



Stone, J. & Mees, P. (2010). Planning public transport networks in the post-petroleum era.

Originally published in *Australian Planner*, 47(4), 263-271.
Available from: <http://dx.doi.org/10.1080/07293682.2010.526550>

Copyright © 2010 Planning Institute Australia.

This is the author's version of the work, posted here with the permission of the publisher for your personal use. No further distribution is permitted. You may also be able to access the published version from your library. The definitive version is available at <http://www.tandfonline.com/>.

Planning public transport networks in the post-petroleum era

Abstract

Oil depletion scenarios suggest that public transport powered largely by electricity, together with cycling and walking, will be the mainstays of future urban mobility. This paper argues that there is great scope, in a time-scale of years rather than decades, for transport planners to increase the number and types of trips for which public transport is a convenient option.

Our argument begins with a snapshot of Melbourne during the last period of intense and sustained constraints on oil supply and an overview of the performance of various transport modes in the three decades from 1976 to 2006. The decline of public transport since 1950 occurred at a faster rate than changes in density and can be reversed without the need for widespread re-creation of the urban form.

The key to making these changes lies in the approach to public transport planning used in successful European and North American cities: service-based network planning. This model offers hope for greater public transport use in Australian cities, and is outlined in the central part of the article. We conclude with some comments on the forms of transport governance required to deliver 'networked' public transport services.

Keywords

Public transport planning, density, networks

Planning public transport networks in the post-petroleum era

Introduction

The oil depletion scenarios explored in other papers in this series suggest substantial declines in mobility and drastic declines in auto-mobility. Increased localisation is likely, with correspondingly greater roles for walking and cycling, and to encourage more people to travel under their own power there is much that planners, legislators and communities will need to do to repair the damage done to the public realm by auto-dependent policies. However, for longer journeys, urban mobility will require some form of external power. Electric cars will play a part, but for reasons of efficiency in the use of both energy and space, many trips will need to be made in shared vehicles. In short, we will need good public transport.

Some of the changes required for public transport to play a positive role in an energy-constrained future are the province of engineers and energy-policy analysts. However, there is great scope, in a time-scale of years rather than decades, for transport planners to increase the number and types of trips for which public transport is a convenient option.

Earlier in this issue, Newman and Wight identified resilient alternatives to the ‘business as usual’ urban planning model under a range of likely oil supply scenarios. There is no doubt that a compact and connected urban form enhances the potential for oil-free mobility through walking, cycling, and greater public transport use. Therefore, some localised intensification of residential development – achieved through inclusive democratic process and with appropriate controls on the quality of design and construction – and, perhaps more important, concentration of employment and other trip destinations, are necessary objectives for urban planners responding to oil vulnerability.

However, we will argue that it is not necessary to intensify land-use across the whole city before significant improvement in both patronage and economic efficiency of public transport becomes possible. This is fortunate for a number of reasons. First, as others have argued, our cities are likely to feel major effects of peak oil within the next decade. Within this timescale, whatever urban development model is pursued, most residents of Australian cities will continue to live in houses and suburban subdivisions that are already built. Alternatives to the car will need to be effective at existing urban residential densities. Second, the proven effectiveness of modern approaches to public transport service design in ‘low density’ suburbs offers a way to break the politicised stand-off between supporters of urban consolidation and residents who choose to live in a detached house on a suburban block.

Our argument for the existence of short-term opportunities to improve public transport in Australian cities begins with a snapshot of Melbourne during the last period of intense and sustained constraints on oil supply and an overview of the performance of various transport modes in the three decades from 1976 to 2006. The decline of public transport since 1950 occurred at a faster rate than changes in density. This is consistent with our international evidence, which shows that residential density, at the scale found in Australian and North American cities, is a poor predictor of the use of public transport and private cars.

In this context, we briefly note the response of some state public transport agencies to recent growth in patronage. This response centres on arguments about capacity constraints

and the need for huge spending on new infrastructure. An alternative, or complementary, approach, used in some European and North American cities and which offers hope for greater public transport use in Australian cities, is service-based network planning. A description of network planning forms the central part of the article. We conclude with some comments on the forms of transport governance required to deliver ‘networked’ public transport services in Australian cities.

Back to the future?

The challenge of peak oil seems daunting, but it is also an opportunity. For the first time since the end of post-War petrol rationing, there is a serious prospect that public transport may become the dominant motorised travel mode in Australian cities.

Urban Australia has dealt with constrained oil supplies in the past. Petrol rationing was introduced during World War II and remained in force until February 1950. The following year, the Melbourne & Metropolitan Board of Works (MMBW) commissioned Australia’s first comprehensive travel survey. The survey found that car ownership rates in Melbourne were still low: the city average was 121 cars per 1,000 residents, with regional rates ranging from 61.5 in inner Melbourne to 183.7 in the wealthy Malvern-Caulfield subregion (Opinion Research Centre 1951, p. 32). Rates of car use were also low, as shown in Table 1.

<i>Transport mode</i>	<i>Share of workers (%)</i>
Train	26.0
Tram	22.1
Bus	8.8
<i>Total public transport</i>	<i>56.9</i>
Bicycle	9.5
Walk (or work from home)	14.1
<i>Total non-motorised modes</i>	<i>23.6</i>
Car	16.2
Van/truck	2.0
Motorcycle	1.3
<i>Total private motorised transport</i>	<i>19.5</i>

Table 1: Travel to work in Melbourne, 1951 (Source: ORC, 1951, p. 35)

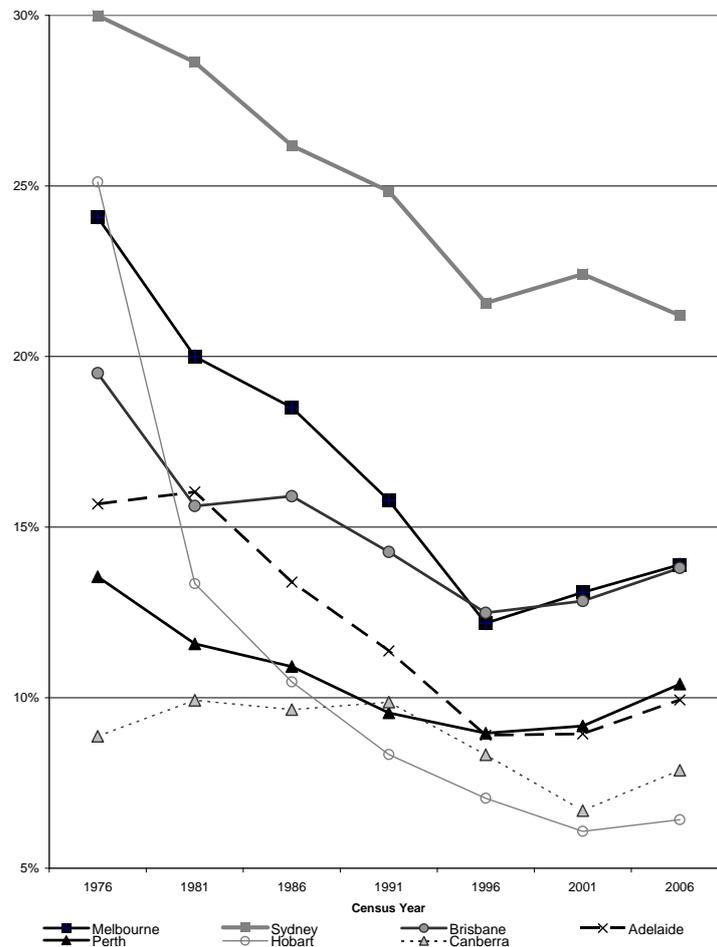
Although walking and cycling rates were much higher than at present, public transport dominated travel in Melbourne. The data for non-work travel, although less detailed, shows a similar pattern. The car was a relatively minor mode, confined mainly to the wealthy, a pattern seen across Australian cities and towns at this time.

The petrol-rationing era was a boom time for Australian public transport. Patronage increased rapidly, enabling a recovery in fortunes from the decline experienced during the

1930s thanks to the Depression and rising car ownership. However, the need to conserve fuel and labour saw service levels constrained, leading to overcrowding. While this ensured healthy surpluses for public transport operators, it also created public dissatisfaction. In the minds of many members of the public, trains, trams and buses became synonymous with discomfort and crowding (Davison 2004, Ch. 1-2).

Public transport in Australian cities declined dramatically once petrol rationing was lifted and rising incomes made cars more affordable. Within a decade of the MMBW's 1951 survey, the car had become the majority travel mode. Despite rapid population growth, public transport patronage began to decline in absolute numbers, not just as a percentage of the travel market. The decline was most rapid for non-work and non-central travel, which worsened the economic problems of public transport operators, as each train, tram or bus might only carry one full load of passengers per day (Mees 2000, chapter 1). Within two decades of the MMBW's survey, most Australian public transport operators were trapped in a vicious cycle of declining patronage, rising deficits, service cuts and fare rises.

Figure 1: Share of work trips by public transport, 1976-2006



(Source for Figs 1 to 5: Mees et al, 2008).

Figure 1 presents the share of work trips carried by public transport in each Australian capital city since 1976, the year in which the question about mode of travel to work was

introduced. All saw steep declines over the two decades to 1996, with modest reversals in most places since 1996 or 2001. The largest decline occurred in Hobart, but this is due to special factors: ferry usage was unusually high in 1976 due to the closure of the Tasman Bridge following the 1975 bridge disaster. Apart from Hobart, the largest decline occurred in Melbourne. In the late 1970s, all cities suffered falls except for Adelaide and Canberra. Both these cities saw rises in mode share between 1976 and 1981 due to pro-public transport policies adopted by the Dunstan and Whitlam governments. This was followed by long declines after the reversal of these policies.

Figures 2 and 3 compare trends on trains with those for buses, ferries and trams, showing the much stronger performance of fixed rail as a transport mode. The substantial increase in Perth does not include the effects of the Southern line to Mandurah, which opened after the 2006 census. Melbourne has the worst performance for trams and buses (there are no passenger ferries), which may come as a surprise given that the city retains Australia's only extensive tram system.

Figure 2: Share of work trips by train, 1976-2006

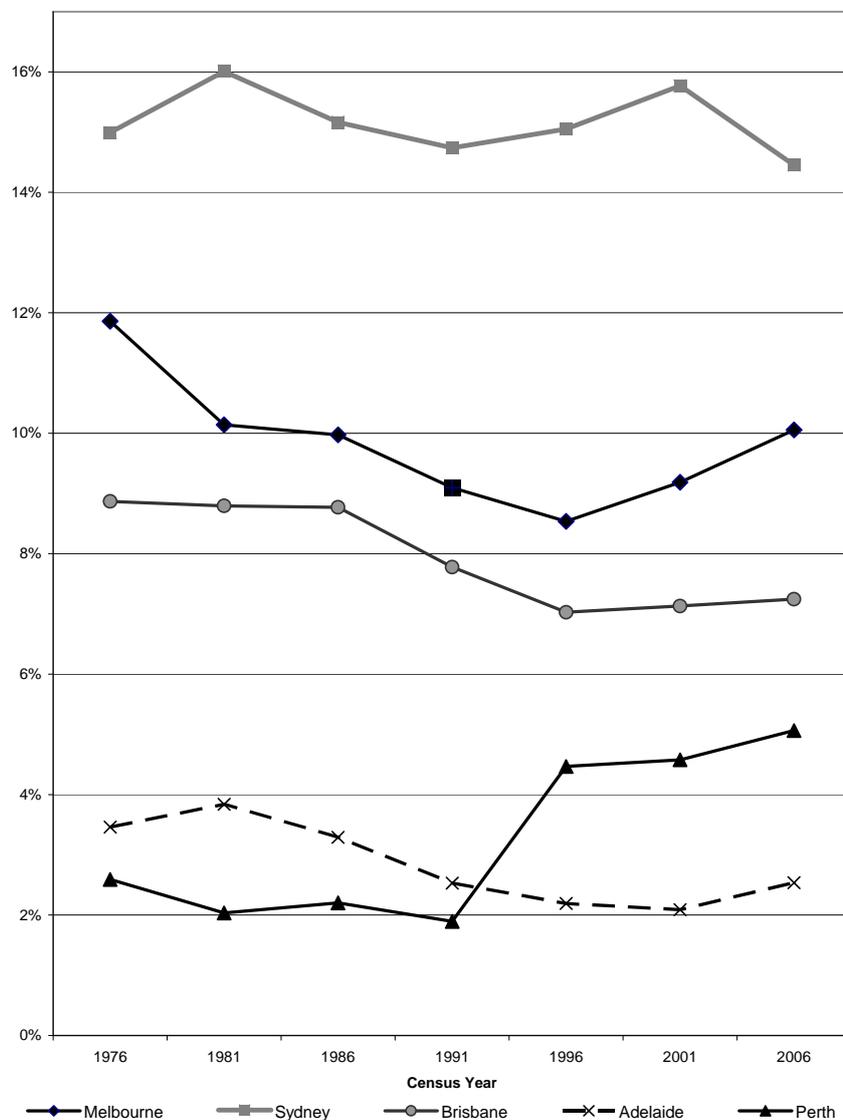
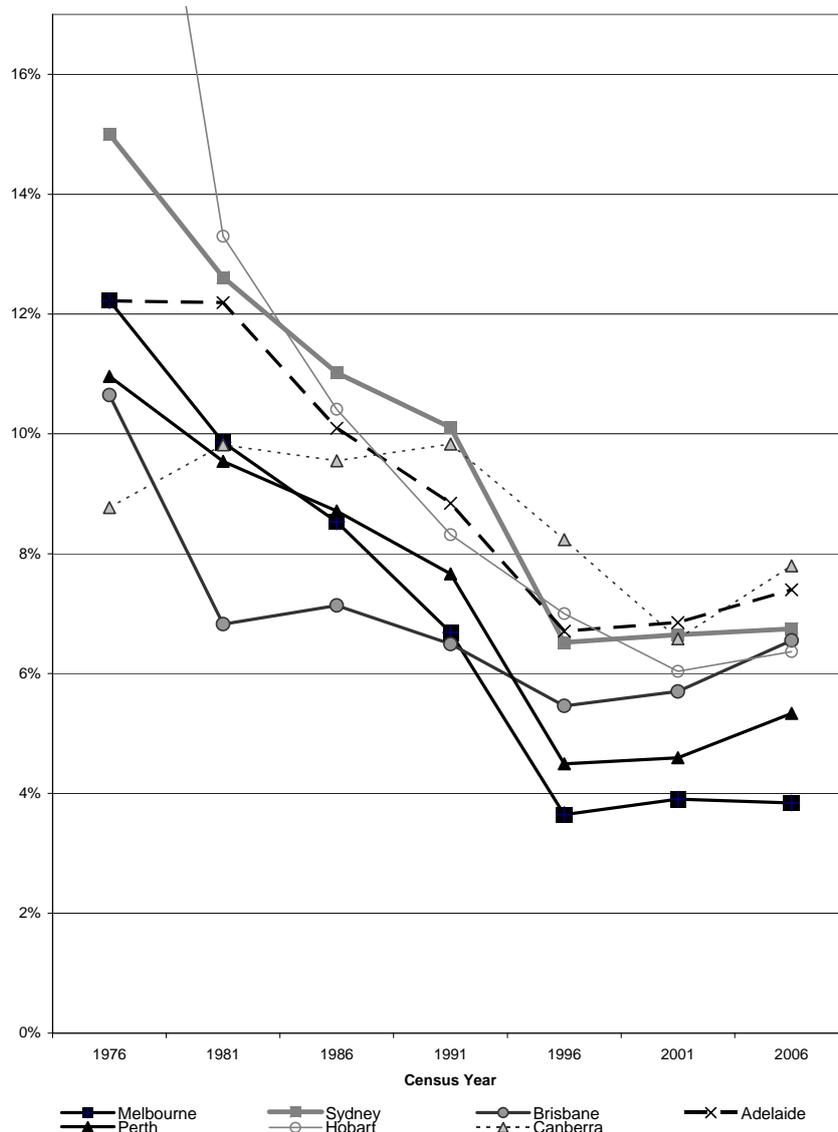
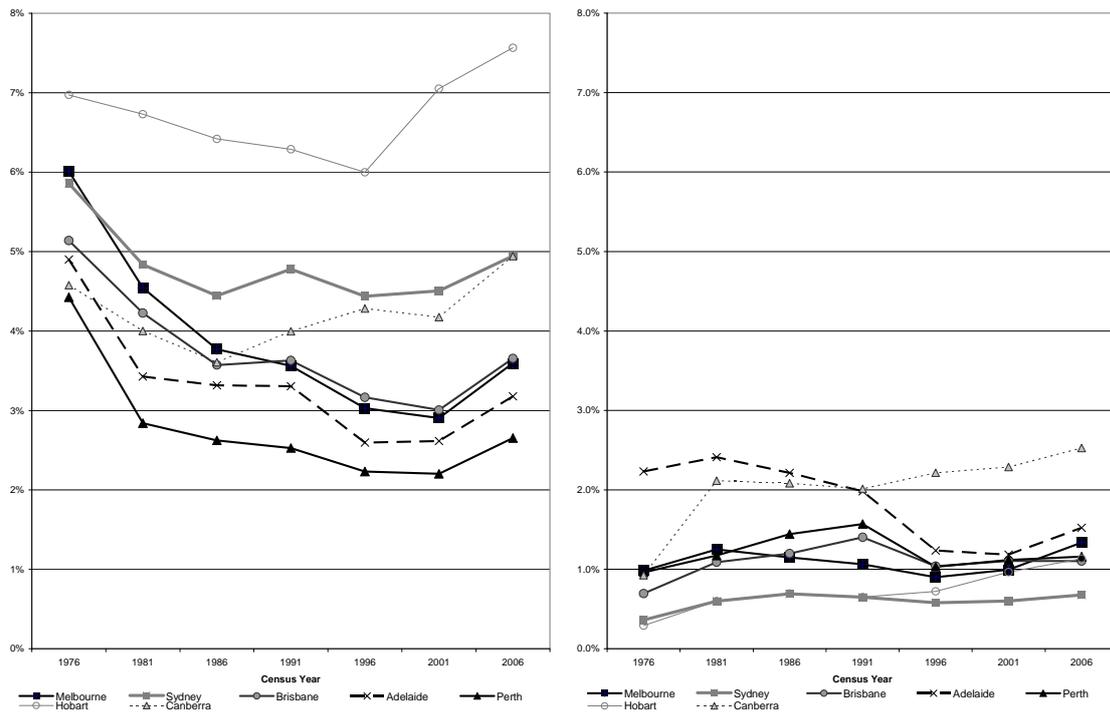


Figure 3: Share of work trips by bus, ferry and tram, 2076-2006



The most encouraging sign is the improvement in mode share and patronage in the last 5 to 10 years in all cities (except Sydney, which saw a decline in the rail share between 2001 and 2006). This trend has been the subject of much excited commentary that has tended to ignore the long-term trends. These trends suggest that the recent recovery, while welcome, is modest by historical standards. There has been relatively little analysis of possible causes, but Gaymer and Kinnear (2009) point to substantial rises in the share of workers employed in the CBD (a reversal of long-term decline), rising petrol prices and increased environmental awareness. Greater numbers of CBD jobs and rising residential populations (and modest changes in densities) may also be significant. This certainly seems to be the major factor behind the noteworthy recent increase in walking, and the much smaller – but more extensively reported – rise in cycling rates (Figures 4 and 5).

Figures 4 & 5: Share of work trips by walking and by bicycle, 1976-2006



Can public transport cope?

The resurgence in public transport patronage, particularly on rail systems, has led to increasing public complaints about overcrowding and reliability in Sydney, Melbourne and Brisbane. Transport planning agencies in those cities argue that their systems face ‘capacity crises’ requiring multi-billion-dollar infrastructure investments just to keep up with growth. This is consistent with recent trends in Australian urban planning, which, as Dodson (2009, p. 109) notes, sees strategic urban spatial planning “replaced by a vigorous new emphasis ... on large-scale urban infrastructure as a solution to urban problems”. As Dodson points out, this ‘infrastructure turn’ is problematic for a number of reasons, not least the way that it narrows the focus of urban planning. It also raises questions about the ability of public transport planning to cope with an oil-constrained future.

The current ‘capacity crises’, by international and local historical standards, represent relatively modest change in public transport mode share. Current public transport for work trips is confined mainly to employment in CBDs: mode shares for suburban work travel and non-work journeys remain very low. Constrained oil supplies will require Australian public transport to do two things now regarded by many planners and politicians as virtually impossible. It will have to accommodate patronage volumes that are an order of magnitude higher than current levels, and it will need to serve travel to and between low-density suburbs.

The best-performing European public transport systems carry much higher patronage loads than their Australian counterparts, usually with less extensive infrastructure. For example, Line A of the Paris RER now regularly carries over a million passengers per day over its two-track central section (RATP 2008, p. 25) – more passengers than the entire Sydney rail network, with its eight tracks entering the CBD. Parisian rail planners have progressively

lifted hourly throughput on RER Line A from 25 to 30 long double-deck trains per hour per direction in peak period..

Even light rail lines regularly carry much higher patronage than heavy rail corridors in Australian cities. The Expo Line, the original part of Vancouver's Skytrain light rail system, carries around 200,000 passengers per weekday, around the same as the entire Brisbane heavy rail system. The new 'Canada' light rail line, which opened in 2009, carried 287,000 passengers on the busiest day of the 2010 Winter Olympics (Translink Media Release, August 6, 2010).

Assessments of the capacity of the existing rail infrastructure in Australian cities and prospects of improvements from recent large investments, such as those made by the Commonwealth through Infrastructure Australia, are beyond the scope of this paper. But, as we discuss elsewhere (Mees 2010a; Stone 2010), issues of skills and governance must be addressed if we are to move beyond the current defensive 'debate' played out in Melbourne and Sydney and get the best value from existing infrastructure and from future investment. Given the international economic outlook, this future investment is likely to be much less than the total sought by public transport infrastructure planners across the country.

Beyond the questions of the availability of infrastructure funds and the purpose to which any investment should be put, a further issue for planners seeking to improve public transport in Australia is the wide acceptance of the idea that the settlement patterns of our cities and towns make greater public transport use difficult, if not impossible.

Is density the issue?

The decline in public transport use after the end of petrol rationing happened much more quickly than changes in suburban population densities. However, it has become almost an article of faith that the reverse is impossible. Many planners, and other commentators on urban issues, appear to believe that getting significantly more people on to public transport will not be possible until massive changes in suburban densities are achieved. The evidence challenges this view.

It is not in any doubt that, across the range from outer-suburban farmlets to Hong Kong high-rise, there is a positive correlation between population density and the ability to operate efficient, attractive public transport services. However, within the range of population densities found in urban regions in Australia and North America, the relationship is not so clear.

Following recent changes in reporting methods by US statistical agencies, it is now possible to make meaningful comparisons of densities across urban regions in Australia and North America. Data on mode share for the journey to work is also available for the same cities. A full discussion of the data collection methods and results can be found in Mees (2010b, ch. 4). In Figures 6 and 7, the overall urban density of each region is plotted against use of public transport and the private car.

Figure 6: Population density vs. public transport use

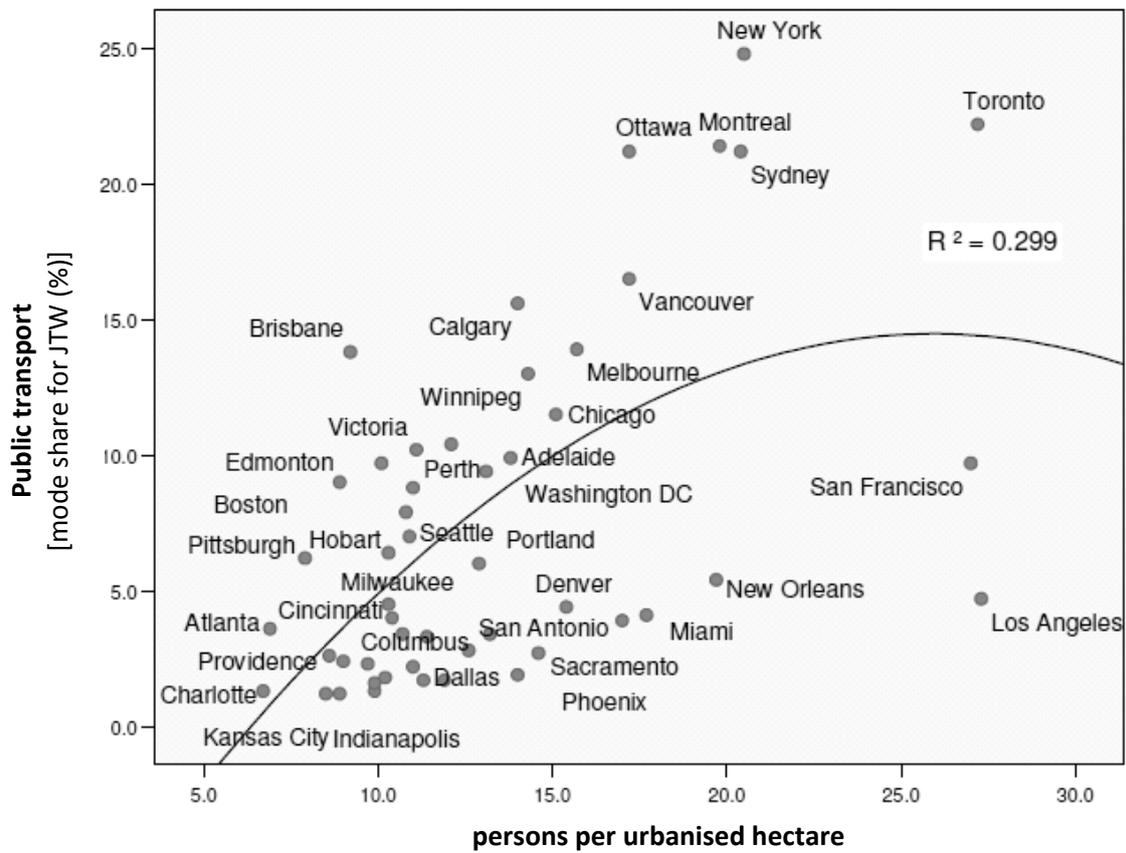
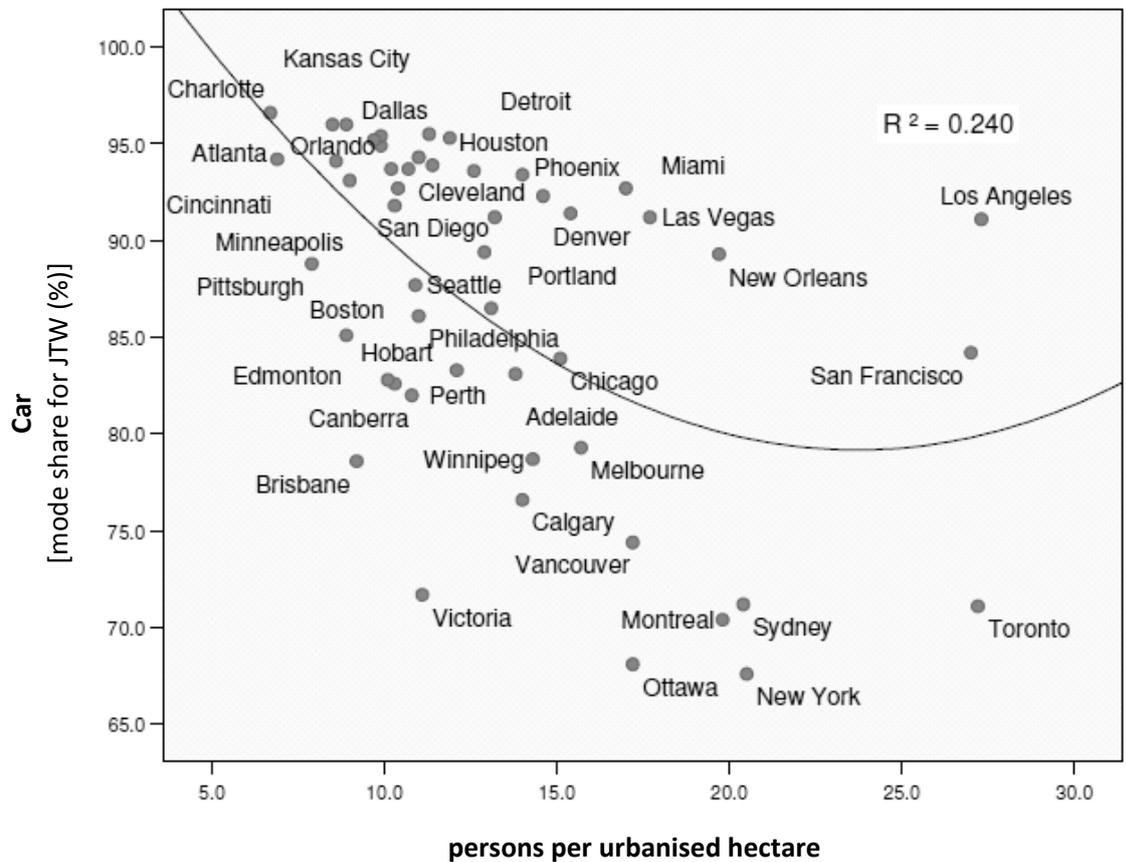


Figure 7: Population density vs. private car use



In a regression analysis, the R^2 values for the choice of public transport and the private car for work trips with regard to density were found to be 0.299 and 0.240 respectively. Across this sample of 41 'dispersed' cities, higher density across the whole urban region is not the explanatory variable that many might expect.

This is not to say that urban intensification plays no role. However, the 'urban consolidation' that has, as described earlier, contributed to recent public transport patronage growth is modest and makes little impact on the density of the whole urban region. Localised, well-designed and democratically sanctioned urban consolidation is valuable, but it is not the whole story.

We saw earlier that close attention to maximising the carrying capacity of available infrastructure is a feature of many successful public transport systems. However, this is not the only lesson Australian transport planners can learn from international best practice. Some regions are now succeeding in a task long thought to be impossible and are making public transport work in areas of low residential density. Without requiring huge public subsidies, they are providing high service levels and attracting high shares of travel in and between low-density suburbs and even in semi-rural locations.

The largely rural Swiss Canton (State) of Graubünden provides a remarkable illustration. Across the whole Canton, the share of workers travelling by car was just below 50 per cent at the last census in 2000, while the share of students was only 4 per cent. Around 19 per cent of workers and 31 per cent of students used public transport, while 30 per cent of workers and 64 per cent of students walked or cycled (Mees 2010b, p. 179). The share of Graubünden workers using cars is much lower than in any Australian city, while public transport's share is higher than any city apart from Sydney. The pattern for students is dramatically more environmentally friendly than can be found anywhere in Australia, and the already-low car mode share is actually declining.

Graubünden can be compared with the North Coast (Richmond-Tweed) district of New South Wales, which covers about the same area but houses 213,000 residents compared with Graubünden's 187,000. Fewer than 2 per cent of North Coast workers used public transport at the 2006 census, while 8 per cent walked or cycled and 87 per cent travelled by car. Figures for trips to school are unavailable, but are likely to be comparable to work trips.

So, what makes public transport work in Graubünden and a growing number of urban, suburban and semi-rural regions in Europe and elsewhere? The key is in the modern approach to public transport planning, which offers a new perspective on balancing competing demands for attractive service levels and economic efficiency.

The network-planning alternative

Public transport is increasingly called on to serve diverse objectives – ranging from providing mobility to the disadvantaged through to alleviating traffic congestion – while making efficient use of financial resources. The challenge for public transport seems daunting. It must cater for travellers with very different needs, ranging from peak-period access to the CBD to all-day access to local shops and community centres. It also needs to provide attractive service frequencies and operating hours for multiple destinations, while

maintaining high occupancy rates. Many observers have argued that these trade-offs present an insoluble problem(see, for example, Roth and Wynne 1982), but there is evidence to counter this assertion.

The essence of public transport, reflected in its name, is carrying people with different trip origins and destinations in the same vehicle. These travellers can then be transported at lower economic and environmental costs than if they travelled separately. This is public transport's strength, but also its weakness, because people don't all have the same trip origins or destinations.

One approach to diverse travel patterns is to provide separate services for different markets: express buses and trains for peak commuters; regular buses for local trips along busy corridors; car-like 'dial-a-bus' for low-demand corridors and times. The problem with this approach is that the more public transport becomes tailor-made, the more it surrenders its environmental and economic advantages. A public transport system offering a direct service between every origin and destination would have low frequencies, low occupancies, high costs and high energy-use per passenger.

The alternative is networks. This approach enables 'anywhere-to-anywhere' travel while keeping occupancy rates high, by carrying different kinds of travellers on the same services. Transfers are integral to a public transport system that offers access to a large number of potential destinations at an affordable cost (Mees 2000; Nielsen 2005). Traditionally, public transport planners have attempted to avoid transfers by designing routes that cater for the most popular travel paths and by creating circuitous bus routes that link many destinations, but the network approach embraces transfers making them the building blocks of a multidestinalional system.

Two US researchers have commented on the importance of transfers:

Surveys asking what passengers ...dislike about transit find that transferring is at or near the top of the list ... (So, traditionally), transfers are avoided ... In contrast, the multidestinalional approach uses transfers to open travel paths to ... destinations that are reachable in radial systems only by lengthy and circuitous travel (Thompson and Matoff 2003, p. 298).

While transfers create many new travel opportunities, they also impose inconvenience. Effective transfer-based public transport requires careful planning to ensure that the inconvenience is reduced to the minimum possible.

Four key elements underpin the creation of high quality, transfer-based networks:

1. *A simple line structure*: simplicity makes the network easier for passengers to understand, and minimises the resources that an operator must provide.
2. *Stable line and operating patterns*: as well as being simple, a network must also be stable. The idea is to provide a consistent, high-quality service across the network all day, rather than operating different service types in peak and off-peak periods, and at nights and weekends.

3. *Convenient transfers*: easy transferring requires attention to timetables and physical facilities. 'Random' transfers are possible when all lines serving an interchange point operate frequently, generally up to a limit of every 10 minutes (6 departures per hour) or better. 'Timed' transfers are needed when services are less frequent, and the timetables for connecting lines must be coordinated (Mees 2010b, chapter 8; Nielsen 2005).
4. *Appropriate institutions and fare systems*: fare systems must allow free transfers. So, a mechanism for the pooling of fare revenues is essential. Pooling of resources is also required to allow cross subsidies for routes that have lower demand but which provide essential components of the 'go anywhere' network. All cities that have created a successful networked public transport system have managed this through a single responsible public agency with the power to plan and share resources across the urban region (Mees 2010b). This approach has achieved positive results in London and Copenhagen and in Swiss, German and Swedish cities and towns. It is also being introduced to improve integration of buses and trains in Singapore (Land Transport Authority of Singapore 2008, pp. 38-39). In Australia, these institutional arrangements are in place in Perth, where public transport patronage has grown steadily since the early 1990s (Stone 2009). Once a public agency has created a sound network plan, successful delivery of individual services can be achieved either through public bodies or via tendering to private companies

There is clear evidence that network planning delivers improved patronage and economic efficiency. The first comprehensive comparison made between network planning and the more traditional approaches was Mees' analysis of Melbourne and Toronto: two cities with similar populations, incomes and urban forms but very different public transport outcomes (Mees 2000). Per capita public transport usage in Toronto was at least twice as high as in Melbourne, despite a much smaller rail system and significantly lower public subsidies. Toronto's performance was the result of network planning by a single public agency offering travellers frequent and direct bus services and easy transfers. Melbourne suffered from indirect, infrequent and poorly connected services that were the consequence of unproductive competition between multiple operators. This theme is further developed, with many international examples, in *Transport for Suburbia* (Mees 2010b).

Analysis of US cities has confirmed the benefits of network planning. Thompson and Matoff (2003) investigated changes in public transport service levels and patronage between 1983 and 1998 in nine urban regions. They found that cities that had adopted a network-planning approach significantly outperformed those using the traditional approach, recording higher growth in patronage and lower rises in subsidies.

The US study showed that short-term improvements to public transport use could be achieved without making changes to the urban form. There is clear evidence that old-fashioned planning paradigms and perverse competition between modes have stifled opportunities to make similar gains in Australasian cities (Mees et al. 2010). Achieving effective public transport networks is a political and institutional task within which planners will play a vital role.

Achieving 'networked' public transport

We have seen that better public transport can be achieved in cities with population densities similar to those found today in Australia. This can be done, in part, by paying careful attention to gaining the maximum capacity from existing infrastructure. It is also necessary to learn from cities with the most successful public transport systems. These cities have common institutional structures for the delivery of public transport services. A public planning agency is required to design the network, provide cross-subsidies, and operate a multi-modal fare system.

Such arrangements are already well established in Perth and are emerging in Brisbane. It is in Melbourne and Sydney where most change is required. This need was recognised by the 2009 Senate Inquiry into urban public transport (Senate Rural and Regional Affairs and Transport Committee 2009, sect. 4.10-4.16), and the directions for reforms required to implement the network approach are summed up in following quote from Infrastructure Australia's 2008 report to COAG:

Simply investing in more capacity is not the only requirement to improve public transport in Australia. Public transport is not administered and managed in Australian cities as well as in many cities overseas ... now is the time for nationwide reform to improve public transport governance (IA 2008, p. 45).

The rapidly approaching challenges of peak oil make this change all the more urgent, and it is essential that planners understand the issues and lead the processes of reform so that first-class public transport can take its place, alongside walking and cycling, as part of the alternative to auto-dependence.

References

- Davison, G 2004, *Car Wars: How the Car Won our Hearts and Conquered our Cities*, Allen & Unwin, Sydney.
- Dodson, J 2009, 'The 'infrastructure turn' in Australian metropolitan spatial planning', *International Planning Studies*, vol. 14, no. 2, pp. 109-123.
- Gaymer, S & Kinnear, R 2009, 'Understanding recent changes in public transport patronage', *Victorian Department of Transport: Transport Research and Policy Analysis Bulletin*, vol., no. 6, p. 7.
- IA 2008, *A report to the Council of Australian Governments*, Infrastructure Australia, Canberra.
- Land Transport Authority of Singapore 2008, *Land Transport Master Plan: A People-Centred Land Transport System* Singapore.
- Mees, P 2000, *A Very Public Solution: Transport in the Dispersed City*, Melbourne University Press, Melbourne.
- Mees, P 2010a, 'Planning for major rail projects: the Melbourne Metro and Regional Rail Link' 33rd Australian Transport Research Forum, Canberra, ATRF
- Mees, P 2010b, *Transport for Suburbia: Beyond the Automobile Age*, Earthscan, London.

- Mees, P, O'Connell, G & Stone, J 2008, 'Travel to Work in Australian Capital Cities, 1976-2006 ', *Urban Policy and Research*, vol. 26, no. 3, pp. 363-378.
- Mees, P, Stone, J, Imran, M & Neilson, G 2010, *Public Transport Network Planning: a guide to best practice in New Zealand cities*, New Zealand Transport Agency, Wellington.
- Nielsen, G 2005, *HiTrans Best Practice Guide No. 2, Public Transport: Planning the Networks*, European Union, Interreg IIIB Stavanger, Norway.
- Opinion Research Centre 1951, '*Survey of Movement of People Within Greater Melbourne*', unpublished report, Melbourne.
- RATP 2008, *Activity and Sustainability Report 2008*, RATP, Paris (available at www.ratp.fr).
- Roth, J & Wynne, G 1982, *Free Enterprise Urban Transportation*, Transaction, New Brunswick, USA.
- Senate Rural and Regional Affairs and Transport Committee 2009, *Report of the Senate Committee Inquiry into Investment of Commonwealth and State funds in public passenger transport infrastructure and services*, Commonwealth of Australia, Canberra.
- Stone, J 2009, 'Contrasts in reform: how the Cain and Burke years shaped public transport in Melbourne and Perth ', *Urban Policy and Research*, vol. 27, no. 4, pp. 419-434.
- Stone, J 2010, 'Turning over a new franchise: Assessing the health of public transport management in Melbourne' 33rd Australian Transport Research Forum, Canberra, ATRF
- Thompson, G & Matoff, T 2003, 'Keeping Up with the Joneses: Radial vs. Multidestination Transit in Decentralizing Regions', *Journal of the American Planning Association*, vol. 69, no. 3.