# How do cities work and why is transport so significant?

***Regional sustainability and the search for new evaluation tools***

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**Keywords**
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**Abstract**
In their bid to place urban development on a more sustainable footing, many regional governments and their communities are presently encountering difficulties with transport development. A key reason for this is the disparity between sustainability objectives and the real outcomes of transport projects favoured under current evaluation methods. This paper tackles this problem in two parts. The first describes the working processes of urban systems and the central role that time plays in the many system feedback processes generic to their organisation. The second examines the way that time is represented in Cost Benefit Analysis (CBA). The paper shows that how time actually manifests itself in urban systems is different to the logic used to represent it in evaluation methods. Consequently, real outcomes from many transport projects — particularly urban motorway developments — fall short of the aims stated at the outset.

**About the Author**
Michelle Zeibots is a Transport Planner, Senior Research Consultant and Doctoral Candidate working at the Institute for Sustainable Futures at the University of Technology, Sydney. Michelle's area of research interest is the relationship between urban structure and the macroeconomic performance of cities. The role that transport infrastructure plays in determining the pattern and character of urban land use development is a central part of the systems theory she is developing to articulate these relationships. Originally trained in architecture at the University of Sydney, Michelle completed an Honours Dissertation under the supervision of Professor Peter Newman at Murdoch University's Institute for Sustainability and Technology Policy. Prior to taking up her Doctoral Candidacy under the supervision of Professor Stuart White at the Institute for Sustainable Futures, Michelle worked in community advocacy, serving as a community representative on the NSW Road Traffic Noise Task Force and the Public Transport Advisory Committee by Ministerial appointment. She has also worked in private practice and assisted Dr Jeff Kenworthy and Dr Felix Laube in their compilation of the Millennium Cities Database for the International Association of Public Transport (UITP).

# How do cities work and why is transport so significant?
### *Regional sustainability and the search for new evaluation tools*

## Introduction

Local transport systems have far reaching consequences for regional development. As the active logistical component of an urban system, they influence the spatial structure of cities and towns, affecting per capita costs for hard and soft infrastructures[1]. Transport also shapes the size of markets, accessibility profiles within local economies, neighbourhood amenity and the sustainability credentials of regions.

Standard transport evaluation methods use a form of Cost Benefit Analysis (CBA) that does not consider these factors. Instead the majority of benefits are attributed to travel time savings. In the face of travel time budget constancy — an empirical phenomenon that will be discussed at some length — simple travel time savings are shown to be methodological artefacts rather than significant or tangible economic benefits. Ironically, projects like urban motorways, with poor economic and sustainability credentials, are often given preference over public transport programs because of this shortcoming. Given the sustainability focus that many regional governments and communities now wish to pursue, the disparity between the results of transport evaluation methods and real outcomes has been put under the spotlight (see SACTRA, 1994 and Rayner, 2003 for example). This is why many administrations throughout the world are in the process of overhauling their transport evaluation tools (see Owens, 1995; Bristow and Nelthorpe, 2000 for example).

The aim of this paper is to reveal why the disparity occurs between the results of evaluation methods and real outcomes on the ground. To begin, a descriptive overview of key organising properties of urban transport systems is provided. This is then set against the logic used to assess transport projects in CBA. How the systems work in practice and the logic used to replicate this are shown to be different. Particular attention will be paid to an array of system feedback processes that follow in the path of a new transport development or service upgrade. These include mode shifting, induced traffic growth, effects on patterns of land use development, changes to market catchment size and general transport costs. In relation to the use of CBA, none of these factors is considered when assessing the relative benefits of urban motorway development.

A mapping technique based on the speed and capacity of a transport system is introduced to identify *travel time budget contours*. The spatial data this generates provides an alternate way of representing time to evaluate the impacts and benefits of transport infrastructures. The key advantage this has

[1] *Hard infrastructures* refer to roads and railways, water and sewerage networks, electricity and gas grids and building stock. *Soft infrastructures* comprise social services such as health and education, civilian policing and law enforcement.





over CBA methods is that it recognises time as a causal factor within a spatial system and not simply as an a-spatial quantity or commodity. Because of this, the method is able to hone in on how a transport infrastructure or service upgrade will change other elements in the wider city system and affect real economic outcomes.

## 1. Why cities?

Any discussion about cities and sustainability needs to start with the question of why humans build and live in cities in the first place. After all, if the tools used by governments to create sustainability do not recognize the fundamental reason for creating cities, tensions and mismatches are likely to occur between methods, policy goals and the day-to-day workings of a city system.

Our primary reason for building cities seems to be economic (Jacobs in Feeny, 1993, p.12). By living in close proximity, people are able to make large numbers of exchanges within relatively short time periods. This is essential to the creation of what economists call the *division of labour*, where individuals specialise in different tasks to increase their combined output (Samuelson, 1992, p.704). Close proximity is essential to labour specialisation because other people must be present to do the tasks that an individuals' own specialisation prohibits them from doing. As tasks become more particular, individuals become more dependent on one another and so need to make more exchanges within a short period of time if they are to sustain their level of industrialisation and standard of living. This is why spatial conditions and cities are of fundamental significance to industrial production (Prud'homme, 1994, p.730).

Close proximity is also essential for generating new industries or economic development. Finding a new use, or adapting an old application to produce a new product or service, creates the work of new industries. Production processes need to be in the same vicinity so that the 'accidents' responsible for the creative process of economic development can take place. This process primarily occurs in cities because the intensity and diversity of human activity make it more likely. New products and services are vital to the economic life of a city, often replacing imports and sometimes becoming exports in a city's trade (Jacobs, 1969, pp.79–84).

Now some people may feel uncomfortable with this definition because it seems narrow. Obviously, people undertake lots of different activities in cities and not all have an economic purpose or relate to labour productivity. Social networks, political movements, personal relationships, artistic and cultural traditions all contribute to the rich fabric of urban life. To portray the building of cities merely as an economic event might be seen to diminish the significance of these other activities.

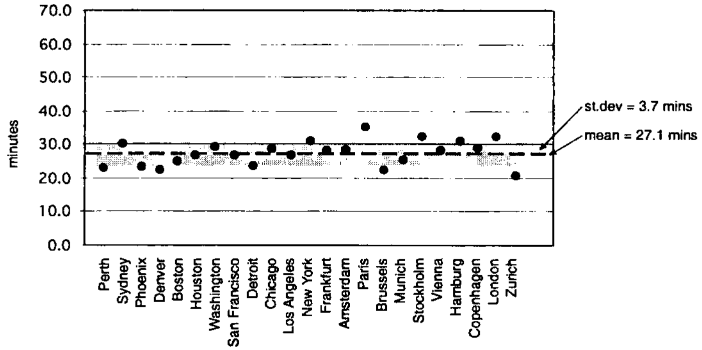
In answer to this concern I would make the point that human communities were doing these things long before they started building cities. Hunter-gatherer communities have sophisticated artistic and cultural traditions that pre-date the rise of large fixed settlements around 10,000 years ago (Rudgley, 2000, p.68). But these communities do not engage in manufacturing and infrastructure development on a scale commensurate with large divisions of labour found only in cities. Even early cities reveal a caliber of activity that sets them apart from the lifestyle and economy of hunter-gatherers. So while art and culture are activities that take place in cities, and which add to their richness, they aren't a distinguishing feature and nor are they the fundamental reason for why we build them.

If it is accepted that building cities is about trying to overcome space and time for economic reasons to do with production, then the role of urban transport can be seen to be of central significance.

## 2. How people use their time in cities

In the early 1970s, social scientists became keenly interested in how much time people allocated to different tasks that make up a typical daily routine. One highly cited study found that irrespective of ethnicity, culture, religion, level of industrialization or access to transport technologies, most populations, on average, spend around 30 minutes on the daily journey-to-work (Robinson, Converse and Szalai 1972, pp.114–117). Transport planners also have a long tradition of interest in this observation and refer to the phenomenon as *travel time budget*[2] *constancy* (Kirby, 1981, p.1 and SACTRA, 1994, pp. 39–40).

**Figure 1 Average travel times for the journey-to-work in 23 industrialised cities (1990)**



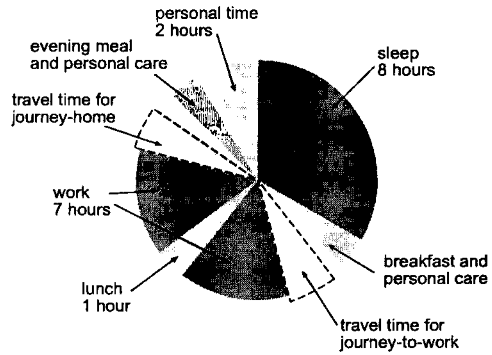

Data source: Kenworthy, JR., Laube, FB., Newman, PWG., Barter, PA., Raab, T. Poboon, C. and Benedicto, G. 1999, *An international source book of automobile dependence in cities 1960-1990*. University Press of Colorado, Boulder, p.610.

[2] There are two aspects to travel time budgets: i) the amount of *time* spent on travel, and; ii) the amount of *money* spent on travel. This paper deals solely with time expenditure. It is important to bear this in mind with respect to the use of the term *travel time budget*





**Figure 2 Typical daily tasks that make-up a daily routine**



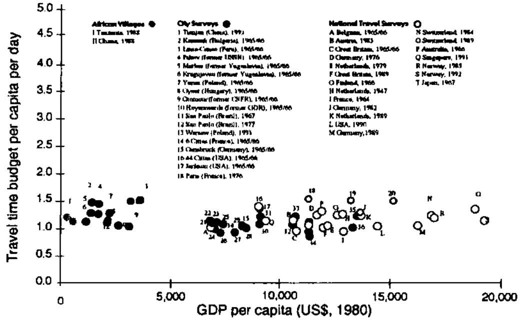

Time allocations are based on data contained in: Robinson, JP, Converse, PE. and Szalai, A. 1972, "Everyday life in twelve countries" in *The use of time: daily activities of urban and suburban populations in twelve countries.* Szalai, A. (ed). Mouton, The Hague.

Figure 1 shows average travel times for the journey-to-work for a selection of EU, US and Australian cities. The average for these cities is just on 27 minutes and there is a difference of only a few minutes between the averages. The explanation for why such similarity occurs is that the other demands on an individual's time, limits the scope for wide variation. Coupled with this is the motivation to try and reduce travel time so as to have more time at destinations, while at the same time there is a motivation to spend more time travelling to access new and novel destinations, which is the whole point of living in a city. An examination of the tasks and activities that make up a typical day shows how these motivations fit within the framework of a daily routine.

There are only 24 hours in a day, everyone has to sleep sometime, eat, maybe tidy up around the house and have a wash. As can be seen in Figure 2, once time spent at work is taken out of the equation, the window left for travel becomes quite narrow. The journey-to-work is not the only reason for travel and of the total number of trips undertaken in cities amounts to around 25 to 30 per cent of that total. In addition to the journey-to-work, travel time budget constancy also applies to travel time for all trips combined. Many studies have shown that on average populations spend somewhere between 70 and 75 minutes on total travel per person per day (Schafer, 1997, p. 459).

In this overview, the journey-to-work will be the primary focus of attention because it is the trip that relates to earning a living and has to do with the productivity of cities as outlined in section 1. It is also

**Figure 3 Average travel time budgets for total daily travel in a selection of international locations**




Source: Schafer, V. 1998, "The global demand for motorised mobility" in *Transportation Research: Part A*. Vol. 32, No.6, p.459.

the trip type that gives rise to high levels of congestion and stretches urban transport networks to their limits because most individuals undertake the journey-to-work at around the same time. Because congestion triggers a range of different feedback processes that will be discussed later, it has special significance.

The figures for travel time budgets discussed so far have been averages. In practice, different people in the same population spend very different amounts of time on travelling to work and other destinations, so it is important to understand how travel time budget constancy manifests itself in practice.

## 3. Travel time budget constancy in practice

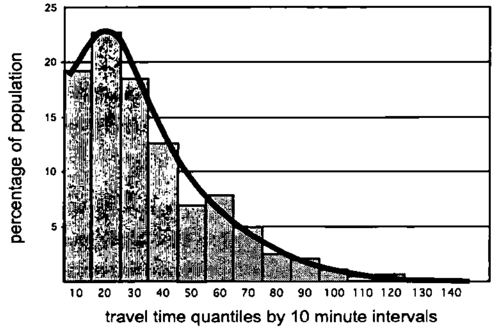
Behind every average is a statistical distribution for an entire population. The distribution shown in Figure 4 is for the Sydney workforce. The significant characteristic of the distribution is its shape, for this is the real face of travel time budget constancy. Not an average, but different proportions of the community spending given amounts of time on their journey-to-work. In this example, around 19 per cent of the population spent less than 10 minutes travelling to work, 23 per cent between 10 and 20 minutes, 18 per cent between 20 and 30 minutes, 12 per cent between 30 and 40 minutes and so on.

In the journey-to-work distributions for other cities, the percentages of the population represented in each travel time quantile may not be exactly the same as those for Sydney, but they are very similar. Slight differences in the percentage of population that falls within each quantile will bring about slight





**Figure 4 Travel time budget distribution for the journey to work for Sydney**

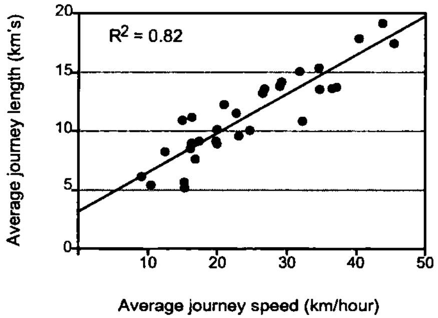



Data source: Transport Data Centre. 2001, *Household Interview Survey for Sydney, 2000.* NSW Department of Transport, Sydney.

changes to the average. When average travel time budgets for the journey-to-work are presented as were shown earlier, it is important to keep in mind that each average is indicative of a distribution similar to that shown here for Sydney. The usefulness of this becomes apparent when the travel time budget quantiles shown in the statistical distribution are translated into spatial data and mapped to show the area that different percentages of the population are prepared to access, as shown in Figure 6.

Before continuing, a few points about travel time data need to be made. Firstly, data on travel time budgets is extremely sensitive to collection techniques (Stokes, 1994, p.28). This is one of the reasons it has not featured in transport models, although there are notable exceptions (see Zahavi, 1979 for details of the UMOT model and Downes and Emmerson, 1983, for a critique of it). Second, despite these problems, average travel time budgets for both the journey-to-work and total travel tend to be similar for populations from different districts within the same city (see for example Hedges, 1993, p.3). So a statistical distribution for a sample of the population living on the outskirts of a city will be similar in shape to those for samples from inner city neighborhoods. Third, differences in land use development patterns, or urban density, do not seem to affect average travel time budgets either (Gun, 1981, p.12). Distributions for populations living in dense urban environments have much the

**Figure 5 Average journey length vs. average journey speed for the journey-to-work in 31 international cities (1990)**




Data source: Kenworthy, JR., Laube, FB., Newman, PWG., Barter, PA., Raab, T. Poboon, C. and Benedicto, G. 1999, *An international source book of automobile dependence in cities 1960-1990.* University Press of Colorado, Boulder, p.610.

same shape as those living in low density districts within the same city.

Differences in trip rates do occur, however. In dense cities, people on average make fewer trips (UITP, 2000). This suggests that people incorporate more purposes into their trips than do those populations residing in low density cities where land uses are more dispersed and single-use development more common. This also reveals an interplay between travel time budgets for the journey-to-work and budgets for all trips combined. In very dense Asian cities where walking and cycling are most prevalent, travel times for the journey-to-work do appear to be slightly higher than those presented in Figure 1 (Kenworthy and Laube et al, 1999, p.610). But trip rates for these same cities are amongst the lowest, suggesting that people are more inclined to incorporate other purposes into their journey-to-work and then spend less time on other trips — so that in the end the empirical nature of travel time budget constancy is maintained. In addition to having lower trip rates, on average trip distances are shorter and average speeds slower, as shown in Figure 5. In low density cities, trip rates are high as people undertake more single purpose trips (UITP, 2000), average distances are longer, speeds higher and individual trip times shorter (Kenworthy and Laube et al, 1999, p.610).





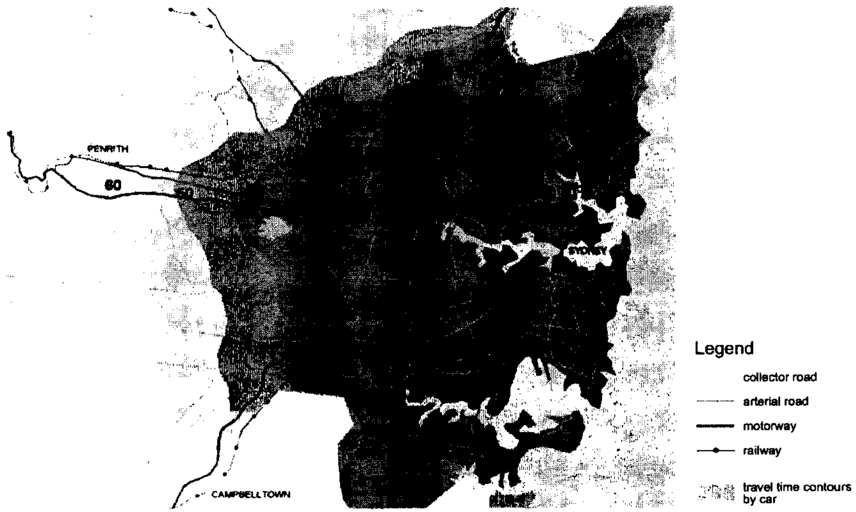
## 4. How changes to transport systems cause people to change the transport mode they use

By mapping *travel time budget contours* it is possible to see how different transport systems produce different shapes and areas of access within given time periods. The area that falls within the range of the contours changes according to the speed and logistical properties of the mode in question.

The map of the Sydney CBD and surrounding suburbs shown in Figure 6 identifies those areas that are accessible by car within the journey times that various proportions of the population are prepared to spend traveling to work. These contours were calculated on the basis that there was no congestion.

In Figure 7 the accessible areas within travel time contours shrink dramatically because empirical data for morning peak period travel speeds was used. The higher number of cars on the roads causes congestion and slows down the road network. Travel time contours for rail and public transport services to the Sydney CBD show a very different pattern. These are shown in Figure 8. In the morning peak period, travel time contours extend far beyond those for the road network. Because they are quicker and extend over a much larger area, most people use public transport services if they work in the CBD — almost 80 per cent of the workforce (Transport Data Centre, 2001).

**Figure 6 Travel time budget contours for journeys by car to the Sydney CBD (2000)**



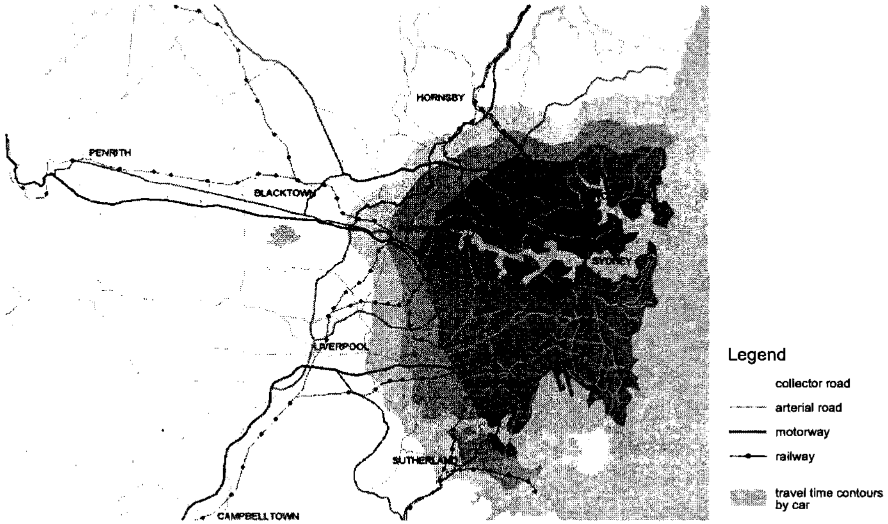

▲ Travel time contours were calculated on the basis of legal speed limits. For arterial roads, speeds were reduced by five per cent as estimates for time spent waiting at intersections.

When the speed and capacity of urban transport services are altered, travel time contours also change. Empirical evidence shows that people change their transport mode to take advantage of the quicker travel times. These changes are dramatic and occur soon after changes to the network (Zeibots, 2003, p.14).

Figure 9 shows the travel time contours from Penrith in Sydney's outer west before the last section of the M4 Motorway was opened in May 1992. Superimposed on this are travel time budget contours for express train services. The bottleneck that occurs where traffic from the motorway joins the Great Western Highway can be seen where travel time contours become smaller. In Figure 10, the contours for car travel expand over a larger area and overtake those for rail services in some cases. This is because access by car became quicker for some people once the bottleneck had been removed. As a consequence they shifted from the rail to the road network.

In the months immediately after the new motorway section opened there was a sharp increase in car trips for combined volumes on the motorway and arterial road that runs next to it (Zeibots, 2003,

**Figure 7 Travel time budget contours for journeys by car to the Sydney CBD in the morning peak period (2000)**

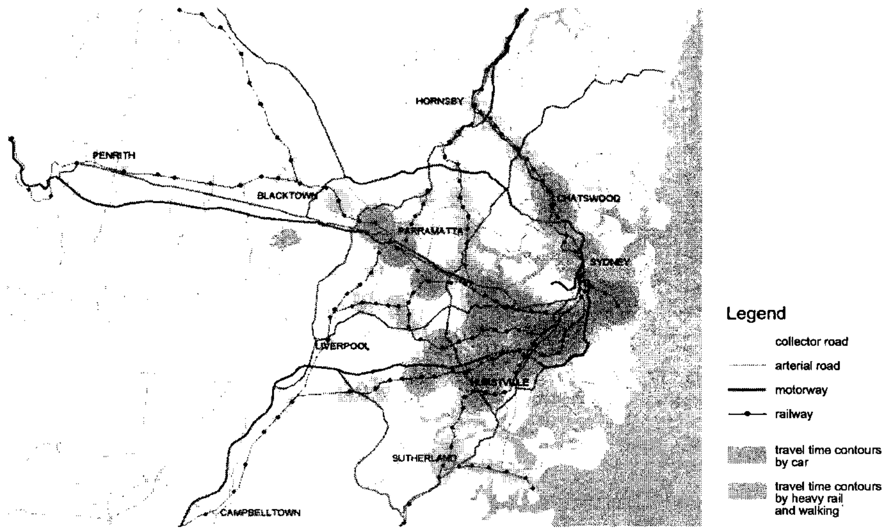



▲ Travel time contours were calculated on the basis of aggregate AM peak speeds published by the Roads & Traffic Authority for 2000/01 in its annual report. The shape of contours would differ if more detail were available. In many districts, particularly those close to the CBD, average speeds are likely to be less than 30km/h.





**Figure 8 Travel time budget contours for journeys by train and walking to the Sydney CBD in the morning peak period (2000)**

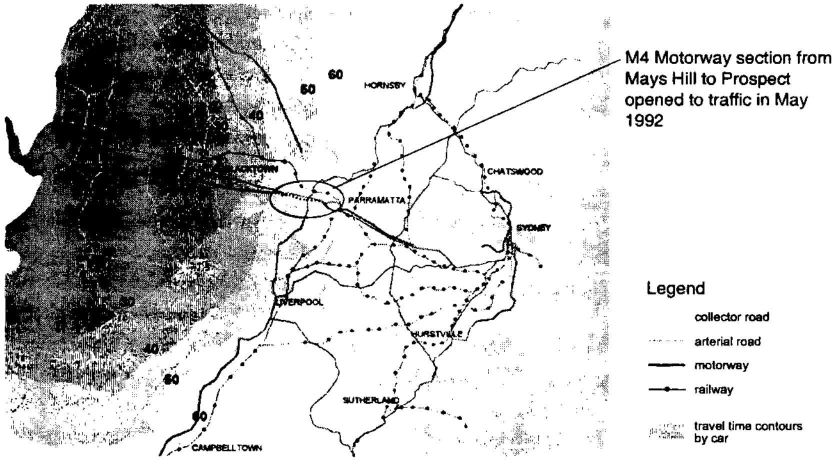



▲ Travel time contours were calculated to include a combination of travel by heavy rail and walking. Estimated walking speed was 5 km/h. Heavy rail speeds were calculated from timetables for the period. Contours would be larger if buses and cycling were included.

p.16). This can be seen in the time series road traffic volume data for the two roads, shown in Figure 12.

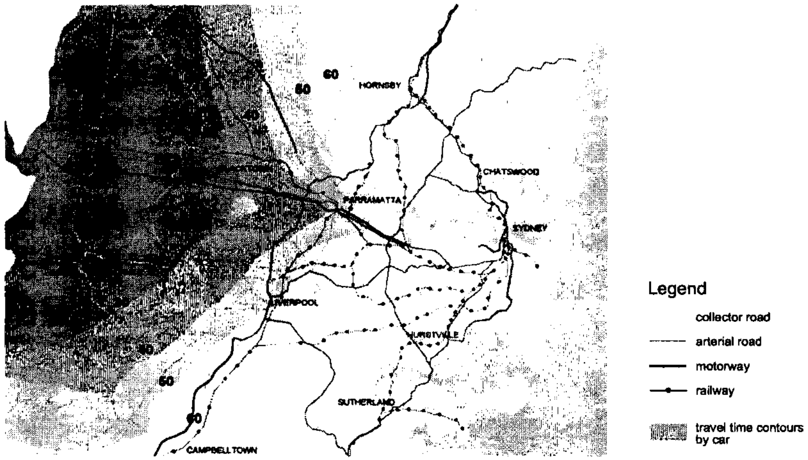
At the same time that car trips increased, rail passenger journeys declined. This can be seen in Figure 13. In this example, not all the increase in car trips can be explained as people shifting from rail to road. A portion of the increase was clearly caused by road users changing routes as they abandoned slower arterial roads for the new motorway. Some of the increase is also explained as business-as-usual growth or increases due to population expansion. In previous years this growth rate was around 3 to 4 per cent (Zeibots, 2003, p.3). But even after all these factors are taken into account, a portion of the increase in trips remains unexplained. These appear to be new and longer trips generated in response to the new regime of travel time contours. Transport planners and engineers refer to these additional trips as *induced traffic growth* (SACTRA, 1994, p.7–8).

**Figure 9 Travel time budget contours for journeys by car from Penrith before opening of the M4 Motorway from Mays Hill to Prospect (1992)**




▲ Travel time contours were calculated on the basis of legal speed limits and service levels calculated from hourly traffic counts. For arterial roads, speeds were reduced by five per cent as estimates for time spent waiting at intersections.

**Figure 10 Travel time budget contours for journeys by car after opening of the M4 Motorway from Mays hill to Prospect (1992)**

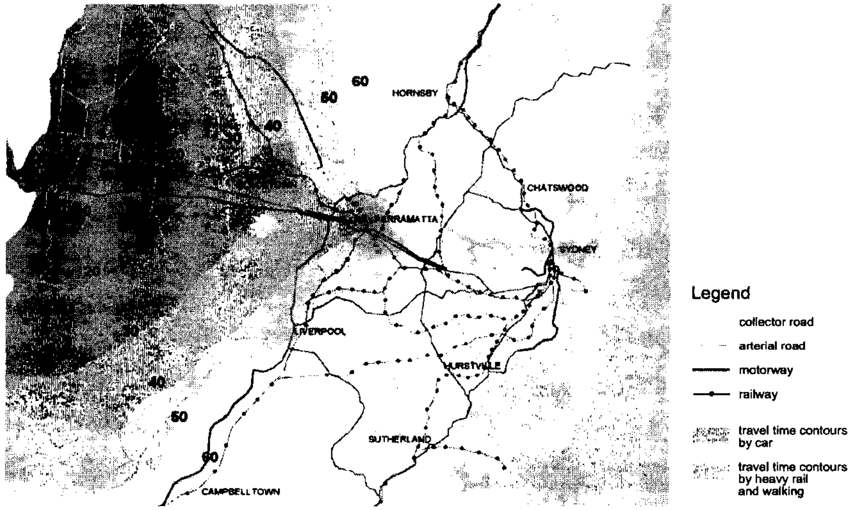



▲Travel time contours were calculated on the basis of legal speed limits and service levels calculated from reassigned hourly traffic counts across the M4 motorway and Great Western Hwy (immediately after opening).





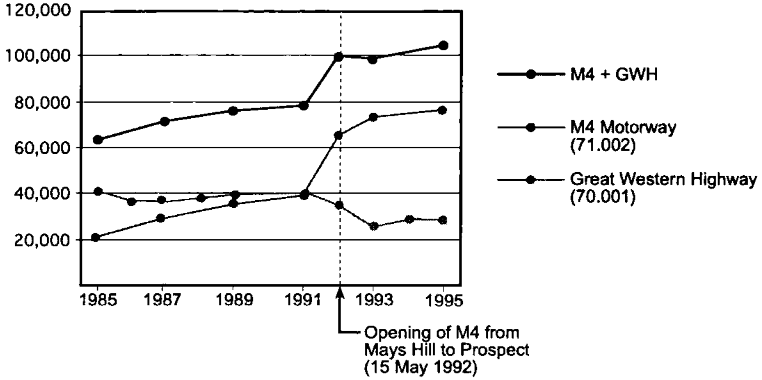
**Figure 11 Travel time budget contours for journeys by car and rail from Penrith after opening of the M4 Motorway from Mays Hill to Prospect (1992)**




▲ Travel time contours for rail services were calculated for express services only.

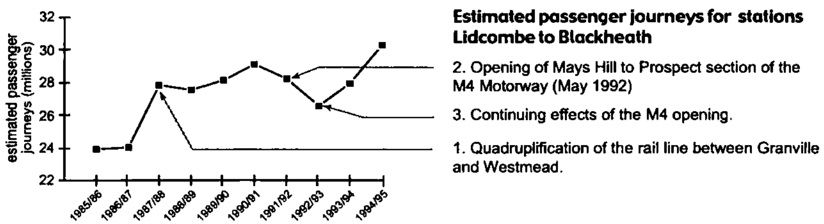
If we cast our minds back to the reason outlined in section 1 for why people build and live in cities, then we can see a more detailed manifestation of that rationale in this data. The urge to save time so that more exchanges can be made motivates people to change modes so they can have more time for doing other things. At the same time other people took advantage of the quicker speeds and made additional trips to make more exchanges or travelled to more distant destinations because the types of exchanges to be made were preferable. These divergent motivations explain the statistical distribution that is the travel time budget constant. All these responses constitute different forms of system feedback. The engine that drives these processes is travel time as encapsulated in the travel time budget constant, acting as the system controller. The way to express this mechanism most clearly is to map it and understand it as spatial data. How useful this is can be appreciated when other forms of system feedback like those in the land use sector are considered.

**Figure 12** **Annual Average Daily Traffic for the M4 Motorway and the Great Western Highway at Pendle Hill 1985–1995**




Source: RTA. 1995, *Traffic volume data for Sydney region 1993*. Roads and Traffic Authority of NSW, and Armstrong, B. 2003, *Personal communication*, 6 January.

**Figure 13** **Estimated passenger journeys for the Western Sydney Rail Line 1985–1995**




* Note that scales on the y axis alter between plots. Scales have been chosen to highlight more clearly fluctuations in passenger estimates.

Source: Zeibots, ME. 2003,*Before and after opening of the M4 Motorway from Mays Hill to Prospect: Sydney case studies in induced traffic growth.* Working Paper. Institute for Sustainable Futures, University of Technology, Sydney, p.23.





## 5. How changes to travel time contours change patterns of land use development

Changing the travel time contours of the transport network not only changes the modes that people use, but also building types and patterns of land use development. The outcomes can be seen in the way changes in urban density and building types follow the shape of travel time contours for different modes. For example data showing urban density differences throughout Sydney show points of higher density development that follow the route of the heavy rail system that serves the city's outer suburbs (ABS, 1993, pp.82–83).

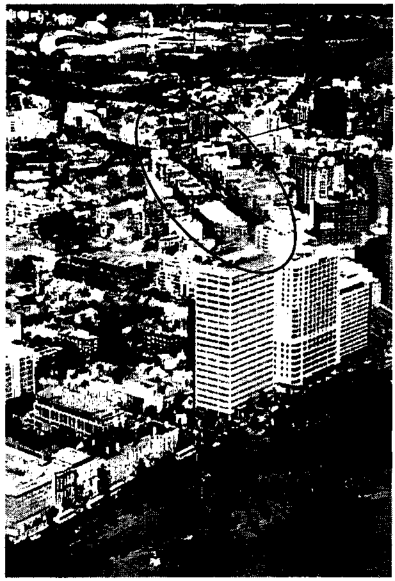
As shown in previous Figures, road networks and car use produces travel time contours that spread over large and diffuse areas. By contrast, travel time contours for heavy rail services provide access between concentrated pockets. Land use development clusters around the walking precincts of stations to take advantage of mass transit services. To access stations, people have to approach on foot. The closer an individual is to a station, the quicker it is to use rail over some other mode. Unlike road-based transport, large spaces for parking are not required, leaving more room for activities. In neighbourhoods serviced by trams and light rail, urban development concentrates in ribbon strips along the route if an on-street facility is provided, rather than in points as is the case with heavy rail. This reflects the different logistical characteristics of different modes.

Land use development supported by road transport and car use does not benefit by forming up in

**Figure 14** **Aerial view of Eastern Sydney showing higher density development at heavy rail stations precincts**


Photograph by Michelle Zeibots, August 2003.

**Figure 15 Aerial view of Eastern Sydney showing remnant ribbon strip development along Oxford Street in Sydney's Eastern Suburbs**



Ribbon strip development along Oxford Street, Darlinghurst in Sydney's Eastern Suburbs

Photograph by Michelle Zeibots, August 2003.

high concentrations. This is because large spaces are required for parking. Ease of parking is needed to keep travel times low for trips by car whereas with public transport, the destination needs to be close to the service stop so that it can be easily reached on foot.

Few cities today rely on only one mode of transport. Most comprise a mixture of different land use patterns created by different transport systems. Over time, however, one form of development can come to dominate older forms. This occurs when travel time contours for one mode overtake those of another so that pressure from one mode to access different markets overwhelms what can be accessed using an alternate mode. This could be seen in the previous example where speeds and areas accessible by car were increased beyond those accessible by rail services. People switched mode as a result. Much the same happens with patterns of land use development. As the area accessible by car increases because of new motorway construction, car based forms of land use development follow in their wake and older buildings are removed or adapted to accommodate the mode that provides greater coverage. Figure 16 shows the dramatic changes to building typologies that can occur when accessibility by one mode — in this case the car — outpaces what can be accessed by





**Figure 16 The changing face of terrace house building typologies in Syney's Inner West**

Photograph by Michelle Zeibots, August 2003.

◀ These terrace houses were built before motor cars were available. The façades are orientated in a way that is appropriate for an approach to the buildings on foot. The alignments work to maximise pedestrian contact.

These recent terrace houses show a radical change to building façades. The relationship between the building and the street has also changed given the different spatial needs for motorvehicle use. ▶

Photograph by Michelle Zeibots, August 2003.

mass transit, walking and cycling. As accessibility profiles change, the size of different markets also changes, so that economic activities taking place within land use sectors are affected. This puts new and different pressures on land use activities and building form, as will be outlined in the next section.

## 6. How changes to travel time contours change the size and shape of market catchments

If travel time data is considered in a spatial format, it is possible to view the data as delineating *market catchment areas* too. The concept of market competition, where suppliers try to increase their custom by providing better and cheaper goods and services than other businesses, is a familiar one. The outcome is supposed to bring benefits to consumers. The idea is often applied to different transport modes — car travel competing with public transport (for example Cevero, 1998, pp.23).

For many land use activities, the way in which they are *housed* becomes an important component in their ability to compete within an urban market. This can be seen most clearly in the retail and housing sectors. The best way to appreciate how this happens, and how it affects urban morphology, is to look at an example.

To the south of Sydney is a Shopping Mall — the largest in the southern hemisphere. With over 4,000 car parking spaces, what was once a modest department store surrounded by specialty shops, has become a massive building complex over a kilometre long and spanning three street blocks. Within the area there are also several small local shopping centres clustered around heavy rail stations.

After expansion of the shopping mall — which saw the removal of a church, school, police station and local park — small business owners located at rail precincts saw a dramatic downturn in trade. Many went out of business. This happened for two reasons. First, the new mall had an enormous amount of car parking available to customers and the area is well serviced by large arterial roads, so accessing the mall was quick and easy. Second, the new mall had a larger number of different shops as well as two department stores, all of which could be accessed via privatised and air conditioned streets, free from road traffic, once a customer was inside the complex.

In the five years prior to expansion, most new residential development within the region was car orientated. Suburban subdivision, with no local rail access and minimal bus services, provided a ready market of customers whose quickest option was the car. The mall is located near a five-way intersection of arterial roads. After expansion, the mall became the quickest and easiest shopping centre to access. So many people did. As the diversity of shops and services in the smaller centres diminished, people who still shopped there, out of necessity, found themselves at the mall more often.

As trade at the mall grew, business at railway precincts shrunk. Other factors to do with trade practice and economies of scale then came into play. The mall owners offered lower rents to essential services to attract them into the mall while at the same time, non-essential specialty shops were charged higher rents. This was all done to increase and consolidate trade and revenue at the mall.

**Figure 16 Streetscape views of car based shopping mall and rail based shopping precinct in Sydney's south**





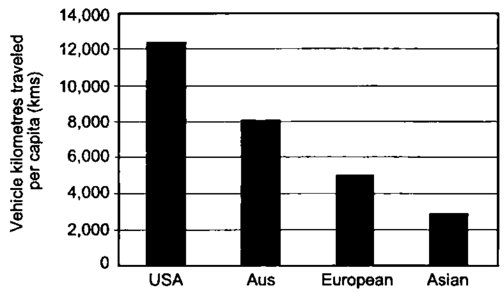
These changes occurred because the areas that fell within the travel time contours for car travel were far greater than those for travel by mass transit, cycling and walking. Those conditions were caused by the decisions of planning authorities. To say that the changes were all the result of consumer preference is to dodge the root cause — the configuration of the prevailing transport infrastructures. People simply wanted quick access to a wide diversity of goods and services — as indeed they always do — and responded accordingly, given the way the environment had been planned for them.

## 7. The relationship between different types of infrastructures and general transport costs

The distances between the people and operating units that make up a city system affects the costs of servicing the city with infrastructures. This is not just the case for transport but other hard infrastructures like water and sewerage, electricity and gas, and also soft infrastructures like education, healthcare and civilian policing. In lower density areas where distances are greater, the amount of materials and energy needed to connect buildings, neighbourhoods and people becomes greater and more expensive too.

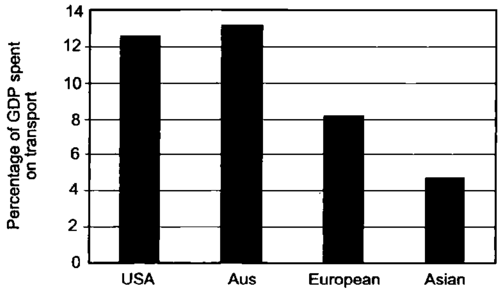
The role of urban density was best illustrated in the pioneer work of Newman and Kenworthy (1989) and then expanded in later research by Kenworthy and Laube et al (1999). In data for the same suite of cities, a clear trend can be found between average vehicle kilometres travelled and urban density as shown in Figure 18. If the trends are taken to their logical conclusion, it can be shown that cities with low urban densities spend higher percentages of Gross Domestic Product (GDP)[3] on transport than those cities with higher urban densities, as shown in Figure 19.

**Figure 17 Average vehicle kilometeres travelled for 32 international cities (1990)**




Source: Kenworthy, JR. and Laube, FB. et al 1999, An international sourcebook of automobile dependence in cities 1960—1990. University Press of Colorado, Boulder.

**Figure 18 Average percentage of city based GDP spent on transport for 29 international cities (1990)**




Source: Kenworthy, JR. and Laube, FB. et al 1999, An international sourcebook of automobile dependence in cities 1960—1990. University Press of Colorado, Boulder.

The upshot of this is that while many regional governments advocate the construction of motorways as a means of improving the efficiency of their transport networks, in aggregate, such constructions have the effect of reducing efficiency and pushing costs up. This is because spatially, they commit the city to a structure that requires a much greater throughput of materials to function. In the same way that businesses rely on the structures that house them to provide a competitive edge, as was outlined in the previous section, entire cities rely on their infrastructures to provide a competitive edge when engaged in global trade with other cities. As a city's infrastructure systems expand and per capita costs increase, inputs to production become greater. Sustaining economic activity within the formation becomes increasingly difficult (Zeibots, 2002, p.3).

## 8. Calculating the benefits of new transport infrastructures: current evaluation methods

Cost Benefit Analysis (CBA) is used in some form by most governments throughout the world to assess the merits of transportation projects. While it is applied in many countries in association with a variety of other assessment tools like Multi-Criteria Analysis (MCA) (Hayashi and Morisugi, 2000, p.77), CBA dominates the evaluation process. By monetising the value of benefits against capital, and sometimes social costs, a single number in the form of a Benefit Cost Ratio (BCR) is produced. Most practitioners view this simple and seemingly obvious assessment method as rigorous and authoritative because of its numerical format (Rayner, 2003, p.4).





But problems have occurred. Despite the intellectual ease that accompanies comprehension of the method, many of the outcomes it supports have been shown to be empirically ill advised. As pointed out by many commentators, developments in appraisal methodology often occur when transport policy objectives change, and policy objectives in turn change, when things begin to go wrong (Bristow and Nellthorpe 2000, p.52).

The most dramatic changes to transport evaluation methods in recent years appear to have taken place in the UK. The shortcomings of several high profile motorway projects during the 1990s prompted widespread public objections that in turn prompted a reassessment of both theory and practice (Owens, 1995, p.44). After the opening of the last section of London's M25 ring-road, in the eyes of many people, traffic conditions and delays appeared to be worse (SACTRA, 1994, p.51 and Owens, 1995, p.44). Problems with induced traffic growth and the inherent inability of CBA to accommodate this empirical outcome were put under the spotlight and made the subject of a government inquiry (SACTRA, 1994).

One of the chief criticisms of CBA has been that only those factors that are easily monetised are considered in the evaluation process (Rayner, 2003, p.1). Impacts on the environment, induced traffic growth and changes to land use patterns are not. In response, some researchers have argued that these other factors, or externalities, should also be monetised and included in the CBA ledger of costs and benefits (see for example Willis, Garrod and Harvey, 1998).

In the UK, decisive change finally came with the election of a new government in 1997. After that period, the so-called *New Approach to Appraisal* was introduced, or NATA 5 (Vickerman, 2000, p.7). NATA 5 and its many EU variants can broadly be described as forms of Multi-Criteria Analysis (MCA) within which are "nested" a form of CBA (Bristow and Nellthorpe 2000, p.52). The MCA component considers impacts that cannot be quantified and attempts to integrate other strategic planning considerations into options. But it does not monetise them and there is no clear guidance given as to when undesirable *qualitative* outcomes should be prioritised over the significance of a benefit that has been given a numerical value using CBA (Rayner, 2003, p.2).

The purpose in relaying what has happened in the UK, is to demonstrate that although the need for change was recognised, and more sustainable outcomes in the transport sector was the desired goal, problems with the evaluation method still plague the decision making process, so that much the same sort of projects and outcomes have been the result on the ground. Rayner (2003) provides a thorough account of these problems in practice.

[3] GDP in this case has been calculated for the city region and not the national or state economy.

The primary problem seems to be the way travel time is treated in CBA during the evaluation process. For this drives right at the heart of the evaluation process and represents something very different to the functional role outlined previously. This fundamental inability to represent time in a functional way is the reason why so many projects with poor sustainability credentials are built.

In CBA, the costs and benefits of a transport project are listed in two groups. Costs include the price of construction, land take and any other losses or negative impacts. In the case of a motorway, benefits commonly include factors like fuel savings, reduced wear and tear on vehicles, reductions in accidents and *travel time savings*.

The primary benefits calculated for motorway projects are travel time savings. As pointed out by Goodwin (1981, p.99), these can be as much as 75 per cent of purported benefits. More recent reports put these at 80 per cent (Rayner, 2003, p.1). For many projects, the travel time savings are of only a few minutes duration on a person-by-person basis. Both the problem, and its significance, is best appreciated by considering an example.

To calculate the travel time savings, an intellectual scalpel is drawn around the project and its immediate region, isolating it from the rest of the city system. Trips currently taking place on the network are recast on the new motorway, where the route may be more direct and provide uninterrupted travel, free of traffic lights and intersections. With more capacity, congestion is assumed to be reduced and travel times made quicker. Under these conditions a typical travel time saving is calculated, multiplied by the total number of trips and then translation into a monetary value.

In most cases the travel time savings are very small. But, if these small time periods are added together, and costed at say $15.50 per hour, a large monetary value can be calculated. For example, if a new urban motorway is proposed and 80,000 vehicles on average are expected to use the road each day with an average occupancy rate of 1.4, and the new project will save 2.5 minutes on each trip, then on paper the project has a daily benefit of $72,333.33. For an entire year, this amounts to $26,401,666.67.

Next, the benefits are divided by the costs. If the benefits are greater than the costs, a Benefit Cost Ratio, or BCR, above one is achieved and the project is deemed to have merit and so should proceed. If the BCR is less than one, because the benefits are less than the costs, the project is presumed to be unviable.

The primary objection often leveled at this evaluation practice is that an individual could not possibly increase their labour productivity by making more meaningful exchanges or increasing their work output in such a small period of time. Nor could they conceivably increase their leisure time and





derive any benefit or utility from that. By extension, no collective increase in utility amounting to the large sum derived out of the calculation could take place, so the resulting number value is an artifact of the methodology and not an indication of any tangible benefit.

In response, some transport economists have argued that the travel time savings are substantive for individuals when considered as increments in a wider scheme of transport projects. Or in other words, the small travel time savings arising out of several urban motorway links produce large travel time savings from which tangible economic benefits do arise, so the evaluation practice is acceptable (Henscha as cited in Welch and Williams, 1997, p.232).

Other arguments have taken place over the monetary value that should be assigned to travel time savings. A long debate has ensued on this point (Welch and Williams, 1997). In the EU, different member countries use different values, or a sliding scale, for different types of traffic (Bristow and Nellthorpe, 2000, pp.53 and 55). But debate over which value should be used steps around the central point of concern which is that if the outlay on time basically remains the same, but other factors of the urban system change, then why value time at all? Why not calculate the benefits arising in other areas and use these to off-set the cost of construction?

For those who argue that assigning monetary values to travel time remains acceptable, the reasoning usually takes this course: the value of time saved is a proxy for the utility of time spent on something else and this includes additional travel to other destinations because greater utility is derived from the new destination that is now more accessible (Goodwin, 1981, pp.99–100).

At a cursory glance this seems reasonable enough, but problems emerge on close consideration of the various system feedback processes. The argument relies on the implicit assumption that all utility transferred through travel time savings is positive. But because some of these processes generate disutilities, confidence in the assertion is misplaced.

The form of system feedback outlined in section 6 can lead to disutilities for many individuals. Some services that were available locally can close down and shift to another location where business prospects are better under the new regime of travel time contours. This means that trips can become longer, take more time than they had before, use more resources than was previously used and consequently cost more money. Most significantly, the greater total costs per capita for transport networks with high proportions of road and motorway orientation do not generally produce cities that are wealthier than those with lower infrastructure costs per capita. Indeed, it can be argued that those with lower infrastructure costs are more efficient.

Contradictory outcomes such as these are inevitable if evaluation methods are construed in such a way that a project is isolated from its operating context so calculations do not reflect the processes that take place in the system in practice. The argument that relies on an easy transfer of utility does not hold up under the weight of broader empirical evidence.

In practice, such casualness in evaluation methods is admissible in times of plenty when the real costs of poorly conceived proposals can be absorbed because there is plenty of 'fat' in the system. But when sustainability becomes the policy goal — largely because the amount of 'fat' in resources and other parameters is no longer present — such costs cannot be absorbed and the evaluation methods that give rise to them must be overhauled.

## 9. What to do instead?

Good critiques offer alternatives, but in this case it is difficult to identify an alternate evaluation method that has both the intellectual simplicity of CBA and is able to render time in a faithful manner. This paper has attempted to outline a variety of system feedback processes that take place in urban systems after time and spatial parameters have been altered by new transport infrastructure projects. If methodology frameworks like that of NATA 5 are to be pursued, then perhaps further tailoring could take place. At present, the various categories that fill the criteria boxes of an MCA framework comprise functions classified as economic externalities. If the system feedback processes outlined in this paper could be treated as functions that are central to the transport function and economic benefits calculated within each of these, then perhaps the result would be a suite of categories from which a number of benefits can be estimated and off-set against the cost of construction.

There is the possibility that these values would never be large enough to off-set the cost of an urban motorway, so that smaller treatments to existing networks, or Least Cost Planning solutions would be favoured. But perhaps the benefits of large urban motorways never have been as great as the cost to construct them.

How real a problem the intellectual separation of a transport project from its wider operating context is, will no doubt be seen in the decades ahead. As global oil reserves become increasingly scarce and energy profit ratios decline, the need to reduce greenhouse gas emissions becomes more pressing and the impacts of global climate change more dramatic, the push for sustainability will be seen to have been a worthwhile project. A key component of this push will include the overhaul of evaluation methods in transport planning and project assessment.





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