There are no government requirements to compel manufacturers to provide occupant protection against rollover for any passenger cars, passenger vans or Four Wheel Drive (4WD) vehicles.

All other collision types have some form of design regulation or consumer test that affects, impacts or compels the manufacturers to account for the collision type. Currently in Australia there are regulated rollover protection structure requirements for buses, earthmoving equipment and tractors. There are no government regulated requirements or consumer tests compelling manufacturers to provide systematic occupant protection against rollover for any passenger cars, passenger vans or Four Wheel Drive (4WD) vehicles.

Further analysis shows that rollover is a rural rather than an urban problem:

<table>
<thead>
<tr>
<th></th>
<th>Vehicle did not rollover</th>
<th>Vehicle did rollover</th>
<th>Unknown or not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>2529</td>
<td>152</td>
<td>654</td>
</tr>
<tr>
<td></td>
<td>75.8%</td>
<td>6.6%</td>
<td>14.4%</td>
</tr>
<tr>
<td>Rural</td>
<td>2304</td>
<td>676</td>
<td>503</td>
</tr>
<tr>
<td></td>
<td>66.2%</td>
<td>19.4%</td>
<td>19.6%</td>
</tr>
<tr>
<td>Total</td>
<td>4870</td>
<td>873</td>
<td>1172</td>
</tr>
<tr>
<td></td>
<td>70.8%</td>
<td>12.2%</td>
<td>17.0%</td>
</tr>
</tbody>
</table>

Table 1: Australian fatal road crashes for 1996, 1997 and 1998

Rollover is more prevalent in four wheel drives (4x4's) and Sports Utility Vehicles (SUV's) than in passenger cars, with some 4x4's having up to 5 times the rollover rate than typical passenger cars. This is of concern given the surge in popularity and hence ever increasing numbers of 4x4 on our roads.

The phenomenon of rollover can be segregated into two issues. The first deals with rollover propensity whereas the second issue concerns rollover crashworthiness. What is needed is either government or consumer testing for:

1. Rollover propensity.
2. Rollover crashworthiness.

### Rollover Propensity

The problem of rollover propensity has been characterised by Kahane, i.e. “rollover risk has two components: directional stability (handling) and rollover stability. A vehicle is directionally unstable if it tends to skid, spin out of control or is hard to steer on course. A directionally unstable vehicle will have many more off-road excursions into loose dirt, ditches etc., where rollovers are more likely to occur. "Rollover Stability" is the tendency of a vehicle to remain upright given that it has come into contact with a tripping mechanism such as loose dirt, ditches etc."

The cause of a large proportion of rollover collisions is entrenched in the dynamic directional stability (handling) of the vehicle. Most rollover collisions start out as a minor directional error. However, the driver typically inputs one or a series of rapid and large steering corrections in an attempt to regain directional control of the vehicle. As a result of the steering correction(s) the vehicle yaws (rotates about its vertical axis) and slides sideways encountering some tripping mechanism.

Rollover stability factor is a measure of how well a vehicle can slide sideways before it rolls and is determined by the ratio of: half the track width divided by the vehicle’s Centre of Gravity (CoG) height. Having encountered a sufficient tripping mechanism the vehicle’s sideways slide speed is converted into a combination of rotation (about the roll axis) and speed i.e. a rollover. Figure 1 illustrates a typical rollover sequence.

As a result of several rollover collisions a testing handling methodology has been developed and is being used by the Victoria Police Force (and other institutions and companies) to evaluate and procure vehicles based on both dynamic directional stability (handling) and rollover stability (Richardson et al.).
Rollover Crashworthiness

In a rollover, injuries and fatalities occur primarily as a result of partial or complete ejection. The vehicle’s structure either collapses around the occupant(s) (i.e., roof crush) or the restraint system does not contain and control the flailing motion of the occupant(s).

Richardson5 and Richardson6 et al evolved and developed a Roll Over Protection Structure performance specification, which is currently being used by the Australian Department of Defence for Military General Service Vehicles. The performance specification is based on energy and force loading requirements and the occupant survival spaces located in seating positions. A Roll Over Protection Structure performance specification has been validated by a combination of computer simulations, impact test, rollover simulations, and analysis of real-world crashes. Figure 3 illustrates a rollover simulation of one of the structures built to the specification. The vehicle is dropped from the rear of a truck.

The structural requirements demand some complex engineering skills but they are achievable and are well within the design and production capabilities of current vehicle manufacturers.

What is ultimately needed is a regulated government or consumer rollover test, that evaluates seat belts, seat belt pretensioners, side air curtains, and roof structure in a full-scale test with anthropomorphic crash test dummies.

United States of America Experience

In the United States of America (USA) rollover presents a similar problem if not worse than in Australia and there has been extensive work on the issue of rollover, including the following:

1. Regulated quasi-static structural test requirement for the forward roof structure (FMVSS216).
2. Consumer information on static rollover propensity.
3. Consumer information on untripped rollover propensity.

The weaknesses with the work carried out in the USA are that:

1. The quasi-static structural test requirement is based on 1.5 times the mass of the vehicle whereas the tractor, earthmoving, and Richardson6 et al requirements are for at least 2 times the mass of the vehicle. The USA quasi-static requirement involves applying a force to the roof structure commencing at the driver’s side “A” pillar area. The manufacturers typically achieve the requirement by using the windscreen as a structural member. This would be acceptable if in a rollover the vehicle rolled only onto this one part of the roof. However, it is typical for the roof to sustain multiple impacts where the windscreen usually breaks during first contact. Hence, the test should be conducted without the windscreen and require multiple impacts to the roof structure. The occupant motion within the vehicle is not considered in the USA test.

2. The USA implemented a rollover rating system into the New Car Assessment Program (NCAP) based on the static rollover stability factor: half the track width divided by the vehicle Centre of Gravity (CoG) height. The rollover rating for NCAP is based on a four-year study of single vehicle crash data from six states. The analysis is based on 226,117 single vehicle crashes of which 45,574 involved rollovers and 100 vehicle types were identified.

3. Consumer information on untripped rollover propensity is not related to the four-year study of single vehicle crash data from the six USA states.
Currently in Australia there is no regulatory or consumer information on rollover propensity.

Proposed Regulations

Currently in Australia there is no regulatory or consumer information on rollover propensity. The Australian New Car Assessment Program has considered propensity protocols but has not announced a position or intention. Let us hope that information will soon be provided so that consumers at least can make an informed choice. Did you know that you could choose between vehicles that have either a 80% or 5% probability of being involved in a single vehicle crash that is a rollover? A methodology has been developed that is simple, effective and repeatable which can discriminate which is a better vehicle. Aren't consumers at least entitled to the information?

To effectively protect 4x4 and passenger vehicle occupants from the threat of injury, regulatory and consumer bodies have developed a range of crash tests to evaluate the vehicle system performance against occupant injury criteria for forward collisions, side impacts, rear impacts and pedestrian collisions. No such regulatory or consumer requirement for rollover exists in Australia to-date or is currently being investigated or considered for implementation. As a result of the high fatality rates, there is an urgent need for a repeatable dynamic vehicle rollover test to evaluate the vehicle rollover crashworthiness system performance for all passenger vehicles.

In collaboration with others offer you the following, which would provide safer vehicles and help reduce the road toll:

1. Information about the propensity of vehicles to rollover so that consumers can make informed decisions.
2. A rollover structural protection requirement for 4x4, people moving utility vans and passenger vehicles.

References

5. S. Richardson, Society of Automotive Engineers – Australia, 1999 Young Engineers Conference, “Development of a 4x4 Rollover Protective Structure Performance Requirement”.
Solution. Engineering of the thin classification units â€“ AKA-SPIDER pump-hydrocyclone units operating in fully automatic mode.

Upgrade. Problem. Is there a high degree of wear of the hydrocyclone parts which are in contact with the pulp. Solution. Solution. The process structuring, engineering with the use of high-performance thickeners AKA-SET in tandem with hydrocyclones-thickening AKA-VORTEX. Automated coagulant dosing systems. Analysis of the density of the condensed product, the purity of the drain.