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Status Report

Insurance Institute for Highway Safety | Highway Loss Data Institute

Safety gains ground

More vehicles earn top honors from IIHS

The IIHS winners' circle for 2015 includes 71 vehicles, as manufacturers put state-of-the-art safety on more models.

The number of vehicles earning either of the Institute's two awards has jumped to 71 from 39 this time last year, giving consumers more choices for optimum protection in crashes. The number of winners in the top tier — *TOP SAFETY PICK+* — has increased by 11, despite a tougher standard for front crash prevention.

"This is the third year in a row that we are giving automakers a tougher challenge to meet," says IIHS President Adrian Lund. "The quest for *TOP SAFETY PICK* and *TOP SAFETY PICK+* awards is driving improvement in the small overlap front crash test and getting manufacturers to offer automatic braking technology on more and more vehicles."

While the bar has been raised for *TOP SAFETY PICK+*, the criteria for *TOP SAFETY PICK* are unchanged: a good or acceptable rating in the small overlap front test and a good rating in each of the Institute's four other crashworthiness evaluations — moderate overlap front, side, roof strength and head restraints (see *Status Report*, Dec. 19, 2013, at iihs.org). The 2015 *TOP SAFETY PICK+* designation is awarded to vehicles that meet those criteria and also have an available front crash prevention system that earns an advanced or superior rating.

For 2014, vehicles could qualify for *TOP SAFETY PICK+* with only a basic rating for front crash prevention. Warning systems that meet the National Highway Traffic Safety Administration's performance criteria but don't include autobrake qualify for a basic rating. For an advanced or superior rating, vehicles must stop or slow down without driver intervention before hitting a target in IIHS tests at 12 mph, 25 mph or both (see *Status Report*, Sept. 27, 2013).

As a result of the change in criteria for 2015, 15 vehicles that qualified for 2014 *TOP SAFETY PICK+* are now simply *TOP SAFETY PICK* winners. In all, there are 33 *TOP SAFETY PICK+* winners and 38 *TOP SAFETY PICK* winners.

"Although forward collision warning on its own is a valuable feature, we decided to tighten our criteria to encourage manufacturers to offer autobrake. Systems that don't

2015 Lexus RC 350

require a driver response to avoid or mitigate a crash have the most potential for reducing crashes," Lund says. "Nevertheless, the models that are losing their plus signs are still great choices for safety, as are all the *TOP SAFETY PICK* winners."

Meeting the small overlap challenge

Most vehicles produced in recent years have had little trouble with the Institute's moderate overlap front, side, roof strength and head restraint tests. The small overlap front test, which replicates what happens when the front corner of a vehicle collides with another vehicle or an object such as a tree or a utility pole, represented a new hurdle when it was introduced in 2012 (see *Status Report*, Aug. 14, 2012). The test is difficult because the crash forces bypass most of a vehicle's energy-absorbing structure. But small overlap crashes are common in the real world, so the Institute wanted to push manufacturers to look for solutions.

	2015 IIHS TOP SAFETY *PICK+*	2015 IIHS TOP SAFETY *PICK*	
Minicars		Chevrolet Spark Honda Fit	
Small cars	Lexus CT 200h built after September 2014 Mazda 3 Subaru Impreza Subaru XV Crosstrek Toyota Prius	Chevrolet Volt Dodge Dart Ford C-Max Hybrid Ford Focus Honda Civic 2-door Honda Civic 4-door Hyundai Elantra sedan Kia Soul	Mini Cooper Countryman Mitsubishi Lancer except Ralliart and Evolution models Scion FR-S Scion tC Subaru BRZ Subaru WRX Volkswagen Golf 4-door Volkswagen GTI 4-door
Midsize moderately priced cars	Chrysler 200 Mazda 6 Subaru Legacy Subaru Outback Toyota Camry Toyota Prius v	Chevrolet Malibu Ford Fusion Honda Accord 2-door Honda Accord 4-door Hyundai Sonata Kia Optima	Nissan Altima Volkswagen Jetta Volkswagen Passat
Midsize luxury/ near-luxury cars	Acura TLX Audi A3 BMW 2 series Infiniti Q50 Volvo S60 Volvo V60	Lincoln MKZ	
Large family car		Toyota Avalon	
Large luxury cars	Acura RLX Hyundai Genesis Infiniti Q70 except V-8 4WD Lexus RC Mercedes-Benz E-Class Volvo S80		
Small SUVs	Honda CR-V Mazda CX-5 Mitsubishi Outlander Subaru Forester	Mitsubishi Outlander Sport Nissan Rogue Toyota RAV4 built after November 2014	
Midsize SUVs	Toyota Highlander	Chevrolet Equinox GMC Terrain Nissan Pathfinder	
Midsize luxury SUVs	Acura MDX Lexus NX Mercedes-Benz M-Class Volvo XC60	Infiniti QX60	
Minivans	Toyota Sienna	Honda Odyssey Kia Sedona	

Except for Volvo models, vehicles only qualify for *TOP SAFETY PICK+* when equipped with optional front crash prevention systems.

For information about how each 2015 winner rates for small overlap front crash protection and front crash prevention, see *Status Report* online at iihs.org/StatusReport. For all ratings for individual vehicles see iihs.org/ratings.

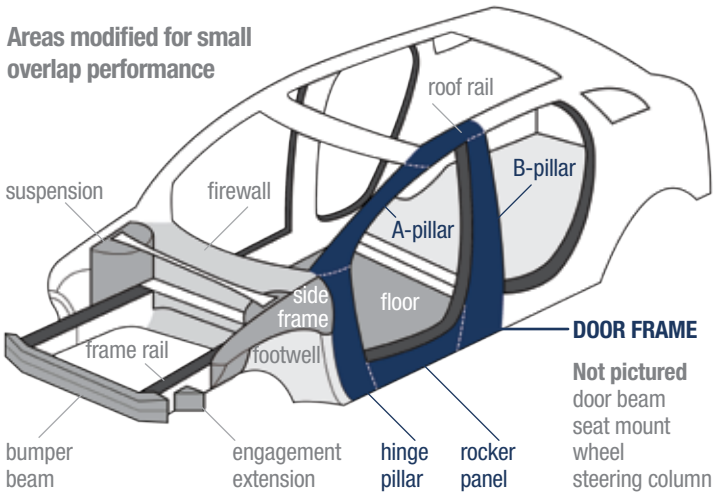
How vehicles are changing for better small overlap protection

As manufacturers have sought to improve their ratings, three main strategies have emerged for improving protection in IIHS small overlap front tests: strengthening the occupant compartment, adding new structures to engage the barrier and creating an additional load path for crash forces.

IIHS researchers identified these types of structural changes in a study of 36 models evaluated since the small overlap test program began in 2012. They found that these modifications work best in combination with each other and that, because they affect dummy movement, they often necessitate changes in the restraint system as well.

The most basic change is to strengthen the occupant compartment, and on nearly every vehicle studied at least one part of the door frame was beefed up.

Extending the bumper and adding engagement structures allow some vehicles to move sideways away from the barrier after striking it. When this happens the dummy experiences less change in velocity but ends up further to the left side of the vehicle, increasing the risk that the head could miss the front airbag if the safety belts and airbags aren't modified to better control the dummy's movement.



Among the vehicles whose structures held up best were those that have reinforced side frames tied into the main frame rail, providing an additional load path. Without such measures, crash forces generally go directly into the front wheel, suspension system and firewall. Major intrusion into the occupant compartment typically results.

One common problem in the small overlap front test is that the steering column moves to the right. When this happens, the front airbag moves as well, and the dummy's head slides off the left side of the airbag. In a few of the modified vehicles, this was addressed by changes explicitly meant to limit steering column motion. In others, reduced intrusion of the door frame and instrument panel was enough to increase steering column stability.

For a copy of "Structural design strategies for improved small overlap crashworthiness performance," by B.C. Mueller et al., email publications@iihs.org. ■

For 2013, IIHS continued to award *TOP SAFETY PICK* to vehicles that earned good ratings in the four older tests, regardless of their small overlap ratings. Those with good or acceptable small overlap ratings earned *TOP SAFETY PICK+*. Only 13 vehicles managed it at the beginning of the award year (see *Status Report*, Dec. 20, 2012).

Since then, automakers have steadily increased the number of good or acceptable small overlap ratings by factoring in the test when they redesign a vehicle or introduce a new model and by making modifications to the structure and airbags between redesigns.

The Honda CR-V, a 2015 *TOP SAFETY PICK+* winner, is an example of a vehicle that was successfully modified for improved protection. Previously, the small SUV earned a marginal rating when it was tested in 2012. The structure didn't hold up, with intrusion into the driver space exceeding 1 foot. The dummy's head barely contacted the front airbag before sliding off as the steering column moved to the right.

Honda made changes to the vehicle's front-end structure, occupant compartment and restraint system for the 2015 model year. In the most recent test, maximum intrusion was 5 inches at the

2015 Lexus NX 200t

parking brake pedal, and the dummy's head remained on the front airbag until rebound. Today's CR-V earns a good rating.

The Toyota Prius v, which also earns *TOP SAFETY PICK+*, saw even greater improvement. The midsize car had been one of the worst performers ever in the small overlap test. In 2012, the structure collapsed, and the dummy's head hit the instrument panel and ended up between the side curtain airbag and the door. Measures taken from the dummy showed left hip and lower leg injuries were very likely.

After the structure was improved and the side curtain airbag was lengthened, the 2015 Prius v performed well all-around, with low levels of intrusion, good restraint performance and low injury measures.

Manufacturers are employing some common strategies when it comes to beefing up structure for small overlap protection (see sidebar). In the CR-V's case, the door frame was strengthened and the side frame under the fender was reinforced. The beefed-up side frame ties into the main frame rail, producing an additional load path for energy absorption. On the Prius v, the front bumper was extended and the door frame strengthened. In addition, structure was added to better tie the door-hinge pillar to the frame rail.

Kia Sedona is 2nd minivan to rate good in small overlap test

When the Institute released small overlap results for minivans in November, the results were disappointing, with three models performing poorly (see *Status Report*, Nov. 20, 2014, at iihs.org). At that time, the Honda Odyssey was the only minivan to earn a good rating in the test. Now the 2015 Kia Sedona joins the Odyssey at the top of the list.

The 2015 Sedona was tested twice, and the good rating is based on the second test. In the first test, the vehicle didn't perform well because the driver door opened. Doors should remain closed in a crash because an open door increases the risk of ejection. In the Sedona's case, the door also performs an important structural function, so the level of crush ended up being much worse than it would have been had the door remained closed.

The doors of most late-model vehicles automatically lock when the vehicle is in gear or reaches a certain speed. In some cases, the feature can be disabled by the consumer. For those vehicles, the Institute's policy is to unlock the doors for the test.

After the Sedona's first test, Kia told IIHS that the door-locking function would be changed so that consumers could no longer turn it off. Sedonas built after November have the new setting, and the company is planning a service campaign to change this on earlier 2015 Sedonas.

In light of the change, IIHS conducted the second test with the doors locked. This time all doors remained closed, resulting in the good rating.

The new Sedona is a *TOP SAFETY PICK* winner, with good ratings in all the other crashworthiness tests, including roof strength. The previous generation had poor roof strength. The Sedona's optional front crash prevention system earns a basic rating. ■

Front crash prevention spreads

The list of 2015 *TOP SAFETY PICK+* winners shows how quickly front crash prevention systems with autobrake are spreading. In total, there are 27 superior-rated 2015 models and 33 with an advanced rating. (Some of those vehicles don't qualify for *TOP SAFETY PICK+* because they don't meet all the crashworthiness criteria.)

Most of the *TOP SAFETY PICK+* winners earn the award only when equipped with optional front crash prevention systems. However, when not equipped, they still meet the crashworthiness criteria for *TOP SAFETY PICK*.

Currently, only three automakers offer standard front crash prevention systems. Volvo models have standard City Safety, a low-speed autobrake system. The Mercedes-Benz C-Class and E-Class have a warning and autobrake system, but the standard autobrake components haven't been tested yet. The Mercedes-Benz M-Class and CLA and the Acura RLX offer standard warning systems. All these vehicles are available with optional systems that earn higher ratings than the standard equipment. The CLA, which earns an advanced rating with its optional system, hasn't been tested for crashworthiness. ■

Laying the groundwork for safety improvements for back-seat occupants

Restraint system changes might make sitting in back even safer, especially for adults

When it comes to advances in occupant protection, the front seat has gotten much of the attention while vehicle restraint system improvements for people who ride in back haven't kept pace. A new study by the Institute and The Children's Hospital of Philadelphia examines the characteristics of back-seat occupants injured in crashes in late-model vehicles to help zero in on ways to make rear seats safer.

Researchers analyzed real-world data on crashes during 2007-12 involving restrained occupants in the front and rear rows of 2000 and newer model passenger vehicles. Data were taken from two federal crash databases, the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) and the Fatality Analysis Reporting System (FARS). The former is a nationally representative sample of police-reported tow-away crashes on public roads, while the latter is a census of all crashes on public roads resulting in a fatality within 30 days of the crash.

Among all passenger vehicle occupants in crashes during 2007-12, 12 percent were seated in back. Children younger than age 13 accounted for 56 percent of back-seat occupants, teenagers ages 13-19 made up 19 percent, and adults accounted for 21 percent of occupants in the back.

Enhancing safety in the rear seat, where children and adults alike sit, is challenging. Vehicle designers have to be sure that changes that help one group won't harm another or interfere with the installation of child restraints.

Although more than half of rear-row occupants were younger than 13, they accounted for only 19 percent of serious injuries in crashes and 24 percent of crash deaths. Adults were overrepresented among rear-row occupants with serious or fatal injuries, and they had lower rates of restraint use. Only 70 percent of 20-54 year-olds and 86 percent of people 55 and older were restrained. This compares with 99 percent of infants, 96 percent of 4 to 8 year-olds and 93 percent of 9 to 12 year-olds.

Restraint use is an important risk factor for injury. The risk of serious injury was nearly 8 times higher among unrestrained rear-row occupants as compared with those using restraints.

The relative risk of death was lower for restrained children up to age 8 in the rear compared with front passengers but was higher for restrained children ages 9 to 12 seated in back. It's not clear that the front seat is safer for preteens. The finding could be due to sparse data on kids this age seated in front. Among occupants ages 13 to 54, researchers couldn't find evidence of a difference in death risk in the rear compared with the front seat.

Belted adults age 55 and older seated in the back had the highest risk of any age group of sustaining a serious or fatal injury in a crash, and they had a higher relative risk of death when seated in the back as compared with the front. The finding is consistent with previous research indicating that adults in the rear are more likely than adults in the front to sustain chest injuries, along with some evidence of an elevated risk of head and neck injuries for restrained women seated in the rear compared with the front (see *Status Report*, Feb. 20, 2014, at iihs.org).

After controlling for occupant age and gender, the relative risk of death for restrained rear occupants was significantly higher than that of front occupants in model 2007 and newer vehicles and significantly higher in rear and right-side impact crashes.

"That doesn't mean that the rear seat in newer vehicles is less safe than in older model vehicles," says Anne McCartt, the Institute's senior vice president of research and one of the authors of the study. "The risk of fatal injury for rear occupants is similar across all of the model years we examined. Instead, the disparity reflects the fact that the front seat is getting safer."

Consumer crash-test information programs largely focus on drivers and front-seat passengers because that's where most people ride and most deaths occur in crashes.

"Enhancing safety in the rear seat, where children and adults alike sit, is challenging," says Dr. Dennis Durbin, director of the Office of Clinical and Translational

Research at The Children's Hospital of Philadelphia Research Institute and the main author of the study. "You have to be sure that changes that help one group won't harm another or interfere with the installation of child restraints."

The study's findings suggest that rear-seat occupants could benefit from some of the same technologies used to protect drivers and front passengers. Front airbags, side airbags and knee airbags, plus features that ready safety belts when a crash is imminent and limit the amount of energy that is transferred to an occupant are among these innovations.

Belt pretensioners tighten up slack when triggered by vehicle sensors and retract the belt almost instantly in a crash. Load limiters manage the force that belts apply to occupants' chests in a crash by allowing some of the webbing to spool out when the forces exceed levels that can cause injuries.

There is some question about the benefits of load limiters. Prior IIHS research on front-seat occupants has indicated in certain severe crashes, including small overlap front crashes, shoulder belts with load limiters may spool out too much, allowing occupants to move enough to strike hard surfaces inside the vehicle (see *Status Report*, Oct. 13, 2007).

Another option would be to develop advanced restraint systems tailored for the back seat, such as inflatable safety belts. Ford offers optional inflatable belts in certain rear seats of the Ford Explorer, F-150 SuperCrew, Fusion, Flex and Taurus, plus the Lincoln MKT and MKZ. Inflatable belts also are available on the Mercedes S-Class.

When deployed, inflatable belts aim to reduce chest injuries by distributing crash forces more widely over the body than with conventional belts. The inflated belt also provides support for the head and neck to prevent excessive motion. When vehicle sensors determine that a severe collision is occurring, the belt's airbag fills with cold compressed gas and expands sideways across the occupant's body.

Side curtain airbags protect people in the back in side crashes, and in front crashes some cars deploy one or both side curtains, depending on the crash angle. There are no vehicles on the market with rear-seat airbags for protection in a full-front crash. The Scion iQ microcar has a rear-window curtain airbag that deploys in a rear crash.

Ford Motor Company

For belted teens and adults up to age 54, sitting in back is no riskier than sitting in the front seat, the study found. However, things change after age 55. Adults this age and older had the highest risk of any age group of sustaining a serious or fatal injury in a crash, and they had a higher relative risk of death when seated in back as compared with the front. The findings suggest a need for advanced restraint systems tailored for the back seat, such as inflatable safety belts (left) like the ones Ford and Mercedes offer on some models.

Under current regulations, the performance of restraint systems for rear seats in frontal impacts is evaluated only in static tests, not crash tests. Assessing the risk of injury to rear-seat occupants isn't required, and IIHS and government crashworthiness programs focus on evaluating occupant protection for people seated in front. In contrast, vehicle evaluation programs in Australia, China, Europe and Japan take into account protection for children in crash tests.

The National Highway Traffic Safety Administration is weighing changes to the New Car Assessment Program to focus on rear-seat restraint system performance. Options include creating a crashworthiness rating for rear-seat child occupant protection and running frontal tests using a 5th percentile hybrid III dummy representing a 108-pound, 5-foot tall woman or child seated in back.

Extending safety belt laws to back-seat occupants also could help. In states that require belt use in all seating positions, 84 percent of back-seat passengers ages 8 and older were observed using safety belts in 2012, compared with 67 percent of back-seat passengers in states that require only front-seat belt use, a federal National Occupant Protection Use Survey found. Primary belt laws also encourage people to buckle up. Under a primary law, a police officer can stop a driver solely because they or their passengers aren't using belts. Thirty-three states and the District of Columbia have primary belt laws, but only 16 of these states cover back-seat occupants, too.

For a copy of "Rear seat safety: variation in protection by occupant, crash and vehicle characteristics" by D.R. Durbin et al., email publications@iihs.org. ■

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