

SAVING LIVES THROUGH RESEARCH AND TESTING

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

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Traffic fatalities account for more than 90 percent of all transportation-related deaths. The National Highway Traffic Safety Administration has been charged with reducing the number of these fatalities by conducting research to improve motor-vehicle and traffic safety, diagnose specific problems, and evaluate their effects. This research has resulted in technical information and motor-vehicle safety standards leading to better crash protection for motorists. Several of the agency's major research efforts and benefits are described below.

FRONTAL-PROTECTION RESEARCH

The National Highway Traffic Safety Administration Authorization Act of 1991 requires that air bags with lap and shoulder belts be provided for both front outboard seating positions in all passenger cars manufactured for sale in the United States after September 1, 1997. Light trucks, multipurpose passenger vehicles, and buses must be similarly equipped.

The detailed performance requirements for these systems are contained in Federal Motor Vehicle Safety Standard (FMVSS) No. 208, Occupant Crash Protection. One such requirement is crash testing in which a vehicle is towed into a rigid barrier at speeds up to 48 kilometers per hour (30 miles per hour) and at angles between the perpendicular and plus or minus 30 degrees off the perpendicular. In "successful" tests, measures of injury recorded from the 50th percentile "adult" dummies indicate that drivers and front-seat passengers will not be seriously harmed in most frontal impacts where the car structure is reasonably intact.

It is projected that once all cars on the road are equipped with air bags, frontal impacts will continue to account for as many as 8,000 fatalities and 120,000 moderate to critical injuries per year. The objective of NHTSA's Frontal Protection Research Program is to reduce the number of these fatalities and injuries. To that end, the program will provide a basis for the possible upgrade of FMVSS No. 208 injury criteria and test devices as well as supplementary test procedures that can be used to evaluate occupant injuries in high-severity crashes.

Research to define the remaining safety problems associated with the frontal impacts of an all air-bag fleet has been initiated. These studies involve investigation of the real-world crash environment and projection of occupant injuries. The next step will be to evaluate and compare the performance of a variety of production vehicles under crash conditions and to conduct assessments of potential benefits to guide the agency in the "final" selection of a test procedure(s).

To project occupant injuries and to identify general laboratory-test conditions that can be used to analyze the safety performance of baseline vehicles, the agency examined files from its National Automotive Sampling System (NASS), a statistical sample of tow-away crashes investigated in detail. Between 1988 and 1995, NASS teams investigated 39,682 crashes, representing an estimated 18 million crashes and 16.6 million injured vehicle occupants nationwide. In these crashes, 2,181 of an estimated 785,932 air-bag deployments during that period were investigated. Data analysis reveals that the pelvis/leg region is at almost twice the risk for moderate injuries as other body regions and that the head and thorax regions are at nearly the same risk for severe injuries.

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NHTSA Allows Manufacturers to Use Lower-Powered Air Bags

In March, as part of a comprehensive air-bag strategy to reduce the risk of death and injury to children and small adults in low-speed crashes, the National Highway Traffic Safety Administration amended its crash protection standard to give manufacturers additional leeway in producing less powerful air bags. In announcing the change, NHTSA Administrator Ricardo Martinez reported that the agency had devised the interim solution to preserve the benefits of air bags while minimizing the risk to children and smaller adults. He also noted that the best safety advice remains the same: drivers and passengers should always buckle up, and children 12 and under should ride in the back seat.

The agency estimates that from 1986 to February 1997, air bags saved the lives of more than 1,750 drivers and passengers. Nevertheless, NHTSA has identified 62 crashes in which the deployment of an air bag resulted in fatal injuries to drivers or passengers, including 38 children. The use of lower-powered air bags could have prevented many of the fatal injuries to these individuals, most of whom were unbelted or improperly belted.

As a result of the change in the agency's crash protection standard, manufacturers have been allowed to depower air bags by 20 to 35 percent. In addition, they have been given the opportunity to perform a new air-bag testing procedure. Under the current procedure, vehicles are propelled into a barrier at 48 kilometers (30 miles) per hour. Under the optional procedure, vehicles may be mounted on a sled that is accelerated at a rate approximating the forces experienced in a crash. The effect on crash-test dummies is measured in the same way as in the standard barrier test, but a new safety criterion, one concerning neck injuries, is specified for the optional test.

Although the interim action of allowing air-bag depowering will promote safety, as a long-term solution manufacturers and suppliers are working on a variety of advanced technologies to tailor air-bag deployment on the basis of factors such as crash severity and the size and position of vehicle occupants. In addition, NHTSA is working on rules to require the development of more advanced air bags on a phased-in schedule.

Traditionally, fatality reduction has been the emphasis of the Frontal Protection Research Program. More recently, however, attention has focused on reduction of injuries that lead to life-long disabilities, such as lower extremity and pelvic injuries in frontal crashes. A supplementary test to the full-barrier test procedure for increased frontal protection should simulate crash modes that result in the highest frequency and risk of injury and fatality. Because FMVSS No. 208 sets performance requirements for full-frontal impacts, analysis focused on frontal-offset impacts as candidate crash modes for simulation. The crash analysis has been coupled with offset-crash testing to determine which impact configurations produce the highest likelihood and frequency of injury or fatality.

Analysis of NASS data is ongoing, and case reviews of Fatal Analysis Reporting System data

are being initiated. The findings to date have led to the preliminary recommendation that a test procedure be developed to simulate a moving car-to-car, frontal-offset crash. No such crash is included in the test procedures being developed in Europe or in the procedures currently used by the Insurance Institute for Highway Safety. As a result, the effects of vehicle mass in a car-to-car crash cannot be taken into account. Moreover, the time to peak acceleration in car-to-barrier tests is substantially longer in duration than that observed in car-to-car tests, indicating a "softer" crash pulse than that experienced in a car-to-car crash.

In the NHTSA tests, occupants using a seat belt with an air bag are unlikely to sustain serious head or chest injuries in the absence of severe intrusion. However, crash-data studies and crash-test results indicate that lower-extremity injuries often occur in offset crashes. To date, the limited number of air-bag crash investigations has precluded a full quantitative description of the serious injury and fatality problems that will remain after an all air-bag fleet is on the road. Therefore, additional air-bag crash-data analysis and a full range of more severe frontal-crash tests are under way. At the conclusion of this research, it is expected that a new frontal-crash test, test dummies, and injury criteria will be available for use in developing and evaluating improved restraint and structural concepts for frontal-crash protection in air-bag-equipped vehicles.

TEST-DUMMY DEVELOPMENT

For several years NHTSA's Research and Development Office has actively supported the development of an advanced frontal-crash test dummy that incorporates improved biofidelic features and significantly expanded instrumentation. The primary goal of the dummy-design effort has been the creation of an effective tool for whole-body trauma assessment in a variety of automotive occupant-restraint environments; a concurrent goal has been the incorporation of "user friendly" design features to facilitate ease of use and maintenance of the dummy in the test environment.

Many advanced features have been incorporated into the agency's new dummy. The design of the shoulder and upper torso promotes more realistic interaction of the dummy with seat-belt and air-bag restraint systems. In addition, a new instrumented abdomen can detect dynamic interactions with seat belts (belt intrusion) and air bags (bag slap). In addition, a new neck structure features multidirectional kinematic biofidelity, leading to more accurate head trajectories and velocities. Other significantly

new design approaches are reflected in the face, pelvis, and femur components.

In the late 1980s NHTSA funded the University of Michigan Transportation Research Institute to design, fabricate, and test a new torso system with advanced performance features. The resulting TAD-50M system incorporated many new design elements in the torso region. Tests confirmed that the new torso design significantly enhanced impact biofidelity and offered more realistic thoracic anthropometry.

In the current dummy-development program, problems in the TAD-50M torso were corrected and improvements were made in both its structure and mechanical performance. In addition, advanced representations of the head and face, neck, abdomen, pelvis, and femur were developed; various instrumentation systems were improved; and additional sensors were incorporated so that dummy responses could be correlated to estimates of human-injury potential with greater confidence.

Development of the new frontal-crash test dummy, named THOR (Test Device for Human Occupant Restraint), was begun by GESAC, Inc., under the direction of NHTSA in 1994. The new dummy is superior to frontal-test devices now used to evaluate automotive-safety systems. It reflects significant improvements in body-segment response biofidelity and incorporates an expanded array of specialized transducers selected for their relevance to automotive-injury mechanisms. In 1997 two THOR systems will be leased by the agency for independent evaluation by organizations using their own test facilities and procedures. A major goal is to obtain input from other countries on these systems to gain international acceptance of them.

CRASH-AVOIDANCE RESEARCH

To identify opportunities for significant safety improvement through development of crash countermeasures using intelligent transportation technologies, NHTSA extensively analyzed available crash data. It concluded that about 90 percent of the more than 6 million crashes that occur every year are the result of driver-related factors. Therefore, the agency's crash-avoidance research has focused on the use of technologies to develop intervention strategies and to validate countermeasure systems capable of preventing specific types of collisions as well as to enhance the motorist's capability to drive safely.

Specifically, the agency determines whether the new technologies function as intended and are safe when used in a wide range of driving and environmental conditions. As part of this re-



National Highway Traffic Safety Administration's THOR design represents significant advance in state of the art of crash-dummy-based injury assessment; major goal is to win international acceptance of design.

search, a clear understanding of driver behavior in normal-driving and emergency situations is being developed and the effect of new technologies that could improve visibility or detect drowsiness that could affect the driving capabilities of motorists. Future research will focus on integration of state-of-the-art crash-avoidance systems into intelligent-production vehicles and into operational tests of the vehicles equipped with the systems.

The cost effectiveness of crash-avoidance measures can only be determined if an accurate estimate of the projected safety benefits of the measures is made. On the basis of simulator studies and limited test-track experimental data, the agency estimated that if the entire vehicle fleet were equipped with select systems for avoiding rear-end, road-departure, lane-change, and merge crashes, approximately one-sixth (more than 1 million) of the collisions that occur every year could be prevented. The net cost savings of this reduction in crashes is estimated to be \$25 billion annually.

In spite of measures to prevent them, crashes will inevitably occur. When they do, information about their location and severity could be transmitted to emergency medical-service providers by high-technology sensing and communications systems in vehicles. An automated collision-notification system is being tested in the Buffalo, New York, area.

The system, with which 1,000 cars are being equipped, would be used to convey the medical history of the vehicle occupants, estimates of the severity of their vehicle crashes and resulting injuries, and other vital information to medical dispatch staff, thereby speeding delivery of medical attention.

CRASH-OUTCOME DATA EVALUATION

The Intermodal Surface Transportation Efficiency Act of 1991 required the U.S. Department of Transportation and the National Highway Traffic Safety Administration to conduct a study of the benefits of safety-belt and motorcycle-helmet use in motor-vehicle crashes. Crash Outcome Data Evaluation Systems (CODES) were developed to provide information necessary to evaluate these benefits. The systems link existing statewide police crash, emergency medical, hospital emergency department, hospital discharge, claims, and other data files so that people injured in motor-vehicle crashes can be tracked through the health-care system. On the basis of information about both injured and uninjured persons, the benefits of protective devices for motor-vehicle operators were determined.

The results of the benefits analysis are contained in a 1996 report to Congress (1). The analysis confirmed that safety belts are highly effective in reducing morbidity (the occurrence of any injury) and mortality and in decreasing the severity of injuries. The analysis also revealed that the average inpatient charge for unbelted passenger-vehicle drivers admitted to an inpatient facility as a result of a crash injury was almost \$5,000 greater than the average charge for belted drivers. Although motorcycle helmets are less effective than safety belts in preventing injury or fatality, they are highly effective in preventing brain injuries. The average inpatient charge for a motorcyclist who sustained a brain injury is more than twice the average charge for motorcyclists receiving inpatient care for other injuries.

Some states have made important discoveries analyzing statewide, population-based CODES data. Wisconsin and New York reported that older drivers are more likely than younger drivers to be injured inside a vehicle and to experience chest injuries, which entail high costs. Missouri observed that regardless of the specific crash characteristics, costs were highest for upper-leg injuries and only slightly lower for pelvic, head/neck, abdomen, and chest injuries. Missouri reported that in rural areas a 120-minute or longer delay in emergency medical-service response results in poor patient outcomes, as defined by increased hospitalizations, more serious injuries, and so on. New York found that in one

county the risk of hospitalization and higher costs increased 10 percent when emergency medical-service response time was greater than 60 minutes. Utah determined that safety-belt users who received treatment were less likely to need bleeding control, cervical immobilization, intravenous placement, oxygen therapy, spinal immobilization, and ventilation than people who were unbelted. Missouri identified higher ejection, serious injury, and death rates for pickup-truck drivers with a comparatively low belt-use rate and used the information to support legislation mandating safety belts in pickup trucks.

NHTSA continues its efforts to promote the development of Crash Outcome Data Evaluation Systems by all states. In 1996 the agency entered into cooperative agreements with six of the seven original CODES states to provide technical assistance to other states interested in developing the systems. New cooperative agreements were also issued to six states, including three states without Crash Outcome Data Evaluation Systems, to use linked data for specific research topics. This year the agency will fund the development of data-linkage capabilities in at least six more states.

REDUCTION OF ALCOHOL-RELATED CRASHES

In January 1990 California reduced its legal blood-alcohol concentration (BAC) limit from 0.10 to 0.08 percent and 6 months later implemented an Administrative Per Se law. The two laws and the publicity surrounding them appear to have contributed to a 12 percent reduction of alcohol-related traffic fatalities in the state, prompting NHTSA to investigate the effects of lowering the BAC limit to 0.08 in five states. The study revealed statistically significant reductions of driver involvement in alcohol-related fatal crashes after the new limit took effect in four of the states (2). These reductions ranged from 4 percent in California to 40 percent in Vermont. Today the 0.08 limit is saving lives in 13 states. According to an independent study, an additional 500 to 600 lives could be saved each year if all states adopted this limit.

The agency developed and tested the standardized Field Sobriety Test, which is routinely used at checkpoints and traffic-violation stops to identify intoxicated motorists. In a pilot test of select DWI-detection measures for use at sobriety checkpoints, a variety of procedures to improve the ability of police to identify alcohol-impaired drivers were evaluated. This test and other studies helped to win approval from the U.S. Supreme Court to set up sobriety checkpoints.

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