DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA–2009–0041]

RIN 2127–AK43

Federal Motor Vehicle Safety Standard; Rearview Mirrors

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

ACTION: Advance notice of proposed rulemaking (ANPRM).

SUMMARY: This document initiates rulemaking to amend Federal Motor Vehicle Safety Standard (FMVSS) No. 111, *Rearview Mirrors*,[1] to improve a driver's ability to see areas to the rear of a motor vehicle in order to mitigate fatalities and injuries associated with backover incidents. The agency and Congress are concerned that vehicles have ''blind zones,'' [2] areas behind the vehicle in which drivers may have difficulty seeing and avoiding a person or other obstacle. Through this notice, NHTSA presents its initial research efforts and solicits additional information that will enable the agency to develop an effective proposal to mitigate backover incidents related to vehicle rear blind zones.

DATES: Comments must be received on or before May 4, 2009.

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: For detailed instructions on submitting comments and additional information on the rulemaking process, see the Public Participation heading of the **SUPPLEMENTARY INFORMATION** section of this document. Note that all comments received will be posted without change to *http://www.regulations.gov*, including any personal information provided. Please see the Privacy Act heading below.

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) or you may visit *http://DocketInfo.dot.gov*.

Docket: For access to the docket to read background documents or comments received, go to *http://www.regulations.gov* or the street address listed above. Follow the online instructions for accessing the dockets.

FOR FURTHER INFORMATION: For technical issues: Ms. Elizabeth Mazzae, Vehicle Research and Test Center, Telephone: (937) 666–4511. Facsimile: (202) 366–3171. For legal issues: Ari Scott, 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, Attention: NVS–010, 1200 New Jersey Avenue, SE., Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

I. Executive Summary

This advance notice of proposed rulemaking (ANPRM) initiates rulemaking to amend Federal Motor Vehicle Safety Standard (FMVSS) No. 111, *Rearview Mirrors*, to improve a driver's ability to see areas to the rear of a motor vehicle to reduce backover incidents. The agency is issuing an ANPRM for two reasons. First, the agency is obligated, pursuant to the Cameron Gulbransen Kids Transportation Safety Act of 2007 (the ''K.T. Safety Act'') Public Law 110–189, February 28, 2008, 122 Stat. 639, to undertake rulemaking to expand the required field of view to enable the driver of a motor vehicle to detect areas

[1] 49 CFR 571.111, Standard No. 111, Rearview Mirrors.

[2] We note that this is different than what many people informally call a ''blind spot,'' a term used to describe an area to the side of the car where people may not be able to see a vehicle when changing lanes.

behind the vehicle to reduce death and injury resulting from backing incidents and initiate the rulemaking in a specified time period. Second, as there are a wide variety of means to address the problem of backover incidents, the National Highway Traffic Safety Administration (NHTSA) is interested in soliciting public comment on the current state of research and the efficacy of available countermeasures.

The problem of backovers claims the lives of approximately 292 people, many of them children every year. A backover is a specifically-defined type of incident, in which a non-occupant of a vehicle (i.e., a pedestrian or cyclist) is struck by a vehicle moving in reverse. Unlike most other types of crashes, many backovers occur off public roadways, in areas such as driveways and parking lots. Furthermore, a disproportionate number of victims of backovers are children under 5 years old and adults 70 or older. While there are several potential reasons for this, children are particularly likely to be missed by drivers of rear-moving vehicles because they cannot be seen due to a ''blind zone'' [3] in the area directly to the rear of vehicle. In addition, children are more likely to move unknowingly into a blind zone when the driver does not suspect anyone to be there.

NHTSA believes that the problem of backovers warrants an appropriate agency action. In response to a Congressional requirement of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA–LU) [4], NHTSA has been gathering data on backover incidents from a wide variety of sources. Based on this research, the agency estimates that on average there are 292 fatalities and 18,000 injuries (3,000 of which are judged to be incapacitating) resulting from backovers every year. Of those, 228 fatalities and 17,000 injuries were attributed to backover incidents involving passenger vehicles under 10,000 pounds. While all passenger vehicle types (cars, sport utility vehicles, pickups, and vans) are involved in backover fatalities and injuries, the data indicate that backover fatality numbers show pickup trucks (72 of 288) and utility vehicles (68 of 228) to be overrepresented when compared to all non-backing traffic injury crashes and to their proportion to the passenger vehicle fleet. Regardless of the type of vehicle involved, backover incidents have garnered significant attention, due to the fact that many have involved parents accidentally backing over their own children or similar situations. In this notice, NHTSA describes some of the research and information-gathering activities it has performed. This research centers on four major topic areas.

The first area involves the nature of backover incidents and backing crashes generally. NHTSA has reviewed the details of documented backover incidents, including the locations of backover victims, the paths the victims took to enter the path of the vehicle, and the visibility characteristics of the vehicles involved. This notice outlines the information we have about these crashes, whether the lack of visibility is playing a significant role, and whether or not the characteristics of a class or type of vehicle are a contributing factor.

A second area of focus involves the evaluation of various strategies for improving rear visibility. For example, one strategy could be to ensure that the vehicles which are over represented in terms of fatalities and injuries are improved. Such a strategy would focus on pickup trucks or utility vehicles.[5] Another strategy, could seek to establish a minimum blind zone area for vehicles under 10,000 pounds. Our research indicates that a vehicle's rear blind zone area is statistically correlated with its rate of backing crashes.[6] Using this correlation, it may be possible to determine which vehicles most warrant rear visibility improvement based on the size of their rear blind zones and the setting of a ''threshold''. Possible strategies such as these are discussed in this notice and comments are requested.

The third topic involves the evaluation of various countermeasures. NHTSA has consulted past agency research, industry and other outside sources, and conducted new research to help determine the costs, effectiveness, and limitations of a wide variety of countermeasures. Four types of countermeasures are described in this notice, including direct vision (i.e., what can be seen by a driver glancing directly out a vehicle's windows), rear-mounted convex mirrors, rear object detection sensors (such as ultrasonic or radar-based devices), and rearview video (RV) systems. While research is ongoing, this notice describes how these systems work, how well they perform in identifying pedestrians, and how effectively drivers may use them. Where possible, we have also included preliminary cost and benefit information. While we examine several application scenarios (all passenger cars and all light trucks, only light trucks, and some combinations) and discount rates of 3 and 7 percent, the net cost per equivalent life saved for camera systems ranged from $13.8 to $72.2 million.[7] For sensors, it ranged from $11.3 to $62.5 million. According to our present model, none of the systems are cost effective compared to our comprehensive cost estimate for a statistical life of $6.1 million.[8]

A fourth topic involves consideration of technical specifications and test procedures that could be used to describe and evaluate the performance aspects of direct view, and rear-mounted convex mirrors, rear object detection sensors, and rearview video (RV) systems. The agency presents preliminary information on potential technical specifications and test procedures that we have identified and we want to solicit information on how these specifications and procedures should be refined for the purposes of developing repeatable compliance tests.

Finally, NHTSA presents a series of questions in this notice. We are requesting public input on a variety of areas, including the areas described above, studies on the effectiveness of various indirect rear visibility systems (i.e., devices that aid a driver in seeing areas around a vehicle, such as mirrors or video systems) that have been implemented in the U.S. and abroad, or technological possibilities that can enhance the reliability of existing technologies. The agency is also seeking information on the costs of implementation of all available technologies to develop more robust cost and benefit estimates.

II. Cameron Gulbransen Kids Transportation Safety Act of 2007

Subsection (b) of the Cameron Gulbransen Kids Transportation Safety Act, directs the Secretary of Transportation to initiate rulemaking to amend Federal Motor Vehicle Safety Standard (FMVSS) No. 111, *Rearview Mirrors*, to expand the required field of view to enable the driver of a motor vehicle to detect areas behind the motor

[3] We note that this is different than what many informally call a ''blind spot,'' a term used to describe an area to the side of the car where people may not be able to see a vehicle when changing lanes.

[4] Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA–LU), Public Law No. 109–59, section 1109, 119 Stat. 1114, 1168 (2005).

[5] Fatalities and Injuries in Motor Vehicle Backing Crashes, NHTSA Report to Congress (2008).

[6] Partyka, S., Direct-View Rear Visibility and Backing Risk for Light Passenger Vehicles (2008).

[7] PRIA, Executive Summary.

[8] $6.1 million is the comprehensive value that NHTSA used for a statistical life. Further information about this value is available in the PRIA published with this notice.

vehicle to reduce death and injury resulting from backing incidents.

The relevant provisions in subsection (b) are as follows:

(b) Rearward Visibility—Not later than 12 months after the date of the enactment of this Act, the Secretary shall initiate a rulemaking to revise Federal Motor Vehicle Safety Standard 111 (FMVSS 111) to expand the required field of view to enable the driver of a motor vehicle to detect areas behind the motor vehicle to reduce death and injury resulting from backing incidents, particularly incidents involving small children and disabled persons. The Secretary may prescribe different requirements for different types of motor vehicles to expand the required field of view to enable the driver of a motor vehicle to detect areas behind the motor vehicle to reduce death and injury resulting from backing incidents, particularly incidents involving small children and disabled persons. Such standard may be met by the provision of additional mirrors, sensors, cameras, or other technology to expand the driver's field of view. The Secretary shall prescribe final standards pursuant to this subsection not later than 36 months after the date of enactment of this Act.

(c) Phase-In Period—

(1) PHASE-IN PERIOD REQUIRED—The safety standards prescribed pursuant to subsections (a) and (b) shall establish a phase-in period for compliance, as determined by the Secretary, and require full compliance with the safety standards not later than 48 months after the date on which the final rule is issued.

(2) PHASE-IN PRIORITIES—In establishing the phase-in period of the rearward visibility safety standards required under subsection (b), the Secretary shall consider whether to require the phase-in according to different types of motor vehicles based on data demonstrating the frequency by which various types of motor vehicles have been involved in backing incidents resulting in injury or death. If the Secretary determines that any type of motor vehicle should be given priority, the Secretary shall issue regulations that specify—

(A) which type or types of motor vehicles shall be phased-in first; and

(B) the percentages by which such motor vehicles shall be phased-in.

Congress emphasized the protection of small children and disabled persons, and added that the revised standard may be met by the ''provision of additional mirrors, sensors, cameras, or other technology to expand the driver's field of view.'' While NHTSA does not interpret the Congressional language to necessarily require that all of these technologies eventually be integrated into the final requirement, we are examining the merits of each of them.

Applicability

With regard to the scope of vehicles covered by the mandate, the statute refers to all motor vehicles less than 10,000 pounds (except motorcycles and trailers). This language means that the revised regulation would apply to passenger cars, multipurpose passenger vehicles, buses, and trucks with a Gross Vehicle Weight Rating (GVWR) less than 10,000 lbs.

Statutory Deadline

The Cameron Gulbransen Kids Transportation Safety Act of 2007 specified a rapid timeline for development and implementation of this rulemaking. Specifically, the Secretary is required to publish a final rule within 36 months of the passage of the Act (February 28, 2011). Moreover, the agency must initiate rulemaking within 12 months of the Act (February 28, 2009). However, it should be noted that under Section 4 of the Act,[9] if the Secretary determines that the deadlines applicable under this Act cannot be met, the Secretary shall establish new deadlines, and notify the Committee on Energy and Commerce of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate of the new deadlines describing the reasons the deadlines specified under the Act could not be met.

III. Existing Regulatory Requirements for Rear Visibility

As of today, no country has minimum rear field of view requirements for vehicles weighing less than 10,000 lbs. All countries do, however, have standards for side and interior rearview mirrors, although differences do exist in terms of mirror requirements. No country requires rearview video systems or any other type of indirect vision device for viewing areas directly behind the vehicle; however, Europe does have performance requirements for systems for indirect vision, if installed.

A. U.S.

FMVSS No. 111, Rearview Mirrors establishes requirements for the use, field of view, and mounting of motor vehicle rearview mirrors for rear visibility.[10] This standard was enacted in 1976 and applies to passenger cars, multipurpose passenger vehicles, trucks, buses, school buses and motorcycles. The purpose of this standard is to reduce the number of deaths and injuries that occur when the driver of a motor vehicle does not have a clear and reasonably unobstructed view to the rear. With respect to passenger cars, the standard requires that manufacturers mount flat (also referred to as ''plane'' or ''unit magnification'') mirrors both inside the vehicle and outside the vehicle on the driver's side. The inside mirror must, except as specified below, have a field of view at least 20 degrees wide and a sufficient vertical angle to provide a view of a level road surface extending to the horizon beginning not more than 200 feet (61 m) behind the vehicle. In cases where the interior mirror does not meet the specified field of view requirements, a plane or convex exterior mirror must be mounted on the passenger's side of the car. While a specific field of view is not indicated for the passenger-side rearview mirror, the driver's side rearview mirror is required to be a plane mirror that provides ''the driver a view of a level road surface extending to the horizon from a line, perpendicular to a longitudinal plane tangent to the driver's side of the vehicle at the widest point, extending 2.4 m (7.9 ft) out from the tangent plane 10.7 m (35.1 ft) behind the driver's eyes, with the seat in the rearmost position.''

If a manufacturer uses an interior rearview mirror which meets the field of view requirements, and wishes to install an exterior passenger-side mirror voluntarily, it may use any type of mirror for that purpose. In the case of light trucks, manufacturers may either comply with the passenger car requirement or have plane or convex outside mirrors with reflective surface area of not less than 126 square centimeters (19.5 square inches) on each side of the vehicle. Reflectance (image brightness) criteria are also established in this standard.

FMVSS No. 111 does not currently establish minimum rear field of view requirements for vehicles, nor does it contain minimum requirements for indirect vision systems, such as rearview video systems. Because of the current absence of a federal regulation of this aspect of performance, there is the possibility that there may be existing State laws or regulations that regulate the vehicle's rear field of view of passenger vehicles.[11] However, as of this time, NHTSA is not aware of any such State laws or regulations. However, we request comment on existing or pending State laws or regulations in this area, as well as the basis and effect of such regulation, if any exist.

B. Other Countries

ECE

In 1981, the United Nations Economic Commission for Europe (ECE) enacted

[9] Cameron Gulbransen Kids Transportation Safety Act of 2007, S.694, 110th Cong. section 4 (2007).

[10] 49 CFR 571.111, Standard No. 111, Rearview mirrors.

[11] See Federalism discussion below in section XV.

Regulation 46 which details uniform provisions concerning the approval of devices for indirect vision.[12] ECE 46 defines devices for indirect vision as those that observe the area adjacent to the vehicle which cannot be observed by direct vision, including ''conventional mirrors, camera-monitors or other devices able to present information about the indirect field of vision to the driver.'' While ECE 46 contains specifications for exterior rearview mirrors, it does not, directly regulate the rear field of view. Specifications are provided to define the required minimum size of the interior rearview mirror's surface area, but not its field of view. This regulation applies to all power-driven vehicles with at least four wheels that are used for the carriage of people or goods, and vehicles with less than four wheels that are fitted with bodywork which partly or wholly encloses the driver.

ECE 46 requires driver and passenger ''flat'' side rearview mirrors as found in FMVSS No. 111. ECE 46 differs from FMVSS No. 111 in that it also permits wide-angle convex mirrors on the driver's side of the vehicle for all classes of vehicles except for certain vehicles over 7.5 tons, for which they are required.

The ECE 46 regulation also outlines requirements for devices for indirect vision other than mirrors for vehicles with more than eight seating positions and those configured for refuse collection. Specifically, it contains a general requirement that camera-monitor devices, if present, shall perceive a visible spectrum and shall always render this image without the need for interpretation into the visual spectrum. The device's visual display is required to be located approximately in the same direction as the interior rearview mirror. The monitor is required to render a minimum contrast under various light conditions as specified by International Organization for Standardization (ISO) 15008:2003 [13] and have an adjustable luminance level. The regulation also defines detection distance, the distance measured at ground level from the eye point to the extreme point at which a critical object can be perceived, as an aspect of camera-monitor device performance.

A January 2008 amendment to ECE Regulation 46 required that a camera-monitor system must display to the driver a flat horizontal portion of the road directly behind the vehicle from the rear bumper outward to a distance of 2000 mm (6.6 ft). It further specified that if an indirect vision device other than a camera-monitor is used, a test object 50 cm (19.7 in) in height and 30 cm (11.8 in) in diameter must be visible in the specified area. However, in a later amendment of UNECE 46 (dated August 7, 2008) this requirement was removed and replaced with the statement, ''Vehicles may be equipped with additional devices for indirect vision.'' [14] This change allows for indirect vision systems to be installed on European vehicles without meeting any performance requirements.

Canada

Canada has rearview mirror requirements that are essentially identical to those in the U.S. All passenger cars are required to have a driver's-side outside rearview mirror. Passenger cars are also required to be equipped with an interior rearview mirror providing ''the driver with a field of view to the rear that is not less than 20 degrees measured horizontally rearward from the projected eye point and extends to the horizon and includes a point on the road surface not more than 60 m (200 feet) directly behind the vehicle.'' If the interior rearview mirror does not meet these requirements, a side rearview mirror must be mounted on the passenger side of the vehicle opposite the driver's side.

Japan

Japanese regulation, Article 44, provides a performance based requirement for rearview mirrors.[15] For light vehicles, rearview mirrors must be present that enable drivers to check the traffic situation around the left-hand lane edge and behind the vehicle from the driver's seat.[16] The regulation requires that the driver be able to ''visually confirm the presence of a cylindrical object 1 m high and 0.3 m in diameter (equivalent to a 6-year-old child) adjacent to the front or the left-hand side of the vehicle (or the right-hand side in the case of a left-hand drive vehicle), either directly or indirectly via mirrors, screens, or similar devices.'' Article 44 does not specify requirements for rear-mounted convex mirrors and rearview video systems, therefore these devices are allowed, but not required under the standard. Rear-mounted convex mirrors are commonly used as backing aids on sport utility vehicles (SUVs) and vans in Japan; however, NHTSA is not aware of research documenting the effectiveness of these mirrors in mitigating backover crashes.

Korea

The Korean regulation on rearview mirrors, Article 50,[17] outlines rearview mirror requirements for a range of vehicles. Article 50 requires a flat or convex exterior mirror mounted on the driver's side for passenger vehicles and buses with less than 10 passengers. For buses, cargo vehicles, and special motor vehicles, flat or convex rear-view mirrors are required on both sides of the vehicle. Article 50 does not address rear-mounted convex mirrors and rearview video systems, therefore these devices are allowed, but not required under the standard. Again, rear-mounted convex mirrors are commonly used as backing aids on SUVs and vans in Korea; however, NHTSA is not aware of research documenting the effectiveness of these mirrors in mitigating backover crashes.

IV. Backover Safety Problem

Based on our information to date, NHTSA has found that the problem of backovers claims the lives of hundreds of people every year. NHTSA defines backover as a specifically-defined type of incident, in which a non-occupant of a vehicle (i.e., a pedestrian or cyclist) is struck by a vehicle moving in reverse. However, because many backovers occur off public roadways, in areas such as driveways and parking lots, NHTSA's ordinary methodologies for collecting data as to the specific numbers and circumstances of backover incidents have not always given the agency a complete picture of the scope and circumstances of these types of incidents. The following sections detail NHTSA's attempts to both quantify the number of backover incidents and determine their nature.

A. Injuries and Fatalities in Backing Incidents

In response to SAFETEA–LU Sections 2012 and 10305, NHTSA developed the Not in Traffic Surveillance (NiTS) system to collect information about all nontraffic crashes, including nontraffic backing crashes. NiTS provided information on these backing crashes

[12] ECE 46–02, Uniform Provisions Concerning the Approval of: Devices for Indirect Vision and of Motor Vehicles with Regard to the Installation of these Devices, (August 7, 2008).

[13] ISO 15008:2003 Road vehicles—Ergonomic aspects of transport information and control systems—Specifications and compliance procedures for in-vehicle visual presentation.

[14] Section 15.3.5 of ECE 46–02, Uniform Provisions Concerning the Approval of: Devices for Indirect Vision and of Motor Vehicles with Regard to the Installation of these Devices, (August 7, 2008).

[15] Japanese Safety Regulation Article 44 and attachments 79–81.

[16] Vehicles manufactured for the Japanese market are right-hand drive.

[17] Korean Safety Regulation Article 50.

that occurred off the traffic way and which were not included in NHTSA's Fatality Analysis Reporting System (FARS) or the National Automotive Sampling System—General Estimates System (NASS–GES). The subset of backing crashes that involve a pedestrian, bicyclist, or other person not in a vehicle, is referred to as ''backovers.'' This is distinguished from the larger category of ''backing crashes,'' which would include such non-backover events such as a vehicle going in reverse and colliding with another vehicle, or a vehicle backing off an embankment or into a stationary object. While the primary purpose of this rulemaking is to prevent backovers, any technology that improves rear visibility should have a positive effect on backing crashes in general.

Based on 2002–2006 data from FARS and NASS–GES, and 2007 data from NiTS, NHTSA estimates that 463 fatalities and 48,000 injuries a year occur in traffic and nontraffic backing crashes.[18] Most of these injuries are minor injuries, but an estimated 6,000 per year are incapacitating injuries. Overall, an estimated 65 percent (302) of the fatalities and 62 percent (29,000) of the injuries in backing crashes occurred in nontraffic situations.

With regard to injuries and fatalities related specifically to backovers, these account for an estimated 63 percent (292) of the fatalities and 38 percent (18,000) of the injuries in backing crashes for all vehicles (cars, light trucks or vans, heavy trucks, and other/multiple vehicles). Other backing crash scenarios account for an estimated 171 fatalities (37 percent) and 30,000 injuries (62 percent) per year. Table 1 shows the fatalities and injuries in all backing crashes. Table 1 also demonstrates that backover victims tend to be more seriously injured than individuals in other backing crashes (i.e., non-backover crash incidents). In fact, more than half (10,000 of 18,000) of the injuries in backovers are more severe than possible (minor) injuries.

TABLE 1—ANNUAL ESTIMATED FATALITIES AND INJURIES IN ALL BACKING CRASHES FOR ALL VEHICLES [19]

Injury severity	Total		Backovers		Other backing crashes	
	Estimated total	Sample count	Estimated total	Sample count	Estimated total	Sample count
Fatalities	463	1,610	292	716	171	894
Incapacitating Injury	6,000	304	3,000	131	3,000	173
Non-incapacitating Injury	12,000	813	7,000	372	5,000	441
Possible Injury	27,000	929	7,000	179	20,000	750
Injured Severity Unknown	2,000	48	1,000	23	2,000	25
Total Injuries	48,000	2,094	18,000	705	30,000	1,389

Source: FARS 2002–2006, NASS–GES 2002–2006, NiTS 2007.
Note: Estimates may not add up to totals due to independent rounding.

B. Vehicle Type Involvement in Backing Incidents

Most backover fatalities and injuries involve passenger vehicles. As indicated in Table 2, 78 percent of the backover fatalities and 95 percent of the backover injuries involved passenger vehicles. An estimated fifteen percent (68) of the backing crash fatalities occur in multivehicle crashes, and an estimated thirteen percent (62) occur in single-vehicle non-collisions such as occupants who fall out of and are struck by their own backing vehicles. About half of the backing crash injuries (20,000 per year) occur in multivehicle crashes involving backing vehicles. Table 3 indicates that all major passenger vehicle types (cars, utility vehicles, pickups, and vans) are involved in backover fatalities and injuries. However, the data indicate that some vehicles may have a greater risk of involvement in backing crashes than other vehicles. Table 3 illustrates that pickup trucks and utility vehicles are overrepresented in backover fatalities when compared to all non-backing traffic injury crashes and to their proportion to the passenger vehicle fleet.

TABLE 2—INJURIES AND FATALITIES AND INJURIES BY BACKING CRASH TYPE FOR ALL VEHICLES

Backing crash scenarios	All vehicles		Passenger vehicles	
	Fatalities	Injuries	Fatalities	Injuries
Backovers: Striking Nonoccupant	292	18,000	228	17,000
Backing: Striking Fixed Object	33	2,000	33	2,000
Backing: Noncollision	62	1,000	53	1,000
Backing: Striking/Struck by Other Vehicle	68	24,000	39	20,000
Backing: Other	8	3,000	8	3,000
Total Backing	463	48,000	361	43,000

[18] Fatalities and Injuries in Motor Vehicle Backing Crashes, NHTSA Report to Congress (2008).

[19] Id.

TABLE 3—PASSENGER VEHICLE BACKOVER FATALITIES AND INJURIES BY VEHICLE TYPE

Backing vehicle type	Fatalities	Percent of fatalities	Estimated injuries	Estimated percent of injuries	Percent of vehicles in non-backing traffic injury crashes	Percent of fleet
Car	59	26	9,000	54	62	58
Utility Vehicle	68	30	3,000	20	14	16
Van	29	13	1,000	6	8	8
Pickup	72	31	3,000	18	15	17
Other Light Vehicle	0	0	*	2	1	<1
Passenger Vehicles	228	100	17,000	100	100	100

Source: FARS 2002–2006, NASS–GES 2002–2006, NiTS 2007.
Note: * indicates estimate less than 500, estimates may not add up to totals due to independent rounding.

C. Age Involvement in Backing Incidents

Table 4 contains the age of the backover victim for fatalities and injuries for all backovers as well as backovers involving passenger vehicles. Table 4 also details the proportion of the United States (U.S.) population in each age category from the U.S. Census Bureau's Population Estimates Program for comparison. Similar to previous findings, backover fatalities disproportionately affect children under 5 years old and adults 70 or older. When restricted to backover fatalities involving passenger vehicles, children under 5 account for 44 percent of the fatalities, and adults 70 and older account for 33 percent. The difference in the results between all backovers and passenger vehicle backovers occurs because large truck backovers, which are excluded from the passenger vehicle calculations, tend to affect adults of working age.

TABLE 4—ALL BACKOVER FATALITIES AND INJURIES BY AGE OF VICTIM

Age of victim	Fatalities	Percent of fatalities	Estimated injuries	Estimated percent of injuries	Sample count of injuries	Percent of population
All Vehicles:						
Under 5	103	35	2,000	8	37	7
5–10	13	4	*	3	33	7
10–19	4	1	2,000	12	75	14
20–59	69	24	9,000	48	383	55
60–69	28	9	2,000	8	54	8
70+	76	26	3,000	18	107	9
Unknown			*	2	16	
Total	292	100	18,000	100	705	100
Passenger Vehicles:						
Under 5	100	44	2,000	9	35	7
5–10	10	4	1,000	3	30	7
10–19	1	1	2,000	12	71	14
20–59	29	13	8,000	46	319	55
60–69	15	6	1,000	8	46	8
70+	74	33	3,000	19	95	9
Unknown			*	2	12	
Total	228	100	17,000	100	608	100

Source: U.S. Census Bureau, Population Estimates Program, 2007 Population Estimates; FARS 2002–2006, NASS–GES 2002–2006, NiTS 2007.

The proportion of backover injuries by age group is more similar to the proportion of the population than for backover fatalities. However, while children under 5 years old appear to be slightly overrepresented in backover injuries compared to the population, adults 70 and older appear to be greatly overrepresented. One reason for the relatively large proportion of injuries in backover crashes among older adults may be that backovers involving younger nonoccupants may not result in an injury while the same backover involving an older nonoccupant may result in a fall and a broken bone.

Table 5 presents passenger vehicle backover fatalities by year of age for victims less than 5 years old. Out of all backover fatalities involving passenger vehicles, 26 percent (60 out of 228) of victims are 1 year of age and younger.

TABLE 5—BREAKDOWN OF BACKOVER FATALITIES AND INJURIES INVOLVING PASSENGER VEHICLES FOR VICTIMS UNDER AGE 5 YEARS

Age of victim (years)	Number of fatalities
0	<1
1	59
2	23
3	14
4	3
Total	100

Note: Estimates may not add to totals due to independent rounding.
Source: U.S. Census Bureau, Population Estimates Program, 2007 Population Estimates; FARS 2002–2006, NASS–GES 2002–2006, NiTS 2007.

D. Special Crash Investigation Backover Case Summary

In addition to collecting police-reported backovers through NHTSA's data collection infrastructure, NHTSA's efforts to understand backover incidents have included a Special Crash Investigation (SCI) program. The SCI program was created to examine the safety impact of rapidly changing technologies and to provide NHTSA with early detection of alleged or potential vehicle defects.

SCI began investigating cases related to backovers in October 2006.[20] SCI receives notification of potential backover cases from several different sources including media reports, police and rescue personnel, contacts within NHTSA, reports from the general public, as well as notifications from the NASS. As of July 1, 2008, SCI had received a total of 52 notifications from a combination of all sources regarding backovers.[21] For the purpose of the SCI cases, an eligible backover was defined as a light passenger vehicle where the back plane strikes or passes over a person who is either positioned to the rear of the vehicle or is approaching from the side. SCI primarily focuses on cases involving children; however, it investigates some cases involving adults. The majority of notifications received do not meet the criteria for case assignment. Typically the reasons for not pursuing further include:

○ The reported crash configuration is outside of the scope of the program,

○ Minor incidents with no fatally or seriously injured persons, or

○ Incidents where cooperation can not be established with the involved parties.

As an example, many reported incidents are determined to be side or frontal impacts, which exclude them from the program. NHTSA requests that commenters submit any other existing backover incident data that could aid in providing a clearer picture of the range of backover accidents.

The SCI effort to examine backover crashes includes an on-site inspection of the scene and vehicle, as well as interviews of the involved parties when possible. When an on-site investigation is not possible, backover cases are investigated remotely through an examination of police-provided reports and photos as well as interviews with the involved parties. For each backover case investigated, a case vehicle visibility study is also conducted to determine the vehicle's blind zones and also to determine at what distance behind the vehicle the occupant may have become visible to the driver.

Through July 2008, NHTSA had completed special crash investigations of 52 backover cases.[22] The 52 backing vehicles were comprised of 17 passenger cars, 21 sport utility vehicles, and 14 pickup trucks. Only 4 of the cases (8 percent) contained vehicles equipped with a backup or parking aid. Eighty-eight percent of the backover crashes (46 of the 52) involved children, ranging in age from less than 1 year old up to 13 years old, who were struck by vehicles. Adults were generally excluded from the study unless they were seriously injured or killed or if the backing vehicles were equipped with backing or parking aids. A total of 6 cases were investigated involving struck adults. Of the 52 backover cases, exactly half (26) involved fatally injured nonoccupants.

A breakdown of the victim's path of travel prior to being struck is as follows: 24 were approaching from the right or left of the vehicle, 19 were stationary behind the vehicle, 10 were unknown, and one was ''other.'' [23]

E. Assessment of Backover Crash Risk by Pedestrian Location

NHTSA believes it would be helpful to know whether and to what degree the pedestrian's location at the start of a vehicle's backing plays a part in the likelihood of the pedestrian being struck. As such, NHTSA used data from a recent NHTSA study of drivers' backing behavior [24] to estimate the relative risk of a pedestrian colliding with a vehicle during a backing maneuver.

A Monte Carlo simulation was used to calculate a probability-based risk weighting for a test area centered behind the vehicle. The probability-based risk weightings for each grid square were based on the number of pedestrian-vehicle backing crashes predicted by the simulation for trials for which the pedestrian was initially (i.e., at the time that the vehicle began to back up) in the center of one square of the grid of 1-foot squares. A total of 1,000,000 simulation trials were run with the pedestrian initially in the center of each square. Additional details about assumptions relating to the vehicle and pedestrian, as well as the simulation, are presented in Appendix A.

Figure 1 summarizes the calculated relative crash risk for each grid square. Note that the white shaded area does not have a zero backover risk; it merely has a low (less than 15 percent of the maximum) risk. This analysis shows that the probability of crash decreases rapidly as the pedestrian's initial location is moved back, further away, from the rear bumper of the vehicle. There are substantial side lobes, giving pedestrians some risk of being hit even though they were not initially directly behind the vehicle. The results suggest that coverage of an area 12 feet wide by 36 feet long centered behind the vehicle would address pedestrian locations having relative crash risks of 0.15 and higher. To address crash risks of 0.20 and higher, an area 7 feet wide and 33 feet long centered behind the vehicle would need to be covered. NHTSA seeks comment on the coverage area that is needed to establish a reasonable safety zone behind the vehicle.

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[20] Fatalities and Injuries in Motor Vehicle Backing Crashes, NHTSA Report to Congress (2008).

[21] Since SCI investigates as many relevant cases that they are notified about as possible and not on a statistical sampling of incidents, results are not representative of the general population.

[22] The data obtained for the SCI cases cited in this report are based on preliminary case information. Data are subject to change based on final investigative findings.

[23] Note that one or more cases examined involved multiple victims, causing the total of the path breakdown scenarios to be 53 rather than 52.

[24] Mazzae, E. N., Barickman, F. S., Baldwin, G. H. S., and Ranney, T. A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

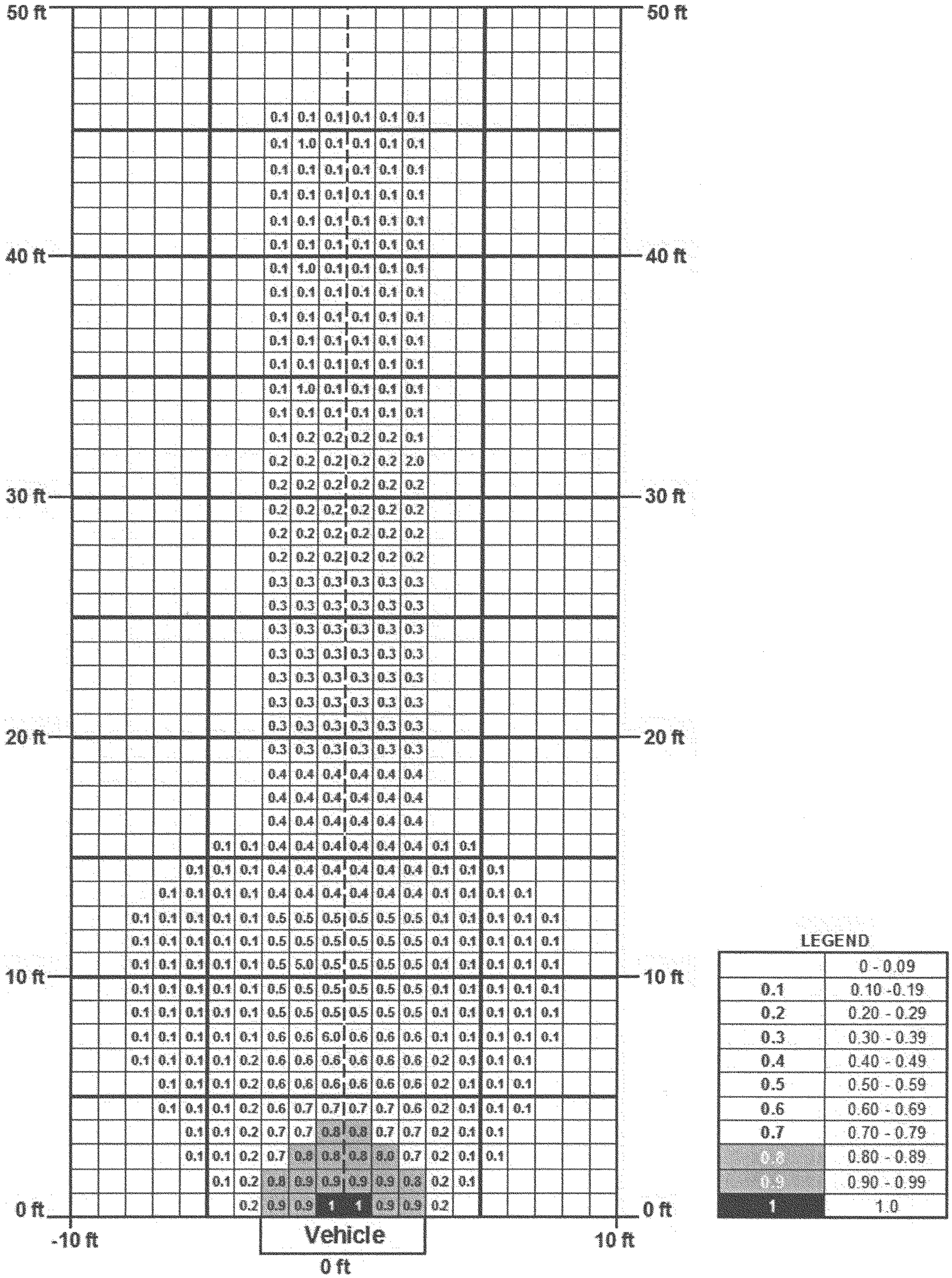

Figure 1. Relative Probability of a Backing Vehicle Striking a Walking Pedestrian as a Function of Pedestrian Initial Location (Empty squares have a crash risk of ≤0.1.)

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V. Technologies for Improving Rear Visibility

Since the early 1990s, NHTSA has actively researched approaches to mitigate backing crashes for heavy and light vehicles by assessing the effectiveness of various backing aid technologies. In recent years, manufacturers have added object detection sensors and video cameras to vehicles to aid drivers in performing backing maneuvers. According to Ward's 2008 Automotive Yearbook, backing aids utilizing sensors and/or video cameras were installed in approximately 14 percent of model year 2007 light vehicles.[25] While these systems are becoming increasingly available, they have typically been marketed as parking aids to help drivers detect and avoid obstacles in low-speed backing scenarios.

To assess whether or not these systems could also be used to detect pedestrians, the agency has, and continues to, evaluate them. The agency has also evaluated rear-mounted convex mirrors and rearview video systems. In the following sections, we outline the technologies we have evaluated, research conducted by the agency and others, and offer our preliminary observations on how they would meet the Congressional directive to improve the rear visibility of current vehicles.

A. Rear-Mounted Convex Mirrors

Description

Rear-mounted convex mirrors are mirrors with a curved reflective surface thereby providing a wider field of view than plane (i.e., flat) mirrors. These mirrors can be mounted at the upper center of the rear window with the reflective surface pointing at the ground (commonly referred to as backing mirrors, under mirrors, or ''look-down'' mirrors), the driver's side upper corner of the vehicle (commonly seen on delivery vans or mail delivery trucks and called ''corner mirrors''), or integrated into the inside face of both rearmost pillars (called ''cross-view'' mirrors). While center or corner-mounted convex rearview mirrors show the driver an area behind the vehicle, rear cross-view mirror pairs are intended to aid a driver when backing into a right-of-way by showing objects approaching on a perpendicular path behind the vehicle.

To view the area behind a vehicle, interior rear-mounted convex mirrors can be viewed directly by the driver, if in his direct line of sight, or they may be looked at indirectly by viewing their reflection in the interior or exterior rearview mirror. In the case of a rear ''look-down mirror,'' the driver can either glance rearward directly at this mirror, or view its reflection in the interior rearview mirror. For a rear convex corner mirror, the driver must look into the driver's side (i.e., exterior) rearview mirror to view the reflection of the rear convex corner mirror. In the case of rear cross-view mirrors, they can be viewed directly by the driver or indirectly by viewing their reflection in the interior rearview mirror.

In the U.S., rear-mounted convex mirrors are sometimes seen on delivery trucks and vans. Rear-mounted convex mirrors are primarily available as aftermarket products in the U.S., but are also available as original equipment on one sport utility vehicle.[26] In Korea and Japan, rear-mounted convex mirrors are used on small school buses, short delivery trucks, and some multipurpose vehicles (e.g., SUVs) to allow drivers to view areas behind a vehicle.

While rear convex cross-view mirrors are available as aftermarket products that mount to the inside of the rear window for all passenger car body types, this is not the case for look down mirrors. Rear convex look-down or corner convex mirrors need to have a rear window that is vertically aligned with the rear of the vehicle (such as a station wagon, SUV or van) in order to have a clear view of the area behind the vehicle.

Research

NHTSA has conducted research on rear-mounted convex mirrors for use on medium straight trucks and to a limited extent, passenger vehicles (i.e., cars, trucks, vans, SUVs). The research and how its results may be related to the improvement of rear visibility are discussed below.

Passenger Vehicle Research

In response to Section 10304 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA–LU),[27] NHTSA conducted a study to evaluate methods to reduce the incidence of injury, death, and property damage caused by backing collisions of passenger vehicles.[28] The examination of two convex mirror systems revealed that pedestrians and objects were not visible in some areas directly behind the vehicle (this area could be described as the area bounded by the vertical planes formed by the sides of the vehicle, and extending rearward). The research also found that the convexity of the mirrors caused significant image distortion, and reflected objects were difficult to discern. It is unknown if this issue can be addressed in future designs. For the tested designs, concentrated glances were necessary to identify the nature of rear obstacles; it is not known if a driver making quick glances prior to initiating a backing maneuver would allocate sufficient time to allow recognition of an obstacle or pedestrian shown in the mirror.

Current Mirror Research

NHTSA is currently evaluating the image quality (distortion and minification) and field of view of rear-mounted convex mirrors. The mirror types being examined include an aftermarket rear convex look-down mirror, aftermarket rear corner convex mirror, aftermarket rear convex cross-view mirrors designed for SUVs and passenger cars (e.g., sedans, coupes), and original equipment rear convex cross-view mirrors on a 2003 Toyota 4Runner.

Figure 2 below illustrates the types of measurements that NHTSA plans to collect to evaluate the image quality and field of view for rear convex mirrors. As illustrated in the Figure, using a test device that simulates a 1-year-old child, the rear convex look-down mirror shows an area directly behind a vehicle (a 2007 Honda Odyssey minivan) but beyond 15 feet from the bumper, the image could not be discerned.

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[25] 2008 Ward's Automotive Yearbook.

[26] Rear cross-view mirrors have been available on the Toyota 4Runner base model vehicles since MY 2003.

[27] SAFETEA–LU, Sec. 1109, 119 Stat. 1168.

[28] Mazzae, E.N. and Garrott, W.R., Experimental Evaluation of the Performance of Available Backover Prevention Technologies, NHTSA Technical Report No. DOT HS 810 634, September 2006.

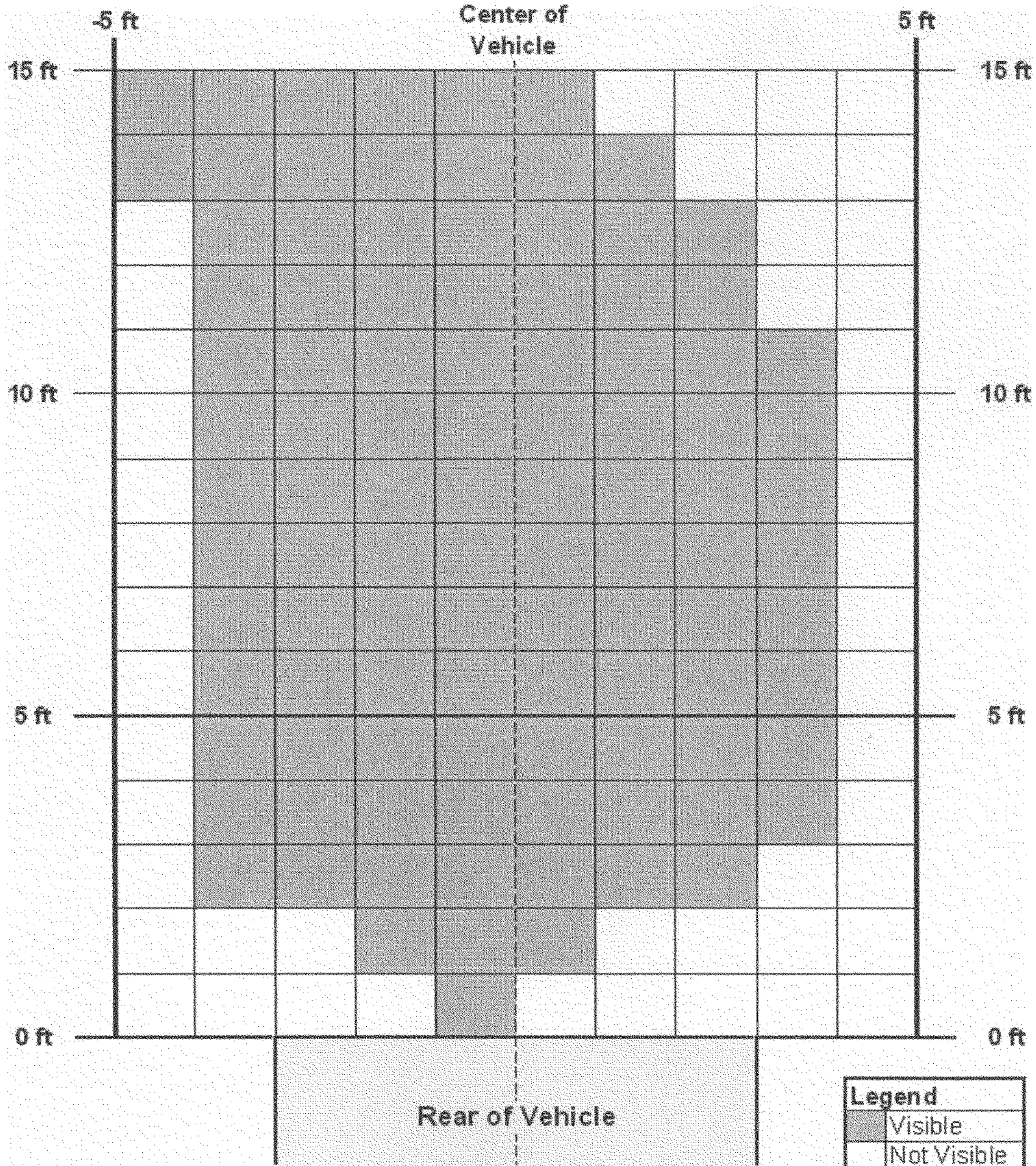

Figure 2. Field of View for an Exemplar Rear Convex "Look-Down" Mirror.

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Using the same 1-year-old child-sized test device, Figure 3 illustrates the measured field of view for an exemplar rear convex cross-view mirror system. The area behind the vehicle cannot be seen, rather, only the area that extends outward from both rear corners of the vehicle.

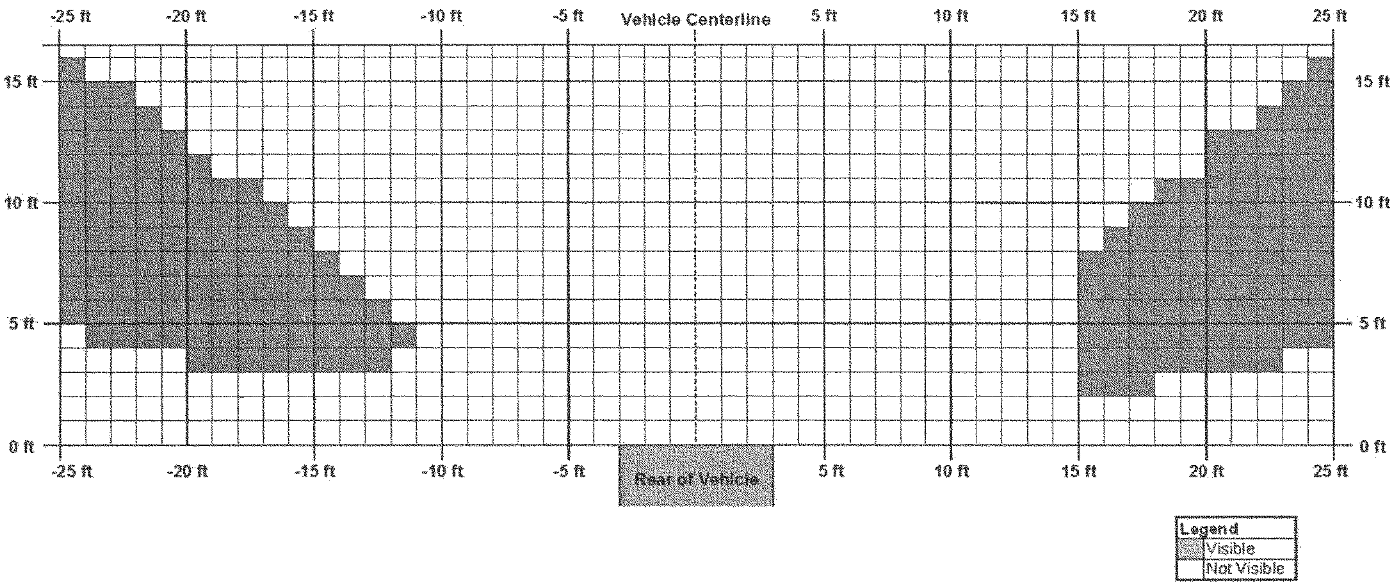

Figure 3. Field of View for an Exemplar Rear Convex Cross-view Mirror System mounted on a 2006 BMW 330i (Shaded Area is Visible).

NHTSA previously evaluated the quality of images displayed by a rear corner convex mirror mounted on a 1996 Grumman-Olsen step van with a 12-foot long box.[29] Using those data, an analysis was performed in which linear extrapolation and two-dimensional interpolation [30] were applied to estimate at which of four locations behind the vehicle a 1-year-old child dummy (i.e., anthropomorphic test device, or ATD) could be visible to a driver using a rear corner convex mirror. The four locations assessed are labeled A through D in Figure 4.

[29] Mazzae, E.N., and Garrott, W.R., Experimental Evaluation of the Performance of Available Backover Prevention Technologies for Medium Straight Trucks, NHTSA Technical Report No. DOT HS 810 865, November 2007.

[30] Measured minutes of arc subtended by the test object were first linearly extrapolated to estimate the effects of differences in the distance from the driver eyepoint to the side rearview mirror and the distance from the side rearview mirror to the rear corner convex mirror. Two-dimensional linear interpolation was then used to correct for reducing the vehicle width from the 7.0 feet for the step van to the 6.0 feet more typical of light passenger vehicle and for estimating minutes of arc subtended at the four locations, A through D. Note that estimates based upon multiple multi-linear extrapolation/interpolation were made because they could be done quickly using data that NHTSA had previously collected.

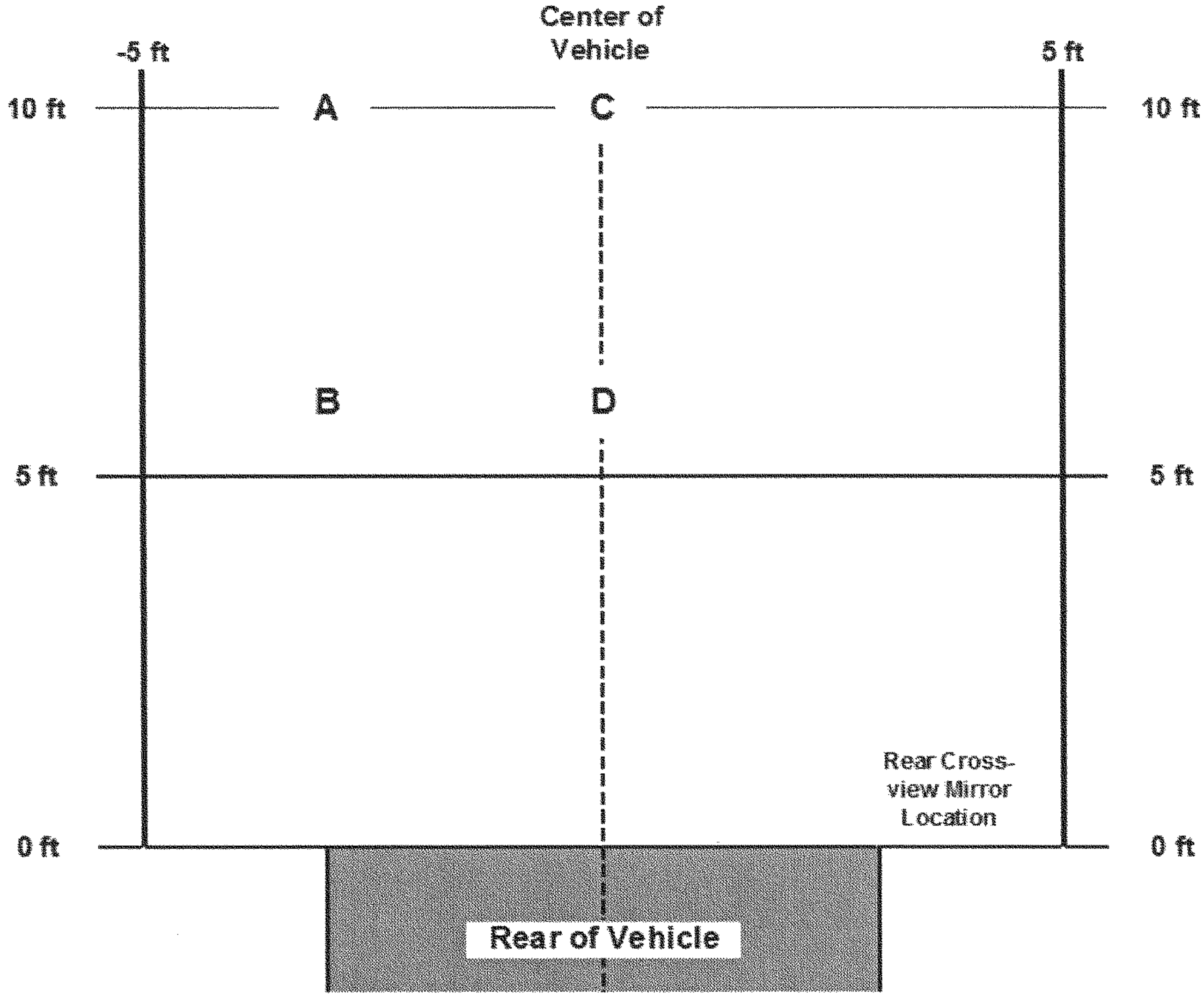

Figure 4. Location of Visibility Calculation Points Behind the Vehicle

The reflected image of the 1-year-old dummy becomes less minified and is easier for the driver to discern as the location of the dummy moves either forward towards the rear bumper of the vehicle or laterally towards the driver's side of the vehicle. Therefore, for a vehicle for which the dummy is visible at Point A, the dummy is expected to be visible anywhere across the entire width of the vehicle for distances up to at least 10 feet from the vehicle's rear bumper.

Estimated visibility of the 1-year-old dummy for each of the four locations (identified in Figure 4) for 9 vehicles is shown in Table 6.

TABLE 6—VISIBILITY OF A 1-YEAR-OLD CHILD DUMMY USING A CORNER REAR CROSS-VIEW MIRROR

Year	Make	Model	Can see Point A?	Can see Point B?	Can see Point C?	Can see Point D?
2008	Chevrolet	Express	No	No	No	Yes.
2003	Volvo	XC90	No	No	Yes	Yes.
2005	Nissan	Armada	No	No	No	Yes.
2007	Saturn	Vue	No	No	Yes	Yes.
2007	Jeep	Commander	No	No	Yes	Yes.
2008	Toyota	Highlander	No	No	Yes	Yes.
2007	Ford	Edge	No	No	Yes	Yes.
2005	Chevrolet	Uplander	No	No	No	Yes.
2003	Toyota	4Runner	No	No	Yes	Yes.

As the table indicates, it is not expected that a driver could see the 1-year-old dummy when the dummy is located directly behind the passenger's side of the vehicle at a distance of 6 or 10 feet back from the vehicle's rear bumper. The quality of the reflected image is better on the vehicle's centerline, with the dummy expected to be visible for six out of nine vehicles when it is located 10 feet back from the rear bumper and visually discernable to the driver for all nine vehicles when it is only 6 feet aft of the rear bumper.

This mirror research is scheduled to be completed in 2009 and will be summarized in a published NHTSA report thereafter. Along with comments received to this notice, NHTSA hopes to use this research information in the development of a proposal.

Observations

Some advantages of rear-mounted convex mirrors include that when compared to video cameras and object detection sensors, they are relatively inexpensive (e.g., less than $40 retail as an aftermarket product) and have the potential to last the life of the vehicle. They also provide a wider field of view than that provided by plane mirrors. However, they also possess inherent disadvantages. In general, convex mirrors compress (i.e., minify) and distort the image of reflected objects in their field of view. This image distortion and image minification make objects and pedestrians appear very narrow and difficult for the driver to discern and identify. These aspects of image quality worsen as the length of the vehicle increases.

Rear cross-view mirrors are positioned to show an area to the side and rear of the vehicle but they do not provide a good view of the area directly behind the vehicle (the area bounded by two imaginary planes tangent to the sides of the vehicle. As such, a pedestrian or object in this area could be invisible to the driver. They can however, help drivers see objects approaching the rear of the vehicle along a perpendicular path. NHTSA is aware that single rear convex look-down mirrors are commonly found on SUVs and vans in Korea and Japan. However, we are unaware of any publicly available studies that have been conducted to assess the effectiveness of these mirrors in improving rear visibility. We seek comment on the availability of any such studies.

B. Rearview Video Systems

Description

A growing number of vehicles in the U.S. are equipped with rearview video systems. These systems can permit a driver to see much of the area behind the vehicle via a video display showing the image from a video camera mounted on the rear of the vehicle. The images may be presented to the driver using an existing screen in the vehicle, such as a navigation system or multifunction display screen, or by adding a display incorporated into the dashboard or interior rearview mirror.

Costs for these rearview video systems are estimated at approximately $58–$88 for vehicles equipped with a navigation system or other type of multi-function visual display, to $158–$189 for vehicles requiring a dashboard-mounted display screen, or $173–$203 for vehicles with an RV display integrated into the interior rearview mirror.[31]

Research

Recent research on rearview video systems conducted by NHTSA and our observations about the research are presented below.

NHTSA Testing in Support of SAFETEA–LU

In response to Section 10304 of SAFETEA–LU, NHTSA examined three rearview video systems (RV): One in combination with original equipment rear parking sensors, one aftermarket system combining both RV and parking sensor technologies, and one original equipment RV system.[32] This examination of RV systems included assessment of their field of view and their potential to provide drivers with information about obstacles behind the vehicle.

Through this study, the agency made the following observations. The rearview video systems examined provided a clear image of the area behind the vehicle in daylight and indoor lighting conditions. RV systems displayed images of pedestrians or obstacles behind the vehicle to a substantial range of 23 feet or more, except for an area within 8–12 inches of the rear bumper at ground level. Beyond the rear bumper, the rearview video systems also displayed areas wider than 50 feet.

The location and angle at which the rearview video camera is mounted on the back of the vehicle affects the size of the field of view provided by the system. The longitudinal range of the images displayed by the two original equipment RV systems tested differed significantly. One rearview video system's camera presented an image having a limited vertical angle, resulting in a substantially shorter longitudinal range along the centerline of the vehicle (ending at approximately 23 feet from the rear bumper at ground level). For a 3-year-old child dummy centered 2 feet behind the vehicle, the shorter visible range exhibited by this particular RV system caused the top of the dummy's head to be out of view.

Observations

We found that RV systems can display areas on the ground almost directly adjacent to the bumper of the vehicle. Furthermore, RV systems offer the possibility of a wide field of view, with some systems able to show 180 degrees behind the vehicle.

However, during the short course of testing, NHTSA also noted some operational issues with video camera performance in certain weather conditions, such as rain and snow. For example, rain drops and the buildup of ice on the video camera lens can significantly reduce the quality of the view provided by the RV system. Also, in evaluating these technologies we have not had the opportunity to assess the long-term performance and reliability of RV systems, as well as the effects of harsh weather conditions on their long-term operation.

C. Sensor-Based Rear Object Detection Systems

Description

Sensor-based object detection systems use electronic sensors that transmit a signal which, if an obstacle is present in a sensor's detection field, bounces the signal back to the sensor producing a positive ''detection'' of the obstacle. These sensors detect objects in the vicinity of a vehicle at varying ranges depending on the technology. To date, commercially-available object detection systems have been based on short-range ultrasonic technology or longer range radar technology, although advanced infrared sensors are under development as well.

Sensor-based object detection systems have been available for over 15 years as aftermarket products and for a lesser period as original equipment. Original equipment systems have been marketed as a convenience feature or ''parking aid'' for which the vehicle owner's manual can contain language denoting

[31] PRIA, section VI.

[32] Mazzae, E.N. and Garrott, W.R., Experimental Evaluation of the Performance of Available Backover Prevention Technologies, NHTSA Technical Report No. DOT HS 810 634, September 2006.

sensor performance limitations with respect to detecting children or small moving objects. Aftermarket systems, however, are frequently marketed as safety devices for warning drivers of the presence of small children behind the vehicle.

NHTSA has investigated the cost of sensor-based rear object detection systems. Currently, we estimate the cost of a backing system based on ultrasonic technology to be $51–$89 and the cost of a system based on radar technology to be approximately $92.[33]

Research

NHTSA Research in Support of SAFETEA–LU

NHTSA examined eight sensor-based original equipment and aftermarket rear parking systems in response to Section 10304 of the SAFETEA–LU mandate.[34] NHTSA conducted testing to measure the object detection performance of short range sensor-based systems. Measurements included static field of view (i.e., both the vehicle and test objects were static), static field of view repeatability, and dynamic detection range for different laterally moving test objects. The agency assessed the system's ability to detect a 74-inch-tall adult male walking in various directions to the rear of the vehicle. Detection performance was also evaluated in a series of static and dynamic tests with 1-year-old and 3-year-old children.

Sensor-based systems tested were generally inconsistent and unreliable in detecting pedestrians, particularly children, located behind the vehicle. Testing showed that, in most cases, pedestrian size affected detection performance, as adults elicited better detection response than 1 or 3-year-old children. Specifically, each system could generally detect a moving adult pedestrian (or other objects) behind a stationary vehicle; however, each system exhibited some difficulty in detecting moving children. The sensor-based systems tested were found to operate reliably (i.e., without malfunction), with the exception of one aftermarket ultrasonic system that malfunctioned after only a few weeks, rendering it unavailable for use in remaining tests.

While examining the consistency of system detection performance, the agency observed that each sensor-based system exhibited some degree of variability in its detection performance and patterns. Specifically, detection inconsistencies were generally noticed at the periphery of the detection zones and typically for no more than 1 foot in magnitude. On average, these sensor-based systems had detection zones which generally covered an area directly behind the vehicle. The system with the longest detection range could detect a 3-year-old child up to 11 feet from the rear bumper (along a 3–5 ft wide strip of area along the vehicle's centerline). The majority of systems were unable to detect test objects less than 28 inches in height.

The response times of sensor-based systems were also evaluated in this study. In order for sensor-based backover avoidance systems to assist in preventing collisions, warnings must be generated by the system in a timely manner and the driver must perceive the warning within sufficient time to respond appropriately to avoid a crash. With regards to system response times, ISO 17386:2004,[35] ''Manoeuvring Aids for Low Speed Operation (MALSO)—Performance requirements and test procedures'', outlines performance requirements for sensor-based object detection systems. This standard recommends a maximum system response time of 0.35 seconds. NHTSA's tests showed that the response times for the eight tested sensor systems varied from 0.18 to 1 second, and only three of them met the ISO response time limit. For the systems that did not meet the recommended 0.35-second limit, it is unlikely (assuming typical backing speeds [36] and driver reaction times) that warnings would be provided to a driver in sufficient time to allow the driver to bring the vehicle to a stop and avoid a possible collision with an obstacle or moving child.

NHTSA Experimental Research: Performance of Sensor-Based Rear Object Detection Systems

NHTSA's 2008 study of drivers' use of rearview video systems [37] involved an observation of drivers of vehicles equipped with an ultrasonic-based rear parking sensor system in addition to an RV system. In a staged experimental trial in which an unexpected obstacle was presented to test participants while backing out of a garage, the rear parking sensor system on the particular vehicle involved in this study detected the obstacle and provided a warning indication of the presence of the obstacle behind the vehicle in 38 percent (5 out of 13) of the event trials for participants with vehicles equipped with the combination system. These data describing the performance of a sensor-based rear parking aid as used by average drivers reflect similar detection performance deficiencies as have been observed in NHTSA's laboratory testing of the detection performance of sensor-based object detection systems.[38 39]

Paine, Macbeth & Henderson Proximity Sensor Research

Paine, Macbeth & Henderson tested the performance of proximity sensor backing aids.[40] They reported that proximity sensors tested exhibited limited ability to detect objects for vehicles traveling at 5 km/h (3.1 mph) or more. According to their conclusions, proximity sensors were prone to produce ''nuisance alarms'' in some driving situations and were deemed an unviable option to reduce backing incidents. While the authors suggested that a more effective system to mitigate backing incidents may be to incorporate sensors and wide-angle video camera technology, no data were provided to support this statement.

GM Experimental Research on Sensor-Based Systems for the Reduction of Backing Incidents

GM outlined the functional capabilities of their ultrasonic rear park assist system. The system was designed to detect larger poles and parking barriers greater than 7.5 cm in diameter with a length of 1.0 meter or more. It was not designed to detect objects less than 25 cm in height. In addition, the system was not designed to detect obstacles directly below the bumper or under the vehicle. GM notes that smaller or thinner objects or pedestrians

[33] PRIA, section VI.

[34] Mazzae, E.N. and Garrott, W.R., Experimental Evaluation of the Performance of Available Backover Prevention Technologies, NHTSA Technical Report No. DOT HS 810 634, September 2006.

[35] ISO 17386:2004 Transport information and control systems—Manoeuvring Aids for Low Speed Operation (MALSO)—Performance requirements and test procedures.

[36] Note that average backing speed was found to be 2.26 mph in NHTSA's ''On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS).'' Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). National Highway Traffic Safety Administration, DOT 811 024, page 34.

[37] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[38] Mazzae, E.N. and Garrott, W.R., Experimental Evaluation of the Performance of Available Backover Prevention Technologies, NHTSA Technical Report No. DOT HS 810 634, September 2006.

[39] Mazzae, E.N. and Garrott, W.R., Experimental Evaluation of the Performance of Available Backover Prevention Technologies for Medium Straight Trucks, NHTSA Technical Report No. DOT HS 810 865, November 2007.

[40] Paine, M., Macbeth, A., and Henderson, M. (2003). The Danger to Young Pedestrians from Reversing Motor Vehicles. 18th International Technical Conference on the Enhanced Safety of Vehicles. Paper Number 466.

may not be detected by this system, and indicates this fact explicitly in the system's instructional materials.[41 42]

Observations

The development of sensor-based systems for use as parking aids has been in progress for at least 15 years. Ultrasonic sensors inherently have detection performance that varies as a function of the degree of sonic reflectivity of the obstacle surface. For example, objects with a smooth surface such as plastic or metal reflect well, whereas objects with a textured surface, such as clothing, may not reflect as well. Radar sensors, which are able to detect the water in a human's body, are better able to detect pedestrians, but demonstrate inconsistent detection performance, especially with regard to small children.

NHTSA is aware that the performance of current sensor-based systems can be influenced by the algorithms that are used for detection. As stated previously, these systems are implemented as parking aids rather than safety systems and thus this may have attributed to the observed performance. While it is possible to modify the detection algorithms of sensor-based object detection systems to allow for better detection of children, one result of such a modification could result in other less favorable aspects of system performance, such as increased false alarms. From a driver confidence standpoint, an increase in false alarms could have the effect of decreasing the system's overall effectiveness as a driver's desire to use the system decreases.

D. Multi-Technology (Sensor + Video Camera) Systems

Description

In the context of this document, multi-technology backing aid systems are those systems that utilize both video and sensor-based technologies. Prior to MY 2007, these technologies functioned independently if both were present on a vehicle. Recently, truly integrated systems that use data from rear object detection sensors to present obstacle warnings that are superimposed on the RV display image have become commercially available. Whether integrated or not, vehicles equipped with both rearview video and sensor technologies have the ability to detect obstacles (via a rear parking sensor system) and alert a driver (by directing their attention to the rearview video system display) to the presence of the obstacle.

Research

As previously mentioned in Part C of this section, NHTSA's work in response to Section 10304 of the SAFETEA–LU mandate included the measurement of the object detection performance of short range sensor-based systems. One of the systems examined was the integrated rearview video and ultrasonic-based rear parking aid system of a 2007 Cadillac Escalade. This system used object detection information from an ultrasonic rear parking aid to present obstacle warnings to the driver through warning symbology superimposed on the RV display image. Specifically, a warning triangle symbol was shown on the RV display image in the approximate location of the obstacle. While the performance of the ultrasonic-based rear parking aid system showed the same issues as other tested systems using that sensor technology, the presentation of integrated warnings may be useful in directing a driver's attention to the image of a rear obstacle presented on the rearview video display. However, in order to assess the effectiveness of this or any other integrated system in mitigating backover incidents, research with drivers using the system is needed.

Observations

Testing of the vehicle examined showed that the integrated rear parking aid and rearview video aspects of the backing aid system performed, from a sensor point of view, the same as would these two technologies if tested separately. The performance of the backing aid technologies present on this vehicle may not represent the performance of all such systems commercially available today. With improved technology integration that may utilize image processing to confirm the presence of rear obstacles, performance enhancements may be possible. The agency seeks comment on whether any recent studies have been performed with other integrated multi-technology backing aid systems.

E. Future Technologies

Description

NHTSA is aware of two additional sensor technologies being developed that could be used to improve a vehicle's rear visibility; infrared-based object detection systems and video-based object recognition systems. As with other sensor systems, infrared-based systems emit a signal, which if an object is within its detection range, will bounce back and be detected by a receiver. Rear object detection via video camera uses real-time image processing capability to identify obstacles behind the vehicle and alert the driver of their presence.

Research

Ongoing NHTSA Backing Crash Countermeasure Research

In addition to the previously mentioned rear-mounted convex mirror research, NHTSA is currently engaged in cooperative research with GM on Advanced Collision Avoidance Technology relating to backing incidents. The ACAT backing systems project is assessing the ability of more advanced technologies to mitigate backing crashes, and refining a tool to assess the potential safety benefit of these technologies. The focus of the ACAT Backing Crash Countermeasure Program is to characterize backing crashes in the U.S. and investigate a set of integrated countermeasures to mitigate them at appropriate points along the crash timeline (prior to entering the vehicle and continuing throughout the backing sequence). The objective of this research is to estimate potential safety benefits or harm reduction that these countermeasures might provide. A Safety Impact Methodology (SIM), consisting of a software-based simulation model together with a set of objective tests for evaluating backing crash countermeasures, will be developed to estimate the harm reduction potential of specific countermeasures. Included in the SIM's methods for estimating potential safety benefits will be a consideration of assessing and modeling unintentional potential disbenefits that might arise from a countermeasure.

Observations

While these technology applications may eventually prove viable, because of their early stages of development it is not possible at this time to assess their ability to effectively expand the visible area behind a vehicle. Similarly, the completion of NHTSA's advanced technology research effort is not expected until calendar year 2011 and thus will not occur prior to the Congressional deadline. The agency seeks comments on the timeframe for the commercial availability of these technologies, and on any other

[41] Instructional materials include the following warning: ''If children, someone on a bicycle, or pets are behind your vehicle, (ultrasonic rear park assist) won't tell you they are there. You could strike them and they could be injured or killed.''

[42] Green, C. and Deering, R. (2006). Driver Performance Research Regarding Systems for Use While Backing. Society of Automotive Engineers, Paper No. 2006–01–1982.

advanced technology developments not identified here.

F. Summary and Questions Regarding Technologies for Improving Rear Visibility

Given the mandate from Congress to improve the rear visibility of vehicles, NHTSA's preliminary assessment of the known research to date seems to indicate that RV systems have greater potential to improve vehicles' rear visibility than sensor-based rear object detection systems and rear-mounted convex mirrors. However, we believe it is premature to limit manufacturers' design options at this time. To this end, we put forth the following questions and solicit comments on our assessments of these technologies, and any information on the feasibility of alternative approaches or systems.

(1) While the objective to ''expand the required field of view to enable the driver of a motor vehicle to detect areas behind'' the vehicle implies enhancement of what a driver can visually see behind a vehicle, the language of the K.T. Safety Act also mentions that the ''standard may be met by the provision of additional mirrors, sensors, cameras, or other technology.'' NHTSA seeks comment regarding the ability of object detection sensor technology to improve visibility and comply with the requirements of the Act.

(2) What specific customer feedback have OEMs received regarding vehicles equipped with rear parking sensor systems? Have any component reliability or maintenance issues arisen? Is sensor performance affected by any aspect of ambient weather conditions?

(3) What specific customer feedback have OEMs received regarding vehicles equipped with rearview video systems? Have any rearview video system component reliability or maintenance issues arisen?

(4) What are the performance and usability characteristics of rearview video systems and rear-mounted convex mirrors in low light (e.g., nighttime) conditions?

(5) Is there data available regarding consumers' and vehicle manufacturers' research regarding backing speed limitation, haptic feedback to the driver, or use of automatic braking?

(6) What types of rear visibility countermeasures are anticipated to be implemented in the vehicle fleet through the 2012 timeframe?

(7) Can rear-mounted convex mirrors be installed on light vehicles other than SUVs and vans? What is the rationale for U.S. manufacturers' choosing to install rear parking sensors and video cameras, rather than rear-mounted convex mirrors as are commonly installed on SUVs and minivans in Korea and Japan? NHTSA is particularly interested in any information on the effectiveness of rear-mounted convex mirrors in Korea and Japan.

(8) NHTSA seeks any available research data documenting the effectiveness of rear convex cross-view mirrors in specifically addressing backover crashes.

(9) NHTSA seeks comment and data on whether it is possible to provide an expanded field of view behind the vehicle using only rear-mounted convex mirrors.

(10) NHTSA is aware of research conducted by GM that suggests that drivers respond more appropriately to visual image-based confirmation of object presence than to non-visual image based visual or auditory warnings. Is there additional research on this topic?

(11) NHTSA requests input and data on whether the provision of graphical image-based displays (e.g., such as a simplified animation depicting rear obstacles), rather than true-color, photographic visual displays would elicit a similarly favorable crash avoidance response from the driver.

(12) To date, rearview video systems examined by NHTSA have displayed to the driver a rear-looking perspective of the area behind the vehicle. Recently introduced systems which provide the driver with a near 360-degree view of the area around the entire vehicle do so using a ''birds-eye'' perspective using images from four cameras around the vehicle. During backing, it appears that, by default, this birds-eye view image is presented simultaneously along with the traditional rear-facing camera image. NHTSA requests data or input on whether this presentation method is likely to elicit a response from the driver that is at least as favorable as that attained using traditional, rear-view image perspective, or whether this presentation is more confusing for drivers.

VI. Drivers' Use and the Associated Effectiveness of Available Technologies To Mitigate Backovers

In order to establish effectiveness estimates for different systems which may be utilized to mitigate backover crashes, the agency has conducted research on vehicles equipped with such systems, including those utilizing ultrasonic and radar sensors and rearview video cameras. As with any passive technology, NHTSA believes that it is reasonable to assume that in order for the technology to assist in preventing backing crashes, the driver must use the technology (e.g., look at the video display, if present), perceive the indication that a pedestrian or object is present, and respond quickly, and with sufficient force applied to the brake pedal, to bring the vehicle to a stop. While we have previously discussed the performance of the technologies, this section will outline what the agency knows about driver use and the resulting effectiveness of technologies that could be used to mitigate backover crashes.

NHTSA has not conducted system effectiveness research with drivers for all of the four system types discussed in this notice. However, that relevant research NHTSA and industry have conducted is summarized here.

A. Rear-Mounted Convex Mirrors

NHTSA has not conducted research focused on examining driver's use of mirrors to aid in the performance of backing maneuvers. However, NHTSA's study of drivers' use of rearview video systems during staged and naturalistic backing maneuvers did produce data regarding drivers' use of the side and interior rearview mirrors as well as direct glance behavior.[43] This behavior suggests that drivers would use the mirrors. Table 7 shows that the mean percentage of total glance time during a backing maneuver in which drivers glanced at the driver-side mirror, passenger-side mirror, and interior rearview mirror. Independent of the presence of a backing aid, drivers spent over 25 percent of the time during a backing maneuver glancing rearward over their right shoulder.

[43] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

TABLE 7—MEAN PERCENTAGE OF TOTAL GLANCE TIME TO MIRROR LOCATIONS FOR A BACKING MANEUVER WITH STAGED OBSTACLE AVOIDANCE EVENT [44]

Glance location	Mean percentage of total glance time during a backing maneuver
Driver-side Mirror/Driver-side Window [45]	15
Interior Rearview Mirror	5
Passenger-side Mirror/Passenger-side Window [46]	15

NHTSA is currently engaged in research to examine the performance of these mirrors in displaying images of rear obstacles. While NHTSA has not yet conducted driving research with these mirrors we are planning to conduct research to examine drivers' behavior and ability to avoid crashes with rear-mounted convex mirrors in 2009. Upon completion, this mirror research will be summarized in a published NHTSA report. Along with comments received to this notice, NHTSA hopes to use this research information in the development of a proposal.

B. Rearview Video Systems

NHTSA has conducted and we are aware of some work conducted by GM that examined drivers' use of rearview video based backing aids and their ability to use them to mitigate crashes. Below is a brief summary of this research.

NHTSA Experimental Research: On-Road Study of Drivers' Use of Rearview Video Systems

NHTSA conducted experimental research aimed to determine whether drivers look at the RV display during backing. While hardware performance testing has shown the rearview video systems can provide to the driver an image of any obstacles behind the vehicle in the RV system's field of view, the driver must take the initiative to look at the display throughout the backing maneuver in order for the RV system to provide any benefit. The goal of this study was to further our understanding of the degree to which drivers may actively use RV systems while backing and whether the provision of such visual information will translate into decreased backing and backover incidents.

This study also provided information useful in estimating the effectiveness of RV and supplemental sensors, in aiding drivers to avoid a backing crash. For example, the number of times per backing maneuver that a driver looked at the RV screen was tabulated. A driver that looks at the screen more often is more likely to notice when an obstacle appears. A look at the beginning of a backing maneuver is less likely to result in a driver's detection of an obstacle than would frequent checking of the screen throughout the maneuver.

Drivers' use of rearview video systems was observed during staged and naturalistic backing maneuvers to determine whether drivers look at the RV display during backing and whether use of the system affects backing behavior.[47] Thirty-seven test participants, aged 25 to 60 years, were comprised of twelve drivers of RV-equipped vehicles, thirteen drivers of vehicles equipped with an RV system and a rear parking sensor system, and twelve drivers of vehicles with no backing aid system. All three system conditions were presented using original equipment configurations of the 2007 Honda Odyssey minivan. All participants had driven and owned a 2007 Honda Odyssey minivan as their primary vehicle for at least six months. Participants were not aware that the focus of the study was on their behavior and performance during backing maneuvers.

Participants drove their own vehicles for a period of four weeks in their normal daily activities while backing maneuvers were recorded. At the end of four weeks, participants returned to the research lab to have the recording equipment removed. At the lab, the participants took a test drive in which an unexpected 36-inch-tall obstacle consisting of a two-dimensional photograph of a child appeared behind the vehicle during a final backing maneuver. Additional details of the test method are provided in Appendix B of this notice.

The results of the naturalistic driving and unexpected obstacle scenario are provided below.

Results for Naturalistic Driving

- A total of 6,145 naturalistic backing maneuvers were recorded in the study, none of which resulted in a significant collision; however, some collisions (i.e., with trash receptacles and other parked vehicles) occurred during routine backing.
- In the real-world backing situations, drivers equipped with RV systems spent 8 to 12 percent of the time looking at the RV display during backing maneuvers.
- On average, drivers made 2.17 glances per backing maneuver with the RV-only system, and 1.65 glances per maneuver with the RV and sensor system.
- Overall, drivers looked at least once at the RV display on approximately 65 percent of backing events, and looked more than once at the RV display on approximately 40 percent of backing events.

Results for Unexpected Obstacle Maneuver

- Drivers with an RV system made 13 to 14 percent of glances at the RV video display during the initial phase of backing in the staged maneuvers, independent of system presence.
- Drivers spent over 25 percent of backing time looking over their right shoulder in the staged backing maneuvers.
- Only participants who looked at the RV display more than once during the maneuver avoided a crash during the staged crash-imminent obstacle event.
- Results indicated that the RV system was associated with a statistically significant (28 percent) reduction in crashes with the unexpected obstacle as compared to participants without an RV system. All participants in the ''no system'' condition crashed, since the staged obstacle event scenario was designed such that drivers without an RV system could not see the obstacle.

Results of this study indicate that drivers looked at the RV display in approximately 14 percent of glances in baseline and obstacle events and 10 percent of glances in naturalistic backing maneuvers. The agency recognized that the timing and frequency of drivers' glances at the RV display has a noticeable impact on the likelihood of rear obstacle detection. However, making single or multiple glances at the RV display at the start of the maneuver does not ensure that the path behind the vehicle will remain clear for the entire backing maneuver.

Overall, this study estimates that video-based backing systems would

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[44] Id.

[45] Note that due to the close proximity of the mirror and window on each side of the vehicle, the driver-side mirror and driver-side window glance locations were impossible to distinguish from each other.

[46] Note that due to the close proximity of the mirror and window on each side of the vehicle, the passenger-side mirror and passenger-side window glance locations were impossible to distinguish from each other.

[47] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

mitigate approximately 28 to 42 percent of backover crashes [48].

GM Experimental Research on Driver Performance Using Video-Based Backing Aid Systems

GM conducted research to investigate ways to assist drivers in recognizing people or objects behind their vehicle while performing backing maneuvers.[49] One study compared parking behaviors for rear camera and ultrasonic rear parking assist systems together, separately, and under traditional parking conditions (i.e., neither system). An obstacle was placed unexpectedly behind a driver's vehicle prior to the start of a backing maneuver to assess the driver's performance in obstacle detection and avoidance.[50] Twenty-four participants struck the obstacle, while five participants avoided the obstacle. Of those participants who avoided the obstacle, three saw the obstacle while looking at the RV display (two in the RV system condition, one in the ultrasonic rear park assist and RV system condition), one saw the obstacle in their mirror (ultrasonic rear park assist and RV system condition), and one participant noticed the obstacle out of the back window (RV system condition). These results indicated that participants with an RV system were less likely to be involved in a backing incident.

GM also sponsored a second research study to evaluate driver performance with rear camera systems.[51] In this study, each participant parked their vehicle using a rear camera and ultrasonic system more than 30 times, including practice trials. During one scenario, participants, unaware that an experimenter placed an obstacle behind the vehicle, were asked to perform a backing maneuver to engage the ultrasonic rear park assist and the rear camera system. In some cases, a flashing symbol was employed in the approximate location of the rear obstacle as presented on the video display screen. While there were no statistically significant effects of either the symbol or the location of the obstacle, 65 percent of participants avoided the obstacle. Greater experience with the camera system and an increased number of trials presented that involved a ruse may have attributed to a higher object avoidance rate in this study than compared to the first study.

Overall, GM's research on rearview video systems suggested that RV systems may provide limited benefit in some backing scenarios.[52]

C. Sensor-Based Rear Object Detection Systems

NHTSA and GM have both conducted research on drivers' use of sensor-based backing aids and their ability to use them to mitigate crashes. Below is a brief summary of this research.

NHTSA Experimental Research: Driver Performance With Rearview Video and Sensor-Based Rear Object Detection Systems

NHTSA's study of drivers' use of rearview video systems (discussed in detail earlier in this document) also involved an observation of drivers of vehicles equipped with both an RV system and an ultrasonic-based rear parking sensor system. The rear parking sensor system tested detected the obstacle and provided a warning indication of the presence of a rear obstacle to the driver in 38 percent (5 out of 13) of the event trials for participants with vehicles equipped with the combination system. Four of these 5 participants crashed into the obstacle.

The test vehicle involved in the study had a control that allowed the driver to disable the parking sensor system. During the course of this study, half of the participants whose vehicles were equipped with a rear parking sensor system either stated or were observed to have turned the system off at least some of the time. Four participants made unsolicited comments to members of the research staff about turning off the rear parking sensor system on their vehicle.[53] One of the four participants reported that he just did not use it. The three other participants stated that they frequently turned the rear parking sensor system off when driving through a restaurant drive-through lane due to nuisance alarms (i.e., audible notifications of the presence of vehicles that the driver is already aware of). A sixth participant did not comment on not using the system, but was observed having the rear parking sensor system on their vehicle switched off during their initial meeting visit. This tendency for some drivers to turn the rear parking sensor system off causes NHTSA to be concerned about the potential for this technology to be effective in mitigating backover incidents.

GM Experimental Research on Driver Performance Using Sensor-Based Backing Aid Systems

GM sponsored a study on the effectiveness of auditory backing warnings provided by a rear object detection system.[54] The study found that only 13 percent of drivers avoided hitting an unexpected obstacle, and over 87 percent of the drivers collided with the obstacle following the warning. Sixty-eight percent of drivers provided with the warning demonstrated precautionary behaviors in response to the warning, such as covering the brake with their foot, tapping the brake, or braking completely. While 44 percent of participants braked, these braking levels were generally insufficient to avoid a collision. Although data provides some evidence that warnings influenced driver behavior, warnings were unreliable in terms of their ability to induce drivers to immediately brake to a complete stop.

This study further suggests that knowledge and experience with a backing warning system may not significantly improve immediate driver response to a backing warning. While specific training on the operation of the system was provided to eight drivers, only one avoided the obstacle. In each case, drivers reported that they did not expect to encounter an obstacle in their backing path. Many drivers also reported that they searched for an obstacle following the warning, but ''didn't see anything'' and continued their backing maneuver. These perceptions suggest that drivers' expectations are important when seeking to influence driver behavior.

NHTSA Experimental Research: Driver Performance With Sensor-Based Rear Object Detection Systems

NHTSA is currently engaged in research to assess drivers' ability to avoid backing crashes in a vehicle equipped with only a sensor-based rear object detection system. This work is scheduled to be completed in 2009 and

[48] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[49] Green, C. and Deering, R. (2006). Driver Performance Research Regarding Systems for Use While Backing. Society of Automotive Engineers, Paper No. 2006–01–1982.

[50] McLaughlin, S.B., Hankey, J.M., Green, C.A., and Kiefer, R.J. (2003). Driver Performance Evaluation of Two Rear Parking Aids. Proceedings of the 2003 Enhanced Safety Vehicle Conference.

[51] Green, C. and Deering, R. (2006). Driver Performance Research Regarding Systems for Use While Backing. Society of Automotive Engineers, Paper No. 2006–01–1982.

[52] Green, C. and Deering, R. (2006). Driver Performance Research Regarding Systems for Use While Backing. Society of Automotive Engineers, Paper No. 2006–01–1982.

[53] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[54] Green, C. and Deering, R. (2006). Driver Performance Research Regarding Systems for Use While Backing. Society of Automotive Engineers, Paper No. 2006–01–1982.

will be summarized in a published NHTSA report thereafter. Along with comments received to this notice, NHTSA hopes to use this research information in the development of a proposal.

D. Multi-Technology (Sensor + Camera) Systems

NHTSA has not conducted research examining drivers' use of any integrated, multi-technology systems designed to aid drivers in performing backing maneuvers. However, NHTSA's study of drivers' use of rearview video systems (discussed in detail earlier in this document) involved an observation of drivers of vehicles equipped with both an RV system and an ultrasonic-based rear parking sensor system that functioned independently. Data from this study indicated that equipping a vehicle with a rear object detection system and an RV system that are not integrated resulted in lesser backing crash avoidance effectiveness than attainable with RV alone. Although statistically not significant due to the relatively small number of test participants, more participants with vehicles equipped with both an RV and a rear parking sensor system (85 percent) crashed into an obstacle than did those (58 percent) driving vehicles equipped with only an RV system. However, the fact that the rear parking sensor system only detected the obstacle in 38 percent of test trials may help explain the result if the drivers relied on the sensor system first. NHTSA's research on the performance of currently available sensor-based systems in detecting rear obstacles has shown their performance to be inconsistent, particularly in the detection of small children. It is possible that those performance deficits for sensor-based rear object detection systems could have a negative impact on the overall effectiveness of RV systems, particularly if drivers rely on the sensor system's auditory alerts to cue them to look at the RV display.

During our study, drivers of the vehicles with RV and sensors looked at the RV system visual display less frequently than did drivers of the same vehicle equipped with only the RV system. NHTSA seeks comment on whether there is research that would indicate why this would occur or if others have found a similar trend.

E. Summary

Table 8 presents a summary of the estimated effectiveness information for systems that may aid in the mitigation of backover incidents that NHTSA has collected to date. Estimates for system performance in detecting rear obstacles and overall effectiveness based on driver use are listed separately. System performance for rearview video systems was assumed to be 100 percent, since these systems have the capability to show any object within their field of view. System performance for sensor-based systems is based on object detection rates seen in the obstacle avoidance event presented in the study of drivers' use of rearview video systems.[55] Overall effectiveness values for rearview video systems alone and combined with a rear parking sensor system are based on results of NHTSA's study of drivers' use of rearview video systems. The value for rear parking sensor systems is calculated based on a combination of the 39 percent object detection rate from the study of drivers' use of rearview video systems and additional data that NHTSA has collected. We note that GM's study of drivers' use of backing warning systems found that only 13 percent of drivers were able to avoid a crash with a rear obstacle in a staged scenario using a rear parking sensor system.[56]

TABLE 8—ESTIMATED SYSTEM PERFORMANCE AND OVERALL EFFECTIVENESS

Countermeasure	System performance in object detection—percent detections	Percent overall effectiveness (technology + driver)
Rear-Mounted Convex Mirrors	(Research underway)	(Research underway).
Rearview Video	100	42[57].
Rearview Video + Sensors	100	15[58].
Sensors	39[59]	17.66[60] (estimate).

F. Questions

(1) NHTSA has not conducted research to estimate a drivers' ability to avoid crashes with a backing crash countermeasure system based only on sensor technology. We request any available data documenting the effectiveness of backing crash countermeasure systems based only on sensor technology in aiding drivers in mitigating backing crashes.

(2) NHTSA has not conducted research to estimate drivers' ability to avoid crashes with a backing crash countermeasure system based on multiple, integrated technologies (e.g., rear parking sensors and rearview video functions in one integrated system). We request any available objective data documenting the effectiveness of multi-technology backing crash countermeasure systems in mitigating backing crashes. We also request comment on what types of technology combinations industry may consider feasible for use in improving rear visibility.

(3) NHTSA requests any available data documenting the image quality of rear-mounted convex mirrors and their effectiveness in aiding drivers in preventing backing crashes.

(4) NHTSA requests any available additional objective research data documenting the effectiveness of sensor-based, rearview video, mirror, or combination systems that may aid in mitigating backover incidents.

(5) NHTSA requests information regarding mounting limitations for rear-mounted convex mirrors.

VII. Rear Visibility of Current Vehicles

The degree of direct rear visibility (i.e., what a driver can directly see with or without the aid of non-required mirrors or other devices) in a particular vehicle depends on a number of factors, including the driver's size and various aspects of the vehicle's design, such as the width of a vehicle's structural pillars (i.e., B and C pillars) and the size of its window openings. Rear seat head restraints can also affect direct rear

[55] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[56] General Motors (2006). Driver Performance Research Regarding Systems for Use While Backing. Society of Automotive Engineers, Paper No. 2006–01–1982.

[57] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[58] Id.

[59] Id.

[60] PRIA, section V.

visibility.[61] Additionally, due to their geometries and the position of a driver's eyes with respect to the bottom of the rear window (or top edge of a pickup truck's tailgate), vehicles with greater overall height and length are likely to have larger rear blind zone areas than shorter vehicles.

To assess a vehicle's rear visibility and how it varies from vehicle to vehicle, in 2007,[62] NHTSA measured the rear visibility characteristics of 44 recent-model light vehicles.[63] NHTSA's measurements involved assessment of the visibility of a visual target over an area stretching 35 feet to either side of the vehicle's centerline, 90 feet back from the vehicle's rear bumper, and 20 feet forward of the rear bumper. Rear visibility metrics were calculated using a subset of this area measuring 60 feet wide by 50 feet long (3000 square feet). The agency selected a 29.4-inch-tall visual target representing the approximate height of a 1-year-old child and the youngest walking potential backover victims. Rear visibility was measured for both a 50th percentile adult male driver (69.1 inches tall) and a 5th percentile adult female driver (59.8 inches tall). The areas over which the visual target was visually discernible using direct glances (i.e., looking out vehicle windows) and indirect glances (i.e., looking into side or interior rearview mirrors) were determined.

While NHTSA measured the area indirectly visible to the driver in the side and interior rearview mirrors, we focused our assessment on direct rear visibility in order to assess the degree to which the vehicle's structure affects what a driver can see out the vehicle's windows. This permitted an assessment of how rear visibility is affected by a vehicle's structure and allowed for better vehicle comparison since this metric varied more than would rear visibility measured using both direct vision and indirect vision devices together. In other words, considering both direct and indirect rear visibility together would allow less room for distinguishing between the qualities of rear visibility amongst vehicles. Examples of the measured direct fields of view for four common vehicles types are shown in Figures 5–8.

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[61] Note that 49 CFR Sec. 571.111 Standard No. 111, *Rearview mirrors,* Section 5.1.1 states that ''The line of sight may be partially obscured by seated occupants or by head restraints.''

[62] Mazzae, E.N., Garrott, W.R. (2008). Light Vehicle Rear Visibility Assessment. National Highway Traffic Safety Administration, DOT 810 909.

[63] Measured vehicles included the ten top-selling passenger cars and light trucks for calendar year 2006.

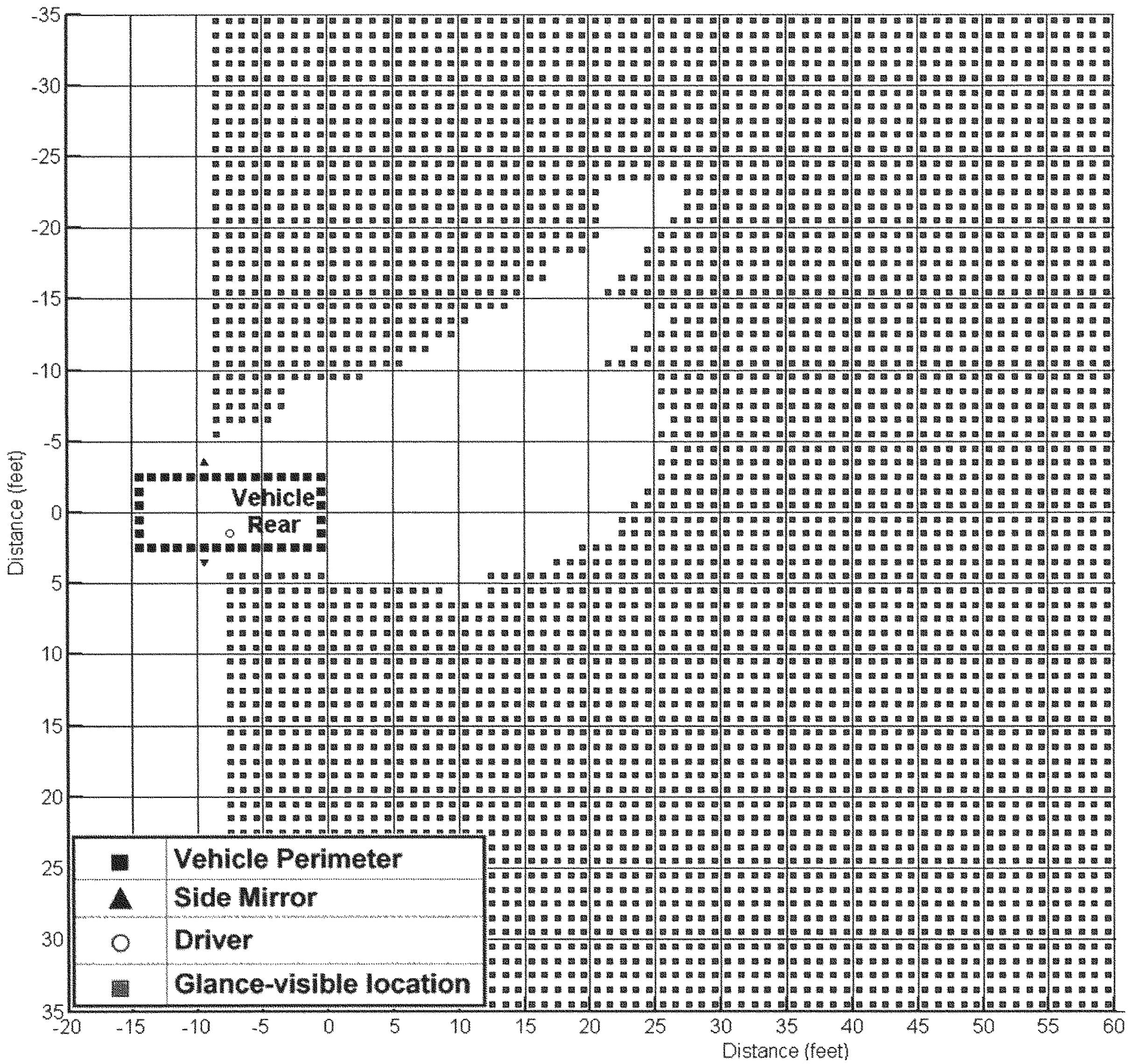

Figure 5. Direct Field of View Measured Using a 50th Percentile Male Driver: Passenger Car (2007 Chevrolet Cobalt, Coupe).

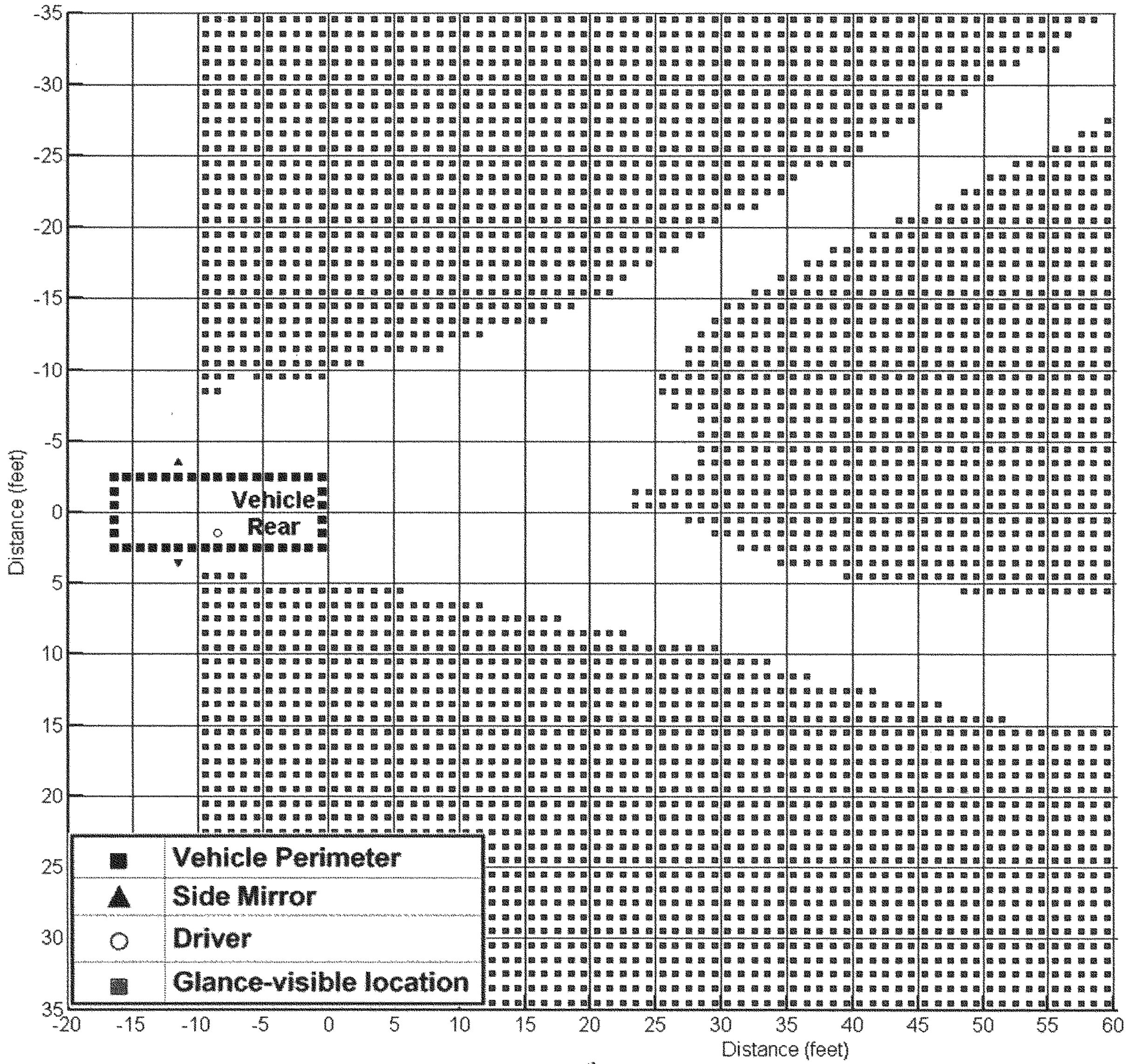

Figure 6. Direct Field of View Measured Using a 50th Percentile Male Driver: Minivan (2007 Honda Odyssey).

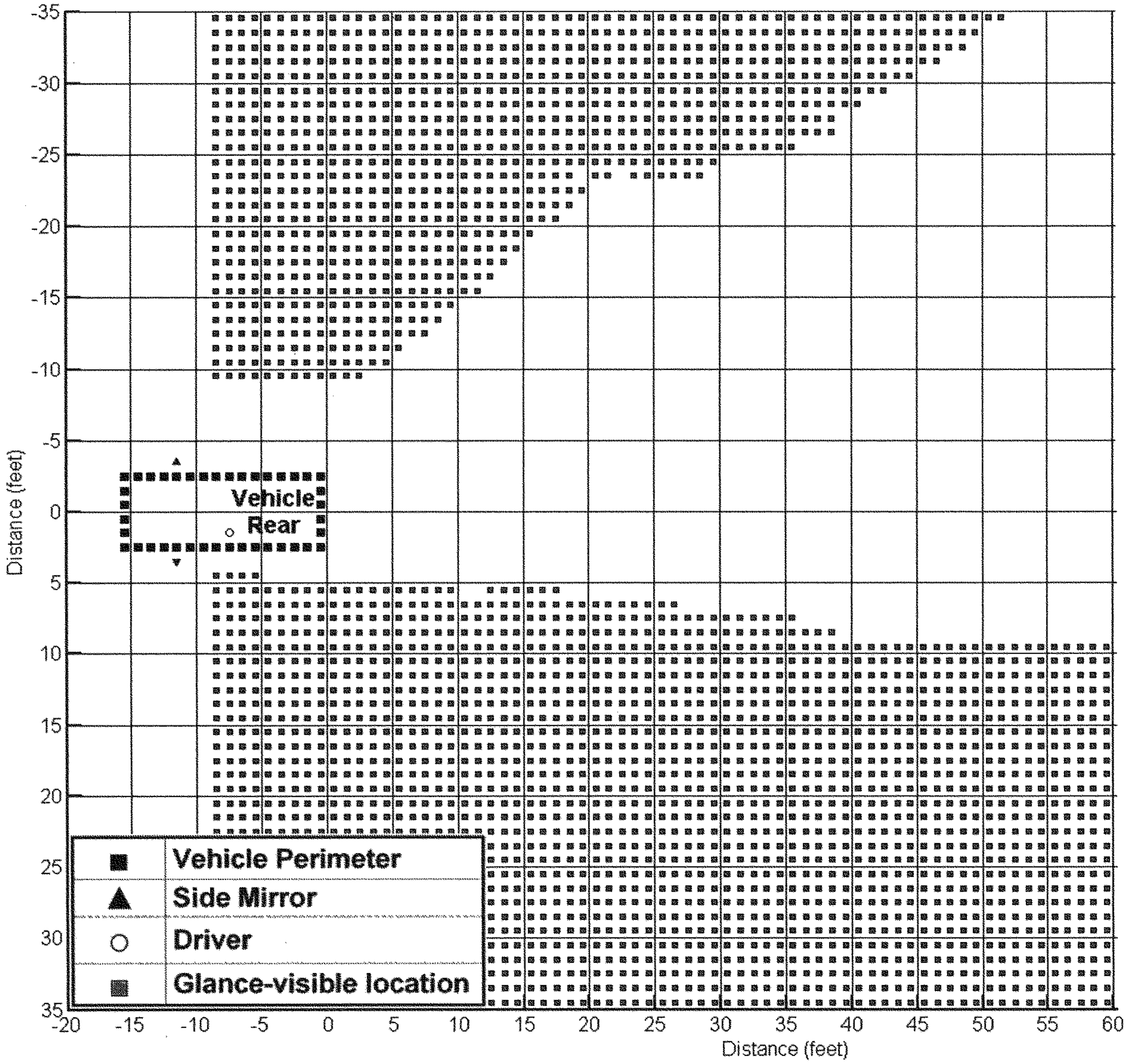

Figure 7. Direct Field of View Measured Using a 50th Percentile Male Driver: SUV (2007 Jeep Commander 4x4).

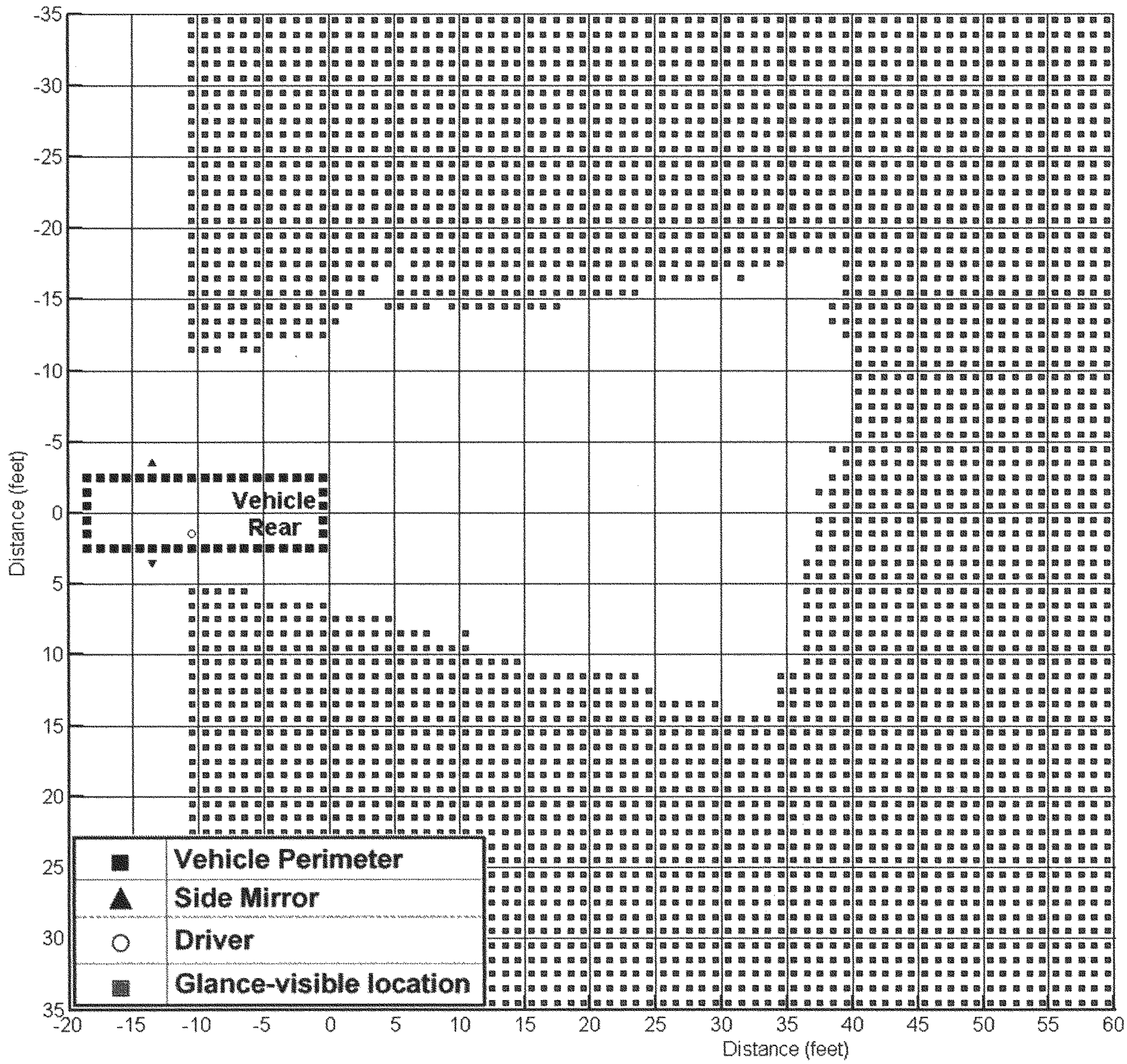

Figure 8. Direct Field of View Measured Using a 50th Percentile Male Driver: Pickup Truck (2006 Ford F-150, 4x4, 4-door Extended Cab).

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Through this study, NHTSA estimated that rear blind zone areas [64] for individual vehicles ranged from approximately 100 to 1,440 square feet over the 3,000 square-foot measurement area. When summarized by vehicle category and curb weight (as a surrogate indicator for vehicle size), as illustrated in Figure 9, the data shows that average direct-view rear blind zone areas varied within these groups. The greatest range of direct-view rear blind zone area size was seen for the 4,000–5,000 lb SUV group. Figure 10 illustrates that SUVs (as a whole) were associated with the largest average direct-view rear blind zone area as well as the largest range of values for the four body types examined. Overall, LTVs (vans, pickups, and SUVs) as a vehicle class were observed to have larger rear blind zone areas than passenger cars, as indicated in Figure 10.

[64] "Rear blind zone area" is defined here to mean the area in square feet within a 50-foot wide by 60-foot long area and at ground level over which a 29.4-inch-tall object is visible using direct vision.

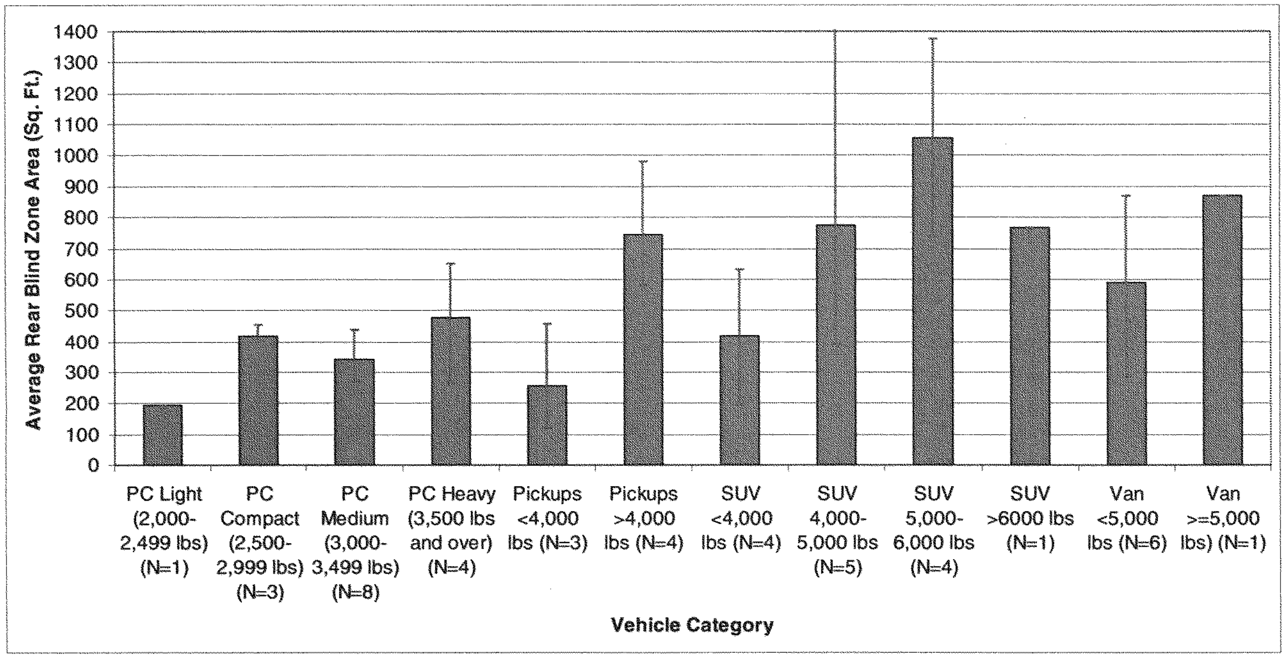

Figure 9. Direct-View Rear Blind Zone Area by Vehicle Category for a Measurement Field of 50 Feet Long by 60 Feet Wide.
Source: Light Vehicle Rear Visibility Assessment, DOT HS 810 909.
Note Error bars show the range of values for each vehicle

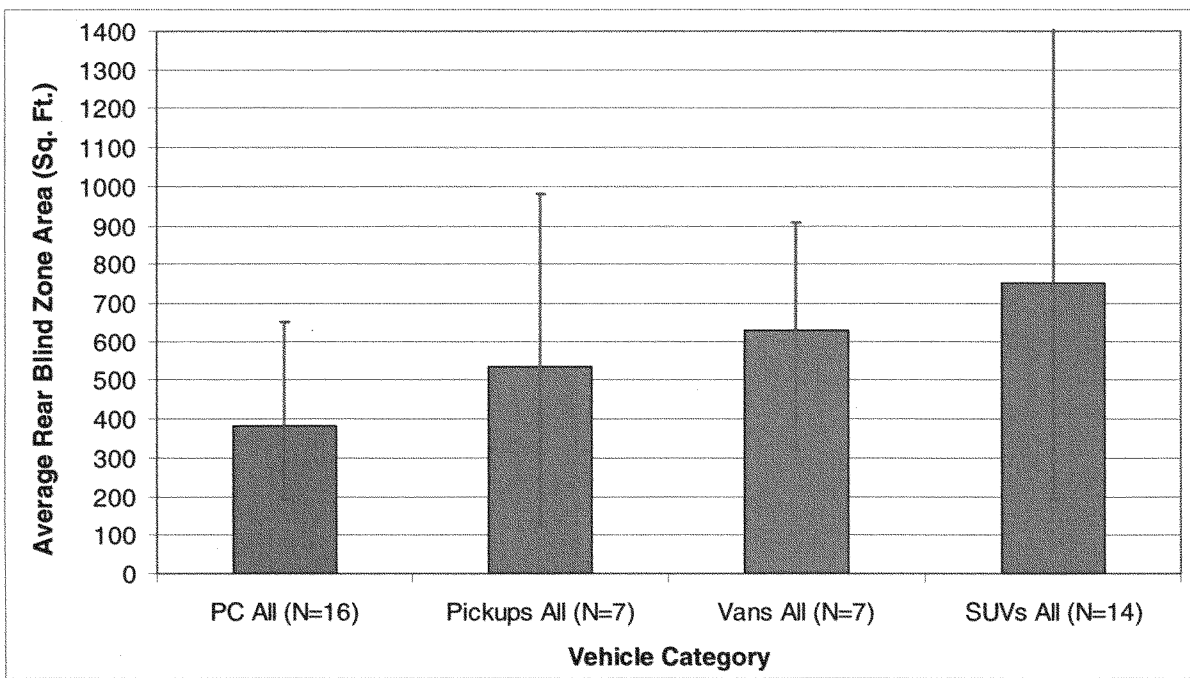

Figure 10. Direct-View Rear Blind Zone Area by Vehicle Category for a Measurement Field of 50 Feet Long by 60 Feet Wide.
Source: Light Vehicle Rear Visibility Assessment, DOT HS 810 909.
Note: Error bars show the range of values for each vehicle category.

For all 44 vehicles, NHTSA also measured the distance behind the vehicle at which the visual target could first be seen, i.e., the direct-view rear longitudinal sight distance. Average direct-view rear longitudinal sight distances were determined by mathematically averaging eight longitudinal sight distance measurements taken in 1-foot increments across the rear of each vehicle. As illustrated in Figure 11, LTVs generally had longer rear longitudinal sight distances than passenger cars. Exceptions to this trend included a few small pickup trucks for which average direct-view rear sight distance values were in the vicinity of those measured for smaller passenger cars, as shown in Figure 12. Average direct-view rear sight distance values were longest for a full-size van, SUVs and pickup trucks with a curb weight of 4,000 lbs or greater.

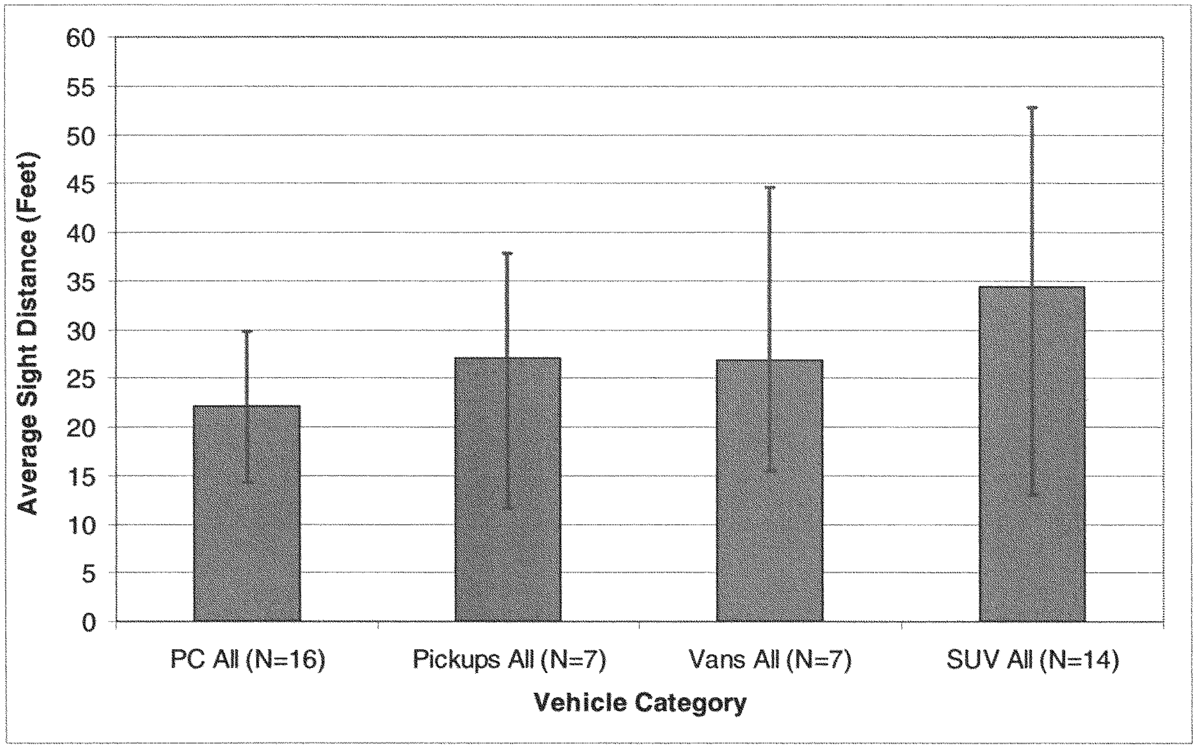

Figure 11. Direct-View Average Rear Longitudinal Sight Distance by Vehicle Category.
Source: Light Vehicle Rear Visibility Assessment, DOT HS 810 909
Note: Error bars show the range of values for each vehicle category.

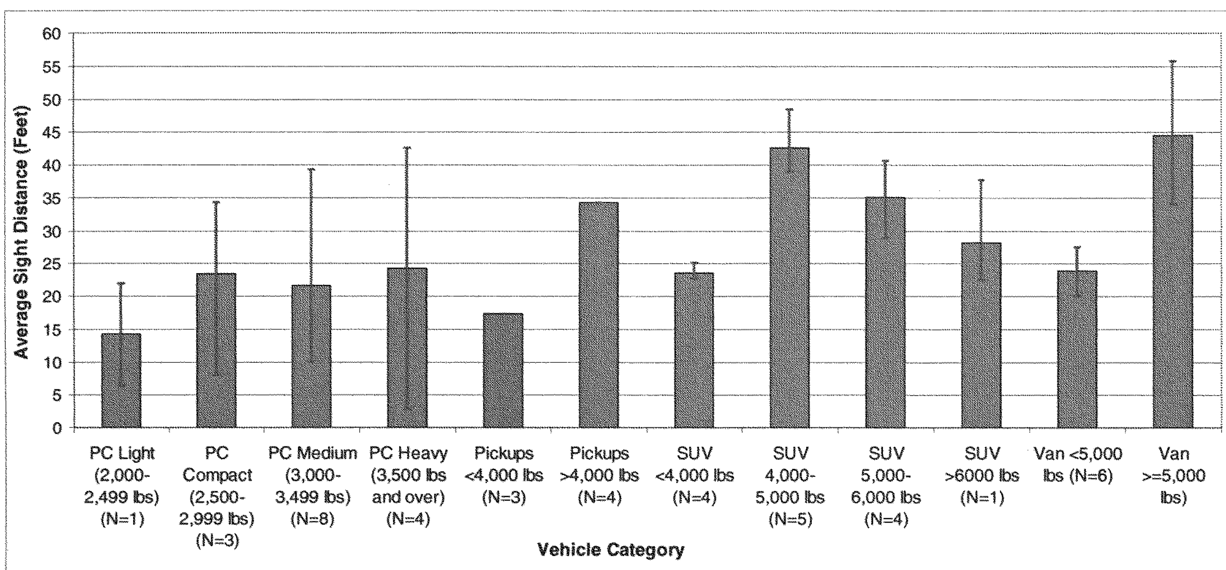

Figure 12. Direct-View Average Rear Longitudinal Sight Distance by Vehicle Category and Curb Weight.
Source: Light Vehicle Rear Visibility Assessment, DOT HS 810 909
Note: Error bars show the range of values for each vehicle category.

Overall, our direct-view rear visibility measurements indicated that LTVs measured in this study exhibited worse rear visibility when compared with passenger cars, but there was overlap amongst all vehicle categories.

VIII. Relationship Between Rear Visibility and Backing/Backover Crashes

Using the direct-view rear blind zone area and longitudinal sight distance measurements [65] discussed in the prior section, NHTSA investigated whether a statistical relationship could be identified between these metrics and all backing crashes, as well as backover crashes (i.e., the subset of backing crashes involving a pedestrian or bicyclist being struck by a backing vehicle).[66] NHTSA assessed the relationship between real world backing/backover crashes and rear visibility based on three metrics: average rear longitudinal sight distance, direct-view rear visibility measurements for a 50 feet long by 60 feet wide [67] test area, and direct-view rear visibility for a 50 feet long by 20 feet wide [68] test area.

Backing risk was estimated from police-reported crashes in the State Data System.[69] To calculate risk, backing rates were derived for 21 vehicle groups with vehicles that had at least 25 backing crashes to account for statistical variability. Backing rate data were provided by the following states for the specified calendar years:

- Alabama (2000–2003)
- Florida (2000–2005)
- Georgia (2000–2005)
- Illinois (2000–2005)
- Kansas (2001–2006)
- Kentucky (2000–2005)
- Maryland (2000–2005)
- Michigan (2004–2006)
- Missouri (2000–2005)
- Nebraska (2000–2004)
- New Mexico (2001–2006)
- New York (2000)
- North Carolina (2000–2005)
- Pennsylvania (2000–2001, 2003–2005)
- Utah (2000–2004)
- Washington (2002–2005)
- Wisconsin (2000–2005)
- Wyoming (2000–2005)

Simple correlation analysis [70] revealed an association between direct-view rear blind zone area and backing crash risk. Specifically, larger blind zone areas tended to be associated with a greater risk of being involved in a backing crash. A statistically significant relationship [71] between backing crash risk and direct-view rear blind zone area was discovered for both test areas, suggesting that this metric is a sensitive predictor of backing crash risk. However, in this analysis, the association between average rear longitudinal sight distance and backing risk was found to be weaker and not statistically significant due to the relatively small number of backover incidents, suggesting that this metric is not a sensitive predictor of backing crash risk.[72]

Logistic analysis [73] for the risk of a backover incident produced results that approached statistical significance for the rear blind zone area metrics, with a similar trend and magnitude as those for all backing crashes. Vehicles with the largest blind zone areas had 2–3 times the risk of a backover incident than those vehicles with the smallest blind zone areas.[74] Conversely, estimated results for the risk of backover using rear longitudinal sight distance were not statistically significant.

IX. Options for Mitigating Backover Incidents

Using rear blind zone area as a metric, NHTSA's research seems to indicate that there is a range of performance amongst vehicles and that LTVs on average had worse rear visibility than passenger cars. NHTSA also found a statistically significant correlation between rear blind zone area and backing crashes. Finally, our crash data appear to indicate that LTVs are overrepresented in backing and backover crashes. Based on these findings, NHTSA has identified potential approaches to improve rear visibility and to address the backing and backover crash risks for passenger vehicles.

A. Approaches for Improving Vehicles' Rear Visibility

One approach would be to eliminate all rear blind zones by requiring that all vehicles have a rear blind zone size of 0 sq. ft. (i.e., no rear blind zone). Such a requirement would be met by a visibility enhancement countermeasure that allowed the driver to see or otherwise determine that a pedestrian is in a specified zone behind the vehicle. This strategy would improve rear visibility for all vehicles.

Alternatively, NHTSA could specify that all LTVs as a vehicle class have no rear blind zone since our crash data indicated that this vehicle category seems to be overrepresented in backing and backover crashes. This alternative would target the class of vehicles which are disproportionately responsible for the largest portion of backover fatalities.

Another approach would be to establish a maximum rear blind zone area limit (based on crash rate) that all vehicles, or LTVs as a vehicle class, would have to meet.[75] The threshold would be applied to all vehicles, such that any vehicle not meeting the minimum rear visibility threshold would be required to be equipped with a rear visibility countermeasure. Because styling engineers would have a target threshold giving them an idea of minimum ''acceptable'' rear visibility, such an approach would allow manufacturers the flexibility to consider and improve those attributes of a vehicle that contribute to rear visibility since they would have the option of not having to provide a rear visibility enhancement countermeasure. Depending on how high or low the threshold was set, for example, the agency could focus countermeasure application on vehicles with the largest rear blind zone areas and those vehicles

[65] Mazzae, E.N., Garrott, W.R. (2008). Light Vehicle Rear Visibility Assessment. National Highway Traffic Safety Administration, DOT 810 909.

[66] Partyka, S., Direct-View Rear Visibility and Backing Risk for Light Passenger Vehicles (2008).

[67] This area was chosen because it was the largest available measurement area for the facility in which these measurements were conducted.

[68] The 50 feet long by 20 feet wide test area was examined to assess how much of the area behind the vehicle was critical to consider for rear visibility in relation to the prevention of backover incidents.

[69] The states provide annual files of their police-reported data under voluntary agreements with NHTSA. These are collected by the National Center for Statistics and Analysis, Office of Data Acquisition. The data are available for agency use. Public release of any of the files requires written approval from the individual state.

[70] A simple correlation measures the strength of the statistical relationship between two variables. For example, one can graph two variables (such as the real-world risk of being involved in a backing crash as a function of laboratory measures of rear visibility) as a scatter plot. A simple correlation analysis measures how closely the plot resembles a line. If the plot suggests a line, then we might conclude that the laboratory measures are useful in predicting real-world involvements. However, it is difficult to use this approach if one suspects that there are complicating (confounding) factors that affect the simple comparison between two variables.

[71] $r=0.51$, $p=0.02$.

[72] $r=0.26$.

[73] A logistic analysis allows us to account for complicating factors (such as systematic differences in how vehicles are used and by whom) by including them in a statistical model. This model predicts the risk of a crash being a backing crash as a function the laboratory measures of rear visibility after removing (controlling for) the effects of measurable complicating factors.

[74] Partyka, S., Direct-View Rear Visibility and Backing Risk for Light Passenger Vehicles (2008).

[75] Additional details on how a rear blind zone area based threshold might be developed are in Appendix D.

that are most involved in backing and backover crashes.

Using these approaches, NHTSA offers our preliminary information regarding the benefits and costs of various scenarios.

B. Cost Benefit Scenarios

For the relevant technologies, we have generated estimates using two different types of video cameras available in the market today and two different types of object detection sensors. For rearview video systems, some manufacturers are using cameras with a 130-degree field of view while others are using ones with a 180-degree field of view. These are noted as ''130° Camera'' and ''180° Camera,'' respectively. Note that these angular values are camera specifications and indicate the angle of view with respect to the center of the camera lens and not the center of the rear of the vehicle. Due to styling issues, cameras on some vehicle models may be mounted off-center and, as a result, their fields of view may not be symmetrical with respect to the center of the vehicle's rear bumper. The sensor technologies included in the estimates are ultrasonic and radar. It should be noted that given our lack of information regarding the effectiveness of mirrors, we could not generate a cost benefit scenario using this technology.

Using various scenarios, NHTSA has developed preliminary estimates of the costs and benefits for improving rear visibility assuming 16.6 million (8.5 million LTVs and 8.1 million passenger cars) total vehicles.[76] One scenario involves the application of a rear visibility countermeasure to all vehicles and a second assumes that a countermeasure is applied to all LTVs and no passenger vehicles. Given that a rear visibility threshold has not yet been established and that NHTSA has not measured all vehicle models sold in the U.S. to determine their rear blind zone areas, two additional, hypothetical scenarios were considered. One scenario assumes that a rear visibility countermeasure would be required for all LTVs and any passenger cars that do not comply with the rear visibility threshold (hypothetically assumed to encompass 25 percent of vehicles).[77] Another scenario assumes that a rear visibility countermeasure would be required for any light vehicle that does not comply with the rear visibility threshold (hypothetically assumed to encompass 75 percent of LTVs and 25 percent of passenger cars).[78] Table 9 presents the overall range of costs and benefits across these four scenarios.

TABLE 9—PRELIMINARY BENEFITS AND COSTS ESTIMATES—ACROSS FOUR COUNTERMEASURE APPLICATION SCENARIOS [79]

Countermeasure technology options	Net cost (does not consider vehicles already equipped with RV) (in $M)	Cost per life saved (in $M)	Total fatalities avoided	Total injuries avoided
RV with 130° Camera and Interior Mirror Display	$1,153–$2,577	$16.17–$57.27	26–69	1,279–5,189
RV with 130° Camera and In-Dash Display	981–2,294	15.69–56.41	26–69	1,279–5,189
RV with 180° Camera and Interior Mirror Display	1,325–3,005	13.76–50.99	31–82	1,689–6,141
RV with 180° Camera and In-Dash Display	1,234–2,811	14.61–52.76	31–82	1,689–6,141
Ultrasonic Rear Object Detection System	277–766	11.25–33.84	5–24	399–1,793
Radar Rear Object Detection System	571–1,397	21.02–49.84	6–26	479–1,976
Rear-mounted Convex Mirrors	(Research in progress)			

Additional details regarding these calculations can be found in the preliminary regulatory impact analysis document, ''Rear Visibility Technologies: FMVSS No. 111.'' NHTSA will continue to gather information on price and vehicle equipment trends for use in refining these estimates of costs and benefits for improving rear visibility.

C. Questions

NHTSA requests comments on benefits and costs for rear visibility enhancement countermeasures and the possibility of developing a rear blind zone area based minimum acceptable rear visibility threshold. Specific questions are as follows:

(1) NHTSA seeks comment on the areas behind a vehicle that may be most important to consider when improving rear visibility. Furthermore, while the distribution of visible area behind the vehicle was not considered in the blind zone area metrics (e.g., rear blind zone area) discussed in this document, it may be helpful to specify some specific areas behind the vehicle that must be visible.

(2) NHTSA invites comment as to how an actual threshold based on vehicles' rear blind zone area could be defined.

(3) For vehicles whose rear visibility does not meet a required minimum threshold and thus require a countermeasure, OEMs may decide to further alter the styling of the rear of the vehicle to the detriment of direct rear visibility (e.g., making the rear window a tiny, circular porthole). Based on the fact that NHTSA's research[80] showed that drivers of RV-equipped vehicles glanced at least one time at the RV display in only 65 percent of backing maneuvers, maintaining good direct rear visibility may be important for the other 35 percent of cases in which the RV system is not used. Therefore, NHTSA is considering specifying a minimum portion of a vehicle's rear visibility that must be provided via direct vision (i.e., without the use of mirrors or other indirect vision device). NHTSA seeks comments on this approach, such as input regarding how a minimum threshold should be specified, and how much of a vehicle's rear area should be visible via direct vision?

[76] This sales figure represents 2007 vehicle sales. For the subsequent NPRM, updated sales figures will be used.

[77] To illustrate this approach, this example scenario assumes that 25 percent of passenger cars will not comply with the rear visibility threshold.

[78] To illustrate this approach, this example scenario assumes that 75 percent of LTVs and 25 percent of passenger cars will not comply with the rear visibility threshold.

[79] Cost calculations presented in Table 9 assume a 3 percent discount rate. Values also consider ranges of effectiveness for the technologies listed. Additional details regarding these calculations can be found in the PRIA.

[80] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

(4) NHTSA requests information regarding anticipated costs for rear visibility enhancement countermeasures.

(5) Given the increasing popularity of LCD panel televisions and likely resulting price decline, what decline in price can be anticipated for LCD displays used with rearview video systems? Will similar price reduction trends be seen for video cameras for rearview video system application?

(6) NHTSA requests information on the estimated price of rear visibility enhancement countermeasures at higher sales volumes, as well as the basis for such estimates.

(7) NHTSA requests any available data on rearview video system maintenance frequency rates and replacement costs. How often are rearview video cameras damaged in the field?

(8) NHTSA requests comments on which types of possible rear visibility enhancement countermeasure technologies may be considered for use on which types of vehicles. This information is important for estimating the costs of countermeasure implementation in the fleet.

(9) NHTSA requests information regarding available studies or data indicating the effectiveness of dashboard display-based rearview video systems and rearview mirror based rearview video systems. What are the key areas that will impact the real-world effectiveness of these systems as they become more common in the fleet?

(10) NHTSA requests objective data on the use, effectiveness, and cost of rear-mounted convex mirrors.

X. Options for Measuring a Vehicle's Rear Visibility

If a maximum rear blind zone area limit threshold is used to establish the need for a vehicle to be equipped with a countermeasure, its rear visibility characteristics would need to be measured and that vehicle's direct-view rear visibility and rear blind zone areas would need to be calculated. As such, if the agency chooses to establish a threshold value for minimum performance, a test procedure would need to be developed. In this section, the agency identifies those test procedures it has identified that could be used for this purpose. The advantages and disadvantages of the different identified methods are also discussed.

A. Rear Visibility Measurement Procedures

Society of Automotive Engineers

The Society of Automotive Engineers (SAE) [81] has created a recommended practice for determining the areas around a vehicle that a driver can see through direct vision (i.e., without the use of mirrors or another indirect vision device). This procedure uses computer-based simulations to describe rear visibility for a particular vehicle. Using standard driver eye points and a three-dimensional computer model of the vehicle, the simulation allows the rotation of sight lines originating from the eye points to determine the areas that the driver should be able to see outside the vehicle.[82] This approach to determine a vehicle's visibility characteristics is theoretical and has not been assessed for reproducibility and repeatability against actual vehicles.

Paine, Macbeth & Henderson

In 2003, Paine, Macbeth & Henderson described a method to approximate a driver's sight line using an H-point machine and laser pointing device. Using the data, a ''visibility index'' was calculated to highlight the researchers' belief that vehicle design plays a major role in the rear visibility of vehicles.

This study, sponsored by the Insurance Australia Group, was designed to be easily repeatable and standardized to enable accurate comparisons between vehicles.[83] The laser device was mounted to the side of the H-point machine's head fixture in the approximate vicinity of where a driver's head would be located. A dimensioned grid was positioned behind the test vehicle and a test target consisting of a cylinder 600 mm (24 in.) tall and 200 mm (7.87 in.) in diameter was used. Additionally, the driver's seat was placed in its lowest and furthest back position and adjusted to ensure that the rear of the H-point device was placed at a 25 degree angle.

Data from this test procedure were used to calculate vehicle ratings by considering several factors including the total visible area behind the vehicle; the visible distance across the rear of the vehicle; and the presence of backing aids such as proximity sensors and rearview camera systems. Consequently, the authors identified several vehicle design aspects that affect rear visibility, including a high bootlid (referred to as the ''trunk lid'' in the US); rear-mounted spare tires; rear head restraints; center high-mounted brake lights; rear mounted wipers; and rear spoilers.

NHTSA believes the rear visibility assessment method outlined by these researchers has merit. However, further refinement may be desirable. For instance, a more accurate eye point for location of the laser beam would better simulate what a 50th percentile male would be able to see. The agency is undertaking research to examine the use of laser-based methods of measuring a vehicle's rear visibility characteristics.

Consumer Reports Linear Rear Blind Spot Measurement Method

Consumer Reports evaluates vehicles for rear visibility and publishes the findings as part of their new vehicle reviews. In their August 2006 report, they examined vehicles to determine the closest distance at which a 28-inch object (approximating the height of a child less than 1 year old) could be detected behind a vehicle.[84] During the evaluation, drivers [85] were seated in the vehicle and asked to detect an object while it was moved outward from the rear of the vehicle along its centerline. The distance from the rear bumper at which the driver could detect the object was measured, and then these sight distances were published as consumer information.

Consumer Reports' data describe a rear sight distance as measured at the centerline of the vehicle, which may not accurately describe rear visibility across the entire width of the rear of the vehicle and therefore not fully address the risk of a backing crash. In addition, the use of human drivers, particularly a single driver of a particular height, to estimate rear visibility for a vehicle is likely to produce results that are subject to variability stemming from individual differences. While this information may be helpful to consumers, for the purposes of establishing a Federal regulation on rear visibility, NHTSA would be required to follow an approach that has demonstrated objectivity and repeatability.

[81] SAE J1050, Describing and Measuring the Driver's Field of View; Revised 2003–01.

[82] Note: NHTSA has not evaluated the engineering drawings or three-dimensional computer models of manufactured vehicles, on which this method appears to rely.

[83] Paine, M., Macbeth, A., and Henderson, M. (2003). The Danger to Young Pedestrians from Reversing Motor Vehicles. 18th International Technical Conference on the Enhanced Safety of Vehicles. Paper Number 466.

[84] Consumer Reports (August, 2006). Blind-zone measurements. *http://www.consumerreports.org/cro/cars/safety-recalls/mind-that-blind-spot-1005/blindspot-measurements/index.htm*.

[85] The heights of the subject drivers were 68 inches (approximate height for a 50th percentile adult male) and 61 inches (approximate height for a 5th percentile small female).

NHTSA's Human-Based Rear Visibility Measurements

In 2007, NHTSA measured the rear visibility characteristics of 44 vehicles using human drivers to report the actual area around a vehicle where they could detect a 29.4-inch-tall test object.[86] During the test procedure, the visual target was moved behind the vehicle over a grid of 1-foot squares spanning 110 feet longitudinally (including 90 feet behind the vehicle's rear bumper) and 70 feet laterally (i.e., 35 feet to either side of the vehicle's centerline). Points on the grid where the entire 3-inch reflector (comprising the top portion of the test object) was visible were recorded and combined to produce a graphical rear field of view representation for the vehicle. Visible areas around the vehicle were assessed for a 50th percentile male and 5th percentile female driver. These driver sizes were chosen to acquire a range of visibility data in relation to driver height and because they have been used by other organizations [87] [88] in similar visibility tests.

NHTSA observed that physical characteristics among drivers can affect rear visibility. These characteristics include the occupant's torso breadth, physical flexibility (e.g., torso and neck rotational range), peripheral visual ability, visual acuity, and the presence of eye glasses.[89] Additional differences relating to driver positioning while backing (e.g., raising the body up from the seat pan to achieve a higher vantage point), driver preferences regarding seat adjustment, and mirror positioning may also affect rear visibility. For example, based on a review of test data, it appears that the particular 5th percentile female driver involved in this testing may have been less restricted in her body movement (i.e., leaned or ''craned'' body more) when attempting to view the visual target. This resulted in a situation that for some vehicles, the measured minimum sight distance and average sight distance values were better for the shorter driver than for the taller driver.

NHTSA's Laser-Based Rear Visibility Measurement Procedure

NHTSA's rear visibility research conducted in 2008 began with an effort to improve upon the previously used human-based rear visibility measurement procedure. Since any compliance test for the Federal motor vehicle safety standards is required by law to be repeatable and reproducible, enhancements were focused on improving this aspect of the measurement procedure. The agency considered known rear visibility measurement procedures, built upon the work by Paine *et al.,*[90] and developed an enhanced version of that procedure that replaced the human driver previously used in rear visibility measurements with a laser-based fixture. The enhanced procedure approximated the direct rear visibility of a vehicle for a 50th percentile male driver using a fixture that incorporated two laser pointing devices to simulate a driver's line of sight. One laser pointing device was positioned at the midpoint of a 50th percentile male's eyes when looking rearward over his left shoulder and the other device was placed at the midpoint of a 50th percentile male's eyes when looking rearward over his right shoulder during backing.

The use of a laser pointing device to simulate driver sight line was also used by Paine, *et al.*[91] However, they used only a single eye point that was approximately at the side of a 50th percentile male driver's head. In addition, ISO 7397–2,[92] which outlines a procedure for verifying the driver's 180-degree forward direct field of view for passenger cars, also uses a laser-based measurement technique. The use of two representative eye points and a wider measurement area have been proven to correlate well with backing crash risk [93] and therefore may result in a more valid measurement method.

More details of NHTSA's revised rear visibility measurement procedure using lasers are provided below.

1. Size of Rear Visibility Measurement Field

The size of the field over which rear visibility is measured should encompass those areas critical to the avoidance of backover crashes. To evaluate the dimensions of this field, NHTSA measured rear blind zone area data for a variety of vehicles and compared these results with backing crash data for those vehicles. In addition, a Monte Carlo simulation analysis of relative backing crash risk as a function of pedestrian location was performed. The results of these analyses are summarized below.

Data analysis was performed to assess the correlation between vehicles' rear blind zone areas measured using a 50th percentile male driver and the backing crash data for 21 vehicles.[94] Results of this analysis for a portion of the field sizes assessed are summarized in Table 10 (Appendix D contains a table summarizing the complete set of areas assessed). Evidence of good correlation in this analysis is given by high correlation coefficient values and a low probability of occurrence by chance. All measurement field dimension combinations listed in Table 10 show good correlation with backing crashes. A similar preliminary analysis recently conducted by NHTSA using laser-based rear blind zone areas measured for 60 vehicles over various measurement field sizes showed a 50 feet square field to be better correlated with backing crashes than narrower field size of the same longitudinal dimension.

[86] Mazzae, E.N., Light Vehicle Rear Visibility Assessment, DOT HS 810 909, September 2008. NHTSA's visual target for this test was a traffic cone with a reflector atop; its height is representative of a 1-year-old child.

[87] See also Consumer Reports (August, 2006). Blind-zone measurements. *http://www.consumerreports.org/cro/cars/safety-recalls/mind-that-blind-spot-1005/blindspot-measurements/index.htm.* Accessed 3/1/2006.

[88] See also Paine, M., Macbeth, A., and Henderson, M. (2003). The Danger to Young Pedestrians from Reversing Motor Vehicles. 18th International Technical Conference on the Enhanced Safety of Vehicles. Paper Number 466.

[89] Note that when a driver wearing eye glasses turns to look over their right shoulder to see behind their vehicle, there is a point at which the line of sight can pass beyond the perimeter of the lens, at which point the driver loses the aid of the corrective lens.

[90] Paine, M., Macbeth, A., and Henderson, M. (2003). The Danger to Young Pedestrians from Reversing Motor Vehicles. 18th International Technical Conference on the Enhanced Safety of Vehicles. Paper Number 466.

[91] Id.

[92] ISO 7397–2, Passenger cars—Verification of driver's direct field of view—Part 2: Test method, first edition, 1993–07–01.

[93] Partyka, S., Direct-View Rear Visibility and Backing Risk for Light Passenger Vehicles, (2008).

[94] Mazzae, E.N., Light Vehicle Rear Visibility Assessment, DOT HS 810 909, September 2008. NHTSA's visual target for this test was a traffic cone with a reflector atop; its height is representative of a 1-year-old child.

TABLE 10—CORRELATION BETWEEN HUMAN-BASED REAR BLIND ZONE AREA MEASURED OVER VARIOUS FIELD SIZES AND BACKING CRASHES (SORTED BY CORRELATION COEFFICIENT)

Measurement field dimensions (width by length)	Correlation coefficient	Probability occurred by chance
50W x 10L	0.60117	0.0039
40W x 10L	0.60117	0.0039
30W x 10L	0.58233	0.0056
30W x 50L	0.55212	0.0095
40W x 40L	0.54681	0.0103
30W x 40L	0.53635	0.0122
20W x 40L	0.52621	0.0143
50W x 50L*	0.52375	0.0148
20W x 50L	0.52367	0.0148

* Blind zone area measured over a field this size was found by preliminary analysis of laser-based measurement data to be well correlated with backing crashes.

Considering the assessment of backover crash risk by pedestrian location described in Section IV.E of this notice, the results presented in Figure 1 suggest that a measurement field centered behind the vehicle and approximately 12 feet wide by 36 feet long would address pedestrian locations having relative crash risks of 0.15 and higher. Given that the analysis described in Appendix A suggests that backover crash risk extends a fair distance (38 ft or more) out from the vehicle, it may result in a more valid characterization of rear visibility if a range similar to this were used for a rear visibility measurement field.

For NHTSA's 2008 rear visibility measurement effort, a measurement field of 50 feet long by 50 feet wide test area was used to ensure that sufficient data were available for use in subsequent correlation analyses relating measurement field and backing crashes. However, based on a combination of the results of the three analyses summarized above, a field size centered behind the vehicle and having the dimensions of 40 feet square or 50 feet is used on the analyses discussed in this section.

2. Coarseness of the Rear Visibility Measurement Field's Test Grid

A measurement field covered by a test grid consisting of 1-foot squares was used. This level of grid detail has provided meaningful rear visibility data in past NHTSA testing, and has been used to produce rear blind zone area data that have been successfully correlated with backing crash risk.

3. Use of an H-Point Machine for Rear Visibility Measurement

To facilitate a repeatable test procedure, an H-Point machine,[95] used by the agency for many other standards and representing a 50th percentile adult male was used in place of a human driver for this measurement effort. The 50th percentile adult male approximates the midpoint for driver height, and has been used by other organizations [96, 97] conducting similar visibility measurement research. An H-Point machine was selected to provide a standardized representation of the seated posture of an adult male driver. The H-point machine's standard configuration was modified to incorporate a fixture mounted in place of the device's neck to hold the laser pointing devices in specific positions to correspond to selected eye points for a 50th percentile adult male driver (as described below).

4. Rear Visibility Measurement Test Object Height

NHTSA's rear visibility tests to date have been based on a test object height representing the approximate height of a 1-year-old child. As indicated earlier in this notice, 1-year-old children are the most frequent (approximately 26 percent of all backovers) victims of fatal backover incidents. The height chosen to represent a 1-year-old child in NHTSA's tests to date was determined by averaging standing height values from the Center for Disease Control's (CDC) growth chart [98] (see Table 11 below) for a male and female 1-year-old child. The average height value obtained was 29.4 inches.

TABLE 11—50TH PERCENTILE CHILD HEIGHT

Age	1	2	3	4	5	6	7	8	9	10
Height—Girl	29.125	33.5	37.2	39.5	42.5	45.25	47.75	50.25	52.2	54.5
Height—Boy	29.6	34	37.5	40.25	43	45.5	48	50.5	52.5	54.5

Source: CDC, 2000.

5. Laser Detector (in Lieu of a Visual Target)

To improve the efficiency of our test procedure, NHTSA's rear visibility measurement effort in 2008 used a different test object than used in prior measurements. This new test object incorporates a laser beam detector that automatically produces an audible signal when the laser beam, simulating the driver's line of sight, intersects with the laser detector. Since laser beams can

[95] SAE J826, Devices for Use in Defining and Measuring Vehicle Seating Accommodation, Rev. JUL95.

[96] See also Consumer Reports (August, 2006). Blind-zone measurements. *http://www.consumerreports.org/cro/cars/safety-recalls/mind-that-blind-spot-1005/blindspot-measurements/index.htm.* Accessed 3/1/2006.

[97] See also Paine, M., Macbeth, A., and Henderson, M. (2003). The Danger to Young Pedestrians from Reversing Motor Vehicles. 18th International Technical Conference on the Enhanced Safety of Vehicles. Paper Number 466.

[98] CDC, Clinical Growth Charts. Birth to 36 months: Boys; Length-for-age and Weight-for-age percentiles. Published May 30, 2000 (modified 4/20/2001) CDC, Clinical Growth Charts. Birth to 36 months: Girls; Length-for-age and Weight-for-age percentiles. Published May 30, 2000 (modified 4/20/2001).

be difficult to detect with the human eye, even in low light conditions, use of a laser beam detector would improve both the accuracy and speed of test conduct.

The laser detector target was constructed with a commercial laser detector mounted vertically on a post. The base of the post was a 12-inch square of wood used to stabilize the fixture and center it within a 1-foot grid square. The target's detection field was horizontally centered with respect to the post and base. The bottom of the laser detector's approximately 2-inch tall detection field was aligned at a vertical height of 28 inches, to simulate a 30-inch overall detection height.

For this approach to be usable and accommodate the 50 feet long test grid and all possible lengths of vehicles to be measured, the particular laser pointing device and laser beam detector were required to have performance ranges of at least 70 feet.

An alternative approach, without a laser detector device, would be to rely on a test operator to visually confirm that the laser beam contacted the test object within the detection area while the test object was positioned within a particular location on the test grid.

6. Eye Midpoint Locations for Use in Positioning Laser Pointing Devices

NHTSA researchers experimentally determined the most appropriate locations for the lasers used to represent the line of sight for a driver glancing over the right and left shoulder. Human eye locations for three male drivers of 50th percentile height were determined using photometric measurements while these drivers glanced at a cone positioned 25 feet behind a vehicle and approximately at its centerline and while looking directly (i.e., 90 degrees from forward) out the left and right sides of the vehicle. Photographs were taken from the rear and right (passenger) side of the vehicle for each of the three drivers and three vehicles. Driver eye positions for each vehicle were determined for both rear-looking glancing postures (rearward over the left and right shoulders) and both side-looking glancing postures (left and right). These eye positions were determined with respect to the vehicles' seats using a scale of rigid rulers. Researchers calculated an average left and right eye point locations to determine a midpoint between the left and right eye for each of the four postures. These midpoint values, which were used to identify locations of the laser pointing device to simulate a driver's line of sight, are provided in Table 12 below. NHTSA welcomes comments on the validity and appropriateness of these eye points for use in evaluating a vehicle's rear visibility for a 50th percentile male driver.

TABLE 12—LEFT-RIGHT EYE MIDPOINT LOCATIONS FOR POSTURE OF DRIVER GLANCING REARWARD AND TO EITHER SIDE

Glancing rearward over the:	Longitudinal (distance forward of the head restraint's vertical face) (in.) (x)	Lateral offset from the vertical centerline of the seat (in.) (y)	Vertical with respect to H-Point (in.) (z)
Left shoulder	3.5	5.5	26.5 *
Right shoulder	5.3	7.0	26.5 *
Left window (−90 degrees from forward)	7.6	−5.5	26.5 *
Right window (90 degrees from forward)	7.6	5.0	26.5 *

* Note: These measurements assume that the distance from the seat pan to the H-Point is 3.6 inches.

7. Vehicle Setup

Vehicle setup conditions may be an important part of a repeatable visibility measurement procedure. Considerations which we used for our recent, laser-based measurements are detailed below.

Fuel Tank—Ensure that the vehicle's fuel tank is filled to capacity, to provide a consistent fuel level (can affect vehicle pitch).

Vehicle Tires—The vehicle's tires should be set to their recommended inflation pressures (can affect vehicle pitch).

Vehicle Position on Test Grid—Position the vehicle on a flat, level test grid such that it is properly aligned (i.e., rear bumper flush with the '0' foot line, vehicle centered on the '0' longitudinal axis of the test grid).

Vehicle Windows—The vehicle's windows should be closed, clean, and clear of obstructions (e.g., window stickers).

H-Point Device Configuration—Place the H-Point device in the driver's seat and adjust the seat as follows:

- Install the H-Point machine in the vehicle per the installation procedure outlined in SAE J826.[99]
- Adjust the driver's seat to the longitudinal adjustment position recommended by the manufacturer for a 50th percentile adult male as specified in FMVSS Nos. 208,[100] 212,[101] 219 (partial),[102] and 301 [103] compliance testing. If this recommended adjustment setting is not available, position the seat at the midpoint of the longitudinal adjustment range. If no midpoint is selectable, then position the seat at the first notch rearward of the midpoint.
- Adjust the driver's seat to the vertical adjustment position recommended by the manufacturer for a 50th percentile adult male as specified in FMVSS Nos. 208, 212, 219 (partial), and 301 compliance testing. If this recommended adjustment setting is not available, position the seat at the lowest point of all vertical adjustment ranges present.
- Use the H-Point machine to adjust the driver's seat back angle at the vertical portion of the H-Point machine's torso weight hanger to that recommended by the manufacturer for a 50th percentile adult male as specified in FMVSS 208, 212, 219 (partial), and 301 compliance testing. If this recommended adjustment setting is not available, adjust the seat back angle to 25 degrees, as specified in SAE J826.
- Adjust the driver's seat head restraint such that the distance from the H-Point to the topmost point of the head restraint, as measured along a line parallel to the seat back, is 32.5 inches.[104] If a distance of 32.5 inches is not attainable given the adjustment range of the head restraint or detent

[99] SAE J826, Devices for Use in Defining and Measuring Vehicle Seating Accommodation, Rev. JUL95.

[100] 49 CFR 571.208, Standard No. 208; Occupant crash protection.

[101] 49 CFR 571.212, Standard No. 212; Windshield mounting.

[102] 49 CFR 571.219, Standard No. 219; Windshield zone intrusion.

[103] 49 CFR 571.301, Standard No. 301; Fuel system integrity.

[104] This 32.5 inch measurement is based on sitting height of 36.3 inches for 50th percentile adult males aged 20 and over. See CDC Web site at: *http://www.cdc.gov/nchs/about/major/nhanes/anthropometric_measures.htm*.

positions, the closest detent position to that height should be used.

• For any head restraints with longitudinal adjustment, the restraint should be positioned fully forward.

Vehicle Seat Positioning—Adjust all seats in positions other than the driver's as follows:

• Vehicles with standard stowable second or third row seats should have all seats in an upright, occupant-ready position. This configuration provides a consistent approach for rear seat positioning to avoid vehicle-to-vehicle test differences. If a vehicle is offered with an optional original equipment third row seat, the vehicle should be measured in this seating configuration to assess the vehicle's rear visibility characteristics in this worst-case condition.

• For seats with longitudinally adjustable head restraints, the restraint should be positioned at the midpoint of longitudinal adjustment

• For seats with vertically adjustable head restraints, the restraint should be positioned in the lowest possible position. This configuration provides a consistent approach for head restraint positioning to avoid vehicle-to-vehicle test differences.

• For seats with an adjustable seat back angle, adjust the seat back angle to that recommended by the manufacturer for a driver's seat back angle position for a 50th percentile adult male as specified in FMVSS 208, 212, 219 (partial), and 301 compliance testing. If this recommended driver's seat back angle setting is not available, adjust the seat back angle to 25 degrees.

• Any rear seating position shoulder belts originating from the headliner (e.g., for use in rear center seating positions) should be latched into their receivers at the seat bite.

8. Measurement Procedure

Once the vehicle has been properly set and the laser fixture has been set up, the laser devices are turned on and a pre-test is performed. To ensure that the laser device and laser detector are capable of performing the test, the laser device shall be properly mounted at the required driver eye point position (as indicated in Table 12), and aimed at the laser detector test object which shall be centered at a distance of 50 feet aft of the vehicle's bumper to determine whether the laser detector is able to sense the laser beam. This confirmation pre-test shall also be performed for the laser detector test object positioned at a distance of 50 feet from the rear bumper and 25 feet laterally to either side of the vehicle. If the laser detector detects the laser beam (e.g., as indicated by a ''beep'' or other confirming signal) in each of these three locations, then the equipment is considered to perform at an acceptable level for use in this test procedure.

To complete the rear visibility measurements, the laser devices while maintaining the x, y, z coordinates may be manually or automatically maneuvered to pan the area behind the vehicle in both the vertical and horizontal directions. The vertical extent of the laser beam movement shall extend from the lower edge of the rear window to the horizon. The horizontal range of laser motion shall permit the evaluation of the direct visibility of the test object as positioned within 1 foot of the rear bumper and 25 feet to both sides of the vehicle's centerline.

The test object is placed on the grid one time in each 1-foot square behind the vehicle. The test observer listens to determine whether the laser detector beeps (or otherwise signals) to indicate that the detector field has been contacted by a laser beam. The test object is considered visible if the laser detector beeps when a laser beam intersects with the test object. An operator records this measurement and repeats the prior steps for all positions in the grid.

Observations About Available Rear Visibility Measurement Procedures

The above descriptions summarize NHTSA's knowledge of existing procedures for measuring vehicles' rear visibility. NHTSA seeks comments on the utility of these methods as objective rear visibility assessment methods.

While the noted laser-based measurement method appears to provide a robust, objective test method, the repeatability of the method must be confirmed. Therefore, to further assess the utility of our laser-based rear visibility measurement procedure, we also assessed the repeatability of the test method as described in the following section.

B. Rear Visibility Measurement Method Variability

To assess the variability of NHTSA's improved rear visibility test method using laser pointing devices, four test vehicles were measured using the laser-based rear visibility measurement protocol. The measurement procedure was completed four times for each vehicle, including repositioning of the vehicle on the test grid. Results of these measurements are illustrated in Figure 13. As indicated in Table 13, the rear blind zone area data varied less than 3.2 percent of the measured value. This variability is believed to be due to the test vehicle's alignment of the rear bumper with respect to the lateral grid axis. More carefully aligning the vehicle on the test grid to ensure that the vehicle's centerline is aligned with the test grid's longitudinal axis will likely reduce variation to 2 percent or less.

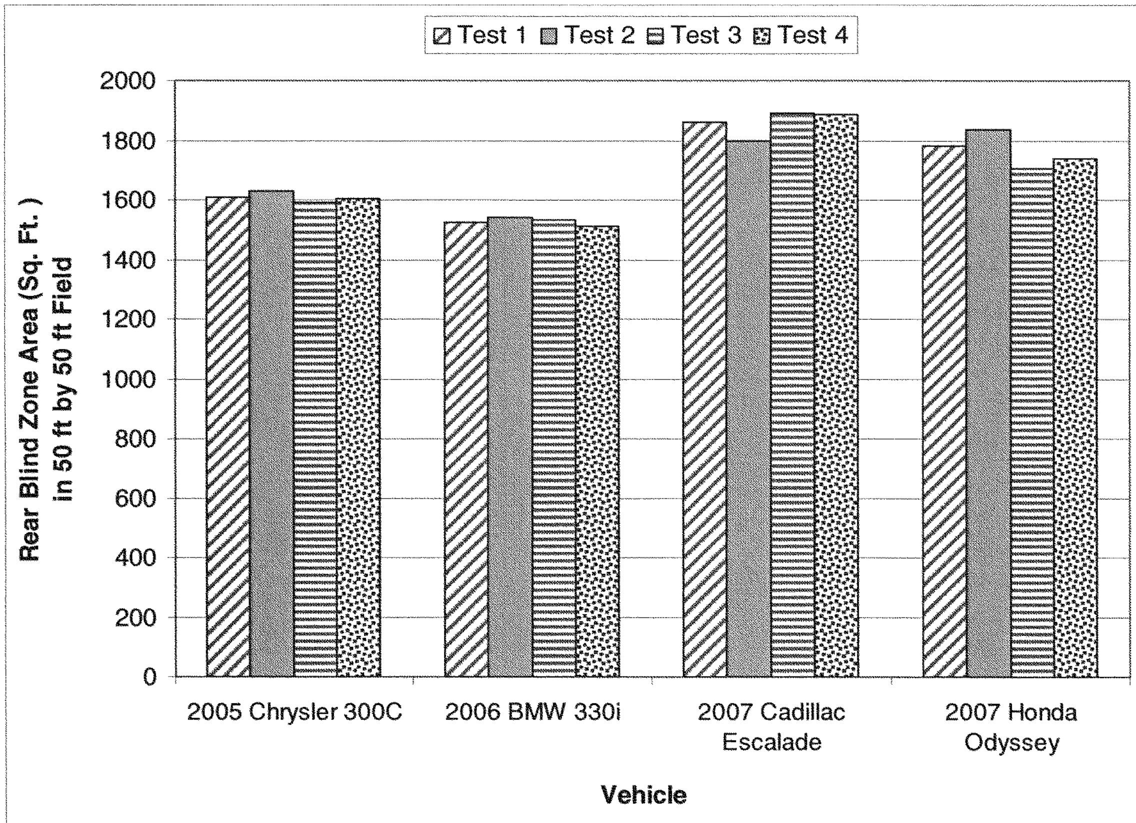

Figure 13. Rear Blind Zone Area Measurement Repeatability Results

TABLE 13—REAR BLIND ZONE AREA MEASUREMENT REPEATABILITY RESULTS AND ANALYSIS

Vehicle	Test 1	Test 2	Test 3	Test 4	Avg	Std. dev.	Min	Max	Range (max-min)	Std dev/ avg (percent)
2005 Chrysler 300C	1608	1631	1590	1604	1608	17.0	1590	1631	41	1.1
2006 BMW 330i	1523	1542	1533	1513	1528	12.5	1513	1542	29	0.8
2007 Cadillac Escalade	1863	1800	1889	1887	1860	41.5	1800	1889	89	2.2
2007 Honda Odyssey	1783	1834	1705	1739	1765	55.9	1705	1834	129	3.2

In summary, this rear visibility measurement procedure seems to provide for a controlled vehicle setup (for test consistency and repeatability) by its use of an automated test object, and dynamic laser movement.

C. Comparison of Human-Based Versus Laser-Based Rear Visibility Measurement Protocols

NHTSA compared rear visibility data for 18 vehicles that were measured using both the human-based and laser-based rear visibility measurement procedures to assess the results (i.e., similar vehicle rankings, etc.) of the test procedure under consideration. This comparison found data from the two measurement methods to be different but correlated to a statistically significant degree.

D. Input From Industry Regarding Rear Visibility Measurement

NHTSA received input from the Alliance for Automotive Manufacturers regarding the method for assessment for the purposes of assessing the need for a rear visibility enhancement countermeasure. The Alliance suggested a protocol similar to that used in FMVSS No. 111 for the measurement of the field of view of the interior rear mirror.[105] This protocol would use a 95th percentile male driver. No additional details regarding a rear visibility measurement procedure were provided by the Alliance or any other group.

[105] Presentation to NHTSA, January 28, 2009 meeting; Alliance for Automotive Manufacturers. Available at Docket Number 2009–0041.

E. Questions

(1) While a 50th percentile male body size was used for the rear visibility measurements outlined here, we note that FMVSS No. 111 currently requires that the driver's eye reference point be at a nominal location appropriate for any 95th percentile male driver for the assessment of rearview mirror field of view compliance. We further note that under FMVSS No. 111 the driver's eye location for school bus mirror compliance testing is the eye location of a 25th percentile female driver. NHTSA requests comment on the use of the 50th percentile male driver size as a midpoint in terms of driver height and whether using multiple driver heights for these tests would cause undue hardship relative to the safety value of assessing different driver heights. Specific information regarding

additional cost, if any, that would be incurred by vehicle manufacturers due to the use of different driver sizes for these different portions of FMVSS No. 111 is requested.

(2) NHTSA has been using seating position settings recommended by the vehicle manufacturers for agency crash tests. For most vehicles, the vertical seat position setting recommended for seats with vertical adjustability is the lowest position. NHTSA seeks comment on whether this setting is the most suitable position for a 50th percentile male, or if a midpoint setting would be more appropriate for measuring rear visibility. NHTSA also seeks comment on whether the specific crash test seating specifications used are the most appropriate for this context.

(3) NHTSA seeks comment on the placements of head restraints. For example, would our test procedure result in the elimination of rear head restraints or a reduction in their size? If so, please identify the affected vehicles and explain why the rear head restraints particularly impair visibility in those vehicles. Similarly, NHTSA seeks comment on the approach to setting the longitudinal position of all adjustable head restraints for rear visibility measurements. While longitudinally adjustable head restraints positioned fully forward may minimize the chance of whiplash, a more reasonable option for this test may be to position the head restraint at the midpoint of the longitudinal adjustment range.

(4) In our testing, we found that the laser beam is difficult to detect visually. Therefore, we used the laser detector. NHTSA invites comment on the availability of other options for detecting the laser beam as used in this test that does not involve the use of an electronic laser detector.

(5) For locating the laser devices at the selected driver eye points, is there another device besides the H-point device which can be utilized for this purpose or should the agency? For simplicity, should eye points be indicated in a similar fashion as is currently in FMVSS No. 111 for school bus testing in which a single eye point is located at a specified distance from the seat cushion/seat back intersection and within a 6-inch semi-circular area?

XI. Options for Assessing the Performance of Rear Visibility Countermeasures

To assess the minimum performance of a required rear visibility enhancement countermeasure, a compliance test would need to be developed. This test would serve to assess whether the system permits obstacles and standing children in the path of a backing vehicle to be detected over a minimum required area. Considerations that the agency has identified which may be necessary for this new compliance test are described below.

A. Countermeasure Performance Test Object

A test object may be needed to assess whether the countermeasure functions over a specified area. Based on the crash data and our testing to date, we have used a test object with an approximate height of 30 inches (0.762 meters). As indicated earlier, this height corresponds to the average height of a 1-year-old child. To further simulate the appearance of a 1-year-old child, some have suggested other dimensional characteristics. Based on our research we have found that that the object would need to be cylindrical in shape with a diameter of 5 inches, to represent the breadth of the average 1-year-old child's head.[106]

Depending on the type of countermeasure, the composition of the test object may be important. For example, rearview video systems would display images of objects of all possible material types, but ultrasonic and radar sensors are better at detecting some materials than others. NHTSA is aware of the requirement detailed in ISO 17386[107] for use of a cylinder composed of polyvinyl chloride (PVC) pipe to test the detection performance of ultrasonic parking aids. NHTSA welcomes input regarding all aspects of the test object.

The Alliance for Automotive Manufacturers has indicated to NHTSA that their suggestion is to use a cylindrical test object with a height of 1 meter (39.37 inches) and a diameter of 0.3 meters (11.3 inches).[108] No requirements for material composition of the test object were suggested by the Alliance.

B. Countermeasure Performance Test Area

One possible compliance test area can be identified using the results of the Monte Carlo simulation (illustrated in Figure 1 and described in Appendix A) that examined backover crash risk as a function of a pedestrian's location behind a vehicle.[109] NHTSA used these results to define an area behind a vehicle that must be visible to the driver. Based on these results, an area over which the test object should be visible could be defined to include an area 8 feet wide at the vehicle's rear bumper that widens symmetrically along diagonal lines of 45 degrees with respect to the vertical plane of the vehicle's rear bumper and extending outward from the vehicle's rear corners. The maximum longitudinal range of this required visible area is 40 feet, as shown in Figure 14.

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[106] Henry Dreyfuss Associates (2002). The Measure of Man and Woman; Human Factors in Design (rev.). New York: John Wiley & Sons.

[107] ISO 17386:2004 Transport information and control systems—Manoeuvring Aids for Low Speed Operation (MALSO)—Performance requirements and test procedures.

[108] Presentation to NHTSA, January 28, 2009 meeting; Alliance for Automotive Manufacturers. Available at Docket Number 2009–0041.

[109] See Appendix B, Method for Assessment of Backover Crash Risk by Pedestrian Location.

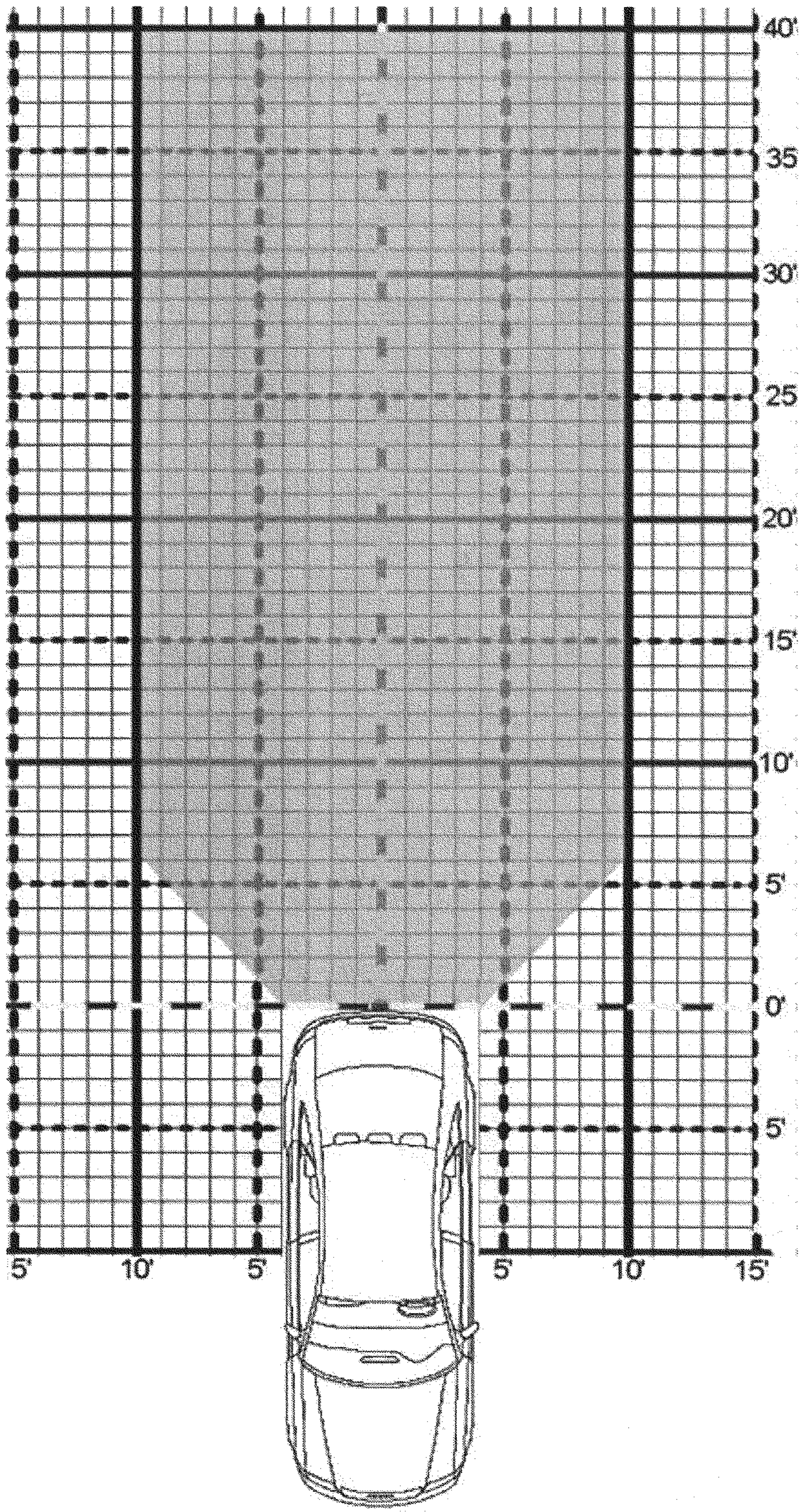

Figure 14. Countermeasure Performance Test Area Illustration

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Alternatively, the test area could be defined based on the results of the above mentioned Monte Carlo analysis, as well as the assessments of the correlation between vehicles' rear blind zone areas and backing crash data. The test area suggested by the combination of results of these three analyses is one that is centered behind the vehicle and having the dimensions of 40 feet square or 50 feet square.

The Alliance for Automotive Manufacturers has indicated to NHTSA that their suggestion is to use a test area composed of 9 test object locations behind the vehicle.[110] The 9 test object locations would consist of 3 rows of 3 locations. The 3 rows would be positioned with one at the rear bumper, and two others positioned 1.5 meters and 3.0 meters aft of the rear bumper. The 3 lateral locations would consist of one at each lateral edge of the vehicle and the third at the vehicle's longitudinal centerline. By this scheme, the test area size would be based on each vehicle model's individual width, and therefore may be different for all vehicle models.

C. Countermeasure Performance Test Procedure

The test procedure currently used for school bus mirrors (section 13, ''School bus mirror test procedures'' of FMVSS No. 111, ''Rearview mirrors'')[111] could be modified and used to determine countermeasure performance. For example, a still photography camera placed with the imaging sensor located at a midpoint eye location for a 50th percentile male (rather than a 95th percentile male), could be used to photograph the test objects as they are displayed in the countermeasure system's visual display. As is done now with cones in rear visibility measurements, for all specified locations of the test object on the test grid, at least a 3-inch tall by 3-inch wide portion of the test object would be required to be visible in order for the rear visibility enhancement system to be deemed compliant. This minimum detection area would represent the area that would need to be visible to adequately identify the test object.

D. Questions

(1) NHTSA invites comments on the need for and adequacy of the described area which rear visibility countermeasure systems may be required to detect obstacles. NHTSA is particularly interested in any available data that may suggest an alternative area behind the vehicle over which a rear visibility enhancement countermeasure should be effective? Is the described area of coverage unrealistically large? Is it adequate to mimic real world angles at which children may approach vehicles?

(2) Is it reasonable to define the limits of the test zone such that it begins immediately behind the rear bumper for the test object defined here or should a gap be permitted before the visibility zone begins? What additional factors should the agency consider in defining the zone?

(3) NHTSA requests comments on potentially requiring only the perimeter of the specified area to be tested for rear visibility enhancement systems. For video-based rear visibility countermeasure systems, NHTSA assumes that confirming the visibility of the test object over the perimeter of the required area is sufficient, since a system able to display the object at the perimeter of the required area should also be able to display the object at all points in between the extremities. Is this a reasonable assumption?

(4) Would vehicles with rearview video cameras mounted away from the vehicle centerline have the ability to detect the test object over the area under consideration? Is there flexibility to relocate such off-center cameras to meet the requirements under consideration, if necessary?

(5) NHTSA seeks comment as to the availability of any mirrors that may have a field of view that encompasses a range of 50 feet, as well as the quality of image that might be provided over such a range. How different is the image size and resolution, and how significant are the differences to the mirrors' potential effectiveness?

(6) If a gap is permitted behind the vehicle before the visibility zone begins, how will systems prevent children who may be immediately behind a vehicle from being backed over?

(7) NHTSA seeks input on what level of ambient lighting would be appropriate to specify for conduct of this compliance test. What other environmental and ambient conditions, if any, should the agency include in the test procedure?

(8) NHTSA invites input regarding the composition of the countermeasure compliance test object and the types of technologies that are likely to be able to provide coverage of the related test area.

XII. Options for Characterizing Rear Visibility Countermeasures

Existing rear visibility technologies, which formed the basis for NHTSA's effectiveness estimates, already contain certain performance levels specified by vehicle manufacturers. Some of these specifications may be necessary to ensure that our effectiveness estimates will be applicable to real-world crashes and to prevent for inferior systems from entering the fleet. However, NHTSA is not aware of consensus industry specifications (*e.g.*, SAE standards) or published recommended practices for rear visibility enhancement systems other than mirrors that may serve this purpose. While FMVSS No. 111 contains performance specifications for convex mirrors, the mirror specifications contained therein may not be adequate for this application. As such, certain performance specifications may be necessary in order to ensure adequate system effectiveness. NHTSA solicits comment on whether the performance aspects we have identified are appropriate or whether additional specifications, particularly for electronic image-based visual displays, should be considered. NHTSA has not evaluated these performance specifications nor have we developed possible compliance tests for them.

A. Options for Display Characteristics

Given that a particular rear visibility countermeasure technology has not been specified, the type of visual display associated with a rear visibility countermeasure has the potential to take a variety of forms. Such visual displays may include mirrors, flashing lights from sensor-based rear object detection system, or a video-based image display. Some characteristics relevant to possible visual display types are described below.

Performance Criteria Which May be Needed for All Rear Visibility Enhancement Countermeasure Displays (e.g., Rearview Video System Displays, Mirrors, and Electronic Warning Displays)

Overall display size—The minimum overall image size should be defined to ensure that drivers will be able to detect small children in the visual display. If the image size is too small, the effectiveness of the system may be impacted by a driver's inability to identify a child or other object.

Image resolution—It may be necessary to define the minimum image resolution so that drivers will be able to identify objects in the display.

Image distortion—A maximum allowable distortion parameter may be

[110] Presentation to NHTSA, January 28, 2009 meeting; Alliance for Automotive Manufacturers. Available at Docket Number 2009–0041.

[111] 49 CFR 571.111, Standard No. 111, Rearview Mirrors.

necessary to ensure that image quality is sufficient to allow drivers to accurately identify objects located behind the vehicle.

Image minification—To ensure that objects behind the vehicle appear in the image of the area behind the vehicle as presented by the countermeasure's display with sufficient size to allow them to be identified by drivers, a maximum allowable minification level may be necessary.

Environmental performance—It may be necessary to specify minimum environmental requirements under which systems would be expected to operate in common real world conditions.

Additional Performance Criteria Which May be Needed for Electronic Visual Displays (e.g., Rearview Video Systems, Electronic Warning Displays)

Display location—In order to facilitate a driver's effective use of an electronic visual display, it may be beneficial to specify a permitted location for the display unit and image. For example, a rearview video image present in the interior rearview mirror must be displayed on the left side of the mirror so that the distance between the driver and image is not too large.

Overall display size—For electronic, rearview video system displays, NHTSA is considering specifying a minimum image size of 3.25 inches measured diagonally for an electronic visual display with aspect ratio of 4:3 [112] (or approximately 4-inch diagonal size for 16:9 aspect ratio displays).

Brightness—A minimum brightness value [113] may be necessary to ensure that the display image can be seen by drivers in a wide variety of ambient conditions, such as glare from sunlight or ambient light.

Contrast ratio—Minimum contrast ratio may be necessary to ensure that the display image can be seen by drivers in a wide variety of ambient conditions.

Image response time—A minimum response time for the system to display an image of the area behind the vehicle may be necessary to enable a driver to engage the system while backing. NHTSA is considering a maximum of 1.25 seconds based on our research to date.[114]

Image "linger" time—To limit unintended distraction to drivers, the maximum image linger time (i.e., the time that the visual display remains on after the vehicle's transmission has been shifted out of reverse gear), may be specified. Some linger time is desirable for situations where frequent transitions from reverse to forward gear are needed to adjust a vehicle's position (e.g., parallel parking and hitching). NHTSA is considering a minimum of 4 seconds but not more than 8 seconds of linger time is appropriate after the vehicle is shifted from the reverse position.

Options for Other Display Characteristics

NHTSA does not believe that a malfunction telltale is necessary for rearview video systems, since video camera or visual display failure would be indicated by the apparent lack of image presented in the visual display. We invite comments on this point and any evidence that would suggest that such an indicator may be necessary.

B. Options for Rearview Video System Camera Characteristics

Currently, NHTSA does not have data which could be used to establish minimum specifications for a rearview video system's camera. However, based upon our knowledge of the current technology the agency believes that requirements for the following categories might be necessary: Low light performance requirements; resolution; and environmental performance limits/ranges.

C. Questions

(1) Are there any existing industry consensus standards for rear visibility enhancement systems which address the parameters outlined in this section? Are there any ongoing efforts to develop such industry consensus standards? If so, when will the standards be published?

(2) Are there additional parameters which should be specified to define a rear visibility enhancement system? What should the minimum specified performance be for each parameter?

(3) Are future rear visibility systems anticipated which may have significantly different visual display types that may require other display specification parameters?

XIII. Conclusion

In developing this notice, NHTSA tried to address the concerns of all stakeholders. Your comments will help us develop a rearward visibility standard to be included as part of FMVSS No. 111. We invite you to provide different views on the questions we ask, new approaches and technologies about which we did not ask, new data, insight as to how this notice may affect you, or other relevant information. We welcome your views on all aspects of this notice but we especially request comments on the specific questions articulated throughout this document.

XIV. Public Participation

How do I prepare and submit comments?

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

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.

Please submit two copies of your comments, including the attachments, to Docket Management at the address given above under **ADDRESSES**.

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

Please note that pursuant to the Data Quality Act, in order 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 the guidelines in preparing your comments. OMB's guidelines may be accessed at *http://www.whitehouse.gov/omb/fedreg/reproducible.html*. DOT's guidelines may be accessed at *http://dms.dot.gov*.

How can I be sure that my comments were received?

If you wish Docket Management 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, Docket Management 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

[112] General Motors, SAE Government and Industry Meeting, May 2008, oral presentation.

[113] Measured in cd/m^2.

[114] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

business information, to the Chief Counsel, NHTSA, at the address given above 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 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 that Docket Management receives before the close of business on the comment closing date indicated above under **DATES**. To the extent possible, we will also consider comments that Docket Management receives after that date. If Docket Management 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 Docket Management 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 that 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.

XV. Rulemaking Analyses and Notices

Executive Order 12866 and DOT Regulatory Policies and Procedures

Executive Order 12866, ''Regulatory Planning and Review'' (58 FR 51735, October 4, 1993), provides for making determinations whether a regulatory action is ''significant'' and therefore subject to OMB review and to the requirements of the Executive Order. The Order 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 ANPRM under Executive Order 12866 and the Department of Transportation's regulatory policies and procedures. As discussed above, there are a number of considerations and technologies that can be applied to address the issue of backovers and the agency lacks the necessary information to develop a proposal at this time. Based on the information we have, we developed this notice and placed in the docket a Preliminary Regulatory Impact Analysis to facilitate public input. Therefore, we have not yet determined whether or not this rulemaking will be economically significant under Executive Order 12866. However, this rulemaking action has been determined to be ''significant'' under the Department of Transportation's Regulatory Policies and Procedures (44 FR 11034; February 26, 1979) and has been reviewed by the Office of Management and Budget.

Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act, 5 U.S.C. 601 *et seq.*, no analysis is required for an ANPRM. However, vehicle manufacturers and equipment manufacturers are encouraged to comment if they identify any aspects of the potential rulemaking that may apply to them.

Executive Order 13132 (Federalism)

NHTSA has examined today's ANPRM pursuant to Executive Order 13132 (64 FR 43255, August 10, 1999) and concluded that no additional consultation with States, local governments or their representatives is mandated beyond the rulemaking process at this time. The agency has concluded that the document at issue does not have federalism implications because it 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's safety standards can have preemptive effect in at least 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 that would unavoidably preempt State legislative and administrative law, not today's rulemaking, so consultation would be unnecessary.

We are aware that, depending on the nature of the proposal ultimately adopted, federalism implications could arise. Currently, there is no Federal requirement regarding visibility of the area directly behind a passenger vehicle. As a result, any State laws or regulations that seek to regulate this aspect of performance would not currently be preempted by Federal law. However, if NHTSA issues a standard on the same aspect of performance, those State laws and regulations would be preempted if they differed from the Federal requirements. Thus, the possibility of statutory preemption of State laws and regulations does exist. At this time, we do not know of any State laws or regulations that currently exist that are potentially at risk of being preempted, but in this document do request comment on any existing or planned laws or regulations that would fall into this category.

Second, the Supreme Court has recognized the possibility of implied preemption: State requirements imposed on motor vehicle manufacturers, including sanctions imposed by State tort law, can stand as an obstacle to the accomplishment and execution of a NHTSA safety standard. When such a conflict is discerned, the Supremacy Clause of the Constitution makes the State requirements unenforceable. *See Geier* v. *American Honda Motor Co.*, 529 U.S. 861 (2000). NHTSA has considered today's ANPRM and does not currently foresee any potential State requirements that might conflict with it. Without any conflict, there could not be any implied preemption.

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 (7) 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 preemptive effect of this document is discussed above. 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.

Protection of Children From Environmental Health and Safety Risks

Executive Order 13045, ''Protection of Children from Environmental Health and Safety Risks'' (62 FR 19855, April 23, 1997), applies to any rule that: (1) Is determined to be ''economically significant'' as defined under Executive Order 12866, and (2) concerns an environmental, health, or safety risk that the agency has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, the agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the agency.

While this document does not make any changes with regard to the standard at issue, the rulemaking is intended, in large part, to address a safety concern that is particularly applicable to young children. In response to the executive order and in alignment with the agency's policies, we have tailored our research efforts addressed in this document to be particularly sensitive to the needs of children. These steps have included, but are not limited to, analyzing accident cases that involve children and designing testing procedures and performance criteria with particular emphasis on the ultimate goal of detecting and preventing accidents involving the youngest children.

Paperwork Reduction Act

Under the Paperwork Reduction Act of 1995 (PRA), a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid OMB control number. There is not any information collection requirement associated with this ANPRM.

National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Public Law 104–113, (15 U.S.C. 272) directs the agency to evaluate and use voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law or is otherwise impractical. 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. The NTTAA directs us to provide Congress (through OMB) with explanations when we decide not to use available and applicable voluntary consensus standards. There are no voluntary consensus standards developed by voluntary consensus standards bodies pertaining to this ANPRM.

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 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 expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted for inflation with base year of 1995). This ANPRM would not result in expenditures by State, local or tribal governments, in the aggregate, or by the private sector in excess of $100 million annually. However, given the cost estimates of some of the technologies at issue, most relevantly RV video systems, it is very possible that the total cost of a proposed rule could substantially exceed $100 million. Given that, the agency has prepared a preliminary assessment of some of the possible costs of the technologies investigated in this ANPRM.

National Environmental Policy Act

NHTSA has analyzed this rulemaking action for the purposes of the National Environmental Policy Act. The agency has determined that implementation of this action will not have any significant impact on the quality of the human environment.

Executive Order 13211

Executive Order 13211 (66 FR 28355, May 18, 2001) applies to any rulemaking that: (1) Is determined to be economically significant as defined under E.O. 12866, and is likely to have a significantly adverse effect on the supply of, distribution of, or use of energy; or (2) that is designated by the Administrator of the Office of Information and Regulatory Affairs as a significant energy action. This rulemaking is not subject to E.O. 13211.

Plain Language

Executive Order 12866 and the President's memorandum of June 1, 1998, 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 ANPRM.

Regulatory Identifier Number (RIN)

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 (Volume

65, Number 70; Pages 19477–78) or you may visit *http://www.regulations.gov*.

Issued on: February 26, 2009.

Stephen R. Kratzke,

Associate Administrator for Rulemaking.

Appendix A—Methodology for Assessing Backover Crash Risk by Pedestrian Location

Monte Carlo simulation was used to calculate a probability-based risk weighting for each square in a grid of 30-cm squares behind the vehicle. The grid of 30-cm squares extended 27 m back from the rear edge of the rear bumper of the vehicle, 6 m forward of the rear bumper, and 10.5 m to the left and to the right of the longitudinal centerline of the vehicle, resulting in a total of 7,700 30-cm grid squares. The probability-based risk weightings for each grid square were based on the number of pedestrian-vehicle backing crashes predicted by the simulation for trials for which the pedestrian was initially (i.e., at the time that the vehicle began to back up) in the center of one square of the grid of 30-cm squares. For each Monte Carlo simulation trial, the pedestrian was initially placed in the center of one square of the grid of 30-cm squares. A total of 1,000,000 Monte Carlo simulation trials were run with the pedestrian initially in the center of each square. Since the Monte Carlo simulation used had left-right symmetry, mirroring was used to increase the effective number of simulation trials to 2,000,000 for each grid square.

Important assumptions were made about the behavior of the driver and the pedestrian for this analysis. The vehicle and pedestrian were assuming to begin moving at the same time and were assumed to be completely unaware of each other. Therefore, the motions of the vehicle and pedestrian were totally independent of the each other. Note that it was possible for the pedestrian to walk or run into the vehicle. If the impact was with the rear of the vehicle, a back-over incident was considered to have resulted. If the impact was with the side or front of the vehicle, the crash was not counted as a backing crash for the purposes of this analysis.

Vehicle Descriptors

Four descriptors were used to define the simulated vehicle in this analysis. The width of the vehicle was assumed to be 6.0 feet for this analysis. The distance that the vehicle backed up during each backing trial was determined by a random draw from a three-parameter Weibull probability distribution for distance backed that was based on data from the ''On-Road Study of Drivers' Use of Rearview Video Systems'' study.[115] To simplify the analysis this simulation assumed that the vehicle backed up at a constant speed based on a random draw from a three-parameter Weibull probability distribution also based on NHTSA's research data.[116]

Since backing maneuvers frequently involve turning, any backing trial more than 25 feet long was assumed to possibly include a turn. To determine whether the vehicle turned to the left, went straight, or turned to the right during each backing trial, a uniformly distributed random number was drawn. There was a 40 percent probability of a left turn, a 40 percent probability of a right turn, and a 20 percent probability of a no turn. The turn, if there was one, did not commence until after 25 feet of backing or 30 feet from the end of the back, whichever was greater. Once turning commenced the rear bumper of the vehicle traveled around a 20 foot radius circle. Since the maximum distance in the turn was 30 feet, the angle which the vehicle turned through ranged from 0 to 85.9 degrees (1.5 radians).

Pedestrian Descriptors

The pedestrian was modeled in the horizontal plane as a circle of radius 0.375 feet. To simplify the analysis, the pedestrian was assumed to move at constant speed and direction. The angle of pedestrian travel was determined by a random draw from a uniform probability distribution extending from −180.0 to +180.0 degrees. Walking speed was determined by a random draw from a triangular probability distribution ranging from 0.0 to 5.0 mph.

To define the position of the pedestrian behind the vehicle, axes were assigned to the grid. An X axis was set up pointing straight back along the longitudinal centerline of the vehicle with its origin at the rear bumper of the vehicle. A Y axis was set up pointing along the (assumed straight) rear edge of the rear bumper with its origin at the center of the rear bumper. Positive Y values were on the driver's side of the vehicle. The pedestrian was always started at the center of one of the 1-foot grid squares. Therefore, the initial positions of the pedestrian, in both X and Y, were always at a half foot mark. All possible initial pedestrian positions were simulated. Therefore, the initial pedestrian X positions ranged from 0.5 to 49.5 feet in 1.0-foot increments. Similarly, the initial pedestrian Y positions ranged from −9.5 to 9.5 feet also in 1.0-foot increments.

Additional Simulation Information

As was previously mentioned, a total of 1,000,000 Monte Carlo simulation trials were run with the pedestrian initially in the center of each square. Each trial simulated 60.0 seconds of time unless the pedestrian collided with the vehicle or the vehicle completed its movement first. Actual backing events do not last for 60.0 or more seconds. The longest backing event out of the 6,185 in the ''On-Road Study of Drivers' Use of Rearview Video Systems'' study[117] data set was 52.8 seconds long. However, for the simulation, both the backing distance and average backing speed were determined independently of each other from Weibull probability distributions. This is actually not correct; statistical analyses of the ''On-Road Study of Drivers' Use of Rearview Video Systems'' study[118] data set indicates that for real driving, as backing distance increases so does average backing speed. However, it was decided to accept the independence of the backing distance and average backing speed so as to simplify the simulation. As a result, 1.1 percent of all simulated backing trials had not been completed after 60.0 seconds of simulation. For the purposes of this analysis it was decided that the normalization process would probably adequately account for not otherwise dealing with this issue.

A count was made of all trials for which the pedestrian collided with the rear bumper of the vehicle. If the pedestrian collided first with either the front or sides of the vehicle, then this was not counted as a backing collision.

After completion of the simulation for all grid squares, a normalization of the backing crash counts for each grid square was performed. The normalization converted each grid square's crash count into its probability of crash relative to the probability of crash for the grid squares for which a crash was most likely to occur. The grid squares for which a crash was most likely to occur were the two directly behind the bumper in the center of the vehicle, i.e., the grid squares at (0.5 ft, 0.5 ft) and at (0.5 ft, −0.5 ft). The relative probability of crash for these two grid squares was set to 1.0. For all other grid squares, the crash count was divided by the crash count for grid square (0.5, 0.5). Note that due to left-right mirroring, the grid squares at (0.5, 0.5) and at (0.5, −0.5) both had the same crash counts. This resulted in a probability of crash relative to the probability of crash for the grid squares at (0.5, 0.5) and at (0.5, −0.5). Since all grid squares were subjected to the same simulation imperfections, this first normalization was expected to reduce the impact of these imperfections of the simulation results.

Figure 1 of this notice summarizes the calculated relative crash risk for each grid square. Note that the white shaded area does not have a zero backover risk; it merely has a low (less than 12.5 percent of the maximum) risk.

This analysis shows that the probability of crash decreases rapidly as the pedestrian's initial location is moved back, further away, from the rear bumper of the vehicle. There are substantial side lobes, giving pedestrians a reasonable chance of being hit even though they were not initially directly behind the vehicle.

Appendix B—Method for On-Road Study of Drivers' Use of Rearview Video Systems

Drivers' use of rearview video systems was observed during staged and naturalistic backing maneuvers to determine whether

[115] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[116] Id.

[117] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[118] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

drivers look at the RV display during backing and whether use of the system affects backing behavior.[119] Thirty-seven test participants, aged 25 to 60 years, were comprised of twelve drivers of RV-equipped vehicles, thirteen drivers of vehicles equipped with an RV system and a rear parking sensor system, and twelve drivers of vehicles with no backing aid system. All three system conditions were presented using original equipment configurations of the 2007 Honda Odyssey minivan. All participants had driven and owned a 2007 Honda Odyssey minivan as their primary vehicle for at least 6 months. Participants were not aware that the focus of the study was on their behavior and performance during backing maneuvers.

Participants visited a test lab to have unobtrusive video and other data recording equipment installed in their personal vehicles, and for a brief test drive. Participants then drove their vehicles for a period of 4 weeks in their normal daily activities while backing maneuvers were recorded. At the end of 4 weeks, participants returned to the research lab to have the recording equipment removed. Then, participants took a second test drive, identical to the first, except that when backing out of the garage bay, an unexpected 36-inch-tall obstacle consisting of a two-dimensional photograph of a child appeared behind the vehicle.

Appendix C—Details Regarding Development of a Possible Countermeasure Application Threshold Based on Rear Blind Zone Area

To begin to investigate what this threshold value might be, NHTSA plotted the average backing and backover rates versus the direct-view rear blind zone areas for 28 vehicles, as shown in Figure C–1. Several options for setting a threshold were examined. One option could be to choose the natural break point on the plotted curve at which the slope dramatically increases for crash rate as a function of direct-view rear blind zone area. This option results in vehicles with the poorest rear visibilities that contribute disproportionately to backover crashes being affected. One observation with this option is that the worst offenders for rear visibility would be captured, but a large percentage of overall backover crashes would not be addressed, such as those involving small pickups.

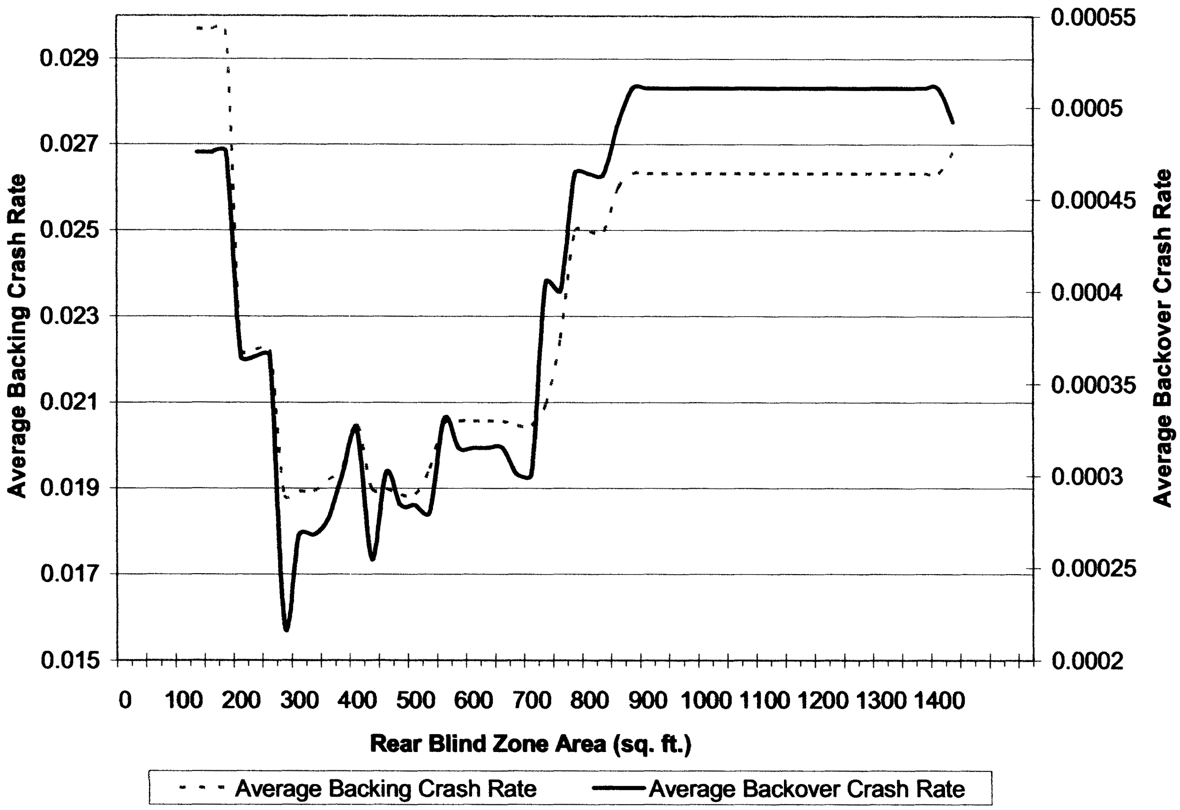

Figure C-1. Backing and Backover Crash Rates as a Function of Rear Blind Zone Area

Appendix D—Results for Analysis of Correlation Between Rear Blind Zone Area Measurement Field Size and Backing Crashes

To support the determination of the dimensions of the rear visibility measurement field, NHTSA's measured rear blind zone area data for a variety of vehicles were compared with backing crashes for those vehicles. Data analysis was performed to assess the correlation between vehicles' rear blind zone areas measured using a 50th percentile male driver and backing crash data for 21 vehicles.[120] Complete results of this analysis for a portion of the field sizes assessed are summarized in Table D–1.

[119] Mazzae, E.N., Barickman, F.S., Baldwin, G.H.S., and Ranney, T.A. (2008). On-Road Study of Drivers' Use of Rearview Video Systems (ORSDURVS). National Highway Traffic Safety Administration, DOT 811 024.

[120] Mazzae, E.N., Light Vehicle Rear Visibility Assessment, DOT HS 810 909, September 2008. NHTSA's visual target for this test was a traffic cone with a reflector atop; its height is representative of a 1-year-old child.

TABLE D–1—CORRELATION BETWEEN HUMAN-BASED REAR BLIND ZONE AREA MEASURED OVER VARIOUS FIELD SIZES AND BACKING CRASHES

[Sorted by correlation coefficient]

Measurement field dimensions (width by length)	Correlation coefficient	Probability occurred by chance
50W × 10L	0.60117	0.0039
40W × 10L	0.60117	0.0039
30W × 10L	0.58233	0.0056
30W × 50L	0.55212	0.0095
40W × 40L	0.54681	0.0103
30W × 40L	0.53635	0.0122
50W × 40L	0.53113	0.0132
20W × 40L*	0.52621	0.0143
50W × 50L**	0.52375	0.0148
20W × 50L	0.52367	0.0148
40W × 30L	0.52341	0.0149
50W × 60L	0.51360	0.0172
30W × 30L	0.51227	0.0176
60W × 50L	0.51891	0.0159
50W × 30L	0.50641	0.0192
60W × 60L	0.50403	0.0198
40W × 20L	0.48513	0.0258
20W × 30L	0.48117	0.0272
50W × 20L	0.47920	0.0280
70W × 70L	0.47331	0.0302
70W × 80L	0.45159	0.0399
70W × 90L	0.43665	0.0478
20W × 20L	0.39522	0.0762
10W × 40L	0.35315	0.1163
10W × 10L	0.27903	0.2206

* This measurement field size was indicated by pedestrian backover crash risk simulation as encompassing pedestrian locations at which risk of a backing crash was 20 percent or higher.

** Blind zone area measured over a field this size was found by preliminary analysis of laser-based measurement data to be well correlated with backing crashes.

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