Sustainable Urban Transport and Land Use Patterns for More Sustainable Cities in Australia: Some Key Policy Implications from An International Comparative Study

A Submission to The House of Representatives Standing Committee on Environment and Heritage Inquiry into Sustainable Cities 2025

by

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INTRODUCTION

Urban transport and the issue of motorisation or “automobile dependence” have become critical shaping factors in the future sustainability and livability of all cities. North American and Australian cities bear the strong imprint of the car in every aspect of their form and function, being characterised by sprawling low density patterns of development that are highly dependent upon the car. However, on a global scale land use and transport patterns in cities vary considerably. Within cities too, urban development patterns can be sprawling or more compact depending, for example, upon whether large freeways or public transport systems lead urban development and whether the planning system encourages consolidation of development around transit. These patterns of urban development have significant implications for water management, land available for food production close to cities and access to quality open space. These implications are not limited to the physical environment, but extend to social factors such as equitable access to affordable transport, severance of neighbourhoods and social isolation in remote, low density environments. Economic impacts include land lost to non-productive urban sprawl and bitumen, congestion costs, transport deaths and so forth (Newman and Kenworthy, 1999).

Analysts and policy makers in all cities need access to high quality, reliable urban data with which to help assess these important issues in cities. In particular, they need to be able to judge their present transport and urban development position, to understand the key factors that lie behind this situation and the main areas that need concerted policy attention.

This submission attempts to provide a summary of the implications and policy ramifications of the **Millennium Cities Database for Sustainable Transport** (Kenworthy and Laube 2001), for the Australian Federal Government’s “Sustainable Cities 2025” inquiry. This database contains comparative data on a wide range of land use, transport, economic and environmental variables for 100 cities worldwide, which are listed by region in Table 1. This submission presents the overall results of an analysis of the database, exploring a wide range of questions related to relationships between different urban factors and their policy implications. The submission does not attempt to present the actual detailed statistical results upon which the implications and policy conclusions are based. These detailed results can be found in an unpublished work by the author from 2001 entitled “Insights into Some Key Transport and Land Use Policy Questions in Cities: A Statistical Analysis of the Millennium Cities Database for Sustainable Transport”.

The thrust of this submission focuses on Objective 5, which is to “develop sustainable transport networks, nodal complementarity and logistics.” It also has significant implications for other objectives outlined for the inquiry such as Objective 7, which is to “provide urban plans that accommodate lifestyle and business opportunities”. Its findings are of central relevance to the overall objectives of the Sustainable Cities 2025 Inquiry.

The **Millennium Cities Database for Sustainable Transport** was compiled over 3 years by Kenworthy and Laube for the International Union (Association) of Public Transport (UITP) in Brussels. The database contains data on 69 primary variables, which depending on the city and the administrative complexity and multi-modality of its public transport system, can mean up to 175 primary data entries. The methodology of data collection for all the factors was strictly controlled by agreed upon definitions contained in a booklet of over 100 pages and data were carefully checked and verified before being accepted into the database. A detailed discussion of methodology is not possible in this submission.

From this complex range of primary factors, some 230 standardised variables have been calculated. Cities can thus be compared across the areas of land use, private, public and collective transport performance, overall mobility and modal split, private and public transport infrastructure, the economics of urban transport (operating and investment costs, revenues), energy and environmental factors. The data are for the year 1995. Data collection on these cities commenced in 1998 and was only completed at the end of 2000. At this point, data for 1995 provides the latest perspective one can reasonably expect for a study of this magnitude.

The list of primary data items that were collected for the study is provided in Appendix 1. Although a detailed account of the study's methodology is not possible here, Appendix 2 does contain definitions of most of the primary data items, including metropolitan area and CBD definitions for all the higher income cities, which are the focus of this submission. Appendix 3 provides the standardised variables calculated from these primary data items. Appendix 4 provides a quantitative summary of some of the key standardised factors examined in the study and averaged for each of the eleven major regions used in the study (both high and low income cities). This allows the reader to gain a sense of the key differences that exist between cities in different parts of the world in terms of the sustainability of their transport systems.

The results presented in this submission are framed around gaining insights into certain key policy issues in urban transport, in higher income cities. Separate analyses were done for the much poorer cities in the overall study and are available from the author but are not generally reported on here because of the focus of the enquiry on Australian cities. Appendix 4, as has already been said, provides summary data on key factors for all groups of cities. These data help to highlight how different the lower income cities are from the wealthier cities in more developed parts of the world.

The discussion in this submission therefore confines itself chiefly to cities in Australia and New Zealand, the USA, Canada, Western Europe and the higher income cities of Asia (see Table 1 for the cities that were included). Of the 100 cities in the study, full data were collected for 84 cities (58 higher income cities and 26 lower income cities) and it is these cities that have been used in the analysis from which conclusions are drawn. Cities marked with an asterisk in Table 1 are the cities for which full data were collected.

The results of the statistical analysis suggest a series of implications for land use, transport, infrastructure, economic, and environmental issues in cities, which are of direct relevance to the terms of reference of the Sustainable Cities 2025 inquiry. All the implications reported in this summary have a statistical significance of 5% or better. From these implications flow a range of recommended urban policies that are presented in this summary. The special value in these policy recommendations is that they are backed up by the world's most detailed and extensive database on transport and land use ever developed for such a wide range of cities worldwide.

The author has many other already published books, papers and book chapters which describe in more detail how the policies discussed below have been enacted in cities around the world. Accompanying this work, the author also has a rich resource of visual material from many cities showing the positive results for the urban environment of reducing automobile dependence and developing more around public transport, walking and cycling.

WESTERN EUROPE	WESTERN EUROPE	HIGH INCOME ASIA	US/ CANADA
			USA
Graz *	Milan *	Osaka *	Atlanta *
Vienna *	Bologna *	Sapporo *	Chicago *
Brussels *	Rome *	Tokyo *	Denver *
Copenhagen *	Turin	Hong Kong *	Houston *
Helsinki *	Amsterdam *	Singapore *	Los Angeles *
Lille	Oslo *	Taipei *	New York *
Lyon *	Lisbon		Phoenix *
Nantes *	Barcelona *	**AUST/NZ**	San Diego *
Paris *	Madrid *	Brisbane *	S. Francisco *
Marseilles *	Stockholm *	Melbourne *	Washington *
Berlin *	Bern *	Perth *	
Frankfurt *	Geneva *	Sydney *	**CANADA**
Hamburg *	Zurich *	Wellington *	Calgary *
Dusseldorf *	London *		Montreal *
Munich *	Manchester *		Ottawa *
Ruhr *	Newcastle *		Toronto *
Stuttgart *	Glasgow *		Vancouver *
Athens *			
LOW INCOME ASIA	**LATIN AMERICA**	**AFRICA**	**EASTERN EUROPE**
SE/E ASIA			
Manila *	Buenos Aires	Abidjan	Prague *
Bangkok *	Rio de Janeiro	Casablanca	Budapest *
Mumbai *	Curitiba *	Dakar *	Krakow *
Chennai *	Sao Paulo *	Cape Town *	Warsaw
New Delhi	Brasilia	Johannesburg *	Moscow
Kuala Lumpur *	Salvador	Harare *	Istanbul
Jakarta *	Santiago		
Seoul *	Bogota *	**MIDDLE EAST**	
Ho Chi Minh City *	Mexico City	Tel Aviv *	
	Caracas	Teheran *	
CHINA		Riyadh *	
Beijing *		Cairo *	
Shanghai *		Tunis *	
Guangzhou *			

Table 1. Cities represented in the Millennium Cities Database for Sustainable Transport by Region.

IMPLICATIONS OF THE "MILLENNIUM CITIES DATABASE FOR SUSTAINABLE TRANSPORT" FOR THE "SUSTAINABLE CITIES 2025" INQUIRY

(1) URBAN FORM AND URBAN TRANSPORT PATTERNS

Urban form and its relationship to urban transport is widely debated in urban policy circles. Urban form emerges in this study as a critical factor in understanding urban transport patterns. The urban form factors of urban density, job density and proportion of jobs in the CBD of cities have the clearest and strongest relationships to urban transport patterns of all factors in the study. The results are stronger and clearer in developed, or wealthier cities, than in developing or less wealthy cities.

Implications – Urban Form and Transport in High Income Cities

Higher densities and greater centralisation in higher income cities are uniformly associated with more environmentally, socially and economically sustainable transport systems. Denser cities have lower levels of private mobility and higher levels of mobility by public and non-motorised modes, as well as taxis and motor cycles. Travel distances are shorter overall, and for the journey-to-work. They have much less extensive provision of infrastructure for private mobility and much higher provision for public transport, especially segregated rights-of-way for public transport operations (mostly rail). They have lower energy use and external costs from their transport systems and they pay less for their urban transport, despite the fact that private transport costs are higher on a per kilometre basis in higher density environments.

Policy recommendations for urban form in high income cities

Cities need to adopt land use policies that limit the spread of their urbanised area through urban growth boundaries and green belts, and provide active incentives for urban redevelopment and consolidation in existing areas. Both jobs and population growth should focus on centres, both the main CBD and other sub-centres throughout the urban area. These centres will naturally favour access by public transport and non-motorised modes, but this tendency needs to be supported by physical planning policies that give priority to these modes and seek to limit private car access.

(2) FREEWAYS, CONGESTION, PARKING SUPPLY AND URBAN TRANSPORT PATTERNS

The provision of urban freeways and the ancillary parking areas that must be supplied, especially in central city areas, are major policy issues that confront cities in the developed and developing world. Provision of this infrastructure for private transport is still seen as offering an immediate palliative to the vexed issue of traffic congestion and the need to retain the economic competitiveness of core areas for office and business location, and to attract shoppers. In this sense, congestion is almost universally viewed as a negative condition in cities, to be minimised at all costs.

The analysis in this study casts a negative light over both freeways and the open-ended pursuit of more parking in the CBD of cities. It also seriously challenges the black and white view that congestion in itself is a negative factor in cities.

Implications – Freeways and Urban Transport Patterns in High Income Cities

Freeways and transport patterns

Increasing freeway provision in high income cities is associated with all the hallmarks of automobile dependence. Freeways are associated with more extensive road systems overall and more parking in the CBD. They appear to promote higher car ownership and car use (but less motor cycle use) and a higher overall daily trip-making rate, especially in cars. Freeways are associated with lower provision of public transport service and lower public transport use. Higher freeway provision is associated with a proliferation of low quality bus lines and greater orientation to park-and-ride systems, both of which do little for transit service, quality or usage. In keeping with their negative effect on public transport, more freeways are associated with lower levels of segregated rights-of-way for public transport, which in effect means less rail systems. As a result, public transport speeds are less competitive with general traffic speed in freeway-oriented urban areas, while car speeds are higher. Freeways are also associated with lower use of non-motorised transport and lower supply and use of taxi services. Finally, cities that build freeways can expect to have longer car trip lengths, overall longer travel distances for all trips and especially longer journeys to and from work.

Freeways and the economics of urban transport systems

Greater freeway provision is associated with an apparent host of economic advantages to private transport, but only in a very limited and ultimately counter-productive context. More freeway-oriented cities tend to have lower fuel prices, lower on-street parking charges and lower parking fines in central city areas. They also have lower operating costs per kilometre of travel and lower user costs per kilometre travelled. However, due to the tendency of freeways to generate greater private transport use and to have deleterious effects on public transport and non-motorised transport, the private transport operating costs per capita and as a proportion of a city's wealth or GDP, increase as freeway provision rises. Furthermore, the total costs that a city incurs for passenger transport, in other words, the total operating and investment costs for private and public transport, increase with increasing freeway provision. In an urban system sense, freeways promote greater spending on passenger transport in order to achieve the same transport ends.

In addition, freeways appear to have a direct association with negative impacts on the economic performance of public transport. More freeway-oriented cities have higher public transport operating costs per passenger kilometre and lower average farebox revenue per vehicle kilometre and per passenger kilometre. Furthermore, higher provision of freeways is associated with lower per capita investment spending on public transport and lower public transport investment as a proportion of city wealth or GDP. And very importantly, the ratio of spending on public transport compared to spending on roads is lower in cities with more freeways.

The implication is that cities which orient themselves more around freeways, actually end up producing an economically counter-productive urban transport system. They spend more on achieving the aim of providing proper passenger transport services for their citizens, and they appear to drain money away from investment in new or refurbished public transport systems, and direct it towards greater spending on constructing and maintaining roads.

Freeways and energy and external costs

More extensive freeway systems in cities are associated with negative energy, emissions and transport death outcomes. Freeway-oriented cities have higher per capita private passenger transport energy use and higher per capita transport emissions. On a more positive note, cities with more freeways have lower transport death rates per vehicle kilometre and per passenger kilometre, but unfortunately this is not reflected in any statistically significant reduction in per capita transport deaths. It appears that increasing car use, and thus automobile exposure, tends to cancel out the better safety performance on a per kilometre travelled basis, so that no real safety benefits can be claimed from urban freeways.

Policy recommendations in relation to urban freeways

All cities appear to reap negative consequences for more sustainable transport from increasing their freeway provision. Any possible individual or sectoral benefits in economic, environmental or social terms, appear to be overwhelmed in a systems sense. The result is that residents of more freeway-oriented environments simply travel more, pay more for that travel, pollute more and do more damage to public transport and other modes than residents of less freeway-oriented cities.

All cities should therefore enact policies that minimise or eliminate altogether, new freeway construction. The City of Vancouver is an example of a city in an auto-oriented culture that has successfully banned freeways within its borders and has reaped enormous benefits in terms of public transport, walking and cycling and high quality mixed use urban re-development. If freeway development is not eliminated or minimised, then any new freeways constructed should be used primarily for the purpose of commercial and freight traffic, with appropriate restrictions on private cars, as in Singapore. Furthermore, consideration should be given in cities with existing freeways, to the imposition of disincentives and restrictions on the movement of private passenger transport. Finally, freeways offer ready-made alignments for the development of new busways and passenger rail services where these are lacking. Cities should therefore give serious consideration to the reclamation of freeway lanes for the provision of urban rail and busway systems. This should be done with no reconstruction of removed lanes. There would therefore be a net reduction in freeway capacity, but a net increase in people-moving capacity of the transport system through the new busway or rail line.

Implications – Congestion and Urban Transport Patterns in High Income Cities

Measuring congestion levels on a metropolitan scale is an imperfect science at best. However, a number of factors are used in this study that indicate the level of intensity with which roads in a city are used, and the average speed that results from this usage pattern. Collectively they provide an insight into relative congestion levels between cities and permit some statistical and policy explorations.

Congestion and transport patterns

The results in this study clearly indicate that as congestion increases, there is less car use, more motor cycle use, more public transport use, more use of non-motorised modes and more taxi use. Moreover, more congested cities are linked with shorter travel distances across the board and lower public transport trip times, due in no small part to the development of superior public transport systems with protected rights-of-way, mostly rail. Naturally, congested cities also have longer duration car trips. Conversely, higher average speed of traffic is associated with more car use, less motor cycle use, less public transport use, less taxi use and less use of non-motorised modes. It is also linked to higher trip distances and shorter car trip times.

Overall, the results suggest that congestion acts as a brake on per capita car use. Congestion encourages greater motor cycle use, and works in favour of public transport and taxis, but only where these options offer speed advantages with respect to cars stuck in congested conditions, and where parking is limited. This is often the case in more congested high income cities, since they commonly have urban rail systems, or less frequently, busways.

It can be said that whilst lower congestion provides better average speed of private travel, and thus on average, shorter car trip times for individual car commuters, the urban system effect is negative, since it encourages less sustainable transport patterns as a whole. The reverse is true for cities that are more congested.

Congestion and the economics of urban transport systems

Overall, it can be said that in high income cities, less congestion appears to work in favour of lower private transport operating costs for individual cars through lower per kilometre costs. However, for the urban system as a whole, the overall cost of passenger transport increases due to increased private transport usage. As well, congestion appears to encourage greater investment in public transport systems and while congestion also increases the operating costs of public and private transport per kilometre, cities with higher congestion spend less money overall on passenger transport. This appears to be due to a suppressing effect of congestion on private travel and a greater shift to more economically efficient public transport and non-motorised modes. The reverse is naturally true for cities as they increase their average speed of traffic through measures to increase road capacity. This benefits individual car users in cheaper per kilometre costs, but creates disbenefits for the urban system as a whole, such as greater overall outlays to run the urban passenger transport system, which in turn creates a competitive disadvantage.

Congestion, energy and external costs

Overall, the results in the high income cities suggest that rather than saving fuel, reduced congestion increases fuel use through its tendency to favour cars, increase urban sprawl and reduce the viability of other modes. It also tends to increase transport emission rates per person and transport death rates per capita, despite improvements in the latter on a per vehicle kilometre and passenger kilometre basis.

Policy recommendations on congestion in high income cities

It would appear that congestion is not the totally negative social, economic and environmental phenomenon it is often portrayed as. In an urban system, congestion acts as a mechanism that limits the growth in automobile dependence. All things being equal, it tends to promote the search for alternatives to private car use, be that a better public transport system or better land use and environmental conditions for walking and cycling. The result tends to be a more sustainable urban transport system as a whole. Naturally, the reverse situation of increasing average speeds, which has been the trajectory for motorising cities over many decades, tends to push urban systems to a less sustainable condition. The notion of "slow cities" seems to gain some significant support from this research.

The policy recommendation is therefore that all cities need to carefully review the issue of congestion and its perceived negative consequences on travel patterns, the economy, and the environment of cities. Only in this way will they be able to pursue the best policy responses to congestion, policies that will be more in line with a well-functioning urban system as a whole. Policies need to be less concerned with removing congestion per se, but rather be aimed more at promoting a better speed-competitive position for public transport and more attractive conditions for walking and cycling. This will generally mean far greater attention to public transport systems with protected rights-of-way, and superior facilities for pedestrians and cyclists, through traffic calming, pedestrianisation and bicycle facilities. The analysis from this database even suggests that there is a case for strategic "planned congestion" in critical areas around the city. At these points public transport and non-motorised modes would be provided with the speed advantage they require with respect to private transport. This of course will run counter to the normal response of widening a road, building a bypass or adding a new river crossing to relieve congestion. The alternative approach suggested here will tend to promote a better equilibrium between all modes and a more sustainable urban transport system.

Implications – CBD Parking Supply and Urban Transport Patterns in High Income Cities

CBD parking supply and transport patterns

The analysis suggests that the more parking a city has in its centre, the greater is the overall orientation of the urban region to private transport, in both transport infrastructure and use. It also suggests that public transport infrastructure, service levels and use are all consistently lower under a high parking regime in the city centre. The latter pattern may be understood in the sense that more centralised cities with a greater quantity and quality of public transport service to the city centre (and this typically means an emphasis on rail-based public transport), tend to have less parking supply. Indeed, they have less need for parking when large numbers of people can be delivered to a confined location by a high-capacity public transport system. Of course, central city bound trips tend still to be a major market share for public transport, even though CBDs are typically diminishing in their share of metropolitan-wide jobs. When there is less parking in a city centre, public transport can compete more effectively for this market share.

CBD parking supply and the economics of urban transport systems

The analysis in higher income cities suggests that as CBD parking supply increases, public transport systems collect less revenue per unit of service and per user, and have greater operating costs per passenger km. The cities spend less on investing in public transport, and they spend less operating their public transport systems because they don't supply as much service. As well, cities with higher parking in their CBD spend proportionately more of their wealth on total passenger transport (private and public transport, operating and investment costs).

CBD parking supply, energy and external costs

Cities that provide more CBD parking have higher private transport energy use per capita and per kilometre of travel, higher transport emissions per capita and greater transport deaths per capita. They also have lower public transport energy use per capita due to lower supply and greater public transport energy use per vehicle kilometre and passenger kilometre. All these results link to the greater automobile dependence and lower orientation to public transport of cities with a generous supply of CBD parking.

Policy recommendations on CBD parking supply in cities

CBD parking supply clearly has an impact on metropolitan scale urban transport patterns. The greater the supply, the less sustainable is the urban transport system. In particular, more CBD parking acts deleteriously upon the role of public transport in the urban system and the economics of its operations. Furthermore, restricting CBD parking supply is a key policy lever that can help encourage the development of high capacity, high quality, radial public transport systems. Such systems still have a key role to play in the overall transport market, despite a general decline in the proportion of jobs to be found in the CBD of cities. This is especially true for lower income cities where, as a rule, jobs have dispersed less and a very strong market for public transport still exists in the central area.

Cities should therefore place a cap on the provision of CBD parking supply, allowing job growth to occur without further growth in parking. They should also actively pursue the possibility of building out existing parking lots with residential development, as has happened in a number of cities such as Toronto and Portland, Oregon. This will enhance the market for public transport and promote walking and cycling to work by the new residents, or reverse commuting on public transport. Such a policy needs to be enacted in conjunction with firm strategies to discourage private transport and improve public transport services into the CBD. Conditions for pedestrians and cyclists also need to be improved through better urban design, pedestrianisation and traffic calming in city centres.

(3) PUBLIC TRANSPORT SERVICE FACTORS AND URBAN TRANSPORT PATTERNS

It is clear from this study that urban form, as well as private transport infrastructure and operating conditions, influence overall transport patterns and the balance that exists between travel modes in cities. The other major player in this whole equation is, of course, public transport itself and the extent of its infrastructure and quality of the services it offers.

Implications – Public Transport Service Factors and The Use of Public Transport and Taxis in High Income Cities

The analysis shows that as all public transport service supply factors such vehicles per capita, vehicle kilometres and seat kilometres per person and per hectare, as well as the ratio of public transport speed to general road traffic speed, increase, so does public transport use. In particular, the spatial intensity of public transport service is by far the strongest explanatory factor in the modal share of public transport in cities. It is virtually the strongest statistical relationship in the whole study. In addition, an increasing extent of reserved public transport right-of-way per (person and per hectare), is also linked to increasing public transport use. This latter factor is primarily measuring the extent of rail in cities, since genuine, fully segregated busways are quite uncommon in cities. These same factors of greater public transport service and infrastructure are also associated with greater non-motorised mode use in cities, as well as fewer total daily trips per capita. This would appear to be in line with ideas that suggest that more compact public transport-oriented environments built around transit stops in cities which have more extensive fixed route transit systems, are symbiotic with good pedestrian and cycling environments. Cities that provide better public transport systems also experience shorter overall trip distances, shorter journeys-to-work, higher car trip times and higher average public transport trip distances, but not higher public transport trip times. This is probably due to more frequent and longer rail journeys at higher speeds in cities where public transport is strongest.

The analysis shows, on the other hand, that the extent of park-and-ride facilities is negatively linked with public transport use (and non-motorised mode use). Furthermore, the length of actual public transport lines per capita bears no relationship to public transport use. It would appear that an increasing supply of poorly serviced public transport (bus) lines does little to promote usage, but this is, unfortunately, a trend in some cities. Fewer, better located, better serviced and physically segregated public transport lines appear to be more successful at promoting use. At the same time that increasing public transport service and infrastructure promotes more public transport use, taxi use also increases. This is not necessarily due to any direct inherent link or benefit derived by taxis from public transport service *per se*. However, it does tend to suggest that the two systems are not in direct competition. Rather, it suggests that they are in some way complementary in cities that have less cars and less car use (eg someone taking public transport to work, but needing to make a trip during the day that is not convenient by public transport may use a taxi).

Implications – Public Transport Service Factors and The Economics of Operating and Building Urban Transport Systems in High Income Cities

The analysis of public transport service factors in relation to the economics of urban transport reinforces the idea of a **virtuous circle** for public transport in higher income cities. That is, more transit investment, a more extensive reserved route system (mostly rail), and greater service provision are associated with greater usage and better economic performance of transit (higher farebox returns and lower operating costs per kilometre). In particular, greater speed competitiveness, usually through urban rail systems, equates to higher economic returns within the public transport system and a generally better picture for the mode, indicative of a more central role for transit within urban transport systems.

In other words, if cities want public transport to perform better economically, it is more prudent to invest in a better system and to expand services in order to bring public transport into a more pivotal role within the urban system. This stands in contrast to the "slash and burn" mentality that has occurred in many cities as a response to declining use and economic performance of public transport. Such cities have sought to cut service in order to reduce costs, only to find that public transport is further marginalised, both in market share and economic performance.

Implications – Public Transport Service Factors and The Energy and External Costs of Transport Systems in High Income Cities

As would be expected from the previous results, increasing public transport infrastructure and service are linked to lower private transport energy use, lower emissions and fewer transport deaths in cities. Greater public transport line length and more park-and-ride facilities in cities are not, however, associated with any such benefits.

Policy recommendations for public transport service factors in high income cities

It is clear from this comprehensive international study that the role which public transport can potentially play in high income cities is directly linked to the confidence and investment that are bestowed upon it through the policy and planning process. Only under increasingly superior service regimes can public transport expect to compete actively with private transport for modal share and to provide cities with the economic, environmental and social gains of which public transport is capable. In particular, the provision of public transport systems with fully protected rights-of-way, is paramount. It is only through these systems that public transport can compete in the most fundamental service quality factor – better speed compared to the car. It is therefore recommended that cities actively pursue development of new fully segregated tram, LRT, Metro, suburban rail and busway systems, as appropriate. Cities must also strive to improve the service density of public transport and to offer superior service quality in all facets (vehicles, stops, information systems etc), to build a "virtuous circle" for public transport.

(4) ECONOMIC FACTORS AND THEIR RELATIONSHIP TO URBAN TRANSPORT AND LAND USE PATTERNS

The data in this study provide an opportunity to explore the impacts of various economic factors on urban transport patterns. The factors examined are the wealth of cities (GDP per capita), the costs of private and public transport, and the level of investment in roads and public transport.

• WEALTH AND URBAN FORM

Implications – Wealth and Urban Form in High Income Cities

Despite claims that increasing wealth will tend towards greater urban sprawl and automobile dependence as residents of cities develop the financial capacity to buy more space, this study finds no significant relationships between any of the key indicators of urban form and the wealth of cities. Many people opt to exploit greater wealth in order to purchase housing in more spatially constrained, but better located, more culturally rich and diverse central and inner locations (eg an apartment in Manhattan or central Paris, compared to a mansion on a 1 acre-plus property on the urban fringe. Such choices are now alos evident in Australian cities, especially Sydney and Melbourne). Any potential relationship between urban form and wealth is thus confounded by quite complex and heterogeneous location and lifestyle choices.

Policy recommendations for wealth and urban form

Denser urban forms are clearly associated with more sustainable transport patterns on virtually every urban transport indicator. It is particularly important therefore, that as cities become wealthier, that they provide attractive high density living opportunities to ensure that those with the financial capacity to make location and lifestyle choices, have the opportunity to live in attractive compact urban environments. If the only attractive residential opportunities for those with higher incomes are sprawling, low density communities, particularly distant gated communities or "golf course estates", then this will work against sustainable transport. It will also tend to deteriorate urban transport options for those on lower incomes through increasing traffic and congestion and a lower quality public realm. It is recommended that the environmental quality of existing and planned high density environments be optimised at every opportunity in order to increase the number of people at all income levels living in more compact communities.

• WEALTH AND URBAN FREEWAYS

Implications – Wealth and Urban Freeways in High Income Cities

There is absolutely no relationship between the wealth of cities, expressed as GDP per capita, and the level of freeway infrastructure provided. It is a conscious policy decision in cities as to whether to build freeway infrastructure. Both wealthy and less wealthy cities within the higher income sample make decisions in favour of and against freeways, depending on their vision for the future of the city. Cities in this group tend to have strong physical planning capabilities, governance arrangements and civil society groups, which make it possible for them to better exercise such choices.

Policy recommendations on wealth and urban freeway provision

The results suggest that there is no inherent or inevitable relationship between rising wealth and freeway provision in higher income environments where governance and planning capabilities are well developed. Decisions to build or not to build freeways are policy driven, irrespective of wealth levels. Where decision-making may be more susceptible to the undue influence of road interests, then a rising level of affluence may result in significant freeway construction. In keeping with previous recommendations, all cities regardless of their wealth, should minimise or eliminate altogether the construction of new urban freeways if the goal of more sustainable transport is to be realised. Existing freeway capacity should also be cut back by exploiting freeway capacity for some form of mass transit.

• WEALTH AND URBAN TRANSPORT PATTERNS

Increasing wealth is often thought to be associated with an inevitable move towards greater automobile dependence. The results in this study within the higher income cities runs counter to this.

Implications – Wealth and Urban Transport Patterns in High Income Cities

Unlike the physical factors already discussed, wealth or GDP per capita has a very weak association with macro-scale transport patterns. In any case, where significant relationships occur, they are in a direction that perhaps runs counter to conventional wisdom. For example, the significance of public transport, walking and cycling actually increases rather than diminishes with increasing wealth within the high income cities.

Implications – Wealth and The Economics of Operating and Building Urban Transport Systems in High and Low Income Cities

Results of this analysis are consistent across all cities and within the high and low income groups. Greater capacity to pay results in more per capita expenditure across the board on passenger transport in cities. However, this is not reflected in a higher proportion of city wealth being spent on passenger transport in higher income cities because the GDP per capita, as cities become wealthier, overwhelms the influence of this higher expenditure. The analysis also suggests that as wealth increases across all cities, the proportion of wealth spent on public transport investment decreases and the cost of public transport for the user rises relative to the user cost of cars.

Policy recommendations on wealth and urban transport patterns

Growing wealth in cities is clearly a force to be reckoned within urban transport policy, one that can tend towards greater automobile dependence and lower use of public transport and non-motorised modes, if market forces or vested interests alone are allowed to hold sway. However, this analysis suggests that there is nothing inevitable about growing wealth that will lead to consequences that are against more sustainable urban transport systems. Cities need to ensure that the expanding capacity to pay for urban travel that comes with greater wealth is accompanied by a genuine choice for citizens in their travel mode. This can be seen, for example, in many very wealthy cities in Europe (eg Zurich) and Japan (eg Tokyo), where quality public transport systems and attractive opportunities for walking and cycling have grown hand-in hand with increasing wealth. In other words, greater wealth can just as easily be expressed in the development of high quality public transport systems such as new rail systems, pedestrianisation and traffic calming schemes, facilities for bicycles and a better public realm, as it can in rampant motorisation. Public institutions in all cities need to be constantly about safeguarding and strengthening their planning capacities and facilitating citizen-based processes that allow such choices to be expressed and acted upon.

• THE COSTS OF TRANSPORT AND THE USE OF PRIVATE AND PUBLIC TRANSPORT

The costs of both private and public transport are frequently cited as important factors in the relative use of these modes. The comprehensive economic data in the database allows these issues to be explored in detail across a representative sample of world cities.

Implications – The Costs of Private Transport and The Use of Private Transport in High Income Cities

It can be concluded from the extensive data in this study that within the high income cities, the cost of private motoring appears to influence the extent of use of private cars, which diminishes as costs become more punitive. It also appears that motor cycles become more attractive in a high car cost regime. As the price of fuel alone rises, there is also a dampening effect on private car use and an increase in motor cycle use.

Implications – The Costs of Public Transport and The Use of Public Transport in High Income Cities

The cost of public transport to the user of public transport is not a significant determining factor in a city's overall comparative use of public transport *in higher income cities*. Public transport use seems to be influenced more by urban structural factors and policy environments that determine how competitive and attractive public transport is compared to other modes. This is not to say that in particular circumstances in certain cities, pricing decisions on public transport fares have no impact. Clearly they can, but such effects are, it would seem, not strong enough to determine a city's overall performance on public transport use compared to other cities, or to counteract differences between those cities in more important or fundamental factors. Public transport user costs are also important for equity reasons, in that fare levels should not exclude the use of public transport by lower income groups. Interestingly however, higher farebox revenue per boarding and per passenger kilometre is associated with *higher* public transport use in high income cities. This is a little counter-intuitive in the sense that higher farebox revenue per boarding and per passenger kilometre is more an indication of higher transit charges to the user. This would normally be thought to reduce the attractiveness of public transport. A possible conclusion here is that people are prepared to pay more for a higher quality service and this can result in higher, not lower use of public transport, where a high enough proportion of the population have the capacity to pay. Finally, public transport use does appear to benefit from higher fuel prices in cities.

Policy recommendations on private transport costs

This study suggests that higher costs of private transport do have a significant dampening effect on automobile dependence, though motor cycle use increases in response to this in higher income cities. It is therefore recommended that the pricing of private transport be increased to better reflect its true costs to the urban system. It is further recommended that this be a tool to be used in conjunction with the development of less auto-dependent urban forms and better alternatives to the car to promote more sustainable transport. The results of this study clearly indicate that physical planning approaches and economic approaches to reducing private transport and enhancing public transport and non-motorised modes will work much more effectively when combined, than if they are deployed separately, or at odds with each other. It is, however, very important in increasing the costs of private transport, to ensure that this is done equitably in both high and low income cities. The best way to ensure this outcome is to provide high quality, convenient and accessible alternative modes of transport to the car and motor cycle in all areas of the city and for as many daily trips as possible.

Policy recommendations on public transport costs

This study indicates that higher user costs of public transport in high income cities has no bearing on usage. In fact, it tends to suggest that people are prepared to pay more for higher quality public transport and to use it more. In high income cities it is recommended that higher quality public transport alternatives be aggressively pursued, even if this means the charging of higher fares to offset increasing costs. Whilst doing this, it is also recommended that appropriate social policies be adopted to ensure affordability for lower income groups.

• TRANSPORT INVESTMENT AND TRANSPORT USAGE PATTERNS

The database has examined the possible influence of different levels of investment in roads and public transport in different cities to see if there is a discernible relationship between these factors and the use of the different modes.

Implications – Road Investment and Private Transport Usage in High Income Cities

The road investment variables do not bear significant relationships to private transport use in the high income cities. The only relationship that suggests some significance is the relative investment in public transport compared to roads. As this factor increases, car and total private transport use diminish (and motor cycle use increases, in line with previous discussions). It may be that private transport use is less sensitive to the level of road investment because a proportion of this investment is for maintenance of the existing system, not new construction. Road maintenance spending would not be expected to have a strong direct impact on road usage.

Implications – Public Transport Investment and Public Transport Usage in High and Low Income Cities

The results obtained for the impact of public transport investment on public transport use in cities are highly consistent across both high and low income cities. Greater investment in public transport leads consistently to higher per capita public transport use. The results for public transport may be stronger and clearer than for roads because essentially all the dollars spent have a direct and tangible impact on the quality of public transport, even that of maintenance (eg refurbishment of vehicles and stops). Construction of new lines and purchase of new, more attractive rolling stock will tend to attract greater patronage.

Policy recommendations on road and public transport investment

Greater road investment tends towards higher dependence on private transport in low income cities, but the same result for high income cities is not apparent. We do know however, from previous results, that more freeways are associated with greater automobile dependence. In this sense road investment in the construction of new high capacity roads should be minimised in all cities, or perhaps eliminated in favour of public transport investment. Greater investment in public transport is associated with clear and consistent benefits in all cities in terms of increased use.

It is recommended that in all cities, public transport investment should have priority over road investment, if sustainable transport is to be realised. This investment should cover strategic investment in the walking and cycling facilities needed for people to gain efficient, safe and comfortable access to public transport systems.

(5) INTERMODAL INFLUENCES ON TRANSPORT PATTERNS

The database provides an opportunity to explore various intermodal interactions. An examination was thus made of the possible interactions between private transport factors and the use of taxis and public transport factors and the use of non-motorised transport.

• PRIVATE TRANSPORT FACTORS AND THE USE OF TAXIS

Implications – Private Transport Factors and The Use of Taxis in High and Low Income Cities

Regular taxi numbers and use are suppressed in high income cities by higher car ownership and use, whereas they increase with increasing motor cycle ownership and use. Shared taxis do not feature significantly in these results. The only significant relationship with shared taxis in high income cities is, that as the number of kilometres travelled per motor cycle increases, so does shared taxi supply and use. This perhaps suggests that in developed cities, an increasing usage of motor cycles, as an alternative to the car, may also be associated with the emergence of shared taxis as a further needed alternative to private transport. In terms of economics, the analyses suggest that a higher cost regime for private transport, including higher fuel prices, does tend to be associated with a stronger taxi industry and a greater role for regular taxis in higher income cities (including a small association with increasing shared taxi use too).

Policy recommendations on taxis

It would appear to be generally true that increasing levels of private car ownership and use in cities tends to suppress the significance of the taxi industry, be it regular or shared taxis. In general, it can be said that for a door-to-door 'private transport' type of trip, a taxi or shared taxi trip is probably a more economically and environmentally efficient way of providing the service (compared to the ownership, storage and operation of one extra car within the urban system). Increasing significance of taxis, along with motor cycles, appears to be symptomatic of an urban system in which automobile dependence is not as advanced or is being better managed. From previous analyses, it is also seen that taxis and public transport do not appear to compete with one another, but rather to have complementary roles. It is recommended therefore that cities seek to optimise the role which taxis can play within the urban system, especially in relation to helping to feed the public transport system in lower density, less accessible areas, and as a way of helping to minimise private car ownership and use. Taxis can also perform an important niche role for particular groups of people for whom using public transport is very difficult or in some cases, impossible (eg people with disabilities).

• PUBLIC TRANSPORT USE AND ITS RELATIONSHIP TO NON-MOTORISED MODES

Implications – Public Transport Use and Non-Motorised Mode Use in High and Low Income Cities

High public transport use environments also tend to be high non-motorised mode usage environments in high and low income cities alike. This is very much stronger for foot trips than bicycle trips.

Policy recommendations on public transport use and its relationship to non-motorised modes.

The strong link between public transport and non-motorised modes is significant in policy terms, in the sense that enhancement of either or both of public transport and non-motorised transport will tend to be associated with positive synergies between them. This will result in a greater modal share to these modes in cities and hence greater urban sustainability. It is recommended that strategies to improve the modal share of public transport and non-motorised mode use be undertaken in a coordinated fashion. For example, an excellent public transport system is of much less value if the public realm around that system, through which people have to walk or ride a bike, is unattractive or dangerous. Coordinated policies on walking, cycling and public transport will reap synergies that exist between the modes.

(6) MODAL INFLUENCES ON TRANSPORT EXTERNALITIES

The database allows an examination of the effects of different modes on important transport externalities. The two analyses undertaken are between private transport factors and emissions and transport deaths and between non-motorised transport and transport deaths.

• PRIVATE TRANSPORT USE AND TRANSPORT EXTERNALITIES

Implications – Private Transport Use and Transport Externalities in High Income Cities

An increasing ***level of motorised mobility in cars*** is associated with increasing per capita levels of all emissions, but a falling level of total emissions per urban hectare (due to lower density cities having more car travel and more geographically dispersed emissions). It is also linked to increasing per capita fatalities in transport, but declining fatalities per vehicle kilometre and passenger kilometre. In other words, high income cities with more car travel are associated with greater overall exposure to road traffic and thus higher deaths, even though on a per kilometre travelled basis, their road traffic systems are safer and better managed. Of course, it can also be argued that pedestrians and cyclists in high traffic environments have retreated from the public realm and this may contribute to the lower death rate per vehicle kilometre and passenger kilometre.

When the ***motor cycle kilometres per capita*** is examined as a separate component of private mobility we find that the picture is different. Increasing motor cycle kilometres per capita is associated with lower emissions per capita and higher emissions per urban hectare. The reason for this is that higher motor cycle use in high income cities is itself an indication of lower levels of overall private mobility and generally denser cities within this category. More motor cycle use is also linked to higher transport deaths per capita and per vehicle kilometre and passenger kilometre, which is some support for the idea that motor cycles tend to be more dangerous modes of motorised transport.

Policy recommendations on private transport use and externalities

Overall, increasing private mobility increases transport externalities, regardless of the quality of vehicle technology or strength of the regulatory environment. This is so despite the high income cities having some apparent reduction in transport deaths per kilometre of travel as car use increases. It is recommended that to reduce emissions and transport deaths in cities, improved technologies and a reduction in automobile dependence be pursued simultaneously.

• NON-MOTORISED TRANSPORT AND TRANSPORT DEATHS

Implications – Non-Motorised Modes and Transport Deaths in High and Low Income Cities

In the high income cities, as the level of both walking and cycling increases, this is actually associated with fewer transport deaths per capita, not more. There is one positive correlation between the proportion of daily trips by non-motorised modes and the transport deaths per vehicle kilometre, which suggests a higher death rate as walking and cycling become more important. However, this is not reflected in the per capita transport deaths, which trend in the opposite direction. The results in low income cities are largely similar, where the data show that as bicycling becomes more important, per capita transport deaths actually decline. However, the death rate per kilometre of private motorised travel increases as walking and cycling increase in a city. This result may be different if the death rate per kilometre actually reflected the kilometres of travel contributed by non-motorised transport.

Policy recommendations on non-motorised transport and transport deaths

The database suggests that there is nothing intrinsically unsafe about walking and cycling where an increasing amount of it occurs, and where the urban environment supports this activity through safer, traffic calmed and pedestrianised streets. It is recommended that non-motorised transport be encouraged for its potential safety benefits, as well as its broader sustainability and health advantages. It is further recommended that cities constantly strive to ensure that existing urban environments are retrofitted for greater pedestrian and cyclist safety and urban amenity, and that new development is optimised for these modes.

(7) SUMMARY

This submission has attempted to provide a policy perspective on a wide range of factors at work in urban areas that help to determine their degree of sustainability, especially in relation to transport. The data tables in Appendix 4, which summarise a number of the key transport factors discussed in this submission, allow the reader to see the vast range in automobile dependence and associated factors that exists across the world's cities today. These data show Australian cities to be amongst the world's most automobile dependent urban environments. The submission has provided important perspectives on the interlinked factors of urban form, wealth, private and public transport infrastructure, the economics of urban transport systems (investment and operating costs) and other key variables and how these influence the degree of automobile dependence in cities. It has also looked at factors such energy and the external costs of urban transport and their relationship to transport usage patterns and the other urban influences mentioned above. The overall conclusion is that more sustainable urban transport systems will only be achieved through a coordinated set of policies on urban land use and urban form, transport infrastructure provision, integration between the various modes of transport and the correct pricing of urban transport. A unifying theme of urban and transport planning policy should be the reduction in car use and the promotion of public transport, walking and cycling to encourage more sustainable cities.

(8) REFERENCES

Kenworthy, J. and Laube, F. The Millennium Cities Database for Sustainable Transport. International Union (Association) of Public Transport, Brussels, Belgium and ISTP, Perth, Western Australia (CD-ROM publication). (2001).
Newman, P.W.G. and Kenworthy, J.R. Sustainability and Cities: Overcoming Automobile Dependence. Island Press, Washington DC. (1999).

APPENDIX 1: List of primary data items in the study.

A. Metropolitan Area Definition
This should be, as far as possible, the functional urban region and should be specified according to whatever local administrative divisions or boundaries there are in the urban region. A map would be useful.

B. CBD Definition
This should reflect the central area with the highest concentration of employment. We will need to get jobs and parking data for that area.

C. Reference Year
Preferably 1995, but there is flexibility.

1. Total land area of the metropolitan area
This should exclude major water surfaces.

2. Urbanised area of the metropolitan area
This should reflect the built up area, ie housing, industrial and commercial areas, city parks (but not regional parks), transport infrastructure (roads and railways) and urban wasteland, but not agriculture, forest, large areas of vacant land, region scale parks etc

3. Total population of the metropolitan area

4. Number of jobs (at place of work) in metropolitan area

5. Number of jobs (at place of work) in CBD

6. Gross domestic product of the metropolitan area

7. Qualitative data on the planning system
This is a brief multiple choice questionnaire which can be filled in in under ten minutes by a knowledgable person. In this case, we need a name of a suitable person who would be prepared to do this for us.

8. Number of private cars and station wagons, RVs, etc. (including company cars, excluding taxis)

9. Number of two-wheeled motor vehicles (motorcycles)

10. Total vehicle kilometres of travel in private cars (all vehiicle kilometres data here and below are for the WHOLE YEAR).

11. Vehicle kilometres of travel on two-wheeled motor vehicles (motorcycles)

12. Passenger kilometres in private cars (or average vehicle occupancy, 24 hours per day, 7days per week, not peak period)

13. Passenger kilometres on two-wheeled vehicles (motorcycles)(or

average vehicle occupancy as per definition above)

14. Average road network speed (7day/24hour)

15. Total centreline length of the road network (all roads including residential)

16. Total length of express road network (ALL segregated expressways, irrespective of ownership or status (free- or tollways))

17. Number of parking places in CBD (off-street)
Excludes permanent residential parking but includes tenant parking under office buildings.

18. Number of parking places in CBD (on-street)

19. Charge for temporary CBD parking (on-street)
This is defined as the maximum 1st hour charge, or if bigger, twice the half-hour charge for those bays restricted to 1/2 hour of use only, or four times the 15-minute charge for those bays restricted to 1/4 hour of use only.

20. Charge for temporary CBD parking (off-street)
As per 19.

21/22. Fines for temporary CBD parking:
We are looking for 3 offences:
- Parking in kerbside no parking zone
- Parking in a way which obstructs public transport vehicles (ie on buslane)
- Parking longer than paid for on a timed, charged parking stall

23. Park and Ride
We are looking for:
(a) the number of facilities, and
(b) the total capacity (number of parking spaces)

24. Qualitative data on the road transport system
This is a brief multiple choice questionnaire which can be filled in in under ten minutes by a knowledgable person. In this case, we need a name of a suitable person who would be prepared to do this for us.

25. Total number of taxis

26. Total number of shared taxis (shared taxis being those which allow a second hirer on WITHOUT consent of the primary hirer)

27. Total vehicle kilometres in taxis

28. Total vehicle kilometres in shared taxis

29. Annual passenger trips in taxis

30. Annual passenger trips in shared taxis

31. Annual passenger kilometres in taxis

32. Annual passenger kilometres in shared taxis

33. Qualitative data on the public transport fare system
This is a brief multiple choice questionnaire which can be filled in in under ten minutes by a knowledgable person. In this case, we need a name of a suitable person who would be prepared to do this for us.

34. Total public transport farebox revenue
This should be the total for all operators which are active in the metropolitan area. It should separate user fare revenue and any direct government reimbursements for reduced fares.

35. Public transport vehicle fleet by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable.

36. Length of lines by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable.
This is defined as the sum of the two-way lengths of all lines, ie:
Line 1 goes from A to B, distance 4 miles, the return route is identical, total length therefore is 8 miles.... and so on for each line. We only require the system total, not the individual lines. This indicator is zero for those public transport modes which are not bound to a route.

37. Length of reserved routes by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable.
Any length reported here must be truly exclusive, ie they are a bus only (NOT a HOV) facility, and they are physically separated from traffic, ie by a concrete barrier or by grade separation. Rail must be on segregated right-of-way, ie no on-street running.

38. Average operating speed by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable.
The operating speed is defined as the revenue vehicle kilometres divided by the revenue vehicle hours.

39. Annual revenue vehicle kilometres by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable.

40. Annual revenue place (seat) kilometres by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable.

41. Annual boardings by mode

This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable. Boardings are UNLINKED passenger trips

42. Annual passenger kilometres by mode
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable. Where passenger kilometres are not directly available, then we need the average length in kilometres of an unlinked trip (boarding) for each mode as above.

43. Qualitative data on the organisation of public transport
This is a brief multiple choice questionnaire which can be filled in in under ten minutes by a knowledgable person. In this case, we need a name of a suitable person who would be prepared to do this for us.

44-51, 62, 63 Travel survey data.

We are looking for the following data (always all purposes, 24hr/7day
unless otherwise specified):

Average daily walk trips
Average daily bicycle trips
Average daily trips on urban transit (all publc transport modes)
Average daily trips on all other modes
Average trip length (distance) of walk trips
Average trip length (distance) of trips by all other modes
Average trip length (distance) of trips by private vehicle (car passenger/driver, RV.s etc.)
Overall average trip length by all modes (distance)
Average trip length (distance) of the journey-to-work (home-based work) by foot
Average trip length (distance) of the journey-to-work (home-based work) by all other modes
Overall average trip length (distance) of the journey-to-work (home-based work)
Average kerb-to-kerb travel time of trips by car
Average kerb-to-kerb travel time of trips by public transport

52. Annual investment spending on ALL public roads (construction and maintenance) for past five years.
This should include all jurisdictions which are maintaining roads.

53. Annual investment spending on public transport (network development, renovation, modernisation of equipment and rolling stock) for past five years
This should be the total for all operators which are active in the metropolitan area.

54. Annual operating expenses on public transport
This should be the total for all operators which are active in the metropolitan area. It should distinguish operations and the cost of finance and depreciation.

56. Cost of driving a private motor vehicle
This should be the representative cost of driving a popular, average car. If motorcycles are significantly used, we also need a corresponding value for motor cycles.

It needs to be detailed by total variable cost, fuel cost, fuel tax cost, total annual fixed cost and annual registration fees.

60. Private passenger transport energy use (litres of petrol, diesel and LPG used in private passenger transport)

61. Public transport energy use
This should be the total for all operators which are active in the metropolitan area. It should separate out minibus, bus, tram, light rail, subway and suburban rail modes as applicable and should include fuel type (diesel, petrol, LPG, electricity)

64. Mortality from motor vehicle accidents
This is all transport deaths according to the WHO's International Classification of Diseases (ICD), and should be the number of deaths from ICD codes E810 to E825,

65. Air pollutant inventory
We are looking for the total annual transport-related emissions for CO, NO_x, SO_2 and VHC for the metropolitan region

66. Qualitative data on the combat of air pollution
This is a brief multiple choice questionnaire which can be filled-in in under ten minutes by a knowledgeable person. In this case, we need a name of a suitable person who would be prepared to do this for us.

APPENDIX 2: Metropolitan Area, CBD and Data Definitions

CITY	METROPOLITAN AREA DEFINITION
W. EUROPEAN CITIES	
Graz	Magistrat Graz
Vienna	Stadt Wien
Brussels	Règion de Bruxelles-Capitale
Copenhagen	Hovedstadsregionen, including Kobenhavn Kommune, Frederiksberg Kommune, Kobenhavn Amt, Frederiksberg Amt, Roskilde Amt
Helsinki	Yhteistyovaltuuskunta (YTV), including Helsinki, Espoo, Vantaa and Kauniainen
Lyon	Grand Lyon
Marseille	Ville de Marseille
Nantes	Nantes District of Nantes agglomeration
Paris	Ile de France Region
Berlin	Land Berlin
Dusseldorf	Landeshauptstadt Dusseldorf
Frankfurt	Stadt Frankfurt am Main
Hamburg	Freie- und Hansestadt Hamburg
Munich	Landeshauptstadt Munchen
Ruhr	Kreise und Staedte: Duesseldorf, Duisburg, Essen, Krefeld, Moenchengladbach, Muehlheim an der Ruhr, Oberhausen, Remscheid, Solingen, Wuppertal, Mettmann, Neuss, Viersen, Bottrop, Gelsenkirchen, Recklinghausen, Bochum, Dortmund, Hagen, Herne, Ennepe-Ruhr
Stuttgart	Landeshauptstadt Stuttgart
Athens	Attika Region
Bologna	Bologna + Casalecchio di Reno + San Lazzaro di Savena
Milan	Milan + hinterland (38 municipalities)
Rome	Commune di Roma
Amsterdam	Amsterdam Agglomeration (Amstelveen, Amsterdam, Diemen,, Ouder-Amstel)
Oslo	Oslo + Akershus
Barcelona	Entitat del Transport de Barcelona
Madrid	Comunidad de Madrid
Stockholm	Stockholms Lan
Berne	Region Bern, including: Allmendingen, Baeriswil, Belp, Bern, Bolligen, Bremgarten, Diemerswil, Ittigen, Jegenstorf, Kehrsatz, Kirchlindach, Koeniz, Mattstetten, Meikirch, Moosseedorf, Muenchenbuchsee, Muri, Ostermundigen, Stettlen, Urtenen, Vechigen, Wohl
Geneva	Republique et Canton de Geneve
Zürich	Planungsregionen Zürich, Zimmerberg, Pfannenstil, Glattal, Furttal, Limmattal and Knonauer Amt
Glasgow	Strathclyde Passenger Transport Authority Area
London	Greater London
Manchester	Greater Manchester
Newcastle	Tyne and Wear County (five districts: Newcastle, North Tyneside, Gateshead, South Tyneside, Sunderland).

Table A2.1 Metropolitan area definitions for the higher income urban regions in the comparative study.

CITY	METROPOLITAN AREA DEFINITION
AMERICAN CITIES	
Atlanta	State of Georgia Counties of Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry and Rockdale
Chicago	State of Illinois Counties of Cook, DuPage, Kane, Lake, McHenry and Will
Denver	State of Colorado: Counties of Adams, Arapahoe, Boulder, Denver and Jefferson
Houston	State of Texas, Counties of Brazoria, Fort Bend, Harris, Liberty, Montgomery and Waller
Los Angeles	State of California, Los Angeles County
New York	State of Connecticut: Counties of Fairfield and New Haven plus Towns of Bethlehem, Thomaston, Watertown, Woodburg, Bridgewater and New Milford; State of New Jersey: Counties of Bergen, Essex, Hudson, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Union; State of New York: Counties of Bronx, Dutchess, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk and Westchester.
Phoenix	State of Arizona, Maricopa County
San Diego	State of California, County of San Diego
San Francisco	State of California, Counties of Alameda, Contra Costa, Marin, San Francisco and San Mateo
Washington	District of Columbia, State of Maryland Counties of Montgomery and Prince Georges, State of Virginia Counties of Arlington, Fairfax, Loudoun and Prince William and the Virginia independent Cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park
OCEANIAN CITIES	
Brisbane	Brisbane Statistical Division
Melbourne	Melbourne Statistical Division
Perth	Perth Statistical Division
Sydney	Sydney Statistical Division
Wellington	Wellington Transport Study Area, including City of Wellington, Lower Hutt, Upper Hutt, Povirua and urbanised section of the Kapiti Coast.
CANADIAN CITIES	
Calgary	City of Calgary
Montreal	Grande Region de Montreal' selon le Plan des Transports
Ottawa	Regional Municipality of Ottawa-Carleton, Municpalite Regionale de Comte Collines-de-l'Outaouais, Communaute Urbaine de l'Outaouais
Toronto	Greater Toronto Area, comprising Metropolitan Toronto, Peel, Durham, Halton and York
Vancouver	Greater Vancouver Regional District
ASIAN CITIES	
Hong Kong	The Territory of Hong Kong, now the Hong Kong Special Administrative Region
Osaka	Osaka-to, Hyogo-to and Kyoto-to
Sapporo	City of Sapporo (shin-Sapporo)
Tokyo	Tokyo-to, Kanagawa-ken, Saitama-ken and Chiba-ken
Singapore	Republic of Singapore
Taipei	Taipei City plus Taipei County

Table A2.1 Metropolitan area definitions for the higher income urban regions in the comparative study (cont.).

CITY	CBD DEFINITION
W. EUROPEAN CITIES	
Graz	1. Bezirk: Innere Stadt
Vienna	1. Bezirk
Brussels	Zones 1, 6,7, 8, 21, 45
Copenhagen	Statistikdistrikt A Indre By, C Voldskvarternerne
Helsinki	The Helsinki Peninsula, including Vironniemi, Ullanlinna, Kampinmalmi
Lyon	2e au Nord de Perrache et 3e Arrondissement a l'ouest de la Rue Garibaldi
Marseille	Hypercentre de Marseille roughly the areas ofLes Grandes Carmes, Belsunce, St.Charles, St.Victor, Prefecture, Lodi, St. Lambert, Vauban and Castellone
Nantes	Part of the inner city on the right side of Loire (Jardin des plantes to Viarme and Graslin)
Paris	Arrondissements I to X
Berlin	Parkraumbewirtschaftungszonen Stadtmitte und westliche Innenstadt
Dusseldorf	Stadtteile Altstadt, Karlstadt, Stadtmitte, Pempelfort, Friedrichstadt, Unterbilk
Frankfurt	Ortsteile Altstadt, Bahnhofsviertel and Innenstadt
Hamburg	Stadtteile (Ortsteile) Hamburg-Altstadt(101-103) Neustadt(104-107)
Munich	Stadtbezirke 1, 2 und 3
Ruhr	Duesseldorf Stadtteile Altstadt, Karlstadt, Stadtmitte, Pempelfort, Friedrichstadt, Unterbilk
Stuttgart	Bezirk Mitte
Athens	Inner ring road area
Bologna	Centro Storico di Bologna (Marconi, Irnerio, Malpighi, Galvani)
Milan	Centro Storico
Rome	Zona Centrale, comprendo i Rioni di Campo Marzio, Colonna, Trevi, Ponte, Parione, Sant'Eustacchio, Pigna, Regola, Sant'Angelo, Campitelli, Ludovisi, Sallustiano, Castro Pretorio, Monti, Esquilino, Celio, Trastevere, Ripa, Testaccio, San Saba
Amsterdam	Binnenstad Amsterdam
Oslo	Oslo CBD
Barcelona	Eixample, Ciutat Vella
Madrid	Almendra Central, comprising Distritos 1-7 of Madird Municipio
Stockholm	Forsamlingen: Adolf Fredrik, Gustav Vasa, Hedvig Eleonora, Kungsholm, plus Redovisningsomradet Jakob and Klara
Berne	Stadtteil I Innere Stadt
Geneva	Secteurs Statistiques de Cite-Centre et St-Gervais-Chantepoulet
Zürich	Kreis 1 Altstadt
Glasgow	Glasgow City Central Area
London	Central London
Manchester	Inner ring road area
Newcastle	Newcastle CBD, bounded by the Central Motorway (E&N), West Central Route (W), and River Tyne (S)

Table A2.2 CBD definitions for the higher income urban regions in the comparative study.

CITY	CBD DEFINITION
AMERICAN CITIES	
Atlanta	Downtown Area, bound by Northside Dve, Memorial Dve, Piedmont Ave and North Ave, incorporating CT 19-21, 27 and 35
Chicago	The Loop, bounded by Chicago River in the North and West, Lake Michigan in the East and Roosevelt Road in the South
Denver	Regional Statistical Area 412
Houston	Area inside the Interstate 610 Loop
Los Angeles	Census Tracts: 2071 south of Sunset Boulevarde, 2073, 2074, 2075, 2076, 2077, 2078, 2079
New York	Manhattan South of 60th Street
Phoenix	Census Tracts 1130, 1131 and 1141
San Diego	Center City
San Francisco	Census Tracts 114, 115, 117, 118, 121-125, 176, 178
Washington	Ring 0
OCEANIAN CITIES	
Brisbane	Census Collector's Districts 3191902-3191904, 3192601-3192603
Melbourne	Melbourne - Inner Statistical Local Area
Perth	Census Zones 101, 130-134
Sydney	Census Collectors' Districts 101-104, 106-107, 109-114, 117, 205, 2003, 2005, 2008, 2010
Wellington	Wellington CBD parking survey area
CANADIAN CITIES	
Calgary	Community Districts: Chinatown, Downtown East, Downtown West, Eau Claire
Montreal	Arrondissement Ville-Marie
Ottawa	Ottawa Central Area plus Hull CBD
Toronto	Minor Planning District 1e
Vancouver	Neighbourhood: Downtown
ASIAN CITIES	
Hong Kong	Comprehensive Transport Study Zones 7-11
Osaka	Kita-ku and Chuo-ku
Sapporo	Kita-ku and Chuo-ku
Tokyo	Chiyoda-ku, Chuo-ku, Minato-ku
Singapore	Planning Areas of Downtown Core, Orchard, Singapore River, Museum, Rochor, Outram, River Valley, Newton
Taipei	Zhongzheng District

Table A2.2 CBD definitions for the higher income urban regions in the comparative study (cont.)

DATA DEFINITIONS

This section of Appendix 2 provides the primary data definitions from which the standardised data in the tables in Appendix 4 were calculated. The same standardised data were used in the statistical analysis whose results are reported in the submission.

AVERAGE ROAD NETWORK SPEED

The average road network speed is defined as: The average speed of all vehicles over 24 hours per day and seven days per week on all classes of roads.

The average road network speed is defined as a 24 hour, seven days-of-the-week kerb-to-kerb average. Sources include output from land use/transport models which generate vehicle kilometres and vehicle hours, household travel survey data and air pollution models.

AVERAGE SPEED OF PUBLIC TRANSPORT

The average public transport speed is defined as: The average 24-hour, 7-day public transport commercial operating speed, detailed by mode and by operator.

Average speed can be calculated, where available, by dividing the revenue vehicle kilometres by the revenue vehicle hours. Revenue vehicle kilometres are all vehicle kilometres in public service, excluding dead-heading. Revenue vehicle hours is the time vehicles spend in operating the revenue vehicle kilometres, and thus excludes lay-overs at termini and time on dead-heading.

The overall average speed of public transport is calculated based upon a weighting of revenue vehicle hours by the various public transport modes.

DAILY TRIPS AND MODAL SPLIT

The average **daily number of trips** by all modes is defined as: The 365 days-of-the year average daily one-way trips on all modes, for all purposes, by all persons. The indicator just includes trips within the metropolitan area (and not trips with only one end in the metropolitan area).

A trip is any travel between an origin and a destination, which may be made using several modes. This definition explicitly includes walking trips. When specific age groups are excluded from the survey (for example trips made by people under 15, or under 5 years of age) the data providers were asked to clearly state or note this. Where only weekday information can be made available, it was necessary to collect the number of workdays in the country as well as conversion factors or estimates for trips in the weekend (normally available at road departments). However, whatever information was available was collected.

A public mode trip is a trip where at least one public transport mode has been used. Thus, a trip involving the use of, for example, the car and the metro was counted as a public mode trip.

The **mode split for all modes** is defined as: The percentage of total trips by non-motorised modes, by private and by public transport.

The table below allocates the most common modes to each of these three classes.

Mode of transport	Grouping
Walking	Non-motorised, non mechanised
Bicycles, tricycles etc	Non-motorised, but mechanised
Rikshaw, becaks etc	Non-motorised, but mechanised
Motor assisted bicycles («mopeds»)	Motorised, Private
Motorcycles	Motorised, Private
Private car drivers	Motorised, Private
Private car passengers	Motorised, Private
Utility vehicles	Motorised, Private
Taxi	Motorised, Private
Vanpools, carpools etc	Motorised, Private
Minibuses (jitneys, bemos etc)	Motorised, Public
Dial-a-bus, demand responsive bus	Motorised, Public
Conventional bus	Motorised, Public
Ferries	Motorised, Public
Fixed guideway modes (rail, metro, trolleybus, etc)	Motorised, Public

FREEWAY NETWORK LENGTH

The freeway network length is defined as: The total centre-line network length of segregated express roads (freeways/motorways).

Express roads must be fully controlled access or segregated highways (ie without any level intersections or traffic lights and no property access).

GROSS DOMESTIC PRODUCT OF THE METROPOLITAN AREA

The GDP of the Metropolitan Area is defined as: Gross Domestic Product of the functional urban area or functional 'economic area'. If the functional economic area is different from the standard metropolitan area definition, the population of the functional economic area was collected for the purpose of per capita GDP calculations.

The area the GDP refers to must not be smaller than the functional area.

Where the area the GDP refers to is obviously too large, the GDP of the metropolitan area is calculated proportionally to the income per capita, as provided by census data.

INVESTMENT SPENDING ON PUBLIC TRANSPORT

The annual public transport investment spending is defined as: The total investment spending on public transport by all levels of government and by all operators and infrastructure providers for the past five years, excluding direct operating expenses.

This indicator thus includes private sector investment in public transport.

Spending in any year consists only of credits actually spent in that year. The year when the authorisations for spending were passed does not count as actual spending in that year.

Public transport investment includes:

- Investment in buildings, metro stations, bus shelters;
- Investment in rails;
- Investment in signalling;
- Investment in electrical equipment;
- Investment to create rights-of-way for public transport on roads;
- Costs incurred to buy or expropriate real estate or land and to deviate road networks for the construction of a new public transport line;
- Urban design improvements linked to the use of public transport;
- Construction of tunnels and bridges related to public transport;
- Purchase cost of new rolling stock and cost of major rolling stock refurbishment.

INVESTMENT SPENDING ON ROADS

The annual spending on roads is defined as: The total spending for investment and maintenance on roads by all levels of government and major private road operators on all types of roads for five recent past years. This indicator thus includes investment in toll roads.

Spending in any year consists only of credits actually spent in that year. The year when the authorisations for spending were passed does not count as actual spending in that year.

Road investment includes:

- Investment in pavement and sidewalks/footpaths;
- Investment in toll stations;
- Investment in road lighting, in discharge equipment for water coming from the road;
- Investment in road signs and road alignment reflectors;
- Investment in tunnels and bridges dedicated to road use;
- Investment in traffic guidance systems (ITS etc.);
- Costs incurred for buying and expropriating land and for deviating existing road networks when necessary for building a new road;
- Landscaping associated with the construction of new roads as well as landscape maintenance within road reservations.

Investment in items not directly related to the use of the road such as sewers, hydrants and green spaces are excluded.

Road spending therefore includes all moneys actually spent for construction, substantial upgrading, and equipping of roads of all kinds, as well as maintenance works.

JOBS LOCATED IN CBD

CBD jobs are defined as: Persons pursuing their gainful employment mainly within the boundaries of the central business district (CBD).

Employment is defined as: Persons pursuing their gainful employment mainly within the boundaries of the metropolitan area.

Employment: number of jobs at place of work
Labour force: persons having gainful employment according to their place of residence.

The data collected concerns employment and not labour force.

Part-time jobs are accounted for proportionally, where specified in the source data, ie two half-time jobs equals one job in this study. Employment in the informal economy is estimated if this is not captured by the standard statistical data available. Employment includes those who are self-employed.

JOBS LOCATED IN METROPOLITAN AREA

Employment is defined as: Persons pursuing their gainful employment mainly within the boundaries of the metropolitan area.

Employment: number of jobs at place of work
Labour force: persons having gainful employment according to their place of residence.

The data collected concerns employment and not labour force.

Part-time jobs are accounted for proportionally, where specified in the source data, ie two half-time jobs equals one job in this study. Employment in the informal economy is estimated if this is not captured by the standard statistical data available. Employment includes those who are self-employed.

JOURNEY-TO-WORK AVERAGE TRIP LENGTH (KM)

Average length of a journey-to-work trip for all modes is defined as:
The average kerb-to-kerb (ie from the boarding into the first vehicle to the exit from the last vehicle) length of a home-to-work commute made in the metropolitan area for all modes.
The indicator just includes trips within the metropolitan area (and not trips with only one end in the metropolitan area).

This definition includes all commutes made by residents of the metropolitan area. A trip is defined as home-to-work if work is the main reason for the trip, even if other purposes are present in the trip (eg. shopping after work).

The distance is defined as a kerb-to-kerb distance (ie. from the boarding into the first vehicle to the exit from the last vehicle).

NUMBER OF CARS

The total number of cars is defined as: All motor vehicles with three or more wheels, which are primarily used for private passenger transport and in use at the reference date.

This includes cars, station wagons, recreational vehicles (inc. four-wheel drives), and utility trucks only if they are mainly used for transporting people (excluding any form of public transport). Any commercial minibuses and taxis are excluded. Only active vehicles are sought (ie. no scrapped vehicles which are still registered). Company cars and rental cars are included.

NUMBER OF MOTOR CYCLES

The total number of motorcycles is defined as: All motor vehicles with two wheels, which are admitted to general traffic.

This definition includes all classes of motorcycles as well as motor-assisted bicycles (mopeds) and motorcycles with attached side-cars.

PARK AND RIDE SPACES

Park and Ride Facilities are groups of car parking places which:

- are exclusively reserved to those who use public transport from that location, or
- are available at a discounted rate to those that use public transport from that location, or
- are located such that they are only attractive to public transport users. (eg they are located where there is no other destination than a public transport stop).

The total capacity is the sum of all P+R places offered in all facilities.

PARKING SPACES IN THE CBD

This is the sum of off-street and on-street parking supply in the CBD defined as follows:

Off-street parking is defined as: The total number of off-street parking places (bays), which are publicly accessible or accessible to tenants of commercial buildings (ie are not private resident's parking).

This includes surface parking areas or lots and underground/covered parking areas and parking lots, including tenant parking attached to specific commercial buildings and parking at workplace. The intention here is to measure the publicly available and commercial tenant off-street parking supply in the central business district. Permanent, private resident parking is excluded.

On-street parking is defined as: The total number of on-street parking places (bays).

The intention here is to measure the publicly available on-street parking supply in the central business district.

PASSENGER KILOMETRES IN CARS

The total car passenger kilometres are defined as: Total annual passenger kilometres travelled in cars on all classes of roads.

This indicator is often not directly available. In those cases, the average car occupancy is collected and this is multiplied by the vehicle kms (VKT) in cars. Car occupancy data are generally supplied from surveys conducted by authorities across a variety of screen-lines. It is also possible to retrieve this item from household survey data or accident records.

Data for 24 hour, 7 days-of-the-week averages of car occupancy were collected. Where it was impossible to retrieve proper 24 hour/7 day averages, as much data as possible were collected for as many periods of the day and days of the week as available, and then a reasonable average was estimated by proper weighting of the occupancy data.

PASSENGER KILOMETRES IN MOTOR CYCLES

The total motorcycle passenger kilometres are defined as: Total annual passenger kilometres travelled on motorcycles or motor-assisted bicycles on all classes of roads.

This indicator is often not directly available. In those cases, the average motorcycle occupancy is collected and this is multiplied by the vehicle kms (VKT) in motor cycles.

Motor cycle occupancy data are generally supplied from surveys conducted by authorities across a variety of screen-lines. It is also possible to retrieve this item from household survey data or accident records.

Data for 24 hour, 7 days-of-the-week averages of car occupancy were collected. Where it was impossible to retrieve proper 24 hour/7 day averages, as much data as possible were collected for as many periods of the day and days of the week as available, and then a reasonable average was estimated by proper weighting of the occupancy data.

POPULATION OF METROPOLITAN AREA

The population is defined as: Total residential population of the metropolitan area.

PRIVATE PASSENGER TRANSPORT ENERGY USE

The total annual private passenger transport energy consumption is defined as: The total annual consumption of propulsion fuel for cars and motorcycles.

For the most part, two items are collected here, namely the total annual consumption of gasoline, motor spirit or petrol as it is variously known, and diesel. Where other fuels, generally liquefied petroleum gas (LPG), are used in significant proportions, they are collected too. It has been necessary to separate freight fuel use from passenger transport fuel use where fuel figures are combined. All fuel data are converted into Megajoules according to standard conversions shown in the table below.

Fuel type	Conversion factor
Motor spirit (Petrol, Gasoline)	34.69 MJ/litre
Automotive Distillate (Diesel)	38.29 MJ/litre
LPG	26.26 MJ/litre
Electric power	3.60 MJ/kWh

Note: 1 Imperial gallon = 4.546 litres
1 US gallon = 3.785 litres
MJ = Megajoules

In some cases it was not possible to collect actual fuel data from any source. In these cases an average fuel consumption per unit distance for an average or typical passenger car and motorcycle was obtained in any units (eg km/l or l/100km or mpg). The figures provided were deemed to represent the average or typical car or motorcycle travelling in road conditions characteristic of the city. This was mainly an issue in developing cities, not so much in developed cities.

PRIVATE TRANSPORT OPERATING COSTS

The operating costs of private transport include both variable and fixed cost of driving a car:
- Depreciation for the car purchase (based on a 10 year life expectancy)
- Fuel
- Cost of spare parts

- Car insurance
- Taxes on car ownership

As an average cost of driving a car is frequently not available, typical vehicles are used in most cases. In Australia and Asia a Toyota Corolla is a typical reference make of car, while in Europe, the Volkswagen Golf is used. In both cases, a 1600 cc model is the reference.

In developing cities where motorcycles are a considerable part of the modal share, the average cost of using a motorcycle is incorporated accordingly.

This indicator **excludes** the cost of travel time.

PUBLIC TRANSPORT BOARDINGS

The total annual public transport boardings are defined as: The total annual public transport boardings, detailed by mode and by operator.

This means, every time a person boards a vehicle, this counts as a boarding. Some operators record linked trips, or revenue trips. This refers to the total public transport journey made by a person, even if the person needed to use a number of public transport services. The conversion factor between the two is referred to as the transfer rate. A conversion factor based on the known transfer rate is thus applied in the case of revenue trips.
Boardings = Linked trips x rate of transfer.

PUBLIC TRANSPORT ENERGY USE

The total annual public transport energy consumption is defined as: The annual public transport traction energy consumption, detailed by mode and by operator.

All traction energy for all modes of public transport is collected for this item. Station energy use is specifically excluded. The data are collected by type of propulsion energy, typically diesel and electricity, but in some cases also petrol (gasoline), LPG, CNG or others. All data are converted to megajoules using standard conversion factors as shown in the table below.

Fuel type	Conversion factor
Motor spirit (Petrol, Gasoline)	34.69 MJ/litre
Automotive Distillate (Diesel)	38.29 MJ/litre
LPG	26.26 MJ/litre
Electric power	3.60 MJ/kWh

Note: 1 Imperial gallon = 4.546 litres
1 US gallon = 3.785 litres
MJ = Megajoules

On the rare occasion that public transport operators do not know the annual fuel use of their vehicles (eg in some paratransit systems), then it was possible to obtain a typical fuel consumption rate per unit distance of the average vehicle (in km/l, l/100km or mpg.

PUBLIC TRANSPORT FAREBOX REVENUE

The total farebox revenue is defined as: The total revenue from passenger fares, including supplements or fines charged for fare evasion.

This definition includes all revenue for transport services.
It does not include:

- Ancilliary revenue (rent, advertising),
- Operating subsidies such as reimbursements for operation of non-profitable lines or direct deficit coverage.

Government reimbursements for subsidised tickets, ie tickets for particular groups of persons (eg pensioners, students, military, etc) were collected but specified separately. These were included in the operating cost recovery.

PUBLIC TRANSPORT OPERATING COSTS

The annual public transport operating cost is defined as: The total operating cost of public transport by all operators.

Public transport operating costs include:

- Purchase of energy and of supplies of goods and services (including subcontractor's services);
- Personnel costs: salaries, charges, retirement pensions, etc;
- Overheads (rent, etc.);
- Financial charges (interest payments);
- Depreciation;
- Maintenance of rolling stock and infrastructure;
- Taxes and fees.

Financial charges and depreciation are specified separately and are excluded from the operating cost recovery.

PUBLIC TRANSPORT OPERATING COST RECOVERY

The public transport operating cost recovery is defined as: The farebox revenue including subsidies to fares and community service obligations divided by the operating costs, excluding financial charges and depreciation.

PUBLIC TRANSPORT PASSENGER KILOMETRES

The total annual public transport passenger kilometres are defined as: The annual public transport passenger kilometres, detailed by mode and by operator.

Should passenger kilometres not be available, it is necessary to instead collect the average trip length, ie the average kerb-to-kerb length of an unlinked public transport trip (boarding).

The passenger kilometres are the result of multiplying these trip lengths with the number of boardings. Where only revenue trips are provided, the average trip length of a revenue trip was collected.

PUBLIC TRANSPORT SEAT KILOMETRES OF SERVICE

The total annual public transport seat kilometres of service is defined as: The total annual public transport revenue seat-kilometres, detailed by mode and by operator.

Revenue seat-kms are calculated for vehicle kms on revenue service runs (ie revenue vehicle kilometres, which exclude trips between the terminal and the depot (dead-heading).

Only sitting places are counted. It thus excludes standing places.

PUBLIC TRANSPORT VEHICLE FLEET

The active public transport vehicle fleet is defined as: The total active vehicle fleet, detailed by mode and by operator. In the case of rail modes, one vehicle corresponds to one car or one wagon or one element for light rail systems. Each slip coach is considered as a vehicle.
On the contrary, one articulated vehicle will be considered as a single vehicle.

It was necessary to group some smaller operators together in some cities. Typically, there are between one and three (sometimes more) large operators present in any one city, and a large number of small operators.

The definition of minibus will mostly vary according to the local context; though, as a general rule, buses of 8 metres length and less area considered as minibus. Jeepneys, Peseros, Busetas, etc are considered as minibuses.

Automated guideway transit systems (such as Vancouver's Skytrain or Lille's VAL) are grouped under metro systems, except for shuttles dedicated to internal transit of airports.
"Other modes" includes ferries, aerial cableways and other modes with generally minor significance in the overall network.

PUBLIC TRANSPORT VEHICLE KILOMETRES OF SERVICE

The total annual public transport vehicle kilometres of service is defined as: The total annual public transport revenue vehicle kilometres, detailed by mode and by operator.

Revenue vehicle kilometres is the distance travelled by public transport vehicles on revenue service runs, and thus excludes trips between the terminal and the depot (dead-heading).

Revenue vehicle kilometres measures car or wagon kilometres in the case of rail modes, **not** train kilometres. Where no wagon kilometres are available, the average number of wagons per train (ie the average train consist size) was collected and multiplied by the train kilometres.

RESERVED PUBLIC TRANSPORT ROUTE LENGTH

The length of reserved public transport routes is defined as: The total length of reserved public transport routes, detailed by mode and by operator.

Reserved routes refer to all route segments that are for exclusive use of public transport vehicles. This includes dedicated tram alignments, segregated railways, and dedicated busways, only if they are separated from the other lanes by physical obstacles which make the access by other vehicles to the bus lane difficult or impossible. For bus lanes, the length of the reserved routes is defined as the two-way length of the facility divided by two.

ROAD NETWORK LENGTH

The total road network length (Indicator 15) is defined as: The total centre-line network length of all classes of roads.

Road network length is defined as the total centre-line kilometres or miles of all public roads. Multiple-lane roads are counted the same as single-lane roads. Unpaved public roads are included. Roads which are predominantly used for forestry and agriculture are excluded. Residential streets are included.

TOTAL PASSENGER TRANSPORT COST

The total cost of passenger transport is defined as: The sum of road and public transport investment and private and public operating costs in a specific year.

This indicator **excludes** the cost of travel time.

TOTAL PASSENGER TRANSPORT COST AS A PERCENTAGE OF GDP

The total cost of passenger transport as a percentage of GDP is defined as: The ratio of the total passenger transport cost divided by metropolitan GDP, expressed as a percentage.

TRANSPORT DEATHS

Transport fatalities are defined as: Persons who have died according to World Health Organisation International Classification of Diseases (ICD) codes E810-E825, and who were residing at the time of death within the metropolitan area.

These statistics are routinely kept by Health or Statistical agencies and are considerably more reliable than police records. Police records always underestimate transport deaths because they only record deaths at the scene of accidents, not up to 30 days later in hospital, as in the WHO records.

TRANSPORT EMISSIONS

Air pollutant emissions are defined as: The total emissions of CO (carbon monoxide), SO_2 (sulfur dioxide), NO_x (oxides of nitrogen) and VHC (volatile hydrocarbons or unburnt petrol) from all transport sources.

It is desirable to include the electricity generation component of public transport, but this will in general not significantly affect the results.

URBANISED LAND AREA

The urbanised area is defined as: Built-up land area of the metropolitan region.

The table below indicates in detail which land uses are considered urban (u) and which ones non-urban (n-u):

Land use category	Type	Comment
Agricultural	n-u	
Meadows, pastures	n-u	
Gardens, parks	u	small, intensive usage
Forest, urban forest	n-u	large, significant 'natural' areas
Wasteland (natural)	n-u	flood plains, rocks and the like
Wasteland (urban)	u	derelict land, culverts
Transport	u	Road area, railway land, airports etc.
Recreational	u, n-u	Depending on intensity of use (example: Skiing area: non-urban, Golf course: urban)
Residential	u	
Industrial	u	
Offices	u	
Commercial	u	
Public Utilities	u	
Hospitals	u	
Schools, Cultural	u	
Sports grounds	u	
Water surfaces	n-u	

n-u=non-urban, u=urban

VEHICLE KILOMETRES OF TRAVEL IN CARS

The total car VKT is defined as: Total annual vehicle kilometres travelled in cars on all classes of roads, including residential streets (definition of a car is as in "number of cars").

Car VKT is defined as the sum of all distances travelled by private motorised passenger vehicles. In some cases this indicator was not directly available from traffic models and was derived from travel surveys, motor vehicle usage surveys or models other than traffic models, such as energy or pollution models.

Estimates sometimes needed to be based on the number of cars multiplied by the average annual distance travelled per car (this was mainly developing cities where transport modelling was less developed). Where the transport or traffic model only produces total vehicle kilometres by all classes of vehicle (cars, trucks, etc.), then an estimate was obtained of the percentage of total VKT which is accounted for by cars (eg in developed cities, this usually falls between 80% and 95% of total VKT).

VEHICLE KILOMETRES OF TRAVEL IN MOTOR CYCLES

The total motorcycle VKT is defined as: Total annual vehicle kilometres travelled in two-wheeled motor vehicles on all classes of roads.

Motorcycle VKT are defined as the sum of all distances travelled by two-wheeled motor vehicles. In many cases this indicator was directly available from traffic models and was derived from travel surveys, motor vehicle usage surveys or models other than traffic models, such as energy or pollution models. Similar comments, as for car VKT, about estimation procedures apply here.

Appendix 3 Standardised comparative variables calculated in the study

Standardised Indicator	Units
Characteristics of the metropolitan area	
Urban density	persons/ha
Job density	jobs/ha
Proportion of jobs in CBD	percentage (%)
Metropolitan gross domestic product per capita	US$
Supply indicators	
Private Transport Infrastructure Indicators	
Length of road per person	m/person
Length of freeway per person	m/person
Length of road per urban hectare	m/ha
Length of freeway per urban hectare	m/ha
Parking spaces per 1000 CBD jobs	spaces/1000 jobs
Public Transport Infrastructure Indicators	
Total length of public transport lines per capita	m/person
Total length of reserved public transport routes per capita	m/person
• *Busway length per capita*	m/person
• *Segregated tram network length per capita*	m/person
• *Metro network length per capita*	m/person
• *Suburban rail network length per capita*	m/person
• *Heavy rail network length per capita*	m/person
Total length of reserved public transport routes per urban hectare	m/ha
• *Busway length per urban hectare*	m/ha
• *Segregated tram network length per urban hectare*	m/ha

• *Metro network length per urban hectare*	m/ha
• *Suburban rail network length per urban hectare*	m/ha
• *Heavy rail network length per urban hectare*	m/ha
Intermodal Transport Infrastructure Indicators	
Number of park and ride facilities per kilometre of reserved public transport route	facilities/km
Number of park and ride spaces per kilometre of reserved public transport route	spaces/km
Number of park and ride facilities per urban hectare	facilities/ha
Car equivalents per number of park and ride spaces	units/space
Private transport supply (cars and motorcycles)	
Passenger cars per 1000 people	units/1000 people
Motor cycles per 1000 people	units/1000 people
Total private passenger vehicles per 1000 people	units/1000 people
Passenger car kilometres per car	km/unit
Motor cycle kilometres per motor cycle	km/unit
Total private passenger vehicle kilometres per vehicle	km/unit
Private collective transport supply (taxis and shared taxis)	
Taxis per capita	units/person
Shared taxis per capita	units/person
Taxi vehicle kilometres per capita	vehicle km/person
Shared taxi vehicle kilometres per capita	vehicle km/person
Traffic Intensity Indicators	
Passenger cars per kilometre of road	units/km
Motor cycles per kilometre of road	units/km
Total private passenger vehicles per kilometre of road	unit equivalents/km
Total single and collective private passenger vehicles per kilometre of road	unit equivalents/km
Passenger car kilometres per kilometre of road	vehicle km/km
Motor cycle kilometres per kilometre of road	vehicle km/km
Total private passenger vehicle kilometres per kilometre of road	vehicle km/km

Total private and collective passenger vehicle kilometres per kilometre of road	vehicle km/km
Passenger car kilometres per urban hectare	vehicle km/ha
Motor cycle kilometres per urban hectare	vehicle km/ha
Total private passenger vehicle kilometres per urban hectare	vehicle km/ha
Total private and collective passenger vehicle kilometres per urban hectare	vehicle km/ha
Average road network speed	km/h
Public Transport Supply and Service	
Total public transport vehicles per capita	units/person
• *Buses per capita*	units/person
• *Tram units per capita*	units/person
• *Metro units per capita*	units/person
• *Suburban rail units per capita*	units/person
• *Heavy rail units per capita*	units/person
Total public transport vehicle kilometres of service per capita	vehicle km/person
• *Bus vehicle kilometres per capita*	vehicle km/person
• *Tram wagon kilometres per capita*	vehicle km/person
• *Metro wagon kilometres per capita*	vehicle km/person
• *Suburban rail wagon kilometres per capita*	vehicle km/person
• *Heavy rail wagon kilometres per capita*	vehicle km/person
Total public transport vehicle kilometres of service per urban hectare	vehicle km/ha
• *Bus vehicle kilometres per urban hectare*	vehicle km/ha
• *Tram wagon kilometres per urban hectare*	vehicle km/ha
• *Metro wagon kilometres per urban hectare*	vehicle km/ha
• *Suburban rail wagon kilometres per urban hectare*	vehicle km/ha
• *Heavy rail wagon kilometres per urban hectare*	vehicle km/ha
Total public transport seat kilometres of service per capita	seat km/person
• *Bus seat kilometres per capita*	seat km/person
• *Tram seat kilometres per capita*	seat km/person
• *Metro seat kilometres per capita*	seat km/person
• *Suburban rail seat kilometres per capita*	seat km/person
• *Heavy rail seat kilometres per capita*	seat km/person

Overall average speed of public transport	km/h
• *Average speed of buses*	km/h
• *Average speed of trams*	km/h
• *Average speed of metro*	km/h
• *Average speed of suburban rail*	km/h
• *Average speed of heavy rail*	km/h
Mobility Indicators	
Overall mobility	
Daily trips by foot per capita	trips/person
Daily trips by bicycle per capita	trips/person
Daily public transport trips per capita	trips/person
Daily private transport trips per capita	trips/person
Total daily trips per capita	trips/person
Mode split of all trips	percentage
Mode split of mechanised trips	percentage
Overall average trip distance	km
Overall average trip distance by car	km
Average distance of mechanised trips	km
Overall average distance of the journey-to-work	km
Average distance of the journey-to-work by mechanised modes	km
Average time of a car trip	minutes
Average time of a public transport trip	minutes
Private Mobility Indicators (cars and motorcycles)	
Passenger car kilometres per capita	km/person
Motor cycle kilometres per capita	km/person
Total private passenger vehicle kilometres per capita	km/person
Passenger car passenger kilometres per capita	p. km per person
Motor cycle passenger kilometres per capita	p. km per person
Total private passenger kilometres per capita	p. km per person

Private Mobility Indicators (taxis and shared taxis)	
Taxi passenger kilometres per capita	p.km/person
Shared taxi passenger kilometres per capita	p.km/person
Taxi trips per capita	trips/person
Shared taxi trips per capita	trips/person
Public Transport Mobility Indicators	
Total public transport boardings per capita	boardings/person
• *Bus boardings per capita*	boardings/person
• *Tram boardings per capita*	boardings/person
• *Metro boardings per capita*	boardings/person
• *Suburban rail boardings per capita*	boardings/person
• *Heavy rail boardings per capita*	boardings/person
Total public transport passenger kilometres per capita	p.km/person
• *Bus passenger kilometres per capita*	p.km /person
• *Tram passenger kilometres per capita*	p.km /person
• *Metro passenger kilometres per capita*	p.km /person
• *Suburban rail passenger kilometres per capita*	p.km /person
• *Heavy rail passenger kilometres per capita*	p.km /person
User cost of transport	
Average user cost of a car trip	%GDP/trip
Average user cost of a public transport trip	%GDP/trip
User cost of private transport per passenger kilometre	%GDP/km
User cost of public transport per passenger kilometre	%GDP/km
Charge for on-street parking in the CBD	%GDP/h
Charge for off-street parking in the CBD	%GDP/h
Average parking charge in the CBD	%GDP/h
Fine for parking in no parking zone	%GDP
Fine for obstructing public transport	%GDP

Public transport productivity	
Overall public transport vehicle occupancy	persons/unit
• *Bus vehicle occupancy*	persons/unit
• *Tram wagon occupancy*	persons/unit
• *Metro wagon occupancy*	persons/unit
• *Suburban rail wagon occupancy*	persons/unit
• *Heavy rail wagon occupancy*	persons/unit
Overall public transport seat occupancy	persons/seat
• *Bus seat occupancy*	persons/seat
• *Tram seat occupancy*	persons/seat
• *Metro seat occupancy*	persons/seat
• *Suburban rail seat occupancy*	persons/seat
• *Heavy rail seat occupancy*	persons/seat
Public transport operating cost recovery	percentage
Average public transport farebox revenue per boarding	US$/boarding
Average public transport farebox revenue per passenger kilometre (user cost)	US$/pass. km
Average public transport farebox revenue per vehicle kilometre	US$/veh. km
Transport Financial Cost	
Public Transport Cost	
Percentage of metropolitan GDP spent on public transport investment	percentage
Public transport investment per capita	US$/person
Public transport operating cost per vehicle kilometre	US$/veh. km
Public transport operating cost per passenger kilometre	US$/pass. km
Private Transport Cost	
Percentage of metropolitan GDP spent on road investment	percentage
Road investment per capita	US$/person

Annual road investment per kilometre of road	US$/km
Private transport operating cost per vehicle kilometre	US$/veh. km
Private transport operating cost per passenger kilometre	US$/pass. km
Overall Transport Cost	
Overall transport operating and investment cost per passenger kilometre	US$/pass. km
Total passenger transport cost per capita	US$/person
Total passenger transport cost as percentage of metropolitan GDP	percentage
Transport Externalities Indicators	
Transport Energy Indicators	
Private passenger transport energy use per capita	MJ/person
Public transport energy use per capita	MJ/person
Total transport energy use per capita	MJ/person
Energy use per private passenger vehicle kilometre	MJ/km
Energy use per public transport vehicle kilometre	MJ/km
• *Energy use per bus vehicle kilometre*	MJ/km
• *Energy use per tram wagon kilometre*	MJ/km
• *Energy use per metro wagon kilometre*	MJ/km
• *Energy use per suburban rail wagon kilometre*	MJ/km
• *Energy use per heavy rail wagon kilometre*	MJ/km
Energy use per private passenger kilometre	MJ/p.km
Energy use per public transport passenger kilometre	MJ/p.km
• *Energy use per bus passenger kilometre*	MJ/p.km
• *Energy use per tram passenger kilometre*	MJ/p.km
• *Energy use per metro passenger kilometre*	MJ/p.km
• *Energy use per suburban rail passenger kilometre*	MJ/p.km
• *Energy use per heavy rail passenger kilometre*	MJ/p.km
Overall energy use per passenger kilometre	MJ/p.km

Air Pollution Indicators	
Total emissions per capita	kg/person
• *Emissions of CO per capita*	kg/person
• *Emissions of SO_2 per capita*	kg/person
• *Emissions of VHC per capita*	kg/person
• *Emissions of NO_x per capita*	kg/person
Total emissions per urban hectare	kg/ha
Total emissions per total hectares	kg/ha
Transport Fatalities Indicators	
Total transport deaths per 100,000 people	deaths/100,000 persons
Total transport deaths per million vehicle kilometres	deaths/1,000,000 vehicle km
Total transport deaths per million passenger kilometres	deaths/1,000,000 p.km
Public/Private Transport Balance Indicators	
Proportion of total motorised passenger kilometres on public transport	percentage (%)
Ratio of public versus private transport speeds	ratio
Ratio of annual investment in public transport versus private transport infrastructure	ratio
Ratio of segregated public transport infrastructure versus expressways	ratio
Ratio of public versus private transport energy use per passenger kilometre	ratio
Ratio of public versus private transport user cost per passenger kilometre	ratio

APPENDIX 4:
Key summary data for cities by world region, 1995

		USA	ANZ	CAN	WEU	HIA
Land Use and Wealth						
Urban density	persons/ha	14.9	15.0	26.2	54.9	150.3
Proportion of jobs in CBD	%	9.2%	15.1%	15.7%	18.7%	19.1%
Metropolitan gross domestic product per capita	USD	$31,386	$19,775	$20,825	$32,077	$31,579
Private Transport Infrastructure Indicators						
Length of freeway per person	m/ person	0.156	0.129	0.122	0.082	0.020
Parking spaces per 1000 CBD jobs		555	505	390	261	105
Public Transport Infrastructure Indicators						
Total length of reserved public transport routes per 1000 persons	m/1000 pers	48.6	215.5	55.4	192.0	53.3
Total length of reserved public transport routes per urban hectare	m/ha	0.81	3.41	1.44	9.46	5.87
Number of P and R spaces per km of reserved public transport route	spaces/km	320	44	132	25	19
Ratio of segregated transit infrastructure versus expressways		0.41	2.00	0.55	3.12	3.34
Private transport supply (cars and motorcycles)						
Passenger cars per 1000 persons		587.1	575.4	529.6	413.7	210.3
Motor cycles per 1000 persons		13.1	13.4	9.5	32.0	87.7
Traffic Intensity Indicators						
Total private passenger vehicles per km of road	units/km	98.7	73.1	105.8	181.9	144.4
Total single and collective private passenger vehicles per km of road	units/km	98.9	73.3	106.1	183.1	149.6
Average road network speed	km/h	49.3	44.2	44.5	32.9	28.9
Public Transport Supply and Service						
Total public transport seat kilometres of service per capita	seat km/pers	1,556.8	3,627.9	2,289.7	4,212.7	4,994.8
Rail seat kilometres per capita (Tram, LRT, Metro, Sub. rail)	seat km/pers	747.5	2,470.4	676.4	2,608.6	2,282.3
% of public transport seat kms on rail	%	48.0	68.1	29.5	61.9	45.7
Overall average speed of public transport	km/h	27.4	32.7	25.1	25.7	29.9
* Average speed of buses	km/h	21.7	23.3	22.0	20.2	16.2
* Average speed of metro	km/h	37.0		34.4	30.6	36.6
* Average speed of suburban rail	km/h	54.9	45.4	49.5	49.5	47.1
Ratio of public versus private transport speeds		0.58	0.75	0.57	0.79	1.04
Mode split of all trips						
* non motorised modes	%	8.1%	15.8%	10.4%	31.3%	28.5%
* motorised public modes	%	3.4%	5.1%	9.1%	19.0%	29.9%
* motorised private modes	%	88.5%	79.1%	80.5%	49.7%	41.6%

Private Mobility Indicators		USA	ANZ	CAN	WEU	HIA
Passenger car passenger kilometres per capita	p.km/person	18,155	11,387	8,645	6,202	3,614
Motor cycle passenger kilometres per capita	p.km/person	45	81	21	119	357
Public Transport Mobility Indicators						
Total public transport boardings per capita	bd./person	**59.2**	**83.8**	**140.2**	**297.1**	**430.5**
Rail boardings per capita (Tram, LRT, Metro, Sub. rail)	bd./person	21.7	42.5	44.5	162.2	238.3
Proportion of public transport boardings on rail	%	36.7%	50.7%	31.7%	54.6%	55.4%
Proportion of total motorised passenger kilometres on pub. transport	%	2.9%	7.5%	9.8%	19.0%	45.9%
Public Transport Productivity						
Public transport operating cost recovery	%	35.5%	52.7%	54.4%	59.2%	137.9%
Transport Investment Cost						
Percentage of metropolitan GDP spent on public transport investment	%	0.18%	0.30%	0.18%	0.41%	0.61%
Percentage of metropolitan GDP spent on road investment	%	0.86%	0.72%	0.87%	0.70%	0.84%
Overall Transport Cost						
Total passenger transport cost as % of metropolitan GDP	%	11.79%	13.47%	13.72%	8.30%	7.08%
Total private passenger transport cost as % of metropolitan GDP	%	11.24%	12.39%	12.87%	6.75%	5.45%
Total public passenger transport cost as % of metropolitan GDP	%	0.55%	1.08%	0.85%	1.55%	1.62%
Transport Energy Indicators						
Private passenger transport energy use per capita	MJ/person	60,034	29,610	32,519	15,675	9,556
Public transport energy use per capita	MJ/person	809	795	1,044	1,118	1,423
Energy use per private passenger kilometre	MJ/p.km	3.25	2.56	3.79	2.49	2.33
Energy use per public transport passenger kilometre	MJ/p.km	2.13	0.92	1.14	0.83	0.48
Air Pollution Indicators						
Total emissions per capita (CO, SO2, VHC, NOx)	kg/person	264.6	188.9	178.9	98.3	36.9
Total emissions per urban hectare	kg/ha	3,563	2,749	4,588	5,304	5,722
Ratio of emissions per capita to private, collective and transit travel		0.020	0.024	0.027	0.020	0.012
Transport Fatalities Indicators						
Total transport deaths per 100,000 people		12.7	8.6	6.5	7.1	8.0
Total transport deaths per billion passenger kilometres		7.0	6.8	7.1	9.6	10.8

Table A4.1 Key land use and transport system characteristics in higher income regions, 1995.

		EEU	MEA	LAM	AFR	LIA	CHN
Land Use and Wealth							
Urban density	persons/ha	52.9	118.8	74.7	59.9	204.1	146.2
Proportion of jobs in CBD	%	20.3%	13.5%	29.4%	15.4%	17.4%	50.8%
Metropolitan gross domestic product per capita	USD	$5,951	$5,479	$4,931	$2,820	$3,753	$2,366
Private Transport Infrastructure Indicators							
Length of freeway per person	m/ person	0.031	0.053	0.003	0.018	0.015	0.003
Parking spaces per 1000 CBD jobs		75	532	90	252	127	17
Public Transport Infrastructure Indicators							
Total length of reserved public transport routes per 1000 persons	m/1000 pers	200.8	16.1	19.3	40.2	16.1	2.3
Total length of reserved public transport routes per urban hectare	m/ha	10.67	2.18	1.15	2.39	2.50	0.32
Number of P and R spaces per km of reserved public transport route	spaces/km	5	50	4	10	9	0
Ratio of segregated transit infrastructure versus expressways		9.11	3.54	3.36	3.16	1.33	0.77
Private transport supply (cars and motorcycles)							
Passenger cars per 1000 persons		331.9	134.2	202.3	135.1	105.4	26.1
Motor cycles per 1000 persons		20.8	19.1	14.3	5.5	127.3	55.1
Traffic Intensity Indicators							
Total private passenger vehicles per km of road	units/km	168.8	180.7	144.1	58.4	236.1	117.2
Total single and collective private passenger vehicles per km of road	units/km	170.9	197.1	146.2	60.0	249.1	131.8
Average road network speed	km/h	30.8	32.1	31.5	39.3	21.9	18.7
Public Transport Supply and Service							
Total public transport seat kilometres of service per capita	seat km/pers	4,170.3	1,244.6	4,481.2	5,450.3	2,698.8	1,171.3
Rail seat kilometres per capita (Tram, LRT, Metro, Sub. rail)	seat km/pers	2,478.8	125.7	316.1	1715.5	402.4	44.6
% of public transport seat kms on rail	%	59.4	10.1	7.1	31.5	14.9	3.8
Overall average speed of public transport	km/h	21.4	20.9	18.4	31.4	18.0	13.6
* Average speed of buses	km/h	19.3	18.5	17.8	25.8	16.2	12.5
* Average speed of metro	km/h	29.5		32.4		33.9	35.4
* Average speed of suburban rail	km/h	37.6	36.6	41.0	34.4	33.0	
Ratio of public versus private transport speeds		0.71	0.68	0.60	0.80	0.81	0.73
Mode split of all trips							
* non motorised modes	%	26.2%	26.6%	30.7%	41.4%	32.4%	65.0%
* motorised public modes	%	47.0%	17.6%	33.9%	26.3%	31.8%	19.0%
* motorised private modes	%	26.8%	55.9%	35.4%	32.3%	35.9%	15.9%

Private Mobility Indicators		EEU	MEA	LAM	AFR	LIA	CHN
Passenger car passenger kilometres per capita	p.km/person	2,907	3,262	2,862	2,652	1,855	814
Motor cycle passenger kilometres per capita	p.km/person	19	129	104	57	684	289
Public Transport Mobility Indicators							
Total public transport boardings per capita	bd./person	**711.5**	**151.8**	**265.1**	**195.4**	**231.0**	**374.9**
Rail boardings per capita (Tram, LRT, Metro, Sub. rail)	bd./person	409.0	18.3	19.2	37.2	40.2	22.8
Proportion of public transport boardings on rail	%	57.5%	12.0%	7.2%	19.0%	17.4%	6.1%
Proportion of total motorised passenger kilometres on pub. transport	%	53.0%	29.5%	48.2%	50.8%	41.0%	55.0%
Public Transport Productivity							
Public transport operating cost recovery	%	58.1%	88.0%	133.0%	95.2%	155.8%	40.7%
Transport Investment Cost							
Percentage of metropolitan GDP spent on public transport investment	%	0.50%	0.61%	0.42%	0.35%	0.65%	0.86%
Percentage of metropolitan GDP spent on road investment	%	1.02%	1.05%	0.11%	0.54%	1.28%	3.17%
Overall Transport Cost							
Total passenger transport cost as % of metropolitan GDP	%	14.76%	14.01%	14.27%	21.96%	14.50%	10.67%
Total private passenger transport cost as % of metropolitan GDP	%	12.39%	11.38%	11.69%	17.47%	12.19%	8.13%
Total public passenger transport cost as % of metropolitan GDP	%	2.38%	2.63%	2.58%	4.48%	2.31%	2.54%
Transport Energy Indicators							
Private passenger transport energy use per capita	MJ/person	6,661	10,573	7,283	6,184	5,523	2,498
Public transport energy use per capita	MJ/person	1,242	599	2,158	1,522	1,112	419
Energy use per private passenger kilometre	MJ/p.km	2.35	2.56	2.27	1.86	1.78	1.69
Energy use per public transport passenger kilometre	MJ/p.km	0.40	0.67	0.76	0.51	0.64	0.28
Air Pollution Indicators							
Total emissions per capita (CO, SO2, VHC, NOx)	kg/person	88.4	147.4	119.1	137.3	77.3	86.3
Total emissions per urban hectare	kg/ha	4,543	12,671	7,362	5,330	13,506	11,920
Ratio of emissions per capita to private, collective and transit travel		0.037	0.060	0.056	0.076	0.037	0.083
Transport Fatalities Indicators							
Total transport deaths per 100,000 people		10.8	11.3	27.6	18.0	15.2	8.6
Total transport deaths per billion passenger kilometres		19.6	29.1	47.3	30.4	37.3	30.0

Table A4.2 Key land use and transport system characteristics in lower income regions, 1995

The key to regional abbreviations used in Tables A4.1 and 4.2 is as follows. The specific cities comprising the regional averages are found in Table 1 at the beginning of the submission.

HIGHER INCOME

USA	US cities
ANZ	Australia/New Zealand cities
CAN	Canadian cities
WEU	Western European cities
HIA	High income Asian

LOWER INCOME

EEU	Eastern European cities
MEA	Middle Eastern cities
LAM	Latin American cities
AFR	African cities
LIA	Low income Asian cities
CHN	Chinese cities