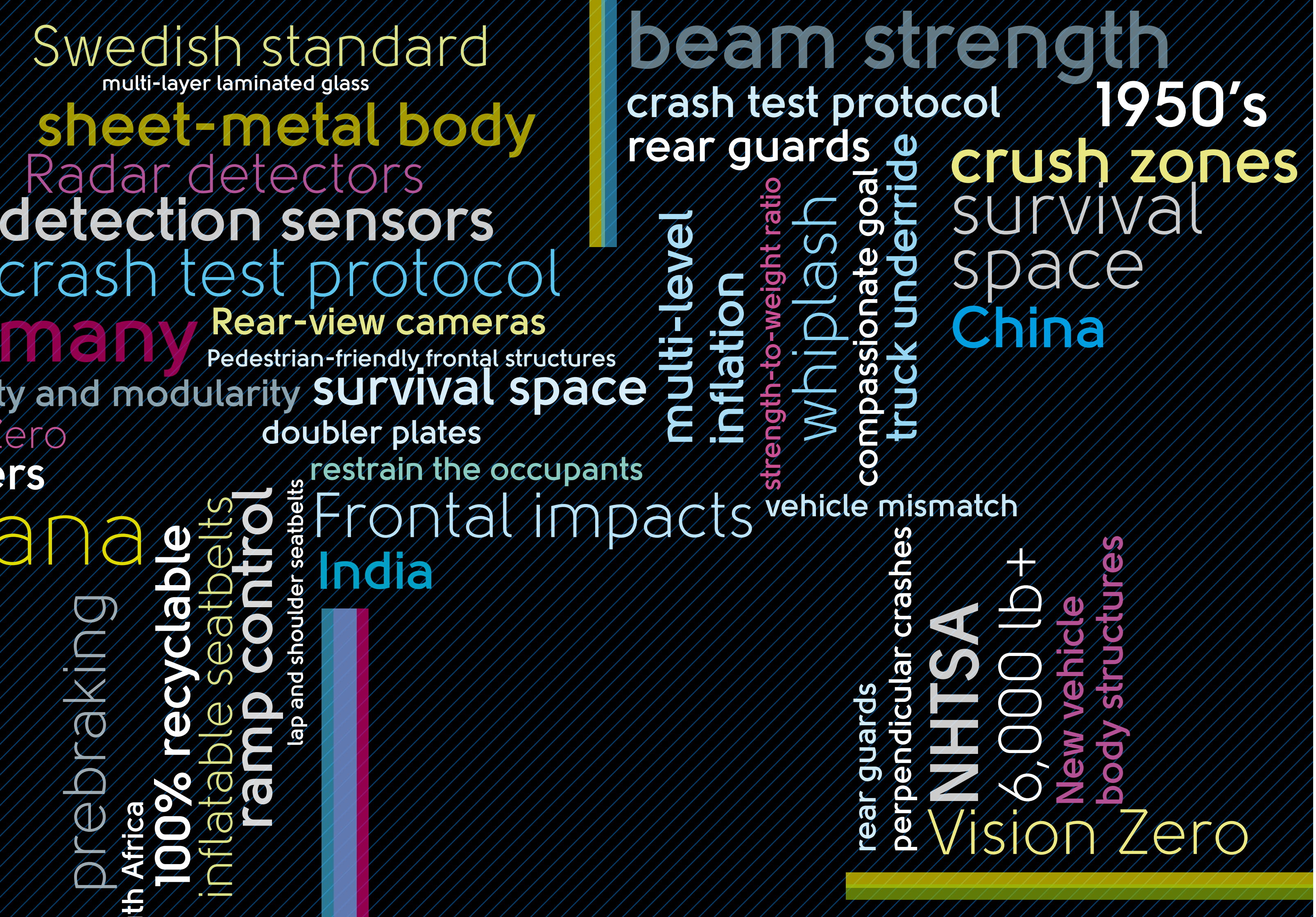
FMVSS 214 NHTSA
USA
210,000
crashworthiness
efficient transportation machine
safer cars
Frontal impacts
Frontal crashes
tubular members
2027
internal baffles
burgeoning traffic congestion
reinforcing gussets
better driver education
Crush zones
seven billion
1.3 million fatalities
disabling injuries
jams
CO_2
Sweden
Ger
Simplicit
Vision Z
rollove
Gha
SUVs
Brazil
Side impacts
Rear impacts
In mid-2011

Global appeal

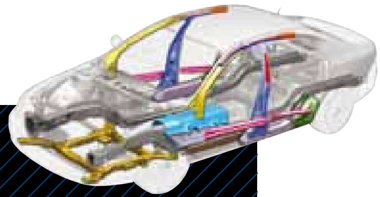
This renowned auto safety expert urges that traffic fatalities worldwide can be reduced further with a more ambitious and innovative approach in vehicle safety

AUTHOR BYRON BLOCH, AUTO SAFETY EXPERT, USA
IMAGES COURTESY OF BMW, DAIMLER, EURO NCAP, IIHS & GM



There are now more than seven billion of us on the planet, increasing at around 210,000 new inhabitants a day. If the projections are correct, another billion will be added within just 15 years, by 2027 – and another billion about 15 years after that. As the BRIC nations of Brazil, Russia, India and China have populations that demand modern automobiles for personal mobility for every citizen, how can the limited resources of materials and energy cope with such a huge demand? How can any nation continue to mass produce vehicles for their own citizens and for export to other markets?

And with vehicle accidents resulting in 1.3 million fatalities worldwide a year – a terrible human toll that must be reduced – what will the implications be for safety? Vehicle-related annual fatalities per 100,000 inhabitants range from a low of 2.9 in Sweden, 4.5 in Germany, 12.3 for the USA to 16.8 in India, 19.9 in Brazil and 33.2 in South Africa. Is the variance due to better driver education, better roads, stricter enforcement and safer cars? If so, how can all nations attain the Swedish standard? And what about the hundreds of thousands suffering disabling injuries each year? How can families and each nation provide suitable care – and at what cost?



Vehicle body structure

There are time-honoured basic performance criteria for automobile bodies. They must have adequate torsional strength, beam strength and overall durability. These strength requirements ensure that the body is rigid and durable enough to survive the loads and forces as the vehicle travelled on bumpy roads at speeds of 60mph or more. That prompted vehicle designs of sheet-metal bodies comprised of many stamped panels of mild steel that were spot-welded together. That steel body was then bolted on top of what was usually two main longitudinal frame rails, with a series of ladder-like crossmembers.

By the late 1950s, most auto makers were converting to 'unitised' bodies in which the sheet-metal bodies were designed with integrated box-section structural members to approximate the strength formerly provided by the heavier full-perimeter frame.

The next generations of vehicles will have to innovate totally new vehicle body structures that use much lighter materials, that take much less resource materials and energy to manufacture, are essentially 100% recyclable, extremely reliable and long-lived, and are easy to maintain. Simplicity and modularity will be critical, so damaged portions can be economically replaced.

"THE NEXT GENERATIONS OF VEHICLES WILL HAVE TO INNOVATE TOTALLY NEW VEHICLE BODY STRUCTURES THAT USE MUCH LIGHTER MATERIALS"

Frontal impacts

13,527 people were killed in frontal crashes in the USA in 2009

Radar detectors will be integrated into the front of most vehicles to prompt pre-braking for impending collisions. Enhanced night-vision windshields (as used by the military) will enable all drivers – especially those of our ageing population – to see much better at night and in inclement weather. Pedestrian-friendly frontal structures and hoods are needed to lessen injury to any pedestrians and bicyclists who may be struck by the vehicle.

Design features must include lap-and-shoulder seatbelts, with shoulder height adjustability, and with automatic pretensioners and belt-load limiters. Innovations should include seatbelts that are built into stronger seats. Ford (left) has started to phase-in inflatable seatbelts to ease stresses on the torso during the ride-down in a crash. There should be airbags for all occupants, while multi-chamber airbags that stay inflated longer could also help distribute crash loads more effectively.

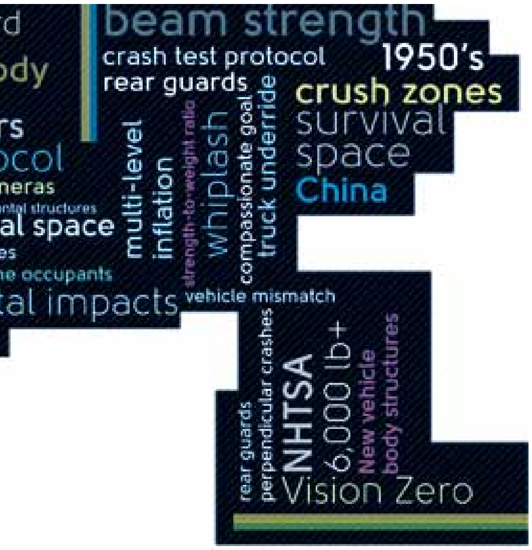
With today's high-pressure fuel-injection systems – and many other combustible fluid containers and lines – the engine compartment is a potential fire source in frontal crashes. A fuel shut-off inertia switch should be standard equipment to immediately stop the fuel pump and engine, thereby helping prevent fuel-fed fires. The inertia switch would also stop cars from continuing to run even after a crash that may have disabled the driver.

Furthermore, how can any nation meet the insatiable demands of an ever-growing population that demands more and more roads and highways to facilitate travel everywhere, and to ease the burgeoning traffic congestion? These jams in our cities often bring movement to barely a crawl, making a mockery out of the car being an efficient transportation machine. A mix is needed for public and private transportation systems – road, rail, ship and aircraft – but can the population adjust its daily routine and minimise the frequency and distances of travel? And who pays the cost for such multi-modal transportation systems?

With hundreds of millions of cars, SUVs, pickups, trucks and buses on the roads around the world, how can the ever-increasing demand for more petrol be satisfied? With the internal combustion engine's production of CO_2 emissions, how can the cumulative effect upon global climate change and global warming be resolved? Hybrids and electric cars serve to partially alleviate the problem but they still consume electricity that must be generated, often by coal-burning plants. The quest for energy resources has led to the dangers of hydraulic fracturing deep within the earth, affecting water supplies and destabilising tectonic plate movement.

Consider that a car can fulfil its basic transportation function with a sheet-metal body that is stamped and spot-welded together, plus a four-cylinder engine, a transmission, steering linkages and suspension, brakes, wheels and tyres, headlights and tail-lights, front and rear seats, some frontal and side airbags, and seatbelts. The total weight need be no higher than about 2,400-3,000 lb.

So why do so many Americans opt for a large SUV, which is primarily



used to commute to work, transport kids to school, or go shopping within a few miles from home? These sport utility vehicles typically range from 4,500 to more than 6,000 lb – a vehicle obesity epidemic that seems to mirror the obesity problem of the American population. We must revert to the intelligent principles observed in nature, where lightweight structures and low energy consumption are the hallmarks of successful design.

The innovation of lightweight, fuel-efficient vehicle bodies can be attained by use of high-strength steels that are stronger yet thinner, with aluminium and magnesium components, and polymer plastics and fiber-reinforced composites. Strengthening includes using structural foams to fill tubular elements, and structural adhesives to permanently bond dissimilar materials. It is important to innovate weight and cost reductions so that all vehicles worldwide can be strong enough to maintain the survival space, and be equipped with sufficient airbags, stability control systems, and other state-of-the-art accident-prevention and crashworthiness features.

And what do all of these trends mean for crashworthiness – for how well or poorly the vehicle itself can help protect you in the event of a collision accident? Although it's preferred to prevent the crash, with improved braking systems and driver education and safer roads, collision accidents will continue to occur. For the forseeable 20 to 30 years and beyond, it's still going to be critical for cars to be designed to prevent needless death and severe injury in accidents that will continue to occur. The quest for Vision Zero demands that we continue to honour the basic principles of vehicle safety.

Side impacts

6,243 people were killed in side-impact crashes in the USA in 2009

In 1998, NHTSA published a final rule amending FMVSS 201 (Occupant Protection in Interior Impact) to permit – but not require – the installation of a dynamically deploying upper-interior head-protection system. Manufacturers installing a head-level airbag had to subject their vehicles to a free-motion headform test at a speed of 12mph, and an 18mph perpendicular vehicle-to-pole test.

The latest rule upgrade modified FMVSS 214 (Side Impact) by requiring all passenger vehicles to provide protection in a 20mph, 75°,

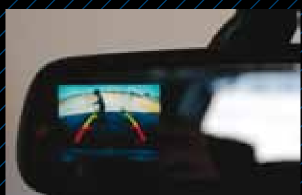
oblique vehicle-to-pole test by simulating a collision sideways into a narrow fixed object, such as a telephone pole or tree. The pole test will be conducted using a 5th percentile female dummy seated full-forward, or a 50th percentile male dummy seated at the mid-track position of the front outboard driver or passenger seats.

It is important to use multi-layer laminated glass for the side windows, so that they won't shatter completely out as tempered glass windows are prone to do, which leave large portals for partial or complete ejection of the occupant. Laminated glass will instead stay intact and serve as a 'life net' to help keep the passengers safely

Rear impacts

1,173 people were killed in rear impacts in the USA in 2009

Rear impacts typically cause the struck vehicle to accelerate, causing potential neck sprain injuries to the seated occupants. There was a time when too many vehicles had their fuel tank located behind



the rear axle and near the rear bumper (think Ford Pinto), where the fuel tank would be crushed and ruptured, with fuel expulsion and fire. The safety principle is to locate the fuel tank in the less-vulnerable, well-protected position forward of the rear axle – albeit it took Detroit's genius engineers only 40 years to figure that out!

Seats also need to be stronger, with high seatbacks or head restraints to avoid dynamic misalignment stress

to the cervical spine and head that often cause hyper-extension 'whiplash' injuries. Rear-view cameras are also needed to show what's behind the vehicle to prevent backing into children, adults and other vehicles.

The three principles

Maintain the occupants survival space: Basic vehicle safety principle number one is to maintain the passengers' 'survival space' from being crushed or intruded into during a collision or rollover accident. This requires that the structural elements be interconnected to distribute the collision forces rather than allow overloads that will cause any door or roof pillar to buckle and fail. *Provide occupant restraints and cushions*: Number two of the principles is to restrain the occupants within the vehicle, and to prevent contact or impact with any injury-causing surfaces or edges. Airbags have been developed to enable automatic cushion-like

protection in frontal and side impacts, and they also help restrain the occupant from excessive movements as the vehicle accelerates, decelerates, or rolls over. More interior surfaces, such as roof pillars, should use energy-absorbing foam to reduce impact forces with the occupant's head. *Frontal and rear crush zones*: Number three is to design the front and rear portions of the body structure to crush to help absorb forces due to impacting with another vehicle or object. Generally, about 20in of crush distance can be effective, except for shorter vehicles that have virtually no front or rear extensions to enable such crush zones.

Rollovers

8,267 of US fatalities were rollovers in 2009 – 35.5% of the total

Although only about 5% of accidents are rollovers, they account for about 35% of fatalities, and are a major cause of quadriplegics when the weak roof buckles and crushes down to fracture the cervical spine. FMVSS 216 began in the mid-1970s but only required a 'slow push' test on one side of the roof, up to a force of 1.5 times the vehicle weight with no more than 5in of roof crush.

FMVSS 216 now requires a slow push test on both sides

of the roof, in sequence, with a seated test dummy, up to a force of three times the vehicle's weight (strength-to-weight ratio, or SWR). Some auto makers such as Volvo, VW and Subaru have opted to make stronger roofs well beyond the minimum 3.0, with stronger roofs with SWR well above 4.0 and even 5.0. Roof designs can be stronger with closed-section tubular members, internal baffle reinforcements or foam-filled, corner gussets, use of composite inserts and more.

Truck underride

When a passenger vehicle crashes into the rear or side of a large truck or trailer, the car's roof is often ripped into, with catastrophic consequences that can include decapitation. However, the FMVSS 223 and 224 standards only address rear guard requirements for trailers, with none for large trucks. And there's no US requirement for any side guards, although Europe has moved ahead with a recommended regulation since the mid-1980s that many nations have adopted.

Rear guards must be strengthened to protect across

the entire rear of the truck, and side guards must be required on large trucks and trailers with sufficient strength to prevent underride by passenger cars at 50mph-plus in 90° perpendicular crashes. European trucks and trailers are leading the world with sideguards but they must be strengthened and crash-tested to ensure

that passenger vehicles will be prevented from the underride hazard. Strengthening can be achieved with additional supports, diagonal braces and gusset plates. US trailers are now slowly adopting side guards, mostly for aerodynamic fuel-efficiency reasons, and they, too, must be made much stronger.

Vehicle mismatch

80% of US deaths in mismatch crashes in 2009 were car occupants

With the traffic mix ranging from compact cars to large SUVs and immense tractor-trailer combination trucks, collisions often involve a 'mismatch' where the larger, heavier vehicle overwhelms the smaller vehicle. About 80% of the fatalities are passenger car occupants.

On our crowded streets and highways, the vehicle mismatch collisions will continue to occur.

What's imperative is that countermeasures be designed into the larger vehicles to help soften the impact forces transmitted to the more vulnerable passenger cars.

A deformable frontal structure – or possibly inflatable external airbags – could be designed into the front of trucks and large SUVs and pickups to mitigate the lethal penetration and overriding by the larger-taller-heavier vehicle versus the typical car. Vehicle weight and large sizes must both be countered with national policies and regulations to encourage their reduction.

"ALL VEHICLES SHOULD BE FUEL-EFFICIENT, STRONG AND STATE-OF-THE-ART CRASHWORTHY"

The inspiration for 'crush zones' took hold in the 1950s when early crash tests showed that frontal and rear structures could absorb and dissipate crash forces rather than allowing intrusion into the passenger compartment. Mercedes, GM, and Ford pioneered development of frontal structures that crushed, so that occupants could 'ride down' the deceleration forces in a frontal crash. With seatbelt restraints, passengers could survive.

Start the revolution!

We are fully aware of many of the issues. We hate the traffic congestion and high cost of petrol. We wonder if it's too late to curtail global warming. We think that cars are too costly, too complex, too expensive to maintain and repair. We try not to think of what may happen in a collision accident. But then we smile, we shrug and we accept the stylish and comfortable and powerful almost-new car that we're driving.

But if you are reading this, you likely have a professional interest in improving the transportation link that we know as the motor vehicle – the cars, SUVs, pickups, work trucks, heavy freight transport trucks and buses. The compassionate goal of Vision Zero is to reduce vehicle-caused deaths to zero. The revolution has already begun: welcome on board! ‹

• Byron Bloch has been a US auto safety expert in design and crashworthiness for 40 years, analysing how and why occupants are injured in crashes, and the role of vehicle design. He advocated adoption of airbags, fuel tanks forward-of-axle, stronger roofs for rollover protection, truck underride guards and more comprehensive testing. He lectures, writes, produces video documentaries, testifies on behalf of car crash victims and demonstrates exemplar designs that are safer. His website is www.AutoSafetyExpert.com