Road Travel Demand

MEETING THE CHALLENGE

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RELEVER LE DÉFI

FOREWORD

In the 20th century, Man conquered Mount Everest, walked on the Moon and plunged to the icy depths of the Atlantic Ocean. However, despite these huge advances in pedestrian, aviation and maritime exploration, surface transport remains constrained by increasing roadway congestion. So, while we soon may be able to jet to Mars, grappling with gridlock remains a vexing problem for metropolitan cities in OECD countries.

Paradoxically, congestion is a positive sign of a healthy economy, indicating high employment rates, large volumes of freight movement and a vibrant social network. The lifeblood of every economy, efficient surface transport remains a vital factor in daily existence. Striving to provide mobility and balance the potentially detrimental logistical, economic, social and environmental ramifications of traffic congestion is at the very essence of influencing road travel demand.

Decreased productivity due to time wasted in traffic snarls, increased air, water and noise pollution, and quality-of-life degradation are all by-products of the rising demand for surface transport. Recent attention has focused on the reduction of greenhouse gas emissions caused by vehicles, as evidenced by the international summits in Rio de Janeiro and Kyoto. Achieving the targeted reductions will require better co-ordinated land use, urban design and transport planning; technological advances; and lifestyle modifications.

The goal to create a balanced and environmentally sustainable road transport system prompted the OECD Steering Committee for the Programme of Research on Road Transport and Intermodal Linkages to form a Working Group to undertake this study on Influencing Road Travel Demand. The working group used the 1994 OECD report *Congestion Control and Demand Management* as a basis for its analysis. Efforts focused on updating the report by highlighting new tools and strategies and best practices that have been developed and implemented over the six years since its publication.

This report represents the culmination of the Working Group's efforts to identify successful strategies and measures that influence travel demand, ameliorate traffic conditions, and increase the efficiency of road infrastructure in the OECD area. It recommends strategies to influence future travel demand.

ABSTRACT
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Travel demand strategies, measures, and practices are key tools in helping OECD Member countries to balance growing demand for travel with addressing environmental concerns and the need to support sustainable transport systems.

This report updates the 1994 OECD report *Congestion Control and Demand Management*, and highlights key policies, effective measures and best practices that have been developed and implemented over the ensuing years to influence travel demand. Based on the experiences of OECD Member countries, it recommends strategies to better manage future travel demand.

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Chapter 1

INTRODUCTION

Scope of the study

This study examines a broad array of measures undertaken to influence travel demand. New research findings and innovative trip-reduction strategies and case studies from OECD countries are used to update the 1994 OECD report, *Congestion Control and Demand Management.*

It highlights successful measures designed to affect travel choices and use of transport modes, ameliorate traffic conditions and maximise efficient use of road infrastructure. The study demonstrates the effectiveness of packaging supply and demand-related interventions and policy initiatives to create greater impact on travel demand. It recommends a number of strategies designed to address current and future travel demand in OECD countries.

This report comprises 14 chapters, nine of which are devoted to a particular category of travel demand measure, ranging from land use and transport planning to communications substitutes and improved traveller information systems, as detailed below.

Each chapter provides information on the supply- and demand-related interventions or policy measures applied, including best practices and promising new approaches.

Chapter 2. Land Use and Transport Planning

Chapter 3. Communication Substitutes

Chapter 4. Traveller Information Systems

Chapter 5. Economic Measures

Chapter 6. Administrative Measures

Chapter 7. Parking Management

Chapter 8. Traffic Management

Chapter 9. Preferential Treatment

Chapter 10. Public Transport

The format adopted for each of the chapters is as follows:

Description. Defines the measures included in a given category and sets out the sub-categories therein.

Objectives and major impacts. Describes the intended objectives for each set of measures (i.e. what specific problem the measure aims to solve) and the expected impacts (i.e. how it is intended to contribute to the solution).

Application of measures. Discusses the circumstances under which the measure is implemented and to which user group or transportation facilities and services the measure applies.

Institutional responsibility for implementation. Describes the organisations or operations charged with implementing and supporting the measure.

Effects on travel patterns. Presents, where available, empirical or modelled data on the impact of each measure on travel demand in terms of trip reduction, vehicle kilometre or mile reduction, reduction in delay, increases in speed or accessibility, and mode split or ridership changes.

Cost-effectiveness. Presents, where available, quantifiable findings or qualitative cost assessments.

Special problems and issues. Discusses the key issues that need to be taken into consideration before implementation, based on experience.

Packaging with other measures. Provides an assessment of which other measures can be packaged with the given strategy to form synergistic impacts and which measures do not complement one another.

Examples. Provides examples of operational projects and programmes that have been implemented in OECD Member countries in relation to each category or sub-category. Strategies enumerated in each section and results on the impact on road travel demand are presented. The examples have been evaluated using the performance measures and factors identified in Chapter 3.

Freight measures and policy packages are explored in Chapters 11 and 12, respectively. Chapter 12 includes empirical evidence demonstrating the success of road travel reduction policies when combined with other strategies. Chapter 13 considers the potential for influencing future road travel demand and includes a discussion of the relationship between growth and transport demand. The final chapter offers a series of observations and policy recommendations aimed at influencing current and future demand.

Why is travel demand increasing?

Analysing the factors that have influenced travel demand in the past is a crucial first step in finding effective and lasting solutions to managing the expected increases in future travel demand in urban areas. A report on urban travel and sustainable development attributes the following six factors to the growth in travel demand (ECMT/OECD, 1995):

- Economic growth.
- Increasing income levels.
- Rising car ownership.
- Transport system improvements.

- Competition between public and private transport; and
- Demographic changes.

Each of these factors is described in greater detail below:

Economic growth

Throughout the OECD region, transport demand is growing in step with economic growth. The subsidisation of transport externalities distorts the "true" costs of travel, thereby making the costs of travel artificially low – and more economically appealing. A modern economic analysis of the relationship between transport and economic growth remains relatively underdeveloped (OECD, 1997).

This raises the issue of the potential to influence travel demand by incorporating the cost of externalities into the price of travel, and charging transport users for the full cost of their journey. However, doing so can be politically and economically contentious, as well as technically challenging.

Some OECD Members have attempted to capture the true travel costs by imposing tariffs and introducing roadway pricing. Sweden's high taxation of fuel and automobiles internalises less than half of the estimated external costs associated with transport. Recent experiments with road pricing in Canada, France, Norway and the United States among other OECD countries, has provided greater insights into travellers' response to price, and tested the potential for capturing these externalities. Further details of these projects are contained in Chapter 5 of this report.

Increasing income levels

Real income growth in OECD countries has averaged 2 to 3% per year over the last 20 years and has been associated with increasing consumption of most goods and services, including travel. Research demonstrates that as real income increases, car ownership increases.

Changing household structure

Demographic and social changes have resulted in a decrease in the size of the average household over time. More dwellings are required, thus leading to larger cities. These demographics have also had a more direct impact on travel through changes in the total number of individuals and households.

Demographic changes

Recent research in the Netherlands indicates a 20% growth in the number of kilometres driven in the decade from 1985 to 1995 (OECD, 1997). More than a third of this increase (38%) is attributable to population growth and "baby-boom" generation drivers. The remaining 62% is attributed to an increase in the number of daily kilometres driven per motorist.

Changing lifestyles

Changes in the demand for mobility should be viewed in the context of modern lifestyle developments(OECD, 1997). With the rise in two-income families, a private car facilitates a variety of activities requiring travel. Daily trips involve diverse commuting patterns that combine trips to school and school-related activities; care of children and the elderly; recreation; and shopping.

Higher incomes and the increase in car ownership, among other factors, have led to a substantial increase in the demand for leisure activities. Many trips are often practical only by car, and in today's highly mobile society, the car fulfils a number of useful purposes. To many, the car symbolises a sense of freedom and independence.

Rising car ownership

Car ownership has risen continuously in many OECD countries. In the EU, the number of cars owned has grown on average by 4.2% per annum over the past 20 years. Per capita car ownership has also increased.

Research indicates that car ownership substantially increases the number of journeys per household as travellers modify their chosen mode of travel (OECD, 1997). Access to a car is also often associated with a considerable increase in distance travelled.

Meeting travel demand: a delicate balancing act

Most often, travel results from a need to access other activities. Only a small proportion of journeys (such as excursions on an old-fashioned, steam-powered locomotive) are made expressly for the transport experience.

The public requires mobility to meet its social, economic, educational and recreational needs. Any changes influencing travel demand must respect these needs while balancing the environmental, safety and health impacts on society without overly compromising the economy's operating efficiency.

Doing so becomes a delicate balancing act for transport planners, policy makers and politicians who are challenged to achieve the right degree of mobility that meets the public's needs while addressing larger economic, societal and environmental concerns.

The potentially detrimental impacts of transport that policy makers must address include: congestion; road crashes; car dependency; air, water and noise pollution; visual blight; energy consumption; and urban sprawl.

- *Congestion.* Road users in congestion experience a direct loss of personal time. Equally important are the indirect effects on the economy through impacts on the production and distribution process, caused by time lost due to unreliability of the transport system for (business) travel and freight transport. Other indirect impacts include environmental effects and road crashes.

- *Road crashes.* In OECD Member countries, over 126 000 people were killed on roadways in 1999 (OECD, 2000).

- *Inaccessibility and car dependence.* Changing settlement patterns, lifestyle changes and the deterioration of some public transport services have all contributed to a greater dependency on the car and increased challenges for ensuring convenient access to other transport modes.

- *Air, water and noise pollution.* Emissions from vehicles and the build-up of pollutants create air pollution problems, the contamination of water run-off from the road surface contributes to water pollution, and increased noise levels caused by passenger and freight vehicles create noise pollution.

- *Visual and physical severance.* In some areas, infrastructure has bisected communities, created urban blight and worsened the aesthetic environment.

- *Energy consumption and global warming.* The text of the 1997 Protocol to the United Nations' Framework Convention on Climate Change (NFCC) adopted in Kyoto, Japan, demonstrates the earnest desire of many of the world's governments to reduce the levels of greenhouse gases.

- *Urban sprawl and decaying urban fabric.* Low-density communities reduce accessibility for those without cars and reduce the efficiency with which the public transport system can serve an urban area as a whole.

There has been some progress in addressing these impacts in recent years, and the focus of these efforts has turned to lessening the detrimental environmental effects of transport use. In particular, a strong emphasis has been placed on the reduction of greenhouse gases, beginning with the 1992 Earth Summit in Rio de Janeiro, Brazil. Moreover, the text of the protocol from the third session of the 1997 Conference of Parties to the FCCC conference held in Kyoto, Japan proposed major reductions in overall greenhouse gas emissions.

In short, the Kyoto Protocol proposes that "Annex 1" countries (OECD and eastern European countries) reduce their overall emissions of greenhouse gases (in CO_2, equivalents) to a level 5% below the 1990 level during the commitment period 2008-12. The EU countries agreed upon a reduction of 8% below the 1990 level.

Public ownership of much of the transport infrastructure is another factor that warrants consideration in influencing travel demand. As citizens place governments under increasing pressure to be more effective and to deliver better services with existing resources, the pressures on the transport system increase. An OECD expert group on performance indicators noted that "public administrations are now expected to meet annual service level targets at reduced costs, develop mechanisms for customer feedback, and designate the dimensions and measures to meet these service level targets" (OECD, 1997). Yet those same citizens also look to the government to solve the problems, such as congestion, which those demands have produced.

Efforts underway to influence road travel demand

In the past, meeting travel demand amounted to pouring enough concrete and asphalt to respond to forecast levels of future road travel demand. This practice, known as "predict and provide" frequently occurred in the absence of other transport planning or land-use policies. The negative impacts of these capacity-increasing projects were seldom adequately mitigated. In the 21st century, given the broad range of factors contributing to the growth in road travel demand and the problems associated with this growth, increasing the capacity of the roadway infrastructure is insufficient. In the

new Millennium, the physical, fiscal and environmental constraints challenge transport planners to shift the focus from a "predict and provide" to an "anticipate and manage" approach. While some OECD countries have embraced this new approach, widespread adoption of this philosophy is needed to maintain sustainable mobility.

This shift in emphasis away from roadway construction and expansion is reflected in the OECD's Road Transport and Intermodal Linkages Research (RTR) Programme, of which this study is a part. Emphasis is being placed on using travel demand management (TDM) strategies to create sustainable transport systems and facilitate intermodal connections that offer solutions to avoid or postpone the need for road capacity expansion.

Pricing is one TDM strategy often considered to defer roadway expansion. To test its potential, in 1992 a computer model was created based on conditions in Sacramento, California. The model estimated that the implementation of a TDM programme consisting of various pricing measures could defer roadway projects in the region for a minimum of seven years up to a maximum of 24 years, resulting in total savings of USD 100-223 million. According to this analysis, larger investments in TDM programmes and services might be justified if additional non-market benefits were included in the analysis, such as reduced environmental impacts and increased travel choices for non-drivers. Pricing applications are further explored in Chapter 5.

Innovative approaches implemented in the Netherlands

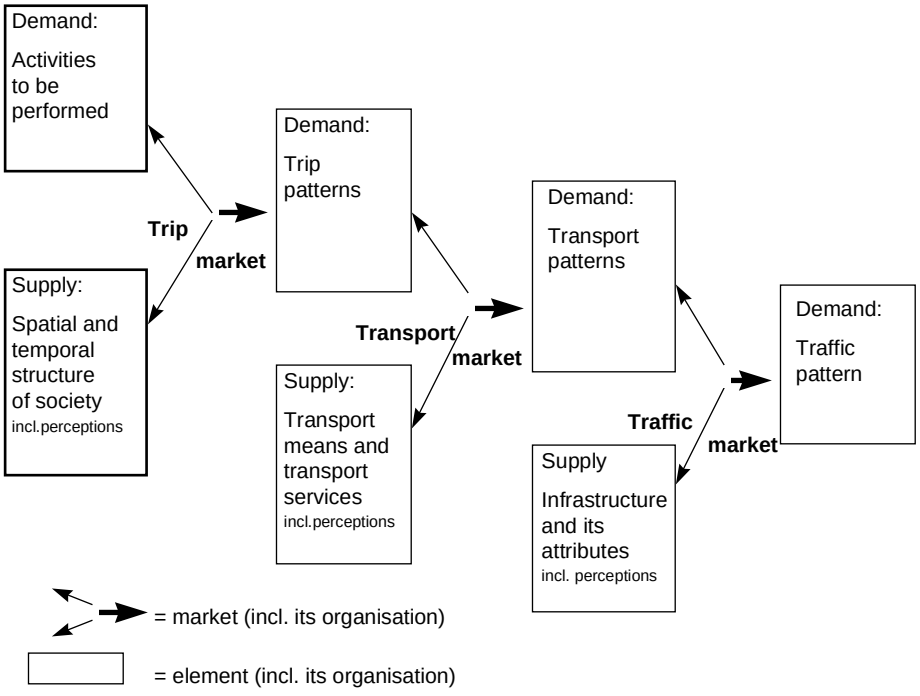
The Dutch Ministry of Transport, Public Works and Water Management has developed a system for analysing options to influence demand and maximise use of existing roadway infrastructure (Van de Riet and Egeter, 1998). This approach regards travel and transport as a set of markets – a system with a dynamic interaction between demand and supply. In this interaction, implicit and explicit choices are made on both the demand and supply sides of each of the markets. The results include a realised supply, a realised demand, and a re-allocation of demand to create supply. This re-allocation of demand to supply in a market can have consequences for the demand and supply side of other markets.

Within the overall transport system, three different markets can be distinguished, each of which has its own supply and demand side: the trip market, the transport market and the traffic market. The three markets and their relationships are depicted in Figure 1.1.

The trip market

In the trip market, the demand side consists of activities to be performed, whose location and time are as yet unknown. The supply side consists of the spatial and temporal distribution of the locations where the activities could be performed and the trips associated with them, as well as how this distribution is perceived. The output of this market consists of a set of trip patterns, an allocation of the activities to locations and times. This part of the system diagram suggests the important role of land-use policies in influencing travel demand. These influences can be quite slow to take effect but can, in the long run, be more influential than policies directly aimed at the supply side of the traffic or transport market. This issue is explored in greater depth in Chapter 2.

Figure 1.1. **Conceptual framework for the domain of traffic and transport**



The transport market

Trip patterns (the output of the trip market) become the demand side of the transport market: the demand for vehicles to transport people and freight. The supply side of the transport market consists of the available supply of vehicles and services to accommodate these trips (specified according to place and time) and how they are perceived. The output of this market consists of a set of realised transport patterns: an allocation of trips to the transport vehicles and services.

The traffic market

Transport patterns (the output of the transport market) become the demand side of the traffic market: the demand for infrastructure to accommodate the vehicles and services. The supply side of the traffic market consists of the available infrastructure with all of its attributes, such as traffic control systems. The output of the traffic market consists of a set of realised traffic patterns: an allocation of transport vehicles and services to the infrastructure. To a certain extent, this output defines the actual and perceived level of service on the infrastructure and thus influences the supply side of the previous markets.

All categories of measures influencing demand must have a place in the different markets of the system diagram in Figure 1.1. Each measure can affect the supply or demand side of a market or both sides, thus influencing the following markets (to the right, in the diagram) and ultimately, road travel demand. It should be noted that measures that influence the demand side of the traffic market can also be measures affecting supply on the other markets of the policy domain. In general, different types of measures influencing travel can be attributed to the different markets:

- *The trip market.* Measures influencing the desire to travel and the traveller's choice of destination and time a trip is made.

- *The transport market.* Measures influencing the traveller's mode choice.

- *The traffic market.* Measures influencing the travellers' route choice.

The distinction between demand and supply categories of measures is illustrated in Figure 1.1. This report uses a slightly modified version of this categorisation relating traffic and transport markets than that used in the report *Congestion Control and Demand Management* (OECD, 1994). Table 1.1 specifies which upon market(s) the different categories of policy measures first have an impact.

Table 1.1. **First impact of categories of measures in relation to the markets in the traffic and transport system**

Chapter	Category	*First impact of measures is on:*		
		Trip market	Transport market	Traffic market
Chapter 2	Land use and zoning	Demand/supply	----------	----------
Chapter 3	Communication substitutes	Demand	----------	----------
Chapter 4	Traveller information services	Supply	Supply	----------
Chapter 5	Economic measures	Demand/supply	Demand/supply	----------
Chapter 6	Administrative measures	Demand	Supply	Demand
Chapter 7	Parking	----------	Supply	Supply
Chapter 8	Road traffic management	----------	----------	Supply
Chapter 9	Preferential treatment	----------	----------	Supply
Chapter 10	Public transport management	----------	Supply	----------
Chapter 11	Freight movements	----------	Demand	----------

Source: Based on OECD (1994), *Congestion Control and Demand Management*. Expanded by OECD Working Group.

The Netherlands offers a useful model for other OECD Member countries considering the implementation of a range of TDM strategies to impact travel demand. Each chapter of this report offers examples of how OECD countries are addressing the trip, transport and travel demand markets and targeting reductions on the supply or demand side and/or both sides.

This chapter has examined a number of factors that help to account for the growth in transport demand in recent years. Changes in demographics, lifestyles and economic conditions have all contributed to the rise in travel demand and transport use. The model framework for individual travel demand management measures introduced in this chapter is used and discussed in subsequent chapters.

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Chapter 2

LAND USE AND TRANSPORT PLANNING

Description

Land-use planning is commonly defined as the formulation and implementation of public policy affecting commercial, residential and industrial development. It encompasses the regulation of overall settlement patterns and the location and functional aspects of new development and redevelopment through planning, development control and issuance of building permits. Land use directly involves and impacts transport planning and provision. Thoughtful land-use planning, carried out in concert and co-ordination with public transport, can manage travel demand most effectively. In particular, transit-oriented developments for communities offering convenient access to public transport, footpaths and cycling facilities can enable residents to reduce or eliminate trips made by car. As a travel reduction measure, land-use planning can be most effective when combined with other travel reduction strategies to form an integrated package.

Land-use planning measures for existing and new developments are typically considered long-range strategies affecting transport demand. Given that most land uses change slowly over time, the overall effectiveness of planning measures can be difficult to ascertain and evaluate over the short term. For example, in the United Kingdom, annual rates of new construction represent on average only 1-2% of existing stock (UK DOE/DOT, 1993). In contrast, existing offices, convenience stores and retail establishments that typically generate many trips are frequently renovated.

In general, research supports a strong correlation between land use/land densities and transport mileage and modal choice. While the relationship between land use and transport is especially well-documented in theoretical studies and model simulations, empirical evidence remains sparse. A recent study found that quantification of these relationships and of the impact that land-use policies have on positively influencing travel demand remains insufficient (ECMT, 1995). Further "real-world" results are needed to support land-use planning as a long-term, viable travel reduction strategy.

Objectives and major impacts

Land-use planning policies are designed to limit car travel in three ways: *by reducing the need to travel* through elimination or reduction of the number of trips taken; *by reducing the length of the trips*; or *by increasing travel by public transport or non-motorised travel*, such as walking and cycling.

Modelling potential impacts of increased density is one mechanism that can provide planners with additional insight for reducing transport demand and vehicle emissions. Computer simulations estimate that emissions reductions of 16% could be achieved over a 20-year period by improving public transport, revitalising city centres and limiting highway capacity expansion (UK DOE/DOT, 1993). Other modelling work indicates that land-use changes implemented over a 25-year period could

reduce fuel consumption by as much as 15% (Steadman and Baren, 1990). Good land-use planning can support travel demand reduction efforts, while poor practices can sabotage or lessen the impacts of supporting alternative transport services and efforts. Sweden's "Big City Commission" confirmed that its poor municipal planning practices over a 15-year period led to a significant deterioration of public transport services, and a lack of the public's ability to view land-use planning in a big-picture context (*Sveriges offentlige utredninger*, 1990).

It is important to address the public's scepticism that land-use measures can create significant and long-term impacts on travel demand. It is difficult to dispel this concern, as computer simulation models do not reflect "real world" experience, especially for the treatment of walking and cycling. The dissemination of concrete results and examples where such measures have been successful is needed to promote these positive results to policy makers and the public alike.

Application of measures

Enforcing laws and regulations at both national and international levels is a major tool for managing land-use planning. The Netherlands, the United Kingdom and Norway have adopted specific national regulations on integrated land-use and transport planning (The Ministry of Housing, Physical Planning and Environment, 1998, Department of the Environment, 1992, Department of Transport; Ministry of the Environment, Norway, 1999). Examples are cited later in this chapter. Other countries have either recently adopted similar regulations or are preparing to adopt them (PIARC, C-10 Committee on Urban Areas, 1999). Scotland's "National Planning Policy Guideline" calls on planning authorities to be more proactive in implementing policies that promote awareness of the impacts of travel decisions, while the "Green Transport Plans" target trip-reduction efforts for hubs such as businesses, schools and hospitals (The Scottish Office, 1999). In an effort to control the detrimental impacts of urbanisation, the Swiss Federal Council Order requires that new residential developments be located in areas that are well served by public transport. Finland has produced public transport and land-use guidelines. Japanese regulations codified in city planning law ("The Area Division" and "The Land Development Permission System") allow authorities to require the provision of transport and network improvements for individual development initiatives.

Countries including the Netherlands, France, Germany and the United Kingdom have created national regulations to strengthen retail development in urban centres (Department of the Environment, London, 1996). Retail planning policy guidance is produced separately for England, Wales, Scotland and Northern Ireland (see examples at the conclusion of this chapter). In Denmark, the Ministry of Environment and Energy has devised an overall national plan that severely restricts the construction of large shopping centres outside city centres. In 1999, Norway implemented a five-year moratorium on the construction of large shopping centres and the expansion of existing centres (*Miljøverndepartementet*, 1999).

On the supra-national level, the "European Spatial Development Perspective" (ESDP) policy initiative was initiated in the early 1990s in co-operation with the European Commission and its member states (European Union, 1999). These policies aim to achieve balanced and sustainable development that encourages land-use development and location policies that reduce dependence on private cars and encourage multi-modal transport in the European Union.

A final version of the ESDP policy document was adopted in May 1999 in Potsdam by the Informal Council of Ministers responsible for spatial planning. In October 1999, agreement was reached on the first step to put ESDP into practice: a twelve-point action programme encouraging EU member states to give priority to demonstration projects pursuing a polycentric and balanced urban

development policy. The action programme appears rather diluted compared with the policies presented in an earlier (1997) draft of the ESDP report. As the ESDP is consultative and not prescriptive, the adoption of such policies is left to each government's discretion. It is hoped that EU countries will adopt and pursue a sustainable land-use planning and transport development approach.

An important policy initiative underway in England is aimed at improving the co-ordination of land-use, transport and economic development at the regional level, and the ESDP serves as a framework reference document for a British Regional Planning Guidance on European issues. EU structural funds are encouraging the development of regional spatial plans. A document entitled "Planning Policy Guidance Note 11 on Regional Planning" has been issued to strengthen the role and effectiveness of Regional Policy Guidance (RPG) (Department of the Environment, Transport and the Regions, 2000).

Institutional responsibility for implementation

Responsibilities for land-use planning typically lie with local authorities. The approval of plans that include more than one municipality is normally carried out by authorities at the national level or by intermediate-level government officials pursuant to delegated authority. Elected officials governing an entire metropolitan level are exceptions, such as is the case in Portland, Oregon (US). There, an elected executive officer and a council elected by districts are responsible for transport planning as well as co-ordinating land-use planning among the 24 municipalities in the region. The Greater London Authority (GLA) is another example of a metropolitan-wide government that oversees land-use planning.

Effects on travel patterns

Existing land-use planning and transport policies and their effects can be classified into five main groups:

- Population density and mixed land use.
- Effects at regional level.
- Effects in urban areas.
- Corridor development.
- Site-specific effects.

Population density and mixed land use

The potential role of density in influencing both the distance people travel and their modal choice has been explored in a variety of studies. Kenworthy and Laube studied major trends in urban land-use development in 46 international cities between 1980 and 1990 (Kenworthy and Laube, 1999). They report that affluent US, Canadian and Asian cities experienced marginal increases in overall metropolitan scale density, while European, Australian and developing Asian cities experienced a decline during that decade. Moreover, density increased in the central business districts (CBDs) in nine out of the 13 US cities studied. Canada has experienced a similar trend, particularly in the city of

Vancouver. In contrast, the density of central business districts in some European and Asian cities continues to decline.

Research by Kenworthy and Newman on the influence of density on transport shows a strong, non-linear, negative association between per capita gasoline consumption and population density in different cities (Kenworthy and Newman, 1989). The same authors confirm this finding in an updated and expanded study (Kenworthy and Laube, 1999).

The authors argue that the relationships between physical factors of urban form, transportation and energy use are so considerable that they suggest that there must be at least a casual link between the factors. Fixed and variable costs of cars adjusted for urban wealth also have a strong correlation between car ownership and car use. However, these relationships are not as apparent as the relationship between these factors and density (Kenworthy and Laube, 1999).

A 1993 report produced by the UK Departments of Energy and Transportation on the effects of density on travel demand includes the following key points (UK DOE/DOT, 1993):

- Higher population densities widen the range of opportunities for the development of local personal contacts and activities.

- Higher population densities within a specified locality increase the scale of local expenditure.

- Higher density patterns of development will tend to reduce average distances between place of residence and the places at which services, employment or other opportunities can be accessed.

- Within any given structure of urban area, increasing the density of population implies greater numbers of personal movements along specific corridors, improving the potential viability of public transport.

Data from the United Kingdom have shown a distinct rise in travel demand as density falls below 15 persons per hectare and a sharp fall as densities increase above 50 persons per hectare.

Between 1992 and 1995, the Netherlands conducted an international comparison of infrastructure entitled “EURINFRA” (Vernon *et al.*, 1996). The project developed indicators to describe the spatial structure of cities and the supply of public transport and mobility. A pilot application using this methodology was used in the cities of Amsterdam, Zurich, Cologne and Frankfurt. The density (defined as the combined number of inhabitants and jobs per hectare) was a crucial spatial characteristic. The transport supply for both public transport and cars seems to be directly related to density. Higher densities appear to be related to greater use of public transport and reduced car use.

A study on the effects of urban density on energy consumption of travel found that a 200% increase in density reduced petrol consumption by about half and energy use by 40% (Gordon, 1997; Gordon and Archer, 1997).

A study of citizens in 22 Nordic cities of differing size concluded that those living in dense cities with a centralised urban structure of residential areas and work sites consumed less energy for transport than those living in less dense cities (Naess *et al.*, 1995, 1996). When the effects of other factors such as income, car ownership and work commutes were examined, the inhabitants of cities with the lowest population density (Halden, Norway) consumed on average 25% more energy for

transport than those in the cities with the highest density (Copenhagen, Denmark). This study also revealed a 28% difference in energy consumption for transport between the city with the most highly decentralised population within its borders (Alta, Norway) and the densest, most centralised city (Randers, Denmark).

A common hypothesis contends that the use of alternative transport modes will increase as the number and mix of land uses located in close proximity to a work site increase. However, research conducted in the Los Angeles area revealed that land-use mix does not affect drive-alone modal share to a degree that is statistically significant (Cambridge Systematics, Inc., 1994). The same study revealed that financial incentives were the only TDM measure that significantly affected modal shifts in areas having a mix of land uses. A 1995 study states that evidence is inconclusive as to whether a jobs/housing balance actually reduces travel (ECMT/OECD, 1995). Similar conclusions are drawn in a 1993 study where simulations suggested that intermixing residential and employment uses within a particular urban zone makes a negligible difference in distance travelled or modal choice (UK DOE/DOT, 1993).

A 1995 study by the California Air Resources Board had more positive conclusions (JHK and Associates, 1995). Based on US references, the study estimated that a jobs/housing balance might achieve an 8% reduction in trips at a given site or within a neighbourhood. Moreover, a World Bank study opined that mixed development is effective in reducing car travel (World Bank, 1997). The study found that locating offices, schools, shops, etc., closer to residential areas would reduce the amount of travel.

The potential for using a jobs/housing balance to reduce travel demand appears to be dependent on the context in which it is applied. More practical experience and evaluation is needed to determine when and where this land-use planning strategy can best be implemented.

Regional structures

Regional policies designed to encourage a multi-centric structure within metropolitan regions are very popular in large urban areas such as Paris and Tokyo (ECTM/OECD, 1995). In some cases, this has served to ease congestion but car dependence has increased as activities have become more decentralised. According to the 1995 ECMT/OECD study, promoting a policy of multi-centric regions does not appear to reduce the need to travel.

A Norwegian study of people's work commutes from 15 small city regions in Sweden (defined by commuting trips of up to 35 km) found that a decentralised, multi-nuclear urban pattern was the least energy demanding (Naess, 1993). These findings were considered surprising even by the authors, especially given the general high mobility in Sweden. Other studies indicate the same results (Rickaby, 1987; Martamo, 1995).

Research conducted in Denmark (Christensen, 1996) and in the United Kingdom (Breheny *et al.*, 1993; Davis *et al.*, 1994) found that car dependency was highest in small towns and rural districts, perhaps owing to the lack of public transport in these areas.

The UK study previously cited suggests that where decentralisation takes place, an effort should be made to locate development in and around settlements with a population of at least 25 000 and preferably over 50 000 residents, with a balance between employment opportunities and the economically-active population (UK DOE/DOT, 1993).

"New Towns", a policy initiative undertaken in the United Kingdom in the 1960s and 1970s sought to reduce urban sprawl through the implementation of a number of strategies, including encouraging the location of businesses in proximity to public transport systems. Initially, the "New Towns" had a high level of self-containment. However, in recent years, many have become decentralised. As employment opportunities have increased in areas outside the "New Towns", residents have begun commuting to businesses located in outlying areas.

Urban structures

Policies to limit low-density urban sprawl have been implemented throughout the OECD region. "Green Belt" controls, designed to support urban regeneration and preserve the countryside have had mixed results. Ontario and Vancouver, Canada, offer successful examples of such policies while the United Kingdom's green belt policy, dating to 1955, has led to a dispersion of the population and increased journeys to the workplace for lower income groups (UK DOE/DOT, 1993).

"Spartacus"

A Norwegian simulation study known as "Spartacus" showed small effects of urban sprawl on car ownership and use in the commuting regions around Oslo and Bergen (Fosli and Lian, 1999). Over a 16-year period from 1980-96, the effects of the changed population distribution (the effect of the population growth itself is not included) created a 2% increase in car ownership in Oslo and a 4% increase in the Bergen region. Similar percentages were found for increases in the distances driven (only 0.3% higher for both cities). Taking into account a 20% increase in the number of new jobs created in the Oslo region during that period, the change in work site locations and commuting patterns represented a 30% increase in the number of work trips made by car from 1980 to 1996. From these results, it can be noted that the decentralisation of work sites had the most significant impact on transport.

Many policies aimed at maintaining and enhancing the vitality of city centres have primarily been adopted for reasons other than for reducing car travel. However, Portland Oregon's urban renewal policy was specifically designed to reduce the number of solo drivers. Restricted parking policies are often implemented in high-density areas that are well served by public transport. This principle is also the basis of current national policy in the Netherlands and the United Kingdom.

Development of centrally located work sites facilitates the use of public transport. A number of studies of company relocations from the central business district to the suburbs attest to this fact. In the San Francisco Bay area, the rate of public transport for work trips among several thousand workers plummeted from 58 to 3% as a result of a single company's relocation (Cervero and Landis, 1992). The previous location was well served by the local metro system (BART). Employees were relocated to three suburban campus locations not served by BART and poorly served by bus. Similarly, moving the headquarters of a Danish insurance company from six different downtown locations to a suburb resulted in a drop in transit share from 60 to 37% and a decline in the rate of cycling from 14 to 9% (*Plandirektoratet, Københavns kommune,* 1990). In Oslo, moving the headquarters of an insurance company from downtown to a peripheral location resulted in a decline of transit usage from 65 to 45% despite the office's proximity to a train and bus transit terminal (Hanssen, 1993). It is important to note that employees were offered free parking at the new location. In Australia, moving the Public Transport Corporation from downtown Melbourne to a new building located just 8 kilometres outside the city centre resulted in a decline in transit usage from 63 to 11% (Bell, 1991). This result was

particularly surprising given the new building's 400 metre proximity to a train station and the fact that nearly three-quarters of the employees lived in the same direction as the organisation's move.

In the Netherlands, several model simulations have been applied to different urbanisation strategies. The results support the 1995 ECMT/OECD study's findings: in highly urbanised areas, the concentration of urbanisation between the main conurbations along public transport infrastructure has positive effects on mobility; and in less urbanised areas, concentration of urbanisation in the city or adjacent to the city contributes to positive effects on mobility.

Corridor development

Corridor development aims to increase densities near public transport corridors and stations. The American term "transit-oriented development" (TOD) is often used to connote residential areas that are located within walking distance of public transport services. A comprehensive US review of literature on transit and urban form published by the Transit Cooperative Research Program (Parsons Brinckerhoff Quade and Douglas, Inc., 1996) offers these findings:

- Residential densities have a significant influence on rail transit station boardings.
- Residents of higher density residential areas are more likely to walk to transit.
- The types and mix of land uses influence the demand for transit as well as the use of non-motorised modes.
- Areas with successful transit-focused development have specific land-use-related characteristics:
  - Strong, respected institutions that people trust to deliver services.
  - Regional growth that channels development to station areas.
  - Regional policies that focus growth in transit corridors and limit it elsewhere.
  - Station-area policies and programmes to support private sector investments and transit-friendly development.
  - Long-term commitment.
- Transit and urban form will best complement each other when associated with a wider policy agenda aimed at improving the quality of urban environments.

The metro lines in Stockholm have had a strong influence on building patterns with denser development in proximity to stations (Sundström, 1989). This has contributed to a higher modal share for public transport than in Gothenburg and Malmö where the public transport system is primarily based on buses.

For many years, development in the Copenhagen region has been based on a "finger plan" with five fingers extending from downtown Copenhagen (Hovedstadsrådet, 1989). The regional policy to concentrate city development in areas close to metro stations in the fingers allows for increased use of

public transport and thereby reduces car traffic in the city. This strategy has met with some success so far. (See examples section at the conclusion of this chapter.)

Site-specific

To a growing extent, consumers shop in stores that are not located in close proximity to their place of residence (Johnston, 1984). Theoretically, there should be a hierarchical centre and service structure so that frequent purchases can be made near homes or jobs, with infrequent shopping trips to more distant locations (Short, 1996). There is some evidence to suggest that patrons of large shopping centres shop more efficiently than do other customers, shopping less frequently and buying more each time they shop (Hallsworth, 1988; Ljungberg *et al.*, 1994).

A recent Norwegian "before-and-after" study of shopping trips taken from three residential areas to two new regional shopping centres showed no increase in distance travelled by car for shopping (Holsen, 1998). Only minor increases in the distance travelled by car are observed for a shopping centre outside Helsinki (Lehtimäki, 1995).

A before-and-after study conducted in Sweden had partially different results. Customers frequenting out-of-town grocery stores increased their vehicle miles driven by 3-13 times (Forsberg *et al.*, 1994). Data from the United Kingdom show that entirely new trips generated by retail developments form a small proportion of all retail trips (around 5%) (UK/DOE/DOT, 1993). The majority of trips tend to be transfers from other destinations and "pass-by" trips. The general consensus is that the traffic-inducing effects created by a shopping centre are dependent upon its geographic location and the population it serves.

Locating services within walking distance to residences and providing pedestrian facilities is essential to promoting pedestrian activity (JHK and Associates, 1995). A study undertaken in the Portland, Oregon, metropolitan region found that the pedestrian environment is a significant factor in explaining car use (Parsons Brinckerhoff Quade and Douglas, Inc. *et al.*, 1993). An empirical study based on TDM data from the Los Angeles area (Cambridge Systematics, Inc., 1994) showed that accessibility alone did not statistically affect the share of solo drivers. Accessibility was measured as easy access for transit users, pedestrian, cyclists, and easy access to nearby amenities. However, accessibility and financial incentives together produced a greater reduction in the drive-alone mode share than financial incentives in isolation.

The Los Angeles study also analysed the influence of specific site characteristics on travel behaviour. When the level of TDM measures was held constant, changes in the perception of safety resulted in a significant change in the public transport and walk/bike mode shares. When TDM measures were available, the public transport share increased by 1.8% from 3.6 to 5.4%. The bike/walk mode share increased by 1.5% between sites characterised as being safe. This was a large shift, given that the bike/walk mode accounted for less than 4% of all trips, even at sites perceived as safe.

The study found that areas considered to be safer were characterised by pedestrian activity, sidewalks, street lighting and devoid of vacant lots. The same study showed that sites with both a high degree of aesthetics and financial TDM measures had at least a 3% lower drive-alone mode share than any of the other land-use and urban design characteristics evaluated in the analysis. The study concluded that the presence of an aesthetically pleasing setting is important in improving the effectiveness of TDM measures.

In contrast, a study undertaken by Cervero on density, diversity and design raises the question whether many built environment variables will prove to be statistically significant in changing travel behaviour (Cervero and Kockelman, 1997). In a previous study of transit supportive designs in a number of US cities, Cervero concluded that micro-design elements such as trees, sidewalk widths, block lengths, etc., are too minor to exert any fundamental influences on travel behaviour (Cervero, 1993).

Cost-effectiveness

The planning literature does not address the cost-effectiveness of traffic restraint measures to a large extent due to the difficulty in quantifying such relationships. A literature review on the cost-effectiveness of transportation control measures (TCM's) characterised land-use planning as "speculative" in reducing regional emissions, although noting its high potential (Apogee Research, Inc., 1997). Teleworking and compressed workweek schedules were similarly categorised. In a more recent literature review by the same company, ranges of travel estimates are given for land use as well as other TCMs. Land-use planning was considered to be among the top three measures, with an estimated reduction in daily VMT ranging from 0.05% to a maximum at 5.4%. Similar numbers were given for percentage reductions in daily trips. The other most cost-effective measures were pricing and mandatory employer trip-reduction programmes.

Special problems and issues

In practice, the general effectiveness of land-use planning measures in influencing travel demand is dependent on a number of factors:

- Measures must be acceptable to the public and politicians alike. Bolder, more comprehensive measures to significantly influence the need for transport are less likely to be accepted. As a result, only less effective measures tend to be approved.

- The availability of undeveloped and affordable land in suburban or more peripheral locations.

- Responsibilities for planning and transport are fragmented and often governed/managed by different authorities.

- Lack of binding regional policies on land use and development.

- Planning is a lengthy procedure. The more controversial the issues, greater the chances that plans will be modified during the process.

- Even with the best intentions, master plans and strategic plans are often modified at a late stage of the planning process.

- Building construction sometimes results from an exemption granted by a development board, planning commission or zoning plan.

- When travel costs are low, people are less likely to shop locally.

- Businesses do not or cannot locate in "the right place" as deemed appropriate by local, regional or national land-use policies.

- Containment policies might lead to greater urban sprawl.

- Some of the best planning measures might create adverse effects on congestion. While higher densities can create more energy-efficient cities, a concentration of traffic can increase air pollution and degrade environmental conditions. Moreover, increased densities can raise the cost of land, thereby stimulating population dispersion.

- To avoid unintended ramifications, land-use policies should be part of an integrated package.

Despite the numerous problems the implementation of land-use planning measures can pose, the examples provided below demonstrate cases where these measures have proven to be effective.

Packaging of measures

The potentially undesirable side-effects described above might result in a negative view of planning measures. Some argue that the correct pricing of car use (congestion pricing and parking pricing) would eliminate the need for other measures, affect a better balance of home/work locations, and create higher residential densities in public transportation corridors. Theoretically, correct pricing would encourage people to relocate closer to work and live near public transport systems in order to reduce transportation costs.

However, when travel is inexpensive, people use mobility to extend their range of job opportunities, patronage of retail facilities, pursuit of leisure activities and location of residence. Employers, retailers and developers locate their services and establishments accordingly. Larger, more affordable and more attractive suburban residences tend to be favoured over those more proximate to the city centre. Increased commuting time and higher fares are readily accepted as a trade-off for these other amenities.

From a political standpoint, correct market pricing of transport is difficult to achieve. In the absence of such pricing, a better integration of land use and transport is among the "second-best" measures (Cervero and Landis, 1996). Despite the view that land-use planning is the most viable tool for influencing travel needs, evidence clearly indicates that such policies are most effective when part of an integrated policy package. In isolation, land-use planning can do little to reduce travel demand.

The effectiveness of land-use planning policies in reducing both travel demand and traffic congestion should not be evaluated under current conditions of already-constrained mobility. In this context, land-use planning becomes a critical tool for maintaining access and choice for future mobility that is further limited. Land-use policies can then function as logical and necessary complements to other policy measures. Data in studies such as the City of Portland's Land Use, Transportation, and Air Quality Connection (LUTRAQ) effort support this finding. The study found that the combination of strategies such as transit-oriented development, major investments in public transport and economic measures is most effective in impacting travel demand. (See examples section at the conclusion of this chapter.)

Conclusions

- Land-use planning can influence road travel demand by reducing the need to travel and trip length, and by increasing alternative mode use.

- Land-use planning in isolation will do little to reduce travel demand; it is most effective in combination with other travel-reduction strategies.

- Research indicates a strong correlation between density of land use and travel behaviour (*e.g.* distances travelled, mode of transport).

- Although authorities at the local level are typically responsible for land-use planning, planning measures are best managed through application and enforcement of national and international policies and guidelines.

- Problems with land-use planning include high land costs coupled with low travel costs, fragmented responsibility for planning, conflicts of interest between the private and public sectors, and difficulty in evaluating cost-effectiveness.

REGIONAL EXAMPLES

ABC-location policy, the Netherlands

Description

In the Netherlands, land-use policies are an important means of influencing travel behaviour and limiting the growth in car use. An ambitious location policy, "The Right Business in the Right Place" or more popularly, the "ABC-policy", has been in existence since 1991 (The Ministry of Housing, Physical Planning and Environment, 1988, 1992). It aims "to require businesses and services with a high potential of public transport use by employees and visitors to be located within easy access to these services." Parking restrictions are an important part of the policy.

Application

The implementation of the ABC-policy has resulted in over one-third (35%) of new businesses locating in a prime or "A" location. During the period 1992-95, since only 6-7% of the net surface area was available for expansion and most businesses had to locate along the motorway due to lack of space in the city centre. Moreover, the local plans were developed before the introduction of the ABC-policy. While adherence to the ABC policy is a prerequisite for receiving national economic grants, some businesses continue to locate at "wrong" locations.

Within the general framework of the regulations, local governments are responsible for implementing and practising the policy. Parking norms are often subject to negotiations with companies. Such negotiations are hampered by the shortage of prime "A" and "B" locations and by the high costs for development of an "A" location. The policy dilemma is whether parking norms should be mitigated in order to stimulate the development of "A" locations, or if parking norms should be handled more strictly to increase the effectiveness of the policy (van Reisen, Boumns *et al.*, 1999).

Effects on travel patterns

The ABC-policy is in its infancy and effects are mostly based on modelling results; however, some empirical evidence exists. The policy has had a significant effect in areas directly controlled by the national government. The Ministry of Housing, Physical Planning and the Environment relocated to a new office building directly adjacent to the central railway station in The Hague, consolidating a number of offices formerly dispersed throughout the country. This resulted in a dramatic drop in auto commuting from 41% to a mere 4%. Commuting by rail has increased from 25 to 57% while bus/tram use has risen from 9 to 20%.

Research on the effectiveness of location policies for companies in North Brabant has revealed that classification of companies according to their mobility profile ignores many company-specific factors that influence employees' preferred mode of transport. Establishment of a company in the "right place" does not mean that employees will travel by the most suitable mode of transport. The choice of transport is related to individual circumstances of companies and employees. Supplementary TDM measures applied at the company level could be a very valuable instrument in creating an optimal result of the location policy.

Planning Policy Guidance 13, United Kingdom

Description

The United Kingdom's Planning Policy Guidance Note 13, known as "PPG 13", was first issued in 1994 before being updated and published by the Department of the Environment, Transport and the Regions (DETR)(Department of the Environment, Department of Transport, 2001). The objectives of the current guidance are to integrate strategic transport planning at the national, regional, strategic and local level in order to:

- Promote more sustainable choices for both passenger and freight transport.
- Promote accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling.
- Reduce the need to travel, especially by car.

To assist in the co-ordination of transport and land-use planning, local planning and highway authorities follow the Regional Transport Strategy (RTS) which forms part of the Regional Planning Guidance (RPG). PPG 12 on Development Plans provides guidance to maintain consistency between local transport and development plans. Local transport plans made statutory by the Transport Act of 2000 have a central role in co-ordinating and improving local transport provision.

The guidance encourages local authorities to adopt complementary development and transport strategies, and consideration of development plan allocations and local transport priorities and investments that are closely linked. In developing the overall strategy, local authorities are advised to:

- Focus on land uses which are major generators of travel demand in city, town and district centres, and those located near major public transport interchanges, with central city, town and district centres taking precedence over outlying locations.
- Actively manage the pattern of urban growth and the location of major travel generating development to make full use of public transport. This may require the phased release of sites for development in order to co-ordinate growth with public transport improvements.
- Locate day-to-day facilities near their clients in local service centres, and adopt measures to ensure safe and easy access, particularly for pedestrians and cyclists.

Local authorities should review their development plan allocations and should:

- Allocate or reallocate sites that are (or will be) highly accessible by public transport for travel-intensive uses, ensuring efficient use of land, while seeking, wherever possible, a mix of uses, including a residential element.
- Allocate or reallocate sites unlikely to be well served by public transport for uses which are not travel intensive.
- National maximum parking standards are introduced in PPG 13 for the major land uses.

DETR undertook a study of the effectiveness of PPG 13 (Ove Arup and Partners, 1999); however, this study examined how local authorities were interpreting the guidance, rather than evaluating its effects on travel patterns.

Planning Policy Guidance 6 – Retail Location, United Kingdom

Description

Planning Policy Guidance 6, known as "PPG 6", (DETR, 1996) sets out the government's policy regarding retail development, particularly on the issue of locating such development in urban centres or on the urban fringe. The current version of the guidance, which was adopted in 1993 and revised in 1996, arose from a concern about the growth of "out-of-town" shopping centres and their effects on traffic growth and on the economic vitality of town centres.

Local planning authorities must take PPG 6 into account when adopting local plans.

Effects on travel patterns

The influence of PPG 6 has been evaluated, and it was recommended that retail guidelines need to be clear and easy to interpret, and that the role of public transport and accessibility of new retail development is critical. The latest version of PPG 6 has had a profound effect on the location of retail development; however, the traffic implications of the policy are not explicitly addressed.

Urban Redevelopment, Singapore

In December 1998, Singapore's Urban Redevelopment Authority completed 55 Development Guide Plans (DGPs) detailing specific land-use proposals, with each DGP covering a planning area with a population of about 150 000 residents served by a town centre. Recent DGPs place great emphasis on intensified development and land use around the Mass Rapid Transit System network and secondary systems including light-rail transit and buses, and call for further public transport expansion and integration.

Singapore's 1991 Concept Plan included two key land-use planning strategies. The first focused on decentralising commercial and other economic activities through the development of four regional and numerous sub-regional centres located at the city's fringe, near Mass Rapid Transit System stations, resulting in better utilisation of the circular MRT network in both directions during peak hours. The second strategy focused on locating employment centres such as industrial estates, business parks and commercial centres near residential areas, thereby reducing the need for people to travel.

A Concept Plan for 2001 is under review. A focus group consultation report issued on land allocation has generated many innovative ideas (Focus Group Consultation, 2000). The plan's main objective is to significantly reduce the demand for road space. While car ownership could be limited by imposing stricter vehicle quotas and/or implementing road pricing to a greater extent, the plan targets the reduction of travel need as the most effective way to achieve the desired results.

Rather than concentrating efforts on improving mobility and travel speeds, the plan's policy focus should shift to improving accessibility; the ability to reach goods, services, activities and destination. Mobility is considered an inadequate index, since it implies that movement is an end in itself rather than a means to an end.

This change in policy focus should lead to increased density and mixed-use development in this compact city. The focus group report calls for exploring more creative use of transport space. Examples include: the conversion of under-utilised road space into recreational space on the weekends; the construction of underground rail networks; the review of parking space standards; and a better utilisation of the land located underneath mass transit viaducts and road flyovers.

URBAN EXAMPLES

Corridor Development, Curitiba, Brazil

Curitiba, Brazil, a city of 1.6 million residents, has successfully integrated transit and land-use planning to achieve its desired settlement pattern (Parsons Brinckerhoff Quade and Douglas, Inc., 1996). The city has an innovative all-bus public transport system that has served as a major policy tool for creating a linear city. Higher density housing and jobs are concentrated in transportation corridors with exclusive busways in the centre, and high-speed roads used by both cars and express buses on either side. The co-ordination of land-use regulation and transit service has resulted in one of the highest rates of transit use anywhere, despite a population that is more affluent and owns more cars than the typical Brazilian city.

Curitiba began with a vision of a linear city that preserved the downtown and concentrated new development in corridors. To achieve directed growth in these corridors, the city uses co-ordinated transport investments and land-use regulations such as higher density mixed use in the transit corridors.

Curitiba's planners define mobility as moving people, not moving cars. The city leaders have been pragmatic, taking small, affordable steps to achieve their vision rather than committing to complex or large systems and projects. Curitiba's leaders are willing to experiment and take risks. The transit corridors are zoned for mixed-use residential and office development in order to guarantee that buildings both produce and attract trips. Density bonuses encourage retail shops and restaurants on the first two floors of all buildings fronting the transitways. Downtown parking is restricted and a pedestrian environment is emphasised.

About 20% of the 1.3 million passengers using Curitiba's public transport system each day previously travelled in cars. The new trend has resulted in reduced air pollution and fuel consumption. From 1974-94, ridership on the integrated transit network grew by an average annual rate of 15% (a similar increase to the increase in route kilometres of service). The market share rose from 8% to over 70% during the same period.

Corridor Development, Portland, Oregon, United States

The City of Portland, Oregon, has been an American leader in developing state-of-the-art, multi-jurisdictional planning programmes for light rail stations. Portland's LUTRAQ project ("Making the Land Use, Transportation, and Air Quality Connection") was an innovative effort to link land use and site design to alternative transport strategies (1000 Friends of Oregon, 1997). This effort resulted in the selection of a non-traditional alternative option over a proposed highway bypass. The alternative emphasised transit improvements, TDM and complementary changes in land-use planning, including a daily parking surcharge for single occupant vehicles of USD 3 and free transit use. The LUTRAQ alternative resulted in 22.5% fewer work trips by single occupant vehicles, 27% more trips by transit and non-motorised transportation modes, 18% less highway congestion; and 10.7% fewer vehicle hours of travel during the afternoon peak period.

Revitalising Central Business Districts, Greenwich Millennium Village, United Kingdom

A sustainable community for the new Millennium began construction in December 1999 beside the River Thames on London's Greenwich Peninsula (English Partnerships). Formerly an industrial site built on mostly recycled land, the Greenwich Millennium Village will ultimately be home to 7 500 residents and employ over 6 500 people in a balanced environment that provides a variety of shopping, recreational and residential facilities and workspaces. By 2005, 1 400 new residences will be constructed in the southern zone of the peninsula (Greenwich Millennium Village, Ltd., 2000).

An excellent public transport system and a network of nearly eight miles of special pedestrian and cycle routes on the peninsula will reduce the need for cars. The transport system will support retail developments with half the number of parking spaces of similar developments.

The village is well served by London's newest and most advanced metro line, with a large underground station and a new bus terminal accommodating up to 50 buses per hour. This terminal will serve as a hub for a fully integrated public transport system, including the United Kingdom's first electronically guided bus service. An underground electronic cabling system will guide the buses for part of the journey along a dedicated 1.3 km busway across the peninsula.

The Irvine Triangle, California, United States

In 1985, the City of Irvine and the Irvine Company, a developer, devised a transport management strategy and monitoring system to control the level of traffic growth in a large, master-planned development known as the "Irvine Spectrum". A strategic approach to influencing travel demand was needed for this commercial development of 3.8 million square metres and 100 000 employees.

Two key aspects of this development strategy included deed restrictions to require property-owners to achieve trip-reductions on their employees' commutes to work and the creation of a Transportation Management Association (TMA) called "Spectrumotion". This TMA is funded by the property owners and provides TDM services to employer tenants and their employees. Spectrumotion offers employers and commuters personalised travel consulting services, information on public transport, vanpool formation assistance and fare subsidies, and a "guaranteed ride home" programme.

The TMA is also responsible for monitoring trip-generation rates at each development site to assess whether actual trips are equal to or less than a "trip ceiling" devised as part of the original agreement. The last annual count concluded that actual trips generated have reached 75% of the overall trip ceiling, with 31% of all Spectrum employees using non-drive-alone alternatives.

Stuttgarter Strasse/Frazösisches Viertel, Tübingen, Germany

Over the next eight years, a former French military barracks in Tübingen will be converted into a mixed residential and commercial community, to eventually house 6 000 residents and offer 2 500 jobs. The area, offering a functional mix of activities, is the basis for development of a "new urban lifestyle". Small lots with high densities and flexible land use are a condition for this development. Parking will be located within a five-minute walk of the neighbourhood in high-technology garages equipped with elevators to move the cars inside. Car sharing is offered to individuals and companies. Residences located in proximity to workplaces have resulted in a high mode share for walking.

District Vauban, Freiburg, Germany

A former French military barracks known as Vauban is being developed into a 38 hectare car-reduced, city district in Freiburg (Forum Vauban, 2000). The project's main objective is to transform Vauban into an ecological and social model community. The first of three development sites within the community was completed in September 1998, and by 2006, Vauban is expected to house over 5 000 residents and offer more than 600 jobs.

Vauban, situated 2.5 km from the city centre, is well served by public transport and bicycling paths. By 2006, trams and regional trains are planned to link to bus lines. Parking is restricted to a communal area located at the district's periphery and car-owning residents pay DEM 25 000 for a parking space. Nearly half of the current 300 households have elected to be "car-free".

A special mobility package was created for residents in the first wave of development. A fleet of cars is available for those who join the local car-sharing organisation. In addition, subscribers receive a free, one-year transit pass and pay only half-price for train tickets for the first year. Future plans to facilitate car-free mobility include delivery services, bicycle trailers and the provision of carts for residents.

SITE-SPECIFIC EXAMPLES

Suburban Activity Centres, United States

A US model examined the relationship between land-use and trip-generation rates, work/trip mode splits and automobile occupancy levels at 83 different office buildings located in six suburban activity centres. The analysis considered the influence of project size, density, land-use mix and parking facilities.

Auto travel comprised over 90% of all work trips made to each of the six suburban activity centres. The existence of plentiful parking and multiple tenants within a given building appeared to induce vehicle work trips to suburban job sites. The project model suggested that the presence of on-site retail establishments within a suburban office building could reduce vehicle trip rates per employee by 8%. Moreover, it suggested that single-tenant mixed-use buildings could experience drive-alone rate reductions of 3%. The model suggested that a 1 million square foot suburban office building would average 0.84 more passengers per automobile than one half that size. Bigger suburban business parks provide more critical mass from which to form employee carpools and vanpools, thereby facilitating use of alternative commuting modes.

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Chapter 3

COMMUNICATION SUBSTITUTES

Description

Communication substitutes constitute another category of measures designed to influence travel demand. This chapter examines how information and communication technologies (ICT) can reduce or substitute the need for physical travel or transport.

ICT measures can be grouped into seven categories:

- Transport telematics.
- Teleworking/telecommuting.
- Teleconferences.
- Electronic commerce/teleshopping/teleservices.
- Non-profit/public teleservices.
- Distance learning and education.
- Entertainment.

Transport telematics include intelligent highways, "smart" cars, computer-aided navigation, travel and traffic information, variable message signs, and road weather information systems. Transport telematics are further described in Chapters 4 and 8.

Teleworking is work carried out from a distance through the use of ICT. There are five forms of teleworking (Gillespie *et al.*, 1995):[1]

- Electronic home working.

1. The generic terms "satellite centre" and "telecentre" are used to describe a variety of arrangements that allow employees to report to work at a location closer to home than their regular offices. "Telecottages" are telecentres located in rural areas whose primary aim is to provide employment opportunities in outlying areas. These rural centres may serve to reduce long-distance commuting. Group work can be accomplished from remote locations in "virtual teams", facilitated by the use of voice and electronic messaging, computer conferencing, and shared databases and appointment calendars.

- "Telecottages" and Neighbourhood Centres (for multiple firms and for individual entrepreneurs).

- Branch/Distance Office (*i.e.* call centres, business process outsourcing centres).

- Mobile or nomadic working.

- Group or team telework (virtual teams).

Telecommuting is considered a subset of teleworking and is defined as the use of telecommunications technology to partially or fully replace the commute to and from work (Mokhtarian, 1991). There are two basic forms of telecommuting: working from home and working from a telecentre located close to home. Self-employed, home-based workers and mobile workers are usually not considered to be telecommuters because they are not replacing or substituting for commute trips normally made to the office.

Teleconferencing (including audio and videoconferencing) is most commonly used for business purposes, but also includes applications of distance-based learning and education. Such technology can often substitute for or reduce the need to travel.

Electronic commerce, teleshopping and teleservices include a variety of transactions that can be carried out using ICT. Examples include: electronic trading of goods and services; online delivery of digital content; collaborative engineering and design; public procurement; electronic banking; share trading; consumer marketing; and after-sales service. Such activities can be categorised as: "business-to-business"; "business-to-consumer"; "consumer-to-business"; "business-to-administration;" and "consumer-to-government."

Today, business-to-business electronic commerce represents 80% of all e-commerce. Consumers' use of the Internet for financial matters and travel bookings are the primary categories. In the future, networked services for health care are expected to increase.

Teleservices provided via the Internet include "telemedicine", a subset of networked healthcare services offering patient diagnoses, emergency management, and treatment including distance disease monitoring, remote surgery and follow-up consultation. "Virtual hospitals" are emerging with the ability to create an automated network of medical centres. Medical personnel in rural areas can electronically link to a network of specialists for expert consultation in delivering appropriate care.

The Internet, video or telephone conferencing and other telecommunications devices used to administer telemedicine have the potential to reduce patients' travel.

Non-profit/public teleservices include electronic access to public libraries, cultural and social online services, medical services and televoting. Public teleservices can offer community information on transport, housing, education and employment opportunities. Human teleservices can benefit the general public, particularly elderly and disabled people through ICT measures such as integrated smart home technology and telemedicine.

Distance learning and education facilitate access to and contact with schools, institutions, universities and enterprises. Virtual classrooms are created using technologies such as interactive multimedia systems and video conferencing, allowing instructor and students to be located in different places. ICT and TV-academies can reduce trips in a way comparable to telecommuting (although distances can be significantly longer in the case of education).

Entertainment: Live sporting events, concerts and theatre can be broadcast to a dispersed audience rather than requiring the audience to travel to the event. Television channels offering movies on demand allow consumers to remain at home, eliminating a trip to a cinema or a video rental store.

Table 3.1 illustrates how the ICTs described above relate to various aspects of daily life.

Table 3.1. **Application of ICT to various activities**

ICT measure/ Technology structure	Commuting	Business	Service	Shopping	Education	Social visits	Leisure	Serving passenger
Transport telematics	X	X	X	X	X	X	X	X
Teleworking	X	X						X
Telecommuting	X	X	X		X	X	X	
Teleconferencing		X	X		X	X		
Electronic commerce		X	X	X				
Teleshopping				X				
Public teleservices		X	X			X		X
Distance learning and education					X		X	X
Entertainment							X	X

Source: Lehto, Mervi and Himanen (1998).

Objectives and major impacts

In general, companies use telecommunications to enhance sales, improve customer service, reduce cost and/or increase productivity. Although telecommunications are seldom used for the explicit goal of reducing travel demand, technology holds the potential to curb growth in VKT/VMT (vehicle kilometres travelled/vehicle miles travelled). Many US-based companies subject to trip-reduction and/or environmental regulations have implemented teleworking programmes to influence employees' travel behaviour. Several case studies are cited in the "examples" at the conclusion of this chapter.

The relationship between transport and telecommunications can be described as one involving substitution (trip elimination or replacement), generation (trip stimulation or complementarity), modification, or neutrality. Complementarity results when the use of one encourages or directly involves the use of the other, or if one increases the efficient use of the other.

Empirical research on the travel impacts of telecommunications technology falls into three categories (Mokhtarian, 1999):

- *Macro-scale studies* of entire sectors of the economy at regional or higher levels (*i.e.* time-series analyses of consumer expenditures on transport and communication).

- *Micro-scale studies* focus on a particular application, such as telecommuting or teleconferencing, and are based on disaggregated data.

- *Micro-scale comprehensive studies* are also based on disaggregated data, including most travel and communication activities, and broaden the scope beyond a single application.

On the macro-scale level, empirical evidence indicates that the net impact of ICT generates more communication and more trips. Recent research conducted in the Netherlands, Germany, Norway and Sweden has found that new communications technology and transport are complements, rather than substitutes (KMPG-BEA, 1999; Hjorthol, 1999; Zumkeller, 1997; Johansson, 1997). A previous macro-study of Australian and British data conducted over 29 years (1960-89) found telecommunications and travel to be substitutes. The study identified rising real income as the main factor determining changes to both transport and communications demand, with a very slight substitution relationship found between the two (Selvanathan, and Selvanathan, 1994).

A 1997 Dutch macro study examined the travel behaviour of frequent, personal computer users, averaging 18 hours of weekly home use (KPMG-BEA, 1997). On average, people in the study group travelled significantly more than the Dutch population (Table 3.2). When compared to a control group with similar socio-economic characteristics, the computer-users made more and longer trips than the others. The most important difference noted was the study group's greater number of business-related trips. This may be attributable to IT penetrating deeper into the service sector than other business sectors, and hence more business trips are made within the service sector.

Table 3.2. **Traveller behaviour of computer users**

Trip category	Frequent at-home computer users		Control group[1] Dutch population		Total Dutch population	
	Number of trips[2]	Kilometres covered[2]	Number of trips[2]	Kilometres covered[2]	Number of trips[2]	Kilometres covered[2]
Total	4.44	57.52	4.20	52.92	3.71	35.13
Work (commute)	0.82	15.60	0.88	15.86	0.52	7.60
Business trips	0.66	11.07	0.45	7.22	0.24	2.88
Visiting/lodging	0.43	6.97	0.55	9.40	0.55	7.94
Shopping	0.82	2.40	0.83	4.17	0.83	3.86
Education	0.16	4.51	0.16	2.08	0.30	1.91
Touring/hiking	0.20	3.17	0.19	1.89	0.17	1.52
Other	1.35	13.80	1.15	12.29	1.10	9.37

1. Group with similar socio-economic characteristics as heavy IT users.
2. Number of trips and kilometres covered per person per day.
Source: KPMG-BEA (1997).

A Norwegian study found similar results (Hjorthol, 1999). No substitution effect was found for persons who used a home computer to perform paid work. In fact, quite the opposite was true: the study group made more car trips than did people who did not use home computers for paid work. While no statistically significant correlation was found between the use of home computers and the number of leisure and shopping trips made, persons with an Internet connection made more social trips to visit friends and relatives, indicating a complementary effect.

A 1997 Danish study evaluated the influence of telecommunications on individual transport for the following five-year period. The study focused on the growth of distance-based work and Internet trade. Drawing from the findings of several international surveys and on consultations with key resource personnel in Denmark, the study concluded that telecommunications use would not reduce total trips made, but might indeed stimulate more travelling due to changes in behaviour (Kristensen and Falch, 1997).

Similarly, a six-month, broad-scope US study of the relationship between various modes of communication (telephones, faxes, e-mail, personal meetings, etc.) and travel found no statistically significant relationship (Mokhtarian and Meenakshisundaram, 1999). An analysis of cross-modal impacts found a tendency towards trip generation rather than trip replacement. Two limiting factors to the study include the small sample size (91 respondents) and the indicator of activity selected (the number of times these communication devices were used rather than the amount of time they were used).

On a macro-scale, empirical evidence of the relationship between telecommunications and travel supports their complementarity, and it appears unlikely that telecommunications will noticeably reduce travel at the system level. To date, the relatively few comprehensive micro-scale studies conducted all appear to support complementarity over substitution (Zumkeller, 1996).

Application of measures

In the mid-1990s, the number of teleworkers in EU countries was estimated at 1.25 million (Korte and Wynne, 1996). Determining the number of teleworkers and telecommuters on an international scale is difficult, given a lack of international consensus on the definitions of teleworking and telecommuting. This discrepancy has resulted in varying estimates, and forecasts are frequently made based on small and unrepresentative samples (Handy and Mokhtarian, 1996). A 1999 survey conducted in ten of the 15 EU member states reported 9 million teleworkers (or 6% of the total workforce) (European Commission, 1999). Three million Europeans reported that they engaged in supplementary telework, defined as working less than one full day per week at home. Half of the teleworkers (2.9 million), equalling 2% of the EU's total workforce, were home-based teleworkers or workers who could be classified as telecommuters. Finland had the highest percentage of telecommuters, at 6.7% of its workforce, followed by Sweden with 5.3%, Denmark with 4.5% and the Netherlands with 4%.

The 1999 EU survey classified four categories of telework:

- Home-based work for an employer.
- Self-employed work in small, home-based offices.
- Mobile telework.
- Supplementary telework.

The United States leads the OECD in teleworking, and telecommuting is being implemented as a transport policy measure. In 1999, over a quarter of all US households reported conducting work from home either as telecommuters, corporate after-hours workers or home-based business operators (European Commission, 1999). Figures for telecommuters in mid-year 1998 numbered 15.7 million or 12.7% of the workforce (European Commission, 1999). The US Government has set a goal of having 20% of the Washington, DC. regional workforce teleworking by 2005. California State authorities have set a target of using telecommuting and alternative work schedules to achieve a 30% reduction in the number of work trips by 2010.

European efforts include the EU's "DIPLOMAT" project that endeavours to employ teleworking strategies to reduce the number of trips by 450 million by the year 2002 (Helonen and Weber, 1998).

The Dutch "Second Transport Structure Plan" aims to reduce car traffic by 5% in peak rush hours through the use of telecommunications (Netherlands Ministry of Transport, 1990).

While home-based telecommuting was formerly the most common form of teleworking over the past decade, countries such as Australia, Japan, France, the United Kingdom and the United States have recently established teleworking centres. At present, Australia has 130 telework centres, while the United Kingdom has more than 100 (Aicholtzer, 1998, Holloway, 1994).

Teleconferences

Many companies teleconference for routine business matters involving branch offices and satellite locations, as well as for communicating with off-site customers where face-to-face contact and building new personal business relationships are not critical (Denstadli and Haukeland, 1999). Such telecommunications tools are a viable way to conduct business and reduce corporate travel.

Electronic commerce, teleshopping and teleservices

E-commerce, including electronic trading of physical goods and electronic material (images, voice, text, software, etc.) and access to services is still blossoming (OECD, 1999). The business-to-business segment accounts for at least 80% of all e-commerce activity. The United States is credited with generating 80% of the total, worldwide e-commerce activity, with the value of e-commerce forecasted to comprise 6.3% of all-American trade by 2004 (Forrester Research). In other OECD countries, e-commerce has been expanding during recent years, with some experiencing yearly growth rates exceeding 100%.

Since October 1998, efforts to define and measure e-commerce have been included in the OECD Work Programme. The lack of a universal definition of the broad range of electronic activities and functions make measurement especially difficult. Hence, teleshopping is considered a subset of e-commerce, including: information retrieval; comparison shopping/finding "best buys"; placing orders; and paying and receiving digital products electronically. Teleshopping can reduce consumers' travel demand through the promotion and delivery of online purchases. Limitations to this medium include the inability to touch, sample or size the merchandise. In the future, this might be overcome through the use of virtual reality and interactive multimedia.

The Internet has boosted the development of ICT-based healthcare services. Forecasts predict that by 2003, there will be nearly 180 million healthcare Internet users worldwide (45% of which will be based in the United States) compared to 48 million in 1998 (of which 80% were in the United States). The impacts of this anticipated increase in Internet use on travel demand in OECD countries is as yet unknown. A key issue for research concerns patterns of consumer behaviour in the business-to-consumer sector, particularly regarding buying and delivery preferences. In addition, there is a need to undertake case studies of distribution scenarios of companies involved in the business-to-consumer market.

Effects on travel patterns

Teleworking/Telecommuting

Since work trips comprise a large share of the total number of trips and are often combined with trips taken for other purposes, teleworking and telecommuting are likely to have more extensive impacts on travel demand than other ICT measures (Table 3.1). Although work trips comprise a large share of the trips made during the congested periods of the day, in many countries the majority of trips are non-work-related. For example, in the United States, work trips comprise only one-third of all trips.

Several comprehensive studies have been performed on the travel effects of teleworking and telecommuting. Results have demonstrated significant net savings in terms of hours and miles travelled in addition to reductions in vehicle emissions by those who are able to work at home or proximate to home at a teleworking centre. A 1996 state-of-the-art literature review of telecommuting projects in the United States provides the reference for many of the case studies cited in the examples given at the end of this chapter (US Department of Transportation, 1997).

A recent Dutch study explored the feasibility of employees teleworking at home or at satellite offices as part of a larger work process study. The goal was to achieve a 30% reduction in peak-hour traffic without adversely affecting work quality. About one-third of the 3 800 civil servants residing in the region participated in the study. Working at home was favoured by 75% of the 1 134 participants, while only 6% favoured working at the satellite centre. The study concluded that a reduction of approximately 70 000 car kilometres per week in commuting could be achieved if all of the participants teleworked 2.5 days per week (Dutch Ministry of Transport, Facility Management Department, 1999).

Teleworking can reduce the number of commuting trips. The best available estimates for the United Kingdom suggest that, in 1993, teleworking reduced total UK car miles by about 1%. The long-term potential for telecommuting is that it could substitute for 5-12% of total car use.[1] A study in Dublin, Ireland, which adopted a "current state-of-the-practice" approach, found less than a 1% substitution effect for car use, with a projected potential of 1.5% for 2016 (Amarach Consulting, 1999).

Overall, teleworking and telecommuting are considered to be among the best telecommunications options for addressing congestion. Evaluations of telecommuting projects unanimously observe net substitution effects. Documented telecommuting programmes report a significant reduction in travel. Reductions of 75% in person miles travelled and 26% in vehicle miles travelled by the telecommuter on a telecommuting day have been reported (Mokhtarian *et al*., 1995). Most or all of that reduction was due to the elimination of the work trip.

On an aggregate and regional level, however, reductions attributable to telecommuting are far less impressive. Because only a small percentage of the workforce may be telecommuting on any given day, and those most apt to telecommute tend to have a longer commute than regional averages, telecommuting translates into savings in vehicle kilometres travelled of about 1% (Mokhtarian *et al.*, 1995, 1996). Further, the long-term effects of telecommuting, especially the impacts on workers' choice of residential location, remain unclear. There remains some question as to whether teleworking applications can achieve and sustain significant travel reductions over time (Mokhtarian, 1997). Evidence suggests that the existence of teleworking programmes may encourage employees to move further away from work. For example, in the United States, statistics report that telecommuters tend to live twice as far from work as the average employee. Telecommuters located far from work may be

reluctant to take excursions from home because they are already travelling so far on the days when they have to commute. Telecommuters with shorter commutes to work may be more likely to take trips for shopping or socialising on their telecommuting days. Consequently, current thought about telecommuting as an effective TDM measure is regarded less optimistically than it was in the past (Mokhtarian, 1997).

Telecentre-based work results in larger savings in person miles than home-based telecommuting. A 1995 US study found that between 38.5 and 150 miles were saved for each commute to a teleworking centre, with savings averaging 93.4 miles (Bagley *et al.*, 1994). This distance compares to an average of 36.1 person-miles saved per telecommuting occasion for home-based telecommuters. It is important to note that the telecentre users who participated in the study travel more than twice as far to their usual work place than home-based telecommuters. These findings support the value of teleworking centres for significantly reducing person miles for workers who live considerable distances from their regular office.

A 15-month demonstration project in Seattle, Washington, begun in 1995 achieved large reductions in commute miles travelled. Nearly 500 employees of Key Bank were moved to branch offices closer to their homes. This strategy, termed "proximate commuting", resulted in a 65% reduction in the number of commute miles travelled, with an average 17% reduction in commute miles travelled per branch (Mullins and Mullins, 1995).

While teleworkers represent a potential market of public transport or alternative transport users, research indicates that few actually switch to other modes. A Dutch teleworking experiment conducted in 1990-91 resulted in a 15% decrease in commute trips. The study of 30 workers employed in Rijswikj, a small town bordering The Hague, revealed a mode shift away from public transport and biking towards the car (Hamer *et al.*, 1991). This work location was not well served by public transport and was difficult to cycle to, making car travel more attractive. In contrast, a San Diego, California, study found no overall change in mode split before and after the introduction of teleworking (Mokhtarian, 1995).

Teleconferencing

Earlier studies of teleconferencing as a substitute for face-to-face contact revealed that total travel actually increased (Egido, 1988; Mokhtarian, 1990). While teleconferencing offers a certain potential for travel substitution, recent analyses suggest that the substitution effect is limited, and that complementarity dominates. (Rangosch, 2000). This could change as more companies adopt teleconferencing as a way to reduce their employees' business travel.

Companies such as SONY, BT, Picture Tel and Regus suggest that teleconferencing can improve the efficiency of business practices and result in travel cost-savings. A 1998 survey identified cost savings of up to 75% achieved through the use of videoconferencing in place of personal travel (Regus Business Centres, 1998). Technological advances and cost reductions are likely to stimulate the use of teleconferences and the substitution of travel-based interactions in the future.

Electronic commerce, teleshopping, and telemedicine

Our current understanding of the impact of e-commerce and teleshopping on travel is limited. However, recent Swiss research seems to indicate a transport-generating effect. The impact of e-commerce on business travel and goods transport was explored in the Swiss EVITA ("Evaluation of

the Impact of Cyber-technologies on Transport and Environment") research project (Buser *et al.*, 2000). Based on analysis of existing literature and 30 case studies of companies with significant ICT adoption, one-quarter of the companies surveyed reported that the substitution effects were so large that their entire business travel volume had been reduced through extensive use of telematics (Rangosch, 2000). In the absence of telecommunications, some respondents speculated that business travel would have increased by 30-50%.

A recent Dutch study estimates that the number of road trips will increase by 38% by 2005 (Transport en Logistiek Nederland, 2000). This figure is derived by attributing 21% of the growth to the "old economy", 9% to growth in the business-to-business segment, and 8% to growth in the business-to-consumer segment of the "new economy." Increases in worldwide Internet sales of USD 3.2 trillion are predicted by 2003. A corresponding growth of online retail package deliveries is predicted to more than double, rising from 2.98 million in 1999 to 6.53 million in 2003 (McCullough, 1999).

Some OECD cities have already noted signs of this increase. San Francisco City planners report that Internet shopping has resulted in unexpected traffic jams due to trucks double-parking as they make their client deliveries (The Urban Transportation Monitor, 2000). The decentralisation of stock and increased direct sale from producer to end-customer are other driving forces behind the growth of physical deliveries. An intelligent distribution pilot project to address this issue will soon be implemented in Munich, Germany. Employees at BMW's engineering headquarters can order goods or request such services as dry cleaning and shoe repair via fax, telephone or via the Internet. The supplier receives the employee's order, commissions the goods and delivers the items to the workplace, or the employee places items such as clothing or shoes in an assigned "shopping box" from which it is picked up, serviced and returned. Some 100 shopping boxes will be established at the work site, where goods can be delivered to employees. To retrieve their merchandise or property from this secured storage area, employees will use a smart card and pin code (SSP Consult, 2000).

The greatest substitution effects can be achieved for goods that can be sent via regular mail or delivered via an electronic network. An earlier OECD report speculated that the distribution of products that can be delivered electronically could be reduced by as much as 90% (OECD, 1999). There are also reports of e-mail substituting for letter mail. In 1998, US Postmaster General Marvin estimated that business-to-business, first-class mail had dropped by over one-third during the previous five-year period due to the increased use of e-mail (*Business Week*, 1998). On the other hand, this development seems to be outweighed by the increase in the distribution of tangible goods delivery by small trucks and vans.

For many companies, getting the goods to the customer is problematic. For many customers, returning goods to the manufacturer is equally difficult. Finding cost-effective, logistical solutions is paramount for profitability. The development of end-to-end solutions that deliver customised, differentiated service is essential.

Cost-effectiveness

Telecommuting can be a cost-effective TDM measure. Literature on economic evaluation of telecommuting can be grouped into micro-scale and macro-scale analyses. The number of telecommuters is a critical factor in any cost-benefit estimation.

Several studies have suggested that telecommuting has the potential to provide benefits to all sectors of the economy. Analyses of costs and distribution across sectors are often unclear. A US

evaluation of four macro-scale cost-benefit studies revealed a failure to account for most costs (Shafizadeh *et al.*, 1998). Discounting methodology was used in only one of the four studies. A comparison of three of the studies showed that an average telecommuter might save between 1 500 and 3 500 VMT per year by telecommuting. The evaluation concluded that greater benefits could accrue from home-based telecommuting than from centre-based telecommuting.

Special problems and issues

Information technology is penetrating deeper into all sectors of society, but the social implications are complex and not well understood. A telecommuting expert noted: "We cannot underestimate the ability of people to surprise "the experts" in their response to change" (Mokhtarian, 1999, 2000). The findings of a recent US report on the adoption of telecommuting in the Federal Government illustrate this point (Vega and Brennan, 2000). The Federal Telework Program is not attracting telecommuters as quickly as had been anticipated. It was hoped that by 2005 60 000 Federal employees will be telecommuting. In 1998, that goal was only half-way met, with only 25 000 employees telecommuting. Reasons for Federal workers' hesitancy to try telecommuting may include such factors as:

- Fear of isolation when working at home.
- Lack of government resources to implement a teleworking programme.
- Lack of interest and/or support from middle managers.
- Concern expressed by managers and co-workers about equity issues.
- Perception that, by not being physically present at work, teleworkers could be overlooked for promotions and employment opportunities.

The US report presented several recommendations aimed both at the Federal agencies and the telecommuters to counter these possible barriers:

- Establish a professional work environment at home, away from family and personal distractions.
- Lessen the feeling of isolation by instituting a regular telephone meeting time or an e-mail "chat" group with colleagues.
- Maintain communication with one's supervisor and on-site colleagues so that misunderstandings related to issues of role and performance are avoided.

A Dutch feasibility study on teleworking (M&I/Partners, 1999) concluded that the drive for telework will increase in the future due to:

- Increased attention to care-taking tasks in households. Teleworking enables a better balance between time spent working and time spent on family/private matters.
- Increased willingness by organisations to support teleworking.
- Serious traffic congestion problems and increased societal pressure to seek alternatives to rush-hour travelling.

- Technological improvements that can create new possibilities for use of telework applications on a larger scale.

Packaging of measures

Telecommunications can be used to reduce transport costs and address travel restrictions. Measures to raise the cost of travel, such as tolls or higher fuel prices, would stimulate greater substitution of telecommunications for travel.

Telecommuting can be combined with other TDM measures such as compressed workweek schedules, ridesharing arrangements and use of public transit.

Economic measures such as tax increases can also be used to encourage telecommuting. Legislation has been introduced in the United States to provide a USD 500 annual credit for expenses incurred in employee telecommuting for at least 75 days per annum. Both the employer and the employee will be eligible for the credit, depending on which party assumes the costs associated with establishing the at-home work site.

Another US legislative initiative will allow participating employers in five cities to trade and exchange "emission credits" obtained from reduced emissions resulting from telecommuting. The credits may be used for compliance requirements with the Federal Clean Air Act.

Conclusions

- Communication substitutes and information/communication technologies (ICT) can be a cost-effective and potentially useful way to manage travel demand; such substitutes include transport telematics, teleworking, teleconferencing, e-commerce, public teleservices, distance education, and entertainment-related technologies.

- Although telecommunications technologies are rarely used for the exclusive goal of influencing travel demand, their use may create an important secondary effect. Macro- and micro-level studies indicate a complementary relationship between ICT and travel.

- The relationship between transport and telecommunications involves trip substitution, trip generation and trip modification. Teleworking and telecommuting have a greater impact on travel than do other ICT measures.

- More research and experience is needed to determine whether ICT, e-commerce and teleshopping generate or limit travel, and stimulate or reduce additional business travel and goods transport.

- Problems with telecommuting include difficulties in attracting telecommuters, who fear isolation, scarce resources and a lack of the communication found in a traditional office; the social implications of teleworking are not well understood.

- ICT measures are most effective in reducing transport costs when they are combined with other TDM and economic measures.

EXAMPLES

Telework Study,Cambridgeshire County Council, United Kingdom

A British study exploring ways to reduce traffic considered all forms of telecommunication-facilitated work including: home-based teleworking; telecentres; mobile teleworking; video conferencing; electronic data sharing; remote diagnostics; and monitoring. The study concluded that if employers in the Cambridge area adopted various forms of teleworking for suitable tasks, traffic reductions on the order of 4-8% would result, with considerably greater reductions in the morning and evening peaks (Home Office Partnership and Hague Consulting Group, 1997).

Hertfordshire County Council Trading Standards Department, United Kingdom

When the Trading Standards Department consolidated its offices from two buildings into one, it instituted a flexible working scheme for those of its employees who make site visits and travel to appointments throughout the County. A number of "drop-in points" were established across the County to provide basic office services (desk, telephone, photocopier, etc.). This allows employees to travel directly to appointments or conduct site visits located closer to their home than the main office, and to conduct business using the drop-in points.

The scheme has been in existence for two years and has reduced travel time to work by 10% and work-related travel by 9 000 miles, representing a reduction of between 5 and 8%. Officers are able to make more efficient use of their workday while supporting an "environmentally-friendly" policy.

Surrey County Council's Epsom Telecentre, United Kingdom

With the county's introduction of this telecentre pilot, the average length of each driver's home-to-work commute was reduced by 19% to 13 miles, and the average home-to-work commute time was reduced by 36% to 30 minutes. Current telecentre usage saves 48 300 vehicle kilometres of travel per year (Mark Cope, 1997).

Ministry of Transport and Public Works, the Netherlands

The Ministry of Transport recruited 60 employees to participate in two experiments conducted in 1990-91. Long commuting distances were a criterion for selection. Participants worked between 20 and 60% of their normal work hours at home and organised their schedules at their own discretion. For a telework share of 20%, an average of 15% fewer commuting trips was reported. Since the study group was composed entirely of long-distance commuters, the impacts were presented as a maximum potential rather than an average impact (Hamer *et al.*, 1991).

Washington, DC, Area Demonstration Project, United States

The Washington, DC, area is among the most active regions in the United States in fostering telecommuting. Since 1992, Congress has appropriated nearly USD 15 million for the development of teleworking centres in metropolitan Washington, DC. Currently, 16 federally funded centres are operating in the region (Maryland, Virginia and West Virginia), with a total of 343 workstations. As of May 1999, the workstations were in use 41% of the time.

The Metropolitan Washington Council of Governments recently completed a telework demonstration project with eight area businesses employing from 110 to 16 000 workers (West, 1999). The eight employers received assistance to start or expand teleworking programmes in exchange for serving as local case study examples.

Surveys revealed an average commuting distance of 25 miles for teleworkers, while the regional average was 14.5 miles. Teleworking was mainly home-based (88%), while 7% was performed from teleworking centres and 5% from satellite offices. Nearly one-quarter of telecommuting (23%) was done on a one day per week basis, while 17% was done two days per week. Teleworkers saved 97 minutes per day in commuting time and 16 vehicle miles were saved per telecommuting day. A net trip-reduction rate of 0.6 trips resulted.

Bellcore Telecommuting Program, New Jersey, United States

Bellcore's employee transport effort was originally motivated by New Jersey's state air quality mandate, which required businesses to develop a trip-reduction plan. Bellcore, a high-technology research company located in suburban Piscataway, strove to achieve an average vehicle occupancy of 1.38 persons among its 6 200 employees.

The telecommuting and commute alternatives programme had strong support from senior management. The number of employees working compressed workweek schedules increased from 20 to 125 and the number of carpoolers rose from 60 to 250. Over two years, the number of regular telecommuters increased from 90 to over 500, with an additional 500 employees telecommuting occasionally. Bellcore has also implemented a videoconferencing system to reduce the need for business trips between Bellcore sites. With this strategy, the company estimates that it has saved millions of dollars in lost productivity.

Probation Videophone Project, San Bernardino County, California, United States

This demonstration project, funded with vehicle registration surcharge grant monies (AB 2766 Discretionary Projects) aimed to reduce the amount of travel required for San Bernardino County probation officers to meet with inmates at detention centres dispersed over a vast geographical region. The Probation Department installed videophones at several detention centres and allowed officers to conduct interviews from their home or office using portable videophones. The programme resulted in a daily reduction of an average of eight trips and over 750 km, achieving substantial annual savings. The kilometres gained by avoiding these long trips, coupled with the savings achieved by not having to reimburse officers for the trips, were substantial and exceeded project costs (Table 3.2) (Acurex Environmental, Inc., 1995; Schreffler *et al.*, 1996).

Table 3.2. **Evaluation of AB 2766 discretionary projects for South Coast Air Quality Management District, California, 1995**

	Economic costs and benefits	Congestion	Environment	Safety	Social inclusion
Managing the need for travel	XX	X	X	_____	_____
Managing traveller's choice of mode	XX	X	X	_____	_____
Managing the user's use of the network	XX	X	X	_____	_____

XX = significant positive impact. X = some positive impact. ___ = no impact.
Source: South Coast Air Quality Management District, 1995.

Residential Area-Based Offices (RABO) Project, California, United States

The RABO project, known informally as the Neighbourhood Telecentres Project, is a multi-year study involving three groups of participants: telecentre users; home-based telecommuters; and non-telecommuters. Four main travel indicators were analysed: person trips; vehicle trips; person-miles travelled (PMT); and vehicle miles travelled (VMT) (Balepuyr *et al.*, 1998). The key findings from a study based on data from more than half of the 20 centres participating in the project can be summarised as follows:

Trips: Person-trips did not change significantly, whereas vehicle trips to the telecentres increased significantly on telecommuting days.

Distance travelled. Both PMT and VMT declined significantly on telecommuting days, by an average of 68 miles (74%) and 38 miles (65%), respectively.

Commute and non-commute travel. A statistically significant increase of 0.5 commute trips on telecommuting days (primarily due to lunchtime trips made to go home from the centre) was noted. Non-commute trips and PMT decreased marginally, while non-commuting VMT increased insignificantly by no more than 2.5 miles on telecommuting days.

Impact on telecommuters' weekday travel. The overall reductions in weekday PMT and VMT were 17 miles (19%) and 10 miles (17%), respectively.

Time of day and purpose. On telecommuting days, telecentre users tended to start travelling later and end their work day earlier than on non-telecommuting days and in comparison to the control group.

Trip chaining. Longer and more frequent commutes to the regular workplace facilitated more efficient linking of activities.

Commute mode choice. The share of drive-alone trips and distance travelled was substantially higher, and the shares of public transport and rideshare trips and distance were lower on telecommuting days than on non-telecommuting days. Introduction of telecommuting did not affect mode choice on non-telecommuting days.

The State of California Telecommuting Pilot Project, United States

The project, which included 22 state agencies, reported significant savings in vehicle kilometres travelled (VKT) (Pendyala *et al.*, 1991, 1992). Participants made virtually no work-related trips on telecommuting days. The majority of participants also reduced the number of non-work trips on telecommuting days. Overall, on the days they worked at home, telecommuters reduced their peak-period trips by an average of 60%, and their total vehicle kilometres travelled by 80%. The programme prompted many participants to seek out shopping, recreation and other non-work destinations that were located closer to their homes, both on telecommuting and non-telecommuting days.

Puget Sound Telecommuting Demonstration Project, Washington State, United States

This demonstration project initiated in 1990 by the Washington State Energy Office included 25 public agencies and private firms. The participants included 104 telecommuters (both home-based and telework-centre-based) and 41 non-telecommuting control group members.

An analysis of 63 home-based and eight telework-centre-based telecommuters revealed interesting differences in their travel (Henderson and Mokhtarian, 1996). The number of daily trips for home-based telecommuters decreased by 32% and the VMT for all trips decreased by 66.5%. Cold starts decreased by 48%, and emission reductions amounted to reductions of 48% in total organic gases (TOG); 49% in carbon monoxide (CO_2); 60% in nitrogen oxides (NO_x), and 66% in particulates (PM).

For the telework-centre participants, although the daily trips increased by 20% (primarily due to an increase in the number of trips home for lunch), the VMT for all trips decreased by 53.7%. Despite a 16% increase in the number of cold starts, overall emissions were reduced by 4% for TOG, 49% for NO_x, and 53% for PM, with no effect on CO_2 emissions.

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Chapter 4

TRAVELLER INFORMATION SERVICES

Description

Traveller information systems have been used with success to influence travel demand by providing timely and accurate information on travel conditions, route and mode options. This information can be received at home, at work or *en route* via a variety of communication media.

- *Prior to departure*, radio and television transmissions, telephones, pagers and computers can provide timely information about travel/traffic conditions, enabling travellers to choose the best mode, route and time of departure. Travellers can modify their trips based on "real-time" information about roadway incidents, traffic speeds along given routes, weather and road conditions, and special events that might disrupt circulation. Information about transit routes, schedules and parking availability at rail stations can further assist travellers with public transit options.

- *Once travel begins*, car radio, visual displays and other more advanced communication devices can provide travellers with information on traffic conditions, transit service, incidents and parking availability at their proposed destination. Roadside variable (dynamic) message signs, electronic signboards and highway advisory radio can alert motorists to current weather and road conditions. Visual displays at bus stops and rail stations can notify waiting passengers of the next train or bus arrival time. Vehicle-based route navigation systems containing map displays can guide motorists travelling through unfamiliar areas to their destinations. Real-time traffic flow data can alert motorists to traffic problems ahead and re-route them around accidents and congestion bottlenecks.

- *In the event of a road crash or mechanical breakdown,* emergency systems enable travellers and operators of transit vehicles to call for assistance. Global Positioning Systems (GPS) can automatically provide a vehicle's location. This is particularly helpful if the driver is injured, disoriented or cannot accurately describe the location. Consumer surveys indicate that emergency systems are considered among the most valued features of traveller information systems.

- *New technology* facilitates locating destinations and services. Devices include in-vehicle traveller information systems listing roadside services, lodging, restaurants, tourist attractions, weather and airline arrival/departure information and kiosks located in airports, shopping malls, transit terminals, hotels and highway rest areas.

Objectives and major impacts

Traveller information systems serve a variety of customers: individual travellers, businesses and commercial carriers, and transport agencies. These systems endeavour to influence solo drivers' behaviour and encourage ridesharing and the use of other modes including public transport, cycling and walking. This is particularly important in congested, polluted urban areas.

Road users who may benefit from traveller information services include:

Commuters, tourists and through travellers who can make informed decisions about their transport mode and route that gets them to their destination in the fastest, safest and most efficient manner. Traveller information systems can:

- Warn motorists about dangerous road conditions ahead (incidents, ice, fog, etc.) and alert them to special events that could disrupt their travel plans.
- Reduce travellers' frustration and anxiety by keeping them better informed of unexpected delays and causes of traffic tie-ups and help them avoid traffic bottlenecks.
- Guide travellers to their destinations in unfamiliar surroundings and assist them in finding roadside services and lodging.
- Summon assistance in case of emergency or mechanical breakdown.
- Help transit users plan their itineraries and provide them with timely information about bus and train schedules and arrival times.

Businesses and commercial carriers can operate more efficiently due to improved ability to schedule, deliver and receive goods and services. Traveller information services can:

- Assist shippers in making "just-in-time" deliveries.
- Allow trucking firms and package delivery services to better manage their fleet operations.
- Help manufacturers and other commercial enterprises with time-sensitive shipments.
- Aid business travellers in keeping their appointments.
- Assist transport service providers in responding to calls for service.

Transport agencies can provide more effective and responsive public services. Traveller information systems assist local governments to better manage travel demand and traffic flow.

Real-time data from vehicle sensors and vehicle probes guide local authorities in adjusting the timing of traffic signals to maintain optimum conditions for traffic flow. Information obtained from remote video cameras allows incident management teams and emergency response crews to locate and respond rapidly to road crashes. Data obtained from automatic vehicle location systems allow transit and school bus dispatchers to monitor the movement of buses, maintain on-time performance and take corrective action to restore regularity of service.

Other local government activities can capitalise on the same communication and information-processing infrastructure that is used to monitor highway incidents, traffic conditions and transit fleets. Traveller information services can also be employed in other government functions such as:

- Co-ordinating evacuation and emergency services following natural disasters.
- Managing special events (sporting matches, concerts, etc.).
- Delivering tourist services and managing tourist facilities.
- Operating public safety, police, fire and public utilities fleets and school bus transport.
- Generating archival data for transport planning purposes.

Application of measures

Investments in an advanced information and communication infrastructure are not only essential to the effective functioning of the transport system, but offer an opportunity for government-wide efficiencies and economies. Today, a wide range of traveller information systems and services are in operation, and new ones are being developed.

Broadcast services are widespread

Most metropolitan areas already benefit from summary traffic reports on commercial radio and television. Some cable television and radio stations offer extensive morning and afternoon drive-time coverage. This programming is typically developed by specialised traffic reporting services that provide traffic information in return for commercial sponsorship. Many communities also have government-operated traffic information services via dial-up telephone or public radio and television stations.

Both government and private entities have expanded their operations to the Internet. There are increasing numbers of Internet Web sites offering regional traffic maps with camera views of congestion or breakdown information. Some state and local governments have also placed traveller information kiosks along strategic roadside and terminal locations and are experimenting with similar services in the workplace. The US Department of Transportation is co-operating with state and local governments and private sector partners in deploying several traveller information models and related services.

Variable message signs are now used in urban areas throughout OECD Member countries for traffic routing (road, bridges and tunnel closures), for indication of parking space availability, and on motorways and trunk roads for speed reduction.

Personal travel information is also becoming more common

Recently, private companies have begun providing custom-tailored traffic information to clients for a fee. The information (including many of those offering broadcast information) is transmitted using various personal communication devices (phones, cell-phones, pagers and PCs).

Greater use of in-vehicle traveller information services

Traveller information may soon be widely available from in-vehicle personal computers. In some countries, most notably Japan, such devices are already in general use. They provide traffic information packaged with other travel-related and entertainment services using CD inputs and wireless communication to information providers. Auto PCs are in the early stages of deployment in the United States.

Road transport information systems provide those who travel in their own vehicles real-time information on the traffic situation – road construction, weather conditions, congestion and accidents – with the most common form being radio broadcasts. Most modern European car radios are equipped with the RDS system of traffic news priority. Traffic information is usually transmitted at regular intervals (*e.g.* every ten minutes or after each full hour), during unusual incidents such as major accidents or during severe weather conditions. Permanent traffic news is also being broadcast at temporary venues where a significant increase in traffic is expected (*e.g.* for special events, sports activities and cultural festivals).

In some countries such as Germany and the Czech Republic, police speed checkpoints are announced on the traffic news. This information is supplied either by drivers from their (negative) experience or by the police themselves. The police may report those areas where speed reduction is desired in the interest of road safety, even though speeds are not actually verified there.

All types of radio stations broadcast traffic news. In large urban areas, the broadcasts concern congestion on motorways, trunk roads and border crossings. Regional and local radio stations concentrate on congestion in their area. Nation-wide news influences all affected drivers, while local news affects those drivers knowledgeable about local geography. The efficiency of news on main roads could be increased by permanent signing and numbering of diversions. This principle is applied to the entire German motorway network, where drivers are advised by radio to use certain numbered diversions to avoid congestion. A major disadvantage of radio news is that it is usually broadcast only in the local language. With worldwide travel on the rise, multilingual broadcasts could be particularly useful.

For public transport applications, historically the only forms of public transport information were timetables and operator's notices available in printed form through information centres in major stations or via telephone. Searching in printed timetables has been, and remains, a complicated task for many customers, and the ability to make a telephone inquiry is limited by personal and technical requirements. Recent technological developments have improved access to information on public transport scheduling and availability to provide better customer service. Detailed information can often be acquired from the Internet, which is particularly advantageous for tourists planning to visit a selected destination.

In most cities, public transport operators have their own Web sites where a wealth of information is available, including:

- A schematic network map detailing transit routes, stops and main attractions in the city (*e.g.* museums, shopping centres, concert halls, etc.).

- Connections between selected stops or places of importance.

- Interactive trip planning services.

- Timetables providing the time and duration of the journey.

- Current and planned engineering works projects, detours, and route diversions.

- Fare information (prices of single tickets, seasonal passes, reduced fares for certain groups of customers, penalty fares).

- Conditions and recommendations for senior and disabled passengers.

Not all transport operators offer the same information, and searching for a transit connection sometimes requires knowledge of the exact name of the stop/station, which may differ from its commonly known name. On the other hand, some operators offer "real-time travel news" which is continuously updated (*e.g.* in London). Similar information may be available on teletext, although there is no active customer participation. Much consideration has been given to the improvement of telephone inquiry services. The main advantage of this service is its accessibility to the largest number of customers, including mobile phone users, who can obtain valuable information during their journey. Traveller information centres are mainly focused on tourists, who are provided not only with transport and local information but also commercial services (*e.g.* accommodation). Public transport can also be promoted through special combined commercial offers, such as a transport ticket combined with admission to a cultural or sporting event.

An important part of the service is information provided to passengers at public transport stations/stops and vehicles. Significant improvement in the delivery of information to passengers has been made at stations, such as electronic information on timetables (departure and destination) of imminent services. In order to increase its effectiveness, traveller information should include information on the actual location of the vehicle. In many cases, only the scheduled time is indicated. Other notable improvements include in-vehicle audio and/or visual announcements of the route and the next station/stop.

To be cost-effective, traveller information systems require three separate but related functions: data collection; data processing; and information dissemination. The collection of timely and accurate data on transport conditions is crucial to the success of any traveller information system. This includes data on lane occupancy, traffic volumes, traffic speeds, road and weather conditions, road construction updates, special events likely to affect travel, movement of transit vehicles and early detection of incidents. While there is no single most effective way to communicate traveller information, an array of increasingly sophisticated sensing and detection devices to carry out these functions includes:

- *Vehicle sensors.* Inductive loop detectors placed below the road surface and other electronic sensing devices capable of recording the passage of vehicles have been the mainstay of data collection operations for many years.

- *Video imaging devices.* Mounted overhead, these are increasingly being deployed in place of loop detectors to monitor traffic and vehicle speeds. Their installation does not require subsurface installation and thus avoids the associated traffic disruption.

- *Closed circuit remote video cameras.* In recent years, increased use of cameras to monitor traffic flow has aided traffic operations managers to detect and clear highway incidents.

- *Automatic vehicle identification.* This technology, widely used for electronic toll collection and for measuring traffic flow, is comprised of vehicle-mounted transponders and roadside reader units. As vehicles pass roadside reader installations, they trigger the transponder to

send coded data via a receiving antenna to the roadside unit. The data from the transponder is sent to a computer for processing and storage.

- *Mobile telephones.* According to one estimate, motorists using mobile telephones report 80% of all highway accidents.

- *Parking information systems.* These systems use vehicle sensors in parking facilities to detect unoccupied spaces. Information on parking availability is then displayed in real-time on electronic variable message signs installed on approaches to the parking facilities. Such information saves motorists' time and reduces fuel consumption, vehicle emissions, and wasted time and productivity spent searching for parking spaces.

- *Automatic vehicle location (AVL).* This technology, utilising Global Positioning Systems (GPS) or radio frequency transponders, is used in transit management, fleet management, and emergency and "mayday" systems. One common application is to monitor the location of transit vehicles to ensure schedule adherence.

More advanced information delivery systems include: portable wireless communication devices such as personal digital assistants (PDAs); Radio-Data System (RDS) protocols; vehicle-based navigation and guidance units; and electronic message boards for transit passengers. Sales of car navigation equipment have reached 250 000 units in Japan and 120 000 units in the United Kingdom. Similarly, it appears likely that US demand for advanced traveller communication devices will grow as the number of localities offering timely and accurate traffic information increases.

A Traveller Information Centre serves as the brain of a traveller information system. This facility – that can either be a dedicated facility or part of an existing traffic management centre – serves as a central collection point for all transport data and its subsequent translation into communicable information. Two categories of information are typically received and processed by a Traveller Information Centre: *pre-determined (static) information* and *event or condition-driven information.* The former includes both information that is not likely to vary from day to day, such as transit schedules and long-term construction schedules and information that varies (special events). Traffic congestion advisories and announcements of disruption in transit service are classic examples of event-driven information.

The function of a Traveller Information Centre is to merge various data streams obtained from electronic monitoring devices, transport agencies and human observers (including airborne observers, police and emergency services, highway maintenance crews, roadside assistance units and transit and airport operators) and process them into communicable information. The output may take different forms, and can be tailored to the needs of the recipient. Until recently, the principal products were bulletins read on the air by experienced radio reporters, or recorded in audio-text for transmission over automated telephone call-in systems. Over the past few years, Traveller Information Centres have begun to translate traffic data into computer graphics displays for presentation in television newscasts and on the Internet. At the present time, video snapshots of freeway traffic are being displayed on television and Internet.

In the future, the output of Traveller Information Centres is likely to be more diverse. In addition to traditional text and graphic presentations, it may include a range of electronic formats suitable for transmission to pagers, in-vehicle navigation units, hand-held computers and other advanced communication devices. Future information output is also likely to be more custom-tailored (*e.g.* by specific route segments) to the needs of individual clients. In the near future, cable television channels dedicated entirely to providing continuous traveller announcements may also be available.

Institutional responsibility for implementation

Traveller information systems can be operated publicly, privately or as public-private partnerships. For many years, national (or federal) and local transport agencies have been monitoring transport conditions and collecting data as part of their transport and incident management responsibilities. Until recently, they seldom shared this information with the travelling public. The job of keeping the public informed was assigned to private traffic reporting services which established their own information collection infrastructure and began offering drive-time reports to radio and television stations in the early 1980s.

Institutional models for traveller information services

Today, the distinction between public and private roles in the collection and dissemination of traveller information is less clear. Keeping travellers informed of current transport conditions is now seen as good transport policy, and there is general recognition that data collected for transport management purposes (and paid for by taxes) should be shared with the travelling public. At the same time, there is broad agreement that many aspects of operating traveller information services are best left to the private sector. Precisely how the public and private sectors should co-operate has been a subject of growing discussion as traveller information systems become a standard element of transport management. Several approaches now being actively explored can be classified into three groups: the public model; the private model; and the public-private co-operation model.

- *The public model* entrusts a local or state transport agency with the exclusive responsibility for operating a traveller information system. Some communities treat the provision of a baseline level of traveller information as a public sector responsibility. The entire system of services is offered free to the public, thus limiting the amount of detail and custom tailoring that can be offered. Montgomery County, Maryland (United States) offers an example of this model. This system includes a data collection infrastructure, a Transportation Management Centre, a transit fleet monitoring system and a comprehensive information communication network, which are all publicly funded and operated. The information communication system consists of roadside variable message signs, highway advisory radio, public kiosks, a telephone dial-in service, a public access cable television channel and an Internet Web site.

- *The private model involving commercial transport reporting services* lies at the other end of the spectrum. These companies possess their own data collection assets and offer traveller information services to commercial broadcasters. Private information providers gather traffic information with the help of airborne observers and remote video cameras and process the data into concise transport bulletins and graphic displays which are transmitted to radio and television stations where they are incorporated into drive-time newscasts. The reports are sold to the broadcasters or offered in exchange for embedded advertising time sold to advertisers.

  In the United States, privately prepared traveller information is broadcast in more than 60 metropolitan markets to an estimated audience of 100 million radio listeners and television viewers. However, expensive airtime on commercial broadcasts limits reporting to only the most serious problems, and the nature of radio/television broadcasting requires that the scope of the reporting be metropolitan-wide. The commercial viability of personalised traveller information offered to individuals for a fee is being explored by start-up businesses in the United States and elsewhere.

- *The public-private partnership model* involves co-operative relationships between the public and private sectors whereby a public agency enters into a partnership arrangement with one or more private sector organisations to institute and jointly operate a traveller information system. The partnership typically involves joint responsibility for data collection, with the private partners assuming responsibility for operating a Traveller Information Centre where the publicly and privately collected data are merged. This enhanced database is then offered for sale to commercial clients such as fleet operators and specialised information service providers operating paging services and in-vehicle navigation services. The public agencies contribute raw data and retain free access to the enhanced data for transport management purposes. An example of this type of arrangement is Partners in Motion, a consortium of 26 public agencies and 12 private organisations that launched a regional traveller information system in metropolitan Washington, DC. in 1997 (see the detailed description in the case studies section of this chapter.)

In the Information Service Provider model, transport agencies make raw data available to private information service providers that, in turn, interpret, customise and market the data to customers. In the United States, this model is patterned after arrangements developed by the National Weather Service and commercial weather reporting services. Private information service providers obtain raw data from the transport agencies and add value by interpreting and tailoring the data to the needs of individual clients. Just as weather reporting services provide specialised reports to the broadcasting industry, ski resorts, utility companies, airlines and agri-business, traveller information service providers hope to market customised reports to the commercial trucking industry, transport service operators, paging services and in-vehicle information services.

Another type of public/private partnership arrangement is the private franchise, as exemplified by the licensing of cable television and mobile telephone services. Under this scenario, the public sector is responsible for transport data collection. Instead of offering the data on an unrestricted basis to all who request it, the local government awards an exclusive distribution franchise to a single, competitively selected information provider in return for a fee or a share of the collected revenue. A variation on this model is the non-exclusive franchise, where two or more private information providers are given the right to serve customers in a defined service area.

In the outsourcing model, a public agency owns the traveller information system, but contracts its operation to a private firm. This approach enables the public agency to take advantage of the marketing, management and organisational skills of private enterprise while maintaining control of the system. This option reflects the current trend to contract out (or outsource) public functions requiring specialised technical and management skills.

Effects on travel patterns

Travellers' behavioural responses and reactions to available information services are important to policy development. A survey of long-distance, recreational travellers along the Interstate 95 corridor in the United States revealed that an average of 10% of travellers altered their route, 14% changed their time of travel and 3% changed their travel plans in response to information about traffic delays. In a survey of 2 000 users of Boston's "SmarTraveler system," 14% of the respondents reported changing their departure time and 12% reported changing their route. In a survey of commuters in the Seattle, Washington area, 29-36% of respondents indicated that traffic messages frequently influence their commute choice. A survey conducted by the US Department of Transportation showed that 20% of the respondents would deviate from their regular route if a delay of more than 15 minutes was

expected (Intelligent Transportation Systems, ITS Deployment Planning Study, US Department of Transportation, 1998).

The effect of information services on users' behaviour is usually confounded by the influence of other factors. However, the following updated examples of modal shift in response to traveller information are available:

- A 21% increase in the number of railway passengers in Britain between 1995 and 1999 was partially attributed to the introduction of telephone and Internet sales and major improvements to the rail inquiry service (an increase in the number of calls by 50%).

- The introduction of an improved timetable-searching programme at Prague Transport doubled the number of Web site visitors, who can also post their own comments and recommendations on public transport quality.

Route and timeframe travel information is likely to influence commercial vehicle operators more than private drivers. Although traveller information systems have failed to produce observable changes in overall traffic flow, traffic patterns, transit usage, or congestion levels, this does not mean that commuters do not act upon the information they receive. As the use of traveller information systems increases, the cumulative effect of travellers' response may become more noticeable. Studies of traveller behaviour suggest that the impact of traveller information may vary among different groups of users, as illustrated in Table 4.1.

Table 4.1. **Potential of traveller information to influence trips**

	Change route	Change time	Change mode	Postpone trip
Commuters	Moderate	Moderate	Weak	Weak
Fleet operators	Strong	Strong	Weak	Weak
Tourists	Strong	Strong	Weak	Moderate
Event goers	Strong	Weak	Weak	Weak
Inter-city/rural	Strong	Strong	Weak	Moderate

Special problems and issues

In some areas, the general public's lack of awareness of the existence of such information presents key problem. Those people likely to seek out and use the information are typically those experiencing problems with their regular commuting. Such systems may have limited impact on other transport users. Recommendations on alternative routing or timing affect more sophisticated drivers, and more marketing and public education is needed to affect the majority of travellers.

Packaging with other measures

As noted in other chapters, traveller information is a key component of any programme to influence road travel demand. Since so much of demand management involves influencing travellers to change their behaviour and use their automobile less or at different times of the day or on different routes, information on road conditions and alternatives is crucial. Information is vital to the efficient operation of traffic management techniques and public transport services. Even strategies such as

roadway pricing require information on available alternatives and how, when and where to use them, as discussed in the following chapter.

Conclusions

- Traveller information services (TIS) influence travel demand by providing timely and accurate information concerning travel conditions, route, and mode choices. TIS may be accessed prior to departure, mid-trip or *en route* in the event of an accident.

- Information provided by traveller information systems allows private commuters, business and commuter carriers, and transport agencies to make informed travel decisions and operate more efficiently.

- Investments in information and communication infrastructure are essential. Today, a wide range of traveller information services is in operation, including widespread broadcast services, Internet and in-vehicle information, real-time hotlines and signing, and central traveller information systems.

- Problems with traveller information services include the general public's lack of awareness concerning the information; sophisticated marketing is needed to reach and educate the majority of travellers.

- Traveller information systems are a key component in any programme which aims to influence road travel demand, and may be operated publicly, privately, or as public-private partnerships according to cost-effectiveness.

EXAMPLES

Public transport services information system – the Netherlands

Before 1992, information services on Dutch public transport schedules were highly decentralised. To encourage the use of public transport, all public transport services and fare information were integrated into a single telephone information system. This system provides the caller with the shortest travel time on public transport from any origin to any destination in the country. This service is still in operation and provides information on timetables, on disruptions to service, and facilities at bus and train stations.

In a country of 14 million inhabitants, about 10 million inquiries are made each year. Recently, an Internet version of this information service was introduced. Empirical studies to identify the impacts of the introduction of this telephone service report that total trips made by public transport have increased by 0.3%, the number of kilometres travelled by public transport has grown by 0.7%, and public transport revenue is up by 0.6%. The greatest increases were realised on the regional bus system, with little to no impact on rail or urban public transport use.

Multimodal travel information – the Netherlands

Multimodal travel information (MRI) provides customers with travel information, including time, mode, route, cost, departure and arrival time from any origin to any destination within the Netherlands. The Dutch Ministry of Transport has fostered the development of MRI with a financial contribution and a tender (*uitbestedin*) for the development and exploitation of a MRI system.

Carpool promotion campaign – the Netherlands

An annual, promotional carpooling campaign is organised in the Netherlands. According to psychological research, behaviour is changed in three steps: knowledge, attitude, behaviour. This three-step process forms the backbone of The Netherlands' carpool communication policy and is taken into account in every carpool programme evaluation. Research shows that 99% of Dutch citizens are familiar with the carpooling concept, and that carpooling has a positive image. For the last several years, the number of carpoolers has remained constant at 750 000.

PEREX (Permanent Improvement of Networks) – Belgium

Perex is the new Flemish centre for traffic control, administration and information. This centre helps to manage traffic by providing data on factors that can influence traffic flow, such as road construction/maintenance, accidents and weather conditions. The data are then analysed to determine what actions should be taken (lane closures, detours, use of variable message signs, intervention of emergency services). This centre serves as both a traffic control and roadway information centre. It is part of an ambitious plan (Walloon Highway Information System for Traffic) to provide political coherence to the electronic management of traffic in Flanders.

TRIM (Traffic Management on the Highways) – Denmark

TRIM is an electronic system for the gathering and presentation of traffic flow data of the highway network with the aim of allowing motorists to avoid congestion. Minute by minute, traffic is registered by a network of cables and loop detectors in the road, and the information is conveyed to drivers via variable message signs on the highway, by radio and over the Internet.

An evaluation has shown satisfaction with the system among users, although many believe that driving patterns and attitudes of other drivers are the real cause of congestion. Congestion itself has not been found to be a motivating factor in causing shifts to public transport. The TRIM system has been in place since 1997 on 100 km of highways around Copenhagen; it has gradually expanded to include a database that allows calculation of speed levels at specific times of day and by day of the week.

Ride-matching services on the Internet – Denmark

In Denmark, a number of online ride-matching services have been established. As of early 2001, the country's largest, free Internet database address, www.pendler.net, listed more than 5 000 registered participants seeking a ridesharing partner. The Web site uses graphics and interactive maps covering the entire country, and many communities have included this ridesharing service on their municipal homepage. Estimation of the effects is difficult, since only the numbers of interested parties are registered and not the resulting ridesharing arrangements. The Danish Council for Ridesharing has been established to co-ordinate a number of different public and private Internet ride-matching services.

I-40 Traveller and Tourist Information System – Northern Arizona, United States

Interstate 40 is a major east-west thoroughfare serving Arizona and adjacent states. The route serves both commercial traffic (25% of volume) as well as tourism trips to and from the more than 25 national parks (including the Grand Canyon), monuments, attractions and recreation areas. The main objective of the I-40 Traveller and Tourist Information System (TTIS) is to "have better informed visitors in the corridor which will result in a safer, enhanced visitor experience". The problems facing the corridor include the mix of commercial vehicles and adverse weather conditions. A Highway Closures and Restrictions System (HCRS) is being implemented to collect, disseminate and store data. Highway advisory radio, variable message signs, and communication with traffic operations centres and key agencies will be used to disseminate information. The HCRS will also communicate with radio and television links, information kiosks, Internet services, dial-in phone services, and wireless systems designed to provide in-vehicle traveller information.

Smart Trek Traveller Information Service – Seattle, Washington, United States

The goal of Seattle's Smart Trek is to "increase public acceptance and awareness of intelligent transportation technology and demonstrate its cost-effectiveness and travel time reduction benefits". Smart Trek, operated by the Washington State Department of Transportation, builds on Seattle's ITS infrastructure and the region's successful partnering with the private sector. Recent additions to this system include: Internet passenger information displays at transit stations; expanded use of variable message signs; rest stop kiosks; highway advisory radio; a university-sponsored cable television traffic channel; parking information and guidance systems at major events; customised data "packages" for pagers; hand-held computers; message watches; and in-vehicle navigation devices. Private companies can retrieve and use this information for free, even to customise and resell it to others. The partnership both provides its customers with access to better information, and creates business opportunities for the private sector.

iTravel – New York/New Jersey/Connecticut, United States

TRANSCOM is an existing coalition of highway and transit agencies in the tri-state area (New York, New Jersey and Connecticut) that have been co-ordinating activities and services since 1980. TRANSCOM owns and operates iTravel, a "one-stop-shopping" service providing travellers with real-time, multimodal, surface transport information for the 29-county New York City metropolitan area. The three major components of iTravel enhancements include a Traveller Information Centre (TIC), a regional Transit Itinerary Planning System (TRIPS) and a Personalised Traveller Service (PTS) operated by private providers. Data on traffic conditions are collected via "Transmit", an automatic vehicle identification system that detects delays using on-board electronic "tags" and roadside readers. Information on road and transit conditions is available free of charge, whereas the PTS is available for a fee via telephone, pagers, faxes and e-mail.

Yosemite Area Traveller Information – Yosemite National Park, California, United States

Mariposa County deployed the Yosemite Area Traveller Information (YATI) programme as a tool to mitigate traffic in and around Yosemite National Park. Given the heavy volume of visitors and the limited access points to the park, YATI seemed a logical short-term strategy to address traffic and environmental concerns.

YATI is an Internet-based system that provides traffic and travel information on road conditions, park access restrictions and travel alternatives. The information is derived from the California State Department of Transportation (Caltrans), the National Park Service and surrounding counties. It serves as a clearinghouse for disparate information sources, and uses a variety of communication channels to disseminate information. These include interactive kiosks at visitor centres, variable message signs on highways, highway advisory road signs and the Internet. YATI is funded by Caltrans as an ITS operational test and operated by the Merced County Association of Governments.

ATIS (Advanced Traveller Information System) – Montgomery County, Maryland, United States

Montgomery County, a suburban residential and employment centre adjacent to Washington, DC, has embarked on a comprehensive local ATIS programme using integrated traffic surveillance, signal control, incident detection, transit fleet management, and traveller information. Its purpose is to provide real-time information on traffic congestion, incidents and construction activities during the peak commute periods and during snow emergencies. Using data collected by the county's Advanced Transportation Management System, information is provided via the County's public access cable channel, highway advisory radio, variable message signs, a traveller advisory telephone system, and Internet information. Future plans include installing traveller information kiosks at key locations, such as shopping malls, transit centres and major employment sites.

Parking Information System – St. Paul, Minnesota, United States

Downtown St. Paul attracts over 4 million annual visitors to the State Capitol and several cultural venues and special events. The Parking Information System provides motorists with accurate, continuously updated information on availability and occupancy status of parking facilities. System benefits include reductions in downtown congestion, energy consumption, and air pollution by minimising time spent by motorists searching for parking.

Real-time space availability is communicated to motorists via a system of uniform colour-coded guide signs located on the approach (the perimeter of information) to the Civic Centre and at key intersections. The signs display the number of available parking spaces in each of the parking facilities ahead. Colour-coded static wayfinder signs complement the electronic signs, serving to guide motorists to each facility. The hard-wired data system communicates information from the parking garages to the signs and evenly distributes available parking so as to minimise traffic congestion in the central business district.

REFERENCE

US Department of Transportation, Federal Highway Administration (1998), *Intelligent Transportation Systems (ITS) Deployment Planning Study*, US Department of Transportation, Washington, DC.

Chapter 5

ECONOMIC MEASURES

Description

Economic incentives and disincentives and travel costs influence travel demand, choice of mode, and time of travel. The range of economic measures applicable to transport policy includes: taxes and duties; road user charges; mileage/kilometre-based charges; quotas for CO_2 emissions; financial incentives and subsidies to support alternative transport modes; alternative transport mode pass programmes; transport allowances; and innovative financing strategies. Each is described in greater detail as follows:

- *Taxes and duties.* Annual taxes on car purchases and ownership can affect consumer choice in several ways. First, the rate of taxation may influence the decision to buy a car or affect the model of car purchased (*e.g.* a smaller, fuel-efficient car *vs.* a larger, less fuel-efficient model). The latter is especially valid if car taxes are differentiated according to environmental impacts. Fuel duties on petrol and diesel influence not only the private costs of driving, but also affect the competitive relationship between private and public transport.

- *Road user charges.* Charging drivers for use of a given roadway can influence travel demand and behaviour. Political will and public support to implement such economic instruments are critical elements to the success of pricing projects. Prior to implementation of such measures, convenient, reliable and affordable transport alternatives to solo driving must be in place.

Road user charges can be collected in a variety of ways: through a vignette system or by manual or electronic payment.

- Under the vignette system, a car must be equipped with a special tag authorising it to be driven in a given area or along a specified roadway. Payment takes place upon purchase or renewal of the permit. Typically, enforcement is managed by the police force or other designated public authority.

- Most priced facilities in OECD Member countries offer motorists the option of paying manually or electronically. For manual payment, motorists pay at an established checkpoint at the entry to a priced bridge, roadway segment or facility. Automated payment using currency and bankcards, and electronic payment are two other common methods.

- Satellite-based positioning systems or land-based beacons combined with an in-vehicle transponder can automatically collect (variable) user fees based on time, place and level of congestion. This system permits variable fees to be collected, and the charges may allow access to an entire network, a single facility, or a particular segment of roadway.

- Mileage-/kilometre-based charges (Litman, 1999a. 1999b). Mileage/kilometre charges are vehicle fees based on actual distances driven. They require regular and independent mileage/kilometre readings coupled with an administrative system capable of collecting the relevant data. In practical terms, an odometer reading could be made when a vehicle's registration and insurance are renewed. Special consideration is needed to overcome the potential for odometer fraud.

Four types of distance-based charges exist: weight-distance charges, pro-rated registration and licence fees, distance-based vehicle insurance, and distance-based emissions charges. Fuel taxes and road user charges belong to separate categories since these measures are not subject to regular odometer readings:

- *Weight-distance charges*. A weight-distance fee is based on the product of a vehicle's gross (or axle) weight multiplied by the distance driven. It is intended to cover the roadway costs imposed by each weight class of vehicle, taking into account that larger and heavier vehicles require more road space, cause more wear and tear on the roadway, generate more noise and cause more damage in crashes than smaller, lighter vehicles.

- *Pro-rating registration and licence fees*. Under this system, existing vehicle registration and licence fees would be pro-rated by distance driven to better represent road use costs. For example, an automobile that currently pays USD 360 in annual registration and licensing fees would pay USD 0.03 per mile, and one that pays USD 60 per year would pay USD 0.005 per mile. This allows the progressive nature of an existing system to be combined with a distance-based charge. Under this scenario, car owners of more valuable vehicles would pay higher fees.

- *Distance-based vehicle insurance*. Distance-based vehicle insurance converts current rates into per-mile or per-kilometre units, incorporating all existing rating factors, such as driving history, vehicle class and territory. To implement this scheme, legislation enabling liability and collision insurance to be sold in distance-based units needs be in place. Low-risk drivers would pay less per mile or kilometre than would high-risk drivers.

- *Distance-based emission charges*. Per-mile/kilometre emission charges are based on average values (based on tailpipe emissions) for each vehicle class or periodic testing of individual vehicles.

In theory, public authorities would establish an upper limit for emissions, in essence creating an emissions quota system. Market forces would ensure that the most cost-effective emission reduction takes place by allowing industries able to achieve emission reductions in excess of the requirement to "trade" their credits to those exceeding the maximum emissions ceiling. In the United States, an emissions trading programme concept for stationary sources has existed since the mid-1970s. The concept was originally intended to target industry emissions of SO_2, and was later expanded to include vehicle emissions.

While the concept has never been applied to the transport sector, there is great interest in its potential to reduce mobile source emissions. A study by the Danish Ministry of Transport found that emission quotas could be cost-efficient instruments to gradually reduce overall levels of traffic and vehicle emissions. A common emission quota system for the energy sector and the transport sector could be considered. Since the price for reducing emissions would be passed on to the consumer, the effects of a CO_2 emissions quota system applied to the transport sector would be similar to a fuel tax (Danish Ministry of Transport, 1997).

Financial incentives and subsidies to support alternative transport modes

The European Union's Environmental Agency opines that until full internalisation of all external costs is achieved for all modes of transport (see section on "Objectives and Major Impacts"), subsidies provide a way of promoting more environmentally friendly transport modes (European Environment Agency, 2000).

Employers, particularly those subject to trip-reduction mandates, may provide financial benefits to encourage and support their employees' use of alternative transport modes. Employer-provided or subsidised bus or rail passes and company vehicles made available for ridesharing to work are examples of the many potential incentives.

National and/or local governments can provide tax incentives or subsidies for carpooling, carsharing arrangements, railway/bus use, and walking and cycling. Public funds might also be used to finance projects and new initiatives that encourage the use of "green" transport modes.

Most OECD Member countries subsidise public transport systems, and patronage of public transport is being widely promoted as an environmentally friendly alternative to the car. The liberalisation of the transport market within the European Union and, to some degree, the rise of the World Trade Organisation (WTO) regime have created new conditions for promoting public transport. Government subsidies are granted only when operations cannot be performed given market conditions, and operators cannot be granted preferential treatment. Public authorities continue to decide the appropriate level and quality of public transport. An alternative strategy provides subsidies directly to users instead of operators (see section on alternative transport mode pass programmes and Chapter 10 on public transport).

Alternative transport mode pass programmes

Many public transport operators offer multiple-ride transit fare tickets that cover numerous lines and transport modes, usually discounted from the average daily rate. Public transit fares can also be discounted or eliminated to encourage use of public transport; and are usually targeted to specific groups such as children, students and pensioners.

Transport allowances

Many companies offer transport allowances to defray their workers' commute costs. Employers may combine the institution of a transport allowance programme with the removal of free employee parking and the initiation of other compatible TDM measures. An allowance of this kind may be paid by the employer or by public authorities.

In some OECD Member countries, transport expenses related to commuting may be deducted from one's taxes. Some systems have criteria favouring the use of public transport by setting an upper limit of daily kilometres travelled, which are compensated independent of mode. Distances above this limit can only be compensated if commuting is done by public transport. Other systems exclude short distances from compensation, but compensate travel by any mode above this distance up to a certain limit (see examples section at the conclusion of the chapter).

Innovative financing strategies

The revenue from fare-paying passengers is frequently insufficient to cover public transport costs. If public transport fares are lowered to boost use, other funding sources need to be considered to meet operating costs. An example is the provision of free public transport in the city of Perth, Australia, financed by parking pricing (see examples section at the conclusion of the chapter).

Objectives and major impacts

Economic measures are applied to the transport sector to influence travel demand by charging drivers the true costs of travel. These costs include such externalities as environmental impacts caused by vehicles, productivity losses due to increased congestion levels, and wear and tear on the physical infrastructure.

Economic measures target the perceived or real costs associated with solo driving either by increasing the costs related to this transport mode or by reducing the costs related to alternative modes of transport. These measures are designed to influence travellers' decisions on if, how, when and where a trip should take place, with the expectation that certain travellers will either refrain from car trips, shift some trips to other modes, or travel during off-peak travel periods and/or on less congested routes. In cases where economic measures such as roadway pricing and duties have been implemented primarily or strictly for revenue generation, travel demand or time of travel has been influenced as a secondary effect.

In general, more efficient pricing requires that external costs be defined at the individual level, meaning that costs and benefits should be clear to the individual consumer (*e.g.* citizen, household or company). Economic efficiency requires that prices reflect marginal costs, thus providing consumers with accurate price signals. If road user prices fail to reflect full marginal costs, consumers will drive more than is optimal, leading to problems such as excessive congestion, accidents and pollution. The aim of internalising costs is to give consumers the savings that result when they drive less or shift to another transport mode, thereby reducing external costs. A conversion from fixed charges to a higher degree of variable charges can increase travellers' motivation for changing travel patterns or modes, provided that transaction costs are not excessive.

Within the European Union, road transport covers about 30% of total infrastructure and external costs, while the equivalent figure for rail transport is 39% (European Environment Agency, 2000). Recent European research, particularly the Pricing European Transport Systems (PETS) project is examining the implications for transport prices and the impacts on transport demand by comparing existing variable taxes and charges with forecasts of marginal costs for different passenger and freight modes in 2010. This has been done in the context of the European Commission's proposals for pricing based on marginal social costs. While marginal cost pricing in urban areas could lead to a major shift from car to public transport, for inter-urban corridors, changes in mode split are much smaller and are not always favourable to public transport. Thus, inter-urban car transport is typically over-priced and urban under-priced, particularly at the peak, in terms of marginal social costs (as opposed to total social costs). This is a consequence of dependence on fuel tax as the major form of charging.

One of the project's leading researchers has noted that it would be more efficient to lower fuel taxes and to implement some form of supplementary charge in urban areas. The case for introducing pricing for cars on inter-urban roads appears weak, except where there are particular congestion problems (European Environment Agency, 2000).

Application of measures

Many OECD Member countries, including Canada, France, Italy, Norway, and the United States assess road user charges in a variety of forms. An EU-sponsored project entitled "PRoGR€SS" is designed to test the feasibility of road user charges in eight major European cities: Bristol, Copenhagen, Edinburgh, Genoa, Gothenburg, Helsinki, Rome and Trondheim, over a three-year period beginning in 2000. Over four years, the project will develop and implement a range of road-pricing concepts and technologies with the aim of demonstrating and evaluating the effectiveness and acceptance of integrated urban transport pricing schemes to achieve transport goals and to raise revenue.

The project involves working with key groups to develop and assess the political, economic and social framework required for implementing urban transport pricing schemes. Using a practical approach, social acceptance of road user charging schemes will be explored as well as these strategies' effectiveness in achieving environmental goals and revenue-raising objectives. The project also aims to develop good practice guidelines for electronic road pricing equipment and concepts.

Commenting on the project, Ms. Helen Holland, Executive Member for the Environment, Transport and Leisure at Bristol City Council (United Kingdom) said: "The key to success in this field is to explore public opinion and to design schemes which will serve the needs of business and residents. The public needs to see the benefits in real terms – better public transport and a cleaner, safer environment. We welcome the involvement of PRoGR€SS as it is taking very positive steps to tackle these issues."

Despite their potential to significantly influence travel demand, economic measures remain hindered by real or perceived concerns about political fall-out and negative public reaction to pricing schemes. Projects such as PRoGR€SS are critical in overcoming these concerns. Strong political leadership, supportive coalitions and a well-informed public are necessary elements to bringing pricing schemes to fruition.

Although mileage-/kilometre-based charges have been debated most recently in the Netherlands, to date no OECD Member country has implemented such a system on a national scale. A private American insurance company launched a pilot project to test the feasibility of offering a distance-based vehicle insurance, receiving a positive reaction from the public (see description under examples.) Steps towards adopting mileage-/kilometre-charging schemes could offer a new and effective strategy to influence overall levels of traffic.

Despite the ongoing liberalisation of the transport market within the framework of the EU, and to some degree the WTO, direct financial aid from national or local governments is still possible for projects aimed at promoting green transport modes. Denmark's Ministry of Transport has allocated funds for new transport demand management and traffic safety projects, including a national mobility centre promoting carsharing, carpooling and intermodal solutions.

Institutional responsibility for implementation

Economic measures such as road pricing often require a political champion to blaze a trail opening this relatively new frontier. Strong coalition building is necessary in order to tailor these schemes to the existing political environment. Public acceptance, education and promotion of these concepts are critical. Advance notice of road charge implementation is needed to ensure that travellers likely to be affected are well aware of the new programme. The public's understanding of the system's

operation and use of resulting revenue (to finance new infrastructure, to support public transport services or other) is essential. Most importantly, it is vital to have alternate transport options in place before new measures are introduced.

Effects on travel patterns

Table 5.1 reports the effects of sustained or increased use of alternative transport modes.

Table 5.1. **Effects of alternative mode use**

Rideshare programmes (United States)	87% continue to rideshare after subsidies expire.
Universal pass (United States)	Carpooling increased by 200% and transit use increased by 73%.
Priced, express lanes for solo drivers (United States)	Ridesharing increased by 20%, and a new transit route was funded using pricing revenues.
High, car-related taxes (Denmark)	Sustains the level of the car fleet and thereby car-based demand.

The potential reductions in vehicle trips (VTR) and CO_2 emissions offered by various economic measures undertaken in OECD Member countries are outlined in Table 5.2:

Table 5.2. **Vehicle trip and CO_2 reductions**

The Autograph Project (United States)	Strong correlation between driving and cost savings
Fuel duty escalator (United Kingdom)	Expected to have saved between 1 and 2.5 tonnes of CO_2 per year by 2010
Toll ring, Bergen (Norway)	Estimated 6-7% reduction in inbound traffic during tolled hours

Based on empirical evidence and computer model predictions, the ability of financial incentives to cause desired shifts in travel patterns appears promising (Nash, 2000). However, the effects of these measures on travel demand are difficult to estimate, as they may be indirect, have different short-term and long-term effects, and are dependent on a number of other interacting factors such as income, taxes, personal preferences, the general development of the national economy, etc. For instance, price elasticity of fuel price increases is rather low in the short term, but higher in the long term. Consumers' response to significantly higher fuel prices has been described as a five-stage adjustment process (von Weizsacher, and Jesinghaus, 1992). It may be possible to identify significant and immediate effects of economic instruments (see below). In other cases, individual impacts may appear modest, but the combined benefits could be substantial.

Cost-effectiveness

The cost-effectiveness of an individual economic measure or programme can be expressed as the programme cost divided by the number of vehicle trips reduced at the site or in the area. The basic problem in determining this figure for road transport is that many journeys are undertaken for which the costs to society – in terms of environmental degradation, congestion, accidents, etc.– outweigh the benefits to the individual. Numerous studies have shown that internalising external costs improves

economic efficiency and total societal benefits (European Commission, 1996; Apogee Research Inc., 1997). Applying a comprehensive strategy of internalisation of the external costs of the transport sector is an efficient way of reducing or redirecting road traffic demand.

Some measures are better suited and more cost-effective than others in either reducing travel demand or reducing vehicle emissions. For example, the "EUCARS" model developed by the European Commission suggests that, while a fuel tax would be the most cost-effective instrument in reducing emissions, it would not necessarily be equally effective in reducing overall traffic. The model also shows road pricing to be a relatively expensive economic instrument in reducing emissions, largely due to high initial costs. However, in terms of reducing travel demand, models point to road pricing as one of the best and most cost-effective measures.

Special problems or issues

Applying economic measures to the transport sector can be politically contentious. Public opposition, administrative barriers and technological problems may arise, along with questions of distribution and equity.

Internalisation of external costs may benefit society as well as the individual; however, at the same time it redistributes welfare between different groups. External costs violate the principle of horizontal equity which implies that individual consumers "pay for what they get and get what they pay for" unless a subsidy is specifically justified. Some households impose greater external costs (in terms of local pollution, traffic noise, accident risks, etc.) than others. Households suffer inequitable impacts if the costs they impose are less than the costs they bear. This can result in an unfair distribution of costs and benefits between individuals. Internalisation of the external costs within the transport sector may serve to correct the imbalance (Litman, 1999c).

A complete picture of the distributional impacts of financial measures influencing road transport demand requires an understanding of the distribution of societal benefits (*i.e.* reduced congestion and environmental degradation) that are generated and the distribution of the subsidies used or revenue created from any new tax related to the transport sector.

In Europe, a particular problem arises when motorists purchase fuel across the national border to take advantage of significantly lower prices. For example, fuel prices in the Netherlands and Denmark have traditionally been higher than in neighbouring Germany. This has led to the reduced sale of petrol at Dutch stations near the border. In Denmark, the risk of revenue loss to the national Treasury from this fuel trade plays a significant role in the national debate about increased fuel prices; however, a report by the Danish Council indicates that the extent of this situation is overestimated. Although higher fuel prices would generate more cross-border trade, this was not found to have a significant impact on government revenue (The Danish Transport Council, 1998).

Packages with other measures

While economic measures have the potential to influence traveller behaviour and affect road travel demand, experience has shown that greater effects may be achieved when they are used in combination with other strategies and initiatives as part of a comprehensive policy package (further discussed in Chapter 13). Before introducing road user charges, better alternative transport options including improved public transport systems, carpool matching services, and pedestrian and bicycling paths need to be put in place. Better integration of traveller information systems and road traffic

management systems can support a variety of mobility options. Drawing on the success of the Swiss, an integration of public transport and carsharing associations appears to be a viable combination, and offers insight on effectively tailoring mobility options to meet travellers' needs.

Conclusions

- Economic incentives and disincentives and their resulting impacts on travel costs can influence travel demand, choice of mode and time of travel. Incentives applicable to transport policy include: taxes and duties; road user charges; mileage/kilometre-based charges; quotas for CO_2 emissions; financial incentives and subsidies to support alternative transport modes; alternative transport mode pass programmes; transport allowances; and innovative financing strategies.

- Economic measures operate by charging drivers the "true cost of travel" including environmental impacts, productivity loss due to congestion, degradation of physical infrastructure, and other externalities.

- Empirical evidence and computer models indicate that financial incentives are effective in influencing travel demand. However, effectiveness is difficult to quantify, and some measures are more cost-effective than others.

- The application of economic measures is limited by (real and perceived) concerns about political fall-out and negative public reactions to pricing schemes. The success of such measures requires strong coalition building and public understanding.

- Economic measures are most effective when used in combination with other strategies and initiatives as part of a comprehensive policy package. Alternative travel modes must be available before road pricing methods can be put into effect.

EXAMPLES – TAXES AND DUTIES

High car taxes – Denmark

Compared to other OECD Member countries, Denmark has traditionally had higher taxes on car purchases and registration, totalling 55% of the sales price of an average car, with specific taxes excluded. Consequently, Denmark's car fleet is relatively small; approximately 350 cars for every 1 000 Danes in 2000. The relatively small car fleet reduces overall car-based transport demand.

However, the level of taxes has fallen in recent years, with the price of new cars declining by 48% between 1980-98. In 1997, taxes on energy-efficient cars were lowered while taxes on energy-greedy cars were raised.

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* Although car-related taxes have fallen in recent years – partly in compensation for the mandatory installation of catalysts and safety equipment in all new cars – such taxes remain high in Denmark compared to other OECD countries. Registration tax is a progressive value-based tax, calculated as a percentage of the retail price (exclusive of duties but inclusive of VAT). A tax of 105% is collected for values of less than DKK 53 000 (EUR 7 123 or USD 6 970), 180% thereafter (figures valid for the year 2000).

** This figure is expected to rise in the coming years – mainly due to the purchase of second cars by many households – but will probably still lie below the OECD average for several years.

Fuel duty escalator – United Kingdom

The UK fuel duty escalator was introduced in 1993, initiating annual increases on fuel duty of 3% above retail inflation. In late 1993, the escalator was increased to 5% above retail inflation, and again increased in 1997 to at least 6% above retail inflation. British petrol prices are already among the highest in the developed world, and this measure was deliberately aimed at pushing them higher. The objective was to send a clear signal to manufacturers to design more fuel-efficient vehicles, and to encourage motorists to avoid unnecessary journeys and consider using travel alternatives.

As a policy objective considered in isolation, the increases applied from 1996 to 1999 are expected to save between 1 and 2.5 million tonnes of carbon (as CO_2) a year by 2010, and small reductions in emissions of local air pollutants according to the British Government's models. At the same time, the policy has been a significant source of revenue for the Treasury. The 1999 increase in fuel duties raised GBP 1.6 billion (EUR 2.60 billion). In light of the carbon savings already expected, the Chancellor announced in his 1999 Pre-Budget Report that the appropriate level of fuel duties would be set on a budget-by-budget basis, taking into account the government's economic and social objectives as well as the UK's environmental commitments. As of October 2001, that remains the current policy.

Revenues from any real increases in fuel duty will be used to finance roads and public transport to reduce congestion and pollution. Due to significant, recent increases in oil prices, the Chancellor announced in his 2000 Budget that, other than the automatic rises due to inflation, there would be no further increase in fuel duty that year.

Bergen toll ring – Norway

A toll ring system installed around the City of Bergen became operational in 1986. The eight tollbooths installed around the periphery accept cash or credit cards. Motorists with electronic accounts can enter the system without having to stop. While the system's primary objective has been to raise revenue to finance road projects, the toll ring has reduced the number of inbound trips by 6-7% during the tolled hours.

Trondheim Road-pricing Trial – Norway

In autumn 1997, a road-pricing experiment was carried out in Trondheim during the morning rush hour to test how pricing would influence travel behaviour. This research project was independent of the operation of Trondheim's toll cordon system.

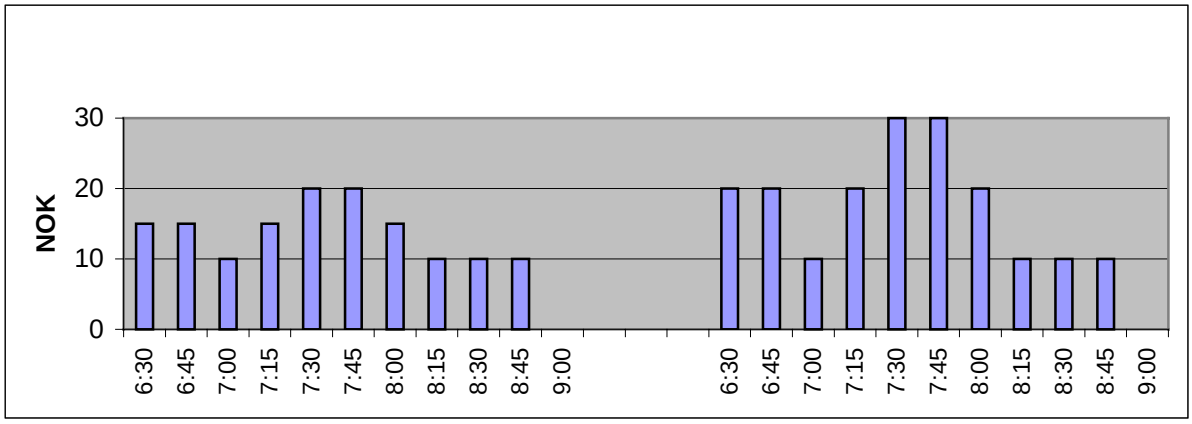
The experiment was conducted over two four-week periods (Tretvik, 1998). The net sample size consisted of 160 households from a residential area in one of Trondheim's western suburbs. Special charging stations were established on the three approach roads leading from that area to the city centre, and all participating cars were equipped with an electronic tag for recording travel behaviour.

For the week preceding the first trial period, participant transaction data was collected from the tolling system to estimate a "normal" monthly household cost for road use. This amount was allocated to each household as its "transport budget". As an incentive to change behaviour, drivers received the cash difference for consuming less than the budgeted amount, with excess consumption having no economic consequence.

To ensure that the charging scheme reflected peak-period traffic volumes, some periods were made as short as 15 minutes (Table 5.3), with a considerably higher price levied during the second trial. The highest amounts charged during the two trial periods were NOK 20 and NOK 30, respectively (approximately USD 2.75 and USD 4, respectively.) The road pricing costs were assessed in addition to payment for the tolling system, with fees ranging from NOK 7-12, dependent on the method of payment used (on a subscription or per-use basis).

Over the two trial periods, an average household reduction of NOK 200 in travel costs was achieved. Extrapolating the travel behaviour of the test group to a larger number of households would have resulted in a considerable impact on traffic flows during peak periods. In evaluating the results, it is important to note that traffic conditions in Trondheim cannot be characterised as congested. However, queuing conditions of varying severity occur during relatively short time periods in the mornings.

Table 5.3. **Trondheim road-pricing trial**
Toll-charging schemes for the two four-week trials



Period 1	
Price	Traffic volumes
NOK 20	- 10%
NOK 15	- 6%
NOK 10	+ 7%
NOK 0	+ 5%

Period 2	
Price	Traffic volumes
NOK 30	- 17%
NOK 20	- 10%
NOK 10	+ 27%
NOK 0	+ 4%

Note: For both periods, results other than the re-timing of car trips were insignificant. The impact on the total daily traffic volume ranged from a decrease of 17% to an increase of 27%.

ROAD PRICING SCHEMES

Electronic Road Pricing Scheme – Singapore

Singapore introduced the Area Licence Scheme in 1975 with the purpose of reducing traffic during peak periods in the Central Business District. The system was based on vignettes and proved highly successful in reducing the number of vehicles entering the tolled area. In 1998, Singapore introduced an electronic road pricing system covering the Central Business District and a number of large expressways in and around Singapore City. The objective was to reduce the number of vehicles entering the tolled areas at certain times of the day, thereby reducing congestion and improving travel speeds on the network.

The Electronic Road Pricing (ERP) system is based on automatic fee collection when vehicles pass one of the 33 ERP gantries. The ERP rates vary with time of day, and are adjusted every three months if necessary to achieve optimal traffic flow on expressways and roads. The charges are aimed to maintain a speed range of 45 to 65 kilometres per hour (kph) on expressways and 20 to 30 kph on arterial roads. The system has thus far proven successful, and a new outer toll ring was anticipated to begin operation in 2000.

Spitstarief **– the Netherlands**

Spitstarief is part of an integral package of road infrastructure and public transport policy measures. Spitstarief includes an electronic fee collection demonstration project, planned for implementation in 2002. The project will assess road user fees on weekdays during the morning rush hours of 7:00–9:00 in eleven corridors leading to the four major cities in the Netherlands. The charge will apply to all vehicles, including freight-traffic. The basic fee will be NLG 7 (EUR 3.18), with a reduced fee of NLG 5 (EUR 2.26) for electronic payment. Expected effects in the long run include a 10-40% reduction in corridor congestion during peak hours and a 5-15% reduction in kilometres travelled during rush hours. The start date is dependent on the outcome of negotiations with regional authorities and Parliamentary approval. After a two-year test period, results will be evaluated and future plans will be discussed.

Intelligent Vehicles Trial (IVT) – Tasmania, Australia

In 1998, the Tasmanian Department of Infrastructure, Energy and Resources undertook a trial to test the feasibility of using Global Positioning Systems (GPS) to better manage road networks. The primary focus of the project was to investigate the technical, policy and regulatory issues involved in implementing a road pricing system for heavy goods vehicles, based on time and place, distance, mass load and other relevant criteria. The trial tested the technical components of a GPS-based system to demonstrate if GPS, in combination with mobile communication, could reliably ascertain vehicle position and transmit this information to a data processing unit. The study concluded that a cost-effective road-pricing system based on GPS could be implemented in Tasmania, and that such a system could enhance efficiency in road network management and provide heavy vehicle operators with access to additional functionality to enhance fleet management efficiency.

MILEAGE-/KILOMETRE-BASED CHARGES

The Autograph System Pilot Project – Houston, Texas, United States

In 1998, the Progressive Insurance Company initiated a pilot project in Texas to test insurance premiums based on actual travel behaviour rather than on historical trends. Some 1 200 "Autograph" systems were installed in cars, including a GPS locator and cellular phone. Insurance costs were based on the actual time of day, miles driven and location of trips taken within five designated risk zones in Houston. The data collected from 500 000 hours and 16 million miles of travel showed that participants took an average of 6.3 trips per day, drove over 41.5 miles and travelled for 90 minutes per day. The average trip was 14 minutes and 7 miles long, at an average speed of 28 mph. Half of the participants realised annual savings of USD 250-500 in insurance costs. The test showed a strong correlation between miles driven and percentage of cost savings. Focus groups conducted after the trial period revealed that users became more aware of their driving patterns and sought to avoid high-risk times and reduce total miles driven to save insurance costs.

FINANCIAL INCENTIVES AND SUBSIDIES

Advantage Rideshare Programme – Riverside County, California, United States

Riverside County is a vast region of suburban communities offering affordable housing outside of the job-rich, metropolitan regions of Los Angeles and San Diego. Consequently, tens of thousands of residents commute to jobs located out of the county.

In 1991, the Riverside and San Bernardino County Transportation Commissions implemented a financial incentive programme to address worsening congestion and air-quality problems. The Advantage Rideshare programme provided up to USD 2 per day for drive-alone commuters that used a commute alternative at least one day per week. The trial subsidy was valid for up to three months. Many participating employers provided a USD 1 matching subsidy as scrip redeemable for purchases at a local supermarket, a chain of service stations or for train fares. Programme evaluations indicate that a majority of participants (87%) continued to rideshare after the subsidy expired and over half of all programme participants are still ridesharing.

Shopping bus in Nagaoka-city – Japan

The city of Nagaoka has an innovative programme to improve inner-city traffic congestion. Free bus tickets are provided to patrons frequenting certain stores in the central shopping district. As a result, bus ridership nearly doubled from a monthly average of 3 600 to 7 000.

ALTERNATIVE TRANSPORT MODE PASS PROGRAMMES

Nike public transit pass for all employees – Seattle, Washington, United States

The combination of limited parking, employee recruitment and a new state trip-reduction mandate led Nike Inc, a manufacturer of sporting apparel, to implement several innovative TDM strategies. Until two years ago, Nike's principal TDM strategy was to provide financial incentives to employees using commute alternatives. Carpoolers, bicyclists and walkers received scrip known as "Nike Bucks" for each day they shared a ride to work. The scrip was redeemable for food, merchandise and a variety of on-site services. Likewise, transit users received an equivalent bus pass subsidy.

In 1998, with the company's rapid growth and the cost of the Nike Bucks programme growing in tandem, the company re-engineered its ridesharing programme. Concurrent with the opening of an adjacent light-rail station, Nike joined the regional transit operator's PASSPORT programme whereby Nike subsidises USD 560 of a USD 570 annual transit pass for each employee. The company also operates a shuttle bus system from the rail station to its headquarters and nearby sites.

Nike's new ridesharing incentive programme, known as "TRAC" (Travelling Responsibly via Alternative Commuting), offers monthly and quarterly prize drawings (valued between USD 25-300) for non-solo commuters who register with the programme.

Universal pass for a whole campus area – Seattle, Washington, United States

The University of Washington draws over 52 000 students, faculty and staff to its 640-acre campus in Seattle, totalling over 225 000 daily vehicle trips to the University District. During a typical day, more than 58 000 vehicle trips are made within the campus alone.

In June 1990, the U-PASS (universal pass) programme was developed to address the need for transportation management. For a monthly fee, the U-PASS is added to the University identification card used by students, faculty and staff. Faculty and staff pay USD 40.50 per quarter for the U-PASS, while students pay USD 30.

U-PASS holders can use transit, shuttle buses, carpools, vanpools, ride-matching services, bicycling, guaranteed rides home, discount parking passes and merchant discounts. The U-PASS programme has resulted in increases in alternative mode use while significantly reducing parking demand at the campus. Carpooling has increased by 33%, transit by 73% and vanpooling by over 200%.

Public transport passes for unemployed persons and pensioners – France

French legislation requires free or reduced public transport passes for unemployed persons and retirees, comprising about 17% of all trips provided by public transport operators.

Financial support is determined locally through agreements between the unemployment benefits agencies, transport authorities (urban, departmental, regional) and local social departments (social/community support services). Tariff reductions and special prices are imposed against compensatory payments from the public authorities to public transport operators in their contracts.

Public transport pass programmes benefiting children – Denmark

In Denmark, financial grants from the government have allowed integration of train and regional bus services enabling passengers crossing regional borders to use a single ticket – even if the journey requires a transfer involving different public transport companies. Similar grants have allowed free public transport for children under the age of 12 accompanied by an adult.

TRANSPORT ALLOWANCES

Commuter allowances benefiting public transport – the Netherlands

The Dutch tax system allows commuters to receive either limited, non-taxed compensation for travel costs or a limited tax reduction. The amount is dependent on the distance travelled and is differentiated by distance and mode of transport used for the work trip. If one travels by any mode, the system allows for a maximum commuting distance limit of 20 km (per day, one-way). Commuters travelling longer distances can only receive the deduction for trips made by public transport (a public transport-declaration). Tax deductions and compensation for the use of public transport are limited to 90 km per day.

The system also includes a levy on leased company cars and is dependent on the amount of private use of the vehicle. If the car is used for business purposes only (less than 1 000 km annually), 3% of the car's value is added as personal taxable income. If the car is used privately, then 20% is added. In this case, the commute distance is regarded as a business activity. By using a leased car, an employee can commute for free and is assessed an annual, general fixed-charge independent of the commuting distance travelled. A new system is currently in development to further limit the allowable deductible amounts and increase the levy on private use of company cars.

Commuter allowances benefiting biking – Belgium

In Belgium, commuter allowances for car transport are fairly limited, while tax credits for commuting by public transport and by bike are more attractive. Excluding short distances, a motorist can receive a maximum of BEF 6 000 (EUR 149) in annual tax credits (except under specific circumstances), whereas a commuter using public transport would receive BEF 11 000 (EUR 273) in annual tax credits. A commuter travelling by bicycle receives BEF 6 (EUR 0.15) for every kilometre travelled between home and work.

Fixed transport allowances independent of mode – Denmark

In Denmark, a fixed transport allowance system has been designed to increase mobility for all groups in the labour market. This system can hinder road travel demand reduction initiatives, since only those with daily commuting distances in excess of 24 kilometres round-trip are compensated. Commuters travelling in excess of 100 kilometres per day receive half compensation.

The allowance remains fixed even if a less expensive, environmentally friendly transport alternative such as public transport, carpooling or biking is chosen. The system slightly benefits alternative modes of transport, although not to the same degree as the Dutch one. This tax deduction has often been debated in Denmark, weighing its social benefits vs. its potentially negative environmental effects. An environmental organisation has proposed to gradually reduce the tax allowance and use the revenue gained to reduce public transport fares in urban areas, at a minimum.

Commuter Choice Tax Benefits – United States

The US Federal surface transportation legislation entitled "The Transportation Equity Act for the 21st Century" (TEA-21) includes a "Commuter Choice Program". TEA-21 amended the Internal Revenue Code to provide certain tax benefits to employers and employees.

The Commuter Choice Program creates tax equity between employees that receive free, employer-provided parking and employees that receive employer-provided transit and ridesharing subsidies.

This programme allows employees to receive tax-free monthly transit and ridesharing benefits up to USD 65 or to use pre-tax income to purchase the equivalent amount in transit and vanpool fares. It provides employers with a tax deduction for providing employees with rideshare incentives and allows them to deduct pre-tax, employee-spending from payroll taxes. Finally, the policy requires employees receiving a monthly parking subsidy in excess of USD 175 to report this amount as personal, taxable income.

INNOVATIVE FINANCING STRATEGIES

Free public transport financed by parking pricing – Perth, Australia

In 1998, the State Government and the City of Perth jointly adopted the "Perth Parking Policy", which sets out a joint approach to the development and management of parking within the central city and immediately contiguous area defined as the "Perth Parking Management Area". Under the Policy, the State Government licenses and imposes a tax on all non-residential parking in the Perth Parking Management Area. This plan modified and extended the City of Perth's 1980s licensing and licence fee requirement imposed on private and public off-street parking.

The City has used this revenue to fund its portion of a cost-sharing arrangement with the State Government for the provision of free public transport within the central City area. The extension of the licensing and fee payment requirement to tenant parking spaces provides a secure financial basis for free public transport within the Perth Parking Management Area. Funds raised may also be expended on improving public transport access from across the region to the central city, enhancing the pedestrian environment, and supporting bicycle access and other initiatives that promote a balanced transport system for the city.

New transit service financed by priced HOV lanes – San Diego, California, United States

As the first dynamic pricing project in the United States, San Diego's Interstate 15 "FasTrak" programme has successfully tested the concept of selling excess capacity on an existing high occupancy lane, and generates over USD 1 million in revenue annually. These funds are used to administer the FasTrak programme, and to fund two new transit routes.

This project allows single occupant drivers to "buy" into the high occupancy vehicle lanes, previously reserved for carpools, vanpools and buses. Vehicles with two or more occupants continue to travel free of charge on this express facility.

Solo drivers opting to use the express lane are assessed a per-trip fee ranging from USD 0.50-8.00. Variable message signs display the rates, which vary depending on the volume of traffic using the express lanes at the time the trip is taken. An electronic transponder mounted on the car windshield communicates with overhead gantries to automatically debit the appropriate fee from the customer's pre-arranged account. To date, over 16 000 transponders have been distributed, with an average of 4 400 trips taken daily.

Interestingly, the ridesharing rate increased by 20% during the demonstration period. This result raises some intriguing questions regarding traveller behaviour in response to pricing. Since those motorists with two or more occupants per car have never been charged a fee to use the express facility, perhaps their sudden recognition that they could receive something for free that solo drivers were required to pay for placed a greater value on this benefit. The notion of getting something for free might have provided incentive for new carpools and vanpools to take advantage of the express lane benefit.

The three-year demonstration project, funded by the Federal Highway Administration, ended in 1999. Due to its success, its state and local co-sponsors, the California State Department of Transportation and the San Diego Association of Governments, have elected to continue and expand the project.

The objectives of using existing capacity in the high occupancy lanes more efficiently, testing the lane-pricing concept, and raising revenue for public transit have been successfully met. The project has not had a measurable impact on traffic congestion in the adjacent, mixed-flow lanes.

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Chapter 6

ADMINISTRATIVE MEASURES

Description

Administrative measures include trip-reduction programmes and policies initiated by governmental agencies and/or public/private partnerships. Such measures can be classified into five categories: transportation partnerships, trip-reduction ordinances, alternative work schedules, auto restrictions and volontary trip-reduction programmes. Each is described in further detail below.

Transportation partnerships are public/private alliances that provide a common means of delivering ridesharing services and forums for involving the business sector in urban mobility issues. Transportation Management Associations (TMAs), of which there are in excess of 70 today, are one of the most common types of transport partnership, and have been in existence in the United States for almost 20 years. TMAs are also common in the Netherlands including public/private co-operative arrangements and business co-operatives, sometimes called Transport Co-ordination Centres (*Vervoers Coordinatie Centrum* – VCC). Additionally, many business associations such as Chambers of Commerce have taken up traffic reduction as part of their mission. There are a number of emerging groups, sometimes organised to focus on specific objectives or transportation management initiatives (TMIs). (Association for Commuter Transportation, 2000).

- *Trip-reduction ordinances (TROs).* TROs typically require new developments to reduce trips and/or trips to existing work sites. While most trip-reduction requirements are initiated by local government, some national (e.g. the US Clean Air Act Amendments) and state governments (*e.g.* Washington State,) have passed such requirements onto existing employers. Other regulations not explicitly requiring trip-reduction may influence traffic demand, such as the Netherlands' ABC Location policy, which limits parking at sites in close proximity to transit facilities.

- *Alternative work schedules (AWS).* By working more hours in a fewer number of days, compressed work schedules, including 9/80, 4/40 and 3/36 shifts, are designed to reduce the number of commute days, and have become a popular employee benefit. Compressed work schedules have also become an effective strategy for employers to meet trip-reduction mandates. Such shifts have been implemented in cities such as Hartford, Connecticut, and Hiroshima to spread the peak commuting period over a longer time period. In Washington State, 41% of work sites have implemented compressed work schedules to comply with the Commute Trip Reduction law, affecting over 48 000 employees throughout the State (Washington State Department of Transportation, 1999).

- *Auto restrictions.* Auto restricted zones are common in Europe where vehicular traffic is prohibited in pedestrian and shopping areas, often located in the city centre. Such zones have been established in the city centres of Bremen, Germany; Leeds, England; and Aalborg,

Denmark. In the United States, officials in Denver, Colorado, initiated "no drive days" in the early 1980s to reduce harmful exhaust emissions, and drivers were prohibited from using their cars for one day each week, based on the last number of the vehicle's licence plate. At the same time, free transit was provided. A similar system has operated in Mexico City and is being proposed for Seoul, Korea.

- *Voluntary trip-reduction programme.* include government and private initiatives to reduce road traffic demand at work sites, schools and other traffic generators. This includes traditional ridesharing programmes (carpools and vanpools), the voluntary transport demand management programmes at employer work sites and traffic reduction initiatives. Rather than mandating programmes, government agencies and public/private partnerships work with employers to implement employee trip-reduction programmes. This is true of the TDM programmes being implemented in the Netherlands and the Green Transport Plans being developed in the United Kingdom. Many regions of the United States also embrace the philosophy of voluntary employer programmes and market TDM strategies to businesses, highlighting the benefits of increased employee productivity, recruitment and retention.

Objectives and major impacts

While administrative programmes and policies in and of themselves do not reduce trips, they create an institutional environment that supports and facilitates trip-reduction. Typically, these measures are implemented by governments through voluntary or mandatory employer trip-reduction programmes, restrictions (auto-restricted zones), work practices (compressed schedules, telecommuting) or in partnership with the private sector (transportation management associations).

The impact of these administrative measures is dependent on the specific trip-reduction strategies facilitated by these new arrangements and practices. For example, a transportation management association (TMA) may administer a carpool programme or transit-discount programme for employers within a business park. The availability of commute options and financial incentives offered by the TMA manages demand and reduces the number of single-occupancy cars driven to the work centre.

Application of measures

The administrative measures described above are most often implemented to encourage, facilitate or mandate desirable travel behaviour among employers, commuters and other travellers. These actions include the provision of commute alternatives (*e.g.* ridesharing, transit, telecommunications) or incentives and disincentives for their use. Measures are sometimes implemented to avoid regulation by demonstrating the effectiveness of voluntary actions in meeting public policy objectives, such as congestion relief.

Institutional responsibility for implementation

Organisations that can facilitate administrative measures are:

- Regional governments (states, provinces, counties), sometimes responding to national mandates (as in the case of the UK Government's Transport White Paper, the Dutch Second National Structure Plan, or the US Clean Air Act Amendments).

- Local governments and special purpose agencies, such as cities and local authorities or regional ridesharing or metropolitan planning organisations.

- Public/private partnerships, including TMAs comprised of employers, developers, transport service providers and government representatives.

- Private and public employers voluntarily implementing transport demand management programmes to either solve a site-specific problem (*e.g.* accessibility, recruitment, parking, etc.) or to avoid regulations.

Affected government policy bodies, implementing agents and other private parties need to come to a consensus that the measures are needed, that they will solve specific problems facing the area, and that the desired travel demand reduction measures will be both effective and cost-effective. Attempts to implement administrative measures without support and a clear understanding of why they are needed, without viable travel alternatives for commuters and lacking incentives for commuters to switch to more sustainable modes, will likely be ineffective.

Effects on travel patterns

Assessing the effectiveness of administrative measures is often problematic because these measures often facilitate, support or mandate actions among employers and commuters to take desirable actions to change travel behaviour. For example, guaranteed ride home (GRH) programmes provide an "insurance policy" to non-driving commuters ensuring their return home in the case of an emergency. Many carpoolers and public transport users claim that the existence of the GRH programme is what prompted them to switch from driving alone to another mode. However, it is the commuters' switching of modes that reduces vehicle trips and kilometres of travel. Likewise, TMAs facilitate the involvement of employers in TDM programmes, yet it is the traffic reduction strategies themselves (such as telecommuting, subsidies, vanpool provision) that reduce trips and kilometres.

Many of the illustrative programmes cited in this chapter are evaluated in terms of their overall effectiveness in increasing the use of non-drive-alone modes, in reducing vehicle trips and vehicle kilometres of travel, or reducing traffic congestion. Some of the quantitative results are presented here.

Increased use of alternative modes

Nearly one-third of employees (29%) in Tucson, Arizona, now commute to work by means other than driving alone. This high ridesharing rate can be attributed to the 1999 passage of an employer trip-reduction mandate affecting 246 work sites and over one-quarter of the region's workforce, which increased the ridesharing rate by 14% (see examples section at the conclusion of the chapter).

Similar results have been achieved in others areas of the United States subject to trip-reduction mandates. A mandate in Washington State has increased alternative mode use to 32% for affected work sites (see examples section at the conclusion of the chapter.)

Vehicle trip-reduction

Overall, research on employer-based TDM programmes indicates that regional mandates can reduce vehicle trips at affected employer sites by an average of 5-10%. The Belgian Action

Programme to foster voluntary company transport plans concluded that a compulsory system was needed to affect modal shift. Participating employers in Washington State have achieved a work-trip reduction of 7%. In the San Francisco Bay Area, 6% of all drivers reported having reduced trips on high air pollution alert days. A staggered work hours project in Hiroshima reported reducing the average driving queue by nearly half, from 5.8 km to 3 km. Trip-reduction at individual work-sites with aggressive TDM programmes in place averages about 20% according to studies conducted by the United States, the United Kingdom and the Netherlands. Some individual case studies report trip-reduction rates of 50% and more (Schreffler, 1998).

Despite these impressive results at individual work sites, the average trip-reduction rate among employers operating in a voluntary environment should be expected to achieve less than 5% and, in some cases, voluntary efforts are unable to decrease the drive-alone rate.

Cost-effectiveness

Assessing the impacts and effectiveness of administrative measures is only one factor in determining the overall efficacy of travel- and traffic-reduction strategies. A programme is valued most when its cost-effectiveness can be demonstrated, particularly in comparison with other means of reducing or accommodating road traffic demand. Employer-based TDM programmes, at the heart of many of these administrative measures, have proven to be relatively cost-effective. A study conducted by the Transit Cooperative Research Programme (TCRP) of the US Transportation Research Board estimated that among 50 employer-based TDM programmes (with an average vehicle trip reduction of 15.3%), the average employer cost per trip reduction was USD 0.75 per day (Association for Commuter Transportation, 1996). A US Department of Transportation study of approximately 25 employer TDM programmes estimated the cost per trip reduction at USD 1.33 per day. When compared to the capital and operating cost of providing road space for a new, solo driver at USD 6.75 per day, TDM strategies offer great potential for achieving considerable cost savings (COMSIS Corporation, 1993).

Special problems and issues

As previously noted, the most common problem with evaluating the impact of administrative measures is the tendency to attribute programme effectiveness to institutional arrangements or programmes themselves, and not to the implementation of specific trip-reduction strategies. For example, the TCRP study cited above noted an average employee trip-reduction of 15.3%, and the study attributes this success to employer-provided financial incentives to foster this mode change. Providing information on commute options to commuters was shown to have no effect on trip-reduction. Therefore, while administrative measures facilitate the implementation of TDM strategies, the impact is dependent on the actual trip-reduction strategies implemented by these programmes.

Packaging with other measures

Administrative measures are dependent on the TDM strategies they induce, require or encourage. As previously stated, the effectiveness of employer-based programmes evaluated was dependent on offering financial incentives or on the provision of new transport services, such as carpools or commuter buses. The parking management examples from Glendale, California, provided in the next chapter were prompted by a regional trip-reduction ordinance mandating employer demand management programmes. Thus, one might conclude that administrative measures facilitate the

implementation of a range of transport management measures and that the effectiveness of the administrative aspect of a programme is dependent on the effectiveness of the trip-reduction strategy itself. As such, administrative measures that facilitate economic measures and new alternative transport services and work arrangements will be more successful than programmes that simply promote the availability of existing options.

Conclusions

- Administrative measures are trip-reduction programmes and policies initiated by governmental agencies and/or public/private partnerships. These measures include transportation partnerships, trip reduction ordinances (TROs), alternative work schedules (AWS), vehicle restrictions and voluntary trip reduction programmes.

- Administrative programmes and policies facilitate and support trip-reduction, and are implemented through employer trip-reduction programmes, restrictions, work practices, or in partnerships with the private sector. The impact of administrative measures varies given specific trip-reduction strategies.

- Administrative measures encourage, facilitate or mandate desirable travel behaviour by providing commute alternatives or providing incentives or disincentives for their use. Measures include ridesharing, public transit vouchers, staggered work shifts and compressed work schedules, and use of telecommunications.

- Assessing the effectiveness of administrative measures is often problematic because these measures depend on the decisions of individual employers and on commuters to change their travel behaviour.

- Studies show employer-based TDM programmes to be relatively cost-effective. However, it is important to realise that the impact of a given administrative measure is dependent on the implementation of the specific TDM strategies it induces, requires or encourages. The existence of institutional arrangements does not guarantee results.

EXAMPLES – TRANSPORT PARTNERSHIPS

Autodate – the Netherlands

Autodate is a car-sharing programme designed to influence travel behaviour by helping travellers make better informed choices about their mode choice, including use of all forms of public transport. Autodate customers are kept abreast of the full range of travel options, and this has allowed many "Autodaters" to give up their private automobile or delay the purchase of a new car.

Research on Autodate shows that average annual automobile use among Autodate customers is 6 000 km, compared to 16 000 km for car owners. However, some users did not own an automobile before using Autodate and this has led to some increases in average trip distance. A 5-16% increase in bicycle, train and transit use has been noted among Autodaters.

Bike Busters Programme – Åarhus, Denmark

The City of Åarhus in Denmark offers free bicycles and raincoats to selected commuters as an incentive to pedal their way to work and leave their cars at home. This project, known as "Bike Busters," has been implemented on a small scale in this Danish city.

Guaranteed ride home programme – Minneapolis and St. Paul, Twin Cities Region, Minnesota, United States

Some commuters prefer to drive to work alone to enable them to return home quickly or get to their child's day care centre in case of illness or in an emergency. To overcome this barrier to using alternative commute modes, a guaranteed ride home (GRH) programme was created to provide commuters with a greater sense of security. Those who carpool, use transit, bike, or walk to work receive a free ride home in the event of illness or a family emergency. Typically, taxi services are contracted for this service by the sponsoring organisation. Over the past decade, while experience has proven that only 11% of eligible commuters have ever used this service, its effectiveness lies in allying commuters' concerns.

Metro Commuter Services (MCS) in the Twin Cities area organised a regional service that fills the gaps between individual GRH programmes and region-wide service. To qualify for the new region-wide GRH programme, commuters must fulfil three basic requirements: they must live or work in the Twin Cities area; they must carpool, vanpool, ride the bus, walk, or bicycle to work or school three times per week; and they must register with MCS. In this region, 8% of those who rideshare reported that they would drive alone if no GRH were available, thereby substantiating the importance of having such a programme in place.

Bay Area Clean Air Partnership – San Francisco, California, United States

The Bay Area Clean Air Partnership (BayCAP) was formed in February 1996 to focus on voluntary actions to improve air quality in the San Francisco Bay area. Founding partners include the Bay Area Air Quality Management District, the Bay Area Council (a regional business coalition) and the Santa Clara Valley Manufacturing Group.

BayCAP's objectives are to:

- Implement voluntary actions to help avoid violations of the national ozone standard.
- Verify community-wide voluntary efforts to reduce emissions and explore possible new voluntary strategies to reduce emissions.

BayCAP is instrumental in administering the annual summer "Spare the Air" campaign, which seeks citizens' voluntary trip-reduction participation on ozone-alert days. In 1998, 6% of surveyed residents said they reduced their trips on "Spare the Air" days. Air-quality planners estimated that this resulted in a reduction of over 200 000 one-way vehicle trips per day.

Coronado Transportation Management Association – San Diego, California, United States

The Coronado Transportation Management Association (CTMA) was formed in 1993, partly in response to a planned trip-reduction ordinance and the need to provide employers with cost-effective ridesharing support services. Its stated mission is to "create and implement programmes that reduce traffic congestion and improve air quality to benefit the quality of life and economic vitality in the City of Coronado". In 1999, the CTMA's services included (among others):

- A subsidised commuter vanpool programme.
- A military outreach programme for workers at two large naval bases.
- Promotion of a commuter ferry service.
- "My Other Car is a Bike" bicycle club.
- A guaranteed ride home programme.
- Sales of discounted transit passes.

The existence of these programmes and services resulted in the reduction of nearly 1 000 vehicle trips from the roads leading to Coronado and almost 61 000 km of travel reduced daily (ESTC, 1999).

TRIP-REDUCTION ORDINANCE

Travel reduction programme – Tucson, Arizona, United States

The Tucson area adopted travel reduction strategies in the 1980s through an Intergovernmental Agreement to address the region's non-attainment of Federal carbon monoxide (CO) pollution standards. Motor vehicles have been the region's number one source of CO emissions. The Travel Reduction Ordinance requires four key employer actions:

- Appointment of a transport co-ordinator.
- Distribution of alternative commute mode information.
- Annual surveys of employees.
- Annual submission of a travel reduction plan.

The ordinance holds employers responsible for reducing employees' work trips. Carpooling, vanpooling, walking, bicycling, telecommuting, working compressed schedules, and use of public transport and low-emission vehicles are all strategies that fulfil this requirement. Over a nine-year period following programme implementation (1989-98), the use of alternative commute modes increased by over 13%.

Commute Travel Reduction programme – Washington State, United States

Nine urbanised counties in Washington State are required to comply with the Commute Trip Reduction (CTR) programme to "reduce air pollution, traffic congestion, and consumption of transportation fuels through employer-based programmes that decrease the number of trips made by single occupant vehicles".

The programme affects all employers with work sites of 100 or more employees. In 1997, employers in Washington State spent over USD 21 million to comply with the regulation, and are eligible for state tax credits on expenditures for employee incentives to switch modes.

In 1993, prior to the requirement, 26% of employees used non-drive-alone modes to commute. By comparison, in 1999, 32% of affected commuters used non-drive-alone modes, equating to a 6% reduction in vehicle trips.

In terms of the most cost-effective strategies, programme evaluations point to the services of the company transport co-ordinator; financial incentives to employees for using commute alternatives; and facility improvements to make the use of alternatives more convenient.

ALTERNATIVE WORK SCHEDULES

Staggered commuting hours – Hiroshima, Japan

Every weekday, 6.17 million commuters travel to Hiroshima's central business district. The morning peak period from 8:00 – 9:00 draws 4.44 million commuters to the area.

Hiroshima City aimed to reduce 58 000 commute trips made during the morning rush hour by requesting central district employers to co-operate with a staggered work hour programme initiated in May 1994. As a result, queues were shortened from 5.8 to 4.9 km by July 1994, and shortened again to 3.0 km by 1997.

AUTOMOBILE RESTRICTED ZONE

Experimental transit mall – Hamamatu, Japan

Inner city problems were becoming increasingly serious with the growth and sprawl of the city, limiting accessibility to the central business district. Hamamatu City implemented an experimental transit mall to increase accessibility to the central district.

Traffic calming plan for the city of Århus – Denmark

This plan, adopted in 1994, was designed to defer car traffic outside the city centre. A river paved over in the 1960s to create more space for roads and parking throughout the city centre has been re-established, and inner roads closed to vehicular traffic. Pedestrian areas have been enlarged and the city centre has been made more attractive. New bus lines and bicycle paths provide more commute alternatives.

Project Jupiter – Ålborg, Denmark

As one of five European cities participating in Project Jupiter (Joint Urban Project in Transport Energy Reduction), the city of Åalborg has implemented a two-phase project aimed at reducing traffic in the city centre. This involves traffic calming measures and road closures allowing only public transport and bicycle access to the city centre, completion of a city-wide bicycle path system, installation of an electronic parking information system, and the development and implementation of energy- and environmentally friendly buses and city cars. The total estimated reduction in car traffic is projected to be 3 000 km per day or 750 000 km per annum.

VOLUNTARY TRIP-REDUCTION

Transportation demand management – the Netherlands

In the Netherlands, TDM receives special attention by company management. Experience has demonstrated that companies can limit car use by 5-10% by using basic measures such as company bicycles and carpool matching. An average trip reduction of 15-20% is possible with stronger measures and disincentives such as parking restrictions.

Action Programme for Transport Plans in Companies – Belgium

The Mobility Department of the Ministry of the Flemish Community initiated an Action Programme with the goal of reducing traffic through voluntary transport plans in companies. The Action Programme included four elements:

- A procedure for developing the plans.
- A marketing concept and communication.
- A means to identify prospective interest within companies.
- A means to realise effective results from the plans.

An evaluation conducted in 1998 concluded that the desired modal shifts could not be attained without mandates. As a result, the voluntary programme was discontinued. A mandate has been proposed but no action has been taken on the legal framework for the compulsory involvement of companies on transport plans.

Green Transport Plans – United Kingdom

Green Transport Plans (GTPs) are strategies devised by businesses indicating methods to reduce their company's reliance on road vehicles. Governments are encouraging the voluntary adoption of GTPs by businesses, schools, hospitals, local authorities and other entities to reduce car use for work commutes and business travel (Department of the Environment, Transport, and the Regions, 1999).

New guidance on local transport plans calls upon local authorities to develop strategies for raising public awareness and to describe their plan to secure widespread voluntary adoption of GTPs in their area. In 1998, one study revealed that about 3% of local authorities had implemented GTPs for their own employees, about 6% had started pilot GTPs among other employers, and 23% had begun contacting employers in the area about GTPs.

USAA vanpool programme – San Antonio, Texas, United States

The United States Automobile Association (USAA) began its vanpool programme in 1977. Officially, USAA developed its programme "to provide safe and economical transportation for employees and to conserve fuel". The programme began with five vans serving employees in communities surrounding the company's headquarters in San Antonio, Texas.

While some of the large employers that helped pioneer vanpooling in the fuel-sensitive 1970s eventually phased out their programmes, USAA's has persevered. Today, USAA owns and operates 145 vans at six locations across the United States, transporting some 1 300 employees to and from work. According to USAA, it has the largest non-commercial vanpool programme in Texas. Vanpoolers pay a monthly average fee of USD 35 and the vehicles receive preferential parking at the site's 9 000-space lot.

SchoolPool programme – Denver, Colorado, United States

In 1993, the Denver Regional Council of Governments (DRCOG) initiated the "SchoolPool" programme for parents who drive their children to private schools.

Because the city's school bus system serves only public schools, most parents with children in private schools drive them to class each morning and back home each afternoon; averaging 10 miles each way and sometimes totalling as many as four daily trips.

The SchoolPool programme helps parents form carpools of students attending the same school to reduce vehicle trips. DRCOG has reported significant success with the programme, reporting savings of over 45 000 vehicle kilometres travelled per day in 1999 among 9 000 registered families.

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Chapter 7

PARKING MANAGEMENT AND PARKING PRICING

Description

This chapter explores the economic measures of parking management and parking pricing as TDM tools. The availability of convenient and free or relatively inexpensive parking is a major factor in whether and where people choose to drive. Parking management strategies can alter the supply, operation, and/or demand of an area's parking system to support local transportation, economic and environmental objectives, and parking pricing can be used as a mechanism to control or influence travellers' mode choice.

Parking management

Parking management includes:

- *Restricted parking supply*. The restriction of parking supply can be one of the most effective strategies in influencing a traveller's choice of mode to reach the desired destination. One strategy rescinds or reduces minimum parking requirements and allows market forces to determine the amount of parking spaces in a given area. Alternatively, parking maximums have been imposed in some suburban locations to limit the parking supply. Some cities have imposed caps on downtown parking to encourage the use of public transport. Restrictions may only apply to specific areas as in the central business district, or may be applicable at certain times, such as during peak periods. Exceptions may be granted for disabled people and/or carpool participants.

- *Preferential parking.* Preferential parking spaces offer motorists desirable locations (such as spaces located near building entrances or in covered garages). These are provided as an incentive to people that rideshare. Employer-owned facilities can offer preferential parking to their workers as a ridesharing incentive.

- *Removal of minimum parking requirements.* Minimum parking requirements have been criticised for bypassing the market for pricing transport and land since they bundle the cost of parking spaces into the cost of development, thereby increasing the cost of all goods and services sold at the sites that offer free parking. These requirements "externalise" the costs of parking, so that one cannot reduce what one pays for parking by consuming less of it.

  It has been argued that the external costs of parking in cities may be greater than all of the other external costs associated with car use combined. The high costs are especially due to minimum parking requirements that increase the density of parking and car usage.

- *Parking guidance systems.* These systems maintain and manage parking in the city centre while reducing car idling by those in search of a parking space. Experiences from the Danish city of Aalborg demonstrate the effectiveness of a parking guidance system. (See examples section at the conclusion of the chapter.)

- *Park-and-Ride.* A parking management strategy that is integrated with public transit connections to provide access to a particular site or city centre and reduce traffic congestion. Typically, Park-and-Ride lots are located at some distance from congested areas and provide staging areas for buses, carpools and vanpools to collect and discharge passengers. (See Chapter 10 for further details.)

Parking pricing

Parking pricing can be used as a mechanism to control or influence travellers' mode choice. Parking pricing measures include parking surcharges; parking user taxes; parking space taxes; and parking cash-out. Parking fees can be assessed for public parking, for a space in a parking garage or at a work site. In larger cities, parking fees are usually highest in the central business district or other congested areas. The amount may vary depending on the time of day as a means to motivate drivers to refrain from driving during peak hours. While parking pricing is common in commercial areas, its use is not widespread in residential areas. (The examples section includes information on a residential parking programme in Korea.)

Parking "cash-out" measures implemented in the United States allow employees to waive their use of a company-provided or company-subsidised parking space in exchange for receiving its cash-value equivalent. This practice has resulted in greater use of commute alternatives.

Objectives and major impacts

Parking management and pricing objectives vary depending on whether public authorities or private companies implement these measures.

Generally, parking policies are used to accomplish one or more of these objectives:

- Reduce inner city car traffic in general.

- Reduce commuter traffic and thereby congestion.

- Release spaces on the street which may then be used for other purposes such as: adding an extra lane during peak periods to improve traffic flow; creating pedestrian and/or bicycle paths; making reversible lanes for public transport vehicles; or adding street landscaping.

Effective parking management programmes can create a more attractive business environment for companies to locate or to expand.

Private companies' objectives focus on:

- Reducing the amount of employee parking that must be provided.

- Increasing visitor and customer parking.

- Providing employees with more choices and better services (such as preferential parking places or financial incentives through parking cash-out) in order to provide a greater degree of flexibility in choosing transport modes for commuting.

Parking pricing may also be used as an alternative source of revenue. For instance, it may be used to improve public transport or used by employers to support their in-house ridesharing programme. This is the case for the City of Perth, Australia, where a parking pricing scheme finances free public transport in the inner city. (See the description under "innovative financing" in Chapter 5.)

Application of measures

Nearly all OECD countries have instituted parking pricing and management. In the most advanced of those programmes, cities such as Zurich, Bremen and Copenhagen have eliminated free public parking. In other cases, developers have used parking management to meet trip-reduction requirements imposed on new developments (see Chapter 2 on Land Use and Transport Planning). In the Netherlands, the national government has established parking parameters on a national level (Harteveld and Bosch, 2001).

These parking policies can be applied to:

- Individual new developments.
- Individual employer work sites.
- Entire employment centres in urban or suburban settings.
- Public facilities, typically in downtown areas.
- Public parking districts in urban or suburban settings.
- Commercial parking through rate regulation or parking taxes.
- Regions through air-quality or funding allocations legislation.

Institutional responsibility for implementation

The development and management of parking pricing policies involve many public and private sector groups. Table 7.1 illustrates the parties potentially responsible for implementing parking pricing policies.

Table 7.1. **Responsibility for implementing parking pricing measures**

National or local government	Employer or developer
General surcharges or increased fees for on-street parking, public parking. Differentiated surcharges on public parking lots: *a)* higher for solo drivers and long-term parking; and *b)* lower or free for carpools, vanpools and car-sharing associations. Tax the private parking providers in terms of: *a)* an annual tax per lot or per square meter utilised for parking; *b)* remove tax-free status of employee parking; *c)* impose a tax on parking revenue (*e.g.* 10% parking charge in private car parks); and *d)* impose a tax per transaction in private car parks (*e.g.* EUR 0.25 per vehicle). State government: tie transport funding allocations to requirements for local trip-reduction plans incorporating parking pricing among other demand management strategies.	Remove, reduce or cash-out employer-provided parking subsidies. Reverse "early bird" or monthly discounts favouring long-term commuter parking. With or without government regulation, impose parking pricing and discount parking for carpoolers. Reduce parking spaces in return for economic support of public transport, carpooling, cycling and other alternatives to solo driving.

Effects on travel patterns

Parking management is widely recognised as the single most influential demand management strategy for changing employee mode choice and managing parking usage. The 1990 US National Personal Transportation Survey found that 90% of American workers that drive to work alone are provided with free parking at the work site. Case studies suggest that 20% fewer commuters would drive alone if they had to pay the full cost of parking. Parking prices are critical to travellers' choice of mode.

A study of eight California employer parking cash-out programmes revealed that the drive-alone rate was reduced by between 4 and 29% when cash allowances were offered to employees in exchange for their parking space (Shoup, 1998).

An effective parking management programme incorporates one or more of the following strategies: initiates or changes parking pricing rates; provides preferential parking to carpools, vanpools and car-sharing associations; and/or constrains the parking supply. Of these, parking pricing is the single most effective method for managing parking demand, followed by controlling the parking supply (Luz, 1996).

Parking pricing is most effective when:

- Work sites are located in densely populated areas where parking is at a premium.
- Other commute options and meaningful benefits to use them are available.
- Free on-street parking options are not located in proximity to the work site or are unavailable.
- Employees know the revenues will be used to support the commute options programme.
- Parking enforcement is adequate (Saito, McKnight and Prassass, 1994).

Overall, when considering the implementation and effectiveness of parking management, the relationship between parking supply and existing parking demand needs to be carefully considered to ensure that demand is high enough to be affected by a reduction of supply or increase in price. Some parking management programmes have failed because convenient, inexpensive parking was readily available nearby or because changes to parking supply or price were inadequate to affect demand.

Cost-effectiveness

Parking management, especially parking pricing, is among the most cost-effective strategies for employers wishing to reduce car trips to work sites and central business districts. Revenue from employee parking or savings on parking leases or operating costs can offset the cost of implementing and promoting alternatives to driving alone. The examples section of this chapter outlines the details of a parking pricing programme in Glendale, California. In short, two employer parking pricing programmes realised reductions of 25-30% in employees' drive-alone rates, and the programme resulted in net cost savings per trip reduced of USD 0.44 (COMSIS Corporation, 1996). Research conducted in the United States cites financial disincentives such as parking pricing and parking supply management as two of the most cost-effective strategies available (in terms of cost per daily one-way trip reduced) (Schreffler and Stempson, 2000).

Special problems or issues

Policy changes to influence parking conditions do not come easily, in part because any change raises equity issues among affected parties. It is also important to consider the specific needs of disabled motorists, and in particular their mobility ranges in determining the location and allocation of preferred spaces. Parking management measures applied at specific sites can create spillover effects. Withdrawing parking spaces can often be counter-productive if it leads to drivers circling the area in search of the few available places. A variable message signing system indicating the number of available spaces is effective in managing such situations (see examples section of City of Aalborg, Denmark). The institution of employer parking management programmes can lead employees to seek parking in adjacent, residential neighbourhoods. This has led some jurisdictions to implement residential parking permit programmes.

Packages with other measures

Successful parking management programmes require that attractive alternatives are available, incentives are in place to use them and information and assistance is offered to travellers on their use and availability. Parking supply and price management largely serve as a disincentive or deterrent to using a single-occupant vehicle to travel to a given destination. As such, alternatives need to be in place to either substitute for the trip (through use of telecommunications) or allow the trip to be taken using a different mode (such as public transport) or at a different time of day (by offering flexible work schedules). Parking management programmes implemented by the public sector often need comprehensive information services to inform travellers about commute alternatives and to locate available parking. The secondary impacts of parking management need to be considered so that drivers do not park in an inappropriate place, such as in residential neighbourhoods or in areas that could impede traffic flow.

Conclusions

- Since the availability of free or inexpensive parking is a major factor influencing the decision to drive, parking management and parking pricing strategies can have a considerable effect on a traveller's mode choice and on the supply, operation and/or demand of an area's parking system.

- Parking management measures include restricted parking supply, preferential parking, removal of minimum parking requirements, parking guidance systems and Park-and-Ride systems. Parking pricing measures include parking surcharges, parking user taxes, parking space taxes and parking cash-out.

- Parking management and pricing objectives vary depending on whether public or private authorities implement the measures. Objectives include reducing inner city car traffic, reducing congestion from commuter traffic, and releasing street space for alternative uses. Parking pricing may also provide a source of revenue.

- Both public and private sector groups share responsibility for the successful implementation of parking pricing policies. Parking management and pricing are among the most cost-effective strategies for employers wishing to reduce car trips to work sites and central business districts.

- Policy changes to influence parking conditions may be difficult to achieve if attractive and viable alternatives are not available. Incentives to use alternatives and information and assistance concerning their use must be in place to facilitate commuter mode shift from the car. Secondary effects of parking management must also be considered (*e.g.* parking spillover, and impeded traffic flow in residential areas).

EXAMPLES

Integrated parking management scheme – Bremen, Germany

The City of Bremen has had great success in reducing car-based traffic in its medieval centre. Half of all trips into the city centre are made by public transport and nearly one-quarter (22%) are made by bike. Public transport is used by 58% of shoppers in the central district. An integrated strategy to raise public awareness, provide better public transport, implement parking management, and promote town planning has led to these impressive results. Key pricing elements in the parking strategy include:

- No free or unregulated parking in urban centres.
- Price and quantity of parking lots determine the appropriate demand for short-term and long-term parking (highest prices at attractive locations).
- Car use plus parking charges should not cost less than using public transit in the city.

Resident parking permit programme – Seoul, Korea

A resident parking permit programme (RPPP) makes parking spaces available along the inner roads of residential areas. A parking lot is assigned to the user who buys one of three types of parking permits: all-day; daytime only; or night-time only. The monthly price for a permit is about KRW 40 000 (USD 36 or EUR 36.7) for an all-day permit; KRW 30 000 (USD 27 or EUR 27.5) for a daytime-only permit; and KRW 20 000 (USD 17 or EUR 18.3) for a night-time-only permit. The price level may vary depending on the city. Normally, community people whose residence is located near the lot are granted priority in buying a permit. In the case of a daytime permit, people who work at a permanent job near the lot have priority.

The introduction of RPPP eased/reduced conflicts between neighbours over limited parking spaces. However, a number of practical and political problems remain. First, not all inner roads can accommodate parking due to inadequate widths of at least six meters. Further, the city government wants to charge for every parking lot, but most of the residents are unhappy with having to pay for residential parking. Currently, charged parking lots account for about 15% of all parking lots in Seoul.

Parking management programme – Glendale, California, United States

Two companies (Nestle U.S.A., Inc., and Commonwealth Land Title Company), members of the Glendale Transportation Management Association (TMA), eliminated parking subsidies for single-occupant vehicles, allowing commuters to decide whether to pay for parking or use a less expensive commute alternative. At the same time, these employers offered a generous programme of ridesharing incentives. The parking pricing and management programme resulted in reductions of 590 daily vehicle trips and nearly 40 000 km of annual travel. This was largely accomplished through carpooling, whereby several employees could share the cost of a parking space. The average occupancy rate of cars arriving at the work site increased from 1.15 to 1.5. Both employers offered financial incentives to those that chose to use a commute alternative, in addition to charging for parking. Because the programme generated revenue from parking fees that exceeded the cost of the incentives and administration, the programmes resulted in net cost savings for each trip reduced.

US West Communications/Qwest, Bellevue – Washington, United States

US West Communications, the former Pacific Northwest telecommunications provider now known as Qwest, consolidated its regional operations into a new headquarters site in suburban Seattle. The City of Bellevue imposed parking maximums on new developments and required tenants to implement a transportation management programme. Thus, US West constructed only 400 parking spaces for its 1 100 employees and imposed monthly parking fees of USD 60 for single-occupant cars, USD 45 for two-person carpools, and no charge for three or more person carpools. Carpools received preferential, guaranteed parking, while solo drivers were offered parking on a “first-come, first-served” basis. The employer also offered flexible work hours and an on-site employee transportation co-ordinator to promote commute alternatives. This programme of parking supply restrictions, parking charges and TDM measures resulted in 47% of US West employees ridesharing to work, 26% driving alone, and 13% using public transport. As compared to the modal split of other employers in the region, this equated to a 47% vehicle trip-reduction over what would have been expected if free and ample parking was provided (COMSIS Corporation, 1993). Bellevue’s parking maximums were partially credited with increasing public transport use to downtown Bellevue from 4% in 1980 to 11% in 1992 (K.T. Analytics, 1995).

Parking management and transit incentives programme – Portland, Oregon, United States

The Lloyd District is a high-density commercial and residential area located across the Willamette River from downtown Portland. In 1997, the City of Portland, the regional transit provider, and the Lloyd District TMA implemented the Lloyd District Partnership Plan. The plan included parking pricing for previously free on-street parking, discounted parking for carpools, discounted transit passes, and other supporting programmes. A study conducted one year after plan implementation revealed that the commuter drive-alone rate in the district had dropped by 7%. The most effective strategies for inducing this change were a combination of parking pricing and the transit discounts to provide a strong disincentive for driving alone and a strong incentive for carpooling and transit use.

"Transit First" policy – San Francisco, California, United States

The City of San Francisco's "Transit First" policy allows parking to occupy up to 7% of a building's gross floor space. New buildings must have an approved parking plan prior to receiving an occupancy permit. In some cases, only short-term parking is approved; while in other cases, a mix of short-term, long-term and carpool parking is approved.

In the early 1990s, city planners indicated that there had not been a major increase in downtown peak traffic over the previous decade in spite of considerable office growth. Downtown transit ridership has remained steady at 60%, while 17% of downtown commuters drive alone and 16% carpool (K.T. Analytics, 1995).

Parking surcharges – Copenhagen, Denmark

Between 1990 and 1991, Copenhagen introduced fees for most of the public parking areas in the inner city. A year later, the number of cars parked in the inner city had dropped by 25%, and traffic to and from the area was reduced by about 10%. An analysis by the regional public transport company showed that 2% of all passengers to the four city stations had recently shifted from car to train/metro. No analyses have been made to estimate the effects on total traffic in the city.

In 1996, the parking fees were raised so that the most expensive places now cost DKR 20 (EUR 2.69 USD 2.64). The effects of the enforcement of this policy have not been estimated to date. Beginning in July 2000, the area subject to parking surcharges was expanded beyond the inner city to the adjacent districts.

Parking guidance system – Aalborg, Denmark

As part of the EU-sponsored Project Jupiter, the city of Aalborg has established a parking guidance system that provides motorists with real-time information on the number of available parking spaces in centre city parking facilities. Parking availability is displayed on variable message signs posted along the main roads leading into the city centre. Roads around the periphery of the city centre lead car traffic to parking spaces located just outside the core central area.

Following the implementation of this guidance system, the percentage of drivers unable to park in Aalborg has been reduced from 21% to 9%; pollutants have been reduced by 0.1%, and 930 km/day have been saved as a result of drivers not having to circle parking lots in search of an available space.

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Chapter 8

TRAFFIC MANAGEMENT

Description

Traffic management measures aim to better meet traffic demand by maximising use of the existing transport infrastructure, improve journey times, and increase reliability of transport networks.

Traffic management measures can be classified into four categories: those that provide extra road capacity during periods of peak demand, those that restore temporary loss of road capacity, those that provide travellers with real-time traffic information, and intelligent transport systems.

Measures that provide extra road capacity during periods of peak demand

- *Re-allocation and flexibility of roadway layout.* Creation of an extra lane by re-allocating the roadway layout or using the hard shoulder as an extra lane during the morning and/or evening rush hours.

- *"Tidal flow" or reversible lane techniques.* Directs peak-period traffic in a single direction when demand is highest. This can be an alternating lane(s) or, in some cases, an alternating carriageway.

- *Ramp metering.* The application of traffic signals to regulate the number of vehicles entering a roadway to optimise the performance and safety of travel on a particular segment.

- *Restricted overtaking for lorries/trucks.* Restricting passing for these vehicles during specified times and on certain stretches of road.

- *Buffer zones.* Areas designed to absorb congestion caused by tailbacks on slip roads and at junctions.

Measures that (partly) restore temporary loss of road capacity

- *Enhanced flow road management.* A variety of measures, such as incident management, the combination and concentration of road maintenance or reconstruction, "4-0" contraflow arrangements and lane (or even road) closures.

- *Incident Management.* Measures intended to ensure clear roads for through traffic as rapidly as possible following an accident or spill.

Measures that provide travellers with real-time traffic information *(see Chapter 4 on traveller information systems)*

- Technology such as *real-time traffic flow information* improves the efficiency of use of road infrastructure. Similar intelligent transport systems hold great promise for facilitating driving, particularly in road safety and traffic flow improvement.

- *Traffic information systems.* It is essential to provide road users with up-to-date, reliable information on traffic conditions *en route*, including advance warning of road detours or closures, road construction projects, traffic accidents, and adverse weather and road conditions.

Intelligent transport systems

- The combination of telematics and information technology holds great potential for better management of travel demand.

- Technology-synchronised traffic signals can reduce or eliminate transit vehicles' waiting time at intersections by predicting their arrival at the next intersection. Intelligent transport systems, such as automatic vehicle guidance or intelligent speed adapters, assist the driver in driving tasks.

Objectives and major impacts

Traffic management measures are intended to achieve a smoother flow of traffic during periods of peak demand and/or during periods of temporary loss of road capacity (*e.g.* during roadway reconstruction and maintenance). Congestion problems can be significantly improved by expanding operating capacity at bottleneck locations. Information for road users on traffic-flow conditions can impact driver behaviour and improve road safety by facilitating optimal route choices by the individual traveller, both before and during the journey, leading to a more efficient use of the available road capacity. Intelligent transport systems improve the safety and comfort of the driver.

Growth in travel demand has increased over the past 20 years, particularly with regard to freight transport. This growth is expected to continue, particularly for road haulage. It is impossible to keep pace with this demand simply by expanding infrastructure capacity; therefore traffic management strategies offer opportunities for maximising the efficiency of the existing road network.

Public support for new infrastructure construction is diminishing in many areas. The construction of new infrastructure in densely populated areas has become increasingly difficult due to land shortages, high costs and/or environmental concerns. The returns offered by new infrastructure appear to be limited and short-lived in relation to costs, land-take and the impact on living conditions.

Technological innovation puts new solutions within reach. Following the notion that creative, clever and cost-effective solutions are needed to tackle congestion, more road authorities are implementing road traffic management strategies.

Road traffic management measures offer a number of advantages, including:

- *Public support.* Research indicates a positive public reaction to efforts aimed at improving the efficiency of the existing road network.

- *Flexibility.* Traffic management can offer dynamic solutions to complex problems. For example, some measures address peak-hour problems which occur only during a limited number of hours and on certain routes.

- *Minimal land-take.* In densely populated areas, space is scarce. Road traffic management allows solutions to be undertaken within the pattern of existing land-use, landscape and living conditions.

- *Quick response time.* Traffic management solutions allow for a faster response time than traditional road capacity investments. Their implementation is generally less time-consuming, involves fewer procedures and is lower in cost than constructing new infrastructure.

Application of measures

Traffic management measures have been widely implemented throughout OECD Member countries. Many measures are in the early stages of implementation; some are pilot projects being tested in real traffic situations, while still others are in the experimental stage.

Many OECD countries have applied measures using data on traffic flows and incidents collected by national Traffic Information Centres (TIC). After processing the data, these TICs distribute the information to service providers, including radio and television stations. In turn, this information is relayed to travellers to provide them with current highway and weather advisory information.

A new application of the use of actual traffic data is an information system that enables TICs to disseminate actual travel times from one point to another on the main highway network to the drivers on that network. Road users appreciate advance warning of traffic delays. For example, the Motorway Traffic Management system in the Netherlands gives early warning to road users to reduce speed when they are approaching a traffic jam.

Intelligent transport systems (ITS) are being researched in a number of OECD Member countries including Australia, Japan, the Netherlands, the United Kingdom and the United States. These countries are investing in ITS research projects, many of which are still in the experimental stage.

Japan is the global leader in the field of automated highway guidance (AVG) systems, with a number of projects underway. The US National Automated Highway System Consortium is researching fully automated motorway traffic, and their new Intelligent Vehicle Initiative (IVI) is focusing on the development of in-car AVG systems. In the Netherlands, an intelligent speed adapter (ISA) is being tested under real road conditions. ISA is an external speed-limiting device that can increase safety, particularly in residential areas. Several systems for priority control strategies at signalised intersections (at local and network level) have been developed and tested over the past two decades, notably the Sydney Co-ordinated Adaptive Traffic System (SCATS) and the UK's Split, Cycle and Offset Optimisation Technique (SCOOT). As a vehicle approaches a traffic signal, it transmits a light, radio or sound wave that is recognised by the traffic signal controller receiver. This transmission results in a command to the controller that allows appropriate adjustments to be made to the control plan at the intersection. Such systems are often used for emergency vehicles such as

ambulances, fire trucks and police cars to permit their uninterrupted travel through a series of intersections.

Institutional responsibility for implementation

Typically, road agencies or authorities responsible for the roadway network implement traffic management measures. These measures are most effective when co-ordinated with regional and local authorities. Applications of road traffic management strategies for the whole road network cannot be implemented without the close co-operation of all road agencies. Forming a partnership of one regional authority or entity responsible for traffic management of the whole network can be particularly effective. For development of new technologies, partnerships are needed between industry and the road authorities. For instance, ramp metering can increase traffic on the minor road network while decreasing traffic on the major highway; careful planning and co-ordination are required to achieve the desired balance. Incident management measures also warrant close co-operation among all the services involved in an accident including police, ambulance, fire, recovery services and the road administrator.

Successful dissemination of traffic information requires close co-operation among all three links of the information chain: the public sector, the private sector and the end user. In many OECD Member countries, governments play a major role in the collection and processing of the information, and in making it available to the private sector. The private sector handles the data distribution (offering of services) and the production and sales of user equipment.

Effect on travel patterns

While traffic management measures may not reduce car travel *per se*, they have proven their ability to improve travel efficiency and highway safety.

A road management pilot project conducted in the Netherlands involved increasing speed during peak-hour traffic by having less variation in speed. To date, there have been no detrimental effects on road safety.

Research on the implementation of tidal flow or reversible lanes indicates that journey times can be reduced by as much as 15 minutes on average. Ramp metering projects in the United States achieved a 16% increase in average peak-hour travel speed, and a 25% increase in the flow of the number of vehicles. Ramp metering avoids clustering on the slip road and allows cars to merge more smoothly into the traffic stream on the motorway. Road capacity may increase by as much as several percentage points, with fewer accidents and traffic jams. Implementation of priority control at signalised intersections reduced delays by up to two-thirds.

A ban on overtaking by lorries can increase road capacity by approximately 3%. The likelihood of accidents is reduced, which in turn reduces the potential of incidental tailbacks. Through incident management measures, police and recovery units can be directed to the scene of an accident much faster, resulting in a timesaving of 15 minutes.

In pilot projects with dynamic route information panels, significant effects were measured in terms of traffic-jam reduction as a result of traffic re-routing. The widespread implementation of driver information systems in the Netherlands has decreased the number of secondary incidents and

improved traffic flow. In addition, these systems have greatly increased the safety of road workers, allowing the quick and easy closure of entire stretches of road for repair or reconstruction.

Cost-effectiveness

Road traffic management strives to operate the existing infrastructure network in an optimal way. This entails first looking for reserves of capacity before turning to new capacity generation. During peak demand, road traffic management measures will not completely solve congestion problems. However, compared to building new infrastructure, the cost-benefit ratio is up to five times greater. Enhanced flow road management strategies allow improved road maintenance planning, resulting in lower costs and reduced travel time.

Special problems or issues

While the effects of some tried-and-tested traffic management measures such as ramp metering and reversible lanes are known, other measures remain in the experimental stage. Road traffic management and intelligent transport systems in particular offer enormous potential, but many remain in development. Expectations concerning automatic vehicle guidance systems are very high; however, their large-scale application is not expected for 15 to 20 years. To date, most experiences are confined to the application of measures on a local scale. Traffic management applications range from local, unimodal measures to larger-scale, intermodal transport operations. Future possibilities include applications at the network level within the trunk road system, at the network level crossing over the boundaries of sub-networks and over modal boundaries.

Packaging with other measures

In most situations, traffic management measures applied in isolation cannot resolve congestion problems. However, they can provide temporary relief and/or be used to complement other traffic management measures, and should be included in congestion management plans.

Conclusions

- Traffic management measures aim to better meet traffic demand by maximising use of existing transport infrastructure, improving journey times and increasing network reliability. Smoother traffic flow is achievable by expanding operating capacity at bottleneck locations and providing better information to road users.

- Traffic management measures include measures to provide extra road capacity during peak periods (*e.g.* flexible roadway layout, reversible lanes, ramp metering); measures to restore temporary loss of road capacity (*e.g.* enhanced flow road management, incident management); measures to provide real-time traffic information; and intelligent transport systems.

- Traffic management measures improve travel efficiency and highway safety. Applied in isolation, they cannot resolve congestion problems, but they can usefully be integrated into an overall congestion management approach.

EXAMPLES

Case studies from the Netherlands and the United States

Peak-hour traffic lanes

In both the Netherlands and the United States, the hard shoulder is used as an extra lane during the morning and/or evening rush hours to create extra capacity. Overhead message signs indicate when the hard shoulder is open to through traffic. These types of special lanes require investment in additional measures such as sign-posting and monitoring, and necessitate replacing the unbroken white line with a broken one. Matrix signs over the carriageway display a red cross when the hard shoulder is not in use as a peak-hour lane. Emergency areas have to be built next to the hard shoulder, which also require sign-posting. Additional sensors detect stationary or slow-moving vehicles on the hard shoulder. The operations room can monitor the situation using overhead video cameras. Moreover, an enhanced form of incident management can be applied, so that emergency services can respond quickly and effectively in case of an accident. Peak-hour lanes are appropriate in certain areas but do require special measures to ensure their safe and effective use.

On those motorways where peak-hour lanes are in use, traffic flow has improved significantly. The evaluation of the peak-hour lane on the A28 in the heart of the Netherlands found that traffic flow had improved on and near the pilot section. Not only were traffic speeds higher, but there was also less variation in speed and average travelling times were generally reduced. To date, there have been no negative consequences on road safety, and the peak-hour lane has improved drivers' subjective feeling of safety. Notably, the incidence of rear-end accidents occurring on the A28 has been reduced by about 80%.

Motorway tidal flow lane

In 1988, the Netherlands instituted the practice of using the tidal flow lane on the A1 roadway exclusively for Amsterdam-bound buses and carpool traffic during the early morning rush hour. Conditions were ideal: the A1 and A6 roadways both link large-scale employment and residential areas and handle highly concentrated traffic flows, car occupancy was low and the length of the tidal flow lane (approximately 10 km) was expected to be sufficient for a 10-minute reduction in journey times.

The first carpool tidal flow lane on a Dutch motorway was implemented in 1993. Construction costs were approximately NLG 62. The trial demonstrated that use of the lane initially grew as expected, but then levelled off. A year later, it was decided to open the lane to all traffic, except lorries.

The tidal flow lane is now open in the morning from 5:30 until 10:00 to Amsterdam-bound traffic from the Gooi area and Flevoland, and from 15:00 until 19:00 for traffic returning home towards Amersfoort. The concentrated flows of commuter traffic during these periods with a favourable ratio in opposing directions allowed for the selection and construction of the tidal flow lane at this location.

The capacity of the carriageway during rush hour has increased so that traffic can flow more quickly. Research has shown that journey times have been significantly reduced, by as much as 15 minutes on average. An additional benefit of the tidal flow lane is that fewer drivers use minor roads in an attempt to avoid congestion.

No overtaking for lorries

At present, lorries are not allowed to overtake during rush hours on approximately 800 km of Dutch motorways. Restricting lorries' travel to the right-hand lane during rush hours can lead to a more effective use of the roads. Fewer cars crowd together in the left-hand lane behind overtaking lorries. Aggressive driving, tailgating and/or accelerating immediately after a freight vehicle has moved back into the right-hand lane have also been reduced. In addition, when traffic jams do occur, they seem to take longer to develop and end more quickly. Drivers of both cars and lorries have responded more positively to the measure than initially expected, and public opinion has become more favourable since the restriction was introduced in 1994.

The number of extremely small separation distances in the left-hand lane, with motorists driving less than one second behind the vehicle in front of them, has decreased significantly. At present, no safety problems have been observed in terms of lane changing. The likelihood of accidents has been reduced, in turn reducing the likelihood of incidental tailbacks. Road capacity has increased by approximately 3%.

Ramp metering (US/NL)

Ramp metering regulates the flow of cars joining the highway such that it occurs at a "metered" rate, facilitating traffic filtering onto the motorway without disruption to the flow of vehicles already on the main carriageway. Special traffic signals on the slip road, which switch on automatically, allow vehicles to join the motorway one or two at a time at intervals of a few seconds.

The Minnesota State Department of Transportation (MNDOT) currently manages more than 350 ramp meters in the Minneapolis/St. Paul metropolitan region of the United States. In one MNDOT study along a freeway corridor, ramp metering improved average peak-hour travel speeds by 16% (from 37 to 43 miles per hour), while at the same time increasing the flow of the number of vehicles by 25%.

Ramp metering offers clear advantages in terms of a more efficient use of existing infrastructure. Clustering on the slip road is avoided and cars merge more smoothly into the traffic stream on the motorway. The absence of vehicles abruptly merging into traffic increases road capacity by as much as several percentage points, with fewer accidents and fewer unexpected traffic jams. One important effect is the reduction in drivers using minor roads to attempt to avoid motorway bottlenecks.

Priority control strategies at signalised intersections (US)

Traffic signals can significantly influence the travel time and performance of transit vehicles, accounting for up to 10-20% of their delay. Reducing the travel time, delay and number of stops for transit vehicles often reduces the total person delay for all roadway users, whether travelling in buses or in private vehicles. In Charlotte, North Carolina, priority control was implemented at 11 signalised intersections for express buses along an arterial roadway. The implementation of this system resulted in a 67% reduction in delays encountered by the buses at these signals, and ridership increased substantially.

Enhanced flow road management (NL)

In 1995, road works caused 13% of the traffic jams and 5% of vehicle hours lost due to traffic congestion in the Netherlands. These statistics inspired a new and improved approach to road management to offer road users reliable journey times during road-work projects. Known as "enhanced flow road management", this combination of strategies includes incident management, the combination and concentration of road-work projects, "4-0" contra-flow arrangements, a corridor-based approach, lane and/or road closures, and communication of upcoming projects to the motoring public.

In essence, the two elements crucial to enhanced flow road management are good planning of road works, and effective communication with all those involved in road maintenance, including: highway authorities, municipalities, police and auxiliary services, and road users.

In recent years, the Dutch highway authorities have found it effective to close lanes on the motorways in order to carry out major repairs, such as was done during maintenance on the A20 and A13 motorways. A publication was produced, setting out the three phases to be considered when closing the motorway for repairs, and this information was communicated to the motoring public.

Incident management (NL)

Accidents cause nearly 2% of the traffic jams on crowded roads in the Netherlands. When road users are confronted with serious and unexpected delays, they are often unable to avoid the accident or take a different route. Driver irritation, impaired access and compromised safety are important factors that need to be taken into account.

Incident management includes a variety of measures to mitigate these situations. Technical measures include: video detection; special emergency service ramps; mobile barriers; and aids and equipment that serve to speed up the detection, reporting and handling of accidents.

One incident management process is designed for accidents involving only private cars, while another is designed for accidents involving commercial freight vehicles. When private cars are involved, the operations room switchboard reports the incident to a central incident room and a recovery vehicle is immediately dispatched. Because both the police and the recovery unit are directed to the scene of the accidents simultaneously, there is an immediate timesaving of about 15 minutes.

If an accident involves one or more freight vehicles, a motorway police unit will first inspect the site and then report back to the operations room which relays the information to the special freight vehicle incident room. Incident management for these vehicles allows freight towing and recovery companies to be contacted directly, rather than waiting for the vehicle owner to do so. This procedure has been approved by the insurance companies and transport organisations.

Incident management significantly improves the quality of services and the speed with which accidents are mitigated. Disruptions to the traffic flow resulting from an accident, a breakdown or a loss of freight from a goods vehicle can be addressed quickly and efficiently.

Freeway service patrols (US)

Congestion on urban motorways can happen under recurring conditions (i.e. due to capacity or operational problems), or under non-recurring situations (caused by accidents or vehicle breakdowns). In the United States, as much as 60% of all highway congestion is considered to be non-recurring congestion.

“Freeway service patrols” handle accidents and incidents as rapidly as possible, to minimise potential disruption to traffic and to maintain traffic flow. This service’s primary objective is to locate incidents, provide personnel to mitigate the incident, reduce the risks to motorists, and reduce incident duration so that full capacity can be restored to the roadway with the least possible delay. Service patrols can be operated from a stationary point and dispatched on a call-in basis or can circulate throughout a specified area. These vehicles range from trucks that can tow or push a vehicle to service vehicles that provide fuel, water and minor vehicle repairs, such as changing a flat tire.

The Illinois State Department of Transportation operates an emergency service patrol in the Chicago area known as the “Minuteman” patrol. Operating since 1961, the Minutemen mitigate over 100 000 incidents per year, with an average cost of USD 55 per incident. These services have been estimated to provide a benefit-cost ratio of 17:1 based on an annual reduction of 9.5 million hours of delay, amounting to USD 95 million in annual savings.

Dynamic route information panels (DRIPs) (NL)

Dynamic route information panels, known as “DRIPs”, are controlled from one of five traffic control centres that monitor the motorway network in the Netherlands. Other traffic management systems operated from these centres include motorway management, access control systems, and bridge and tunnel monitoring. The motorway traffic management system provides the traffic control centres with data on traffic intensity every four seconds. Using a simple algorithm, the central computer calculates the length of the tailback. The information on the DRIP displays is updated every other minute. At present, DRIPs are used to provide five types of information: route information, route choice information, information about road obstructions, information about other incidents, and weather and road conditions. Strategies have been developed to ensure that the text displayed on the panels is clear and easy to read at a glance.

Studies carried out in 1997 and 1998 on Rotterdam’s ring road showed DRIPs’ direct impact on traffic distribution. Significant effects were measured in terms of traffic congestion reduction as a result of traffic re-routing.

Motorway driving in the Netherlands is relatively safe and, in comparison with other roads, relatively few accidents occur on Dutch motorways. One major cause of multiple pile-ups on the motorways is the need to brake suddenly for slow-moving or stationary traffic at the back of an unexpected traffic jam. The traffic jam may have been caused by an accident further ahead or by road works.

The motorway traffic management system warns road users well in advance that they should reduce speed when they are approaching a traffic jam. When approaching an incident, the system displays a reduced speed limit of 70 km an hour, and immediately before the accident or traffic jam, a speed limit of 50 km an hour. The system can also warn drivers that they are approaching fog or road works.

The information is displayed on overhead gantries, with matrix signals spaced approximately 300 to 500 metres apart. A variety of driver information can be displayed including speed restrictions, a red X for a lane closure; lane-change arrows; and an “all clear” sign.

The data from traffic detectors are sent to a central computer at one of five traffic control centres. The computer automatically controls the matrix signals when a traffic jam builds up and ensures that the system warns road users to reduce speed well in advance.

A significant portion of the 2 200 km of motorway in the Netherlands has now been equipped with the system. This traffic management system has resulted in a decrease in the number of secondary incidents and has lead to significant traffic flow improvement. In addition, the system has greatly increased the safety of road workers, allowing entire stretches of road to be quickly and easily closed for road works.

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Chapter 9

PREFERENTIAL TREATMENT

Description

Preferential treatment is used to improve the travel speed, safety, reliability and attractiveness of other modes to encourage modal shifts from solo driving to other transport alternatives.

Preferential treatment measures described in this section include bus and high-occupancy vehicle (HOV) express lanes, HOV by-pass lanes at highway on-ramps, bicycle/pedestrian facilities, and traffic signal pre-emption.

- *Bus/HOV lanes.* Special lanes typically used during peak travel hours, giving priority to buses and often to other vehicles transporting a designated number of occupants, such as carpools and vanpools.

- *HOV by-pass lanes.* Special lanes that allow high-occupancy vehicles to by-pass ramp meters or have their own meter, thus eliminating or reducing queuing and improving travel time.

- *Bicycle/pedestrian facilities.* May include the provision of lanes separated from vehicular traffic, and special features such as lighting or grading.

- *Traffic signal pre-emption.* A special-purpose traffic signal control function that gives priority to public transport and/or emergency vehicles. Typically, it is used in conjunction with bus lanes or tram routes.

Objectives and major impacts

Road management authorities use preferential treatment measures to encourage solo drivers to change their mode of transport and to increase the appeal of other transport options. These measures optimise existing road capacity while minimising the new investment required to meet growing travel demand. It is important that these measures enhance travel, making it more reliable, convenient, efficient and comfortable.

Application of measures

Bus lanes

Priority bus lanes facilitate the operation and flow of public transport. Many of these special lanes are designated for use during peak congested periods, offering riders a faster commute. The use of bus lanes combined with traffic signal pre-empting can make travel by public transport faster and more convenient than that by private car.

HOV lanes

HOV lanes are special lanes reserved for use by buses and sometimes also by carpools and vanpools. They are typically located adjacent to general purpose or unrestricted lanes. An HOV lane can be newly constructed, converted from a general-purpose lane or created from a lane-widening project. HOV lanes can operate in one direction or be bi-directional (reversible) lanes, and can either be barrier-separated or designated using pavement markings.

HOV lanes are prevalent in North America, and an inventory conducted in January of 1998 reported 137 HOV projects totalling 1 790 lane kilometres on the continent (Federal Highway Administration, US Department of Transportation, 2000). Elsewhere, according to a 1992 report, HOV facilities were in operation in 16 other metropolitan areas worldwide (Turnbull, 1992). Non-exclusive HOV lanes on arterial streets constitute the largest number of applications globally. These types of projects were identified in at least 75 cities in 1992.

The effectiveness of HOV lanes is largely dependent on monitoring and enforcement. On some systems, surveillance cameras located at regular intervals are used to monitor vehicles and identify violators.

Bicycle/pedestrian facilities

Bicycle and pedestrian facilities are critical to encouraging and facilitating use of these modes. Bicycle ownership in several OECD countries is quite high, as illustrated in Table 9.1.

Table 9.1. **OECD Member countries with significant per capita bicycle ownership**

	FY	Total number of bicycles (10 000 units)	Number of bicycles per person
Netherlands	1997	1 650	1.00
Denmark	1995	450	0.91
Germany	1997	6 300	0.77
Norway	1995	300	0.71
Sweden	1995	600	0.71
Japan	1997	7 274	0.59
Belgium	1995	520	0.53

Source: Association for Promoting the Bicycle Industry (1998), *Handbook of Statistics on Bicycles*, Japan.

In the Netherlands, where bicycle ownership is highest among OECD Member countries, excellent cycling paths have been in existence for over 30 years. The city of Tilburg has cycling paths located every 500 metres throughout the city. With increasing concern and public awareness about global warming and suburban sprawl, the Netherlands is particularly active in promoting cycling. With one-quarter of its land already lying below sea level, the Netherlands is particularly vulnerable to the potential effects of global warming on reducing landmass. Consequently, the Dutch Bicycle Master Plan was created to expand a network of cycle paths and bicycle lanes from 2 000 km to 19 000 km between 1990 and 1996. The plan includes strategies to the year 2010 to encourage modal shifts from the car to the bicycle and to public transport. The plan also promotes safe cycling and provides information on bicycle-parking facilities and tips to prevent theft.

Denmark also actively promotes use of both bicycles and public transport. To discourage car use, a national policy imposes a 200% tariff on cars (see Chapter 5). More cycle paths are under construction in the city of Århus, where the flow of car traffic into the one square kilometre city centre has been severely limited. Increased cycling has revitalised shops in the centre city, and now 20% of all trips into the city are taken by bicycle, with 30% of all trips taken by public transport.

The City of Paris, France, is developing a bicycling network in response to a major public transport strike that nearly paralysed the city in 1995. Authorities constructed a comprehensive series of 150 km of cycle paths between 1996 and 1998, attempting to provide bicyclists with good access in and around the city.

In general, the organisation responsible for roads is charged with implementing total road design. Where the establishment of bicycle lanes is involved, the road authority must design intersections and control road traffic carefully, so as to maintain the targeted traffic speed while at the same time maintaining safety and smooth traffic flow. The existence of such facilities make cycling a safe and efficient alternative to solo driving.

Traffic signal pre-emption

Traffic signal pre-emption is widely employed throughout Europe. More than 90% of all Swiss intersections give throughway priority to trams. In recent years, advances in information communication technology have enabled the use of traffic signal pre-emption systems to expand. These systems can be used in conjunction with information systems that convey the real-time arrival of buses and trams and operational conditions to users, and as an operations management information tool used by bus operators (see Chapter 4).

To highlight one example, trial implementation of a Public Transport Priority System on bus lanes is underway on a portion of National Highway Route 35 in Sapporo, Japan. Systems employ two-way communication between optical vehicle detectors installed along bus lanes and devices installed in buses to control the bus priority response system at traffic signals. This warns vehicles travelling illegally on the bus lanes and provides bus operators with operations management information. A 6% reduction in waiting time at traffic signals was achieved, bus ridership increased by nearly 13% (12.7%), and the level of traffic decreased by 21.7%. Accrued annual economic benefits of this system are estimated at JPY 69 million.

Institutional responsibility for implementation

Preferential measures are commonly included as part of a larger TDM package. The co-operation of national, regional and local institutions involved in traffic management is indispensable in implementing these measures. TMAs involving partnerships between industry and government and related institutions are particularly effective in implementing TDM measures. Road management agencies responsible for TDM implementation are required to formulate plans based on the status of traffic congestion, and to evaluate the effectiveness of TDM measures in reducing congestion.

Effects on travel patterns

Exclusive bus lanes can significantly reduce travel time for public transport users, thus making this mode of transport superior to other options. For example, in Dublin, Ireland, bus lanes have reduced travel time by 20%. Up to 60% of Dubliners who currently use public transport formerly drove cars. (See examples section at the conclusion of the chapter).

Assessing the regional impacts HOV lanes on travel patterns is often difficult given the lack of a methodology that can directly attribute improvements to their existence. Some evidence from the United States indicates their effectiveness in promoting ridesharing. The California Department of Transportation (Caltrans) has studied the effects of adding HOV lanes on existing highways along State Routes 210 and 110 in Los Angeles County. Between 1992 and 1997, Caltrans noted a 25% growth in the number of carpools using the HOV lanes during morning peak hours (Long, 2000). On other highways in the region without HOV lanes, Caltrans observed either no change or a decrease in the number of carpools. Another Caltrans study conducted on an HOV facility along State Route 55 in Orange County, California, had similar findings (Giuliano *et al.*, 1990). The carpooling rate increased despite no significant increase in ridesharing among the population of Route 55 commuters. Therefore, the existence of these HOV lanes appears to have increased carpool formation and use.

HOV facilities have also been implemented throughout Europe and Asia. In December 1999, the City of Madrid, Spain, initiated an HOV facility as a way to maximise existing roadway capacity in an environmentally protected area. As a result, travel time in the urban area fell from 35 minutes to 12 minutes and bus ridership increased by 16%. In Troisdorf, Germany, a system of exclusive bikeways increased the number of cyclists by 5% between 1988-96. Terraced bus stops have been introduced in Osaka, Japan, which feature bus terminals on parking shoulders that allow traffic to pass while the bus is picking up or discharging passengers. The bay-shaped part of the bus stop is used as a sheltered waiting area for passengers. Efforts have been made to ensure that the bus-waiting areas are comfortable, with attractive planters and special pavements.

Cost-effectiveness

Bus lanes usually do not require new or extensive infrastructure investment, as most are created from the existing infrastructure. Depending on the situation, the establishment of barriers, the use of special colours for pavement surfacing and the upgrading of bus stops may be needed.

In most cases, bicycle and pedestrian facilities are created through redistribution of the existing road space, but some up-front investment in road system infrastructure is sometimes necessary. As in the case of the Dutch bicycle road systems, it is desirable to position such city-based efforts within a national government traffic system project and to establish clear and comprehensive project goals.

Traffic signal pre-emption is cost-effective because it can be put in place within the existing traffic system infrastructure. IT technology and advances in traffic control technology are increasing the use of traffic signal pre-emption.

Special problems or issues

In Japan, where it is difficult to secure space for cycle paths, cycling on sidewalks is permitted. Consequently, accidents involving elderly pedestrians and bicycles occur frequently and the introduction of exclusive lanes for bicycles has been actively pursued in recent years.

Bicycling in some metropolitan areas can be dangerous, particularly if exclusive bicycling lanes are not provided. Public campaigns to educate the motoring public about driving safely in the presence of bicyclists and pedestrians are critical. TMAs and other similar organisations often undertake such efforts.

Conclusions

- Preferential treatment is used to encourage solo drivers to change their mode of transport by improving the travel speed, safety, reliability and attractiveness of alternative modes. Preferential treatment measures include bus and high-occupancy vehicle (HOV) lanes, bicycle/pedestrian facilities and traffic signal pre-emption.

- Preferential measures are commonly included as part of a larger TDM package, and require the involvement and co-operation of local, regional and national institutions in order to be successful. Partnerships between public and private sectors are particularly effective in the implementation of TDM measures.

- The effects of preferential measures on travel patterns vary, and impact assessment is often difficult due to lack of methodology to directly link improvements to the existence of bus lanes, HOV lanes or other measures.

- Preferential treatment facilities are extremely cost-effective because they are often created through redistribution of existing road space and thus require minimal investment in new infrastructure.

- Problems with preferential measures include difficulty in securing space for new traffic corridors, particularly for cycle paths. Biking can be particularly dangerous in urban areas and public campaigns to educate the public about road sharing are critical.

EXAMPLES – BUS LANES

Bus lanes – Copenhagen, Denmark

As in many OECD cities, Copenhagen has established separate bus lanes, thereby providing preferential treatment to public transport. The system has significantly increased bus access to the city centre (although the lanes do not cover all stretches of the road network) and has thereby made the bus system more attractive to commuters.

Quality Bus Corridors – Dublin, Ireland

Quality Bus Corridors (QBCs) are part of the Dublin Transportation Office's short-term action plan for 1998-2000. A dozen QBCs were constructed in and around Dublin to expedite travel of the 800 city buses operating during peak hours.

The increased efficiency of the bus fleet was expected to draw 3 500 additional passengers during the morning peak hour. Preliminary results report that buses are now travelling 20% faster than cars during peak hours. Along with higher service frequency (one bus every minute during peak hours), an increase of 20% in the market share for buses is expected during peak hours. Between 40 and 60% of the new passengers are believed to be former solo drivers. By the end of 2000, Dublin planned to have established a comprehensive QBC network.

Key route buses – Nagoya, Japan

A key route bus service with special bus lanes has been added to complement the existing subway in Nagoya. Together, they comprise a systematic transport network. The buses travel on special bus lanes in the centre of the road, and special transport islands have been built on these lanes to allow passengers to alight and disembark. Moreover, traffic signal pre-emption for key route buses eliminates unnecessary stops at intersections and facilitates operation by reducing travel time.

Bus lanes – Almere, the Netherlands

All major roads in Almere have exclusive bus lanes. Intersections feature traffic signal pre-emption system for buses and special gates are designed to prevent illegal lane changes. Bus stops are arranged at intervals of about 600 metres to increase bus speeds (ordinary bus stop intervals in Netherlands are about 400 metres). Corresponding to bus stop intervals, housing zones are districted by city planning in circles within a 400-metre radius from each bus stop.

The daily ridership of Almere's bus system is 20% higher than the national average of 13% due to its high level of service, offering reliable, eight-minute headways.

CARPOOL LANES/HOV

United States

El Monte, California

This project offers a good example of the effectiveness of HOV lanes in per person throughput. The El Monte Busway, constructed in 1973, was originally intended exclusively for buses. During a transit strike in 1976, the lanes were opened to carpools and vanpools with three or more occupants, and have subsequently remained open to all HOVs. A 1997 traffic count documented that a single, westbound HOV lane on the El Monte Busway carried 49% of all the travellers in the corridor during peak hours compared to the remaining four mixed flow lanes combined which carried the remaining 51%. Of the HOV lane users, 49% were bus riders, while the remaining 52% were carpoolers, vanpoolers or motorcyclists. (For safety reasons, motorcyclists are allowed to travel on the HOV lanes in California.)

San Francisco-Oakland Bay Bridge, California

This project offers a good example of HOV lanes' effectiveness in throughput on tolled facilities. Solo travellers pay a toll to cross the San Francisco-Oakland Bay Bridge, while buses, carpools, and vanpools cross free of charge. In 1998, the four HOV lanes carried approximately 63% of all westbound travellers crossing the bridge during the morning commute, compared to the 18 mixed-flow lanes that carried the remaining 36% of travellers. A Caltrans commuter survey conducted in 1995-96 found that 48% of the westbound drivers formed their carpools by picking up riders in the vicinity of the Bay Bridge (termed "casual carpoolers"), and 31% of the carpoolers credited the existence of the HOV lane as their primary incentive for carpooling.

In 1999, 60% of the carpool respondents to the annual survey of Bay Area commuters stated that the existence of the HOV lanes influenced their decision to carpool. In addition, 64% reported that they would discontinue carpooling if the lanes were eliminated.

Orange County, California

On State Route 55, one lane in each direction has been converted into an HOV lane. This route links two major Southern California regions, Orange County and Riverside County. The HOV lanes are in operation 24 hours a day and can be used by cars carrying two or more persons. During morning peak periods, these lanes carry between 1 000 and 1 500 cars, transporting between 2 300 and 3 200 commuters.

Pittsburgh, Pennsylvania

A reversible HOV lane separated from regular lanes is in operation on State Highway 279. Separated by a concrete barrier in the median strip, this lane can be used by buses, vanpools and cars carrying three or more persons in a city-bound direction from 5:00-12:00 and in the opposite direction from 14:00-20:00.

Since its establishment, the number of cars using this lane during morning peak periods has increased from 146 in 1989 to 345 in 1991, and the number of users from 1 100 to 2 200. During an experiment conducted in 1992 when the lane was opened to carpools of two persons, 868 cars and 2 600 people used the lane during morning peak periods.

Bellevue, Washington

A TMA in Bellevue, Washington implemented a programme to encourage carpooling among its employees. Carpooling increased from 9 to 18% as a result of reducing car park rates by half for carpools and allocating them preferential parking spaces.

New Jersey

Due to the American public's longstanding misperception that HOV lanes are under-utilised, there is increasing pressure to convert HOV lanes back to general-purpose lanes. This perception is largely due to commuters' observation of HOV lanes as being virtually unused when compared to the adjacent, congested general-purpose lanes. Even though the HOV lanes carry more people in fewer vehicles than the general-purpose lanes, it is erroneously believed that the HOV lanes would accommodate more travellers if converted to general-purpose lanes.

As a result of mounting public pressure, in November 1998, the New Jersey Department of Transportation converted two of its HOV facilities to mixed-flow or general-purpose lanes. The two converted facilities are located on Interstates 80 and 287, respectively.

Preliminary observations suggest that the conversion of the Interstate 80 facility has resulted in an increase in the number of vehicles in the corridor above the historic-growth level. This increase is probably attributable to the disruption of carpools and vanpools, and new vehicles being drawn to the highway to take advantage of the additional capacity.

Melbourne, Australia

Operation of an HOV lane on Eastern Highway, a major trunk road joining the eastern outskirts of Melbourne with the city centre, commenced in February 1992. Operating from 7:00-9:30 Monday to Friday, usage is limited to cars carrying two or more persons, buses, taxis and motorbikes with permits. Travelling times for cars using the HOV lane fell by approximately nine minutes and costs were reduced by AUD 1.1 million annually.

Fargemeinshaften – Salzburg, Austria

The goal of the *Salzburg testet Fahrgemeinschaften* demonstration project was to encourage participants to rideshare. Commuters in areas surrounding the City of Salzburg were encouraged to leave their cars at home or at special parking lots and use only one car (*e.g.* a "carpooling car") to continue their journey.

The following incentives were provided to promote this scheme:

- Car parks were provided at a dozen locations.
- Reduced-fee, preferential parking was offered at public garages.
- Preferential on-street parking was available.
- Preferential car parking at the work place was available.
- A carpool matching and information centre was established in October 1997.
- Carpoolers could receive a ride home at half price.

A telephone hot-line providing information and a ride-matching service were established. Participants in this carpooling scheme received a membership card that enabled them to claim all the benefits of this demonstration.

Leeds, United Kingdom

The Leeds HOV lane demonstration project was initiated in May 1998. This dual, two-lane A647 Stanningley Road radial route into Leeds from the west was the first HOV scheme introduced on an urban road in Europe. The HOV lane was located in the inside lane, nearest to the curb, to allow buses to continue servicing existing bus stops, and opened to buses, motorcycles, bicycles and vehicles carrying two or more people in both the morning and evening peak periods.

The project was intended to provide throughway priority to the 30% of carpools of two or more occupants travelling during the morning peak periods. In June 1999, morning peak HOV journey time-savings of four minutes were reported for a 5 km trip from the Leeds Outer Ring Road to the Inner Ring Road. Non-HOV journey times also improved, thereby increasing the advantage of the A647 over alternative routes through residential areas.

At a roadside survey conducted in July 1998, over half (58) of the 102 HOV drivers interviewed reported that the HOV lane had been beneficial to them, and over one-quarter (26) said they had formed new carpools. In November 1999, the Leeds City Council made the HOV lane permanent.

BICYCLE AND PEDESTRIAN FACILITIES

The Dutch Master Plan – the Netherlands

The Dutch Bicycle Master Plan (BMP) largely shaped bicycling policy in the 1990s. The BMP's national subsidy financed the construction of nearly 700 km of bicycle routes. Between 1990 and 1996, provision of bicycle paths and lanes increased by approximately 2 000 to total 19 000 km. The BMP has also supported bicycle parking facilities and theft prevention devices.

Exclusive bikeway – Troisdorf, Germany

The establishment of roads and cycle paths in Troisdorf City is a significant part of its municipal transport plan. To that end, the "Troisdorf City Bicycle Traffic Concept" was formulated in 1986-87 and, in 1989, a model bicycle project was initiated as part of the state government's "North Rhine-Westphalia State: Bicycle-friendly City Gemeinde". This project's main feature was to designate cycling paths/bicycle priority routes on existing roadways.

In 1993, the cycle path network within the city was extended by 50 km. A "Veloroute" was established consisting of four kilometres and approximately 30 widened intersections specifically for bicycles. In addition, 16 pedestrian islands were converted to give priority to bicycles. According to a survey conducted in 1996, the percentage of bicycle users in Troisdorf increased from 16 to 21% during the period 1988-96.

Exclusive bikeway – Strasbourg, France

In Strasbourg, bicycles are promoted as an environmentally friendly and economical means of transport. A programme for providing a large-scale cycling path network is being implemented in conjunction with this promotion. A total of 160 km of bicycle lanes, rental facilities and patrolled cycle parking areas have been provided to encourage cycling, and three facilities rent bicycles at FRF 20 per day. Currently, bicycles are used for 15% of all trips in Strasbourg, with plans to increase this rate to 25% in the future.

Rent-a-cycle system – Amsterdam, the Netherlands

In the spring of 1998, a self-service, rent-a-cycle system was introduced in Amsterdam. Some 40 depots, each with about ten bicycles, were established within the city. A parking space at the desired destination can be reserved in advance for those who wish to “park and ride”. Rental fees are NLG 12 per day, and a pre-paid card is required to access and unlock the rental bike from its space. A similar system, "call-a-bike", has recently been implemented in Munich, Germany, using public pay phones to locate the bicycles.

Rent-a-cycle system – Copenhagen, Denmark

In April 1997, the existing rent-a-cycle system in Copenhagen, Denmark, was converted to a free, self-service system. A DKK 20 coin is required to use a bike, which is remitted upon return of the bicycle. As a result of the programme, the number of bicycle thefts in the city fell by 15% between 1994-95, declining by an additional 12% the following year. In the future, the programme aims to provide free bicycles through corporate sponsorship.

TRAFFIC SIGNAL PRE-EMPTION

Public transport priority system – Sapporo, Japan

In 1996, a demonstration project of a public transport priority system was conducted on a bus lane of National Highway Route 35 in Sapporo. This system provides buses with priority throughway at intersections, using two-way communication between optical vehicle detectors installed along bus lanes and devices installed in buses. The system also cautions vehicles travelling illegally on bus lanes and provides bus operators with operations management information.

The trial reduced operating time by 6%, and increased bus ridership by nearly 10% over the previous year, increasing to 12.7% six months later. A 21.7% decrease in traffic on the trial routes was achieved, giving rise to economic benefits with an estimated value of JPY 69 million annually.

KOMFRAM System – Göteborg, Sweden

The “KOMFRAM System” tracks the position of all trams and buses in the city, and conveys real-time information to users on their status and operation. With this system, buses and trams transmit information to their route computers via magnetic loops and radios located underground at each stop. Based on this information, route computers adjust signals, station message boards and the direction of tram routes. On-board computers record time and location as well as making automatic announcements. Public transport use increased by 30% between 1991 and 1996.

BON – Hannover, Germany

In the 1980s, a traffic management system known as BON was initiated. BON provides users with public transport arrival times by automatically detecting the position of the vehicles and co-ordinating this with scheduled operation timetables. This system incorporates traffic signal controls that give priority to trams.

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Chapter 10

PUBLIC TRANSPORT

Description

Public transport is a key TDM tool that can contribute to the fulfilment of a variety of societal goals including (Ferreri, 1992):

- Providing general mobility.
- Providing access to employment and educational opportunities.
- Shaping urban development towards a sustainable future.
- Reducing traffic congestion in key travel corridors.
- Producing savings in energy consumption.
- Reducing automobile emissions.

Public transport carries a significant proportion of peak period commuters in many OECD cities throughout the world. Even in some of the largest American cities where car ownership is high, public transport accounts for a majority of downtown-bound work trips.

There are a number of ways to increase public transport usage. Four types of improvements include:

- *New services* including new public transport routes and lines, employer buses and new public transport systems.
- *Improvements to existing services* including increased frequencies, reduced travel times, improved facilities for waiting and boarding, etc.
- *Supporting services* to complement line-haul public transport services, such as Park-and-Ride lots, intermodal terminals and shuttle connector services.
- *Improved information and marketing* to enhance user familiarity with the system and to promote the benefits of the system.

Other measures to improve public transport and increase ridership, such as pricing (fare discounts and financial incentives for using public transport) and preferential treatment for buses aimed at reducing travel times, have been covered in Chapters 5 and 9, respectively.

Objectives and major impacts

Public transport service improvements can entice motorists to shift their mode of travel, thereby contributing to reduced traffic congestion and air pollution. Service improvements aim to make public transport as convenient and attractive as possible in order to counter the advantages of the private automobile. Travellers perceive improvements such as reduced waiting times and more frequent service as far more important than reducing the time spent in the public transport vehicle. Supporting services to make public transport use more convenient include the provision of seamless connections, feeder systems, and amenities at transport boarding areas. Improved information and marketing is designed to highlight the simplicity and reliability of public transport.

Evaluating public transport improvements should be based on increases in ridership and a calculation of automobile trips reduced, or by decreases in road volumes or parking occupancy. Therefore, it is extremely important to know what proportion of new users of a given service switched from driving alone and what proportion switched from other routes or other modes, such as carpooling, bicycling, etc. For example, the Congestion Pricing Pilot Programme in San Diego described in Chapter 5 funded a new express bus service in the corridor. Over 80% of the riders had no car available to them for the trip, and 90% of these riders used other public transport routes before using the new express service; resulting in a net effect of 10% new passengers.

Application of measures

Public transport systems can be found throughout the OECD region, including bus routes, on-demand services, trams, and light or heavy rail systems. Service expansion or improvements are most often implemented to meet new travel markets or growing demand, expand or complete service coverage in an area and/or make the existing public transport system more efficient and effective.

New service

In many urban areas, the potential exists to provide public transport services to activity centres or growing residential areas that are not presently served. The service could be a brand new route (for example, the Inland Breeze express bus service funded with toll revenue in San Diego, California) or service extensions (for example, the Capelle metro extension in Rotterdam or the opening of the Lille metro in France). In addition, "tailored" service can be provided to specific employment sites (for example, the First Hill Express in Seattle). These new services can be provided by the area's public transport operator, by private operators, or by a co-operative of riders ("buspools") (Kuzmyak and Schreffler, 1993).

Improvements to existing services

Many studies demonstrate that bus service improvements that result in decreased waiting time or travel time are more effective than fare reductions in increasing ridership (Pratt, 2000). A study by the Danish Ministry of Transport showed that a 20% reduction in time spent on public transport has a greater impact on use than a reduction in fares. One means to reduce waiting time is to increase the frequency of service and reduce headways. In San Diego, revenue from bridge tolls was used to increase the frequency of bus service to Coronado Island employment sites, thus reducing automobile trips on the bridge. In Seattle, an agreement between the public transport operator and local employers and a large university led to increases in service and the provision of additional buses in off-peak

periods. Travel times can be reduced via priority treatment of public transport vehicles (see Chapter 9), such as the key route bus service in Nagoya, Japan. In Denmark, the national railway company has succeeded in increasing ridership through service improvements, and has been able to reduce travel times to key provincial cities by using bridges and tunnels over/under the Great Belt.

Supporting services

To make public transport more attractive to potential users, especially those currently driving a car, supporting services and facilities are often needed. Park-and-Ride systems are common among OECD Member countries and are considered a convenient collection system for public transport in outlying areas. Users can drive their cars to the lot and take public transport for the most congested portion of their trip. Park-and-Ride systems are also becoming widely used for large special events, such as concerts and sporting matches.

Supporting facilities can include multimodal centres that allow for convenient transfer between modes such as bicycle storage at rail stations (26 000 bicycle parking spaces offered at 72 metro stations in Copenhagen) or transfer centres at major transportation hubs (such as the *Transferium* at the Ajax football stadium in Amsterdam).

Other support includes guaranteed ride home programmes, providing, for example, a taxi ride home if unscheduled overtime work or a family emergency requires a trip home at a time when public transport is unavailable. Support services can also include prepayment and integrated fare payment to allow for easier use of public transport. Fare prepayment in the form of transit passes or tickets is quite common. Less common are integrated ticket systems, in which a single ticket provides access to a variety of transport modes such as train, bus, ferry and even taxi. In Denmark, transport users previously needed several tickets for long journeys that combined train and bus or metro travel. Today, a single train ticket provides free use of the local bus or metro network, making public transport a substantially more attractive option. In the Netherlands and Germany, for a nominal fee, transport users can take a taxi trip to or from the train station. In Strasbourg, users of peripheral parking lots are given return tram tickets to the city centre. Daily or off-peak public transport passes for families are becoming more common, including the *Ticket Liberté Famille* in Lyons and the *schöne Wochenende Karte* on the German railways.

Finally, many "trunk" public transport routes and rail lines are fed by connector or shuttle services that transport riders from termini or stations to employment centres or major event venues. Shuttles are used to link commuter rail stations to employment sites or, in some cases, to link high-density residential complexes to rail stations. For example, a shuttle bus operates between Tyson's II, a major regional shopping and employment centre in Northern Virginia and a suburban metro station in West Falls Church, just outside Washington, DC.

Improved information and marketing

Public transport use should be made "user friendly" and provide clear and accurate information before and during the trip (as discussed in Chapter 4, Traveller Information Services). This begins with the operator's basic awareness of its potential market of users, and design of materials tailored to this clientele. In 1998, the French government organised a public awareness day aimed at reducing auto traffic in city centres. The objective of the "*In town without my car"* public campaign, now held annually in many European cities every September, was to publicise and encourage the use of other travel mode options. Clearly, marketing alone in the absence of convenient and attractive public

transport will not prompt drivers to leave their cars. However, good marketing of effective systems provides potential public transport users with practical information that facilitates their use of these alternative travel options.

Institutional responsibility for implementation

In most OECD Member countries, the bulk of funding for public transport comes from national, provincial/state or local governments. In the United States, the federal government provides capital funding and operating subsidies that are generated from state gas tax and local sales tax revenue. Typically, municipal or regional operators that are owned or franchised by government provide transport as a public service. In the past, public transport operators were viewed as a public utility.

A movement in the 1970s and 1980s to privatise public transport in the United States and the United Kingdom led to a certain amount of deregulation that resulted in private vendors operating many public transport services. In other cases, private vendors are able to competitively bid on routes and services. This desire to increase competitiveness within the public transport industry is currently being debated in EU member states.

Increasingly, the private sector is also being solicited for public transport funding. Many private employers have implemented their own employee bus systems to enhance their ability to recruit and retain employees, including *Reader's Digest* and *National Geographic* magazines in the United States and Philips Electronics in the Netherlands. Employers and developers have also helped to capitalise and subsidise public transport by co-funding service or, as with the case of the U-PASS programme in Seattle, guaranteeing the purchase of a specified number of monthly bus passes.

Effects on travel patterns

Most of the service improvements and expansions can and have increased public transport usage. However, most empirical evidence shows that public transport service improvements (and fare reductions) are inelastic with respect to demand. Therefore, a 1% increase in frequency or coverage results in less than a 1% increase in ridership. This relationship is true both for new express and local bus service.

The key to assessing whether public transport improvements could reduce road travel demand is being able to estimate how many automobile drivers are likely to be attracted to the service. Most ridership evaluations have found that 50% or fewer riders of a new or improved service switch from driving alone, with the majority of riders coming from other public transport services or routes (Pratt, 2000). Other methods include assessing changes in traffic volumes on area roads or reductions in automobile vehicle kilometres of travel (VKT). However, quantifiable changes in traffic volumes associated with changes in public transport services have never been empirically measured. One source stated: "Normally, the proportion of urban travellers using public transport services and the impact of service changes are small enough at any one location and point in time that auto traffic impacts cannot be seen and isolated from other events" (Pratt, 2000). One evaluation of new and expanded bus services estimated the effects of these improvements on VKT in ten cities in the United States. The reduction was estimated at 0.13% in larger cities and 0.03% in smaller cities (Wagner and Gilbert, 1978).

Several of the examples used in this chapter point to some short-term or localised impact on traffic levels in the corridor or areas served by new or enhanced public transport services. The opening

of the Lille metro slowed road traffic growth in the city by one year. A new commuter shuttle bus system in Hamamatu, Japan, resulted in a peak-period traffic reduction of 3.1% and 8.3%, respectively, on the two bridges entering the city. The implementation of a Park-and-Ride system for tourists visiting the Kenroku-en gardens in Kanazawa, Japan, eliminated four kilometres of queues and reduced the travel time from the highway exit to the gardens from nearly two hours to just 20 minutes.

Priority treatment for public transport vehicles can also benefit automobile users. A signal priority pilot programme implemented as part of the EU CENTAUR project resulted in a 10% reduction in bus travel times overall and a reduction of over 20% during peak congestion periods with no appreciable negative impact on general flow. Moreover, the system led to an overall time-saving of 5% for private cars travelling on the same roads.

Improved information can contribute to increased public transport patronage. The introduction of telephone and Internet sales and major improvements in caller inquiry services are cited among the factors that led to a 21% increase in railway passengers in Britain between 1995 and 1999.

Cost-effectiveness

Operating costs for public transport are usually highest during peak periods, when transport vehicles are operating at maximum capacity with the highest load factors. Typically, premium fares are charged during peak periods. An evaluation of almost 60 pilot projects in California provides some figures on the cost-effectiveness of line-haul public transport and shuttle services. The cost per vehicle trip reduced (*i.e.* automobiles removed from the road) ranged from USD 0.22 to USD 35.00 for line-haul bus services and from USD 3.68 to USD 75.00 for shuttle services. The equivalent cost per mile of travel (cost/VMT) reduced was USD 0.03 to USD 2.20 for line-haul service and USD 0.05 to USD 27.70 for shuttles (Pansing *et al.*, 1998). The evaluation concluded that public transport service improvements were moderately cost-effective, with express line-haul bus service improvements being far more cost-effective than shuttle services. Shuttles were generally seen as having higher costs and lower ridership. These public transport projects were also seen as being less effective and less efficient than vanpool projects or those involving financial incentives or disincentives.

Special problems or issues

The principal challenges for public transport are derived from the same travel and transport impediments which face all modes of travel. The traffic congestion that frustrates motorists can slow "express bus" services unless preferential treatment is provided via high-occupancy lanes, signal pre-emption and other means to provide priority for public transport vehicles. Travel patterns are changing; with the journey to work becoming an increasingly smaller proportion of all trip making. Trip chaining is becoming more prevalent as travellers need to make stops along the way to drop off children at school, use their car for business trips, and travel longer distances to shop and seek entertainment.

Public transport must either become more flexible to serve a larger variety of needs, or be better targeted in the travel markets that it serves. As stated earlier, public transport will continue to serve a significant proportion of work trips to city centres in high-density corridors. The remaining question is whether land-use patterns and public transport innovations can effectively and efficiently serve lower density areas.

Packages with other measures

Public transport is most effective when supported with complementary measures, especially:

- Preferential treatment for public transport vehicles.
- Parking at rail stations or Park-and-Ride lots for express bus service.
- Accurate and accessible information before and during the trip.
- Subsidies for public transport users in the form of financial incentives to employees, sports spectators, etc.
- Integration of modes at intermodal centres.

Other chapters in this report suggest that these complementary measures are key to increasing public transport ridership and, therefore, reducing automobile use by shifting private car drivers to buses, trams, trains, etc.

Conclusions

- Increasing public transport ridership through the introduction of new and supporting services, improvements to existing services, and improved information and marketing will increase general mobility, promote sustainable urban development, reduce traffic congestion and emissions, and save energy.
- Improved public transport services can motivate drivers to change their travel behaviour; service improvements viewed as most important by travellers include reduced waiting times and more frequent service. Public transport options may include bus routes, on-demand services trams, and light/heavy rail systems.
- Operating costs for most forms of public transport are highest during periods of heavy use; studies show that service improvements are moderately cost-effective. Evaluations of public transport should be based on increases in ridership and decreases in traffic volumes and car travel.
- The challenges facing public transport are similar to those facing other transport modes; these include sensitivity to congestion, changing travel patterns, and diverse travel needs. Public transport is most effective when combined with other TDM measures.

EXAMPLES

Metro line extension to Capelle – Rotterdam, the Netherlands

In 1994, a new extension of the Rotterdam metro was opened to the large conurbation of Capelle aan den Ijssel about 10 km from the centre of Rotterdam. The new extension provided a more direct public transport link for area residents working in Rotterdam, reducing average travel times by 25-30 minutes each way. Between 1994 (the opening of the metro extension) and 1998, public transport use increased by 48% and ridership increased from 8 250 daily users to 12 200 in 1998. Work trips made by automobile from Capelle decreased from 64 to 53% during the same period. The share of public transport use increased from 21 to 23% and Park-and-Ride use doubled from 3 to 6%.

An evaluation in 1998 determined that the new metro extension had significantly increased public transport use and decreased automobile use. Between 1994 and 1998, traffic volumes on the major highway link between Capelle and the Rotterdam Ring decreased by 8%. While not all of this decrease can be attributed to the metro line, it certainly was a large contributor, given the increase in public transport use. At the same time, office and retail development in Capelle was also likely to have influenced travel patterns in the region.

Free bus service – Hasselt, Belgium

In 1997, free public bus transport was instituted in Hasselt, a town of 100 000 inhabitants located in the Limburg region of Flanders in Belgium. At the same time, the city's bus network and service frequency were markedly improved, and the fleet was increased from eight to 27 buses while the number of service routes was more than doubled from four to nine.

In 1998, the inner city ring road was transformed into a "one-way" road with preferential treatment for public transport. In late 1997, an evaluation of bus riders determined that one-third of the travellers made trips they would not otherwise have made due to the free fare. Of the two-thirds of the riders who had undertaken the same journey before fares were eliminated, 25% drove and 32% walked or cycled. Consequently, the free fare did induce some car drivers to give up their cars, but it induced more riders to make new trips or switch to transit from non-motorised modes.

In 1998, the cost of new facilities was estimated at EUR 2.5 million and the cost to subsidise bus operators' lost income estimated at EUR 600 000. Since this experiment was evaluated, persons under 12 and over 65 can travel free of charge on buses in Flanders.

Multimodal integration and service improvements – Copenhagen, Denmark

Several improvements have been made to the Danish national railway system and to Copenhagen's public transport system. Previously, a separate ticket was needed for the long-distance train service and the use of a connecting city bus or metro train. Now, all passengers with a train ticket can also use the metro or bus without incurring an extra charge.

Improvements include: better terminal facilities, closer proximity of train and bus loading areas, and improved rail travel times to and from Copenhagen through the use of tunnels and bridges under and over the Great Belt. In addition, 26 000 bicycle-parking spaces have been provided at 72 metro stations around Copenhagen, averaging about 360 spaces per station. Bicycles may be brought aboard metro vehicles for a small fee. All of these improvements have made public transport more attractive and have increased the business of the national railway company and regional public transport provider.

ClubCard, Vitesse Arnhem – the Netherlands

The city of Arnhem has instituted a mobility management plan for spectators attending football matches at the Gelredrome sports field. Fan club members of the Dutch football team Vitesse Arnhem can ride for free on public transport in Arnhem for two hours before and after each match by displaying their "ClubCard". Shuttles from satellite parking areas to the sports field are provided, in addition to 16 000 bicycle-parking spaces located nearby. For rail passengers, bus service is provided from the central train station in Arnhem. The implementation of the mobility plan led to the following mode split for spectators attending the football matches: 35.5% arrived by train and public transport, 10.5% walked or cycled, 28% used the satellite parking and shuttle service, and approximately 15% parked at the venue (Hamersveld, 1999).

Shuttle bus system for commuters and school children– Hamamatu, Japan

In this sprawling city, schools, factories and industrial centres located in outlying rural areas were poorly served by public transport. Consequently, workers primarily commuted to these facilities by private automobile.

To reduce traffic congestion, shuttle bus services were implemented from various parts of the city to each of the large schools and main factories. In May 1998, there were 71 shuttle buses operated by 40 different transport companies, with a total ridership of about 500 commuters. In addition, 30 express school shuttles carried 900 riders. The new system reduced peak traffic at the two bridges serving the city by 3.1% and 8.3%, respectively.

Park-and-Ride at a shopping centre – Kanazawa, Japan

To reduce commuter traffic from the southern part of the Kanazawa, a Park-and-Ride system was established in the parking lot of a large shopping centre. To use the lot, participants purchase a bus pass and gift certificate at the shopping centre. The bus serving the Park-and-Ride lot partially operates on an exclusive lane that reduces the normal 23-minute travel time to the city centre by five minutes. About 150 riders are using the service, and patronage is increasing, prompting the need for more spaces in the Park-and-Ride lot. It is estimated that a reduction of 600 vehicle trips is needed to decrease traffic to an acceptable level.

Park-and-Ride for tourists visiting Kenroku-en – Kanazawa, Japan

Since 1988, a Park-and-Ride system has been in operation to reduce tourist traffic to the Kenroku-en (a Japanese garden located in the city centre). During several days every May, visitors may park and ride to the gardens for a fee of JPY 1 000 per car. Shuttles operate from two 650-space parking lots located near the west and east exits off the Hokuriku highway. The shuttle buses operate at six-minute intervals. Travel time reliability is maintained with the use of a one-kilometre temporary bus lane leading to the central district and one-way street regulations imposed around Kenroku-en. Some 2 000 cars use the Park-and-Ride system each day from both the west and east exits. The Park-and Ride system has eliminated the previous 4.1 km queue to the gardens, and the time required to travel from the highway exits to Kenroku-en has been reduced from 114 to a mere 20 minutes.

Tyson's Corner/Fair Lakes shuttles – Northern Virginia, United States

Tyson's II is a large development in suburban Virginia that includes office buildings, high-density residential complexes and a regional shopping mall. In 1986, a private bus operator instituted a shuttle bus system between the development and the West Fall Church metro-rail station. The shuttle's operating cost is subsidised by Fairfax County. The service transports residents to the metro station in the morning and shuttles commuters and shoppers from the station to the development. In 1991, the service was carrying about 300 riders per day. In the morning period, 46% of the riders were travelling to the metro station, while 54% were travelling from the metro station to Tyson's II.

Fair Lakes is another suburban office/residential/retail complex in Fairfax County, Virginia. In 1988, the same private operator began operating a shuttle service between the development and the Vienna metro-rail station. The shuttle service is free, and the complex's developer recoups the fees through charges to the apartment and building managers. The shuttle carries about 240 riders per day, with over two-thirds of the passengers travelling to the metro station in the morning and the remaining one-third using the shuttle to travel from the station to their office in the Fair Lakes complex.

Children's' Court Shuttle – Los Angeles, California, United States

In July 1992, a shuttle service was initiated to link a regional busway/commuter rail station to two new Los Angeles County buildings. The objective was to encourage some of the 800 employees and 400 daily visitors to use public transport rather than drive to the site. On average, 239 employees and visitors used the shuttle service each day. The shuttle reduced 16 760 vehicle trips annually and 835 000 miles of travel. The shuttle was moderately cost-effective, costing USD 3.02 per ride, USD 19.90 per daily vehicle trip reduced and USD 0.40 per mile reduced. The evaluation of the project concluded that the shuttle succeeded in providing non-automobile accessibility to visitors, but did not influence an increase in ridesharing and public transport use among county employees to the new site (COMSIS Corporation, 1996).

First Hill Express – Seattle, Washington, United States

The First Hill area is a major activity centre located just outside downtown Seattle. The centre is comprised of seven medical institutions, one university and several large medical office buildings totalling almost 15 000 employees. Parking is limited and public transport service inadequate as it most often requires a transfer downtown.

In 1988, Seattle Metro, the regional public transport provider, initiated a special express bus service for First Hill employees from six Park-and-Ride lots as part of a unique public/private partnership. In exchange, employers purchase a minimum number of monthly passes in order to subsidise the operation of the express bus service. Employers then resell the passes to their employees, many at a discounted rate. Many support services are also provided to First Hill pass holders, including a taxi back-up service for mid-day and evening trips. First Hill pass holders can also use any bus in the metro system. The First Hill Express Service has been credited with increasing public transport ridership among participating employers by as much as 75% (Kuzmyak and Schreffler, 1993).

Anaheim commuter express bus service – Orange County, California, United States

A commuter express bus service was implemented in 1994 to serve three suburban communities, downtown Anaheim and the Anaheim recreation area. The service was a partnership of the City of Anaheim and five private employers, including Disneyland. Fare subsidies were offered to riders and were initially higher for city employees than for private employees. A single bus, known as a buspool or subscription bus, carried 15-20 regular daily riders and 5-10 part-time riders. An evaluation of the service concluded that marketing the service to part-time riders and user subsidies made the buspool viable. The bus service reduced 3 600 vehicle trips per year and 650 000 miles of travel (Acurex Environmental Corporation, 1996).

National Geographic buspools – Maryland, United States

In 1974, the National Geographic Society implemented a buspool service in conjunction with the relocation of its bindery plant from downtown Washington, DC to suburban Maryland, 20 miles away. Some of the 1 200 employees did not have access to an automobile for commuting, and transit service to the new site was inadequate. In order to minimise the inconvenience to its employees, National Geographic contracted a local bus company to provide buspool service on 11 routes, most of which served reverse commutes from the District to Maryland. The routes from Washington, DC served 850 daily commuters, or about 35% of the workforce (Kuzmyak and Schreffler, 1993).

Reader's Digest magazine implemented a similar service in the 1920s when it relocated its headquarters from New York City to suburban Westchester County and its ridesharing programme is still in existence.

Integrated mass rapid transit, light-rail and land-use planning – Singapore

The Singaporean cities of SinChoa Chu Kang, Sekang and Pungool offer good examples of integrated public transport and land-use planning. A fully automated light-rail transit system was opened in April 1998 connecting the Bukit Panjang New Town to the MRT system at Choa Chu Kang. In Sekang, a comprehensive light-rail transit system, expected to open in 2002, is integrated with an MRT station. Sekang is the first new town in which light-rail has been planned from the outset. An industrial development will be built on top of the MRT depot to optimise the use of land. Punggol will also have an integrated MRT/LRT system with most of the flats located within 300 metres walking distance from the nearest LRT stop.

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Chapter 11

FREIGHT MEASURES

Description

Although many of the TDM measures described in other chapters apply to both goods and passenger vehicles, this chapter concentrates solely on freight travel demand. Freight transport represents an important sector of industry in its own right. In the United Kingdom, for example, it accounts for nearly 4% of gross output. Much of the change in goods traffic comes from the industry itself.

One major factor in the development of freight transport is the increasing globalisation of trade. Consequences of globalisation include: increased distance from point of production to point of sale, increased complexity of logistics networks and increased lead times that cause inventory levels to rise.

In all OECD countries, it has been noted that an increase in the average length of haul is the single most important determinant of the increase in goods traffic. Some of this is a consequence of the increasing intensity of trade (as a proportion of countries' industrial output), which in turn comes from the opening of trade barriers. For these reasons, freight demand cannot be isolated either from other transport markets or from its socio-economic context.

Increasingly, goods transport is becoming more integrated with the industry it serves (ECMT, 1999). Just-in-time delivery organises the logistics around the production processes involved. Industry now looks at the combined costs of transport and warehousing, with a view to minimising total costs. Accordingly, the measures herein must be considered along with the land-use policies discussed in Chapter 2.

Commercial pressures and competition are leading companies to carefully examine their transport costs, as falling transport costs should lower costs for the product transported, thereby increasing demand for the product. These savings can be substantial. In the United Kingdom, during the decade 1988-98, the ratio of manufacturing stocks to output fell by 20%, resulting in savings of GBP 17 billion (EUR 27.75 billion) for industry, with further savings of GBP 11 billion (EUR 18 billion) for the wholesale and retail sectors (DETR, 1998). The freight transport industry is considering further cost-cutting improvements including:

- Reducing empty vehicle running, by locating suitable return loads.
- Improving vehicle specifications, particularly with regard to aerodynamics and power-train specification, which can reduce fuel consumption by 20% (DETR, 1998).
- Improving driver training which can reduce fuel costs by 8% or more (DETR, 1998).

- Creating more environmentally friendly transport systems.

- Eliminating delays in journey through better route planning.

Objectives and major impacts

The demand for goods transport is driven by the demand for the goods themselves. Since demand stimulates production and consumer purchases that fuel an economy, the objective of many measures is not to reduce demand, but rather to maximise the efficiency of freight transport through improved loading and routing, improved vehicle design and use, and intermodalism. The Dutch Transactie/Modal Shift Programme offers a prototype to assist the freight transport industry in achieving these efficiency improvements (see examples section at the conclusion of the chapter).

Unlike passenger transport, where existing infrastructure can cope with increased demand (up to a point), encouragement of modal shifts in goods traffic often requires specialised infrastructure. The capital costs required can render the argument for modal shifts economically infeasible, even though there may be other strong reasons (environmental, for example) for it to be encouraged. The United Kingdom's Freight Facilities Grant and ULS-Schiphol have created a programme to haul freight using modes that support environmental objectives (see examples section at the conclusion of the chapter). Similarly, the bilateral agreement between the EU and Switzerland, which includes a distance/weight-based tax on heavy goods vehicles, is designed to influence modal choice. This tax, combined with the provision of new Trans-Alpine rail tunnels, offers another strategy to meet the shifted transport demand.

To reduce traffic, some OECD countries have limited or banned freight vehicle transport during peak periods and/or through city centres with limited manoeuvrability. A ban imposed by the City of Sapporo aims to shift the timing of deliveries to off-peak hours, without necessarily reducing the number of trips. Other countries, such as Denmark, are attempting to improve the loading efficiency of vehicles specifically in the central city (see "City Logistics" in the examples section of this chapter). The need to restrict the entry of freight vehicles to city centres depends on the specific geography of the city in question, and the kind of industries to be served. The ability to provide an efficient and environmentally friendly alternative depends on the ability to find a suitable site for a city logistics centre or railhead, which is often determined by the layout of the city. The examples cited at the conclusion of this chapter are from European cities, which tend to be densely developed and based on medieval road layouts.

Application of measures

Measures to improve the efficiency of the logistics industry will continue to emerge wherever companies find opportunities to do so. Given the diverse nature of the industry, ranging from companies consisting of a single truck, a driver and a mobile phone to mega-corporations with thousand-vehicle fleets, a "one-size-fits-all" approach is particularly difficult. Government agreements with motor manufacturers can provide an impetus to develop cleaner and more efficient vehicles. For example, the EU voluntary agreements with the European, Japanese and Korean manufacturers associations on passenger vehicles is expected to have consequential effects on the energy efficiency and emission levels of light-duty vehicles.

Measures to encourage modal shift are being undertaken as the situation dictates. Where infrastructure investment can be justified on the grounds that it promotes more efficient goods

transport, it may be in a government's best interest to assist. One example of how government can promote rail over truck transport is through its finance and construction of train tunnels that permit the double stacking of containers.

In cases where freight is transported across international borders, different approaches may be warranted. The Swiss-EU bilateral agreement is a special case where international agreement is needed to avoid distortions of travel patterns due to intervening international borders. In May of 1999, international transport issues were discussed at an ECMT meeting where countries considered the legal harmonisation of transport systems within Europe; the increasing levels of trade between Europe and Asia; the obstacles which goods carriers encounter at border crossings; and potential future financing for transport infrastructure (ECMT, 2000).The advent of globalisation will require further co-ordination and collaboration among nations to facilitate freight transport across borders.

Institutional responsibility for implementation

The freight industry is keenly interested in controlling its own costs, remaining competitive and generating a profit. Governments in a number of OECD countries have financed pilot projects or provided infrastructure capital where an economic case can be made. Government at every level plays a role in regulation of freight traffic. Examples include the City of Sapporo which institutes time bans on goods traffic; the United Kingdom's, freight facilities grants funded by the national government, and the EU regulation on truck drivers' working hours (see examples section at the conclusion of the chapter).

Effects on travel patterns

The UK Government's award of nearly GBP 30 million (EUR 48.9 million) in freight facilities grants saved over 4 million lorry trips in fiscal year 1997-98, thereby demonstrating the importance of government support in affecting modal shifts for freight transport. Sapporo's lorry ban reduced on-street parking levels by 30%, suggesting that such restrictions improve loading efficiency.

The Swiss-EU bilateral agreement (OTA) aims to shift routes and reduce vehicle-kilometres travelled. Under the OTA, the Swiss anticipate two sharp decreases in the number of import/export vehicle-kilometres, first in 2001 and then in 2004. Experts predict a 20% reduction in vehicle-kilometres travelled from the baseline scenario by 2005 (although tonne-kilometres will rise). Initially, it is expected that the higher weight limit will bring some of the traffic diverted through France or Austria back to Switzerland. Subsequently, the switch to rail encouraged by the tax is expected to reduce the number of vehicle-kilometres which, by 2011, should be down to the baseline scenario. Until 2010, the Swiss expect the number of tonne-kilometres to be markedly higher than in the baseline scenario, notably owing to the increase in maximum authorised weight.

Cost-effectiveness

No data are available for this report on the cost-effectiveness of the examples, although some savings to the logistics industry were noted in the introduction.

Special problems and issues

Measures to promote greener modes (*e.g.* ULS-Schiphol or the United Kingdom's FFG) would in some cases be more effective if administered at an international level, given the global nature of trade. Measures of this kind might not be undertaken unless appropriate facilities can be provided for the entire link. City logistics programmes can result in an increase in the number of light-duty vehicles in the city centre, so that the total number of vehicles may not be reduced, but may even increase.

Packaging with other measures

Measures to reduce freight traffic often need to be considered in conjunction and co-ordination with land-use measures. Examples include the need to provide city logistics centres or parking spaces for freight vehicles when time restrictions are in force. Conversely, efforts to induce a shift from suburban shopping centres to city centre shops need to take account of how goods will be delivered. Grants to construct capital facilities will need to consider their relationship to land-use policies.

When economic measures are applied to goods traffic, the more specialised nature of goods vehicles and the longer lead times needed to make a modal shift should be considered.

Conclusions

- Freight transport constitutes an important sector of industry in its own right, and increased goods transport and globalisation of trade necessitates freight-specific TDM measures.

- Since demand for freight transport is linked to economic demand for the goods themselves, the objective of freight TDM measures must be to maximise efficient freight transport rather than reduce travel demand.

- The freight industry is receptive to any measures that can improve logistics efficiency, resulting in cost savings. The diverse conditions surrounding freight transport call for specialised solutions.

- Modal shifts in goods transport often require new, specialised infrastructure development, thus increasing cost. Freight traffic reduction measures must be considered in conjunction with both private sector parties and land-use policy makers at every level of government.

EXAMPLES

Bilateral Overland Transport Agreement – Switzerland

A bilateral agreement between the European Union and Switzerland, which became effective on 1 January 2001, aims to:

Enhance productivity, thereby reducing the number of vehicle-kilometres travelled by Swiss domestic and import/export transport.

Redirect some of the traffic currently diverted through France and Austria to Switzerland (GS UVEK, 2000).

An increase in the maximum authorised weight (MAW) limit, together with a mileage-related heavy vehicle tax (MRHVT), will have a direct impact on the forecasted volume of freight traffic (for vehicles over 3.5 tonnes MAW) in Switzerland over the next few years, compared to the baseline scenario (the current 28-tonne limit and no MRHVT). The tax, proportional to MAW and distance, is also dependent on the European emissions category of the vehicle. Under the agreement, Switzerland will raise the maximum authorised weight to 34 tonnes on l January 2001, and to 40 tonnes in 2005. During the transitional phase (to 31 December 2004), there will be a quota on reduced-rate journeys across Switzerland for a limited number of 40-tonne vehicles and light or unladen journeys.

Efficiency and modal shift analysis and implementation – the Netherlands

The Transactie/Modal Shift Programme in The Hague provides consulting services to transport and forwarding companies in an effort to reduce vehicle-kilometres (not vehicle trips). These services include implementation of various measures (such as planning, vehicle technology, management information, cargo balancing, decentralised warehousing, and mode shift). The government partially subsidises the costs of the consultants, as well as some of the implementation costs.

City centre lorry bans – Japan

To reduce traffic congestion in the city centre, Sapporo experimented with restricting goods-vehicle loading/unloading to 9:30-11:30 and 14:30-16:30 between October 1997 and February 1998. The ban reduced loading times, as operators sought to make the most efficient use of the time available.

City logistics – Denmark and the Netherlands

City logistics are receiving increasing attention as a means of reducing freight transport through better co-ordination of different vehicles and better use of available storage capacity in each vehicle. In Odense, Denmark's third largest city (185 000 inhabitants), a study has shown excellent potential for reducing freight-transport, pollution, and energy consumption by establishing a city logistics terminal, located just outside the city centre. The study estimates that total freight traffic could be reduced by 2% through use of lorries with a maximum weight of six tonnes. While this practice would reduce energy consumption and CO_2 emissions by 15%, the study estimates it would increase hydrocarbon emissions by 14%. If smaller vehicles are used, total freight traffic rises by 2%, but CO_2 and other types of pollution are significantly reduced. The system has been implemented to some degree in Copenhagen, but not yet in Odense. Similar studies are underway in Amsterdam, Tilburg and Hertogenbosch (the Netherlands).

Freight Facilities Grants (FFGs) – United Kingdom

To increase the use of rail for freight transport, the UK Government created the Freight Facilities Grant (FFG) in 1975. FFG is intended to influence freight companies' choice of rail, where a purely commercial decision would be to transport goods by road. The grant contributes a percentage of the rail-related capital costs; specifically, those incurred solely by the company's modal choice of rail over road.

The Railways Act of 1993 requires freight train operators to pay charges for access to the rail network. These charges are normally passed on to the customer via the operator's haulage charge, thereby deterring companies' choice to use rail. To compensate, the Railways Act of 1993 also introduced a new rail freight grant, called the Track Access Grant (TAG). This is specifically designed to help defray the cost of rail access charges for freight traffic that would otherwise be hauled by road. Almost 250 projects have benefited from these grants since 1975, for a total of over GBP 185 million (EUR 301.3 million). The UK Government has increased the budget by ten times its initial level, and intends to extend the grants to cover coastal and short-sea shipping as well as railways and inland waterways.

Underground Logistic System (ULS) – Schiphol Airport Amsterdam, the Netherlands

ULS-Schiphol is a public-private partnership project that will link the flower auction centre near Schiphol with the airport and a new rail/freight terminal (Ondergonds logistiek Systeem Schiphol). The project will employ intelligent vehicles and automatic terminal handling of unit loading devices and other small load units and small containers. The project aims to create more reliable transport between the flower auction centre and the airport, and to affect a modal shift (for European journeys) from road to rail transport or airfreight. The project is in the preliminary design phase, but discussions continue about the possibility of smaller load units and tunnel size.

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Chapter 12

IMPLEMENTATION AND COMBINATIONS OF DIFFERENT MEASURES

Description

Implementing comprehensive change

Experience throughout the OECD region has shown the following factors critical in implementing successful TDM measures:

- Packaged, complementary solutions are usually more effective than a single measure.
- Public and corporate involvement is important in gaining sufficient support for and understanding of planned measures.
- Public information and education can increase the potential for change and make measures more effective.
- Formulation of a clear vision for the future is vital.

Influencing and affecting the public's travel demand and choice of modes can require education, behavioural and lifestyle changes and the existence of feasible transport options and incentives. The ECMT noted that "even tough measures can find acceptance if the measures in question are related to clearly-defined objectives, and there is sufficient co-ordination between the different levels of authority" (ECMT, 1995).

Objectives and major impacts

Influencing travel behaviour and reducing transport demand requires a strategically tailored policy package to affect the greatest impacts. The advantages of implementing TDM measures in combination with other strategies are detailed below:

Policy package advantages

- Enables the establishment of a stable strategy for the future based on broad coalitions.
- Comprehensive strategies involving institutional reforms are more effective than individual measures implemented on an *ad hoc* basis.

- Any negative impacts from individual measures may be counterbalanced or compensated for by other elements in the policy package.

- It is easier to communicate packaged initiatives to the public.

- Synergistic impacts may be realised whereby the combined effects are greater than the sum of the effects of the individual measures.

Application of measures

Criteria for implementing demand management measures

While some change in travel demand is achievable through promotion and voluntary action, affecting wide-scale change requires a comprehensive re-orientation of the policies, perks and penalties that motivate travellers' decisions and influence their choice of mode. Such an effort could impose costs on parts of society and require behavioural and lifestyle modifications. If such efforts are to gain public support, it is essential that political and administrative decisions be made on the basis of relevance, involvement, choice, effectiveness and equity, as described below.

Relevance

Demand management policies should be linked to commonly perceived and tangible problems. Once a common understanding of a problem is established, public and political consensus can be sought for an appropriate solution. For example, the general public is probably not cognisant of the link between their use and choice of transport modes and the subsequent production of greenhouse gas emissions. When publicly acknowledged as a major policy issue, appropriate actions can be pursued, and support can be solicited through well-targeted public-awareness campaigns.

Involvement

Demand management planning requires public involvement to design strategies and measures that affect communities and quality-of-life. Participation of citizen and corporate stakeholders is critical to ensure successful implementation. The integration of strategies through co-ordination and co-operation is also essential.

Choice

If TDM measures and packages are to succeed, it is vital that a range of viable options be available from which individuals and companies can select. Options must provide attractive alternatives to single-occupancy vehicle travel in the form of transit services, carpooling, cycling, walking, etc. Virtual mobility, changing land-use patterns, new organisational paradigms for home and work life, and logistics innovations are among the aspects which may further enhance and expand these options.

Effectiveness

Assessing the effectiveness of TDM measures arises during the planning process and following implementation. In the planning process, cost-benefit analyses of each measure and strategy

considered and of alternative ways to achieve the same objectives should occur. Following implementation, careful evaluation of results should help policy makers, planner, and programme managers fine-tune these measures.

Equity

An equitable distribution of burdens is based on the principle that one gets what one pays for and pays for what one gets – unless a public subsidy is justified. Arguments for that should then be clearly stated and the rules governing the subsidy must be transparent.

The three types of equity related to transport planning and implementation include horizontal equity, vertical equity with regard to income and social class, and vertical equity with regard to mobility need and ability (Litman, 2000):

- *Horizontal equity*. This is concerned with the equitable allocation of cost and benefit allocation across individuals and groups that are considered comparable in wealth and ability. In current transport systems, the price users pay does not accurately reflect the costs they impose on society in terms of externalities such as pollution, congestion and accidents. Costs are thereby passed on to other individuals or groups.

- *Vertical equity with regard to income and social class*. This focuses on the allocation of costs between income and social classes. According to this definition, transport is most equitable if it provides the greatest benefit at the least cost to disadvantaged groups, thereby compensating for overall social inequity. This definition is often used to support transport subsidies and oppose price increases.

- *Vertical equity with regard to mobility need and ability*. This is a measure of how well an individual's transport needs are being met compared to other community members. It assumes that everyone should enjoy at least a basic level of access, even if people with special needs require extra resources. Vertical equity by need/ability tends to focus on two issues: access for physically disabled people to public facilities; and support for transit and special mobility services. The lack of standards for transport needs and the determination of a consistent way of measuring access encumbers the implementation of this concept.

Institutional responsibility for implementation

From a public policy perspective, it is useful when local and regional TDM initiatives are tied to national or international policies and guidelines. This enables pursuit of a general course of action aimed at influencing travel demand and provides a basis for common evaluation. TDM strategies have several characteristics that influence the substance and scope of policy intervention. Implementation of such measures may be directed to a specific site such as a transport plan for a company, on an area-wide basis, as in regional or community growth management strategies, or to both.

A second policy consideration for TDM measures is their ability to be orientated to different markets, as described in Chapter 1: *the trip market*, managing the need or desire to travel; *the transport market*, influencing travellers' choice of mode; and *the traffic market*, managing the use of the infrastructure.

Since the planning process often bridges traditional institutional and jurisdictional boundaries, successful implementation of demand management programmes may require new forms of

organisation in government, and partnerships with and among businesses, public authorities, citizens and stakeholder groups. Some changes along this line have already occurred. For example, the United Kingdom has formed a new institutional arrangement to integrate transport, local government and regional planning decisions in the Department of Transport, Local Government and Regions. Within the European Commission, the former separate directorates of transport and energy have been merged into a single directorate.

Effects on travel patterns

Evaluating combined effects of demand management

If TDM measures are to be taken seriously, rigorous evaluation techniques are necessary. Quantitative measures are needed to substantiate anecdotal information on costs, benefits and effects. In this respect, there is a need for consistent evaluation methods to enable accurate compilation and comparison of data across time and countries. Schreffler (1994) recommends that "Future evaluation measures should focus on vehicle trip, net trip, and vehicle miles/kilometres of travel reductions. In order to make demand management measures more operational and gain valuable experiences, tailoring the results of evaluative exercises to the user's needs is necessary." By establishing rigorous evaluation of demand management measures, it becomes easier to exchange experiences and to select the right instruments to apply to real-world situations.

A study of 50 US employers demonstrates the effectiveness of packaging various measures. These employers experienced an average trip-reduction of 15.3% among their "successful" TDM programmes. Employer programmes that focused on financial incentives and disincentives realised a 16.4% reduction in employees' vehicle trips to work, while employers that provided commute alternatives such as vanpools and shuttle buses to proximate train stations realised an average trip reduction of 8.5%. Most revealing, however, was that programmes that *combined* incentives and improved commuter alternatives realised an impressive 24.5% trip reduction. In contrast, employer programmes that focused solely on promotion and information realised a net *increase* in trips of 1.4%, thereby underscoring the need for additional measures to reduce employees' drive-alone rate.

Table 12.1 suggests a model for organising future evaluations of TDM measures on a variety of socio-economic factors.

Table 12.1. **TDM evaluation model**

TDM evaluation matrix format

	Economic costs	Congestion	Environment	Safety	Social inclusion
The trip market (managing the desire to travel)					
The transport market (managing travellers' choice of mode)					
The traffic market (managing road users' use of the road network)					

TDM measures' effectiveness can be evaluated quantitatively in terms of the reduction or diversion of vehicle trips and vehicle miles/kilometres. There are, however, qualitative effects to be taken into consideration, such as how the measures influence the attitude and behaviour of people and businesses in question (*e.g.* do travellers feel motivated to change their behaviour, and do certain initiatives create aversion or even anger? Moreover, how do concrete initiatives influence institutional and organisational patterns of society?). Three types of potential impacts include (Danish Environmental Agency, 1998):

- Effects on knowledge and attitudes ("soft" effects):
  - Change in peoples' knowledge about different transport opportunities.
  - Change in peoples' attitude toward different transport opportunities.
  - Change in peoples' use of transport opportunities.
  - Change in peoples' traffic and transport related behaviour in general.
- Effects on traffic and environment ("hard" effects):
  - Change in the level of traffic.
  - Change in the composition of traffic.
  - Utilisation rates in the transport system.
  - Concrete use of specific transport services.
  - Environmental effects.
- Effects on time use and congestion.
  - Economic effects.
- Effects on planning and management:
  - Dissemination of TDM concepts.
  - Management consequences of TDM measures in relation to other types of solutions.
  - Change in the practice and attitudes of traffic and transport companies, private business and public authorities.
  - Change in institutional relations and the positions of power within transport planning.

Cost-effectiveness

The US National Association of Regional Councils commissioned a study of the relative cost and effectiveness of TDM measures as part of a general evaluation on the effectiveness of transport control measures. The three most effective types of measures identified were those related to pricing,

mandatory employer trip-reduction programmes, and land-use planning, respectively (Apogee Research Inc., 1997).

Another study, commissioned by the Transportation Research Board in the United States, cites the following elements as the most cost-effective TDM strategies in terms of reducing trips, kilometres and emissions:

- Financial incentives (*e.g.* vanpool, carpool and public transport subsidies).
- Financial disincentives (*e.g.* parking charges).
- Bicycle and walk-to-work programmes and subsidies (*e.g.* bike loan programmes).
- Parking supply management (*e.g.* limiting parking).

Special problems and issues

Policy package disadvantages

Implementation of a suite of measures can be complex and time-intensive and may involve compromises with stakeholders to achieve consensus. Combining some measures may actually be counterproductive (such as flexitime and vanpooling). As many effective TDM programmes include both incentives and disincentives, it is appropriate to implement the incentives first, and highlight the equity benefits that result. Once implemented, disincentives such as increased fuel prices, parking charges and traffic restrictions can follow.

Packaging of measures

The "packaging" or combination of complementary measures can create synergy, producing greater impacts than individual measures. Effective implementation of individual measures as described in this report will benefit from broad strategies that integrate initiatives within the different dimensions of the overall traffic and transport markets. This method also offers the advantage of identifying potential conflicts across measures before such new packages are implemented.

Possible packages of demand management measures

The following section offers six TDM strategies and guidance on the packaging of measures that have been or could be implemented together to realise the most effective results in influencing demand. These relate to the trip, transport and traffic markets previously described in Chapter 1.

Combining initiatives aimed at managing the need or desire for travel

Strategy 1*:* Provide viable alternatives to driving alone while gradually increasing road transport costs.

- Create Park-and-Ride lots at major approaches to large cities, allowing car drivers to park for free and switch to public transport (United States).

- Provide Internet access to electronic databases that can match and co-ordinate potential ridesharing partners (United States; Denmark).
- Establish safe and centrally located parking areas along the highway network for rideshare participants (Denmark).
- Improve quality and attractiveness of public transport (OECD-wide).
- Enhance car-sharing association membership and integrate car sharing and public transport through mutual discount arrangements and free parking sites for carpoolers at transit stations (Switzerland).
- Change transport allowances tax systems/cash-out parking subsidies in order to promote use of ridesharing and public transport for commuter transport (Sweden; Netherlands; Belgium; United States).
- Increase fuel prices and/or introduce road pricing. Use revenue to reduce labour market taxes, improve public transport and/or compensate low-income groups (United States).
- Introduce marginal pricing systems such as variable mileage/kilometre-based charges (United States).

Over the short term, responsiveness to fuel price increases or the introduction of road pricing can be expected to be weak. Motorists may simply choose to pay whatever it costs to continue driving. Theoretically, price elasticity of fuel price increases is rather low over the short term, but higher over the long term (see Chapter 5). Increasing the costs of car use without having viable alternatives in place risks derailing all efforts of a pricing strategy to internalise external costs. A dual approach, based on introducing better alternatives to car use along with a gradual increase of prices, is the preferred solution.

Strategy 2: Integrate land-use and TDM measures.

- Create institutional arrangements that allow for the co-ordination of land-use decisions and transport infrastructure investments, road traffic operations and public transport management (United Kingdom).
- Apply smart growth programmes focusing on higher densities, mixed-use and favourable mortgages for homes located in multimodal areas (Netherlands; Oregon, United States).
- Avoid construction of major leisure, shopping and cultural facilities outside city centres and along the highway network at the expense of development in the city (Denmark).
- Apply transit-orientated development and promote new urbanism focusing on the development of neighbourhoods that encourage walking, biking and transit use (Curitiba, Brazil).

One of the fundamental relationships in understanding how and why the transport system operates is the linkage between land use and transportation. The City of Portland, Oregon (United States), has institutionalised the land-use/development decision-making process. Portland's growth management strategy aims to reduce the dependence on the personal automobile for mobility in the region, and to co-ordinate transportation investments with land-use policies (Meyer, 1999).

Combining initiatives aimed at managing travellers' choice of mode

Strategy 3: Introduce green transport plans.

- Start by promoting voluntary transport plans to private and public companies (United Kingdom; Netherlands; Belgium).
- Improve alternatives to single-occupancy vehicle transport in terms of quality, reliability, price, etc.
- Add financial incentives for the use of alternatives possibly financed by parking pricing (Perth, Australia).
- Create local and regional TMAs (United States; Netherlands).
- Make free parking at the work place subject to taxation, thereby motivating employers to consider transport alternatives.
- Offer transport allowances that benefit ridesharing and public transport (United States).
- Require all major work sites to have green transport plans.

Experiences from the United States, the United Kingdom and the Netherlands show that transport plans implemented in relation to a specific work site are among the most effective measures to manage commuter traffic. An analysis conducted by the US Department of Transportation (DOT) based on case studies of 22 employer sites concluded that the right mix of TDM initiatives at individual employment sites reduced vehicle trips by an average of 20%.

Strategy 4: Implement traffic reduction measures in city centres along with logistics innovations for freight transport.

- Implement parking management in city centres (Bremen).
- Improve public transport to/from/in the centre connected to Park-and-Ride stations in the suburbs (Copenhagen).
- Promote show-rooms (where merchandise can be viewed) combined with lower prices if the good is collected from centres located at/close to Park-and-Ride stations.
- Institute freight transport regulations in the city centre.
- Improve co-operation between freight distributors, and increase use of technology to increase freight capacity (Munich, Nuremberg, Zurich, Amsterdam and others).

As described in Chapter 7, the City of Bremen, Germany, has achieved a significant reduction of car traffic in the centre through integrated parking management and improved public transport. German, Dutch, Swiss and British cities have improved city logistics through more efficient distribution of freight in city centres (The Danish Road Directorate/City of Aalborg, 2000). The City of Bremen is currently working to integrate these strategies.

Although the introduction of such a strategy might reduce levels of traffic in the city centre, it is unknown whether it will also reduce total levels of traffic. To date, experiences with city logistics projects indicate that while total energy consumption, emissions and traffic in the city decrease, the total level of traffic in a broader area might not necessarily decrease.

Combining initiatives aimed at managing the user's use of the network

Strategy 5: Institute road user charges in co-ordination with intelligent traffic management systems.

- Introduce a system of variable road user charges. Charges may vary depending on factors such as the time of the day, the congestion level and the type of roadway chosen for the given trip. Charges should be lowest in off-peak periods and on the highway network, thereby reducing traffic on arterial congested roads (Singapore).

- Use of variable message signs to display dynamic traffic information regarding delays and queues (Belgium), and estimated travel time (Paris, France). Use of a variety of media to convey information to travellers such as via the Internet (Oslo, Norway), cable television, highway advisory radio, a traveller advisory telephone system, and traveller information kiosks located in key areas such as shopping malls, transit centres and major employment sites (Maryland, United States).

- Make dynamic traffic information and route planning available on the Internet (Bavaria, Germany; Copenhagen, Denmark).

- Implement ramp metering on highways (Netherlands; Sweden; United States; United Kingdom).

A system of road user charges, combined with the provision of traveller information, provides a good basis for achieving results. Public acceptance might increase if people feel that traffic flow has improved as a result.

Strategy 6: Promote virtual mobility and a more flexible labour market.

- Define a national or regional telecommunication strategy promoting teleworking (Washington, DC, United States; Netherlands; United Kingdom).

- Promote the use of teleconferences instead of meetings whenever possible (SONY, BT, Picture Tel and Regus).

- Promote flexible working hours for the labour market such as staggered hours and the possibility to work part-time at home before coming into the office.

- Revise tax regulations on IT equipment and teleworking if feasible.

- Establish "virtual mobility centres" in central cities, where companies can rent rooms equipped with the newest technology for teleconferences.

- Provide incentives to reduce VMT among vehicles not used for commuting purposes.

While “virtual mobility” seems to offer some potential, it remains to be seen if greater use of telecommunications for teleworking, telecommuting and teleconferencing will contribute to overall decreases in travel demand. Combining telecommunications with flexible working hours can allow a more efficient use of the existing transport systems, allowing travel to be done outside of peak hours.

De Palma and Marchal (1998) investigated the combined impacts of separate TDM policies implemented sequentially. Drawing their hypotheses from an evaluation of new TDM measures in Geneva using innovative, dynamic traffic models, first, they argued that the impacts could be sub-additive since the policy impacts offer decreasing benefits. On the other hand, they argued that the results of a given policy could be minimal or even negative if the transport system is far from the social optimum. For example, information provision of alternative transport options will not be beneficial in influencing travel demand if the roads are under-priced. They stated that the benefits gained from a first policy to improve the transport system should enhance the impacts of a second policy.

De Palma and Marchal (1998) also investigated the combination of staggered hours/flexible hours and fuel pricing, and found that “the sum of the impacts of two policies implemented separately are not as great as the impact obtained when these policies are jointly implemented.” Their analysis shows that: *i)* it may be dangerous to perform partial analysis on subsections of the network; and *ii)* it is necessary to consider the whole set of policies, since separate evaluations may be misleading.

Conclusions

While there is close interplay between different types of measures and effects, their relationship and impacts are not well understood. There are many remaining questions about TDM that need to be addressed. Some of them include (Danish Environmental Agency, 1998):

- Are successful results achieved at one site or in one area transferable?
- Do results at one site or in one area bring real effects at a system level in the form of changed patterns of traffic and transport, reduced environmental degradation, etc., or are the results being overtaken by suppressed transport demand or an overall growth in traffic?
- Are results stable and sustainable over time or are effects diminishing by the replacement of the responsible transport co-ordinators in private companies or employees in public authorities, changed priorities at the executive level or the general increase in traffic?
- Do new priorities in local transport planning lead to a dominating influence of large companies?
- To what extent do changes in habits and attitudes lead to real reductions in traffic levels?
- To what extent are soft effects a prerequisite for hard effects?

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Chapter 13

TRANSPORT CHALLENGES FOR THE FUTURE

Description

This chapter outlines issues of concern to transport strategists in planning future mobility and influencing road travel demand. Two key factors for consideration include:

- How the proposed solution fits into the context of a sustainable transport system.
- The complex interactions between the markets for transport and the economy as a whole. How can these challenges be met without adversely affecting the economy? Can and should transport growth be uncoupled from economic growth?

A common underlying current to these issues relates to the difficulty in determining the true cost of transport. Many transport-related costs are rendered artificially low through government subsidises and coverage of externalities that are not borne directly by the user but by society as a whole. Raising environmental awareness has resulted in a slight internalisation of some externalities. For example, some countries have enacted national legislation holding vehicle manufacturers accountable for the recycling costs of vehicles, noise and pollution. Nevertheless, the external costs of travel remain substantial. Table 13.1 shows these external costs as a percentage of gross domestic product.

Table 13.1. **Estimated external costs of transport in OECD Member countries as a percentage of GDP**

Cost item	Road	Other modes	All modes
Noise	0.1	0.01	0.3
Local pollution	0.4		0.4
Global pollution			1.0 – 10.0
Accidents	2.0		1.5 – 2.0
Travel time	6.8	0.07	8.5

Source: Banister, 1998.

On the subject of externalities, Banister (1998) remarked "if these costs are not paid by the user, there is little incentive to make efficient decisions. Although people are aware of the environmental costs of transport and are supportive of actions by governments to improve environmental quality, it is only provided that it results in no change in their lifestyles and they can continue their use of the car, and provided that it costs no more". He concluded: "this is a problem with no solution". There need not be an overall cost to the economy as a whole, however, as "the macroeconomic impact of internalisation policies in general is likely to be very small" (SACTRA, 1999).

In exploring ways to meet future transport demand, the UK Government commissioned the Standing Advisory Committee on Trunk Road Assessment (SACTRA) to study the effects of improvements to transport links. The study unveiled some unforeseen detrimental findings and concluded that although improvements to transport systems may reduce costs for users of a particular link, they may also expose local firms to competition or induce additional traffic (SACTRA, 1999). Since the transport networks of the United Kingdom (like those of most OECD Member countries) are mature, it was difficult for SACTRA to identify clear, non-marginal economic growth stemming from transport investment. The study noted that "although there are clearly good reasons to believe a well-developed economy must have a well-developed transport system, it does not follow that marginal change in investment in transport in an already well-developed economy will necessarily have a big impact on either level or growth rate of income per head" (SACTRA, 1999).

Evaluating future transport projects

In planning future transport projects, officials in OECD countries must consider a wide range of factors in the context of fiscal and environmental constraints and their ensuing trade-offs. For example, the United Kingdom uses a taxonomy of factors to evaluate proposed transport projects, which provides a good planning model for other countries.

The genesis for this model occurred in July 1998, with the UK Government's published review of road projects, entitled: *A New Deal for Trunk Roads in England* (DETR, 1998). This report described the outcome of a strategic review of road-building schemes being planned or in progress, and outlined its intentions for the future. A portion of that document described a "new approach to appraisal". The new approach uses the government's five over-arching objectives as its basis:

- Protect and enhance the built and natural environment.
- Improve safety for all travellers.
- Contribute to an efficient economy and support sustainable economic growth in appropriate locations.
- Promote accessibility to everyday facilities for all, especially those without a car.
- Promote the integration of all forms of transport and land-use planning, leading to a better, more efficient transport system.

These criteria are, in turn, analysed using a sub-set of 17 criteria as illustrated in Table 13.2.

Table 13.2. **The new approach to transport project appraisal, United Kingdom**

Sub-criteria for project appraisal	
Environmental impact	Noise
	Local air quality (PM_{10} and NO_2)
	Carbon dioxide savings
	Landscape
	Bio-diversity
	Heritage
	Water
Safety	Accidents
Economy	Journey times
	Vehicle operating costs
	Journey time reliability
	Scheme costs
	Regeneration
Accessibility	Access to public transport
	Community severance
	Pedestrians and others
Integration	*Extent of integration*

Source: DETR, 1998.

The improved appraisal process in the United Kingdom includes the production of a one-page summary table that lists a proposed scheme's qualitative and quantitative impacts. The table does not require all factors to be priced, but where monetary costs can be derived, they are included. Consequently, the internalisation of all costs is not a basis for a cost-benefit analysis (CBA). Glaister notes that CBA "is still included as the final line in the Appraisal Summary Table [but] this is merely to provide continuity with previous appraisals, and it is not envisaged that this line should play a central part in the appraisal" (Glaister, 1999).

A number of economists and transport experts have commented on this appraisal process for roadway projects. Price notes that the United Kingdom's former process lacked transparency, focusing on overall economic benefits rather than localised environmental and/or local economic developments' impacts (Price, 1999).

Marshall (1999) offers a different analysis of transport systems and distinguishes trip substitution (by linking trips, by technology or by trip modification) and trip switching (mode, destination or shifting time of travel). This analysis cuts across the UK taxonomy in which shifting and trip linking are both classified under "use of the road network". This demonstrates the variability of appropriate classification systems.

The OECD's Working Group on Road Sector Performance Indicators examined the actions of individual Member countries in evaluating TDM projects and listed the following set of factors as important considerations for planning road projects:

- Accessibility/mobility.
- Safety.
- Environment.

- Equity.
- Community.
- Programme development.
- Programme delivery.
- Programme performance.

The group noted that when it comes to defining accessibility, "many of these measures also apply to social equity and community" (OECD, 1994). It appears sensible to simplify the classification, which considers all of the performance measures under the single heading of "social inclusion". The OECD working group focused as much on process as on outcome. For example, their measure of "community" includes "processes for public participation and procedures to reconsider prior decisions" (OECD, 1997). Glaister (1999) commented that: "To be useful, an appraisal technique must gain the acceptance of those who will have to be influenced by it". This applies to appraisals of proposals for future projects to influence road travel demand.

Other OECD Member countries are also testing transport project evaluation methods. The US Transportation System Management (TSM) Program emphasises economic factors in its assessments. Ferguson (1999) noted the "complex linkages between various TSM strategies, travel behaviour impacts, and desired policy outcomes, particularly the highly circuitous route air pollution reduction strategies must take in order to achieve measured success." The adoption of a broader view should allow for more direct appraisal of such factors.

Uncoupling economic growth and transport growth

Many OECD countries have explored the issue of uncoupling transport growth from economic growth. The UK Government charged SACTRA (1999) to examine de-coupling and to explore whether it would be possible to reap the benefits of economic expansion while reducing some of the negative effects of congestion and environmental impacts.

Two elements to this linkage are the contribution of transport to economic growth, and the effect of economic growth on stimulating movement (SACTRA, 1999). In an ideal world, the beneficial aspects of the former (sometimes known as the transport intensity of the economy) should be maximised while minimising the latter. However, the relationship between transport and the economy is complex and there is very likely to be a trade-off between the two.

It is necessary to be clear about the desired goal of uncoupling. Reducing the need to travel and reducing car dependency should be regarded as separate and distinct objectives, and they cannot necessarily be remedied with the same cures (Solomon, 1998). The objective of the SACTRA study was to identify policies and practices that can reduce growth in travel demand and traffic without sacrificing prospects for economic growth and competitiveness. Over the past 50 years, virtually all transport growth has been in the road sector, which accounts for the great majority of and demand for surface travel.

There is no firm consensus as to why transport growth should have grown in tandem with or faster than GDP growth across the OECD region. In part, this lack of consensus may stem from a lack of analysis. It has been noted that: "the state-of-the-art in developing a modern economic analysis of

the relationships between transport and the economy is relatively undeveloped." (SACTRA, 1999). Another commentator has expressed: "the excessively narrow conceptual and methodological paradigm which dominates urban transport studies [which] has tended to eschew *understanding* in favour of *prediction*" (Gillespie *et al.*, 1999). The problem is not confined to OECD countries. Bannister (1998) sees future transport growth lying "particularly with the emerging economies of Central and Eastern Europe and those of the Pacific Rim and stresses that over the longer term, the greatest growth is likely to be in China and India."

This relationship between investment in transport infrastructure and economic growth has been investigated by the OECD (2002, forthcoming). The RTR Working Group on this topic concluded that employment impacts and contributions to improved accessibility and social inclusion are unlikely to be created by transport investment alone. There is a need for a whole range of initiatives covering training, housing, social services, etc., in order to ensure that spending on regeneration will have the desired effect.

Income is strongly implicated in the link between traffic growth and economic growth. "The size of the income effect on traffic growth is large, and can be the most important single factor. The elasticity of traffic volumes with respect to personal income can often be close to one. Traffic can grow in proportion to income" (SACTRA, 1999). The link tends to be less intense as traffic levels reach saturation. An unexplored issue here is the distribution of income. The shift of wealth from rich to poor may shift resources from those with a low income and a low elasticity of demand for travel to those with a high elasticity.

An OECD workshop on sustainable transport development suggested four areas where work on uncoupling might be usefully concentrated (OECD, 1999):

- Sector-by-sector studies on the effects of current trends in transport provision and use.
- Transport prevention: better logistics; better weight-to-volume in freight shipments; removal of market distortions.
- Quality-of-life issues: shifting the demand for travel through pricing or e-commerce.
- Influences on modal choice.

Sectoral studies

The OECD workshop explored different sectors of the distribution system to better understand the link between transport growth and GDP. The workshop concluded that the most productive results are likely to come from focusing on personal travel, specifically within/from the leisure and holiday sector.

Over the past 40 years, leisure travel has become progressively less expensive, thereby increasing the number of trips. It has been estimated that by 2020, leisure activities may account for as much as 40% of all land transport (in terms of kilometres travelled) and 60% of air travel across all European countries (Banister, 1994). After a long post-war period of decline, movie theatre attendance is on the rise, and entertainment and leisure travel is also increasing. Today's cinemas are increasingly being located within multiplex entertainment centres on the edge of town or in suburbia, warranting an extended journey for city dwellers. This trend is likely to increase both trips and vehicles miles travelled.

While freight transport growth (measured as tonne-kilometres) has grown more slowly than GDP in Europe, passenger transport growth has exceeded GDP growth. Therefore, a focus on passenger transport is likely to yield the greatest results. This is not to say that the freight sector offers few potential savings in distribution costs and miles travelled. In fact, much is already being done by industry, as described in Chapter 11.

Changes in market structure, such as completion of the EU's internal market, and the establishment of free trade areas among the United States, Canada and Mexico through the North American Free Trade Agreement (NAFTA), should also be considered in de-coupling transport and economic growth. Some commentators have suggested that a poor transport system is itself a barrier to trade. SACTRA points out that where logistics firms shift to fewer distribution centres, "additional traffic is induced, thus increasing environmental externalities, such as pollution" (SACTRA, 1999). Some argue that this outcome is economically sub-optimal, although others suggest that, in fact, emissions are lower. GDP growth also stimulates freight growth by stimulating demand for more exotic goods.

Transport prevention

Technology provides a means to reduce the need to travel. The dynamics of communications technology are entirely different from those of a transport system. In an ECMT symposium, it was noted that "Physical networks adapt to new requirements at an extremely slow pace. It can take half a century or more to completely reconstruct a rail, road or even an airline network. In contrast, a new equilibrium of communication flows might be established within minutes" (Andersson, 1995). *The Economist* described how, "although the Internet is already affecting people's lives, a further transformation is essential if the hype about what you can do on line is not to fall flat. These are still early days for the Internet – it is about as developed as commercial flying was before the DC3 – and yet the transformation is already on its way" (*The Economist*, 1999).

One might, however, be sceptical of the effect of technology on travel. Andersson (1995) notes that, over the period of approximately 1825 to 1985, "the per capita growth of communication in France has been almost perfectly proportional to personal transportation, with a positive correlation close to one" (Andersson, 1995). This suggests that transport growth has outstripped GDP growth, as has communication growth. Developments in communications in the past (post, telegraph, telephone or television, for example) have not broken the link between transport and economic growth. Why should one be any more optimistic about the information revolution?

As noted earlier, land-use planning is a major determinant of the level of travel demand. However, bigger cities and longer journeys within them do not necessarily equate to more journeys. Evidence from the United Kingdom and Germany (Adams, 1998) shows that the average daily number of trips per person has hardly changed in the past 25 years. However, this trend is not the case for other countries, such as in the United States. While redesigning cities may lead to shorter journeys, it may not reduce their absolute number.

Quality-of-life issues

In today's fast-paced society, people have a need to travel for work, education and leisure. Solomon sees the growing intensity of transport as a feature of our "post-modern" culture: "One of the most outstanding features of the latter end of the twentieth century is an incessant amount of movement and an insistence on change… the endlessly expanding movement of goods, persons, images and ideas across a world transport and media system of roads, vehicles, fuels, electricity and electronics. It is how our culture operates, and is socialised and to some extent desensitised within that culture" (Solomon, 1998).

The basic human need for personal contact suggests that electronic communication will never replace all the travel that it could potentially replace. Too much uncoupling could simply make this trend worse. Adams (1998) argues that allowing teleworkers to spend more time at home does not necessarily mean that they are any more connected to their physical neighbourhood.

Changes in lifestyle are reflected in increased travel demand and variant travel patterns. For example, young people pursuing higher education are often required to leave home at 18 or 19, rather than later in life.[2] Having increased mobility from a young age can also create expectations for such future demand. Solomon (1998) observed that: "In general, it would seem, there is a direct correlation between adult power/status and childhood mobility". Demand for travel now may therefore be the result of social changes that occurred a generation ago. Furthermore, it suggests that it may take another generation to influence such behaviour.

Improved quality-of-life and the demand for novelty and change is also evident in taste for luxury goods and trips, notably in the selection of distant holiday destinations. Similar demands also affect freight and, indeed, "one of the main impacts historically of improvements in transport has been to reduce the costs of long-distance trade and thus to make markets better integrated" (SACTRA, 1999). Today's supermarket offers consumers international gourmet items and produce such as strawberries from Israel and beans from Zimbabwe. The transport system makes the provision of such out-of-season products possible.

Transport improvements might be thought, *prima facie*, to improve labour productivity by reducing the time spent travelling to work, and to expand the labour pool through improved access to jobs. Higher wages or lower prices can manifest these gains. However, as SACTRA (1999) noted, the effect on wages "might go either way, competition for local jobs by distant employees would tend to reduce local wages, while competition for workers by distant employers would tend to increase wages for local residents". Attitudes towards flexibility in the labour market, to "getting on one's bike" to look for work, can amplify or even reverse the expected economic benefit of a particular transport infrastructure improvement.

As roads and skies grow more congested, travel time has become less predictable. It is possible that as reliability of travel time decreases, transport users will build in the maximum expected cost, "just to be on the safe side". This would represent a wasted asset just as much as the congestion itself. Where an employer is paying for that time, travel time unpredictability becomes lost productivity and reduces GDP (since that employee could be more usefully employed on some other task). These trends are not irreversible. The Danish Council of Transport (1999) "does not consider needs as irrefutable facts, but rather as circumstances subject to historical change. Therefore, the need for mobility is viewed in the context of modern lifestyle developments".

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2. This is not an entirely new phenomenon. During the Second World War, many young British women leapt at the opportunity to leave home that was granted to them by conscription into the armed forces.

Modal choice

What makes an individual choose how to travel from one place to another? A prospective traveller considers and weighs different factors such as speed, comfort, price, privacy and accessibility. Today's public transport must provide travellers with efficient, convenient and reliable transport, particularly if it seeks to create mode shifts from the single-occupant car. Changing the public's behaviour and attitudes is a long and arduous process. Information needs to be made available on viable transport options in which the public has confidence.

Changing attitudes requires acknowledgement of the relative status of different modes. There are social and psychological influences affecting car use, and a tendency among motorists to consider car travel a right, rather than a privilege. Also, "driving has become one of the most important indicators of adulthood; it is widely considered more important than acquiring the power to vote" (Mackay, 1998). For all their sensitivity to environmental issues, many young people find the lure of the car irresistible. Such attitudes are not immutable, however. Gillespie *et al.* (1998) paint a picture of a "post-Fordist" city (Newcastle-upon-Tyne) in which "there was little evidence that non-car owning households aspired to car ownership" and "for home-based travel, the car has become incorporated into people's lifestyles, but these lifestyles appear not to have been built around car dependency". European data seem to confirm that car use is socially shaped, rather than being "the automatic consequence of economic level or population density" (Wickham, 1999).

Is car use self-engendering? Solomon notes that "seemingly, the more aggressive the ego, whether male or female, the more endless the demands for room in which to move and to be seen to move" (Solomon, 1998). To the extent that cars engender aggression, and aggression engenders the demand for mobility, perhaps human nature creates its own travel demands.

Sustainability

In exploring ways to create more sustainable transport systems, travel cost is a key issue. The environmental impacts of travel remain largely externalised (as illustrated in Table 13.1) The average car emits more than 2 billion cubic metres of pollutants during its years of service. Although this represents a major cost for society, it is not the only cost, since significant environmental damage is caused in the production process before the car even reaches the road. Moreover, the environmental impacts extend beyond the service life of the vehicle, when it has to be scrapped (Armstrong, 1994). There is a strong link between the uncoupling issue and sustainability, and there have been a number of attempts to produce "green" measures of GDP, which reflect society's use of natural resources as well as material production. None is without its drawbacks and its critics. However, all bear something in common with Brundtland's view that: "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

Even without specifying an accounting system in detail, a sector that uses resources faster than they can be replaced must represent a growing proportion of economic activity on a broader, sustainable measure. Whitelegg (1993) lists three conditions for a physically sustainable society and argues that the transport sector fails all three:

- Its rate of use of renewable resources does not exceed their rates of regeneration.

- Its rate of use of non-renewable resources does not exceed the rate at which sustainable renewable substitutes are developed.

- Its rate of pollution emitted does not exceed the environment's ability to absorb it.

Recent work by the United Kingdom's Department of the Environment, Transport and the Regions shows what might be achieved by such pricing strategies. With intensive application of the government's transport policies, it would be possible to reduce carbon dioxide emissions from road traffic to 90% of 1996 levels (DETR, 2000). To achieve this, a package of policies would be needed, including improvements to public transport, road user charging cordons and/or workplace parking levies in all urban areas together with inter-urban charging on the most congested 4% (by length) of the motorway network.

A shift away from cars would have major implications for industry as a whole. "The motor industry itself is but a small cog in a great industrial wheel – a mega-industry that provides employment to a large proportion of the labour force in OECD countries, but which consumes tonnes of fuel and raw materials annually" (Armstrong, 1994). The motor industry uses 30% of the developed world's iron and steel production, 46% of its lead, 23% of its aluminium, and 41% of its platinum (Armstrong, 1994). Several primary industries thus depend on the motor industry for their livelihood, and the economic effects of transport changes would be far reaching. The environmental impacts of such changes would be felt far beyond the roads along which the cars are actually driven. Attempts to uncouple transport growth from economic growth could produce profound changes in the international industrial infrastructure.

This chapter has discussed the importance of involving a wide range of stakeholders in implementing TDM measures, and in evaluating the range of external costs that such measures may impose on the economy and the environment. Such analysis may allow the link between travel growth and economic growth to eventually be severed. For the foreseeable future, transport experts will continue efforts to reduce travel demand without sacrificing economic growth and activity.

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Chapter 14

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Managing road travel demand requires a shift away from the traditional "predict-and-provide" way of planning within transport institutions. This approach was based on predictions of future traffic at a global level or in specific traffic corridors. Solutions were then designed to maintain or improve the flow of traffic at the expected higher levels, usually resulting in capacity expansion projects. However, recent US research indicates that increased highway capacity can actually induce travel demand, thereby exacerbating the problem. Providing viable transport options is essential to reducing road travel demand and car dependency. If highway capacity is expanded at the expense of investments in public transport, pedestrian and bicycle facilities, affecting modal shift becomes more problematic.

Moreover, the predict-and-provide approach is outdated as countries strive to meet international environmental requirements such as the Kyoto Protocol. Measures undertaken to influence road travel demand must enable countries to reduce greenhouse gas emissions without hampering economic development.

Traditional efforts to manage road travel demand have focused on initiatives within the transport sector such as car taxes, parking policies and public transport improvements. However, recent Danish research indicates that many of the determinants of growth in road traffic are not found within the domain of traffic authorities or within the reach of initiatives by private or public organisations (Danish Road Directorate Ministry of Transport, 2000). As discussed in Chapter 13, mobility is deeply ingrained in modern lifestyles. Thus, the driving forces behind traffic growth are found among a wide range of political, social and economic factors.

A new, viable strategy for transport planning could be termed "anticipate and manage". Instead of planning to accommodate growth in travel and its related problems, the aim is to anticipate growth and minimise its detrimental impacts. Efficient transport planning should focus on access (which can be reached through different means such as road infrastructure, rail transit or virtual mobility), rather than vehicle flow, as the measure of transport service quality.

In the new Millennium, the planning culture must emphasise least-cost evaluation and planning methodologies:

- Strategies to reduce travel demand are considered equally with strategies to increase capacity.

- All significant impacts are taken into account (including consideration of indirect and cumulative impacts) in terms of accessibility, economy, generated traffic, environment, health and social mobility.

- Assessment of alternatives is based on economic efficiency involving an estimation of all significant internal as well as external costs and benefits.

- The public is involved in developing and evaluating alternatives.

Only after such a comprehensive process is undertaken should a decision be made regarding how to proceed. This reduces institutional bias toward facility construction, allowing demand management strategies to receive appropriate consideration. In addition, efforts to influence road travel demand require comprehensive and long-term planning, data gathering from many sectors of society (economic figures, behavioural patterns, environmental impacts, etc.) and co-ordination among numerous entities. Since the planning process often bridges traditional institutional and jurisdictional boundaries, implementation of TDM programmes requires new forms of organisation in government and partnership among public authorities and business, special interests, citizen groups, and other stakeholders. Institutional arrangements may not need to go as far as merging planning organisations.

In the seven years since the publication of the OECD report on *Congestion Control and Demand Management*, measures therein described have proven effective in influencing road travel demand, and new instruments have been developed. In particular, the recent implementation of road pricing and parking pricing shows great promise. Electronic fee collection is facilitating the effective implementation of such economic measures. In underscoring the findings of the 1994 report, the current OECD study reconfirms the general cost-effectiveness of pricing measures, especially when combined with improved transport alternatives and public information.

Transport plays an intermediate role in the economy, serving as the means to an end rather than the end itself. The quality of infrastructure is relevant to many sectors of the economy, supporting trade, commerce and employment. In growing economies – as is the case in most OECD countries – transport is becoming increasingly important. It is essential to take appropriate measures to cope with both the negative environmental impacts of road traffic and the growing imbalance between supply of infrastructure and the demand for road transport. Congestion is a natural part of our transport system, and while it may not be entirely eliminated, it can be better managed.

The difficulties in curbing travel demand are immense. Public awareness of the problem, political leadership, and general support of economic and other measures are the key to unlocking gridlock. While no single solution or measure can reduce current and future travel demand, a combination of measures which target both the supply and the demand side of the transport system and influence the "trip market" the "transport market" and the "traffic market" holds great potential. Measures can be targeted for implementation at different levels, be it local, national or international. A growing number of measures also involve the participation of private partners. Market forces, when combined with reforms in other sectors of the economy, may play a more important role (*e.g.* flexible working hours may also be considered a positive measure in the labour market). Technology can play a major role in breaking the link between traffic growth and economic growth on a long-term basis; however, it is unable to solve short-term problems.

In order to break the direct link between growth in transport demand and economic growth, the implementation of more stringent economic measures, such as pricing, will need to be placed on the policy agenda. Successful pricing demonstrations throughout the OECD region may serve to build confidence in its effectiveness. Breaking the link between traffic growth and economic growth

requires viable measures that have outcomes whose net effect on economic welfare can be assessed. The OECD workshop on transport growth suggested that the leisure sector be explored for potential answers. The challenge lies in determining the whole range of economic welfare effects.

Most measures require time for the effects to manifest themselves, while policy makers and politicians aim for short-term solutions. Consequently, the potentially more effective measures are often bypassed in favour of "quick fixes". Traffic management experts can play a major advocacy role in gaining political support for the adoption and implementation of long-range measures.

Recommendations

The Working Group makes the following recommendations.

- In the public debate on transport policy, the real factors that influence people's behaviour are misunderstood. There are unrealistic expectations about the possibilities of eliminating road congestion and the potential of public transport in mitigating major congestion. Transport policy makers and experts should play a more active role in the public debate in order to promote a more realistic view. As this report has demonstrated, many instruments/measures are available to reduce travel demand, but successfully implementing change relies on raising public awareness and influencing human behaviour.

- More and better data are needed on the real impacts of measures influencing road traffic demand. Harmonisation of definitions and evaluations methods is necessary.

- Successful implementation of TDM programmes requires new forms of organisation in government and partnership among public authorities and business, interest organisations and citizens groups. A new planning culture is necessary in order to make this possible.

- Influencing road travel demand is not the exclusive responsibility of different levels of government (whether international, national, regional or local). Private partners can also play an important role. Further study of the market forces that may influence travel demand should be undertaken in order to widen the range of stakeholders in this respect.

This report provides best practices and information on integrating land-use and transport planning policies, adopting new technology, providing viable transport alternatives, and public education efforts designed to achieve reductions in travel demand in the new Millennium. Adoption of these strategies and techniques may lead to a 21st century scenario in which Man finally conquers the surface transport sector.

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Annex

TERMS OF REFERENCE

The objective of the study on influencing road travel demand is to identify policies and practices that could assist OECD countries in reducing the overall demand for mobility through the implementation of demand management and other strategies and the promotion of alternative modes of transport.

The project proposal calls for the establishment of a working group to: *i)* compare and assess policies and practices that have been implemented in various countries; *ii)* investigate measures to influence the level, location and timing of demand for transport; and *iii)* identify measures that can ensure the most efficient use of existing infrastructure.

Expected outcome

The development of sustainable transport systems through enhanced use of demand management strategies and alternative transport modes to reduce traffic volumes.

Outputs

Identification of policies and measures to influence road travel demand and increase the efficient use of existing road infrastructure.

Goals

Identify best practices and strategies and measures that have proven to be successful in reducing road travel demand and increasing the efficient use of existing road infrastructure in various OECD countries.

Technical motivation

Rapid increases in the levels of motorisation among OECD Member countries are generating significant problems for the efficient operation of the transport system, road safety and the environment. The conventional approach of increasing the supply of infrastructure (*i.e.* building more roads) has proven to be difficult for political, economic, social and environmental reasons. These issues raise complex technical questions of forecasting, modelling and evaluation.

Economic motivation

Many countries report expected increases in road travel demand on urban motorways of approximately 50% by 2005, and increases in delays of 400% or more if improvements are not made to the current transport system (OECD, 1994). Increasing congestion generates significant costs for industry and for society through added pollution. For every minute that an automobile or truck is delayed, there are associated costs related to, among other things, the value of the driver's time, inefficient use of capital, the use of fuel, and the costs associated with not getting a product to its destination as quickly as possible.

Reducing the overall level of road travel demand and reorienting it towards other modes of transport could reduce such delays and their associated costs. The performance of the transport sector affects all sectors of the economy (industry, trade, agriculture, etc.). A more efficient transport system has the potential to contribute positively to an economy's GDP.

Reasons justifying international co-operation

The dimensions of the problem are global – as a result of the general level of existing and forecast travel – as well as local – as a result of the demand at specific locations/times and of variations in local conditions. Virtually every OECD Member country is exploring policies to tackle urban congestion problems and options to better manage the supply of existing infrastructure. In addition, there is a strong value-added case for the transfer of information between countries on the effectiveness of demand management strategies.

Tasks

The study will distinguish between policies and strategies aimed at reducing the overall demand for mobility (*i.e.* land use planning, telecommuting, etc.), those aimed directly at restricting road travel demand (*i.e.* road pricing, area licensing, etc.), those intended to increase the efficient use of existing road infrastructure, and those directed to making alternative transport modes more attractive. It will consist of the following main tasks:

- Compare and assess policies and strategies which have been implemented in various countries aiming at influencing the level, location and timing of road travel demand in order to determine which are the most effective.

- Compare and assess policies and strategies that have been implemented in various countries aimed at increasing the efficient use of existing networks.

- Assess their success (and failure) in meeting their stated objectives, and evaluate their impacts on traffic demand, congestion and the mobility need.

- Examine potential strategies to uncouple the traditional relationship between economic growth and transport growth.

- Propose recommendations on "best practices" for use by Member countries.

The report will emphasise best practices implemented in various countries, and offer OECD Member countries a series of strategies and measures to lessen the impact of the expected increase in road travel demand.

Most appropriate working method

The Steering Committee has recommended that a Working Group composed of traffic engineers, urban planners and economists be assembled to achieve the stated goals. The Group will begin in 1999 and continue for no longer than 18 months, not including the editing of the final report.

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