SAFETY REQUIREMENTS FOR SMALL MOTORISED ALTERNATIVE VEHICLES

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ABSTRACT

In recent times there has been an increase in the development, availability and use of small, motorised vehicles that may be alternatives to more conventional modes of personal transport such as bicycles or cars. Much of the interest in these 'alternative vehicles' (AV) is in their perceived benefits for pollution and congestion reduction.

To date there has been no uniform global approach to rules and standards governing the use of AVs. Regional requirements have mostly been applied on an ad hoc basis, differing significantly between jurisdictions. This has led to a highly prescriptive approach. This has tended to constrain innovative design, often because the vehicle concerned does not meet a regulatory definition.

In many jurisdictions there appears to be confusion amongst retailers, suppliers, consumers and enforcement agencies as to what types of AV may be legal and what rules govern their use. The differences between jurisdictions also mean that manufacturers and suppliers cannot easily design a single vehicle to market in a number of regions.

We review the types of AV that are available, or are under development, the limitations of the infrastructure on which they might be used and the safety issues arising from a mix of conventional road/path users and AVs.

INTRODUCTION

Alternative Vehicles (AVs) are small motorised wheeled vehicles that are used for personal transport but differ in construction from conventional vehicles such as cars, motorcycles and bicycles and do not comply with applicable vehicle regulation for cars or motorcycles. In Australia most types of AV cannot be registered and cannot be used on public infrastructure. Exceptions include electric wheelchairs, mobility scooters and power-assisted pedal cycles.

There are an increasing number of new types of AV that attract public attention. There is also lobbying to allow these vehicles to be used on public paths, cycleways or roads. The argument is often put forward that these vehicles will be used instead of cars and so will result in reduced pollution and less traffic congestion. Countering this are concerns about the safety of pedestrians and cyclists, if these vehicles are used on footpaths or bicycle paths, and concerns about the riders of these vehicles, if they mix with conventional cars.

A review of international practices suggests that jurisdictions are having difficulty catering for alternative vehicles. There are no international vehicle standards that can be applied in their entirety to cover all concerns about the safety and operation of alternative vehicles.

ROAD VEHICLES

In Europe there is a class of vehicles known as quadricycles that are car-like but are not required to comply with modern crashworthiness requirements. Similarly, in the USA there are regulations to allow Low Speed Vehicles on some roads.

Transport Canada and the Insurance Institute for Highway Safety have each conducted crash tests of quadricycles and have expressed strong concerns about the lack of crashworthiness and the risk to occupants in relatively low speed collisions with cars.

Figure 1. Transport Canada crash test of a car-like quadricycle vehicle (40km/h full frontal)

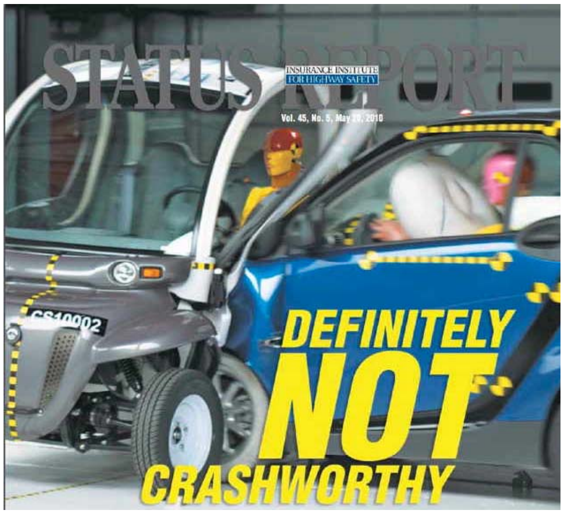

Figure 2. Cover of IIHS Status Report

In contrast there are now several models of fully electric car that have similar environmental benefits to electric quadricyles but are designed to meet car crashworthiness standards. For example the Mitsubishi i-MiEV recently achieved a 4 star rating from the Australasian New Car Assessment Program.

In the author's view any car-like vehicle should be required to meet crashworthiness regulations that apply to conventional cars. They are not considered to be alternative vehicles.

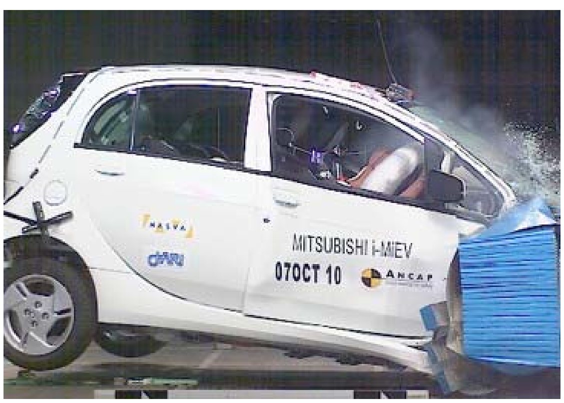

Figure 3. ANCAP crash test of Mitsubishi i-MiEV (64km/h frontal offset)

Power-assisted bicycles (PAB) are a form of AV that regularly shares the roads with cars. Like cyclists and motorcyclists, the riders of these vehicles are highly vulnerable to injury in a collision, compared with car occupants. A key difference, compared with quadricycles, is that the riders of bicycle-like vehicles feel vulnerable and usually ride accordingly.

In Australia power-assisted bicycles are limited to a motor power of no more than 200W. They must also have human (pedal) power as the primary means of propulsion. There are proposals to change from power-limiting to electronic speed-limiting for electrically powered PABs. The concept is that the electrical propulsion cuts out at speeds above 25km/h (the same as light mopeds in some European countries) but the rider can still use pedal power (or other human power) to travel at higher speeds, like a conventional bicycle.

Based on an analysis of speed and injury risk (see later), it is proposed that no AV be capable of powered travel in excess of 25km/h and that only those AVs capable of human propulsion above this speed be permitted to use roads with traffic travelling at commuting speeds (e.g posted speed limit greater than 50km/h). This is the current situation with power-assisted and unpowered bicycles in Australia.

In Australia bicycle lanes beside roads and dedicated bicycle paths are designed for a bicycle no more than 800mm in width. This width limit should apply to all AVs.

FOOTPATH VEHICLES

Vehicles that are intended to mix with pedestrians on footpaths are associated with special safety concerns. With frail (aged or very young) pedestrians any type of collision could lead to serious injury and even the need for a pedestrian to dodge out of the way of a vehicle can be hazardous. Therefore a vehicle used on footpaths must be capable of travelling and manoeuvring at very low speeds (one or two km/h) so their riders can avoid collisions with pedestrians.

It is noted that bicycles are not capable of travelling at the very low speeds needed for safely mixing with pedestrians because they need to travel at a minimum speed in order to be stable. This is one reason that most jurisdictions do not let bicycles ride in pedestrian areas - except where there are shared facilities designed for this purpose.

Footpath vehicles should also be top speed limited (4km/h for busy areas and 10km/h for other areas - see later). Limits on vehicle width are also appropriate. In Australia there are national guidelines for the design of footpaths and these are based on a standard unpowered wheelchair that is 740mm wide. This maximum width would be appropriate for any AV that uses a footpath.

AVs are being promoted as a "green" alternative to cars and as a means of commuting to work or to a bus/train station. Any relaxation of current requirements to permit AVs on footpaths should be based on stringent safety and environmental conditions. Zero tailpipe emissions and minimal engine noise are appropriate (i.e. electric powered AVs). Portability is also a consideration. A kerb mass limit of 60kg would allow the rider to manually negotiate steps and other common obstacles and for two people to lift the vehicle, where necessary. An exception is mobility scooters designed for mobility-impaired riders, where extra features are needed and a kerb mass limit of 150kg is recommended.

BICYCLE PATHS

Most major cities in Australia have strategies to encourage bicycle use, including the provision of infrastructure designed for bicycles, such as dedicated bike paths (separate from roads) and shared paths where pedestrians and bicycles travel in an orderly manner. Bike paths are usually designed for vehicles no more than 800mm in width travelling at up to 25km/h, where conditions permit. These limits should apply to AVs using bike paths.

It is important that any AVs that use bike paths do not hinder the flow of bicycle traffic. Therefore it is recommended that any powered AV be capable of maintaining a speed of 8km/h on a 5% gradient.

SAFE SPEEDS

The risk of fatal injury in the event of a collision is strongly linked to the collision speed that, in turn, is linked to vehicle travelling speeds. The fatality risk for pedestrians and cyclists reaches 5% at collision speeds of 25km/h and 10% at 30km/h (Wramborg 2005). The corresponding values for modern cars are 65km/h and 70km/h respectively. Car occupants have much less risk due to advanced restraint systems (seat belts and airbags), a strong passenger compartment and energy absorbing structures at the front.

This analysis indicates that, for vulnerable road users, collisions in excess of 25km/h should be avoided. This is the proposed maximum powered speed for any AV. Under many circumstances lower speeds are appropriate.

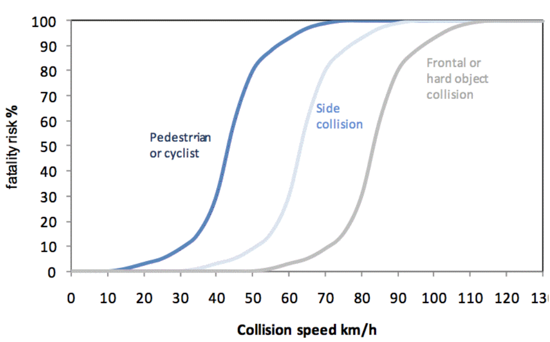

Figure 4. Risk of fatal injury (Wramborg 2005)

A design aim for pedestrian infrastructure should be to minimise the risk of any collision with a vehicle. A primary factor in collision avoidance in these cases is vehicle speed.

In a study of the pedestrian danger from reversing motor vehicles, Paine (2003) evaluated the probability of collision avoidance for a range of detection distances and car speeds. The results apply to any vehicle moving slowly in either the forward or the reverse direction. Based on 95% collision avoidance, a rule of thumb is that the vehicle speed in km/h should be no more than twice the detection distance in metres. Therefore, for a vehicle travelling at 10km/h, the detection distance (at which the driver is alerted to an object in the path of the vehicle) should be no less than five metres.

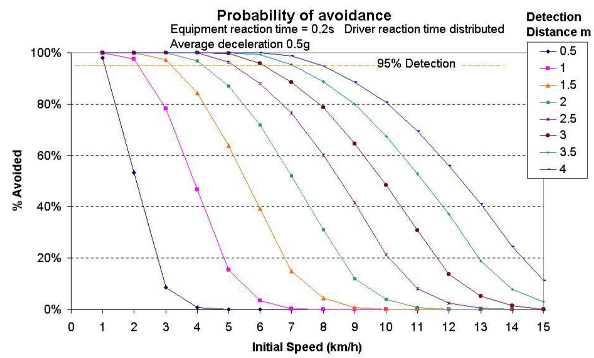

Figure 5. Low speed collision avoidance (Paine 2003)

The results of this analysis place severe limitations on the safe speeds at which alternative vehicles can share infrastructure with pedestrians. On un-crowded footpaths (typical of residential streets and shared paths) a 5m hazard detection distance is considered typical. In these circumstances a 10km/h speed limit is appropriate. On busy footpaths and footpaths with visual obstructions, such as blind corners, a hazard detection distance of 2m is considered typical and so a 4km/h limit would be appropriate.

Mobility scooters have a collision-avoidance disadvantage because the front of the vehicle is some one metre forward of the rider's eyes ("forward projection" = 1m). This reduces the distance available to stop once a hazard is detected. It is therefore important that conservative decisions are made about appropriate speeds for AVs on footpaths.

With the proposed electronic speed limiting of AVs there is scope to have speed ranges to suit the particular infrastructure. In this case a speed range indicator, clearly visible to other infrastructure users, would be appropriate.

OTHER CONSTRUCTION REQUIREMENTS

Other vehicle construction to be considered include:

- Maximum acceleration
- Braking performance
- Rider controls (throttle, braking, steering)
- Height with rider
- Tipping stability
- Manoeuvrability
- Lighting & conspicuity
- Minimum and maximum noise
- Vehicle identification

CONCLUSIONS

Since infrastructure on which AVs would be expected to operate tends to be bicycle or pedestrian-based there is good scope for achieving a global or national standard that will be compatible with existing infrastructure and will ensure that AVs can operate safely amongst other infrastructure users. It is recommended that an international working group be formed to develop a draft standard for construction and performance of AVs, taking into consideration the factors raised in this paper. It is important that infrastructure designers contribute to this standard.

The development of technical standards is only one part of an overall policy framework to deal with AVs. More daunting are the tasks of determining if and how vehicle registration and rider licencing should apply to AVs and which types of AV should be allowed to use public infrastructure. There are also issues of accident insurance and regulation amendments to consider.

Vehicles complying with a global technical standard should not automatically be granted access to public infrastructure. If, after a range of policy issues have been considered, it is decided that particular types of AV will be allowed to use public infrastructure in a certain region then global technical standards will assist in the implementation of this policy.

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DISCLAIMER

This paper represents the author's views and does not represent the views or policy of any organisation. It is intended as a discussion paper and is based on research conducted for several projects over the past decade. I thank my colleagues in those projects.