Special issue: safety advancements

STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

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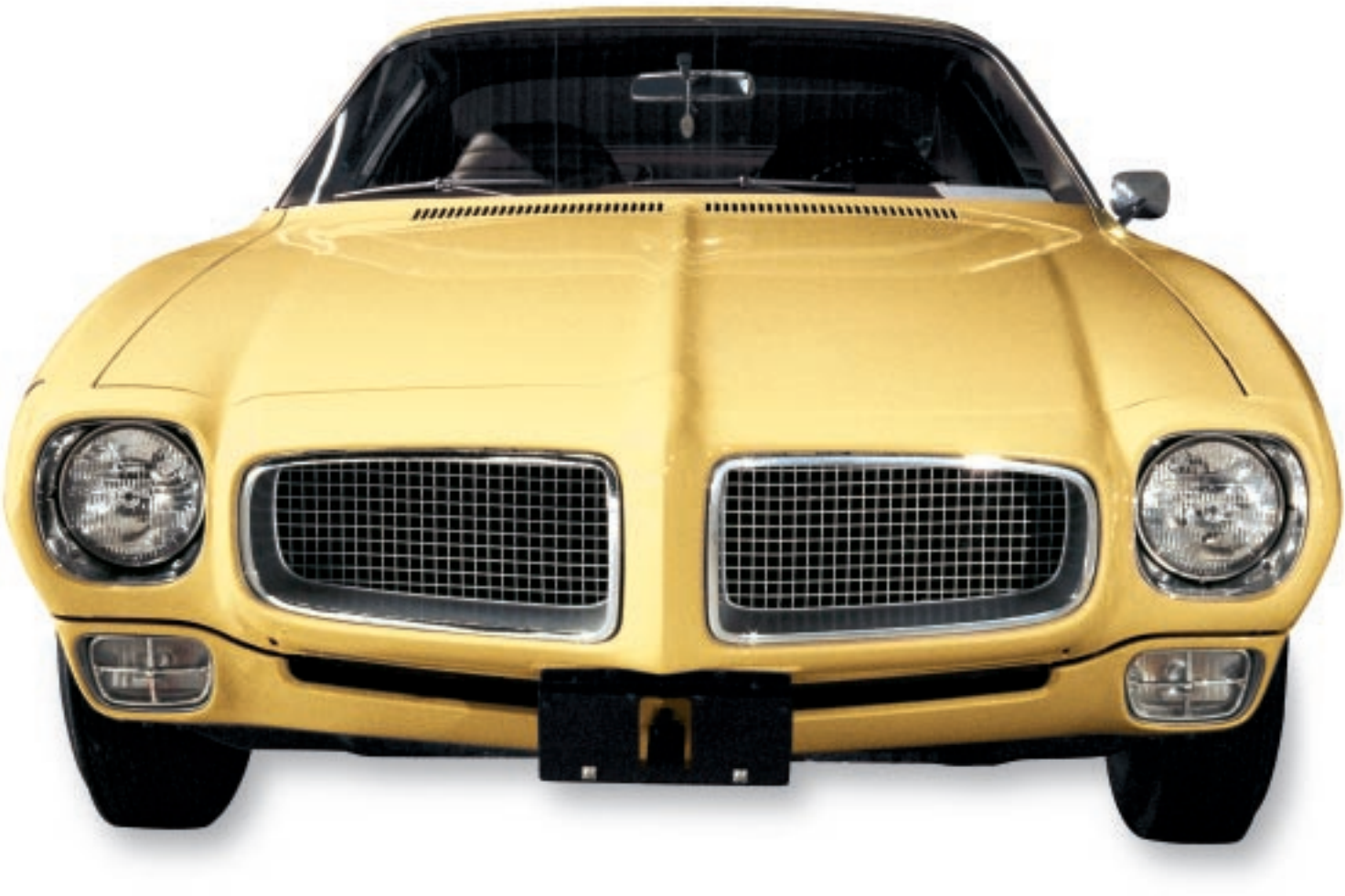


They're getting better

and not just compared with old models like this; safety technology improvements are being introduced every year

The crash protection in passenger vehicles is getting better — and not just compared with cars made 20, 10, or even 5 years ago. Advanced frontal airbags soon will be introduced in a number of models. Side airbags that include head protection are becoming more common. The structural designs of many cars are improving. Some bumper systems are getting better, too. This is happening with little intervention from the government. A federal rule has been proposed to encourage automakers to develop and use advanced frontal airbags, but this regulation isn't likely to be final anytime soon. There are no federal requirements for side airbags, and so far the government doesn't assess vehicle structure in frontal offset tests. The safety technologies and other improvements are happening largely because safety is selling. This *Status Report* focuses on some key vehicle improvements.

In 6 of 10 new vehicles, occupant protection improves, crash tests show

Good structural design is key to good performance in the 40 mph offset test

When automakers redesign their passenger vehicles, more of them than ever are paying attention to aspects of occupant crash protection that go beyond government requirements. In particular, vehicles' structural designs are being improved to do a better job of preventing intrusion into the occupant compartment and preserving the space for occupants to survive.

To assess important aspects of frontal crashworthiness, the Institute conducts 40 mph frontal offset crash tests. The most recent test series involves 10 models with wholly new designs or engineering changes that could affect crashworthiness. Three passenger vans, three midsize cars, and four small cars were tested.

How they rate: Only 2 of the 10 vehicles tested — Honda Odyssey and Ford Windstar passenger vans — earn good overall ratings. Five are rated acceptable, and three are marginal or poor.

Which ones improved, which didn't: The Odyssey, Mitsubishi Galant, and Hyundai Sonata performed substantially better in the 40 mph crash test, compared with their predecessor models. The structural performances of the Saab 9-3 and Volkswagen New Jetta also improved, but the Nissan Quest — re-engineered to accommodate a fourth door — performed significantly worse than the three-door version. Structurally the Mazda Protege and Dodge Neon performed about the same as their predecessors.

The Institute's frontal offset crash test into a deformable barrier is especially demanding of vehicle structure. The driver side of the vehicle hits the barrier, so a relatively small area of the front-end structure must manage the crash energy. This means intrusion into the occupant compartment is more likely to occur than in a full-width test.

"Good structural design is the key to good performance in the offset test," Institute president Brian O'Neill explains. "If a vehicle's front-end structure absorbs and manages the crash energy so the occupant compartment remains largely intact, with little or no intrusion, then the dummy's movement is likely to be controlled, and injury measures are likely to be low. On the other hand, poor structural design means a greater likelihood of poor control of the dummy and high injury measures."

Improved structural designs: The crash test of the 1999 Mitsubishi Galant, compared with its predecessor 1995 model, provides a good example. Photos taken after the offset crashes show how much more space there is around the driver dummy in the redesigned 1999 Galant, compared with the 1995 model. "The occupant compartment of the old Galant virtually collapsed in the test," O'Neill says. "There was lots of intrusion. But the new Galant fared a lot better. The occupant compartment held up reasonably well, so the dummy's movement was controlled better than in the old model, and the injury measures were lower."

Specific intrusion measurements quantify the Galant's improvement. For example, the width of the driver door opening at the bottom of the window was reduced by 25 centimeters during the crash test of the 1995 Galant, but the reduction was much less — only 5 centimeters — in the test of the 1999 model.

Another good comparison involves the Honda Odyssey. In the 40 mph test of the 1996 model, the instrument panel moved 13 to 15 centimeters rearward, toward the dummy. But after Honda completely redesigned the Odyssey for the 1999 model year, the structural performance improved. Rearward movement of the instrument panel was only 1 or 2 centimeters, for example.

"The way to protect people in serious frontal crashes is to ensure that the space around them isn't compromised. When major intrusion occurs, even the best restraint system cannot prevent injuries. It's the same concept as shipping a fragile object — it doesn't matter how well it's pro-

CRASHWORTHINESS RATINGS

New vehicle designs compared with older versions of the same models

small cars	old	new
VW NEW JETTA old 1994-99 (early), new 1999	M	A
MAZDA PROTEGE old 1995-98, new 1999	A	A
DODGE/PLYMOUTH NEON old 1995-99, new 2000	P	M
KIA SEPHIA old 1996-97, new 1998-99	P	P
midsize cars		
SAAB 9-3 old 1995-98 (Saab 900), new 1999	M	A
MITSUBISHI GALANT old 1994-98, new 1999	P	A
HYUNDAI SONATA old 1995-98, new 1999	P	A
passenger vans		
FORD WINDSTAR old 1995-98, new 1999	G	G
HONDA ODYSSEY old 1995-98, new 1999	M	G
NISSAN QUEST old 1996-98, new 1999	M	P

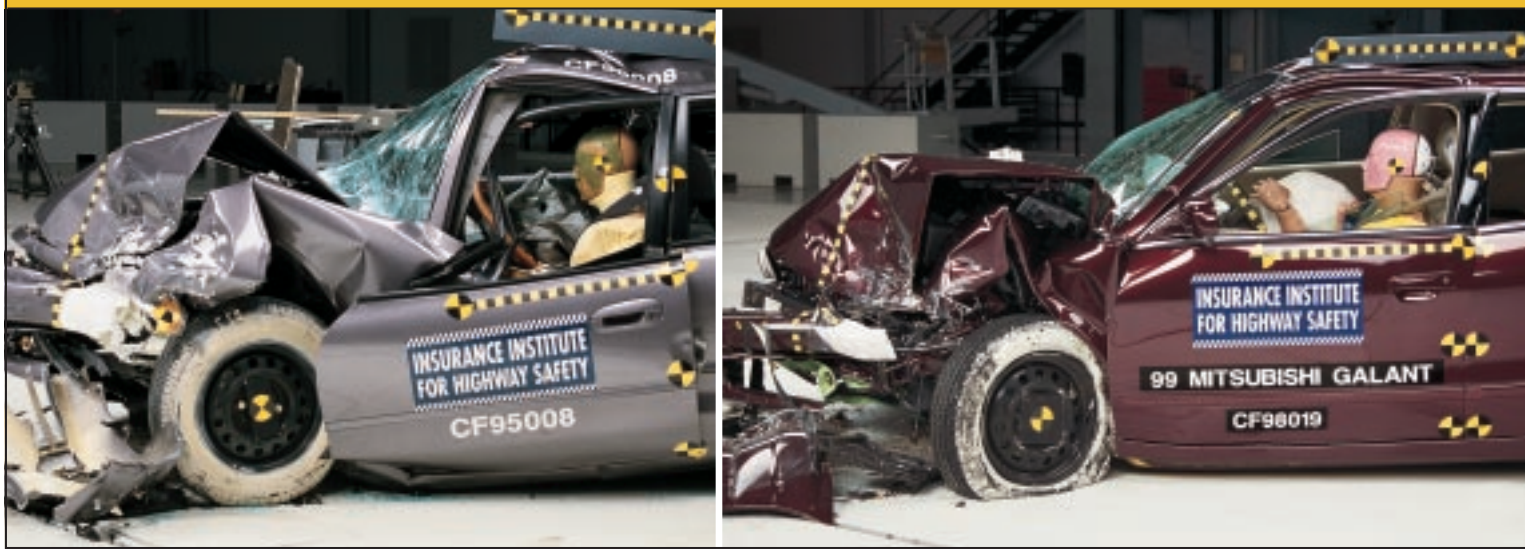
For complete evaluations of these and other vehicles, visit www.highwaysafety.org

good G M marginal
acceptable A P poor

tected by foam or other packaging inside a box, if the box gets damaged or crushed during transit, the object is likely to break. Today more of the vehicles we test have improved structural designs, and their occupant compartments, or safety cages, remain largely intact. This means even in serious crashes the restraint systems should protect the occupants, so fewer people are going to be injured or die in these vehicles," O'Neill also says.

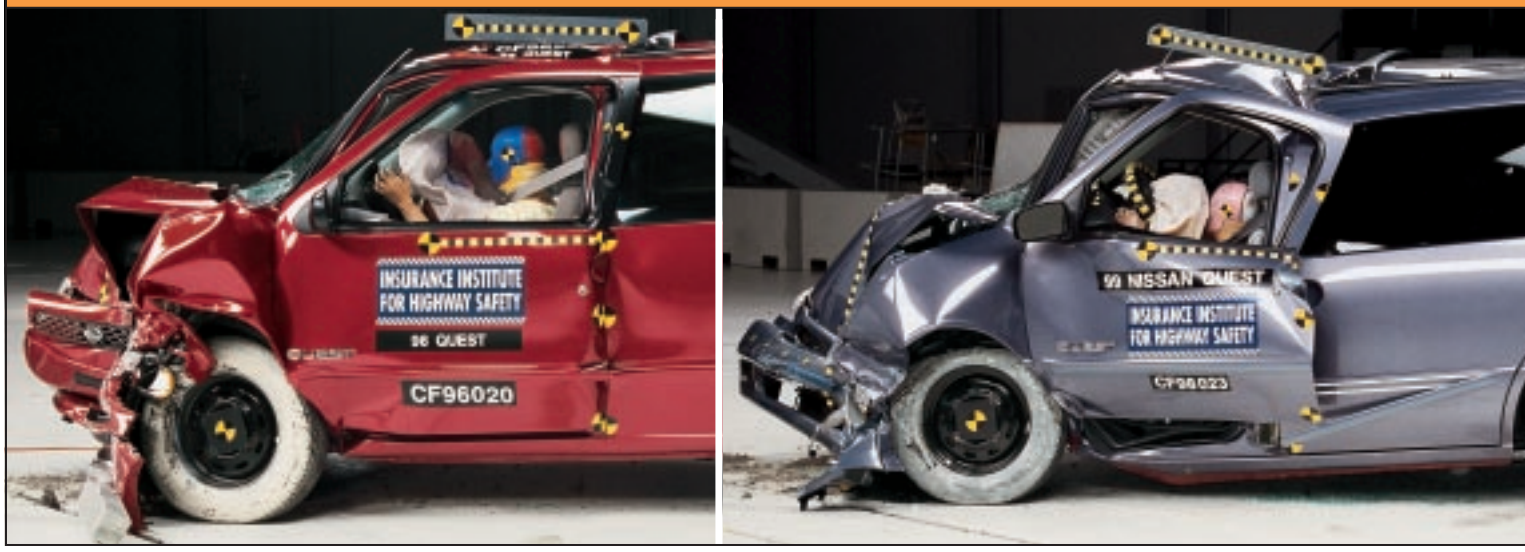
These design improvements aren't happening because any government regulation is demanding them. "It's because nearly every automaker has moved on its own to incorporate an offset test into the development process for new and redesigned models. The manufacturers are doing this because they know many car buyers want the best occupant crash protection they can get," O'Neill points out.

1995 Mitsubishi Galant **IMPROVED for 1999 model year**



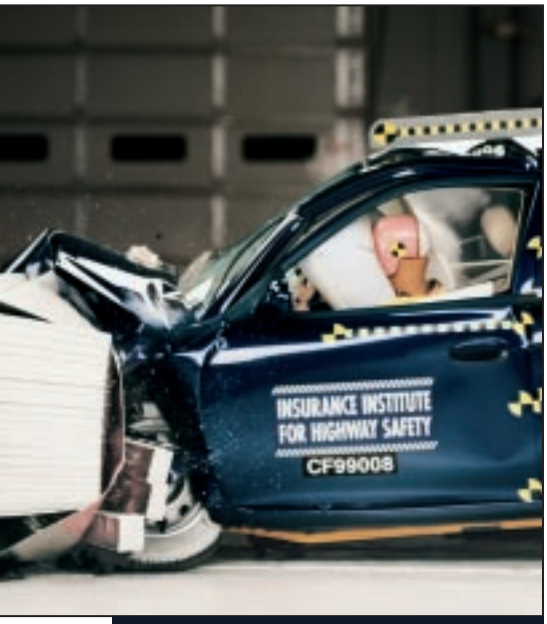
A 1995 Mitsubishi Galant (above left) earned a poor rating for structural performance in the Institute's 40 mph frontal offset crash test. The occupant compartment virtually collapsed — note the buckling of the roof and the displacement of the driver door. In contrast, the redesigned 1999 Galant's structure/safety cage (above right) is rated acceptable. Its driver survival space was maintained well. Even small design modifications can affect a car's structural integrity. Engineering changes associated with adding a fourth door to the Nissan Quest for the 1999 model year (below right) resulted in worse structural performance than the 1996 Quest (below left) in a 40 mph frontal offset crash test. Note the extreme buckling of the roof rail and door sill of the re-engineered model compared with the earlier model.

1996 Nissan Quest **DIDN'T IMPROVE for 1999 model year**



Complementary tests: The Institute's crashworthiness evaluations are based primarily on results from the frontal offset crash test at 40 mph. Each vehicle's overall evaluation is based on three aspects of performance — measurements of occupant compartment intrusion, injury risk measures from a Hybrid III dummy positioned in the driver seat, and analysis of slow-motion film to assess how well the restraint system controlled dummy movement during the test.

The federal government has been testing new passenger vehicles in 35 mph impacts since 1978. This program has been a major contributor to crashworthiness improvements — in particular, improved restraint systems in new passenger vehicles. The Institute's offset test, which involves 40 percent of a vehicle's front end hitting a deformable barrier at 40 mph, complements the federal test involving the full width of the front hitting a rigid barrier. The government test is especially demanding of vehicle restraint systems but not so much so of vehicle structure. An offset test is more demanding of structure.



DIDN'T IMPROVE

1997 and 1999 Kia Sephias performed worst among small cars the Institute tested

Impressive crash test performance for Ford with side airbags that also protect the head

For the first time, automakers are beginning to offer side airbags with head protection in more popular and less expensive passenger vehicles. Ford Motor Company rolled out its new side airbags for 1999 models, and Institute crash tests demonstrate the potential benefits of this safety technology in side impact crashes.

In collaboration with Ford, the Institute conducted two crash tests of Lincoln Town Cars, a 1999 model in which the new side airbag with head protection is standard equipment and a 1998 model without a side airbag. In each test, the car was propelled sideways at 18 mph into a rigid pole. The pole is relatively narrow, so there was major penetration into the side of each car. In the impact without the side airbag, the crash dummy's head hit the pole with more than enough force to cause death in an actual collision. The head injury criterion was 5390, or more than five times the reference value (1000) used to indicate the likelihood of a serious head injury like a skull fracture. In contrast, the head injury criterion in the same crash test with a side airbag was 376, well below the injury reference value. Dummy injury measures also indicate the benefits of side airbags that protect the thorax. In the crash test of the Town Car with this technology, both the thoracic trauma index and lateral acceleration of the pelvis were reduced.

"The side airbag with head protection makes this kind of crash survivable despite the severity," Institute president Brian O'Neill points out. "This airbag restraint system should protect people in a range of serious side impacts in which there's intrusion in the area near an occupant's head, including two-vehicle crashes."

Side airbags of this type are "relevant to the recent public concerns about crash compatibility among different types of vehicles," O'Neill adds. "The most effective way to address compatibility problems is to upgrade side impact protection because these are the crashes in which in-

ADVANCED SIDE AIRBAGS

18 mph side-into-pole crash test results
Lincoln Town Cars with & without side airbags

Dummy Injury Measure	Injury Reference Value	Crash Test Results SIDE AIRBAG 1999 Town Car	NO SIDE AIRBAG 1998 Town Car
Head injury criterion	1000	376	5390
Neck compression (kN)	4.0	0.2	6.4
TTI (g)	85	59	66
Pelvic lateral acceleration (g)	130	39	48

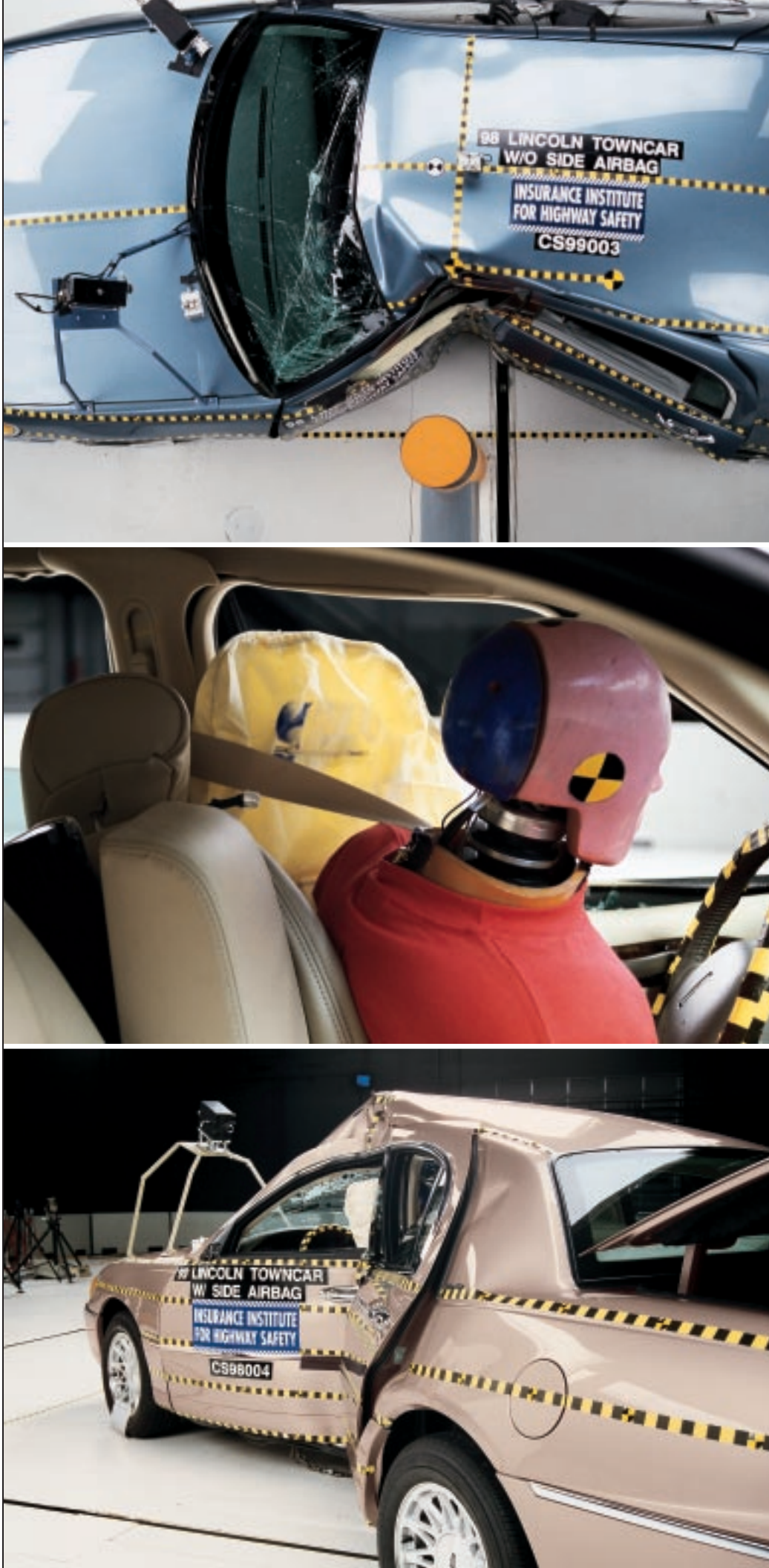
compatibility is most apparent. Ford is doing this with its new side airbag system."

Ford's side airbag deploys from the driver or front passenger seatback, inflating forward and upward to cushion the head and chest. Initial inflation is away from the occupant, toward the vehicle's B-pillar and door. According to Ford's Priya Prasad, these airbags thus "are designed to minimize the risk of head, neck, and chest injuries to out-of-position occupants."

The 18 mph speed of the Institute's test may not sound like one at which a crash could be serious, but O'Neill explains that "a side impact into a fixed object at 18 mph is, in fact, very severe" (see photos).

Because head injuries are a leading cause of death in side impacts, many automakers are developing airbags designed specifically to protect people's heads in these crashes. Ford isn't the first. Side airbags with head protection are in all BMWs, Saabs, and Volvos plus some Mercedes models (see *Status Report*, Dec. 27, 1997; on the web at www.highwaysafety.org). But Ford is the first manufacturer to offer side airbags with head protection in some more popular and less expensive vehicles. This technology is standard or optional in the 1999 Ford Explorer and Mercury Mountaineer (utility vehicles), Ford Windstar (passenger van), Mercury Cougar, Lincoln Continental and Town Car, and Jaguar XJ8 and X200. More Ford vehicles in model year 2000 also will offer this protection: Ford Taurus and Focus (a new model), Lincoln LS (new), and Mercury Sable.

The federal government estimates that side airbags with head protection in all cars could prevent about 600 deaths from head injuries in crashes each year.

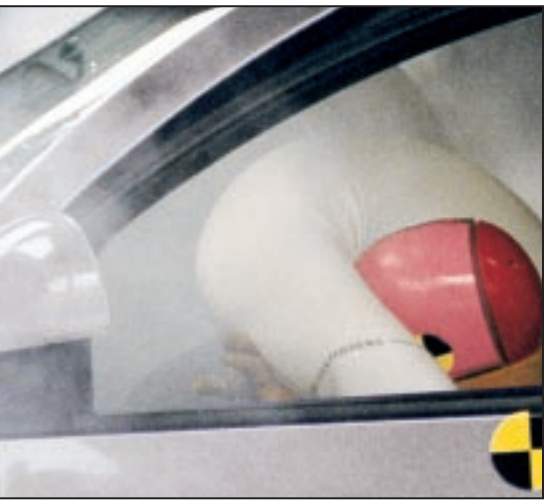


Photos from film of the crash test (left) show how the dummy's head was cushioned by the side airbag in a 1999 Lincoln Town Car. The severity of the 18 mph impact is apparent from the occupant compartment intrusion into the Town Car without side airbags (top right photo) and in a side view of the crashed Town Car with side airbags (bottom right). Smeared greasepaint on the deflated airbag (middle right) indicates where the dummy's head was cushioned instead of hitting the pole.

On the brink of advanced frontal airbags in new cars

More new cars soon will have airbags with deployment thresholds that are higher when safety belts are used. Plus inflation forces will vary according to crash severity.

Last year, the National Highway Traffic Safety Administration proposed new requirements intended to reduce the risk of injury from inflating airbags without sacrificing the lifesaving benefits (see *Status Report*, Oct. 10, 1998; on the web at www.highwaysafety.org). These requirements, which are supposed to promote the development and use of advanced airbag technology, aren't likely to be final for years.



Meanwhile, automakers are phasing in advanced designs ahead of the final rule.

Dual thresholds, two-stage inflators: The first phase will be airbags with higher deployment thresholds for belted occupants and different inflation forces depending on crash severity. "These two concepts customize airbag protection to particular situations," Institute research vice president Susan Ferguson says. "For example, an airbag wouldn't inflate in a relatively slow-speed crash if an occupant were using a belt. In such instances, the airbag wouldn't be needed because the belt alone would provide enough protection. But if the occupant weren't belted, the airbag would deploy. And if the crash were more severe, the airbag would inflate with greater force to protect people with and without belts."

Airbags with dual thresholds have been in Mercedes and BMW cars for several years and now are appearing in Volvo S80s and Acura RLs. The Acura's airbags also include two-stage inflators that vary inflation forces according to crash severity. Mercedes may introduce such inflators very soon, perhaps before the 1999 model year is out. For the 2000 model year, both dual thresholds and two-stage inflators are expected in more cars including BMWs and Acuras.

The 2000 model Ford Taurus will have both technologies. Plus the driver airbag will inflate with less force if someone is sitting very close to it. In 2001s, the forces of the passenger bag will vary according to an occupant's weight, with lower forces for lighter (presumably smaller) people.

Chrysler will use dual thresholds and two-stage inflators beginning with 2001 models. Toyota will use two-stage inflators, but not dual thresholds, in 2000 models. General Motors says some of its cars will have two-stage inflators by 2001.

Occupant sensing systems: On the horizon are sensors that will detect the presence of small children in front of airbags and automatically switch the bags off. General Motors is scheduled to introduce this technology in some 2000 model cars. Later will come airbags that sense people's weights and positions during crashes, tailoring inflation to balance protection with the risk of injury to occupants who are very close to inflating bags.

Advancements like these depend on technology that senses people's weights and continuously monitors their positions in the vehicles. "This will require very reliable sensors and will take more time," Ferguson points out. "Even though the manufacturers have been working on ways to automatically switch off airbags when children are riding in front of them, most automakers say they haven't found a system yet that works with sufficient reliability."

Better bumpers on most vehicles the Institute tested

Automakers respond to 5 mph tests with improved bumpers

Eight of the eleven 1999 models the Institute tested had better bumper results than their predecessor models. On the other hand, only three vehicles — Volkswagen New Jetta, Honda Odyssey, and Nissan Quest — averaged less than $300 damage per test in four crashes at 5 mph.

"This means there's still too much unnecessary damage," Institute president Brian O'Neill say. He adds that "designing effective bumpers is no great engineering challenge, but unless it's a priority we'll continue to see some manufacturers using inferior designs."

Elantra compared with Protege: Results of the rear-into-pole test provide the biggest contrast — from only $8 damage to the Hyundai Elantra to $2,837 damage to the Mazda Protege. The bumper design priorities of these two automakers explain the difference. The 1997 Elantra model had a poor rear bumper system. After the Institute tested it and reported $1,612 damage in the rear-into-pole test, Hyundai redesigned the rear bumper and improved the performance. Mazda, however, put inferior rear bumpers on its 1999 Protege — worse than those on the predecessor model — and the result is huge damage in two rear crash tests at 5 mph.

To a consumer, the bumpers on the 1997 and the new Protege appear virtually identical. But underneath are major changes. The rear bumper on the earlier model included an aluminum bar and energy-absorbing foam material. But these have been replaced on the 1999 by a piece of plastic that broke in the pole test, allowing extensive damage to the car's sheet metal.

The improved 1999 Elantra's rear bumper allowed virtually no damage in either the rear-into-flat-barrier test or the very de-

5 MPH CRASH TEST RESULTS

Repair costs reflect January 1999 prices

	Front Into Flat Barrier	Rear Into Flat Barrier	Front Into Angle Barrier	Rear Into Pole	Total Damage 4 Tests	Average Damage Each Test
Small cars						
Volkswagen Jetta						
1999 model	$141	$43	$690	$149	$1,023	$256
1997 model	$150	$0	$772	$245	$1,167	$292
Hyundai Elantra						
1999 model	$471	$66	$1,077	$8	$1,622	$406
1997 model	$245	$354	$688	$1,612	$2,899	$725
Dodge/Plym. Neon						
1999 model	$359	$63	$388	$1,022	$1,832	$458
1997 model	$134	$92	$344	$509	$1,079	$270
Mazda Protege						
1999 model	$169	$626	$977	$2,837	$4,609	$1,152
1997 model	$598	$144	$479	$709	$1,930	$483
Kia Sephia						
1999 model	$0	$411	$684	$1,134	$2,229	$557
1997 model	$362	$460	$758	$1,337	$2,917	$729
Midsize cars						
Mitsubishi Galant						
1999 model	$199	$431	$791	$250	$1,671	$418
1995 model	$812	$259	$761	$1,651	$3,483	$871
Saab 9-3						
1999 model	$0	$135	$578	$971	$1,684	$421
1994 model (Saab 900)	$0	$0	$867	$1,152	$2,019	$505
Hyundai Sonata						
1999 model	$384	$281	$1,032	$908	$2,605	$651
1996 model	$819	$0	$1,276	$1,740	$3,835	$959
Passenger vans						
Nissan Quest						
1999 model	$0	$239	$631	$240	$1,110	$278
1996 model	$485	$0	$625	$1,294	$2,404	$601
Honda Odyssey						
1999 model	$462	$258	$175	$168	$1,063	$266
1996 model	$83	$473	$1,043	$560	$2,159	$540
Ford Windstar						
1999 model	$341	$0	$337	$1,036	$1,714	$429
1995 model	$0	$82	$857	$1,268	$2,207	$552

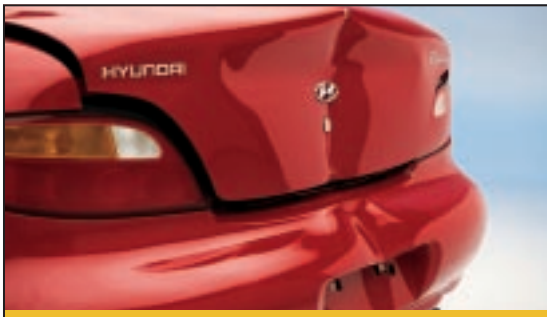
manding rear-into-pole test, compared with total damage of almost $2,000 (1999 prices) in the same tests of the 1997 model. The difference is that Hyundai strengthened the reinforcement bar underneath the plastic bumper cover and added energy-absorbing foam to the rear bumper.

"This is what bumpers are supposed to do. Their purpose is to prevent damage in low-speed collisions, and Hyundai earns praise for the improvements," O'Neill says.

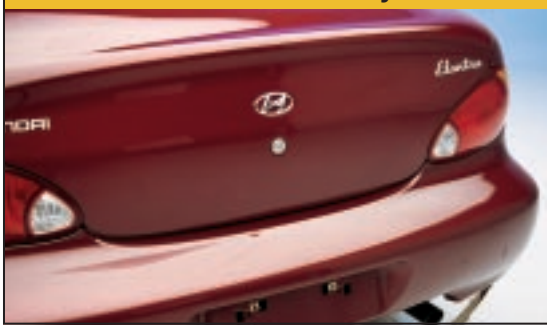
Protege to improve: Now Mazda is coming around. Brian Betz of this company says, "We'll make improvements to the rear bumper by August of this year. We are making changes based on results of the tests."

Damage to the 1999 Mitsubishi Galant was cut by more than half in the Institute's low-speed crash tests, compared with the 1995 Galant, which the Institute rated poor for bumper performance. Most of the improvement is because of much better performance in the rear-into-pole crash test. Damage to the 1995 model from this test alone was $1,651, compared with only $250 damage in the pole test for the 1999 Galant model.

To assess bumper performance, the Institute conducts four crash tests at 5 mph — front and rear flat-barrier impacts plus two localized impacts, front-into-angle-barrier and rear-into-pole.

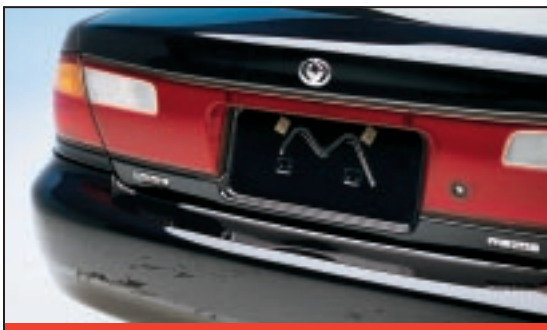


IMPROVED
1997 to 1999 model year

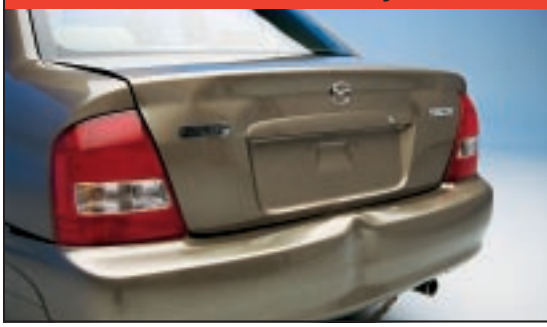


The 1997 Hyundai Elantra (top photo) sustained $1,612 damage in a 5 mph rear-into-pole crash test. After this car was redesigned for 1999 (above), damage cost only $8.

With energy-absorbing foam and a pretty good reinforcement bar, the 1997 Mazda Protege (immediately below) sustained $709 damage in the rear-into-pole test. After redesign, the 1999 Protege (bottom) sustained four times as much damage.



DIDN'T IMPROVE
1997 to 1999 model year



STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

SPECIAL ISSUE

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This special issue focuses on advanced safety technologies. Other special issues have focused on the following subjects:

ANOTHER NEW SAFETY TECHNOLOGY

The Institute recently tested an advanced seatback/head restraint combination, which will be featured in an upcoming *Status Report*.

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