Department of Transportation

National Highway Traffic Safety Administration

Supporting Statements: Part B

Drivers' Use of Camera-Based Rear Visibility Systems Versus Traditional Mirrors

OMB Control No. 2127-0756

Abstract:[1]

This information collection is a revision of a currently approved information collection, OMB Control Number 2127-0756, "Drivers' Use of Camera-Based Rear Visibility Systems Versus Traditional Mirrors." The National Highway Traffic Safety Administration (NHTSA) is conducting research as part of a multi-year effort to gather information to aid in determining whether camera-based rear visibility systems can provide the same level of safety as the rearview mirrors currently required under FMVSS No. 111, Rear Visibility. NHTSA published an ANPRM (RIN 2127–AM02) responding to two petitions received from vehicle manufacturers seeking permission to install camera-based systems (sometimes referred to as camera monitor systems (CMS)), instead of outside rearview mirrors, on both light vehicles and heavy trucks. This research will help answer important safety questions posed in the ANPRM and inform NHTSA's response to the petitions, by aiding in determining whether CMS can provide at least the same level of safety as the currently-required mirrors. Research results will be published in the form of one or more technical research reports available via the National Transportation Library and/or future published Federal Register notices.

The research is voluntary and examines the use of camera-based systems versus rearview mirrors for both light vehicles and heavy trucks. Study participants are members of the general public who are licensed car and/or commercial truck drivers aged 25 to 65 who are healthy and able to drive without assistive devices. The research protocols are reviewed by an independent Institutional Review Board.

The full information collection request includes six information collections: Interest Response Form, Candidate Screening Questions, Experimental Data Collection, Post-Drive Questionnaire: Drive with Camera Monitor System, Post-Drive Questionnaire: Drive with Traditional Mirrors and Post-Drive Questionnaire: Final Opinions.

This is a revision of a currently approved information collection (IC) to extend the approval period, increase the number of respondents, and revise the burden calculations. The currently approved collection permitted 200 respondents annually across multiple complementary studies within the research taking place over the original approved period. NHTSA is requesting an additional 156 respondents. This estimate includes an additional 78 annual respondents which are necessary to achieve current research objectives and reflects changes based on revised response rate information that NHTSA has obtained through the information collected to date. It

[1] The Abstract must include the following information: (1) whether responding to the collection is mandatory, voluntary, or required to obtain or retain a benefit; (2) a description of the entities who must respond; (3) whether the collection is reporting (indicate if a survey), recordkeeping, and/or disclosure; (4) the frequency of the collection (e.g., bi-annual, annual, monthly, weekly, as needed); (5) a description of the information that would be reported, maintained in records, or disclosed; (6) a description of who would receive the information; (7) if the information collection involves approval by an institutional review board, include a statement to that effect; (8) the purpose of the collection; and (9) if a revision, a description of the revision and the change in burden.

also requests approval for an additional 78 annual respondents to permit examination of additional questions critical to the rulemaking effort that may arise, thus requesting 156 respondents complete the research annually. This request reflects changes based on revised response rate information that NHTSA has obtained through the information collected to date. There are changes to the number of respondents for some individual ICs, time for completion of some individual ICs, wages, and federal wage rates. Additionally, NHTSA has included contractor costs that were not part of the original collection package. As such, there are revisions for burden hours, opportunity costs, and costs to the federal government. This request shows a reduction of 55 burden hours and an increase of change of $203,094 federal government costs.

B. JUSTIFICATION

B.1 Describe the potential respondent universe and any sampling or other respondent selection to be used.

The respondent universe includes individuals solicited through print and online newspaper advertisements in the West Central Ohio area. No statistical methods are used in selecting study participants. Study participants are selected based on a set of criteria that serve to ensure that participants are generally representative of average U.S. drivers, have no recent criminal convictions, and hold no biases that may impact study results. The criteria state that participants must:

a. Be aged 25-65 years

b. For drivers of passenger light vehicles: Hold a valid U.S. driver's license and drive at least an average number of miles (e.g., 11,000) annually

c. For drivers of heavy trucks: Hold a valid U.S. commercial driver's license and drive at least an average number of miles (e.g., 11,000) annually in a commercial truck

d. Have no more than 2 points on current driving record

e. Have no recent criminal convictions including criminal driving offenses

f. Have no uncorrected vision or hearing problems

g. Be in good general health, able to drive continuously and safely for a period of 3 hours without the need for assistive devices

h. Self-report that they are able to read, write, speak, and understand English

i. Be willing to drive to NHTSA's Vehicle Research and Test Center and spend up to approximately 3 hours participating in a research study

j. Not have anyone in their household who works for or is retired from any automotive manufacturer, which may constitute a conflict of interest with the research.

Criteria satisfaction is determined using a standard set of demographics, driving behavior, and general health questions. Specific questions were developed and reviewed through their use in multiple studies to ensure their wording is clear and only the minimum relevant information is obtained for the purposes of assessing individuals' suitability for study participation. No health information is stored; only a net response indicating

whether a candidate participant "meets criteria" is retained. Participants contact information is retained only for the duration of the study and used to schedule facility visits and provide appointment reminders. Contact information is stored separately from study data and destroyed after study completion.

For both light vehicle driver and commercial truck driver samples, we attempt to balance age and sex to the extent possible based on availability of candidate participants.

B.2 Describe the procedures for the collection of information.

No statistical methods (e.g., stratification) are employed. This is a convenience sample.

Candidate participants who view and choose to respond to an advertisement complete the *Interest Response Form* (hosted online on a secure website). These advertisements are placed in local newspapers, including those in Marysville, Bellefontaine, Delaware, and Kenton, Ohio. Ads can be placed in physical newspapers, on newspaper websites, and on Facebook. The ads contain a link to a website that describes the study in detail including the general participation requirements.

Individuals, whose responses to the *Interest Response Form* meet study participation criteria, are contacted, and asked to complete the *Candidate Screening Questions*, which is accessible via a secure website. Individuals, whose responses to the *Candidate Screening Questions* meet study participation criteria, are scheduled for study participation according to their availability. *Interest Response Form* and *Candidate Screening Questions* data is only used for the purposes of identifying suitable study participants and is not used in any other way.

Scheduled participants are randomly assigned to groups corresponding to different vehicle conditions/configurations. Vehicle conditions consist of a vehicle model for which a mirror-equipped version and a version equipped with a camera-based rear visibility system are available. Camera-based rear visibility systems differ for the light vehicle and heavy truck parts of data collection.

Participants experience a production vehicle equipped in two different configurations: 1) equipped with original equipment, FMVSS-compliant outside mirrors, and 2) equipped with a production or prototype camera-based rear visibility system in place of traditional outside mirrors. Participants are asked to complete drives along a specified route on a controlled test track and/or on public roads while their eye glance behavior and driving behavior are recorded. Upon completion of each test drive, participants complete the Post-Drive Questionnaire, after driving the test route in a mirror-equipped vehicle and after driving a vehicle equipped with a camera-based rear visibility system. The questionnaire addresses their subjective impressions of general use, comfort, and visibility while using the two visibility technologies.

After the *Experimental Data Collection* is completed, participants complete the Post-Drive Questionnaire to gather participants' opinions and preferences regarding the tested rear visibility technology. Participants' responses to scale-based questions are combined for analysis. Responses to open-ended questions are qualitatively summarized and described in the technical report without reference to individual participants.

Vehicle instrumentation include cabling for connecting to the vehicle's Controller Area Network (CAN) bus and sensors for capturing vehicle position, acceleration, velocity, longitudinal and lateral distances between vehicles during steady state driving and lane changes. One or more video cameras capture image data documenting the driving environment and in-vehicle audio data. An eye tracker records driver eye glance behavior. All these data streams are passed to an in-vehicle data acquisition computer for recording and synchronization during the test drive. Upon completion of the test drives, data is transferred from the computer to an encrypted portable hard drive. Data files are then copied to a limited-access local area network (LAN). Raw data files, including video and audio data, are stored on the LAN server. Processing and analysis of data containing PII is only performed while accessing the LAN. Data not containing PII and that relate to driving performance measures are copied to a different limited-access network drive where research staff can access and analyze the data. All data is protected as confidential according to IRB requirements and best practices for protecting participant information.

B.3 Describe methods to maximize response rates.

Recruitment of light vehicle drivers is accomplished using print (newspaper or flyer) or online study recruitment advertisements. Recruitment of professional commercial truck drivers is conducted using both online and print advertisements as well as through partnership with local trucking companies. Working with trucking companies to identify drivers for study participation helps to ensure that the sample includes a sufficient number of productive, employable, commercial truck drivers. Individuals interested in participation respond to the advertisement by visiting a secure website containing a brief study description. Along with the study description, a web link is provided that interested candidate participants can follow to begin the screening process.

Study participation likelihood is increased by the provision of monetary compensation at an hourly rate, as well as mileage reimbursement for travel to and from the test site. Monetary compensation is consistent with normal experimental practice and should encourage study participation. We anticipate payment to both light vehicle and heavy truck drivers at an anticipated hourly rate of approximately $65.00.

B.4 Describe any tests of procedures or methods to be undertaken.

For testing involving driving an instrumented vehicle, both light vehicle and heavy truck *Experimental Data Collections* utilize the same data collection approach. Vehicles are equipped with varying rear visibility technologies. Participants are randomly assigned randomly to the order of rear visibility technologies. Participants are asked to drive a government-owned instrumented vehicle on a test track, public road, or in a simulated environment (i.e., driving simulator). Participants' driving behavior and eye glance behavior is observed and recorded as they perform a driving task that requires making lane changes. This is repeated until all conditions are evaluated.

As this research remains flexible to permutations of vehicle classification, setting of testing, and vehicle maneuver, these are offered as anticipated research question; however, there may be slight variations and potentially additional variables in order to meet research objectives identified through the course of the research. Anticipated

research questions being investigated in driver behavior observation experimental data collection are described below.

1. **Lane Change Performance**
    - Does lane change performance differ when driving with a camera-based rear visibility system compared to traditional outside rearview mirrors?
    - Does driving with a camera-based rear visibility system result in differences in distance judgments when passing a slower moving vehicle compared to traditional outside rearview mirrors?
    - For the heavy truck part of data collection: Is driving at night with a camera-based rear visibility system affected by issues of blooming or glare from other vehicles' headlights?

Several driving performance metrics are used to evaluate whether differences in driving performance while changing lanes exist across the conditions. A lane change is defined by a lateral velocity greater than 0.3 m/s without a subsequent lateral reversal. The lane change ends once the lateral velocity returns below this threshold. Dependent measures related to lane change performance include the total time to complete a lane change, longitudinal distance to a slow forward vehicle at lane change start, resultant distance to an adjacent rearward vehicle at lane change start, longitudinal distance to an adjacent rearward vehicle when passing in front of a slower moving vehicle, and the total time to pass a slower moving vehicle.

Data is aggregated for all participants and the mean, median, and standard deviation for each dependent variable is calculated. Separate analyses are performed for each system.

For the light vehicle part of data collection, separate paired samples t-tests are performed within each camera-based rear visibility system to assess whether each of the lane change performance dependent measures differ between the mirror and camera-based rear visibility system conditions. For the heavy truck data part of collection, within each camera-based rear visibility system, separate 2 (Rear Visibility Technology) x 2 (Time of Day) mixed analysis of variance (ANOVA) is performed to assess whether each of the lane change performance dependent measures differ across conditions.

2. **Eye Glance Behavior**
    - Does driving with a camera-based rear visibility system lead to differences in eye glance behavior compared to traditional outside rearview mirrors?

Eye glance metrics are gathered to evaluate whether differences in eye-scanning patterns exist across conditions. Specifically, proportion of total glances to rear visibility technology, average glance duration to rear visibility technology, and proportion of long glances to rear visibility technology are calculated and compared for each condition.

Data is aggregated for all participants and the mean, median, and standard deviation for each dependent variable is calculated. Since the Rear Visibility Technology and Time of Day (for the heavy truck part of data collection) are nested within camera-based rear visibility systems, separate analyses are performed for each camera-based rear visibility system.

For the light vehicle part of data collection, separate paired samples t-tests are performed within each camera-based rear visibility system to assess whether each of the eye glance

behavior dependent measures differ between the mirror and camera-based rear visibility system conditions. For the heavy truck part of data collection, within each camera-based rear visibility system, separate 2 (Rear Visibility Technology) x 2 (Time of Day) mixed analysis of variance (ANOVA) is performed to assess whether each of the eye glance behavior dependent measures differ across conditions.

3. Post-Drive Questionnaires

- Do drivers' subjective impression of general use, comfort, and visibility differ for camera-based rear visibility systems compared to traditional outside rearview mirrors?
- For heavy trucks: Is driving at night with a camera-based rear visibility system affected by issues of blooming or glare from other vehicles' headlights?

Subjective ratings about each rear visibility technology are assessed via a post-drive questionnaire. Questions asked are concerning the general ease of using each rear visibility technology, the image quality provided by each rear visibility technology, and how well each rear visibility technology aided in driving performance. Data is aggregated for all participants and the mean, median, and standard deviation of ratings is calculated for use, trust, and safety.

B.5 Provide the name and telephone number of individuals consulted on statistical aspects of the design.

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