TOYOTA

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March 29, 2013

The Honorable David L. Strickland, Esq.
Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

RE: Petition for Rulemaking to Allow Adaptive High-beam Systems into FMVSS No. 108

Dear Administrator Strickland:

On behalf of Toyota Motor Corporation, Toyota Motor North America, Inc. (Toyota) hereby submits a petition for rulemaking pursuant to 49 U.S.C. § 30162 and 49 CFR Part 552. Toyota requests that the National Highway Traffic Safety Administration (NHTSA) initiate rulemaking to amend the current 49 CFR Part 571, Federal Motor Vehicle Safety Standard (FMVSS) No. 108, *Lamps, reflective devices, and associated equipment*, to permit manufacturers the option of equipping vehicles with an advanced forward lighting design we call Adaptive High-beam System (AHS) headlamps[1].

Background

In April 2011, Toyota met with NHTSA officials – including from the offices of rulemaking, enforcement, research, and chief counsel – to discuss Toyota's system and any potential compliance issues. At that time, NHTSA had expressed concerns regarding compliance with S6.2.1 of FMVSS No. 108, which prohibits the installation of any "additional lamp, reflective device or other motor vehicle equipment .... that impairs the effectiveness of lighting equipment required by this standard." Toyota was strongly urged to file a formal request for interpretation of the standard. In September 2011, Toyota submitted a formal request for interpretation of FMVSS No. 108 with regards to AHS, which detailed the system function, its potential failure modes, as well as preliminary benefit estimations (i.e., number of lives saved).

After significant consideration, Toyota has come to understand the regulatory challenge that our request for interpretation poses to NHTSA and we have determined instead to file the present petition for rulemaking requesting an amendment to FMVSS No. 108 to accommodate AHS.

[1] In Toyota's September 2011 request for interpretation, we referred to the same system as "All Zone Beam" headlamps; however, since submission of the request, Toyota has marketed this system in Europe and Japan under the name "Adaptive High-beam System" and we have adopted this name for use in this petition as well.

Technical Description

AHS is a form of adaptive driving beams (ADB) similar in concept to the widely-used automatic high beam (AHB) headlamps, except that AHS preserves the superior illumination benefits of high beams in more cases than AHB can do, while still protecting against undesirable glare in the eyes of oncoming drivers or the mirrors of preceding drivers.

In brief, AHS contains a beam pattern control system that automatically switches among three headlamp modes: a low beam mode that emits a low beam pattern that complies fully with FMVSS No. 108, a high beam mode that emits a high beam pattern that complies fully with FMVSS No. 108 and a third mode that varies the beam pattern to respond to the light sources in front of the vehicle (either an oncoming vehicle's headlamps, a preceding vehicle's taillamps, or both). The variable beam pattern in the third mode is created through the use of a mechanical shade technology that is similar to the one employed in current headlamps.

When the AHS sensor detects a light source in front of the vehicle, it automatically switches to full low beam mode or to the variable beam pattern, depending upon the location of the other light source (i.e. whether light is detected in an approaching vehicle in an oncoming lane or in a preceding vehicle in front of the AHS-equipped vehicle, or both). A camera senses the light source, and an onboard computer processes the necessary information to output a signal to the system to return to low beam mode or to shape a variable beam pattern that respects the need for glare protection for that other driver, while retaining a substantial portion of the visibility benefits associated with the high beam pattern on either the left side or right side of the roadway, depending upon the location of the detected light source. The details of how the Toyota system works are contained in confidential appendices attached to this petition.

In all cases, the driver retains control of the headlamp system through the ordinary operation of the light control switch. The driver can activate or deactivate the AHS system at any time, and can manually switch to low beam mode or high beam mode at any time. The vehicle does not default to AHS unless the driver has selected that mode. Just as with conventional high beam and low beam modes, an ignition of the vehicle will activate the mode last selected by the driver, which could be low beam mode, high beam mode, or AHS mode.

Toyota requests that the requirements of FMVSS No. 108 be amended in order to allow the AHS system. As required by the standard, the Toyota design contains a low beam mode that complies fully with the photometric and other requirements of FMVSS No. 108 for the low beam headlamp. Likewise, the design contains a high beam mode that complies fully with the requirements for the upper beam headlamp. When tested in either of these modes, the headlamp will comply with the standard's requirements. The variable beam pattern in the third mode of operation is thus an "additional" mode of forward lighting that is subject to S6.2.1 of FMVSS No. 108, as stated previously. Toyota respectfully submits that the AHS headlamp design does not impair the effectiveness of the required lighting equipment.

Regulatory History

NHTSA has explained that the purpose of its photometry requirements for forward lighting is "both to ensure adequate illumination of the roadway and overhead signs and to avoid unnecessary glare to other drivers." See Interpretation to Mr. Hyodo of Koito Manufacturing Company, February 10, 2006. Toyota's AHS design respects these dual objectives and takes advantage of the strengths of each conventional mode (low beams to reduce glare; high beams to improve illumination) and combines them into an optimized beam pattern that is tailored to the immediate driving situation and the presence (or absence) of light sources from other vehicles, either oncoming or preceding. NHTSA has also explained that "[g]enerally, we interpret 'make inoperative' to equate to 'impair the effectiveness.'" See Interpretation to Mr. T. Barron, May 16, 1996. In this case, as both the conventional low beam mode and conventional high beam mode remain fully operational and available for selection by the driver at any time, there is no basis to conclude that AHS has "made inoperative" the required forward lighting equipment.

NHTSA has also offered this explanation of the obligation to avoid impairment of effectiveness: "'[e]ffectiveness may be impaired if the device 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.'" See Interpretation to Mr. Wallach of Air Chex Corporation, October 17, 2006. The AHS headlamp design is consistent with these admonitions: it does not create any noncompliance with FMVSS No. 108 when the lamp is in the conventional low beam mode or conventional high beam mode; it does not have the potential for confusion with a signal sent by another lamp; it does not functionally interfere with another lamp, nor does it modify the lamp's candlepower below the minima or above the maxima permitted by the standard in the relevant visibility zones. While 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. For example, the variable beam pattern mode in the presence of an oncoming driver is shaped to have a left-side beam pattern (the side emitting light closer to the oncoming driver on U.S. roads) that remains within the specified minima and maxima candlepower, while the right-side beam pattern (the side that is away from the oncoming driver on U.S. roads) provides some candlepower above the low beam maxima at a few test points to improve the forward and sideways illumination. Details of the variable beam patterns, including specifics about candlepower at each regulated test point, are included in the confidential Appendices A and B attached to this petition.

Benefits

Toyota submits that the AHS headlamp design offers potentially significant safety benefits in avoiding collisions with pedestrians, pedal cyclists and objects on the side of the road in unlit or low lit environments. Research published by UMTRI identifies a target population of about 2,334 pedestrian deaths per year in the U.S. that can be attributed to the effects of darkness. This estimate excludes other nighttime risk factors, such as alcohol and fatigue. UMTRI's research, *Preliminary Assessment of the Potential Benefits of Adaptive Driving Beams*, UMTRI-2011-37, concludes that low-beam headlamps do not adequately support driver vision at higher speeds at night, and that improved headlighting systems – especially those like Toyota's AHS headlamp design that can be successful in controlling unwanted glare – could potentially "offer substantial improvements in safety" over current low-beam headlamps, particularly for reducing the risk of nighttime pedestrian crashes.

UMTRI's research and conclusions about the limitations of low-beam headlighting are consistent with NHTSA's own conclusions about the limitations of low-beam headlamps. NHTSA's publication, *Driving at Night Can Be Deadly...*, cautions drivers that the distance illuminated by low-beam headlamps is less than the stopping distance of a vehicle traveling 40 mph or more, whereas the distance illuminated by high-beam headlamps is longer than the stopping distance of a vehicle traveling more than 50 mph. Because Toyota's AHS headlamp design would allow drivers to have the improved visibility benefits of high-beam headlamps without the glare-inducing disbenefits of conventional high-beam headlamps, the AHS headlamps offer the potential for substantial benefits in reducing the risks of nighttime pedestrian crashes. A copy of the NHTSA publication is enclosed. In addition, Toyota has annotated the publication to illustrate the potential benefits of the AHS headlamp design, and has enclosed a copy of this annotation in Appendix C.

To further quantify the benefits of the AHS system, Toyota has analyzed the FARS database for fatal pedestrian and pedal cyclist crashes that were a result of the pedestrian or pedal cyclist not being visible. The results of the FARS analysis were combined with the benefits of adaptive driving beams over traditional low beam headlamps calculated by UMTRI to estimate a potential benefit of the AHS system to save approximately 9 lives per year. Refer to Appendix D for a comprehensive overview of the benefit calculations.

This estimate of potential safety benefits from AHS headlamps are also consistent with the potential benefits identified in published NHTSA research into the possible safety benefits of advanced forward-lighting concepts. This report, *Investigation of Safety-Based Advanced Forward-Lighting Concepts to Reduce Glare*, DOT HS 811 033, September 2008, noted that FMVSS No. 108 and other standards for headlamps assume the presence of two beam patterns: "a high beam for driving at relatively high speeds and in conditions of little adjacent traffic, and a low beam for driving at lower speeds and when there are many other vehicles in proximity." Refer to the report at page 38.

The report focuses on an advanced forward lighting system which "involves using a 'prime beam' optimized for forward visibility as the main beam pattern, subtracting portions of light when needed to reduce glare to oncoming or preceding drivers" (page 38). The report concludes that "[t]he prime beam approach appears to be a promising one for ensuring adequate forward visibility under a wide range of conditions while controlling glare to other drivers and for studying characteristics of lighting as they pertain to visual performance and safety" (page 38). The lighting system evaluated in this research used a shielding system to change the beam pattern in the presence of oncoming or preceding drivers, similar to the concept for Toyota's

AHS headlamps. Additional benefits of adaptive driving beams are explicitly cited in the various other technical reports listed in the attached page of references.

System Quality

Toyota recognizes that the potential benefits of the AHS headlamps would be illusory if the system is not robust enough to ensure satisfactory performance in reasonably foreseeable conditions. To document the robustness of the design under various assumptions, Toyota is enclosing information about its failure modes analysis in confidential Appendix A.

In order to quantify the real-world benefits of the AHS system, Toyota examined the penetration of this system into the markets of Europe and Japan. Currently, the Lexus LS is the only available vehicle with AHS headlamps as an option in Europe. Sales data for the LS in Europe shows that approximately 1,600 customers have opted for the AHS system since its introduction in 2012. Additionally, AHS is available in the Japanese market as an option on the Lexus LS as well as the Toyota Crown. Sales numbers for these two vehicles indicate approximately 7,000 LS vehicles and approximately 8,000 Crown vehicles equipped with AHS have been sold since the system's introduction in Japan in 2012. Thus there are currently approximately 15,000 vehicle equipped with AHS headlamps in Japan for a worldwide presence of approximately 16,600 vehicles.

At the time of this writing, Toyota is not aware of AHS system malfunctions or complaints. Specifically, a search of Toyota's internal warranty claim database does not produce a single result showing a warrantied repair to any component of AHS for any of the 16,600 vehicles currently on the road since their introduction into the market. Additionally, Toyota is not aware of any customer complaints received as a result of AHS. In fact, the only feedback that Toyota has received has been overwhelmingly positive. Subjective customer feedback has noted the substantial improvement in available light relative to AHB, AHS's effectiveness in poor-visibility conditions, the system's ease of use, and its convenience. Lastly, Toyota has neither received, nor is aware of any complaints from other drivers of other vehicles towards undue glare from AHS.

Although Toyota does not have access to other manufacturers' warranty databases, Toyota is not aware of any other vehicle equipped with substantially similar technology that has ever suffered a warrantable defect in its shaded adaptive driving beam system; nor is Toyota aware of any complaints from customers of other manufacturers' vehicles stemming from their proprietary systems.

Conclusion

In light of the aforementioned benefits to pedestrian safety and the robustness of Toyota's Adaptive High-beam System, we recommend amendment of FMVSS No. 108 to explicitly allow such technology within the standard. Specifically, Toyota provides the following amendments to the language of S4 and S9.4 by way of example:

S4 *Definitions.*
Adaptive driving beam **means a forward lighting beam pattern that automatically adjusts to the presence of other vehicles by eliminating the upper beam lighting intensity in the immediate vicinity of said other vehicles.**

S9.4 *Headlamp beam switching device.*
(a) Each vehicle must have 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. The switch must have no dead point and, except as provided by **subsection (b) or in** S6.1.5.2, the lower and upper beam must not be energized simultaneously except momentarily for temporary signaling purposes or during switching between beams.

(b) A vehicle may have a means of switching to an adaptive driving beam system which may produce different beam patterns on the left side and right side of the vehicle in order to maintain upper beam intensity in all areas except those occupied by another vehicle.

We stand ready to respond to any additional questions you or your staff may have about the AHS headlamp system, its operation and its projected benefits. Thank you for your consideration. Should you or your staff have any questions regarding this petition, please contact me or Mr. Kevin Ro of my staff at (202) 463-6831.

Sincerely,

Tom Stricker

Tom Stricker
Vice President
Technical and Regulatory Affairs

CC: Mr. Christopher J. Bonanti, *Rulemaking*
Mr. O. Kevin Vincent, Esq., *Chief Counsel*

References

Flannagan, M. J., & Sullivan, J. M. (2011, June). *Feasibility of New Approaches for the Regulation of Motor Vehicle Lighting Performance*. University of Michigan Transportation Research Institute, Ann Arbor, MI. Sponsored by NHTSA. Docket No. NHTSA-2011-0145.

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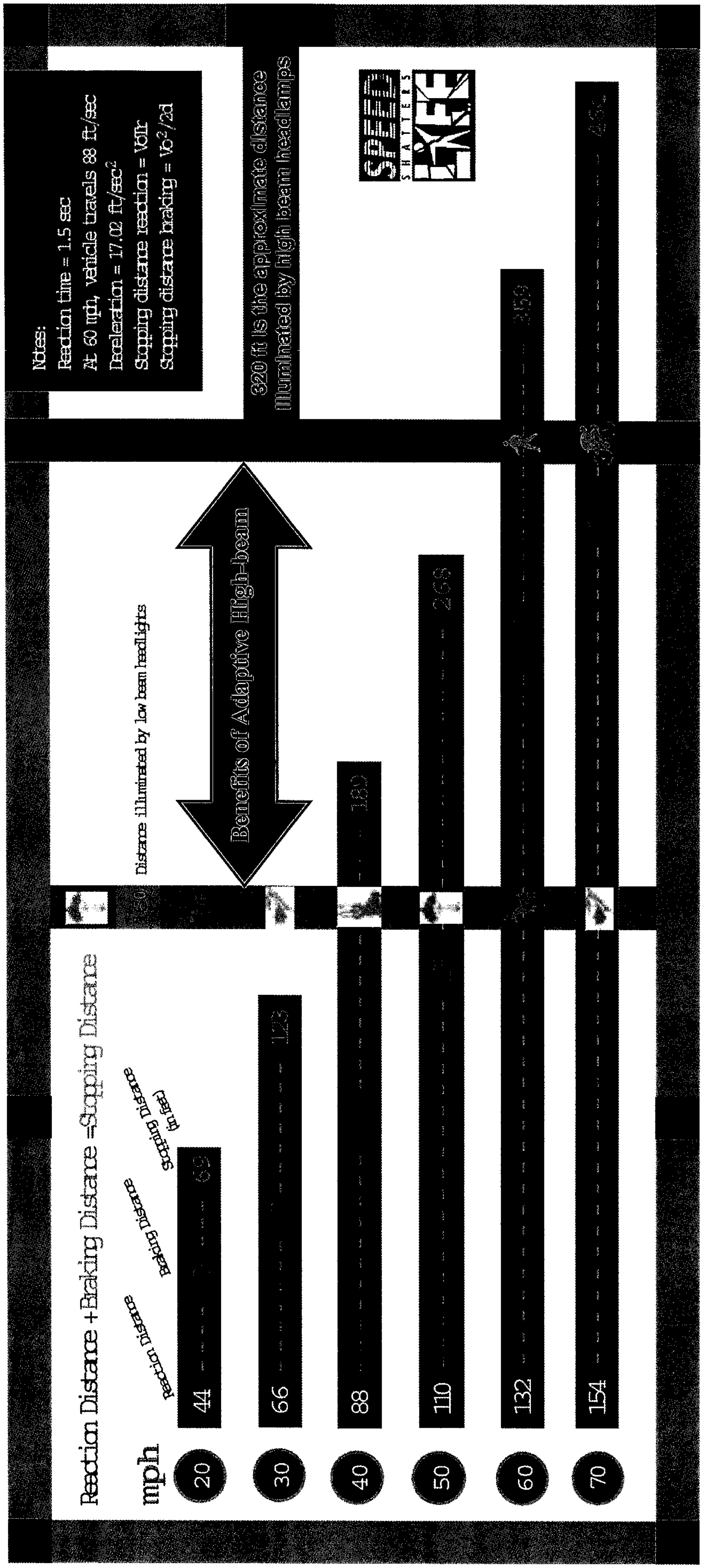
APPENDIX C


Reaction Distance + Braking Distance = Stopping Distance
mph
Reaction Distance
Braking Distance
Stopping Distance (in feet)
20
44
69
30
66
123
40
88
180
50
110
268
60
132
359
70
154
Distance illuminated by low beam headlights
Benefits of Adaptive High-beam
Notes:
Reaction time = 1.5 sec
At 60 mph, vehicle travels 88 ft/sec
Deceleration = 17.02 ft/sec^2
Stopping distance reaction = Votr
Stopping distance braking = Vo^2/2d
320 ft is the approximate distance illuminated by high beam headlamps
SPEED SHATTERS LIFE

APPENDIX D

1. *FARS Analysis*

To estimate the benefits of the Adaptive High-beam System (AHS) system, Toyota has conducted an in-depth analysis of the FARS database with respect to the target population that would benefit most from increased lighting at night: pedestrians and pedal cyclists. To provide the best possible estimate of the benefit of AHS, the most recently available FARS data was averaged over the previous five years from 2005 through 2009. In order to assess a target population of pedestrians and pedal cyclists that would benefit solely from the increased visibility of the AHS system, all other factors that might have led to the subject pedestrian crashes were eliminated.

First, pedestrian and pedal cyclist crashes were assessed by crash related factors at the person level. In addition, only crashes that occurred in situations in which AHS would be active were used. In other words, this assessment only includes the total number of pedestrian and pedal cyclist crashes that occurred at night (6PM through 6AM, as defined by NHTSA), at travel speeds above 20 mph[1], and that were not coded as being alcohol related with respect to the driver. The results are presented in Table 1, which shows the five most prevalent related factors in pedestrian and pedal cyclist crashes with 'Not Visible' being the most prevalent related factor. As shown, the average number of pedestrian and pedal cyclist crashes for 2005 through 2009 in which AHS would be effective was 453.

Table 1. Pedestrian and pedal cyclist related factors 1, 2, and 3 and their sums for 2005 through 2009.

	Pedestrian Factors 1					Pedestrian Factors 2					Pedestrian Factors 3					Summed Pedestrian Factors					
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	Avg 05-09
Not Visible	389	435	333	324	283	46	78	96	88	93	18	14	9	24	35	453	527	438	436	411	**453**
Dart/Run into Rd	9	12	8	9	11	49	66	35	30	37	.	5	5	3	5	58	83	48	42	53	57
Improp Crossing	12	37	36	28	41	108	109	82	85	72	18	14	13	15	16	138	160	131	128	129	137
Walk, etc in Rd	20	19	32	31	37	151	145	112	95	86	10	17	9	10	6	181	181	153	136	129	156
Failure to Yield	16	16	16	22	18	20	35	24	27	23	35	28	23	36	37	71	79	63	85	78	75

As shown in Table 2, all of the striking vehicle related factors for pedestrians and pedal cyclists are listed. For vehicle related factors that are not present in Table 2, there were no pedestrian or pedal cyclist crashes listed for any of the years 2005 through 2009. As shown, there was an average of 298 crashes where there were no striking vehicle related factors. This assessment also accounts for the same scenarios in which AHS would be effective (nighttime, greater than 20 mph, non-alcohol related) as discussed previously.

[1] It should be noted that although travel speed was not recorded in approximately 60% of the FARS cases, approximately 93% of the travel speeds that were recorded were above 20 mph. Therefore, all of the cases in which travel speed was not recorded were included in this analysis. In order to ensure that this assessment was accurate, the number of cases which occurred at *posted speed limits* (as opposed to *recorded travel speed*) of 20 mph or greater were calculated to be 452, or nearly identical to the travel speed assessment.

Table 2. Striking vehicle related factors for pedestrian/ pedal cyclist crashes 2005 – 2009.

	Crash Year					Average 05-09
	2005	2006	2007	2008	2009	
Drowsy, Asleep	1	-	2	2	-	1
Emotional	1	-	1	1	-	1
Other Drugs	3	3	5	3	5	4
Inattentive	16	10	11	16	19	14
Road Rage	-	-	-	-	3	1
Other Physical	1	-	1	1	-	1
Law Enforcement off	3	1	6	1	2	3
Invalid License	-	-	1	-	-	0
Improper Loading	-	-	1	-	-	0
Improper Towing	-	-	1	1	-	0
W/O Required Equip	-	-	-	1	3	1
Improper Tailing	2	-	-	1	2	1
Improper Lane Change	2	-	1	-	-	1
Not in Lane	7	5	5	-	3	4
Driving Shoulder	-	-	-	-	1	0
Imp Entry/Exit	-	1	-	-	-	0
Prohibited Pass	-	-	-	1	-	0
Pass Wrong Side	-	-	-	-	1	0
Pass Insufficient Dist	-	-	2	1	-	1
Erratic/Reckless	1	1	-	1	-	1
Failure to Yield	14	12	22	10	3	12
Driving too Fast	-	-	-	3	-	1
Driving in excess of max	17	19	23	9	-	14
Racing	-	-	-	3	-	1
Other Improper Turn	1	-	2	-	1	1
Op Inexperience	-	-	-	-	1	0
Weather	11	9	5	8	-	7
Glare	1	10	5	5	-	4
Curve, Hill, etc	8	5	4	1	-	4
Tree, Plants	1	2	1	2	-	1
Moving Vehicle	4	6	-	3	-	3
Parked Vehicle	1	-	1	1	-	1
Inadequate Defroster	-	2	1	-	-	1
GDL non-compl	-	1	2	-	-	1
Restr non-compl	2	3	1	1	2	2
Other Obstruct	2	-	1	-	-	1
Flat Tire	-	-	1	-	-	0
Debris in Road	1	-	1	-	-	0
Live Animal	-	1	-	-	-	0
Vehicle in Road	2	3	-	3	-	2
Phantom Vehicle	-	-	1	-	-	0
Pedestrian	10	17	10	9	4	10
Water, Snow, Oil	-	5	-	3	4	2
Haul Hazmat Improperly	-	-	-	1	-	0
Hit and Run	38	47	34	41	12	34
Homicide etc	2	-	1	-	2	1
Other Violation	8	7	3	6	15	8
Cell phone in vehicle	8	10	5	5	9	7
Cell phone in use	-	-	-	1	1	0
Navigation Sys	-	-	-	-	1	0
Unknown	5	3	-	4	16	6
None	280	344	277	287	301	**298**

Taking into account the crashes that have no driver related factors attributable to the crash (from Table 2) as a percentage of total pedestrian and pedal cyclist crashes as a result of being not visible (from Table 1) results in 65.8% applicability of the AHS system to total crashes. To determine the target population of potential lives saved as a result of AHS, the total number of cases that were coded with 'Not Visible' as the *only* crash related factor at the pedestrian/pedal cyclist level were assessed and the results are presented in Table 3.

Table 3. Pedestrian and pedal cyclist cases with 'Not Visible' as the only coded factor in FARS.

	Crash Year					
	2005	**2006**	**2007**	**2008**	**2009**	**Average 05-09**
All Pedestrian Crashes	85	98	86	85	56	82
Target Population (nighttime, non-alcohol related, travel speed greater than 20 mph)	56	65	66	62	38	**57**

As shown in Table 3 the target population of cases applicable to AHS for not visible cases is an average of 57 fatalities between 2005 and 2009. By multiplying this target population with the applicability percentage of AHS at the striking vehicle level found above (65.8%), the resulting total of potential lives saved is found to be 37.5 lives per year. This number represents the total number of lives saved by the AHS system if every fatal crash that occurred were a result of insufficient visibility. In order to determine the effect of visibility on pedestrian crashes, Toyota relied on analysis conducted by the University of Michigan Transportation Research Institute (UMTRI).

2. *UMTRI Report on Adaptive Driving Beam (ADB) Benefits*

To further refine the benefits of AHS, the FARS analysis was used in conjunction with the UMTRI report, *Preliminary Assessment of the Potential Benefits of Adaptive Driving Beams* (Flannagan et al.), which quantifies the benefits of increased visibility with respect to pedestrians and road delineation using the CHESS model. The UMTRI report assigns an overall Figure of Merit (FOM) of various headlighting systems and the overall FOM takes into account each of the five subscales: pedestrians opposed and unopposed, delineation opposed and unopposed, and discomfort glare. The results of the CHESS simulations are presented in Table 4.

Table 4. CHESS figure of merit and subscales, for average current Tungsten-Halogen (TH) low-beam systems, and for Adaptive Driving Beam (ADB) systems based on current 50th or 75th percentile high-beam photometry and with 0.20, 0.10, or 0.05 glare factors.

Headlighting System (high-beam percentile, glare factor)	Overall FOM	Pedestrians		Delineation		Discomfort glare
		unopposed	opposed	unopposed	opposed	
TH low-beam average	73.4	47.1	35.1	92.2	91.2	3.9
ADB (50, 0.20)	76.3	65.2	45.1	91.8	90.5	14.7
ADB (50, 0.10)	78.4	65.2	50.8	91.8	90.9	4.4
ADB (50, 0.05)	79.1	65.2	53.0	91.8	91.4	0.2
ADB (75, 0.20)	78.1	71.2	50.5	92.0	90.7	19.8
ADB (75, 0.10)	80.2	71.2	53.6	92.0	91.1	7.5
ADB (75, 0.05)	81.2	71.2	58.4	92.0	92.0	1.6

While the UMTRI report uses a hypothetical Adaptive Driving Beam (ADB) system, the concept is the same as the AHS system in that the ADB uses the high beam illumination with glare control to the opposing driver(s) at various reduction percentages of 80, 90, and 95 percent (0.20, 0.10, and 0.05, respectively in Table 4). From Table 4, it is shown that pedestrian visibility for Tungsten-Halogen (TH) scored 47.1 for unopposed and 35.1 for opposed. Pedestrian visibility for the ADB 75th percentile with 95% glare control (most similar to the AHS system) scored 71.2 for unopposed and 58.4 for opposed. This results in an overall benefit of 24.1 for unopposed (71.2 – 47.1 = 24.1) and 23.3 (58.4 – 35.1 = 23.3) for opposed. Effectively, this results in a 24.1% reduction in pedestrian crashes when unopposed to oncoming glare and a 23.3% reduction in pedestrian crashes when opposed to oncoming glare.

3. *AHS Benefit Results and Discussion*

By taking into account all crash related factors that would be applicable to the AHS system and applying those to the FARS data for the years 2005 through 2009, it was found that a total of 37.5 fatalities per year average were a direct result of the pedestrian or pedal cyclist not being visible to the driver of the striking vehicle. Therefore, this is the target population of benefit of the AHS system. Taking into account the improvement in visibility of adaptive driving beams, such as AHS, over traditional low beam tungsten-halogen headlamps, UMTRI found that a reduction in pedestrian crashes of 24.1% and 23.3% for unopposed and opposed scenarios, respectively, was possible. By comparing these reductions in crashes to the average total number of fatal crashes, the AHS system benefit was found to be **between 8.7 and 9.0 lives per year**.

While this analysis focused primarily on pedestrian and pedal cyclist fatalities, it should be noted that the benefits of the AHS system will likely extend to other fatality populations as well. For example, the UMTRI report highlights the improvement that ADB systems would have in crashes that occur as a result of visibility of road delineation. In addition, there are roughly 200 fatalities per year in FARS that are coded as a result of collisions with animals. In addition to fatalities, injuries that could be prevented by the AHS system, specifically to pedestrians and pedal cyclists, should also be considered.

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Pursuant to §512.5(2)