STATUS REPORT

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In this test collision, the truck bumper intrudes dangerously close to the passenger cabin.

Front End, Energy-Absorbing Truck Guards Reduce the Risks for Motorists

Head-on collisions between trucks and cars are deadly encounters for auto occupants. Researchers report that nearly two-thirds of the German car passengers killed in truck crashes were the victims of such impacts.

To help prevent such deaths, researchers at the Technical University of Berlin developed a new front crash protection system for trucks that, its researchers say, could greatly reduce occupant death and injury if adopted by vehicle manufacturers.

Data from a previous study showed that the average speed for real-world, head-on fatal crashes between cars and trucks in Germany is about 47 to 56 mph. Crash tests demonstrate that auto passenger compartment deformation in impacts with heavy trucks can occur at speeds of 37 mph due to the stiffness and height of truck front ends. The researchers goal was to develop a design that can prevent passenger compartment deformation and intrusion at those speeds.

The researchers developed a design incorporating a front-end soft plastic exterior face to absorb minor collisions without damage, with a metal honeycomb mounted behind to a support frame. In a more severe crash, the honeycomb absorbs some of the crash force. The support frame prevents the car from sliding beneath the truck's front end and transfers the crash energy to the chassis of the truck.

In 70 kph, or 44 mph, overlapping frontal impacts, the researchers report the guard spreads the crash force over a broad area of the car, which greatly reduces the intrusion into the passenger compartment. In a comparison test with-

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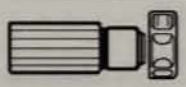
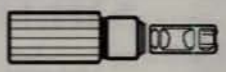
SAFETY RESEARCH

This special issue of *Status Report* focuses on research findings presented at the Twelfth International Technical Conference on Experimental Safety Vehicles in Goteborg, Sweden earlier this year.

The conference is made possible through bilateral agreements between France, the Federal Republic of Germany, Italy, Japan, Sweden, the United Kingdom, and the United States. Agencies of these governments, the automotive industry, and vehicle safety research organizations meet periodically to share state-of-the-art safety technology. The conference reflects the international concern over traffic deaths and injuries around the world.

The complete proceedings of the conference will be published by the National Highway Traffic Safety Administration (NHTSA) and should be available early next year. Copies may be obtained by sending a self-addressed mailing label to: Linda O'Connor, Technical Coordinator, NRD-01, NHTSA Office of Research and Development, 400 Seventh St. SW, Washington, D.C. 20590.

Truck and Car Collisions Resulting in Injury or Fatality in Bavaria During 1984				
Type of Collision Truck/Car	Injured Persons in the Car Number	Percent	Fatalities Number	Percent
Front/Front 	260	15.6	49	38.0
Front/Side 	325	19.4	37	28.7
Front/Rear 	291	17.4	2	1.5
Rear/Front 	263	15.8	22	17.1
Side/Front 	343	20.5	10	7.7
Other Types	189	11.3	9	7.0
Total	**1,671**	**100.0**	**129**	**100.0**

Study Shows Heaviest Trucks Pose Most Danger for Motorists

A new West German study reveals that head-on crashes with automobiles account for nearly 40 percent of occupant fatalities in truck related crashes.

Researchers for HUK-Verband, an association of insurers, report that per one billion kilometers, or 621.5 million miles, of travel, trucks are involved in 31 crashes with fatalities in the Federal Republic of Germany, compared with 18 for automobiles.

The heaviest trucks represent a particular hazard for motorists: Trucks weighing between 12 and 16 tons make up only 9 percent of all registered trucks but account for 27 percent of crashes with fatalities. In West Germany, one-half of all truck-related, fatal crashes involve passenger cars.

In cooperation with German authorities, HUK-Verband researchers conducted a study of injury crashes involving trucks in Bavaria during 1984. The researchers limited the study to crashes involving trucks over 3.5 tons that were manufactured after 1976. This produced 2,269 crashes for study.

Of those 58 percent involved automobiles. A total of 1,671 automobile occupants were injured and 129 died of injuries. The largest segment, 21 percent, involved cars hitting the sides of trucks. The second largest group, 17 percent, involved trucks striking automobile rear ends.

Although not the largest category, head-on crashes between cars and trucks emerged as the most lethal, accounting for 38 percent of all deaths.

The researchers also found that the injury crashes involved mostly trucks weighing between 12 and 16 tons. Because of the mass of the trucks and their high bumpers, which tend to override automobiles, severe to fatal injuries occurred in crashes with speeds as low as 19 mph, and crashes at 34 mph often caused "a massive intrusion of the car's interior," which could be fatal to front seat occupants.

"The absence of a front protection system was also a disadvantage for the truck," the researchers report. "All tests without a front protection system were

characterized by a strong deformation of the kinetics of the truck's front wheel axle. The impact against the tire shifted the axle, the spring assemblies were also damaged, as was the steering assembly. . . . the high risk in secondary collisions through the loss of controlled steer[ing] was thus confirmed."

The researchers note that to prevent override, a truck frontal crash guard design must have a 12-inch ground clearance so that the automobile's deformation structure can engage in a crash. In addition a front crash guard should be deformable so that it too can absorb some of the energy in a crash.

In tests of an air bag equipped Mercedes, instrumented dummy measurements confirmed that the addition of a lower guard enhanced the effectiveness of the air bag.

The researchers estimate that improving frontal crash protection would lower head-on collision injuries by 10 to 20 percent.

"Passive Safety Measures for Trucks, Effectiveness and Priorities," 89-1B-0-009, was written by M. Danner, K. Langwieder, H. Appel, and V. Middelhauve.

Front-end protection system rides low enough to keep car from sliding under the truck in a crash.

Truck Guards Reduce Risks for Motorists

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out the crash guard attached, the truck overran the automobile, driving the car engine back into the fire wall, and damaging the passenger compartment.

The frontal crash guard also reduced damage to the truck, preventing deformation of the steering axle and loss of control.

Frontal crash guard absorbs crash force and reduces damage to the truck itself.

Modifying trucks to incorporate frontal crash guards will, the researchers say, also reduce noise and improve fuel economy through more aerodynamic styling.

"Truck Front-End Protection Systems," 89-1B-0-004, was written by S. Gruttert, Hermann Appel, and K. Langwieder.

NHTSA Reviews A Decade Of Crash Test Results

The 300 odd cars slammed into walls at 35 mph in the National Highway Traffic Safety Administration's (NHTSA) New Car Assessment Program (NCAP) have not been demolished in vain. NHTSA researchers report considerable improvement in vehicle test scores since the "temporary" consumer information test series began in 1979.

"After 10 years of testing in NCAP, significant trends toward improved dummy responses can be noted for the passenger car fleet," say NHTSA researchers.

Overall, consumers are driving safer cars. "Comparison of the performance of the tested 1981 passenger car fleet to the tested 1988 passenger car fleet shows a significant improvement in potential safety performance for restrained occupants in high speed frontal crashes," say the researchers.

The tests, which use instrumented dummies in the driver and front passenger seats, are designed to provide measures of relative performance in real-world crashes within classes and sizes of vehicles. The dummies' instrumentation gives readings for head injury based on the head injury criterion (HIC), chest injury based on chest accelerations (Chest Gs), and leg injury based on femur load. (For a review of the NCAP program see *Status Report* Vol. 21, No. 4.)

The researchers concluded that average HIC and Chest G values decreased by

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NHTSA Reviews A Decade Of Crash Test Results

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10 to 20 percent over the decade. Passenger vehicles that were in the worst performance group (i.e., HIC greater than 1250 and/or Chest G greater than 70) dropped from 51 to 25 percent of the weighted fleet average for the period.

To examine automobile manufacturer response to the test data, the researchers compared a weighted average of the 1981 and 1988 scores: Test scores for the 1988 U.S. passenger car fleet were significantly lower.

The researchers found that as a group, heavier vehicles performed better than lighter vehicles, but when the data were weighted by vehicle registrations, the performance differences were reduced. "This indicates that especially in the small weight class that the poorer performing vehicles have the lower sales volume," they say. They also noted that many of the poorer performing small cars tested in the early years are gradually being eliminated from the fleet.

A much larger percentage of light trucks and vans (56 percent unweighted and 45 percent weighted) were in the poorer performance group than were passenger cars (38 percent and 25 percent, respectively). "These data indicate the frontal crash test performance is not as good for light trucks and vans as for passenger cars," say the researchers. However, it is possible to produce reasonably good performers in all light truck and van categories. Eleven of 43 of the light trucks and vans tested were good enough to meet the injury criteria of Standard 208 in the NCAP test conditions.

Very few of the dummies in the driver locations were restrained sufficiently to avoid contact with some portion of the steering assembly—31 percent experienced head contact with the steering assembly severe enough to place the vehicles in the lower performance group. The light trucks and vans showed an even higher probability of severe head to steering assembly contacts with 46 percent ranking in the poorer performance group.

The 33 late model passenger cars with the better performance levels were evenly distributed among the small, compact, and intermediate weight classes, and had a variety of restraint systems. The researchers conclude, "The performance of these vehicles strongly indicates the capability and the increasing trend of the manufacturers to incorporate design parameters in their vehicles which produce low dummy responses in the 35 mph NCAP tests."

"Analysis of Frontal Crash Safety Performance of Passenger Cars, Light Trucks and Vans and an Outline for Future Research Requirements," 89-2A-0-001, was written by James R. Hackney, William T. Hollowell, and Daniel S. Cohen.

Eurobag: An Air Bag Possibility For The Aftermarket

Volvo researchers have developed and tested a new driver side air bag called the "Eurobag," which is designed to reduce the head and facial injuries that occur despite belt usage, especially in high speed frontal crashes.

The new, smaller air bag, which is contained entirely within the steering wheel, has an inflator that is 15 percent smaller in diameter and 20 percent lower in height than in conventional air bags. The smaller components allow the electronic sensor and diagnostic components to be fitted into the steering wheel. Thus, the researchers say, the system could be installed as an aftermarket item.

"The final prototypes were verified in a large number of sled tests and full-scale collision tests. The system fulfilled all criteria. Furthermore, a number of different rough-road tests were performed, and these proved positive, i.e., the sensor did not trigger," say the researchers. In 30, 35, and 40 mph crash tests, the Eurobag reduced head injury criterion (HIC) scores by 24 to 29 percent. Facial pressure was reduced by an average of 80 percent.

The Volvo researchers conclude that "a small bag optimized for belted drivers is an excellent complement to the seat belt."

"The Development of an Advanced Airbag Concept," 89-2A-0-009, was written by Lennart Johansson, Jan Billig, Hugo Mellander, Bernd Werner, and Peter Hora.

Doctors Treating More Minor Facial Injuries in Crashes

Some recent studies of crashes involving belted drivers indicate that although fatalities and serious injuries are greatly reduced by wearing seat belts, as belt use becomes more common, physicians are treating more minor facial injuries.

An evaluation of injury cases compiled in the National Accident Sampling System (NASS), between 1980 and 1983 showed that 61 percent of unrestrained drivers sustained head, face, and neck injuries. Among belted drivers, however, 87 percent had such injuries. Similar results have been found in Germany and the United Kingdom.

During the last three years, the National Highway Traffic Safety Administration (NHTSA) has conducted research to assess the extent of these injuries.

In a study of data from the 1981-85 NASS files, researchers David S. Zuby of the Transportation Research Center, Inc., and Roger A. Saul, from NHTSA's Vehicle Research and Test Center, analyzed crash data to learn more about the nature of the injuries and their causes. From NASS the researchers culled 170 reports involving restrained drivers in frontal crashes with

head or facial injuries caused by striking a steering wheel.

Speed was correlated with the severity of the injury. Although 50 percent of all steering wheel facial injuries occur in crashes at less than 15 mph, 60 percent of the more severe injuries occur at higher speeds. Of the 170 cases, injuries to the upper and lower jaw accounted for between 40 and 50 percent of all the facial trauma. Another 21 percent occurred in the nasal region.

Thirty-four percent of the facial injuries involved bruises, 20 percent involved fractures, 35 percent cuts, 7 percent scrapes, and 1 percent torn tissue. More than 90 percent of the injuries were rated as minor.

Although 20 percent of the injuries were recorded as fractures, they commonly involved missing or broken teeth or nasal region fractures, which are usually considered minor. More severe injuries involved fractured jaws and the bone structure around the eye.

"Restrained Drivers' Facial Skeleton Injuries Resulting from Steering Assembly Contact: A Conspectus," 89-4A-0-003, was written by David S. Zuby, Roger A. Saul.

Review of Fatal Crashes Confirms Air Bags Can Reduce Occupant Deaths

A study of car occupant fatalities in Britain indicates that air bags and devices that automatically tighten seat belts could significantly reduce fatalities among both belted and unbelted front seat occupants.

Adding underride guards to the front, sides, and rear of large trucks would also significantly reduce the deaths of belted front seat occupants, say the British researchers whose work was supported by the Insurance Institute for Highway Safety.

In January 1983 Britain's seat belt use law took effect. One of the world's most successful belt use statutes, surveys showed that in the two years following the law's implementation, belt use among front seat occupants was about 95 percent. Automobile occupant fatalities declined by 23 percent in the first 12 months of the law and by 17 percent in the second year.

The researchers evaluated crashes involving 176 car occupants killed in frontal collisions during the first two years following implementation of the law to ascertain what further steps might be taken to reduce fatal injuries in frontal crashes.

Using data derived from police and pathology reports, the researchers ascertained that 116 of the fatally injured occupants were drivers, 39 were front seat passengers, and 21 were rear seat passengers. Of the drivers, 82 percent were using belts and 76 percent of the front seat passengers were belted. None of the 21 rear passengers were belted.

The crashes most frequently involved collisions with other cars, heavy trucks, and fixed objects. Thirty of the 47 crashes involving trucks were head-on. In 24 percent of all the frontal collisions, "there was significant underrun of the struck vehicle," the researchers report.

The researchers found belted drivers who died were more likely to sustain head and neck injuries than belted passengers. Among the fatally injured belted front seat passengers, they report 45 percent suffered some head injury compared with 74 percent of the drivers.

About one-half of the fatally injured belted drivers had severe or critical chest injuries. The steering system, followed by seat belt webbing, played a prominent role in these injuries and direct contact with the striking vehicle was responsible for 11 of the more severe chest injuries, they concluded. Twenty-six of the belted drivers experienced severe to fatal abdominal injuries. Of this group, two-thirds were injured by sources within the car, most often the steering wheel, followed by the seat belt.

An analysis of possible countermeasures revealed that 69 percent of the occupant deaths could have been prevented by application of existing technologies, the researchers say. Of the deaths considered preventable, 77 percent could have been avoided by application of a single countermeasure.

While seat belts work well in lower speed crashes, at higher speeds they permit drivers to contact the steering wheel as they ride down the crash. For the belted passenger, virtually all of the crash forces are concentrated on the belt webbing which can cause injuries. For the driver and especially the passenger, the addition of a pretensioning device to take up belt slack, coupled with an air bag to help spread and absorb the crash forces, will greatly improve the chances of survival without serious injury.

"The air bag is by far the most needed countermeasure, not only in terms of supplementing protection provided by seat belts in severe frontal crashes (along with a belt pretensioner) but also for saving the lives of unbelted front seat occupants, who comprised 20 percent of the front seat occupants killed," the researchers point out.

Britain should "encourage the installation and use of rear seat belts . . . not only to reduce the deaths of these occupants but also to further reduce deaths among front seat occupants that result from additional loading on them by unbelted rear seat passengers in frontal crashes."

"Characteristics of Fatal Frontal Impacts and Future Countermeasures in Great Britain," 89-2B-00-13 was written by Peter F. Gloyns, Stephen J. Rattenbury, and Ian S. Jones.

New Child Restraint Protects Child From Birth to Age of 10

A group of automotive engineers have found an effective way to build restraints that protect children ranging from infancy to the age of 10.

In a study undertaken for Electrolux Klippan, a producer of seat belts and air bags, and the Gothenburg and Folksam Insurance Company of Stockholm, researchers at Chalmers University of Technology developed an adult passenger seat that converts into a fully integrated child restraint system that will meet European safety standards.

The child restraint system would also effectively eliminate problems related to incorrect installation. The padded seat is folded into the seat back cushion of the passenger seat. Folded down it becomes a booster seat that elevates an older child who can properly use the adult lap and shoulder belt.

To convert the restraint system into a seat for an infant, the rearward facing seat

Front passenger seat in adult position.

Booster seat is unfolded from the seat back.

Rearward facing seat partially unfolded from the booster.

Three-point adult belt together with booster cushion. Seated farther back than an adult, the child will receive better side support and lap belt fit.

Integrated head rest can be moved up or down. Seat angle can be adjusted.

back is unfolded and the integrated head rest is moved to accommodate a larger child. The angle of the seat can also be adjusted.

One of the advantages of the built-in system, the researchers point out, is that it can be crash tested together with the car, so that it is possible to evaluate the system's performance in relation to the automobile's performance.

In response to a petition, the National Highway Traffic Safety Administration (NHTSA) last year amended Federal Motor Vehicle Safety Standard 213 to permit manufacturers to install built-in child restraint systems in vehicles. NHTSA says built-in systems can be at least as safe as add-on child restraints and may encourage their use.

"Integrated Child Restraints in Cars for Children Aged 0-10," 89-1A-0-007, was written by L. Karlbrink, M. Krafft, and C. Tingvall.

Properly Used Child Restraints Reduce Fatality Risk

When used properly child safety seats greatly reduce the risk of fatality, says a National Highway Traffic Safety Administration (NHTSA) researcher. But chances are that adults who become involved in severe crashes are unlikely to see to it that their children ride protected.

In a paper estimating the number of lives saved between 1982 and 1987, Susan C. Partyka says child seats saved an estimated 713 lives and the use of safety belts saved another 125. Nonetheless, Partyka says, this represents only about one-third of the children that could have been prevented from dying in crashes if all children under five years of age used child seats on every trip.

Using data from the Fatal Accident Reporting System (FARS) and police reports on belted or unbelted occupants, Partyka found 7,060 fatal crashes involving passenger cars built after 1973 and that were occupied by at least one child under the age of five.

Comparing fatal injury outcomes of children riding with restrained and unrestrained drivers, Partyka estimated that child seat use reduces the risk of infant fatality by 69 percent and toddler fatality by 47 percent.

FARS data indicate that in crashes resulting in fatalities many children are riding unrestrained. In crashes in which small children died, an estimated 68 percent were unrestrained.

Although 50 states require small children to ride restrained, estimates of child restraint use vary widely. NHTSA's 19-city survey shows 80 percent of the children seen are buckled into safety seats. But many states, notes Partyka, report child restraint use rates under 40 percent.

Even though surveys indicate child restraint use is up, the benefits do not meet expectations. One possible explanation is that child seat use is lower in serious accidents than it is in general traffic. Such a view is supported by the fact that adult belt use in crashes is lower than belt use seen in general traffic. This means the adults most likely to become involved in serious crashes are the least likely to buckle up and are also less likely to protect their own children.

Says Partyka, "it appears clear that safety seat use in accidents is much lower than reported in observation surveys. While child seat use has increased over the last five years, children in serious accidents are still all too often unprotected."

"Lives Saved by Child Safety Seats from 1982 Through 1987," 89-1A-0-002 was written by Susan C. Partyka.

Researchers Find Risk of Fractures Increases

Swedish researchers say that the risk of minor injury in vehicle crashes does not increase with age, but the risk of fractures does.

Older drivers are involved in more crashes involving injuries per miles driven than other drivers. So researchers investigated whether the higher risk is tied to a greater tendency to be injured at more advanced ages.

In a study of data from the Volvo Car Crash Register, researchers from Uppsala University found 2,637 belted front seat occupants involved in head-on crashes. The crash register, which contains only reports on crashes involving Volvos, allowed the researchers to control for the weight of the vehicles, collision speed, direction of impact, and the occupant's sex, age, height, weight, seat belt use, and seating position.

A total of 704, or 26 percent of all front seat occupants received injuries requiring medical care, the researchers report. Among this group, 529 received at least one fracture and 144 had a chest fracture. Thirteen percent of the occupants involved in low speed collisions had injuries serious enough to require medical attention, 24 percent in the medium speed crashes, and 47 percent of the occupants in high speed impacts.

When comparing the risk of injury by age group, the researchers found that relative to young people aged 18 through 24, people in the 25 through 34 age group had the greatest increase in risk of injury requiring medical attention. There was, however, no systematic rise in risk of injury associated with older drivers.

The researchers did find, however, that the risk of a fracture is much greater for older individuals than for young persons. Among those aged 65 through 74, the risk of a fracture was more than three times greater than persons aged 18 through 24. And the risk of a rib fracture is nearly 11 times higher than the youngest age group.

"Age and Risk of Injury," 89-1A-0-012, was written by Bengt Brorsson, Uppsala University, Uppsala, Sweden.

Researchers Compare Side Impact Tests With Collisions in the 'Real World'

For years regulators on both sides of the Atlantic have been investigating ways to limit the human damage that results from side impacts. In 1988 the National Highway Traffic Safety Administration (NHTSA) issued a notice of proposed rulemaking to improve side impact standards for automobiles.

A new dummy and moving barrier crash test procedure was proposed and across the ocean, the European Economic Community through the European Experimental Vehicle Committee (EEVC) proposed an alternative moving barrier, dummy, and procedure.

The NHTSA proposal would require new cars to withstand an impact from a moving barrier with a mass representing the median value of U.S. cars and of a stiffness similar to that of light trucks. The barrier would approach the stationary test car at a speed of 33.5 mph, or 54 kph, striking the car side with barrier wheels turned, to simulate a typical intersection crash in which the striking vehicle is moving at 30 mph and the struck car is moving at 15 mph. Side impact dummies positioned in the front and rear would measure chest and pelvic loads.

The EEVC's proposed barrier is softer than the NHTSA barrier, and this is more representative of the average European car. The barrier would strike the passenger car perpendicular to it at a speed of 31 mph, or 50 kph. A European-developed dummy known as "Eurosid" would assess potential head, chest, abdomen, and pelvis injuries.

Under a research program sponsored by the British Department of Transport and Road Research Laboratory, Ford Motor Co., Rover, and Nissan U.K. researchers from the accident research unit of ICE Ergonomics in Loughborough, England, analyzed data from side impact crashes in the United Kingdom. The purpose of this study was to see how closely the European and U.S. tests simulate real world crashes.

The researchers found that in actual crashes most of the fatal impacts were the result of collisions with objects other than cars, most commonly trees and utility poles. The proposed test impact angles, however, do reproduce vehicle-to-vehicle side impacts in which there are serious injuries.

They also found that among the side impact crashes studied in England, the European barrier is 200 kg lighter than the median mass of the striking vehicle in fatal crashes and the American barrier is 200 kg heavier.

Both test procedures produce crash severities that are well below the median crash severity for side crashes resulting in serious injury or death, the researchers report.

In addition field data show that when two or more people are seated side by side, they frequently interact in side impacts. Individuals seated on the side of the vehicle furthest away from the impact often are hurled into people seated adjacent to the struck side.

The researchers report "Nearly 40 percent of fatal [killed] struck side occupants have this additional side loading applied to some part of their body, aggravating their injuries." Neither test proposal simulates this interaction, the researchers note, and they recommend further study and improvements in belt systems.

Both test proposals seek to limit chest and pelvic injuries that are commonly seen in fatally injured occupants. Nonetheless the body regions that most often sustain injuries that have the most propensity for long term impairment – head, arm, and legs – are not addressed by the proposed dummies. "Without a suitable test requirement," they say, "the injuries with the most potential for the disablement of survivors will not be reduced."

By adding padding to the A-pillar, B-pillar, and side header rails, the researchers say, 19 percent of all head injuries in side crashes could be avoided. The field data show that 59 percent of the head injuries of fatally injured occupants were associated with striking objects inside the car. Other head injuries are caused by direct contact with the striking vehicle or ejection.

"Side Impact Regulations — How Do They Relate to Real World Accidents?" 89-5A-0-024, was written by Pete Thomas and Mo Bradford.

Tests Examine Seat Belt Systems In Side Impacts

Almost half of the 8,000 annual automobile occupant deaths in side impacts are related to head injuries. Many are caused by ejection, others by contact with hard surfaces within the automobile such as door rails and side pillars.

Seat belt use will prevent ejection-related injuries and it is possible that belt restraints also can help prevent occupants from striking hard surfaces within the auto interior but little is known about the kinetics of side impacts involving belted occupants.

Recently researchers from Honda Research and Development Company examined the effects of several seat belt systems on occupant head behavior and the level of impact protection they provide in side crashes in a series of 10 high-speed crash tests.

The tests were conducted on an Acura Integra hatchback, a subcompact model, using a moving deformable barrier and side impact dummies. The impact speeds

were about 34 mph. The researchers tested the performance of lap belts, standard three-point manual belts, two-point automatic belts, and three-point automatic belts. For comparison purposes, they also crashed a car with the dummies unbelted.

The researchers found that in every test immediately after the barrier struck the test car, the driver dummy's head or face struck the barrier or the upper edge of the vehicle door. At that test speed, the researchers report, the peak accelerations experienced by the driver dummy's head at the moment of impact suggested that belt restraints may not provide effective protection for the driver in side impacts.

However, the researchers note, it was apparent that after hitting the barrier or the door, that the restrained dummy's head was pulled back inside the passenger compartment by the belt. The shoulder belts were more effective in reducing the outward movement of the dummy's head than the lap belt alone.

The three-point manual belt performed somewhat better in reducing the outward movement of the dummy driver's head than the three-point automatic belt, in that the outward and upward movement of the dummy was more fully restrained. Both were better than the lap belt alone or the two-point automatic belt.

The researchers also found that during the crashes involving the dummies seated in the front seats, the driver dummy invariably experienced a secondary impact with the dummy seated in the passenger position.

"Effects of Belt Restraint systems on Occupant Protection Performance in Side Impact Crashes," 89-5A-0018, was written by N. Shimoda, Y. Nishida, and A. Akiyama.

Belt System Offers Uniform Protection In All Seating Positions

BMW, the German auto maker, says it has designed a new front seat belt system that is attached directly to the seat and thus provides maximum protection to people of all sizes and in all seat adjustment positions.

Current lap and shoulder belts have proven to be highly effective in restraining vehicle occupants, but the shoulder belt placement on the occupant still depends to a large extent on the adjustment of the seat because the shoulder belt upper anchorage is attached to the car body. This affects comfort and protection because the shoulder belt cannot be adapted perfectly to every seat adjustment position. This is a particular problem for many two-door cars.

In an attempt to solve this problem, BMW developed a new belt system fully integrated into the seat.

This new system provides several advantages. All belt anchorage points move with the seat as it is adjusted so that the belt provides effective protection in all seat positions. The head restraint and shoulder belt anchorage adjust in tandem eliminating incorrect adjustment. A special clamping device in the belt retractor reduces the amount that the belt extends in an impact. Restraint forces engage immediately in a crash, which reduces occupant forward displacement. A ramp integrated into the seat shell combined with a rigid seat base provides more pelvic support to prevent submarining, the tendency of occupants to slide out from under their seat belts.

The new seat and belt system also offer improved protection in side impacts and rear end collisions because of the high-strength seat frame structure. The wraparound effect of the seat and belt system strengthens protection in rollover crashes because the occupants are held in

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their seats more effectively.

"The Effect of Fully Seat-Integrated Front Seat Belt Systems on Vehicle Occupants in Frontal Crashes," 89-5B-0-015, was written by J. Haberl, F. Ritzl, and S. Eichinger.

Leg Shields For Motorcyclists? Two Studies Clash

After the United Kingdom Department of Transport drafted motorcycle specifications for leg protectors in July 1987, Japanese and British researchers conducted separate test programs to evaluate the effects of leg protectors that met the British specifications. The two programs differ widely in their conclusions.

The British researchers, sponsored by the Transport and Road Research Laboratory, concluded that the leg protectors offer significant reduction in potential leg injury without any increase in potential head injury, while the Japanese, sponsored by the Japan Automobile Manufacturers Association, report that not only do the protectors fail to reduce lower leg injuries, they could also cause more serious injuries to the upper leg and other parts of the body as well.

The British reported the leg protectors to be beneficial under almost all circumstances. The British conducted tests impacting a large motorcycle with a moving vehicle and a stationary vehicle. For the tests, the British chose the most popular medium sized cars in the United Kingdom. The motorcycle used was a Norton Interpol III. The leg protector consisted of a fiber glass shell, energy absorbing material, and a strong rigid element to position the protector system components and attach it to the motorcycle. Tests were conducted with and without the leg protectors. Impact configurations chosen were 30 degrees to the front and side, zero degree offset-front, 60 degree front corner, and 90 degree side impacts.

Researchers used a dummy with instrumented aluminum honeycomb legs and accelerometers in the head, chest, and pelvis. Accelerometers were also fitted to the motorcycle engine.

Results showed that the impact on the leg was always significantly lower in the tests where leg protection was used. Researchers found no instances where the potential for leg injury was made worse nor was the risk of head injury increased with leg protection. British researchers concluded that the leg protectors offer a worthwhile reduction in injury risk.

The Japanese study differed from the British research in several ways. A medium sized motorcycle was tested because that size vehicle represents 50 percent of crashes in Japan. The leg protectors were sheet steel and aluminum honeycomb with padding of polyurethane foam.

A Toyota Crown passenger automobile was selected as the opposing vehicle. A modified Hybrid II crash test dummy was selected with legs made of breakable bakelite bone and urethane foam muscle. The dummy was not instrumented to measure forces or accelerations.

Three test conditions were chosen to represent real world collisions with a moving car: 45 degree angled collision, broadside collision, and offset frontal collision (front of motorcycle struck by front fender of car). To be consistent with an earlier British study, a 30 degree barrier impact test using a dummy with steel bones was used.

High speed film analysis was used to study the effects of leg protectors on motorcycle and rider trajectories. Fracture modes of leg bones and head velocity were observed to determine injury effects of reinforced leg protection.

Test results for all three collision types indicated that bone fractures occurred in both the upper and lower leg. The leg was restrained by the leg protector forcing the dummy to move with the motorcycle. Researchers found that the leg protectors caused higher hip lifts and a more violent ejection of the dummy that could result in serious head injuries and neck and spinal cord damage. Japanese researchers found that the leg protectors complying with British specifications failed to reduce leg

PEDESTRIAN PROTECTION

The European Experimental Vehicles Committee has set up a working group to develop methods for improving passenger car protection for pedestrians.

Crash data show that the bumper, the leading edge of the hood, and the top of the hood cause the most serious pedestrian injuries. Of the three, bumpers strike pedestrians most often and these pedestrians are most likely to suffer leg injuries.

In fact research done by the U.S. Department of Transportation shows that 70 to 85 percent of pedestrians injured in crashes sustain leg injuries. However, head injuries are the most frequent cause of pedestrian fatalities, and these often result from striking the top of the hood.

The working group plans to develop three separate subsystem tests for the bumper, hood edge, and hood top and will outline measures to lessen the dangers to pedestrians.

Test methods will be considered that evaluate what happens when these parts strike child and adult dummies at speeds up to 25 mph. Methods will include dummy tests, mathematical computer simulations, and crash data.

The study is scheduled to be completed by March 1990.

"Study of Test Methods to Evaluate Pedestrian Protection For Cars," 89-6A-0-001, was written by J. Harris.

injury and increased potential for more serious injuries.

That two studies on the same subject using different vehicles, crash configurations, and test dummies could draw different conclusions is not surprising. But these two have achieved a polarity that will require further research to end the controversy.

"Leg Protection and Its Effect on Motorcycle Rider Trajectory," 89-6B-0002 was written by B.P. Chinn, P.D. Hopes and M.P. Finnis. "Difficulties in Leg Protection Research," 89-6B-0007 was written by S. Sakamoto.

Two-Year Study Begins on Improving Truck Visibility

Researchers in West Germany have found that at night trucks with low silhouettes are involved in more crashes than other trucks. For example, in the early '80s flat bed trucks had the highest rate of side and rear impact crashes. Making such trucks more conspicuous might lower these collision rates. Researchers are undertaking a two year study of 1,000 trucks equipped with reflective tape to improve nighttime conspicuity. The study will also assess the effects of pollution and normal wear and tear on the tape.

The National Highway Traffic Safety Administration (NHTSA) conducted a similar study of trucks outlined with reflective tape, but these findings were inconclusive because the research design was poorly executed. The Insurance Institute for Highway Safety urged NHTSA to follow up with a large scale fleet evaluation of reflective tapes. (See *Status Report*, Vol. 22, No. 14, Dec. 26, 1987.) To date, however, no further action has been taken.

"Large Scale Experiment About Improving the Night-Time Conspicuity of Trucks," 89-4B-0-007, was written by H.J. Schmidt-Clausen.

In a Variety of Tests, Four Antilock Brake Systems Perform Well

England's Transport and Road Research Laboratory tested a BMW 320i, Mazda 626 GT, Honda Prelude, and Ford Escort to evaluate driver control and brake stopping distances with their antilock braking systems. U.S. versions of the BMW and Mazda have the same type of brakes–the Ford Escort and the Honda Prelude do not. Tests results show these antilock systems to be highly effective.

The researchers tested the cars loaded and unloaded on a variety of wet and dry pavements representative of road surfaces in the United Kingdom. Most of the testing compared the performance of a vehicle with its antilock system either fully functioning or at least partially disabled. Three separate braking tests were performed on each vehicle.

In a straight line braking test, the driver sharply braked the vehicle from different speeds, starting at 12 mph and increasing in six mph increments to the final test at 62 mph.

Braking on a curve involved driving the vehicle at constant speeds in increasing increments through a curved path and then braking while still turning.

The split surface braking test examined the controllability of a vehicle when it is braked heavily on a split surface, simulating the effect of snow, ice, or water on one side of an otherwise dry road.

Tests showed that BMW's and Mazda's electronic antilock brake systems performed well. Researchers found the improvements in stopping distances impressive, and the controllability for both the BMW and Mazda under sudden braking conditions on all surfaces was excellent.

Honda's somewhat simpler electronic system performed in a similar way to the more complicated electronic systems and the stopping distances were found to be significantly reduced when compared to the antilock system disconnected.

The Ford Escort's simple mechanical antilock system provided good control.

"Braking and Stability Performance of Cars Fitted with Various Types of Antilock Braking Systems," 89-4B-0-013 was written by B.J. Robinson and B.S. Riley.

VEHICLE CONSPICUITY

A common complaint heard from motorists involved in collisions is that they did not see the oncoming vehicle until it was too late.

One of the keys to avoiding multiple vehicle crashes is to increase the visibility of vehicles so that other motorists can readily spot and react in time to avert a collision, says a researcher from Sweden's Road and Traffic Research Institute.

In a paper analyzing the record of daytime running lights as a crash avoidance measure, the researcher says studies consistently show benefits from daytime running lights. A 1981 Swedish study found a requirement for daytime running lights or low-level beams in that country since 1977 has reduced daytime crashes involving other vehicles by 13 percent. Head-on collisions were lowered by 10 percent, angular crashes by 9 percent, and rear-end impacts by 2 percent. The largest benefit, however, was for car collisions with bicyclists and pedestrians: Crashes with bicyclists were reduced by 17 percent and car-pedestrian collisions by 21 percent. In the United States, a study conducted by the Insurance Institute for Highway Safety found a 7 percent reduction in relevant multiple vehicle daytime crashes.

Studies show that the lights-on policy has improved motorists' peripheral and central vision perception of oncoming traffic and that they tend to estimate a car with running lights as being closer to them than an unlit car.

"Vehicle Conspicuity," 89-4B-0-004, was written by Kare Rumar.

SPECIAL ISSUE

Vol. 24, No. 8, August 26, 1989

This special issue of *Status Report* focuses on designing safer vehicles. Other issues have focused on the following subjects:

Truck Crash Congestion	23:12, 1988
Making Traffic Laws Work	23:6, 1988
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