



PATREC

Planning and Transport Research Centre (PATREC)

CONGESTION ABATEMENT THROUGH TRAVEL DEMAND MANAGEMENT

PHASE 1: REVIEW OF INSTRUMENTS AND TOOLS

PHASE 1 - REPORT A: The Travel Demand Management Matrix: An International Review of TDM Instruments

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Table of Contents

1	INTRODUCTION.....	4
1.1	Background.....	4
1.2	The Purpose of Developing the TDM matrix.....	4
1.3	The Structure of this Report.....	5
2	TRAVEL DEMAND MANAGEMENT.....	6
2.1	Defining Travel Demand Management.....	6
2.2	Policy Objectives.....	6
2.2.1	Congestion and System Reliability.....	6
2.2.2	Air Quality and the Environment (a complementary objective).....	7
2.2.3	Health (a complimentary objective).....	7
2.2.4	Economic Development.....	7
2.3	A Comment on Supply.....	8
3	TRAVEL DEMAND MANAGEMENT MATRIX.....	9
3.1	Introducing the Travel Demand Matrix.....	9
3.2	Conceptual model – columns in matrix.....	9
3.2.1	Push, Pull or Travel Behaviour Change Instruments.....	9
3.2.2	Transport Markets.....	11
3.2.3	Behavioural Responses.....	11
4	TRAVEL DEMAND MANAGEMENT INSTRUMENTS.....	12
4.1	Improving alternative modes.....	12
4.1.1	Walking.....	12
4.1.2	Cycling.....	14
4.1.3	Public Transport.....	14
4.1.4	Taxi and motorbikes.....	15
4.1.5	Incentives and subsidies.....	15
4.2	Integrated Land Use and Transport.....	16
4.2.1	Regional.....	16
4.2.2	Local.....	18
4.3	Workplace-based instruments.....	20
4.3.1	Employer support.....	20
4.3.2	Financial incentives/disincentives.....	20
4.3.3	Alternative work arrangements.....	21
4.3.4	Tele-working.....	21
4.4	Travel Behaviour Change Programs.....	22

4.5	Information Programs	23
4.6	Management of Road Space.....	24
4.7	Governance and Administrative	25
4.8	Parking.....	26
4.8.1	Parking Demand Management	26
4.8.2	Parking supply	28
4.9	Taxes and charges	28
4.9.1	Taxes	28
4.9.2	Road user charges	28
5	TDM: CASE STUDY CITIES, COUNTRIES AND REGIONS	31
5.1	Overview.....	31
5.2	Vancouver	31
5.3	The Netherlands.....	32
5.4	London	33
5.5	Singapore	34
6	CONCLUSION	35
7	ACKNOWLEDGEMENTS.....	35
8	REFERENCES.....	36
	APPENDIX: THE TRAVEL DEMAND MANAGEMENT MATRIX.....	39

1 INTRODUCTION

1.1 Background

The Transport Portfolio responded to the PATREC Strategic Business Plan 2013-2016 by identifying a range of research priorities, one of which was “Demand Management”, with the following component questions:

DM1: *What are the key demand management instruments available for managing transport congestion in Perth? What is the relative contribution that each of these instruments can make to reducing congestion?*

DM2: *What are the broader economic and social costs associated with demand management instruments (e.g. impact on CBD retail and social equity from implementation of congestion pricing schemes)?*

DM3: *What are the key lessons that Perth can learn from other jurisdictions regarding community acceptance and the successful implementation of demand management instruments?*

This report provides a preliminary review of existing travel demand instruments (TDM) implemented across Australia and in selected cities around the world. The material covered in the review also considers instruments that have been developed in theory, possibly proposed in practice but not as yet implemented. This review is limited to cases described in publically available written form.

The review is divided into two parts:

This report (Report A): a review of TDM experiences and investigations from around the world.

Second report (Report B): a review of the range of available and applied congestion indicators and policy appraisal tools within and beyond the transport literature.

Both parts of the review will lay the foundation for further analysis of TDM and its applicability to Perth in the proposed Phase 2 of the study.

1.2 The Purpose of Developing the TDM matrix

Travel demand management (TDM) is the application of demand strategies to improve the efficiency of the transport system. A primary focus of demand management is to encourage alternatives to the use of single occupant vehicles (SOV) on the journey to work, with the aim of reducing congestion. Whilst, a review of international experience reveals that demand-side strategies are often wider in scope than the journey to work, broader in aim than to alleviate congestion and may also involve supply-side aspects – these remain the dominant factors in policy making. The travel demand management matrix identifies eighteen categories of targeted demand instruments to improve transport network efficiency. These are aimed at reducing the demand for single occupancy vehicle trips or to redistribute these trips in space or in time.

The TDM matrix is an overview of instruments aimed at shifting demand away from SOV travel. The matrix identifies the specific travel demand instrument as well as the targeted trip purpose (e.g., journey to work, education, shopping, recreation) along with the anticipated behavioural response (mode shift, revise time of departure, shorter trips or trip reduction). In addition the instruments are classified as push (penalising travel by single occupant vehicle), pull (incentivising the use of alternative modes) or influencing travellers’ attitudes or perceptions (behaviour modification

programs). Finally the information sources and a brief description of any trials undertaken to test the instruments, are outlined.

1.3 The Structure of this Report

Section 2 opens by defining TDM and TDM instruments, where instruments may be thought of as general policies or specific interventions aimed at modifying travel behaviour (section 2.1). The focus of this report is to identify and review cases of TDM instruments aimed specifically at easing congestion (section 2.2.1). However, any instrument that reduces the overall level of traffic may result in the complementary benefits of environmental quality or positive health outcomes (sections 2.2.2 and 2.2.3). Economic development and productivity (section 2.2.4) are somewhat more complicated because they are both complementary and competing objectives to congestion abatement.

In section 2.3 a distinction between supply-side and demand-side instruments is made. It is noted that it is not possible to maintain a strict adherence to 'supply-side' - being any policy that affect the level of service offered on the transport network, and 'demand-side'— being how travellers weigh up or choose between existing transport options. This report relaxes the strict definitions by defining supply-side as any infrastructure or operational improvements to roads, including future planning by marking out reserves (Section 2.3.1). In addition, supply-side instruments include significant public transport investment in infrastructure (light or heavy rail, newly developed busways) or a substantial boost to public transport rolling stock. The report includes demand-side instruments that impose disincentives to SOV travel; provide incentives to switch to alternative travel options (mode, time of day, no-travel) and programs aimed to affect the traveller's perception of or attitude towards existing travel options (Section 2.3.2). Measures aimed to move people out of their cars (disincentives) are labelled as push instruments. Incentives to use alternatives to SOV travel are called pull alternatives. Programs aimed at educating or influencing travellers' perceptions of transport alternatives (behaviour modification programs) do not change the conditions in which travellers make their choice but aim to affect the way travellers evaluate their options.

Section 3 provides an overview of the conceptual framework informing the TDM matrix. Along with the classification of instruments based push, pull or behaviour modification programs, Section 3.1 introduces trip purpose and type of anticipated response to the TDM instrument. Following this, **Section 4** outlines eighteen categories and sub-categories of TDM instruments. Within each of these categories and sub-categories, common policy instruments are described and several case studies introduced in order to provide concrete examples of the instruments. There have been numerous other similar approaches to developing typologies of TDM instruments. Broaddus et al (2009) identified a number of TDM instruments for developing countries according to whether they provided incentives for alternatives to SOV use (Push), disincentives for SOV use (Pull) or a combination of incentives and disincentives. Rose (2007) developed a typology of TDM measures based on considering when travel demand problems occur, and where they occur or may be targeted. Other overviews of a range of TDM instruments have been developed (Austroads 1995; OECD 2002) although these do not locate instruments within a specific framework. Finally **Section 5** looks at four national and regional contexts where a range of TDM policies have been implemented: the Netherlands; Vancouver, Canada; London; and Singapore.

2 TRAVEL DEMAND MANAGEMENT

2.1 Defining Travel Demand Management

Contemporary understanding of TDM relates to the provision of competitive transport alternatives or maximising the opportunity available to travellers: *“Managing demand is about providing travellers, regardless of whether they drive alone, with travel choice, such as work location, route, time of travel and mode”* (FHWA 2012 p 10). Meyer (1999, p. 576) also views TDM as policies aimed at providing effective travel options: TDM “is any action or set of actions aimed at influencing people’s travel behaviour in such a way that alternative mobility options are presented and/or congestion is reduced.” Other views of TDM focussed on resource efficiency where travel demand management was seen as “... a general term for strategies and programs that encourage more efficient use of transport resources (road and parking space, vehicle capacity, funding, energy, etc.)” Litman (2003, p. 245). A key objective of TDM is to optimise the use of the current transport infrastructure so as to reduce or delay the need for road capacity expansion. As such, despite having other benefits, the principal reason for TDM policies is to abate congestion on existing road networks.

Current planning strategies in WA to reduce traffic congestion include a suite of instruments spanning supply-side approaches (investment in public transport, expanding the road network and optimising road network efficiency) and demand management defined implicitly as “supply” of active transport networks, limiting SOV opportunities (through parking management and road pricing) and travel behaviour change program. Integrated LU-T planning is considered as a separate initiative (Department of Transport, Moving People Network Plan for Perth and Peel Regions to 2031, 2013 (draft in confidence)).

For the purpose of this study on congestion abatement, TDM is defined as any instrument or set of instruments aimed at reducing congestion, by means of influencing behaviour change, without having to supply additional road or public transport infrastructure. The range of instruments include financial instruments, stricter regulations on car use, travel behaviour change programs, improved active transport networks and improved connectivity of the public transport network.

2.2 Policy Objectives

2.2.1 Congestion and System Reliability

Travel demand management offers an alternative to road expansion to help relieve congestion and improve system reliability. Where TDM aims to provide competitive substitutes to car travel, the road system benefits from a more even spread of travel (and non-travel) alternatives being undertaken; meaning that there is less demand on one part of the network at a particular time of day.

- Congestion is generally attributable to the number of vehicles approaching the capacity of the road space. When this capacity is neared there is a breakdown in traffic flows leading to a slowdown in speed. At high levels of congestion there is also a reduction in vehicle throughput.
- System reliability refers to the day to day dependability of network conditions, rather than the natural rhythms experienced over the day. A transport network with a high degree of reliability means that travellers can anticipate journey times when making planned or routine trips. The reliability of the system is strongly dependent on the level of congestion, because at high levels of congestion a small variation in total demand on the route or a small incident can have a large and lasting effect.

Travel demand instruments aim to balance peoples' needs to travel a particular route at a specific time with the capacity to efficiently handle the level of realised demand.

2.2.2 Air Quality and the Environment (a complementary objective)

Private vehicle travel accounts for approximately 43% of the transport sector's greenhouse gas emissions and contributes a substantial proportion of other air pollutants (Department of the Environment, 2014). TDM instruments aimed at improving environmental outcomes typically seek to decrease the use of private vehicle travel. This may be achieved by shifting travellers to high occupancy modes (bus and rail) or active modes (cycle and walk); providing some advantage for low emission vehicles (e.g., free parking for electric vehicles – not covered in this review because it does not relate to congestion); or through alternative work arrangements (flexitime and telecommuting). TDM instruments aimed at alleviating congestion complement environmental outcomes in two ways. First any TDM aimed at reducing the overall volume of traffic reduces emissions. Secondly, emissions are higher under the stop and start conditions of congested traffic and easing congestion leads to lower emissions per vehicle kilometre.

Demand-side instruments specifically aimed at air quality and environment are not included in this review. Such instruments include incentives for purchasing cleaner energy vehicles or vehicle design regulations to reduce emissions. However, some TDM instruments aimed at abating congestion have positive environmental outcomes and others do not. Benefit calculations of TDM instruments need to account for broader objectives rather than their impact on congestion alone.

2.2.3 Health (a complimentary objective)

Demand instruments aimed at moving people out of cars and onto public transport or to take up walking or cycling have positive health benefits. Active travel, including public transport, provides opportunity to combine low to moderate aerobic exercise meeting the recommended level of 30 minutes a day for at least 3 days a week (Haskell et al 2007). Beyond the immediate health benefit of exercise, shifting transport to alternate modes has the potential to improve air quality and to reduce vehicle accidents. "Apart from encouraging a sedentary lifestyle, reliance on motor vehicle transport has a range of adverse health effects (traffic accidents, air and noise pollution, and greenhouse gas emissions)" (Manson 2001, p230).

As with the air quality and emissions, this report considers the health benefits of TDM instruments that are aimed at abating congestion, but does not consider any demand strategies that are specifically aimed at improving health.

2.2.4 Economic Development

Wider economic impacts are additional benefits not captured by the direct impacts of transport investment. Whilst being relatively new and requiring a greater investigation into the behavioural response parameters, these impacts feature in the UK appraisal guidelines (Guhnemann et al 2013). The effects include encouraging agglomeration and direct productivity gains in terms of reducing the marginal costs of production. In addition labour supply gains (new entrants into the labour market) and shift to higher taxable wages are considered. Apart from agglomeration effects, wider economic impacts appear to be relevant to significant transport investment (e.g., major highways or airport expansion). Agglomeration should be considered in TDM when considering integrated land-use and transport policies.

2.3 A Comment on Supply

Congestion can be alleviated through supply and/or demand strategies. Supply-side instruments include construction of new capacity as well as enhancements to existing transport network operations. Demand instruments aim to change the way people evaluate their travel options using the existing transport network. However such a strict definition poses some difficulty in framing the possible instruments for managing travel demand. Many of the existing TDM instruments presented in the TDM matrix aim to improve the level of supply offered by non-car alternatives. Extensions to bicycle lanes to improve cycling safety or improved connections between public transport modes are examples of supply instruments that affect alternate (non-car travel) modes. Integrated land-use and transport represent planning decisions, but the implementation of these decisions are necessarily supply initiatives as they guide the building or evolution of places and the transport function. Whilst it is impractical to define the scope of a TDM review by whether an instrument affects the supply-side or the demand-side of the transport function, it is necessary to specify the boundary of scope for the purpose of this review. Two broad areas of transport policy are disregarded from the analysis:

Road building and improvements to road efficiency: Road capacity is the most important factor affecting the level of congestion. Municipal governments manage the level of congestion by way of transport investment in lanes (lane kilometres) and removing intersections along freeways and major arterial routes highways. The second supply instrument available to transport authorities is to improve operational efficiency. Smart intersections, controlled freeway on-ramps and other intelligent transport systems are used to improve the travel time on existing roads. The third supply instrument is the capacity of the network to manage and limit incidents. Intersection design, improved safety engineering, road management for special events and incident response are not considered to be demand management strategies in this report.

Public transport infrastructure investment: Construction of urban rail, metro systems and light rail are not considered to be demand-side instruments. Major investment in public transport rolling stock is also considered to be a supply instrument. However, improvements to localised public transport services may require additional staff or a redeployment of assets. For the purposes of this report such incremental changes are included in the 'pull instruments' that improve the quality of service of non-car modes.

Supply-side measures include delivery, efficiency management and planning of road infrastructure and investment in public transport infrastructure

- Expand the road network
- Optimise road network efficiency by way of intelligent transport systems
- Future planning of road hierarchy, key performance indicators, HR resourcing to deliver infrastructure and manage road network)
- Invest in public transport such as light rail construction, implementation of new rail links or purchase of additional rolling stock

3 TRAVEL DEMAND MANAGEMENT MATRIX

3.1 Introducing the Travel Demand Matrix

Following the initial scan of literature, nine categories were established to organise the range of TDM instruments available. The categories are organised according to the extent that they provide incentives for alternative modes, or disincentives for SOV use. The categories (rows in the matrix) are:

1. Improving alternative modes
2. Integrated land use and transport
3. Workplace-based instruments
4. Travel behaviour change programs
5. Information programs
6. Management of road space
7. Governance and administration
8. Parking
9. Taxes and charges

Of the nine categories, five have associated sub-categories. In total, eighteen broad categories and sub-categories help present TDM instruments for discussion. However, some instruments fit within more than one category; for example, parking instruments, a category of their own, can be applied at the workplace. Within the material discussed in this section and the additional material contained in the matrix, each TDM policy type is described in relation to a conceptual model (see Figure 1): the type of travel market the TDM instrument addresses; whether the instrument provides a disincentive or incentive to particular types of travel; and what type of travel response is relevant. One or more case studies that exemplify particular TDM instruments are introduced and their major characteristics described.

3.2 Conceptual model – columns in matrix

3.2.1 *Push, Pull or Travel Behaviour Change Instruments*

Push and pull approaches, can also be distinguished as ‘carrots’ and ‘stick’ (Meyer 1999), or ‘command and control’ and ‘incentive based policy’ (Santos et al 2010) approaches to TDM. Instruments are categorised as to whether they provide a *disincentive* for motorised modes during peak periods (push), whether they *incentivise* alternative modes or times of travel (pull) or inform/persuade individuals to change their perceptions of or attitudes to the existing travel alternatives (behaviour modification programs).

Push instruments aim to reduce the relative attractiveness of driving a SOV. For example, one type of push approach to TDM relates to an additional car use tax or a dedicated road user charge. Alternatively, instruments may aim to increase the cost of parking or limit the parking supply at a major destination. A third type of instrument is that of limiting the road space available to cars along certain routes or at specific time during the day. Push instruments are not designed to encourage any particular form of alternate travel (mode shift, travel less often, adjust time of departure, etc.).

Travel Demand Management Matrix - Summary

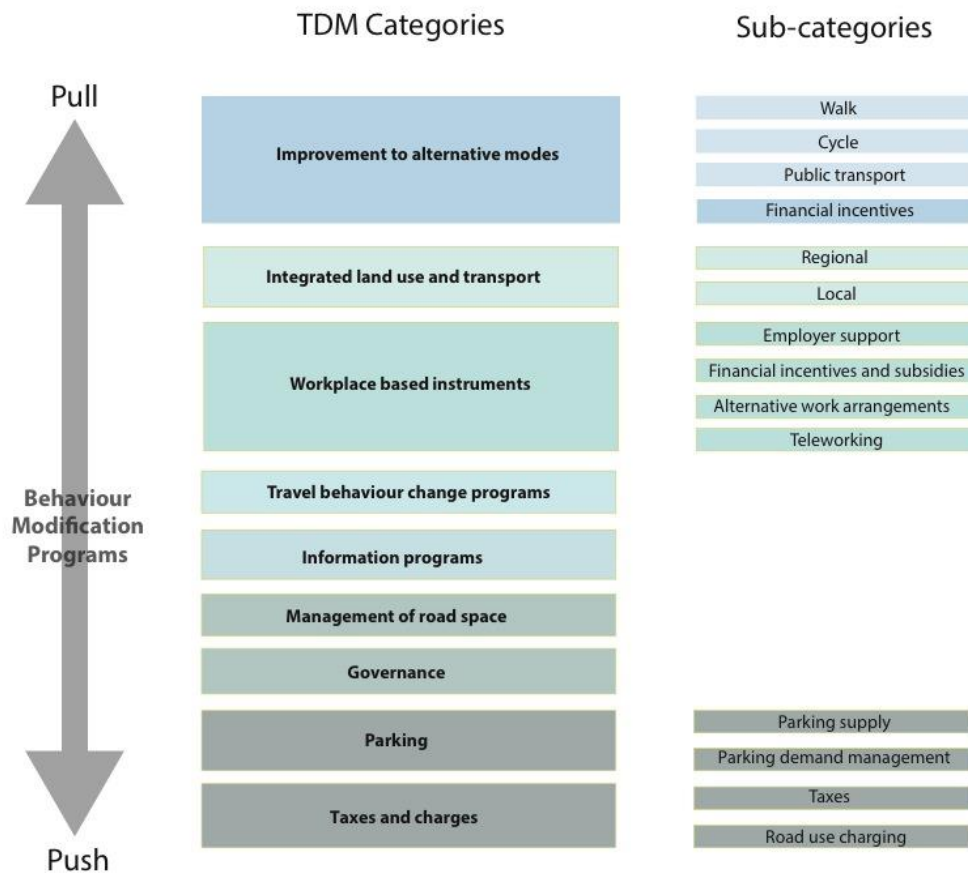


Figure 1: Conceptual model underpinning the TDM matrix

Pull instruments represent other ways to encourage choices away from private vehicle by improving the availability or the quality of the alternatives. Reducing the cost of travelling by public transport may be achieved by direct reduction in fares. Alternatively, an improvement to the level of service in terms of headway frequency, multimodal accessibility (e.g., park and ride) or overall travel time may be implemented to shift travellers out of their cars. Improvements to active transport networks such as bicycle lanes or improved pedestrian conditions are also considered to be pull instruments.

Travel behaviour change and information programs may be achieved by informing the community of the travel outcomes by mode (i.e., by way of information on untested modes) or changes to attitudes (e.g., social norms around environmentally friendly travel). Travel behaviour change programs usually include a range of strategies including the provision of information, support and feedback, and incentives for sustainable travel. Travel behaviour change and information programs shift demand by working directly on the consumer's preference function. Where push and pull instruments change the levels of service on the transport network, travel behaviour change and information programs aim to alter the way travellers weigh up their transport options.

Travel demand management measures include incentives (pull measures) and disincentives (push measures) to enact travel behaviour change. In addition TDM measures may provide information or education to affect people's perception of or attitudes towards travel alternatives with intention being behavioural modification.

- Push measures are designed to make travel by SOV less attractive.
- Pull measures improve the competitiveness of alternate travel options, including no- travel.
- Behaviour modification programs rely on changing travellers' perceptions or attitudes toward alternate travel options

3.2.2 Transport Markets

Most TDM instruments aim at spreading the peak hour travel load and therefore relate to work based trips. However, Meyer (1999) separates instruments into categories of 'transport markets' such as work, shopping and tourism related travel. Different transport markets have differing demand responses to incentives and/or disincentives. We use the categories: commute (work based travel); shopping; recreational; educational; or multiple where the TDM covers a range of transport markets. Transport markets may have varying geographic scale and travel during the day or during the week. Individual's travel behaviour varies according to these different types of transport market.

3.2.3 Behavioural Responses

Instruments are distinguished according to the type of change to travel demand the instrument was trying to achieve. Four main TDM objectives were identified:

- Reduce the need for travel – eliminate the necessity of some trips
- Manage the mode of travel – shift to an alternative travel mode
- Manage the time of travel - peak spreading.

4 Travel Demand Management Instruments

4.1 Improving alternative modes

Improving the quality of infrastructure, networks and services of alternative modes of transport to the car, such as walking, cycling and public transport, manages travel demand by increasing the attractiveness of alternative modes of travel to the private vehicle. Improving travel for pedestrians, cyclists and public transport users can have benefits beyond addressing the problem of congested roads. For example, the marginal social benefits of active transport – walking and cycling – may include less congestion through a decrease in demand for car travel, and increased health and wellbeing for individuals. Public opposition to road use pricing may manifest itself in arguments based on vertical equity concerns. For example, to shift the demand of peak hour commuters from SOV to public transport there needs to be adequate capacity of train and bus services and rolling stock. The improvement of alternative modes of travel to SOV is likely to be of critical importance to the successful planning and implementation of more ‘push’ style TDM instruments, such as levies and road use pricing (Meyer 1999).

4.1.1 Walking

There are a number of ways conditions for pedestrian travel may be improved in order to provide an incentive for people to switch away from motorised vehicle travel. For example, **new infrastructure** for pedestrians may be provided or existing infrastructure may be improved. This infrastructure may be targeted towards potential highly utilised pedestrian routes. Infrastructure may be planned in order to connect places that people walk to and from, improving the connectedness of a pedestrian network. Alternatively, improvements to the built environment for pedestrians may be targeted across larger areas such as neighbourhoods or local government areas, through **street improvement programs**. The concept of area-wide street improvements is reflected in a number of related concepts; for example the woonerf (Netherlands), Home Zone (UK), Shared Zones (Australia and New Zealand) and Complete Streets (US).

Case Study: Shared space

Auckland, N.Z.

As part of recent planning for the Auckland central business district, a number of inner city streets have been designed according to the 'shared spaces' principle. One overall objective guiding the planning was to address congestion within the centre and increase the quality of the street environment for cyclists and pedestrians. 'Shared spaces' are improvements to the street, better integrating the needs of residents, pedestrians, cyclists and cars into the design of the street and is underpinned by a philosophy of 'shared responsibility' for safety and risk minimisation. 'Shared spaces' combine rather than separate the functions of the streets. Modifications typically include the removal of kerbs to create a continuous space; a reduction in parking space; and the minimisation of conventional road signage leading users of the street to reduce speed, raise awareness and minimise the risk of accidents (Karndacharuk et al 2014).

An example of 'shared spaces' in the CBD is the City of Auckland's Fort Street improvements. Planned improvements and the introduction of 'shared space' in the Fort Street area, which included a number of smaller streets in Auckland CBD, were set out in the City of Auckland city centre masterplan. The cost of the modifications was estimated to be \$23 million and was funded through an additional rate targeted towards residents and business owners in the Auckland CBD. The street design features of the Fort Street 'shared spaces' are illustrated in Figure 2.

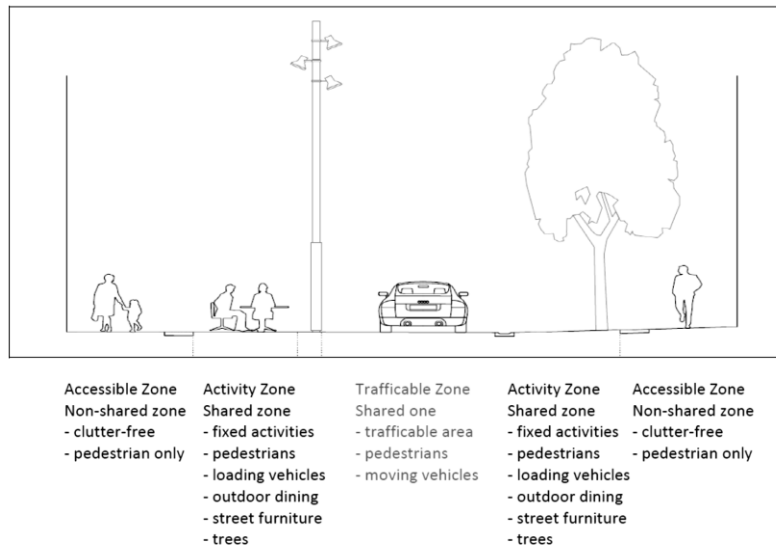


Figure 2: Shared space - Auckland City Council

A year following the implementation of the Fort Street 'shared space' the City of Auckland commissioned an evaluation of the improvements¹. The evaluation included surveys of pedestrians and businesses; video observations of pedestrian and vehicle movement; vehicle counts; and indicators of economic activity. The evaluation found that the 'shared space' concept was well received and that, although there had been a few negative responses noted based on perceived safety issues, no accidents had occurred in the street.

¹ See: <http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/ccmp/Documents/fortstareaevaluationfullreport.pdf>

4.1.2 Cycling

TDM policies that aim to improve cycling are similar to those that improve pedestrian travel. Infrastructure for cyclists includes cycle paths and modifications to existing roads to improve the safety and quality of cycling trips. Networks of well-defined, well-connected paths that are linked to places where people go for work and recreation can increase the attractiveness of cycling trips. Infrastructure and services for cyclists also includes bicycle parking at key activity nodes, including workplaces and public transport stops and end-of-trip facilities including change rooms, showers and bicycle repair centres. Bike share schemes enable short-term access to bicycles through a city-wide network of hire stations and have also been linked to an increase use of private bicycles and cycling rates as well (Fishman et al 2013). Furthermore, **changes to the road rules** may improve the safety and quality of cycling trips on roads. Following a recent Queensland parliamentary inquiry into how to improve the interaction between cyclists and motorist on roads, changes have been made to the road rules in Brisbane, Australia, that require motorists to stay a minimum of 1 metre away when passing cyclists in a 60km/hour zone and 1.5 metres when the speed limit exceeds 60km/hour.

Case Study: Dedicated bicycle facility

King George Square Cycle2City – Brisbane, Australia

The King George Square Cycle Centre is a jointly funded (Brisbane City Council and Queensland State Government) \$7 million facility located at the King George Square train station in central Brisbane. The facility was provided for commuting cyclists whose workplaces did not provide adequate end-of-trip facilities. The centre includes over four hundred parking spaces for bikes, lockers, showers, laundry service, and bicycle maintenance service. The facility provides a range of membership options from casual to annual rates, and provides incentives for referrals.

An evaluation by Griffith University (Burke, Sipe and Hatfield 2010) was conducted a year after the opening of the facility in 2010. The key findings of the evaluation were:

- The facility had led to a reduction in approximately 56,000 VKT.
- 6% of members had switched mode of travel, from motorised vehicle to bicycle.
- Operating costs were not matched with revenue from membership fees in the first year. There was a tension between balancing operating costs and attracting new members through alternative pricing strategies.

4.1.3 Public Transport

Improving the quality and coverage of public transport networks and services is an important TDM instrument. For TDM policies that impose a disincentive on SOV use, efficient, reliable and comfortable alternatives need to be available. Improving the capacity of public transport may be critical to the success of other TDM policies and mechanisms such as cordon pricing. There are several aspects of public transport networks that may be improved in order to manage travel demand.

- **Improvements to the public transport and the integration of different public transport modes or services** (a new bus route to link with a new railway station). For example, the introduction of the Joondalup and Mandurah railway lines in Perth was accompanied by a redesign of the bus network in order to better integrate bus services with rail stations.

- **Improving public transport services** is a key factor in providing an alternative for SOV use and may include **improving the reliability** of existing services and **increasing the frequency** of services along routes.
- **Improving the quality of stations and stops** contributes to the comfort and ease of access to public transport stops and can therefore contribute to the management of travel demand through improving the overall attractiveness of public transport modes.
- Better integration between transport modes may be achieved by the physical linking of modes and services. Better integration may also occur through **improved ticketing**. Perth, as well as cities such as Spain, London, and some German and Swiss cities, provides examples of urban public transport systems with successful integrated electronic ticketing systems. Moving from mode to mode, or service to service, is facilitated with efficient and convenient single ticket or card systems.

4.1.4 Taxi and motorbikes

Improvements to the taxi services can lead to a reduction in the need for car ownership and can support travel by alternative modes, such as walking and public transport. Improvements may derive from increased services and the improved quality or efficiency of services. Providing adequate parking or prioritising the on-road movement of small vehicles, such as motorbikes and e-bikes, can contribute to a reduction in congestion (although motorbike transport may not necessarily lead to a reduction or shift in travel demand on roads at peak hour).

4.1.5 Incentives and subsidies

- **Financial incentives and subsidies** may be provided for travel by alternatives to SOV, particularly public transport. An example is the provision of **reduced public transport fares** for students and children. Subsidising children’s travel in this way provides an incentive for travel by bus and train and therefore may reduce the rate children are driven to school, a significant contributor to peak hour travel.
- **Free public transport travel to major events** provides an incentive for people to travel by bus and train, rather than SOV, to large events, where the movement of many people is likely to cause increased congestion.
- **Reward schemes** provide direct incentives to peak hour commuters who choose to travel outside the peak period, shift mode to public transport or choose not to travel and instead, telework. See the Spitsmijden case study below for an example.

Case Study: Peak avoidance incentives
‘Spitsmijden’, The Netherlands
<p>‘Spitsmijden’ refers to a Dutch program launched in 2006 that provided an incentive for drivers participating in the program to avoid peak hour travel in certain locations (Tillema et al 2013). The scheme, a collaboration between government agencies, private companies and universities, was instigated as an alternative approach to counteract the acceptability issues associated with available road pricing instruments that worked by providing disincentives for car travel at peak times. The scheme used positive rather than negative pricing signals, rewarding volunteers in the scheme with a financial incentive if they chose to travel outside peak travel times in four locations in the Netherlands. The participants (500) were recruited through licence plate monitoring of the routes. The participants were regular commuters along the selected congested road ways and were rewarded for travelling on the roadway outside congested periods (7.30am – 9.30am), if they chose an alternative mode to commute, or if they chose not to travel by working from home. An evaluation of the scheme² was conducted following a preliminary trial and a reduction of approximately 50% in participant’s</p>

² http://www.spitsmijden.nl/resultaten/english/Experimental_design_and_modelling_-_Spitsmijden.pdf

peak hour trips was observed; primarily due to a shift towards travel outside the peak hour time period rather than a shift to alternative modes or working from home.

For more details see: Donovan (2011)

4.2 Integrated Land Use and Transport

The integration of transport and land use planning is an effective long-term TDM instrument. Most travel demand is derived from the need or desire to access activities associated with different places. The planning of land use that integrates existing and future planned transport networks and infrastructure, and vice versa, facilitates the development of urban forms and structures that may encourage travel by alternatives modes to SOV. For example, land use may be intensified and diversified in places served by good quality public transport in order to increase the opportunities for travel. TDM instruments based on integrated land use and transport can be used at different scales – a regional scale, such as a metropolitan region or growth area, or at a local scale involving individual developments or a smaller precinct scale.

4.2.1 Regional

- **Growth strategies** refer to long-term strategic land use and transport planning for regions or precincts experiencing rapid urban growth. Current regional growth strategies in Australian states are based on targets for a percentage of new dwellings to be within the existing urban boundary, therefore limiting the need for dispersed transport networks at the urban fringe.
- **Corridor planning** refers to the intensification of urban development along transport corridors, or 'spines'. Corridors are an effective urban form for high frequency and efficient public transport services. Increasing densities along corridors or at identified nodes along corridors can facilitate a shift in demand from SOV use to travel by public transport, walking and cycling.
- **Transit Oriented Development (TOD)** refers to developments located near good quality public transport stations and exchanges. Successful TODs cater for the needs of residents through a pedestrian oriented area and a mix of land uses reducing the need to travel outside the TOD area, as well as enabling connection to other places in the region through good quality public transport service and links. TODs need to be thought of as a regional strategy, with individual TODs interacting with other TODs within a broader regional context (Thomas and Bertolini 2014).
- Buying goods and services contribute to a significant amount of travel in urban areas. **Retail planning policies** can incorporate a variety of mechanisms that integrate land use and transport planning and reduce the demand for SOV travel. These mechanisms may include increasing the diversity of land use in retail precincts; improving public transport connections to retail precincts; improving the quality of the built environment for pedestrians and cyclists; and through using parking strategies.

Case Study: Integrated land use and transport

The ABC location policy, Netherlands

The ABC location policy in the Netherlands is an example of an integrated land use and transport policy instrument that attempted to **better link parking supply to land use types**. The policy is based on a simple goal of better matching business types with their location within the regional spatial context. The ABC policy regulates the development of commercial land uses according to an evaluation of business access needs (a mobility profile) and an evaluation of the regional accessibility of the location (an accessibility profile). A business' mobility profile is based on the number of workers per development area; the intensity of car use for business activities; the visitor intensity; and freight or goods mobility needs.

- Locations that are most accessible to public transport such as the inner city and activity centres adjacent to public transport stations are deemed 'A' locations.
- Locations in areas adjacent to 'A' locations with reasonable access to public transport are deemed 'B' locations.
- Locations that have poor access to public transport and alternatively are well serviced by motorways are deemed 'C' locations.

The policy works in a number of ways. It is implemented through the land use planning system, primarily through locating car dependent business in areas most accessible by car, and for business that use public transport or active travel modes in areas accessible by these modes. The policy also operates through the regulation of the supply of parking. In addition, the policy provides signals to developers and businesses regarding future government infrastructure spending. For example, government can plan to improve the accessibility of areas identified under the policy as A-locations by investing in pedestrian and cyclist infrastructure. The policy therefore involves multiple levels of government in the Netherlands. At the national level, related ministries set the broad policy framework and organise the categories of business mobility needs and accessibility. The provincial government monitors broad demand and supply indicators and can intervene to adjust specific policy factors. The policy is directly implemented by local government through the local planning and development assessment processes.

Although the broader strategic intent and design of the ABC location policy have been widely supported, Schwanen, Djist and Dielemen (2004) outlined a number key criticisms of the specifics of the policy details. The nature of this criticism was based on the inability of the policy to address growth in the office sector. The increase in residential space in accessible locations created a shortage of spaces in urban centres and office based firms were unable to be located in A and B locations. There were other criticisms directed at the design of the policy including the mismatch between the simplicity of land use categories outlined in the policy, with the complex spatial arrangements of the places they were applied to. Furthermore, a mismatch between the types of travel behaviour associated with business types was identified. Differences between travel behaviour type (for example, between a car-dependent workplace and a workplace that has a more diverse travel mode share profile) may be related more so to individual level factors than related to business type.

4.2.2 Local

There are a wide range of TDM instruments that operate at a local scale to integrate land use and transport planning. These may involve evaluations of developments according to general integrated land use and transport principles; requirements for developers to provide financial contributions for transport infrastructure; and integrated land use and transport strategic planning at the local scale. Examples of local scale TDM instruments include:

- **Impact assessments** at the development or precinct scale, such as social-cost and health impact assessments are used to identify potential consequences to the quality of urban life and travel, if the development were to go ahead. Impact assessments can use measures and indicators that draw attention to more sustainable outcomes for land use and transport systems. For example, developments near good quality public transport networks, or those that provide bicycle parking may be evaluated highly because of their potential to reduce car use and facilitate active travel. Specific **transport assessments** may be required for new developments. These assessments evaluate potential impacts for developments that are likely to generate or attract large volumes of trips.
- **Travel plans** outline strategies to improve the ongoing travel behaviour for residents within urban precincts, large developments, workplaces or schools. Plans can be managed by a specific individual or small. Travel plans can be made a requirement for new developments as part of the development assessment process.
- **Trip reduction and travel distance ordinances** are requirements for new developments in particular areas to commit to specific targets relating to number of trips and the distance of trips.
- **Developer contributions** are financial contributions made by developers to fund public infrastructure as part of approval of a development assessment.
- **School travel programs and investment in infrastructure around schools** may increase rates of children's active travel to school and therefore reduce congestion around schools.

Case Study: Transport Assessments

United Kingdom

In the U.K. the National Planning Policy Framework requires that developments that will generate or attract a large amount of traffic be subject to a transport assessment. A transport assessment evaluates the likely impacts of a development on the existing and future travel activity and transport systems. The transport assessment is carried out in order to inform the assessment of a development. According to the U.K government guidance on transport assessments (2007), the following factors are to be incorporated into an assessment:

1. The local policy context
2. The scale of the development and its trip generation potential.
3. The existing transport networks and uses.
4. The potential environmental impacts.
5. A consideration of all modes, including walking and cycling.
6. The cumulative impact of current and future development in the broader area.

Transport assessments operate as a TDM instrument by either mitigating car dependent developments in areas that are accessible to alternative modes, or requiring compliance with best-practice standards for a range of mobility options. Transport assessments may also identify issues that can be addressed through ongoing travel management that can be incorporated into a **travel plan**. Transport assessments in the UK rely on associated databases to provide comparable impact assessments. The TRICs system uses extensive travel surveys based at a range of development types, in order to facilitate scenario planning and evaluation required by transport assessments.

In Perth, the WAPC has a number of transport assessment guidelines for development available on its website³. The assessments are provided for transport and land use planners as a guide for assessing the potential impacts of sub-division and development at the regional and local scale. However, unlike in the U.K., there are no statutory requirements to use the guidelines.

³ See: <http://www.planning.wa.gov.au/publications/1197.asp>

4.3 Workplace-based instruments

Workplace-based TDM include a range of instruments that are provided to employees to encourage travel to work by modes other than SOV. Although these instruments are administered by employers in the workplace, governments can play a facilitating role in the regulation and administration of employment based TDM instruments. Workplace-based instruments are often implemented as part of a package of instruments to manage the demand for commuter travel. Workplace-based instruments have been used extensively in the U.S. It is also important to note that the potential success of TDM workplace initiatives may be undermined by other workplace practises such as tax structures that encourage car use (Ker 2003).

4.3.1 Employer support

- **Carpooling (Ridesharing)** involves employees sharing a ride to their place of employment. The employer can use a range of strategies to facilitate compatible commuters sharing rides to work. **Vanpooling** differs from carpooling in that employer subsidises a small van or bus transport service. This TDM instrument is usually used when employees live long distances from their place of employment.
- **Preferential parking** provides reserved parking spaces for employees who carpool. The spaces provided are usually the best quality spaces (for example, sheltered) or where parking is limited.
- **Guaranteed ride home** is a service provided to employees who carpool, or use alternative modes to SOV to travel to work, where a 'ride home', usually by taxi, is subsidised by the employer in the case of an emergency.
- **Bike storage, loan schemes and end of trip facilities may be provided** at the place of employment in order to increase the attractiveness of cycling to work. Bike loan schemes may be used to provide bicycles for employees who do not have access to bicycles.
- Many of these specific instruments may be encompassed within **workplace travel plans** . Travel plans are often developed for large workplaces such as universities, hospitals, in order to communicate and organise strategies to reduce travel by SOV.

4.3.2 Financial incentives/disincentives

- **Subsidies for public transport or car share schemes** may be provided by the employer in order to increase the attractiveness of alternative modes of travel to SOV.
- **Workplace parking schemes and levies** are pricing mechanisms that allow the employer to disclose and recover the cost of the provision of parking spaces at workplaces. Parking schemes and levies encourage a shift in the demand away from commuter travel by SOV through making travel by other modes relatively affordable and therefore more attractive.
- **Salary sacrifice schemes** allow employees to receive part of their remunerations in the form of concessional tax benefits. Although salary sacrifice schemes may incentivise SOV use, alternatively they may be designed to incentivise travel by alternative modes of transport.

Salary sacrificing schemes have been linked to incentivising car travel by providing tax relief instruments for car ownership. However, salary sacrificing may also be used as means to incentivise alternative modes of travel. As part of a 'green transport plan', the U.K. government introduced legislation allowing employers to offer bicycles and related safety equipment as tax-free benefits for employees. The tax-benefits are accessed by a typical salary-sacrificing scheme. The salary-sacrificing scheme allows employees to forego part of their salary for a loan of bicycle and safety equipment. The reduction in an employees' gross salary leads to a decrease in taxable income and therefore provide employees with an incentive to loan or purchase a bike. Typical savings from participating in the scheme can range of 30-45% of the usual cost of the hire of the bike and equipment (University of Cambridge 2013). Cyclescheme, a private company, was established to assist workplace employees, their employers and cycling retailers in accessing tax incentives.

4.3.3 *Alternative work arrangements*

- **Flexible working hours** provide employees with more flexibility in when they chose to start and finish work. This provides greater opportunities for employees to travel outside peak hours. The degree of freedom for employees can vary according to these different work arrangements. **Staggered working hours** are varied start and finished times usually set by employers for different groups of employees, and provide more certainty for employers but less freedom for employees than flexible working hours.
- **Compressed working week** result from arrangements between employers and employees regarding the length of the working day. Employees can work an extra hour per day in order to take a regular day off; for example working an extra hour per day for nine days, to take the tenth day off. Compressed working weeks can lead to the spreading of peak demand, and the reduction of travel to work on the allocated day off.

4.3.4 *Tele-working*

- **Telecommuting** involves employees working at places other than the workplace through the use of communication technologies. Telecommuting allows home-based work, thus eliminating the need for some commuter travel. Telecommuting programs or arrangements are primarily based on negotiations between employers and employees.
- **Teleconferencing** similarly uses communication technologies to allow meetings and conferences to be conducted from a range of locations. Travel to meetings can contribute a significant number of trips during the working day. Teleconferencing reduces the need for travel to and from meetings.
- **Teleshopping**, whilst technically not a workplace based TDM instrument, can reduce the need for smaller 'additional' trips on the way to and from work.
- **Distance Education** involves the reduction in the need for students to travel to school through the use of telecommunications. Whilst, distance education is prominent in regional areas of Australia, post-secondary school education institutions are increasingly employing web-technologies to allow students to work from places other than universities, for example.

4.4 Travel Behaviour Change Programs

Travel behaviour change can occur when individuals initiate change towards more sustainable travel behaviour and habits without coercion from government through 'push' policies. Travel behaviour change programs are targeted towards changing the decision-making and behaviour of individuals, households or workplaces usually through a range of strategies including the provision of information, support and feedback, and incentives for sustainable travel. Decisions regarding travel are made at different scales: individual travel behaviour; household travel behaviour; and workplace travel behaviour. Travel behaviour change programs are targeted at behaviour at each of these scales, often at different types of travel including the commute to work and school travel. A couple of examples of travel behaviour change programs are:

- **Individualised marketing** refers to travel behaviour change programs that are specifically designed for individuals. The programs involve targeting individuals and households with information regarding sustainable travel options and benefits. **Indimark™** is a travel behaviour change program that targets individual travel mode change through providing information regarding existing services and infrastructure. The objective of this approach is, not necessarily to change the amount of travel but rather the mode of travel, away from SOV use to more travel by public transport, cycling and walking.
- **Travel blending** (Ampt 2003) is a program that has the objective of increasing households blending of travel modes and blending of activities in order to reduce travel. The program involves households keeping diaries of travel behaviour in conjunction with the provision of information and education about such factors as the rates of emissions and costs. Travel blending programs can incorporate a wide range of participant organisations including transport service providers, local governments, businesses in the community, schools as well as households and community groups.

Case study: Travel Behaviour Change Program

Travel Smart in Australia

In the late 1990's growing concerns over urban traffic congestion and the environmental impacts of increasing motorisation led to a new TDM strategy used by the Australian federal and state governments. Travel behaviour change programs were incorporated into the suite of most state government transport policies and resulted in Australia becoming an international exemplar for the use of travel behaviour change programs as a strategy for demand management. Travel behaviour change programs have now been used by several Australian State Government agencies for over a decade. Some examples of travel behaviour programs developed and implemented by state government agencies in Australia include:

- An **individualised marketing** program was trialled in South Perth, WA in 1997 involving 380 households. The program was followed up with a larger program in 2000. The program involved marketing travel behaviour change through personalised information and incentives. The program was evaluated through before and after surveys and found to be an effective in managing travel demand, with decreases in the percentage individual car trips and increases in the percentage of trips by all other modes (Roth et al 2003), although these findings have been disputed (Stopher 2003).
- A **travel coaching** program was implemented in Adelaide, SA (Roth 2011) involving the individual coaching of fifty volunteers at the University of South Australia.

- A **travel blending program** was undertaken in Adelaide, involving 96 households (Rose and Ampt 2001). Information regarding ‘blending’ household activities was provided to the participating households and travel diaries captured before and after travel behaviour. The program involved 900 households and a range of neighbourhood scale service providers, including local government and community organizations.

A **Travel Smart Local Government Program** saw the WA State Government provide seed funding for local government travel smart officers. The officers were involved in the implementation of household and community travel behaviour change programs, helped liaise between local and state government, and were change agents within the local government organisation (Murphy 2012). Evaluations of travel behaviour change programs suggest that they are an effective means of managing key types of demand for travel. Stopher et al (2004) identified four issues that evaluations of travel behaviour change programs need to address. These are 1) a survey of the travel behaviour of participants before and after program implementation; 2) data on the number of trips, distance and time travelled and travel mode; 3) the necessity of a large sample in order to detect small changes to travel behaviour; and 4) the need to evaluate social, health and community benefits of travel behaviour change.

4.5 Information Programs

The use of communication information better informs potential drivers’ decision-making with regard to travel. Although many information programs are utilised in the management of movement of existing traffic on the road system (lane choice) and therefore are outside the scope of this report, there are a number of examples of the use of information programs to manage decisions regarding route and mode choice and the time of travel.

- **Advanced Traffic Management Systems (ATMS)** involves the use of communication and sensory technology to manage traffic flow. ATMS may be used as a TDM instrument by improving the travel time and reliability of vehicles other than SOV through traffic signal priority and responsive lane restrictions to encourage high occupancy vehicles, PT and or/freight vehicles and discourage low occupancy vehicles (Rose 2007).
- **Advanced Traveller Information Systems (ATIS)** involves information provision to influence departure time, mode or route choices (Rose 2007). ATIS may use radio, wireless or mobile phone technology in order to communicate real-time transport services and conditions of congestion on routes. ATIS may be useful as a TDM instrument for non-recurring congestion; for example pre-trip information on congested routes may allow travellers to select a different route or time of travel. Alternatively, ATIS may also be utilised in communications regarding the real-time information of PT services and may contribute to higher overall rider satisfaction with alternative modes to SOV.
- **Advanced User Payment Systems (AUPS)** are integrated payment systems that improve the efficiency of transport systems that require charges. AUPS may be used for public transport systems, enabling users to better integration between modes. AUPS may also be used for integrated payment with parking and tolls along with broader pricing initiatives such as congestion pricing (Rose 2007).

4.6 Management of Road Space

Management of road space can occur through the restriction or prioritisation of particular modes in areas or road lanes, or alternatively by managing the impact (speed and volume) of motorised vehicles in order to improve other modes of travel such as cycling and walking. It is important to note that some objectives of the management of road space may not necessarily relate to TDM. In many cases the management of road space is used to better facilitate the movement of motorised vehicles within transport systems. Management of road space becomes a TDM instrument when the focus is on switching from Single Occupancy Vehicles (SOV) to High Occupancy Vehicles (HOV), and therefore decreasing the demand for road space per traveller. Four examples of the management of road space for TDM are:

- **Dedicated lanes** may be provided for buses or HOV vehicles in order to allow these vehicles to travel unimpeded along congested roads. Dedicated lanes are usually located adjacent to lanes for general traffic and they may be permanent or operate at specific times, particular in peak travel periods.

Case Study: High Occupancy Toll (HOT) Lanes

San Diego, U.S.

<p>The U.S. Federal Highway Administration (2001) introduced a three year demonstration project of High Occupancy Toll (HOT) lanes on the I-15 in San Diego in 1998. Volunteer SOV were charged for use of the HOT lanes. Two types of pricing structures of HOT lane use were used during the demonstration program. The first involved a fixed monthly fee for participants in the program and the second involved a variable charge according to the level of congestion on the road. Revenue raised by the program was partly hypothecated and redirected into public transport improvements along the corridor. An ex-post evaluation of the program involved traffic studies including traffic volume, mode, speed and time, as well as panel surveys gathering attitudinal responses of HOT lane users. The evaluation found that during the demonstration program use of the HOT increased and SOV users of the HOT lanes reported travel time savings. The variable charge for HOT use resulted in a greater spread of peak traffic volumes in HOT lanes as SOV drivers responded to higher prices during congested periods and chose not to use the HOT lane, or chose to travel at less congested times when prices were lower. Furthermore, the variable price was more acceptable to the program participants than the fixed monthly fee. Part of the revenue raised from HOT lanes was used to fund a bus service along the transport corridor. The evaluation found that there were modest increases to ridership of the bus service; however the increase in ridership did not meet the original objectives of the program.</p>

- **Traffic signal prioritisation** gives road-based public transport, such buses and trams, priority at traffic signals in order to maintain or improve reliability of public transport vehicle flow. Approaching buses and trams may automatically or manually prompt traffic lights.
- **Local area traffic management (LATM)** refers to the use of traffic calming infrastructure to reduce vehicle speeds and consequently improve the safety of local streets for pedestrians and cyclists. LATM shares similarities with other street scale improvements (See Section 4.1.1. above).
- **Car free areas** are used to restrict vehicles from roads in designated areas permanently or at different times of the day or week. Car free areas are used in many European cities such as Rome and Oxford in the U.K and are usually located in city centres, commercial districts, or where there is a high volume of pedestrian activity. City centres can also have restrictions for some vehicles and not others. For example vehicles with licence plates ending in odd (even) numbers may be restricted on odd (even) days. Examples of cities that have area restrictions based on licence plate numbers include Athens and Mexico City. However, such schemes have

been found to lead to perverse outcomes such as households purchasing additional cars in order to avoid restricted travel (Eskeland and Feyzioglu 1997).

4.7 Governance and Administrative

Governments can use regulatory mechanisms to manage travel demand. Governance based TDM instruments may involve the direct intervention into travel markets. Alternatively, they can be regulatory mechanisms that facilitate relationships between public and/or private organisations and local businesses. These instruments strengthen existing, or create new opportunities, for communication and collaboration. Governance based TDM instruments usually are based on legal or statutory mechanisms.

- **Vehicle quotas** are TDM instruments that ration vehicle ownership and sometimes the use of vehicles at particular times. There are a number of different methods that can be used to organise the quota system, including a public auction of a quota number of licences to own vehicles, or through the use of allocating quotas to access city centres by licence plate numbers.
- Vehicle quotas can be incorporated into **tradeable driving rights/ permit schemes**. These schemes involve the introduction permits or quotas to access roadways. Such schemes allow the pricing of scarce resources according to market mechanisms. The cost of access to roadways at peak times is driven by the exchange of driving rights permits.
- **Area wide transport plans** are plans that outline actions to limit travel or shift demand to public transport, walking and cycling within a neighbourhood or precinct area. Sometimes area wide transport plans may incorporate travel co-ordinators; usually professionals who provide individualised or group advice and assistance to business-owners, employees or residents regarding transportation options.

Case Study: Area wide transport plan
Rouse Hill, N.S.W. Source: Wiblin et al. (2012) see also Premier's Council for active living (no date)
<p>Planned since the early 1980's, the Rouse Hill Town Centre is a transit-oriented development located in an urban growth area, 40km north west of Sydney. When completed, the 122 ha development site is planned to accommodate 4,500 new residents, 1,800 dwellings and generate 12,000 permanent jobs (Premier's Council for Active Living 2010). Travel demand management was planned into the development. Through a developer contribution, \$3 million were allocated specifically for TDM and a further \$16 million for other sustainable transport instruments.</p> <p>A number of key features were incorporated in the Rouse Hill Area Wide Travel Plan. These included:</p> <ul style="list-style-type: none">• A dedicated transport co-ordinator.• A Green Travel Club for employees of the Rouse Hill development. The club provided opportunities for networking, rideshare information, social events and incentives for sustainable transport to and from and within the development.• A shop-front for 'green travel' information within the Rouse Hill Town Centre.• Events and promotions.• An advocacy body for the development's sustainable transport objectives. <p>In an evaluation of the early-stages of the TDM initiative, Wiblin, Mulley and Ison (2012) conclude that area-wide travel planning is more complex than workplace-based travel planning. The experience at Rouse Hill</p>

Town Centre demonstrates that area-wide travel planning must address the travel behaviour for a range of different groups and individuals – employers, employees, residents, commuters, and shoppers.

- **Transportation partnerships or transportation management associations** involve the collaboration of public, private organisations and local businesses in addressing travel issues over a precinct or regional scale. The purpose of partnerships may range from providing information and networking opportunities for sustainable mobility programs, through to allocating grants and funds for transport improvement projects. TDM may occur through travel planning, behaviour change programs or the provision of infrastructure for pedestrians, cyclists or public transport users.
- **Travel safety, public health or environmental awareness campaigns** may be used to communicate messages to the public regarding the health, wellbeing and environmental benefits of active travel or reducing SOV use.
- Businesses or workplaces may have **car share schemes** that provide short-term hire of cars. By providing opportunities for households and individuals access to a car when travel by car is essential, the cost of vehicle ownership may be reconsidered.
- **Shuttle bus services** may be provided by government agencies in order to provide small-scale transport options that are responsive to the needs of some community members. Shuttle buses can be used for travel to shopping centres, places of education such as universities and technical colleges, or public transport stations and exchanges.
- **Carbon reduction or air quality targets** are indirect TDM instruments, providing organisations and workplace specific carbon reduction or air quality targets that may instigate other travel reduction or sustainable mobility policies and mechanisms.

4.8 Parking

Parking is an influential factor in shaping demand for travel. Applying a price for parking increases the total cost of travel and therefore can lead to a decrease in demand for travel by private vehicles. As cars spend most of their time parked, the availability and cost of parking spaces at origins and destinations plays an important role in shaping the decision to own and use motor vehicles. Parking as a TDM instrument may be used in two ways: managing the demand of the existing parking supply, or adjusting the supply of parking.

4.8.1 Parking Demand Management

The management of demand for existing parking spaces enables a more efficient use of both land resources and road spaces. Drivers cruising for parking can contribute significantly to the congestion on roads (Shoup 2006). Managing the demand for car parking spaces can therefore influence the level of congestion on roads. TDM parking policies and instruments are often based on creating efficient markets by revealing the hidden costs of parking spaces. The correct pricing of car parking space influences both the level of demand for vehicle travel and the duration that the car is parked. However it should be noted that the management of demand for parking influences vehicles driving to destinations within areas where parking is priced. Parking demand management does not influence through traffic and parking policies can be undermined by adjacent areas outside of parking policy areas that may attract drivers.

A number of instruments are identified in the TDM matrix related to the management of parking demand.

- **Improved enforcement** means that existing parking restrictions are better monitored and applied. Improving enforcement can contribute to the successful operation of other parking policies and therefore may have an indirect influence on the management of travel demand.

- **Cash-in-lieu of parking** offers employees the option of receiving cash as an alternative to employer provided car-parking spaces. The option allows greater flexibility for employees who can commute to work by modes of transport alternative to SOV to forego parking spaces that they may never use.
- **Unbundling parking** refers to the process where parking is separated from individual dwellings (usually apartments and units) in order create a distinct market for car parking spaces. Unbundling parking spaces allows the cost of parking spaces to reflect land values therefore creates its own market conditions – i.e. residents may choose not to purchase or rent an additional parking space, and instead substitute car travel with public transport use.
- **Preferential parking** may be provided to HOV in order to provide an incentive for people to car pool to work or events. Preferential parking spaces may be used when parking supply is limited and there is excess demand for parking space, or they may be provided in attractive locations (i.e. the closest space to destinations). Discounted rates may also be provided for preferred travel types. For example, in the Perth CBD, three car parks currently provide discount rates for carpool vehicles.
- **Performance-based parking** means that the cost of parking space vary according to the time of day. In a study of the effects of performance based pricing in Seattle, U.S., Ottosson et al (2013) concluded that price elasticity does vary at different times of the day and can be used to determine pricing for parking during peak and non-peak periods. The outcomes of such market based instruments for parking, as illustrated by performance based pricing, is that the costs of travel by car (for example, the opportunity cost of land taken up by parking spaces) are incorporated into individual decision-making regarding travel, and that there are less individuals ‘cruising for parking’ and therefore less congestion on roads.

Case Study: Performance Based Parking

SF Park, San Francisco, U.S.

<p>In 2011 the City of San Francisco introduced an innovative performance-based parking program. SF Park is a citywide parking program that used parking sensors and metres to allow parking prices to respond to demand for parking. The price of street parking spaces varied based on occupancy rates, informed by research by Shoup (2011). In other words, the more demand for on street parking at particular times and in particular places, the higher the price of parking spaces, and therefore a responsive lowering in overall demand for spaces. The program was justified on the basis that it would reduce congestion, create safer streets and improve the economic viability of the streets, neighbourhoods and the city centre. The ambitious program was partly funded by a U.S. Department of Transportation grant.</p>

<p>An evaluation of the program is currently under way. The evaluation will be based on an extensive database informed by the ongoing monitoring of occupancy rates. SF Park (2014) identifies four expected outcomes of the evaluation.</p>
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- | |
|--|
| <ol style="list-style-type: none"> 1. Increased parking availability. 2. Reduced parking search time. 3. Reduced cases of double parking 4. Decreased long-term on street parking. |
|--|

4.8.2 *Parking supply*

Travel demand may also be managed by adjusting the supply of car parking spaces. TDM may occur by either increasing or decreasing supply. For example, car parking may be increased at public transport stops in order to facilitate the use of public transport to access activity centres. Alternatively, car parking may be decreased in areas that are sufficiently serviced by public transport in order to shift demand to alternative modes of travel to SOV.

- **Park and ride** involves the increase of parking supply at public transit interchanges in order to facilitate inter-modal connections. Park and ride is used extensively in Western Australia, as well as the U.K., Sweden and the U.S., as a means of providing access to public transport for large urban catchments of low density residences. Park and ride facilities may also be provided for bicycles. Parking caps may involve the decrease or limitation of parking space supply in activity centres in order to shift demand to other modes of travel.
- **Parking caps** have been used in the Perth central business district since the 1980's and there are now parking caps at Murdoch and Curtin activity centres. The parking caps are determined by modelling of the regional road network at peak conditions and are allocated based on bays per hectare of site area.

4.9 Taxes and charges

Taxes and charges are pricing mechanisms that create a disincentive for SOV use and can shift demand to alternative modes. The use of tax and charges is often justified by the assumption that the incorrect pricing of transport services and infrastructure results in over-consumption and that the means to address this is through the use of pricing signals. There is widespread support among transport economists and increasingly among transport bureaucrats, that some form of pricing of congestion would be the most effective means to manage the demand of use of urban roadways (King, Manville and Shoup 2007; Hensher and Bliemer 2014). However, the acceptability of pricing mechanisms aimed at decreasing peak-hour congestion amongst the public, is often raised as a significant barrier. There have been innovative approaches to addressing this barrier (see Stockholm below) but it remains that political factors are a significant factor in the planning and implementation of taxation and road use charging schemes.

4.9.1 *Taxes*

- **Fuel taxes** increase the marginal tax of kilometres driven and can be used to reduce overall demand for travel by private motorised vehicles. However, as they are broad-based and not targeted towards travel along particular routes or at the busiest times, they are not particularly effective in the management of demand to reduce congestion. Workplace taxation schemes may be designed in such a way that incentivises SOV use. The **fringe benefits tax** (FBT) is an example where the design of the tax incentivises car ownership as part of a salary package and promotes car use as a means of lowering taxation rates. TDM may also address the redesigning of taxation schemes in order to avoid incentivising car ownership and use.

4.9.2 *Road user charges*

Charging road users attracts a great deal of support from transport economists and planners. Three types of instruments illustrate road use charging as a demand management mechanism

- **Distance based charges** allocate road use prices according to the overall distance vehicles travel. Distance based charges are often collected once-a-year, through insurance or vehicle registration transactions. Annual distances travelled have usually been recorded by odometer

readings. In Germany, the LKW-Maut is a road user charge for freight vehicles based on the distance driven in addition to the vehicle type (number of axels and emission category of the vehicle). However, it is important to look at the design and overall objectives of charges in order to appraise their potential to manage travel demand. In the case of LKW-Maut, it is arguable whether travel demand management was the intended outcome of the design of the charge, as revenue raised by the charges is directed towards expanding and maintaining the road system – supply factors. The use of **time-based charges** as well as distance-based charges may allocate prices for road use more effectively. Road use is charged at varying peak and non-peak rates. The cost of travel for the road user is based on the overall use of the road at that time.

- **Cordon charging** involves charging drivers when they enter a cordon area, usually a city-centre. The cordon charge may make other modes more attractive, shifting demand away from private vehicle to public transport, for example. The cordon charge also works as a disincentive for vehicles moving through the cordon area, as opposed to vehicles travelling to a location within the cordon (Ker 2003). In this way the cordon charge has the effect of freeing space in congested roadways for consumers and employees of city firms improving economic efficiency of city centres. Lower volumes of vehicles may also improve inner city environments for walking and cycling. London, Stockholm and Singapore provide examples of cities that have implemented cordon charging.

Case study: Cordon Pricing

Stockholm, Sweden.

Acceptability issues are a critical factor for the implementation of TDM policy. For example, whilst road pricing is widely accepted as a sound and effective way of managing travel demand, as Zhu, Du and Zhang (2013) note, there are major barriers in the form of public acceptability based on the perception that road pricing is an additional tax on congestion, the additional transaction fees, the welfare and distributional costs, and concerns over privacy. Ubbels and Verhoef (2005) distinguish between public, political and business acceptability issues, although these are often interdependent.

In 2006 the city of Stockholm in Sweden introduced a **congestion charge** for motorists travelling into the inner urban core of the city. The congestion charge provides a useful case study of how TDM policies can be designed in order to improve the acceptability. The implementation of the congestion charge differed from other cordon charges (for example, in London U.K.) in that the charge was initially introduced as a trial, followed by a referendum on whether the charge should be permanent. The initial trial ran for six months from January to July 2006. The cordon area was approximately 30km². Unlike the London cordon scheme which charged £5 (later £8) per day, the Stockholm scheme used a range of prices during throughout the day. Higher prices were charged at peak hour in order to manage excessive demand and congestion. Concerns regarding the equity of the scheme were addressed through the use of exemptions to the cordon charge. Efficient fuel vehicles, vehicles owned by disabled driver, taxis, buses and emergency vehicles were exempt from the charge.

The ‘trial followed by referendum’ model was a key factor contributing to the success of the scheme. The City of Stockholm articulated the intent of the congestion charge as a “test” to improve the efficiency of the transport system and stated an objective of a 10-15% reduction in vehicle traffic into the cordon area. Public acceptance of the charge increased substantially during the trial period. The trial was presented as part of a package of policies targeted to reducing congestion in the inner city. The two other primary policies that supported the congestion charge were increased public transport services (primarily buses into and out of the city at peak times) and increased park and ride facilities on public transport links to the city. Forecasted traffic studies revealed differing rates of reduction of traffic volumes as a result of the scheme, yet some evaluations indicate that the targeted reductions in volume of 10-15% were surpassed (Eliasson 2009).

- The public acceptability of TDM instruments, in particular ‘push’ mechanism that impose a disincentive on travel that leads to congestion, can be significantly dependent on the use of revenue generated by the instrument (Ubbels and Verhoef 2005). Although technically not a TDM instrument, the use of **hypothecated revenue from a tax or road user charge** effectively commits the revenue for a specific purpose, in particular funding options that counteract direct effects of the tax. For example, the revenue raised by road use charges may be directed into improving public transport infrastructure and services to provide better alternatives to drivers who may want to avoid the additional cost associated with the road use charge.

5 TDM: Case Study Cities, Countries and Regions

5.1 Overview

The following section highlights some cities and regions that provide examples of the implementation of TDM policy instruments.

5.2 Vancouver

The greater region of Vancouver has, over the past thirty years, transformed its urban form and transport systems and become an exemplar city for more sustainable models of urban transport (Punter 2003). The transformation began in the early 1990's where, supported by an extensive public participation program, a series of policy and plans and the creation of a regional scale of urban governance led to an integrated approach to land use and transport planning and infrastructure development.

Vancouver's reputation as a leading region for innovative transport policy has much to do with the governance of its planning and transport functions. Governance refers to the spatial and institutional relationships between public, private and civic governing agents. Fragmented governance of transport systems may impede the implementation of TDM policy. Metro Vancouver (formerly the Greater Vancouver Regional District) is the regional governing body representing twenty four local authorities. The objectives of the authority are to plan and deliver key urban utilities and service and provide democratic governance that enables greater participation from the public. Translink is the regional transportation authority that plans, finances and manages all transportation infrastructure and services in the Vancouver region. Translink is controlled by local governments yet operated within a regional policy framework and is funded by revenue generated by fare and levies from the transport sector – charges, tolls, fines, fare, and fees. Although services are contracted, Translink was the first regional governing body in North America that had authority over all transport modes and systems.

The management of urban travel demand has been a key objective in Vancouver's transformation. In the 1990's there was a planned increase in the supply of housing supply in the downtown Vancouver area. This increase in the capacity of centrally located housing was supported by improvements to the regional transport network with additional public transport infrastructure, such as the Skytrain, and support for other alternative modes of travel. In addition to improving the accessibility of the downtown area, Vancouver's regional growth strategy identified **transit oriented developments** (TOD) as a strategy to reduce car travel and urban sprawl in the greater Vancouver region. TODs are developments that integrate land use and transport objectives and manage travel demand through providing accessible alternative to SOV use and through reducing the need to travel great distances by containing activities within a higher density urban precinct. An example of a successful TOD is Collingwood Village located at the Joyce-Collingwood station on the Expo line of Vancouver's elevated rail, the Skytrain. Collingwood Village is part of corridor of connected TODs. Some of the development's features include high quality public spaces, extensive bicycle parking, underground car parking and a variety of housing types.

Vancouver has also implemented other policies supportive of managing travel demand. There have been a number of regulatory changes to the **supply of parking** in Vancouver. For example, the municipality of Vancouver, including the central business district, has maximum parking requirements. New developments with access to good quality public transport stops and stations are occurring with unbundled parking. The TOD Marine Gateway is an example of a development that has unbundled car

parking spaces from the sale of apartments. Another example of innovative TDM approach is the **car share schemes**, MODO. The scheme was established in 1997 and allows long or short-term hire of a range of vehicle types. The scheme has grown in popularity and is now being integrated with developments in the Vancouver area. For example, a development at Oakridge in Vancouver provides priority car park spaces for MODO co-op vehicles, similar to disabled access parking.

5.3 The Netherlands

The Netherlands has a strong tradition of spatial planning and since the 1960's urban growth within the Netherlands has been shaped by a number of policies that integrate land use and transport planning (Schwanen, Dijkstra and Dieleman 2004). From the 1960's until the late 1980's, **urban growth policies** were directed towards growth areas and sub-centres on the fringe of the urban centres, under a strategic directive of concentrated decentralisation. In the 1990's a policy shift towards consolidation saw urban growth channelled into existing urban centres. The urban centres of the Netherlands including Amsterdam, The Hague, Utrecht, and Rotterdam are considered amongst the most successful exemplars of compact city policies (Hull 2011). These policies include subsidies for housing improvements in city centres and the **ABC location policy** (see Case Study above).

The cities of the Netherlands, as well as many other northern European and Scandinavian cities, in particular Copenhagen in Denmark, are exemplars of **cycling friendly cities**. Pucher and Buehler (2008) evaluated the policies and approaches in these countries in order to provide an example of best practice planning for cycling, and founded the reasons these cities provide practicable alternatives to travel by motorised vehicles was through:

- dedicated bike lanes along busy routes, with good signage. In 2004 Copenhagen and Amsterdam had approximately 400km of dedicated cycle lanes each;
- area wide traffic calming in local streets;
- intersections designed to accommodate safe cycling;
- provision of bike parking;
- integration of cycling and public transport;
- bike education – for cyclists and motorists;
- traffic laws;
- promotional events; and
- a range of complementary taxation, parking and land-use policies.

The Netherlands has also produced a number of approaches to **street scale improvements** that have managed travel demand by making walking and cycling more attractive (Hamilton-Baille 2008). The *woonerf* or 'living streets' were streets that integrated pedestrian paths and the road into a singular surface. The streets often had entrances creating the feeling that one was entering a distinct area. The concept of the 'living street' has been revitalised in the broader 'shared space' movement that is based on the elimination of signage and visual cues for cars, requiring drivers to slow down and exercise caution in streets that are shared with pedestrians and cyclists.

5.4 London

In recent years London has introduced a number of innovative policies and schemes with the intention of managing travel demand and improving the urban quality of the city centre. The London **cordon charge** provides an important international example of congestion pricing. The planning of the congestion charge began in 1998 as part of Mayor Ken Livingston's election campaign. Following a period of public consultation and debate, the charge was introduced in February 2003. Ison and Rye (2005) identify three factors that contributed to the successful implementation of the cordon charge.

1. Consensus that congestion was a problem.
2. The objectives of the charge were clearly articulated by policy makers.
3. The design details of the charge were simple and some degree of flexibility was evident to respond to implementation challenges.

The cordon area covers 21km² of central London, bound by an inner ring road with 174 entry and exit points. Motorists entering the cordon area between the hours of 7am and 6.30pm between Monday and Friday are required to pay a congestion charge. The cordon charge can be paid through multiple transaction points (internet, phone and shops) and is enforced through the use of 700 cameras. There is ongoing monitoring of traffic along the boundary road as it was highlighted the road that could become highly congested as a result of the cordon charge. In order to address equity issues exemptions to the charge were granted to residents, private hire vehicles, alternative fuel vehicles, breakdown vehicles and emergency vehicles. The revenue raised by the cordon charge was reinvested in **improving London's public transport network and services**, contributing to the ease in which the policy was accepted and ultimately implemented (Ison and Rye 2005). In 2004, London also moved from requiring minimum off-street parking to imposing **maximum standards for off-street parking**, leading to a reduction of 40% in the parking supply (Guo and Shuai 2014).

London is also making changes to improve the quality of its streets for pedestrians and cyclists. An example of a **streetscape improvement scheme** is Kensington High Street, an important shopping precinct in London. The streetscape improvements, which began in 2000, involved the 'decluttering' of the streetscape and included the widening of pedestrian paths, provision of bicycle parking, additional pedestrian crossing and the simplification of street signage (Hamilton-Baille 2008). The improvements were based on the 'shared space' concept, where vehicles respond to the lack of visual cues such as signage and curbs and therefore reduce speeds and are more aware of pedestrians and cyclists who share the road space. A more recent example of a shared space street scheme is Exhibition Road in Kensington, the site of many key cultural institutions.

5.5 Singapore

Singapore has attracted much attention from transport policy makers and researchers due to its strong regulatory approach to managing travel demand of SOV. Singapore was an early adopter of policies that directly managed demand of SOV. Singapore has used a **cordon charge**, the **Area Licencing System**, since 1975 charging drivers to enter the CBD. In 1998 the original system was changed from a paper based system charging cars to enter restricted zones per day, to an electronic system that charged cars each time they crossed the area boundary. Due to the success of the congestion charge, the scheme has been extended to additional congested major roads. In 1990 Singapore introduced a **Vehicle Quota System**, capping the number of vehicles permitted to using the road system. The quota is organised according to a competitive bidding process that allocates vehicle use entitlements for ten years. The vehicle quota system works is supplemented with vehicle purchase and ownership fees and taxes. However, it is important to note that car use has increased and the average distances travelled by cars in Singapore is high given the size of the island, possibly due to the ongoing expansion of road and highway capacity and little congestion (Lam and Toan 2006).

Singapore has also planned and invested in land use development and alternatives to SOV in order to manage travel demand. Singapore has an extensive rail system (Mass Rapid Transit), a smaller light rail system, bus system and a highly regulated taxi-cab service. To facilitate the movement of road based public transport and to better integrate travel between modes Singapore also uses additional TDM instruments including bus priority signalling, park and ride and integrated public transport networks and fare system. Since the 1970's land use planning in Singapore has resulted in increased densities in areas well supported by public transport.

6 Conclusion

This report presents the first part of an initial investigation into the potential TDM response to the issue of traffic congestion in Perth, Western Australia. The literature review informing this report was initiated in response to a question identified by the Transport Portfolio during the development of the PATREC Strategic Business Plan 2013-2016: *What are the key demand management instruments available for managing transport congestion in Perth?* To address this question this report presents a matrix of TDM instruments and provides a range of case studies illustrating concrete examples of a selection of TDM instruments and details on their implementation and evaluation in Australian and international contexts. A conceptual model guiding the categorisation of instruments was outlined, organising instruments according to the type of travel demand response targeted, the relevant transport market, and whether the instrument provided an incentive to change mode from SOV, or provided a disincentive for SOV use. Accompanying this report on the range of TDM instruments available to policy makers is a second report reviewing the range of available and applied congestion indicators and policy appraisal tools within and beyond the transport literature. Together, the two reports present the first stage in a broader inquiry into three further critical questions regarding the capacity of TDM to address congestion in Perth.

1. *What is the relative contribution that each of these instruments can make to reducing congestion?*
2. *What are the broader economic and social costs associated with demand management instruments (e.g. impact on CBD retail and social equity from implementation of congestion pricing schemes)?*
3. *What are the key lessons that Perth can learn from other jurisdictions regarding community acceptance and the successful implementation of demand management instruments?*

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APPENDIX

The Travel Demand Management Matrix

Improving alternative modes:						
Improving modes of transport, such as walking, cycling and public transport, manages travel demand by increasing the attractiveness of alternative modes of travel to the private vehicle.						
Categories	TDM Instrument	Description	Push/Pull	TDM type	Travel purpose	Example
Walking and Cycling	Infrastructure supply and network improvements	Building infrastructure, such as dedicated or shared paths, in order to extend the existing cycling and pedestrian network.	Pull	Mode shift	Multiple	In Bogota, Colombia the Ciclorutas is a city wide network of over 300 km of pedestrian and cyclist dedicated pathways. The Ciclorutas is supported by a secondary network, linking residential areas to activity centres such as Bus Rapid Transit stations.
	Street scale improvement	Programs that improve the quality and safety of local streets and major activity streets. Lowering traffic speeds in residential areas and around high trip attractors such as schools, shopping centres and main streets.	Pull	Mode shift	Multiple	An example of a main street improvement project is the recent development of 'shared space' approach in Kensington High Street, London. The Dutch concept of the 'woonerf', the UK 'home zones' and the US 'complete streets' are examples of approaches to streets scale

						improvement at the neighbourhood scale.
	Legislation and rules	Adapt laws and rules that improve the rights, safety and priority of cyclist and pedestrians in the transport system. For example rights of way, minimum clearance laws, and priority at crossings and intersections.	Push/ Pull	Mode shift	Multiple	The recent introduction of new cycling laws in Queensland requiring drivers give cyclists a 1.5 metre clearance is a relevant example.
	Education programs	Education and awareness programs for cycling and for road safety can develop confidence and skills for active travel. These are particularly effective with children and young adults.	Pull	Mode shift	Multiple	Education programs for cyclists and pedestrians are common throughout the world, however the Netherlands and Germany have innovative travel education programs. The Netherlands 'traffic garden' built in the 1950's is an education centre featuring miniaturised streets where children can learn skills to navigate safely in city streets.
	Better integration with other modes	Providing transport infrastructure and/or services that facilitate inter-modal trips. This includes providing space for bikes on public transport, parking for bikes at stations, and locating public transport stops in close proximity.	Pull	Mode shift	Multiple	The Denmark Park and Bike Terminal in the City of Aarhus is a good example of a drive-ride intermodal project, where a commuter can drive a car with their bicycle to a terminal with sufficient parking space that is located on the main cycling network.
	End of trip facilities	Providing facilities such as bike-parking and showers for cyclists and pedestrians at key activity nodes, such as workplaces and stations.	Pull	Mode shift	Commute	The Netherlands and Denmark lead the way in cycling parking. An example is at the Utrecht Central Station.

	Bike share	Bike share programs provide short-term access to bicycles through a city-wide network of hire stations.	Pull	Mode shift	Multiple	Many international and national cities have bike share programs including New York, Paris, London, Melbourne, Melbourne and Brisbane.
Public Transport	Network improvements	Improving and/or increasing public transport infrastructure, routes or rolling stock in order to enhance the capacity and intermodal connections of the public transport network.	Pull	Mode shift	Multiple/commute	In the early 1980s Portland transformed its transport system by reconfiguring its 'hub and spoke' bus lines that focused on the city centre, into a grid of frequent bus lines. The network plan improved connections and accessibility for city. See www.humantransit.org "Portland: the grid is 30 years old...thank a planner".
	Service improvements	Improving public transport services including the frequency and reliability of services. This may be achieved through integrating services and timetabling of different modes or through providing priority to public transport modes, such as priority lanes, dedicated lanes and signalling.	Pull	Mode shift	Multiple/commute	Zurich in Switzerland uses 'pulse timing' to better integrate bus and rail transfers. Buses and trains are timed to arrive at transfers stations at half-hourly intervals, allowing better integration between inter-modal travel.
	Improved quality of stations and stops	Improving the quality of stations can lead to a more comfortable experience for public transport users and therefore increase its attractiveness. Improvements may be better shelter at public transport stops, more lighting or safe road crossings adjacent to stations.	Pull	Mode shift	Multiple/Commute	Many international and national examples.
	Improved information and ticketing	Improving useability of public transport timetables and ticketing information – online,	Pull	Mode shift	Primarily commute	There are many international and national examples of integrated public transport ticketing systems, such as

		at stops, on board – increases the legibility and ease of moving from mode to mode.				the Oyster Card in London and Perth's Smart Rider. Tri-Met in Portland U.S., has introduced a mobile app ticketing system.
Other modes	Improved taxi services.	Improvements to the taxi services can lead to a reduction in the need for car ownership and can support travel by alternative modes, such as walking and public transport. Improvements may derive from increased services and the improved quality or efficiency of services.	Pull.	Mode shift	Multiple.	Many examples.
	Motorbikes and e-bikes	Providing adequate parking or prioritising the on-road movement of small vehicles, such as motorbikes and e-bikes, can contribute to a reduction in congestion (although motorbike transport may not necessarily lead to a reduction or shift in travel demand on roads).	Pull	Mode shift	Commute	North Sydney Council has provided electric bikes to council workers for work travel as a substitute for cars.
Financial incentives and subsidies	Reduce public transport fares	Providing subsidies or incentives for particular types of travel or travellers can contribute to modal shifts in peak hour.	Pull	Mode shift	Primarily commute	The use of fare concessions for student travel is widespread.
	Public transport to special events	Provide transport subsidies (like free PT travel) to major events in order to reduce congestion.	Pull	Mode shift	Recreation	An example of a major travel demand management strategy for a major event was Transport for London's plan for the London 2012 Olympics.
	Reward schemes	Reward schemes may be used to provide direct incentives to peak hour commuters who	Pull	Time of travel/	Commute	'Spitsmijden', a Dutch program launched in 2006, provided an

		choose to travel outside the peak period, shift mode to public transport or choose not to travel and instead, telework.		reduce travel/ mode shift		incentive for drivers participating in the program to avoid peak hour travel in certain locations.
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Integrated land use and transport:

The planning of land use that integrates existing and future planned transport networks and infrastructure, and vice versa, facilitates the development of urban forms and structures that may encourage travel by alternatives modes to SOV.

Categories	TDM Instrument	Description	Push/Pull	TDM type	Travel purpose	Example
Regional	Growth strategy	Growth strategies can enable better integration between land use and development planning and transport planning and policies.	Pull	Reduce travel/ Mode shift	Multiple	Many cities and regions have growth strategies. Portland, U.S. is frequently used as an example of a city with a growth strategy that successfully integrates land use and transport.
	Corridor planning	The integration of land use and transport planning for activity corridors -higher density; frequent PT service; linear transport networks; nodes of activity centres along corridors.	Pull	Reduce travel/ Mode shift	Multiple	There are many examples of corridor planning that integrates land use and a range of transport modes. Arlington in the U.S is one example.
	Transit Oriented Development	Increased residential density and mixed uses around public transport stations.	Pull	Reduce travel/ Mode shift	Multiple	Transit Oriented Developments are used in many city and regional approach to integrating land use and transport. Cities that have good examples include Portland, Vancouver, the Netherlands and Copenhagen.
	Accessibility and land use planning tools	Greater accessibility means that people can get to the activities they need or want to travel to easier. Measures of accessibility incorporate both land use and transport systems. Tools that measure accessibility can better inform planning for land use and transport.	Pull	Reduce travel/ Mode shift	Multiple	A tool developed by Curtis and Scheurer (2010), the Spatial Network Analysis of Multi-modal Transport Systems (SNAMUTS) is currently being used to evaluate the quality of urban transport networks in a number of

						national and international cities, as well as Perth.
Local	Impact assessment	Impact assessments are formal evaluations of developments, precincts or policies that can manage travel demand by incorporating assessment criteria that focus on improving outcomes for alternative modes of travel to the SOV.	Push/pull	Mode shift	Multiple	The UK has recently required developments that are likely to be large trip generators and attractors to be subject to a Transport Assessment.
	Travel Plans	Travel plans consist of a package of strategies and instruments that promote alternatives to SOV use.	Pull	Mode shift/ reduce travel	Multiple	Travel plans are used extensively in the U.K. In London, the O2 (formerly the Millennium Dome) has an example of a best practice travel plan.
	School travel programs	Schools generate a large amount of travel activity. School travel programs may include improvements to the built environment, traffic safety, travel behaviour or flexible school start times in order to reduce vehicle congestion around schools and increase sustainable mobility.	Pull	Mode shift / time of travel	School	Many national and international cities, including Perth have examples of school travel programs. Many European countries such as the Netherlands, Germany, Denmark and Switzerland, have high rates of children walking and cycling to school.
	CPTED and Design Out Crime	Designing or adapting the built environment for crime prevention. Increasing the perceived safety of areas such as public transport stations can influence people's decisions to use alternative modes of transport.	Pull	Mode shift	Multiple	The Australian Urban Design protocol (http://www.urbandesign.gov.au/) includes a number of case studies of places that have used CPTED principles.

Workplace-based instruments:

Workplace-based TDM instruments include a range of instruments that are provided to employees to encourage travel to work by modes other than SOV.

Categories	TDM Instrument	Description	Push/Pull	TDM type	Travel purpose	Example
Employer support	Car or van pooling	Employers can provide support for carpooling, or the shared use of commuting vehicles amongst two or more individuals. Also larger employers may rent small buses and vans to provide a vanpool commuter service.	Pull	Mode shift	Commute	Carpooling (or ridesharing) is commonly used in the U.S. Commuter Connections in Washington State is an example of a carpool scheme. Also see the San Diego iCommute Program.
	Preferential parking	Employers can provide parking to preferred modes of travel, for example carpool vehicles.	Pull	Mode shift	Primarily commute	Examples of the use of preferential parking are widespread. However, several Californian cities provide best practice examples as a travel demand management strategy. The City of Gardena has ordinances for workplaces to provide 10% of the parking to be located closest to workplace entries and to be reserved for carpool or vanpool vehicles.
	Guaranteed ride home	Guaranteed ride home is a service provided to employees who carpool, or use alternative modes to SOV to travel to work, where a 'ride home', usually by taxi, is subsidised by the employer in the case of an emergency.	Pull	Mode shift	Commute	Guaranteed ride home schemes are common in workplaces in the U.S.
	Bike storage/ end of trip facilities	The provision of good quality, end-of-trip facilities for active modes of travel. These can	Pull	Mode shift	Commute	See 'End of trip facilities' in Improving Alternative Modes above.

		include lockers, showers, and parking spaces for bikes.				
Financial incentives/disincentives	Subsidies for public transport or car share schemes.	Employees may subsidise alternative modes to SOV including free public transport travel passes and subsidies for car-share schemes.	Pull	Mode shift	Commute	Eco-passes are used in the United States as a workplace travel demand management subsidy. Public transport agencies sell to employers the right to free travel for a group of their employees.
	Workplace cash-in-lieu parking schemes.	Commuters who are offered subsidized parking are also offered the cash equivalent if they use alternative travel modes.	Pull	Mode shift	Commute	The City of Nottingham in the U.K. has introduced a workplace parking levy that requires employers to provide a fee for the provision of car parking spaces at workplaces. The implementation of this controversial levy was facilitated by public consultation and the hypothecation of the generated revenue towards public transport improvements.
	Salary sacrifice	Salary sacrifice schemes allow employees to receive part of their remunerations in the form of concessional tax benefits. Salary sacrifice schemes may incentivise either SOV use or alternative modes of transport depending on the agreements in place.	Pull	Mode shift	Commute	As part of a 'green transport plan', the U.K. government introduced legislation allowing employers to offer bicycles and related safety equipment as tax-free benefits for employees.
Alternative work arrangements	Flexible working hours or staggered start and finish times	Flexible starting and ending work times.	Pull	Time of travel	Commute	Flexible working hours are widely used (for example the Fair Work Ombudsman in Australia has guidelines).
	Compressed working week	Providing the option for employees to work more hours over fewer days.	Pull	Reduce travel	Commute	An example of a compressed working week policy used to manage travel

						demand is provided by Washington State Department of Transport: http://www.wsdot.wa.gov/choices/compressed.htm
Tele-working	Tele-commuting	Telecommuting involves employees partially or completely working at places other than the workplace through the use of communication technologies.	Pull	Reduce travel	Commute	Hub Australia (http://hubaustralia.com/) provides shared work and learning spaces in Melbourne, Sydney and Adelaide.
	Tele-conferencing	Tele-conferencing involves the use of communication technologies to allow meetings and conferences to be conducted from a range of locations.	Pull	Reduce travel	Commute	There is a wide range of companies that provide tele-conferencing technologies and support.
	Tele-shopping	Use of communications to purchase goods	Pull	Reduce travel	Shopping	Tele-shopping is now widespread.
	Distance Education	Partial or complete substitution of telecommunications for the attendance at primary, secondary or tertiary education sites.	Pull	Reduce travel	Education	Increasing in Australia and US.

Travel behaviour change programs:

Travel behaviour change programs usually include a range of strategies targeted towards changing the travel behaviour choices of individuals, households, schools or workplaces including the provision of information, support and feedback, and incentives for sustainable travel.

Categories	TDM Instrument		Push/Pull	TDM type	Travel purpose	Example
	Individualised marketing	Individualised marketing of travel behaviour change programs use information, incentives and education in order to reduce or change the mode of individuals' travel. Participation is usually voluntary and programs are adapted for the relevant contexts.	Pull	Mode shift/ reduce travel	Multiple	There are many examples of individualised marketing of travel programs in Australia cities, including several interventions as part of Perth's Travel Smart program.
	Travel Blending	Travel blending approaches aim to improve the blending of travel activities in order to reduce travel. Programs usually involve travel diaries and monitoring of everyday travel activity.	Pull	Mode shift/ reduce travel	Multiple	There have been a number of examples of Travel Blending programs in Sydney and Adelaide (see Rose and Ampt 2001).

Information Programs:

The use of communication information in road transport better informs potential drivers' decision-making with regard to travel.

Categories	TDM Instrument	Description	Push/Pull	TDM type	Travel purpose	Example
	Advanced Traffic Management Systems (ATMS)	Use of communication and sensory technology to primarily manage traffic flow, not manage travel demand of SOV. However ATMS may facilitate other demand management measures including signal priority and linking, lane restrictions to encourage HOV, PT and or/freight vehicles and discourage low occupancy vehicles (Rose 2007).	Push/Pull	Mode shift	Commute	ATMS is well established across the US. Australian cities have adopted ATMS
	Advanced Traveller Information Systems (ATIS)	These systems use a range of telecommunications, wireless and visual technology to provide information to travellers in order to influence departure time or mode choice before the trip is undertaken (Rose 2007).	Pull	Time of travel/ Mode shift	Commute	The Puget Sound Regional Council in North Western U.S. has incorporated a comprehensive ATIS system in their regional transport planning in order to support the management of travel demand.
	Advanced User Payment Systems (AUPS)	Managed payment system includes integrated payment and smart charging across modes and/or with parking and tolls along with broader pricing initiatives such as congestion pricing (Rose 2003).	Push/pull	Time/ Mode shift	Commute	There are few examples AUPS, but these systems may become more evident with technological innovations and in cities with multiple transport system transactions.

Management of road space:

Management of road space can occur through the restriction or prioritisation of particular modes in areas or road lanes, or alternatively by managing the impact (speed and volume) of motorised vehicles in order to improve other modes of travel such as cycling and walking.

Categories	TDM Instrument	Description	Push/Pull	TDM type	Travel purpose	Example
	Dedicated lanes and road space reallocation to alternative modes of transport	Providing road space for alternative modes, either by preferential treatment (HOV lanes) or by physical exclusion of vehicles (dedicated bus or bike lanes), increasing the efficiency and therefore attractiveness of these modes.	Pull	Mode shift	Commute	California in the U.S. has a large number of HOV lanes. For dedicated bus or bike lanes, cities such as Copenhagen, Amsterdam and Vancouver provide examples.
	Traffic signal pre-emption	Enables buses/ light rail to control traffic signalling on roads in order to enhance the reliability and efficiency of the service.	Pull	Mode shift	Commute	Traffic signal pre-emption for public transport is widely used including in Singapore, Calgary and Portland.
	Local Area Traffic Management (LATM)	The planning and management of local area road space to reduce vehicular traffic speeds and volumes, and improve amenity and safety for walking and cycling.	Pull	Mode shift	Multiple	Many Australian local governments have Local Area Traffic Management plans. For international examples of LATM see the Complete Streets and woonerfs discussed in 'Street scale improvements'.
	Vehicular restrictions	Cars and motorised vehicles are restricted in locations, such as alleyways or heavily pedestrianized city centres either permanently, temporarily or routinely.	Push	Mode shift	Multiple	Widespread including central Copenhagen, Oxford, Melbourne, and Perth.

Governance and administration:

Governments can use regulatory mechanisms to manage travel demand. Governance based and administrative TDM instruments may involve the direct intervention into travel markets, or regulatory mechanisms that facilitate relationships between public and/or private organisations and local businesses.

Categories	TDM Instrument	Description	Push/Pull	TDM type	Travel purpose	Example
	Vehicle quotas	Vehicle quotas are TDM instruments that ration vehicle ownership and sometimes the use of vehicles at particular times.	Push	Mode shift / reduce travel	Multiple	Singapore has used a vehicle quota scheme since 1990. The quota is organised according to a competitive bidding process that allocates vehicle use entitlements for ten years.
	Tradeable Driving Rights/Permits	These schemes involve the introduction of permits or quotas to access roadways. The cost of access to roadways at peak times is driven by the exchange of driving rights permits.	Push/pull	Reduce travel	Multiple	An example of a tradeable driving right scheme is proposed by Raux (2004) in an issues paper published by the OECD and the International transport Forum.
	Transportation partnerships	A non-profit, member controlled organisation that provides information, co-ordinates and manages demand in specific transport systems – for example a Transport Management Association.	Pull	Mode shift/ time.	Commute	A Green Travel Club was established as part of the Rouse Hill Town Centre in NSW. The club provided a travel coordinator, information, incentives and advocated for the travel needs of its members.
	Travel, public health or environmental awareness campaigns	Campaigns that raise the awareness of the costs of increased motorised transport and the benefits of non-motorised modes of travel.	Pull	Mode shift	Multiple	The Greater Wellington Travel Demand Management Plan contains a public awareness strategy.
	Car share schemes	Car share schemes allow members to reserve cars for short term use. Car share operators store and maintain vehicles.	Push/pull	Reduce travel	Multiple	An example of a well-developed car share scheme is mobil.punkt in Brenham, Germany. See: http://www.mobilpunkt.info/

	Shuttle bus services	Government may provide small vehicle shuttle services to provide public mobility – for example, demand responsive transport; special shuttle services; circulating shuttles.	Pull	Mode shift	Commute or shopping	There are many examples of shuttle bus services. For a list of TDM shuttle service case studies in U.S. cities see: http://www.vtpi.org/tdm/tdm39.htm
	Carbon reduction or air quality targets	TDM strategies may share synergies with carbon reduction or air quality targets. Such targets may require vehicle use restrictions in particular locations and at certain times.	Push/pull	Reduce travel/ Mode shift	Multiple	The European Union has regulated for Low Emission Zones that restrict vehicles or types of vehicles in many European cities.

Parking:

Parking is an influential factor in shaping demand for travel. Applying a price for parking increases the total cost of travel and limit demand. Alternatively, controlling the supply of parking can lead to a decrease in demand for travel by private vehicles.

Categories	TDM Instrument	Description	Push/ Pull	TDM type	Travel purpose	Example
Parking demand managem ent	Improved enforcement	Increased enforcement of parking restrictions to address problems such as parking spill over.	Push	Mode shift / time of travel	Multiple	Improved enforcement was used as a means to manage travel by the University of California, Berkley in their Parking Travel demand management Strategy.
	Cash-in-lieu of parking schemes	Cash-in-lieu schemes allow developers to reduce on-site parking for a fee. Revenue of the fee can be used to fund the provision or management of on-street parking. Cash-in-lieu schemes may be included in the land use planning systems or at the workplace.	Pull	Mode shift	Primarily commute	There are many local, national and international examples of cash-in-lieu schemes, however there are good examples in California and also Toronto.
	Unbundling parking	Unbundling parking refers to the process where parking is separated from individual dwellings (usually apartments and units) in order create a distinct market for car parking spaces.	Pull	Mode shift / reduce travel	Multiple	Soma Residences in San Francisco, a 278 unit development in an city area well served by public transport, provided 200 unbundled parking spaces. The use of parking is coordinated by a parking manager. The unbundled parking allowed the development to meet affordable housing objectives.
	Preferential parking	Prioritised parking spaces may be provided for preferred modes of travel (HOV) at workplaces (see above: Workplace-based instruments),	Pull	Mode shift	Primarily commute	The City of Perth currently has three city car parks that provide discounted rates for carpool vehicles.

		shopping centres, public car parks or public transport stations.				
	Performance based parking	Performance based parking means that parking prices adapt to the supply of parking in the system and demand is managed. Often performance based parking systems use communications and information technology to monitor parking spaces, forecasts of travel times and enabling parking space reservation.	Push/Pull	Mode shift / time of travel	Multiple	SF Park in San Francisco is a good example of a large performance based parking scheme (see Shoup's book <i>The High Cost of Free Parking</i> (2011)). Also Seattle, U.S., has recently introduced a performance based parking pricing. For a detailed report on the implementation of the policy see: http://www.seattle.gov/transportation/parking/docs/SDOT_PbPP_FinRpt.pdf
Parking supply	Park and Ride	Park and ride involves the increase of parking supply at public transport interchanges in order to facilitate inter-modal connections.	Pull	Mode shift	Commute	There are many national and international examples of 'park and ride' schemes and Perth uses 'park and ride' in order to facilitate access to public transport stations.
	Cap or reduce parking supply	Intervening in parking supply can be used to manage the demand for SOV use by reallocating existing parking space, imposing maximum parking space regulations, or eliminating parking space altogether	Push	Mode shift	Multiple	Examples from San Francisco, U.S. are the Rincon Hill Plan (2005) and the Market and Octavia Neighbourhood Plan (2008). Perth has a parking cap on specialised activity centres such as Curtin University and the Murdoch Activity Centre.

Taxes and charges:

Tax and charges are pricing mechanisms that create disincentives for SOV use and can shift demand to alternative modes.

Categories	TDM Instrument	Description	Push/ Pull	TDM type	Travel purpose	Example
Taxes	Fuel tax	A fuel tax works as TDM for aggregate travel but it is not well targeted towards demand related to geographic areas, different parts of the road network, and time.	Push	Reduce travel	Multiple	Fuel taxes are widely used to manage aggregate travel demand, however Australia is ranked as one of the lowest countries in the OECD in terms of the rate of fuel tax behind most EU countries (Bureau of Resource Economics 2014).
	Fringe Benefit Tax	Fringe benefit tax (FBT) exemptions may be granted to particular types of travel for company cars. The structure of FBT concessions may provide perverse incentives for car use. Alternatively, FBT can be redesigned in order to provide incentives for alternative modes of travel.	Push	Mode shift	Commute / Workplac e-based	In 2009, Pedal Power, a non-profit Canberra based cycling group made a submission to the Australian Tax Review, suggesting a repeal of FBT concessions for cars, the introduction of FBT concessions cycling and public transport, and corporate tax concessions for the provision of cycling friendly infrastructure and programs at the workplace.
Road user charges	Distance charges	Distance-based charges allocate road use prices according to the overall distance vehicles travel. In order for distance-based to address congestion, some incorporation of the time of travel, as well as overall distance travelled, is important.	Push	Reduce travel	Commute / freight	Examples of countries with distance-based charges include New Zealand, Switzerland, and Germany (LKM-MAUT).

	Tolls	Tolls on roads, bridges and tunnels are often used to fund transport infrastructure. However this is usually road infrastructure and therefore reduces their effective as a demand management tool. Variable toll charges may be implemented in order to reduce demand for travel at congested times.	Push	Time of travel/ Mode shift	Commute	Oslo, Norway uses a toll tax to partly fund public transport infrastructure, although the large proportion of the revenue raised goes to funding road infrastructure.
	Congestion charge / cordon charge	A charge on travelling that is higher under congested conditions than uncongested conditions. An example of a congestion price is a cordon charges. Cordon charges are fees for motorists that enter a cordoned area, usually a city centre.	Push	Reduce travel/ Mode shift	Commute	Singapore, London and Stockholm have cordon-charging schemes in place. There are similarities and differences between the schemes but they are generally viewed by the public, policy-makers and academics (King et al 2007; Hensher and Puckett 2007) as effective programs to reduce inner urban congestion and provide a revenue source for alternative transport modes.

