Small overlap crashes

New consumer-test program aims for even safer vehicles

Also in this issue
Vol. 47, No. 6
August 14, 2012

- Real-world small overlap frontal crash results in driver injuries
- ESC proposed as standard feature for truck tractors, certain buses
A new Institute crash test evaluates how well vehicles protect people in frontal crashes involving 25 percent of a vehicle’s front end. Most cars in this inaugural round earn marginal or poor ratings.

Only 3 of 11 midsize luxury and near-luxury cars evaluated earn good or acceptable ratings in the Institute’s new small overlap frontal crash test, the latest addition to a suite of tests designed to help consumers pick the safest vehicles. The Acura TL and Volvo S60 earn good ratings, while the Infiniti G earns acceptable. The Acura TSX, BMW 3 series, Lincoln MKZ and Volkswagen CC earn marginal ratings. The Mercedes-Benz C-Class, Lexus IS 250/350, Audi A4 and Lexus ES 350 earn poor. All of these cars are 2012 models.

In the test, 25 percent of a car’s front end on the driver side strikes a 5-foot-tall rigid barrier at 40 mph. A 50th percentile Hybrid III dummy representing an average-size male is belted in the driver seat.

“Nearly every new car performs well in other frontal crash tests conducted by the Institute and the federal government, but we still see more than 10,000 deaths in frontal crashes each year,” Institute President Adrian Lund says. “Small overlap crashes are a major source of these fatalities. This new test program is based on years of analyzing real-world frontal crashes and then replicating them in our crash test facility to determine how people are being seriously injured and how cars can be designed to protect them better. We think this is the next step in improving frontal crash protection.”

The number of drivers of 0-3-year-old passenger vehicles involved in fatal frontal crashes has fallen 55 percent since 2001. Much of the improved outlook is due to the success of consumer information testing like the New Car Assessment Program begun by the National Highway Traffic Safety Administration (NHTSA) in 1978 and crashworthiness evaluations the Institute started in 1995. In NHTSA’s frontal test, passenger vehicles crash at 35 mph into a rigid barrier covering the full width...
of the vehicle. In the Institute’s 40 mph offset frontal test, now called a moderate overlap frontal test, 40 percent of the total width of a vehicle strikes a deformable barrier on the driver side.

In a 2009 Institute study of vehicles with good ratings for frontal crash protection, small overlap crashes accounted for nearly a quarter of the frontal crashes involving serious or fatal injury to front seat occupants. Another 24 percent of the frontal crashes were moderate overlap crashes, although they likely occurred at much higher speeds than the Institute’s moderate overlap test (see Status Report, March 7, 2009; on the web at iihs.org). An additional 14 percent occurred when passenger vehicles underrode large trucks, SUVs or other high-riding passenger vehicles. The Institute is exploring countermeasures for large truck underride crashes and in other research has found that the problem of crash incompatibility between cars and SUVs is being reduced (see Status Report, March 1, 2011, and Sept. 28, 2011).

### Structural integrity

The key to protection in any crash is a strong safety cage that resists deformation to maintain survival space for occupants. Then vehicle restraint systems can do their jobs to cushion and protect people.

“It’s Packaging 101. If you ship a fragile item in a strong box, it’s more likely to arrive at its destination without breaking. In crashes, people are less vulnerable to injury if the occupant compartment remains intact,” Lund explains.

Most modern cars have safety cages built to withstand head-on collisions and moderate overlap frontal crashes with little deformation. At the same time, crush zones help manage crash energy to reduce forces on the occupant compartment. The main crush-zone structures are concentrated in the middle 50 percent of the front end. When a crash involves these structures, the occupant compartment is protected from intrusion, and front airbags and safety belts can effectively restrain and protect occupants.

Small overlap crashes are a different story. These crashes primarily affect a car’s outer edges, which aren’t well protected by the crush-zone structures.
The Institute’s new test reflects the severity of real-world small overlap frontal crashes. The majority of the cars evaluated experienced substantial occupant compartment intrusion.

Crash forces go directly into the front wheel, suspension system and firewall. It is not uncommon for the wheel to be forced rearward into the footwell, contributing to even more intrusion in the occupant compartment and resulting in serious leg and foot injuries. To provide effective protection in small overlap crashes, the safety cage needs to resist crash forces that aren’t tempered by crush-zone structures. Widening these front-end structures also would help.

“These are severe crashes, and our new test reflects that,” Lund says. “Most automakers design their vehicles to ace our moderate overlap frontal test and NHTSA’s full-width frontal test, but the problem of small overlap crashes hasn’t been addressed. We hope our new rating program will change that.”

Vehicle test performance varied widely in the three rating categories: structure, restraints and kinematics, and dummy injury measures. The majority of the cars had lots of occupant compartment intrusion, which contributed to their low overall rating. Occupant motion varied greatly as well, with the dummy missing the airbag in some cases. In others, safety belts allowed the dummy’s head and torso to move too far forward toward the A-pillar. Forces measured on the dummy indicated high risk of injury for the legs and feet in several vehicles.

Structurally, the Volvo S60 was best. With only a few inches of intrusion, the occupant compartment looked much the same as it did in a prior moderate overlap...
deploy, they don’t always do so early

When they do

side impacts — think so-called T-bone

because they are designed mainly for true

tecting torso airbags, don’t always deploy

ing head-protecting curtains and chest-pro-

these types of crashes. Side airbags, includ-

end and occupant compartment deform. If

many vehicles because of the way the front

column and driver airbag move inboard in

or structures. At the same time, the steering

into the path of the sideways-moving interi-

test dummy, however, keeps moving forward

and A-pillar move in the same direction. The

ures including the driver door, side window

wards away from it, and the interior struc-

tions including the driver door, side window

and A-pillar move in the same direction. The

test dummy, however, keeps moving forward

into the path of the sideways-moving interi-

or structures. At the same time, the steering

column and driver airbag move inboard in

many vehicles because of the way the front

end and occupant compartment deform. If

the dummy misses the airbag or slides off it,

the head and chest are unprotected.

Front airbags are calibrated to deploy in

these types of crashes. Side airbags, including

head-protecting curtains and chest-protect-

ting torso airbags, don’t always deploy

because they are designed mainly for true

tside impacts — think so-called T-bone

ashes at intersections. When they do

deploy, they don’t always do so early

enough or extend far enough forward to

adequately protect people. The result is an

airbag gray zone with gaps between what

front airbags cover and what side airbags

do — if they deploy at all.

Without airbag protection, people in real-

world small overlap frontal crashes can sus-

tain head injuries from direct contact with

the A-pillar, dashboard or window sill or by

hitting trees, poles or other objects. Chest in-

uries happen when people contact the steer-

ing wheel, door or other intruding structures.

Every luxury car and near-luxury car the

Institute evaluated earns good ratings for

head, neck and chest injury risk based on

measurements from the dummy’s sensors.

This is true even though there are many

cases of serious upper body injuries in real-

world crashes with similar vehicle damage.

One possible reason for the differing re-

sults is that real people move more during

a crash and are prone to be out of position

at the start, compared with relatively stiff

and precisely positioned crash test dummies.

Not all drivers are the same size as

the dummy or seated exactly the same way.

A close call for the dummy could mean an

actual injury for a person. In several crash

tests, the dummy’s head barely missed the

intruding structure of the vehicle, where a

real person may have made contact and

sustained an injury. Another reason is that

the frontal crash dummy the Institute uses

in the small overlap test is not good at mea-

uring risks from lateral forces. Side crash

dummies do a better job of this but can’t

“sense” — or record — much of the frontal

action in these tests.

Side curtain and torso airbags deployed

in the Acura TL and Volvo S60, although the

S60’s torso airbag fired too late in the

crash to protect the dummy’s chest from

August 14, 2012 | 5

Real-world small overlap crash results in driver facial injuries

Hollyn Mangione knows first hand the risks of a small overlap frontal crash. Driving her 2012 Kia Soul to a friend’s house on a
clear evening last November, Mangione, 48, encountered an oncoming 1999 GMC Yukon that had veered into her lane on a rural
road in Hanover County, Virginia.

“I looked up and saw the other vehicle coming toward me, and I

remember thinking, is there someplace I can go? Can I get off the

road? I took my foot off the accelerator trying to buy myself some time to make a decision. There wasn’t anywhere to go on this narrow road because it was tree-lined, and there was a big ditch.

“I remember thinking, please just stay in your lane,” she recalls. “Once I heard the boom and felt it, I was unconscious.” Afterward, she says “I remember the EMT holding my head and my telling her, ‘That really hurts.’ And saying to them, ‘But I’m stuck over here where my knee is pinned in the car.’ And then I don’t remember anything until they were putting IVs in, in the ambulance.”

Mangione, who was using her safety belt, sustained facial injuries from contact with the Kia’s
door frame. She had a left facial fracture and laceration, concussion, whiplash, left eye injury and
dental injuries. Crash damage to Mangione’s small car was similar to damage patterns in the Insti-
tute’s small overlap crash test. The driver’s space was compromised by intruding structure. The A-
pilar, hinge pillar and forward portion of the window frame were driven rearward and inboard as the

wheel and tire were forced rearward. The side curtain and torso airbags didn’t deploy. ■
Safety belts and airbags are especially taxed in small overlap frontal crashes. Gaps in airbag coverage or too much belt slack can leave occupants vulnerable to injuries.

**Top left:** The test dummy’s head and chest missed the front airbag as the steering column moved to the right in the Lincoln MKZ. The side curtain airbag deployed but didn’t have sufficient forward coverage to protect the head. **Middle:** The Acura TL’s front and side curtain airbags did a good job of protecting the dummy’s head.

Potential contact with side structures. One or both of the curtain and torso airbags didn’t deploy in seven of the cars evaluated. Of the six curtains that deployed, four didn’t provide sufficient forward coverage. The Institute lowered restraint and kinematics scores if side airbags didn’t deploy or coverage was lacking.

“Side curtain airbags and torso airbags are designed to deploy in side impacts, but they can be beneficial in small overlap frontal crashes as well,” Lund says. “If they do deploy, curtain airbags also need to extend far enough forward to protect the head from contact with side structures and outside objects.”

For example, in the Lincoln MKZ test, the dummy’s head and chest completely missed the front airbag as the steering column moved to the right. The side curtain airbag deployed but didn’t extend far enough forward to protect the dummy’s head. In comparison, the Acura TL’s front and side curtain airbags worked well together to keep the head from coming close to any stiff structures or objects that could cause injury.

Engineers at some manufacturers have indicated that they are adjusting airbag algorithms across their fleet to deploy side airbags in small overlap frontal crashes.

Another restraint and kinematics issue Institute engineers flagged was excessive forward movement of the driver dummy caused by too much shoulder belt webbing spooling out of the retractor. This was the case with the BMW, Mercedes and Volkswagen. Like most new vehicles, these cars have safety belts equipped with load limiters that allow occupants’ upper bodies to move forward in frontal crashes when belt loads exceed a specific threshold. Load limiters allow some belt spoolout after the initial impact to reduce belt-force-related thoracic injuries such as rib fractures by allowing people to “ride down” deflating front airbags. However, too much spoolout can compromise belt effectiveness by allowing belted occupants to move enough to strike hard surfaces inside the vehicle. This concern is greater in small overlaps where occupants may load only a small part of the front airbag or miss it completely.

**Tougher award criteria**

The Institute’s TOP SAFETY PICK award recognizes passenger vehicles that do the best job of protecting people in front, side, rollover and rear crashes based on ratings in Institute evaluations. The front rating is based on the moderate overlap test.

The Institute plans to make the top award criteria more stringent by adding the small overlap frontal test to its battery of evaluations. The existing criteria will continue for the 2013 award cycle, but vehicles that excel in the new test will be recognized.

“We won’t have evaluated many vehicles in the small overlap test in time for the 2013 award,” Lund explains. “Models meeting the current award criteria still offer outstanding protection in most crashes, and they will continue to earn TOP SAFETY PICK in 2013. However, those vehicles that also do well in the new test will get to claim a higher award level that will be announced later this year.”

The Institute has tightened award criteria twice since the first winners were announced for 2006 models. Good rear test results and availability of electronic stability control became a requirement starting with 2007 models, and a good roof strength rating became a deciding factor for 2010 models (see Status Report, March 24, 2009). Stability control is no longer a separate requirement since 2012 and later vehicles must have the feature as standard under federal rules.

Automakers have been quick to rise to the occasion whenever the Institute has added a new evaluation to its vehicle test program, and the small overlap test should be no exception.

“Manufacturers recognize that this crash mode poses a significant risk to their customers and have indicated that they plan structural and restraint changes to improve protection in small overlap frontal crashes,” Lund says.

Next, the Institute will assess midsize moderately priced cars, including such topselling models as the Ford Fusion, Honda Accord and Toyota Camry.
Truck tractors, buses could get standard ESC under NHTSA proposal

Electronic stability control (ESC), a crash avoidance feature required on 2012 and newer model passenger vehicles, could become standard on new large truck tractors and certain large buses if the National Highway Traffic Safety Administration (NHTSA) adopts a proposed rule announced in May.

Analysis of the real-world experience of ESC indicates the technology is saving lives by helping to prevent rollovers and loss-of-control crashes in cars, minivans, pickups and SUVs (see Status Report, Sept. 28, 2011; on the web at iihs.org). Researchers haven’t yet been able to quantify ESC’s real-world effect for large trucks.

NHTSA has been conducting extensive research on stability control systems for truck tractors and large buses since 2006. The agency has sponsored studies of crash data to help examine the potential safety benefits, conducted test track studies to understand how the systems respond in different maneuvers, and undertaken simulator evaluations to understand how drivers might use the systems. NHTSA also has evaluated data on dynamic test maneuvers from truck makers and brake suppliers. The agency used this information to develop test maneuvers that define what systems must do to comply with the proposed regulation and to predict the effectiveness of stability control systems.

The agency estimates that ESC on truck tractors could prevent 40 to 56 percent of untripped rollovers and an additional 14 percent of loss-of-control crashes each year. Requiring ESC for all truck tractors and certain buses with a gross vehicle rating of more than 26,000 pounds would prevent as many as 2,329 crashes and as many as 858 injuries, plus save as many as 60 lives annually. NHTSA based its estimates for truck tractors and large buses on an initial target crash population of 10,313 crashes (5,510 rollovers and 4,803 loss-of-control crashes), 327 fatalities (111 rollover and 216 loss of control) and 3,358 injury crashes (2,217 rollover and 1,141 loss of control).

There are two kinds of stability control systems available for truck tractors: ESC and roll stability control. Roll stability control systems automatically intervene if sensors monitoring a truck tractor’s lateral acceleration and wheel speed detect a high rollover risk. Tractor-based systems can selectively apply brakes on the tractor’s drive axle and the trailer, plus modulate engine power to slow down the truck and keep it upright. Trailers can have roll stability control, too, but trailer systems only control trailer brakes, not the tractor’s, and can’t reduce engine power. Roll stability control can reduce rollovers but isn’t meant to help drivers maintain directional control. That ability is unique to ESC.

ESC incorporates all of the features of roll stability control but with the added benefit of a steering-angle sensor and a yaw sensor to measure the tractor’s directional stability. These sensors help mitigate severe oversteer and understeer conditions. If measures exceed specific thresholds, ESC reduces engine power and can selectively apply brakes on multiple tractor axles in order to bring the vehicle back into line, plus apply the trailer brakes as needed to slow down the truck.

“We support NHTSA’s decision to require ESC rather than roll stability control,” says Anne McCartt, Institute senior vice president for research. “Although it’s more costly, ESC affects a wider range of rollover and loss-of-control collisions than roll stability control.”

About 26 percent of 2012 model truck tractors and 80 percent of new buses have ESC, NHTSA estimates. If adopted, the rule would take effect within two years of publication. The agency isn’t requiring in-service truck tractors and buses to be retrofitted but seeks comments on a future ESC retrofit mandate.

Single-unit trucks aren’t included in the current proposal because NHTSA needs to determine how effective ESC would be for these vehicles. The agency plans a feasibility study and could consider a future ESC requirement. Estimating the technology’s potential benefits for single-unit trucks is challenging, NHTSA says. Compared with truck tractors, the single-unit truck fleet varies by model in terms of weight, wheelbase, axles, cargo type and other factors that affect the calibration and performance of stability control systems. Another issue is that because multiple suppliers handle the design and building of each vehicle, chassis suppliers who fit brakes and potentially stability control often don’t know the vehicle’s ultimate function. NHTSA also notes that stability control systems are more widely available for air-braked vehicles, including truck tractors, than for hydraulic-braked single-unit trucks. Only about 1 percent of new single-unit trucks have these systems now, NHTSA says.

“We commend the agency for moving ahead with an ESC mandate for new tractor tractors and large buses independent of its ongoing research on single-unit trucks,” McCartt says. “We encourage NHTSA to expedite this research and also to explore the feasibility of a retrofitting requirement so a bigger proportion of the fleet benefits from ESC.”

August 14, 2012