Sustainable Transport

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A Background paper prepared for the State Sustainability Strategy

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Executive Summary

In principle it is recognised that to develop a sustainable transport system will require extensive effort over a prolonged period of time. But for all of that there are a number of actions that can be started in the immediate future and that can be built on as resources allow that will ensure we move as rapidly as is practicable toward our desired objectives.

The two main areas where new initiatives are required revolve around:

- changing existing planning processes to require economic, environmental and social (Triple Bottom Line) evaluations of all initiatives and programs(old and new);
- developing a set of tools that will allow the inclusion of triple bottom line (sustainability) criteria into the evaluation

and the core objectives that these initiatives are aimed at addressing are:

- to maximise the positive benefits and minimise the negative impacts of transport / land-use decisions on sustainability
- to move away from dependence on oil-based fuels
- to institute open and accountable processes that allow public and private scrutiny of processes that impact sustainability
- to continue public / community / stakeholder participation in decision-making

there is also a need to implement a number of strategies to ensure sustainability and these are:

- to enact the recommendations of the Freight Network Review
- to repeat the Freight Network Review processes for urban private car use
- to institute a user-pays system for transport / land-use
- to employ Multi-Criteria Analysis (MCA) for all transport / land-use projects (new and old)
- to extend the Freight Network Review to cover the rest of the state

Introduction

It is increasingly clear that current transport systems are not environmentally—and, consequently, not socially or economically—sustainable over the long term.[1]

The requirements for a sustainable transport system imply that the movement of people and goods occurs in an environmentally, socially and economically sustainable way; mobility for communication and enabling social contacts as well as for access to goods and services is to be considered as a means rather than an end in itself.

Environmentally sustainable mobility will require changes in behaviour and innovative approaches – technological as well as societal - at all levels of society and all sectors of the economy.

Generally, transport in the future will be characterised by a massive shift from less sustainable to more sustainable modes accompanied by a relative decrease in transport activity.

All the necessary policies, operational changes and measures will support and accompany a shift towards more environmentally sustainable transport (EST), while not necessarily decreasing economic and social welfare.

A key feature of transport under an EST scenario is illustrated in Figure 1. Transport activity, while less than under the business as usual (BAU), is still greater under the EST scenario than it is now. This is made possible by much greater use of transport modes that are more respecting of the environment, the economy and the needs of society. Thus, attainment of EST does not necessarily mean a reduction in transport activity, only a reduction in certain types of transport activity.

The EST criteria will likely not be met by technology alone. Indeed, contrary to much of current transport and environment policy, the results of the EST research suggest that attainment environmentally sustainable transport will require at least as much focus on changing transport-related behaviour[2] as on improving vehicles, fuels and infrastructure. It is anticipated that less than half of the effort in meeting EST criteria will come from technological improvements or from reducing the size and power of vehicles. More than half will come from managing mobility, from using vehicles more efficiently (better occupancy and loading), shifts towards more sustainable transport modes (e.g., road freight to rail freight, car as driver to walking, cycling, using public transport or teleaccess) and from reducing the need for physical movements of people and goods (demand management).

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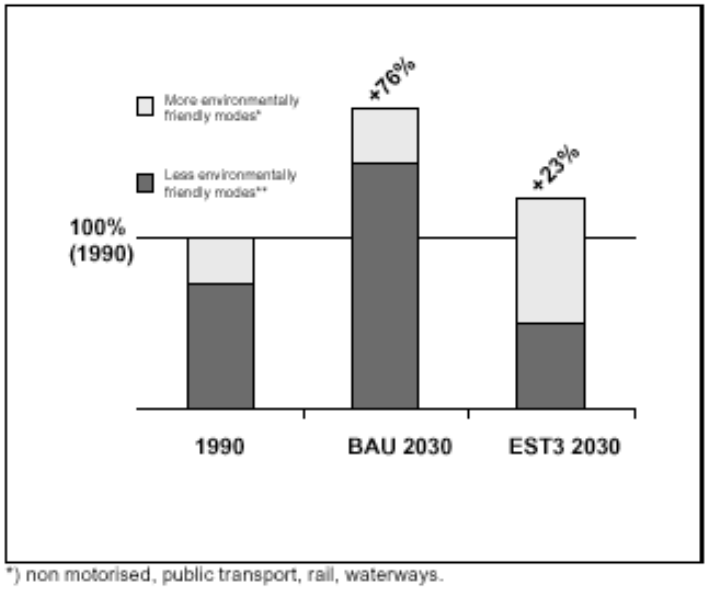
[1] For more information see:
OECD, 1996: Environmental Criteria for Sustainable Transport, OECD, Paris and
OECD, 1999: Report on Phase II of the OECD EST Project; Vol 1, Synthesis of EST Scenarios, Paris.

[2] It should be noted that the only effective existing program that operates to undertake this is the DPI TravelSmart program.

Figure 1 Modal structure of transport activity for passengers and freight



*) non motorised, public transport, rail, waterways.
**) individual motorised transport for the movement of passengers and freight.

As many countries develop mid- to long-term policy strategies for transport, this finding is important in that it may constructively guide our own efforts in the future.

Sustainability: Definitions and implications

Sustainability has been variously defined. One way to understand the meaning of sustainability is to see it as either narrow resource sustainability or broad environmental, economic and social sustainability. Resource sustainability could be defined in either absolute terms as 'the total extractions and throughputs per community, firm, or society' or in relative terms as 'energy and materials extractions and throughputs per unit of GDP'. Resource sustainability is only narrow as a concept in relation to environmental and social ('broad') sustainability defined as 'societal well-being per unit of environmental impact' (where impacts encompass pollution, wilderness and habitat loss or damage, unintended and problematic climate or genetic alterations and energy and materials extractions and throughputs in excess of replacement capacity).

In this usage, environmental and social sustainability is conceptually broader than resource sustainability in two ways:

1. resource extraction or throughput is broadened to incorporate comprehensive measures of environmental impact and

2. GDP is broadened to include measures of societal and environmental well-being.

The second change is very much larger than the first for two reasons.

1. the larger share of environmental impacts relate to the extraction, processing and throughput of resources and, in the case of many forms of energy, the use of the resource. That is, if resource sustainability is improved, most kinds of environmental impact will be lessened as well in the process.

2. well-being as a societal objective is significantly different from GDP growth as a societal objective in many ways.

Concerns regarding resource sustainability and environmental impacts and inputs in total, suggest to most sustainability analysts that sustainable economic growth implies continuous reductions in material and energy extractions from nature per unit of economic output. That is, production must become less resource intensive, either more efficiently utilising energy and materials or dematerialising output by creating products and services that use little or no energy or materials.

As well, sustainability also implies a need for absolute reductions in the use of selected materials (non-renewable oil-based products in the movement of people and freight, for example), a maximisation of materials re-use and recycling and the limiting of renewable resource use to amounts well within nature's capacity to supply them continuously.

Obviously, such conclusions carry enormous economic, moral, political and practical consequences. The most important implication of this perspective is that economic growth should be optimised in terms of long-term environmental and resource capacities rather than only maximised in its own terms. A second implication is that to the extent that economic activity is not an end in itself (and sustainability analysis generally presumes that it is not), we must maximise those outputs (summarised as well-being) per unit of economic output. Thus the need for sustainability analysis to be undertaken in terms of a three-dimensional model of societal functioning where well-being is taken to be the primary goal of human activity and both economy and society are understood to be dependant on the environment and resources. Sustainability theory, to which we now turn, understands the environment as sustaining the economy and the economy in turn as helping to create and maintain well-being.

What Does "Freight Mobility" Mean?

"Freight mobility" is not a widely discussed issue. Some of the concepts of personal mobility may also apply to freight, e.g., the cost and time required to move freight between various locations in a city, a region, or the world. Without trying at this point to define freight mobility, we can at least suggest that it should incorporate the following considerations:

•Manufacturers' ability to obtain raw materials from distant sources.

•A city's ability to obtain food, energy, construction materials and other goods at costs that do not discourage development and growth.

•The ability for manufacturers to consolidate production so as to achieve economies of scale and sell to a larger market.

•Ability to achieve lower density within metropolitan areas (because it is easy to transport goods within the region) while the metropolitan areas themselves grow (in part because economies in freight movements make it possible to achieve economies of scale and density in public services, production, housing and other areas of the economy).

•Individuals' ability to obtain groceries, energy and other goods without increased costs, disruptions in service (e.g., of natural gas delivered to customers through pipelines), or greater expenditures of time.

•Producers and individuals being able to send and receive packages or other shipments of many different sizes without excessive cost or time.

Sustainability theory: The triple bottom line

An effective process of choice regarding indicators is rooted in sustainability theory. That theory has now evolved to the point where widely diverse individuals and organisations share an analytic perspective – called the triple bottom line. The World Bank has utilised the triple bottom line as a " . . . systematic way of testing the economic, environmental and social sustainability" of specific funding proposals. In the words of Bank official Ismail Serageldin: "A proposal has to be economically and financially sustainable in terms of growth, capital maintenance and efficient use of resources and investments. But it also has to be ecologically sustainable and here we mean ecosystem integrity, carrying capacity and conservation of natural resources, including biodiversity. Ecological sustainability is the domain of the biologist and the physical scientist. The units of measurement are different, the constructs are different and the context and time scale are different. However, equally important is the social side and here we mean equity, social mobility, social cohesion, participation, empowerment, cultural identity and institutional development. The social dimension is the domain of the sociologist, the anthropologist and the political scientist."[3]

Elkington, for example, argues that forward-looking firms develop a long-term vision and actively seek to not only meet their economic, but their environmental and social responsibilities as well. As he put it: "The new agenda for business will increasingly revolve around values and ethics. Successful companies will be better at identifying, understanding and responding to the values of those they work with and serve."[4] Triple bottom line analysis will allow firms to understand and even to anticipate some of the ethical demands that they face or will face. Elkington advocates use of life cycle assessment (LCA) techniques to determine environmental and social impacts on a product-by-product and firm-by-firm basis. Sustainability indicators can be seen as performing functions similar to LCA at the community and society level.

To fully understand costs, benefits, trade-offs and opportunities triple bottom line indicators must be selected that directly measure economic, social and environmental outcomes in their own terms.

While there are two-way positive and negative flows among all corners of the triple bottom line, sustainability analysis focuses on human well-being as the central objective of prosperity, a goal that in turn depends on the perpetual availability of benefits from nature. The character and efficiency of these two causal links, in effect, determine sustainability outcomes. At these two points of causal linkage, Robinson and Tinker identify two forms of 'decoupling' essential to moving human societies and economies toward sustainability.

[3] Serageldin, Ismail (1996), Sustainability and the Wealth of Nations, pg. 3. Washington: World Bank.
[4] Elkington, John (1998), Cannibals with Forks, pp. 407. Gabriola Island, BC: New Society. [Provides an insightful business-oriented discussion of triple bottom line thinking.]

One is the decoupling of economic output (GDP) from energy and material throughputs (either through more eco-efficient production techniques or the enhanced exchange of literally non-material goods and services). In other words, sustainability seeks GDP growth rates that significantly exceed throughput and extraction growth rates. If possible, GDP should grow while throughput and extraction decline.

The other decoupling, of social well-being from GDP growth, poses even greater challenges to public policy and contemporary values. This goal does not necessarily,

Air Freight

Air freight is the newest, fastest and most expensive freight mode. The speed and reliability of air service allow dramatic innovation in business practices and open new markets for certain types of commodities. The expense of air freight limits the tonnage that is handled, but the high value of shipments makes air freight an important factor in international trade.

There are three types of air cargo services: freight moving in commercial passenger aircraft ("belly" cargo), freight moving in aircraft specially dedicated to freight and express services for small packages. The first two services compete with surface transport for high-value shipments.

Every air freight move is an intermodal move, as a highway move is required at each end of the shipment. Businesses that depend upon air freight often locate at or next to airports to minimize the time and expense of the local move. For example, large companies may keep inventories of expensive parts at a warehouse next to an airport; when need for the parts arises, they can be dispatched by the next available flight. The expense of air freight is justified by the savings from consolidating inventories at one location; it may even be quicker to deliver the parts by air freight than by using highway transport from a closer warehouse.

Express services are decidedly different, as the focus is on small shipments, including many shipments direct to consumers or end users of the product. Typical shipment weights are 2 kilograms for domestic services in North America and 20 kilograms for intercontinental shipments. Door-to-door service is key for express services and carriers offer customers a variety of options, e.g., next morning, next afternoon, or second-day delivery. For such services, the cost of the air transport is actually secondary to ordering and billing costs. Once the packages have been picked up, the key is to minimize the amount of sorting required and to minimize the time required to make the delivery. Using aircraft for moving the packages to and from a central sorting facility allows overnight deliveries to be made across an entire continent. The speed of air transport is essential for these express services; the cost, at well under $1 per kilogram, is inconsequential. As traffic volumes rise beyond the capacity of a single sorting facility, carriers may open additional sorting hubs and they may begin to do more preliminary sorting at the local terminals in order to allow some use of trucks for deliveries to regions that can be reached in an overnight drive. A highway-based system will work fine, but only if the maximum distances are less than 500 miles and if there is enough volume to support the added cost of the truck.

however, suggest that economic growth is not a positive outcome; it implies only that we should seek to improve quality of life faster than we increase wealth. In everyday language, the goal of this decoupling is 'getting more well-being for our money'.

Both decouplings can be advanced through 'policy wedges' or interventions. The first decoupling might be advanced, for example, through green taxation (on energy and raw materials rather than wages) or enhanced public or private expenditures on sustainable production innovation. The second decoupling (of prosperity and well-being) might be achieved, for example, through increased expenditures on education or health care, or through reductions in work time (so that more time was available for family and community life). Such improvements might come about through increased prosperity, but

would be politically controversial if they implied, as they often do, some change in economic distribution , Robinson and Tinker[5] assert.

A vision of Sustainable Transport (ST)

Sustainable transport in the future will, by definition, meet all criteria. In building a vision of such a system, two alternate pathways need exploring. The first consists of developing a scenario in which the criteria are met solely through technological means while transport activity continues to grow as projected in current forecasts. One conclusion of this exercise is that only fossil fuel-free technology (e.g. hydrogen-based) will be able to meet the criteria. The other pathway consists of reaching the ST criteria solely through demand-side management. This scenario is deemed to be politically infeasible as it placed significant restrictions on individual mobility and the movement of goods. The working group then developed a scenario that meets the criteria by combining some of the most promising currently existing and tested technological features of the technologies with the more politically acceptable features of the demand-side scenario. In this scenario, transport is characterised by the following.

- There is a significant decrease in car ownership and use with many cars running on hybrid-electric/fuel cell engines.
- There is a focus on reducing long-distance travel for passenger travel and on much greater use of non-motorised means for short-distance trips together with supporting infrastructure.
- Longer-distance freight movements are significantly decreased — hydrogen will be widely used as a fuel both directly and in fuel cells.
- Rail is all electric, with high speed modes and increases in efficiency.
- More efficient and less polluting inland and coastal shipping vessels will be used — hydrogen may also be used as a fuel.
- Long-distance air travel is substantially reduced. Aircraft in use are more efficient, conventional types. Rigid airships may be used for shorter journeys.
- Electric power for transport is generated with much greater efficiency than at present, using a high proportion of renewable fuels.
- Relatively small changes in the form of settlements have been implemented in order to reduce the need for movement of people and freight.

[5] Robinson, J. and J. Tinker, (1997), “Reconciling Ecological, Economic and Social Imperatives: A New Conceptual Framework, “ in Ted Schrecker, ed., Surviving Globalism: The Social and Environmental Challenges, London: Macmillan, 71-93.

- Greater use of telecommunications is made to avoid passenger travel and the movement of goods

- Regionalisation of production occurs to avoid long-distance freight movement; volumes of production are reduced.

- Continuing public education campaigns are implemented to help support lower levels of travel and to lead to more sustainable consumption.

Criteria for sustainable transport

The following six criteria may be considered as being the minimum number required to address the wide range of transport environmental impacts.

CO_2

Climate change is prevented by avoiding an increase per-capita carbon-dioxide emissions from transport such that atmospheric concentrations of CO_2 are stabilised at or below their 1990 levels. Accordingly, total emissions of CO_2 from transport should not exceed 20% of total CO_2 emissions in 1990.

VOCs

Damage from carcinogenic VOCs and ozone is greatly reduced meeting WHO Air Quality Guidelines for human health and ecotoxicity. Total emissions of transport-related VOCs should not exceed 10% (or less for extremely toxic VOCs) of total transport-related VOC emissions in 1990.

Noise

Noise caused by transport no longer results in outdoor noise levels which present a health concern or serious nuisance. Depending on local and regional conditions, this may entail a reduction of transport noise to no more than a maximum of 55-70 decibels during the day and 45 decibels at night and indoors.

NO_x

Damage from ambient NO_2 and ozone levels and nitrogen deposition is greatly reduced meeting WHO Air Quality Guidelines for human health and ecotoxicity. Total emissions of NO_x from transport should not exceed 10% of total transport-related NO_x emissions in 1990.

Particulates

Harmful ambient air levels are avoided by reduced emissions of fine particulates (especially those less than 10 microns in size). Depending on local and regional conditions, this may entail a reduction of 55% to 99% of fine particulate (PM_{10}) emissions from transport.

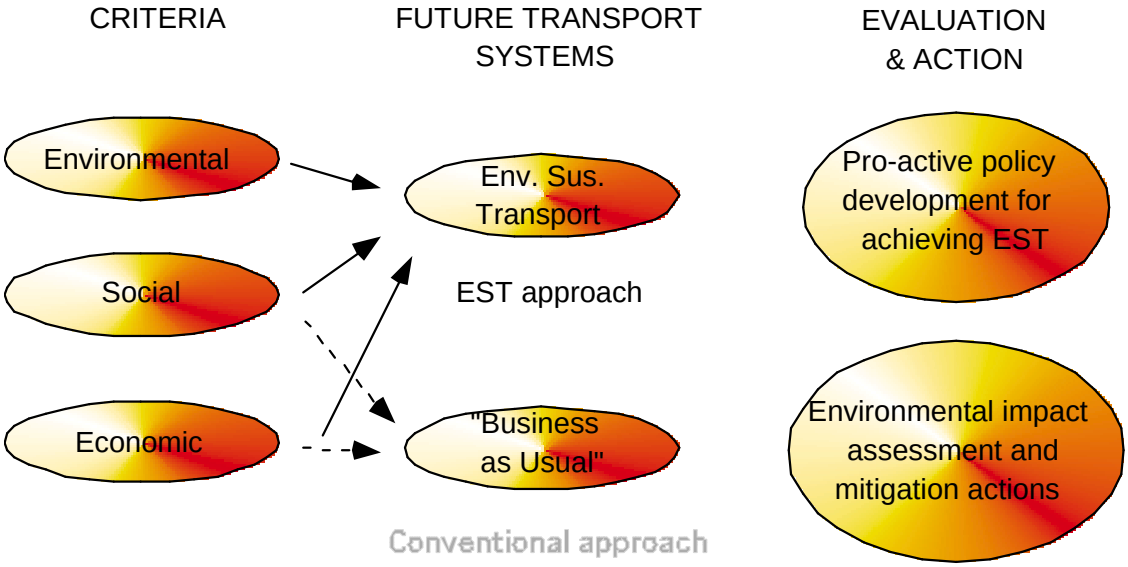
Land-Use

Land use for the movement, maintenance and storage of all transport vehicles is reduced to the extent that local and regional objectives for ecosystem protection are met. Compared to 1990 levels, this is likely to entail a smaller share of land devoted to transport

Generally transport in the future will be characterised by a massive shift from highly-polluting to less-polluting modes accompanied by a relative decrease in transport activity. This shift is accompanied without necessarily decreasing economic and social welfare.

The criteria will likely not be met by technology alone. Indeed, contrary to much of current transport and environment policy, achieving environmentally sustainable transport will require greater demand-side than supply-side measures. The workgroup participants generally have anticipated that one third of the effort necessary to meet the criteria will come from technology and two thirds from demand-side management. As many countries develop mid- to long-range policy strategies for transport, this finding is important in that it may help guide those efforts.

Environmentalists and policy advisors have been increasingly expressing concerns about urban transport and its environmental consequences in recent years as levels of activity have risen.



Over the past 20 years there have been significant changes and developments in the ways in which freight operations are carried out and the concerns about the negative environmental and social impacts of freight vehicle activity.

First, distribution and logistics systems have changed considerably, with a significant degree of centralisation in manufacturing sites, stockholding points and retailing. Supply chain structures have also changed substantially, especially for larger companies where many have taken increasing control over the supply chain and the distribution of goods to their premises.

Second, the stockholding patterns and hence the goods delivery patterns required by manufacturers, retailers and other urban premises, have changed substantially, with a tendency towards more frequent, smaller deliveries. This move towards more frequent deliveries has resulted in a growing use of smaller freight vehicles.

Third, the level of current concerns about the environmental impacts of our urban activities and especially our urban transport systems, were not present 30 years ago. It is now widely acknowledged that new urban sustainability policies are necessary if urban areas are to continue to be desirable places in which to live, work and spend our leisure time.

Fourth, there has been a major growth in the demand for and the outsourcing of service activities in the last 10 to 20 years, which has resulted in a substantial growth in service vehicle movements in urban areas. Thus, to achieve a balanced approach to urban distribution a greater understanding of the goods and service requirements of urban

premises and the freight and service operations that provide for these needs is essential, if urban areas are to continue to be economically and environmentally viable.

Movement of goods and services in urban areas

The movement of goods and services in urban areas is influences by a number of factors, the most critical of which can be regarded as:

- the design of the distribution system
- the type of premises being served
- the range and variety of the products used/sold
- the time of deliveries to premise

The problems that freight transport operations experience in urban areas are not[6] well understood. Research has shown that it is possible to gain a detailed appreciation of the problems experienced by goods and service vehicles in urban areas, with the result that six categories of problems experienced by goods and service vehicle operations (for further details of the individual problems within each of these six categories see Allen et al, 2000) are defined:

- Traffic flow/congestion problems
- Transport policy-related problems
- Parking and loading/unloading problems
- Customer/receiver-related problems
- Problems of freight transport and service companies' own making
- Other issues that cause problems

Freight and Environmental Trade-offs

Understanding the sustainability concerns related to freight transport requires an examination of trade-offs between different kinds of environmental and social disruption.

For instance, large commercial barges are among the most energy-efficient forms of transport and are widely favored for their ability to move large commodity shipments off roads and highways, thus reducing congestion, air pollution and potential for accidents and noise. Nonetheless, their use can cause damage to the rivers and canals they travel and in particular, they often require extremely disruptive damming and dredging operations in order to make waterways navigable.

Similarly, if a freight link is being added to a pristine virgin environment, air transport — being completely localized in its impact — can be much less disruptive to the local environment than a road or railroad. However, air is much more expensive and also much less energy-efficient. There are similar trade-offs in the choice of materials. For instance, wooden rail ties treated with creosote cannot be recycled. One suggested alternative is the use of tropical hardwoods used to make very durable ties, avoiding the use of creosote. However, that promotes logging in tropical rain forests, which is often not an acceptable alternative.

Clearly, there are also important trade-offs with efficiency. Barges are slower than trains and trains are slower than trucks. Trucks are the most energy-intensive of the three alternatives as well as the most polluting. They are also the most flexible, how-ever and offer a level of service significantly superior to that of trains and barges for the movement of many manufactured goods.

[6] Allen. J, S. Anderson, M. Browne and P. Jones, A framework for considering policies to encourage sustainable urban freight traffic and goods/service flows, Summary Report, University of Westminster, March 2000. Available from http://www.wmin.ac.uk/transport/projects/u-d-summ.htm

However, if efficiency in freight transport operations is to be encouraged and promoted by sustainable transport policies, it is important that policymakers consider the supply chain when devising suitable policy measures and recognise the existing efficiency of operations at a supply chain level, rather than simply focusing on individual goods vehicle activity in urban areas.

Getting the prices right

Getting the incentive structures right will increase the efficiency with which resources are employed. In addition, for purposes of integrating economic and environmental sustainability, user charges should be giving signals which induce:

i the efficient use of available capacity (including scarce road space);

ii an efficient choice of vehicles and fuels;

iii an efficient split of traffic among modes; and

iv efficient infrastructure maintenance and management.

For social sustainability, it is usually considered

How Much Energy Does it Take to Get Cereal to the Breakfast Table?

Consider the energy consumed by freight transport related to producing and delivering boxes of breakfast cereal to families in a developed world city. For simplicity, assume that there are three main freight movements between the farm, the local grain elevator, the production plant and the supermarket. We can estimate the fuel consumed by each leg of the move using typical trip lengths, vehicles and fuel efficiency:

- Movement of grain in 10-tonne truckloads from the farm to a local grain elevator (50 km @ 3.4 km per liter for the truck => 15 liters for the trip or 1.5 liters per tonne).
- Movement of the grain in 90-tonne hopper cars from the grain elevator to a production facility (750 km @ 5 liters/1000 net tonne-kilometers => 3.9 liters per tonne).
- Movement of the grain in 20-tonne truckloads from the production plant 75 kilometers to a local supermarket (75 km @ 2.1 km per liter => 1.8 liters per tonne).

If we assume that it takes a tonne of grain to make 2000 boxes of cereal and that grain is in fact the only component of the cereal, i.e. no sugar and no preservatives, we find that it will take about 7 liters of fuel to get 2000 boxes of cereal to the supermarket. Since cereal sells for about $6 per box, the entire shipment is worth $12,000 and the cost of the fuel is inconsequential, whether the cost is $1.00 or $6.00 per liter (or more).

After the cereal is delivered to the supermarket, many individual shoppers will buy it and bring it home. If 1,000 people go shopping by car, traveling an average roundtrip distance of six kilometers to the supermarket and if they each buy two boxes of cereal and the cereal accounts for only 5% of what they buy, we can also estimate the fuel that they use to bring the cereal home:

- Bring the cereal home from the supermarket (1000 6-kilometer roundtrips at 8.5 km per liter => 6000 automobile-kilometers and 700 liters of fuel consumed, of which 35 liters are attributable to the cereal).

In this simplified case, the amount of fuel used by consumers in going to the store to pick up the groceries is five times as great as the fuel consumed by trucks and trains to get the groceries to the store. The 2000 boxes of cereal in this example required the equivalent of just 5 kilometers of travel in the farmers' trucks, 8.3 kilometers in the railroad's covered hopper and 3.8 kilometers in the delivery truck, but 300 kilometers in the shoppers' automobiles. The forces that created the supermarket have created an extremely efficient system for moving goods to the stores, but at the time required an increase in personal travel to buy the goods.

desirable to avoid regressive taxation structures as well as to ensure accessibility for the poor, which may involve providing some facilities and services for which payments by users are less than the real costs.

In practice, the instruments available for charging for road use are limited. Until recently, direct congestion charges could only be implemented by a cordon of toll points around the congested area, which has worked well in Singapore but is only suitable when the number of tolling points is small and there is an efficient and scrupulously honest administration for enforcement. Simpler forms of charging vehicles to cross a cordon into the city (motivated by the potential for revenue generation rather than altering behavioral incentives) have been introduced in some Scandinavian cities in the 1990s. New electronic tolling systems, such as that now being introduced in Singapore, will make more complex time-sensitive applications easier.

Currently, despite their limitations, fuel taxes are the only instrument through which any charge is made for road use in many countries. If there are no other charges for road use then users should pay not only for the resource cost of fuel (generally the international border price) but also for the other costs imposed on society associated with the consumption of fuel, such as externalities. Any taxation over and above resource and externality costs should be imposed on consumption goods but not on inputs to production. Any luxury or sumptuary taxation should be set in ways that minimise the distortion of consumption patterns.

There are numerous problems of evaluation of the cost elements (particularly environmental costs) and their allocation between vehicle categories. It is also clear that fuel price is not a very good proxy for congestion charges in urban areas.

Because the costs of road use and the environmental impacts of transport vary from circumstance to circumstance there is therefore no unique retail fuel price appropriate to all countries and circumstances. It is therefore strategically important that:

i) there should be a commitment to the general principles for determining fuel taxation;

ii) total road cost accounts should be compiled, accompanied by an analysis of how these costs can be attributed to different vehicle categories.

Revenues from road use and expenditures on roads could also be institutionally linked in a more businesslike way. Because urban congestion charges relate to urban transport system costs, it would be appropriate for revenues from a congestion charge or tax to be assigned to an Urban Transport Fund, to be spent on whatever urban transport expenditures (including public transport investment or revenue support) appear to be most cost-effective in improving the quality of the urban transport system. Clear evidence that the proceeds of a congestion charge were being devoted to improve the situation might help overcome the historic resistance to such new charges. As in the case of Road Funds, the creation of Urban Transport Funds must be associated with appropriate,

accountable, institutional arrangements that enable stakeholders representatives to ensure oversight of expenditures.

Transport and land use interactions

Recognition that transport demand patterns are very closely dependent on the structure of land use has been the traditional basis on which urban transport demand has been forecast. It has also, consequently, been fundamental to the design and provision of transport facilities. The converse effect of transport provision on land use has also been long recognized. Transport infrastructure can provide access to new areas, thereby enabling land-use patterns to change. However, because the impacts tend to be much more indirect and long term in emergence there has been a tendency for transport planning to be organised to serve land user rather than vice versa. Distortions in land markets create excessive transport demands. Breaking free from these constraints of the past will be very difficult.

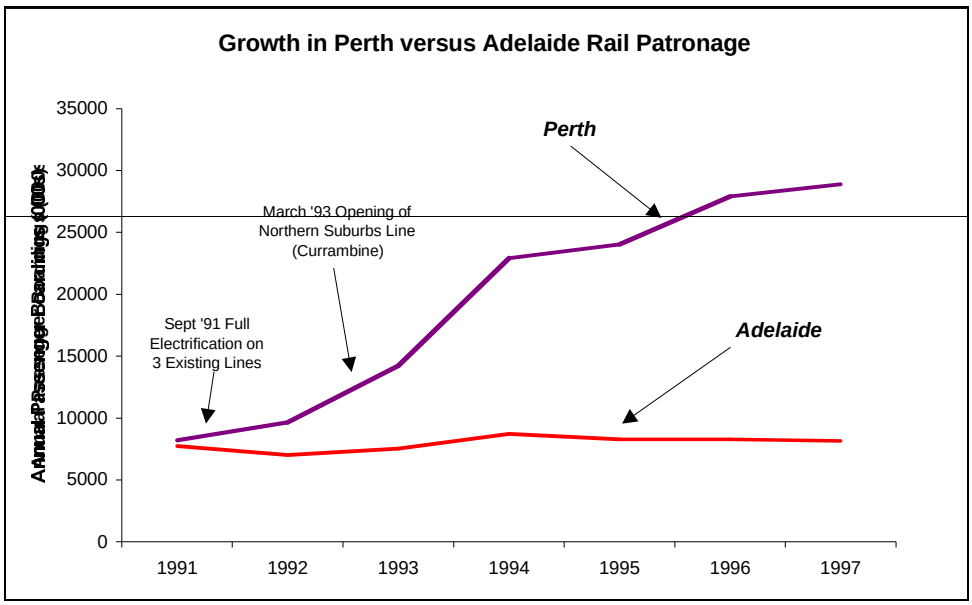
Urban form, urban transport and a sustainable environment

The environmental implications of urban form have been subject to increasing attention. Careful research by Newman and Kenworthy has demonstrated a strong inverse relationship between fuel consumption per capita and urban residential density. The close relationship between fossil fuel consumption and most vehicle emissions (although this can be altered through improvements in vehicle and fuel technology), has thus given rise to a school of thought that puts urban form at the center of the argument. The fact that public transport, if well utilised, is less fuel intensive than private transport has led to increasing attention being paid to a search for urban transport forms that are favorable to public transport. Because public transport is particularly suitable for handling concentrated corridor flows the development of a multi-nuclear linear city has been advocated as being particularly desirable environmentally.

The International Union (Association) of Public Transport in Australia (UITP) advises that public transport in Perth is in urgent need of additional rolling stock[7]. The first priority is to make public transport an attractive and competitive option to the motor car. Where this has been done, the benefits are very clear. Since electrification of its urban rail system and the construction of a 31 km line to the northern suburbs (paid for entirely from WA government funds), Perth's rail patronage has quadrupled in 6 years. Adelaide, which has retained a non-competitive diesel service has remained stagnant (Figure 2).

[7] The International Association of Public Transport (UITP), 2002, "Policy Options for Passenger Transport in Australian Cities of the Future", p12.

Figure 2 Perth and Adelaide rail patronage, 1991-1997



There is also value in examining the value of the 'Livable Neighbourhoods' concept to assist in the task of transport demand management. When we develop mixed land us communities where employment, services, education and residences are all in close proximity there is a tendency to reduce the length of trips and also change modes (eg more people will cycle or walk in preference to using motorised modes).

The corollary of the strong inverse relationship between residential density and fuel consumption per capita is a strong positive relationship between the level of land rents - and hence the average amount of space consumed per capita - and general urban density. Insofar as residential space is viewed as a good, it may be regarded as a proxy for the quality of the private environment. There may therefore be a trade off to be made between some aspects of the external environment (which would be enhanced by densification) and the internal domestic environment. Some basis has to be found for confronting that trade-off.

A quality urban public transport service has been identified as a key factor in encouraging business investment and location in an urban centre, especially technology companies. A report of a global survey by Jones Lang LaSalle and LaSalle Investment Management states that "A global average of 77% of respondents felt proximity to good public transport was a critical factor in location decisions, particularly for firms in tight labour markets"[8]. Business wants to know that its workforce can gain convenient reliable access to its workplaces and that those workers can arrive at work in a state that enhances productivity. Long, stressful two-way car commutes are an important contributor to worker stress.

[8] Bangkok Post, June 21, 2001 (Real Estate section).

Furthermore, new global economy jobs are seeking out urban locations with the greatest amenity and ability for face-to-face networking, which encourages innovation and synergies and also provides workers with a higher quality of life. Increasingly such locations are those that provide the most attractive, liveable urban environments, especially in their public spaces. Inevitably, these places are also those that have the best public transport services and which have managed to restrain the dominance of the private car and its adverse effects on the quality of urban life.

Increasingly, Perth will be judged on the quality of life and its business environment. It is no accident that Zurich, one of the wealthiest cities in the world and with arguably the best urban public transport system in existence, has also been voted in a business survey as the most liveable city in the world.

Road construction

The Bureau of Transport Economics predicts the increased cost of congestion between 1995 and 2015 for the five major Australian cities will be $16.8 billion per annum, an increase of 1.3 times[9].

But there is growing acceptance in the UK, USA and Australia that it isn't possible to build our way out of traffic congestion through road construction[10].

An analysis of 68 cities in the US between 1982 and 1997 shows that those cities that were aggressive in expanding their road networks fared no better (actually did worse) in reducing rush hour congestion than those cities that did the least to add new road space[11]. This is in a context of highway network total lengths on average increasing faster than population growth.

Failure to address this issue is clearly not sensible. Like the UK and increasingly the US and Canada, Western Australia must fully recognise that no amount of urban road building will be able to keep pace with the projections of urban traffic growth. Investment in comprehensive public transport networks employing state of the art technology in both the hardware of public transport (vehicles, stops, operations systems) and its software (seamless ticketing systems, superior passenger information systems, mobility chains) will have to deployed if we are to meet the urban transport challenge.

[9] Bureau of Transport Economics, 1999, "Urban Transport – Looking Ahead", Information sheet 14, Commonwealth of Australia.
[10] Richardson, E., Chambers, L. and James, B., 1999, Induced Traffic in Urban Areas, Department of Transport Technical Report R397, Western Australia.
[11] Surface Transportation Policy Project, 1999, "Why are the Roads so Congested ?: A Companion Analysis of the Texas Transportation Institute's Data on Metropolitan Congestion", Washington, US.

The role of public transport in sustainable transport systems

The economic impacts from failing to address efficient and sustainable mobility in Perth is insidious yet has the potential to have major impacts on the productivity of our economy.

In addition to capacity questions, it has been shown that public transport oriented urban environments have the most cost-effective urban transport systems. Calculating the total economic costs of passenger transport systems in cities (including all operational and investment costs for both private and public transport systems), car-oriented Australian cities spend 13.5% of their metropolitan Gross Domestic Product on passenger mobility. By contrast, the Western European cities with their well-developed public transport systems spend only 8.3%[12]. Available evidence on the economics of urban passenger transport suggests that automobile dependence is a drain on city economies soaking up valuable financial resources that could otherwise be invested in more income and employment-producing activities.[13]

The economic benefit from public transport in a city is often not understood. It has been calculated that by eliminating one car from a typical household over a working life $750,000 in extra superannuation could be accrued[14]. These funds are then available for more productive purposes in a city. Given concerns over an ageing population and our financial capacity to support a less-productive population, investments in public transport systems that allow many people to live with one less car or no car, seem like a very good investment.

The economic benefits of spending on public transport has been shown to be significantly better than the benefits derived from road spending. A major study concluded that public transport spending has more than twice the potential to improve worker productivity than highway spending. Furthermore net economic benefits from transit expenditures occur sooner for the economy as a whole than do net benefits from highway expenditures.[15]

In Australian capital cities the average per capita CO2 emissions from transport was 2,882 kg. Of this figure only 108 kg or 4% was caused by public transport. For the Australian cities, CO2 emissions from public transport averaged only 0.12 kg per passenger km, while from private transport it was more than double at 0.26 kg per passenger km.[16] Thus transfers to public transport have large potential to reduce greenhouse gases and reduce our contributions to global warming.

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[12] Kenworthy, J. and Laube, F. (2001) The Millennium Cities Database for Sustainable Transport. International Union of Public Transport (UITP), Brussels

[13] Newman, P. and Kenworthy, J. (1999) Sustainability and Cities: Overcoming Automobile Dependence. Island Press, Washington DC.

[14] Warman, B. (2001) Cars – Where are they taking us. Charter, Keck, Kramer Research, Strategic Property Consulting, Research Insight, March.

[15] Aschauer, D.A. and Campbell E.J. (1991) Transportation spending and economic growth. Bates College, September. Reported in Earthword: The Journal of Environmental and Social Responsibility 4 (38).

[16] Kenworthy, J.R. and Laube, F.B. et al (1999) *An International Sourcebook of Automobile Dependence in Cities, 1960-1990*. University Press of Colorado, Niwot, Boulder, Colorado.

The enormous untapped capacity of public transport to contribute to greenhouse gas reductions is clear by examining other cities around the world. In a large international comparison of cities, the highest CO2 per capita figure from public transport was in Munich where public transport plays a pivotal role. Public transport usage at the time averaged 404 annual trips per capita compared to 92 in Australian cities. Despite having nearly 4.5 times as much public transport use compared to Australian cities, CO2 emissions from public transport were a mere 230 kg per capita, or just over double the Australian figure[17].

Australian cities average approximately 200 kg per capita per annum of CO, VHC, NOx and SO2 and have 8% of total motorised passenger kms on public transport. Western European cities, with 19% public transport have an average of 100 kg per capita of these emissions from transport[18].

A suburban train with 1000 people on it eliminates 800 cars from the road. A single track of railway can move 20,000 to 50,000 people per hour (the latter figure was achieved in Sydney on the line to Home Bush Bay). This is 8 to 20 times the capacity of a lane of freeway[19]. A double-track railway also only requires 2.5 hectares of land per km compared to 10 ha per km for a 6 lane freeway[20].

Increasing car dependency is reinforcing social inequality in urban areas. Inner city gentrification and urban redevelopment is pushing low-income groups towards the urban fringe of cities where multiple car ownership is enforced by the lack of public transport. In the same way that a household can gain an extra $750,000 in superannuation over a working life through one less car, it can also afford to borrow an extra $80,000 for a mortgage. One less household car would also allow an average Melbourne mortgage to be paid off in 12 years rather than 25 years[21].

There is a need to give greater policy consideration to those sections of the community who have low levels of accessibility to employment opportunities by tackling the cause of the problem. Provision of greater mode choice and pricing signals (taxation) that encourage better employment location decisions will assist in dealing with the cause of this problem. Better public transport coupled with better employment locational decisions can help reshape Australian cities into multi-centred urban environments where it is as easy to move across and around the city on public transport as it is to access the CBD.

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[17] Ibid

[18] Kenworthy, J. and Laube, F. (2001) The Millennium Cities Database for Sustainable Transport. International Union of Public Transport (UITP), Brussels

[19] See Laird et al op cit

[20] Hill, D. (2001) Liveable, Sustainable Cities. Australasian Railways Association, ARA/LLDCN Urban Rail Conference, Sydney, 5 April.

[21] Warman, B. (2001) Cars – Where are they taking us. Charter, Keck, Kramer Research, Strategic Property Consulting, Research Insight, March.

Increasing mobility costs confronting the lower socio-economic households (eg western suburbs of Sydney) can account for up to 25% of household income[22]. This is likely to be exacerbated by the predicted increase in the price of oil[23].

The Disability Discrimination Act 1992 requires people with disabilities be given equal opportunity to access life activities. A lack of a suitable public transport network will isolate this vulnerable group from access to urban activities most people take for granted.

The limitations of land use planning

One approach, widely adopted in OECD countries is the use of directive land use planning. In practice, controlling the growth of urban areas is fraught with problems, which suggests that caution should be used in attempting any rigid control of urban structure. First, master plans typically underestimate urban growth and demand and controls may prevent densities from growing as they might in some areas while forcing them to be too high in others. Second, master plans typically do not succeed in controlling overall urban growth nor do they ensure efficient use of urban land and urban transport. Third, individual preferences for greater living space limit the political attractiveness of plans that are seen to limit residential location unduly.

Where transport prices do not reflect full social and environmental costs, the land market will generate inefficient land-use patterns. The institutional dimension remains critical. Land use planning depends for its success on the co-existence of a technically competent land use planning agency and an efficient (and uncorrupt[24]) administration. Where either of these is absent the impact of attempts to plan land use may be perverse.

Transport prices and land use

Except within the most restrictive and dictatorial of regimes transport prices will have a significant effect on land use. Under-pricing transport will encourage excessive dispersion of activities with attendant unsustainable consequences. This applies not only to private transport, but also to public transport. Hence where the case is being made for public transport subsidies, either for distributional reasons or as a countervailing distortion to the under-pricing of roads, the longer term distorting effects on land use must be carefully considered. It may be better to get all transport prices about right and to rely on more direct instruments to deal with distributional and modal distortion issues, than to systematically under-price all transport.

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[22] The International Association of Public Transport (UITP), 2002, "Policy Options for Passenger Transport in Australian Cities of the Future", p13.

[23] Les Magoon, 2001, "Oil Production Curve Cause for Concern", Australian Energy News, December 2001, p30.

[24] 'Uncorrupt' in this context does not limit itself to corruption in the form of monetary transfers in the form of bribery but also to the actions of powerful individuals who 'corrupt' existing processes to foster narrow, non-triple bottom line outcomes.

These problems are as serious in the under-pricing of land uses. The costs of servicing an outer fringe suburb on a green-field site are far in excess of those in an inner suburban brown- or green-field site. Yet most of the pricing signals developed by existing government processes would imply to a purchaser that the best option for them is to purchase in an outer suburb at the expense of the total system.

A trivial example is that the cost to connect to public utilities is the same independent of the buildings location and independent of the true costs of that connection. These pricing distortions lead to highly dysfunctional behaviours – as would be expected.

Eco-efficiency: The concept and its context

Much of past and current work on mitigating the impacts of transport activity has focused on vehicle operation by, for example, seeking to shift modal shares, improve vehicle technology and develop new fuel sources. Despite the relative importance of vehicle use impacts in disrupting the environment, participants are cautioned not to ignore impacts related to infrastructure construction, vehicle production and disposal and fuel/energy production. These can be significant and ought to be taken into consideration by policy-makers (see table 1).

Table 1 Transport related life-cycle impacts Source: INFRAS, 1996.

	Rail vs. Road Operations only	Rail vs. Road Operation & energy generation	Rail vs. Road Total effect (include. Rolling stock & infrastructure)
Energy	1:8	1:5	1:2.5
CO_2	1:78	1:40	1:5
NO_x	1:50	1:44	1:15
Noise	1:1	1:1	1:1
Land-use		1:32	1:2
Accidents	1:6		

Industrialised countries' relatively high levels of economic growth have been enabled by the use of massive amounts of the earth's geological and biological resources. The use of these resources has typically not been constrained by scarcity but rather, by the availability of capital, labour and knowledge. This has led to a "through-put" economy that wastes energy and materials at alarming rates. In Germany, for example, each citizen's annual consumption entails the movement of 70 tonnes of materials and 500 tonnes of water. Globally, more materials are moved by the action of humans than are moved by geological forces. Less than 20% of these materials ultimately end up in products; the rest are returned to the environment as wastes (ultimately, many of the materials incorporated into goods also are returned to the environment as waste at the end of products' life cycles).

In 1992, Friedrich Schmidt-Bleek of the Wuppertal Institute estimated that the wealthier nations of the world would have to, at a minimum, reduce their use of energy and materials by half, in order to not surpass these limits. He pointed out that this reduction did not necessarily translate into a net loss of welfare since great improvements were possible in resource and energy productivity. However, a factor two increase in the resource and energy productivity of the more industrialised nations would not be sufficient if less industrialised countries increased their use of materials and energy as they develop. Allowing for these countries to double their current rates of resource and energy use, industrialised countries would have to "dematerialise" -- that is, increase the resource and energy productivity -- their economies by at least a factor of ten (and to a factor of 20 to 50 when population growth is taken into account) over the next fifty years.

Some have pointed out that the practical difficulties of accomplishing such drastic changes in resource productivity may discourage many firms and governments from

adopting the factor ten goal as a guide for decision-making. Ulrich von Wieszäker and Amory Lovins have pointed out that the intermediate target of a factor four increase in resource productivity is not only possible by combining existing technology and process changes, but that it is already taking place in a number of innovative firms. They assume that the implementation of a factor four increase in resource productivity by less industrialised countries would allow these to bypass a phase of unsustainable resource and energy use as they seek to develop. This assumption may not hold true and some have suggested that a factor four increase in resource productivity in industrialised nations can only be considered as an intermediate stage towards the goal of a factor ten improvement if the rest of the world is to have "room" to develop.

We need to focus on value creation rather than physical output in the design and delivery of products, in order to reduce overall environmental impacts. It entails a major shift in business thinking, emphasising service, rather than material intensity and might have the potential for leading to a significant de-materialisation of both consumption and production. Promoters of the concept assume that consumers value the services rendered by products rather than the specific products themselves (ie you're not seeking the plane that takes you off on your holiday; you are rather, interested in the destination itself). Implicit in this view is the notion that real wealth and value can be generated through the use of less material and energy inputs and the creation of less environmentally harmful outputs.

It is suggested that we focus on the following three key features:

Value creation

Eco-efficiency encourages firms to re-examine how their products and/or services create value for customers. By focusing on the services provided by their products, businesses can explore alternative strategies for delivering the same, if not greater, value to customers with less environmental impact. For example, are consumers interested in *travelling between* destinations or *carrying out activities* at a specific location? Are people interested in *owning cars* or having access to *quick and spontaneous mobility*? By linking such broader definitions of value creation to environmental concerns, advocates of eco-efficiency argue that considerable reductions in environmental impacts can be achieved with greater overall value to consumers, stakeholders and society.

Dematerialisation/increasing service intensity

Closely linked to the notion of value creation is that of selling services to consumers rather than specific goods. This focus on long-term relationships with customers implies increasing inputs of knowledge and skills to make up for decreased material intensity. In extreme cases, firms assume ownership of their products throughout the life-cycle and derive profit from leasing products' functionality to customers. Firms, by designing closed loop systems where materials and components are re-used and/or recycled into new products, can greatly increase the resource productivity of meeting consumers' needs. Examples include leasing the cleaning power of solvents for industrial production and, in the transport sector, the freight capacity of trucks or the family sedan. In many

cases, increasing the service intensity of the economy implies de-coupling ownership and use of products.

Decreasing life cycle impacts

In seeking to improve their environmental performance, firms have generally concentrated on reducing the impacts of internal production processes. Business has typically viewed its environmental responsibility as ending once their product is in the customer's hands. Eco-efficiency recognises that companies can do much more to reduce the environmental impacts associated with the use and disposal of their goods and calls for these impacts to be accounted for within the firm. Reducing life cycle impacts is seen by advocates of eco-efficiency as a net gain since it reduces future environmental liability, increases competitiveness in an environment characterised by more stringent legislation and enhances the firm's public image. However, while many firms have developed specific indicators of life-cycle impacts, these mostly remain relative and do not necessarily provide a frame of reference from which to reduce overall impacts on the environment.

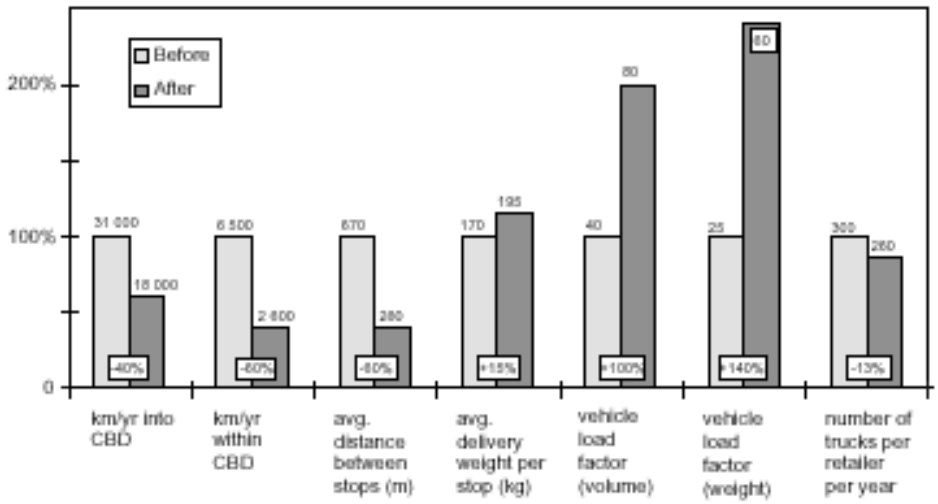
It should be stressed that transport is mostly a derived activity that generally does not in itself create value. Rather, value is generated through the access to people, goods and services that transport facilitates by linking spatially separated activities and locations. Responding to access needs might involve improving the quality of physical movement necessary to link destinations (e.g. travel speed, duration of travel, etc.), reducing the spatial separation between destinations and/or eliminating the need for physical movement altogether. Most efforts aimed at improving the quality of access have focused on the first of these strategies (e.g. improving mobility). This tendency has, in part, been fuelled by relatively low-cost access to energy and materials necessary to build and operate both vehicles and infrastructure.

Case study: City Logistik Kassel

The distribution of goods is an essential activity in urban areas. It is, however, typically characterised by the inefficient use of overall private carrier freight capacity leading to unnecessarily high levels of human health and environmental impact. Growing traffic congestion also renders the task of delivery goods within cities more and more difficult, time consuming and expensive. In response to these constraints, several private freight operators in the city of Kassel came together in 1994 to address the economic and environmental impacts of their delivery operations. Their solution, "City Logistik Kassel" became one of the first of a growing number of similar initiatives aiming to rationalise inner-city freight distribution. City Logistiks Kassel united ten delivery firms into a partnership that agreed to co-ordinate and bundle deliveries at a dedicated transhipment facility for distribution by a neutral carrier. The partnership expected to save costs by increasing vehicle utilisation, rationalising delivery routes and better scheduling deliveries. Analysis of the project by the University of Kassel has confirmed these some of these expectations (see figure 3).

Nevertheless, the researchers pointed out several drawbacks to the City Logistik experiment, not the least of which was the limited absolute impact on freight distribution within Kassel's central business district (City Logistik only accounts for 3% of CBD freight distribution). Other drawbacks included the initial underestimation of transhipment and bundling costs which reduced expected cost savings from City Logistiks. The researchers also noted that, while City Logistik increased the efficiency of freight distribution for participating carriers, it did not address the overall growth in freight volumes.

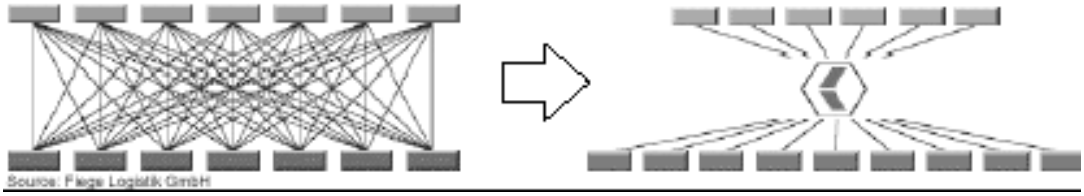
Figure 3 Effects of City Logistics in Kassel



Effects of City Logistiks in Kassel (for the ten participating carriers)
Source: Strauss, 1997

Case study: Fiege Logistik

As seen in the previous example, Freight logistics management can prove to be a fruitful arena in which companies can combine cost reduction and environmental initiatives. Fiege Logistik GmbH, a German freight logistics management company, is one of a large and growing number of firms that help streamline freight transport operations within and between companies in an effort to better rationalise freight transport. By helping companies develop flexible freight delivery boundaries, bundle consignments and increase load factors, set dedicated delivery dates and reduce friction in multi-modal transport chains, Fiege has helped firms significantly reduce the number of vehicle trips necessary for getting goods to consumers. In one example cited, Fiege was able to help a large company reduce its total yearly number of trips between suppliers and outlets from 12800 to 640 by bundling loads at a trans-shipment facility -- representing a factor of 20!)



Transport — and in particular the access to people, goods and services that it provides — has been one of the principal factors in this century's unprecedented economic and social development. However, as transport-related environmental impacts continue to mount, it is increasingly clear that current transport systems are not environmentally — and consequently, socially or economically — sustainable over the long term.

Global impacts

Transport is responsible for 25% of global carbon dioxide emissions from fossil fuel use. Tremendous growth of these emissions has contributed to a significant rise in atmospheric CO_2 concentrations from their pre-industrial levels, which has, in turn, contributed to a generalised warming of average global temperatures. If continued, this warming will likely lead to a rise in sea levels and has the potential to radically change the earth's climate in massive and unpredictable ways. Transport-related emissions of nitrogen oxides and volatile organic compounds lead to the formation of tropospheric ozone — another contributor to global climate change.

Regional impacts

The combustion of fossil fuels produces pollutants which can travel over large distances and damage

Freight's "Public Relations" Problems

Freight transport and regional economic activity are generally intertwined — and the relationships are easily understood at a local level. The employees of the paper mill know the importance of the trucks and railroads that deliver pulpwood and chemicals and pick up the newsprint and paper products. The workers, their neighbors and their friends and relatives live with the noise of the local freight yard, the large trucks lumbering through their streets, just as they live with the smell of the paper mill. As the developed world becomes less dependent upon manufacturing and extractive industries, however, fewer people are financially dependent on and tolerant of, the activities that generate the freight traffic. Moreover, people tend to view the supermarket and the mall as the source of the goods that they buy — they do not make a clear connection between the truck traffic and the goods they acquire.

As cities develop and particularly as they shift from manufacturing to information economies, their residents are less tolerant of the disruptions that result from freight operations. The most widespread conflict is related to the treatment of trucks in traffic congestion. Capacity and congestion are general problems for trucking, especially in and around cities. Congestion reduces mobility and increases fuel consumption and emissions. Congestion and high costs of home delivery could also limit Web-based retail commerce, where the final delivery of products to homes and small businesses can be very costly. Alliances are developing among the major express carriers and the national postal services to deal with this issue. Congestion is also a concern at the regional level, especially where choke points limit flow through a region.

Cities across the world — from New Delhi to New York City — impose restrictions on truck activity, including prohibitions of large trucks and the limiting of truck activity to certain zones or to off-peak times. There are many more automobile drivers than truckers and as the link between personal well-being and local freight becomes less appreciated, the initial political pressure is to restrain truck traffic, without considering the consequences to local economies and personal freight distribution. Around major intercity freight facilities, truck traffic may be perceived as a nuisance, particularly as residential areas expand and come into closer contact with the freight terminals. Noise, aesthetics and night lights all become greater concerns. Similarly, ports around the world are under great pressure to release land for residential or office development. Areas once covered by port facilities, rail yards and warehouses are now viewed as prime spots for expanding the real estate development in major ports around the world.

human health, plants, animals and ecosystems. These pollutants and their derivatives such as tropospheric ozone and acidifying compounds lead to the destruction of aquatic ecosystems, impair the growth of crops and forests and give rise to respiratory problems and diseases among humans.

Local impacts

Many of the environmental impacts of transport are also felt at the local level, especially in urban areas. Fossil fuel-based transport is responsible for the release of several toxic compounds (e.g. carbon monoxide, benzene and other volatile organic compounds, fine particulate matter and lead) that endanger human health. Transport activity is possibly the most important contributor to health risks associated with toxic air pollutants. These harmful substances are also deposited into local waterways further endangering ecosystems and posing a threat to human health. Other local impacts include health-endangering noise pollution and habitat-disrupting land-use.

Trends are unsustainable

Even if all present, planned and reasonably foreseeable legislative, technological and societal changes were to come about, serious doubts would remain as to the sustainability of future transport systems. Projecting current "business as usual" trends 20 years into the future, transport could be characterised by the following:

- Car ownership and total distance travelled will be at substantially higher levels than in 2002 although vehicles will be more fuel-efficient and less polluting. Use per vehicle will remain practically the same or will be slightly less. Petrol and diesel will continue to be the most widespread sources of transport energy, with some increase in the use of gas-based derivatives, hybrid and electric vehicles. Generally, fuel prices will only increased slightly in real terms.

- These same trends will likely hold for small commercial vehicle and truck use whose total volume of travel will be underpinned by significantly higher levels of both light and heavy-duty road freight transport. Increases in road freight activity will be generally larger than those for car use. Rail and water-borne freight will also grow, but at a much lower rate than for road freight.

- Use of surface public transport will grow, albeit at a much smaller rate than car use.

- Walking and cycling will be at similar, if not slightly lower levels, than in 2002.

- Aviation will experience significantly larger increases in activity than any other mode.

- Generally, motorised road vehicles and aeroplanes will comprise the dominant transport modes into the future.

Environmental Impacts from transport in the future

- Although emissions of nitrogen oxides, carbon monoxide, volatile organic compounds and fine particulates will substantially decrease from their current levels, evidence suggests that growth in vehicle numbers and levels of travel might reverse these positive trends. Many of these pollutants will likely be on the rise again in the future with little prospect for technological "fixes". Generally, there will be a decline in the relative contribution of the car to transport-related air pollution accompanied by an increase in the contribution of road freight traffic and a marked increase in the contribution of aircraft.

- Despite all foreseeable policy, carbon dioxide emissions from the transport sector will have doubled within 30 years contributing to dangerously high concentrations of atmospheric CO_2.

- While transport noise nuisances will decrease slightly overall, some specific modes, such as aircraft, may generate significantly higher levels than today.

- Land use for transport infrastructure (roads and parking, rail corridors, airports and harbours) will likely increase with growing transport activity leading to higher levels of water pollution, habitat destruction, bio-diversity loss and community disruption.

- Extrapolating current estimates of transport's unaccounted costs, transport in the future is likely to place a significantly large economic and social burden on society.

Likely advances in technology will not be sufficient to overcome increased environmental impacts stemming from growing transport demand. Assuming current trend projections, transport is moving away, rather than toward, environmental sustainability.

A new policy approach is required

Conventional approaches to mitigating transport's environmental impacts have taken observed and projected

Timescales of Change

In economics and in transport, theoretical analyses often refer to systems in which price mechanisms cause an equilibrium between supply and demand. The concept of an equilibrium is perhaps worthwhile for educational purposes, as it allows very elegant theories to be postulated. Nevertheless, we must recognize that in economics, as in the physical sciences, the timescale is important. Though systems might ultimately reach equilibrium, this can take a long time.

With transport systems, the timescale for changes must be measured in decades (or centuries) for some systems, while other systems can be changed quite quickly. New vehicle technology can be introduced in a matter of months or years, but the new vehicles themselves will likely be introduced slowly as older vehicles wear out or as demand justifies fleet expansion. A motor carrier might change over its entire fleet of tractors in 5 to 10 years, but a railroad will take 20 years or more to change over its fleet of locomotives or freight cars. Public outcry and strict legislation can hasten change, but such instances are rare. Adjustments in the route structure are much slower; it is not difficult to add or delete a few links in the network or to upgrade a few terminals, but it takes generations to adjust the nature of the network. The major transport routes may last, in one form or another, for hundreds of years.

Railroad rationalization is an example of a process that requires a long time to reach equilibrium. In the United States and Canada, the railroads took approximately 70 years (beginning in about 1925, when the network reached its route-mile peak) to rationalize their networks from what was suitable when rail was dominant for both freight and passenger to what is appropriate for a modern heavy-haul railroad devoted to freight transport. This sounds like a long time, but the transition has not yet taken place on a large scale anywhere else in the world.

transport trends as givens and have sought to assess the environmental impact of these developments ex-post. This approach has led to important efficiency gains and has helped to reduce certain environmental and health risks stemming from the transport sector. It has not — and likely will not —, however, lead us towards meeting long-term environmental objectives.

A new policy approach is needed which places environmental criteria up front along with other policy goals. Recognising this need, the Minister of Transport initiated the Freight Network Review. One of the working groups that came from that review was that dealing with ‘Sustainable Freight Transport’. This working group is charged with giving some precision to the concept through the use of criteria that can be quantified. Unlike conventional approaches to transport system development, this project has started with a vision and a commitment to development of a series of measures for the evaluation of environmentally sustainable transport.

Environmental sustainability and the efficiency of urban freight transport

The Government is keen to identify transport policy measures which will reduce the environmental impacts of urban freight and service operations and which also make freight and service transport operations more efficient. The discussion group technique used in the early stages of the work has proved helpful in identifying which transport policy measures could deliver triple bottom line benefits. It has also indicated that some policy measures are likely to prove unattractive to one or more companies in the supply chain.

There are three plausible goals for urban freight transport policies that address triple bottom line concerns in an attempt to make freight transport more sustainable:

i. to maximise the ease and efficiency with which goods and service vehicle activities can be performed without worsening the environmental and social impacts that they impose on the urban area;

ii. to minimise the environmental and social impacts caused by goods and service vehicles in urban areas without worsening the ease and efficiency with which these vehicle activities can be performed;

iii. to improve the ease and efficiency with which goods and service vehicle activities can be performed and at the same time reduce the environmental and social impacts that they impose on the urban area.

When considering how to reduce the environmental and social impacts caused by goods and service transport it is important to determine which impact(s) need to be reduced and the means by which the activity causing those impacts can be altered.

It is important to recognise that if goods and service vehicle operations become easier to perform and hence more economically efficient as a result of new policy measures and/or company initiatives, it is not necessarily the case that this will also lead to the operations becoming more environmentally and socially sustainable. In fact, in some cases the reverse is true; as some operations become easier to perform their environmental impact increases (for example, if at its most extreme, all regulations and restrictions governing the use of goods and service vehicles in urban areas were abolished, these operations would become easier to perform, but some of the environmental impacts that these operations caused would rise - many current restrictions are in place for good reason).

It is obviously more desirable to attempt to identify policy measures and company initiatives that have the twin effects of making goods and service vehicle activities more efficient and that also result in a reduction of the social and environmental impacts that these operations cause.

Measures that reduce one environmental impact of urban freight may well increase another impact (for instance banning heavy goods vehicles from an urban area may be beneficial in terms of visual intrusion, physical intimidation and noise, but may lead to a greater total number of trips performed by smaller vehicles and hence more fossil fuel use and pollutant emissions). In determining appropriate measures to reduce the impacts of urban freight transport it is necessary to understand the particular problems that the measures need to alleviate in the specific urban area in question. There are unlikely to be universally applicable solutions.

Policy measures that may make urban freight operations more efficient to perform

Below is a list of policy measures that are means by which policy makers could make it easier to perform urban freight operations and that would result in greater operational efficiency. Many of these measures also have the potential to make urban freight transport operations more environmentally sustainable.

- Relaxing loading/unloading time restrictions
- Allowing freight/service vehicles into pedestrianised areas which currently have vehicle access restrictions
- Relaxing freight vehicle size/weight restrictions
- Improving on-street loading/parking facilities for freight and service vehicles
- Allowing freight/service vehicles to use bus lanes
- Allowing longer hours for freight and service vehicle access (e.g. remove any out-of-hours curfews)
- Improved traffic/roadwork information
- Better enforcement of parking regulations for private cars
- Car use reduction strategies

Freight and Information Technology

"Intelligent Transport Systems" (ITS) are technologies aimed at improving traffic management and coordination among providers and users of highway and intermodal transport. ITS includes numerous applications that improve certain aspects of highway performance, e.g., automatic monitoring of traffic, quicker response to accidents and other emergencies, automated toll collection, weigh-in-motion scales for heavy trucks,

and expedited customs procedures. For freight, ITS offers some hope of reducing congestion in cities and administration delays on highways. While the technologies have yet to play a major role in reducing congestion, the state of the art is advancing rapidly.

The Internet is becoming a critical factor for freight transport. An obvious example is the rise in package deliveries due to online shopping. But more importantly, by providing new capabilities for exchanging data, facilitating business-to-business exchanges and hosting supply-chain and inventory-management programs, the Internet serves as a platform for new types of business transactions that will affect freight flows, prices of commodities and prices for transport. These changes will improve the efficiency of the markets and reduce costs both for commodities and for transport.

- Road infrastructure/building/ bypasses
- Improved road signing
- Develop or extend existing truck routes
- Improving access to back of premises
- Traffic calming - traffic management
- Traffic light sequencing
- Fixed width restrictions
- Policies to improve public transport
- Designing freight/service vehicle facilities into building design/ planning permission
- Encourage relocation of premises to less dense areas
- Park and ride depositories
- Develop urban transshipment center/s
- Quality Partnerships

Policy measures that may make urban freight operations less efficient to perform

Below is a list of policy measures that policy makers may potentially introduce in an attempt to make urban freight transport more environmentally sustainable. These measures are likely to make it more difficult to carry out goods and service vehicle operations in urban areas and could reduce the efficiency of these operations.

- New/enlarged pedestrianised areas (greater vehicle access time restrictions)
- Lower speed limits in urban areas
- Greater vehicle weight/size restrictions
- More loading/unloading time/parking restrictions
- Develop urban transshipment centre/s
- Alternatively-powered vehicles
- More bus/cycles lanes

- Urban road user charging

Company initiatives that may make urban freight operations more efficient and sustainable

As well as policy measures that can be implemented by central and local government to help make freight and service transport more efficient and at the same time more environmentally sustainable, there are a number of initiatives that can be taken by companies themselves to improve efficiency which would also make vehicles operations more environmentally sustainable. The research has identified many initiatives that companies could implement, either within their company or in the supply chains in which they operate, in order to achieve the twin goals of reducing the environmental impact of freight transport operations and, at the same time, making these operations more efficient.

The list of these company initiatives is shown below.

- Self-imposed collection and delivery time bans
- Receiving premises helping to unload vehicle
- Receiver not needing to check deliveries
- Service companies obtaining as much information as possible when a problem is reported
- Staff at the premises making deliveries/consolidating collections
- Receivers relaxing need for early morning delivery/being more realistic/truthful about when they really need delivery
- Receivers operating timed delivery systems efficiently
- Premises accepting out of hours collections and deliveries
- Days of week that premises accept collections and deliveries
- Premises allowing goods and service vehicles to use off-street facilities where they exist
- Communication systems with shippers and receivers about distribution matters
- Freight and service operators buying the right type/size of vehicle for the operation

Energy Use of Ocean Freight

In ocean shipping, vessel speed capability trends have mirrored trends in fuel prices, since, as is true for other vehicles, higher speed requires more fuel. For container ships, from the 1970s through the mid-1980s, as fuel prices generally increased, average speed of new vessels declined. From the mid-1980s onward, speeds have steadily increased (Drewry Shipping Consultants 1999. Container Market Outlook: High Risk & High Stakes: Where is the Payback? London, 1999.) — a trend likely mirrored for other ship types. The higher speeds offer greater schedule flexibility — in addition, the larger ships require faster speeds to make up for the increased port time these ships require. The smallest container ships (1,000 to 1,200 tonnes) average between 36 to 51 tonnes of fuel per day, while the larger ones (2,900 to 3,100 tonnes) consume between 74 and 157 tonnes of fuel per day.

- Urban container concept
- Companies encouraging employees to use public transport for journey to work
- Finding the right person at the receiver's premises
- Using IT or common sense to allocate job to best suited engineers
- Communication with the driver/engineer
- Routeing and scheduling
- Pricing by suppliers/wholesalers to deter single drop trips delivering small quantities
- Operating fewer but larger premises/distribution centres/warehouses
- Smooth, reliable supply from suppliers to transport company/supplier
- Virtual transshipment systems
- Shared user distribution
- Use of local suppliers/consolidated deliveries from them
- Driver efficiency
- Premises receiving fewer, bigger deliveries
- Combined collection and delivery trips
- Consolidation of goods to be returned
- Achieving backloads for returning vehicles
- Goods vehicles/drivers providing equipment and parts to service engineers
- Premises using fewer goods suppliers
- Use of vehicle telematics and data capture
- Modal shift
- Vehicle fuel efficiency
- The use of cleaner and alternative vehicle fuels
- Designing more environmentally-friendly vehicles

- Driver training/driver safety
- Design of freight vehicle reception facilities at premises

The company initiatives listed above vary in terms of:

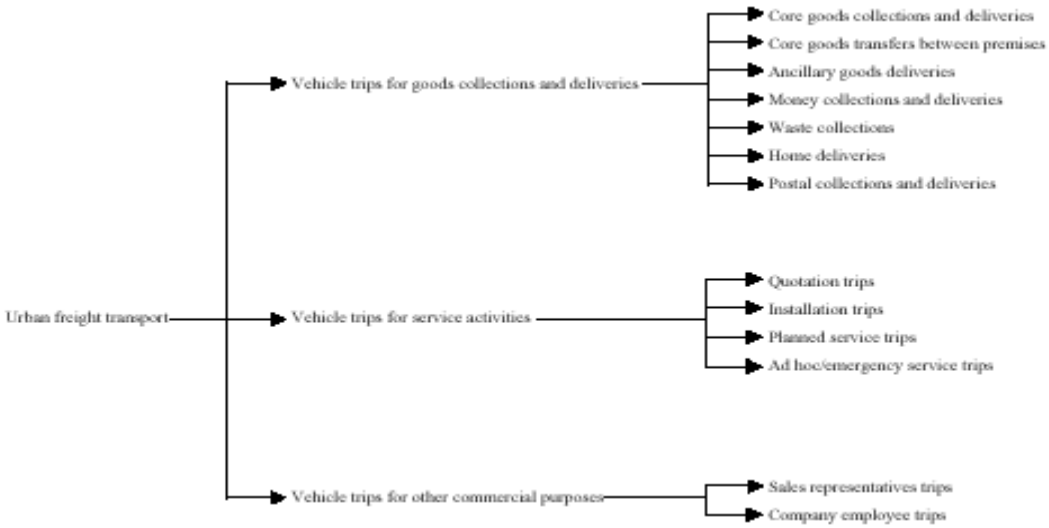
- responsibility for action - i.e. which party or parties in the supply chain need to change their operations to realise the initiative and
- support for the initiative - i.e. which other party or parties in the supply chain need to support the initiative in order for it to be successful.

Of the company initiatives listed:

- some require the action of one party in the supply chain and the support of none of the others (these are the easiest to achieve in managerial and implementation terms as long as they are commercially viable);
- some require the action of one party in the supply chain and the support of other parties such as retailers, goods suppliers and freight transport companies (these are more difficult to achieve in managerial and implementation terms as they require dialogue and agreement between supply chain parties);
- some require the action of more than one party in the supply chain to jointly implement changes to their operations so that the new more sustainable approach is feasible (these can prove more difficult as they require inter-company agreement and joint planning and working). The initiatives can result in additional resource requirements, such as labour or capital equipment, for one or more of the parties and in these cases, in order for such changes to be implemented, it will be necessary that one of the following happens:
    - an improvement in some aspect of service or a reduction in operating costs to make the switch commercially viable,
    - any cost savings by one party in the supply chain are divided so as to compensate those parties that incur higher costs as a result of the change, or
    - the change in practice will have to be encouraged or made compulsory by central or local government (either through fiscal measures and price signals or by direct regulation).

The company initiatives also vary in terms of the time it would take to bring about the desired effect. For instance, the benefits of driver training programmes are immediate, whereas modal shift from road to rail and its associated benefits would take far longer to achieve.

Figure 4 Definition of urban freight transport



Barriers

The development and implementation of sustainable transport alternatives suggest change from traditional ways of doing business and with the potential for change comes barriers as stakeholders resist these opportunities. What are the barriers to sustainable transport with which public officers must contend at the local level? For example, the Ontario, Canada, strategy for sustainable transport identifies the lack of awareness and education as a fundamental barrier to sustainability.[25]

General categories of barriers to sustainability at the local level may include perceptual/behavioral, institutional/structural and economic/financial[26]. According

to the Transport Association of Canada, significant barriers exist between identifying the local vision for sustainable transport and in turning the vision into reality. In general, these barriers include:

- lack of integration of administrative decisions among municipal agencies;
- competition among adjacent municipalities;
- an existing built area favoring urban sprawl;
- social forces, such as lifestyles accustomed to urban sprawl; and

[25] Transport and Climate Change Collaborative. 1995. *A Strategy for Sustainable Transport in Ontario*. Toronto, ON: The Collaborative.

[26] Moore, J. 1997. *Inertia and Resistance on the Path to Healthy Communitites*, In Eco-City Dimensions: Healthy Communities, Healthy Planet, ed. M. Roseland. New Haven, CT. New Society Publishers.

- market forces, such as developers resistant to innovative design.[27]

More specifically, barriers to sustainable transport at the local level may include cultural and behavioral barriers, professional norms as barriers, traditional economic development practices and traditional urban planning methods and practices. Often, these barriers coexist, creating a seemingly insurmountable wall between the present and the future vision of what a sustainable community should become.

Strategic plans often include policy measures, such as the UK Sustainable Development Strategy.[28] This plan includes four major policies to make British transport more sustainable:

- Tax and pricing measures for full user cost accounting for transport users;
- Planning and assessment improvements for transport infrastructure decision making;
- Improvements in vehicle technology; and
- New land use planning measures to reduce travel needs.

Table 2 Modification model for sustainable comprehensive plans

Comprehensive Plan Elements	Traditional Objectives	Sustainability Objectives	Sustainability Indicators
Land Use	Zones and separated land uses Long-term approach based on current trends	Integration of uses Employment opportunity near res. Long-term approach based on changing attitudes and uses	Mixed use neighborhoods Job/housing balance Integration of sustainable measures
Transport	Reduce congestion through construction Mobility Access through mobility	Reduce congestion through construction Mobility through alternative modes Access through alternative means	VMT reduction, non-rec. Travel reduction Increased transit use Pedestrian/bicycle facility development Telecommuting

[27] Transport Association of Canada. 1998. *Achieving Livable Cities*. Ottowa, ON Transport Association of Canada.

[28] Quinn, M. J. 1994. *Land Use Planning to Reduce the Need to Travel*. In Transport Congress: *Civil Engineers – Key to the World Infrastructure*. Washington D.C.: American Society of Engineers.

Environmental	Provide adequate service levels Landfill development as needed "Encourage" environmental objectives	Provide efficient service levels Solid waste regeneration Mandate environmental responsibility	Water service density Reduce water usage per household Number of recycling households Number of recycling businesses Environmental impact assessment in development review
Economic Development	Attract new business Suburban development Attract real estate development -subdivisions	Attract "green" business Urban in-fill/ redevelopment Attract real estate development – transit oriented/mixed use	Business recycling/ efficient resource use Regeneration Transit Oriented Developments

Martin[29] identifies six broad policy options available for development and implementation in the local context:

- Transport demand management;
- Transport supply and traffic management;
- Improve service quality and efficient public transit;
- Improve multi-modal facilities;
- Optimize urban space and infrastructure and long-term land use planning; and,
- Promote and support public

The Role of Rail in Regional Freight Movements

The railway network, so it has been said, is no longer critical for regional mobility but recent changes to public perceptions as to what is and is not acceptable have changed these ideas. It was said that "Once it is possible for a truck to move 15 to 20 tons of freight at 35 to 70 kph over reasonable roads, then the truck will be cheaper and often more energy efficient than the railroad for general freight. Trucks do not need a high-speed, interstate highway to take most of the short- and medium-length shipments of general merchandise from the rail. Thus, the extensive regional rail networks that were critical for nineteenth-century development were really not a factor for development in the latter half of the twentieth-century. The decline of the railroad around the world was to a large extent a slow, painful adjustment of the transport system and of economic geography to the development of a superior mode of transport. There were simply too many rail lines for a world with paved roads and large trucks." Not true any more. The days of urban rail have come back and with a vengeance.

[29] Martin, D.J. 1995. *Solving the Problems Caused by Traffic Saturation of Cities – New Approaches to Mobility*. In *Urban Transport and the Environment for the 21st Century*, ed. L.J. Sucharov. Southampton, UK. Computational Mechanics Publications.

transport.

The most wide ranging statement on sustainability in the United States, the President's Council on Sustainable Development, delivered its final report in the spring of 1999. In a series of recommendations, the report develops a policy approach for sustainable community development. Chapter 4 of the report, "Metropolitan and Rural Strategies," focuses on policies and actions that communities can undertake in order to move toward sustainability. Three action areas are of primary concern:

1) providing information and technical assistance;

2) providing economic incentives and financial assistance; and

3) developing local capacity and partnerships.

Further, the report stresses that green infrastructure and land use and development are two strategic areas that hold promise for the future of communities. Green infrastructure is defined as "the network of open space, airsheds, watersheds, woodlands, wildlife habitat, parks and other natural areas that provides many vital services that sustain life and enrich the quality of life".[30] Community-level transport policies and decisions have significant impact on green infrastructure and land use practices.

Evaluation methodologies

Introduction

This section examines the scope for developing quantitative indicators of eco-efficiency for the access system:

- it describes three indicators that have been developed for corporate eco-efficiency and analyses their usefulness as the basis for indicators in the access system; and

- assesses the scope for developing indicators of eco-efficiency in the access system.

Quantitative indicators of eco-efficiency

Operationalising eco-efficiency means developing indicators which capture some measure of value added per unit of resource input. Methodologies for measuring eco-efficiency are in their infancy. This section reviews three:

- 'Material Intensity Per unit of Service' (MIPS), being developed by the Wuppertal Institute in Germany;

- 'Value : impact assessment', as developed by Procter & Gamble; and

[30] President's Council on Sustainable Development. 1999. *Towards a Sustainable America: Advancing Prosperity, Opportunity and a Healthy Environment for the 21st Century*. Washington. D.C. The Council.

- ’Eco-fitness analysis’ at Dow Europe.

Material Intensity Per Unit of Service (MIPS)

MIPS meets the basic criterion for an eco-efficiency measure by attempting to quantify material intensity (the input) per unit of service (the output). It has been developed by the Wuppertal Institute on the basis that material flows can be used as a proxy for all environmental impacts. The validity of this assumption is open to serious question, but MIPS is still of interest as a measure of material intensity for its own sake.

In its ’purest’ form, material intensity is taken to be the unweighted summation of all the life-cycle material movements which form the inputs to a process or product, even including flows such as rainwater diverted by buildings and oxygen consumed in combustion. Some form of distinction between different material flows is likely to be necessary to make the concept useful in practice.

The output - units of service - is a concept which captures the eco-efficiency notion of replacing goods with functionality or services as the aim of the ’production’ process. Operationalising the concept in mathematical form is more difficult, although the Wuppertal Institute has proposed some simple formulae.

MIPS can be applied both at the firm level, for individual products or processes and at higher levels - measuring the material intensity of an entire economy, for instance. There is also work which is attempting to make the concept more useful in practice by developing a *Computer Aided Material Flow Analysis* software package as a tool for:

- holding material flow data in an accessible form;
- conducting macro-scale resource intensity analysis; and
- developing eco-efficient products.

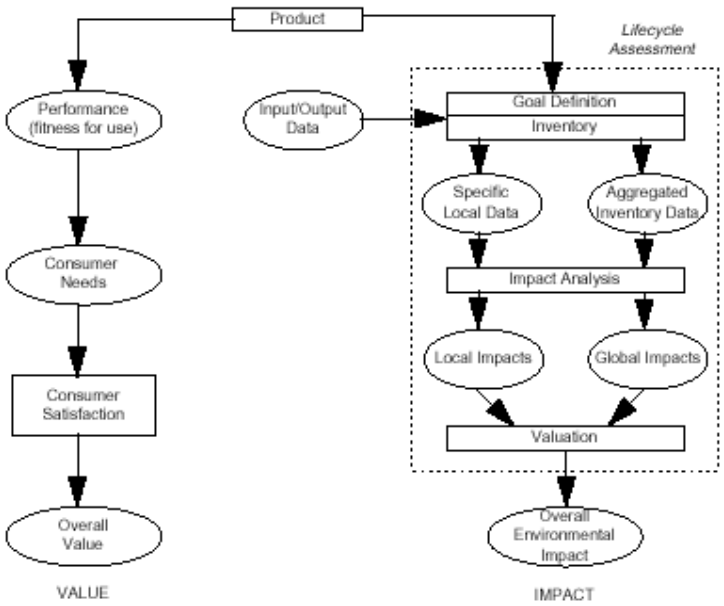
Value : Impact Analysis at Procter & Gamble (P&G)

This tool is similar in many ways to MIPS, but with a broader understanding of both value and impact:

- For impacts - in place of the assumption that material flows provide an adequate proxy for all environmental impacts, this methodology substitutes a full life-cycle assessment, which considers materials and energy use and environmental impacts.
- For value - in place of the idea that physically similar services can be compared, P&G take a more commercially-driven view that products and services should perform in the marketplace if they are truly providing more value to consumers (i.e. they should maintain or increase market share).

Figure 5 illustrates the structure of P&G’s value:impact assessment methodology.

Figure 5 Value:impact assessment methodology at Procter & Gamble



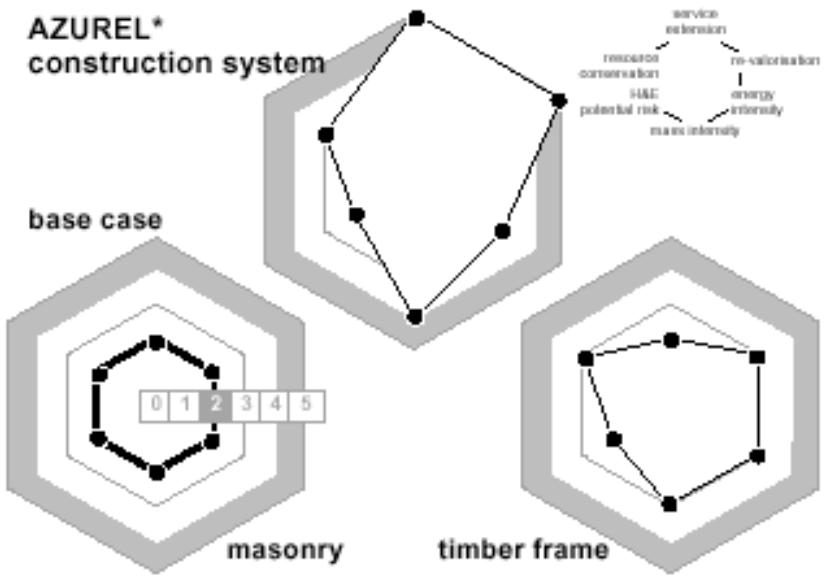
Source: Hindle et. al, 1993[31]

Eco-Fitness Analysis at Dow Europe

Dow Europe has developed an 'eco-fitness analysis' methodology which is strongly related to the seven elements of eco-efficiency. In common with the other two approaches reviewed, this aims to compare the life-cycle environmental burdens of different ways of providing a product or service. The distinguishing feature of this approach is that it does not attempt to aggregate all environmental impacts into a single figure. Instead, it offers a visual representation of six different indicators:

[31] Hindle, P., P. White and K. Minion. 1993. *Achieving real environmental improvements using value:impact assessment*, in Long Range Planning, Vol. 26, No. 3, pp. 36-48.

Figure 6 "Eco-compass" diagram of environmental impact at Dow Europe



The external boundary of the hexagon in Dow's 'eco-compass' diagrams represents the 'ideal' eco-profile, while the inner shape shows how far each of the three designs is removed from this ideal on the six parameters of eco-efficiency.

Source: Ayres, 1995[32]

- *Material (mass) intensity* - based on a life-cycle inventory approach
- *Energy intensity* - also based on a life-cycle inventory approach
- *Resource conservation* - based on an assessment of the proportion of materials used which are renewable or abundant
- *Re-valorisation* - the potential for re-using, recycling or generating energy from the incineration of a product
- *Durability and functionality (service extension)* - how long does the product last and does it provide any additional value to its user?
    - *Environmental and health risk potential* - an assessment of ecotoxicity based on around 20 different parameters.

These indicators are presented visually as an 'eco-compass'. The aim is to enable choices to be made about how genuinely to improve overall eco-efficiency, which make different trade-offs explicit.

[32] Ayers, R.U. 1995. *Achieving Eco-Efficiency in Business: Report of the WBCSD Second Antwerp Eco-Efficiency Workshop March 1995*, World Business Council of Sustainable Development, Geneva.

Table 3 Relationship between elements in the access system

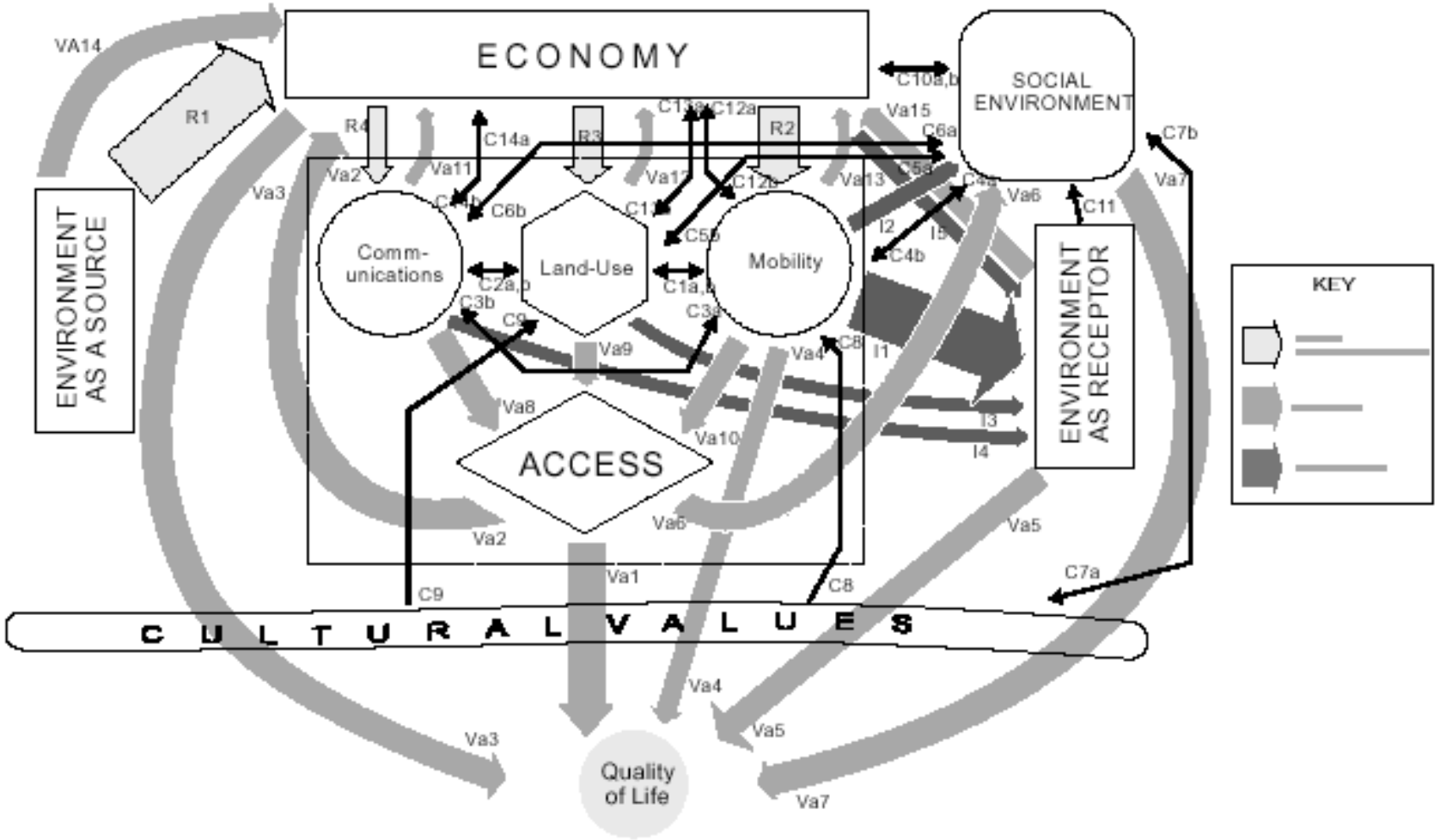
Label	From	To	Explanation
Resource flows			
R_1	Environment as source	Economy	The environment provides materials and energy to the economy to sustain the access system. Sectors most closely related to the access system include the construction industry, the automotive industry and the transport industry (freight and passenger).
R_2	Economy	Mobility	The economy supplies materials and energy to the mobility system, eg. by the extraction, refining and distribution of fuel. There is no explicit distinction made between capital and running costs in this crude model.
R_3	Economy	Land use	The economy supplies the resources to maintain, renew and incrementally alter the land use system.
R_4	Economy	Communications	The economy supplies the resources to maintain and operate electronic and non- electronic communications systems. Postal systems are included in the communications system insofar as they deliver information rather than goods.
Environmental impacts			
I_1	Mobility	Environment as receptor	The mobility system has numerous adverse impacts on the physical environment, including CO_2 emissions, other air (and water) pollution, ecological damage, noise and visual intrusion.
I_2	Mobility	Social environment	Some negative external impacts of mobility act more or less directly on the social or human environment, with no strong intermediary role for the physical environment. Notable examples are accidents and community severance.
I_3	Land use	Environment as receptor	Construction of new buildings has some negative environmental impacts, such as noise, the need to dispose of waste and (in some cases) new land- take.
I_4	Communications	Environment as receptor	Construction, operation and maintenance of electronic communications systems has some negative environmental impacts which are probably small by comparison with those of both the mobility and land- use systems. Postal services rely on physical distribution networks and are therefore also part of the mobility system.
I_5	Economy	Environment as receptor	The operation of supplying resources to the mobility and land use systems has impacts of its own, eg. in the refining of oil.
Flows of value			
V_{A1}	Access	Quality of life	Access in itself offers quality of life: the ability to reach journey ends is fundamental to all human activity.

V_{A2}	Access	Economy	Access, for both goods and people, is an essential element in the functioning of the economy.
V_{A3}	Economy	Quality of life	With access as an essential prerequisite, the economy creates value, which contributes to quality of life.
V_{A4}	Mobility	Quality of life	Mobility contributes to quality of life independently of access. The car may serve many psycho- social functions, for instance; and travel is often part of leisure/ tourism activities.
V_{A5}	Environment as receptor	Quality of life	The quality of the physical environment affects quality of life directly, eg. air pollution damages health.
V_{A6}	Access	Social environment	Access contributes positively to the social environment, in addition to its direct function for individuals, such as by facilitating social interaction.
V_{A7}	Social environment	Quality of life	The social environment influences quality of life strongly. If for instance, community severance by transport links reduces the frequency and intensity of social interaction, this is likely to have a negative impact on quality of life.
$V_{A8,A9,A10}$	Mobility, land use, communications	Access	Access to journey ends is the primary value added by the access system: most travel is in order to gain access to a function such as the provision of goods or services, or social interaction. NB: The term 'access' is distinguished in this study from the term 'accessibility'.
$V_{A11,A12,A13}$	Mobility, land use, communications	Economy	It might be argued that the role of the industries which support the access system in the economy is so important that the provision of mobility and construction of new land uses has economic value in itself, independent of whether they perform an economically useful service.
V_{A14}	Environment as source	Economy	The flow of resources provided by the environment is of fundamental value to human society.
V_{A15}	Environment as receptor	Economy	The ability of the environment to receive by- products and wastes from human activity is also of fundamental value, although the role has only been realised more recently. When the environment is unable to absorb these by-products, this role becomes transparent in costs to human activity eg. the phase- out of CFCs.
Cause-effect interactions			
C_{1a}	Mobility	Land use	Mobility affects land uses via the mechanism of accessibility (as distinct from access , which is the value provided by the ability to reach certain ends). For instance, new infrastructure - ie. cheaper mobility - changes patterns of accessibility and thereby generates pressures for new or modified land uses to take advantage of that accessibility. In general, journey lengths tend to increase.

C_{1b}	Land use	Mobility	Land use also affects mobility by the mechanism of accessibility. For instance, more mobility will be required to service the access requirements of a less accessible work or home location. There are other mechanisms than accessibility, however, eg. existing land use patterns in many cities constrain the provision of further parking space and hence the expansion in car ownership and its associated mobility.
C_{2a}	Communications	Land use	The increasing value of communications as a means of access is making teleworking more feasible. There is evidence that teleworkers in some areas and information-intensive activities in general, may be beginning to re-locate to rural environments where the quality of life is perceived as higher.
C_{2b}	Land use	Communications	Dense settlement patterns may be necessary to support certain communications technologies such as cable television and associated telematics applications.
C_{3a}	Communications	Mobility	There is a link between 'telecommuting' and mobility patterns: the direction and magnitude of that impact, however, is unclear and still the subject of research.
C_{3b}	Mobility	Communications	Communications and information technology may provide a tool for improving the eco- efficiency of the mobility system. Public transport guidance and tracking schemes, as well as in- car information systems, are already moving in this direction.
C_{4a}	Mobility	Social environment	Increasing mobility is likely to have profound social consequences, which may be both positive (eg. possibility of more travel for leisure purposes) and negative (eg. as a contributory factor in the disintegration of community). These effects are in addition to the negative effects on the human/ social environment of accidents, severance etc.
C_{5a}	Land use	Social environment	Land use changes may influence the social environment, eg. as peripheral locations become more accessible and hence attractive, a decline in town- centres as high- quality residential and business districts may lead to the creation of urban ghettoes.
C_{6a}	Communications	Social environment	If more functions are performed electronically rather than with physical access (eg. education, libraries, shopping etc.), some foci for social interaction may be lost.
$C_{4b,5b,6b}$	Social environment	Mobility, land use, communications	The social environment influences mobility and land use directly, independently of cultural values and attitudes. For instance, a tendency towards smaller households creates demand for new housing; whilst a more mobile society is likely to create demand for mobility as well as communications.
$C_{7a,b}$	Social environment	Cultural values	There is clearly a strong relationship between these two, with cause and effect in both directions.

$C_{8,9}$	Cultural values	Mobility, land use	Some aspects of cultural values may influence mobility or land use, eg. a cultural preference for urban life may make policies aimed at increasing urban density more acceptable. There are also strong cultural values associated with cars.
$C_{10a,b}$	Economy	Social environment	There are multiple interactions between the economy and the social environment, in both causal directions. The economy, for instance, may exert an influence on the social environment and hence on the access system via advertising.
C_{11}	Environment as receptor	Social environment	The quality of the physical environment is likely to have an important influence on the social environment. In particular, support for policies aimed at restraining mobility is likely to be stronger in a situation where the damaging consequences of unrestrained mobility are apparent.
C_{12a}	Mobility	Economy	The cost and quality of mobility may have an influence on the economy independently of access, eg. by enabling the use of 'just- in- time' manufacturing methods, which rely on frequent and reliable deliveries.
C_{12b}	Economy	Mobility	Economic developments and events can have a direct influence on mobility eg. via the price of oil, or the development of technologies with important transport applications; or geographical imbalances in labour markets may create demand for migrant workers. 'Transport poverty' - ie the inability of the poorest sections of the population to gain a minimum basic mobility through poverty - is clearly also related to wider issues of income distribution.
C_{13a}	Land use	Economy	The spatial distribution of land uses at a regional or national level has important regional economic implications, so that a largely rural, agricultural area might seek to attract other land uses in order to boost its economic prospects.
C_{13b}	Economy	Land use	Economic developments - such as agricultural production techniques - have a profound long- term impact on land uses. More short- term trends, such as the state of the housing market, may also have an influence.
C_{14a}	Communications	Economy	New communications technologies are having a profound impact on the economy, in combination with other elements in the 'information revolution', as they become both major industries in themselves and a driving force for change in other economic sectors.
C_{14b}	Economy	Communications	Economic forces may also generate demand for communications, eg. via the globalisation of economic activities.

Figure 7 Eco-efficiency in the access system, showing cause-effect linkages



Multicriteria Analysis Methods

Most policy decisions concern choices between a finitie number of options, the details of which have already been predetermind before they are subject to Multicriteria Analysis (MCA). This does ot exclude the possibility that, following MCA, the decision making group may use insights from the MCA, coupled with expertise from other sources, to re-define some options and run the MCA again. To do so would be quite normal. However, the basic MCA method itself does not re-define the options. It is concerned simple with assessing the strengths and weaknesses of the options as they stand.

In real life applications it is not uncommon to be facing several objectives at once with no obvious way of deciding which one should be **the** objective and the rest be represented as constraints to achieving this objective. For example, we may be interested in simultaneuously maximising economic returns, minimising environmental damage, maximising societal benefits, minimising capital costs, eliminating purchases of private lands, etc. Problems of this type, where the decision variables are infinitely variable, subject to constraints and where there exist multiple objectives are common but difficult to manage.

Using MCA to explore stakeholder viewpoints

A main goal is to help the responsible decision making group to identify one or more of the options being considered as 'the best'. Although it has been emphasised that MCA supports decision makers and certainly does not 'make the decision' in any mechanistic way, the underlying goal is to provide prescriptive guidance.

The MCA approach may be used to generate a better understanding of the reasons for divergences in view and to provide a 'map' of the question under debate. It may even suggest ways forward that may be mutually acceptable to stakeholder groups whose fundamental viewpoints are opposed to one another.

From the outset, the aim is not to achieve a consensus view within the group on the relative attractiveness of the options, but to expose the variety of views and to try to understand better where the differences were most marked and why.

The eight steps involved in MCA are listed below:

i) Establish the decision context

ii) Identify the options to be appraised

iii) Identify objectives and criteria

iv) Scoring

v) Weighting

vi) Combine the weights and scores

vii) Examine the results

viii) Sensitivity analysis

Appraisal and evaluation in government

In practice the most common form of analysis in government is cost-effectiveness analysis (CEA), where the costs of alternative ways of providing similar kinds of output are compared. Any differences in output are compared subjectively with the differences in costs. The Treasury 'Green Book' on Appraisal and Evaluation in Central Government is most frequently applied to CEA.[33]

Less common, although widely used in transport and health and safety, is cost benefit analysis (CBA), in which some important non-marketed outputs are explicitly valued in money terms.

Both CEA and CBA are analytical ways of comparing different forms of input or output, in these cases by giving them money values and might themselves be regarded as examples of multi-criteria analysis. However this manual is concerned with techniques for comparing impacts in ways which do not involve giving all of them explicit monetary values, although they may include data from cost-effectiveness or cost-benefit analyses.

The techniques described in this manual are in many respects an 'alternative' to defining monetary values for all the major costs and benefits when this is impractical. However MCA must not be seen as a short cut, nor as an easier technique for inexperienced people to use. The use of these techniques is in important ways more demanding of experience and good training than the use of CEA, which generally uses market values, or of CBA, which also uses valuations of non-marketed quantities based on analysis which has already been completed elsewhere.

Advantages of MCA over informal judgement

MCA has many advantages over informal judgement unsupported by analysis:

- it is open and explicit;
- the choice of objectives and criteria that any decision making group may make are open to analysis and to change if they are felt to be inappropriate;
- scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values and amended if necessary;

[33] HM Treasury (1997) *Appraisal and Evaluation in Central Government: Treasury Guidance*. "The Green Book". The Stationary Office, London. The Green Book includes and annex on "Costs and benefits not easily valued", which briefly discuss both CBA and MCA approaches.

- performance measurement can be sub-contracted to experts, so need not necessarily be left in the hands of the decision making body itself;

- it can provide an important means of communication, within the decision making body and sometimes, later, between that body and the wider community; and

- scores and weights are used, it provides an audit trail.

The performance matrix

A standard feature of multi-criteria analysis is a performance matrix, or consequence table, in which each row describes an option and each column describes the performance of the options against each criterion. The individual performance assessments are often numerical, but may also be expressed as 'bullet point' scores, or colour coding. Table 4 shows a simple example.

In analytically more sophisticated MCA techniques the information in the basic matrix is usually converted into consistent numerical values.

Table 4 Performance Matrix

Options	Cost	Social	Habitat destruction	Tourism potential	Pollution reductions	Job creation
Option A	24	✓			★	1
Option B	32	✓	✓	✓		2
Option C	12				☆	1
Option D	41		✓			4

Note: A tick indicates the presence of a feature. Job creation potential is shown on a 4-point scale. The best pollution reductions are shown with a solid star and an open star the next best.

Scoring and weighting

MCA techniques commonly apply numerical analysis to a performance matrix in two stages:

i) Scoring: the expected consequences of each option are assigned a numerical score on a strength of preference scale for each option for each criterion. More preferred options score higher on the scale and less preferred options score lower. In practice, scales extending from 0 to 100 are often used, where 0 represents a real or hypothetical least preferred option and 100 is associated with a real or hypothetical most preferred option. All options considered in the MCA would then fall between 0 and 100.

ii) Weighting: numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale.

Assessment Methods

There have been a number of frameworks and assessment methods developed to assist in the assessment of integrated transport plans and infrastructure projects. It is worth noting that the key criteria at the broad level are reasonably consistent between methods although the application of these criteria at the project level has traditionally been limited, either in the technique used or the alternative projects considered.

The transport objectives the assessment methods judge projects and programs against are embedded within the methods.

WA Treasury Project Evaluation Guidelines and Strategic Asset Management

WA Treasury have published a set of guidelines to assist State Government agencies in project evaluation and a format for presentation of projects to Cabinet (Treasury Department, 2000). The Strategic Asset Management process is also included in the evaluation process.

The aim of the Guidelines is "to improve the allocation of scarce State financial resources in the Western Australian economy and, in the process, optimise the State's economic growth and, hence, the welfare of it's residents" (Treasury Department, 2000, pvii).

The evaluation process comprises three components:

- Financial evaluation – to ascertain the most efficient strategy for delivering outputs within the perspective of the agency, and in turn whole of government.
- Economic evaluation – to ascertain the if the outcome achieved is in the public interest through use of, amongst other methods, benefit cost analysis.
- Social-impact analysis – to ensure a balance between quantifiable and unquantifiable factors in the context of the Government's desired outcomes.

A strategic justification is required that entails "demonstrating that the investment proposal is consistent with the agency's broad objectives" (Treasury Department, 2000, p11). The Guidelines tend to assume project evaluation within agencies in the sense of there not appearing to be an appraisal across a group of agencies or a portfolio. For example, there has been little, if any, comparison between modes and non-built solutions. The outcome of this tends to be more of the same in terms of the normal way of doing business within an agency.

The Guidelines are helpful but need to develop a broader framework and specify the whole of Government outcomes. The following appraisal methods endeavour to address this challenge.

The project evaluation reporting requirements to satisfy the needs of Cabinet include:

- A project evaluation summary.
- A project definition report.
- A strategic justification statement.
- A financial justification statement.
- A budgetary impacts report.
- A Triple Bottom Line report covering economic, social and environmental issues.

The guidelines make explicit reference to the use of strategic asset management (SAM). SAM is a decision process that considers a range of options before new physical infrastructure is constructed (Treasury, 1994).

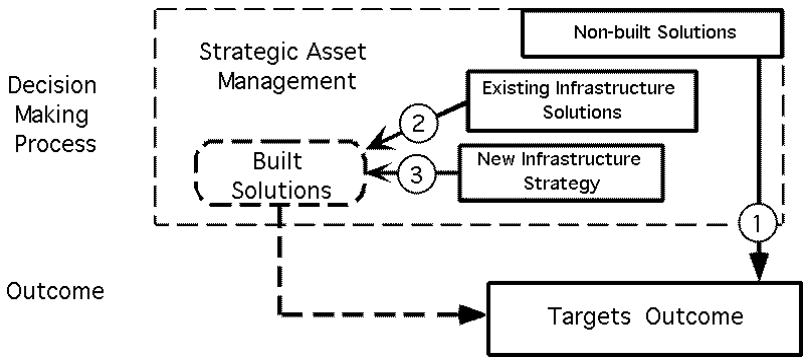
"In many circumstances it is possible, and desirable, for government to provide services without creating assets. Non-asset solutions may involve the rationalising of facilities, re-shaping community attitudes and demands, or changing the rules, for example, by altering legislation" (Treasury, 1994).

Non-asset based options can comprise non-built solutions (ie managing demand through regulation and voluntary measures) and system improvements to gain greater efficiencies and effectiveness from existing assets (eg use of turning lanes to allow increased through put of vehicles).

In the context of the achieving targets, SAM could be applied in the following way:

Figure 8 shows the SAM decision making process. The major infrastructure projects in the transport sector are roads, new public transport services, networks and stations, cycleways and footpaths. The first stage is to consider the effectiveness of non-built solutions, or demand management options. In this case the aim of non-built solutions is to maximise the use of existing public transport, cycling and walking infrastructure and services and defer the demand for new road infrastructure. Having completed this stage, consideration is then given to modifying existing infrastructure to maximise its effectiveness in the second stage. The creation of new infrastructure should only be considered when there are no cost effective options available in the first and second stages.

Figure 8 Strategic Asset management Decision Model



Main Roads Project Assessment

Main Roads WA has developed a model to aid in prioritising major projects across the State and to help formulate the 10 year investment plan. The assessment method (Value for Money Rating) comprises:

- Economic benefits – quantifiable value of the project to the community (conventional cost benefit ratios). They are quantified by multiplying the benefit cost ratio by the net present value of the project cost.

- Other benefits – estimated benefits that are not covered in conventional cost benefit ratios. If no benefits are quantified, the value for money rating equals zero.

- Community Assessment (CA) scores – a modified version of the multi-criteria assessment analysis developed to simplify the assessment of a large number of projects. The CA scores are not applied to benefits quantified in the cost benefit ratios. An assessment is done for each project under the headings of Economic, Social, Safety and Environment and rated on the following five point scale with attached multipliers:

Multiplier		**Multiplier scale**		
		VMR1	**VMR 2**	
M1	Economic Impact Multiplier	0.5	0.0	Highly detrimental
M2	Social Impact Multiplier	0.67	0.5	Detrimental
M3	Safety Impact Multiplier	1.0	1.0	Neutral
M4	Environmental Impact Multiplier	1.5	1.5	Beneficial
		2.0	2.0	Highly beneficial

Two value for money ratings are being tested and applied:

$$\text{VMR 1} = \frac{\text{M1} * \text{M2} * \text{M3} * \text{M4} * \text{NPV(Economic Benefits + Other Benefits)}}{\text{NPV Project Cost}}$$

$$\text{VMR 2} = \frac{\text{NPV(Economic Benefits + Other Benefits)}}{\text{NPV Project Cost}} + \text{CA}^{1}$$

$$^{1}\text{CA} = (\text{M1}*\tfrac{1}{4}) + (\text{M2}*\tfrac{1}{4}) + (\text{M3}*\tfrac{1}{4}) + (\text{M4}*\tfrac{1}{4})$$

The application of the MCA tends to be useful for the selection of appropriate routes between two points or an appropriate public transport system to serve a specific area (Symonds Travers Morgan, 1996). The current application of MCA by MRWA tends to be policy neutral (ie doesn't reflect policy generated targets) and is not suitable for the application of non-built solutions. It is also contingent on the use of numerical weightings that can hide important qualitative issues.

MCA as a technique comprises the following components:

- A finite number of alternative plans or options;
- A set of criteria by which alternatives are judged; and
- A method of ranking the alternatives based on how well they satisfy the criteria.

An integral part of the Asset Management Planning process is to focus project selection towards those key Corporate Performance Indicators which measure progress towards achievement of community expectations.

UK New Approach to Appraisal

The "New Approach to Appraisal" (NATA) was developed to assist the UK Government to deliver the "New Deal for Transport" and is applied to all major schemes above £5 million. The context for this was a realisation that the projected growth in traffic demand could not be satisfied through an expanded road building programme without major fiscal and community impacts. Also at this time there was acceptance that induced demand existed[34].

This new approach was integrated transport planning. Road network expansion could still occur however it had to be included in multi-modal plans (known as Local Transport Plans) incorporating travel demand management, pricing, regulation and "integration" with land use plans.

Local Transport Plans are used for:

- Capital maintenance of principal highways, bridges and street lighting.
- Major public transport schemes (new road schemes, guided busways and other bus priority schemes, some park and ride schemes, etc).
- Supporting the block of smaller integrated transport schemes (eg pedestrianisation, cycleways, safe routes, etc).

The UK Government's objectives for transport are:

- To promote a strong economy and increase prosperity [35];
- To provide better protection for the environment; and

[34] Induced demand occurs when expanding the road network releases latent demand. Induced demand greatly undermines the benefits identified in expanding the road network to the extent that projects are not viable in cost benefit terms. In other words, a new approach was required.

[35] Subsequent research has shown that, at current UK levels of road provision, there are no appreciable benefits from some road construction on the economy and the impacts may in fact be negative.

- To develop a more inclusive society (DETR, 1998).

The stated aim of NATA is to improve "the consistency and transparency with which decisions on all transport investment projects are made. It does this by presenting the key economic, environmental and social impacts of projects in a clear, consistent and balanced way using a one-page Appraisal Summary Table (AST) and associated work sheets".[36]

NATA uses a one-page summary of the main economic, environmental and social impacts of a highway. Its five basic criteria (and their sub-criteria) are:

- **Economic Benefit and Cost** - including total project (scheme) costs, plus system efficiency measures of benefits on journey time, vehicle operating costs and journey time reliability plus desired distributional impacts on regeneration (economic revitalisation);
- **Safety** - including reduction in vehicle and medical costs;
- **Accessibility** - including level of access to public transport, as well as impacts on "community severance" and pedestrians;
- **Environmental Impact** - including sub-criteria for noise, local air quality, landscape, bio-diversity, heritage, water; and
- **Integration** - with other government programs and policies.

Some of the impacts summarised in the AST are presented in money terms. The process used to derive these values is often termed "cost-benefit analysis". Those impacts presented in this way include Safety and Transport Economic Efficiency. The key principle underlying these valuations is "willingness to pay". Other impacts summarised in the AST are presented in quantitative terms. However, it might be easier to determine what weight to put on environmental impacts if these could be valued in monetary terms, in a way which reflected the value that individuals placed on the environment (as has been done for the value of a life saved).

US Transportation Efficiency Act 21 (TEA-21)

The fore-runner to TEA-21 was the Inter Surface Transport Efficiency Act passed by the US Federal Government. This Act was adopted to provide greater flexibility in the funding of transport infrastructure in the US to achieve a number of objectives with air quality a key objective. Funded projects have to be included in a multi-modal plan typically proposed by metropolitan planning organisations and State transport departments.

[36] Quoted from http://www.roads.dtlr.gov.uk/roadnetwork/heta/hetacoba.htm.

The equivalent to the Local Transport Plan process in the US is the creation of Metropolitan Planning Organisations. For example, the Boston Metropolitan Planning Organisation (MPO) is one of the 13 Massachusetts regions established to carry out federally funded transport plans and programs. It comprises a partnership between local, regional, state and federal agencies/authorities and is supported by a group called "Central Transportation Planning Staff". The Boston MPO was established in 1973 to:

- Work together on the federally required transport planning process.
- Establish a Joint Regional Transportation Committee (JRTC) to ensure citizen participation in regional transport planning.
- Work together to ensure compliance with federally mandated planning documents.
- Establish a joint technical staff to support decision making.

The Boston Region 2000-2025 Transportation Plan tends to mirror the planning process applied in the UK NATA. The Boston Plan comprises a testing of options (mainly infrastructure) against a set of policy objectives. The Plan contains a set of projects for roads, transit, pedestrians and cyclists and travel demand management. The anticipated budget is US $18 billion for:

- US $4.5 billion to complete the "Central Artery",
- US $0.9 billion for Federal Transit funds,
- US $9 billion for transport system maintenance and improvement, and
- US $3.9 billion for capacity expansion.

Underpinning the 2000-2025 Plan is a Transportation Improvement Plan (TIP). The TIP comprises a staged, multi-year, inter-modal programme of transport projects consistent with the 2000-2025 Transportation Plan. The Federal Highway Administration and the Federal Transit Administration require the Plan be reviewed and recertified on a triennial basis

As an overview, the Boston Plan seems light on in terms of land use transport integration, growth management and effective travel demand management. It does however provide a linkage between the overall policy objectives and funding of projects.

Transport projects in the US seeking federal funding under TEA-21 are required to address seven key criteria (or planning factors) set by that legislation. Those seven criteria are:

- ***Economic Vitality*** – support the economic vitality of the US, the states and metropolitan areas, especially by enabling global competitiveness, productivity and efficiency;

- ***Safety*** – increase the safety and security of the transport system for motorised and non-motorised users ;

- ***Accessibility*** – increase the accessibility and mobility options available to people and freight;

- ***Environment*** – protect and enhance the environment, promote energy conservation and improve quality of life;

- ***Integration*** – enhance the integration and connectivity of the transport system, across and between modes, for people and freight;

- ***Efficiency***– promote efficient system management and operation (including efficient user movement and costs); and

- ***Preservation***– emphasise preservation of the existing transport system.

In a narrow technical sense, TEA-21 itself was primarily a spending authorisation bill. However, in a much broader sense, TEA-21 has expanded the set of benefits and impacts which are to be formally considered as factors in transport investment decision-making[37] by setting:

- ***Benefit Criteria*** -- policy concerning the types of impacts that are explicitly recognised as benefit goals to be considered in project decision-making; and the types of distributional impacts and externality impacts which are to be considered in determining project acceptability;

- ***Set-asides*** – creation of programs, or continuation of ISTEA (the previous surface transport authorisation) created programs, to fund some types of projects which are deemed to be socially beneficial though they might not normally past the traditional benefit-cost tests;

- ***Targeting*** – allocation of funds for disadvantaged areas and populations where there are special needs based on equity considerations.

Together, these policies effectively altered appraisal requirements for projects to be selected for federal funding. They were accompanied by a requirement to streamline the project planning process and added more flexibility to State and Local decision-making, while still requiring benefit-cost assessment where appropriate.

[37] Weisbrod, Glen, and Weiss, Martin (2001). *Development of Benefit-Cost Policy in the Era of TEA-21*. Paper prepared for Benefit-Cost Analysis Symposium, Transportation Association of Canada. February 2001.

Perth Strategic Transport Evaluation (STE) Model Output Framework

The Perth STE Model is a traffic/transport model developed very specifically to answer policy type questions.

A suggested framework was built around the outputs of the STE Model that mirrors the UK NATA criteria. The STE Model framework is outlined in Table 5.

	Objective	Measures
STE Model Outputs	Economic	Transport Systems Costs – financial impact measure. Economic efficiency – transport system efficiencies.
	Environment	Greenhouse – CO^2 emissions. Regional Air Quality.
	Safety	Total crash costs.
	Social	Health – physical activity and air pollution impacts. Affordability – average travel costs by geographic area. Social inclusion – transport self-sufficiency by geographic area.
	Robustness	Mode split diversity – passenger and freight.

Table 5 STE Model Output Framework

Robustness is the measure of the system being able to sustain shocks that may severely impact on a transport mode. For example, an over-reliance on road vehicles exposes the community to negative impacts of major rises in oil prices. The affordability and social inclusion measures are similar to the targeted allocation of funds under TEA 21, although interventions to influence land use patterns (eg location of public housing) are also appropriate to consider.

Oregon Benchmark Model

The Oregon Progress Board monitors 90 indicators or benchmarks to ascertain the economic, social and environmental health of the state of Oregon. The indicators are grouped into the following seven categories:

Benchmark	Examples
Economy	Per capita income, new companies, unemployment.
Education	Reading and math scores, drop out rates.
Civic engagement	Time spent volunteering, voter turnout, State arts funding.
Social support	Teen pregnancies, youth drug abuse, infant mortality.

Public safety	Overall crime and juvenile arrest rates, recidivism.
Community development	Affordable housing and freeway congestion.
Environment	Air quality, fish stocks, land and wildlife preservation.

The Governor of Oregon through involvement of business and community leaders has identified ten sustainable community objectives. The objectives that relate more directly to transport are:

Economic	A resilient economy that provides diversity of good economic opportunities for all citizens.
Community	Downtowns and main streets that are active and vital. Efficient and compact development that saves infrastructure investments and natural resources.
Environmental	Efficient use of and reuse of resources and elimination of harmful toxins and emissions to the environment.

Implementation of sustainability criteria includes the need to be practical, holistic, transparent, involve a broad cross section of residents and be integrated into decision-making frameworks.

While the Oregon Benchmarks are at a broad level, they do provide a number of principles worth building into the investment evaluation process. A paper provided to the Tasmanian Government states that the "Benchmarks have been a powerful catalyst for change by facilitating collaboration to achieve established goals".

The benchmarks that relate directly to transport are shown in Table 6.

Benchmark	Measure	Target
Traffic congestion	Percentage of miles of limited-access highways in Oregon urban areas that are congested.	Maintain 1995 levels – 49%.
	Hours of travel delay per driver per year in urban areas: a) Portland b) all other	1997 a) 52 b) 12 2010 a) 65 b) 13
Commuting	Percentage of Oregonians who commute to and from work by means other than a single occupancy vehicle.	1990 – 29% 2000 – 36%
Vehicle Miles Travelled	Vehicle miles travelled per capita in Oregon metropolitan areas (per year).	1990 – 7,733 2000 – 8,156
Road Condition	Percentage of roads in fair or better condition: a) state b) county.	1990 a) 70% 2000 a) 78%

Table 6 Oregon Benchmarks

Suggested WA Approach

The assessment methods are effective if they are able to align outputs that are most effective in achieving desired outcomes. Based on the comparison of the above assessment methods and the outcomes derived for the Oregon Benchmarks, TIIRIS and the STE Traffic Model, the suggested criteria are:

Criteria	Sub-criteria
Economic vitality	Economic development and enhancement and value for money.
Environment	Protect and enhance the environment and natural resources and promote energy conservation.
Accessibility or social inclusion	Equity of access to destinations and transport choice, including minimising community severance, strong regions and targeted to disadvantaged communities.
Health and safety	Protect and improve the health of the community.
Integration	Integrate across transport modes, land use and transport and with other government programmes (eg health and education).

Use of the UK NATA approach is advocated. This comprises a summary table with supportive analysis, such as benefit cost analysis, financial analysis and social and environmental impact assessments. The preference is to have these projects nested in regional and local integrated transport and place-based plans, however there is likely to be a time lag until these plans are developed. There are a number of integrated transport plans that could be used a lighthouse projects (eg Rockingham Transit Plan).