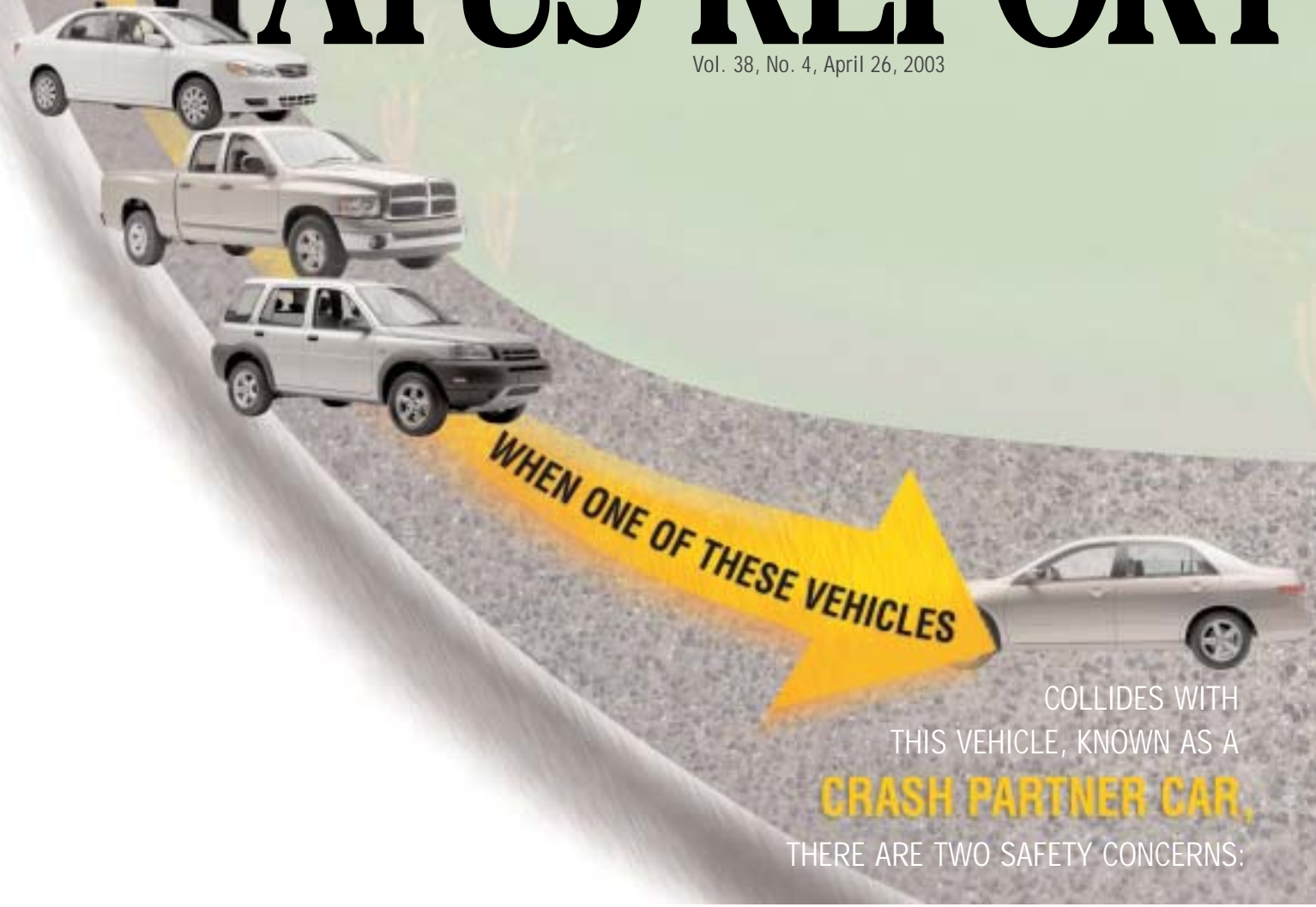


Special issue: incompatibility of vehicles in crashes

STATUS REPORT

INSURANCE INSTITUTE
FOR HIGHWAY SAFETY

Vol. 38, No. 4, April 26, 2003




WHEN ONE OF THESE VEHICLES
COLLIDES WITH
THIS VEHICLE, KNOWN AS A
CRASH PARTNER CAR,
THERE ARE TWO SAFETY CONCERNS:

One is the risks for people in the crash partner car (above), specifically whether the design characteristics of SUVs or pickups increase the risks for people in crash partner cars. This is the focus of debate about

CRASH INCOMPATIBILITY.

The second concern involves the risks for people in SUVs, pickups, or cars (top left) in all kinds of crashes, not just two-vehicle collisions with crash partner cars. Both of these concerns are important. Both need to be addressed to reduce vehicle incompatibility in crashes.

The issue isn't new. Back in the 1970s the introduction of subcompact cars led to concerns about what would happen in collisions with traditional sedans. What risks would the occupants of small cars face because of the big weight



mis-
matches
between their
cars and the heavier
sedans? Today's concerns
focus on not only weight mis-
matches but also mismatches involv-
ing vehicle geometry and stiffness when
cars collide with SUVs and pickup trucks.

These concerns are fanned by the increase in sales of SUVs in recent years. They accounted for about 6 percent of all passenger vehicles 1 to 4 years old registered in 1990-91. A decade later the corresponding percentage had tripled to 18. During 2000-01, SUVs and pickups (all model years) accounted for 30 percent of total passenger vehicle registrations.

Many purchasers say they buy SUVs in part because they believe there's a safety advantage. But do SUVs provide better protection than cars to their occupants in crashes? What about other people on the road? Are SUVs particularly hazardous, or aggressive, to people in the cars with which they collide?

Self protection versus partner protection:

Two kinds of occupant death rates can be used to address these questions and provide insights about the relative safety of cars and SUVs. One kind summarizes the numbers of occupants killed in a particular type of vehicle (SUV, pickup, or car) per million of that type registered. These death rates can be used to compare crashworthiness among the vehicle types — that is, to compare the protection provided to their own occupants, which is sometimes referred to as *self protection*.

For these crashworthiness comparisons to be meaningful, it's necessary to isolate vehicle

weight effects because SUVs and pickups are, on average, heavier than cars, and weight is an important determinant of death rates. Everything else being equal, lighter vehicles have higher occupant death rates.

Small and lightweight vehicles have high death rates for their own occupants in all kinds of crashes, single- as well as multiple-vehicle. However, in crashes between two vehicles the heavier ones can increase the deceleration forces — and the injury risks — for occupants of the lighter ones. So an issue is the extent to which people in vehicles such as very large and heavy SUVs have lower risks at the expense of increased risks for occupants traveling in other vehicles.

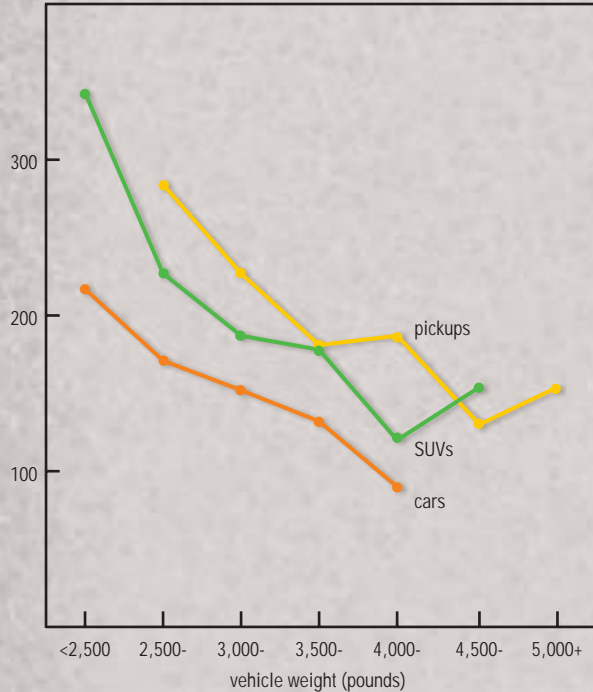
To assess this concern, it's important to consider not only what happens to people inside particular types of vehicles (self protection) but also what happens to people inside the other passenger vehicles with which they collide. These other passenger vehicles sometimes are referred to as *crash partners*, and reducing the risks produced by particular vehicle types for the occupants of their crash partner vehicles sometimes is referred to as *partner protection*.

Car crash partner risks can be assessed by comparing the numbers of occupant deaths that occur in cars in crashes with SUVs, pickup trucks, or other cars per million of those vehicles registered. These death rates indicate the risks for occupants of crash partner cars resulting from collisions with the different vehicle types (see pp. 4-5). Again, it's important to isolate the effects of vehicle weight when comparing crash partner death rates. This allows comparisons of the risks to occupants of partner cars when the other vehicle is, for example, a heavy car versus a heavy SUV.

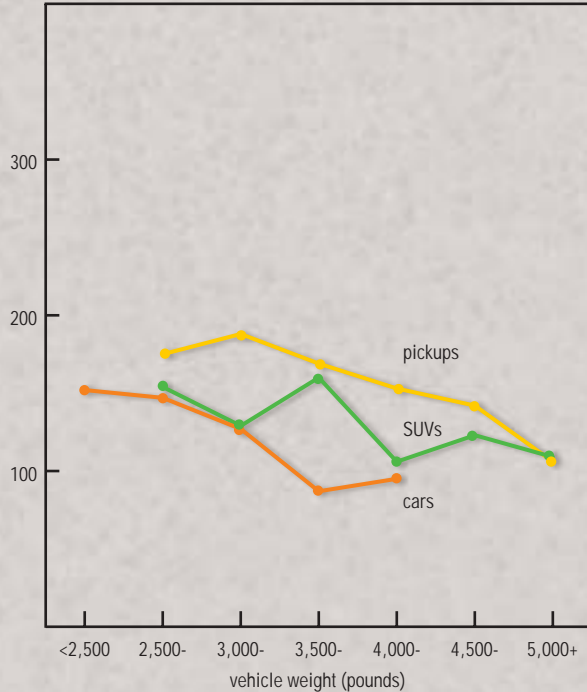
The combination of self and crash partner death rates takes into account the deaths in vehicles in all crashes (single- and multiple-vehicle) plus the deaths that occur in crash partner vehicles in two-vehicle collisions. This combination provides a more complete assessment of occupant safety.

OCCUPANT DEATHS PER MILLION REGISTERED VEHICLES

Deaths in 1987-89 model cars, SUVs, and pickups during 1990-91



Deaths in 1997-99 model cars, SUVs, and pickups during 2000-01



Death rates in all vehicles: Small and lightweight vehicles provide much less protection to their occupants in crashes than larger and heavier vehicles. This is true regardless of vehicle type (SUV, pickup, or car). During 1990-91, occupant deaths per million registered vehicles 1 to 4 years old were highest in the lightest vehicles.

Occupant death rates also vary by vehicle type. In each vehicle weight category, occupant death rates in vehicles 1 to 4 years old during calendar years 1990-91 were lower in cars than in SUVs or pickup trucks. A decade later (2000-01) the patterns had changed somewhat. Most noticeable is that the death rates were substantially lower across the board for all three vehicle types in

every weight category. An example involves vehicles weighing 3,000 to 3,499 pounds. During 1990-91, the self-protection death rate for cars was 152 per million cars registered. The corresponding rate for SUVs in the same weight category was 187 deaths per million, and for pickups it was 227 deaths per million. By 2000-01 these rates had dropped to 127 (cars), 129 (SUVs), and 188 (pickups).

There still were relationships between occupant death rates and vehicle weights during 2000-01, but these relationships were less pronounced than they had been a decade earlier. The biggest changes occurred in the death rates for the lightest cars (those weighing less than 2,500 pounds). This change reflects in part the fact that cars in this weight

category got heavier, and heavier vehicles generally have lower occupant death rates. Fifty-four percent of 1987-89 model cars in the lightest group weighed less than 2,250 pounds. A decade later, fewer than 9 percent were as light.

Comparisons of death rates by vehicle type reveal other changes from 1990-91 to 2000-01. During the more recent years, cars still had lower death rates than pickups, but cars and SUVs in the same weight categories had similar death rates.

Deaths in cars and SUVs don't occur in the same kinds of crashes. Single-vehicle rollover crashes consistently account for about 20 percent of car occupant deaths. In contrast, the corresponding percentage of SUV occu-

SUVs are designed to be driven off-road, but this isn't where they're mostly driven. They're used just like cars and mix with cars in urban and rural traffic. Their higher ground clearance, which is needed for off-road use, contributes to the issue of

CRASH INCOMPATIBILITY.

Concerns focus not only on vehicle weight mismatches between cars and SUVs but also on mismatches involving differences in the heights of their structures. Research indicates that height mismatches are major contributors to the incompatibility problem.

Crash partner risks: In two-vehicle crashes involving SUVs, pickups, or cars in which deaths occur in crash partner cars, the partner death rates vary according to the type and weight of the other vehicle. Except for the heaviest pickup trucks, partner death rates are significantly lower than occupant (or self protection) death rates because improved crashworthiness can be effective in all kinds of crashes. In contrast, crash partner risks are relevant only in crashes involving two passenger vehicles. Fewer than 35 percent of all car occupant deaths occur in two-vehicle crashes with other passenger vehicles, including other cars.

pan deaths that occurred in single-vehicle rollovers was 52 during 1990-91 and 48 a decade later. Another example involves 1997-99 vehicle models in the 3,000-3,499 pound weight category. Twenty-two percent of the occupant deaths in cars of this weight during 2000-01 occurred in single-vehicle rollovers. The corresponding percentage for SUVs was 41 and for pickups 37.

The risk of a fatal single-vehicle rollover crash is about twice as high for SUV occupants as it is for car occupants.

The heavier the weights of the SUVs, pickups, or cars involved in crashes in which deaths occur in partner cars, the higher the



partner car death rates. In every vehicle weight group except one, the death rate in partner cars is lower when the other vehicle in the collision is another car than when it's an SUV or a pickup truck.

This overall pattern is apparent for vehicles during both 1990-91 and 2000-01. However, during the intervening decade the death rates in partner cars went down, regardless of whether the other vehicles in the collisions were cars, SUVs, or pickups. Another change is that there was much less difference between SUVs and cars in terms of their car crash partner death rates in 2000-01, compared with a decade earlier.

Balancing self and partner protection: For overall safety, it's important to maintain an appropriate balance between self protec-

tion and risks for occupants of crash partner cars. A good example involves vehicle weight. Increasing weight generally increases self protection, but this benefit diminishes as vehicles get heavier and heavier. At the same time, the disbenefits (or negative consequences) for occupants of crash partner cars don't appear to decrease as the other vehicles get heavier and heavier.

At some point heavy vehicles cost more lives in crash partner cars than they save among the people they transport. Thus, the heaviest group of 1997-99 pickup trucks had car crash partner death rates during 2000-01 that were the same (106 per million registered pickups) as their self protection rates.

Comparing self and partner death rates for each vehicle type shows that more occupant

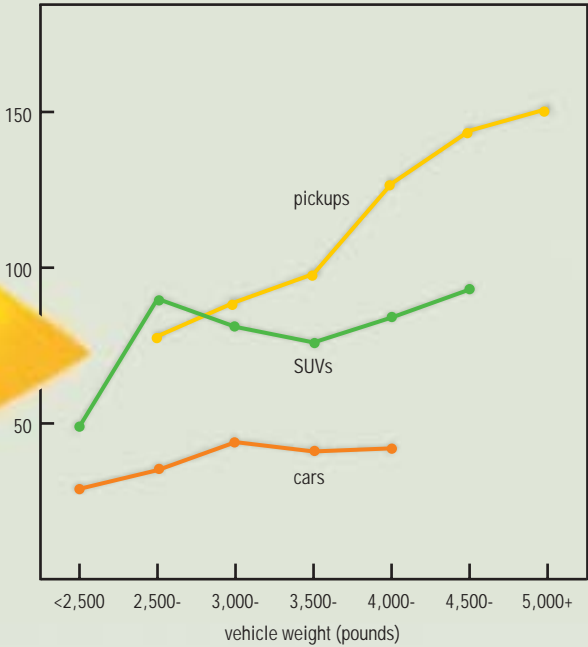
deaths occur even in heavy SUVs and pickups than in their crash partner cars. An example is the group of SUVs weighing 4,500 to 4,999 pounds. The occupant death rate in these vehicles 1 to 4 years old during 2000-01 was 123, and their car crash partner death rate was 64. Thus, there were twice as many deaths inside the relatively heavy SUVs as in their crash partner cars.

Compared with cars, both SUVs and pickups have proportionately more car crash partner deaths than occupant deaths. This indicates that SUVs, and especially pickups, do pose greater risks than cars for the occupants of their crash partner cars.

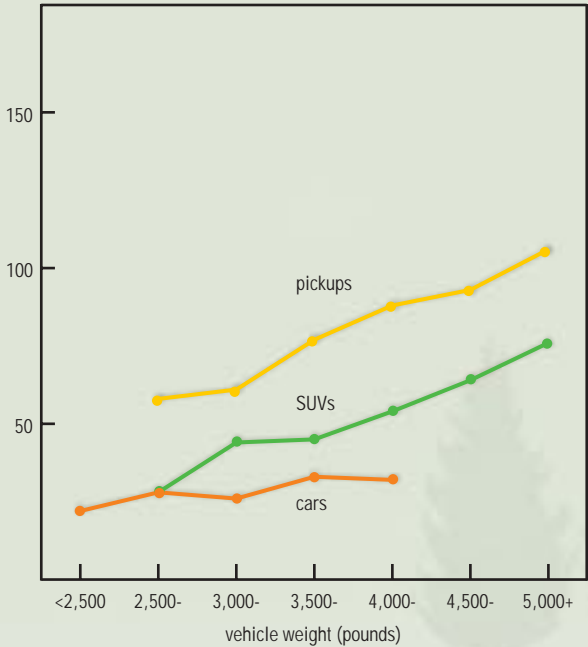
What is it about SUVs and pickups, beyond their weight, that increases the risks for occupants of their car crash partners? A clue is

CRASH PARTNER RISKS: DEATHS IN CARS IN COLLISIONS WITH OTHER PASSENGER VEHICLES

Deaths in crash partner cars (all model years) in collisions with 1987-89 model cars, SUVs, or pickups, per million registered, during 1990-91



Deaths in crash partner cars (all model years) in collisions with 1997-99 model cars, SUVs, or pickups, per million registered, during 2000-01



apparent in crash partner death rates by direction of impact. In front-to-front crashes, car crash partner death rates are about the same for SUVs and cars of about the same weight. But in front-into-side crashes, death rates in side-struck partner cars are much higher when the other vehicle is an SUV than when it's a car.

Perspective on the issue of incompatibility:

It often has been claimed that overall occupant death rates are lower in SUVs than in cars. The implication is that SUVs are safer than cars. However, this is largely because of the heavier weights of SUVs. For example, only 5 percent of all 1997-99 model cars weighed more than 4,000 pounds, while the corresponding percentage for SUVs was 49.

So it's disingenuous for defenders of SUVs to claim they're safer than cars. Most of their advantage in terms of self protection is simply due to mass. It's also undeniable that SUVs, as a group, have a rollover problem. They're

about twice as likely as cars to be involved in fatal single-vehicle rollover crashes.

When it comes to occupant deaths in crash partner cars, the partner death rates are higher when the other vehicle is an SUV or a pickup versus another car. The most important differences are the elevated risks for people in cars struck in the side by SUVs, compared with being struck in the side by other cars.

How can these findings guide us to appropriate countermeasures to improve the protection provided to all occupants of all kinds of passenger vehicles? First, the results demonstrate that progress has been made in self protection in both cars and SUVs. Occupant death rates during 2000-01 were significantly lower than corresponding rates during 1990-91 (see p.3).

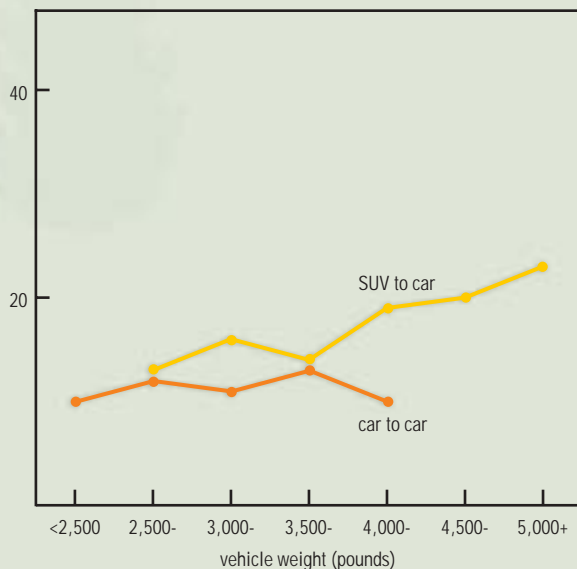
Many factors contributed to the improvements. Belt use rates in the United States increased from 49 percent in 1990 to 71 per-

cent in 2000. Only 3 percent of 1987-89 vehicle models were equipped with airbags, compared with 100 percent of 1997-99 models. Average car weights increased about 350 pounds, while SUVs got 650 pounds heavier. Passenger vehicle crashworthiness improved. Alcohol-impaired driving decreased. All of these changes contributed to the significant improvements in self protection.

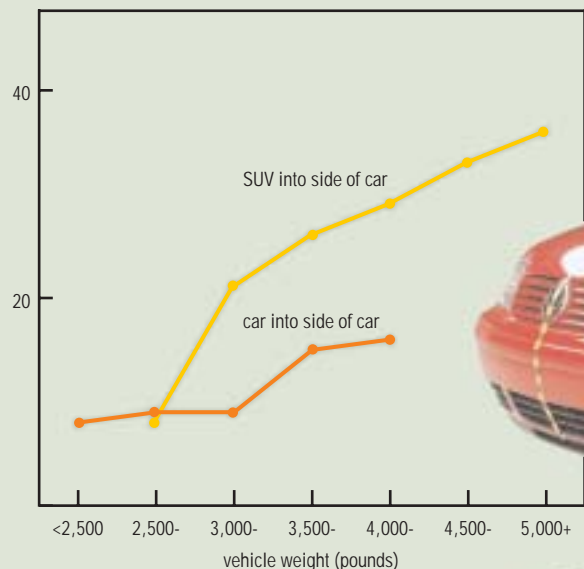
Crash partner death rates also are coming down. But in this regard it's important to recognize that the risks to car occupants in crashes with SUVs can be influenced by changes to both cars and SUVs. The reductions in partner death rates that occurred between 1990-91 and 2000-01 demonstrate this. They occurred while the weights of SUVs in the fleet were increasing, and they were due mainly to the many improvements in self protection for car occupants, not to design changes to SUVs to reduce the risks to occupants of their crash partners.

**CRASH PARTNER RISKS BY CRASH CONFIGURATION:
DEATHS IN CARS IN COLLISIONS WITH SUVs VERSUS OTHER CARS**

Front-to-front crashes: Car crash partner deaths in crashes with SUVs versus other cars (1997-99 models, per million registered), during 2000-01



Front-into-side crashes: Car crash partner deaths in crashes with SUVs versus other cars (1997-99 models, per million registered), during 2000-01



What to do? A high priority should be to address the problem of SUVs striking the sides of cars. The risks are much greater to occupants of cars that are struck in the side by SUVs, compared with being struck in the side by another car, even when the striking car and SUV weigh the same. This indicates that the problem relates to differences in the configurations of the two vehicle types. The higher ride heights of SUVs mean their front ends strike cars' relatively weak doors in side impacts. Higher SUV hoods put car occupants' heads at great risk.

In the short term, the increased risks to car occupants struck in the sides by SUVs should be addressed by improving self protection in cars, specifically by adding inflatable head protection systems like curtains or side airbags that protect both the head and thorax. These should be added to new cars as standard equipment as soon as possible. Improving side airbags that protect the thorax and improving vehicle side structures around the B-pillar also would reduce the risks.

To promote such improvements, the Institute recently began a crashworthiness evaluation program that will provide consumer information on the relative safety of new vehicles in side impacts. For the first time in any crash test program conducted for regulatory or consumer information purposes, the impactor that hits the sides of vehicles in these tests simulates the front end of an SUV.

What can be done to the front ends of vehicles to make them more compatible in two-vehicle crashes? In many front-to-front collisions between cars and SUVs, the structures of the two vehicles designed to manage crash forces override or underide, thus negating their crash energy management designs. A fundamental need is to ensure that such structures interact in crashes.

Ford's introduction of so-called blocker-beams on some of its SUVs is one approach intended to increase the likelihood of structural interactions in crashes. Other designs that might reduce structural mismatches are adjustable suspensions that automatically lower ride heights on the highways but allow for upward adjustment and greater clearance off-road or, for example, in low-speed driving through deep snow.

These SUV design innovations are promising, but car design changes also will be needed to improve compatibility in crashes. The occupant compartments of both cars and SUVs need to be strong so they'll remain intact in a wide range of serious crashes (frontal offset crash testing is helping to accomplish this). And in the longer term, test procedures and criteria need to be developed to ensure that vehicle front-end stiffnesses match.

Something else that needs to be addressed is the issue of SUV rollover crashes. Some of the newer SUV designs have lower centers of gravity and wider track widths, so they should be more stable than the older designs. Dynamic rollover rating systems being

developed by the National Highway Traffic Safety Administration should help prospective SUV buyers choose models with a lower risk of rolling over. Electronic stability systems now available on some SUVs (and likely to become more prevalent) should reduce the likelihood that SUV drivers will lose control and spin sideways, which often precedes rolling over. Sensors can detect when a rollover begins and trigger the deployment of inflatable curtains that cover side windows and remain inflated throughout the event to help prevent full or partial occupant ejection.

Future designs should be driven by good data from research and testing as well as experience in real-world crashes. Evidence from these indicates that crash compatibility and partner protection improvements are needed. Still, the highest priority in the short and even medium term should continue to be self protection for people riding in both cars and SUVs.

An international effort involving the Institute and automakers is under way to develop both short- and long-term measures to reduce the adverse consequences for car occupants in crashes with SUVs and pickups. Two working groups have been convened, one to address front-to-front crashes and another to address crashes in which the fronts of SUVs strike the sides of cars.

(Note: This information is from a statement by Institute president Brian O'Neill before the U.S. Senate Committee on Commerce, Science, and Transportation, February 26, 2003.)



Car occupants are about twice as likely to be killed in a side impact if the other vehicle is an SUV than if it's a car of about the same weight. In the short term, the best way to address this is by adding

**SIDE AIRBAGS
WITH HEAD
PROTECTION**

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SPECIAL ISSUE

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Vol. 38, No. 4, April 26, 2003

This special issue focuses on vehicle compatibility in crashes. Recent special issues have focused on the following subjects:

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What works & doesn't work	36:5 (2001)
Vehicle improvements	36:3 (2001)
Side impact protection	36:1 (2001)
State traffic safety laws	35:10 (2000)
Driver death rates	35:7 (2000)



There are all kinds of mismatches involving vehicles. When it comes to safety, a

MISMATCH OF CONCERN

involves car weight and geometry versus the weight and geometry of SUVs and pickups.

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