Increasingly, policy-makers are turning to travel demand management strategies to address some of the problems of urban transport, particularly traffic congestion. Travel demand management is defined as the use of policy instruments to influence behaviour change to improve the efficiency of transport systems thus reducing congestion, deferring the need to supply additional transport infrastructure. It further has the potential to achieve other policy objectives relating to air quality, environment, health and economic development. An international review of the range of instruments and tools available to policy-makers and planners in Perth is summarised in this Perspective.

**INCREASING DEMAND FOR TRAVEL IN PERTH**

A functioning urban transport system is a vital component of any city. Transport systems provide the means for people to access activities, goods and services. Growing urban populations have placed increasing demands on city transport infrastructure. With a 32% population growth from 1.52 million in 2004 to 1.97 million in 2013 (ABS 2014) and an average annual GDP growth of 5.7% from 2002/3 to 2012/3 in the Perth metropolitan area, demand for transport and other infrastructure to keep pace is high, with commensurate needs for infrastructure planning and policy development to accommodate the growth.

The Bureau for Transport and Regional Economies suggests that the continued growth in traffic is likely to have significant affects on the ability of urban transport systems to function efficiently and equitably (BTRE 2007). The social cost of congestion on Perth roads is expected to rise from $0.9 billion in 2007 to $2.1 billion in 2020.

**Travel Demand Management Solutions**

As the population continues to grow, and in particular when there is a simultaneous increase in competition for infrastructure funding as the economy slows as the resources boom construction phase ends and iron ore prices fall, policy-makers are increasingly turning to ways to more efficiently and effectively manage the use of existing road infrastructure, deferring the need for more roads whilst still reducing congestion levels.

However, the problem of solving traffic congestion in cities is more complex than just that of costs. Building additional roads, or increasing the supply of transport infrastructure, is unlikely to lead to a sustained reduction in congestion levels due to the effect of induced demand where a good road infrastructure promotes car usage (Duranton and Turner 2011). Furthermore, mature cities often find there is limited space to build additional transport infrastructure.

The inherent difficulties of using supply-side approaches to address urban transport problems have led to the increased recognition of the need to manage the demand for travel particularly of single occupancy vehicles (SOV) on roads. **Travel Demand Management (TDM)** is a key policy strategy for the mitigation of urban traffic congestion. TDM is defined as any policy instrument or set of instruments aimed at influencing behaviour change to defer the need for additional road or public transport infrastructure.

TDM policies have a range of other potential benefits for urban areas aside from increasing the efficiency of road infrastructure i.e. improving air quality, increasing healthy behaviour through active travel (travel which encourages physical activity such as walking or cycling) and facilitating economic development.

**Characteristics of Travel Demand**

Travel demand in cities is very complex, for example travel to and from work, school, shopping and recreational activities all have different demand responses to incentives and disincentives to travel by particular modes. An understanding of the factors shaping demand for travel in cities is essential in order to develop policy responses to effectively manage travel demand. A range of travel demand strategies have thus emerged internationally, such as measures targeted to control levels of demand at particular times or places, addressing congestion; or measures used to control particular types of vehicles, addressing environmental objectives such as meeting emissions targets.

There are different behavioural responses sought by TDM Strategies, for example to reduce congestion, the behavioural responses may be reducing overall travel, shifting to an alternative mode to the SOV, or by changing the time of travel to limit demand in peak times. Demand for travel may be managed by either providing incentives (pull mechanisms) or by creating disincentives (push mechanisms) for particular types of travel.

**WHAT ARE THE OPTIONS?**

From a comprehensive review of over one hundred international and national transport research papers, conference proceedings and policy reports a range of instruments aimed at reducing the demand for single occupancy vehicle trips or redistributing these trips in space or in time, were identified and classified into nine types:
1. Improving Alternative Modes

Improving alternative travel modes to car travel, such as walking, cycling, public transport, taxis and smaller vehicles, incentivises mode shift by increasing the diversity of travel options available to people to access their everyday activities. Tools used to promote this are:

- **Legislation and rules** to better protect cyclists’ and pedestrians’ right of way in streets. Queensland Road Rules now require motorists give cyclists a minimum one metre clearance when passing cyclists in a <60km per hour or one and a half metres in > 60km per hour speed zone.

- **End of trip facilities** for cyclists, including secure parking, showers and change rooms, may be supplied at major public transport stations, workplaces or schools and universities in order to provide a more comfortable trip by bicycle. The King George Square Cycle2City in Brisbane for example provides bike parking, lockers, showers and maintenance service.

- **Improving the safety and design of public transport stations** contributes to the overall comfort and security of travel by public transport. The use of “Crime Prevention through Environmental Design” (CPTED) principles may be applied to the stations in order deter criminal activities and increase perceptions of safety, facilitating increase travel by public transport.

- **Subsidising public transport** for particular groups, such as school children and university students, provides incentives for travel for many educational trips to be made by public transport. Free public transport to major events also restricts demand for mass vehicle travel and therefore can limit non-recurrent road congestion.

2. Integrating Transport and Land use Planning

Integrating transport and land use planning at the regional and local scales can improve accessibility, reduce the distances required for travel and facilitate mode shift to public transport, cycling and walking. Integrating transport and land use planning can occur at a broad strategic policy level, guiding metropolitan development patterns, or at the local scale, through assessment of developments and subdivision to increase residential densities around transportation hubs.

TDM instruments that integrate transport and land use planning include:

- **Transit oriented developments** are models of urban development surrounding transit nodes such as rail stations. Transit oriented developments integrate development based on the relationship between stations potential to be a place for people to live and it’s function as a link in the wider transport network – its accessibility.

- **Accessibility planning tools** provide indications of the accessibility of the metropolitan land use and transport networks. These tools can be use in scenario planning or evaluating options for land development or transport infrastructure.

- **Travel impact assessments** evaluate the impact of large developments or subdivisions on the transport system. Transport impact assessments are a requirement for development likely to generate or attract a large amount of traffic in the U.K. as part of their National Planning Policy Framework.

- **Travel plans** outline strategies to manage the travel behaviour of residents in large developments, workplaces or schools. Travel plans can be made a requirement for new developments as part of the development assessment process.

3. Workplace TDM Instruments

The commute to work contributes to peak hour congestion on roads. **Workplace TDM instruments** are travel options provided within workplaces, offering incentives for employees to travel to work using an alternative mode to SOV, including cycling, carpooling, public transport and walking. Workplace TDM instruments may also provide the options or incentives to travel outside peak hour.

Workplace TDM instruments include:

- **Guaranteed ride home schemes** are a service provided to employees who carpool or use other alternative modes of travel to SOV, where a ‘ride home’, usually by taxi, is subsidised by the employer in case of an emergency.

- **Salary sacrifice schemes** allow employees to receive part of their remuneration in the form of concessional tax benefits for certain modes of travel. Cyclescheme in the U.K. is a scheme where employers can salary sacrifice bicycles and bike safety equipment.

- **Flexible working hours** provide employees with more flexibility in when they choose to start and finish work therefore creating the opportunity for employees to travel outside peak hours. **Compressed working weeks** reduce the need for commuter travel by allowing employees to work additional time each day in order to take a regular day off each fortnight.

- **Telecommuting** involves employees working at places other than the workplace through the use of communication technology. Telecommuting allows home-based work, thereby eliminating the need for commuter travel. Shared, centralised office space may be hired by individuals, providing access to office facilities, teleconferencing spaces and social interaction for remote and home-based workers. Hub Australia (http://hubaustralia.com/) provides shared work and learning spaces in Melbourne, Sydney and Adelaide.

4. Travel Behaviour Change Programs

Travel behaviour change programs are targeted to changing the decision-making and behaviour of individuals in the households or workplace, usually through a range of strategies including the provision of information, support and feedback, and incentives for sustainable travel. Travel behaviour change programs have been implemented in Perth under the Travel Smart banner.

Travel behaviour programs include:

- **Individualised marketing** refers to travel behaviour change programs targeted towards changing individual decisions about travel mode. An extensive individualised marketing program was conducted in South Perth in 2000, with favourable results recorded (Roth et al 2003)

- **Travel blending** involves monitoring, evaluation and information targeted at households in order to increase the blending of activities leading to a reduced number of trips. A travel blending program was conducted in Adelaide involving 96 households (Rose and Ampt 2001).
5. Information and Communication Services

Information and communication services provide information about the performance of transport systems, communicated in an effective and convenient manner to travellers so that informed travel choices may be made.

Information and communication TDM instruments include:

- **Advanced Travel Information Systems (ATIS)** provide real-time information relating to the transport system via radio, wireless or mobile phone technology. ATIS may be utilised in communications regarding public transport services.

- **Advanced User Payment Systems (AUPS)** are integrated payment systems that improve the efficiency of transport payment systems. AUPS may be used to integrate public transport fares, parking fares and road user charges for example (Rose 2007).

6. Management of Road Space

Management of road space can be an effective TDM instrument by restricting or prioritising particular modes in areas or road lanes. Additionally, the speed and volume of traffic may be managed in order to create safer streets. Management of road space also includes providing a more informed road classification system that reflects future planning for all modes of transport.

Instruments that manage travel demand by managing the supply of road space include:

- **High occupancy vehicle (HOV) lanes** are provided to prioritise the movement of HOV vehicles over SOV vehicles on roads. HOV lanes are usually located adjacent to lanes for general traffic and they may be permanent or operate at peak travel times. HOV lanes are widespread amongst cities in the United States.

- **Road network management plans** are integrated tools for monitoring and managing the functioning of road networks. Melbourne’s road networking operating plan, Smartroads, is an example. Smartroads identifies a road hierarchy based on the intended priority modes, land use activity and the time of day the road is generally used. The road hierarchy is then subject to network operating analysis, level of service measures and operational gaps in the network are identified (Wall 2011).

- **Road diets** involve the reduction in road capacity for vehicles. Typically, road diets involve the conversion of four lane roads to three lane roads – one lane for each direction and a central turning lane. Road diets can improve the operational efficiency of vehicle traffic by separating turning vehicles, limit speed and provide safety for pedestrians.

7. Governance and Administration

Governance and administration TDM instruments include regulatory or administrative mechanisms that facilitate relationships between public and/or private organisations so that alternatives to travel by SOV are facilitated. Examples of governance and administrative TDM instruments are:

- **Vehicle quotas** ration vehicle ownership and sometimes the use of vehicles at particular times. Singapore has used a vehicle quota system since 1990. The quota is organised according to a competitive bidding process that allocates vehicle use entitlements for ten years.

- **Area wide transport plans** are plans that outline actions to limit travel or shift demand to public transport, cycling and walking at the neighbourhood, precinct or local government area.

- **Car share schemes** provide short-term hire of cars to individuals or businesses. By providing more opportunities for individuals and households to access cars when needed, may restrict the necessity for car ownership.

8. Parking TDM Instruments

The price and supply of parking spaces influence the level of demand for travel by car. Parking TDM instruments can manage travel demand by either creating pricing signals for existing parking supply, or by increasing or restricting the amount of parking supply in strategic locations.

Parking TDM instruments include:

- Providing requirements for maximum parking requirements for developments and managing on-street parking in urban areas with access to good quality public transport services.

- Applying parking levies and quotas in central city areas, or in urban areas constrained by high demand for land and

San Diego, US, a high occupancy toll lanes trial, allowing SOV to use car pool lanes for a price. Two schemes were compared – a variable and fixed price. Some revenue was hypothecated and redirected to transit.

Rouse Hill, NSW, area wide transport plan for a future TOD in Sydney’s north-west. Through a developer contribution, $3 million was allocated to TDM, and a further $16 million to other sustainable transport measures
services. The Perth Parking Levy is an example. The levy, an annual licence fee for non-residential parking, is one of a suite of parking demand strategies incorporated in the Perth Parking Policy. Other instrument include the setting of maximum levels of parking for non-residential developments, the use of the levy to fund the Central Area Transit (CAT) service, and by identifying priority, short stay and general parking zones.

- Demand responsive parking schemes are monitoring systems that adjust the price of parking based on the supply of parking spaces available at the time of demand. The SF Park initiative in San Francisco is a good example of a demand responsive parking scheme.

Taxes and charges are pricing mechanisms that create direct disincentives for SOV use. Introducing direct costs to travel and using pricing signals to reflect demand on the transport system, provides a disincentive to drive at particular times or places. Taxes and charges are ‘push’ measures.

Examples of taxes and charges used for demand management are:

- Tolls may be charged for the use of transport infrastructure, such as roads, bridges and tunnels. Tolls may be used to manage congestion by applying variable prices, charging higher costs when the infrastructure is most demand in order to ‘push’ people to travel outside peak times. Although tolls are often used to fund transport infrastructure, often this is more road infrastructure, leading to increases in overall travel demand.

- Congestion taxes are pricing mechanisms that create direct disincentives for people to travel by car at peak times. Cordon charging involves charging drivers when they enter cordon area, usually a city centre. Cordon charges have been implemented in Singapore, London and Stockholm, and have been found to be effective in managing demand for travel (Eliasson 2009).

Instrument – Key-learning

Choice of instrument for implementation should be cognisant of:

- the specific behavioural response being targeted:
  - trip substitution – eliminating the necessity of some trips
  - mode shift – shifting to an alternative travel mode
  - reducing travel distance – encouraging shorter trips, or trip chaining
  - peak spreading - managing the time of travel to avoid peak travel times;

- The relevant transport market – an individual’s travel behaviour varies depending on travel purpose e.g. work, shopping, recreation, education etc. Different transport markets have differing demand responses to incentives and/or disincentives; and

- Whether the instrument provides an incentive (pull) to change mode from SOV, or a disincentive (push). In practice, TDM instruments are mostly applied in combination, capitalising on complementarity. Best outcomes are achieved when push factors such as charging are accompanying by pull factors. When implementing push instruments, there must be alternative travel options in place e.g. accessible public transport should be in place if road pricing instruments are implemented e.g. London and Stockholm congestion cordons were implemented with improvements to public transport and park and ride facilities.

Choosing the Best Options

To support policy-makers in making decisions about the most effective instruments to use in their particular contexts, a range of related appraisal tools, evaluation procedures, performance and congestion measures have been developed and applied that may be used as the basis for selecting, implementing and reviewing TDM initiatives.

Subjective Assessment and Participatory Models

These types of tool are used because strong evidence on TDM effectiveness is not always available. The tools are variants of group decision and community engagement decision techniques. By asking stakeholders (transport experts and citizens) their opinion on what TDM they consider to be most important and effective, subjective assessment makes use of local expertise as well as the opinions of the affected community, through rating, ranking and weighting. Forms of these models include: importance-performance analysis, short-listing, normative group and Delphi techniques and multi-criteria decision analysis.

Sketch Models

The development of sketch models have been principally undertaken in the US, tailored to workplace incentives for employees to choose alternate commuting modes to the car. Sketch models aim to provide decision-makers with a rough estimate of travel behaviour change. The models import behavioural parameters from reviews of previous TDM studies. In many cases these parameters are transferred from other settings, and as such, have not been calibrated to the region in which the model is to be applied.

Whilst all sketch models provide estimates of travel behaviour responses, they vary in the level of detail used for the base case. The TDM Evaluation Model, COMMUTER and The Trip Reduction Impacts of Mobility Model (TRIMMS) were developed primarily for
workplace TDM project and usually require the baseline data of current commuter pattern of affected employees. The TDM Evaluation Model may be extended to local area analysis, in which case, zone-to-zone trips by mode split describe the base case. Washington State’s TDM Effectiveness Estimation Methodology (TEEM) incorporated integrated land-use and transportation initiatives, in which case the base case scenario required information about land-use.

The second difference between models is the extent to which the benefit calculations are embedded into the models. The TDM Evaluation Model and TEEM provide estimates of behavioural response, leaving it to the user to compute any benefits associated with this change using another platform. COMMUTER imputes the reduction of total emissions for a number of pollutants based on travel behaviour change estimates. TRIMMS provides the most flexible platform for including benefit calculations. However, it does require the user to import the benefits.

The rapid appraisal method is adopted from a part of the three-stage filtering process as outlined by the Australian Transport Council (ATC 2006). The first stage, strategic merit test, comparable with short-listing, determines whether a proposed TDM project aligns with the strategic priorities of the relevant decision authority. A rapid cost-benefit analysis – using ‘likely’ behavioural parameters and a rough project cost estimate – is then applied to the alternatives that pass the strategic merit test.

Network Models

Four-Step Travel Modelling
The sketch planning tools do not provide insights into the impact of TDM on congestion. The developers of TRIMMS embedded the tool into a four-step model to assist transportation planners in estimating the impacts of TDM on traffic flows and traffic congestion in corridors. The Transportation Demand Management Assessment Procedure (TDMAP) combines the four-step model with TRIMMS to produce estimates of changes in travel behaviour at the traffic assignment level.

Activity-Based Models
Activity-based models showed a significant improvement to the traditional four-step travel demand model by providing a deeper insight into individual decision-making process. These models consider travel as being derived from the demand for personal activities. Travel decisions, therefore, become part of a broader activity scheduling process based on modelling the demand for activities rather than merely trips. These models have a significant advantage in analysing the impact of TDM strategies as they predict a wider range of impacts, including secondary and synergistic effects of the strategies under consideration (Shiftan 2008).

Strategic Policy Assessment Tools
At the level of support for strategic and policy direction setting, where portfolios of TDM initiatives need to be assessed, there are fewer tools reported in the literature, particularly in relation to transport and TDM, presenting a substantial opportunity for innovation. Marginal abatement cost curves are borrowed from climate research. These tools cannot be readily transferred to congestion analysis because the basis of the change is behavioural; in climate science the basis of the change is usually an improvement in technology. However, marginal abatement is effectively another way of reporting a cost-benefit result.
This Perspective is based on the results of the first phase - REVIEW OF INSTRUMENTS AND TOOLS - of a longer term research project: CONGESTION ABATEMENT THROUGH TRAVEL DEMAND MANAGEMENT.

The full reports on which this Perspective is based are available at: www.patrec.org

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

REPORT B: Review of TDM Appraisal and Evaluation Tools

Key References