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Differences in transport and land use in thirteen comparable Australian, American, Canadian and European cities between 1995/6 to 2005/6 and their implications for more sustainable transport

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Abstract

This paper summarises the findings of thirteen comparable North American, Australian and European cities in relation to a range of transport and land use-related indicators and their changes between 1995/96 and 2005/06. The trend comparison helps to highlight the influence of existing land use and transport policies in different cities and an examination of land use and transport vision documents in the thirteen cities shows where they are heading and the likely effectiveness of their policies. Overall, the data show that there have been some improvements in urban transport in terms of growth in public transport and reductions in car use in the decade considered, but there are also some negative trends. Generally the data show that whilst public transport has been holding its own or improving in many cities, much more needs to be done for it to compete better with the car. The paper will highlight some overall general recommendations in relation to urban transport and land use in order to move more consistently towards sustainable transport.

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1. Introduction

There can be little doubt that cities need to become more sustainable and there is perhaps no greater indicator of the overall direction of sustainability in cities than the land use-transport system and the characteristics and trends within this system in cities of the world (Newman and Jennings, 2008; Kenworthy, 2006). In order to effectively address the issue of conforming land use and transport systems to reduced automobile dependence, it seems evident that policy responses across a wide range of topics need to be pulling in the same direction and that they need to be large enough to effect major, rather than marginal changes.

In this paper we summarise for thirteen comparable cities in the USA, Canada, Australia and Germany, a range of urban land use, as well as private and public transport infrastructure and use factors for 1995/6 and 2005/6. First of all the data are presented in five tables and the results discussed from an overall perspective on the whole sample, especially the trends. The highly summarised results of current, major policy documents in terms of urban planning and transport in each city to see what the cities have envisioned for themselves over the coming decades is presented (Kenworthy and Inbakaran, 2011). The stated policies and strategies are analyses in the light of the objective data evidence between 1995/6 and

2005/6 of which way each city is trending and then draw some broad policy conclusions about the implications of all the findings.

2. Methodology

The data on the thirteen cities in this paper for 1995/6 are derived from the Millennium Cities Database for Sustainable Transport (Kenworthy and Laube, 2001), and an ongoing update for 2005/6 of selected cities in this database. Data for 1995/6 and 2005/6 were collected over a number of years in each case, from a variety of sources. These sources included Census data, published reports from various government agencies, transport surveys and public transport operator data. Much of the data, however, do not appear in public documents and must be sought out from each city by making contact with relevant people, for the most part in government agencies. Email and phone calls are used to obtain this support. Data collection takes a long time because of often long delays in obtaining responses, up to several years delay in data publication, and also the considerable number of emails frequently needed to clarify data and seek other sources. The data represent a unique set of urban characteristics, which are rarely if ever brought together in this way, nor reality checked for reliability and consistency to ensure the best available data are used in every case. Only a part of the data that has been collected is used in this paper. A list of the thirteen cities can be found in Table 1. The cities were chosen based on similarities such as population size, comparable levels of economic advancement[1], as well as significant cultural comparability, all so as to be relevant to a more detailed benchmarking exercise for the Melbourne region[2]. The second part of the paper involves qualitative evaluations of information on relevant transport and urban planning policies in the various cities which were gleaned from reviews of current policy and strategy documents available for the cities. This information is presented only in highly summarised form here and some conclusions are drawn. Full detailed descriptions of the policies in each city and descriptive comparisons of the actual trends in each city over the 1995 to 2005 period in relation to these policies are set out in a longer document (Kenworthy and Inbakaran, 2011).

3. Results and Discussion

The primary focus of this paper is what has been happening in twelve, US, Canadian and Australian cities and one European city in terms of urban transport patterns and land use and especially public transport. Before looking specifically at public transport, however, it is necessary to understand a little about the different cities and some of the significant patterns and changes in land use and other transport factors that have occurred alongside the changes in public transport. The following tables therefore first explore some aspects of urban form and transport that help to paint a picture of these thirteen cities and the changes they have undergone in the decade from 1995/6 to 2005/6 (referred to from hereon simply as 1995 to 2005).

Urban form

Table 1 presents for each city for the two years, data on population and some urban form factors in terms of urban densities and centralisation of metropolitan employment (proportion of jobs in the CBD). The data reveal that these thirteen “peer cities” are all medium size cities

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[1] The average metropolitan GDP (not national GDP) for the thirteen cities in 2005/6 was $US35,280 (1995 US dollars), with a median value of $33,623 in Phoenix.

[2] See Peer Cities Study, Department of Transport, Melbourne. (http://www1.transport.vic.gov.au/VTSP/homepage.html)

ranging in population in 2005 from 2,116,581 in Vancouver to a high of 5,555,912 in Toronto, with an average for the thirteen cities of 3,713,608 and a median value of 3,743,000 in Melbourne. All cities in the study experienced significant population growth over the 10 years (except Berlin which shrank), the 1995 average population for the sample being 3,202,494 (16% growth to 2005).

Average urban density of the thirteen cities in both 1995 and 2005 was stable at 19.8 persons per ha. However, of the thirteen cities, eight rose in urban density, while five declined. On the other hand the average job density rose slightly from 9.3 to 10.0 jobs per ha (with ten cities increasing in this factor and only three declining), leading to an overall small increase in the "activity intensity" (population + jobs) of the whole sample. Overall, the density data suggest a stabilising, if not a turnaround, in the longstanding post-World War 2 decline in the density of relatively wealthy cities in the USA, Australia and Canada, which is a significant turning point in the evolution of urban form. Most of these cities have had policies for some years attempting to limit urban sprawl and to increase densities, particularly around transit (see later). The data here suggests that the effects of such policies can now be seen, in metropolitan-wide densities, albeit in only small changes in some cases. In summary, it could be said that the trend in densities in these cities is generally favouring higher public transport use. Public transport use is influenced by higher urban densities through the greater concentration of people that live within the catchments of public transport stops and through the indirect effect of higher urban density in facililitating mixed land uses; more people tend to generate demand for shops and other urban facilities in close proximity (witness the return of supermarkets to CBDs in Australia as resident populations have burgeoned in the last two decades). This in turn helps to generate higher demand for public transport .

Another factor of relevance, especially in transport terms is the degree of centralisation of the metropolitan area measured as the proportion of metropolitan-wide jobs that are focussed in the main centre (the CBD). The concentration of jobs in the CBD of cities is an important element in understanding the overall urban structure of a region and is generally termed 'centralisation' (although today with the development of significant sub-centres in cities, "decentralised concentration" has become very important in the way cities function in transport terms). More centralised cities tend to have less central city parking, stronger rail systems (at least in the developed world) and more use of public transport, especially for radial trips (see Thomson (1978), Strong-Centre Archetype city).

The data in Table 1 show that on average the centralisation of these cities has reduced marginally from 10.4% to 10.1% of metropolitan jobs in the CBD, with five cities actually increasing in this factor over the ten years. The trend in centralisation is somewhat mixed and it is more difficult to say how this may be affecting public transport use on a metropolitan scale, especially since the absolute number of jobs in CBDs is still generally growing, even though the proportion this represents of total metropolitan jobs can decline due to faster growth elsewhere.

Table 1. Population and urban form in thirteen cities, 1995 and 2005

City	Year	Population (persons)	Urban density (persons/ ha)	Job density (jobs/ha)	Activity Density (persons+ jobs/ha	Proportion of jobs in CBD (%)
Melbourne	1996	3,138,147	13.7	5.7	19.4	9.4%
	2006	3,743,000	15.6	6.5	22.1	9.9%
Sydney	1996	3,741,290	18.9	8.0	27.0	12.8%
	2006	4,282,000	19.5	8.8	28.2	12.7%
Montreal	1996	3,224,130	31.7	13.3	45.0	16.3%
	2006	3,487,520	25.6	12.4	38.1	17.8%
Toronto	1996	4,628,883	25.5	12.8	38.3	6.5%
	2006	5,555,912	26.9	14.5	41.4	6.4%
Vancouver	1996	1,898,687	21.6	10.4	32.1	12.6%
	2006	2,116,581	25.2	14.1	39.3	11.0%
Berlin	1995	3,471,418	56.0	24.8	80.8	20.2%
	2005	3,395,189	54.1	24.6	78.7	20.6%
Atlanta	1995	2,897,178	6.4	3.6	10.0	6.3%
	2005	3,826,866	8.1	4.2	12.3	7.1%
Denver	1995	1,984,578	15.1	9.0	24.1	8.6%
	2005	2,256,442	14.7	9.4	24.1	7.2%
Houston	1995	3,918,061	8.8	4.2	13.1	7.2%
	2005	4,853,225	9.6	4.8	14.4	5.8%
Phoenix	1995	2,526,113	10.4	4.3	14.7	2.7%
	2005	3,590,804	10.9	5.1	16.0	4.9%
San Diego	1995	2,626,714	14.5	6.6	21.1	5.8%
	2005	2,824,259	14.6	7.7	22.3	5.1%
San Francisco	1995	3,837,896	20.5	8.9	29.4	13.9%
	2005	4,071,751	19.8	9.6	29.4	11.3%
Washington	1995	3,739,330	14.3	9.2	23.5	12.4%
	2005	4,273,361	12.6	8.3	20.9	11.3%
Average	1995	3,202,494	19.8	9.3	29.1	10.4%
	2005	3,713,608	19.8	10.0	29.8	10.1%

Private transport infrastructure

An important factor in influencing transport patterns of any metropolitan area is the extent to which private motorised transport is catered for. Table 2 presents data on this by way of road and freeway supply, CBD parking supply and car ownership in each of the cities. It can be seen that on average the supply of roads went down by 8% over the decade in the thirteen cities, with seven cities declining, two remaining the same and four increasing very marginally. Road provision is, overall, tending to favour more public transport use. However, this factor is strongly linked to densities because of the greater efficiency in supplying road access to properties in dense environments. Where densities are increasing, overall road provision will trend downwards because less total road infrastructure is needed to service more compact development.

A perhaps more significant factor is the level of freeway supply because freeways are premium road infrastructure designed to move high volumes of traffic at high speed. Freeway provision is also a policy decision that is consciously made by cities and is both a hard

quantitative, measurable piece of data that indicates a city's transport priorities, as well as quite a symbolic one. It has symbolic and cultural significance because some of the most high profile transport infrastructure debates can be seen in protests over the development of freeways and their often destructive effects on the urban fabric and natural environment (Schiller, Bruun and Kenworthy, 2010). It has been known for many years that freeways promote car use and undermine public transport (Watt and Ayres, 1974).

We find that in terms of the trend in freeway provision, the average for all thirteen cities in 1995/6 and 2005/6 was 0.133 metres per person, so overall, no change. Within this picture, however, it can be seen that six cities increased in freeway provision per capita (Sydney, Montreal, Toronto, Berlin, Denver, Washington), while seven declined (Melbourne, Vancouver, Atlanta, Houston, Phoenix, San Diego, San Francisco). Overall, it would appear that in these relatively wealthy cities, freeway provision is showing some signs of stabilising. However, the cities that declined in freeway provision did so on average by 11%, while those that increased did so by 20%, so the picture is still quite mixed.

It should be noted that the data collected in this study on the overall average speed of each city's road network shows that in 1995 the average speed for the thirteen cities was 46.4 km/h, while in 2005 it had declined marginally to 45.1 km/h (a 3% reduction), a trend that should not be unexpected given the declines in road and freeway provision in many cities. Six cities declined in average speed while three remained the same and four increased. Overall, the trend in freeway development (and declining average road speeds), probably marginally favours the competitiveness of public transport compared to the car.

Parking in the central areas of cities is generally an indicator of the city's public transport orientation, as explained in detail by Thomson (1978) in his landmark archetypal cities analysis. Cities with strong radially oriented rail systems have very much less parking. A detailed analysis of the full set of wealthy cities in the Millennium Cities Database (Kenworthy, 2008) shows very clearly that those cities with strong rail systems have significantly and systematically lower CBD parking than those with weaker rail systems, and much lower than those with only buses.

It can be said clearly that in the decade from 1995 to 2005 in this group of cities, CBD parking as a ratio of CBD employment declined significantly from 508 to 440 parking spaces per 1000 CBD jobs (13% less). Within the sample seven of the thirteen cities experienced declines (an average of 31% less CBD parking), while six cities rose in this factor, but only on average by 13%. It can reasonably concluded, that the trend in CBD parking would, overall, tend to favour increased use of public transport in these cities.

The final important factor in Table 2 is car ownership, which is clearly on an upward trend in these cities from an average in 1995 of 554 up to 594 in 2005 (a 7% increase). Only in Vancouver and Atlanta did the car ownership rate fall and only on average by less than 2%. Naturally, this dominant upward trend in car ownership would tend to work against public transport.

Table 2. Private transport infrastructure factors in thirteen cities, 1995 and 2005

		Length of road per person (m/person)	Length of freeway per person (m/person)	Parking spaces per 1000 CBD jobs	Passenger cars per 1000 people
Melbourne	1996	9.5	0.084	349	594
	2006	7.3	0.081	268	649
Sydney	1996	6.9	0.059	197	516
	2006	6.9	0.070	206	554
Montreal	1996	4.5	0.145	455	429
	2006	4.5	0.156	300	446
Toronto	1996	4.1	0.080	239	464
	2006	4.7	0.089	174	485
Vancouver	1996	5.1	0.077	444	520
	2006	4.7	0.069	389	506
Berlin	1995	1.5	0.018	174	354
	2005	1.6	0.022	415	361
Atlanta	1995	8.7	0.201	727	746
	2005	7.5	0.152	694	738
Denver	1995	8.6	0.198	623	630
	2005	8.7	0.264	461	758
Houston	1995	9.6	0.206	698	693
	2005	8.7	0.175	745	735
Phoenix	1995	9.2	0.179	1,503	531
	2005	6.9	0.158	709	536
San Diego	1995	5.3	0.193	767	555
	2005	5.4	0.184	856	655
San Francisco	1995	4.5	0.148	157	600
	2005	4.4	0.146	208	658
Washington	1995	5.3	0.135	271	573
	2005	5.0	0.164	291	641
Average	1995	6.4	0.133	508	554
	2006	5.9	0.133	440	594

Before turning to public transport, it is useful to examine briefly how these data on urban form and private transport infrastructure may have affected mobility by private motorised modes. Table 3 summarises the car vehicle kilometres and car passenger kilometres per capita as well as the car vehicle kilometres per car in the thirteen cities over the decade. The data show that the average increase in car vehicle kilometres per person was only 2.0%, while for car passenger kilometres it was similar at 2.4%. Such increases in ten years are relatively low and looking at the data in more detail it can be seen that in four cities, car vehicle kilometres and passenger kilometres per capita actually declined. These data tend to support the current literature which is showing that car use in industrialised nations, including Australia, appears to have reached a peak around 2004 (Millard-Ball and Schipper, 2010; Newman and Kenworthy, 2011). The data on car usage per car shows a drop of 4.3% over the decade, not surprisingly given the more significant increase in car ownership, compared to the increase in car use – more cars are owned but are on average being used less. Seven cities showed a decline in this factor (by an average of 11%) and six increased (by an average of 5%).

Table 3. Private motorised transport use in thirteen cities, 1995 and 2005

		Passenger car kilometres per capita (km/ person)	Passenger car passenger kilometres per capita (p.km/ person)	Passenger car kilometres per car (km/car)
Melbourne	1996	7,649	11,918	12,883
	2006	8,275	11,586	12,758
Sydney	1996	6,945	10,506	13,472
	2006	7,553	11,406	13,642
Montreal	1996	5,427	7,597	12,648
	2006	5,333	6,453	11,959
Toronto	1996	5,493	6,818	11,828
	2006	5,020	6,290	10,350
Vancouver	1996	6,746	9,310	12,981
	2006	6,971	9,987	13,766
Berlin	1995	3,071	4,300	8,665
	2005	3,495	4,858	9,678
Atlanta	1995	20,197	24,641	27,074
	2005	18,146	24,135	24,574
Denver	1995	11,465	17,771	18,209
	2005	14,176	21,769	18,705
Houston	1995	17,110	25,323	24,681
	2005	14,505	21,032	19,738
Phoenix	1995	11,352	15,082	21,394
	2005	11,733	15,605	21,877
San Diego	1995	13,339	18,675	24,032
	2005	14,180	19,285	21,654
San Francisco	1995	12,772	17,242	21,300
	2005	12,155	17,867	18,458
Washington	1995	11,681	17,288	20,393
	2005	14,420	20,621	22,504
Average	1995	10,250	14,344	17,658
	2006	10,459	14,684	16,897

Public transport infrastructure and service

The paper now turns to what has been happening with significant public transport infrastructure and service items such as the level of reserved route for public transport, the availability of rolling stock, the amount of service provided by the public transport systems in each city and the average speed of the public transport system. Table 4 summarises these data for all modes and all operators of public transport that existed in the cities in 1995 and 2005.

On average the thirteen cities increased by 10% in the per capita amount of reserved route provided for the operation of their public transport systems, with ten cities showing increases, two declining (Melbourne and Sydney) and one (Phoenix) remaining without any reserved

route for its public transport system in 2005 (though a light rail system is now operational there).

A similar generally positive picture is seen in service provision, with the per capita supply of public transport service (vehicle kms of service per person per year) expanding on average by 12% and only Montreal and Atlanta declined in this factor. Likewise, when service provision is expressed on a spatial basis in terms of the kilometres of service driven per hectare of urbanised land, it has increased by 8% and in this factor only Montreal declined.

In terms of the potential speed competitiveness of public transport, the situation was marginally better in 2005, with the overall average speed of the public transport system (weighted by passenger hours spent in each mode) in the thirteen cities increasing by just under 2%. When combined with the falling average speed of general road traffic discussed earlier, it can be seen that the ratio of public transport system speed to road traffic speed in the thirteen cities went from 0.58 in 1995 to 0.61 in 2005, a small but positive trend. However, in absolute terms it means that in the thirteen cities, on average, public transport speeds are still not nearly competitive with cars, though the suburban rail systems in 2005 in the nine cities that had suburban rail, experienced an average speed of 48.1 km/h, in excess of average road traffic speed for the whole sample.

Finally, it can also be seen in Table 4 that the supply of public transport rolling stock has increased on average by 8%. These figures, like all the public transport data, represent all modes of public transport and each wagon for the rail modes are counted as one vehicle. Seven of the thirteen cities increased in fleet provision, one remained the same and five declined. However, of the seven that increased, they did so by 28%, whereas the cities that declined did so by less than 2%. This trend supports the provision of better public transport services in many of these cities.

In summary, there are few if any factors measured here, except the rising car ownership, where the trend would work against increasing use of public transport in the thirteen cities as a group. Though there are variations amongst the cities, there are generally more cities with positive trends in the factors than those with negative trends, and very often the positive trend in those cities is greater in percentage terms than the negative trend in the other cities.

Having gained something of an overall view of some significant factors that relate to the potential performance of public transport systems in the thirteen cities, the paper now turns to the trends in public transport use.

Table 4. Public transport infrastructure and service in thirteen cities, 1995 and 2005

		Total length of reserved public transport routes per capita (m/1000 persons)	Total public transport vehicle kilometres of service per capita (vehicle km/person)	Total public transport vehicle kilometres of service per urban hectare (vehicle km/ha)	Overall average speed of public transport (km/h)	Total public transport vehicles per 1000 persons (units/ 1000 persons)
Melbourne	1996	119.8	49.4	676	27.6	0.89
	2006	106.9	52.1	813	28.9	0.78
Sydney	1996	225.0	75.4	1,428	32.3	1.21
	2006	207.6	77.6	1,511	30.2	1.17
Montreal	1996	68.5	55.9	1,773	22.8	1.00
	2006	119.2	49.9	1,278	28.1	1.00
Toronto	1996	92.0	50.9	1,300	24.1	0.78
	2006	80.1	54.9	1,476	25.8	0.80
Vancouver	1996	53.7	45.6	985	28.7	0.62
	2006	55.5	54.9	1,383	21.7	0.74
Berlin	1995	140.2	115.3	6,455	26.6	1.43
	2005	155.2	124.8	6,746	29.3	1.33
Atlanta	1995	22.4	28.3	180	31.3	0.37
	2005	52.6	24.2	197	30.5	0.36
Denver	1995	2.9	23.8	359	26.8	0.45
	2005	25.4	38.1	561	25.2	0.77
Houston	1995	0.0	18.6	164	25.2	0.80
	2005	52.1	19.9	192	24.4	0.61
Phoenix	1995	0.0	12.5	130	23.9	0.32
	2005	0.0	17.5	191	22.3	0.38
San Diego	1995	44.9	20.3	296	23.8	0.33
	2005	53.4	30.1	439	28.2	0.53
San Francisco	1995	55.0	51.8	1,034	26.3	0.92
	2005	76.8	56.3	1,113	29.0	1.31
Washington	1995	116.1	41.2	590	30.8	0.80
	2005	116.3	57.1	722	31.9	0.88
Average	1995	72.0	45.3	1,182	26.9	0.76
	2006	85.0	50.6	1,278	27.4	0.82

Public transport usage and cost factors

The litmus test of any public transport system is how much it gets used. There are a number of ways of gaining insight into this. In Table 5 we reveal three such indicators: the annual boardings per capita (the number of trip legs people make each year), the annual passenger kilometres per capita (the distances that the users actually travel) and the overall seat occupancy of public transport expressed as a percentage (i.e. what percentage of the seats offered by public transport are actually occupied: derived by dividing annual passenger kilometres by annual seat kilometres of service). Also in this table is an indication of the relative user cost per average public transport trip in the city.

The data show that average usage across the thirteen cities in terms of boardings increased by 7% over the decade (seven cities increased, one remained the same and five declined) though the average for the cities that increased was 20% and for those that declined it was 5%. In terms of the distances that people travel on public transport, it rose by double that amount (14%), indicating that people are not only travelling more frequently on public transport, they are travelling further. Eleven cities showed an increase in per capita public transport passenger kilometres (an average increase of 15%) and in the two cities that declined, it was only by 3%.

These data are in accordance with other data explained in Newman and Kenworthy (2011), which show, for example, quite a significant turnaround in the fortunes of public transport in both the USA and Australia over recent years (in the case of the USA, the increases in public transport use per person have exceeded the increases in car travel).

In addition, in terms of the internal productivity of public transport systems, Table 5 shows that the average seat occupancy has increased from 29% to 32% in the thirteen cities. Nine cities showed an increase in this factor, one remained identical and three declined. The data especially suggest that, notwithstanding the crowding in most public transport systems in the peak periods and the difficulty in getting a seat, there is still a lot of spare seat capacity in the inter-peak and off-peak periods. Only Montreal had more than 50% of seats occupied in terms of a system-wide average in 2005, while Denver, the lowest had only 22%. Sydney, somewhat surprisingly given the size of the city and the demand on the public transport system (it has the highest public transport use per capita in Australia), had only 24%.

The final item in Table 5 shows the average user cost of a public transport trip. It uses all the farebox revenues collected to calculate this factor, which is then normalised to 1995 US dollars for both years and expressed as a per mille of city GDP per capita per passenger km (per mille uses a base of 1000 as opposed to 100 for the more usual per cent, due to the very small figures involved). Interestingly, when normalised in this way, it shows that the real user cost of public transport has declined in the thirteen cities by a significant 21% from 1995 to 2005. Only one city, Vancouver, rose in the user cost of public transport, which increased by 13%. It would appear that, like many of the other factors already discussed, the falling price of public transport to users should favour an increase in the use of this mode (interestingly though, Vancouver had a healthy increase in transit use, despite user cost rising).

Overview of the data

When one considers the fact that a significant majority of the trends in the factors examined in Tables 1 to 4 and the transit user cost factor in Table 5 tend to favour an increase in public transport usage in the thirteen cities, the increase per capita in public transport boardings and passenger kilometres is quite modest, though still positive from both a sustainability perspective and in the light of strong and sustained negative trends in the post-war decades.

Table 5. Public transport usage and cost indicators in thirteen cities, 1995-2005

		Total public transport boardings per capita (boardings/ person/year)	Total public transport passenger kilometres per capita (p.km/person/ year)	Overall public transport seat occupancy (persons/seat in % terms)	User cost of public transport (‰ per capita GDP/ pass.km)
Melbourne	1996	101.2	994.2	31%	0.0028
	2006	103.6	1056.7	28%	0.0024
Sydney	1996	140.9	1509.1	23%	0.0033
	2006	136.4	1551.9	24%	0.0032
Montreal	1996	206.3	992.9	42%	0.0051
	2006	206.3	1122.2	55%	0.0035
Toronto	1996	158.2	1050.5	37%	0.0051
	2006	153.7	1125.0	37%	0.0049
Vancouver	1996	118.2	767.3	40%	0.0031
	2006	133.6	928.1	43%	0.0035
Berlin	1995	311.2	1735.6	29%	0.0048
	2005	410.2	2253.2	35%	0.0041
Atlanta	1995	50.6	357.8	24%	0.0024
	2005	39.3	341.5	30%	0.0016
Denver	1995	32.2	204.6	20%	0.0022
	2005	38.2	316.2	22%	0.0015
Houston	1995	20.5	183.9	23%	0.0020
	2005	19.5	183.1	28%	0.0011
Phoenix	1995	15.1	100.2	23%	0.0025
	2005	16.8	116.7	25%	0.0024
San Diego	1995	27.0	206.5	22%	0.0035
	2005	31.8	307.5	28%	0.0019
San Francisco	1995	103.3	809.8	30%	0.0025
	2005	102.8	902.6	29%	0.0019
Washington	1995	100.0	780.9	33%	0.0033
	2005	108.9	873.0	30%	0.0021
Average	1995	106.5	745.6	29%	0.0033
	2006	115.5	852.1	32%	0.0026

The modest size of the increases is further highlighted by the fact that most of the cities that did gain in usage only increased by just a handful of boardings per capita in the decade. The only cities that stood out were Berlin (already the highest in this sample in terms of public transport use with 410 boardings per capita, compared to the whole sample average of 115), gaining almost 100 boardings per capita. This gain alone was three to five times the *absolute* per capita public transport usage in some US cities in 2005 (e.g. Phoenix 17 per capita, Houston 19, San Diego 32) and roughly equal to the total per capita public transport use in Melbourne in 2006. Vancouver was the only other city where one can see what seems to be a reasonably significant gain in absolute public transport use (15 boardings per capita growth), and Vancouver was in fact the only city where the user cost of public transport increased (suggesting that cost may be secondary to other factors in encouraging public transport use).

Looking at the situation between the cities in public transport use, it is very clear that Berlin is the highest with 410 boardings per capita in 2005. The three large Canadian cities perform relatively well for automobile cities, with an average of 189 boardings per capita, the two Australian cities (Melbourne and Sydney) had 120 per capita, while the seven US cities averaged only 51 per capita. These patterns are reflected in other factors such as activity densities, with Berlin the most compact of the cities at 79 persons+jobs per ha, the three Canadian cities here with 40 per ha, the two Australian cities with 25 per ha and the US cities with 20 per ha. Likewise, car usage is lowest in Berlin (3,495 car km per person per year), rising to 5,775 km in the Canadian cities, 7,914 km in the Australian cities and a very large 14,188 km in the seven US cities.

Three key overall findings revealed by these data are that:

(1) there are clearly very large differences in cities around the world in the comparative performance of public transport and the passenger transport system generally, as well as the associated urban form, infrastructure and service characteristics of the transport system;

(2) there are many generally positive trends in these cities in urban form and transport from 1995 to 2005 that need to be continued and strengthened, and;

(3) much more needs to be done to increase the significance of public transport and to reduce car use in order to transform cities into more sustainable urban forms with generally more sustainable transport systems.

There are a number of urban planning and transport related policies and strategies that can be examined in selected cities in this sample that help to characterize and explain what has been happening in these cities over the decade under investigation and what to expect in the future. Together, these help to better understand, explain and respond to the above three points. The next section addresses these matters.

4. Land Use and Transport Policies in The Thirteen Cities: Policy Implications and Conclusions

This section presents the distilled results of a very detailed examination of the transport and land use vision documents on each city set out in Table 6. It is clear when examining these documents for the thirteen metropolitan areas, that they have many very clear policies and strategies that support the growth of public transport and try to minimise further motorisation, though the strength, consistency and mutually supportive nature of the policies varies considerably. The detailed qualitative examination of these documents was conducted under five general topics concerning increasing densities and enhanced sub-centres, the supply of private transport infrastructure, limiting car use, increasing the supply of public transport infrastructure and service and other direct policies to enhance public transport use. These policies were then contrasted against the performance of the land use transport system in each of the cities as depicted in the 1995-2005 data presented in Tables 1 to 5. A full and detailed discussion of each city can be found in Kenworthy and Inbakaran (2011). This section distills some overall perspectives from the policy documents listed in Table 6[3].

It is clear from the data between 1995 and 2005 that there are many positive trends at work in all the cities and these beneficial changes should be noted and built upon. However, it is

[3] Although the data for 1995/6 and 2005/6 represent „snapshots“ from those years, the aggregate nature of most of the data being compared means that year-by-year fluctuations are generally of a smaller nature than the values separated by a whole decade. Urban densities in whole metropolitan regions change slowly, as do most of the other variables and indeed the reason for the updates being separated by 10 years is specifically to ensure enough time for changes of a meaningful magnitude to have occurred, given the intense amount of work involved in performing the update.

clear that there are no cities where all the indicators are trending towards greater sustainability. It is also apparent from policy documents that nearly all cities have policies on land use that are consistent with higher densities, more mixed land use and greater "centredness", with the exception of Montreal. How well they implement the words of those policies is an entirely different matter, but in general the trends over the decade under consideration have been more positive than negative and the trend in declining densities in the post-war period has been either reversed or slowed considerably. What also stands out is that where land use is not densifying, it is hard to get the transport trends going in the direction of more public transport/less car use even if there are some gains here and there (e.g. Montreal, Denver and Washington show this). As has been glaringly apparent for decades, land use must work in concert with transport policies, but the empirical data in this paper demonstrate this quite strikingly at a metropolitan scale.

Table 6. Land use and transport policy/vision documents in the thirteen cities

City	Policy Documents
Atlanta	Envision 6; Plan 2040
Denver	Metro Vision Regional Transportation Plan 2030; Metro Vision 2035 Draft 2011
Houston	2035 Regional Transportation Plan
Phoenix	Maricopa Association of Governments Regional Transportation Plan; 2010 Statewide Transportation Planning Framework
San Diego	2030 Regional Transportation Plan: Pathways for the Future (RTP); Regional Comprehensive Plan (RCP)
San Francisco	Transportation 2035 Plan for the San Francisco Bay Area
Washington	Financially Constrained Long-Range Transportation Plan (CLRP)
Montreal	Transportation Management Plan Greater Montréal Area
Toronto	The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area (GTHA); Places to Grow - Growth Plan for the Greater Golden Horseshoe
Vancouver	Transport 2040; Metro Vancouver 2040 – Shaping our Future
Berlin	Mobil 2010; Land Use Plan (FNP)
Sydney	Connecting the City of Cities (NSW Metropolitan Transport Plan); Sydney Towards 2036–discussion paper update to the (2005) Metropolitan Strategy
Melbourne	The Victorian Transport Plan (2008); Melbourne 2030 – Planning for sustainable growth (2002) + Planning @ 5 Million (2008

In terms of transport policies towards both private and public transport, all the cities have a quite clear commitment to improving public transport and many are focussing their attentions on new rail extensions as well as major improvements to buses. However, when it comes to private transport infrastructure, the intent of the policies are more mixed. Indeed, policy conflicts, inadequacies and inconsistencies are relatively common when one compares the land use, private transport and public transport policies. For example, many cities still have significant road expansion programmes, which can negate or counteract the substantial investments in new transit services. The idea of "planned congestion", or strategically using pinch points and inadequate road connections to leverage a switch to other modes through improvements in these other options alone, seems not to have penetrated the policy consciousness in these cities to any significant degree.

What also seems apparent from the policy overview is that whilst cities are willing to try to densify and diversify/mix their land uses, create polycentric urban forms based on transit-oriented development to support greater walking, cycling and public transport and to make conditions better for pedestrians, cyclists and transit users, there is no evidence of any significant restraint on car ownership or car use. This restraint is lacking in both a physical sense and an economic sense. No city has a programme to remove any major road infrastructure in the way Seoul and many other cities have done in selected "road diet"

projects (see Schiller, Bruun and Kenworthy, 2010), projects that have proven remarkably successful. And none of these cities are advocating the use of any significant economic imposts on car ownership or use in the way for example Singapore has done successfully through its Certifcate of Entitlement and Road Pricing schemes (Newman and Kenworthy, 1999), a path that Shanghai has also been successfully following for some years and is now quite divergent from other Chinese cities in terms of its slow and small growth in cars. Singapore, for example, between 1995 and 2005 has reduced slightly its freeway per capita provision, it has remained stable in car use and car ownership (at very low levels for a wealthy city), even despite a small reduction in city density (from a very high level) and a reduction in public transport use per capita (Kenworthy, 2011). When one considers the data on each of these cities and how in numerous cases the public transport performance and delivery factors have headed in the right direction, and in some cases also aspects of private transport (e.g. reduced parking and freeway provision), but with only a tiny response in terms of an upturn in public transport use, or reduction in car use, it is difficult to ignore restraints on cars as a missing element in the policy mix. In other words, cities can do many things right in terms of providing superior conditions for alternative modes, which are all very important and need to continue, but to get the maximum potential from these “carrots”, there needs to be greater political willingness to impose some of the “sticks” too.

Based on the data evidence in this paper and the review of the policy documents, it can be concluded that these cities, and most likely the majority of cities in the world, need to continue or begin:

• Densifying their land use patterns, both population and jobs and creating mixed land uses, but not in *ad hoc* ways, but rather in strong centres (both CBD and sub-centres) that provide focal points for public transport and which shorten local trip distances sufficiently to be undertaken by walking and cycling.

• De-emphasising major new high capacity road construction and congestion relief as a metropolitan transport policy in favour of strategic use of congestion to leverage gains in green modes and a speed advantage to public transport in particular corridors.

• Removing some high capacity road infrastructure in critical locations where large environmental advantages are to be gained and where alternative transport can be improved and used effectively (see examples of Portland, Vancouver and Seoul in Schiller, Bruun and Kenworthy (2010) which gained large advantages in terms of city image, livability and sustainabilty by scrapping existing freeways or not building them in the first instance).

• Restraining parking supply in the CBD of cities and in sub-centres (not just increasing its cost), in order to reduce car travel demand and improve the public realm so that alternative modes can provide attractive options.

• Imposing economic restrictions on car ownership in line with the true social costs of car ownership. The data show that car travel is being distributed across more and more cars resulting in a reduction in the kilometres travelled per car, but an increase in the space demand and availability of cars.

• Expanding the premium public transport infrastructure of the city in terms of reserved rights-of-way for buses, LRT and trains so as to improve the speed and reliability of services. This will work in concert with de-emphasising major new road capacity.

• Expanding the public transport vehicle fleet to allow service expansion and better comfort levels for public transport patrons.

• Growing the public transport service level through expansion of the network and increasing frequencies (but not through low grade bus services in sprawling suburbs that have to chase ever thinner passenger markets).

• Imposing both physical and economic restraints on car use in parallel with improvements to alternative transport options.

• Radically improving conditions for pedestrians and cyclists in all parts of the city to allow better access to public transport modes and more conducive conditions for walk and bike-only trips.

Unless such policies work together in a coordinated way, the empirical data and qualitative data examined for this paper from individual cities suggests that gains in sustainable transport will be marginal and therefore not of a scale needed to fundamentally alter the nature of the city or contribute in a major way to global sustainability.

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