FMCSA's Advanced System Testing Utilizing a Data Acquisition System on the Highways (FAST DASH) Safety Technology Evaluation Project #3: Novel Convex Mirrors

The Federal Motor Carrier Safety Administration (FMCSA) established the FAST DASH program to perform efficient independent evaluations of promising safety technologies aimed at commercial vehicle operations. In this third FAST DASH safety technology evaluation project, researchers evaluated a set of novel prototype mirrors to determine whether the mirrors perform as well as traditional production mirrors across the basic functions of field of view (FOV), image distortion, and distance estimation. Photographs of both types of mirrors and a summary of key findings are presented in Figure 1.

Production	Prototype
	
• Field of view was not as great as prototype mirrors. • Image distortion was not an issue. • Most drivers preferred production mirrors over prototype mirrors.	• Increased field of view. • Increased image distortion, which affected drivers' ability to estimate distances. • Prototype mirrors will require: 1) refinements to increase utility, and 2) field testing to increase user acceptance.

Figure 1. Grouped image. Side-by-side comparison of production and prototype mirrors.

BACKGROUND

Large trucks, because of their size and design, have extensive areas around their bodies that are obscured from the driver's direct and indirect vision. These blind spot areas have the potential to hide other road users from the drivers (due to restricted FOV), contributing to safety weaknesses and crashes during maneuvers such as lane changes and merges. Cameras, novel mirror designs, and object detection technologies provide viable options to enhance, supplement, or replace current standard mirror configurations on heavy vehicles.

Conventional convex mirrors are shown to reduce blind spots substantially when compared with conventional planar mirrors, but with distortion to objects via indirect visibility. This distortion narrows the horizontal dimensions of the corresponding image, and is a potential problem for drivers. The proposed novel prototype mirror is expected to reduce distortion when compared to a conventional convex mirror, while also increasing driver FOV.

STUDY PROCESS

The study process included the following steps:

- **Mirror Development:** Novel mirrors were developed. Manikins were created and used in simulations, supporting specification of the mirror views prior to fabrication of prototype mirrors.
- **Controlled Performance Evaluation:** The research team performed preliminary FOV mapping with the prototype and production mirrors in a controlled area to assess capabilities of the mirrors.

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- **Static Evaluation:** The intent of the static evaluation was to introduce the prototype mirrors to commercial driver's license, class A (CDL-A) drivers and to solicit their feedback on the utility, look, and effectiveness of the mirrors, as well as their overall preferences. This allowed researchers to understand how drivers assess the prototype mirrors, and to examine the mirrors' potential limitations and areas for improvement before production. Nine drivers participated in the static evaluation.

- **Dynamic Evaluation:** This supplemental test drive garnered feedback from an experienced heavy-vehicle driver in a dynamic test setting featuring real-world scenarios and tasks aimed at comparing the production and prototype mirrors. One driver, employed by the contracted research institution, participated in the dynamic evaluation.

STUDY FINDINGS

Static Evaluation

Drivers were asked to evaluate the prototype mirrors across the following: FOV, image distortion, and distance estimation. Drivers classified the image distortion of each mirror type (production, prototype) and position (door/hood, driver-side/passenger-side). Participants classified the majority of the prototype door mirrors as distorted. The lower regions of both of the hood mirrors were classified as most distorted. Among the four mirror positions, drivers identified all four of the prototype mirrors as creating more image distortion than the production mirrors; however, the passenger-side hood mirror was not rated significantly worse.

Drivers were asked to estimate distances to a cone placed on alternating sides of the truck at one of two positions rearward from the door mirrors. The results of these estimates provide some limited insight into the effect of the prototype mirrors on judging objects in nearby lanes of traffic on the road. Cones were positioned in different locations that were visible in each mirror on the driver side and passenger side. The true cone locations surrounded the tractor-truck rear axle on the driver side and the trailer rear axle on the passenger side. The distance estimates were subtracted from the true distance and those gaps were averaged across drivers. The average gap estimated by the drivers was smaller for the prototype mirrors than the production mirrors on both the driver- and passenger-side mirrors; however, the distance was not significantly lower.

Dynamic Evaluation

A staff member of the contracted research institution participated in a supplemental dynamic evaluation targeting components of the mirror evaluation that could not be captured in a static evaluation. This driver had similar reactions toward the mirrors as participants in the static evaluation. Though safe driving behaviors did not diminish using the prototype mirrors versus the production mirrors, the prototype mirrors did not offer much improvement over the production mirrors. The driver performed equally in overtaking and merging tasks with both mirrors. The driver noted that the door-mounted prototype mirror did provide a larger FOV, but the passenger door-mounted prototype mirror made driving safely discernably more difficult due to the distortion and reduction in size of the objects viewed in the prototype mirror. The driver also had no difficulty in the parking lot tasks, utilizing the passenger-side prototype mirror to perform a curb dock, but relying heavily on the flat mirrors for the alley dock, as is the nature of the task.

User Acceptance

The drivers in the study had limited acceptance of the prototype mirrors. Drivers provided feedback regarding both positives and negatives of the prototype mirrors, as well as ways to improve them and/or follow-up tests that they would like to see. General positive comments included the following: "field of view is larger," "actual image presentation is clearer," "more definitive," "I like the design better, no sun glare." General negative comments included the following: "harder to place things in the mirror," "too distorted," and "still a bit of work to do on the mirror."

CONCLUSION

In summary, the prototype mirrors' FOV was greater than the production mirrors. However, this increase was demonstrated to exist at the cost of increased image distortion. Of the nine participating drivers, eight stated that they would prefer to use the production door mirrors on their vehicles, and six of the nine drivers stated that they would prefer to use the production hood mirrors on their vehicles. The extreme shape of the door mirrors requires further development to reduce the resulting areas of distortion.

To read the complete report, please visit: http://ntl.bts.gov/lib/60000/60400/60468/15-021-FAST_DASH_3-FINAL-508C.pdf.