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Contents

The issues of rollover crashworthiness of heavy trucks and the design of appropriate roll prevention and protection devices for these vehicles were examined by UMTRI and presented by Winkler et al. (*35*). The vehicle models used in the study were based on the TruckSim truck dynamics simulation package, developed at UMTRI. Simulations of a selected set of vehicles were developed to study their dynamics when subjected to maneuvers that caused them to undergo rollover.

In the 1990s, the industry addressed the truck occupant protection issue under the auspices of the Crashworthiness Task Force of the SAE Truck Occupant Protection Committee. That group spearheaded an SAE cooperative research project (CRP) that developed a series of SAE recommended practices (SAE J2418–J2426), which detail heavy-truck cab-testing procedures. The test procedures were based on heavy-truck accidents in which a truck occupant fatality occurred. The underlying research work that was the basis for those RPs is described in a three-volume set of reports from the Heavy Truck Crashworthiness Cooperative Research Project (CRP-9, CRP-12 and CRP-13), which are available through SAE. The first volume (CRP-9) is the accident investigation work. The other two deal with a finite element evaluation of a truck cab in a rollover simulation (CRP-12) and the development of the recommended practices (CRP-13).

PROTECTING OTHERS

A study of fatal crashes between large trucks and cars by the Insurance Institute for Highway Safety estimated that front, rear, or side underride occurred in half of these crashes (*36*). A federal rule to upgrade the rear impact guard standard for new trailers took effect in January 1998. Underride in frontal collisions continues to be a major problem.

Overall, a collision of a light vehicle with a truck is more than twice as likely to produce a K or an A injury in the light vehicle than a collision with another light vehicle. The aggressivity of trucks is caused by their greater mass, the geometric mismatch between trucks and light-vehicle structures, and greater stiffness of trucks in comparison with light vehicles (*37*). Some general concepts as possible countermeasures have been proposed by UMTRI to improve the crash outcomes for light-vehicle occupants in collisions with heavy trucks (*38*). These are front underride prevention, a crash-attenuating truck front structure, a deflecting front structure, and a layered application of these countermeasures.

From the analysis of crash data, observation of crash damage, and collision and injury modeling analysis, when the impacting light vehicle underrides the front of the truck, the injuries to its occupants are likely to be severe, with a high probability of fatality. Further, the largest number of fatal crashes results from collisions with the front of the truck. The prevention of front underride may be accomplished either through changes in the truck frontal structure to ensure that these structural members are low enough to engage the crash-absorbing mechanism of the light vehicle or through the use of properly designed underride guards added to the existing truck structure. The analysis in the UMTRI study showed that a reduction of 27% to 37% in fatalities could be possible through prevention of front underride (*39*).

Once frontal underride is prevented, crash outcomes can be improved through proper management and dissipation of the collision energy. There are several examples of innovative truck structures that can perform such an energy dissipating function. These include front underride guards that are designed to deflect and absorb collision energy, truck fronts built of collapsible structural members, and an add-on (mounted on existing truck structure) crash attenuator. With more radical changes in truck design (changes in position of the truck engine, cab and associated structural members), it may be possible to achieve crush distances of as much as 12 ft, and it is estimated that a 25% to 50% reduction in fatalities can be achieved (*40*).

Another method of managing the collision energy is to deflect the impacting vehicle through the use of an appropriately designed truck structure. This produces large reductions in the collision energy absorbed by the light vehicle and greatly improves (46% to 72% fatality reduction) the resulting injury outcomes. The greatest drawback of this countermeasure is the possibility of secondary collisions, and further analysis of this aspect must be undertaken before adoption (*41*). Several distinct countermeasures could be used simultaneously in a layered system of aggressivity reduction to provide greater improvements in crash outcomes (*42*).

According to the National Center for Statistics and Analysis, in 2001 there were 438 fatalities and an estimated 3,000 injuries to nonvehicle occupants (this includes pedalcyclists) in crashes involving a large truck. The majority of these are pedestrians. As for fatalities, this number represents approximately 2% of the total number of fatalities in large-truck crashes (*43*). As part of intelligent vehicle systems, CWSs that include pedestrian detection and warning and back-up warning systems have been proposed. These could be applied to heavy vehicles in order to prevent collisions with pedestrians. However, little research to date has been done for heavy vehicles in this area.

TECHNOLOGY DEPLOYMENT

There are significant differences between the way light-duty passenger and medium- to heavy-duty CMVs are produced and sold that have profound effects on efforts to introduce new technologies into these vehicle populations. First and most important are the sheer size and the resulting economies of scale, or conversely, the lack thereof, which exist in the two markets. Approximately 17 million light-duty passenger vehicles are sold in the United States every year, compared with approximately 0.5 million medium- to heavy-duty vehicles (GVWR >10,000 lb). For Class 8 vehicles (GVWR >33,000 lb), the vehicle population that is the focus of most CMV safety efforts, the corresponding figure is only about 175,000 produced each year. Unless there are parallel applications in the light-duty market near total market penetration is necessary for any new technology in order to achieve sufficient volumes to ensure the economic viability of the product given the comparatively small size of the commercial market. While there are examples of successful niche marketing of products, it is extremely difficult to obtain sufficient market penetration—especially of purely safety-related products—unless there is nearly universal market recognition and acceptance of the need and the value of a given technology.

CMVs are not consumer products as automobiles are but are considered capital equipment used by businesses to perform business functions. Because they are bought for a specific business application, buyers demand that manufacturers enable them to highly tailor the designs of the vehicles that they purchase in order to obtain the specific performance and functionality they need. Often, the drivers of CMVs are not the same as their buyers. In these cases, there is great emphasis on economics. Buyers are very cost conscious and tend not to specify equipment or technologies that they do not perceive will yield direct and immediate economic benefit to them. Thus, unlike light-duty vehicles, for which manufacturers can push advanced technologies into the market, particularly on higher-priced luxury models, CMV buyers need to be convinced ahead of time that the cost, functionality, and performance of new technology will yield measurable benefits before they will opt to purchase it.

An added complication for safety technologies is that the beneficiaries of heavy-truck safety are primarily other drivers, not the owners or drivers of the trucks. In a highly competitive business atmosphere, truck buyers are not easily motivated to purchase new technologies solely for the public good. Added equipment must also contribute to their company's profitability in some way and thereby enable them to compete with other companies that have not purchased the same technologies. For this reason, many new safety technologies that are developed and demonstrated are very slow to be deployed. Those safety devices that do gain widespread acceptance generally have secondary–ancillary functions or capabilities that offer a short-term payback to the buyer.

Given these realities, the federal government plays an important role in the process of introducing new safety technologies into the commercial market. Large demonstration programs, involving broad involvement of all the suppliers of a given technology and all the medium- to heavy-truck manufacturers are essential to creating both a sufficient body of data and evidence that a product or technology performs well, in addition to a sense within the industry that the product will be cost-effective and, therefore, worth buying. It is a difficult task to create this critical mass and one that often only the government can accomplish.

In some cases, regulation may be the only way to achieve significant deployment. Even when there is a general consensus that the total benefits of introduction of a new safety technology would outweigh the total costs, there is still the problem of convincing individual vehicle buyers to pay for societal benefits. A regulatory requirement would level the playing field by requiring all companies to buy the equipment and thus eliminate the competitive financial disparity. Regulations are always controversial. It is extremely difficult to quantify the benefits of a technology before the fact. Also, when new technologies are introduced, current buyers pay for future benefits. Finally, there is the issue of individual privacy versus public benefit. For example, more extensive driver monitoring may be beneficial to society in general but may intrude on individual drivers' privacy rights.

SUMMARY

The basic technologies now exist to create trucks and buses that can continuously measure and react to their environment, surrounding traffic, and driver status and actions. Technologies can make these vehicles perform better in response to drivers' commands, keep drivers alert and better informed of possible safety threats, and even take actions independent of drivers. Onboard monitoring of virtually everything in, on, and around the vehicle is possible, and this information can be transmitted anywhere in the world. While research to refine these basic vehicle technologies is certainly necessary, the biggest challenges for the future appear to be in addressing concerns such as benefits, costs, and privacy issues. Even when the overall benefits to society clearly outweigh the costs, implementation of new technologies is often extremely slow, because those who have to pay for the equipment are typically trucking companies but the beneficiaries are predominantly passenger car drivers. Furthermore, costs are often imparted today for benefits that will be realized only at some future date.