seat. It has been used by NHTSA as well as other organizations in

[89] Michael Sivak, *et al.* 1996. The Location of Headlamps and Driver Eye Positions in Vehicles Sold in the U.S.A. UMTRI–96–36. University of Michigan, Transportation Research Institute, p. 9.

[90] J. Cobb. 1990. Roadside Survey of Vehicle Lighting 1989. Research Report 290, Department of Transport, Transport and Road Research Laboratory (cited and discussed in Michael Sivak, *et al.* 1991. The Influence of Truck Driver Eye Position on the Effectiveness of Retroreflective Traffic Signs. UMTRI–91–35. University of Michigan, Transportation Research Institute, p. 8.).

[91] The American Association of State Highway and Transportation Officials (AASHTO) uses similar values for driver's eye height for measuring sight distances. A Policy on Geometric Design of Highways and Streets. 2011. AASHTO (hereinafter "AASHTO Green Book"). It recommends 1.08 m for passenger vehicles and 2.33 m for large trucks (and notes a range of 1.8 to 2.4 m for large trucks). *Id.* pp. 3–14. The AASHTO values are based on a 1997 study by the Transportation Research Board, which estimated the values for passenger cars, multipurpose vehicles, and heavy trucks. Daniel B. Fambro, *et al.* 1997. NCHRP Report 400: Determination of Stopping Sight Distances. Transportation Research Board, National Research Council, National Cooperative Highway Research Program. The driver eye height values used by AASHTO for passenger cars and large trucks appear to be the 10th percentile values reported in the NCHRP report for passenger cars and heavy trucks, respectively. NCHRP Report 400, pp. 44–45 (Tables 31 and 33). The mean values in the NCHRP report are 1.15 m (passenger cars), 2.45 m (large trucks), and 1.48 m (MPVs). Since these estimates are based on a dynamic road survey conducted (largely) in 1993, they are based on older vehicles than the MY 1996 vehicles surveyed by UMTRI. The heights found by UMTRI are lower than in the NCHRP report; this is consistent with the observation that driver eye heights have tended to decrease over time. *See* AASHTO Green Book, p. 3–14.

[92] Seyed Davoodi *et al.* 2011. Motorcycle Characteristics for Sight Distance Investigation on Exclusive Motorcycle Lanes. Journal of Transportation Engineering, 137(7): 492–495.

[93] Specifically, this is based on the mean of 1.43 m reported in Davoodi *et al* and the standard deviation reported in another paper (.117 m). *See* Terry Smith, John Zellner & Nicholas Rogers. 2006. A Three Dimensional Analysis of Riding Posture on Three Different Styles of Motorcycle. International Motorcycle Safety Conference, March 2006. This paper compares the riding posture (using anatomical landmarks) of a sample of human test subjects to the posture of the Motorcycle Anthropometric Test Dummy (MATD). The paper reports, among other things, the standard deviation of the vertical location of the test subjects' left infraorbitale (a point just below the eye) relative to the infraorbitale of the MATD of .117 m. In other words, the study reports the standard deviation of the vertical location of the infraorbitale relative to a fixed point.

[94] SAE J941, Motor Vehicle Drivers' Eye Locations.

[95] SAE J3069, p. 3.

[96] *See, e.g.,* FMVSS No. 208, S10.1; FMVSS No. 210, S4.3.2.

the context of visibility measurement. SAE J826 JUL95 defines and specifies a procedure, including a manikin (''H-point manikin''), for determining the exact location of the H-point in a vehicle; it specifies the H-point in relation to the hip location of a driver in the driver seating position. The rear visibility test procedure uses the J826 manikin and procedure to locate the H point. It then uses anthropometric data from a NHTSA-sponsored study of the dimensions of 50th percentile male drivers [97] to locate the midpoint between the driver's eyes.[98] In practice, a testing laboratory typically uses an H-point manikin fitted with a camera (which is needed for the field of view and image size tests) positioned at the driver's eye midpoint.

We considered a simplified version of this procedure to determine the approximate vertical and lateral position (the Z and Y coordinates) of the expected eye position of a 50th percentile male driver. The driver's seat positioning test procedure in S14.1.2.5 and part of the test reference point procedure (S14.1.5(a)) in FMVSS No. 111 locates the center of the forward-looking eye midpoint with respect to the H-point. We considered using the Z and Y coordinates of the forward-looking eye midpoint to specify the position of the photometer in front of the windshield. This procedure would locate the photometer approximately where the eyes of an average male driver would be. Mounting the photometer at different but nearby locations (*e.g.,* a location corresponding to the forward-looking eye midpoint of a 5th percentile female) would add additional testing burden while likely not affecting the outcome of the test. This alternative test procedure would appear to be practicable. The H-point machine is a fairly standard piece of laboratory test equipment used in other FMVSS and SAE standards. Compared to the proposed test procedure, there would likely be some additional work involved in positioning the manikin, but this may not add an exceptional amount of cost or time to the test, particularly if the laboratory performing the test already had an H-point machine. This alternative might be preferable to the proposed option if it were determined ranges utilized by the proposed option did not have a sound basis.

[97] L.W. Schneider, D.H. Robbins, M.A. Pfliig, & R.G. Snyder. 1985. Anthropometry of Motor Vehicle Occupants; Volume 1-Procedures, Summary Findings and Appendices. National Highway Traffic Safety Administration, DOT 806 715.

[98] *See generally* 75 FR 76232.

Alternative 2

As another alternative for specifying the lateral and vertical position of the photometer(s), we considered obtaining from the manufacturer of the stimulus vehicle the coordinates of the midpoint of the 50th percentile male's drivers' eyes. We believe most vehicle manufacturers would have this information and could supply it to NHTSA. The purpose of this would be to save the Agency time in doing the test, perhaps if an H-point machine were not readily available. While there would be some difference between the photometer location compared to Alternative 1, we believe such relatively small changes would not meaningfully affect test outcomes. If a manufacturer desired to conduct testing following NHTSA's test procedures, it could use a stimulus vehicle it manufactures, or, if it desired to use a stimulus vehicle manufactured by another manufacturer, it could potentially obtain information from the manufacturer of that vehicle.

Alternative 3

We also considered, as an alternative for locating the photometer with respect to the Z and Y axes, using SAE J941 JAN2008, Motor Vehicle Divers' Eye Locations. This document describes a procedure for locating a mid-centroid driver's eye ellipse. We tentatively concluded that, for purposes of compliance testing, J491 would not provide an easy enough to follow procedure; we believed that it would be easier to use the H-point machine instead.

Alternative 4

As a final alternative for locating the photometer laterally, we considered specifying the test procedure such that NHTSA could place the photometer anywhere from the driver's side A pillar up to and including the passenger side A-pillar. This would give an extra margin of safety with respect to glare directed at the driver and would also ensure passengers are not glared. Or, photometers could be positioned at the geometric center of the windshield, which would limit the range of testing.

We seek comment on the desirability of each of these options, whether we should adopt one, or multiple options, and the relative merits of each.

b. Preceding Vehicles

For preceding vehicles, the safety concern is the ADB system could glare the driver by shining excessive light onto the inside or outside rearview mirrors. To measure glare on the outside rearview mirrors, we propose placing the photometer anywhere against or directly adjacent to the mirror's reflective surface. To measure glare on the inside rearview mirror, we propose placing the photometer on the outside of the rear window, laterally and vertically aligned with the interior mirror. We are not proposing more detailed procedures for placing the photometers because the locations of the mirrors themselves largely determine the placement of the photometer, and we do not expect test results to be affected by small variations in the placement of the photometer. We seek comments on this aspect of the proposal.

4. Photometers and Photometric Measurements

We propose that in compliance testing, NHTSA would use a sampling rate of at least 200 Hz when recording test data. We would sample over all the distance ranges for which we are proposing a corresponding glare limit. Illuminance meter and data acquisition equipment would be configured and any necessary steps would be taken to isolate measurement of the light emitted by the ADB test vehicle. We seek comment on the appropriateness of this minimum sampling rate, as well as whether a maximum sampling rate should be specified and, if so, what it should be. We also seek comment on whether there are other aspects of the photometric equipment or measurements that should be specified.

For each test run, illuminance data would be continuously recorded as the ADB vehicle approached the stimulus vehicle through the range defined for the specific test scenario being run. This inter-vehicle distance is measured from the intersection of a horizontal plane through the headlamp light sources, a vertical plane through the headlamp light sources and a vertical plane through the vehicle's centerline to the forward most point of the relevant photometric receptor head mounted on the stimulus vehicle.

In determining the set of recorded illuminance values we would look at within each distance interval to determine compliance, we propose to use the recorded values starting with (and including) the first recorded value up to and including the last recorded illuminance value in each distance range. Any recorded illuminance values in a distance interval greater than the applicable glare limit for that distance would be considered a test failure, provided the value is not a small spike. Values above the applicable glare limit lasting no longer than 0.1 sec. or over a distance range of no longer than 1 m would not be considered test failures. This allows for electric noise in the photometers as well as momentary pitch changes of the test and stimulus vehicles caused by bumps in the test track.

The proposal differs from SAE J3069. For purposes of determining whether an ADB system complies with the glare limits, SAE J3069 considers only illuminance values recorded at distances of 30, 60, 120, and 155 meters, instead of sampling multiple illuminance values within these distance ranges.[99] Because an oncoming or preceding driver could be glared anywhere from 15 m to 220 m, and because the real test of an ADB system's performance is how it operates over the full distance range within which it may be glaring other drivers, we tentatively conclude it is necessary to sample illuminance values throughout this full range, and not simply evaluate ADB system performance at the four distance points at which the derived glare limit changes. Because we are sampling illuminance within these ranges, there is no need to use interpolation. The Agency would look only at these recorded values and not interpolate any values in evaluating compliance. We seek comment on these aspects of the proposal, in particular on whether there are any safety impacts in choosing the proposed test over the SAE approach.

iii. Considerations in Determining Compliance With the Derived Glare Limit Values

The lower beam photometric test points in Table XIX of FMVSS No. 108, from which the proposed glare limits are derived, apply to direct illumination from a headlamp. They do not include ambient light or reflected light from the road surface or signs. Ambient light refers to light emitted from a source other than the ADB system. This includes moonlight, light pollution from nearby buildings, or light coming from the stimulus vehicle. Reflected light refers to light from the ADB vehicle's headlights reflected off the road or other surface into the photometer(s) on the stimulus vehicle.

We propose to account for light from these sources in a couple of ways. To minimize ambient light, we propose that testing occur when the ambient illumination recorded by the photometers is at or below 0.2 lux.[100] We are also proposing the test only be conducted on dry pavement as well as pavement that is not bright white to avoid intense roadway reflections. Nevertheless, some degree of ambient light is unavoidable. Accordingly, in testing compliance the Agency will zero the photometers with the stimulus vehicle's headlighting system on and the stimulus vehicle in the orientation it will be during the test (for example, facing east). If the test involves a curve such that the orientation of the stimulus vehicle changes during the test, the photometers will be zeroed in the direction of the maximum ambient light.

There are more finely grained ways to measure ambient illumination. For driving scenarios in which the stimulus vehicle is moving, we could, for example, dynamically measure ambient illuminance by driving the stimulus vehicle over the test course and continuously recording ambient illuminance over this run. We have tentatively decided this would be unnecessary because we are not proposing to use any roadway illumination. We do not anticipate ambient illumination will vary significantly at different points on a test course section used for a particular driving scenario. We have tentatively decided there is no need to further adjust the measured illuminance values to account for reflected light from the ADB headlights.

We note that FMVSS No. 108 is unusual among the FMVSSs because it requires that lighting equipment be ''designed to conform'' to relevant requirements, as opposed simply to comply with relevant requirements. As we have explained in the past, when NHTSA initially proposed in 1966 that lamps ''comply'' with FMVSS No. 108, industry represented that it could not manufacture every lamp to meet every single test point without a substantial cost penalty unjustified by safety. NHTSA accepted this argument. In adopting the standard, the Agency specified that lamps be designed to comply or designed to conform with the applicable photometric specifications. On a number of occasions since, 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. Thus, historically, there has never been an absolute requirement that every motor vehicle lighting device meet every single photometric test point to comply with Standard No. 108.[101] Lighting equipment design, technology, and manufacturing have evolved and advanced since the late 1960's when the Agency initially adopted the design to conform language, and it may be arguable whether the Agency would come to the same conclusion were it to revisit this issue. Such matters are beyond the scope of this rulemaking. We simply note that we are proposing to extend the design to conform language of the current FMVSS No. 108 to the proposed requirements.

There are other adjustments to the measured illuminance values we could potentially make, but we have tentatively decided not to propose. NHTSA requests comment on the following:

- Should pitch correction be addressed directly, or are the momentary spike provisions enough to meet the goals of this rulemaking?
- SAE J3069 allows a 2.5 sec reaction time (*i.e.,* a glare limit may not be exceeded for more than 2.5 sec), motivated by the ''sudden appearance of an opposing or preceding vehicle due to a cresting a hill, a vehicle entering a roadway, etc.'' Should the Agency consider such a reaction time requirement in the regulation?
- Should the Agency specify specific photometry equipment and/or filtering based on the test vehicle's light source technology? Should the Agency specify different equipment to test HID, halogen, LED, or pulse width modulated headlamps?

iv. Additional Test Parameters

1. Test Scenarios

We are proposing a variety of different scenarios the Agency would be able to run to test for compliance. Scenarios would be specified in the regulatory text. For each scenario, we specify speeds of the ADB and stimulus test vehicles, the radius of curvature of the track, the superelevation, the orientation of the ADB and stimulus test vehicles, and the particular vehicle maneuver tested. Values proposed for speed, radius of curvature, and superelevation are consistent with a standard formula used in road design specifying the relationship between these parameters. The formula, referred to as the simplified curve formula, is

$$0.01e + f = \frac{V}{15R}^{2},$$

where f is the coefficient of friction, V is the vehicle speed, R is the radius of curvature, and e is superelevation.[102]

The proposal specifies vehicle speeds of up to 70 mph, depending on whether the test track is straight or curved (and how tight the curve is). We propose to

[99] If there is no illuminance value recorded at a specified distance, SAE J3069 specifies an interpolation procedure to generate an illuminance value at that distance.

[100] *See* SAE J3069 at 5.5.2.1, 5.5.3.1 (''No other vehicle lighting devices shall be activated or any retro-reflective material present and care should be taken to avoid other sources of light, reflected or otherwise.'').

[101] *See* 62 FR 63416 (Nov. 28, 1997).

[102] AASHTO Green Book, pp. 3–19 to 3–20.

use speeds up to 70 mph when testing on a straight track. We believe an upper limit of 70 mph is reasonable because freeways and other arterials frequently have speed limits this high. We believe that for an ADB system to operate at a sufficient level of safety it should be able to operate at these speeds, both because these speeds are typical of real-world driving, as well as because safety concerns regarding glare are magnified at higher speeds.

We propose using a straight track or a track with a radius of curvature from 320–380 ft. (for vehicle speeds of 25–35 mph); 730–790 ft. (for vehicle speeds of 40–45 mph); and 1100–1300 ft. (for speeds of 50–55 mph). The first range of radius of curvature corresponds to (approximately) the smallest radius of curvature appropriate for a vehicle traveling 25–35 mph; these speeds roughly correspond to the minimum speed for which we propose to allow ADB activation. The second range of radius of curvature roughly corresponds to the higher ADB minimum activation speeds of some of the ADB-equipped vehicles the Agency tested. Finally, to evaluate ADB performance at higher speeds, we are proposing an 1100–1300 ft. radius taken at 50–55 mph. We tentatively believe it is important to include actual curves because curves may present engineering challenges to ADB systems. For example, in oncoming situations, a curve presents an engineering challenge in that the opposing vehicle appears from the edge of the field of view at a close distance; in a tight curve, an oncoming vehicle will enter the camera field of view at a closer distance than in a larger-radius curve. Performing adequately on large-radius curves at relatively high speeds presents a slightly different engineering challenge than performance on tight curves at lower speeds.

We also propose superelevation (*i.e.,* the degree of banking of the track) of 0 to 2%. We attempt to minimize the degree of banking because photometry design as well as the existing and derived glare limits are based on flat surfaces.

We are proposing three basic maneuvers for testing compliance. These are oncoming (where the ADB and stimulus vehicles approach each other traveling in opposite directions); same direction/same lane (where the stimulus vehicle precedes the ADB vehicle in the same lane); and same direction/passing (where the stimulus vehicle begins behind the ADB vehicle, in the adjacent lane, and then passes the ADB vehicle from either the left or the right). During each of these maneuvers, each vehicle would be driven within the lane and would not change lanes. For each of these types of maneuvers, we specify the stimulus vehicle speed, ADB vehicle speed, radius of curvature (if testing on a curve), and superelevation with which the Agency may test.

The proposal differs significantly from SAE J3069 in several respects. First, as discussed above in Section VIII.b.ii, we are proposing to test with actual vehicles and not simply test fixtures. Second, this proposal effectively tests at higher speeds than SAE J3069. SAE J3069 specifies a minimum speed (above the ADB activation threshold speed) but does not specify maximum speed. Because some of the proposed testing scenarios employ a moving stimulus vehicle as well as a moving ADB vehicle (at speeds of up to 70 mph for both), the proposal would require a faster reaction time from ADB systems (and, as discussed earlier in Section VIII.b.iii, we tentatively decided not to include a reaction time allowance). Third, the proposed test scenarios include curves. SAE J3069 specifies a straight track and accounts for curves by specifying test fixtures up to two lanes to either side of the ADB test vehicle, so that ''in a straight-line encounter, an ADB must continuously track the angular location of an opposing vehicle as that angular position becomes progressively further from the center of the camera's field of view with decreasing distance to the opposing vehicle.'' We tentatively believe it is important to test on curves because the safety effect of glare could be magnified when a vehicle is travelling at speed on a curve. In addition, the Agency's testing revealed that existing ADB systems may not always appropriately shade oncoming vehicles in curves; we believe it is important to include this scenario to ensure that ADB systems operate safely. We seek comments on these differences, including the safety impact of adopting the proposed test versus the SAE standard.

The Agency has tentatively concluded that these proposed test scenarios are objective and strike a reasonable balance between safety and practicability. The proposal includes realistic vehicle speeds, interactions, and road geometries. We believe it is not unreasonable to expect an ADB system to avoid glaring other motorists in these scenarios. We considered, but are not proposing, a broader set of scenarios and/or test parameter values (*e.g.,* additional radii of curvature, testing with multiple stimulus vehicles). This would have allowed the Agency to test with a greater degree of realism. However, a broader range of test scenarios may have led to less confidence in the repeatability of test results. In any case, we tentatively believe that the proposed set of scenarios is sufficient to provide a minimum level of safety; they include a broad range of actual vehicles on a test track traveling at (up to) highway speeds, on curved and straight road segments.

At the same time, we tentatively conclude that the scenarios we are proposing are practicable, although some scenarios might be challenging for some ADB systems. The Agency's testing indicated that the ADB systems we tested generally performed well on straight roads, for oncoming and preceding glare.[103] However, we did see some exceedances for a stationary stimulus vehicle in this scenario, suggesting a stationary oncoming vehicle may be more difficult for ADB systems we tested to handle.[104] ADB systems also generally performed well in shading preceding vehicles on curves. We observed that ADB systems we tested had difficulties staying within the glare limits on curves for oncoming vehicles.[105] It may be that on a curve the stimulus vehicle coincides with larger horizontal angles of the beam pattern where the intensity of light may be higher. Accordingly, it may be possible to design headlamps so the intensity of light at these wider angles is brought down to the proposed glare limits.

Additionally, it might also be the case that ADB systems experiencing test failures are not able to view, classify, and adapt to an oncoming vehicle through a curve in a realistic high-speed interaction. The Agency's research included testing on various curves, but of particular applicability to this proposal are tests conducted on a curve with a radius of 764 ft. at 62 mph. As shown in the research report graphs,[106] the ADB systems we tested were unable to react fast enough to avoid providing glare well above the same vehicles' lower beam. As part of this proposal, the Agency considered the real-world significance of this situation and recognized 62 mph is unusually fast for this radius of curvature. Accordingly, the Agency is proposing a lower speed (40–45 mph), which more adequately reflects the typical speed most drivers would approach this type of curve.

We found that some vehicles performed well in all passing maneuver scenarios, while other vehicles did not perform as well in certain passing

[103] ADB Test Report, p. 172.

[104] *Id.* at p. 102.

[105] *Id.* at p. 173.

[106] *Id.* at p. 192 (Fig. 84).

scenarios (for example, the Audi produced high levels of glare in straight and right curve passing maneuvers).[107] We found that the ADB systems generally performed well with respect to oncoming motorcycles, but produced excessive glare in a scenario involving a preceding motorcycle.[108]

There are some common scenarios we considered but are not proposing to test because we recognize that current ADB systems could not reasonably be expected to perform well, or they might be difficult to specify to ensure repeatable results. For example, the proposal does not include testing ADB performance when approaching a vehicle at an intersection oriented perpendicular to the ADB vehicle's direction of travel. [109] We have tentatively decided not to include this scenario because NHTSA's testing indicated that existing ADB systems would have a difficult time complying with this, and we believe the magnitude and effect of glare in this situation would be relatively minimal because the vehicle illuminated by the ADB system would be stopped or preparing for a stop. Examples of other scenarios not proposed are testing with multiple stimulus vehicles; performing more complicated vehicle maneuvers; and performing on dips or hills (this is discussed below in Section VIII.b.iv.5).

We seek comment on all aspects of the proposed test scenarios. Is 70 mph an appropriate maximum speed? Will it be practicable for manufacturers to run compliance tests based on these proposed test procedures, if they so choose to do this as a basis for their certification?

2. Lane Width

We also propose that any test track or road we use have a lane width from 10 feet to 12 feet. The Federal Highway Administration classifies roads by functional types: Arterials, collectors, and local roads.[110] Design speeds on arterials and collectors range from about 20 mph on up;[111] because these roads generally provide enhanced mobility, it is reasonable to believe speeds are generally higher than this. Design speeds for local roads are generally lower, ranging from about 20 to 30 mph.[112] ADB systems are typically designed to activate at speeds above typical city driving speeds; activation speeds of vehicles tested by NHTSA ranged from 19 to 43 mph. Thus, ADB systems could conceivably be used on all types of roads, although ADB would be less likely to be used on local roads (at least in urban settings).

While 12-foot lanes are standard on arterials such as interstates and expressways, a sizeable proportion of collectors and local roads (as well as other types of arterials) have narrower lanes. Arterials and collectors together make up approximately one-third of all roadways.[113] About 55% of arterials and collectors have 12-ft. lanes.[114] However, about 33% have 10 or 11 ft. lanes.[115] Local roads account for approximately two-thirds of all roadways.[116] Local road widths generally range from 8 to 10 ft.[117] NHTSA's testing was conducted on several different track configurations with lane widths of 9, 10.5, and 12 feet.

We tentatively believe using lanes with widths from 10 feet to 12 feet would be adequate to cover a sufficient range of road widths the ADB would encounter in the real world. This would allow lanes narrower than specified in SAE J3069, which tests on a 12 foot lane, but is consistent with the Insurance Institute for Highway Safety headlight testing protocol, which uses a lane of 10.8 ft.[118] We believe that using the proposed range better reflects the range of lane widths on roads where ADB would likely be used. The less the lateral separation between the ADB-equipped vehicle and either oncoming or preceding vehicles, the greater the glare risk (although differences in lateral separation of only a couple of feet may not be expected to have a material effect on the amount of glare). At the same time, we do not believe it is necessary to use lanes narrower than 10 feet because at the speeds at which ADB is operational, lane widths would not, typically, appear to be under 10 feet. Narrower lanes might also affect the safety of running the test.

3. Number of Lanes, Median, and Traffic Barriers

We propose to test using two adjacent lanes. The effects of glare decrease as the angle between the glare source and the observer increases. Accordingly, the glare risk is most acute on 2-lane roads.[119] A properly-functioning ADB system should be capable of detecting and not glaring vehicles in non-adjacent lanes. However, we tentatively conclude that if a system detects and avoids glaring in same lane and adjacent lane scenarios, additional lanes will likely not affect test outcomes. A median of 0 to 20 feet may separate the two lanes. The median may include a barrier wall, but the barrier must not be taller than 12 inches less than the mounting height of the stimulus vehicle's headlamps.

4. Road Surface

We propose that the road surface be of any material (*e.g.,* concrete, asphalt, etc.) but shall not be bright white. Avoiding a bright white road surface will assist in limiting the effects of ambient and reflected light.

We follow SAE J3069 and specify that the road surface have an International Roughness Index (IRI) of less than 1.5 m/km.[120] The IRI is an internationally recognized measure of road surface roughness; the lower the IRI value, the smoother the road, with an IRI of 0 corresponding to a perfectly smooth road. A smooth road is important for the proposed test because an uneven road surface can cause the ADB-equipped vehicle to change pitch, which can lead to anomalies or spikes in the illuminance measurements.[121] This could lead an otherwise compliant headlight beam to exceed the glare

[107] *Id.* at p. 173.

[108] *Id.* at p. 173.

[109] ADB Test Report, p. 110.

[110] *See* Highway Functional Classification Concepts, Criteria, and Procedures, Federal Highway Administration (*hereinafter* "HFCC"), *available at https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/fcauab.pdf.* Arterials (such as interstates and expressways) generally handle longer trips; collector roads collect and disperse traffic between arterials and the lower level roads; and local roads provide access function to homes, businesses, and other locations. Arterials provide relatively high levels of mobility and less access, whereas the opposite is true for local roads, and connectors fall in between. Higher levels of mobility are generally associated with higher speeds.

[111] AASHTO Green Book, p. 6–2 (rural collectors); AASHTO Green Book, p. 6–11 (urban collectors); HFCC p. 43 (arterials); AASHTO Green Book, p. 7–2 (rural arterial); AASHTO Green Book, p. 7–27 (urban arterial). Various speed ratings can be used to describe a road—*e.g.,* operating speed, running speed, speed limit, and design speed. The discussion here focuses on design speed, which is "a selected speed used to determine the various geometric design features of the roadway . . . [and] should be a high-percentile value in this speed distribution curve[.]" AASHTO Green Book, pp. 2–54 to 2–55.

[112] AASHTO Green Book, p. 5–2 (rural local); p. 5–11 (urban local).

[113] Highway Statistics 2014. Department of Transportation, Federal Highway Administration, *available at https://www.fhwa.dot.gov/policyinformation/statistics.cfm,* Table HM–220 (miles); Table HM–260 (lane-miles). All citations to tables are from this edition of Highway Statistics. We consider arterials and collectors together and separately from local roads because of the way the data is reported. If the analysis were based on vehicle miles traveled, the result would likely be similar. *See* HFCC pp. 22–23.

[114] Calculated from Table HM–53.

[115] Calculated from Table HM–53.

[116] Calculated from Table HM–220.

[117] HFCC, p. 23.

[118] IIHS Headlight Test and Rating Protocol (November 2016), p. 5 (3.3 m).

[119] 2007 Report to Congress, pp. iv–v.

[120] SAE J3069 7.1.

[121] *See* John D. Bullough, Nicholas P. Skinner & Timothy T. Plummer. 2016. Assessment of Adaptive Driving Beam Photometric Performance. SAE Technical Paper 2016–01–1408, doi:10.4271/2016–01–1408, p. 3.

limits. (The photometry requirements and the lower beam pattern are based on a nominally level vehicle headlighting system; an increase in vehicle pitch shifts the beam pattern up, which could glare oncoming or preceding vehicles.)

An IRI value of 1.5 corresponds to a newly paved road without any potholes, pitting, or bumps.[122] The Federal Highway Administration classifies roads with an IRI less than 1.5 as ''Good,'' those with an IRI from 1.5 to 2.7 as ''Fair'', and those with an IRI greater than 2.7 as ''Poor.'' [123] Approximately 37% of pavement miles on Federal-aid highways were rated as having ''Good'' ride quality in 2012.[124] This suggests the proposed IRI value is realistically achievable on a test track because it is realistically achievable on the much less-controlled environments of actual roads. The vehicle test facility at which NHTSA conducted its testing regularly measures the IRI of at least some of its track surfaces and has generally found them to have IRI values within the proposed range.

5. Grade of Test Road

We propose to use a road approximating a uniform, level road, with a longitudinal grade (slope) not exceeding 2%. We are not proposing to test on sloped (dipped or hilly) roads. Even headlights with compliant lower beam photometry can glare oncoming or preceding vehicles on sloped roads because the hill geometry may place that vehicle in the brighter portion of the lower beam pattern. NHTSA's testing was consistent with this, showing ADB headlights and FMVSS-compliant lower beams glared oncoming and preceding vehicles on roads with dips.[125] It would be neither practical nor consistent with the approach of this rulemaking (extending the existing lower beam glare requirements to ADB systems) to require this performance of ADB systems.

c. Repeatability

The Agency has collected extensive testing data and is docketing this data. The Agency has done several different analyses of this data to assess the repeatability of the proposed compliance test.

One method is pooled standard deviation.[126] Same-direction and oncoming curve scenarios tended to have the smallest maximum pooled standard deviation values across all four distance ranges. Also, maneuvers involving the stimulus vehicle (also referred to here as the ''DAS'' vehicle) being stationary tended to have smaller pooled standard deviations. This was especially true for curve maneuver scenarios in which the DAS vehicle was stationary, likely because of the short period of time in which the test vehicle's heading was in the direction of the stimulus vehicle.

Another method is visual analysis of data plots from each scenario the Agency tested.[127] These plots demonstrate each run collected data such that the overall shape of the curve (illuminance as a function of distance) is consistent across each test repetition. In most cases, the deviation between data collection runs is small, and for those where larger differences occur, differences can be reasonably attributable to faulty sensors or lack of rigorous equipment configurations for the particular situation such as the motorcycle photometers were not mounted on the motorcycle itself but were on a car positioned nearby (these data are useful for other findings but not for evaluating repeatability). Finally, these plots allow us to evaluate the extent to which the variability within the test itself can be reasonably accounted for in the basic design of the ADB headlighting system. That is to say, this method allows the Agency to evaluate the magnitude of noise within test results as compared to proposed limits. The method of visual analysis further supports the Agency's tentative conclusion that the proposed test provides manufacturers with adequate notice as to the results of any compliance testing the Agency may conduct on its product. The Agency seeks comment on this analysis and these tentative conclusions.

The Agency further examined its research results to understand the validity of the tests. This examination is part of the basis for which the Agency has confidence the proposed tests can generate accurate results and adequately distinguish between an ADB system that is likely to expose others to excessive glare and an ADB system that will not. Table 5 shows results of NHTSA measurements in the baseline (static) condition in which we would expect the photometry to be the least influenced by uncontrollable factors. This is the most basic progression beyond testing headlamps outside of the typical photometric lab used in most regulatory test procedures. As a general observation, we note the mean of each static measurement is below the proposed glare limits for each distance for a lower beam headlighting system. We also note the upper beam illumination at 120 meters is higher than one would expect for an FMVSS headlighting system; however, we also note all four of these vehicles were originally designed to the UNECE standard, which allows for considerably higher intensity upper beam headlamps. Consistent with the information provided to us by the vehicle manufacturer, the Mercedes-Benz and Audi vehicles' upper beam headlamps appear to be within the FMVSS upper beam maximum limit while the other two vehicles are likely outside of this limit. While we were unable to do a standard laboratory photometry test on these headlamps, these data provide confidence NHTSA measurements are reasonable.

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[122] Michael W. Sayers & Steven M. Karamihas. 1998. The Little Book of Profiling, Basic Information About Measuring and Interpreting Road Profiles. University of Michigan. p. 48.

[123] 2015 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Report to Congress, Department of Transportation, Federal Highway Administration, Federal Transit Administration, p. 3–4, *available at https://www.fhwa.dot.gov/policy/2015cpr/pdfs.cfm* (last accessed Sept. 26, 2018).

[124] *Id.* p. 3–3. Many states appear to use similar categorization. The Virginia DOT considers interstates and primary roads with an IRI less than .95 to be ''Excellent,'' and those with an IRI from .95 to 1.6 to be ''Good.'' Approximately one third of interstates in Virginia were rated Excellent, and half were rated Good. Virginia Department of Transportation. State of the Pavement 2016. pp. IV–V, *available at http://www.virginiadot.org/info/resources/State_of_the_Pavement_2016.pdf* (last accessed Sept. 26, 2018).

[125] ADB Test Report, pp. 102, 108, 114.

[126] ADB Test Report, pp. 138–146. The pooled variance is a weighted mean of variances of individual groups, groups in this case being the six different test vehicle/stimulus vehicle combinations. This ignores differences in mean values for different groups and compares only the variability within the groups. The pooed standard deviation is the square root of this. Standard deviations calculated by comparing all values to the overall mean are larger because that calculation includes variability between the groups. The pooled standard deviation method of measuring repeatability measures how well values from one repetition to another of the same maneuver compare to each other for any test vehicle even if the means for the different test vehicles are different.

[127] ADB Test Report, pp. 147–162.

Table 5

Baseline Measured Illuminance Values by Headlighting System Mode and Ambient Conditions (Receptor Head 1), Small DAS

DAS Vehicle Heading	Distance	Vehicle Headlighting System Setting		Audi A8 (n=3)		BMW X5 (n=3)		Lexus LS460 (n=2)		Mercedes-Benz E350 (n=3)	
		ADB	DAS	Average (lux)	SD	Average (lux)	SD	Average (lux)	SD	Average (lux)	SD
NW	N/A	OFF (ambient)	OFF (ambient)	0.01	0.04	0.00	0.01	0.00	0.00	0.00	0.01
NW	30 m (98 ft.)	OFF	LOWER	0.47	0.03	0.52	0.03	0.49	0.02	0.46	0.01
		LOWER	LOWER	1.41	0.57	2.02	0.06	1.59	0.10	1.74	0.05
		LOWER	OFF	1.27	0.04	1.51	0.10	1.09	0.08	1.27	0.05
		UPPER	OFF	31.48*	0.05	31.48*	0.02	31.48*	0.07	31.50*	0.05
NW	60 m (197 ft.)	LOWER	LOWER	0.95	0.00	0.88	0.04	0.80	0.02	0.97	0.03
		LOWER	OFF	0.47	0.02	0.37	0.03	0.30	0.02	0.48	0.05
		UPPER	OFF	30.77*	1.15	31.49*	0.01	31.47*	0.01	22.95	5.50
NW	120 m (394 ft.)	LOWER	LOWER	0.71	0.09	0.60	0.03	0.56	0.01	0.64	0.05
		LOWER	OFF	0.26	0.09	0.10	0.01	0.10	0.03	0.15	0.01
		UPPER	OFF	10.87	0.48	14.83	0.28	16.92	2.75	6.67	1.15
SE	N/A	OFF (ambient)	OFF (ambient)	0.03	0.03	0.12	0.07	0.07	0.07	0.02	0.01
SE	30 m (98 ft.)	OFF	LOWER	0.53	0.03	0.72	0.10	0.59	0.07	0.52	0.03
		LOWER	LOWER	1.73	0.08	1.95	0.22	1.68	0.08	1.83	0.03
		LOWER	OFF	1.23	0.09	1.41	0.18	1.15	0.08	1.33	0.03
		UPPER	OFF	31.48*	0.07	31.46*	0.00	31.48*	0.01	31.50*	0.04
SE	60 m (197 ft.)	LOWER	LOWER	0.96	0.01	1.00	0.13	0.90	0.07	0.98	0.01
		LOWER	OFF	0.41	0.10	0.47	0.08	0.38	0.06	0.48	0.01
		UPPER	OFF	28.69	0.56	31.46*	0.00	29.76	1.91	21.20	3.45
SE	120 m (394 ft.)	LOWER	LOWER	0.75	0.03	0.74	0.12	0.67	0.06	0.77	0.10
		LOWER	OFF	0.23	0.05	0.21	0.08	0.16	0.07	0.23	0.03
		UPPER	OFF	10.73	0.31	13.96	1.44	16.91	2.05	6.85	1.05

***Note: Trials averaged to obtain these noted values include at least one instance of measurement clipping because of raw illuminance level data exceeding the measurement range of the illuminance meter**.

Table 6

			Average Maximum Illuminance by Receptor Head 1 Static and Dynamic – Oncoming, Straight, Curve, Adjacent Lane Maneuvers with Small DAS Vehicle											
			Audi			BMW			Lexus			Mercedes-Benz		
			Lower Beam			Lower Beam			Lower Beam			Lower Beam		
Maneuver Scenario	Range (m)	Glare Limit (lux)	Dynamic (n=3)	Baseline (n=3)	% Diff	Dynamic (n=3)	Baseline (n=3)	% Diff	Dynamic (n=3)	Baseline (n=3)	% Diff	Dynamic (n=3)	Baseline (n=3)	% Diff
Straight, DAS 0 mph, ADB 62 mph	15-29.9	3.109	1.63	Not Reported		2.58	Not Reported		1.67	Not Reported		2.27	Not Reported	
	30-59.9	1.776	0.74	1.27	-42%	2.01	1.51	33%	0.94	1.09	-14%	1.05	1.27	-17%
	60-119.9	0.634	0.35	0.47	-26%	0.29	0.37	-22%	0.33	0.30	10%	0.36	0.48	-25%
	120-239.9	0.281	0.18	0.26	-31%	0.03	0.10	-70%	0.14	0.10	40%	0.15	0.15	0%
Straight, DAS 62 mph, ADB 62 mph	15-29.9	3.109	1.50	Not Reported		2.98	Not Reported		1.73	Not Reported		2.27	Not Reported	
	30-59.9	1.776	0.80	1.27	-37%	1.60	1.51	6%	1.06	1.09	-3%	0.98	1.27	-23%
	60-119.9	0.634	0.45	0.47	-4%	0.29	0.37	-22%	0.34	0.30	13%	0.36	0.48	-25%
	120-239.9	0.281	0.23	0.26	-12%	0.03	0.10	-70%	0.15	0.10	50%	0.15	0.15	0%
ADB curves Left, DAS	15-29.9	3.109	1.90	Not Reported		2.00	Not Reported		2.19	Not Reported		2.61	Not Reported	
	30-59.9	1.776	1.07	1.27	-16%	0.86	1.51	-43%	1.23	1.09	13%	1.27	1.27	0%

0 mph, ADB 62 mph	60-119.9	0.634	0.55	0.47	17%	0.18	0.37	-51%	0.58	0.30	93%	0.62	0.48	29%
	120-239.9	0.281	0.46	0.26	77%	0.03	0.10	-70%	0.44	0.10	340%	0.47	0.15	213%
ADB curves Left, DAS 62 mph, ADB 62 mph	15-29.9	3.109	1.93	Not Reported		1.92	Not Reported		1.94	Not Reported		2.54	Not Reported	
	30-59.9	1.776	1.08	1.27	-15%	0.86	1.51	-43%	1.16	1.09	6%	1.26	1.27	-1%
	60-119.9	0.634	0.57	0.47	21%	0.21	0.37	-43%	0.59	0.30	97%	0.64	0.48	33%
	120-239.9	0.281	0.47	0.26	81%	0.07	0.10	-30%	0.47	0.10	370%	0.49	0.15	227%
ADB curves Right, DAS 0 mph, ADB 62 mph	15-29.9	3.109	2.28	Not Reported		1.63	Not Reported		1.75	Not Reported		2.38	Not Reported	
	30-59.9	1.776	1.63	1.27	28%	0.78	1.51	-48%	1.21	1.09	11%	1.35	1.27	6%
	60-119.9	0.634	0.78	0.47	66%	0.22	0.37	-41%	0.57	0.30	90%	0.77	0.48	60%
	120-239.9	0.281	0.57	0.26	119%	0.07	0.10	-30%	0.40	0.10	300%	0.58	0.15	287%
ADB curves Right, DAS 62 mph, ADB 62 mph	15-29.9	3.109	2.54	Not Reported		1.79	Not Reported		1.73	Not Reported		2.44	Not Reported	
	30-59.9	1.776	1.53	1.27	20%	0.73	1.51	-52%	1.14	1.09	5%	1.30	1.27	2%
	60-119.9	0.634	0.71	0.47	51%	0.16	0.37	-57%	0.54	0.30	80%	0.70	0.48	46%
	120-239.9	0.281	0.54	0.26	108%	0.00	0.10	-100%	0.37	0.10	270%	0.52	0.15	247%

Table 6 includes results of the lower beam headlamp illumination measurements when taken through NHTSA dynamic tests including oncoming scenarios, on a curve (right and left), and on a straightaway with the stimulus vehicle moving and stationary. For purposes of examining the validity of the proposed test, the Agency first considered results of lower beam testing only to remove potential variabilities in test results from the performance of ADB systems. The most closely comparable measurements are the baseline and the straight maneuver as the general orientation for these situations place the vehicle mounted photometers in similar locations for each test. We note measurements for dynamic situations differ from the static in positive and negative ways meaning sometimes the dynamic test produces a higher illumination reading, while in others, it produces a lower illumination measurement as compared to the baseline measurement. Also of significant note, for straight situations, the far distance (120–239.9 m range) produced generally higher percentage differences between the baseline and the dynamic situation. This may be expected as stray light will have a larger percentage contribution considering the smaller base value. Additionally, vehicle pitch variation as measured in angles would have a larger contribution if the lower beam headlamp cutoff were to approach photometers. This second possibility seems the less likely of the two as dynamic measurements were not consistently higher than the baseline measurement for that range and orientation but similar to the other measurement ranges. Sometimes the baseline measurement was higher, and sometimes the dynamic measurements were higher.

Curve situations (both left and right) demonstrated a greater difference between baseline and dynamic tests, particularly at the far distance range. Importantly, the difference did not seem to be compounded with the stimulus vehicle moving as opposed to stationary. One possible explanation for the difference between baseline results and curve results is the orientation of the two vehicles is different. While for the straight situations photometers are in a similar place within the test vehicles' headlamp beam pattern, for the curve situation the vehicle orientation moves the stimulus vehicle (and mounted photometers) out toward larger horizontal angles of the beam pattern where the intensity of light seems to be higher in three of these test vehicles. The BMW consistently did not demonstrate this difference, leading the Agency to believe the test is measuring true differences in vehicles' beam patterns even at large angles in the curve situation. Additionally, the right curve with and without the stimulus vehicle moving recorded similar results as the left curve with and without the stimulus vehicle moving for each of the vehicles tested. As such, the Agency tentatively concludes the difference between baseline and curve situations do not demonstrate variability within the test procedure itself but are caused by variations in beam patterns of test vehicles. Not the topic of this section, however, this examination leads the Agency to tentatively conclude situations in which these far distance curves produced glare beyond tentative limits can be designed out of headlamps.

Considering the confidence established in the Agency's ability to measure lower beam performance in an outdoor test on-vehicle, the Agency next evaluated the performance of the ADB system and evaluated the tests' ability to measure ADB headlighting systems in a dynamic way. First, we compared oncoming straight results between lower beam and ADB as shown in Table 7.

Table 7

			Audi (n=3)			BMW (n=3)			Lexus (n=3)			Mercedes-Benz (n=3)		
Maneuver Scenario	Range (m)	Glare Limit (lux)	Lower Beam	ADB	Quotient (ADB / Lower Beam)	Lower Beam	ADB	Quotient (ADB / Lower Beam)	Lower Beam	ADB	Quotient (ADB / Lower Beam)	Lower Beam	ADB	Quotient (ADB / Lower Beam)
			Illuminance (lux)			Illuminance (lux)			Illuminance (lux)			Illuminance (lux)		
Straight, DAS 0 mph, ADB 62 mph	15-29.9	3.109	1.63	2.00	1.23	2.58	3.23	1.26	1.67	1.50	0.90	2.27	2.50	1.10
	30-59.9	1.776	0.74	0.78	1.06	2.01	1.85	0.92	0.94	0.99	1.05	1.05	1.14	1.08
	60-119.9	0.634	0.35	0.32	0.90	0.29	0.37	1.28	0.33	0.44	1.34	0.36	0.41	1.16
	120-239.9	0.281	0.18	0.14	0.80	0.03	0.05	1.99	0.14	0.37	2.70	0.15	0.16	1.05
Straight, DAS 62 mph, ADB 62 mph	15-29.9	3.109	1.50	2.89	1.93	2.98	2.99	1.01	1.73	1.49	0.86	2.27	2.34	1.03
	30-59.9	1.776	0.80	0.81	1.01	1.60	1.95	1.22	1.06	0.94	0.89	0.98	1.04	1.07
	60-119.9	0.634	0.45	0.42	0.93	0.29	0.38	1.33	0.34	0.35	1.04	0.36	0.39	1.09
	120-239.9	0.281	0.23	0.22	0.98	0.03	0.08	2.65	0.15	0.22	1.46	0.15	0.14	0.93

We expected the straight scenario would pose the least difficult situation for the performance of the ADB system itself and allow the Agency to evaluate the test. As such, we expected ADB results to be similar to lower beam results for the same maneuver. Table 7 compares the maximum illumination value recorded for lower beam headlamps as compared to ADB systems and presents the quotient of the ADB divided by the lower beam. Ideally, we would expect the quotient to equal 1. A value less than 1 identifies results in which the ADB is dimmer than the lower beam, while values greater than 1 identify results in which the ADB is brighter than the lower beam. In general, the results indicate the quotient is close to 1 with some exceptions. The far distance range produced a quotient 2.65 on the BMW, meaning ADB system results for that range are more than twice as bright as lower beam results. This result is, however, a ratio of small numbers, namely 0.08 divided by 0.03. To provide context around these small numbers, the research threshold value for that range is 0.281 (0.3 as proposed today), much greater than recorded results for either headlighting system. The far distance range for the Lexus vehicle produced a ratio of 2.7 meaning ADB results are approaching three times as bright as the lower beam. Unlike results for the BMW, the Lexus measurements are not particularly small numbers. In fact, the ADB measurement for that test was 0.37 lux, which is above the research threshold for the far distance range. Interestingly, the Mercedes-Benz ADB results were within 16% of lower beam results for all ranges corresponding to the straight maneuver. This leads the Agency to the tentative conclusion favorable ratios between the lower beam and ADB systems are technically possible, and the test procedure is useful in discerning the performance of the ADB system in the straight maneuver.

The Agency research also included the evaluation of more complex maneuvers and scenarios to evaluate the ADB performance in situations that are more likely to challenge the ADB system's functionality. Table 8 presents results of the ADB system's performance on the curve maneuver.

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Table 8

Curve Scenarios

Maneuver Scenario	Range (m)	Glare Limit (lux)	Audi (n=3) Lower Beam Illuminance (lux)	Audi (n=3) ADB Illuminance (lux)	Audi (n=3) Quotient (ADB / Lower Beam)	BMW (n=3) Lower Beam Illuminance (lux)	BMW (n=3) ADB Illuminance (lux)	BMW (n=3) Quotient (ADB / Lower Beam)	Lexus (n=3) Lower Beam Illuminance (lux)	Lexus (n=3) ADB Illuminance (lux)	Lexus (n=3) Quotient (ADB / Lower Beam)	Mercedes-Benz (n=3) Lower Beam Illuminance (lux)	Mercedes-Benz (n=3) ADB Illuminance (lux)	Mercedes-Benz (n=3) Quotient (ADB / Lower Beam)
ADB curves Left, DAS 0 mph, ADB 62 mph	15-29.9	3.109	1.90	2.05	1.08	2.00	2.22	1.11	2.19	2.24	1.02	2.61	2.77	1.06
	30-59.9	1.776	1.07	1.22	1.14	0.86	1.00	1.17	1.23	1.32	1.07	1.27	1.42	1.11
	60-119.9	0.634	0.55	1.61	2.92	0.18	0.38	2.14	0.58	0.81	1.41	0.62	1.06	1.71
	120-239.9	0.281	0.46	0.50	1.09	0.03	0.07	1.96	0.44	0.49	1.10	0.47	0.59	1.27
ADB curves Left, DAS 62 mph, ADB 62 mph	15-29.9	3.109	1.93	2.08	1.08	1.92	2.11	1.10	1.94	1.88	0.97	2.54	2.77	1.09
	30-59.9	1.776	1.08	1.22	1.13	0.86	0.92	1.07	1.16	1.30	1.12	1.26	1.40	1.11
	60-119.9	0.634	0.57	1.99	3.49	0.21	0.79	3.76	0.59	1.92	3.23	0.64	1.60	2.49
	120-239.9	0.281	0.47	0.50	1.07	0.07	0.11	1.48	0.47	0.51	1.07	0.49	0.60	1.23
ADB curves Right, DAS 0 mph, ADB 62 mph	15-29.9	3.109	2.28	2.59	1.14	1.63	1.60	0.98	1.75	2.14	1.22	2.38	2.45	1.03
	30-59.9	1.776	1.63	1.61	0.98	0.78	0.77	0.98	1.21	1.21	0.99	1.35	1.39	1.03
	60-119.9	0.634	0.78	2.95	3.77	0.22	1.24	5.58	0.57	1.64	2.87	0.77	1.14	1.49
	120-	0.281	0.57	0.65	1.15	0.07	0.14	1.98	0.40	0.42	1.05	0.58	0.89	1.53

	239.9													
ADB curves Right, DAS 62 mph, ADB 62 mph	15-29.9	3.109	2.54	2.64	1.04	1.79	1.78	0.99	1.73	2.36	1.36	2.44	2.74	1.12
	30-59.9	1.776	1.53	1.95	1.27	0.73	0.75	1.03	1.14	11.19	9.80	1.30	1.46	1.12
	60-119.9	0.634	0.71	3.23	4.53	0.16	2.33	14.37	0.54	4.28	7.93	0.70	1.54	2.21
	120-239.9	0.281	0.54	0.61	1.12	0.00	0.06	275.97	0.37	0.40	1.09	0.52	0.84	1.61

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As discussed previously, the lower beam exceeded research thresholds for the long range for all vehicles except the BMW. Beyond this, several ADB performance aspects were observed in this test. Again, building on the lower beam performance, the ADB performance was evaluated as a quotient of the maximum illumination as compared to the lower beam for each distance range. Audi results showed high quotients for each of the curve tests for the 60–119.9 m range. Not only is the quotient high, the maximum illumination for that range was reported as 1.61, 1.99, 2.95, and 3.23 lux as presented in the table above. To put these values in perspective, the research threshold for that range is 0.634 lux. While the lower beam, in some cases, exceeded this threshold, the maximum exceedance for the lower beam was a measurement of 0.78 over the threshold by just 23% on the Audi. Based on the confidence in the Agency's test, established in the previous discussion, the Agency tentatively concludes differences shown on curves are true differences in the ADB performance and not variability in the test itself. To further establish this tentative conclusion, the Agency looked at details of the test and plotted the illuminance as a function of distance as shown below. Results for the oncoming curve-left test show the passenger car stimulus vehicle and the SUV stimulus vehicle where both the stimulus vehicle and the ADB vehicles are moving at 62 mph.

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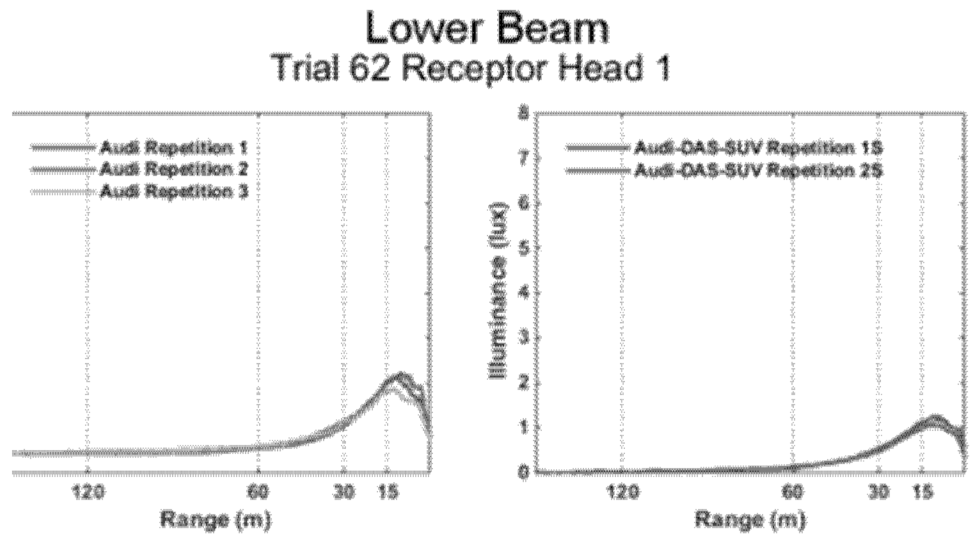

Figure 2

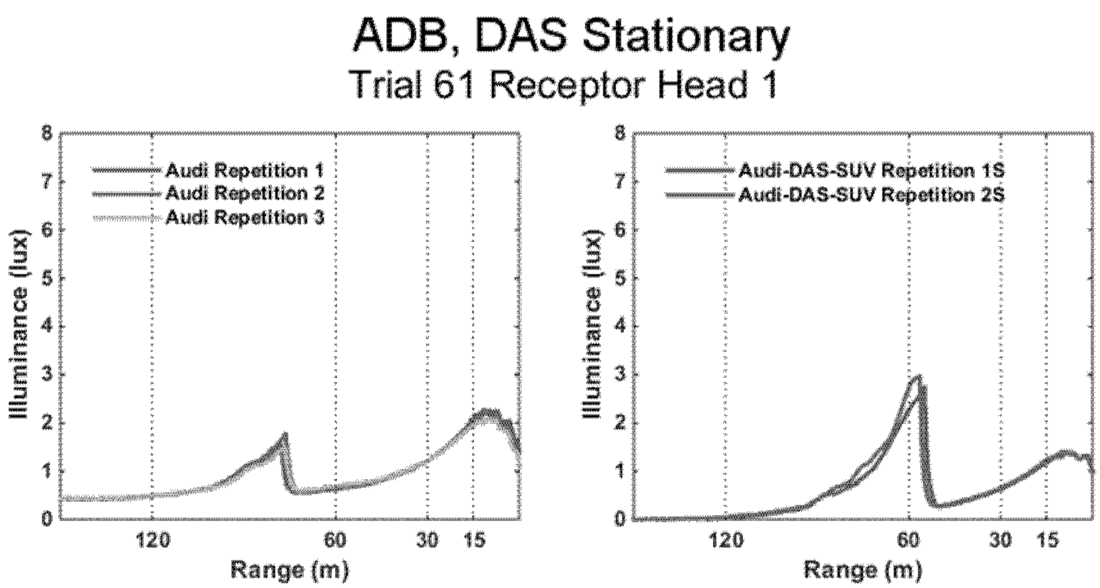

Figure 3

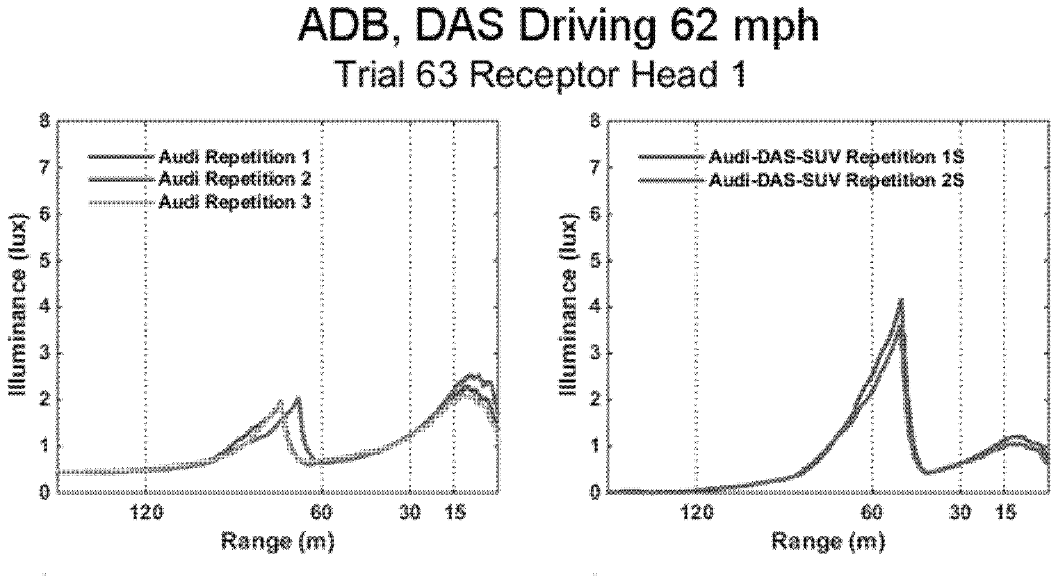

Figure 4

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By comparing the plots, we can see the ADB system is providing a full upper beam (or at least not shading the stimulus vehicle) until suddenly recognizing and dramatically lowering the glare (at round 70 m for the moving passenger car stimulus vehicle and 50 m for the moving SUV stimulus vehicle). The sudden lowering of the illuminance appears to happen sooner for the two stationary stimulus vehicles. The Agency tentatively considers this outcome a byproduct of the ADB system's lack of ability to view, classify, and adapt to an oncoming vehicle through a curve at a realistic but generally high-speed interaction. Further support of this tentative conclusion is that for each of the curve interactions listed above, glare measurements are higher when the stimulus is moving as compared to when it is stopped for the 60–119.9 m range.

Taken together, these results support the Agency's tentative conclusion that the proposed test is repeatable and sufficient in its ability to measure ADB performance using a vehicle-based, dynamic test. Further, the Agency tentatively concludes the variability in the test is small enough that a manufacturer can reasonably anticipate results of any compliance test the Agency would conduct if taken into consideration during design stages of the vehicle and headlighting system.

IX. Certification and Aftermarket

Motor vehicle manufacturers are required to certify that their vehicles comply with all applicable FMVSS.[128] FMVSS No. 108 also applies to replacement equipment (*i.e.,* equipment sold on the aftermarket to replace original equipment installed on the vehicle and certified to FMVSS No. 108 at the time of the first sale to a purchaser other than for resale).[129] Replacement equipment must be designed to conform to meet any applicable requirements and include all functions of the lamp it is designed to replace or capable of replacing.[130] Each replacement lamp which is designed or recommended for particular vehicle models must be designed so that it does not take the vehicle out of compliance with the standard when the individual device is installed on the vehicle.[131] A manufacturer of replacement equipment is responsible for certifying that equipment.[132] It may be the case that only the manufacturer of the original equipment and/or vehicle would be able to make a good faith certification of ADB replacement equipment because requirements are vehicle-level, not equipment level. We seek comment on this.

X. Regulatory Alternatives

The two main regulatory alternatives NHTSA considered were the ECE ADB requirements and SAE J3069. However, as noted earlier, the ECE requirements are not sufficiently objective to be incorporated into an FMVSS. Accordingly, the main regulatory alternative we considered is SAE J3069.

In the preceding sections of this document we discussed in detail specific aspects in which the proposal follows and differs from SAE J3069. In general, there are two major ways in which they differ.

First, the proposal would require a more robust and realistic track test to evaluate glare. This track test is the major element of the proposed rule. It is ultimately based—as is the SAE J3069 track test—on the glare limits developed in NHTSA's Feasibility Study. These glare limits are the foundational element of the track test. The proposal and SAE J3069 differ somewhat in the way the proposed glare limits are specified, but they are largely similar. The proposal differs significantly from SAE J3069, however, in the way that it would test for compliance with these glare limits. SAE J3069 specifies testing on a straight portion of road, and instead of using oncoming or preceding vehicles, uses stationary test fixtures positioned at precisely specified locations adjacent to the test track. The proposed test procedure would permit the Agency to test on curved portions of road (with various radii of curvature) using a broad range of actual FMVSS-certified vehicles as oncoming or preceding vehicles.

Second, the proposal would require additional laboratory-tested equipment-level photometric requirements to regulate both glare and visibility. With

[128] *See, e.g.* 49 U.S.C. 3015.

[129] S3.3 (the standard applies to ''[l]amps, reflective devices, and associated equipment for replacement of like equipment on vehicles to which this standard applies.'').

[130] S6.7.1.1.

[131] S6.7.1.2.

[132] 49 U.S.C. 30115; Letter from Stephen Wood, Acting Chief Counsel, to George Van Straten, Van Straten Heated Tail Light Co., Inc. (Aug. 11, 1989).

respect to glare prevention, we propose to require that the part of the ADB beam that is cast near other vehicles must not exceed the current low beam maxima, and the part of an ADB beam that is cast onto unoccupied roadway must not exceed the current upper beam maxima. SAE J3069 requires the former but not the latter. With respect to visibility, we propose that the part of the ADB beam that is cast near other vehicles must comply with the current lower beam minima, and that the part of the ADB beam that is cast onto unoccupied roadway comply with the upper beam minima. SAE J3069 does not have any laboratory-based requirements for the former, and for the latter specifies the low beam minima, not the upper beam minima.

NHTSA has tentatively concluded that the differences between the proposal and SAE J3069 are necessary to ensure the ADB systems meet the dual safety needs of glare prevention and visibility.

NHTSA is particularly concerned about ensuring, to a reasonable degree, that ADB systems do not glare other motorists. The attraction of ADB is that it is able—if designed and functioning properly—to provide enhanced illumination while not glaring other motorists. However, if an ADB system does not perform as intended, it does have the potential to glare other motorists. NHTSA is particularly concerned about this because glare is a negative externality that might not be sufficiently mitigated by market forces alone. Headlamp design involves an inherent tension between forward illumination and glare. A vehicle manufacturer's incentive, absent regulation, might be to provide forward illumination at the expense of glare prevention because the benefits of forward illumination are enjoyed by the vehicle owner, while glare prevention principally benefits other motorists. NHTSA is especially mindful of the many comments and complaints NHTSA has received from the public expressing concerns about glare. The proposed regulation is, therefore, largely focused on glare. This is consistent with the current headlamp regulations, which have included photometry requirements regulating glare since the standard's inception.

NHTSA tentatively believes that the proposed requirements are preferable to SAE J3069. The proposed track test would require that ADB systems be able to negotiate a variety of real-world conditions and not simply be engineered to recognize specified fixtures. We tentatively believe the proposal will lead to ADB systems that prevent glare more effectively, particularly in real-world situations where the other vehicle enters the field of view of the ADB camera from the side and not from a far distance. We also believe that requiring that the part of the ADB beam that is cast near other vehicles must not exceed the current low beam maxima, and the part of the ADB beam that is cast onto unoccupied roadway must not exceed the current upper beam maxima would provide further assurance against glare compared to the less stringent SAE specifications. We tentatively conclude that the regulatory requirements we are proposing would meet the need for vehicle safety and would be sufficient to determine whether an ADB system was functioning properly so as not to glare other motorists.

While the bulk of the proposal is related to glare, and there is reason to believe that manufacturers have an incentive to provide sufficient forward illumination, we also include a very limited set of laboratory tests to ensure a minimum level of visibility. NHTSA tentatively believes that the limited set of proposed laboratory photometric tests not included in SAE J3069 would provide important safety assurances. These laboratory-based requirements only require that the ADB complies with the existing photometry requirements that ensure that minimum levels of illumination are provided. We tentatively believe that if ADB systems did not provide these minimum levels of illumination the driver might not have sufficient visibility.

At the same time, we tentatively believe that more stringent requirements relating to visibility are not necessary. Manufacturers have a market incentive to provide drivers with sufficient illumination. In addition, if an ADB system is malfunctioning in not providing adequate illumination, vehicle owners can file complaints both with the manufacturer and NHTSA. This would make it possible for NHTSA to identify the safety concern, open a defect investigation, and, if the investigation suggests the ADB system is defective, require the OEM to recall and remedy the vehicle. This is largely not the case for glare, because a motorist who is glared by another vehicle is rarely able to identify that vehicle and submit a complaint. Moreover, we believe potential safety benefits of ADB technology justify focusing on what we believe is the most acute regulatory concern (glare), and not including equally stringent requirements and test procedures related to visibility. Based on the Agency's testing, and on the experience with ADB systems in Europe and Asia, it appears that current systems have generally been providing adequate illumination. However, we tentatively believe these minimum requirements are necessary.

A more detailed discussion of the expected likely costs and benefits of the proposal as compared to SAE J3069 is provided below in Section XI, Overview of Costs and Benefits.

As an alternative to the proposed requirements and compliance test procedures, the Agency could more closely follow SAE J3069. We earlier discussed specific ways in which we depart from SAE J3069. We could choose to conform to SAE J3069 with respect to some or all of these test attributes. The major ways the proposal could further conform to SAE J3069 would be by using stationary fixtures, instead of moving vehicles, limiting the array of road geometries we would test with, and not requiring the additional laboratory-based photometric requirements not also included in SAE J3069. We could also incorporate SAE J3069 by reference.

We seek comment on the relative merits of the proposal and SAE J3069 generally, and the advisability of conforming to or departing from SAE J3069 in any of these respects. In particular, with respect to differences between the proposal and SAE J3069: What are the relative merits and drawbacks of each with respect to the statutory criteria of objectivity, practicability, meeting the need for safety, and appropriateness for the type of vehicle? NHTSA is also interested in views regarding differences between the proposal and SAE J3069 in terms of the repeatability of test results. NHTSA is also interested in learning whether there are any other alternatives that should be considered by the Agency.

XI. Overview of Benefits and Costs

NHTSA has considered the qualitative costs and benefits of the proposal. (For the reasons discussed in Section XI, Overview of Benefits and Costs, NHTSA has not quantified the costs and benefits of the proposal.) NHTSA has analyzed the qualitative costs and benefits of the proposal compared to both the current baseline in which ADB systems are not deployed as well as the primary regulatory alternative (SAE J3069). Based on this analysis, NHTSA tentatively concludes that ADB should be permitted and that the proposed requirements and test procedures are the preferred regulatory alternative.

a. Proposal Compared to Current Baseline in Which ADB is Not Deployed

We have tentatively concluded that the proposal to permit ADB and subject it to requirements and test procedures to ensure that it does not glare other motorists and provides sufficient visibility would have greater net benefits than maintaining the status quo.

We have tentatively determined that the proposal to permit ADB and subject it to requirements and test procedures would lead to greater benefits than maintaining the status quo in which ADB is not deployed. The anticipated benefits are a decrease in fatalities and injuries associated with crashes involving pedestrians, cyclists, animals, and roadside objects due to the improved visibility provided by ADB. The improved visibility is a result of increased upper beam use and an enhanced lower beam. Although it is difficult to estimate these benefits, NHTSA performed a data analysis to explore how driving in better light conditions affects pedestrian and cyclist fatalities. The analysis focused on pedestrian/cyclist fatalities and injuries under various light conditions and explored the correlation between pedestrian/cyclist fatalities and injuries with light conditions, as well as several other risk factors (location, speed limit, alcohol use, and driver distraction). The analysis used data from the Agency's Fatality Analysis Reporting System and the National Automotive Sampling System General Estimate System. These databases contain detailed information on crashes involving fatalities and injuries, respectively, including information on the conditions under which the crashes occurred. This analysis suggests that the size of the target population—pedestrian and cyclist fatalities that occur in darkness—is 15,065 over 11 years or 1,370 per year. This analysis is discussed in more detail in Appendix A. The Agency tentatively concludes this analysis demonstrates that a properly-functioning ADB system could provide significant safety benefits beyond that provided by existing headlighting systems.[133]

The possible disbenefits of this rulemaking would be any increases in glare attributable to ADB. A properly-functioning ADB system would not produce more glare than current headlights because it would accurately recognize and shade oncoming and preceding vehicles. The Agency's research testing of ADB-equipped vehicles leads NHTSA to tentatively conclude that an ADB system that complied with the proposed requirements would not lead to any significant increases in glare. Accordingly, we do not expect any significant disbenefits.[134]

ADB is currently not permitted by FMVSS No. 108, and is therefore not currently available to consumers. The proposed rule, by allowing the introduction of ADB systems, would expand the set of choices open to consumers. ADB systems are optional, and the proposed rule in no way restricts or imposes additional costs or requirements on any existing technologies that consumers are currently able to purchase. Consumers are therefore no worse off under the proposal. Because the proposal expands the set of consumer choices (compared to the status quo), it is an enabling regulation. The estimated cost savings of an enabling regulation would include the full opportunity costs of the previously foregone activities (*i.e.,* the sum of consumer and producer surplus, minus any fixed costs).

Because we expect positive benefits and cost savings from enabling the use of new technologies, we tentatively conclude that the proposal would lead to higher net benefits compared to the status quo. We seek comment on the potential benefits and cost savings of this proposal, including quantitative data that could help estimate their magnitude.

b. Proposal Compared to SAE J3069

NHTSA also compared the proposal to SAE J3069. As discussed below, although the proposal is likely more costly (due to higher compliance testing and equipment costs), these higher costs are likely outweighed by the higher safety-related benefits (and lower glare disbenefits).

The proposal would likely result in greater benefits than the regulatory alternative because the proposed requirements require more illumination (but not at levels that would glare other motorists). Above we broadly estimated the size of the target population. We tentatively believe that the proposed requirements would be more effective—*i.e.,* more likely to lead to a greater reduction in crashes—than SAE J3069 because the proposal would require ADB systems to provide more illumination. Two of the proposed laboratory-based photometric requirements do this. We propose that the part of the ADB beam that is cast near other vehicles must comply with the current lower beam minima, and that the part of the ADB beam that is cast onto unoccupied roadway comply with the upper beam minima. SAE J3069 does not have any laboratory-based requirements for the former, and for the latter specifies the lower beam minima, not the upper beam minima. We believe the proposed requirements would offer meaningful safety assurances. The lower and upper beam minima have been in place for decades. They indicate what have been the longstanding minimum acceptable levels of illumination for adequate visibility. Along with this, they provide an appropriate tradeoff between illumination and glare. While requiring the lower beam minima for the dimmed portion of the ADB beam may not provide much benefit when the ADB system is dimming portions on an oncoming or proceeding vehicle, any activation of the dimmed region due to a false positive (dimming for a lamp post or sign) could have safety implications (because there would not be another vehicle's headlamps to illuminate the road). Because SAE J3069 does not require ADB systems to meet any minima within the dimmed portion of the ADB beam, it could lead to insufficient illumination. On the other hand, it might be possible that the more demanding road test we propose to test for glare could incentivize manufacturers to equip vehicles with ADB systems that provide less illumination (to ensure that they do not fail the glare road test) than they would if we adopt requirements more similar to SAE J3069. However, we tentatively believe the proposed requirements will result in a greater reduction in crashes due to increased illumination.[135]

[133] As discussed in Appendix A, the analysis requires a variety of assumptions and, while partially accounting for some confounding factors (such as alcohol-related crashes), is not able to isolate the effect of darkness on crash risk. (Toyota also estimated the target population, using a different methodology, in its rulemaking petition.) Determining a more specific target population is difficult because of a variety of data limitations (*e.g.,* headlamp state (on-off, upper-lower beam) is not known in many of the pedestrian crashes).

[134] We do recognize, as the ADB Test Report notes, that there are situations in which ADB might not adequately perform, such as at intersections and on dipped segments of roadway. We believe that at intersections the safety concern is lessened because the encountered vehicle is likely stationary. We also note that current headlights, which are unable to actively adapt the beam, can glare other vehicles at intersections and on dipped roads because the roadway geometry becomes such that those vehicles are exposed to relatively bright portions of the beam.

[135] The proposal and the alternative both are most likely to be cost-effective using the DOT's $9.7 million value of a statistical life. However, due to the relatively more stringent performance requirements of the proposal, it would likely accrue more safety benefits than does the alternative.

The Agency has also tentatively concluded that the proposed requirements would lead to smaller disbenefits in terms of glare than the regulatory alternatives, for two reasons. First, the proposal requires a much more realistic road test to evaluate glare, including actual vehicles and curved portions of the roadway, instead of fixtures simulating vehicles and curves. This would require that ADB systems be able to meet a variety of real world conditions and not simply be engineered to recognize specified fixtures. We tentatively believe this will lead to less glare, particularly in real-world situations where the other vehicle enters the field of view of the ADB camera from the side and not from a far distance (such as situations in which the ADB-equipped vehicle is overtaken or encounters an oncoming vehicle on a small-radius curve). Second, the proposal would require that in the undimmed portion of the ADB beam the current upper beam maxima be met; SAE J3069 does not specify any maxima. The upper beam maxima limit the amount of light projected on objects that are not detected by the ADB system such as cyclists, pedestrians, and houses near the road.

NHTSA tentatively concludes that the proposed rule would likely have higher costs than SAE J3069. This is due to compliance testing costs, and, possibly, to component costs.

We would expect higher costs for compliance testing. The proposed road test for compliance with the proposed glare limits is more complex than the testing required by SAE J3069 because it involves actual test vehicles and more scenarios. The proposal also includes requirements for static photometry testing that are not included in SAE J3069. If a manufacturer concluded that testing was necessary to certify an ADB system, then testing for compliance with the proposal would be more costly than compliance testing for a standard more closely based on SAE J3069.

We do not expect design and development costs to be significantly higher than they would be under SAE J3069. ADB is currently offered as an optional system in Europe, among other markets. We tentatively believe that the European ADB (if modified to produce a U.S.-compliant beam [136]) systems are essentially capable of complying with the proposed requirements. The Agency tested a variety of European vehicles in a road test similar to the one that is proposed today to measure glare. The vehicles passed many of the scenarios we tested, although we observed that the ADB systems had difficulties staying within the glare limits when encountering oncoming vehicles on curves when both vehicles were travelling at approximately 60 mph. In consideration of these test results, the proposal does not include any tests on curves at these higher speeds. (In the proposal, we are proposing that the vehicle's speeds not exceed 45 mph in this scenario.)

However, we do believe that it could be more costly to equip a vehicle with an ADB system that complies with the proposal rather than with the minimum requirements of SAE J3069. For instance, the proposal requires that the undimmed portion of the ADB beam meet the current upper beam minima. The European systems we tested similarly used the upper beam (ECE driving beam) to illuminate regions outside the dimmed portion of the beam. SAE J3069, however, requires only that the lower beam minima be met in this region. Accordingly, an SAE J3069-compliant system could use a lower cost light source. As another example, while the European systems NHTSA tested employed relatively sophisticated LED arrays or shading devices, a system that complied with the minimum requirements of SAE J3069 could employ less sophisticated technology.

NHTSA has tentatively concluded that the likely additional (*i.e.,* as compared to SAE J3069) benefits associated with the proposal exceed the likely additional costs of the proposal. The somewhat greater costs it would require to equip a vehicle with an ADB system that complies with the proposed requirements would likely be outweighed by the greater benefits (and smaller glare disbenefits) that we tentatively believe would be likely to result from the proposal. For instance, a system that saved money on a narrow field of view camera would not provide glare protection on small radius curves in real world driving. Additionally, any cost savings to be gained from a less intense light source used for the undimmed portion of the beam would be negated by the relative increase risk to pedestrian detection.

NHTSA seeks comment on all these issues, in particular the relative costs of compliance with the proposal, SAE J3069, and the ECE requirements (especially specific data and cost estimates), as well as the relative benefits of these alternatives.

[136] Because the headlamp photometry requirements in FMVSS No. 108 differ from ECE-required photometry, in order for an ECE-compliant system to be sold in the U.S., the headlamp photometry would need to be modified, which would entail some design cost. This is true for any European-model vehicle sold in the U.S.

XII. Rulemaking Analyses

Executive Order 13771

Executive Order 13771 titled ''Reducing Regulation and Controlling Regulatory Costs,'' directs that, unless prohibited by law, whenever an executive department or Agency publicly proposes for notice and comment or otherwise promulgates a new regulation, it shall identify at least two existing regulations to be repealed. In addition, any new incremental costs associated with new regulations shall, to the extent permitted by law, be offset by the elimination of existing costs. Only those rules deemed significant under section 3(f) of Executive Order 12866, ''Regulatory Planning and Review,'' are subject to these requirements. As discussed below, this rule is not a significant rule under Executive Order 12866. However, this proposed rule is expected to be an E.O. 13771 deregulatory action. Details on the estimated cost savings of this proposed rule can be found in the rule's economic analysis.

Executive Order 12866, Executive Order 13563, and DOT Regulatory Policies and Procedures

Executive Order 12866, Executive Order 13563, and the Department of Transportation's regulatory policies require determinations as to whether a regulatory action is ''significant'' and therefore subject to OMB review and the requirements of the aforementioned Executive Orders. Executive Order 12866 defines a ''significant regulatory action'' as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

We have considered the potential impact of this proposal under Executive Order 12866, Executive Order 13563, and the Department of Transportation's regulatory policies and procedures. This NPRM is not significant and so was not reviewed under E.O. 12866.

However, pursuant to E.O. 12866 and the Department's policies, we have identified the problem this NPRM intends to address, considered whether existing regulations have contributed to the problem, and considered alternatives. Because this rulemaking has been designated nonsignificant, quantification of benefits is not required under E.O. 12866, but is required, to the extent practicable, under DOT Order 2100.5. NHTSA has tentatively determined that quantifying the benefits and costs is not practicable in this rulemaking.

Quantifying the benefits of the proposal—the decrease in deaths and injuries due to the greater visibility made possible by ADB—is difficult because of a variety of data limitations related to accurately estimating the target population and the effectiveness of ADB. For example, headlamp state (on-off, upper-lower beam) is not reflected in the data for many of the pedestrian crashes. Nevertheless, we attempt to broadly estimate the magnitude of the target population in Appendix A. (Toyota's rulemaking petition also includes a target population analysis using a different methodology.)

Quantification of costs is similarly not practicable. The only currently-available ADB systems are in foreign markets such as Europe. We tentatively believe that an ECE-approved ADB system (modified to have FMVSS 108-compliant photometry) would be able to comply with the proposed requirements. It would be possible for NHTSA to estimate the cost of such systems by performing teardown studies, but we have not done so. Among other reasons, even if NHTSA performed tear-down studies for ECE-approved systems, NHTSA would still need to estimate the cost of the compliance with the main regulatory alternative, SAE J3069. However, there are not any SAE J3069-compliant systems on the market to use in a tear-down cost analysis because ADB systems are not currently available in the U.S. It might be possible for NHTSA to estimate the costs of an SAE J3069-compliant system with an engineering assessment, but such an assessment would require additional time and resources.

We therefore tentatively conclude that a quantitative cost-benefit analysis is not currently practicable. We believe that a qualitative analysis (see Section XI, Overview of Benefits and Costs) is sufficient to reasonably conclude that the proposed requirements are preferable to the current regulatory alternative.

Executive Order 13609: Promoting International Regulatory Cooperation

The policy statement in section 1 of Executive Order 13609 provides, in part:

> The regulatory approaches taken by foreign governments may differ from those taken by U.S. regulatory agencies to address similar issues. In some cases, the differences between the regulatory approaches of U.S. agencies and those of their foreign counterparts might not be necessary and might impair the ability of American businesses to export and compete internationally. In meeting shared challenges involving health, safety, labor, security, environmental, and other issues, international regulatory cooperation can identify approaches that are at least as protective as those that are or would be adopted in the absence of such cooperation. International regulatory cooperation can also reduce, eliminate, or prevent unnecessary differences in regulatory requirements.

Although this proposal is different than comparable foreign regulations, we believe that the proposed requirements have the potential to enhance safety.

Executive Order 13132 (Federalism)

NHTSA has examined this proposed rule pursuant to Executive Order 13132 (64 FR 43255; Aug. 10, 1999) and concluded that no additional consultation with States, local governments, or their representatives is mandated beyond the rulemaking process. The Agency has concluded that the rule does not have sufficient federalism implications to warrant consultation with State and local officials or the preparation of a federalism summary impact statement. The rule does not have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.''

NHTSA rules can have preemptive effect in two ways. First, the National Traffic and Motor Vehicle Safety Act contains an express preemption provision: When a motor vehicle safety standard is in effect under this chapter, a State or a political subdivision of a State may prescribe or continue in effect a standard applicable to the same aspect of performance of a motor vehicle or motor vehicle equipment only if the standard is identical to the standard prescribed under this chapter. 49 U.S.C. 30103(b)(1). It is this statutory command by Congress that preempts any non-identical State legislative and administrative law address the same aspect of performance.

The express preemption provision described above is subject to a savings clause under which ''[c]ompliance with a motor vehicle safety standard prescribed under this chapter does not exempt a person from liability at common law.'' 49 U.S.C. 30103(e) Pursuant to this provision, State common law tort causes of action against motor vehicle manufacturers that might otherwise be preempted by the express preemption provision are generally preserved. However, the Supreme Court has recognized the possibility, in some instances, of implied preemption of State common law tort causes of action by virtue of NHTSA's rules—even if not expressly preempted.

This second way that NHTSA rules can preempt is dependent upon the existence of an actual conflict between an FMVSS and the higher standard that would effectively be imposed on motor vehicle manufacturers if someone obtained a State common law tort judgment against the manufacturer—notwithstanding the manufacturer's compliance with the NHTSA standard. Because most NHTSA standards established by an FMVSS are minimum standards, a State common law tort cause of action that seeks to impose a higher standard on motor vehicle manufacturers will generally not be preempted. However, if and when such a conflict does exist—for example, when the standard at issue is both a minimum and a maximum standard—the State common law tort cause of action is impliedly preempted. See *Geier* v. *American Honda Motor Co.,* 529 U.S. 861 (2000).

Pursuant to Executive Order 13132, NHTSA has considered whether this proposed rule could or should preempt State common law causes of action. The Agency's ability to announce its conclusion regarding the preemptive effect of one of its rules reduces the likelihood that preemption will be an issue in any subsequent tort litigation.

To this end, the Agency has examined the nature (*e.g.,* the language and structure of the regulatory text) and objectives of this proposed rule and does not foresee any potential State requirements that might conflict with it. We do note that many or most states have laws that regulate lower and upper beam use. These laws require that a motorist use a lower beam within a certain distance of an oncoming or preceding vehicle. We do not believe that there is a conflict between the proposed rule and these laws because the proposed rule would allow an additional type of lower beam. A vehicle equipped with a compliant and properly functioning ADB system should not glare other vehicles, as long as the proposed requirements are sufficient to meet the goals of this proposal—*i.e.,* to protect oncoming and preceding motorists from glare. NHTSA does not intend that this proposed rule preempt state tort law that would effectively impose a higher standard on motor vehicle manufacturers than that established by this rule. Establishment of a higher standard by means of State tort law would not conflict with the standards proposed in this NPRM. Without any conflict, there could not be any implied preemption of a State common law tort cause of action.

National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321–4347) requires Federal agencies to analyze the environmental impacts of proposed major Federal actions significantly affecting the quality of the human environment, as well as the impacts of alternatives to the proposed action. 42 U.S.C. 4332(2)(C). When a Federal agency prepares an environmental assessment, the Council on Environmental Quality (CEQ) NEPA implementing regulations (40 CFR parts 1500–1508) require it to ''include brief discussions of the need for the proposal, of alternatives [. . .], of the environmental impacts of the proposed action and alternatives, and a listing of agencies and persons consulted.'' 40 CFR 1508.9(b). This section serves as the Agency's Draft Environmental Assessment (Draft EA). NHTSA invites public comments on the contents and tentative conclusions of this Draft EA.

Purpose and Need

This notice of proposed rulemaking sets forth the purpose of and need for this action. As explained earlier in this preamble, ADB technology improves safety by providing a variable, enhanced lower beam pattern that is sculpted to traffic on the road, rather than just one static lower beam pattern, thereby providing more illumination without glare to other motorists. In addition, ADB technology will likely lead to increased upper beam use, thereby improving driver visibility distance at higher speeds. In this document, NHTSA tentatively concludes that FMVSS No. 108 does not currently permit ADB technology. This proposal therefore reconsiders the currently-existing standard by addressing the safety needs of visibility and glare prevention to improve safety. This proposal considers and invites comment on how best to ensure that ADB technology improves visibility without increasing glare.

Alternatives

NHTSA has considered a range of regulatory alternatives for the proposed action. Under a ''no action alternative,'' NHTSA would not issue a final rule amending FMVSS No. 108, and ADB technology would continue to be prohibited. NHTSA has also considered the ECE requirements and SAE J3069, which are described above in this preamble. Under this proposal, NHTSA incorporates elements from these standards, but departs from them in significant ways, which are also described above. NHTSA invites public comments on its proposal.

Environmental Impacts of the Proposed Action and Alternatives

This proposed action is anticipated to result in increased upper beam use as well as greater illumination from lower beams (albeit in patterns designed to prevent glare to other motorists). As a result, the primary environmental impacts anticipated to result from this rulemaking are associated with light pollution, including the potential disruption of wildlife adjacent to roadways. The National Park Service (NPS) defines ''light pollution'' as the introduction of artificial light, either directly or indirectly, into the natural environment.[137] Forms of light pollution include sky glow (the bright halo over urban areas at nighttime), light trespass (unintended artificial lighting on areas that would otherwise be dark), glare (light shining horizontally), and overillumination (excess artificial lighting for a specific activity).[138] Light pollution caused by artificial light can have various effects on flora and fauna, including disrupting seasonal variations and circadian rhythms, disorientation and behavioral disruption, sleep disorders, and hormonal imbalances.[139]

Although this rule is anticipated to result in increased levels of illumination caused by automobiles at nighttime, NHTSA does not believe these levels would contribute appreciably to light pollution in the United States. First, the Agency proposes to require that the part of an ADB beam that is cast near other vehicles not exceed the current low beam maxima and the part of an ADB beam that is cast onto unoccupied roadway not exceed the current upper beam maxima. Although overall levels of illumination are expected to increase from current levels due to increased high beam use and the sculpting of lower beams to traffic on the road, total potential brightness would not be permitted to exceed the potential maxima that already exists on motor vehicles today. These maxima would not only reduce the potential for glare to other drivers, but would also limit the potential impact of light pollution.

Second, we note that ADB systems remain optional under the proposal. Because of the added costs associated with the technology, NHTSA does not anticipate that manufacturers would make these systems standard equipment in all of their vehicle models at this time. Thus, only a percentage of the on-road fleet would feature ADB systems, while new vehicles without the systems would be anticipated to continue to have levels of illumination at current rates.

Third, while ADB systems generally would increase horizontal illumination, they likely would not contribute to ambient light pollution to the same degree as other forms of illumination, such as streetlights and building illumination, where light is intentionally scattered to cover large areas or wasted due to inefficient design, likely contributing more to the nighttime halo effect in populated areas. According to NPS, the primary cause of light pollution is outdoor lights that emit light upwards or sideways (but with an upwards angle).[140] As the light escapes upward, it scatters throughout the atmosphere and brightens the night sky. Lighting that is directed downward, however, contributes significantly less to light pollution. Lower beams generally direct light away from oncoming traffic and downward in order to illuminate the road and the environs close ahead of the vehicle while minimizing glare to other road users. As a result, any increases in lower beam illumination are not anticipated to contribute meaningfully to light pollution. As discussed further in the next paragraph, increases in upper beam illumination would be anticipated largely in less populated areas, where oncoming traffic is less frequent and small sources of artificial light (such as motor vehicles) likely would not change ambient light levels at nighttime to a meaningful degree.

Fourth, NHTSA believes that the areas that would see the greatest relative increase in nighttime illumination are predominantly rural and unlikely to experience widespread impacts. The

[137] National Park Service, Light Pollution. *https://www.nps.gov/subjects/nightskies/lightpollution.htm* (last accessed Sept. 26, 2018).

[138] Chepesiuk, R. 2009. Missing the Dark: Health Effects of Light Pollution. *Environmental Health Perspectives,* 117(1), A20–A27.

[139] *Id.*

[140] NPS, Light Pollution Sources. *https://www.nps.gov/subjects/nightskies/sources.htm* (last accessed Sept. 26, 2018).

Agency's proposal would require ADB systems to produce a base lower beam at speeds below 25 mph. These slower speeds are anticipated primarily in crowded, urban environments where the current impacts of light pollution are likely the greatest. As a result, such urban environments would not experience changes in light levels produced from motor vehicles as a result of this proposal. In moderately crowded, urban environments, nighttime vehicles may travel above 25 mph, thereby engaging the ADB system. However, in those cases, upper beam use would likely be low, as the high level of other road users would cause the ADB system to rely on lower beams for visibility in order to reduce glare for other drivers. These areas may experience small increases in light pollution as the upper beams occasionally engage, as well as increased illumination associated with lower beam shaping by the ADB system. In rural areas, where traffic levels are lower and driving speeds may be higher, the use of ADB systems is anticipated to result in increased upper beam use. However, the low traffic levels would result in only moderate additional light output, and the low quantity of artificial light sources in general would mean that light pollution levels overall would be anticipated to remain low.

The proposed action is anticipated to improve visibility without glare to other drivers. In addition to the potential safety benefits associated with reduced crashes, this rule could result in fewer instances of collisions involving animals on roadways. Upper beams are used primarily for distance illumination when not meeting or closely following another vehicle. Increased upper beam use in poorly lit environments, such as rural roadways, may allow drivers increased time to identify roadway hazards (such as animals) and to stop, slow down, or avoid a collision.

In addition, the impact of added artificial light on wildlife located near roadways would depend on where and how long the additional illumination occurs, whether or not wildlife is present within a distance to detect the light, and the sensitivity of wildlife to the illumination level of the added light. Wildlife species located near active roadways have likely acclimated to the light produced by passing vehicles, including light associated with upper beams (which would be the same under the proposal in terms of brightness, directionality, and shape as under current regulations). Any additional disruption caused by increased use of upper beams is not feasible to quantify due to the extensive number of variables associated with ADB use and wildlife.

NHTSA is unable to comparatively evaluate the potential light pollution impacts of the proposal compared to the other regulatory alternatives (ECE requirements and SAE J3069). For example, the proposal requires that the undimmed portion of the adaptive beam meet the upper beam minima and the dimmed portion of the beam meet the lower beam minima. The SAE standard does not establish minima for either condition. However, NHTSA also proposes that the undimmed portion of the beam may not exceed the upper beam maxima, whereas the SAE standard does not specify an upper beam maxima for the undimmed portion. Thus, while NHTSA proposes more stringent requirements for ADB systems, the wide variations still permitted under the proposal and the SAE standards make it difficult to compare them with any level of certainty. However, to the degree to which ABD systems would function similarly under each of those standards, the environmental impacts would be anticipated to be similar.

NHTSA seeks comment on its analysis of the potential environmental impacts of its proposal, which will be reviewed and considered in the preparation of a Final EA.

Agencies and Persons Consulted

This preamble describes the various materials, persons, and agencies consulted in the development of the proposal.

Tentative Conclusion

NHTSA has reviewed the information presented in this Draft EA and tentatively concludes that the proposed action would not contribute in a meaningful way to light pollution as compared to current conditions. Any of the impacts anticipated to result from the alternatives under consideration are not expected to rise to a level of significance that necessitates the preparation of an Environmental Impact Statement. Based on the information in this Draft EA and assuming no additional information or changed circumstances, NHTSA expects to issue a Finding of No Significant Impact (FONSI). Such a finding will not be made before careful review of all public comments received. A Final EA and a FONSI, if appropriate, will be issued as part of the final rule.

Executive Order 12988 (Civil Justice Reform)

With respect to the review of the promulgation of a new regulation, section 3(b) of Executive Order 12988, ''Civil Justice Reform'' (61 FR 4729, February 7, 1996) requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect; (2) clearly specifies the effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct, while promoting simplification and burden reduction; (4) clearly specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. This document is consistent with that requirement.

Pursuant to this Order, NHTSA notes as follows. The issue of preemption is discussed above in connection with E.O. 13132. NHTSA notes further that there is no requirement that individuals submit a petition for reconsideration or pursue other administrative proceeding before they may file suit in court.

Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.,* as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996), whenever an agency is required to publish an NPRM or final rule, it must prepare and make available for public comment a regulatory flexibility analysis (RFA) that describes the effect of the rule on small entities (*i.e.,* small businesses, small organizations, and small governmental jurisdictions). The Small Business Administration's regulations at 13 CFR part 121 define a small business, in part, as a business entity ''which operates primarily within the United States.'' (13 CFR 121.105(a)). No regulatory flexibility analysis is required if the head of an agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. The SBREFA amended the Regulatory Flexibility Act to require Federal agencies to provide a statement of the factual basis for certifying that a rule will not have a significant economic impact on a substantial number of small entities.

NHTSA has considered the effects of this rulemaking action under the Regulatory Flexibility Act. According to 13 CFR 121.201, the Small Business Administration's size standards regulations used to define small business concerns, manufacturers of the vehicles covered by this proposed rule would fall under North American Industry Classification System (NAICS) No. 336111, *Automobile Manufacturing,* which has a size standard of 1,000 employees or fewer.

NHTSA estimates that there are six small light vehicle manufacturers in the U.S. We estimate that there are eight headlamp manufacturers that could be impacted by a final rule. I hereby certify that if made final, this proposed rule would not have a significant economic impact on a substantial number of small entities. Most of the affected entities are not small businesses. The proposed rule, if adopted, will not establish a mandatory requirement on regulated persons.

National Technology Transfer and Advancement Act

Under the National Technology Transfer and Advancement Act of 1995 (NTTAA) (Pub. L. 104–113), ''all Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments.'' Voluntary consensus standards are technical standards (*e.g.,* materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies, such as the Society of Automotive Engineers (SAE). The NTTAA directs this Agency to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

SAE International has published a voluntary consensus standard (SAE J3069 JUN2016) for ADB systems. The foregoing sections of this document discuss in detail areas in which we follow or depart from SAE J3069.

Paperwork Reduction Act

Under the Paperwork Reduction Act of 1995 (PRA) (44 U.S.C. 3501, *et seq.*), Federal agencies must obtain approval from the Office of Management and Budget (OMB) for each collection of information they conduct, sponsor, or require through regulations. This rulemaking would not establish any new information collection requirements.

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) (UMRA) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by States, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for 2013 results in $142 million (109.929/75.324 = 1.42). The assessment may be included in conjunction with other assessments, as it is here.

This proposed rule is not likely to result in expenditures by State, local or tribal governments of more than $100 million annually.

UMRA requires the Agency to select the ''least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule.'' As discussed above, the Agency considered alternatives to the proposed rule. We have tentatively concluded that none of the alternatives are preferable to the alternative proposed by the NPRM. We have tentatively concluded that the requirements we are proposing today are the most cost-effective alternatives that achieve the objectives of the rule.

Plain Language

Executive Order 12866 and E.O. 13563 require each agency to write all rules in plain language. Application of the principles of plain language includes consideration of the following questions:

- Have we organized the material to suit the public's needs?
- Are the requirements in the rule clearly stated?
- Does the rule contain technical language or jargon that isn't clear?
- Would a different format (grouping and order of sections, use of headings, paragraphing) make the rule easier to understand?
- Would more (but shorter) sections be better?
- Could we improve clarity by adding tables, lists, or diagrams?
- What else could we do to make the rule easier to understand?

If you have any responses to these questions, please include them in your comments on this proposal.

Regulation Identifier Number (RIN) 2127–AL83

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

Privacy Act

Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (65 FR 19477–78).

XIII. Public Participation

How do I prepare and submit comments?

Your comments must be written and in English. To ensure your comments are correctly filed in the Docket, please include the docket number of this document in your comments.

Please organize your comments so they appear in the same order as the topic to which they respond appears in the preamble. Please number comments as they are numbered in the preamble. For example, a comment concerning the placement of the photometer on an oncoming vehicle might be labeled ''VIII.b.ii.3.a—Photometer Placement for Oncoming Vehicles,'' or ''VIII.b.ii.3—Photometer Placement.''

Your comments must not be more than 15 pages long. (49 CFR 553.21). We established this limit to encourage you to write your primary comments in a concise fashion. However, you may attach necessary additional documents to your comments. There is no limit on the length of the attachments.

Comments may also be submitted to the docket electronically by logging onto the Docket website at *http://www.regulations.gov.* Follow the online instructions for submitting comments.

Please note pursuant to the Data Quality Act, for substantive data to be relied upon and used by the Agency, it must meet the information quality standards set forth in the OMB and DOT Data Quality Act guidelines. Accordingly, we encourage you to consult guidelines in preparing your comments. OMB's guidelines may be accessed at *http://www.whitehouse.gov/omb/fedreg/reproducible.html.*

How can I be sure that my comments were received?

If you wish the Docket to notify you upon its receipt of your comments, enclose a self-addressed, stamped postcard in the envelope containing your comments. Upon receiving your comments, the Docket will return the postcard by mail.

How do I submit confidential business information?

If you wish to submit any information under a claim of confidentiality, you should submit three copies of your complete submission, including the information you claim to be confidential business information, to the Chief Counsel, NHTSA, at the address given above under **FOR FURTHER INFORMATION CONTACT**. In addition, you should submit a copy, from which you have deleted the claimed confidential business information, to the docket at the address given above under **ADDRESSES**. When you send a comment containing information claimed to be confidential business information, you should include a cover letter setting forth the information specified in our confidential business information regulation. (49 CFR part 512.)

Will the Agency consider late comments?

We will consider all comments received before the close of business on the comment closing date indicated above under **DATES**. To the extent possible, we will also consider comments the docket receives after that date. If the docket receives a comment too late for us to consider in developing a final rule (assuming that one is issued), we will consider that comment as an informal suggestion for future rulemaking action.

How can I read the comments submitted by other people?

You may read the comments received by the docket at the address given above under **ADDRESSES**. The hours of the docket are indicated above in the same location. You may also see the comments on the internet. To read the comments on the internet, go to *http://www.regulations.gov.* Follow the online instructions for accessing the dockets.

Please note: Even after the comment closing date, we will continue to file relevant information in the docket as it becomes available. Further, some people may submit late comments. Accordingly, we recommend that you periodically check the Docket for new material. You can arrange with the docket to be notified when others file comments in the docket. See *www.regulations.gov* for more information.

XIV. Appendix A to Preamble—Road Illumination and Pedestrian/Cyclist Fatalities

The Agency examined crash risk that could reasonably be linked to vehicle headlighting to demonstrate the safety issue which ADB optional equipment could potentially impact. We explored the correlations between pedestrian and cyclist fatalities (FARS 2006–2016 data) and light conditions, as well as the correlations between pedestrian and cyclist injuries (GES 2006–2016 data) and light conditions. Then the ratios of pedestrian/cyclist fatalities over injuries were also examined. The Agency tentatively believes that a higher ratio of fatalities to injuries demonstrates among potential other influences, driver recognition and attempts to avoid these crashes. The basic concept is that limited visibility can result in late reactions and deadly crashes.

The following tables indicate combined pedestrian and cyclist fatalities, associated with light vehicle (<=10,000 lbs.) crashes only and in ''all areas'' (rural, urban, and others), decreased from 4,755 in 2006 to the lowest number of 4,130 in 2009, but the fatalities increased steadily from 2009 to the highest number of 5,912 in 2016. In particular, there was an increase of 7.1% from 2015 to 2016 in pedestrian and cyclist fatalities.

TABLE A.1—LIGHT CONDITION PEDESTRIAN/CYCLIST FATALITIES FROM FARS 2006–2016

[Light vehicle types <=10,000 lbs.]

Year	Day light	Dark	Dark but lighted	Dawn	Dust	Dark & ukn. light	Others	Not-rept.	Unknown	Total fatalities
2006	1,386	1,561	1,571	92	128	0	0	0	17	4,755
2007	1,433	1,472	1,495	66	98	0	0	0	18	4,582
2008	1,285	1,425	1,463	79	122	0	0	0	13	4,387
2009	1,252	1,199	1,463	71	97	39	0	0	9	4,130
2010	1,254	1,321	1,483	77	84	45	5	2	5	4,276
2011	1,247	1,402	1,569	57	113	35	4	3	8	4,438
2012	1,335	1,589	1,726	79	105	29	2	3	6	4,874
2013	1,336	1,532	1,641	74	113	25	1	5	7	4,734
2014	1,393	1,615	1,697	90	111	25	4	2	10	4,947
2015	1,453	1,789	1,973	91	135	67	2	3	6	5,519
2016	1,499	1,905	2,183	88	138	72	2	3	22	5,912
Total	14,873	16,810	18,264	864	1,244	337	20	21	121	52,554

In addition to the fatality data, GES 2006–2016 data are used to explore how many pedestrians and cyclists were injured (*e.g.,* 'severity' not equal zero) under various light conditions. With both FARS and GES data, we are then able to calculate the ratio of 'fatalities over injuries' (Fatality Rate) under various light conditions, to compare the relative fatality rates (%) under various light conditions.

TABLE A.2—GES 2006–2016 WEIGHTED INJURED PEDESTRIAN/CYCLISTS

[Light vehicle types <=10,000 lbs. only]

Year	Day light	Dark	Dark but lighted	Dawn	Dust	Dark & ukn. light	Others	Not-rept.	Unknown	Total injuries
2006	67,100	9,288	22,531	1,582	4,333	0	0	0	1,471	106,305
2007	71,729	8,285	28,216	1,404	4,010	0	0	0	736	114,379
2008	84,521	8,889	22,009	1,606	3,179	0	0	0	1,209	121,414
2009	73,771	8,037	24,157	1,588	2,935	1,376	20	0	260	112,142

TABLE A.2—GES 2006–2016 WEIGHTED INJURED PEDESTRIAN/CYCLISTS—Continued

[Light vehicle types <=10,000 lbs. only]

Year	Day light	Dark	Dark but lighted	Dawn	Dust	Dark & ukn. light	Others	Not-rept.	Unknown	Total injuries
2010	84,670	6,359	25,808	2,946	4,400	537	0	106	99	124,925
2011	80,876	7,344	27,996	2,056	3,373	292	0	436	379	122,753
2012	80,933	8,864	33,913	707	4,192	499	12	377	81	129,579
2013	74,277	8,305	28,805	960	4,181	457	15	47	116	117,161
2014	77,258	8,901	28,520	1,326	4,604	347	11	293	54	121,316
2015	76,817	9,074	27,223	1,627	3,268	602	15	401	73	119,099
2016	96,861	12,922	34,791	2,361	4,549	1,378	0	406	287	153,556
Total	868,813	96,267	303,969	18,163	43,024	5,488	73	2,065	4,766	1,342,629

From the previous fatalities and injuries tables, the following table provides ratios of fatalities over injuries (fatality rates) under various light conditions. 'Dark' condition resulted in the highest fatality rate. In other words, the following table provides the probability or risk of pedestrian/cyclist fatality under certain light condition when a crash occurred, which could further lead to the relative risk (RR) comparison of two different light conditions.

Table A.3

Fatalities over Injuries Ratios of Pedestrians/Cyclists

(FARS 2006-16, and all injuries: GES 2006-16)

Counts	Day Light	Dark	Dark but Lighted	Dawn	Dusk	Dark & unkn. light	Other	Not-report	Unknown	Total Fatalities
Fatalities (FARS)	14,873	16,810	18,264	864	1,244	337	20	21	121	52,554
Injuries (GES)	868,813	96,267	303,969	18,163	43,024	5,488	73	2,065	4,766	1,342,62 9
Ratio of (fatalities /injuries)	1.71%	17.46%	6.00%	4.76%	2.89%	6.14%	27.40%	1.02%	2.54%	3.91%

These tables indicate that there are 16,810 pedestrian and cyclist fatalities under 'Dark' condition (FARS 2006–16); under the same condition, GES data (2006–2015) indicate there are 96,267 injured pedestrians/cyclists. The fatality rate, *e.g.,* fatalities/injured persons = 17.46% ('Dark' condition). Similarly, there are 18,264 pedestrian and cyclist fatalities under 'Dark but Lighted' condition and 303,969 injured pedestrians and cyclists, which resulting in a ratio of 6.00% (in ''Dark but lighted'' condition).

The Agency first noted the trend within these unfiltered ratios seeming to indicate the possible relationship between the amount of light available to a driver and the fatality risk to pedestrians and cyclists. That is to say, if we examine fatalities rates for 'Daylight' (1.71%), 'Dark but lighted' (6.00%), and 'Dark' (17.46%), and assume these represent decreasing visibility, we note there appears to be an inverse relationship between the amount of light available and the odds for a pedestrian or cyclist being killed if a crash occurs.

However, light condition may not be the only risk factor contributing to the pedestrian/cyclist fatality rate but many other confounding factors may simultaneously contribute to different fatality rates under different light conditions. Other confounding factors may include driver or pedestrian behaviors, vehicle type, travel speed, road condition, driver drinking status, rural/urban difference, EMS, person age/health condition, and more. The next table examines a similar fatality rate comparison made by focusing on a smaller target population of 'nondrinking' crashes only because it is likely light condition and drunk driving are themselves related.

TABLE A.4—PEDESTRIAN/CYCLIST FATALITIES INCLUDING 'DRIVER NOT DRINKING' CRASHES ONLY

[Light VEH <=10,000 lbs, FARS 2006–16]

Year	Day light	Dark	Dark but lighted
2006	1,302	1,369	1,335
2007	1,351	1,294	1,267
2008	1,200	1,250	1,263
2009	1,167	1,050	1,257
2010	1,194	1,180	1,265
2011	1,162	1,245	1,336
2012	1,256	1,431	1,493
2013	1,254	1,378	1,439
2014	1,305	1,474	1,472
2015	1,372	1,642	1,762
2016	1,413	1,752	1,936
Total	13,976	15,065	15,825

TABLE A.5—PEDESTRIAN/CYCLIST INJURIES (INJ_SEV NOT ZERO) INCLUDING 'DRIVER NOT-DRINKING CRASHES' ONLY

[Light veh. <=10, 000 lbs. and GES 2006–16]

Year	Day light	Dark	Dark but lighted
2006	63,535	7,929	19,083
2007	69,553	7,479	26,293
2008	81,003	8,161	19,560
2009	71,870	7,184	22,758
2010	84,006	6,144	24,672
2011	79,471	7,088	26,387
2012	79,724	8,519	32,113
2013	72,970	7,811	25,655
2014	76,201	8,533	27,474
2015	75,831	8,558	26,409
2016	95,226	11,915	33,339
Total	849,390	89,321	283,743

TABLE A.6—RATIOS OF PEDESTRIAN/CYCLIST FATALITIES OVER INJURIES INCLUDING 'NOT-DRINKING DRIVER' CRASHES ONLY DURING 2006–2016 AND LIGHT VEHICLES <=10,000 LBS.

Year	Day light	Dark	Dark but lighted
Fatalities	13,976	15,065	15,825
Injuries	849,390	89,321	283,743
Ratio of (fatalities/injuries)	1.65%	16.87%	5.58%

In examining previous tables, we note the trend demonstrating an inverse relationship between light and the fatality risk for pedestrians continues for crashes not involving alcohol. If our hypothesis considering long distance visibility contributes to the fatality risk to pedestrians and cyclists, then we should also expect a relationship between speed, light, and fatality risk. That is to say, we would expect that at low speeds, a driver may be more likely to react in time to overcome limited visibility and mitigate crash severity but less likely to be able to reduce crash severity at higher speeds. The following analysis considers both speed limit and light condition.

Correlations between the pedestrian/cyclist fatal probability and risk factors could be described by the following equation, where 'p' stands for the probability of 'pedestrian/cyclist fatality', '1-p' stands for the probability of 'pedestrian/cyclist non-fatality', and 'p/(1-p)' is the 'odds' of the crash resulting in 'pedestrian/cyclist fatality' versus 'pedestrian/cyclist non-fatality'. We conducted a multiple logistic model that included 'light condition', 'speed limit' and 'drinking' into the consideration simultaneously. The logit model provides the odds ratio (OR) of two different crash conditions associated with each predictor variable, such as comparing the better light condition with darker light condition; comparing higher speed limit (+5 MPH) with next lower speed limit; and comparing the alcohol involved crash with not-alcohol involved crash. The OR value of larger than 1.0 indicates the higher chance of pedestrian/cyclist fatality while less than 1.0 for lower chance of pedestrian fatality. The model treats pedestrian/cyclist fatal crash as 'outcome', in which FARS 2006–2016 fatalities and GES 2006–16 injuries are used.

$$\frac{p}{1-p} = \exp(\beta_0 + \beta_1 LightCondition + \beta_2 SpeedLimit + \beta_3 Drinking)$$

Or, the probability of pedestrian/cyclist fatality is expressed by:

$$p = \frac{\exp(\beta_0 + \beta_1 LightCondition + \beta_2 SpeedLimit + \beta_3 Drinking)}{1 + \exp(\beta_0 + \beta_1 LightCondition + \beta_2 SpeedLimit + \beta_3 Drinking)}$$

TABLE A.7—PEDESTRIAN/CYCLIST FATALITY ODDS RATIOS FROM LIGHT CONDITION AND SPEED LIMIT

Comparison between two different light conditions	Odds ratio (OR) point estimate	95% OR confidence lower	95% OR confidence upper	P-value
'dawn or dust' vs. 'day light'	1.930	1.781	2.092	<0.0001
'dark but lighted' vs. 'day light'	2.711	2.596	2.830	<0.0001
'dark' vs 'day light'	5.004	4.807	5.209	<0.0001
higher speed limit (5 MPH)	1.512	1.490	1.534	<0.0001
Drinking versus NOT	1.965	1.849	2.087	<0.0001

ANALYSIS OF MAXIMUM LIKELIHOOD ESTIMATES AND PARAMETER ESTIMATE OF EQ.

Comparison between two different light conditions	Parameter estimate (β_i)	Standard error	Wald chi-sqare	P-value
intercept	−2.8634	0.0295	9397.9	<0.0001

ANALYSIS OF MAXIMUM LIKELIHOOD ESTIMATES AND PARAMETER ESTIMATE OF EQ.—Continued

Comparison between two different light conditions	Parameter estimate (β_i)	Standard error	Wald chi-sqare	P-value
'dawn or dust' vs. 'day'	−0.586	0.0292	29.4	<0.0001
'dark but lighted' vs. 'day'	0.1809	0.0157	132.1	<0.0001
'dark' vs 'day'	0.7940	0.0147	2904.1	<0.0001
higher speed limit (5 MPH)	0.4133	0.00734	3174.6	<0.0001
'Drinking' vs 'not-drinking'	0.6753	0.0309	477.97	<0.0001

When fatality chances under two different light conditions are compared, the pedestrian/cyclist fatality chance under 'dawn or dusk' condition is 2 times the fatality chance under 'day light' condition (OR = 1.93); similarly, the pedestrian/cyclist fatality chance under 'dark' condition is 5 times the fatality chance under 'day light' (OR = 5.00); the fatality chance under 'dark' condition is 1.87 times (5.00/2.7 = 1.85) the fatality chance under 'dark but lighted' condition, or in other words, the fatality chance under 'dark but lighted' condition is approximately 54% (2.70/5.00 = 0.53) of the fatality chance of 'dark' condition. This analysis seems to indicate an improvement of light conditions could be helpful for improving and reducing fatality probability. With a higher speed limit (+5 MPH), the pedestrian/cyclist fatality chance is 51% higher (OR = 1.51) approximately. Drinking may result in 2.0 times fatality rate.

List of Subjects in 49 CFR Part 571

Motor vehicle safety, Reporting and recordkeeping requirements, Rubber and rubber products.

Proposed Regulatory Text

In consideration of the foregoing, 49 CFR part 571 is proposed to be amended as set forth below.

PART 571—FEDERAL MOTOR VEHICLE SAFETY STANDARDS

■ 1. The authority citation for part 571 of title 49 continues to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117, 30166; delegation of authority at 49 CFR 1.95.

■ 2. Amend § 571.108 by:
■ a. Revising paragraphs S9.4.1, S9.4.1.1, S9.4.1.2, S9.4.1.3, S9.4.1.4, and S9.4.1.5;
■ b. Adding paragraphs S9.4.1.5.1 through S9.4.1.5.3 in numerical order;
■ c. Revising paragraph S9.4.1.6;
■ d. Adding paragrpahs S9.4.1.6.1 through S9.4.1.6.8 in numerical order;
■ e. Removing S9.4.1.7;
■ f. Revising paragraph S9.5;
■ g. Adding paragraphs S14.9.3.12 through S14.9.3.12.8.1, tables XIX–d and XXI, and figures 23 through 25 in numerical order; and
■ h. Removing the appendix to the section.

The revisions and additions read as follows:

§ 571.108 Standard No. 108; Lamps, reflective devices, and associated equipment.

* * * * *

S9.4.1 *Semiautomatic headlamp beam switching devices.* As an alternative to S9.4, a vehicle may be equipped with a semiautomatic means of switching between lower and upper beams that complies with 9.4.1.1 though S9.4.1.4 and either 9.4.1.5 or 9.4.1.6.

S9.4.1.1 *Operating instructions.* Each semiautomatic headlamp switching device must include operating instruction to permit a driver to operate the device correctly including; how to turn the automatic control on and off, how to adjust the provided sensitivity control, and any other specific instructions applicable to the particular device.

S9.4.1.2 *Manual override.* The device must include a means convenient to the driver for switching to the opposite beam from the one provided.

S9.4.1.3 *Fail safe operation.* A failure of the automatic control portion of the device must not result in the loss of manual operation of both upper and lower beams.

S9.4.1.4 *Automatic dimming indicator.* There must be a convenient means of informing the driver when the device is controlling the headlamps automatically. For systems certified to Option 1, the device shall not affect the function of the upper beam indicator light.

S9.4.1.5—*Option 1 (Semiautomatic Headlamp Beam Switching Devices)*

S9.4.1.5.1 *Lens accessibility.* The device lens must be accessible for cleaning when the device is installed on a vehicle.

S9.4.1.5.2 *Mounting height.* The center of the device lens must be mounted no less than 24 in. above the road surface.

S9.4.1.5.3 *Physical tests.* Each semiautomatic headlamp beam switching device must be designed to conform to all applicable performance requirements of S14.9.

S9.4.1.6—*Option 2 (Adaptive Driving Beam Systems).*

S9.4.1.6.1 The system must be capable of detecting system malfunctions (including but not limited to sensor obstruction).

S9.4.1.6.2 The system must notify the driver of a malfunction. If the ADB system detects a fault, it must disable the ADB system and the lighting system shall work in manual mode until the fault is corrected.

S9.4.1.6.3 The system must be designed to conform to the photometry requirements of Table XIX–d when tested according to the procedure of S14.9.3.12, and, for replaceable bulb headlighting systems, when using any replaceable light source designated for use in the system under test.

S9.4.1.6.4 When the system is producing an upper beam, the system must be designed to conform to the photometry requirements of Table XVIII as specified in Table II for the specific headlamp unit and aiming method, when tested according to the procedure of S14.2.5, and, for replaceable bulb headlighting systems, when using any replaceable light source designated for use in the system under test.

S9.4.1.6.5 For vehicle speeds below 25 mph, the system must produce a lower beam (unless overridden by the manual operator according to S9.4.1.1) designed to conform to the photometric intensity requires of Table XIX–a, XIX–b, or XIX–c as specified in Table II for the specific headlamp unit and aiming method, when tested according to the procedure of S14.2.5, and, for replaceable bulb headlighting systems, when using any replaceable light source designated for use in the system under test.

S9.4.1.6.6 When the system is producing a lower beam with an area of reduced light intensity designed to be directed towards oncoming or preceding vehicles, and an area of unreduced intensity in other directions, the system must be designed to conform to the photometric intensity requirements of Table XIX–a, XIX–b, or XIX–c as specified in Table II for the specific headlamp unit and aiming method, when tested according to the procedure of S14.2.5, and, for replaceable bulb headlighting systems, when using any replaceable light source designated for use in the system under test, within the area of reduced intensity.

S9.4.1.6.7 When the system is producing a lower beam with an area of reduced light intensity designed to be directed towards oncoming or preceding vehicles, and an area of unreduced intensity in other directions, the system must be designed to conform to the photometric intensity requirements of Table XVIII as specified in Table II for the specific headlamp unit and aiming method, when tested according to the procedure of S14.2.5, and, for replaceable bulb headlighting systems, when using any replaceable light source designated for use in the system under test, within the area of unreduced intensity.

S9.4.1.6.8 When the ADB system is activated, the lower beam may be provided by any combination of headlamps or light sources, provided there is a parking lamp. If parking lamps meeting the requirements of this standard are not installed, the ADB system may be provided using any combination of headlamps but must include the outermost installed headlamps to show the overall width of the vehicle.

* * * * *

S9.5 *Upper beam headlamp indicator.* Each vehicle must have a means for indicating to the driver when the upper beams of the headlighting system are activated. The upper beam headlamp indicator is not required to be activated when an Adaptive Driving Beam System is activated.

* * * * *

S14.9.3.12 *Test for compliance with adaptive driving beam photometry requirements.*

S14.9.3.12.1 *Stimulus Vehicles.* There shall be one stimulus vehicle equipped with photometers to measure the light emitted by the ADB-equipped vehicle being tested (test vehicle). The stimulus vehicle may be of any of the vehicle types defined in 49 CFR 571.3 (excluding trailers, motor-driven cycles, and low-speed vehicles) and shall be certified as conforming to all applicable FMVSS, be from any of the five model years prior to the model year of the test vehicle, and be a vehicle on which it is possible to locate a photometer to measure oncoming glare as specified in S14.9.3.12.3.

S14.9.3.12.2 *Photometers.*

S14.9.3.12.2.1 The photometer must be capable of a minimum measurement unit of 0.01 lux.

S14.9.3.12.2.2 The illuminance values from the photometers shall be collected at a rate of at least 200 Hz. Multiple photometers (or photometric receptor heads) may be used provided that they satisfy the requirements of S14.9.3.12.3.

S14.9.3.12.3 *Photometer Placement.* The photometers are placed in positions that are free from shadows and reflections from the stimulus vehicle's surface during the test.

S14.9.3.12.3.1 The photometer is oriented such that the plane in which the aperture of the meter resides is perpendicular to the longitudinal axis of the stimulus vehicle and facing forward or rearward according to the test.

S14.9.3.12.3.2 *Placement of photometers to measure glare to oncoming vehicles.*

S14.9.3.12.3.2.1 *Longitudinal position.* The photometer shall be positioned outside the vehicle, forward of the windshield and rearward of the headlamps.

S14.9.3.12.3.2.2 *Lateral position.* The photometer shall be positioned between and including the vehicle longitudinal centerline over to the driver's side A-pillar.

S14.9.3.12.3.2.3 *Vertical position.* The photometer shall be positioned between the bottom of the windshield and the top of the windshield subject to the lower and upper bounds specified in Table XXI.

S14.9.3.12.3.2.4 If it is not possible to so position the photometer, the vehicle is not eligible as a stimulus vehicle.

S14.9.3.12.3.3 *Placement of photometers to measure glare to preceding vehicles.* Photometers may be positioned at any location on the driver's side outside rearview mirror and/or the passenger's side outside rearview mirror, and/or outside the vehicle, directly outside the rear window, horizontally and vertically centered with respect to the inside rearview mirror.

S14.9.3.12.4 *Test road.*

S14.9.3.12.4.1 *Test Scenario Geometry.* Test scenarios shall involve straight roads and curved roads.

ADB TEST MATRIX

Test matrix No.	Stimulus vehicle speed (mph)	Test vehicle speed (mph)	Radius of curve (ft.)	Superelevation (%)
1	60–70	60–70	Straight	0–2
2	0	60–70	Straight	0–2
3	40–45	60–70	Straight	0–2
4	60–70	40–45	Straight	0–2
5	25–30	25–30	320–380	0–2
6	0	25–30	320–380	0–2
7	40–45	40–45	730–790	0–2
8	0	40–45	730–790	0–2
9	30–35	40–45	730–790	0–2
10	40–45	30–35	730–790	0–2
11	50–55	50–55	1,100–1,300	0–2
12	50–55	40–45	1,100–1,300	0–2
13	40–45	50–55	1,100–1,300	0–2

S14.9.3.12.4.2 The curves shall be of a constant radius within the range listed in the ADB test matrix table.

S14.9.3.12.4.3 The test road shall have a longitudinal grade (slope) that does not exceed 2%.

S14.9.3.12.4.4 The lane width shall be from 3.05 m (10 ft.) to 3.66 m (12 ft.)

S14.9.3.12.4.6 The lanes shall be adjacent, but may have a median of up to 6.1 m (20 ft.) wide, and shall not have any barrier taller than 0.3 m (12 in.) less than the mounting height of the stimulus vehicle's headlamps.

S14.9.3.12.4.7 The tests are conducted on a dry, uniform, solid-paved surface. The road surface shall have an International Roughness Index (IRI) of less than 1.5 m/km.

S14.9.3.12.4.8 The road surface may be concrete or asphalt, and shall not be bright white.

S14.9.3.12.4.9 The test road surface may have pavement markings, and shall be free of retroreflective material or elements that affect the outcome of the test.

S14.9.3.12.5 *Test Scenarios.*

S14.9.3.12.5.1 The scenarios specified in the table below, and as illustrated in Figures 23, 24, and 25, may be tested:

ADB TEST ORIENTATION

Direction	Lane orientation/maneuver	Test matrix No.	Measurement distance (m)
Oncoming	Adjacent	1, 2, 5, 6, 7, 8, 11	15 to 220.
Same Direction	Same Lane	1, 5, 7, 11	30 to 119.9.
Same Direction	Adjacent/Passing	2, 3, 6, 8, 9, 13	15 to 119.9.
Same Direction	Adjacent/Passing	4, 10, 12	30 to 119.9.

S14.9.3.12.5.2 For each of the test runs that include a passing maneuver, the faster vehicle will be located in the left adjacent lane throughout the test run (See Fig. 25).

S14.9.3.12.5.3 For each of the test runs that include a curve, the test vehicle must meet the compliance criteria specified in S14.9.3.12.8 anywhere along the curve.

S14.9.3.12.5.4 The measurement distance is the linear distance measured from the intersection of a horizontal plane through the headlamp light sources, a vertical plane through the headlamp light sources and a vertical plane through the vehicle's centerline to the forward most point of the relevant photometric receptor head mounted on the stimulus vehicle.

S14.9.3.12.6 *Test conditions.*

S14.9.3.12.6.1 Testing shall be conducted on dry pavement and with no precipitation.

S14.9.3.12.6.2 Testing shall be conducted only when the ambient illumination at the test road as recorded by the photometers is at or below 0.2 lux.

S14.9.3.12.7 *Test Procedures.*

S14.9.3.12.7.1 *Vehicle preparation.*

S14.9.3.12.7.1.1 Tires on the stimulus and the test vehicles are inflated to the manufacturer's recommended cold inflation pressure ±6895 pascal (1 psi). If more than one recommendation is provided, the tires are inflated to the lightly loaded condition.

S14.9.3.12.7.1.2 The fuel tanks of the stimulus and the test vehicles are filled to approximately 100% of capacity with the appropriate fuel and maintained to at least 75% percent capacity throughout the testing.

S14.9.3.12.7.1.3 Headlamps on the stimulus and test vehicles shall be aimed according to the manufacturer's instructions.

S14.9.3.12.7.1.4 The ADB system shall be adjusted according to the manufacturer's instructions.

S14.9.3.12.7.1.5 To the extent practicable, ADB sensors and the windshield on the test vehicle (if an ADB sensor is behind the windshield) shall be clean and free of dirt and debris.

S14.9.3.12.7.1.6 The headlamps lenses of the stimulus vehicle and the test vehicles shall be clean and free from dirt and debris.

S14.9.3.12.7.2 Prior to the start of each test, the photometers will be zeroed in the orientation (with respect to the surroundings) in which the test scenario will be conducted. For tests conducted on curves with ambient light sources such as the moon or infrastructure lighting that cannot be eliminated, the photometers will be zeroed in the direction of maximum ambient light. The vehicle lighting on the stimulus vehicle shall be in the same state as it will be during the test.

S14.9.3.12.7.3 The ADB system shall be activated according to the manufacturer's instructions.

S14.9.3.12.7.4 For each test run, a speed that conforms to the ADB test matrix table will be selected for each vehicle. The vehicle will achieve this speed ±0.45 m/s (1 mph) prior to reaching the data measurement distance specified in the ADB test orientation table and maintain it within the range specified in the test matrix table throughout the remainder of the test. During each test run, once the test speed is achieved and maintained, no sudden acceleration or braking shall occur.

S14.9.3.12.7.5 All vehicles shall be driven within the lane and will not change lanes during the data collection potion of the test.

S14.9.3.12.7.6 The illuminance values for each photometer and the measurement distance shall be recorded and synchronized.

S14.9.3.12.8 *Compliance Criteria.* The maximum illuminance, as calculated according to S14.9.3.12.8.1, shall not exceed the applicable maximum illuminance values in Table XIX–d.

S14.9.3.12.8.1 The maximum illuminance will be the single highest illuminance recorded within the distance range excluding momentary spikes above the limits lasting no longer than 0.1 sec. or over a distance range of no longer that 1 meter.

* * * * *

TABLE XIX–d—ADAPTIVE DRIVING BEAM PHOTOMETRY REQUIREMENTS [1]

Range (m)	Maximum illuminance oncoming direction (lux)	Maximum illuminance same direction (lux)
15.0 to 29.9	3.1	18.9
30.0 to 59.9	1.8	18.9
60 to 119.9	0.6	4.0
120 to 220	0.3	4.0

[1] For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded to the nearest 0.1 lux, in accordance with the rounding method of ASTM Practice E29 Using Significant Digits in Test Data to Determine Conformance with Specifications.

* * * * *

TABLE XXI—VERTICAL POSITION RANGES FOR PHOTOMETER USED TO MEASURE ONCOMING GLARE

Vehicle type (weight class)	Lower bound (m)	Upper bound (m)
Passenger Cars	1.07	1.15
Trucks, buses, MPVs (light)	1.26	1.58
Trucks, buses, MPVs (heavy)	1.99	2.67
Motorcycles	1.30	1.66

"Light" means vehicles with a GVWR of 10,000 lb. or less. "Heavy" means vehicles with a GVWR of more than 10,000 lb.

Heights are measured from the ground.

* * * * *

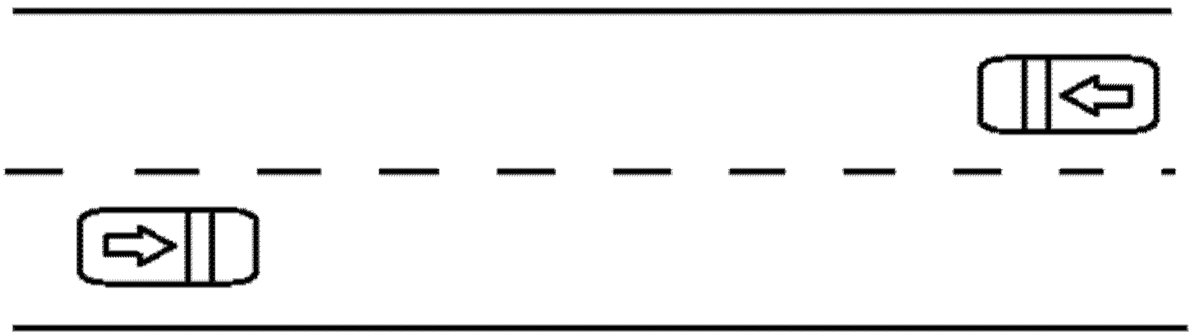

Figure 23

Adjacent Lane Oncoming

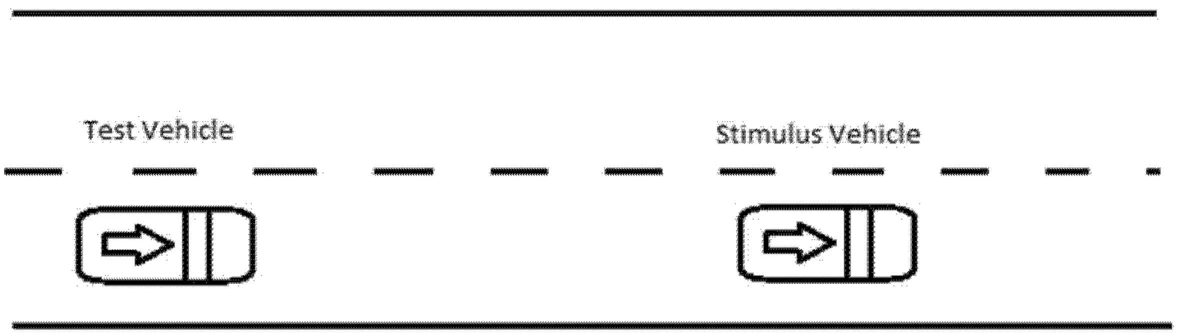

Figure 24

Same Lane / Same Direction

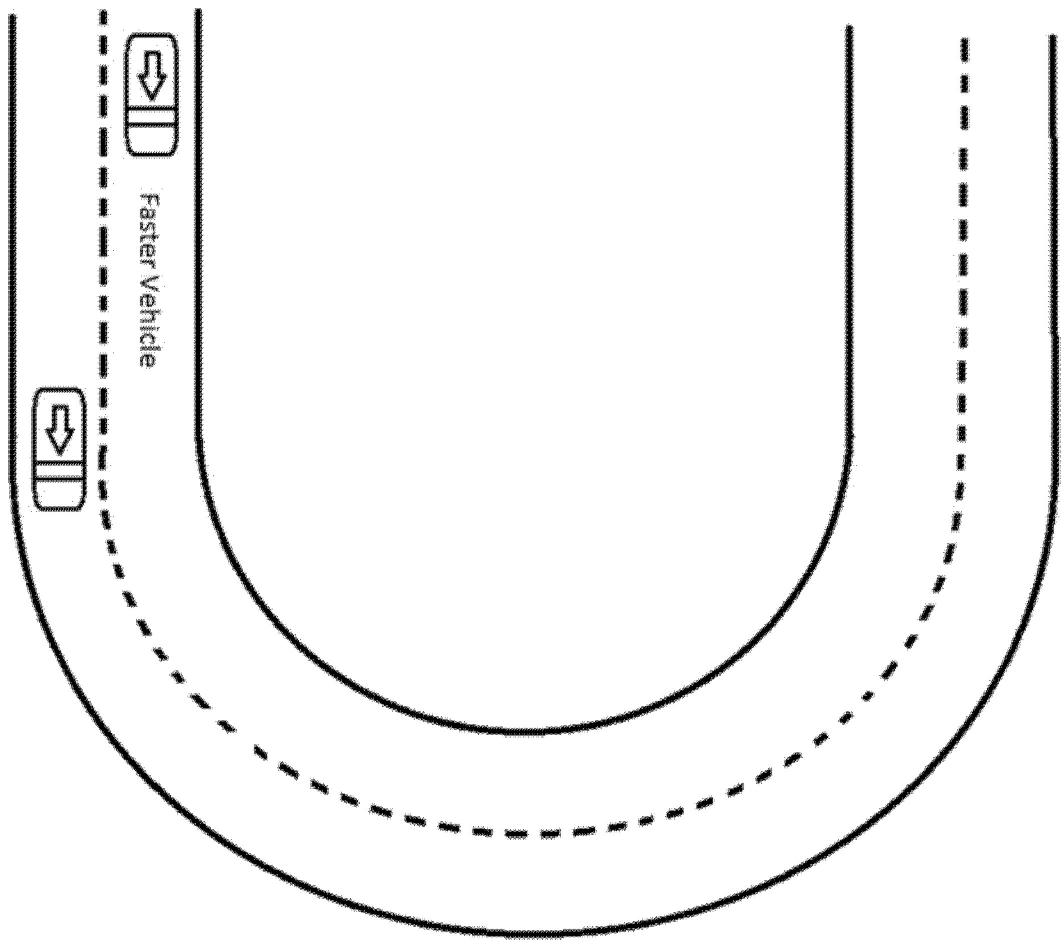

Figure 25

Adjacent Lane - Same Direction – Passing

Issued in Washington, DC, under authority delegated in 49 CFR 1.95 and 501.5.

Heidi Renate King,

Deputy Administrator.

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