

The Challenges of Planning for Autonomous Mobility in Australia

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Abstract: Transport planning in the twenty-first century is facing diversifying challenges. While there is some evidence that the car is lessening its hold on urban lives, desires for mobility unencumbered by the timetables or routes of others remain strong. Accordingly, there has also been unprecedented growth in non-car modes of travel that are able to mimic the independence offered by the private car. These include conventional modes, such as walking and cycling, but also new technologies, such as carsharing and motorised scooters. In this paper we explore whether and how urban transport planning in Australia is recognising and governing 'autonomous mobility'. We begin by developing a conceptual model of autonomous mobility that identifies its core characteristics and present a typology of autonomous mobility that illustrates ways in which various transport modes (including cars, public transport, cycles, walking and newer alternatives) meet these characteristics. The paper then turns to an analysis of transport policy and asks: how is autonomous mobility being imagined and planned for in Australia? Focusing on the example of NSW, we suggest that though this planning continues to privilege the motor vehicle, some shifts toward recognising and encouraging newer modes as viable transport solutions can be identified in specific local government areas. The paper concludes with signposts for ways in which autonomous mobility can be better incorporated into mainstream transport policy.

Introduction

Transport scholarship's longstanding interest in understanding travel behaviour has recently shone a more intense light on the factors influencing car use (see Lucas et.al. 2011). Though diverse frameworks are applied, the concept of automobility is central. Put simply, automobility is a concept that describes and explains not just a mode of travel but a society characterised by reliance on the private car and the diverse processes (cultural, political, economic) through which car dependent mobility is produced and reproduced. In the words of John Urry (2004: 27), automobility is a 'self-organising autopoietic, non-linear system that spreads worldwide, and includes cars, car-drivers, roads, petroleum supplies and many novel objects, technologies and signs'. Patterns of sociability, propensities for ever-increasing personal travel, city infrastructures and economic organisations have been and are propelled by the system that pivots around the private motor vehicle. Transport planners have likewise paid considerable attention to the ways in which preferences for automobility are both implicitly and explicitly maintained through urban planning. Metropolitan strategies and infrastructure policies across Australia, for example, have privileged road building over other forms of transport for most of the past fifty years (Curtis and Low 2012). Aldred's (2012) analysis of cycling policy likewise shows the absence of cycling from mainstream transport discourse.

There are signs, nonetheless, that automobility may be loosening its hold on urban lives, both in Australia and elsewhere (Millard-Ball and Schipper 2011; Newman and Kenworthy 2011). In Sydney, for example, the share of trips to work by car declined between 2006 and 2011, with a corresponding increase in the share of public transport and cycling trips (Mees and Groenhart 2012). It is possible that Sydney has reached 'peak car' - saturation with respect to car use. Second, there is increasing regulatory and everyday enthusiasm for alternative forms of personal mobility. Instances here include the inclusion of carsharing and electric vehicles in a number of local government policy frameworks (e.g. Council of the City of Sydney 2011) and the 2012 loosening of regulations on electric bikes in NSW to bring the state in closer alignment with international standards. Building upon these trends, as well as conceptual advances in understanding automobility, our purpose in this paper is to offer a different understanding of automobility - 'autonomous mobility' - that explicitly opens spaces for alternative ways of travelling around the city. We develop this conception in the first section of the paper. The second section provides two illustrations of how transport planning has, and could, respond to, and encourage, these forms of mobility. In essence, we look beyond the association of the private car with automobility to explore other ways autonomous mobility can be supported by transport planning.

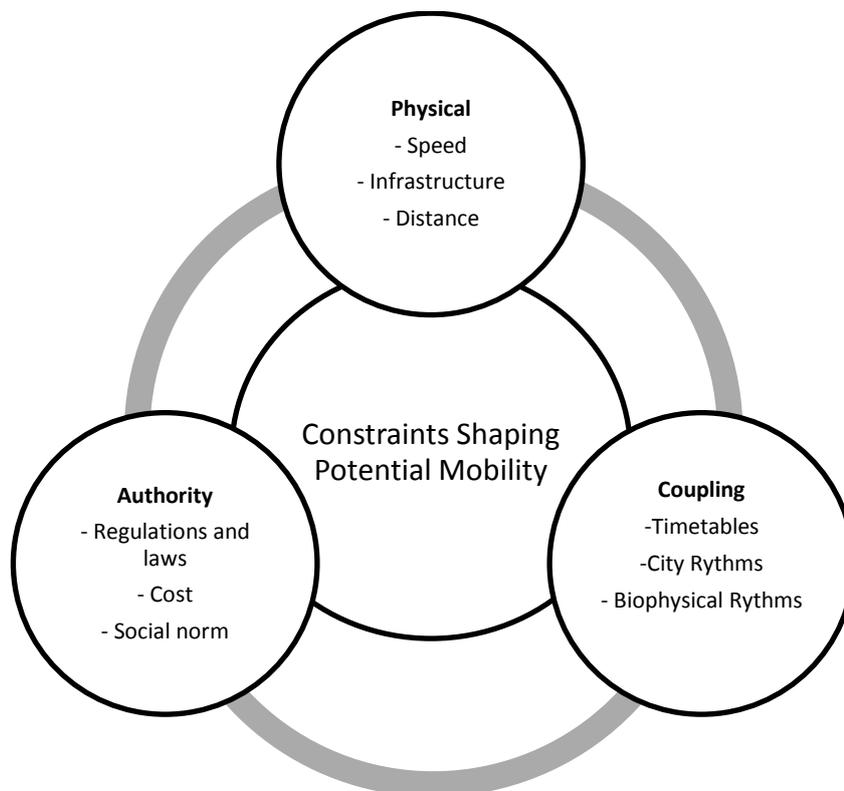
1. Moving From Automobility to Autonomous Mobility

Private cars, and private car travel, are intricately linked with individual fulfilment, being the transport mode perceived to be most able to facilitate the independence and flexibility required of successful individuals (Cohen 2012; Goodwin 2010). Contemporary engagements with automobility question the strength of this association and instead develop richer, less-dichotomised, understanding of personal mobility. Most pertinent to our paper is Furness' (2010) reminder that auto also means independent and individual. Indeed, according to Furness' historical analysis, cycling 'was the first mode of transportation to clearly articulate the idea of autonomy and personal mobility to technological practice' (2010: 16). Moreover, the term automobility is an etymological combination of 'autonomy' and 'mobility' (Featherstone 2004). Automobility, therefore, can be redefined as being autonomously mobile - able to move independently and to come and go where and when one wants. Cars have been easily associated with automobility because they have enabled a series of personal freedoms such as detachment from the schedules of public transport and the (relative) mastery of distance and time. Yet a conceptualisation of autonomous mobility as freedom from constraint reveals that the private car cannot necessarily claim exclusivity over the term automobility, and that other forms of mobility display characteristics of freedom and autonomy.

The automatic coupling of autonomous mobility with private car use has been questioned by various theoretical traditions. Psycho-social research on attachments to the private car often draws upon the way it enables feelings of social acceptance, appealing to cultural norms on the 'right' way to travel. There is evidence, however, that the private car is increasingly questioned as a symbol of status and progress, with other ways of connecting impinging on its position of cultural icon. This includes attachments to mobile telecommunications, the rise of social networking and the increasing popularity of alternative modes such as cycling. It is the emergence of a collective distaste for the private automobile as an object, and a collective mistrust of the car's ability to deliver the autonomy it promises. Similarly, the private car is increasingly physically constrained by congestion and authoritatively constrained by regulation.

The contribution of time geography provides tools to further refine the notion of automobility as freedom from constraint. Swedish geographer Torsten Hägerstrand developed time geography in the 1960s as a way to illustrate how a person navigates his or her way through the spatial-temporal environment and is constrained by limitations (Hägerstrand 1967; 1970). Hägerstrand identified three categories of constraints shaping potential mobility:

- *Physical constraints*: the limitations on autonomous movement due to instrumental restrictions. This includes constraints imposed by the speed capacity of the mode and any need to stop for refuelling or recharging. This also includes constraints imposed by requirements for fixed infrastructure.
- *Coupling constraints*: the need to be in one particular place at a certain time and for a certain time period. This includes the constraints on autonomous mobility imposed by timetables, as well as city rhythms (such as the peak hour) and biological rhythms (such as night and day).
- *Authority constraints*: laws, rules, or even norms that set limits to the access of specific areas at specific times. This includes traffic laws such as speed limits and property laws which prohibit access. It also includes the constraints imposed by economic cost and notions of social acceptability.



Autonomous mobility, therefore, is not just the removal of Hagerstrand's constraints on mobility, but is also supportive of agency. This can be interpreted as agency to not only move and connect, but also as agency to choose. Once we start to unpick the way private car use actually restricts, instead of supports, agency and choice, we can see that it is not really autonomous mobility at all.

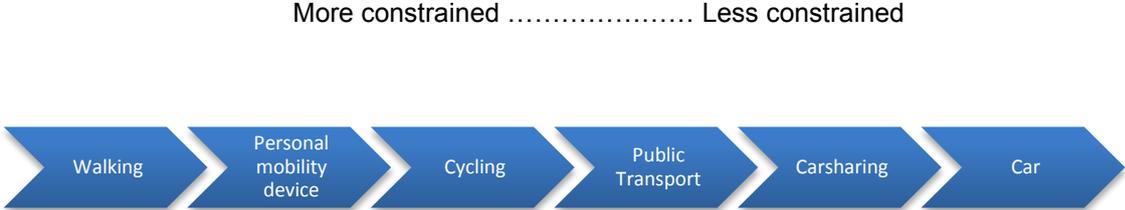
2. Operationalising Autonomous Mobility

In light of our previous comments about the myriad disconnections between the private car and autonomy, in this section we consider the extent to which diverse modes of transport facilitate autonomous mobility. We do so not in order to make definitive statements about each of the modes, but to illustrate our conceptual argument. We focus on five different modes of transport: walking, cycling, travel by personal mobility devices, public transport, carsharing and private car travel. With the exception of personal mobility devices, these encompass the most prevalent means of getting around cities, especially in Australia. Personal mobility devices – small, scooter and/or bike like devices with battery-powered motors – are included because of their increasing prevalence, novelty and potential.

Speed

The faster the average speed the less constrained the mode. Speed here is conceptualised as the time it takes to cover the distance between two destinations if all other constraints were removed. The car, with its greater engine capacity, will be the most autonomous here, though importantly this autonomy is reduced if congestion is taken into account. Although also car-based, carsharing displays a greater degree of constraint because of the increased time it takes to access and return the shared car. Walking is the slowest mode and therefore the most constrained and least autonomous.

Figure 1: Spectrum of Autonomous Mobility in Relation to Speed



Routes and Infrastructure

The greater the ‘fixity’ of the infrastructure required to support the mode the more constrained it will be. Cars and carsharing are both modes constrained to roads and are required to find a substantial amount of space for the physical object of the car at the end of each journey. Public transport is constrained to rail lines and roads, hence all of these modes score highly for this type of constraint. PMDs and walking have relatively lower score against this constraint, with walking requiring even less infrastructure than the paths required by most PMDs.

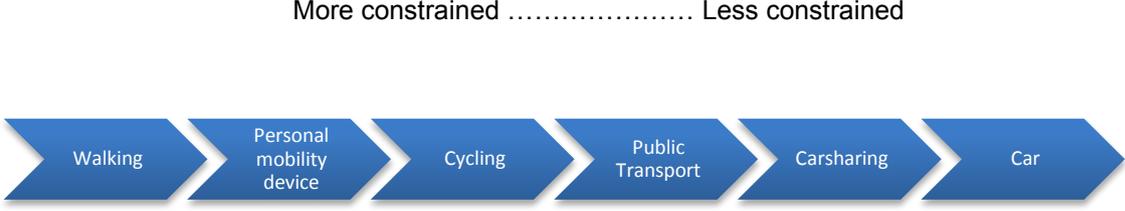
Figure 2: Spectrum of Autonomous Mobility in Relation to Infrastructure



Distance capacity

The further the mode is able to travel prior to needing to stop for either refuelling or recharging, the less constrained it is. Capacity for distance is conceptualised as defined either by technology (for example, an eBike that can only travel 20km on one single charge, a car that can travel 300km on a tank of petrol) or, for modes powered by the body, by what is considered to be the average distance coverable by the average person (for example, studies suggest that the average people will walk to a train station is 800m). The private car therefore scores low on this constraint, with walking and PMD use both highly constrained given the relatively short distances able to be covered by these modes.

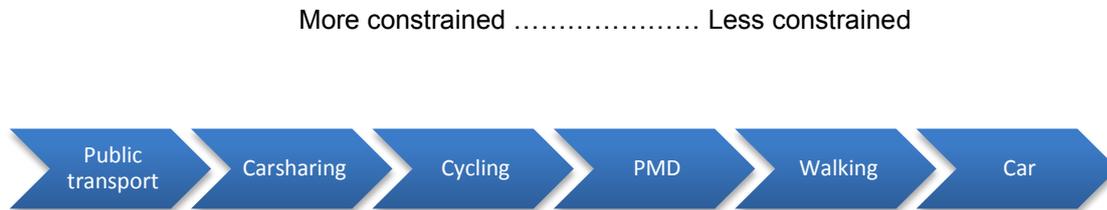
Figure 3: Spectrum of Autonomous Mobility in Relation to Distance



Set timetables

The less requirement there is to adhere to a mode-related time schedule the less constrained the mode will be. Timetables here are conceptualised as set times, not the kind of 'tempo' or rhythms associated with coupling constraints such as the school run or peak hour traffic. Public transport is obviously conceptualised as highly constrained by timetables, with carsharing also relatively constrained by the need to adhere to a booking schedule.

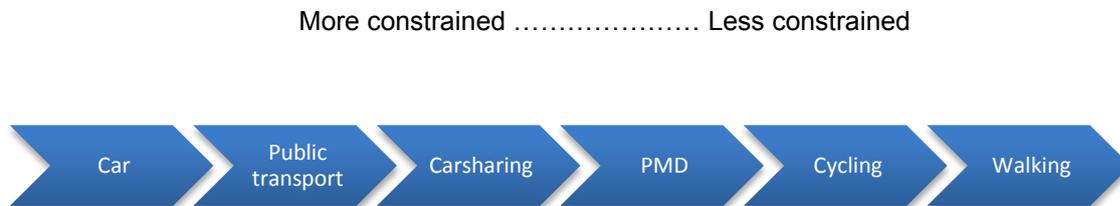
Figure 4: Spectrum of Autonomous Mobility in Relation to Timetabling



City rhythms

The more impacted a mode is by the rhythms of various collections of others (such as peak hours and school hours) the more constrained and less autonomous it is. This is very much linked to the capacity of the mode to absorb any increase in users. The car is increasingly constrained by congestion arising from its coupling to peak hour whereas walking is less affected by the movements of others and is therefore less constrained. Public transport is constrained by city rhythms in a different way in that the less users, for example outside of peak periods, the less regular the service.

Figure 5: Spectrum of Autonomous Mobility in Relation to City Rhythms



Bio-physical rhythms

This refers to the impact of the seasons, night and day, and the weather. People are less likely to walk for transport at night and less likely to use a PMD for transport in the rain, these modes are therefore more constrained by bio-physical rhythms. Private car use, however, is relatively insulated from biophysical rhythms and less constrained.

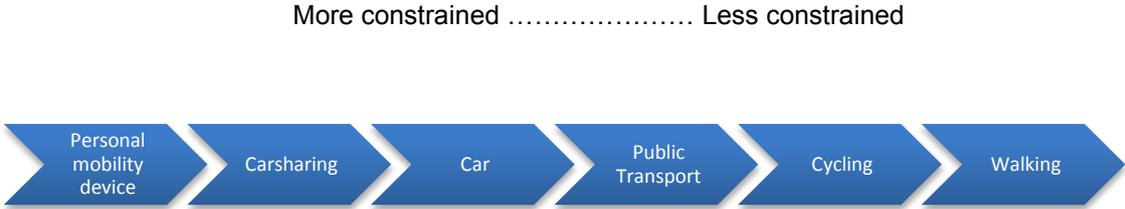
Figure 6: Spectrum of Autonomous Mobility in Relation to Bio-physical rhythms



Regulations and Laws: The latent autonomy embedded within the private car is extremely constrained by regulations and laws, with speed limits being the most obvious example. PMDs are also constrained by regulation, for example relating to their availability in certain countries. Again, the autonomy of walking becomes obvious here because walking is relatively unregulated by law. Even

so, walking is still constrained by property laws. This demonstrates the way all mobility is constrained and by implication subjugated. Perhaps true automobility is an impossibility?

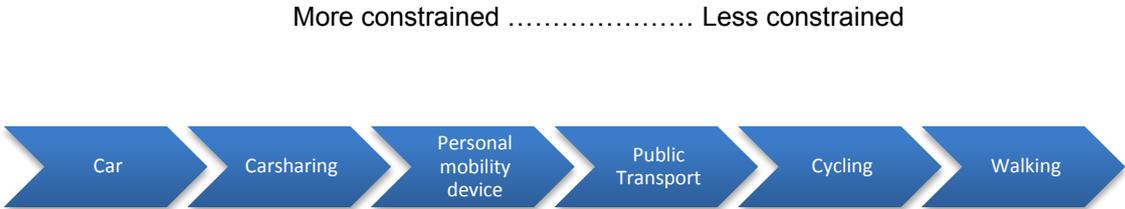
Figure 7: Spectrum of Autonomous Mobility in Relation to Regulation



Costs

This refers to the way the economic cost constrains a mode. As the most expensive mode, private car use is conceptualised as constrained by this measure, with walking again scoring as relatively free of constraint.

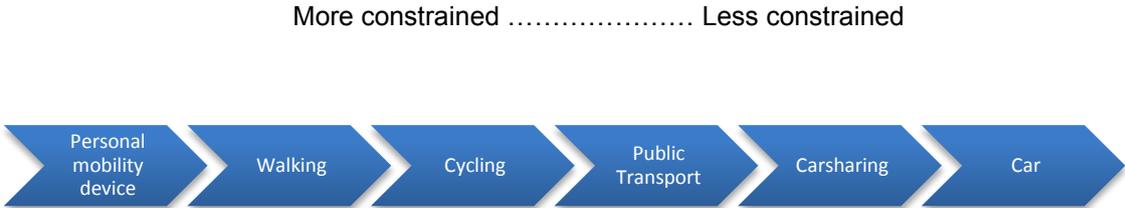
Figure 8: Spectrum of Autonomous Mobility in Relation to Cost



Social/cultural norms

Mobility is also constrained by degrees of social acceptability. In car dominant cultures, the car will be free of constraint. Walking is generally a socially acceptable way to travel and is also therefore free of constraint. The use of PMDs, however, is likely to attract cultural critique and can therefore be conceptualised as more constrained according to this variable.

Figure 9: Spectrum of Autonomous Mobility in Relation to Social/Cultural Norms



Different transport modes hence have different capacities and potentials for facilitating autonomous mobility. While each mode is influenced by different types of constraints, each mode also displays degrees of autonomy. Indeed, for some constraints – such as costs, health and city rhythms – the private car is not obviously the most autonomous. The primary aim of the conceptualisation is to demonstrate the way the private car is not necessarily the least constrained, or more autonomous, mode of travel. This position enables a different way of thinking about autonomous mobility that extends beyond traditional conceptualisations of it as bound to the automobile. The question remains, however, of how might transport planning support these different modes of being autonomously mobile, a question we explore in the next two sections.

3. Planning for Autonomous Mobility

Transport planning facilitates car-based automobility in a myriad of ways. In the Australian case this includes a tax system that privileges cars, as well federal and state budgets that prioritise road building. At the local level it also includes land use planning that does not always heed the need to integrate development and transport, as well as minimum rather than maximum car parking requirements. Yet a collective shift away from private car use as the guardian of autonomous mobility is undeniably reliant on the work of transport and land use planners. Facilitating development of the infrastructure and urban form required to support autonomy in alternative modes has potential to foster the uptake of these modes. Indeed, it will no doubt be structural changes rather than programs of individual behaviour change which will result in a decoupling of private car use and ways of living and working in modern life. In this section we take two quite different means of becoming autonomously mobile and consider the ways they can be facilitated by transport planning.

(a) Carsharing

Internationally, and in Australia, carsharing has captured the imagination of transport scholars and planners (see Shaheen and Cohen 2012). Carsharing is a broad concept that encompasses a variety of different business and operational models (Barth & Shaheen, 2002; Shaheen & Cohen, 2012). Carsharing models can be peer-to-peer, one-way, or affiliated with a specific public transport network. Carsharing organisations can be for-profit companies, cooperatives, or non-profit organisations (Cohen et al., 2008; Hampshire & Gaites, 2011). We adopt a specific conceptualisation of carsharing as a for-profit service that provides members with access to a fleet of vehicles, typically on an hourly basis. Cars are parked in dedicated car bays around cities, in neighbourhoods and major employment centres, as well as at public transport stations. Users are required to become a member of a carsharing organisation and then book a car via the internet and access the car using a smart. Members are billed at the end of the month for time and/or kilometres travelled. Carsharing organisations in this model are privately owned and they target their services at households and businesses (Shaheen et al., 1998). Examples include Zipcar in the United States and the United Kingdom (<http://www.zipcar.com/>) and GoGet in Australia (<http://www.goget.com.au/>). Over the past two decades, this model of carsharing has become a mainstream transportation mode for over a million users worldwide, with organisations now operating in more than 1,100 cities, across 26 countries, and on five continents: Asia, Australia, Europe, North America, and South America (Shaheen & Cohen, 2012). In Sydney, Australia's largest city, the local inner city authority has a target of 10 per cent of households becoming members of a carsharing provider by 2016. A recent study indicates this target will be reached ahead of schedule by 2014 (City of Sydney, 2012).

There are considerable sustainability benefits associated with carsharing. The concept is linked to reduced personal vehicle kilometres travelled (VKT) and reduced car ownership (Cervero and Tsai 2004; Shaheen et al. 2009; Martin and Shaheen 2011b; Sioui et al. 2012). Carsharing operates as one link in a chain of mobility options, filling in the gaps left by the limited carrying capacity, timetables and inflexibility associated with other alternative modes (Kent and Dowling 2013). Of key importance is that as a result of its use as part of a suite of alternative transport options, carsharing supports the development of infrastructures and cultural critical mass required to support other alternative modes of transport (Huyer 2004).

The way the built environment is planned and managed can support carsharing in a variety of ways. First, carsharing is dependent on higher density residential and commercial environments that are supportive of alternative transport (Bergmaier et al. 2004). Carsharing is a complement to other alternatives to the private automobile and only makes sense as part of a wider transportation package, in neighbourhoods where public transport, walking and cycling are viable options (Huyer 2004; Enoch and Taylor 2006; Goldman and Gorham 2006). Higher residential and commercial densities, a well-connected and maintained active transport environment, a mix of uses, and parking pressures, all underpin carsharing because they support the suite of transport choices required to complement it. Indeed, carsharing has been most successful in locations where public transport, walking and cycling are viable options (Huyer 2004; Barth et al. 2004) and vehicle ownership is low (Millard-Ball et al. 2005; Burkhardt and Millard-Ball 2006). As a result, carsharing is overwhelmingly concentrated in metropolitan cores where the high density, mixed uses and already well serviced public and active transport networks make reduced reliance on private automobility more of a reality (Stillwater et al. 2009; Duncan 2011). By planning to support other modes that are alternative to the privately owned car, transport planners are therefore simultaneously enabling carsharing.

A second way planning can support carsharing is through provision of various immediate infrastructures, most notably, car parking. For the reasons outlined above, carsharing 'works' in areas where access to car parking is constrained. The provision of on-street and public off-street parking dedicated to carsharing is therefore essential to the ongoing survival of the carsharing concept. Referencing our constraints schedule above, by providing a space for the parked shared car, urban planning is removing a constraint from autonomy through carsharing. Australian carsharing companies often enjoy access to free, or reduced rate, on-street car parking provided as a form of support by local government (Shaheen et al. 2010). The costs to local government of this support can be significant. For example, a recent survey for the City of Sydney suggests the planning and conversion of on-street car parking spaces to exclusive use carsharing bays is \$1.19 million AUD. This cost excludes revenue forgone from otherwise paid on-street car parking bays, as well as the unquantifiable public irritation that often results from conversion of an on-street bay to an exclusive use carsharing bay. Nevertheless, a number of local government areas across Australia have developed and implemented carsharing policies, usually as a way to fulfil strategic goals to support sustainable transport. Ostensibly these policies allow for the provision of car parking space however they also specify plans to promote the use of carsharing and its integration with other alternative transport options. In return, these local authorities are able to negotiate conditions of use, including requirements to provide low-emission vehicles and disclose data on scheme utilisation (City of Sydney 2010).

(b) Personal Mobility Devices

Our second example is drawn from another transport solution that relies on new forms of technology: personal mobility devices. PMDs are motor-assisted, low-speed, lightweight devices with one, two, three or four wheels [see: <http://www.youtube.com/watch?v=q3kzJCCiWlc>]. Considerable international attention has focused on the Segway, but for our purposes they are not a PMD because their weight and range makes them inappropriate in pedestrian environments. Like bicycles, PMDs can facilitate autonomous mobility through relatively ubiquitous routes and infrastructure, limited timetabling constraints and ability to bypass congestion. PMDs are designed to transport one person on footpaths, shared use paths, cycleways and trails and can be an important component of a package of sustainable transport solutions. A PMD rider can travel short distances quickly and with minimal physical exertion. As such, PMDs may address one of the key challenges in transport planning: reducing private car use for trips of less than 5km, for which most people are reluctant to walk (see Faulks et.al. 2013; Rodier and Shaheen 2008). Moreover, using public transport combined with PMDs for those first and last few kilometres of the daily commute could significantly reduce journey travel times and congestion.

Transport planning does not have an immediately obvious role in facilitating PMD use. Currently there is no accepted regulatory framework for these devices in Australia. In some jurisdictions motorised scooters are legal providing they cannot travel at more than 10 km/h and their motor does not exceed 200 watts power output. In NSW, PMDs are a form of motor vehicle and are subject to the same legislation as motor vehicles. In NSW, motor vehicles must be registered for use on a road or road-related area unless it is specifically exempt (for example, motorised wheelchairs and power assisted pedal cycles are exempt). In NSW in 2013 PMDs do not meet the minimum Australian design standards for safety and so cannot be registered in NSW. This means they must not be used on roads or in any public areas such as footpaths, car parks and parks.

Thus far, debates about the regulation of PMDs and conditions of use have been filtered through the lenses of road safety, recreation or economic development. Though legitimate framings of PMDs, we suggest that there is also a potential advocacy role for transport planning here. Transport planning could foster a more overt introduction of concerns of sustainable transport into the debate and hence broaden understanding. This does not need to emanate from conventional transport planning agencies, but could include transport advocacy groups. Indeed, there is also evidence that some local governments are taking advocacy and leadership roles in this field. The City of Ryde, for example, has commissioned research on PMD use within its boundaries and is working with other agencies to reconsider current regulatory restrictions on PMDs (see Dowling, Irwin and Faulks 2013).

Transport planning can also fulfill an educative and facilitative role in integrating and managing PMD use in the public arena. This might entail, for example, guidelines to manage PMD riders using public pathways. An illustrative set of guidelines is provided in Table 1 below. In contrast to carsharing with the focus on *providing* appropriate infrastructure, sustainable transport planning in relation to PMDs could focus on the appropriate use of *existing* infrastructure. Footpaths, shared paths and to a lesser extent cycleways are a central component of Australian urban infrastructure, but non-car forms of

autonomous mobility will see their increased use and consequential increased pressure on sharing them. Thus transport planning in this respect could provide guidelines, for example, that may include prohibiting the use of PMDs in certain areas and restrict certain types of behaviour that can create conflict with other path users. In this example, the work of transport planning is 'soft' rather than 'hard', reliant on signage, education and community engagement.

Table 1: Addressing PMD Use in Existing Infrastructure

Education and Oversight Component	Example for Shared Paths
Rules	Speed limit Give way to pedestrians Keep to left
Signage	Showing it is a multi user path (walking pedestrians, bicycle and PMD riders), Speed limit
Education Program	Adjust speed to pedestrian volume Shared Path Etiquette Promoting road safety and riding skills

5. Conclusion

It is now widely accepted that sustainable transport futures are dependent on shifting urban infrastructures, urban planning and urban lifestyles away from the private car. In this paper we have offered some deliberately speculative comments on how to begin such a shift. Conceptually we have uncoupled 'auto' and 'mobility'; and applied this uncoupling to a diversity of transport modes. Our key finding here is that elements of 'autonomous mobility' are enabled by diverse modes, and that in relation to dimensions like coupling constraints, the private car underpins minimal autonomous mobility. Because of its preliminary nature the paper did not compare transport modes across a combination of constraints on autonomous mobility. This will be the focus of future research.

The second section of the paper turned to an equally preliminary analysis of how transport planning might facilitate non-car autonomous mobility. Focusing on two emergent rather than established modes – carsharing and PMDs – we identified a number of different entry points through which transport planning can ameliorate the autonomy constraints faced by these modes. These include conventional infrastructure and parking policies, as well as community engagement around infrastructure use. Both examples underline the necessity of thinking differently if a shift toward sustainable transport is to be achieved.

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