HUMAN FACTORS CONSIDERATIONS IN THE DESIGN OF TRUCK LIGHTING, SIGNALING, AND REARVIEW MIRRORS

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16. Abstract

This analytical research dealt with human factors considerations in the design of truck lighting and signaling, and rearview mirrors. The analyses began with describing the relevant differences between cars and trucks in terms of the vehicles and the operating environments. Next, the potential functional implications of these differences were discussed. That was followed by brief descriptions of potential countermeasures to the problems. Finally, research topics that address the problems and the potential countermeasures were outlined.

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INTRODUCTION

A majority of human factors research on transportation safety has concerned cars. The findings of such car-oriented research have been frequently applied directly to trucks as well. However, there are potential problems with indiscriminate application of research findings from car-oriented studies to trucks. The differences between cars and trucks in terms of the vehicles and the operating environments might be substantial enough to warrant special considerations for trucks.

The present study examined several such differences between cars and trucks that have potential impact on the performance of the following vital components of vehicles: lighting (including rear lighting and headlighting) and signaling, and rearview mirrors. In the discussion of these differences, the following common three-part format will be used:

(1) Description of the potential problem that stems from a particular difference between trucks and cars, or between the environments in which they are operated.

(2) Brief descriptions of potential solutions to the problem.

(3) Research topics that address the problem and the solutions.

LIGHTING AND SIGNALING

Recessed Taillights

Description. Taillights of trucks are sometimes mounted slightly underneath the bed of the truck (or trailer). For the driver of a following car, this generally does not create any problems, because the truck's taillights are usually near that driver's eye level. However, the resulting geometry can lead to problems for following truck drivers. Since truck drivers sit higher than car drivers, the recessed taillights on a truck ahead might become partially obscured by the bed of the truck at short and intermediate following distances.

The following example illustrates the problem. Let us assume that the taillights are 6 cm in radius, are recessed 15 cm, and their top edges are 2 cm below the bed of the truck. Furthermore, their center-to-ground mounting height is 118 cm, and the following truck driver's eye level is 245 cm. With this geometry, the taillights begin to be obscured at a following distance of 9.1 m. If they are recessed 30 cm, obscuration begins at about 18.1 m. Such following distances are short, but may not be uncommon, especially for trucks.

Potential countermeasures. An obvious solution is for taillights not to be recessed. An alternative would be to change the shape of the bottom of the truck bed just above the recessed lights from horizontal to inclining, to reduce or eliminate the obscuration at short following distances. Increasing the mounting height of the lamps could also eliminate or decrease the problem.

Potential research topics.

(1) Survey of the frequency and extent of recessing of truck taillights.

(2) Survey of the frequency of following distances that produce partial or complete obscuration of taillights.

(3) Experimental studies, evaluating the degree of impairment for detection of partially obscured taillights.

Side Turn Signals

Description. The long length of truck trailers creates a need for side mounted turn signals. Side mounted signals give passing motorists an indication that a truck may be turning. (A cost/benefit analysis has shown substantial net benefits of side turn signals [Farber, Grush, and Relabek, 1976]). Dwyer (1988) estimates that this valuable addition is installed on about 85% of all trucks currently being built. However, the placement of these lights can lead to problems for passing truck drivers. These lights are frequently mounted under the bed of the truck. Because of the higher seating height of truck drivers, the recessed side turn signals may be partially or fully obscured by the bed of the truck (see the discussion in the previous section on recessed taillights). Because the lateral separation of vehicles is generally smaller than the longitudinal separation, the obscuration of recessed side turn signals is likely to be more frequent than the obscuration of recessed taillights.

Potential countermeasures. The potential countermeasures listed under the preceding section (Recessed Taillights) apply here as well.

Potential research topics.

(1) Estimation of the frequency of partial and total obscuration of recessed side turn signals when viewed by truck drivers from the adjacent lane.

(2) Assessment of constraints on the mounting positions of side turn signals.

Increased Seating Height Leading to Increased Brake Reaction Times

Description. The average seating height of a truck driver is substantially above the seating height of a car driver (Olson, Cleveland, Fancher, Kostyniuk, and Schneider, 1984). Consequently, the standard rear lights of all vehicles (as well as the supplemental high-mounted stop lamp of automobiles) are below, rather than directly in, a truck driver's horizontal line of sight. It is known that driver reaction time to visual stimuli is generally a monotonic function of the visual angle between the point of fixation and the relevant stimulus (Cohen, 1984). The higher seating height of truck drivers may therefore cause them to have longer reaction times to brake lights, relative to car drivers. This problem is compounded by the fact that trucks have longer stopping distances (Olson et al., 1984). Additionally, the difference in the relevant visual angles between car and truck drivers will be greatest when the lead vehicle is close, precisely in the conditions when short reaction time is most critical.

Potential countermeasures. Increasing the mounting height of rear lights of cars (beyond the height of the high-mounted stop lamps) is probably not feasible because of space limitations. On the other hand, on trucks there is more available space above the current locations of rear lights. Alternatively, driver education, stressing the fact that reaction time to the same stimulus (i.e., brake lights on a car ahead) will be different depending on whether one is driving a car or a truck, could be of value.

Potential research topics.

(1) Determination of the size of the difference in brake reaction times for the two geometrical situations of interest.

(2) Assessment of truck drivers' introspections concerning differences in their reaction time as a function of the vehicle they are driving.

Relatively Slow Speed on Hills and After Entering a Highway

Description. Truck speed is more influenced by hills than is car speed. Furthermore, it takes trucks much longer to get up to speed when they enter a highway. An encounter with a truck that is moving substantially slower than the rest of traffic can be surprising and potentially dangerous.

Potential countermeasures. Consideration should be given to an automatic slow-vehicle warning system. Such a system would be activated at low speeds, provided that the brakes are not applied. The system could consist of a dedicated lighting device. A problem with this approach is that low speed is relative: on limited-access highways with a speed limit of 100 km/h low speed might be 80 km/h, while on city streets it could be 30 km/h. Furthermore, the informativeness of such a device may depend on it being universal: vehicles without it (older trucks during introduction and cars) might be at a disadvantage. An alternative countermeasure would involve a unique truck indicator. This could be provided by an additional amber presence light. Over time, the drivers would learn that the amber (non-flashing) light was associated with trucks. Since "amber (yellow)" is already being used as a warning color, the connotation of possible danger would be effective from the outset.

Potential research topics.

(1) Survey of the speed distributions of cars and trucks in hilly areas, and shortly after they have entered a highway.

(2) Laboratory investigation of the potential benefits of an automatic slow-vehicle warning device.

(3) Field study investigating the effects of an automatic slow-vehicle warning device on accident rates of trucks and other vehicles.

(4) Laboratory study on the effect of the additional amber taillight on the discriminability of cars and trucks. The key question here would be: Is the proposed amber light more effective than the current identification lights?

Misperceived Distance Due to Misperception of Clearance Lights as Taillights

Description. Clearance lights are mounted on top of trucks to improve the visibility of trucks. However, in certain circumstances these clearance lights may be perceived as taillights. This misperception may occur especially in low-visibility conditions when the visibility of taillights is obscured but clearance lights (but not the identification lights) are visible. There are two reasons clearance lights may, in certain situations, be more visible than taillights. First, the dirt from rain or snow road spray often coats the lenses of the taillights, making them appear dimmer, but has less of an effect on the higher-mounted clearance lights. Second, the road spray itself can obscure the taillights more than the clearance lights. If the taillights of a truck are not visible, the clearance lights may be perceived as taillights. Because the clearance lights are higher in the visual field than the actual taillights, the distance to the vehicle ahead can be misperceived as greater than the actual distance. Height in the visual field is known to be an effective distance cue in laboratory studies (Epstein, 1966), and it may be especially important in an impoverished visual environment (such as at night or in inclement weather) in which other distance cues are not available.

Potential countermeasures. A potential countermeasure is to make clearance lights and taillight systems very distinct from each other. For example, clearance lights could be made amber instead of red.

Potential research topics.

(1) Study to determine the identifiability of current clearance and rear lighting systems. This could involve a laboratory simulation of the low-visibility conditions described above.

(2) Distance estimation study, to assess the extent of the potential misperception of distance.

Misperceived Distance Due to Misperception of Truck Taillights as Car Taillights

Description. Truck taillights are typically mounted higher than car taillights. Crosley and Allen (1967) argued that the higher-mounted taillights of trucks might be perceived as taillights of a more distant car. (This presumed effect would be mediated by the same mechanism that could produce misperceived distance because of misperception of clearance lights as taillights, discussed in the previous section.) Furthermore, Crosley and Allen argued that this effect is more pronounced for small lateral separations of the lights, or if the output of the lights is reduced because of dirt.

Potential countermeasures. A potential countermeasure would involve increasing the light output of truck taillights. This would eliminate the dimness of truck lights that may contribute to the misperception. The increase in intensity also may be an aid in distinguishing between trucks and cars. Another possible measure is to make truck taillighting systems distinct from car lighting systems. A unique truck indicator, such as the additional amber presence light described in the section on "Relatively Slow Speed," could fulfill such an objective. Finally, mounting truck taillights at the same level as car taillights would presumably reduce or eliminate misperception of distance, but it would likely introduce other problems (e.g., increased dirt accumulation).

Potential research topics.

(1) Distance estimation study, to assess the extent of the potential misperception of distance. The relevant factors in such study would be the mounting height, lateral separation, and light output of the taillights.

(2) Laboratory study on the benefits of an additional amber taillight on the estimation of distance.

(3) Survey of the extent of dirt deposits on truck taillights.

Lack of Center High-Mounted Stop Lamp

Description. Center high-mounted stop lamps (CHMSLs) have been required equipment on all passenger cars (but not trucks) sold in the U.S. since September 1, 1985. The initial evaluation of the effectiveness of this device indicates that it reduces the likelihood of rear-end collisions by 22% (Kahane, 1987). There are three possible explanations for the benefit of CHMSLs. First, the location of the CHMSL is generally closer to the line of sight of following drivers than are the standard (low-mounted) stop lamps (Sivak, Conn, and Olson, 1986). Consequently, reaction time to brake signals from CHMSLs should be faster than to signals from standard stop lamps (Cohen, 1984). (The reaction-time benefit has been shown to be present even for the second and third vehicle behind the initial braking vehicle [Schmidt-Clausen, 1977]). Second, since a CHMSL is a dedicated lamp (functioning *only* as a stop lamp), when it is energized it unambiguously conveys the "stop" message. Third, CHMSLs are less likely to be coated by dirt, since they are mounted higher than standard stop lamps.

Regardless of which of the three explanations constitutes the mechanism for the benefits of CHMSLs on cars, it is apparent that CHMSLs on trucks would likely result in a reduction of accidents in which trucks are rear-ended. There is an additional likely mechanism for the benefits of CHMSLs for trucks: Because trucks frequently brake continuously for an extended period of time, at night drivers following trucks without CHMSLs are less likely to see the transition from presence to stop signals. Finally, as more and more cars become equipped with CHMSLs, vehicles without them will be at an additional disadvantage, since drivers might rely heavily on CHMSLs for the conveyance of the "stop" message.

Potential countermeasure. Installation of CHMSLs on trucks.

Potential research topics.

(1) Laboratory assessment of the ambiguity of the message conveyed by the stop-signal systems on trucks with and without CHMSLs.

(2) Laboratory evaluation of the potential savings in brake reaction times to stop signals on trucks equipped with CHMSLs.

Reduction in Voltage in Long Wire Runs to Trailer Lamps

Description. The long wire runs on tractor trailers sometimes result in significant voltage drops at rear lamps. Such a situation leads to a reduction in lamp output, and thus to a reduction in lamp effectiveness. However, it is possible that the reduction in light output is made less important by the longer stopping distances of trucks.

Potential countermeasures.

(1) Increase in the thickness (i.e., decrease in the gauge) of the wire for long wire runs.

(2) Installation of higher wattage bulbs.

(3) Setting standards that would take into account the expected variance in voltage.

Potential research topics.

(1) Survey of the actual voltage at rear lamps for a variety of truck/trailer configurations.

(2) Evaluation of the net effect of the increased reaction time to truck rear lamps (due to reduced light output), and the increased stopping distance of trucks on the likelihood of rear-end collisions involving trucks.

(3) Cost evaluations of the the above-indicated countermeasures.

Maintenance Problems with Top-Mounted Rear Lights

Description. As indicated by Dwyer (1988), maintenance of top-mounted identification and clearance lamps is "difficult, costly, and, at times, dangerous" (p. 86). Consequently, lamps with long expected life would be highly desirable. Some progress has already been made by improving shock resistance of the lamps, and by improving the protection of the lamps from corrosion (Dwyer, 1988). However, additional improvements in this area would be welcomed.

Potential countermeasures. One possible solution to the maintenance problem of top-mounted rear lamps would be the use of longer-lasting light emitting diodes (LEDs). However, in comparison to tungsten lamps, LEDs have several disadvantages. First, they are relatively expensive. Second, the choice of colors is somewhat limited. (This may not be a problem for automotive lighting and signaling, which relies only on red and amber.) Third, their light output is affected by very low ambient temperatures (Dwyer, 1988). Another alternative is to run tungsten lamps at a slightly lower temperature. This would prolong their life, albeit at some cost in their effectiveness. Finally, considerations should be given to placement of the bulbs, whenever possible, from inside of the truck. This would substantially facilitate access to the bulbs by reducing the mounting height (relative to the inside platform).

Potential research topics.

(1) Since an LED rear light is made up of several LEDs, determination of what constitutes a failure would be of importance (Dwyer, 1988).

(2) Determination of the frequency of exposure to very low ambient temperatures (at which there is substantial drop in light output of LEDs).

(3) Evaluation of potential problems with replacing bulbs that are mounted from inside the truck (e.g., gaining access in a loaded truck).

Decreased Conspicuity of Flatbed Trucks

Description. Federal regulations require that trucks have top-mounted outboard clearance lamps (one on each side) and an inboard cluster of three identification lamps. However, because of space limitations, flatbed trucks are exempted from these requirements. The lack of top-mounted lamps results in somewhat reduced conspicuity of flatbed trucks viewed from the rear (Ziedman, Burger, Smith, Mullholand, and Sharkley, 1981). The reduced conspicuity, in turn, has been suggested as the explanation for the increased involvement of flatbed trucks in nighttime rear-end collisions (Carsten, Schultz, and Campbell, 1987).

Potential countermeasures. If, indeed, the decreased conspicuity of flatbed trucks is the reason for their overinvolvement in nighttime rear-end collisions, then improvements in the lighting and signaling of flatbed trucks would be desirable. Such improvements could take the form of higher light output for the existing lamps, or installation of additional lamps.

Potential research topics.

(1) Quantification of the conspicuity handicap of flatbed trucks in relation to other types of trucks.

(2) Experimental determination of the changes in rear lighting of flatbed trucks (e.g., increased light output of the existing lamps) that would compensate for their decreased conspicuity.

Increased Seating Height and Headlamp Performance

Description. The increased seating height of truck drivers affects the nighttime brightness of retroreflective traffic signs. The problem arises because retroreflective sign materials reflect most of the incident light back at the angle of incidence. In this case, most of the light is reflected back to the location of the headlamps. For car drivers this is almost optimal, since the angles formed by the locations of car drivers' eyes, traffic signs, and headlamps are relatively small. For truck drivers the situation is substantially different. Because of their increased seating height, those angles are relatively large. Consequently, the amount of light reflected back to the eyes of the truck driver is substantially smaller than for a car driver.

Let us assume the following typical situation. The traffic sign is at a distance of 137 m, mounted 3.25 m to the right of the left headlamp and at the height of 2 m. The mounting height of the headlamps is .7 m for the car and 1 m for the truck. The eye height is 1.1 m for the car driver and 2.45 m for the truck driver. The lateral separation between the eyes of the driver and the left headlamp is .35 m in both vehicles. The drivers of both vehicles sit 1.8 m behind the headlamp. (For cab-over trucks this distance is smaller, but the effect of this variable on the angle of interest is negligible.) The resulting observation angle (the angle between the eye position, traffic sign, and headlamps) is .24° for the car driver and .63° for the truck driver. For a typical encapsulated-lens traffic sign material, this difference in observation angle results in a reduction of about 56% of the light (from the left headlamp) for the truck driver (in relation to the light reaching the car driver). The analogous computations for the right headlamp (with an assumed lateral separation of .9 m between the eyes and the lamp for both drivers) yields the corresponding angles to be .40° for the car and .71° for the truck, with the resulting reduction of 60% in the returned light. (To the extent that headlamps are mounted wider apart on trucks than cars, the above calculations are conservative.)

In addition to the decreased brightness of traffic signs, the changed geometry also has pronounced effects on the brightness of retroreflective materials worn to enhance conspicuity of other traffic participants (e.g., pedestrians and bicyclists).

Potential countermeasures. Decrease the observation angle by increasing, whenever possible, the mounting height of truck headlamps.

Potential research topics.

(1) Survey of the observation angles for cars and trucks.

(2) Evaluation of the decrement in conspicuity and legibility of traffic signs for truck drivers.

(3) Evaluation of the decrement in conspicuity of pedestrians and bicyclists for truck drivers.

(4) Evaluation of the effects of the headlamp mounting height on glare.

Inclement Weather and Headlamp Performance

Description. As discussed above, trucks are driven more often through inclement weather than are cars. Consequently, deposits of dirt on headlamps should be more substantial on trucks. If that is the case, then truck headlamps (due to the increased light scatter) would be more glaring to oncoming traffic and to preceding traffic via rearview mirrors. Additionally, the increased light scatter might result in somewhat reduced visibility for truck drivers. However, the increased mounting height of truck headlamps might, to some degree, counteract the increased glare and reduced visibility.

Potential countermeasures.

(1) More frequent cleaning of truck headlamps.

(2) Use of headlamp washing systems.

Potential research topics.

(1) Survey of the extent of the dirt problem on truck headlamps.

(2) Computer simulation of the combined effects of increased dirt and increased mounting height on glare and visibility.

Effects of Higher-Mounted Headlamps

Description. Truck headlamps are mounted generally higher than car headlamps. This situation has several, somewhat contradictory, implications for trucks and truck drivers.

(1) Longer visibility distances for *non-retroreflectorized* targets.

(2) More glare to oncoming drivers.

(3) More rearview-mirror glare to the preceding traffic.

(4) Less dirt on headlamps, with resultant less light scatter and, consequently, less glare to the other traffic participants.

Potential countermeasures. It is not clear whether a change to the current situation is desired (see the next paragraph).

Potential research topics. The higher-mounted truck headlamps appear to have both positive and negative consequences. Therefore, a comprehensive, quantitative evaluation of all effects would be desirable. Such an evaluation would determine whether the net effect is positive or negative, and would therefore indicate whether countermeasures are needed.

Vehicle Load and Headlamp Aim

Description. Correct aim of vehicle headlamps depends on the pitch of the vehicle, which in turn is affected by vehicle load and acceleration/deceleration. For a given truck, there might be substantial pitch differences between the loaded and empty conditions, leading to substantial differences in headlamp aim. A consequence of misaim upward is increase in glare to other traffic, while misaim downward results in reduced visibility for the truck driver (Bhise, Matle, and Hoffmeister, 1984).

Potential countermeasures.

(1) Manual control of headlamp beam angle (Holmelius, 1984).

(2) Automatic headlamp-leveling devices (Schmidt-Clausen, 1984).

Potential research topics.

(1) Survey of headlamp aim of trucks in actual use. (An analogous survey has recently been performed for cars [Olson and Winkler, 1985].)

(2) Computer simulation of the effects of truck headlamp misaim on glare and visibility, using a computer model such as CHESS (Bhise, Matle, and Hoffmeister, 1984).

(3) Evaluation of the sensitivity of headlamp aim on vehicle load as a function of truck type (e.g., straight truck vs. tractor trailer).

Relatively Short Life of Truck Headlamps

Description. Trucks accumulate mileage faster (on a per year basis) than do cars. Much of this additional exposure is during nighttime. Consequently, truck headlamps have to be replaced relatively often.

Potential countermeasure. High-intensity-discharge (HID) sources are now being considered for use in vehicle headlighting. One of their major advantages (in comparison to tungsten sources) is the substantially longer life. While there are still several areas of potential concern with HID headlamps (e.g., color rendition of objects [Simmons, Sivak, and Flannagan, 1989]), application of HIDs for truck headlighting should be explored.

Potential research topic. Cost/benefit analysis of the use of HID lamps in comparison to halogen lamps.

REARVIEW MIRRORS

Weather Effects on Rearview Mirrors

Description. Rearview mirrors are used in all types of weather conditions. However, trucks are driven more often in inclement weather conditions than cars (since truck drivers generally do not have the luxury of selecting the time of day or the day of travel). Furthermore, trucks tend to be driven for longer periods of time without a stop. This poses a problem when mirrors ice up or become frosted. The problem is compounded by the usual absence of inside rearview mirrors in trucks. The iced or frosted mirrors can lead to potentially dangerous errors in estimating distances and/or lateral positions of following vehicles.

Potential countermeasure. A solution to this problem would be to install heated outside rearview mirrors.

Potential research topics.

(1) Laboratory evaluation of the decrement in distance and location estimation when viewing objects through an iced or frosted rearview mirror.

(2) Evaluation of the benefits of heated mirrors on distance and location estimation.

(3) Evaluation of the frequency with which weather effects on mirrors occur in different parts of the country.

Increased Area of Blind Spots

Description. As seating height of a truck driver increases, so does the extent of blind-spot areas (Daigo, Yokoi, and Nakano, 1982) and the need for larger rearview mirrors (Burger and Mullholand, 1982). This problem is especially acute on the passenger side. As Olson and Post (1979) have pointed out "it is possible for one or more passenger cars or even a small truck to be in these areas and not be visible to the operator [of the truck]" (p. 1). The reason for the increased blind-spot areas is that, in comparison to cars, the seating height and the windows on the doors are substantially higher. Conventional mirror systems do not fully eliminate these blind spots.

Potential countermeasures.

(1) Low-mounted portholes in doors on the passenger side.

(2) Mirrors mounted *forward* on the passenger side of the truck. This is an option only for conventional (engine forward) trucks.

(3) Properly located convex mirrors (for cab-over trucks).

(4) Periscope mirror systems (Satoh, Yamanaka, Kondoh, Yamashita, Matsuzaki, and Akizzuki, 1982).

(5) Video systems, providing information about the blind areas.

Potential research topics.

(1) Computer simulations and experimental investigations of fields of view for conventional and cab-over trucks, with and without low-mounted portholes.

(2) Computer simulations and experimental investigations of fields of view for conventional (engine forward) trucks, with and without forward-mounted mirrors.

Absence of Inside Rearview Mirrors

Description. A potential problem for truck drivers is glare from outside rearview mirrors. Although truck mirrors are higher up (and thus do not produce as much glare as car mirrors), they can pose a problem especially when being followed by another truck (with headlamps mounted relatively high). When the outside mirror is producing glare, the truck driver does not have the option of using the inside mirror as a car driver does, since trucks generally do not have inside mirrors. This can be a problem in certain situations, such as estimating distances of following vehicles.

Potential countermeasures. Potential solutions to this problem include the use of dual-setting prism mirrors or continuously-changeable mirrors. Such options would allow the truck driver to use the outside mirror even in the presence of glare.

Potential research topics.

(1) The primary issue is to determine whether the potential problem described above is real, or whether the increased seating height eliminates the problem. This could be ascertained by field measurements of illuminance reaching the eyes of truck drivers through the outside mirrors.

(2) If the above investigation indicates that substantial glare values are present despite the greater mounting height of mirrors, the extent of the impairment--in terms of disability and discomfort glare--should be evaluated.

(3) Research to determine whether the problem (if it is a problem) can be eliminated by reducing the reflectivity levels of mirrors.

Aerodynamic Reasons for Splash Being Attracted to Truck Mirrors

Description. Dick et al. (1985) argue that "the problem of road splash covering the mirrors is getting worse as vehicles become more aerodynamically efficient" (p. 13). Furthermore, the relatively large size of truck mirrors might contribute to this effect. Because there are usually no inside mirrors in trucks, splash and the associated reduction in visibility through the outside mirrors are more important for trucks than cars. The problem is further compounded by the fact that trucks are used for longer periods of time in adverse weather conditions.

Potential countermeasure. Dick et al. (1982) suggest the use of air deflectors mounted around the borders of the mirror as a way to eliminate the low pressure that presumably attracts splash.

Potential research topics.

(1) Field evaluation of the magnitude of the "splash on mirrors" problem for trucks.

(2) Computer simulations of the effect of air deflectors on pressure around truck mirrors.

CONCLUSIONS

In the context of optimal truck lighting/signaling and rearview mirrors, this report examined a variety of differences between trucks and cars, and their operating environments. Table 1 summarizes the findings in terms of the relevant differences and the potential safety implications of these differences. Future experimental research should (1) quantify the extent of the problems, (2) determine potentially effective countermeasures, and (3) evaluate the cost/benefits of these countermeasures.

TABLE 1

Vehicular and Environmental Differences Between Trucks and Cars, and Their Potential Safety Implications

Relevant Difference	Potential Safety Implications
Recessed rear or side lamps	Reduced visibility of rear or side signals
Increased seating height	Increased reaction time Decreased effectiveness of headlamps for retroreflective targets Increased area of blind spots
Slow speed and acceleration	Greater closing speeds
Higher-mounted taillights	Less accurate distance perception
Top-mounted clearance lamps	Less accurate distance perception Maintenance problems
Lack of center high-mounted stop lamps	Reduced effectiveness of stop signals
Long wire runs to rear lamps	Reduced effectiveness of rear lights
No clearance or identification lamps on flatbed trucks	Decreased conspicuity of flatbed trucks
More frequent usage in inclement weather	Reduced effectiveness of rear signals Reduced effectiveness of rearview mirrors
Higher-mounted headlamps	Improved visibility Net effect on glare uncertain (height in itself increases glare but height also reduces the amount of likely dirt deposits and thus it reduces glare)
More substantial variations in vehicle load	Increased variability of headlamp aim and consequent reduction in headlamp effectiveness
Greater annual mileage	Reduced life of headlamps
No inside rearview mirror	Increased effective glare
Aerodynamic differences	Increased deposits of splash on rearview mirrors

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