Attachment C

Queensland Government

Segway PT Safety

A review of the legislative and safety implications of Segway PT use on or around the road network

Branch	Road Safety Policy
Division	Road Safety, Registration & Licensing Division
Department	Department of Transport and Main Roads
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Executive Summary

A Segway PT (Personal Transporter) is a self-balancing personal transportation device with two wheels. The rider stands upright on a platform between the wheels and holds onto a steering column. The rider controls the device by leaning and shifting their weight forwards, backwards and side to side (Segway Inc., 2011).

This report examines the current legislation surrounding Segway PT use in Australia and internationally and detail what changes would be necessary to allow use on the Queensland road network. The safety implications of Segway PT use on road and road-related areas are also discussed.

Currently, the Segway PT cannot be registered or ridden on a road or road-related area under any circumstance. The Segway PT device is not specifically defined in Australian law and there are no rules about these devices in the Australian Road Rules (ARRs) or the Queensland Road Rules (QRRs) (NTC, 2009). The Segway PT is not specifically addressed by the Australian Design Rules (ADRs) and the device is not compliant with any of the existing vehicle categories.

Recently, the Australian Capital Territory (ACT) introduced an exemption to allow some limited use of Segway PTs on pathways around Lake Burley Griffin and areas of the Commonwealth Parliament House precinct in Canberra. While Queensland legislation does allow limited exemptions to be provided from contraventions of the QRRs, legislative amendment would be necessary to issue exemptions from vehicle registration or driver licensing requirements. Importantly, exemptions from the QRR may only be issued if the exemption will not compromise public safety.

The current National Transport Commission (NTC) policy on Segway PT use states that the Segway PT is "considered unsafe for road use and may only be used on private property where there is no public access (see appendix A)."

An examination of the safety specifications of the Segway PT revealed that in optimal dry conditions the Segway PT has similar speed, manoeuvrability and braking capabilities to that of a bicycle. Although, in poorer (wet, slippery or loose gravel) conditions or when taking emergency evasive action the Segway PT underperforms the bicycle due to it's high centre of gravity and relatively poorer surface friction (Goodridge, 2003). The stabilisation function that keeps the Segway PT upright can actually throw the operator from the device during an extreme braking manoeuvre (Liu & Parthasarathy, 2003). Inexperienced controllers are likely to have difficulty controlling the device in an emergency situation. A study looking at the training required to operate a Segway PT concluded that safely handling the device in most standard situations requires little training. However, the ability to respond to unforseen incidents and control the Segway PT in emergency situations requires regular practise (Darmochwal & Topp, 2006).

Segway PT use on road-related areas such as footpaths is problematic as the braking, manoeuvrability constraints, and significantly greater speed and mass of the Segway PT, have the potential to cause significant damage and injury, particularly to pedestrians (Sobhani, Young, Logan & Bahrololoom, 2011).

Allowing Segway PT use on the road also raises serious safety concerns, where the Segway PT operator becomes the vulnerable user as they mix with other faster moving and heavier vehicles. Researchers generally accept that the potential for conflict increases when vehicles using the same road are travelling at different speeds (Meyer, Gomez-Ibanez & Tye, 1999).

Like other risky transport modes the injuries that can be sustained while operating a Segway PT can be severe (Vincent, Block & Black, 2009). However, unlike other highly vulnerable and risky transport modes such as cycling, the risk of injury associated with Segway PT is not mitigated by health and environmental benefits. In fact, Segway PT use is likely to replace greener transport modes such as walking and cycling.

The NTCs position on Segway PTs states that the devices "are not needed on the road network and so the current regulations which prevent them from being used do not need to be altered; and Segway PTs are undesirable on footpaths and other road related areas as they are potentially dangerous to pedestrians and so the current regulations which prevent them from being used in these areas do not need to be altered (see appendix A)."

In summary, the NTC recommendations and the safety issues highlighted provide little support for allowing Segway PTs on the Queensland road network, either on the road or on road-related areas such as footpaths. The current requirement for Segway PTs to be only operated on private property with no public access appears appropriate.

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1 Introduction

A Segway PT (Personal Transporter), also sometimes known as a Segway HT (Human Transporter), is a self balancing personal transporter that was first introduced into the retail market in 2001 (Segway Inc., 2011). Interest in and use of the Segway PT has gradually increased since, and it is estimated that approximately 80,000 devices have been purchased from the Segway PT's US manufacturer, Segway Inc. (Boniface, Mckay, Lucas, Shaffer & Sikka, 2011). The devices have been adopted by airport and shopping centre security, police officers, and tour groups in various locations throughout the world as well as by some commuters, although mainly in the USA (Goodridge, 2003).

1.1 Background

There is currently no provision for the Segway PT in the Australian Road Rules and the device is not specifically defined within the Australian Design Rules. As such, regulation of the Segway PT by way of registration or licensing is not possible and the device is currently prohibited from operating anywhere on the Australian road network. In September 2011, the Attorney General in the Australian Capital Territory (ACT) introduced a nine month trial exemption from this prohibition to allow some limited use of Segway PTs around Lake Burley Griffin and areas of the Commonwealth Parliament House precinct in Canberra.* Following this exemption and due to the increasing interest in the Segway PT more generally, several Australian jurisdictions have been approached by importers, distributors and/or tour group companies to seek advice on the status of operating the Segway PT elsewhere on the Australian road network. Currently in Queensland Segway PTs can only be operated on private property with no public access and are not permitted on roadways or road-related areas, such as footpaths.

1.2 Purpose

This report will examine the current legislation surrounding Segway PT use and what changes would be necessary for the devices to be permitted in some form on the Queensland road network. This report will also examine the safety implications of Segway PT use on road and road-related areas and will identify some of the safety issues associated with allowing Segway PT to use the road network.

* The ACT exemption has since been extended for a further 3 years.

1.3 What is a Segway PT?

A Segway PT is a battery powered, two wheeled personal transportation device. According to the manufacturer, a Segway PT is "an innovative device, which requires no special skills to ride and can go anywhere the operator desires" (Segway Inc., 2011). The basic structure of a Segway PT consists of a handle bar, adjustable controlling shaft and a standing platform. *Figure 1* below presents two Segway PT models currently available. The model on the left, known as the 'i2', is the basic model designed for use on relatively smooth terrain like paved or grassed surfaces. The retail price for this type of device is USD$6,295 – 6,799 (Segway Inc., 2011). The model on the right, known as the 'x2', is designed for use over more variable terrain. It has a bigger more stable base, has larger 'off-road' tyres and is able to travel longer distances without recharging. The retail price for this type of device is USD$6,895 – 7,420 (Segway Inc., 2011).

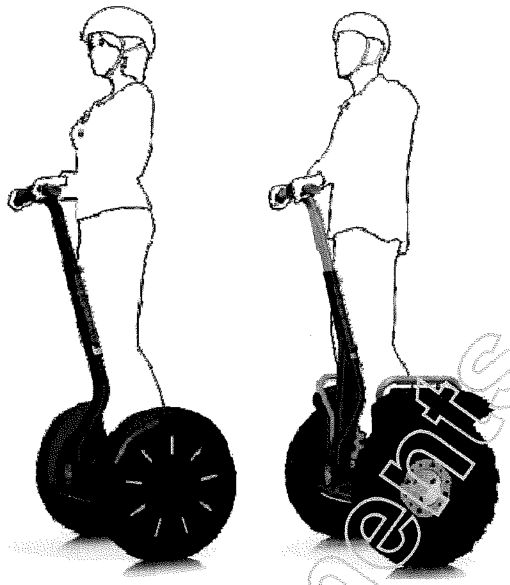


Figure 1: Two models of the Segway PT currently available

Source: (Segway Inc., 2011)

The entire Segway PT unit balances intuitively on two wheels. The technology behind this is known as dynamic stabilisation (Boniface et al., 2011). To provide this dynamic stabilisation, the Segway PT uses five specially designed gyroscopes and tilt sensors and 10 high speed micro processors to control two powerful electric motors (Goodridge, 2003). The Segway PT is powered by two electric motors each of which are capable of maintaining a power output of 1.88 kilowatts (2.5 horsepower) and enable the device to travel at a software limited top speed of 20km/h. The unit moves forward if the rider leans forward and moves backwards if leaned backwards. To gently stop the device the rider straightens up and for a more severe braking manoeuvre the rider leans sharply backward for a short period of time. To manoeuvre left or right the rider twists the handles in the direction the wish to travel and the controlling shaft tilts similar to a cornering bicycle (Liu & Parthasarathy, 2003).

2 Legislation relating to Segway PT use

2.1 Australian Road Rules

The Segway PT device is not specifically defined in Australian law and there are no rules about these devices in the Australian Road Rules (ARR).

Currently, the Segway PT cannot be registered or ridden on a road or road-related area under any circumstances. The current National Transport Commission (NTC) policy on the Segway PT use states that the Segway PT is "considered unsafe for road use and may only be used on private property where there is no public access."

The NTC has given the following advice (see Appendix A):

> The use of Segway PTs on public roads and road related areas is prohibited in all Australian jurisdictions, with recent exception being for some limited use in the ACT. This is consistent with the NTC's determination outlined below and the following recommendations were made:
>
> - Segway PTs are not needed on the road network and so the current regulations which prevent them from being used do not need to be altered; and
> - Segway PTs are undesirable on footpaths and other road related areas as they are potentially dangerous to pedestrians and so the current regulations which prevent them from being used in these areas do not need to be altered.
>
> These recommendations were discussed by the National Road Safety Strategy Panel, which agreed that there was no compelling reason for allowing the use of these devices on the road network that outweighed the potential safety risk of a comparatively low speed unprotected class of road user mixing with motor vehicle traffic, or of motorised vehicles being permitted to mix with pedestrian traffic. Further, the NTC does not plan to undertake any action to modify the Australian Road Rules or other national regulatory instruments to accommodate these devices.

Other points to note are:

- The Segway PT is not eligible for conditional registration as its primary use is transportation on roads and road-related areas.
- The Segway PT exceeds the two benchmarks currently used in determining the status of a vehicle that may be used on paths and the like: the output power and/or speed (200 watts/10 kph). This excludes a Segway PT from use on the footpath and defines it as a motor vehicle.
- Segway PTs low road speed makes it unsuited for on-road use in many situations as it may disrupt traffic flow and put the rider at heightened risk because of the speed differential.
- In addition, there is the further concern of introducing another class of vulnerable road users to the traffic mix.

These safety specifications are discussed further in section 3 of this report.

2.1.1 Queensland Road Rules

In 1999 Queensland adopted the ARR into state legislation. This means that the road rules in all jurisdictions of Australia are essentially uniform. As such there is also no provision for the Segway PT in the Queensland Road Rules (QRR).

Currently, the offences that are contravened by using a Segway PT device on roads or road-related areas in Queensland are as follows:

- Section 288 of the QRR – Driving on a path - $60 fine
- Section 289 of the QRR – Driving in a nature strip - $60 fine
- Section 10 of the *Transport Operations (Road Use Management – Vehicle Registration) Regulation 2010* – Vehicles used on road must be registered - $160 fine
- Section 20 of the *Motor Accident Insurance Act 1994* – Driving an uninsured class 15 vehicle - $200 fine
- Section 5(1)(c) of the *Transport Operations (Road Use Management – Vehicle Standards and Safety) Regulation 2010* – Vehicle must comply with vehicle standards - $100 fine and one demerit point
- A penalty would also apply if the rider did not hold a current driver licence - maximum $6000, 18 months imprisonment and 5 years disqualification.

In Queensland there are a number of other small vehicles and devices such as mopeds and skateboards that are allowed to be used on roads and road-related areas with various restrictions. There are also some vehicles and devices that are prohibited from road use. Lists of examples of these categories can be found on the Department of Transport and Main Roads' (TMR) website here:

http://www.tmr.qld.gov.au/Registration/Registering-vehicles/Wheelchairs-and-small-devices/Small-vehicles-and-devices.aspx

As discussed earlier the ACT has introduced an exemption to allow some limited use of Segway PTs on the road network. While Queensland legislation does allow limited exemptions to be provided from contraventions of the QRR, there is no ability to issue exemptions from vehicle registration or driver licensing requirements without legislative amendment. Exemptions from the QRR may only be issued if the exemption will not compromise public safety. As will be discussed in section 3 of this report, this provision would make the issue of a Segway PT exemption problematic. No other jurisdictions have indicated that they intend reconsidering prohibitions of Segway PTs on the road network at this time. If there is a move to change the position on the prohibition of Segway PTs a nationally agreed commitment is preferred.

2.2 Australian Design Rules

The Australian Design Rules (ADRs) are the national standards for the design and construction of motor vehicles. ADRs specify the safety, emission control and anti-theft performance and features that vehicles must have and demonstrate before being supplied to market. ADRs specify the requirements considered appropriate for various categories of vehicles. Vehicle categories are also defined within the ADR scheme (Department of Transport and Regional Services, 2011). The Segway PT is not yet specifically addressed by the vehicle categories identified within the ADRs; however, since the Segway PT is a two wheeled vehicle, it is appropriate to examine the definitions of the two wheeled vehicle categories in ADRs. *Table 1* below presents the vehicle category definitions for various two wheeled vehicles.

Table 1: Australian Design Rules vehicle category definitions for two-wheeled vehicles

Section Number	Vehicle Category	Definition
4.2.1	PEDAL CYCLE (AA)	A vehicle designed to be propelled through a mechanism solely by human power.
4.2.2	POWER-ASSISTED PEDAL CYCLE (AB)	A pedal cycle to which is attached one or more auxiliary propulsion motors having a combined maximum power output not exceeding 200 watts.
4.2.3	MOPED - 2 Wheels (LA)	A 2-wheeled motor vehicle, not being a power-assisted pedal cycle, with an engine cylinder capacity not exceeding 50 ml and a *Maximum Motor Cycle Speed* not exceeding 50 km/h; or a 2-wheeled motor vehicle with a power source other than a piston engine and a *Maximum Motor Cycle Speed* not exceeding 50 km/h.
4.2.5	MOTOR CYCLE (LC)	A 2-wheeled motor vehicle with an engine cylinder capacity exceeding 50 ml or a *Maximum Motor Cycle Speed* exceeding 50 km/h.

Source: (Department of Transport and Regional Services, 2011)

From the table above it can be seen that the Segway PT is not specifically defined in the ADRs system of vehicle categories. With two electric motors and a combined power output of 3.76 kilowatts (5 horsepower) the Segway PT cannot be classified as either a 'Pedal Cycle' or a 'Power-Assisted Pedal Cycle' (which must either rely on human power or a maximum power output of 200 watts). The device also cannot be classified as a 'Motorcycle' as it is not capable of exceeding 50km/h. If the Segway PT were to be placed into one of the vehicle categories above it would most appropriately come under the 'two-wheeled moped' classification as it is a two-wheeled motor vehicle that is not capable of exceeding 50km/h. However, a closer look at the specific moped ADRs reveal the Segway PT device is missing many features required of a moped to be operated on Australian roads (see *Table 2* below). A two-wheeled moped must have, among other features: rear vision mirrors, lighting and signalling devices, vehicle markings and motorcycle style braking systems (Department of Transport and Regional Services, 2011). The Segway PT has none of these features. Hence whilst not specifically defined within the ADRs vehicle categories the device is also non-compliant with the closest relevant ADR of two-wheeled moped.

Table 2: Segway PT compliance with 3rd edition ADRs – Two-wheeled mopeds

ADR	Description	Compliance		Details
		Y	N	
14	Rear Vision Mirrors		X	Not fitted. Cannot maintain required field of view due to variable forward / back lean
19	Installation of Lighting and Light-Signalling Devices on L-Group Vehicles		X	Not fitted. Cannot maintain correct orientation of lights due to variable forward / back lean. Cannot meet location requirement for some lights. Unlikely to be able to fit brake lights.
33	Brake systems for Motor Cycles and Mopeds		X	Segways do not have a conventional braking system and therefore cannot comply. As Segways are untested, it is unknown as to whether they would comply with the braking performance requirements of the rule
42	General Safety Requirements		X	Does not meet mudguard & audible warning device (horn) requirements. Could be fitted with a horn
43	Vehicle Configuration & Dimensions	X		Meets width limit
45	Lighting & Light-Signalling Devices not covered by ECE Regulations		X	As for ADR 19
46	Headlamps		X	As for ADR 19
47	Retroreflectors		X	As for ADR 19
50	Front Fog Lamps		X	As for ADR 19
51	Filament Lamps		X	As for ADR 19
52	Rear Fog Lamps		X	As for ADR 19
53	Front and Rear Position (Side) Lamps, Stop Lamps and End-outline Marker Lamps for L-Group Vehicle		X	As for ADR 19
54	Headlamps for Mopeds		X	As for ADR 19
57	Special Requirements for L-Group Vehicles		X	Does not meet control location requirements. Lack of seat
61	Vehicle Markings		X	Does not have required vehicle markings and has no provision for mounting a registration plate
83	External Noise	X		Meets requirement

Source: (Department of Transport and Regional Services, 2011)

2.3 What changes are necessary for the Segway PT to gain access to the Australian road network?

The essential steps involved in gaining general road access for any vehicle type, including the Segway PT, are as below:

a Establish the need for access to road network by the new vehicle type. Benefits must outweigh the costs. The need must be examined and established in a consistent way at the national level.

b Define the new vehicle category.

c Develop a portfolio of ADRs that should apply to the new vehicle category. This may involve developing or adopting new ADRs.

d Vehicle manufacturers to complete the certification and type approval protocols for each vehicle make/model of the new category that they wish to supply to market.

e State road transport agencies register the vehicles of the new category and afford access to their road network.

f State road transport agencies also enforce in-service vehicle standards to ensure that the registered vehicles continue to meet the ADRs that the vehicles were built to.

At this stage in Queensland, steps a, b, c and d of the above list have not happened. Hence logically, if the Segway PT was to be allowed on the Queensland road network steps e and f would have to wait until the prerequisite steps a, b, c, and d were completed.

2.4 Legislation in non-Australian jurisdictions

The manufacturers of the Segway PT have invested considerable effort in lobbying government in the USA to allow use of the Segway PT devices on the road network. In particular, they are seeking regulation to allow Segway PT use on footpaths and in other pedestrian spaces in order for their customers to operate it anywhere that a pedestrian may go. Although traffic law typically prohibits or severely restricts the operation of most types of vehicles (especially motorized vehicles) in pedestrian spaces, manufacturers have promoted legislation in every state in the USA to classify Segway PTs as Electric Personal Assistive Mobility Devices (EPAMDs). By classifying the Segway PT as an EPAMD the device and driver would be considered a pedestrian just like a wheelchair user. Presented below in *Figure 2* is a graphical representation of Segway PT legislation across all states in the USA. The values corresponding with each bar represent the number of states (out of a possible 51) that have adopted that legislative requirement. In total 41 states have passed some form of legislation that deals with Segway PT operation. Of those, 31 allow use in some form on the road network, either on the road or on road related areas like footpaths and bike paths. Lights and reflectors have been mandated in 20 and 22 states respectively whilst only 9 states have a requirement that the operator must wear a helmet (although most states in the USA are yet to adopt helmet legislation for bicycles as well). Finally, 10 states have adopted a minimum age requirement for use of the Segway PT and this ranges from 10-15 years of age (Rodier, Shaheen & Novick, 2004).

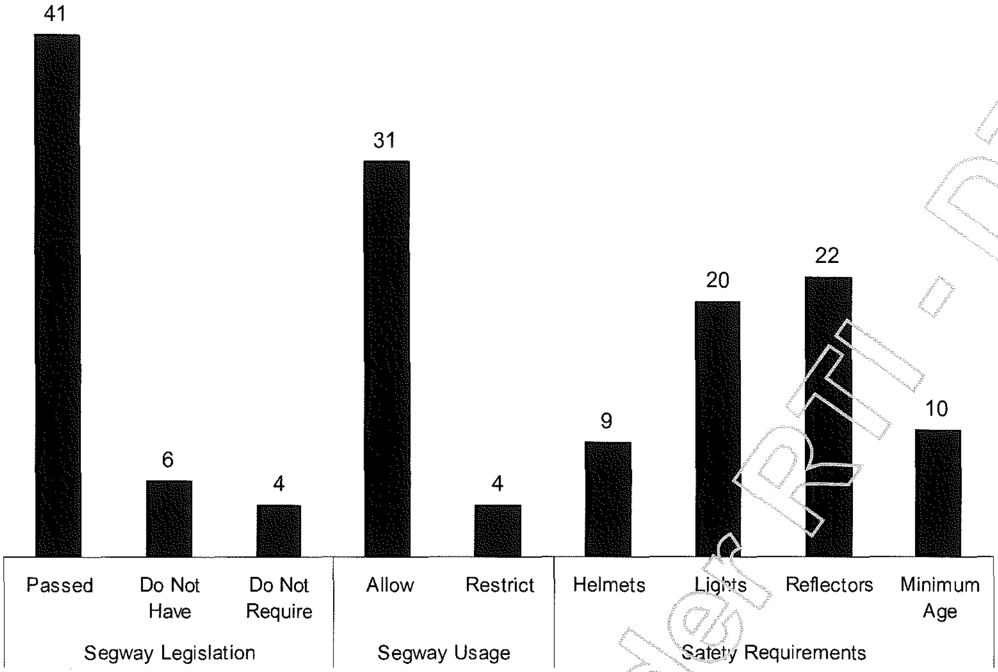


Figure 2: Summary of Segway PT legislation in across the 51 states in the USA (values represent the number of states that have implemented the particular legislative requirement)

Source: (Rodier, et al., 2004)

Pedestrian advocates in the USA have been quite vocal in their opposition to the classification of Segway PTs as EPAMDs as they believe that the speed and weight of Segway PT will create hazards and discomfort for pedestrians. This is reflected in the literature, which notes that Segway PT operators may travel at much higher than pedestrian speeds, with limited vehicular manoeuvrability, including long stopping distances and wide turn radii. Despite these concerns many states in the USA have designed their legislation to mandate Segway PT operation only on footpaths and prohibit roadway use, which is the opposite of the regulation generally applied to bicycles, especially in urban areas (Goodridge, 2003).

3 Safety Specifications of a Segway PT

To determine if it would be safe to operate a Segway PT in the road network, and where within that network it is safest for Segway PT use, it is important to understand the device's safety specifications. Of particular importance are the Segway PTs capabilities and limitations with regard to speed, manoeuvrability and braking. These are covered below in detail.

3.1 Speed

When examining the safety specifications of a Segway PT, it is first important to understand its capacity to travel at speed, as the speed the device is travelling at is then critical in determining its manoeuvrability and braking/stopping distance. Upon the first public unveiling of the Segway PT in December of 2001, the media reported the consumer version of the Segway PT as having a top cruising speed of 27-29km/h (Goodridge, 2003). This was confirmed in a series of 'road tests' where the maximum Segway PT speed was measured at 29km/h, which was approximated to be more than seven times walking speed (Landis et al., 2004). The current consumer models of the Segway PT have been equipped with a software-controlled maximum speed limit of 20km/h. Bicycles by comparison are capable of averaging 20-35 km/h, depending upon the level of exertion of the rider.

With dual electric motors, which have a combined power output of 3.66 kilowatts (5 horsepower), and weighing just 37.6kg to 43kg the Segway PT has a high power to weight ratio. The device is therefore able to travel at significant speeds and achieve maximum speed quickly with fast acceleration. In response to claims the Segway PT is too fast for pedestrian spaces, the manufacturer proposed that electronic speed governors could be set for lower speeds, as low as walking pace on footpaths, to protect pedestrians (Segway Inc., 2011). However, in practice this is unlikely to happen. Liu and Parthasarathy (2003) argue that speed is essential for the device to be a market success, since, for the average able-bodied person to consider the relatively high cost of the device worthwhile, the device must be as fast as its cheaper market competitor, the bicycle. It follows from this argument, that if the travel speeds of the Segway PT are made much slower than a bicycle, then it could not compete in the transportation marketplace. Furthermore, Segway PT owners may eventually find a way to bypass the electronic speed governor by modifying the hardware or replacing the software, in much the same way that owners of cars and computers make unsupported performance enhancements using aftermarket technology (Goodridge, 2003). Given that most automobiles are capable of travelling at nearly twice the maximum posted speed limit, it seems inevitable that Segway PTs will be operated at speeds of at least 25 km/h. And like other light powered vehicles such as electric bicycles, mopeds, and electric scooters, Segway PTs will be operated at their top cruising speed whenever conditions allow their users to do so (Goodridge, 2003). For these reasons, it is therefore appropriate to consider the safety implications for the Segway PT when it is operated at this maximum speed.

3.2 Manoeuvrability

The Segway PT's manoeuvrability is a key factor in determining the safety implications of allowing use of the device on the road network. Already established is the capability of a Segway PT to travel at speed and the fact that when conditions allow, the device is likely to be operated at its maximum speed. It is now important to understand how the device handles.

The Segway PTs parallel wheel configuration makes it compact enough, in theory, to be manoeuvred through most pedestrian spaces that accommodate wheelchairs (Goodridge, 2003). However, an important caveat to make is that this is dependent upon the operator's level of skill. When stationary, the Segway PT can turn in place by rotating its wheels in opposite directions (Boniface et al., 2011). This gives it greater manoeuvrability than most vehicles when standing still. However, at higher speeds, the Segway PT's turning ability is limited by its high centre of gravity and narrow wheelbase (Goodridge, 2003). Much like a top-heavy vehicle, when travelling fast enough the Segway PT has a tendency to flip when turning, sending the device and operator over sideways (Vincent et al., 2009). Bicycles are also top-heavy, but cyclists lean into turns as shown in *Figure 3(A)*. The maximum lean angle with respect to the outside wheel for a Segway PT is shown in Figure 2(B) and is dependent upon the device's centre of gravity. Given the upright position of the operator, he or she is unable to adjust his or her weight far enough to the side to turn sharply without risk of flipping the device. Another important factor in a Segway PTs ability to manoeuvre at speed is the adhesion of its tyres to the pavement or riding surface (Darmochwal & Topp, 2006). A preliminary analysis revealed that there was little difference between a basic model Segway PT (with standard tyres) and a bicycle with regard to tyre adhesiveness to pavement.

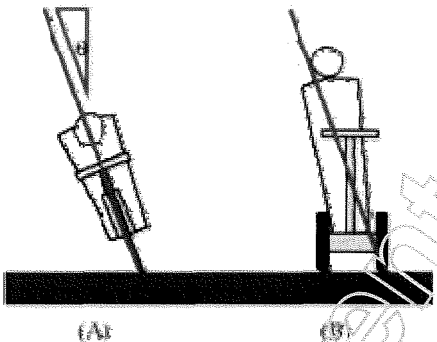


Figure 3: The lean angle required when cornering a bicycle (A) and Segway PT (B)

Source: (Goodridge, 2003)

With a forward software controlled cruising speed of 20 km/h and a centripetal acceleration of 0.3 Gs (assumed to be the maximum lean angle of a Segway PT operator using standard tyres), the turn radius of a Segway PT is approximately 10.5m. With a forward cruising speed of 29 km/h (maximum speed the device is capable of) and the same centripetal acceleration, the turn radius of a Segway PT is almost 15m. From this we can conclude that when travelling at or below walking speed, the Segway PTs manoeuvrability is similar to that of a wheelchair and as such could be appropriate for pedestrian spaces. Although as identified earlier the Segway PT is likely to be operated at its maximum operating speed whenever possible, in which case its manoeuvrability is similar to that of a bicycle and like a bicycle would not be appropriate for most pedestrian spaces (Goodridge, 2003).

Darmochwal and Topp (2006) had participants complete a range of manoeuvres while operating a Segway PT. One included a slalom event where Segway PT operators were required to manoeuvre their device around a series of pylons as quickly as possible. The researchers noted that the riders had to continuously concentrate on the cornering and keeping track, "riding slalom showed clearly the concentration requirement of inexperienced riders in complex situations" (p. 35). Practically all operators frequently sped up and stopped, cornering was jerky, and most of the riders had problems with steering changes and keeping track. Several times pylons were skipped and almost every rider touched or went over one of the pylons, on some occasions, several times.

Landis et al. (2004) observed that several times inexperienced riders mishandled the steering when under stress. For example, when taking evasive actions inexperienced operators were more likely to fall off or overcompensate and end up travelling uncontrollably backwards. Darmochwal and Topp (2006) conclude "it became clear that after a short period of practice riding, the handling of the Segway PT in standard situations was no problem at all, reactions to unforeseeable incidents however, required more practice and experience if the riders were not to react falsely" (p. 35).

Novice Segway PT operators often underestimate the power of the two 1.88 kilowatt driven motors that power the device. When operated on wet ground, starting on an uphill gradient or attempting to move over small steps, if the device is tilted too far forward the wheels are likely to slip as the internal processors attempt to keep the device upright. This can result in strong, jerky movements, which can throw the rider off the Segway PT. There is also a risk of injuries and crashes if the device continues to travel for some metres. For example, the Segway PT may lurch into the traffic flow, or the steering grip may bounce and rise up while moving, potentially hitting a pedestrian (Darmochwal & Topp, 2006).

Some other limitations of the Segway PT in terms of manoeuvrability are its inability to climb up steps greater than 10 cm high (Darmochwal & Topp, 2006), raising concerns about how a Segway PT would handle the curb separating the road from the footpath if evasive action was required.

3.3 Braking

The ability to stop quickly and safely in the event of an emergency is crucial for the safety of both the operator of the Segway PT and other road users around them.

Goodridge (2003) conducted an emergency stopping-distance experiment with an experienced, physically fit college-aged Segway PT owner/operator. The Segway PT operator was signalled to stop as fast as possible on level, dry asphalt from the Segway PT's top speed of approximately 20 km/h upon an acoustic and visual signal. The total stopping distance including reaction time was recorded. The average abrupt stopping-distance from 20 km/h was 5.7m. At the slowest speeds, the braking distance of a Segway PT was negligible.

To brake when riding a Segway PT, the operator straightens up from the forward leaning position they are in. However, when making a sudden braking manoeuvre, the operator must shift his or her weight sharply backward (Goodridge, 2003). Since the Segway PT is a self balancing two wheeled device with a high centre of gravity, any such sudden and large shifts in weight have the potential to throw the operator backward off the platform. *Figure 4 (A)* shows the lean angle present in a bicycle applying maximum rate of deceleration. *Figure 4 (B-D)* shows the lean angles of a Segway PT at increasing rates of deceleration. It is clear that to achieve a rate of deceleration similar to that of a bicycle, the operator must shift his or her weight substantially behind upright. Goodridge observed that the extreme backwards lean that is displayed in *Figure 4 (D)* is attainable by some expert operators who are able to shift their weight sharply backwards whilst also lowering their body and thus their centre of gravity towards the platform. However, such a skilful manoeuvre is not likely to be achievable by an inexperienced operator.

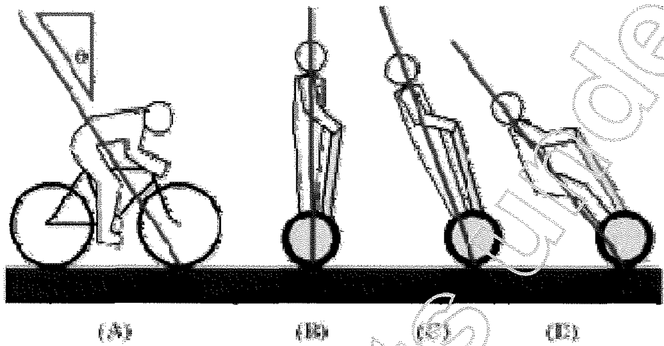


Figure 4: Lean angle required to stop a bicycle (A) and Segway PT (B-D)

Source: (Goodridge, 2003)

The maximum deceleration rate is also limited by the tyre friction on the travel surface. Different surfaces have different levels of friction based on their surface texture and the presence of loose material or liquid. Also, when a tyre is skidding there is less friction. Cars with anti-lock brakes detect when tyres begin to slide and reduce braking enough to return to maximum friction (Landis et al., 2004). Cyclists can usually correct for a skid, but face a challenge maintaining balance if the front tyre begins to slide (Darmochwal & Topp, 2006). On a Segway PT wheel traction is extremely important for the dynamic stability control. If the wheels slip during hard braking gravity will pull the operator toward the ground very quickly. For this reason, the Segway PT operator may need to be careful about not attempting to brake harder than the surface friction allows. On loose or wet braking surfaces, the maximum safe deceleration for a Segway PT may be as low as 0.3 Gs (shown above in *Figure 4(C)*) (Goodridge, 2003).

With a velocity of 20 km/h and an immediate deceleration rate in poor conditions of 0.3 Gs, the braking distance of a Segway PT is about 5.2m. By comparison the stopping distance of a bicycle travelling at the same speed with a deceleration rate of 0.6 Gs is 3.8m and the stopping distance of a car also travelling at 20 km/h with a deceleration rate of 0.8 Gs is 2.7m (see *Table 3*). However, this does not include reaction time, which depends on age and level of preparation. For the Segway PT stopping distance experiments described above (Goodridge, 2003), the prepared operator's reaction time was between 0.7 and 0.8 seconds. For the purpose of estimating typical stopping times, an alert operator reaction time of 0.75 seconds adds about 4.3m to the stopping distance of any vehicle when travelling at 20 km/h (Liu & Parthasarathy, 2003).

Stopping distance also incorporates hazard perception/recognition time, which is the amount of time that may elapse before a vehicle operator notices that braking is needed. Hazard perception time may easily be longer than one second when the user is looking at road signs, instrumentation, people, or adjacent traffic. This delay adds an additional 5.5m to the stopping distance at 20 km/h regardless of vehicle type (Goodridge). Therefore, in poor conditions from a software controlled top speed of 20 km/h, once hazard perception and reaction time have been taken into account, the typical stopping distance of a Segway PT is approximately 15m.

Table 3: Stopping distances of different modes of transport travelling at 20 km/h on poor braking surfaces

Vehicle Type	Deceleration Rate	Braking Distance	Reaction Dist. 0.75s	Hzd. Percp. Dist. 1s	Total Stop Distance
Segway PT	0.3 Gs	5.2m	4.3m	5.5m	15m
Bicycle	0.6 Gs	3.8m			13.6m
Car	0.8 Gs	2.7m			12.5m

This analysis illustrates that under optimal conditions the Segway PT has similar stopping characteristics to a car or bicycle. However, when operating in poor conditions, the Segway PT's rate of deceleration is limited by the high centre of gravity and low surface friction, and the braking distance is as much as 50% poorer than that of a car.

Darmochwal and Topp (2006) observed novice Segway PT riders attempting an emergency braking manoeuvre on dry flat asphalt (the best possible conditions), and found that in 14% of all cases, the minimum deceleration value (3.5 m/s^2) for the braking of motorcycles was not reached, and in 37% of all cases the minimum deceleration value (5.0 m/s^2) demanded for motor cars was not reached. The researchers went on to say "often, shortly after the riders began to brake and reached the maximum deceleration rate, a sudden loss of control over the device happened. At that point the dynamic balancing system of the Segway PT tried to compensate the backward shift of the braking leading to an oscillating of the Segway PT, which increased the stopping distance and in some cases caused the operator to fall" (p. 38). In comparison to slower but controlled braking, the stopping distance becomes clearly longer if the rider brakes too fast and has problems controlling the device. Darmochwal and Topp concluded that the advanced rider could stop the device safely in most cases, while beginners obviously had considerable problems with the control of the device.

4 Where does the Segway PT belong?

As this report has so far discussed, currently the Queensland Road Rules do not provide any provision for Segway PT use on the road network (NTC, 2009) and the device does not fit any of the current vehicle classifications identified in the Australian Design Rules. An examination of the safety specifications of the Segway PT revealed it has very similar speed, manoeuvrability and braking capabilities to that of a bicycle in optimal dry conditions. However, in poorer conditions (wet, slippery or lose surfaces) the manoeuvrability and braking capabilities are considerably inferior. When considering the safety implications of allowing Segway PT use, it is important to consider where the devices would be used. To this end, there are five options:

- Only allow Segway PTs on road-related areas, but not on the road;
- Only allow Segway PTs on the road, but not road-related surrounding areas;
- Allow Segway PTs anywhere on the road network;
- Ban Segway PTs from the road network; or
- Allow Segway PTs on entertainment precincts and private property.

4.1 Comparison to Bicycles

As Segway PTs are currently not permitted to travel anywhere within the road network, comparisons are often made with bicycles when considering where a Segway PT could potentially be used. As discussed above, in optimal conditions bicycles have similar capabilities with regard to speed, manoeuvrability and braking. Currently in Australia, bicycles do not require licensing or registration and may be operated on designated bike paths or roads except where signed otherwise. Under the Australian Road Rules (NTC, 2009) a bicycle rider over the age of 12 is not permitted to ride on a pedestrian footpath. However, under a 'law of jurisdiction' clause, Queensland does allow bicycle riders of any age to ride on footpaths, so long they keep left, always give way to pedestrians and do not ride in a manner that inconveniences or endangers other footpath users (*Transport Operations (Road Use Management – Road Rules) Regulation, 2009*). It has been suggested that, given bicycles are allowed to be ridden on road and road-related areas in Queensland, Segway PTs should also be permitted. The similar safety specifications and capabilities of Segway PTs and bicycles support this argument. However, bicycles are still a risky mode of transport. Cyclists are 13.25 times more likely to be involved in a fatal crash than the occupants of a car when measured by kilometre travelled (see *Table 4*). Critics may argue that is simply an artefact of the greater distance cars are able to travel. However, even per trip (2.67 times more likely) or per hour (4 times more likely), travelling by bicycle is still significantly more risky than travelling by car.

Table 4: Fatality rates per kilometre, trip and hour per 100 million population in the UK

	Per Km	Per Trip	Per Hour
Air	0.03	55	15
Bus	0.03	0.3	0.1
Rail	0.1	2.7	4.8
Van	0.2	2.7	0.6
Car	0.4	4.5	15
Water	0.6	25	12
Bicycle	4.3	12	60
Foot	5.3	5.1	20
Motorcycle	9.7	100	300

Source: (RSPC, 1997)

Clearly, riding a bicycle does present a greater risk of fatality than travelling by car. However, it has been argued that there are health, fitness and environmental benefits of riding a bicycle that offset the added risk of fatality compared to travel by car (Rojas-Rueda et al., 2011). Rojas-Rueda et al. estimated the health and environmental benefits of bicycle use compared to travel by car in Barcelona, Spain. Researchers compared participants in a bicycle hire scheme ($n = 181{,}982$) who always commuted via bicycle to those whose primary mode of travel was a car. Amongst cyclists, Rojas-Rueda et al. estimated that there would be slight increases in the mortality rate (per billion kilometre travelled) due to on road incidents and exposure to air pollution, however, these were far outweighed by the reduction in mortality rate due to increased physical activity. It was estimated that 12.46 fatalities would be saved each year due to the increase in physical activity and resulting health and fitness benefits. In addition, annual carbon dioxide emissions were estimated to be reduced by over 9 million kilograms (almost a 1% decrease in emissions from all motor-vehicle activity). Another study estimated the change in life expectancy resulting in replacing short car trips with bicycle rides (Johan, Boogaard, Nijland & Hoek, 2010). Authors reported an average decrease in life expectancy of 5-9 days due to the increased risk of traffic incident and up to a 40 day decrease in life expectancy due to the increased exposure to air pollutants. However, once again these decreases were far outweighed by the estimated 14 month increase in life expectancy from the health and fitness benefits of regular physical activity.

The same argument, for benefits to health and the environment, cannot be made for Segway PTs. Despite the best efforts of the manufacturer to market the device as a replacement for cars, in reality the device is likely to replace walking and/or cycling. This is due to the limited storage capacity of the devices and the issues surrounding secure storage of the devices. As such, Segway PTs would have a negative health and fitness implications for its operators. Segway PTs must also be charged regularly to power the device. In Australia, this electricity is likely to come from coal burning power stations, adding to annual carbon dioxide emissions.

These issues reduce support for the argument that Segway PTs should be allowed to operate on the road network because they are like bicycles, .

4.2 Segway PTs on road-related areas

The Australian Road Rules (NTC, 2009) define a road-related area as including any of the following:

- an area that divides a road;
- a footpath or nature strip adjacent to a road;
- an area that is not a road and that is open to the public and designated for use by cyclists or animals; or
- an area that is not a road and that is open to or used by the public for driving, riding or parking vehicles.

Of particular interest to safety is the use of Segway PTs on pedestrian footpaths – this will be the focus of this section. In pedestrian areas, the Segway PT should not operate faster than at a walking speed (Darmochwal & Topp, 2006). However, a Segway PT can travel up to seven times faster than the average walker, empowering the operator with considerable speed. This report has noted that Segway PTs can travel at speeds similar to a bicycle, and where the terrain permits they are likely to be operated at maximum speed and at this speed their manoeuvrability and braking capabilities are similar to that of a bicycle. On the footpath the Segway PT is the more powerful unit and has the capability of causing injury to pedestrians (and even other users like cyclists) in the event of a crash, so its ability to avoid conflicts, and the potential for and severity of injury and damage should such conflicts arise, should be considered.

4.2.1 Potential for conflict or crashes

As identified earlier, operating a Segway PT on a footpath has the potential to cause conflict between the Segway PT and pedestrians or cyclists. This presents a significant problem, as the Segway PT has a higher mass than a bicycle, and operates considerably faster than the average pedestrian, and therefore has greater kinetic energy than either of these transportation modes. This means that injuries and damage due to crashes involving Segway PTs are likely to be more serious than those involving bicycles and pedestrians. Another consideration to be made is the platform of the Segway PT, which is positioned at about the height of an adult shinbone and has sharp metal edges, and so has the potential to cause considerable injury to pedestrians (Darmochwal & Topp, 2006).

An average Segway PT weighs between 37.6kg and 43kg and is rated for a maximum load of 150kg (up to 35kg of cargo and an operator weighing up to 115kg) (Boniface et al., 2011). This could amount to a total weight of almost 200kg travelling at a speed of at least 20km/h (or potentially as fast as 29km/h if the software controlled top speed is circumvented). *Figure 5* shows the relationship between speed and mass and the resulting kinetic energy. As can be seen, the heavier the Segway PT and operator and the faster the travelling speed, the greater the kinetic energy. Kinetic energy can be conceptualised as 'potential energy' – if it is not dissipated properly with the correct braking systems the consequences of an impact can be deadly (Sobhani, Young, Logan & Bahrololoom, 2011).

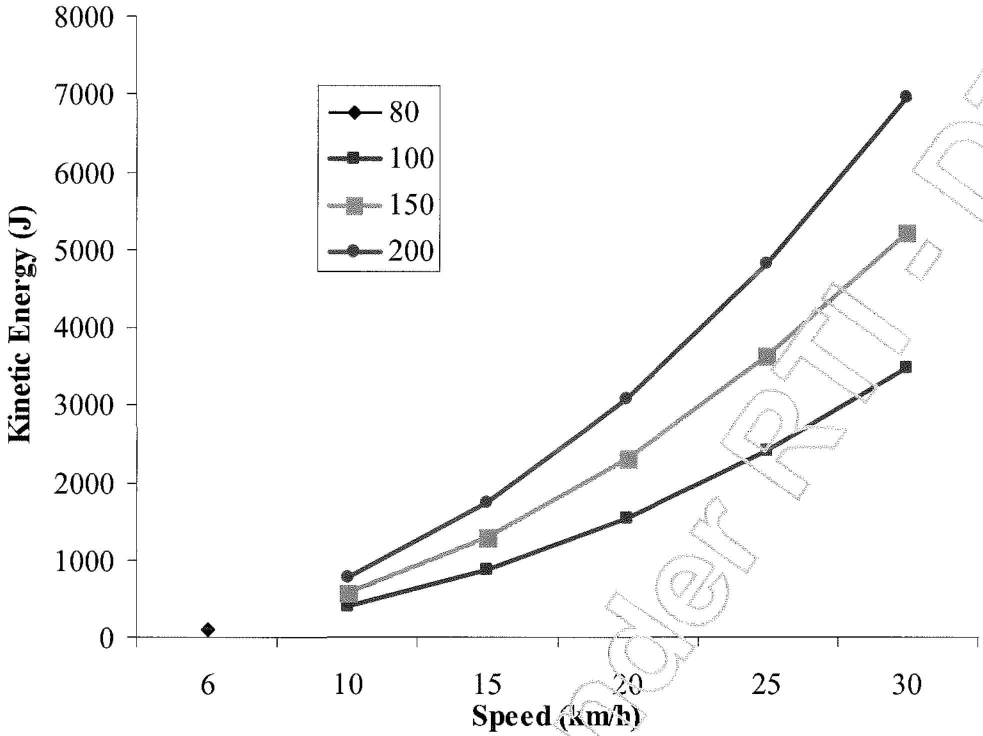


Figure 5: Kinetic energy of a Segway PT at varying speeds (10, 15, 20, 25 & 30 km/h) and different total weights (100, 150 & 200 kg) compared to an average pedestrian (black dot)

Given the manufacturers claims that the Segway PT is designed for use in pedestrian spaces and has similar characteristics to a pedestrian, we can compare the potential for conflict between Segway PTs and pedestrians. A pedestrian weighing 80kg walking at an average speed of 6 km/h (represented by the black dot in *Figure 5*) would have a kinetic energy potential of 111.1 J. This is compared to a Segway PT carrying maximum load, weighing 200kg and travelling at its potential top speed of 29 km/h (represented by the red line in *Figure 5*), which would have 62 times as much kinetic energy (6944.4 J). Whilst it is possible to have a similarly sized pedestrian travelling at a similar speed, a 150kg person sprinting at 20 km/h would be a very rare occurrence on a footpath. Such a person would still have three times less kinetic energy (2314.8 J) than the Segway PT carrying maximum load and travelling at maximum speed. This pedestrian, however rare, would also be much better able to dodge and weave around other pedestrians than a person on a Segway PT (Goodridge, 2003).

Footpaths that are likely to be shared by different age groups with various activity and reaction levels are at greater risk. It has been shown that the Segway PT, which can travel up to seven times faster than a walking pedestrian, increases the conflicts between pedestrians and Segway PT users. Liu and Parthasarathy (2003) conducted a hindrance/conflict analysis to estimate the frequency of such conflicts arising between Segway PTs and pedestrians on a footpath. Their model assumes that pedestrian and Segway PT users would be the only modes travelling along the footpath. They calculated the frequency of hindrance between pedestrians and Segway PT users travelling in the same and opposite direction and estimated the potential for conflict to arise as a result. They found the frequency of conflict is directly related to the travel speed and flow rate of the modes involved. As such the frequency of conflicts may become very high when the pedestrian flow increases (e.g., busy urban footpaths). Liu and Parthasarathy conclude that Segway PT use along busy footpaths would create enormous hindrance/conflicts, which would impede both pedestrian and Segway PT use, and even has the potential to spill over into motor-lanes. How a Segway PT could negotiate pot-holes and uneven surfaces are also causes of concern, particularly due to its inability to handle steps of more than 10cm.

4.3 Segway PTs on the road

According to the manufacturer, the Segway PT was designed and constructed for use in pedestrian areas; the device was never intended to interact with motor cars on traffic roads (Landis et al., 2004). So far this paper has highlighted some of the problems associated with permitting Segway PT use on footpaths and the very likely potential for conflict with vulnerable pedestrians. It is now worthwhile considering the implications of allowing Segway PTs to be operated on the road itself. The ARR define a road as "an area that is open to or used by the public and is developed for, or has as one of its main uses, the driving or riding of motor vehicles" (NTC, 2009).

There are several issues that would need be resolved if the Segway PT was to be permitted to travel on roads in Queensland. Currently the Segway PT is not identified within the Australian or Queensland Road Rules nor is it specifically defined within the Australian Design Rules meaning legislative change would be required for the device to be regulated under registration or licensing schemes. There is also the potential for a large speed differential to exist should Segway PTs and cars interact together on the road. On the road the Segway PT operator becomes the vulnerable user and consideration needs to be given to protective equipment that may need to be worn by operators. These issues are considered in detail below.

4.3.1 Speed Differential

Speed differential is the difference between the speeds of vehicles that are travelling in the same direction along a roadway (Solomon, 1964). For example, if traffic generally moves at 60 km/h and a Segway PT is only capable of travelling at 20 km/h, the speed differential is 40 km/h. A speed differential above 30 km/h begins to present significant safety concerns (Solomon). When the speed differential approaches 45 to 55 km/h, the likelihood of a collision between fast-moving vehicles and a slow moving Segway PT increases very quickly. Rear-end collisions are very common on roads and streets carrying vehicles with large speed differentials (Research Triangle Institute, 1970). Given a Segway PT operator is considerably more exposed and vulnerable than a driver of a car, injuries sustained from being hit at speed from behind are likely to be severe or even fatal. In general when the speed differential is high, it is also likely that crashes will be more severe, cause greater property damage, and result in more injuries and fatalities. As such keeping the speed differential as low as possible is very important for safety reasons, as indicated by *Table 5* below.

Table 5: Speed differential and the risk of crashes

Speed Differential	Likelihood of Crashes
10mph (16km/h)	Minimal
20mph (32km/h)	3 times greater than at 10 mph
30mph (48km/h)	23 times greater than at 10 mph
35mph (56km/h)	90 times greater than at 10mph

Source: (Research Triangle Institute, 1970)

Solomon (1964) conducted a comprehensive study of more than 10,000 crash-involved drivers and their vehicles and examined how other roadway, driver, and vehicle characteristics affect the probability of being involved in a crash. He found that the probability of being involved in a crash per vehicle-mile as a function of on-road vehicle speeds followed a U-shaped curve, known as the Solomon curve (see *Figure 6* below). Speeds considerably below or above the median had the highest probability of being involved in a crash. Cirillo (1968) conducted a similar study of 2,000 vehicles on urban highways that addressed impact of speed differential on crashes that involved two or more vehicles and found a similar U-shaped curved relationship between speed differential and crash risk. Hauer (1971, as cited in Meyer, Gomez-Ibanez & Tye, 1999) provided a theoretical foundation for the Solomon curve stating “if I drive at 45 mph, while the median of the pack is 60 mph, how many cars will pass me in an hour and hence have a chance to collide with me?” (p. 276). Modelling of this theoretical distribution was nearly identical to the Solomon curve (Meyer et al.).

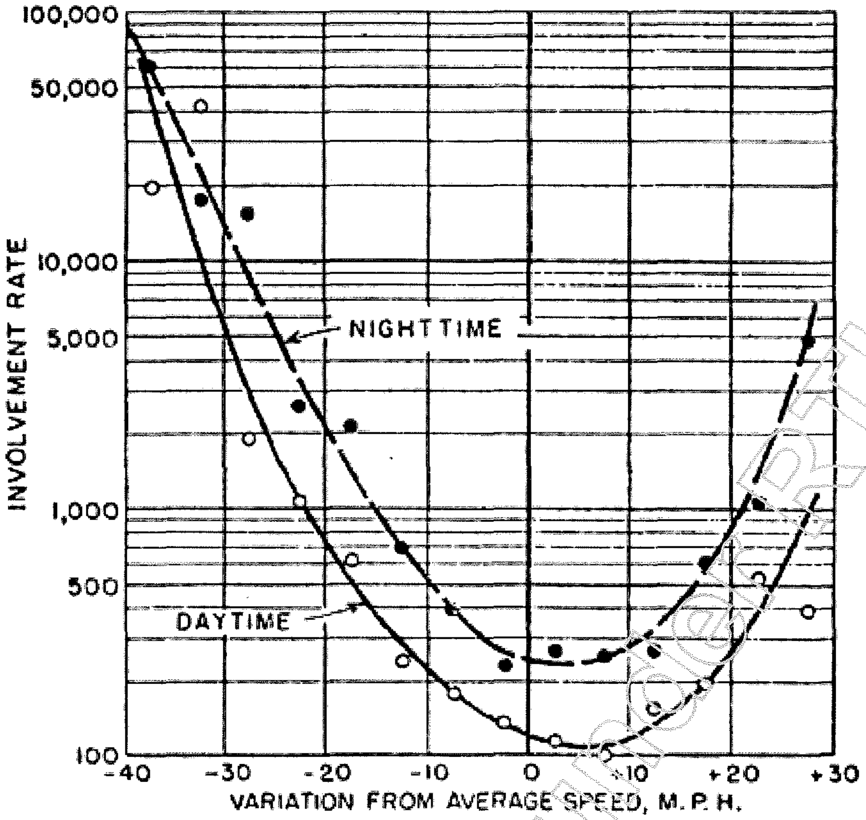
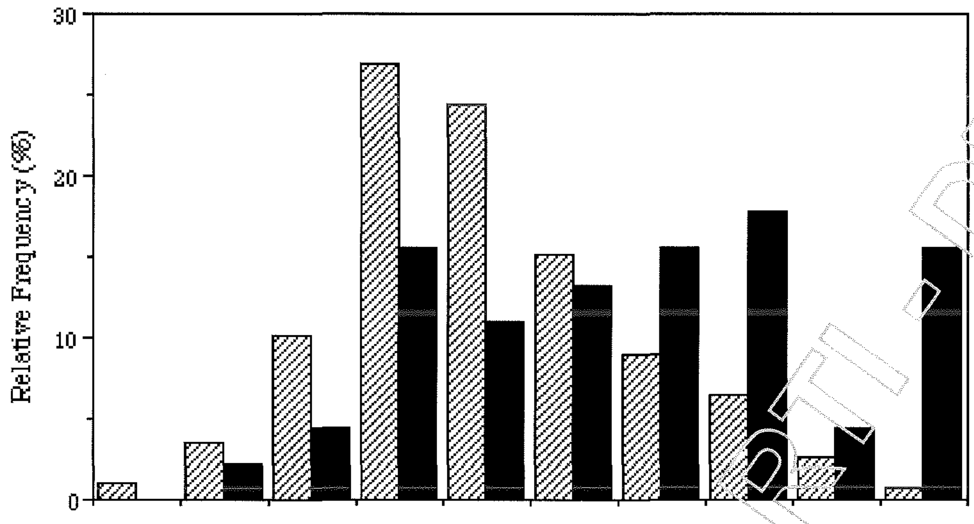


Figure 6: Variation from average speed vs. the accident involvement rate (per 100 million vehicle miles)

Source: (Solomon, 1964)

Two potential problems with the Solomon (1964) and Cirillo (1968) studies have been identified: the police reports, driver's reports, and third party estimates used were subject to error and unknown reliability; and many of the crashes involving slow speed likely involved vehicles that were stopping or slowing to turn or just entering the road. The Research Triangle Institute (1970) conducted a study where data was collected on 114 crashes involving 216 vehicles on a state highway in Indiana. To address the problems raised with the earlier studies, the researchers combined automated speed monitoring devices with trained on-scene crash investigators, and distinguished vehicles slowing to negotiate a turn from vehicles moving slowly in the flow of traffic. Reporting on these results West and Dunn (1971) confirmed the findings of Solomon and Cirillo but found that crashes involving turning vehicles accounted for 44% of all crashes observed in the study, and that excluding these crashes from the analysis greatly attenuated the factors that created the U shape of the Solomon curve.

In a more recent study examining the relationship between speed differential and crash involvement, Moore, Dolinis and Woodward (1995) analysed the speeds of 45 vehicles involved in severe crashes in the Adelaide metropolitan area and compared these with speeds of other vehicles passing through the crash locations at the same time of day, day of week, and season. Travelling speeds of vehicles involved in crashes were determined using crash reconstruction techniques. Overall, crash-involved vehicles were relatively more frequent than controls in the highest speed categories, as shown in *Figure 7* below.



	<35	35-44	45-54	55-64	65-74	75-84	85-94	95-104	105-114	≥ 115
Controls	5	16	46	121	110	68	40	29	12	3
Cases	0	1	2	7	5	6	7	8	2	7

Speed Category (km/h)

Figure 7: Observed frequency of speeds for accident involved vehicles (black bars) compared to expected frequencies of control vehicles (striped bars) in 60km/h zones.

Source: (Moore, Dolinis and Woodward, 1995)

As can be seen in the above figure, the observed frequency of speeds for crash involved vehicles in 60km/h zones was below the expected frequency at all speed differentials below the posted speed limit (i.e. vehicles travelling less than 60km/h) and this trend was reversed for vehicles travelling greater than 25km/h above the speed limit. These results cast doubt over the findings of the previous studies conducted decades earlier by Solomon (1964), Cirillo (1968) and The Research Triangle Institute (1970). It appears the effect of speed differential on crash involvement for vehicles travelling below the posted speed limit is not nearly as severe as predicted by these earlier studies, and less of an issue than the speed differential of vehicles travelling significantly above the posted speed limit. Although Moore et al.'s (1995) results must be viewed cautiously as the sample size was small, the comparison speeds were collected up to 3 years after the crash occurred, and the degree of confounding by blood alcohol concentration was unknown. To the authors knowledge there have not been any further studies into the relationship between speed differential and crash involvement and clearly further research is needed to clarify the relationship. What is clear is that deviations from mean speeds on roads can cause conflicts between vehicles to arise, whilst the specifics of this relationship are still unclear, wherever possible attempts should be made to reduce any speed differential. Hence introducing the Segway PT, with software controlled speed of 20km/h or even a potential maximum speed of 29km/h (if the software were to be bypassed), to the road network is likely to increase the potential for conflict and crashes on the roads.

5 Injuries sustained while operating a Segway PT

As with most modes of transportation, inappropriate use of, or having a crash while using a Segway PT, has the potential to cause serious injury and perhaps even death (Vincent, Block & Black, 2009). When considering the potential safety implications of allowing Segway PTs on the road network, it is important to understand the incidence and severity of injuries resulting from riding a Segway PT. Although, due to the relatively small number of Segway PTs in existence, there are not many published studies examining injuries sustained when riding one. The limited literature on Segway PT-related injuries is presented below.

Boniface et al. (2011) examined admissions due to Segway PT related injury at a hospital in Washington, DC over a three year period from April 2005 to November 2008. Researchers identified 41 cases that presented to the hospital with injuries due to Segway PT use, each of whom had fallen off the device; there were no cases involving a motor vehicle crash. Several cases involved the rider striking an immobile object, including a park bench, a signpost, a light pole, and a tree. Only seven patients (17.1%) had documented helmet use while using the Segway PT. Ten of the 41 patients (24.4%) were admitted. Four patients (40% of admitted patients) had traumatic brain injuries. The Injury Severity Score (ISS) for the admitted patients ranged from 4 to 27 (ISS scores can range from 1 to 75). There were 3 "severe" injury cases (ISS > 16), 4 "moderate" injury cases (ISS 9 to 15), and 3 "minor" injury cases admitted (ISS < 9). Two underwent surgery during their hospital stay. In addition, one patient presented with rib fractures and a significant hemothorax. The maximum intensive care unit stay was two days, and the median hospital length of stay was 2.5 days, with a range from 2 to 7 days. There were 10 other patients with fractures; several of these patients had sustained injuries that were likely to need orthopaedic surgery in the week after their hospital visit.

5.1 Summary

Like other risky transport modes the injuries that can be sustained when operating a Segway PT can be severe and have long lasting ramifications. As this report discussed earlier, the risk of injury associated with Segway PT is not mitigated by health and environmental benefits to the same extent as other highly vulnerable and risky transport modes such as cycling. This is because Segway PT use is likely to replace greener transport modes and as such have negative health and environmental impacts. Caution needs to be taken when considering allowing use of these devices on public road and road-related areas. As Segway PTs become increasingly popular worldwide it likely that there will be more published literature around the types, severity and incidence of injuries sustained either while operating the device or arising from a conflict with one. When more information becomes available a clearer picture will be able to be formed about the implications of allowing Segway PT use within the road network.

6 Conclusion

The Segway PT device is currently not defined in Australian or Queensland law and there are no rules about these devices in either the Australian Road Rules or the Queensland Road Rules. The Segway PT is also yet to be specifically defined by a vehicle category within the Australian Design Rules. As such, with the exception of a limited exemption in the ACT for use around Lake Burley Griffin and areas of the Commonwealth Parliament House precinct in Canberra, the Segway PT cannot currently be registered or ridden on a road or road-related area in Australia. To allow Segway PT use on the Queensland road network in some form a legislative amendment would be required. Specific exemptions to the Queensland Road Rules may only be issued if the exemption will not compromise public safety. Sections 3 and 4 of this report have identified several important issues regarding public safety both to the operator of the Segway PT and other road users that would make this provision problematic.

An examination of the safety specifications of the Segway PT revealed that in optimal dry conditions the Segway PT has similar speed, manoeuvrability and braking capabilities to that of a bicycle. Although, in poorer (wet, slippery or loose gravel) conditions or when taking emergency evasive action the Segway PT underperforms the bicycle due to it's high centre of gravity and relatively poorer surface friction. The stabilisation function that keeps the Segway PT upright can actually throw the operator off the device in the event of an extreme braking manoeuvre. These safety issues raise concerns for allowing Segway PT use on the Queensland road network.

Further analysis revealed it is undesirable to allow the Segway PT to be operated on footpaths as their braking and manoeuvrability constraints and significantly greater speed and mass, compared to pedestrians, results in much a much higher kinetic energy. If not dissipated appropriately, this energy has the potential to cause significant damage and injury, particularly to the vulnerable pedestrian. Allowing Segway PT use on the road also raises serious safety concerns. On the road the Segway PT operator becomes the vulnerable user as they mix with other faster moving and heavier vehicles. The potential for conflict and crashes increases when vehicles using the same road are travelling at different speeds. The literature into the relationship between crash involvement and speed differential is still unclear but it is generally accepted that the greater the differential the greater the potential for conflict. In the case of Segway PTs, the slower moving devices are likely to be passed very regularly by other faster moving vehicles increasing the chances of a crash.

Given the similarities between bicycles and the Segway PT a comparison was made between the devices for the safety implications of their use within the road network. Bicycles are a risky mode of transport, however, these risks are mitigated by the health and environmental benefits associated with cycling. Segway PTs, however, are most likely to replace green forms of transport and as such have detrimental health and environmental effects. These issues raise doubt that the liking of Segway PTs with bicycles is entirely valid.

The National Transport Commission (NTC) have provided the following recommendations in relation to allowing the use of Segway PTs on the Australian road network:

- Segway PTs are not needed on the road network and so the current regulations which prevent them from being used do not need to be altered; and

- Segway PTs are undesirable on footpaths and other road related areas as they are potentially dangerous to pedestrians and so the current regulations which prevent them from being used in these areas do not need to be altered.

Based on the views of the NTC, and evidence that allowing Segway PT operators onto the Queensland road network may place both Segway PT operators and other road users (eg. pedestrians and cyclists) at risk, it is recommended that Segway PTs continue to operate only on private property.

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Appendix A – NTC Position on PMDs

National Transport Commission
Level 15 / 628 Bourke Street
Melbourne VIC 3000
P 61 3 9236 5000
F 61 3 9642 8922

13 January 2006

Mr Robin Dunlop
Level 10, Petherick Tower
38-42 Waring Taylor Street
WELLINGTON NZ

Dear Robin,

Personal Mobility Devices

Several jurisdictional road authorities have been approached by importers, distributors or users of Personal Mobility Devices (PMDs), such as the Segway, to seek advice as to the status of these PMDs within jurisdictional and national legislation. These road authorities have subsequently raised the issue with the Australian Road Rules Maintenance Group (ARRMG) to determine what changes are necessary to allow the use of such devices.

Under current legislation, PMDs with motors that have a power output exceeding 200 watts, are motor vehicles, and are therefore required to meet the standards for registration, and be operated only by licensed drivers.

The ARRMG noted that the use of such devices would require consideration of changes not only to road rules, but also to vehicle standards, registration requirements and, possibly also to licensing policy and third party insurance coverage. Consideration of the impact on all of these areas and the development of workable policy positions to accommodate a new class of vehicle was beyond the scope of the ARRMG, and in the absence of a policy position by any jurisdiction to allow PMDs to be used, the amount of work required could not be justified.

The ARRMG made the following recommendations:

- Segways are not needed on the road network and so the current regulations which prevent them from being used do not need to be altered; and
- Segways are undesirable on footpaths and other road related areas as they are potentially dangerous to pedestrians and so the current regulations which prevent them from being used in these areas do not need to be altered.

These recommendations were discussed by the National Road Safety Strategy Panel, which agreed that there was no compelling reason for allowing the use of these devices on the road network that outweighed the potential safety risk of comparatively low speed unprotected class of road user mixing with motor vehicle traffic, or of motorised vehicles being permitted to mix with pedestrian traffic.

As a consequence, NTC does not plan to undertake any action to modify the ARR or other national regulatory instruments to accommodate these devices.

Yours sincerely

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Chief Executive

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