SPECIAL ISSUE: CRASH AVOIDANCE FEATURES

STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

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FUTURE VEHICLES

are here right now, and a handful of them have gee-whiz features that aim to avoid crashes altogether — or at least help some drivers avoid some crashes by supplying critical information at critical times. These features may alert a driver who has become distracted, for example, or improve another driver's ability to see a hazard lurking just around a bend. In the wake of the huge success of electronic stability control (see *Status Report*, June 13, 2006; on the web at iihs.org), expectations for the new features are high. However, their benefits are hard to predict.

"It's tempting to become cheerleaders for any new feature that promises to address some mistake or another drivers make, because they make a lot," says Adrian Lund, Institute president. "But for the most part the features being installed in current models simply give drivers information. How will the drivers respond? Will they use the information correctly? Will it elicit the right response? Will drivers become annoyed by too much information? We don't know yet because the features aren't on enough vehicles to conduct controlled evaluations of their benefits. What we can do is compare their promise based on how many crashes they have the potential to prevent and how they'll prevent them."

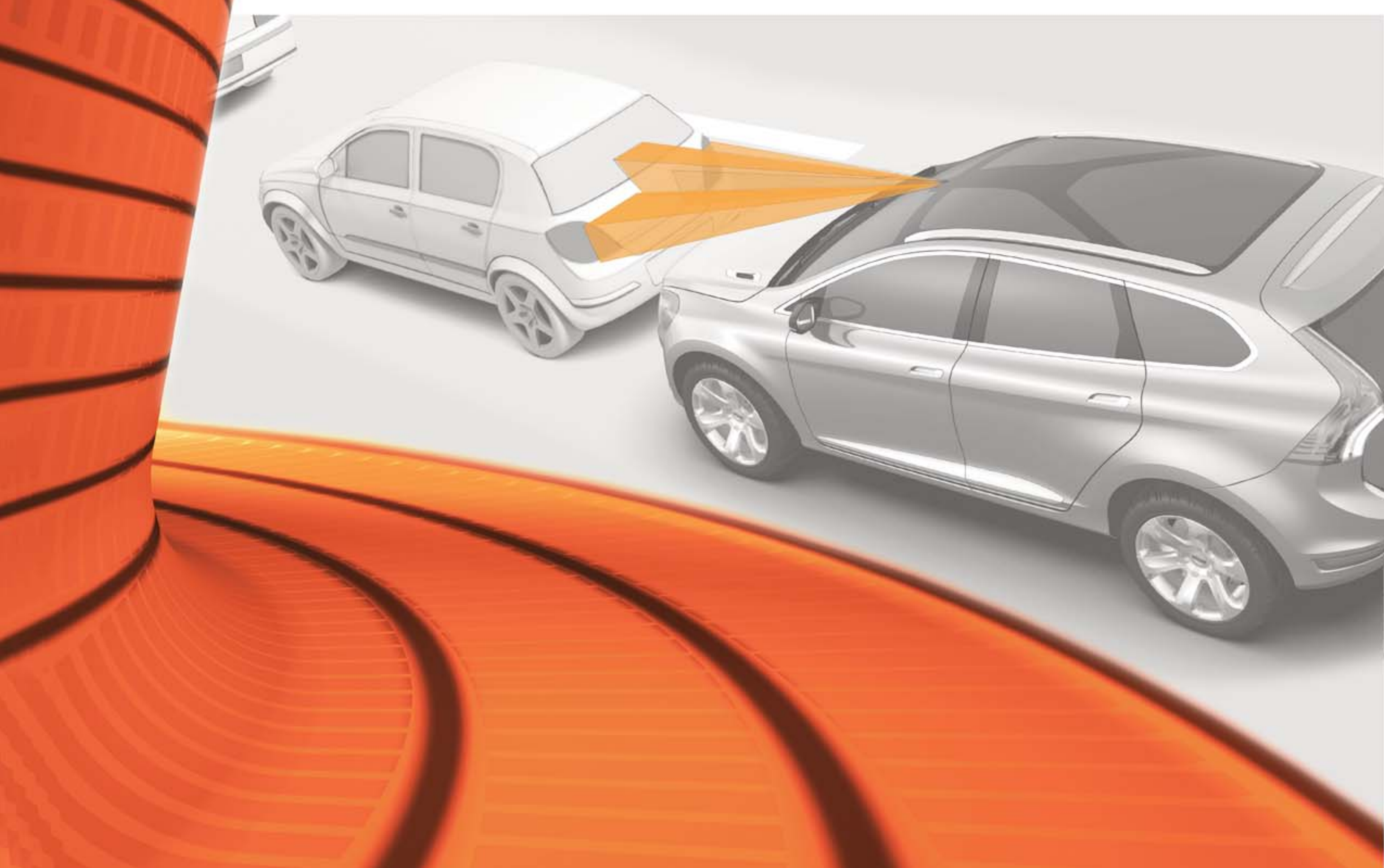
A new Institute analysis takes a step in this direction. First researchers identified the kinds of crashes that five emerging technologies are intended to prevent or mitigate. Then the researchers counted such crashes that occurred during 2002-06, assigning relevant ones to the technologies designed to prevent them.

"No new feature can prevent more crashes than would have occurred — or save more lives than would have been lost — if the feature never had been invented," Lund explains. "So the counts of relevant crashes and crash deaths indicate a new feature's maximum promise, not its expected benefit."

A main finding is that two systems, forward collision warning and lane departure warning, show more potential to avoid or mitigate crashes, including fatal ones (see facing page). Blind spot detection systems don't show as much potential to reduce deaths simply because not as many fatal crashes are relevant to this technology.

Right now there aren't many vehicles to choose from that have any of the five features the Institute analyzed. The winner among the manufacturers at this early stage is Volvo, which puts some version of all five technologies on some of its models.

FORWARD COLLISION WARNING AND LANE DEPARTURE WARNING SHOW MORE PROMISE THAN THREE OTHER FEATURES. BLIND SPOT DETECTION DOESN'T SHOW AS MUCH POTENTIAL.



Forward collision warning with automatic braking: More occupant deaths occur in frontal crashes than any other kind. Some of these collisions could be avoided, and the severity of others could be reduced, if appropriate action were taken sooner. A new vehicle feature addresses this by detecting, usually by radar, when a driver is headed for trouble. Then the driver is alerted and, in some cases, braking is applied.

The systems differ among manufacturers in terms of when and how they activate. Forward collision avoidance on Acuras, Mercedes, and Volvos begins by sounding alarms and/or flashing lights to warn drivers of hazards. Safety belts are tightened in Acura models. When a crash is imminent, brakes are applied, often with progressively more pressure.

Such systems could be relevant to more than 2 million frontal crashes that occurred per year during 2002-06, including nearly 1.4 million front-into-rear collisions plus 0.5 million angle collisions into other vehicles and 0.4 million single-vehicle crashes into objects on the road. Together such crashes account for almost 40 percent of the approximately 6 million crashes reported to police each year.

"These numbers are so big that a lot of crash-reducing potential is associated with forward collision avoidance," Lund points out, cautioning that "it won't prevent all 2-plus million relevant crashes per year. For example, some of the drivers braked before they crashed, and warnings may not make some of them aware of a danger any sooner. Drivers also may pay less attention to the road ahead, relying too much on the technology to warn them and bail them out of danger. But if forward collision warning can prevent a fraction of the frontal crashes *(continues on p.4)*

HOW MANY CRASHES ARE RELEVANT?

Relevant crashes are those a given crash avoidance feature was developed to prevent or mitigate. Here are counts of the average numbers of annual crashes during 2002-06 that are relevant to five new technologies:

	ALL RELEVANT	FATAL
FORWARD COLLISION WARNING WITH AUTOMATIC BRAKING Prevents or mitigates frontal crashes by alerting drivers of emergencies and, in some cases, automatically applying the brakes	2,268,000	7,166
EMERGENCY BRAKE ASSISTANCE Prevents or mitigates frontal crashes by detecting panic braking, readying the brakes, and/or boosting brake pressure	417,000	3,079
LANE DEPARTURE WARNING Alerts drivers who begin to stray from their travel lanes	483,000	10,345
BLIND SPOT DETECTION Warns drivers of vehicles in adjacent lanes	457,000	428
ADAPTIVE HEADLIGHTS Improves night vision around corners and curves	143,000	2,553
TOTAL UNIQUE CRASHES	3,435,000	20,777

Note: Total isn't sum of counts in each column because some crashes are relevant to more than one of the five technologies.

THE COUNT OF CRASHES THAT'S RELEVANT TO EACH TECHNOLOGY ISN'T THE SAME AS THE NUMBER OF CRASHES THE TECHNOLOGY CAN BE EXPECTED TO PREVENT. IT'S THE UPPER LIMIT OF POTENTIAL. THE ACTUAL BENEFIT IN TERMS OF CRASHES AVOIDED AND LIVES SAVED WON'T BE AS GREAT BECAUSE EVEN THE MOST PROMISING CRASH AVOIDANCE TECHNOLOGY WON'T PREVENT EVERY CRASH IT'S INTENDED TO ADDRESS. WHAT CAN BE SAID IN ADVANCE OF WIDE APPLICATION OF THE FEATURES IS THAT SOME SHOW MORE PROMISE THAN OTHERS.

DRIVER RESPONSE

is key to the success of any crash avoidance feature. If drivers see and respond to features and don't compensate by taking more risks behind the wheel, crashes can be reduced. But if motorists respond by changing how they drive, potential benefits may not pan out.

Drivers don't change their behavior in response to many safety features but do respond to those that give direct and immediate feedback — for example, when acceleration is boosted or brakes are improved (see *Status Report*, Oct. 13, 2007; on the web at iihs.org). This could be the case with studded snow tires, which have delivered a less-than-expected benefit, possibly because drivers who think they won't skid go too fast for conditions.

"Some motorists will respond to emerging crash avoidance features the same way," says Anne McCartt, Institute senior vice president for research. "They'll drive faster or pay less attention to the possibility of a hazard ahead if they think a gadget will alert them if needed."

Previous experience indicates that more automatic features — those that apply brakes automatically to avoid a collision, for example — will be the most effective. Yet many of the features being introduced on current cars give motorists feedback by activating a warning light. Then drivers have to take appropriate action to avoid crashes. Such features might not live up to their hype.

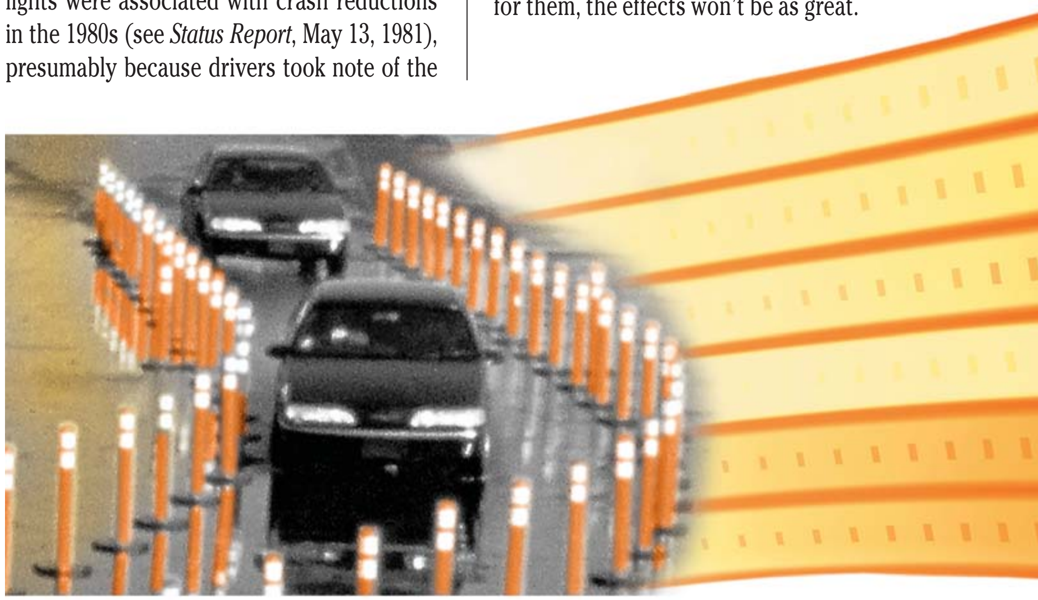
Of course, benefits will be disappointing if drivers simply turn off crash avoidance features that are annoying or don't seem to help. This could be the case with blind spot detection systems (see facing page), which could activate continuously in heavy urban traffic.

"It's hard to predict," McCartt points out. "Automakers are designing so as to limit how much a feature may annoy drivers, but people's reactions are hard to foresee."

Antilock example: When antilock brakes were introduced on passenger vehicles, expectations were high for crash reductions, based on how cars with antilocks performed in tests by the Institute and others (see *Status Report*, Jan. 29, 1994). But the initial outcome on the road was to increase crashes, and antilocks never have produced a large safety benefit. The problem could be that the tests involved skilled drivers in controlled settings while real-world driving is fraught with unforeseen circumstances for motorists whose skills may be limited. Drivers also might compensate for antilocks. Assuming they can stop quicker if they need to, they drive faster and/or delay brake application.

Brake light example: Experimental fleets equipped with center high-mounted brake lights were associated with crash reductions in the 1980s (see *Status Report*, May 13, 1981), presumably because drivers took note of the new feature. Yet studies conducted after the lights became ubiquitous showed lesser effects, possibly because the novelty wore off.

The best way to assess the effectiveness of any new feature is to equip lots of vehicles with it and then evaluate its on-the-road performance compared with similar vehicles without it. Even this can be confounded if vehicles are equipped with multiple features at the same time, as is the case with the crash avoidance features being introduced now. Concurrent introduction makes it hard to distinguish the individual effects of each feature.



THE PROMISE OF ANTILOCK BRAKES ON THE TEST TRACK DIDN'T PAN OUT, POSSIBLY BECAUSE DRIVERS OFFSET THE BENEFIT.

(continued from p.3) it's intended to address, then it really will produce a sizable benefit in terms of occupant safety."

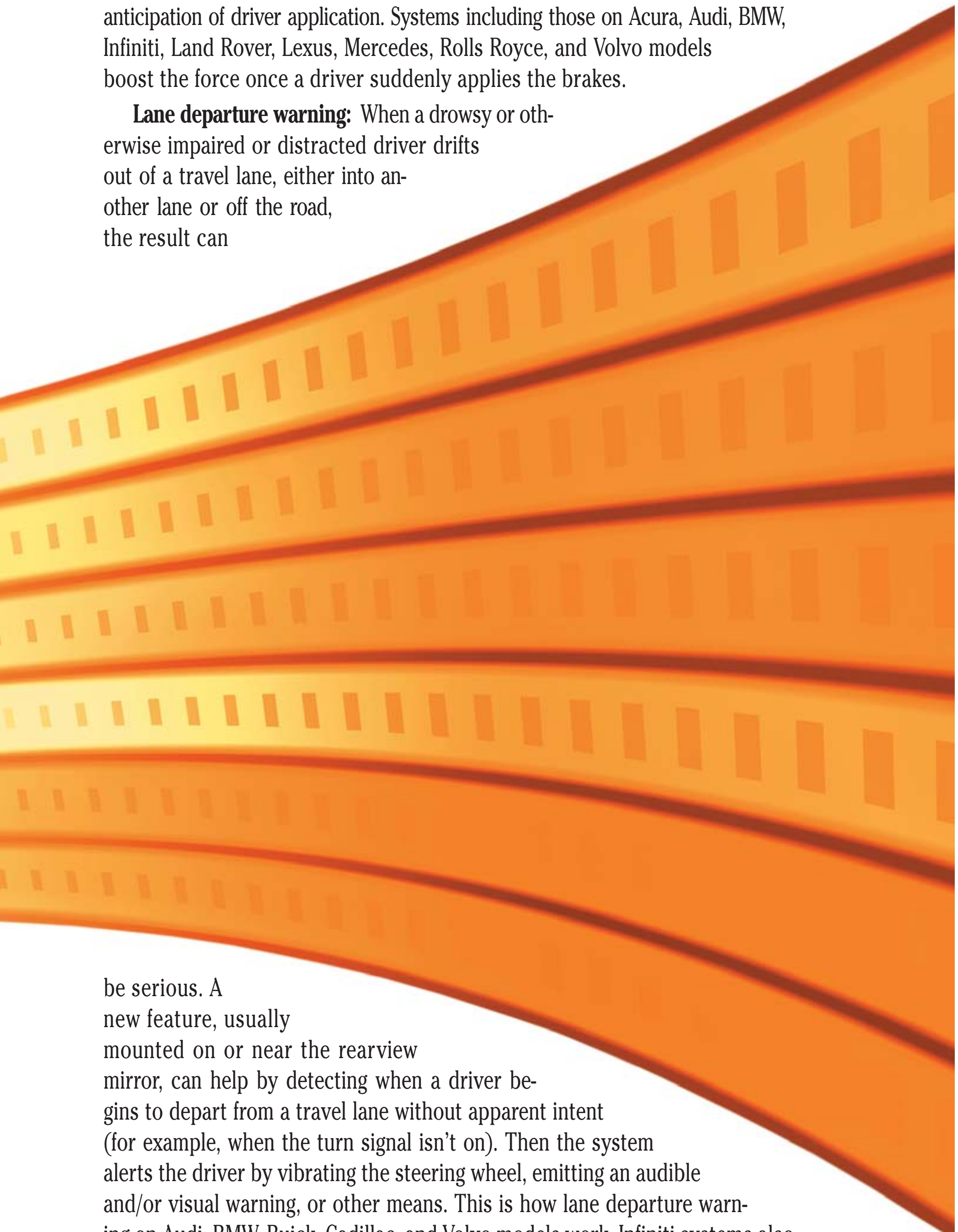
Of the nearly 2.3 million crashes that occurred annually during 2002-06 and might have been prevented by frontal collision avoidance systems, more than 7,000 involved occupant deaths. If this feature, assuming it's on all passenger vehicles, could prevent half of these crashes, the safety potential would be substantial. On the other hand, if drivers don't heed the warnings or otherwise compensate for them, the effects won't be as great.

Emergency brake assistance: Besides frontal crashes that could be avoided if hazards were detected sooner, there are those involving drivers who did see and brake for hazards but couldn't stop in time to avoid crashing. More than 400,000 such crashes occurred annually during 2002-06, and about 3,000 of them involved occupant deaths.

Crashes like these might be avoided if drivers had technology, being introduced now, that senses panic braking or a situation when a driver might be about to apply brakes hard. Then brake assistance readies the brakes for activation and/or applies extra pressure. Of course, some of the crashes this feature addresses also might be avoided or mitigated by forward collision warning. As many as 257,000 crashes, including 855 fatal ones, are relevant to both technologies.

The systems on BMWs and Volvos move brake pads closer to discs for quicker activation. Infiniti's system pressurizes the brakes in anticipation of driver application. Systems including those on Acura, Audi, BMW, Infiniti, Land Rover, Lexus, Mercedes, Rolls Royce, and Volvo models boost the force once a driver suddenly applies the brakes.

Lane departure warning: When a drowsy or otherwise impaired or distracted driver drifts out of a travel lane, either into another lane or off the road, the result can



be serious. A new feature, usually mounted on or near the rearview mirror, can help by detecting when a driver begins to depart from a travel lane without apparent intent (for example, when the turn signal isn't on). Then the system alerts the driver by vibrating the steering wheel, emitting an audible and/or visual warning, or other means. This is how lane departure warning on Audi, BMW, Buick, Cadillac, and Volvo models work. Infiniti systems also brake selected wheels to nudge a vehicle back in lane.

The potential benefit is to prevent head-on collisions, sideswipes, and crashes into off-road objects, which numbered almost 500,000 per year during 2002-06. More than 10,000 of these involved deaths.

It's possible in the case of this technology, unlike the other four the Institute analyzed, to establish a somewhat more precise prediction of the safety benefit than the maximum number of relevant crashes. A roadway feature called rumble strips already is in wide use along the sides of highways, and in some cases down the middle of two-lane roads, for the same purpose as lane departure warning. The idea is to keep drivers from drifting out of their lanes. Institute researchers and others have evaluated rumble strips, finding they reduce head-on crashes and oncoming sideswipes as well as run-off-the-road crashes by 25-30 percent (see *Status Report*, Feb. 7, 2004; on the web at iihs.org). If lane departure warning works as well as rumble strips, more than 100,000 collisions per year and 2,500 deaths could be prevented when all vehicles have this feature.

WHICH VEHICLES HAVE WHAT FEATURES?

The five crash avoidance features the Institute analyzed are on only a few passenger vehicles (mostly upscale models), but the technologies are being added all the time. This is the way innovative features often are introduced before they filter down to more popular vehicle lines. So far, automakers including the following are using the features the Institute analyzed:

FORWARD COLLISION WARNING WITH AUTOMATIC BRAKING

Acura, Mercedes, and Volvo

EMERGENCY BRAKE ASSISTANCE

Acura, Audi, BMW, Infiniti, Land Rover, Lexus, Mercedes, Rolls Royce, and Volvo

LANE DEPARTURE WARNING

Audi, BMW, Buick, Cadillac, Infiniti, and Volvo

BLIND SPOT DETECTION

Audi, Buick, Cadillac, Mazda, Mercedes, and Volvo

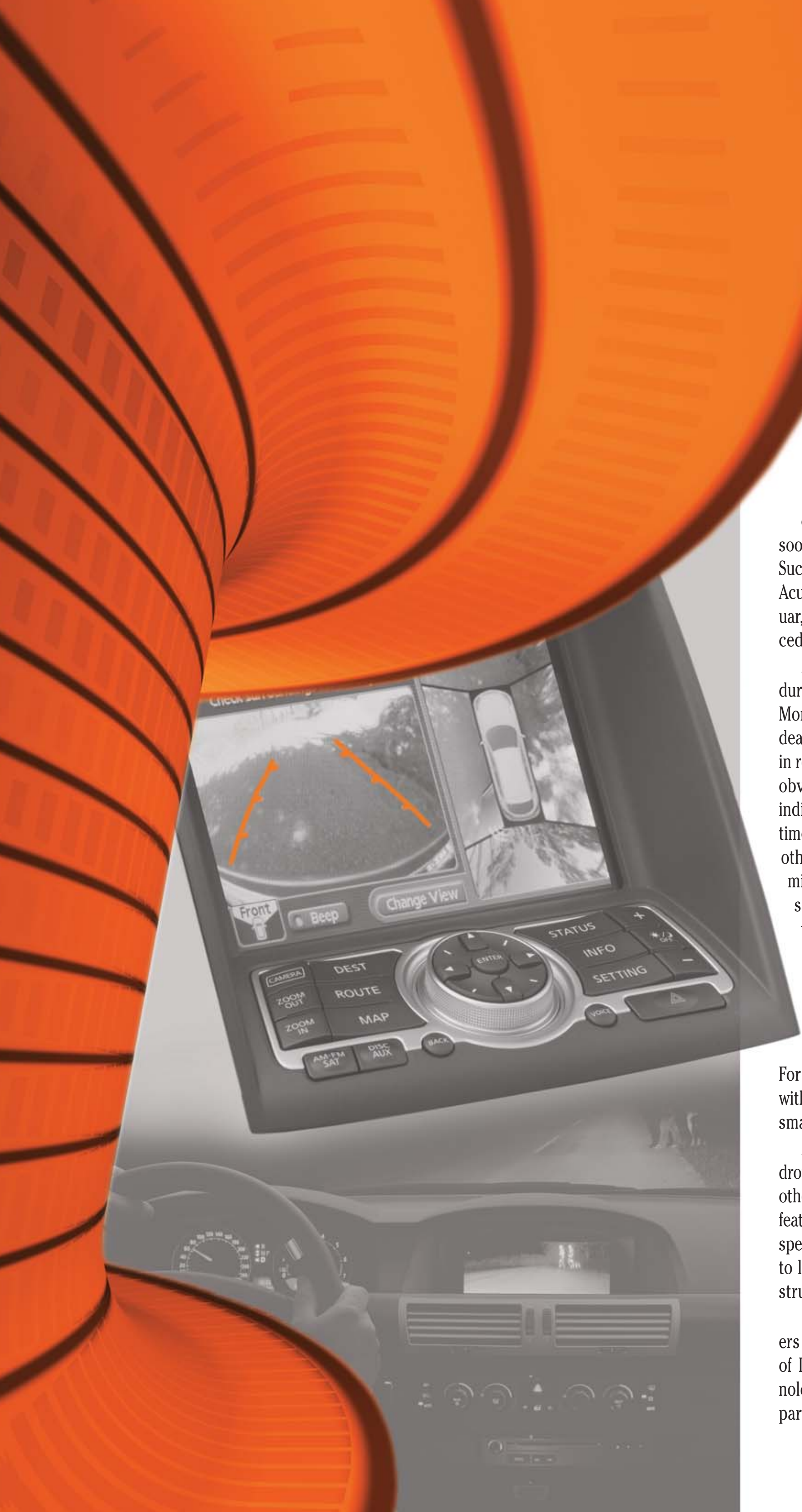
ADAPTIVE HEADLIGHTS

Acura, Audi, BMW, Buick, Cadillac, Infiniti, Jaguar, Land Rover, Lexus, Lincoln, Maserati, Mercedes, Porsche, Volkswagen, and Volvo

Blind spot detection: Side- and rearview mirrors help drivers keep track of nearby motorists, but blind spots on either side still allow adjacent vehicles to "hide." To warn drivers of the presence of hiding vehicles, features are being added to some Audi, Buick, Cadillac, Mazda, Mercedes, and Volvo models that sweep nearby lanes, looking for vehicles approaching from behind and entering blind spots.

A light comes on to warn a driver of a hiding vehicle. In some cases, the light flashes or becomes brighter if the driver activates a turn signal in the presence of a conflicting vehicle. In Mazdas, there's a beep as well as a light.

"We don't know if people will notice the lights. Some people don't use their side mirrors, where the warnings usually are located. These factors could limit the safety potential. And drivers who often navigate in heavy traffic might get so used to the lights and beeps that they pay little attention to them," Lund says. Relevant crashes number about 450,000



per year, but only a small proportion of these involve occupant fatalities. This limits the potential benefit, even if motorists do heed the warning lights.

Adaptive headlights: The high beams on all passenger vehicles help drivers see better on dark roadways, and the active lights being introduced on some models can help even more by pivoting in the direction of travel when drivers steer around curves and corners. The purpose is to help drivers see sooner what may be looming around the bend. Such headlights are on some models made by Acura, Audi, BMW, Buick, Cadillac, Infiniti, Jaguar, Land Rover, Lexus, Lincoln, Maserati, Mercedes, Porsche, Volkswagen, and Volvo.

Almost 150,000 crashes occurred annually during 2002-06 on dark or semi-dark curves. More than 2,500 of these collisions involved deaths. If adaptive headlights were effective in reducing these numbers, there would be an obvious benefit. However, several studies indicate that motorists increase their nighttime speeds on roads where reflector posts or other curve markers are installed. Drivers might respond to adaptive headlights the same way, thus offsetting the potential safety benefit.

Other features: The Institute's analysis of five crash avoidance features doesn't cover every one being installed to enhance safety or even every system designed to help drivers avoid mistakes. For example, some vehicles are being outfitted with rear cameras to reveal hazards, including small children, when drivers back up.

Another feature warns drivers who become drowsy, as indicated by eyelid movement and other means. Still another driver-assistance feature shows key information, such as travel speed, in a head-up display to reduce the need to look away from the road to consult the instrument panel.

Besides such safety features, there are others designed more for convenience. A couple of Lexus models, for example, include technology that automatically guides a car into a parallel parking space.

"These and other features are proliferating as technology becomes more accessible and affordable," Lund says. "Eventually the idea is to link technologies designed for both vehicles and roadways, building an interactive communications system. Then the future really will have arrived."

Another important safety goal is to quickly and unobtrusively detect would-be drivers who are impaired by alcohol and then keep them off the road by preventing them from starting their vehicles. Researchers are trying to figure out which of several technologies could be incorporated into vehicles without inconveniencing the vast majority of motorists who aren't impaired (see *Status Report*, April 2, 2005; on the web at iihs.org).

About the analysis: Starting with information from the federal Fatality Analysis Reporting System and General Estimates System, Institute researchers sorted passenger vehicle crashes reported to police during 2002-06 according to the types of impacts (head on, sideswipe, etc.). Then crashes were assigned, by type, to the technologies developed to avoid them. At the same time, collisions that couldn't possibly be affected by a given technology were eliminated from that technology's count of relevant crashes.

For example, a total of 2,268,000 relevant crashes is associated with forward collision warning. How did researchers arrive at this number? They began with the count of all collisions in which a passenger vehicle (car, van, SUV, or pickup truck but not other vehicle type such as a motorcycle or large truck) struck another vehicle, object, structure alongside the road, etc.

Several groups of crash types in which warnings likely wouldn't have helped then were discarded. For example, collisions that occurred off the roadway were excluded because most crash avoidance features are tuned to detect traffic situations on the road ahead, and it's unclear how the features would respond to the plethora of roadside objects and hardware. Also excluded were crashes coded as caused by driver avoidance of obstacles because such maneuvers indicate that the drivers already were aware of the dangers.

Crashes involving more than two vehicles were subtracted because researchers couldn't determine the sequence of events in these collisions well enough to determine whether or not a given technology would make any difference. The researchers also subtracted crashes of all types in which the motorists were deliberately turning, merging, or changing lanes. The idea was that such collisions wouldn't be influenced by any kind of warning system because, after all, the maneuvers were made intentionally.

The researchers went through similar exercises for each of the other four crash avoidance features to produce counts of relevant crashes. Then they refined the counts to hone in on crashes a technology might truly be expected to avoid or mitigate. Finally, the crashes relevant to each feature were broken out to see how many involved injuries and deaths.

"This gave us the best idea of a feature's promise," Lund says. "It's the upper limit of crashes that a feature potentially could prevent if it were 100 percent effective."

There was some overlap. For example, both forward collision warning and emergency brake assistance are intended to prevent various kinds of frontal crashes, so some frontal collisions were deemed relevant to both of these features. Adding across the five technologies, the relevant fatal crashes might appear to number more than 23,000. But because of the overlap, the number of unique fatal crashes adds to 20,777.

None of the crash counts reflects the effects of electronic stability control. By helping drivers maintain control of their vehicles during emergencies, this feature already is preventing some crashes that otherwise might be addressed by the technologies the Institute assessed. This is another reason the crash counts represent upper limits of safety potential, not benefits expected to pan out.

AVERAGE ANNUAL CRASHES BY CRASH TYPE, 2002-06

	ALL	FATAL
CRASHES WITH INTENTIONAL TURN/MERGE/LANE CHANGE	1,727,000	4,711
CRASHES WITHOUT INTENTIONAL LANE CHANGE		
Angle	612,000	3,416
Front to rear	1,714,000	1,772
Single vehicle	1,614,000	18,590
Head on	41,000	2,839
Other front to front	10,000	607
Sideswipe with vehicle going same direction	174,000	521
Sideswipe with vehicle going opposite direction	96,000	2,014
Other kinds of crashes	3,000	120

THERE ARE MANY NEW CRASH AVOIDANCE FEATURES BESIDES THE FIVE THE INSTITUTE RECENTLY ANALYZED. EVENTUALLY THE IDEA IS TO LINK THEM TO OTHER VEHICLES AND TO THE ROADWAY INFRASTRUCTURE, BUILDING AN INTERACTIVE COMMUNICATIONS SYSTEM. THEN THE FUTURE REALLY WILL HAVE ARRIVED.

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SPECIAL ISSUE

This *Status Report* focuses on crash avoidance features. Recent special issues have included:

THERE'S NO CRYSTAL BALL TO FORESEE THE SAFETY BENEFITS OF CRASH AVOIDANCE FEATURES