Passenger Safety

Passenger safety (including drivers) in vehicles is by far the most considered field of automotive safety. Although the focus is only now falling on pedestrian safety, passenger safety has been at the top of the agenda since the World's various automotive regulatory bodies were founded. The result of decades of concentrated effort is a good public understanding of simple concepts such as crash cages and crumple zones whilst the industry has developed specialists in almost all related technical areas.

In this section, we look at the key safety considerations when designing a vehicle, as well as more technical aspects affecting systems and components.

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Pedestrian Safety

Designing for Pedestrians in Impact

In direct response to proposed and actual EU legislation, manufacturers are trying to stop pedestrians impacting with hard-points at the front of vehicles. The principle responses are to either raise the bonnet to a stance that better absorbs energy, or to use airbags to cushion against these hard-points. Although these approaches offer a way to maintain existing styling traits, they are unlikely to be as simple or effective as more dramatic changes in vehicle front design.

In 2000, 28% of UK road fatalities were pedestrians. Key improvements seem to revolve around giving the right amount of support, in the right areas, to a pedestrian in impact. It is suggested that bumpers have a deeper profile or a support structure below the surface to reduce “pitching of the leg-form and bending of the knee joint”. ‘Foam plastics’ could be used to absorb the energy of the impact as they possess good ‘recovery characteristics’ to reduce permanent damage to the vehicle in “low-speed car-to-car collisions”.
At the leading edge of the bonnet it is desirable to reduce the stiffness of the structure and avoid the location of catches and other fixings close to the surface. Bonnet reinforcing structure and panel seams add to the number of risk areas for impact. Statistics by the (UK) Transport Research Laboratory predict design improvements could prevent 8% of all pedestrian fatalities and 21% of serious injuries. The UK Department of the Environment, Transport & the Regions (DETR) is more optimistic, believing up to 20% of pedestrian fatalities could be prevented within 8 years.

Several key changes to design can be considered as a means to improve pedestrian impact performance:

- Bumper foam needs to be 20-40mm thicker than on current vehicles and may need to be bigger in the vertical direction.
- “A low level foam-covered beam is needed to reduce rotation of the knee joint. This could be disguised under a spoiler-style skin.”
- Lights should be kept below the upper leg crush zone or designed to deform in a controlled way.
- Under bonnet clearance should be at least 75mm, with special consideration paid to major features such as shock absorber mounts. Some suggestions have been made that double-wishbone suspension may be an alternative - this depends on the packaging in this area.

There is some difference of opinion on bonnet leading-edge height. Some sources state that anything above 650mm in height is undesirable where other point out that “making the hood edge height higher is effective in lowering the vehicle-head collision speed”. It is noted though, that “if the edge of the hood is too high, it might be dangerous for children because their heads might be directly hit by the front of the car”. They chose 800mm as a suitable height as it is lower than the head of a 3 year old child. There is no defining conclusion on the subject of leading edge height; it makes more sense to look at reducing hard points, improving controlled plastic deformation to absorb energy and stiffening lower bumper structure to minimise leg injury.

In tests on bonnet structure, it was concluded that steel, backed with a ‘soft foam elastic material’ performed better than any other metal-based structure. No solely polymer structures were tested. Traditional bonnet design involves dangerous points of reinforcement and its performance in impact is very difficult to predict or control.

Modifying existing methods of manufacture to improve pedestrian impact performance may not be the ideal direction to take. It should be noted that bonnet clearance needs are different for children and adults, that clam-shell bonnets are preferred, that simply raising everything for greater clearance over componentry will increase drag and thus fuel consumption. Existing vehicle structures cannot produce uniform responses to impact and some common practices - such as the use of MacPherson strut suspension - are almost incompatible with long-term improvements in this field.

Headlight design may also need to change. The front of the headlight could become part of the passive safety system, where the lens will be collapsible and packaging requirements will alter as the lighting unit is moved back from the likely point of impact.

**Bonnets**

Looking specifically at the bonnet area, user intervention in the engine bay area is constantly decreasing. In fact, with current levels of reliability, most users need access to the engine bay only to replenish items like the screenwash. Given that the bonnet is simply a reinforced sheet metal lid on most vehicles, why not separate access to the engine from that of the replenishable fluids? Access to these items could be tidied away to a more convenient
place. This would allow the bonnet to be replaced by simpler, stiffer structure that could save weight or be used more efficiently in dissipating the energy of an impact.

With the bonnet replaced by a stiffer structure, it may then be possible to create a more efficient body using fewer and lighter materials. The result would be a vehicle that weighs less, requires less energy to propel and impacts with decreased momentum; ideal characteristics for a safety- and environmentally-conscious vehicle. If access from above is not required for most major engine bay components, it is then feasible to more densely package them, moving all major hardpoints even further from areas of pedestrian impact as well as reducing the vehicle’s footprint.

**Bumpers**

Research into bumper development used ‘special energy absorbing elements’ made of PolyPropylene under a PolyPropylene skin to achieve a balance in impact performance across the bonnet leading edge, bumper and spoiler area. Although an ideal vehicle front “is not completely achieved by choosing special material properties only”, the only firm suggestion relating to styling is that features creating high local stiffnesses should be avoided.

**Safety Principles**

There are two main routes to improving vehicle safety. Firstly, there is prevention - keeping people, objects and vehicles away from each other and out of harm's way. This is achieved by combining many hundreds of factors such as driver education, design of pedestrian crossings and requirements for vehicle performance and maintenance. It is this approach that brought about much of the earlier vehicle legislation that addresses lighting, turning indicators and basic demands on components such as windscreens, mirrors and tyres.

As traffic volumes increased, so did the rate of accident and injury. This lead to further requirements and laws for the design of vehicles as well as a rethink (in most countries) of speed limits and road networks. It begun the second stage of safety design - passenger or passive safety.

Nils Bohlin of Volvo invented the modern seat belt in 1959. This was the three point seat belt and made such a difference to crash safety that it was included as a basic requirement to install belts in cars in some of the earliest European legislation - although compulsory use came much later. In effect, this was the first in a long line of developments from Volvo to improve passenger safety; an aspect of design that most other manufacturers cared little for until the 1990s.

Nowadays, safety is considered in many more ways than ever before - from the structural performance of a vehicle in impact to the ability of a driver to see clearly past an A- or B-post. Increasingly, pedestrian impact is also being considered.

**Visibility**
Preventive safety is about designing a vehicle that can be easily seen by other road users, a vehicle that is easy to see out of and a vehicle that presents a driver with all the information they require and no more. Good visibility is key to identifying problems quickly and making the correct decision in good time. Poor visibility due to weather leads to dramatic increases in the rates and severity of road accidents.

**Energy Transfer and Absorption**

Reactive safety is about minimising damage and injury once an accident becomes unavoidable; this means designing structures and devices that absorb the energy of impact rather than transfer it to a person or object in a dangerous and uncontrollable way.

**Vehicle Control and Handling**

ABS, or anti-locking brakes, are an example of control assistance that aids the safe performance of a vehicle. This and other systems such as traction and stability control can enable safer driving by compensating for limits in human ability. They make a substantial difference when a vehicle is being used to its maximum but can lead to a reliance or complacency by drivers which can in turn negate the safety benefits. Manufacturers recognise that there is a point at which safety features make a driver feel so at ease that their driving deteriorates and becomes more dangerous.