Travel demand management: strategies and outcomes

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Executive summary

The purpose of this research was to gain insight into the methods that are being used internationally to manage travel demand, and observe the success, or not, of these methods. Understanding the approach taken to travel demand management (TDM) internationally can provide key and critical insights of potential value for New Zealand.

For the purposes of this research, the NZ Transport Agency's (the Transport Agency) working definition of TDM is:

> *An application of strategies, policies and initiatives to reduce travel demand or redistribute demand across multiple modes of transport.*

Research approach

This research does not offer recommendations or advice about how TDM in New Zealand should be delivered. Instead, this research highlights some of the key strategies observed in other international locations, and, where possible, highlights what has been the most appropriate or has had the greatest impact for those jurisdictions.

This should provide some insight as to what may be appropriate in a New Zealand context when considering strategies for managing travel demand.

Methodology

With the guidance of the Transport Agency and the project steering group, six case studies focusing on specific cities were selected for analysis of their TDM programmes and strategies. These cities were chosen, in some cases, because of their apparent success in meeting mode share targets, or their long history of sustainable mode share. These cities have a range of different governance structures, transport systems and histories, and were chosen to provide an assortment of perspectives and approaches to managing travel demand. The research was not limited to official TDM programmes, which are sometimes only inclusive of behaviour change, but extended to a range of TDM interventions carried out by the jurisdictions.

The selected cities were

- Amsterdam
- London
- Singapore
- Sydney
- Seattle
- Vancouver

Each of the six case study cities included an extensive range of TDM approaches and strategies and it was not possible to cover all of these within this research. Consequently, the case studies were structured around the following headings:

- A city snapshot describing population, mode share and background context to the city.

- The governance framework outlining the political environment; transportation bodies; the reasons for implementing TDM and how it is defined; which organisations are specifically responsible for TDM programmes; and the funding model.
- A range of different TDM strategies are then described. These strategies are divided into four categories, as recommended by Litman (2014):
  - improve transport options
  - financial Incentives
  - land use planning and development
  - outreach and implementation programmes
- Key insights are then outlined to summarise what the research learnt from the investigation.

In addition to these case studies, 10 focus areas were also included in this research. These focus areas provided the opportunity to both undertake some broad analysis of different approaches to TDM, as well as more in-depth investigations of particular policies and initiatives. The focus areas are divided into three groups.

1. The leadership and business models and performance evaluation focus areas provide the overarching methodology for planning, implementing and reviewing TDM policies and programmes.
2. The persuasive technologies, mobility as a service (MaaS), freight and TDM, and transport management associations focus areas reflect particular themes and programmes.
3. Focus areas outlining selected examples of policy and programme implementation covering: San Francisco's TDM programme; San Francisco's SF*park* demand responsive pricing pilot; the Netherlands' Beter Benutten 'optimising use' programme; and, the Massachusetts Institute of Technology TDM travel behaviour change programme.

These focus areas cover an eclectic range of information and so do not follow one structure. However, each includes key insights relevant to the area studied.

This research report provides a qualitative and observational look at TDM across a range of international settings. To do this a combination of literature review, desktop analysis and qualitative interviews was used to provide insights into the chosen case study and focus areas.

Critical insights

Drawing on from the cumulative research carried out for this report and the key insights gained from each of the case studies and focus areas this research report concludes with a section outlining a number of critical insights relevant to the practice of TDM more generally.

TDM goals, objectives and targets need to be clearly defined and communicated.

Cities and focus areas had various reasons for implementing TDM policies. Most case study cities developed their transport goals around one or two indicators, predominantly sustainable mode share or changes in vehicle kilometres travelled. The nature of these goals determined the combination of TDM strategies adopted by a city. This indicates the importance of clearly defining goals when formulating TDM policies and strategies.

The term 'TDM is used inconsistently.

There is no single definition or scope of TDM. It can apply to a wide range of policies and programmes. This can lead to confusion concerning the roles that TDM can play in transport and land use planning.

To maximise effectiveness, integrating and prioritising TDM principles into policies and planning activities is critical.

All case study cities are integrating TDM into overall policy and planning decisions, rather than implementing TDM as a special programme added after the basic planning process is complete. This appears to be the most effective way of achieving TDM goals.

TDM strategies tend to have synergistic effects: they tend to be most effective and beneficial if implemented as integrated programmes that include a combination of improved travel options and incentives for travellers to use the most efficient options for each trip. In addition, incentives appear most effective when personalised.

For outreach and implementation programmes to successfully change travel behaviour, alternative mode supporting infrastructure and services must be in place.

This research indicates that successful travel behaviour change programmes had complementary infrastructure that improved access to sustainable transport modes (public transport, walking, cycling) that responded to the targeted population's needs.

There are no silver bullets when trying to change travel behaviour on a large scale.

The most effective programmes include both improvements to transport options and incentives for travel behaviour change. Each strategy comes with a cost, be it money, political capital, time or a combination of these. Some strategies that tend to be most effective at changing behaviour quickly, such as pricing, are difficult to politically implement. In other cases, strategies to change behaviour require infrastructure improvements to improve sustainable modes.

Major events or construction projects are an opportunity to trial TDM strategies and can lead to long-term travel behaviour change.

Many cities have made use of major events or disruptions to test new TDM strategies, which are often considered successful and made permanent. Public acceptance often increases after users experience these strategies. Short-run success following events has not always translated into long-term change. Identifying which outcomes may have long term benefits has been beneficial for relevant cities.

Persuasive technologies can influence travel behaviour and come with both benefits and challenges.

The impacts and benefits of emerging persuasive technologies such as personalised persuasive technologies, social networking, gamification, MaaS and other app-based projects, depend on public policies. These new services and technologies offer new opportunities for TDM. They also raise security and equity of access challenges. As a result, these tools will require careful planning to minimise risks and maximise benefits.

TDM policies need to account for emerging mobility trends and services.

Examples of emerging mobility trends and services include ride hailing, the sharing economy, MaaS, e-commerce and associated deliveries, integrated navigation and payment apps, and autonomous vehicles. These trends are affecting demand for travel modes in each of the cities profiled in this research. While they can support TDM by providing convenient alternatives to car travel, they can also increase total vehicle travel and congestion. They too will require careful analysis and planning, to minimise risks and maximise benefits. Policies that are flexible enough to adapt to changing mobility trends have been more successful in staying relevant.

Abstract

Travel demand management (TDM) is being implemented in numerous different ways throughout the world, to address congestions issues and encourage modal shift. This research outlines some of the many TDM strategies being used internationally to provide insights of potential value for the New Zealand context. This information is presented through six city case studies and 10 focus areas. The cities (Amsterdam, London, Singapore, Sydney, Seattle and Vancouver) were chosen to provide variety in approach. The focus areas analyse specific approaches to TDM through investigations of initiatives. The research identified seven critical insights: clearly defined and communicated TDM goals are important; the term TDM is used inconsistently; integration and prioritisation of TDM principles in wider policy maximises effectiveness; reliable alternative transport infrastructure and services are needed for modal shift; there are no TDM ‘silver bullets’; major events or construction projects create opportunities to trial TDM strategies; persuasive technologies have benefits and challenges; and TDM policies need to account for emerging mobility trends and services. Rapid technological changes are providing opportunities and complexities for TDM strategies and areas of future study include issues of equity and accessibility, and the potential of future mobility technologies and choices.

1 Introduction

MRCagney, in association with Traffic Planning Consultants, was commissioned to assist the NZ Transport Agency (the Transport Agency) in understanding how transport demand management (TDM) has been used internationally to shape travel behaviour and achieve mutual benefits for individuals and communities.

This research report provides findings into approaches to TDM based on a review of international case studies. It emphasises the need for an integrated and coordinated approach to TDM, rather than the implementation of one single measure or approach, or a 'scattergun' approach of measures.

This project seeks to inform the Transport Agency about:

- international strategic approaches to TDM
- what recent TDM developments have shown promise
- how TDM success can be measured
- how TDM strategies interact with one another

This study does not offer recommendations or advice concerning how TDM should be implemented in New Zealand. Instead, it highlights key strategies and programmes observed in other international locations, and, where possible, highlights factors that contribute to their success. In doing so the key and critical insights outlined could provide an awareness of what may be appropriate in a New Zealand context when considering strategies for managing travel demand.

1.1 What is travel demand management (TDM)?

There are many definitions of TDM. It generally refers to policies and programmes that change travel behaviour, as opposed to changing transportation facilities or vehicles.

For the purposes of this research, the project's steering group defined TDM as 'an application of strategies, policies and initiatives to reduce travel demand or redistribute demand across multiple modes of transport.'

Other notable definitions include the following. In 1996, the Institution of Engineers, Australia defined TDM as an 'intervention (excluding provision of major infrastructure) to modify travel decisions so that more desirable transport, social, economic and/or environmental objectives can be achieved, and the adverse impacts of travel can be reduced' (Rose 2007).

Litman (2019a) writes that 'Transportation demand management (TDM, also called mobility management) is a general term for strategies that result in more efficient use of transportation resources'.

According to Gärling and Schuitema (2007), TDM should seek to achieve three conditions: it should reduce the attractiveness of car use; activate car-use reduction goals; and then facilitate the attainment of those goals.

TDM strategies are sometimes categorised as either 'soft' (incentives or information) or 'hard' (improvements to non-auto modes or restrictions on private car travel). TDM strategies can also be categorised into 'carrot' and 'stick', where 'carrots' incentivise travellers by providing rewards for travelling by the desired mode, and 'sticks' disincentivise the uptake of car travel by making it more expensive or less convenient.

As this research report will demonstrate, there are sometimes inconsistencies between the way the term TDM' is defined and the way it is used. Each of the cities reviewed as part of this research defined TDM differently and different organisations also define the term variously. This impacts on the way TDM is understood, implemented and funded.

Due to these diverse definitions and interpretations, it can be difficult to clarify TDM goals and how they relate to other strategic goals. Most conventional transport projects are intended to achieve one or two goals such as reduced congestion or crash risk, but many TDM strategies can also help the costs of providing parking, improve mobility for non-drivers, reduce pollution emissions and improve public health – impacts that may not be considered in conventional transport evaluations. This finding suggests that transportation agencies should carefully consider how TDM programmes are organised within their organisations, how the term is applied, and how their activities are planned and organised. As a result, some case study cities are rebranding TDM to reflect 'sustainability', 'healthy community' or 'resilience' goals.

1.2 TDM goals, objectives and targets

This research outlines the importance of clearly defining TDM goals (what an organisation ultimately wants to achieve), objectives (specific ways to achieve goals), and targets (measurable outcomes to be achieved). This helps evaluate potential TDM strategies, organise TDM programmes, measure performance, and communicate the value of TDM to diverse stakeholders. The majority of earlier TDM programmes had a limited set of goals, such as traffic and parking congestion reductions, but these have expanded in recognition of the many benefits that TDM can potentially provide. Table 1.1 identifies typical TDM goals, objectives and targets.

Table 1.1 Typical TDM goals, objectives and targets adapted from Litman (2019a)

Goals (what we ultimately want to achieve)	Objectives (specific ways to achieve goals)	Targets (measurable outcomes to be achieved)
• Traffic and parking congestion reduction • Road and parking facility cost savings • Consumer savings and affordability (savings to lower-income households) • Traffic and parking congestion reduction • Road and parking facility cost savings • More independent mobility for non-drivers • Increased traffic safety • Improved public fitness and health (due to more walking and cycling) • Energy conservation • Air, noise and water pollution reductions • More compact and efficient land use • Local economic development	• Reduce urban-peak vehicle trips • Reduce automobile ownership • Shift trips from peak to off-peak periods • Shift travel to more resource-efficient modes (from single-occupant auto to walking, cycling, ridesharing and public transport) • Shift from congested to less congested routes. • Shift from more distant or more congested to closer and less congested destinations. • Improve and encourage non-auto mobility options • Encourage more compact and accessible land development	• Specified reductions in automobile mode share or travel. • Specified increases in walking, cycling, ridesharing and public transport mode share or travel. • Specified improvements in the quality of mobility for non-drivers. • Specified reductions in traffic crashes, user costs or pollution emissions.

1.3 Categories of TDM strategies

TDM strategies can be categorised in several different ways, including how they influence travel behaviour, the types of travel they affect, and the type of organisation that implements them. Table 1.2 below identifies four major categories of TDM strategies: improving transport options, financial incentives, land use planning and development and outreach and implementation programmes. These categories are used in the literature review and case studies in this report.

Table 1.2 TDM categories and strategies (adapted from Litman (2014)

Improve transport options	Financial incentives	Land use planning and development	Outreach and implementation programmes
• Walking and cycling improvements • Public transport improvements • Rideshare programmes (carpooling) • High occupancy vehicle (HOV) priority • Taxi and ride-hailing service improvements • Telework • Carsharing • Flexitime • Guaranteed ride home	• Efficient parking pricing • Road tolls/congestion pricing • Fuel tax increases • Distance-based pricing • Commuter financial incentives (parking cash out, public transport subsidies, etc)	• Complete streets • Smart growth/new urbanism • Transit-oriented development • Location-efficient development • Parking management • Streetscaping • Traffic calming • Parking regulations	• Commute trip reduction programmes • Freight transport management • Mobility management marketing programmes • School and campus transport management • Tourist transport management • Transport planning reforms • Persuasive technologies

People vary in the types of travel changes they make and the incentives that will influence them. TDM strategies often have synergistic effects, that is, they become more effective if implemented together. For example, by itself, a public transport service improvement may only reduce 5% of affected travel, and by itself a parking pricing incentive may reduce 15% of travel, but together they may reduce 30% of affected travel by giving travellers both positive and negative incentives to change mode. For these reasons, TDM should generally be implemented through coordinated programmes that include a diverse and integrated set of strategies, so there is something for almost everybody. Most examples and case studies described in this report apply multifaceted, integrated TDM programmes.

Table 1.3 shows the links between TDM goals, objectives and strategies. This table helps identify the planning objectives and TDM strategies that are the most effective for achieving particular goals.

Table 1.3 Links between TDM goals, objectives and related strategies (Litman nd)

Goal	Objectives	Related strategies
Traffic congestion reduction	Reduce urban-peak vehicle trips	Congestion pricing Efficient parking pricing Improve and encourage space-efficient modes* HOV priority Commute trip reduction programmes
Parking cost savings	Reduce vehicle ownership and trips	Efficient parking pricing Improve and encourage non-auto modes

Goal	Objectives	Related strategies
Consumer savings and affordability	Improve affordable access options	Improve affordable modes* Improve affordable housing options in walkable urban neighbourhoods Locate jobs and commercial centres near quality public transport
Independent mobility for non-drivers	Improve non-auto access options	Improve non-auto modes* Locate jobs and commercial centres near quality public transport. Improve affordable housing options in walkable urban neighbourhoods
Traffic safety	Reduce total vehicle travel, particularly higher-risk driving	Improve non-auto modes* Distance-based vehicle insurance and fees Efficient road and parking pricing More compact, smart growth, development
Improved public fitness and health	Increase active travel (walking and cycling)	Improve and encourage active modes* Create more compact, walkable communities More compact development School transport management Complete streets and traffic calming
Energy conservation and pollution emission reductions	Reduce total vehicle travel, particularly high petroleum consuming vehicles Reduce impervious surface	Improve and encourage energy-efficient modes* Efficiently price roads and parking Increase fuel taxes Distance-based vehicle insurance and fees Freight transport management More compact development Commute trip reduction programmes Parking management
Efficient land use development	More compact, mixed development	Smart growth development policies Improve space-efficient modes* Commute trip reduction programmes Parking management
Local economic development	More liveable neighbourhoods and commercial areas	Improve space-efficient modes* Parking management Commute trip reduction programmes Complete streets and traffic calming Tourist transport management

* These generally include walking, cycling, ridesharing, public transport and telework. Energy-efficient modes can also include efficient and alternative fuel vehicles.

1.4 Report approach

This research report provides a qualitative analysis of various TDM strategies and programmes across a range of international settings. A combination of literature review, desktop analysis and qualitative interviews was used to provide insights into the chosen case study and focus areas.

This report comprises six city case studies and 10 focus areas. These were selected with the guidance of the Transport Agency and project steering group. The six case studies focus on cities that were selected because of their internationally recognised transport programmes and strategies. These cities have a range of different governance structures, transport systems and histories, and were chosen to provide an assortment of approaches to managing travel demand. In some cases, they were chosen because of their apparent success in meeting mode share targets, in other cases because of their long history of sustainable mode share. The research was not limited to official TDM programmes only, which are sometimes only inclusive of behaviour change, but extended to a range of TDM interventions carried out by the jurisdictions.

The selected cities are:

- Amsterdam
- London
- Seattle
- Singapore
- Sydney
- Vancouver.

The following structure has been used to present each of the six case studies in order to refine the focus of this research given the extensive range of TDM approaches and strategies that these cities are undertaking:

- A city snapshot describing population, mode share and background context to the city.
- The governance framework outlining the political environment; transportation bodies; the reasons for implementing TDM and how it is defined; which organisations are specifically responsible for TDM programmes; and their funding model.
- A description of their TDM strategies. The strategies are divided into four categories, adapted from categories outlined by Litman (2014):
  - improve transport outcomes
  - financial incentives
  - land use planning and development
  - outreach and implementation programmes
- Key insights are then outlined to summarise what the research learnt from the investigation.

The 10 focus areas are categorised into three groups. First, two focus areas concentrating on approaches to overarching TDM strategy and delivery are presented, ahead of the case studies. These provide a useful framework for the remainder of the research report and cover:

- leadership and business models
- performance evaluation

The second group are general focus areas that provide a broad analysis of different TDM strategies around the following areas:

- persuasive technologies

- mobility as a service (MaaS)
- freight and TDM
- transport management associations (TMAs)

The third group of focus areas provide more in-depth investigations of particular initiatives. They include analysis of:

- San Francisco's TDM programme
- San Francisco's *SFpark* demand responsive pricing pilot
- The Netherlands' Beter Benutten ('optimising use') programme
- The Massachusetts Institute of Technology TDM travel behaviour change programme.

2 Literature review

There is extensive and detailed literature concerning TDM, with numerous analyses of strategies, policies, programmes, and projects around the world. This literature review identifies key factors that influence travel demand, relying to a large degree on the findings of previous reviews and systematic meta-analyses. This provides background and context for identifying policies that are more, or less, likely to succeed at influencing travel demand and mode choice.

The evidence from this literature review emphasises the need for TDM to be viewed as an integrated set of policies, as opposed to individual policies applied once other transport decisions, such as infrastructure, service or land use, are already made. Few, if any, examples of TDM posit that one policy or approach will solve a jurisdiction's travel demand needs. Instead, the need for a multi-pronged approach to travel demand is discussed by researchers and practised by many jurisdictions.

The literature also emphasises the need for more comprehensive transport planning which accounts for the full costs of roadway expansions and the full benefits of TDM, including many impacts that tend to be overlooked or undervalued in conventional economic evaluation. This is sometimes called 'least-cost planning', which allows funds that would otherwise be dedicated to road and parking facilities to be used for TDM strategies, if they are more cost effective overall, considering all benefits and costs.

Vieira et al (2007) found that multi-instrumentality, or the use of a number of complementary approaches, should be considered when planning transport policy interventions to maximise results. Likewise, the majority of TDM literature covers a full range of interventions to move demand away from single occupancy vehicle (SOV) use and toward more sustainable transport options (Balcombe et al 2004; Broaddus et al 2009; Donovan et al 2008).

Various policies are suited for different cities and for a range of residents within those cities, meaning there is a need for a range of different policies within a broader TDM programme (Habibian and Kermanshah 2011).

2.1 Demand elasticities

Transportation planning often involves predicting the likely impacts that a project, policy or programme will have on future travel activity. Older transportation models were developed to predict the impacts of roadway projects and were less effective at predicting the effects of TDM strategies. For example, older transportation statistics and models often overlook short trips, non-commute trips, travel by children, and walking or cycling links of car trips. For example, a bike-bus-walk trip is often coded simply as a public transport trip, the walking links are overlooked, and children's travel to school is often only counted if they are driven by an adult. Although most models can account for the effects of changes in travel speed, they often ignore the effects of changes in travel comfort and convenience (for example, better user information or fare payment systems, or better public transport waiting conditions), although experience indicates that these factors do affect travel activity. Similarly, few models account for walkability factors such as the quality of sidewalks, ease of crossing busy streets, and topography. Newer travel models tend to be better at predicting the travel changes resulting from TDM strategies, but there are still significant omissions and biases.

A strategy's impacts on travel activity is generally measured based on demand 'elasticities', defined as the change in travel activity that results from each 1% change in a factor such as travel speeds, financial costs or service quality. Transport models often combine time and money into a 'generalised cost'. Various research has investigated the impacts of travel cost changes. These impacts tend to increase

over time as travellers take price or service quality changes into account when making long-term decisions, such as where they will live or whether to purchase a car. Short term elasticities are typically one-third of long-term elasticities (Litman 2018b; Dargay and Gately 1997).

The elasticity of public transport travel to generalised costs is typically estimated to range from -0.4 to -2.0, depending on conditions, meaning that a 10% reduction in generalised costs will increase ridership on that mode by 4% to 20% (Wallis 2003; TRL 2004). The elasticity of automobile travel to generalised costs (fuel, tolls, parking fees, vehicle wear and travel time), ranges from -0.5 to -2.0 (Lee 2000). These effects tend to increase over time as travellers take cost changes into account when making longer-term decisions. Guidance published by the Transport and Infrastructure Council Australia (2018) estimates short-run elasticities for urban public transport demand to be -1.0 for peak services and -1.5 to -2.0 during off-peak, while in the long run, these may be double.

Because many factors affect travel activity, travel demand often seems inelastic with regard to individual infrastructure or service factors such as changes to public transport or speed, or even pricing (Transport and Infrastructure Council Australia 2018; Wang 2011). For example, a 10% fuel price increase typically reduces vehicle travel by just 3%, which is considered inelastic, but since fuel only represents about a quarter of total vehicle expenses, including depreciation, financing, insurance, registration and parking fees, this means the elasticity of vehicle travel with respect to total financial costs is about -1.2, which is considered elastic.

Litman's (2014) categories to sort types of different TDM strategies have been adapted to structure this literature review. The categories, outlined in more detail in table 1.2 are as follows:

- improved transport options
- financial incentives
- land use planning and development
- outreach and implementation programmes.

2.2 Improved transport options

Transport options other than private vehicles include walking, cycling, ridesharing and public transport, *flextime* (allowing commuters to shift from peak to off-peak) and *telework* telecommunications that substitute for physical travel). The quality of travel options significantly affects users' transport decisions. Research indicates that jurisdictions that devote more money and space to walking, cycling, ridesharing and public transport have significantly more use of these modes, and lower rates of automobile ownership and use than in jurisdictions that invest more resources in roads and parking facilities (Henao et al 2015; Peterson 2017). Matas et al (2008) highlighted the association between improved access to jobs via public transport and a lower probability of car ownership in Madrid and Barcelona. Transport user surveys have also suggested that people expect to reduce rates of car ownership in response to the availability of public transport infrastructure (Cullinane 2002).

The provision of various new or improved transport options has been correlated to increased use of these services, or related modes. Examples include bikeshare schemes dramatically increasing rates of cycling (Midgley 2011), increases in cycling accompanying improvements of bike lane infrastructure (Parker et al 2013) and increases in ridership following service improvements to rail networks (Transport for London (TfL) 2019b).

2.2.1 Induced traffic and the fundamental law of road congestion

New or improved road infrastructure is typically justified based on congestion reduction benefits. However, because travel demand is elastic with respect to the overall time and money cost of travel, decongestion benefits do not typically materialise in practice (Metz 2008). Empirical studies have shown that demand simply increases until roads return to their previous equilibrium level of congestion – the so-called 'fundamental law of road congestion' (Duranton and Turner 2011).

This reflects the fact that new transport infrastructure often influences changes in where people live and work. New road infrastructure can also increase car travel by reducing the share of people travelling by public transport, walking and cycling or encouraging people to re-time trips from off-peak to peak periods. A growing body of empirical evidence shows that both road investment and rapid transit investment can influence the shape and size of cities (Baum-Snow 2007; 2010; Grimes 2011; Garcia-López 2012; Heblich et al 2018).

The benefits (and costs) of land use changes go significantly beyond the transport system, so it is difficult to assess whether the outcomes are 'good' or 'bad'. However, this evidence highlights that expanding transport infrastructure or services can be ineffective in relieving traffic congestion or managing overall travel demands. Further, improved public transport infrastructure or cycling infrastructure can increase the share of trips taken by non-car modes, reducing *exposure* to congestion, but it does not tend to reduce overall congestion levels. Complementary policies are therefore required if the aim is to manage transport demands.

2.3 Financial incentives

Changes to the financial cost of travel can affect how people travel and whether they choose to travel at all. There is a range of evidence within the literature on the impact of:

- parking prices
- fuel prices or congestion charges applied to specific routes
- distance-based vehicle insurance and registration fees
- public transport fares.

Travel demand is generally considered to be inelastic with respect to financial price, ie a 10% price increase causes less than a 10% reduction in use of the affected mode. However, as previously described, that is partly an artefact of the price structure of vehicle travel: most TDM strategies only affect a minor portion of total vehicle costs – either fuel, road and parking facilities, insurance or vehicle ownership. Pricing reforms are among the most effective TDM strategies.

Different charges have an impact on travel behaviour in a range of ways. Vehicle purchase taxes or registration fees may determine the number and type of vehicles owned. Fuel prices tend to affect the types of vehicles people own (high prices encourage more efficient and alternative fuel vehicles) and the number of kilometres driven. Road tolls, with higher rates under congested periods, tend to influence decisions about route or mode (Litman 2018b).

Transport prices can be structured to reduce particular problems and can also be targeted to specific areas or time periods that are experiencing high congestion or public transport crowding.

Automobile travel is currently under-priced – motorists seldom pay the full costs of the road and parking facilities they use, or the marginal costs of congestion, crash or pollution costs they impose on others (Shoup 2006). Existing transport fees and taxes can generally be changed quickly and with minimal

transaction costs, compared to new infrastructure investment. As a result, transportation pricing reforms tend to be economically efficient. Price increases are often politically controversial, although experience indicates that road and parking pricing tends to become more politically acceptable after residents experience their benefits (Domonoske 2019).

2.3.1 Parking prices

Litman (2018) suggests that:

> *Motorists tend to be particularly sensitive to parking price because it is such a direct charge. Compared with other out-of-pocket expenses, parking fees are found to have a greater effect on vehicle trips, typically by a factor of 1.5 to 2.0* (USEPA 1998). *For example, a $1.00 per trip parking charge is likely to cause the same reduction in vehicle travel as a fuel price increase averaging $1.50 to $2.00 per trip.*

However, while public transport fares apply for travel throughout the entire network, parking prices are typically set on a location-specific basis. This makes it difficult to interpret the impact of local changes in demand for parking in response to a price change. While a portion of the reduction in demand will be accounted for by people choosing to travel by different modes, like public transport, walking, or cycling, or choosing not to travel, some people will choose to drive to other locations with lower parking prices.

Most estimates of parking price elasticities appear to describe the impact of changes to parking charges on local parking demands, rather than citywide vehicle kilometres travelled. However, reductions in vehicle travel to specific places can still have a positive impact on overall transport outcomes if roads leading to those locations are congested.

MRCagney (2014) reviewed 32 previous research papers on parking elasticities. They found that much of the literature on the effects of parking price changes on car travel demand related to CBD commuters, with very limited evidence on non-commuter travel demand. They highlight limitations with the available evidence base:

> *It is misleading to suggest that anyone parking price elasticity could be used with confidence in analysing parking price policies. The elasticity will depend on the nature and type of parking spaces affected by a particular price change and the opportunities for using alternative parking facilities. These opportunities will differ by time of day and the elasticities themselves would differ for, say, shoppers as opposed to commuters. They would also depend on the physical measures adopted for controlling parking spaces in addition to the price charged.*
>
> *As noted, most of the evidence available related to short-run changes. It is not clear whether long-term effects will differ substantially from these and, if so, in what way.*

MRCagney (2014) conclude that the elasticity of car travel demand with respect to parking prices, principally related to commuters, is likely to fall in the range of -0.10 to -0.60. They recommend a ‘best guess’ elasticity of commuter car travel with respect to CBD parking changes of -0.30, meaning a 10% increase in price will lead to a 3% reduction in demand.

Marsden (2006) undertook a similar literature review and drew similar conclusions with respect to commuter parking, finding a range of parking demand elasticities relating to pricing from -0.1 to -0.6. The study found significant variations to an average of -0.3, depending on circumstance, such as the availability of other parking options.

Marsden (2006) also reviewed the more limited evidence on elasticities for non-commuter parking, principally retail parking, finding that some studies, but not all, suggest that demand for retail parking is more sensitive to price than demand for commuter parking.

Ostermeijer et al (2019) found that Amsterdam residents own about 30% more vehicles if parking is bundled (included at no additional cost) with housing compared with what they would own if they were forced to pay directly for parking at home.

Litman (2018b) also points out that measuring and applying parking price elasticities is challenging because most parking is currently free – an increase from zero to a positive price represents an infinite increase. Based on a review of selected studies, he suggests that:

> *Shifting from free to priced parking typically reduces drive alone commuting by 10-30%, particularly if implemented with improvements in transit service and rideshare programs and other TDM strategies.*

This again reflects other findings of this review: that no one policy to manage demand should be carried out in isolation, rather a coordinated approach is necessary.

2.3.2 Fuel price increases and congestion pricing

Several studies have estimated price elasticities of demand in response to changes in the financial cost of driving due to fuel price changes, toll roads, and congestion charges. The effect of fuel prices appears to be less significant than that of congestion charges. Kennedy and Wallis (2007) summarised effects of fuel price increases on traffic volume and fuel consumption from New Zealand and international studies, with the cost of fuel appearing to be less significant than parking prices or public transport fares.

Although New Zealand does not have an existing congestion pricing scheme, studies of congestion pricing schemes in Sweden, London, Milan, and Singapore provide relevant estimates of price elasticities and effects on demand.

Croci and Douvan (2016) evaluate the effects of congestion charge on modal shift, pollution emissions and crashes, from London, Stockholm, and Milan's congestion charge experience. All saw traffic reductions, while Stockholm and Milan also saw improvements in air quality and a reduction in crashes.

Various literature discussing congestion charge effects finds variations in demand elasticities ranging in most cases from -0.47 to -2.49 (Croci and Douvan 2016; Börjesson 2017; Evans 2008). The Singapore congestion pricing scheme, the longest standing, appears to have lower demand elasticities than others, with a range of --0.069 to -0.303 depending on the source (Olszewski 2007; Olszewski and Xie 2005).

It appears the congestion charge in Stockholm has had the strongest influence on travel demand, and this appears to have increased over time. Börjesson (2017) compares this change to a smaller Swedish city, Gothenburg, which also has a congestion charge, and which has seen a reduction in its demand elasticity, ie a reduction in the influence of the charge on car travel demand. The author suggests this may be to do with different land use variables in each city, as well as public transport infrastructure.

Interestingly, in Stockholm, the strong influence of the congestion charge appears to be tempered slightly when company cars, taxis and light and heavy trucks are included in the analysis (as opposed to private vehicles only).

When considering the travel demand effects of congestion pricing, the literature appears to show a range of potential impacts from such charges. Differences in influence can, in some cases, be accounted for by the types of vehicles being affected by the charge, or differences in land use between jurisdictions.

2.3.3 Distance-based vehicle fees

Distance-based vehicle fees (also called pay-as-you-drive, usage-based and per-kilometre pricing) mean a vehicle's insurance premiums and registration fees are based directly on how much it is driven (Bordoff and Noels 2008; Ferreira and Minike 2010). The more you drive the more you pay and the less you drive the more you save. Existing pricing factors are incorporated so higher-risk motorists pay more per unit than lower-risk drivers. For example, a $500 annual insurance premium becomes $0.04 per kilometre, and a $2,000 annual premium becomes $0.10 per kilometre, giving higher-risk drivers the greatest incentive to reduce their vehicle travel.

If fully implemented this is expected to reduce affected vehicle travel by 10% to 15%, but is not a new fee, just a different way to pay existing fees. Because higher-risk drivers have a greater incentive to drive less it can provide proportionately large crash reductions, so a 12% reduction in vehicle travel is likely to reduce crashes by 15% to 20% (Greenberg and Evans 2017; Litman 2012).

Distance-based pricing can be implemented by individual insurance companies, or governments can encourage or mandate this type of pricing for fairness sake (it causes each vehicle's premiums and fees to more accurately reflect its crash and road use costs) and as a TDM strategy.

2.3.4 Public transport fares

A literature review by MRCagney (2014) suggests that the average short-run elasticity of public transport demand, with respect to fare levels, is -0.35, implying that a 10% fare reduction typically increases ridership by approximately 3.5%. The review also suggests that:

- long-run effects are likely to be up to 50% higher
- fare change influence is likely to be lower during peak periods than off-peak or weekends
- higher-income passengers or passengers with cars are likely to be more price-sensitive than lower-income passengers or passengers who do not own cars, potentially because they have an immediate alternative choice of travel
- price sensitivity is likely to be higher for short trips and trips to non-city centre locations.

Several papers review the literature on the travel demand effects of public transport fare changes (Nijkamp and Pepping 1998; Holmgren 2007; Hensher 2008). They highlight variation in fare price influence depending on context (such as between different countries, or different types of transport) and methodological differences. Generally, they find that public transport patronage is inelastic with respect to fare price, especially in car-dependent cities in Australia, New Zealand and the US compared with European cities.

Fare increases, while providing a short-term increase in revenue, are generally found to have significantly negative impacts on ridership in the long run, negating short-term revenue increases (Paulley et al 2006).

Holmgren (2007) finds the relationship between fare price, patronage and service provision increases the effect of price on demand. This reflects the fact that fare reductions may increase demand, leading transport agencies to add additional bus services, which in turn improves quality of service and attracts additional users. The same can also happen in reverse. This highlights the importance of considering policy interventions holistically and asking whether there is likely to be feedback between policies that leads to larger (or smaller) effects than anticipated.

2.4 Land use planning and development

A large body of literature points to how land use policies can be used to create more compact, mixed and multimodal communities. Benefits cited include reduced distances between destinations, increased portions of trips made by sustainable modes, and transport trends such as lower rates of car ownership or reduced driving distances.

An analysis of empirical studies of the impact of urban form on travel behaviour by Ewing and Cervero (2010) considered three transport outcomes – vehicle miles travelled (VMT, equivalent to vehicle kilometres travelled), walking trips and public transport trips – and measuring urban form using the 'five Ds':

- density (ie the number of residents or employees per hectare)
- diversity of land uses (ie whether areas have a mix of residential and business activities)
- design of street networks (eg whether there is a street grid or a sparse curvilinear road network)
- destination accessibility (ego how close a location is to major employment centres)
- distance to public transport facilities.

Ewing and Cervero's (2010) key finding was that travel behaviour is not strongly influenced by one single urban form variable, but combinations of variables may have a larger effect. As an example, a 10% increase in distance to the city centre leads to a roughly 2% increase in vehicle kilometres travelled (VKT) on average.

They also found that demand for different travel modes was affected by different land uses. For example:

- VKT is correlated most heavily to the accessibility of a destination, followed by street network design.
- After controlling for other variables related to urban form, population and job density are only weakly associated with travel behaviour.
- Walking is most heavily correlated to the mix of housing and business in the area (land use diversity), intersection density, and the quantity of destinations within walking distance.
- Public transport use is correlated most tightly to its proximity and street network design variables, followed by land use diversity.

Ewing and Cervero (2010) also examined whether their findings were biased by residential sorting. For example, people who prefer to drive may choose to live in further away suburbs, whereas people who prefer to walk may locate in neighbourhoods conducive to walking. They found that, while residential sorting reduces the overall magnitude of effects, the overall findings still stand.

In a working paper, Ahlfedlt and Pietrostefani (nd) found similar results. They reviewed 300 analyses of the cost and benefits of city compactness. They reviewed the relationship between sustainable mode choice and three measures of city compactness. These measures were economic density (the number of people living or working in an area), morphological density (the density of the built environment in terms of surface coverage, building footprint and street connectivity), and mixed land use (the extent to which residential, employment, retail and leisure opportunities are located close to each other). They reported a positive association between each measure and sustainable mode choice.

These studies suggest that policies influencing urban form, such as district plan rules or street design guides, can change transport demand, especially in the case of promoting walking or public transport use (Rodriguez et al 2010). Location, on the other hand, is the factor that appears to more heavily influence a reduction in car travel (Ewing and Cervero 2010).

Other urban form variables can also contribute to managing travel demands. According to Litman (2018a), these can include land use planning initiatives such as complete streets, smart growth, transit-oriented development, location-efficient development, parking management, streetscaping and traffic calming. A 2012 study from California analysed the impacts of neighbourhood 'smart-growth' characteristics on travel behaviour. Smart-growth characteristics included residential and employment density, mix of land uses, footpath coverage, and existence of cycle lanes and frequent public transport. They found that the overall number of person-trips in smart-growth areas was similar to other areas, but that more trips were made by walking, cycling, and public transport (Handy et al 2013).

It should also be noted that land use decisions can work against TDM goals. One example is a connection between urban motorway construction and subsequent faster suburban population growth, further increasing motorway usage (Baum-Snow 2007). Again, the literature here suggests that a combination of land use development policies have a greater influence on travel demand than one approach on its own.

2.5 Outreach and implementation programmes

Outreach measures are commonly referred to as 'voluntary behaviour change programmes', and often considered to be 'soft' approaches to TDM. They aim to reduce car trips without committing to physical infrastructure, service improvement, new regulation or price changes (Brog et al 2009). Common measures include personal travel planning, travel awareness campaigns, workplace travel plans, school travel plans and car sharing schemes (Chatterjee and Bonsall 2009).

While some researchers have concluded that voluntary behaviour programmes are insufficient to significantly influence behaviour alone, and should be conducted as part of a mixture of measures to tackle travel mode and behaviour (Kent and Ampt 2012), others warn not to dismiss behaviour change programmes too quickly, noting that difficult-to-change behaviours are more changeable at the time of major life events, such as moving house or taking on a new job (Klöckner and Ellen 2004; Stanbridge and Lyons 2006; Waerden et al 2003). Ralph and Brown (2017) suggest there is a 'right time and right place' to change travel behaviour, and that campaigns are likely to be most effective when combined with other measures, such as public transport infrastructure/service that exceeds expectations.

Cairns et al (2004) reviewed the impact of workplace travel plans in the United Kingdom (UK), finding that:

- 10% of plans achieve no change
- 20% reduce car use by >0 - 10%
- 35% reduce car use by >10 - 25%
- 25% reduce car use by >25 - 35%
- 10% reduce car use by over 35%.

Other research has found inconclusive or statistically insignificant effects. Petrunoff et al (2016) investigated the effectiveness of behaviour change programmes over three years at a large hospital outside of Sydney, Australia, finding that the programme had a small but statistically insignificant effect on people's travel to work mode. Phillip and Taylor (2010) found that voluntary behaviour change programmes can have a role in reducing car use, but that more long-term research is required to determine the true effectiveness of such programmes.

A growing body of research points to the potential of personalised technology to influence travel demand. Persuasive technology, alongside smartphone proliferation and increasingly accessible transportation data have expanded opportunities to use data and personal devices to influence individual behaviour (Jariyasunant et al 2012).

In comparison to previous travel behaviour change initiatives, which had often relied on pen and paper travel surveys, modern technology, automated tools and personalised data are believed to add a scalable element to these initiatives.

Semanjski et al (2016) tested the effects of personalised mobility incentives to users with different attitudinal profiles, finding different reactions to mobility-related information. The study found smartphones could effectively provide alternative travel suggestion incentives and sense any resulting behaviour change.

The study also found smartphone delivery of personalised messages led to almost twice the number observed behaviour changes compared to messages from traditional communication channels.

Gamification has been identified, both in the literature and in some cases of practice, as a further means to extend perceived benefits of smartphone proliferation for influencing travel behaviour. It is defined as ‘the use of game design elements in non-game contexts’ (Deterding et al 2011). It is increasingly being used as a method in fields such as health and fitness. A well-documented example of gamification was the Netherlands’ ‘Spitsmijden’ programme that gave commuters financial incentives or points to avoid the morning peak, which saw a dramatic shift in the time commuters travelled (Knockaert et al 2012; Ettema et al 2010).

3 Focus area - leadership and business models

A basic principle of planning is that decisions should be coordinated so that individual, short-term decisions support long-term strategic goals. This is particularly important for emerging issues, such as TDM, which require new policies and programmes. The focus of this section is on the leadership and business models that support the roll out of TDM programmes and strategies.

Successful TDM programmes require leadership that coordinates efforts by various jurisdictions and organisations, including regional and local governments, government agencies and private organisations in order to effectively achieve community goals. In many cases, successful TDM requires policy and planning reforms to support more collaboration among different jurisdictions, agencies and groups. A key challenge can be trying to promote and fund programmes with new, sometimes difficult-to-evaluate goals such as increasing affordability, more independent mobility for non-drivers, improving public fitness and health, and supporting more efficient land development.

Each level of government has a critical role to play in effective TDM planning. Central and regional governments can provide leadership and incentives and vehicle travel reduction goals and targets. They also have the ability to reform transport policies and agencies to support more comprehensive analysis and multimodal planning. Local governments frequently have more control over land use regulations, urban design and parking policies. They can also support local commute trip reduction and institution-based transport management programmes, as well as the development of TMAs discussed further in chapter 17 of this report. Moreover, they are best placed to identify context appropriate solutions. The need for strong support for TDM at a central and regional level through clear strategy and objectives, while allowing sufficient flexibility to implement the right intervention for the local context, is critical to ensure long-term planning and investment is aligned.

It is important that each level of government ensure TDM goals and interventions are considered throughout the planning and project development phases - this is an ongoing challenge for many jurisdictions. Having dedicated staff responsible for managing TDM programmes and ‘championing’ TDM is one way of ensuring goals are met.

3.1 Leadership: integrating TDM into policies and planning practices

Successful TDM requires integration of various policies and planning practices. Many jurisdictions incorporate TDM into their planning processes. Including TDM in long range plans is often the first step for ensuring it is integrated into all levels of jurisdictional plans. Long range plans guide major investment decisions in transport and land use, and inclusion of TDM principles and goals can have important implications for establishing effective non-SOV alternatives as cities grow. While including TDM in high level planning is important for setting strategy, it must be supported through specific actions and programmes at the local level to be effective. Coordination between levels of government is critical to ensure goals and investment decisions are aligned.

One approach to supporting TDM planning is mandating strategies into legislation, including vehicle travel and transport emission reduction goals, and employer trip reduction laws. For example, Washington State in the USA has a strong history of state-down efforts to manage travel demand through legislation. In the early 1990s, two key pieces of legislation – the Growth Management Act and the Commute Trip Reduction law - were adopted. These legislative changes have provided a robust but flexible framework which allows individual jurisdictions to respond to local needs and preferences. Both laws have influenced

TDM planning and implementation in Seattle. However, local implementers note that while having TDM requirements embedded in legislation has many benefits such as dedicated funding, it can also mean a lack of flexibility in 'right sizing' interventions. Another risk is that TDM becomes synonymous with a particular programme, narrowing decision makers' understanding of the full range of policy levers available in TDM implementation. In recent years there has been a shift to allow more flexibility in both setting targets and identifying context specific interventions within the Washington Commute Trip Reduction programme. For further details, please refer to chapter 7, the Seattle case study.

Another example is Vancouver, Canada, which includes TDM strategies and goals in major planning documents ensuring that individual planning activities are all viewed through a 'TDM lens'. More information is available in the Vancouver case study, chapter 10 of this report. The inclusion of TDM strategies in legislation and planning documents have proven successful with both Seattle and Vancouver experiencing declining automobile mode share since their TDM programmes have been implemented.

The City of Cambridge, Massachusetts has also supported and encouraged TDM efforts in private institutions through legislation. In 1988, Cambridge enacted the Parking and Transportation Demand Management (PTDM) Ordinance as a tool to manage growth in vehicular traffic. New developments must take steps to promote alternatives to driving alone, negotiate a contract with the city on specific mode share requirements, conduct monitoring and submit annual reports on mode share and parking for both cars and bikes (Cambridge Community Development Department 2019). This legislation has supported the Massachusetts Institute of Technology's (MIT) TDM programme. More information is available in the MIT focus area – chapter 14 of this report.

Various jurisdiction in New Zealand incorporate TDM principles and strategies into planning documents such as the Auckland Transport Alignment Project (ATAP). However, local implementers note that more central government guidance surrounding the definition of TDM and funding streams under the Government Policy Statement as well as regional or city targets for sustainable travel would be useful in supporting long-term travel planning and outcomes (RA Kurucz and T McNaughton, pers comm, Auckland Transport TDM Team, January 2019).

Developing a coordinated TDM strategy between central, regional and local government for implementation is important to ensure that resources are used efficiently and that plans are aligned and do not contradict one another. For example, investments in high-quality regional public transport systems, such as rail or bus rapid transit, become more successful and beneficial if supported by local policy reforms, such as increased allowable densities, reduced parking requirements, along with pedestrian and cycling facility improvements around public transport stops and stations to create transit-oriented development.

3.2 Developing TDM programmes

To support a comprehensive and coordinated approach to TDM planning and implementation, various actions can be taken at different jurisdictional and stakeholder levels. Table 3.1 shows the plans and strategies that can be adopted across different of levels of government and key agencies and stakeholders – central/regional, local and site/employer. These are categorised according to the key types of TDM strategies as defined by Litman (2014): improving efficient mobility options; incentives to reduce driving; compact land use management; and implementation programmes. Finally, potential performance indicators at each level are outlined. This table shows there are several different ways in which various levels of government and a wide range of stakeholders can provide input into the development and implementation of TDM programmes.

Table 3.1 TDM plans and strategies across different levels of governance (adapted from (SANDAG 2012))

TDM STRATEGIES	Geography	Central/regional	Local	Site/employer
	Type of plan	• Government policy statements • Regional modal plans • Regional TDM plans • Unitary plans	• General plans • Comprehensive plans • Corridor plans • Climate action plans • Parking management plans • Modal plans • Local TDM plans	• TDM site plans • Construction mitigation plans
	Implementation tool/mechanism	• Growth management policies • Complete streets • Active transportation grant funds • Commuter benefit tax exemptions • TDM grant funds	• Trip reduction policies and ordinances • Parking policies and ordinances • Complete streets • Development agreements • Growth management policies • Design guidelines	• Transportation Management Association (TMA) • Commuter benefit programme • Parking regulations • TDM coordinator • End of trip facilities
	Improve efficient mobility options	• Funding for public transport and active transport modes • Public transport/high occupancy vehicle lanes	• Public transport priority and dedicated lanes • First-mile last-mile solutions • Comprehensive bike and pedestrian network • Bike share • Secure bike parking and end of trip facilities • Promote rideshare schemes	• Secure bike parking and end of trip facilities • Public transport facilities (shelters) • Car share/bike share scheme • Employee shuttles
	Incentives to reduce driving	• Advanced traveller information systems • Road pricing	• Parking maximum policies • Priority public parking for shared vehicles • Real-time parking information • Demand based pricing • Restrict commuter parking to peripheral areas • Unbundle the price of parking • Congestion pricing • Demand price on-street parking • Provide reduced rate employer public transport packages	• Reduce or eliminate free parking • Provide priority parking for shared vehicles • Institute parking maximums • Parking cash out • Unbundle the price of parking • Charge market rates for parking • Subsidise public transport fares
	Compact land use management	• Smart growth tool kit • Growth management boundaries	• Urban design guidelines that support alternative travel modes • Street design that accommodates all users • Restricted car use in pedestrian oriented areas	• Site design that supports alternative transport modes
	Implementation programmes	• Education and awareness programmes for all modes	• Promotion and outreach to major employers and the community • Enforcement of TDM policies • Dedicated TDM staff • Form TMAs	• Designate an employee transport coordinator • Flexi hours/telework • Branch relocation for employees • Real-time travel information • Gamification/incentives
	Performance measures	• Public transport usage • Public transport and car travel times • Mode split and mode shift • Non-motorised trip counts • Public transport and roadway LOS • Public transport and roadway capacity available	• Level of service (LOS) • Mode split and mode shift • Pedestrian and bicycle counts • Public transport travel time reliability • Vehicle kilometres travelled • SOV trip reduction	• Parking and vehicle counts • Average vehicle ridership (AVR) • Vehicle employee ratio • SOV trips eliminated/reduced • Vehicle kilometres reduced

3.3 Delivery models – managing and supporting TDM programmes

Methodologies for delivering TDM strategies can be dedicated programme teams or project-based and typically involve a range of partners at different administrative levels and geographical scales. Having dedicated TDM programme staff is frequently seen as important to the effective implementation of TDM strategies. Duties may include:

- identifying and championing regulations to support TDM goals
- supporting interagency collaboration
- data collection and compliance monitoring
- monitoring implementation and achievement of strategies.

Funding for TDM staff can be drawn from specific TDM-related initiatives such as parking or road pricing, or fees associated with development. In other cases, the position is seen as a general cost to the jurisdiction to support broader transport, land use and environmental goals.

While dedicated staff can champion goals, where the staff are placed within an agency can significantly impact outcomes. Creating a separate TDM team can mean that goals are 'siloed' and other departments are able to abdicate responsibility for incorporation of TDM strategies across all projects. Placing TDM at a core strategy and planning level ensures TDM goals and strategies are aligned across all departments. An administrator for the Beter Benutten project, further details below, noted that 'if you are trying to achieve short term outcomes then dedicated staff in a project team is necessary. If you are aiming to foster institutional change then training a broader cross section of staff to understand and apply TDM principles is going to be much more effective' (R Dautzenberg, Programme Manager, Beter Benutten, Ministry of Water, Infrastructure and the Environment, pers comm, 2 December 2018).

In New Zealand, several urban areas have dedicated TDM teams with varying scopes, approaches and funding levels. These teams sit in different locations within broader organisational structures. While the teams primarily focus on behaviour change initiatives, they may also have responsibility for other programmes as well as supporting broader TDM goals in other operational areas. More information on programme delivery in the New Zealand context is provided in the Dedicated Auckland TDM team section below.

A 2012 baseline review of the Atlanta TDM programme found that the success of an organisational model depends more on cooperation and clear definition of roles than the type of structure it actually follows (whether programme work is coordinated by a regional planning body or contracted out to TMAs) (ICF International 2012). Most important was ensuring there was strategic vision and policy guidance to coordinate programmatic efforts with clearly defined roles.

While there is always a trade-off in terms of resources, it would be more effective if staff working in departments that address TDM goals (within transportation, environmental and planning agencies) are trained to consider TDM principles and goals. This would be even more effective if also supported by dedicated staff who can hold the different agencies and departments accountable to meeting strategic goals set by policymakers and agency leaders.

Collaboration with both private sector and community groups can be critical to the effectiveness of programmes. Including businesses and community members in the identification of problems and the development of appropriate solutions means that they have greater ownership over TDM programmes. This is likely to increase programme effectiveness and the likelihood that behaviour change is sustained

long term. TMAs are one mechanism to engage the private sector as is discussed in the TMA focus area, chapter 17 of this report.

The following three sections outline different models of delivering TDM projects.

3.3.1 Lake Washington Urban Partnership – Seattle

Urban Partnership Agreements (UPA), funded by the Federal Highway Administration (FHWA) were designed to provide a comprehensive policy response to urban congestion using the 'four T's' of transit, tolling, technology and telecommuting. The Lake Washington UPA was a partnership between Washington State Department of Transportation (WSDOT), Puget Sound Regional Council (PSRC) and King County designed to reduce congestion on the 520 corridor east of Seattle and was funded at US $154.5 million. It should be noted that this is only one project within a broader TDM programme in Seattle and the Puget Sound Region, as discussed in the case study in chapter 7.

WSDOT was responsible for overall project management and led the SR 520 bridge variable tolling, real-time travel signage and active traffic management projects. King County led the public transport bus projects consisting of enhanced bus services along the corridor, real-time information signs at public transport stations and expansion of two existing park and ride facilities. The project had specific TDM elements including telecommuting and outreach which were led by PSRC. However, these strategies built on existing delivery structures such as the Commute Trip Reduction programme (discussed in further detail in section 11.8.1) and were implemented without federal funds.

Interestingly, within this delivery structure, the term TDM is limited to a narrow scope of primarily behaviour change activities. This is also reflected in the project evaluation which notes that while 41% of new public transport riders said they used to drive alone, TDM activities are described as showing minimal impact on SOV mode share (FHWA 2014). This highlights the importance of where TDM principles are placed in the strategic planning process to impact on project delivery, funding and evaluation.

3.3.2 Beter Benutten – Netherlands

Beter Benutten was a comprehensive accessibility programme with the goals of reducing congestion and providing an efficient transport network. Stage one ran from 2011-2014 with the goal of reducing congestion by 20% in the busiest regions at the busiest times. From 2014-2017, the goal was to reduce door-to-door travel times compared to baseline levels. Led by the Ministry for Infrastructure and the Environment, the programme brought together central government, regional government, and businesses to deliver the strategy. The funding structure was also collaborative. A total of EUR 1.7 billion has been invested by the participants with 50% of the funding coming from the central government and the remaining 50% a combination of regional government and businesses.

The central government was responsible for coordinating the programme, collecting and sharing knowledge and lessons learned and evaluating the programme's success. At the regional level, there was a wide range of stakeholders as partners including local and regional government, the national road and water authority, regional business associations and individual businesses. Each region was responsible for establishing their own organisational/governance structure and these have varied. Programme managers indicate that regional interventions were more successful in terms of project selection, process and outcomes when a dedicated team was sited together rather than a project team operating from different offices or organisations. For further details on Beter Benutten please refer to the focus area in chapter 11 of this report.

3.3.3 Dedicated Auckland TDM team

In Auckland TDM delivery is overseen, coordinated, and delivered by the Travel Demand team within Auckland Transport (AT). The team was represented at major infrastructure developments such as the City Rail Link (CRL), the Auckland Manukau Eastern Transport Initiative (AMETI) busway, Waterview, as well as producing a TDM strategy for the CBD to coordinate activities associated with all the new development taking place in Auckland. The team also worked directly with businesses and business associations. One dedicated unit can oversee and unite the TDM activities of a number of work streams. A TDM department ensures integration of all TDM-related initiative and the agglomeration effect of coordination cannot be underestimated. The TDM team in AT has a statement of intent target that it had to achieve, one of the few divisions of AT that had to achieve a statement of intent. This meant continual reporting back to the Executive Leadership Team, and also ensured that TDM was at the heart of all major decision making at the highest level.

3.4 Key insights

Higher levels of government have a key role in developing TDM strategy and goals. Strategic goals should be developed in collaboration with regional and local partners to foster a sense of ownership at the implementation level and ensure they reflect local needs. This strategic direction ensures that local level strategies are aligned with overall goals and can guide investment decisions.

Ensuring that TDM is considered at all stages of planning is critical to successful outcomes. Legislation requiring TDM to be incorporated into the planning process can provide an important framework for local planning.

Flexibility is essential. Developing a programme that can be ‘right sized’ for a range of contexts across local jurisdictions is consistently seen as important for generating results. This is evident in the regional approach of Beter Benutten and the increasingly decentralised approach to the Commute Trip Reduction (CTR) programme in Washington State with local jurisdictions able to set their own goals and targets and develop alternative interventions within the CTR framework.

Dedicated TDM staff. Ensuring there is staff dedicated to overseeing TDM strategy, planning and implementation at the central, regional and local levels is important. This ensures that planning is consistent across levels of government and supports the full integration of TDM strategies as many of these require coordination across a range of agencies and stakeholders, dedicated staffing is critical for implementation. As noted above, there are also risks associated with where TDM staff are located within an agency.

Stakeholder and industry collaboration. Many of the TDM governance approaches have a strong emphasis on stakeholder and industry collaboration. Ensuring that communities and businesses (particularly employers) are involved in identifying both the problem that needs to be solved and the best solution for their context, generates commitment to a project or programme. It can also enable governments to leverage business innovation and funding by promoting TDM solutions as an amenity rather than a requirement. Increasingly, governments in the jurisdictions reviewed are broadening their engagement efforts to smaller businesses.

4 Focus area - performance evaluation

There are various methods used to evaluate TDM programmes. There is value in having a clear evaluation framework from which to start. This will identify the key indicators used to measure outcomes of TDM programmes, recognise the value of good data and information sources and the importance of setting baseline data for evaluation, and be aware of the range of economic evaluation tools available to evaluate TDM programme cost efficiencies.

Establishing clear goals and objectives for TDM programmes is critical to identifying the strategies that can best support them. Determining key indicators for evaluating the outcomes of these strategies is equally important.

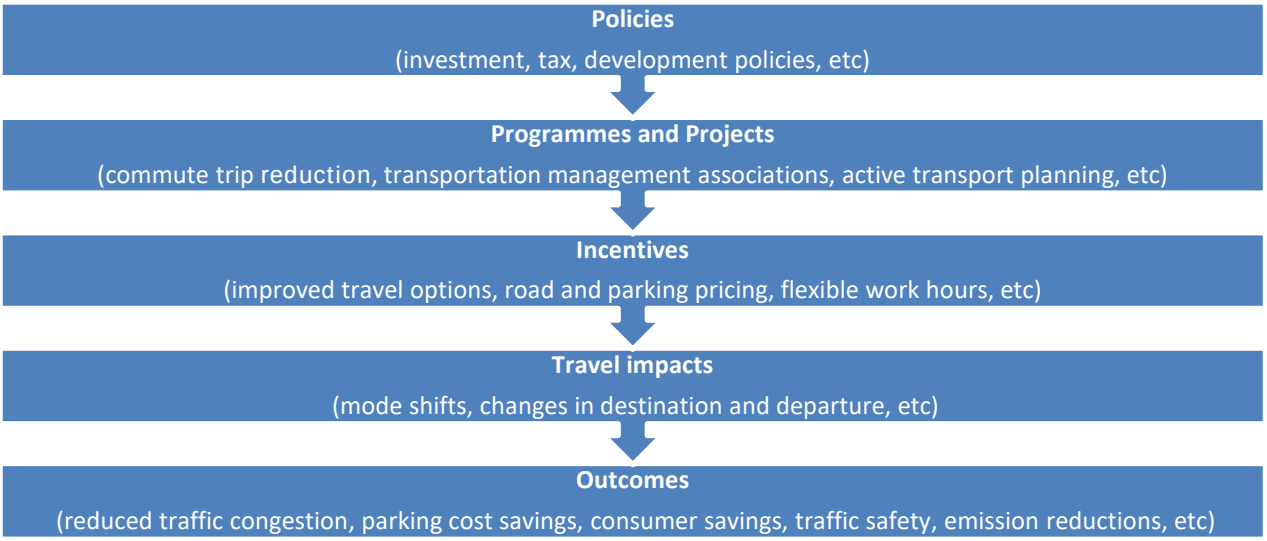
However, TDM programme evaluation can often be challenging since some outcomes are difficult to quantify and isolate. It may be difficult to predict how people would have travelled if a particular TDM strategy had not been implemented. Another evaluation challenge is measuring results and holding a single agency or implementing body accountable for a strategy that may be best addressed collaboratively. When funding streams are linked to measurable outcomes, each of these factors must be considered when designing programmes from policy goals, right through to evaluation.

A comprehensive and consistent data collection and evaluation framework is helpful to establish pre-implementation baselines, evaluate programme effectiveness, compare effects across strategies and jurisdictions, and for research purposes, to determine which strategies are most effective. A robust data collection programme can also support the assessment, prioritisation, and selection of proposals for TDM strategies.

Figure 4.1 shows the relationship between different layers of TDM strategies noting that some will provide a foundation for others to effect travel behaviour change (Litman 2019). Policies with measurable criteria are critical for benchmarking and tracking performance of specific TDM objectives and outcomes over time.

However, policies that are not quantifiable may still serve a broader purpose to guide decision making and achieve outcomes. For example, there are many reasons to improve walking and cycling conditions and encourage more compact development in order to create healthier and more attractive communities, and to provide more independent mobility for non-drivers, regardless of the amount that car travel is reduced. Whether measurable or not, every policy should have clear intent and be supportable.

Figure 4.1 Relationship between TDM strategies and travel impacts



4.1 Evaluation framework

Establishing an evaluation framework is critical for measuring whether or not a TDM programme has met its objectives (outcomes) and how effectively the programme itself has operated (process/governance). Litman (2006) suggests that an evaluation framework should identify the following:

- perspective and scope, and the geographic range and timescale of impacts to consider
- goals (desired outcomes to be achieved) and objectives (ways to achieve goals)
- evaluation criteria, including costs, benefits and equity impacts to be considered
- evaluation method, how impacts are to be evaluated, such as benefit/cost analysis
- performance indicators, practical ways to progress toward objectives
- base case definition, that is, what would happen without the policy or programme
- how results are presented, so results of different evaluations can be compared.

Another important resource for TDM programme evaluation is the 'Framework for appraisal and evaluation of travel demand management measures'. This was developed for Austroads and drew on the experience of both Australian and New Zealand practitioners (Rose 2007). It incorporates many of the key points made by Litman above, as well as providing a robust framework for project selection and evaluation.

4.2 Key indicators

A number of key indicators are used to measure outcomes of TDM programmes and some of the key indicators are shown in table 4.1. The selection of the most appropriate measures will depend on the type of strategy being measured.

Considering the sources of information that are already collected by the jurisdiction or available through smart technologies is important when designing the programme and selecting evaluation criteria. If a

measurement is onerous or unrealistic then, even if a programme is effective, the results may not accurately reflect the success.

Table 4.1 Key performance indicators (adapted from the Victoria Transport Policy Institute TDM Encyclopaedia (Litman 2019)

Key indicator	Description
Awareness	The portion of potential users who are aware of a programme or service
Participation	The number of people who respond to an outreach effort or request to participate in a programme
Utilisation	The number of people who use a service or alternative mode
Mode share	The portion of travellers who use each transportation mode
Mode shift	The number or portion of SOV trips shifted to other modes
Average vehicle occupancy	Number of people travelling in private vehicles divided by the number of private vehicle trips (excludes public transport and active modes)
Average vehicle ridership	All persons divided by the number of private vehicle trips (includes public transport and active modes)
Vehicle trips or peak period vehicle trips	Total number of private vehicles arriving at a destination (also called trip generation)
Vehicle trip reduction	The number or %age of private vehicle trips removed
Vehicle kilometres travelled (VKT) reduction	The number of trips reduced multiplied by average trip length
Congestion	Travel times or average delay. This can also be calculated as the 'congestion reference flow' of a segment of roadway which measures when hourly traffic demand exceeds the maximum sustainable hourly throughput (Standards for Highways United Kingdom 1997)
Public transport service quality	This can include coverage (# of jobs or households within a certain walking distance from public transport), level of service, patronage, frequency of service, comfort and information availability
Land use density and mix	Number of job opportunities and services within a certain travel time for residents. This can be tailored for each mode.
Safety	Per capita casualty rates by mode and distance travelled by that mode
Accessibility	Travel time and costs by mode required by various users to access destinations and services such as employment, education, healthcare and recreation.
Availability and quality of affordable modes	Walking, cycling, carpool, vanpool and public transport
Energy and emissions reductions	VKT reductions multiplied by average vehicle energy
Health impacts	Number of people using active modes (walking and cycling) as well as reducing obesity, diabetes, heart disease and related illnesses. This can also include a reduction in sick days
User satisfaction	Degree that affected people like a TDM programme, its incentives and outcomes.

Some indicators in this table measure outputs (such as mode share, programme participation and changes in vehicle travel) and others measure outcomes (such as crash casualty rates and emission reductions). Including a combination of these factors in TDM programme evaluation can help to understand how outcomes may be connected, for example, how improving walking and cycling conditions and public transport service quality affect traffic congestion, crashes and pollution emissions.

When measuring the outcomes of TDM programmes there are obvious benefits in being able to draw on routinely collected data such as traffic counts or employer surveys. However, there are more complex outcomes related to areas such as health (productivity gains, asthma and obesity rates) that will require more nuanced measurement than simply emission reductions. This again highlights the importance of considering outcome measurement when setting goals and objectives.

Measuring the longer-term effects of TDM programmes should also be considered. Many evaluations focus on immediate impacts. However, conducting ongoing monitoring of impacts on behaviour change (for example a year or longer after implementation) provides an opportunity to understand the longevity of the programme's impact (Clavelle et al 2009).

4.3 Data collection, information sources and setting baselines

When designing TDM performance evaluation programmes, it is important to choose a suitable set of data that is available, accurate and consistent. Traditional sources include traffic counts, regional travel surveys, census data, plus targeted surveys of TDM programme participants. New methods include individual account-based information, booking and payment platforms and GPS assisted mobility and lifestyle apps. New technologies, such as smart phones and GPS tracking systems can provide new types of data suitable for measuring TDM outcomes.

However, these 'big data' sources can present new problems related to privacy, availability and coordination. The information sources outlined in table 4.2 below can be used for pre-implementation measurement to set baselines and post implementation measurement. A 'baseline' is intended to reflect conditions before an intervention is implemented. If possible, baseline data should be collected before a new TDM policy or programme begins. For example, the Washington State Commute Trip Reduction Act requires jurisdictions and employers to perform targeted travel surveys before establishing their trip reduction programmes. The Washington State Department of Transportation administers the survey every two years.

Travel surveys will continue to be an important method of data collection. An investigation into innovative travel data collection for New York City found that the most promising format was a smartphone app incorporating both a travel survey and accessing the phone's GPS data (State University of New York 2016). This finding was based on metrics such as data collected, respondent and administrator experience and survey instrument characteristics. Table 4.2 below describes ways to collect data for TDM performance evaluation. The value of these data sources is very much contingent on the type of TDM strategies being considered and the programme specific objectives and goals. It may also be the case that when collecting baseline data there are fewer sources of information available and therefore the value of the source is relative to the context.

Table 4.2 TDM measurement data sources

Data source	Description and examples
Surveys and census data	National and regional travel surveys, and census data related to vehicle ownership and travel, provide key baseline and trend data, and can be useful for measuring outcomes at a local or regional scale.
Participant surveys	Targeted surveys collect information on the travel patterns of worksites with TDM programmes, or areas with transportation management associations. For example, Seattle supplements the biennial state-wide commute trip reduction employer survey with general mode-share survey while London has developed a TDM tracker – a biannual quantitative survey to track customer attitude and behaviours regarding crowding and congestion.
Smart card system data	Public transport patronage data can support travel surveys and eliminate bias in survey design. Data can be accessed quickly at low cost. There are some limitations in travel purpose and traveller characteristics. In Seattle the ORCA data analysis project is using regional smart card data and cross referencing with other data sets including automatic vehicle location data, automatic passenger counts and commute trip reduction data to measure and understand public transport behaviour. (Puget Sound Regional Council 2017)
Automatic number plate recognition	Used to match vehicles passing distinct locations to provide information on travel times and demand patterns. Used in Singapore and Stockholm for congestion charging and Amsterdam for parking enforcement and understanding traffic patterns in congested neighbourhoods
GPS tracking	GPS-enhanced surveys can provide a more accurate and detailed account of personal travel than what survey respondents are able to recall and report, and GPS data sets have been used to correct significant trip underreporting errors associated with pen-and-paper or phone-based activity survey. There are some concerns around sample size for GPS based data sources as well as differences in behaviour between older and younger users.
Smart phones	Travel surveys using smartphones reduce respondent burden and increase accuracy of travel data collection. Supplementary sensing technology present within most smartphone devices can address some of the limitations of GPS devices. There are sampling bias concerns due to income and age distribution and use of smartphones. In Singapore, the Future Mobility Survey app was developed and administered to a subset of the Household Interview Travel Survey to reduce respondent Burden and therefore reporting rates increase accuracy of trip start/stop times and trip duration, decrease underreporting of short and walking trips, and increase cost-effectiveness of collecting multiple days of travel data.
Parking lot surveys, sensors, smart meters	Parking occupancy rates. Manual surveys count the number of parking spaces that are occupied during peak periods. San Francisco utilises electronic systems to evaluate the effectiveness of its SF*park* programme
Booking and payment platforms	These can be used to track utilisation and demand for services. However, there may be privacy issues related to accessing this data.
Location based social networks	Drawing on 'check in' data from social network sites such as Facebook or foursquare is a way to generate origin-destination data with low data collection costs, good spatial and temporal coverage as well as real-time capability.
Passive mobile phone tracking	Mobile phone traces are generated every time a mobile device attempts to connect to the communication network. These are huge data sets that can be collected with no burden to participants and used to infer traveller behaviour.
Bluetooth data	For developing origin-destination movements and observed travel times.

Increasingly, there are a range of effective data sources that are self-reported through the use of apps. This can be a cost-effective means of getting a large set of data, although subject to sampling bias. There are an increasing number of initiatives around the world that encourage people to provide this kind of tracking data through the use of incentives and rewards schemes to encourage more sustainable travel choices. Examples of these are provided in figure 4.2.

Figure 4.2 Examples of TDM tracking and rewards programme cost effectiveness

Commute.org is the Transportation Demand Management Agency in San Mateo County California, which works to reduce motor vehicle travel. It offers trip planning, support services, contests and rewards to encourage efficient travel. For example, rideshare commutes that start or end in San Mateo County can earn up to $25 e-gift rewards for each 10 carpool-days tracked, with a limit of four rewards ($100) per person. Ridesharing trips are tracked through the *STAR Commute Tracker* app or by connecting a Scoop or Waze Carpool account to a STAR account to automatically track carpool trips.

Get miles is a 'frequent flyer programme for ground transportation'. It awards points for all modes of transportation: car, plane, train, subway, bus, boat, bicycle and foot. The more eco-friendly the mode, the more points users earn. The City of Sacramento has partnered with Miles to reward residents for using resource-efficient travel options.

Mobility options discovery and engagement is an integrated platform to give drivers information and incentives to choose more resource-efficient travel options including shifts in departure times and routes to avoid traffic congestion, and shifts to resource-efficient modes to earn intrinsic and extrinsic rewards, including information on avoided pollution emissions and gift cards. Employers, local businesses, and other stakeholders can offer reward points that may be purchased, earned, and transferred among participants.

Qummute (https://agilemile.com) by *Agile Mile* is a website and TDM platform that provides trip planning, ridematching, support services trip tracking and rewards. Commuters who use non-auto modes earn points which can be redeemed for rewards.

RideAmigos (https://rideamigos.com). The *Commute Tracker App* automatically detects trips between home and worksites smartphone location and records results.

It is important to evaluate TDM programme cost effectiveness, that is, the ratio of total benefits to total costs. Cost effectiveness can also be used to understand the relative value of TDM strategies compared to more traditional projects. For example, how a TDM programme's costs and benefits compare with road and parking facility expansion projects. TDM programmes are often justified based on 'least cost planning' principles, which ranks potential transportation improvements, including demand management and capacity expansion projects, based on their overall cost-efficiency. Ensuring that TDM principles are incorporated in the strategic levels of agency planning is critical to ensuring that they are considered in the suite of strategies for achieving broader transport, environmental, liveability, and economic goals. Appendix B identifies various tools for evaluating TDM programme cost efficiency.

4.4 Key insights

How TDM programmes are evaluated can affect their perceived value. Conventional transportation programme evaluation tends to overlook and undervalue many TDM programme benefits, such as parking cost savings, vehicle ownership savings, traffic safety, more independent mobility for non-drivers, improved public fitness and health, and support for more efficient land use development (reduced sprawl). More comprehensive performance evaluation tends to recognise more benefits and therefore increases support for TDM policies and programmes.

There are a core set of key indicators that are commonly used to measure TDM programme performance, including commute mode share, vehicle trip generation and per capita vehicle-kilometres.

However, now these indicators are beginning to be expanded to cover additional impacts such as health outcomes as outlined in table 4.1.

TDM performance indicators should be directly linked to policy goals and objectives. Performance evaluation should include qualitative data (such as user satisfaction) and quantified, monetised estimates of impacts, to support economic evaluation of programme benefits.

Understanding what data sources exist and what will need to be collected as part of the project will determine resource allocation for programme evaluation.

It is important to consider how to 'right size' programme evaluation for different geographic scales when developing national or regional scale TDM programmes. The administrative burden of data collection and the relative value of the information will differ for large cities and smaller jurisdictions.

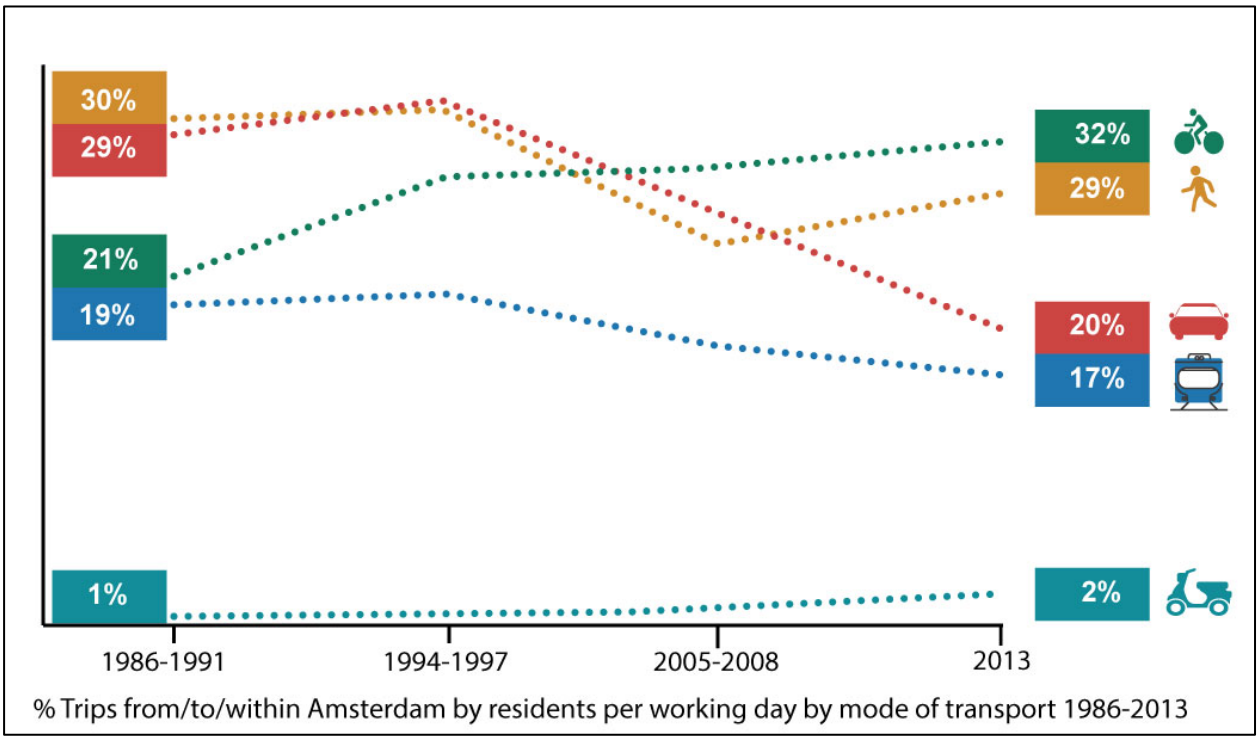
TDM programme evaluation should capture strategic lessons learnt from successes and failures, support research for understanding how specific TDM strategies affect outputs and outcomes and enable knowledge sharing across jurisdictions is beneficial to ensure experiences in one location can be used to inform programme development elsewhere.

5 Amsterdam case study

5.1 Introduction

Historically, Amsterdam has taken a structural approach to TDM, restricting the construction of car-based infrastructure, investing in cycling and public transport and enacting parking policies to reduce car trips both to and within the city. Policies undertaken in Amsterdam since the 1970s have been so successful in reducing car use that bicycle congestion from bicycles is now more of an issue than vehicle congestion. This was not always the case: cycle mode share had dropped from 75% in 1955 to only 25% in 1970 (Buehler and Pucher 2007). Now, it is estimated that 63% of Amsterdam residents use their bikes daily and an estimated 61% of trips are undertaken by walking or cycling, as shown in figure 5.1 (City of Amsterdam 2015). As Amsterdam city seeks to accommodate strong population and job growth, policies to reduce car use are integrated throughout strategic plans and supported by behaviour change interventions at both the regional and local level. At the regional level, there is a dedicated TDM project which builds on the success of the national Beter Benutten programme detailed in a separate focus area within this report, which implemented strategies to optimise use of the existing infrastructure.

Figure 5.1 Mode shift in Amsterdam 1986 - 2013 (City of Amsterdam 2015)



5.2 City snapshot

Amsterdam is the capital and most populous city in the Netherlands with 863,000 residents. The OECD estimates its 2014 urban area at 804 km^2 (OECD 2014). Its population-weighted density is estimated at 86 persons per hectare (Atlas of Urban Expansion 2019). For comparison, Auckland's 2014 urban extent is estimated at 488 km^2. Using slightly different methodologies, various sources estimate Auckland's 2013

built-up area density and population-weighted density at 38 to 43 people per hectare, respectively (Atlas of Urban Expansion 2019).

Amsterdam's metropolitan area, which includes the commuting zone, is much larger at 2,580 km^2. The Amsterdam metropolitan region has a population of 2.4 million and is situated within one of the largest conurbations in Europe with a population of more than 7 million. This area is highly congested, compounded by growth in truck traffic from the Port of Rotterdam, the world's busiest port.

Despite being a major capital city with a sizeable population, there is limited use of private vehicle transportation and considerable incentives to use alternatives. Amsterdam's topography and development patterns support cycling and walking; the city is mostly flat and densely developed. Mixed use neighbourhoods keep trip distances relatively short and cycle lanes and short cuts make cycling a preferred mode choice. Additionally, the city has a wide-ranging and accessible sustainable transportation network. There are more than 500 km of bicycle lanes and 84% of people live within 1 km of a public transport service area (Deloitte 2018).

In contrast, car use is difficult in the central city. Targeted policies have reduced priced parking spaces, and many cul-de-sacs, one-way streets and other traffic calming measures make car travel more difficult. Speed limits are set to 30 km/h in residential areas, where all traffic modes are mixed in one lane and 'fietstraat' or cycling streets welcome cars as 'guests' while bikes are given priority. High house prices and polycentric regional development have also created a dual transportation system. While the central city inside the A10 ring road is easily accessible by active modes, there is a large amount of car-based regional commuting in and out of the city; an estimated 120,000 people leave the city daily for work while 360,000 travel in (Posaner 2017).

Car use reduction in Amsterdam began in the 1970s, prompted by protests over high traffic death tolls, particularly among children. This outcry, along with a 1973 oil embargo, pushed politicians to enact policies to reduce car use and invest in public transport and cycling infrastructure.

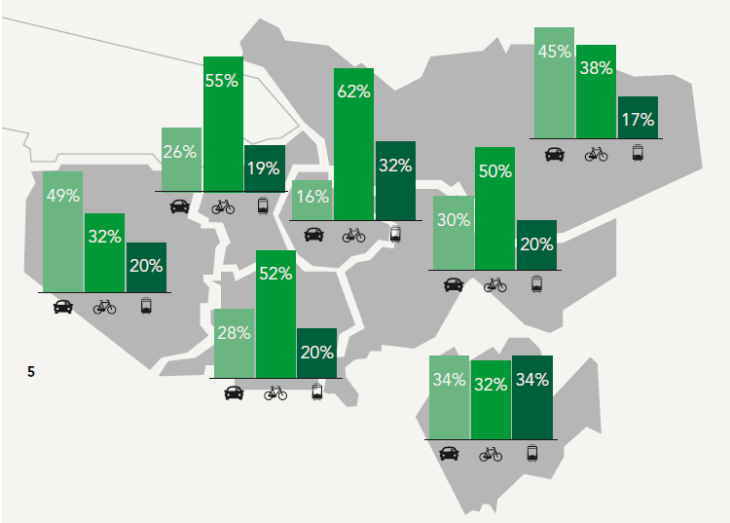
Key policies to reduce car travel and drive mode shift towards active modes and public transport were introduced in the 1980s and created the framework for the current mobility landscape. The 'compact city' policy developed by the city council aimed to increase inhabitants in the city centre, along with the market for services and amenities (Le Clerq and Bertolini 2003). Council policies to expand the public transport system to reduce car dependency were introduced for three spatial levels: local public transport (streetcar/tram, bus, metro system), regional public transport (regional railway lines and buses), and national and international public transport (national railways).

The 'ABC' business location policy was initiated by the central government and implemented in jurisdictions throughout the Netherlands. The policy aimed to reduce car travel by requiring businesses to locate based on their transportation needs. Businesses approved for location near public transport hubs were required to restrict parking supply. This policy was not deemed to be successful, with businesses frequently choosing to locate in areas with high parking supply contrary to the policy goals, and it was discontinued in the 1990s. Major cycling infrastructure investment also occurred in the 1980s, along with traffic calming measures to make cycling more appealing. Creating this safe and connected environment has been instrumental in supporting the strong growth in cycling mode share.

As shown in figure 5.2, mode share differs considerably by neighbourhood. The city government is taking a neighbourhood-based approach to support mode shift, engaging residents in the most appropriate strategies to encourage the use of alternative modes (Kune. Strategic Advisor Mobility and Public Space, City of Amsterdam, pers comm 2019). Research has also shown that a great deal (40% to 60%) of car traffic in the city centre and surrounding neighbourhoods is 'through traffic', or traffic with both the origin

and destination outside the area. Amsterdam's city government is therefore taking steps to eliminate through traffic in the city centre, while keeping it accessible for residents, visitors and suppliers (City of Amsterdam 2019).

Figure 5.2 Neighbourhood mode share Amsterdam (City of Amsterdam 2018)



There are an estimated 234,000 cars owned by Amsterdam residents and while car ownership per person is declining, the total number of vehicles continues to increase due to population growth.

The city has a comprehensive public transport system operated by the public transport authority Gemeentelijk Vervoerbedrijf (GVB), including buses, trams, ferries and the metro. The underground metro has five lines including the newly opened north/south line. In 2017, 31% of public transport journeys were completed by metro. The tram system, operating since 1875, has 15 lines and covers the entire city with the exception of the Noord district. In 2017, 48% of public transport journeys were made by tram. The bus network consists of 41 routes and accounted for 21% of public transport trips in 2017. GVB also operates six ferry routes across the IJ Canal. These are free for pedestrians, cyclists, mopeds and scooters. A total of 241 million journeys were made using the GVB network in 2017, an increase of 12% since 2014 (Amsterdam Yearbook 2018).

5.3 Governance framework

Amsterdam is governed by a city council, the College of Mayors and Alderpersons, and district committees. The city council is the highest governing body and consists of elected representatives who make policy decisions and oversee the mayor and city agencies. The mayor is appointed by the national government and together with the alderpersons (or deputy mayors) is responsible for daily operations and policy implementation. Amsterdam has seven city districts each managed by a district committee.

Amsterdam metropolitan area (Metropoolregio Amsterdam, MRA) is an informal partnership of 33 municipalities, the provinces of Noord-Holland and Flevoland, and the regional transportation body. The MRA's work is focused on three priority areas: strategic planning, traffic and economic development.

5.3.1 Transport bodies

The city government Department of Mobility and Public Space owns and is responsible for the urban traffic and transport system excluding rail, which is a national system. Operational focus areas include programming urban space in coordination with external partners; limiting the impact of major construction

projects; developing and implementing modal plans; and optimal use of infrastructure and public space. The major public transport authority for the city of Amsterdam is the Gemeentelijk Vervoerbedrijf (GVB), as noted above.

The city of Amsterdam is also part of a regional transportation body (Transport Authority Amsterdam) which is a formal consortium of 15 municipalities with policy and grant funding powers to address regional transportation issues, excluding trains as these are managed and operated by the central government.

5.3.2 TDM responsibility

Amsterdam city's integrated approach to managing demand is driven by the need to maintain accessibility and meet liveability goals while faced with continued growth and constrained geography. By 2030 the number of trips made daily is expected to increase by 20% to 40 % compared with 2015. This will result in congestion, logistical problems for goods transport, pressure on parking availability and unsafe traffic situations (Amsterdam Smart City 2018). Amsterdam has also set the goal of being emissions-free by 2025. To achieve this, Amsterdam is implementing strategies to reduce the need for car ownership and trips, increase the use of cycling and public transport, and move from individual to collective forms of mobility.

Within the city of Amsterdam, TDM is integrated throughout transport and land use planning documents and policies rather than delivered by a dedicated group. Wiard Kune, Strategic Advisor for the Mobility and Public Space group, notes that planning for a liveable, sustainable and accessible city and reducing car trips 'is in the city's DNA' and therefore incorporated throughout planning and programme delivery (Kune pers comm 2019). Key groups that contribute to TDM strategy and implementation include mobility and public space, smart mobility and a specific group responsible for managing growth and planning in the business district of Zuidas.

At the regional level, the Building Accessibility Together (Samen Bouwen Aan Bereikbaaheid) programme of the MRA seeks to manage regional growth within the existing infrastructure. The project was established to build on the success of the national Beter Benutten programme. There are two demand management projects within the programme: urban accessibility focuses on first-mile last-mile connections to increase public transport and cycle use; smart and sustainable mobility focuses on the six key bottlenecks in the region and implements TDM strategies to address these including cycling promotion, flexwork, MaaS pilots and sustainable logistics.

5.3.3 Incorporating demand management into planning documents

The structural approach that Amsterdam has taken to incorporate travel demand principles into policies, planning documents and programme delivery strategies is evident in its planning documentation. The city's long-term comprehensive plan is *Structural Vision Amsterdam 2040,* medium-term mobility planning is covered by *Mobility Approach Amsterdam,* while short-term planning is governed by modal plans.

5.3.3.1 Structural Vision Amsterdam 2040

Structural Vision Amsterdam 2040 is the city's comprehensive plan and it incorporates a number of goals relevant to demand management. The city plans to increase dwelling density in order to accommodate an estimated 70,000 new dwellings between now and 2040; transform mono-functional areas into mixed use areas; enhance regional transportation and increase the number of links between key locations; and increase the quality of public space through high-design standards, and by allocating more space to walking and cycling.

5.3.3.2 Amsterdam's Mobility Plan 2030

By 2020, the Amsterdam metropolitan area and the Dutch government will invest an additional €10 billion in improving accessibility throughout the region. Strategies in the medium-term *Mobility Plan 2030* include:

- Creating more space in the city centre through restricting car traffic and limiting speeds to 30 km/h, introducing new cycle and ferry connections across major waterways, and creating more parking for bikes and shifting car parking off street.
- Improving traffic flow on important routes by improving public transport and cycle infrastructure, ensuring fast, efficient routes in and out of the city for cars, providing space for loading and unloading goods from vehicles, building more (and better) park and ride facilities on the outskirts of the city, and designating priority routes for each mode of transport.
- Linking Amsterdam's city centre with its outskirts through cycle and public transport connections.

Planning documents focus on continued investment in transit-oriented development and cycling and public transport connections. Within the central city there is a major focus on car-free policies and improving liveability through more space for cyclists and pedestrians.

5.3.4 Funding model

Amsterdam uses revenue generated from aggressive parking pricing policies to support a mobility fund. For example, the gross revenue from paid parking for 2012 was approximately €160 million. Around 38% of this was spent on management and maintenance of the parking system, 39% went to the general city budget, and 23% was spent to fund mobility measures including cycling, public transport and safety improvements (Lange 2014). This spending is split proportionally across the central city and the seven districts to implement area-specific mobility strategies. TDM strategies are considered alongside other projects and are selected based on impact and cost effectiveness.

The two 'action' sections of the regional Building Accessibility Together programme are funded evenly between the central and regional government at a total of €20-30 million per year and focus primarily on behaviour change initiatives (N Verveen, Programme Manager, Smart and Sustainable Mobility Rijkswaterstaat West-Nederland Noord, pers comm, 10 April 2019). They coordinate with the city of Amsterdam to determine if a TDM project is likely to have a regional or more local impact to determine who will fund it.

5.4 Overall approach to TDM

As noted above, Amsterdam's government takes an integrated approach to TDM rather than identifying a specific team for delivery. Further, the city government does not typically set goals for mode share, they rather set goals for things like the number of kilometres of safe bike infrastructure delivered. Previously, goals have been set for reducing car trips: In 2001 the government set a goal to reduce car use in the city centre by 25%. This was reached by 2005 along with a 30% growth in the share of visitors to the city using public transportation. This shift was largely achieved through the restriction of parking in the central city (Dijk and Parkhurst 2014).

This chapter will review key strategies that Amsterdam has undertaken to manage travel demand. Strategies are organised into four major categories defined by Litman (2014):

- improve transport options
- financial incentives

- land use planning and development
- outreach and implementation programmes.

5.5 Improve transport options

This section addresses the commitment Amsterdam has made to improving alternatives to driving through public transport and cycling infrastructure investment.

5.5.1 Public transport

Amsterdam's public transport network is a critical part of the city's holistic approach to reducing car trips through more efficient use of existing infrastructure. The city has a public transport mode share of approximately 17%. There are two reasons for this relatively low mode share: the convenience of walking and cycling in dense mixed-use neighbourhoods; and, the relatively high price of public transport fares. These are set at the national level, which limits the city's ability to use pricing to incentivise patronage (PWC 2014). The city's comprehensive plan *Structural Vision Amsterdam 2040* (as outlined in section 5.3.3) identifies the need for a 'network-wide leap' to ensure a robust regional public transport system. To meet environmental goals and make alternatives to the car more appealing, the city will be investing another €400 million over the coming years in new trams, metros, zero-emission buses and public transport infrastructure. Key goals for public transport within the *Mobility Approach Amsterdam* are:

- Making more journeys by public transport than by car – through improved travel times and reliable services.
- Improving rail traffic throughout the region – with more control and frequency during peak hours and more freedom during off-peak hours.
- Balancing public transport and automobile traffic – prioritising and separating modes where necessary.
- Improving public transport transfers.

The national public transport smart card (OV Chipkaart) was introduced in 2011. While integrated ticketing is seen as a positive pull factor for public transport use, it is still considered to be a relatively expensive mode in Amsterdam. To streamline public transport use and reduce the cost for the city's large number of visitors, Amsterdam has introduced the iCard, which can be used for transport and access to museums.

5.5.2 Cycling

Amsterdam is frequently lauded as the cycling capital of the world. In 2017, 80% of Amsterdam residents over the age of 12 owned a bicycle. The city's bicycle network consists of 767 km of dedicated cycle paths, the majority of which have been built since the early 1980s, when major policy changes drove the shift towards alternative transport modes. This investment also reflected national trends: in the early 1990s the government included the bicycle in its national Transport Structure Plan and issued a separate masterplan to guide urban and regional traffic policies in facilitating comprehensive safe bicycle infrastructure (Oldenziel and Bruhèze 2011).

This investment, along with traffic calming measures, has created a safe and connected environment, instrumental in supporting strong growth in cycling mode share. However, local planners note there is still room for improvement. Efforts to promote cycling are still an important part of Amsterdam's transport programmes. An estimated 50% of drivers commuting by private vehicle at peak times live within 15 km

of their workplace – this is seen as a key target group for e-bike promotion. Interventions considered to be instrumental in the growth of cycling mode share include: separate and connected cycling facilities, bike parking, car-free zones and traffic calming, reduced on-street parking, and mandatory cycling education for schoolchildren (Dill et al 2010).

As with many TDM strategies, it is difficult to isolate the effectiveness of individual interventions aimed at increasing cycling mode share. Dill et al (2010) also find cycling interventions are expected to be 'interactive and synergistic'. For example, the impacts of bike parking, training programmes and marketing campaigns are probably influenced by the extent and quality of the existing bike network and supporting facilities, while bike-to-school and employer based cycling programmes are more likely to have an impact on mode share in traffic-calmed residential areas.

To improve first-mile last-mile connections and promote public transport use, the national railway has also introduced the *OV fiets* or 'public transport'. These are available at major public transport stations and park and rides, with membership connected to the public transport smart card *OV Chipkaart.* There are efforts to include bike share at metro stations to build on the success of this scheme. However, local implementers note there is no appetite for a broader bike share scheme given the existing issues created by the volume of bikes in the city. Instead, they will focus on creating electric mobility hubs in neighbourhoods to include bikes, scooters, cargo bikes and cars, to further reduce the need for car ownership (Kune, pers comm 2019).

The popularity of cycling in Amsterdam has also created challenges for the city. Cycling congestion on popular routes is an issue due to the high cycling mode share and the increasing size of bikes, such as cargo bikes. Demand for bike parking facilities is another issue, particularly secure bike parking for expensive e-bikes. Finally, not all residents of Amsterdam view cycling as a preferable mode choice: the city has a high migrant population, many of whom view cycling as unsafe. Increasing cycling mode share among this population is seen as an outreach opportunity.

5.5.3 Car-Free Amsterdam

The Car-Free Amsterdam programme was implemented by the Mobility and Public Space group to create more living space and improve air quality by giving more priority to public transport, walking and cycling. The four pillars of this approach are:

- Clean and shared transportation – a shift to alternative modes as well as employer-based efforts to reduce car trips. Infrastructure strategies include 'bicycle streets' (30 km/h speed limit and cars are 'guests'), improved footpaths and public transport.
- More space – creating more space for walking, cycling, public transport and commercial vehicle loading needs through the elimination of parking.
- Customisation – context-specific strategies depending on the needs of the neighbourhood and balancing resident and visitor priorities including improving air quality and increasing open space.
- Innovative enforcement – monitoring through sensors and cameras to improve enforcement.

The group is also seeking to foster TDM principles within the city government, as the biggest employer in Amsterdam. They are hoping to institute a 're-timing' of travel by encouraging employees to start work at 10 am to reduce peak hour trips. Once this is implemented, they will seek to partner with other large employers to develop similar policies (Kune pers comm 2019).

5.6 Land use planning and development

Like many European cities, Amsterdam is dense and compact with mixed use neighbourhoods and a transport system that supports public transport and active modes. Historically, the city has developed specific policies to support the integration of land use and transport planning. The city's current strategy is to continue investment in transit-oriented development - building homes, offices and facilities in places that are easily accessible by bike or public transport. Where this is not possible, the council will invest in new cycling and public transport connections (Aluvihare et al 2018).

5.6.1 Transit-oriented development

Amsterdam's ABC policy (section 5.2) was not considered a success and ended in the 1990s, leaving a gap in integrated land use and transport planning. More recent interest in transit-oriented development has arisen to bridge the gap. The idea of developing compact, mixed-use areas near public transport stations to make efficient use of the existing transport infrastructure has been increasingly popular in the Netherlands. However, translating this into successful projects has been difficult. In Amsterdam, several transit-oriented office nodes in outer areas of the city have high vacancy rates. This has been attributed to the design of the developments, and a lack of housing, shopping and entertainment opportunities nearby (Pojani and Stead 2014).

Although the council of Amsterdam has tried to plan new developments along major public transport lines, there are a number of challenges, including: cultural and socioeconomic stigma associated with living adjacent to train stations; and cycling's strong mode share to complete trips in central areas and to provide easy access to train stations in less dense areas. Another challenge is decentralised control through municipalities competing for central funding and each public transport node in Amsterdam having its own development organisation run by the private sector. The financial district of Zuidas is one example where TOD investment has been successful, largely due to the concentration of high-profile international businesses willing to invest in the area. A major infrastructure project, Zuidasdok, is commencing in 2019 and will expand the train station as well as take the A10 ring road underground.

5.6.2 Traffic calming

Amsterdam is well known for its long history of traffic calming to create a safe and attractive environment for cycling and walking. Many residential streets are restricted to speeds of 30 km/h and in 'woonerfs' or 'living yards' this is decreased to an average speed limit of 7 km/h (walking speed) and parked cars are used to create a winding passage which forces vehicles to move at a slower pace. The city has also started creating cycling streets or 'fietstraat', which restrict speeds to 30 km/h and consider cars as guests. All of these efforts support residents' modal preference for cycling.

5.6.3 Parking management and enforcement

Amsterdam has pursued a strong policy of removing on-street parking to reduce car numbers in the city, dedicate space to active modes and improve liveability. Growing pains associated with this reduction include an estimated 50,000 km of travel per day from searching for car parking spaces (Kune 2014). Parking apps have been introduced to provide real-time availability and address the negative externalities associated with this traffic. Parking restrictions are continuing, with a further 10,000 on-street parking spaces to be removed by 2025. As on-street parking is removed, the city also attempts to shift parking to buildings managed by private companies. This allows the allocation of more public space for other modes, including dedicated public transport lanes.

5.6.4 Low emissions zones

In 2008, Amsterdam established a low emission zone (LEZ) for commercial and heavy goods vehicles. Vehicles must meet low emission European standards to enter the zone and vehicles are scanned, so enforcement is close to 100%. Fines for breaching the standards are set at €95 for vans and €65 for mopeds. There are some exemptions and short-term permits available for a daily fee. In 2018 the LEZ expanded to taxis, tourist coaches, buses, mopeds and scooters. The city provides an interactive map allowing drivers of different vehicles to identify specific restrictions that apply to them. The low emissions zone for mopeds and scooters extends beyond the ring road and will apply to tourist coaches from 2020.

5.7 Financial incentives

Amsterdam's key strategy to reduce car trips has been aggressive parking restriction and parking pricing policy. Starting in the early 1990s, parking policy has been a strong instrument to drive mode shift in the city and achieve liveability and environmental goals. The provision of park and ride locations at key public transport nodes around the A10 ring road is a key strategy to encourage public transport use for regional commuters and visitors.

5.7.1 Parking pricing

Amsterdam was the first Dutch city to introduce paid parking, installing 500 parking meters at Schiphol airport in 1964 (Mingardo 2016). However, pricing only became an effective tool to regulate the scarcity of parking spaces, when it took the form of a municipal parking tax in 1991. Prior to this, cities were responsible for enforcing parking infractions, but revenue went to the central government.

The year 1995 (figure 5.1) was a turning point for mode shift in the city, after city-controlled parking tariffs were introduced. In 2001, the city government estimated that *without* parking tariffs, car use within the city ring would have increased by 13% instead of the observed reduction. Another report estimates the effect of paid parking has been a 20% decrease in car traffic in the inner city, as well as a 20% reduction in traffic searching for a space to park (Hermann and Kodransky 2011).

Amsterdam has continued to increase parking prices to manage demand and now has some of the highest hourly on-street parking rates in Europe. The revenue generated supports parking management and the Amsterdam Mobility Fund, which is spent on public transport and active modes.

Residential parking permits are issued to residents at an annual cost of up to €500 depending on the parking zone (City of Amsterdam 2019). Total permit quantity is capped, and residents can wait years for a permit if the cap in their area has been reached. To remain on the waiting list, people must own a car and therefore incur much higher parking prices in the interim. Research estimates that the waiting list for parking permits reduces car ownership by approximately two %age points every year (De Groot et al 2016). However, providing residential permits can also act as an incentive to car ownership as it effectively subsidises parking: in Amsterdam, De Groot et al (2016) estimate that residential parking permits subsidise the cost of parking at a rate of €3,200 annually when compared to the on-street or commercial cost of parking.

The Smart Mobility group implemented a programme to incentivise people to give up parking permits in exchange for a one-off payment of a €500 public transport budget; however, this was not successful (Kune 2019). As noted above, people may have to wait years to obtain a parking permit and are therefore reluctant to give them up. Other initiatives are being considered including parking permit sharing. New developments have no parking minimums and generally one off-street parking space is provided per five dwellings. The government provides 0.1 on-street parks per dwelling for visitors (Kune pers comm 2019).

5.8 Outreach and implementation programmes

5.8.1 Beter Benutten – optimising use

Amsterdam participated in the national Beter Benutten (optimising use) programme which is discussed in further detail in the Beter Benutten focus area of this report (chapter 11). The region implemented more than 30 TDM strategies to reduce travel times by 10% in the busiest areas during rush hour. Measures included employer-based initiatives, bike and public transport promotion, intelligent transport system projects, and urban logistics initiatives. The programme resulted in an estimated 18,000 avoided car trips per rush hour.

Under the Beter Benutten programme, a mobility portal was created for the Amsterdam Arena venue to support trip planning. This is an online platform where visitors can find details about traffic to and from the Arena Poort area. Users can pay for bus journeys, parking spaces, or train tickets in advance. When they register for payment, postal codes are collected to identify their point of origin, and emails are requested so that travel advice can be sent to visitors, based on real-time traffic intensity and historic data. This means people can be guided to take certain routes at certain times, reducing traffic congestion (City of Amsterdam 2015).

5.8.2 Managing regional growth – 'Building Accessibility Together'

The regional 'Building Accessibility Together' programme is a way to continue the success of the Beter Benutten programme. As part of the MRA's mobility strategy, it seeks to accommodate the projected growth of 250,000 homes and 75,000 jobs by 2040 within the existing transport infrastructure. The focus is on reducing commuter traffic through better first-mile last-mile connections to public transport. A key reason for adopting the regional approach was to eliminate parochial funding focus within the many municipalities to address land use and transport issues which affect the region as a whole (N Verveen, Programme Manager - Smart and Sustainable Mobility Rijkswaterstaat West-Nederland Noord, pers comm, 10 April 2019).

There are four work streams within the programme, two that are focused on integrated transport and land use planning and two that are considered 'action' programmes, implementing interventions. The Smart and Sustainable Mobility project is currently funded for three years (2018-2020) and focuses on TDM behaviour change interventions across the region and in the six main bottleneck corridors. In 2019, these interventions are expected to result in a 13 kilotonnes of CO_2 reduction and 6,100 fewer peak trips (Samen Bouwen aan Bereikbaaheid 2019). There is an annual review where lessons learned from each of the measures are incorporated into the following year's programme.

Projects considered particularly successful by the manager of the regional Smart and Sustainable Mobility project include employer agreements. As an example, the programme will install cycling infrastructure in return for employers allowing workers to telecommute once a week. Capturing the momentum of major infrastructure disruptions to create behaviour change is also seen as a key strategy. For example, when the Velser tunnel crossing was closed for expansion, the programme instituted a cycling promotion and provided a replacement ferry across the canal. Upon project completion an estimated 3,500-5,000 people continued cycling and the ferry was retained despite a reduction in car travel times following the tunnel expansion (N Verveen, Programme Manager - Smart and Sustainable Mobility Rijkswaterstaat West-Nederland Noord, 10 April 2019).

5.8.3 Breikers – transport management association

Breikers is a transport management association established by the business community in the metropolitan region of Amsterdam as part of Beter Benutten. When the Beter Benutten programme ended, Breikers continued as a foundation in the Zuidas area of Amsterdam. Services offered include mobility scans and advising on the implementation of mobility budgets for employees to replace lease cars. Breikers are also talking with the government about making employee mobility flexible for tax purposes. Breikers partner, the Enexis group, organised their first car-free day in 2018. More than 24 organisations participated with 35,000 employees. This resulted in an estimated CO2 reduction of 35,000 kilograms (Breikers 2019).

5.8.4 Smart Mobility

Amsterdam sees itself as a 'living lab' for new technology, with a specific programme addressing Smart Mobility. The Dutch Bureau for Economic Policy Analysis is predicting organic growth in personal mobility of 23 to 50% by 2050 in the Netherlands (City of Amsterdam 2015). In recognition of this, the city established the Smart Mobility programme in collaboration with regional partners, academic institutions, the Amsterdam Economic Board, Amsterdam Smart City, the public transport operator GVB, and private partners. The Smart Mobility Action Plan identifies a range of projects, leveraging technology to improve mobility. The goal is to improve the safety, accessibility, air quality, quality of life and attractiveness of Amsterdam. The four key themes of the plan are the internet of things, a view of the city and smart use of space, MaaS and autonomous cars. The city is currently tendering for a collaborative new MaaS Zuidas Pilot in which the government will subsidise the development of the service and employers will act as paying customers and offer the service to their employees. This pilot is part of a national programme of regional trials and builds on the initial Zuidas Mobility Experience pilot.

Amsterdam is known for its open data sharing advancements: The DataPunt ('Data Point') is where much of the information from the municipality of Amsterdam is held and is made accessible to all Amsterdam residents with the aim of accelerating data innovation in Amsterdam. The traffic and infrastructure section offers 40 data sets covering parking, public transport and freight routes, among other categories, all of which can be used to advance smart mobility options (City of Amsterdam 2015). The city is also creating a public beacon network that developers can use for real-time travel information. A variety of user friendly apps have already been developed for real-time train, ferry, park and ride and parking space information. The city has partnered with Google and TomTom, agreeing to share data and improve their 'picture of the city', in return for real-time traffic information and origin-destination data.

While Amsterdam has a goal of moving towards shared mobility, there are some limitations. Carshare use has grown in the city but remains low. Local implementers note there are reservations about the growth of carshare schemes as these have been shown to attract mode share away from cycling and public transport (W Kune, Strategic Advisor, Mobility and Space, City of Amsterdam, pers comm, 29 April 2019). In 2017, 93% of people in the Netherlands had access to a smart phone, supporting the potential for increasing 'smart mobility' solutions (Deloitte 2017). This compares to 70% ownership rate for New Zealanders in 2015 (Research New Zealand 2015).

5.9 Key insights

Amsterdam's city government incorporates TDM principles throughout their planning process and programme delivery rather than creating a single dedicated programme – designing the city and its transportation system to reduce the need for car travel is 'in its DNA'.

At the regional level, a dedicated TDM work stream sits within the 'Building Accessibility Together' programme which aims to accommodate regional growth within the existing transport infrastructure. This builds on the national Beter Benutten project and is currently funded for 2018-2020 to reduce congestion at major bottlenecks and support mode shift through behaviour change TDM strategies.

First-mile last-mile connections to public transport especially with the extended catchment provided by e-bikes is a major focus to manage demand. This is because, while the central city is well served by public transport and cycling infrastructure, there is still a major challenge connecting commuters to workplaces in a region where high property prices have pushed many out of the city.

Parking policies have played a major role in mode shift: 1995 was a turning point for reducing car trips in the city when parking tariffs were introduced. The city now has high parking prices, continues to aggressively reduce on-street parking, and has a comprehensive park and ride strategy integrated with public transport. A key feature of parking pricing is that revenues directly support the city's Mobility Fund which invests in public transport and active modes to encourage mode shift. Leadership support has been critical in managing parking, which is often highly politicised. The recently elected council campaigned on aggressive parking reductions which indicates it remains a viable strategy.

Outreach and behaviour change interventions also play an important role in Amsterdam's TDM efforts. A suite of 30 interventions implemented under the Better Benutten programme removed an estimated 18,000 trips per rush hour. The regional Building Accessibility Together programme is incorporating a variety of outreach efforts to accommodate regional growth within existing infrastructure, while TMA's like Breikers (with 650 member employers) focuses on work-place strategies such as employee mobility budgets and car-free days.

Smart Mobility is a major focus for the city, which is seen as a leader in data sharing. It has a Smart Mobility Action plan for leveraging technology to improve mobility with a wide range of travel apps already created and the city is currently undertaking a second MaaS pilot. While technology and big data can support efforts to encourage behaviour change and evaluate programme performance, it should be noted that this work stream is seen as complementary to other more substantial TDM strategies such as parking and infrastructure and service provision.

6 London case study

6.1 Introduction

London faces many of the same challenges as some New Zealand cities – rapid growth, limited space to build new infrastructure, a desire to improve air quality, high house prices, and a need to transport people over significant distances, especially during peak times. Additionally, the city now faces a significant surge in private hire taxis (such as minicabs) and ride-hailing companies, as well as online shopping and delivery – fundamentally changing some demand patterns in the city.

6.2 City snapshot

London, a city of 11.2 million people, is the largest in the UK, as well as the capital of the UK (Atlas of Urban Expansion 2019). The Atlas of Urban Expansion estimates the 2013 urban extent of London at 2,507 km^2. For comparison, it estimates Auckland's 2014 urban extent at 488 km^2. It estimates London's built-up area density at 63 people per hectare, compared to 38 people per hectare in Auckland (Atlas of Urban Expansion 2019).

Following World War II, London's population significantly declined until the early 1990s, when it began to steeply rise again. The population is now at its highest level ever. Against this rise in population, car travel demand has decreased, while all public transport modes have seen growth at a rate outstripping general population increase (Transport for London 2014).

The city has made good progress on moving mode share away from the private vehicle in the last 20 years. Car mode share has continuously tracked downward since 1999, while public transport journey stages roughly doubled between 1993 and 2009, increasingly making up a greater portion of the city's mode share (Aldred et al 2018). Figure 6.1 illustrates the mode shift in London based on Transport for London data.

Figure 6.1 London mode share 1997 - 2017 all aggregate trips (Transport for London 2018)

Despite the city's mode share trends, Londoners are making fewer trips overall, across all modes, with a 20% reduction over the last 12 years. This is believed to be due to economic factors, and increased rates of home delivery and flexible working, meaning the city's residents are beginning to travel less. Most recently, the economic risk of change associated with Brexit is believed to be further contributing to fewer trips (Badstuber 2018).

The city's transport centrepiece is the London Underground, the world's oldest underground railway network, with 11 lines covering 402 km across 270 stations. Up to five million journeys are made on the system daily. The city's bus network operates 9,300 buses across 675 routes, with more than six million bus journeys made every weekday.

London is one of the most heavily car congested cities in Europe, with an estimated cost of £1,680 and 227 hours lost per driver to congestion in 2018 (INRIX 2018). However, Londoners are also reported to have high levels of satisfaction with their public transport service (O'Sullivan 2016).

Other major influences of demand in London include decreasing highway capacity since the 1990s, increased public transport offerings, changing attitudes to car ownership and use, evolving work arrangements, altered personal economic circumstances and altered demographics (Transport for London 2014).

Londoners are considered highly knowledgable about their transport options (Sheffield 2019). Because of this, Transport for London (TfL) is challenged to think creatively about ways to influence travel demand if it wants to see a reduction in travel at peak times or a shift towards particular modes.

London's major geographic obstacle is the River Thames, which the city straddles. Access is maintained via a series of bridges across the river, and transport services either have tunnels underneath the river or bridges over it. Beyond the Thames, there is relatively little geographic impediment to London's growth, with the surrounding area mostly sitting at an elevation of less than 50 m.

Current London Mayor, Sadiq Khan, wants to increase the %age of people walking, cycling and taking public transport to 80% of journeys by 2041. The current proportion of trips using those modes is 63%.

6.3 Governance framework

In 1998, the greater London Authority (Referendum) Act was passed, which led to the creation of the position of Mayor of London (2000) and a democratically elected London Assembly. This same act also saw the establishment of TfL, the local government body responsible for London's transport system. The Mayor of London is the chair of the board for TfL, the controlling agency for the city's transport services.

The mayor has significant influence over TfL but is still accountable both to the organisation's board and to the London Assembly, which is made up of 25 elected members. There are 32 boroughs in London that work on implementing TfL plans in their areas. Each borough also has an elected mayor, serving a four-year term.

The Mayor of London is in charge of producing London's spatial development strategy, known as The London Plan. This is a shared responsibility between the Mayor of London, the city's 32 boroughs and the Corporation of the City of London. This document is revised and republished to reflect national and local policies where appropriate. It is currently being updated.

At a national level, the UK's Department for Transport is responsible for policy and guidance on road networks, maintaining the country's highways, setting the strategic direction for the rail industry, improving bus services through funding and regulation, road safety, and aviation and marine policy. The department

also cites a responsibility toward 'working to make our roads less congested and polluted by promoting lower carbon transport, including cycling and walking' (Department for Transport 2018).

6.3.1 Transport bodies

Transport for London is the main agency for the city's transport services. It runs the city's buses, the London Underground (The Tube), the Docklands Light Railway (DLR), London Trams, London River Services, Victoria Coach Station, the 580 km network of main roads in the city, and traffic lights in the city. TfL also regulates taxis and private hire minicabs (private pre-booked car transport).

TfL is generally considered successful at managing the city's transport and achieving the goals set within the Mayor's transport strategies. This success has been attributed in part to the influence of a series of vocal and charismatic mayors championing a transport agenda. This is generally considered to be particularly the case under the city's first mayor, Ken Livingstone (Sheffield 2019; Badstuber 2015).

When a new mayor is elected, TfL produces a document called the Mayor's Transport Strategy which incorporates the mayor's vision for transport during their tenure.

6.3.2 TDM responsibility

As TfL is the body with sole transport responsibility in London, it is also the body responsible for TDM efforts. Within TfL, there is an official TDM Programme. The programme sits under the department of Customers, Communication & Technology. As of the 2017/2018 financial year, the TDM Programme Director was paid £110,000-£114,999 annually (Transport for London 2018a).

The programme's budget in 2017/18 was £3.99 million (approximately NZ$7.7 million). This programme focuses on behaviour change in response to disruptive events such as roadworks. The strongest example of behaviour change success under the official TDM Programme was the 2012 Olympics, which will be discussed in detail later.

The city's TDM Programme reports regularly to the TfL board. When reporting to the TfL board, TDM Programme staff describe their approach as 'to provide accurate and timely information for our customers and partners to influence travel behaviour and enable customers to make informed travel choices' (Transport for London 2017).

London's official TDM Programme describes its key performance indicators as being broadly split between attaining levels of awareness of its campaigns and achieving outcomes in terms of trips being retimed or rerouted.

Beyond the official TDM programme, much of TfL's broader work also constitutes travel demand management. This includes initiatives to disincentivise car travel, such as the city's congestion charge and ultra-high emissions zone.

TfL comprehensively monitors its own mode share data via the annual *Travel in London* report. This includes monitoring of travel trends across active travel, motorised travel, and public transport use, as well as general mode share monitoring for the whole city.

6.3.3 Funding model

Underpinning all the work being undertaken by TfL is substantial investment in improving the city's overall transport network. TfL's 2018 budget showed an expected total net capital spend of £13.3 billion on the city's transport system between 2016/17 and 2021/22. This includes station upgrades, extensions to underground lines and other improvements. Additionally, key additions to the city's mode provision since 2000 have included a shared cycle scheme (Santander Cycles) and integrated fares (Oyster Card).

London's transport system is not without substantial difficulties. In particular, TfL currently has an operating deficit. This has been due to the removal of £700 million in government grants in 2018, the Mayor's fare freeze policy, and significant delays to the city's major new crossrail line opening, delayed from December 2018 to at least 2020, with potential total costs of £17.6 billion up from the originally forecast £15.4 billion (National Audit Office 2019).

In 2010, an international study of TDM practices rated London positively in terms of physical, operational, financial, organisational and political progress; however, it found the city was being held back by a lack of integration and research (Black and Schreffler 2010). While one-off projects like the congestion charge and the 2012 Olympics have been successful, 'patchy' support for TDM, particularly from the city's boroughs is a problem for the city, along with claims of 'silo' thinking within TfL (Black and Schreffler 2010). '

London's public transport fares have been 'frozen', or kept at the current rate, since 2016. This is expected to hold until 2020.

6.4 Overall approach to TDM

London has made some significant TDM decisions under the TfL umbrella. Not only does the city run an official TDM programme, which covers behaviour change, but 'sticks' (disincentives) have historically been used successfully in the city, including congestion charging and parking reform. The city's latest transport approach, Healthy Streets, quantifies the health benefits of London achieving its transport mode share goals.

This section will review key strategies that London has undertaken to manage travel demand. The strategies are organised into four major categories defined by Litman (2014):

- outreach and implementation programmes
- financial incentives
- improve transport options.
- land use planning and development

6.5 Outreach and implementation programmes

London's biggest success in terms of TDM outreach came as a result of careful planning for the 2012 Olympics. The programme put in place for the Olympics has since been adjusted for use across London more generally but is generally still reactive to particular events or disruptions.

6.5.1 London Olympics

The 2012 Olympics were 'Britain's largest peacetime logistical exercise' (BBC News 2011), with a significant focus on transport. Considerable pressure was put on the city to deliver a Games that succeeded transport wise and informed the comprehensive TDM policy that has since been labelled a success.

London's Olympics (2012) were a major TDM success story for the city, and provided the framework to develop a broader, integrated TDM programme for London. The Games presented the greatest demand the UK transport network had ever experienced. The goals of the Olympic Games TDM plan were to keep the city moving, leave a lasting legacy, and only build new infrastructure where essential. The TDM methodology was developed from 2008 to 2012.

The programme focused on four Rs: reduce, re-time, re-mode or re-route. The target of the games was to reduce background travel demand (normal travel not related to the Olympics) by 30% at certain times. This was exceeded, with a rate of 35% behaviour change on weekdays during the games. At weekends, this twice reached 40%. Behaviour change in this context was defined as people changing their journey in some way (reducing, re-timing, re-routing or re-moding).

Specific interventions included the provision of information and advice to businesses, regular travellers and spectators. The following initiatives were used:

- Businesses were provided with site-specific advice, including TDM toolkits and travel workshops, advertising, mail drops and daily bulletins about travel.
- Spectators were given specific journey planning support through a targeted Olympics 2012 travel website, specific travel passes for the games and 'widespread real-time information.
- Regular travellers made use of the 'Get Ahead of The Games' website, which included visualisation tools outlining expected demand at locations during the games, targeted emails, an extensive marketing campaign emphasising the need to change travel plans and walking maps handed out at stations.

Research analysing the TDM strategy post-2012 has argued the success of the Games' TDM programme was due to strong political leadership, an effective marketing campaign and successful harnessing of public enthusiasm for the London Games to be a success. Additionally, over £11 million was invested in improved walking and cycling facilities relating to the Games.

One of the most significant barriers to travel behaviour prior to the Olympics, was the ability for staff to work flexible hours or change their hours to travel outside of peak times. During the Olympics, communication with employers meant that increased flexibility for workers was seen. However, in many cases, this was only extended for the duration of the Olympics, and employers were less enthusiastic about granting their workers flexible hours once the Games finished (Sheffield 2019).

6.5.2 TDM programme

The 2012 Olympics acted as a catalyst for a wider TDM programme in London, mostly focused on reducing negative effects of disruption to the city's transportation network. Generally, the programme focuses on communication and relieving disruption from infrastructure work and major events, but also has a focus on areas where demand exceeds supply at certain times.

Techniques from the 2012 Olympics have been adopted to influence the projects the TDM team now focuses on. The TDM team reported its successes in 2017/2018 as follows:

- A406 Neasden road improvement works – 14% of frequent drivers influenced to travel outside the busiest times, leading to a 3% reduction in total traffic flows.
- Tower Bridge closure – drivers who received TDM messages were 6%age points more likely to re-time their journeys to avoid the worst congestion in the AM peak.
- Crowding at peak times on London Underground and rail – up to 6% of regular customers responded to TDM programme information by avoiding the very busiest times.
- Tour de France – pre-event communications led to traffic levels in central London being 17% lower than on a typical day.

- Walking Tube Map – a quarter of Londoners are aware of TfL's 'Walking Tube Map' – a map giving walking times between tube stations to encourage walking instead of using the Underground. Over a third of people aware of the map say they have been encouraged to walk more as a result of using it;
- Thameslink London Bridge – demand at targeted London Overground stations down by between 10 % and 20 % during peak times.

Awareness levels are measured by the rate of people 'clicking through' from emails, webpages, and social media engagement, as well as qualitative research. Re-timing and re-routing are measured by tracking demand at the busiest times. This includes monitoring arrival times at London Underground stations or monitoring regular drivers in a particular area.

6.5.3 Smarter Travel (Sutton)

An earlier rendition of London's TDM Programme was called Smarter Travel. A showcase example of this was in the borough of Sutton. £5 million was spent on the programme from 2006 to 2009, encouraging the 184,500 residents of the borough of Sutton to reduce car use.

The programme involved travel planning for schools and larger employers, direct travel advice and information to households and medical patients, reward programmes, advertising, car club, cycle training and facilities, and a touring roadshow.

Results were:

- 75% increase in average cycle traffic
- an increase in cycling's mode share, from 0.6% to 2.1%
- an increase of more than 16% in bus patronage
- an increase in walking's mode share from 19.4% to 22%
- a reduction of 6% in car mode share
- traffic levels reduced by 3.2% (National Social Marketing Centre 2016).

The programme did not continue due to cuts to TfL's marketing budget between 2008 and 2016 (Sheffield 2019).

6.6 Financial incentives

London's main approach to reducing car travel has been through the implementation of charges, initially based on location and, more recently, based on emissions. As outlined below, the policies have been tested as mobility trends change.

6.6.1 Congestion charge

One of London's most significant TDM strategies has been the city's congestion charge, introduced in 2003. Drivers who enter the 21 km^2 congestion zone in the centre of the city must pay a daily charge of £11.50. The congestion zone is in force between 7 am and 6 pm every weekday. The charge does not apply to people with disabilities, and residents inside the zone only pay 10% of the charge (£1.15).

The charge was originally considered a success, with the number of vehicles coming into central London 25% lower than in the previous decade. In particular, private cars entering the zone decreased by 39% between 2002 and 2014. As a result of decreased traffic volumes in the zone, more space has been available for allocation to cyclists and pedestrians.

Strong political will (primarily in the hands of the city's mayor), extensive public consultation – including changes where necessary, and improved funding (in many cases from the congestion charge) for public transport, are all cited as reasons for the charge's success. On the day the charge came into force, 300 additional buses were put on London's streets to ensure alternative modes were successful.

Despite this success, changing trends have rendered the congestion charge less effective. In particular, significant growth in private hire services and ride-hailing, such as Uber, and increasing online shopping are believed to be reversing some of the original benefit gained from the congestion charge. London's current mayor, Sadiq Khan, has acknowledged difficulties with the congestion charge in the modern day. In April this year, a previous exemption for minicabs was removed from the charge. Additionally, it is widely believed that the congestion charge will be further overhauled, although official policy does not yet indicate this. The introduction of an ultra-low emissions zone to London (in 2019) may be a signal of change to come to the congestion charge. The zone will add an additional £12.50 to the congestion charge zone for older vehicles. This zone is set to be expanded in 2021.

It should be noted that London's congestion charge area is small, covering only the core city centre area. The charge area was temporarily expanded to the west in 2007, but this extension was removed in 2011 (Transport for London 2012).

6.6.2 Emissions-based parking scheme

In 2018, an emissions-based parking charge scheme was introduced in the City of London (Greater London's financial district only), charging the most polluting vehicles at a higher rate than other vehicles.

Low emission cars (electric, hybrid) are charged £4 per hour; petrol and diesel vehicles registered from 2005 onward, £5.20 per hour; and other vehicles are charged £6.80 per hour.

The scheme uses an emissions-based parking product called RingGo. Drivers must pay for parking using the RingGo app, which has access to national vehicle data to determine which category cars fit into. Drivers paying with cash are penalised by paying the highest rate.

The city expects to see a gradual shift towards cleaner vehicles over a longer period of time.

6.7 Improve transport options

Public and active transport investment has always been a significant part of London's mode shift strategy. The city invests heavily in expanding its public transport network, in particular its trains and buses, and in developing cycleways to encourage a city-wide shift to cycling. TfL is increasingly looking to adopt the management of suburban rail to bring it in line with pricing and standards seen in the central city.

6.7.1 London overground

A standout example of successful demand management in London is TfL's takeover of the concession to run the London overground network in 2007. This was part of wider TfL policy to integrate outer London rail lines with the city's inner-city transport infrastructure.

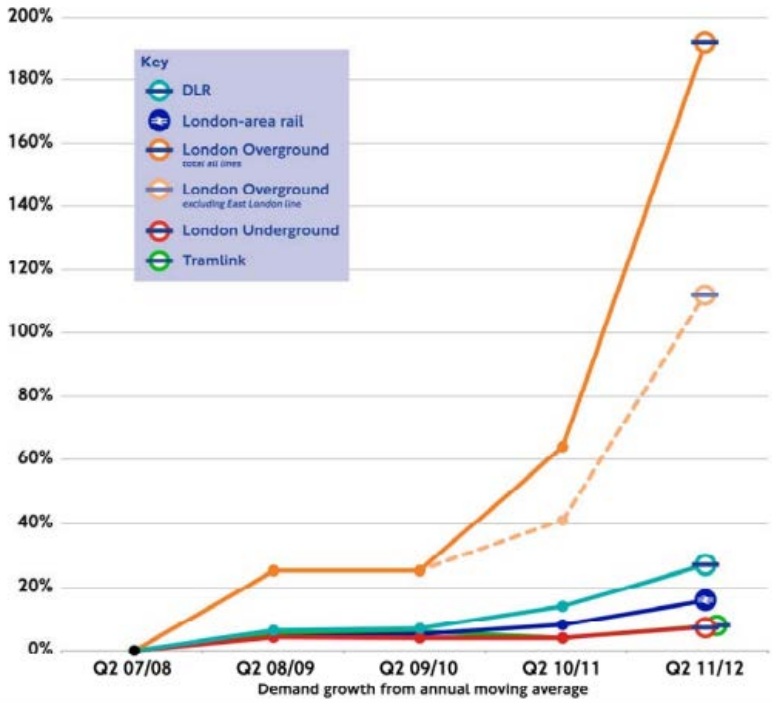
Previously, this network was run by a rail operator, Silverlink Metro, with the service described by the London assembly as 'shabby, unreliable, unsafe and overcrowded' (London Assembly 2006). One commentator described the overground as 'created out of old yogurt pots and bits of string. Most of the infrastructure was already there; it had just been forgotten' (Engel 2015).

Since 2007, when TfL took over the running of the line, several changes have been made. These changes have involved new trains, revamped stations, improved service frequency and enhanced

marketing. Importantly, the line was marketed under the same branding as the underground network. This included adding the overground to standard Tube maps and allowing passengers to pay by Oyster card (the city's integrated ticketing system). Since 2008, annual passenger numbers on the line have grown from 33 million to over 190 million – with no drop-in ridership in any year (Transport for London 2019b). There has also been investment in extending the line toward the east of London.

In particular, the line's success since TfL took it over has been put down to increased frequency of trains, extended coverage (with an extension of the line into East London), new trains, station enhancements, better management, serving quality improvements, connectivity and marketing. The line's success has prompted calls for similar treatment for suburban rail services in other parts of the city, in response to growing demand for transport in the city (Sims et al 2016). Figure 6.2 shows the marked increase in ridership of the overground subsequent to TfL taking over the operation.

Figure 6.2 Overground ridership 2007/8 -2011/12 (Transport for London 2019)



6.7.2 Cycling superhighways

London has made significant investment in creating conditions to encourage cycling. One of the most noteworthy in this space has been the city's Cycle Superhighways and Quietways. The first superhighways (protected cycling space on some of London's busiest roads) were opened in 2010. There are now eight across the city. The first four superhighways were designed with a focus on adding a low-cost improvement to current road or cycling infrastructure. The early superhighways were recognised by their bright blue paint and were criticised for being little more than painted lines on the road, instead of more substantial infrastructure. Later superhighways involved a redesign of streets, in some cases re-claiming car traffic lanes for cycling.

The results of the superhighways have been tracked using cycle counters. A 2016 report looking at counts on the East-West and North-South superhighways saw significant increases in morning and

evening peaks (up by 55% at their peak). At its busiest, on the East-West Superhighway, the number of cyclists comprised 52% of all traffic. On the North-South Superhighway, cyclists made up 70% of all traffic at its busiest (TfL Programmes and Investment Committee 2016).

In addition to superhighways, quietways (continuous routes along less-busy back streets) have been instigated. In general, difficulties have been reported in getting design consistency across quietways. In part, this is due to London's boroughs having control over the roads, not TfL.

Under the current mayor, there is a plan to merge the branding of all cycle routes into one name, to reduce confusion. TfL will also establish the world's first cycling infrastructure database to record details of all cycling facilities in London. This data could be used by third parties to create personalised journey planning for cycling.

6.7.3 Peer-to-peer carsharing

Peer-to-peer carsharing is emerging in London as a new transport options for residents. Hiyacar is a private peer-to-peer carsharing service, running in London since 2016. The company allows individual car owners to rent their cars to other drivers through a web-based platform. The company provides insurance in place of the owner's insurance, and drivers are charged an insurance premium on a case-by-case basis (Hiyacar 2019). This service is considered part of a growing trend toward a sharing economy in transport.

6.8 Land use planning and development

London measures public transport accessibility levels, a measure of how far any given location in the city is from a frequent public transport service. This reflects walking time to public transport access points, the number of services available, and average waiting time for that service. This data is then used by the city to identify where new transport and development investment should be made. This approach is now 'deeply embedded in strategic and local planning' for the city (TfL 2015). This section outlines further land use plans and programmes in the city seeking to address the city's mode share goals.

6.8.1 Healthy Streets agenda

Mayor Sadiq Khan's transport strategy is now underpinned by a Healthy Streets agenda, 'a system of policies and strategies to help Londoners use cars less and walk, cycle and use public transport more'. The same policy is also included in the 25-year spatial development strategy for Greater London. It 'puts human health and experience at the heart of planning the city' (London Assembly 2019). The theory behind the approach is that if every Londoner walked or cycled for 20 minutes a day, the National Health Service would save £1.7 billion in treatment costs over the next 25 years.

The approach is made up of 10 indicators that should influence street design; they include factors relating to noise, safety, interactivity, air quality, shade and shelter. The approach means that health is prioritised in all planning decisions, which connects to the mayor's goals to increase the active mode share of Londoners.

The plan is a long-term vision for improving the experience people have on streets, which would then encourage the mode shares desired by the current transport plan for the city. The approach includes detailed toolkits and checklists for designers, which design proposals are run by.

The approach has been internationally celebrated and is one of London's more innovative, current policies that can be considered TDM. The TfL plan for embedding the Healthy Streets approach includes

a £2.1 billion spend on a Healthy Streets portfolio for TfL. This means all street spending will fall under the portfolio and all investment decisions are assessed against the 10 Healthy Streets indicators

6.8.2 Mini Holland

London's Mini-Holland programme began in 2016 and awarded £30 million each to three outer London boroughs – Enfield, Kingston and Waltham Forest. With the money, the boroughs were to create a new network of cycle routes and improve streets to encourage walking and cycling. Alongside this, the boroughs have run complementary programmes involving cycle training, cycle roadshows, bike maintenance courses and cycle parking.

The projects focused on the theme of filtered permeability, or modal filtering: making roads more difficult to access for cars compared to cyclists or pedestrians (Aldred et al 2018).

After one year, people living in parts of the mini-Holland boroughs were walking and cycling 41 minutes more per week than people in comparable areas. The study found no significant reduction in overall car use, but a change toward more positive public attitudes to cycling. Residents in 'high-dose' mini-Holland neighbourhoods were 24% more likely to have cycled in the previous week compared with people in non-mini-Holland areas. The absolute change in mode was greater for walking than cycling (Aldred et al 2018).

6.8.3 London plan (parking maximums replace minimums)

In February 2004, an updated London Plan was passed by the Greater London Authority. This required local authorities to change their parking policy from minimum parking requirements to maximum parking requirements. This means a shift from requiring developments to provide a minimum number of carparks, to a cap preventing developers providing more than a certain number of car parks in developments. A 2013 study found a 40% reduction in the number of residential parking spaces following the reform (Guo and Ren 2013). In real numbers, for the study area, this meant a reduction of 143,893 parking spaces across 22 of London's boroughs.

London is now considered to have one of the most restrictive parking schemes among worldwide cities (Li and Guo 2017). Li and Guo (2017) carried out a 10-year review of the policy's effects on the building of new multifamily housing developments. Overall, they found no effect on the number of new developments being built across the city, but a difference in where new developments were built. The restrictions were found to encourage high-density car-free or low-car developments in inner London, but not in outer London. The authors believe this lends weight to the practice of supporting maximum parking standards in central areas, near public transport hubs, as these are likely areas of lower car ownership. Additional studies have concluded that, in inner London in particular, the removal of parking minimums had the stronger effect, rather than the extra step, of adding maximum parking requirements (Li and Guo 2014).

6.9 Key insights

London has used significant and varied measures to shift travel demand towards various goals since the inception of the city's transport authority Transport for London (TfL) in 2000.

The influence of the city's mayor, who chairs the TfL board, in these strategies cannot be understated, as programmes are set in motion, changed, discontinued or given substantially more funding, depending on who chairs the board. This can be seen by the implementation of the city's congestion charge, cycle share scheme, and the city's current Healthy Streets approach.

London's approach is highly holistic, with a huge number of policies and approaches looking to meet the city's mode share goals.

London makes use of both 'carrot' and 'stick', in particular penalising people who drive in the centre of the city via congestion and emissions-based charges. Generally, cycling is viewed as a mode share that needs to grow and significant investment has gone into making it a more attractive mode.

The city's main 'stick', the congestion charge, is no longer working effectively for the city. This is due to changing trends in transport demand, in particular the rise of ride-hailing and home delivery services.

The city's official TDM programme can be described as reactive, it currently acts as a means of softening the blow on traffic of various interruptions, such as significant road works or special events. That being said, the city is beginning to use these same techniques to pre-emptively address areas with transport overcrowding, almost treating overcrowding as a disruptive event akin to roadworks.

The 'official' TDM programme sits under the marketing branch of TfL. This is an inaccurate portrayal of the work being undertaken in the TDM space at TfL. Not only can many projects be classified as TDM that are not part of this team's work, but the marketing label has negatively affected the team in the past. Cuts to the marketing budget of TfL meant the Smarter Travel programme (the precursor to what is now called the TDM Programme) was cut.

The 2012 Olympics were the city's biggest behaviour change challenge, and success story. Maintaining that success in the long term has been difficult.

Beyond behaviour change programmes, the city has heavily invested in its public transport, cycling and walking infrastructure, with the understanding that behaviour cannot be changed if a viable alternative is not offered to travellers. A clear example of this was the introduction of 300 new buses to the network on the day the congestion charge was launched.

7 Seattle case study

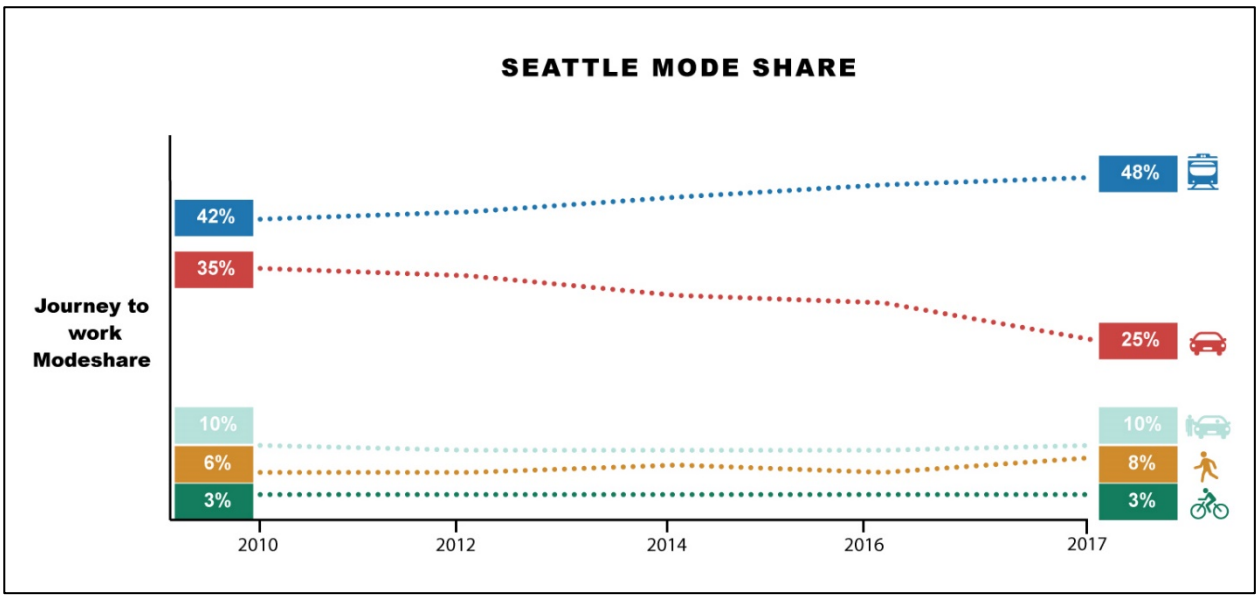
7.1 Introduction

TDM in Seattle is an interrelated and mature set of interventions based around integrated transport and land use planning, commute trip reduction policies, and investment in public transport. Voter-backed initiatives have enabled a major investment in the city's bus network including the 'RapidRide' service. These investments have resulted in significant increases in bus ridership in contrast to falling patronage in most other US cities.

The 2017 Seattle City Centre Commute Mode Split Survey shows that nearly half (48%) of downtown Seattle's 262,000 workers are using public transport to commute. Overall, more than 75% of downtown commuters are using a method of travel other than driving alone.

Figure 7.1 shows commute mode change from 2010-2017. Drive alone rates dropped from 35% to 25% over this period, in which an additional 60,000 jobs were added in the city (EMC Research 2017). However, regional drive alone commute mode share remains high at 72% in 2017, with Seattle ranking 4th in the US for congestion and 53rd in the world (Tomtom Traffic Index 2019).

Figure 7.1 Seattle City Centre Commute Mode Share for commuters starting work between 6am and 9am, 2010-2017 (EMC Research 2017)



7.2 City snapshot

Seattle has a population of 725,000 while the wider metropolitan area has a population of 3.87 million, containing almost half of Washington State's population and making it the 14th largest metropolitan area in the US. The region is experiencing high growth rates as a major technology employment hub and is expected to add 1.8 million residents and 1.2 million jobs by 2050. The OECD estimates Seattle's urban area at 1,670 km2 (OECD 2014). For comparison, the Atlas of Urban Expansion estimates Auckland's 2014 urban extent at 488km^2. Seattle's 2010 population-weighted density was estimated at 18 persons per hectare (Duke 2012). Using slightly different methodologies, various sources estimate Auckland's

2013 built-up area density and population-weighted density at 38–43 people per hectare, respectively (Atlas of Urban Expansion 2019).

The city's transportation network includes a range of public transport options, and two major highways that dominate road access to the city. Ridesharing is an important part of the transport network in Seattle comprising 10% of commuter trips as shown above. This includes both carpool and vanpool which is a popular rideshare strategy in the state.

The public transport system includes light rail, street cars, bus, heavy rail, ferries and the RapidRide frequent bus service. There is a wide range of providers for these services including public transport agencies, and city and state departments of transportation. The public transport system is supported by Park and Ride, vanpool and carpool services.

Seattle is also geographically constrained in the city centre between the waterfront and the interstate corridor of I-5. Approximately 262,000 people travel to or through the centre of the city each day from around the region. To accommodate the city's high rate of growth, there is a large number of major construction projects being undertaken, including the closure of the Alaskan Way Viaduct to be replaced with the State Route 99 tunnel. To address these major changes to the transport network, the city has developed the 'One Center City' plan to keep people and goods moving while also improving public space and pedestrian access.

7.3 Governance framework

Seattle is located in the state of Washington which has a governor supported by an executive of elected and appointed heads of department, and a state legislature. Washington state is divided into eight regions for transport management, one of which is King County, in which Seattle is located. Seattle is governed by an elected mayor and council. The Puget Sound Regional Council (PSRC) is the Metropolitan Planning Organisation for the region.

7.3.1 Transport bodies

The Washington State Department of Transportation (WSDOT) owns and maintains the state highway system, operates the state ferry system, and works with partners to maintain local roads and transport systems as well as support alternatives to driving. WSDOT manages the state-wide Commute Trip Reduction (CTR) programme which is a core component of Seattle's TDM strategy. The agency has also adopted a 'practical solutions' approach to how they plan, build, operate, and maintain the transport system; this approach includes demand management as a key strategy.

The Seattle Department of Transportation (SDOT) manages the city's roadways and public space, developing modal plans and the Move Seattle 10-year strategic plan. The public transport system is operated by a number of providers as mentioned previously.

As the regional Metropolitan Planning Organisation, PSRC is responsible for planning regional growth through the Vision 2040 plan as well as the regional transportation plan, which is updated every four years and includes the regional TDM plan as an appendix. It is also responsible for helping local jurisdictions access federal funds: PSRC selects projects to receive over $240 million in federal transportation funding each year. PSRC is responsible for regional data collection including about travel behaviour.

7.3.2 TDM responsibility

The CTR programme and broader TDM strategies are coordinated across the state, regional, and local levels of government. WSDOT convenes the CTR Board and develops the state-wide TDM strategic plan. Regionally, the TDM Steering Committee at PSRC develops a TDM plan to support implementers in the greater Seattle area including employers and major institutions, local jurisdictions, public transport agencies, TMAs and transportation providers. At the local level, SDOT has a CTR programme manager but implementation is mostly undertaken by the service delivery partner Commute Seattle, one of four TMAs in the region. For further information on TMAs please refer to chapter 11.

The regional council defines TDM as 'helping people use the transportation system more efficiently through education, incentives, products and programmes that remove barriers to non-drive alone modes such as public transport, carpool, vanpool, walking, cycling and teleworking (Puget Sound Regional Council 2017).

7.3.3 Creating a framework

Washington State passed two key pieces of legislation in the early 1990s, which created an important framework for TDM in Seattle. In 1990, the Growth Management Act (GMA) was passed in response to dramatic growth in the preceding decade. The Act established state-wide goals and procedures for managing growth, requiring state and local governments to designate urban growth areas, prepare comprehensive plans, and coordinate regional transport strategy. This included a requirement for TDM strategies and programmes for county and local plans, and public transport agencies. Examples of strategies included: efforts to shift the timing and mode of trips to avoid peak travel times and to increase the share of trips by public transport, ridesharing, cycling, and/or walking; efforts to decrease trip lengths; and efforts to eliminate certain vehicle trips all together.

In 1991, the Washington State Legislature passed the Commute Trip Reduction Law (renewed in 2006 as the Commute Trip Reduction Efficiency Act) to meet environmental goals as part of the state's Clean Air Act, by reducing emissions, congestion, and fuel consumption. It requires major employers (100+ employees) to implement strategies to reduce the number and length of drive alone commute trips for employees.

7.3.4 Key TDM planning documents

TDM principles are incorporated into many of the key planning documents in Seattle such as the comprehensive plan required by the GMA. The state and region also create TDM plans, while the city of Seattle develops a CTR strategic plan every four years.

Washington State's TDM strategic plan 'Expanding Travel Options: Faster, Smarter and More Affordable' recommends practical, strategic initiatives to prioritise smarter, faster, and more affordable transportation options. It seeks to shift planning discussions from a construction-first focus to making the best use of what is already available in neighbourhoods, communities and the state. The state-wide TDM plan has a strong focus on allowing local jurisdictions the ability to define their own goals and strategies; this flexibility is recognised as key for designing success in regional and local plans.

The state-wide TDM plan has three main goals: increase the use of high-efficiency transportation options for commutes; expand the availability and use of transportation options; and increase policymakers support for TDM. Along with setting state-wide trip reduction targets, key focus areas of the plan include: incorporation of TDM approaches in a broader range of policies and plans at the state, regional and local level; connecting TDM projects with public health, sustainability and social equity; and increased use of mode shift in plans and projects to deliver transportation performance. It is important to note that a shift is

taking place in terms of how TDM is viewed at the state planning level and this is the first time that the state-wide TDM plan has moved beyond CTR goals to a broader approach.

The Puget Sound 'Regional TDM Action Plan' is developed by PSRC in collaboration with regional partners (Puget Sound Regional Council 2017). The primary objective of the plan is to connect all people with travel options that optimise the transportation system's capacity. Key strategies are: expanding programmes; better information provision; enhancing the existing transportation system; maximising new investments; influencing policy; and research and advocacy. PSRC recognises that because TDM activities are wide-ranging in scope, scale, timing and geography, it is challenging to demonstrate the cumulative impact of all TDM activities on system performance. Performance measures include mode split, public transport ridership and the number of vanpools (discussed further in section 7.5.3 below).

Seattle's CTR Strategic Plan outlines key programme targets (Seattle Deaprtment of Transportation 2019). Between 2007/8 and 2015/16 the city-wide (as opposed to city centre) drive alone rate for CTR affected employers decreased from 37% to 31%. For the period 2019–2023, the target is 28.8%, which supports the Seattle 2035 Comprehensive Plan target of 25%. The VMT target per employee is 4.0 for 2019-2023. The overall drive alone rate for the city is also separated into network targets for 11 areas of the city based on past performance and the existing transport network. The plan outlines key benchmarks for the programme, and these are grouped into the following categories: commute and climate outcomes, programme reach, cross-programme integration, and programming impact and cost effectiveness. Key data sources to evaluate these benchmarks include the biennial CTR survey, CTR employer programme reports, the regional household travel survey and the American Community Survey (Census Bureau).

7.3.5 Funding model

The CTR programme is funded at US$6 million statewide every two years and for every taxpayer dollar that goes into the programme, businesses invest an estimated US$20 in their CTR transport management plans (WSDOT 2017). Approximately half of the state funding is allocated to administering the programme at the state level including a biennial travel behaviour survey. The remaining funds are allocated to jurisdictions on a per capita basis to support local programmes. CTR affected employers are required to implement a number of interventions to reduce their employees drive alone rates. Companies are able to choose from a list of options which include measures such as outreach, public transport subsidies and facilities to support active modes. Investment in these measures represents the estimated business contribution to CTR funding indicated above. WSDOT is also moving to a 'least cost planning' framework which it is hoped will elevate the consideration of TDM strategies to make better use of existing infrastructure (R Gotla, Transportation demand management planner, Washington State Department of Transportation, pers comm, 20 December 2018).

In 2018, PSRC reviewed TDM funding sources for the region's cities, TMAs and public transport agencies based on a limited definition of TDM strategies (education, incentives, products and programmes) (Moore 2018). Seattle reported that 22% of its TDM funding came from federal Congestion Mitigation and Air Quality (CMAQ) funds, 27% came from the state as CTR funding, and 51% came from general funds. Seattle's TMA Commute Seattle received 6% of funding from CMAQ, 25% from WSDOT through CTR and other mobility grants, 42% from public partnerships and a further 27% from private partnerships.

Seattle's CTR programme manager noted that having dedicated state funding through the CTR programme afforded reliability of funding and flexibility of application compared to federal CMAQ funding (Spicer 2018). Regionally, there has been discussion of TDM strategies being funded at 1% of every project. Alternatively, a dedicated pool of money could be set aside from which projects could compete for funding – like the existing budget for walking/cycling projects. The 1% allocation would be a greater

overall pot of money but there are concerns that TDM funding would get subsumed into overall project costs (M. Moore, Puget Sound Regional Council, pers comm, 2018).

7.4 Overall approach to TDM

As noted above, TDM in Seattle is an integrated approach encompassing land use planning, employer engagement programmes and public transport investment. It is also underpinned by specific legislation that requires TDM strategies to be identified in planning documents and mode share targets to be set. This section will review key strategies that Seattle has undertaken to manage travel demand. Strategies are organised into four major categories defined by Litman (2014).

- improve transport options
- financial incentives
- land use planning and development
- outreach and implementation programmes.

7.5 Improve transport options

Investment in public transport has been a critical part of Seattle's strategy to achieve mode shift. Investment and promotion of active modes and rideshare (carpool) services, as well as managing travel flows in the city centre during major construction projects are also key.

7.5.1 Public transport

One of the key factors supporting TDM in Seattle is public transport investment. Voter backed measures (such as the Seattle Transit Benefit District ballots, Sound Transit 1, 2 and 3) have enabled the city to fund frequency and reliability improvements across public transport modes with bus improvements key to this. Seattle used funding from a sales tax and city vehicle registration fee to subsidise bus routes that were in danger of either removal or reduction of service. As of 2016, the fund administrators claim to have added 270,000 annual service hours, saved five routes from removal, and increased frequency on at least 38 routes, among other service improvements.

Bus patronage increased from 87.5 million trips in 2010 to 102.3 million trips in 2015. In 2015, an estimated 25% of residents lived within a 10-minute walk of a frequent service and this jumped to 64% in 2017. Sound Transit 3 recently approved $154 billion to expand the light rail system by adding 37 stations to the 41 already built or planned. To gauge expected impact on ridership, when three additional light rail stations were opened in 2016, ridership increased by 75%. Investment in robust alternatives to commuting by car have played an important role in supporting outreach efforts to achieve TDM goals.

This rapid increase in public transport patronage also poses a challenge for the city as they struggle to find enough bus drivers to meet service demands, similar to some of the current challenges facing Auckland and Wellington.

Establishing coordinated public transport fares throughout the region has also been an important strategy to create mode shift. The One Regional Card for All (ORCA) was launched in 2009, combining over 200 fare media. ORCA cards allow users to draw fares from a single account.

The ORCA card also offers two products employers can offer as part of a public transport benefits package to employees. The ORCA 'passport' allows benefits-eligible employees to use the card for public transport, vanpool and guaranteed ride home programmes. This latter programme provides employees

with a direct trip home in the case of an emergency which can encourage people to try public transport by easing anxiety about modal options in the case of a one-off emergency. The retail 'business choice' allows businesses to buy cards at retail cost. The two programmes quickly accounted for over half of ORCA's initial adoption (Shared Use Mobility Center 2017).

King County Metro Transit introduced a flat fare structure in 2018 to simplify a complicated zone-based charge. While this may incentivise higher overall patronage, it has the potential to reduce the incentive for people to save money by shifting travel off-peak.

7.5.2 Cycling and bikeshare

Seattle cycle commuting mode share is 3%, which, although low, still places it 5th out of all US cities. In 2017, cycling hit a 10-year low for commute mode share after remaining fairly constant for a decade. Possible reasons for the drop include the fragmented nature of the cycle network and safety concerns surrounding the large number of construction projects happening in the central city (Balk 2018).

However, the city has demonstrated a commitment to providing bike infrastructure and supporting bike programmes. Planning documents call for the construction of protected bike lanes, the installation of 1,500 new bike parking spaces, and the promotion of cycling commute programmes for employees. Seattle has also created an interactive bike map which helps people plan their trip and understand how the cycling network in the city can help connect them to employment, education, and other services.

Seattle introduced a city bike share programme 'Pronto' in 2014 with 54 stations and 500 bikes, but the programme was discontinued in 2017 due to low levels of ridership and revenue. They are currently piloting a dockless bike scheme with permits being reviewed for three main operators: Jump, Lime and Lyft. The pilot included 10,000 bikes but results showed there was excess demand and they plan to extend the fleet to 20,000. Evaluation of the pilot showed that bike parking was the biggest challenge and there are plans to increase supply and educate the public on how to park (Clark 2018).

7.5.3 Rideshare

The Seattle region has a long history of rideshare programmes and these continue to expand. Central Puget Sound boasts the largest vanpool programme in the nation with more than 2,200 public vans in operation every weekday (Puget Sound Regional Council 2017). This is supplemented with preferential treatment for vanpools and carpools on ferries. King County offers a variety of vanpool options from fixed monthly pass commute services, to first-mile last-mile connections to public transport. King County Metro is currently trialling TripPool a flexible van pool service that connects people to local park and ride facilities. The service incentivises users by providing partial subsidies above $2.75 (one-zone peak) public transport charges, and full subsidies for ORCA monthly pass holders.

The region's ride-matching system, which helps people form and maintain carpools and vanpools, has been expanded to serve the entire state (Puget Sound Regional Council 2009). 'RideshareOnline' is a state-wide database of people seeking to carpool or vanpool. It also offers matching services for people seeking to bike to work together and matching services for special events.

A longitudinal study of travel behaviour in the Puget Sound Region showed that the availability of HOV lanes are one of the factors contributing to people's willingness to carpool or vanpool (Wang and Chen 2012). In the Seattle region, the HOV system consists of a network of special-use highway lanes which connect major population and employment centres.

Three of the region's public transport agencies are working on programmes to leverage ride-hailing services Uber and Lyft to provide enhanced mobility options to their customers. These partnerships are

focused on solutions for first-mile last-mile connections, managing demand at park and ride lots, and providing guaranteed ride home services when fixed-route services are unavailable at certain times.

7.5.4 One Center City Action Plan

The One Center City Near-Term Action Plan is a US$30 million investment in projects and programmes that manage travel demand for goods and people through the central city during the current period of construction and growth (One Center City 2018). Key strategies include investment in public transport, hot spot signal improvements, pedestrian and cycling improvements and an expansion of TDM programmes and marketing. The specific TDM programming is funded at 10% of the overall budget (US$3.4 million) and includes expanded access to public transport passes, commute trip planning tools, shared mobility hubs and support for an open marketplace for mobility solutions.

7.6 Land use planning and development

Incorporating demand management principles into land use planning including the provision of park and ride facilities has been an important part of Seattle's success in reducing drive alone rates.

7.6.1 Seattle's comprehensive plan

The Washington State Growth Management Act (discussed in section 7.3.3), required Seattle to develop a comprehensive plan incorporating specific TDM strategies. An evaluation of Seattle's 20-year comprehensive plan in 2014 showed that their strategy to accommodate growth within walkable, affordable, mixed-use areas known as 'urban villages' had been successful in capturing 75% of housing and 80% of job growth. In addition, public transport networks vastly improved and eight of the 10 villages saw a significant rise in people taking public transport on weekdays.

7.6.2 Major institution master plans

Applying TDM requirements for major new employment sites is also seen as an important tool where the city can have a big influence on drive alone rates. Seattle requires major institution master plans (MIMPs) for 13 of the city's largest colleges, universities and hospitals which include sections on reducing employee drive alone rates and mitigating their impact on street parking around the institution. The Children's Hospital 2010 MIMP to manage a planned expansion is seen as a major TDM success story for the city. Previously, through participation in the wider state commute trip reduction programme, discussed further below, the hospital had already reduced its employee drive alone rate from 72% in 1995 to 40% in 2010. The 2010 MIMP aimed to reduce this to 30% by 2030 through strict parking pricing policies and incentives, free public transport passes, and investment in active modes. Between 2010 and 2015, they managed to reduce the drive alone rate to 37.4% for their 6,000 employees.

When the Gates Foundation sought approval for a new headquarters in 2008, Seattle required paid parking for the 1,200 employees and other efforts to reduce drive alone rates as part of their MIMP. Before the move, 90% of employees drove alone. When the new facility opened in 2011 the drive alone rate reduced to 42% and has continued to drop since then. The city sees paid parking as a first step for employers to reduce drive alone rates, while the revenue can also help fund incentives for their broader commuter programme. Charging daily parking rates rather than a monthly fee so that people can factor in the incremental cost to their commute decisions is also seen as critical for behaviour change.

7.6.3 Park and ride

In 2016, 30 park and rides in the Puget Sound region provided almost 20,000 parking spaces with occupancy rates over 97% (Puget Sound Regional Council 2017). There are concerns that this excess demand creates overcrowding on trains and buses, affects travel times and excludes people who do not have flexibility in their time of travel from accessing the public transport system.

Public transport authorities are implementing strategies to better manage parking capacity by providing reserved parking for customers that carpool to park and rides and working with vanpool groups to consider relocating to locations with available parking capacity. The region has recently made changes to legislation to introduce pricing to park and rides to manage demand. To address equity concerns, they are exploring lower rates for people who qualify for the ORCA lift card, which is available for low income earners.

7.6.4 Parking policies

Historically, Seattle has taken several steps to reduce parking requirements for new developments, particularly those located in areas served by frequent public transport. In 2018, the city council approved a range of new parking policies to support overall goals of reducing parking and discouraging driving. These included: expanding the number of areas that fall under the definition of frequent public transport service; allowing underutilised private parking lots to be used by the public; and 'unbundle' parking fees from rental leases (Fesler 2018). The parking reforms also include a raft of changes to cycling policies to support reduced driving, including cycle parking requirements for residential and commercial properties and at new light rail stations.

Parking is also a critical strategy for employer programmes that target a reduction in the provision of parking spaces and price all remaining spaces with exemptions for rideshare vehicles.

7.7 Financial incentives

Seattle has implemented a number of financial incentives to reduce car trips including paid on-street parking and road pricing.

7.7.1 Tolls and congestion pricing

Seattle implemented a high occupancy toll in 2015 on two corridors with the primary goal of funding corridor improvements as well as enabling faster and more predictable trips. These use variable pricing with rates adjusting every few minutes based on real-time traffic conditions. The express toll lanes flow an average of 14 to 25 miles per hour faster than the regular lanes during the peak commute. However, not all the lanes are meeting performance benchmarks and there are public perception and equity concerns about allowing variable rates to go above the existing $10 cap to improve performance (Giordano 2017).

In the 2019/2020 budget, the City of Seattle included $1 million to conduct the second phase of work on investigating congestion pricing (Lloyd 2018). If Seattle did introduce congestion pricing, it would be the first city in the US to do so. Mode shift is a major goal for a congestion pricing policy to meet climate change goals, and generated revenue would be directed towards public and active transport. Another impetus for considering a congestion charge is to mitigate the impact of the opening of the tunnel on State Highway 99 that replaced the Alaskan Way Viaduct. The tunnel will be tolled to pay for the construction and there are concerns that this will move traffic to surface streets to avoid payment.

7.7.2 Parking pricing

SDOT manages paid parking for approximately 12,000 spaces across Seattle, and in 2015 installed meters that allow time of day pricing to better manage demand. Pricing is changed annually to aim for occupancy targets of 70% to 85% (Seattle Department of Transportation 2018). The goal of this variable pricing is to reduce congestion, noise and pollution by helping motorists find parking more easily.

7.8 Outreach and implementation programmes

Seattle's key implementation programme is underpinned by the state-wide CTR legislation which has helped to create a robust framework for TDM strategies both in the city and state-wide.

7.8.1 Commute trip reduction programme

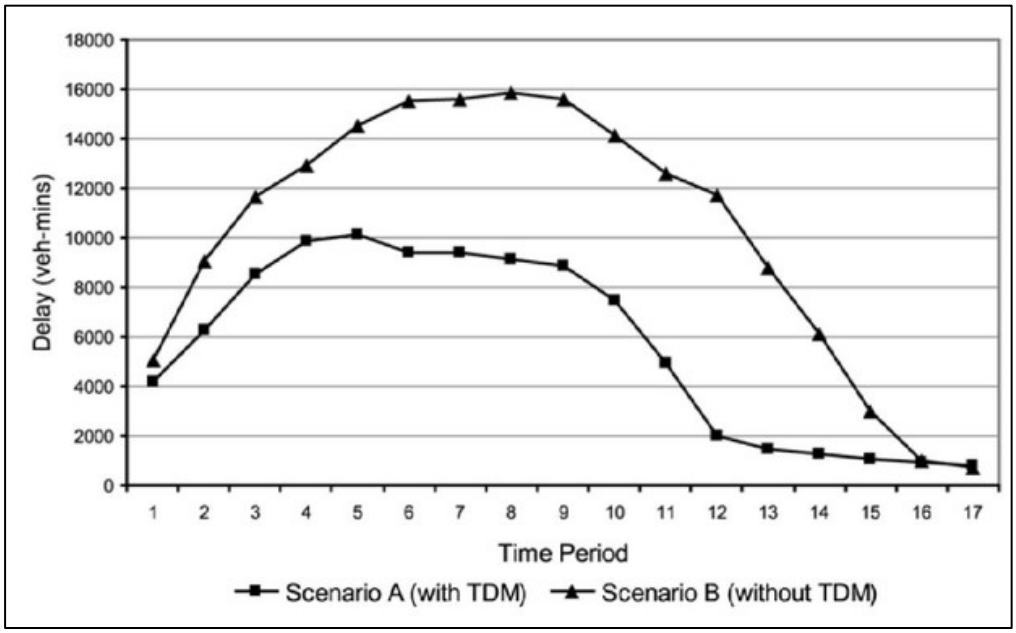
Seattle's CTR programme forms a central part of their TDM strategy, creating a framework to establish relationships with employers, engage in regional coordination and innovate with new outreach strategies. Under the programme, CTR affected employers are required to establish an 'employee transport coordinator' and identify targets to reduce drive alone rates through application of a combination of suggested interventions related to parking pricing and reduction, public transport subsidies, flexible schedules and telework, and bike facilities.

A biennial survey is administered by the state to measure success. In Seattle, much of the CTR programme delivery and coordination is undertaken by the city's TMA, Commute Seattle, which is led by a partnership between the Downtown Seattle Association, King County Metro, Sound Transit and the Seattle Department of Transportation.

Statewide, over 1,000 worksites and over 530,000 people participate in the CTR programme. Since 2007, the programme has reduced vehicle miles traveled by an estimated 154 million miles and prevented 69,000 metric tonnes of greenhouse gases being released annually. One of the reasons for the success of the CTR programme is seen as employer buy-in: TDM strategies are viewed as a way to attract and retain employees. Moreover, the relationships built with employers through this programme, along with TMAs, are important for achieving TDM goals.

A 2007 study looked at the impacts of employer-based TDM programmes (CTR) on travel times on interstate I-5 corridor (Georggi et al 2007). By comparing CTR programmes of 189 employers against traffic conditions that would have existed without these plans, the study authors report savings in terms of congestion, travel delay (see figure 7.2), vehicle speed, fuel use and carbon emissions. The authors note that because of the dispersed nature of employer-based programmes, estimating the impacts on the system can be challenging.

Figure 7.2 CTR impact on travel times on the I-5 corridor (Source: Georggi et al 2007))



While having TDM embedded in legislation is seen as a positive point of difference for the state, it can also mean a lack of flexibility in identifying location specific goals and interventions. To improve this, Seattle was allowed to implement an 'alternate CTR plan' in 2012 which set area specific targets, rather than citywide, and tailored strategies to geographic needs and travel options. Setting network goals establishes a metric more closely associated with what can reasonably be achieved with available transportation infrastructure and services.

Seattle's CTR programme manager noted that one strategy which has had limited success is the attempt to establish a CTR type programme with residential building managers in the city through the NavSeattle programme. SDOT found that it was hard to establish the necessary relationships to implement the programme successfully due to high turnover of both residents and building managers. TDM strategies such as public transport subsidies, investment in active modes and parking policies were much harder to apply in a residential setting. The programme was found to be more successful with government-owned and managed buildings as it was easier to establish the necessary relationships with a more stable building management structure.

Recent strategies focus on extending the CTR and broader TDM efforts to smaller businesses and to encompass all trips. The PSRC estimates that 80% of trips in the Puget Sound area are non-work related and extending demand management principles to this broader range of travel could have a much greater impact.

In addition to the core programme, the state CTR board has established a $250,000 pilot grant programme to test new approaches to trip reduction. The two projects selected focus on extending CTR to populations not targeted by traditional TDM approaches such as small and medium businesses and the Seattle-Tacoma International Airport (SeaTac) employees who work off-peak hours or are employed by smaller employers. Results of these programmes are anticipated in 2019.

7.9 Key insights

Key state legislation provides an important framework. The early 1990s Growth Management Act and the Commute Trip Reduction Law underpin TDM implementation and provide an important vehicle for strategic coordination and information sharing. Benefits of the legislative framework include reliable funding and the requirement to set specific goals. Drawbacks include a lack of flexibility in rightsizing both interventions and data collection, which can be burdensome to smaller jurisdictions.

CTR employer programmes are an important tool to achieve state and city mode share goals. For an annual state-wide investment of $3 million matched 20:1 by employers, an estimated 154 million miles of travel have been avoided since 2007. However, the dispersed nature of these programmes can mean it is difficult to measure system impact. Local implementers note that the relationships established through the CTR framework are critical to success and enabling the trial of new strategies. TMAs provide an important coordination role, supporting employers to reduce drive alone rates through public transport subsidies, parking restrictions, promotion of rideshare and active modes, among other incentives.

Commuter trip reduction plans work in specific contexts. Seattle has reduced its drive alone rate for CTR affected employers to just 25%. For major institutions such as Seattle's Children's Hospital, participation in the CTR programme along with changes implemented under their major institution master plans have had a major impact on mode shift. However, some initiatives to engage non-commuter populations have not been as successful. Attempts to develop a CTR type programme with residential building managers were challenging because of high resident turn over and difficulty in establishing the strong relationships with building managers that have been so critical to the successful implementation of CTR employer programmes.

Public transport investment is important. This has played a major role in Seattle's TDM success. Voter backed ballots have funded improved service and frequencies across modes. Buses are a big success story with rising patronage in contrast to most other US cities. Commute mode share for public transport is 48% in Seattle. Integrated fares through the ORCA card and employer-specific products such as the 'ORCA passport' provide an important tool for employers to reduce drive alone rates.

Moving beyond commuters is the future. To expand the reach of TDM efforts, the new focus for implementers is on non-commute trips. Planners estimate that 80% of trips in the Puget Sound Region are non-work based and managing demand for these trips can have a major impact on system performance and environmental goals.

8 Singapore case study

8.1 Introduction

Singapore is regarded as a world leading city in implementing TDM policies. It was the first city to implement a congestion charge in 1975, and the first to implement a vehicle quota system in 1990. Managing transport demand has been a core policy pursuit throughout Singapore's history, and major transport and land use policies have consistently been oriented around Singapore's TDM goals.

8.2 City snapshot

Singapore is a 709km^2 island city-state off southern Malaysia (Index Mundi 2017). From 1970 to 2010, the urban area increased from 32% to 52% of the area of the island (Barter and Dotson 2013). The Atlas of Urban Expansion estimates the 2013 urban extent of Singapore at 420 km^2. For comparison, it estimates Auckland's 2014 urban extent at 488 km^2. It estimates Singapore's built-up area density at 186 people per hectare. Using slightly different methodologies, various sources estimate Auckland's 2013 built-up area density and population-weighted density at 38–43 people per hectare, respectively (Atlas of Urban Expansion 2019).

Since gaining independence in 1965, Singapore has experienced rapid economic and population growth. From 1965 to 2010, its GDP per capita grew from the equivalent of about NZ$760 to about NZ$94,000. Meanwhile, its population increased from 1.87 million to 5.84 million over the same period (Worldometres 2019). For comparison, Auckland's GDP per capita was NZ$58,717 in 2016, while Wellington's was NZ$67,888 (Statistics NZ 2017). In 2013, Singapore's richest 10% of residents accounted for 44% of national income, compared with 33% in New Zealand in 2014 (World Inequality Database 2014).

Singapore's government operates under an authoritarian structure and has a single-level governance structure as both a city and a state. This structure has likely made implementing aggressive and innovative, and cohesive TDM policies more feasible. Because of its governance context, Singapore is often regarded as a 'special case' for transport and land use policy, though researchers believe it can offer several lessons for cities with different governance structures (Barter and Dotson 2013).

Singapore has relatively low mode share for private vehicles. In 2016, cars accounted for about 27% of all trips, with 22% by bus, 18% by its mass rapid transit (MRT) metro system or light rail, and 17% by active modes (LTA 2018).

The foundation for its current modal split comes from aggressive policies that began in the 1970s and 1980s to restrict car ownership and use. These policies have been adjusted over time but remain critical to shaping transport behaviour today. Consistent public transport-oriented land use development and more recent public transport infrastructure investment have also contributed to Singapore's modal split.

8.3 Governance framework

Researchers indicate that Singapore operates under an authoritarian structure, though the government is still somewhat responsive to public opinion (Barter 2013). Still, it has been more willing to implement car restriction policies, which have generally been relatively unpopular among the public, than other city and national governments worldwide.

Singapore's master planning originates from 'concept plans', which are reviewed every five years. They are translated into statutory land use and transport master plans (LTMPs) that shape Singapore's strategic, long-range vision. Singapore's TDM goals stem from its first concept plan in 1971, which planned for a compact urban form with high-density corridors and a strong central business district (CBD) (Barter and Dotson 2013). It prioritised integrated land use and transport planning, managing private car use, providing an efficient public transport system, and increasing road capacity as far as practicable (Olszewski 2007). Development of an efficient public transport system progressed slowly. Otherwise, though, Singapore has consistently pursued the original concept plan's priorities until today, with small shifts in policy focus relative to other cities.

The government has consistently stressed that car restriction policies are necessary due to limited land availability and limited ability to expand the road network. Singapore's status as an island state limits its ability for expansion. As a city and country, it must also accommodate national needs that are typically located outside urban areas, such as reservoirs or military training grounds (Tan 2018). Limited ability to expand the road network and urban extent remains a central argument used by the government to justify car restriction policies.

Singapore's structure as a city state means it does not face the same policy conflicts between multiple levels of governance. However, it still requires coordination among various government agencies. As described by Barter and Dotson (2013):

> *While overall the strategic spatial planning and transport policy directives for Singapore are integrated, this has been largely achieved without the administrative and legal integration of institutions and governance of land use and transport. Instead, inter-agency committees ensure the integration of planning and implementation. This is contrary to a view that is often advocated that integrated plans can only flow from integrated institutions.*

8.3.1 Transport bodies

Singapore's transport planning is tightly concentrated in the Land Transport Authority (LTA), established in 1995. As described by Barter and Dotson (2013), the LTA 'is responsible for planning, policy and regulation of all urban (or land) transport modes', making Singapore 'one of the pioneers of integrating so many urban transport responsibilities within one organization'. The LTA constructs and maintains roads and public transport infrastructure and is included in creating the concept plans (Barter and Dotson 2013).

The LTA closely coordinates policy with the Urban Redevelopment Authority, which directs national land use planning and leads concept plan preparation (Barter and Dotson 2013).

8.3.2 TDM responsibility

TDM in Singapore is not implemented through a stand-alone department or government body. Rather it is incorporated throughout transport and land use policy.

Singapore's key motivation to manage travel demand has been to optimise vehicle traffic flow at busy times in support of efficient commerce and trade. This varies from other cities that may use TDM to pursue health, environmental or liveability goals. Transport and land use planning has consistently been oriented around these TDM goals. Singapore's approach to TDM is thus wide ranging and not limited to individual government programmes or agencies.

Several policies limit car ownership in Singapore. These include substantial taxes, fees, and duties on car purchases. In 1989, the government implemented a vehicle quota system to more tightly restrict vehicle

growth, which is still in use today. These policies have significantly limited current and historic car ownership growth, despite residents' rising affluence.

Raising car ownership costs in the early 1970s did not sufficiently accomplish the government's goal to maintain efficient levels of congestion. In 1974, Singapore thus implemented a congestion pricing scheme, which was transitioned to an electronic scheme in 1998. Reflecting its desire to promote efficient car movement, a key measure by which Singapore measures the system's success is vehicle speeds within the congestion pricing restricted area. Road prices are adjusted quarterly to promote speeds that maximise vehicle throughput. This speed is lower than free-flowing traffic. Despite the common perception, the congestion pricing scheme is thus not used to create congestion-free roads (P Barter, pers comm, 15 April 2019). The scheme's coverage area has been consistently expanded. It remains critical to Singapore's TDM today.

8.3.2.1 Differing TDM goals lead to differing TDM policies

Since Singapore's motivation for TDM is largely to promote efficient car vehicle movements, its TDM policies have historically focused less on outcomes for non-car owners. For example, Singapore has historically not used car restriction measures to promote walkability or liveability. It has generally prioritised road infrastructure over other possible uses, including pedestrian or cycling infrastructure. According to Barter and Dotson (2013), 'the arterial roads by their design, scale and land-take are wide and not integrated with the surrounding areas, but instead act as barriers to pedestrian movement'. They argue that Singapore's limited TDM goals have reflected 'an overly narrow conception of the payoffs to be gained from containing cars'.

Further, unlike many other cities, Singapore's significant public transport investment came well after car restriction policies. The first line of its MRT system did not launch until 1987, and the government has been unwilling to provide consistent subsidies for bus services.

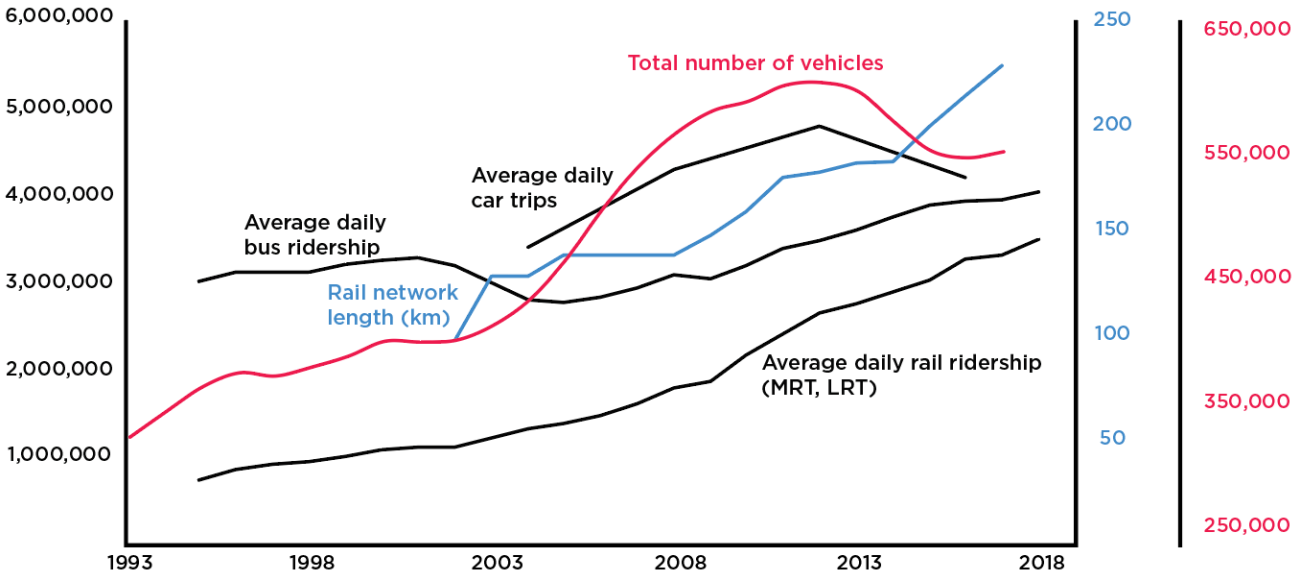
Singapore's parking policies, too, have reflected the city-state's desire to favour efficient car trips over pedestrian space. According to Barter (2011), Singapore has been 'surprisingly persistent in using minimum parking requirements, despite [its] wider traffic constraint policies'.

8.3.3 Recent trends

In the early 2000s, Singapore relaxed policies restricting car ownership, choosing instead to rely on congestion pricing to limit traffic in busy areas. This shift contributed to a dramatic rise in the number of trips by car and the total number of cars owned, and relatively flat public transport ridership for much of the 2000s.

In 2008/2009, the government reversed course and significantly tightened existing policies constraining car growth. It also began a period of heavy investment in its rail network and took more drastic steps to improve bus routes and services. Since 2009, public transport ridership has risen rapidly, car population growth has halted, and the number of daily trips by private vehicle declined by about 600,000, or 12.5%, between 2012 and 2016, as shown in figure 8.1. This represented the first decline since 1997. It should be noted that average daily taxi and ride-hailing trips rose by 200,000 during this period. Total travel demand rose from 14.7 million trips to 15.4 million trips over this time (Cheng 2018).

Figure 8.1 Transport network and patronage trends (data from LTA 1993-2018)



This recent progression may reflect an evolution in Singapore's TDM goals. Over the past decade, the LTA has put increasing focus on pedestrian, cycling, and rail infrastructure, and on improving bus services. These investments reflect the government's efforts to make living without a car a first-class option. In recent years, there have also been some indications that Singapore may be slowing its road investments, which have otherwise continued steadily since the 1970s, and it recently reduced parking minimums in several areas (Channel News Asia 2018).

Singapore's 2013 Land Transport Masterplan (LTMP), and preliminary planning for its forthcoming LTMP 2040, do not mention the term 'travel demand management'. Rather, they focus on infrastructure investments to improve mobility options for non-car travellers, with the goal that 80% of homes will be within a 10-minute walk of a train station by 2030 (Land Transport Authority 2013).

8.3.4 Funding model

Singapore's transport policies, described in detail in the following sections, are a significant source of government revenue. In the 2015 fiscal year, the government collected the following revenues:

- SG$399 million (NZ $443 million) from motor vehicle excise duties
- SG$920 million (NZ $1.02 billion) from additional registration fees
- SG$693 million (NZ $770 million) in road taxes
- SG$129 million (NZ $143 million) in special tax on heavy oil engines
- SG$150 million (NZ $167 million) from electronic road pricing (the congestion pricing scheme) (Ong 2018).

These revenues total SG$2.3 billion (NZ$2.5 billion) (Singapore Budget 2017).

In fiscal year 2017/2018, the LTA's operating budget was SG$3.8 billion (NZ$4.2 billion) (Land Transport Authority 2018).

8.4 Overall approach to TDM

Sections 8.5 to 8.8 review key strategies that Singapore has undertaken to manage travel demand. Strategies are organised into four major categories defined by Litman (2014):

- financial incentives
- improve transport options
- land use planning and development
- outreach and implementation programmes.

8.5 Financial incentives

Singapore has used three main types of policies to restrict car ownership and use:

1. Road taxes, vehicle fees, and private vehicle import duties
2. Area licensing scheme (ALS), a congestion pricing tool, which was transitioned in 1995 to the electronic road pricing (ERP) system
3. Vehicle quota system (VQS).

8.5.1 Taxes, fees, duties, and the vehicle quota system

Singapore has relied on several taxes, fees and duties to increase the cost of car ownership as part of its TDM goals. These include:

- import duties – also called excise duty
- a one-time registration fee
- an additional registration fee (ARF) based on the vehicle's open market value (OMV)
- a preferential additional registration fee scheme, which provided ARF rebates on a new car if the buyer de-registered their old car before it was 10 years old
- an annual road tax.

Broadly, taxes, fees and duties were increased to make car ownership more expensive in the 1960s, 1970s and 1980s. In 1983, for example, the ARF reached 175% of the vehicles' OMV (Poon 2016).

8.5.2 Vehicle quota system

Though taxes, fees and duties limited the rate of car ownership growth, car ownership still grew consistently throughout the 1970s and 1980s. This reflected Singapore's rising affluence; per capita income rose 3.4 times between 1975 and 1989 (Poon 2016). The government thus concluded that stronger tools were needed to suppress car ownership growth.

The VQS was introduced in 1989. It sets a fixed number of certificates of entitlement (COE), which are required to purchase a vehicle and are auctioned to the highest bidders twice per month. Though included in this document in the current financial incentives section, the VQS' most important feature is capping the number of new cars. As described by Poon (2016), it provided the government with an 'effective policy instrument to have absolute control over the growth of vehicle population'. It remains the key determinant of car numbers today. The VQS has also furthered increased car prices. Along with

taxes, fees and duties, the COE premium increased the cost of a medium sized car to six times the OMV in 1997 (Olszewski 2007).

The quota was set to allow 3% vehicle growth for most of the 1990s and 2000s. In effect, however, the quota varied from year to year, as COEs from older vehicles (that were deregistered) were also added to the pool of available COEs. The quota has been reduced gradually since 2008 to 0.5% growth and then to no growth in recent years (Poon 2016).

Since the VQS allowed for tighter management of vehicle growth, it allowed the government to rely less on taxes, fees and duties to suppress car ownership growth (Poon 2016). The ARF, in particular, has been gradually reduced since the VQS's introduction.

The extreme cost of car ownership raised the public's concern that car restriction policies were unfair and unequitable. In response, Singapore introduced the Off-Peak Car scheme in 1991 (originally called the 'Weekend Car Scheme'). The scheme allowed for more widespread car ownership without contributing to peak congestion, by reducing car fees and taxes for cars permitted to only during off-peak hours: mostly on weekends, public holidays and at night (National Library Board 2016).

Singapore has implemented several other measures to reduce the inequalities borne from car restriction policies. For example, cars with an OMV higher than SG$20,000 (NZ$22,200) pay a higher ARF fee.

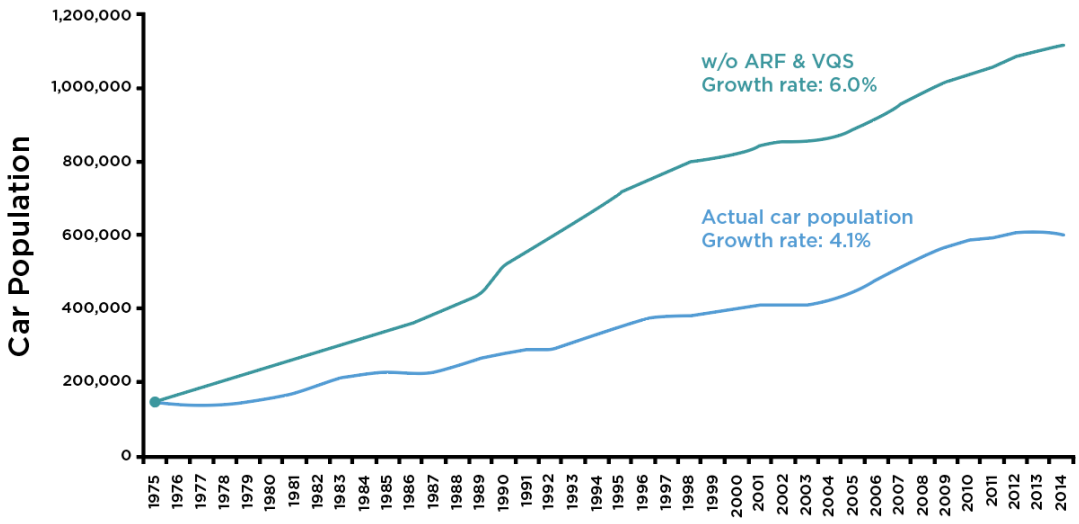
The high cost of car ownership and relatively low ownership rates has led to substantial taxi use. Taxis provide an important transport role for the people who cannot afford private vehicles due to their high cost, but have enough money to regularly use taxis instead of public transport (Barter, pers comm 15 April 2019). In 2014, taxis accounted for about one million trips per day, and the number of taxis per million people was about triple the rate for New York City (Agarwal et al 2016).

8.5.3 Effect of taxes, fees, duties and the VQS

According to several researchers, these taxes, fees and duties were effective in substantially reducing the growth in vehicle ownership, which was further restrained by the VQS after its introduction in 1989. From 1973 to 1982, vehicle growth increased 35%, well below the 100% to 150% projected by the OECD (Olszewski 2007).

As shown in figure 8.2, Poon (2016) estimates vehicle growth rate would have been significantly higher without the ARF and VQS, based on population growth and per capita ownership rates in comparable cities.

Figure 8.2 Impact of the additional registration fee (ARF) and vehicle quota system (VQS) policies on car ownership (Poon 2016)



As can be seen in figure 8.2, policy adjustments limited, but did not halt, car growth. Further, these tools did not prevent congestion growth, as described by Poon (2016):

> *The high upfront taxes turned out to be a blunt restraint measure that had limited impact on congestion in local areas. Addressing neither temporal nor geographical dimensions of travel demands, they could not ensure the optimal utilisation of our roads.*

Barter (2018) notes that increasing the cost of cars may also create the perverse effect of elevating their status in society. The high upfront cost can encourage car-owners to drive more, having already made a large investment. He observes that Singapore's VKT per car is relatively high given its modal split (P Barter, pers comm, 15 April 2019).

8.5.4 Area licensing scheme and electronic road pricing

The area licensing scheme, established in 1974, represented the world's first congestion pricing system (Olszewski 2007). The scheme initially spanned about 725 hectares (roughly 1% of Singapore's total area) and was focused on its CBD. Its coverage area was consistently expanded in subsequent decades and prices were increased. The system was transitioned to an electronic system, called electronic road pricing (ERP) in 1995 (Poon 2016). It remains a key determinant of travel demand today.

The system provided a straight-forward, flexible means for managing travel demand. As described by Olszewski (2007), 'the pricing levels were set and adjusted experimentally, not based on theoretical models'. The congestion pricing scheme was eventually extended to the expressways, and to weekends and nights.

ERP rates are adjusted to achieve the following average traffic speeds:

- 45 to 65 km/h for expressways.
- 20 to 30 km/h for arterial roads and roads within the restricted zone.

These speeds were determined by the Nanyang Technological University in a study on local traffic characteristics in 1995 and were considered to allow the highest number of vehicles without exceeding road capacity. This does not correspond to free-flowing traffic. ERP rates can vary between time periods as short as 30 minutes.

8.5.5 Effects of ERP

Though Singapore does not have exceptionally low city-wide congestion (it ranks 55th of 189 large cities on the TomTom Traffic Index) its congestion pricing scheme appears to be an effective mechanism to manage traffic in restricted areas.

Traffic congestion has been quite sensitive to congestion pricing adjustments (Olszewski 2007). Several metrics highlight its effect:

- In the three months after the ALS's implementation, traffic into the restricted zone decreased by 44%.
- The number of vehicles entering the restricted area during the morning peak was nearly 38% lower in 1991 than before the ALS's introduction in 1975, despite the country-wide number of vehicles doubling in that time.
- Applying the ALS to evening peak also had measurable impacts. After implementation, speeds in the restricted zone increased from 9% to 15% between 6 pm and 8 pm (Poon 2016).

Congestion pricing may also allow the government to more openly embrace mobility innovations. For example, its approach to the emergence of ride-hailing has been relatively relaxed, as road pricing allows the city to manage potential congestion increases that could accompany increased ride-hailing (P Barter, pers comm, 15 April 2019). The system may also prepare Singapore well to manage the rise of autonomous cars, if it occurs. As such, the LTA has been supporting development and testing of automated vehicle technology in four organisations (Land Transport Authority 2018).

The government is expected to roll-out an updated congestion charging system in 2020 that uses GPS technology. This will make the system significantly more flexible, including enabling the government to more easily price more roads throughout the Island. The system is expected to cost the government the equivalent of approximately NZ $610 million to roll out (Yu 2016).

8.5.6 Fare discounts for early travel

Transport providers in Singapore have used fare discounts to incentivise off-peak MRT use and mitigate overcrowding. The first initiative was launched by SMRT, a public transport service provider that manages and operates several MRT lines. It began offering SG$0.10 fare discounts for commuters exiting nine city area stations before 7.30 am, Monday through Saturday. It also included discount breakfast offers through partner companies.

The early travel discount scheme was tripled to SG$0.30 cents in 2011, and the eligible period was lengthened by 15 minutes. It was raised to SG$0.50 in 2012 and expanded to additional stations. About 3% to 4% of commuters were observed to shift their travel out of the morning peak period following the scheme change (Poon 2016).

LTA expanded the coverage, discount and time period of the early travel discount scheme in 2013. It began a one-year trial offering free travel on the rail network for commuters ending in the city area before the morning peak period. The trial found a 9% decrease in commuters existing city stations from 8 am to 9 am, and a 7% shift to other periods (Poon 2016).

8.6 Improve transport options

Despite having aggressive car restriction policies, Singapore has only established a world-class public transport network in the past 10-15 years.

Buses have accounted for more riders than rail throughout Singapore's history, and continue to do so (although the gap has shrunk significantly in the past decade). However, buses have received significantly lower investment than might be expected. P Barter, pers comm, 15 April 2019 describes that for much of Singapore's history, including after car restriction policies were launched in the 1970s, the bus system was relatively neglected by the government.

This reflects several abnormal features of Singapore's bus system. First, despite heavy government involvement in the transport system, bus planning and operations have been largely privatised. Only in the past decade has the LTA taken a more active, though still indirect, role in planning bus routes. This has led to a network that Barter describes as 'tangled' with some redundant services.

Second, surprisingly, Singapore's Government has historically not subsidised bus operations. This has led to significantly lower frequencies than might be expected. However, services have been improving in the past decade. In 2013, a minimum of 80% of bus services ran every 10 minutes or less during weekday peak hours, compared to every 15 minutes in 2008 (Land Transport Authority 2013). The 2012-2017 Bus Service Enhancement Programme further introduced or amended 80 bus services and funded the purchase of an additional 1,000 buses. The LTA also took over public bus operations in 2016, which may lead to further improvements in future years.

Singapore's increased focus on public transport investment in the past 10 years may reflect evolving TDM goals. TDM in Singapore has historically been principally focused on maximising vehicle throughput. This has created a public perception that car ownership could be allowed to rise if congestion could be managed. In the late 1990s and early 2000s, policies to restrain car ownership were relaxed. This led to a rapid increase in the number of cars and worsened congestion. Between 1997 and 2004, the number of cars grew 10% and the number of car trips grew by 23%. It also reduced sustainable modal share during congested periods: morning peak trips by public transport dropped from 67% in 1997 to 63% in 2004 and 59% in 2008 (Land Transport Authority 2013).

Government statements and actions in the past decade suggest TDM goals may need to be broadened. For example, the 2008 LTMP included the following statement:

> *Moreover, simply building more roads will not solve our transport problems in a sustainable way because the demand for road space is insatiable. The more roads we build, the more traffic will be generated. Hence, the projected increase in travel demand must be met largely by public transport rather than by the car…*

The LTA's goals have shifted to making public transport a premium option. Singapore has invested heavily in rail infrastructure in the past decade. From 2008 to 2013, the length of the rail network increased from 138 km to 178 km. New MRT lines have been opened nearly every year since 2013, and more remain under construction. Its MRT network is now roughly 200 km, about 15% smaller than Hong Kong's (Land Transport Authority 2019) (Transport and Housing Bureau, Hong Kong 2018). Its primary LTMP goals are now oriented toward journey times and public transport access. They include the goals that by 2030 (Land Transport Authority 2013):

- 8 in 10 households will be within a 10-minute walk of a train station
- 85% of public transport journeys less than 20 km will be completed within 60 minutes
- 75% of journeys in peak hours will be undertaken on public transport.

Its recent focus also includes significant investments in walking and cycling infrastructure. It should be noted that Singapore's high temperature and humidity levels can act as a barrier to walking and cycling trips.

Singapore has consistently expanded its road network throughout its history. According to the Atlas of Urban Expansion, roads occupied 26 % of expansion areas from 1990-2014, compared to 19% in Auckland and 20% in Sydney over the same time period (Atlas of Urban Expansion 2019).

8.6.1 Embracing transport innovation

Singapore may be one the first cities in the world to implement full-size autonomous buses on its roads. Volvo recently unveiled an autonomous, electric bus designed in collaboration with Singapore's Nanyang Technological University (NTU). It has an 80-person capacity. NTU professor, Subodh, expects it to be trialled in mixed traffic later in 2019 (Toh 2019). Autonomous buses could provide a means for significantly reducing operational costs, which could be used to increase bus frequencies (MRCagney 2017).

Singapore also appears to be embracing mobility as a service (MaaS), as MaaS Global, the company with the most advanced MaaS offering through its Whim app, announced it will begin piloting its app in Singapore in partnership with local transport providers in 2019 (MaaS Global 2018).

8.7 Land use planning and development

Singapore's public transport network has been supported by highly concentrated land use around public transport spines. Tightly integrated transport and land use has been an explicit and consistent goal since the 1970s. The government also owns significant land holdings (enabled by the 1966 Land Acquisition Act), which are strategically sold to support transport and land use goals (Olszewski 2007).

Singapore's planning follows land transport master plans, which integrate land use and transport. According to Barter and Dotson (2013) 'Overall, a high degree of land use/transport integration is being achieved on the ground in Singapore'.

High density development has often been built before rapid transit services in areas where public transport infrastructure is expected. In some cases, development has occurred 10-15 years before rapid transit has been implemented (P Barter, pers comm, 15 April 2019).

Singapore is also able to exert significant influence on land use development because of its heavy involvement in housing development. In 2015, 82% of residents lived in public housing, which are typically made up of dense towers.

8.8 Outreach and implementation programmes

Singapore has been a leader in offering innovative public transport incentive schemes. The schemes aimed to address overcrowding on the MRT system resulting from growing ridership while infrastructure was built to expand capacity. The early travel discount scheme described in section 8.5.6 was one such programme. Other programmes have successfully mixed financial incentives with gamification and social interaction among participants.

8.8.1 Incentives for Singapore's commuters (INSINC) programme

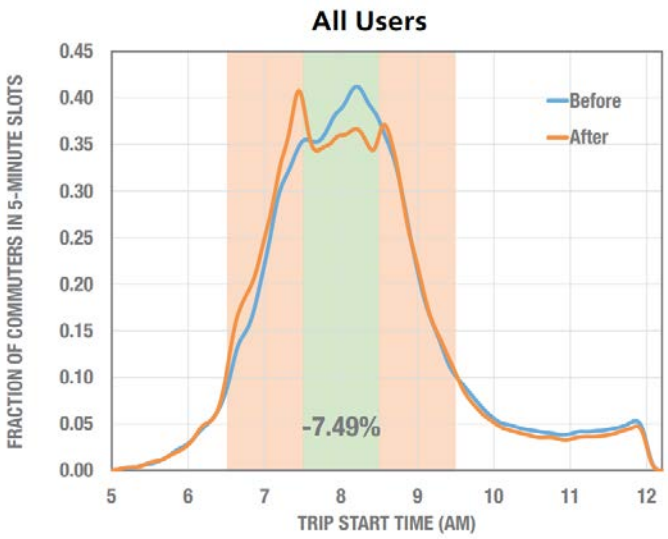
Singapore expanded upon its discounts for early travel in 2012, with a pilot called Incentives for Singapore's Commuters (INSINC). It was started by researchers from Stanford University and the National University of Singapore, with support from LTA.

The INSINC programme also incorporated gamification, whereby participants received credits for MRT trips, with greater rewards for shoulder-peak travel. Credits were automatically tracked with participants' MRT cards. They could be redeemed for small monetary prizes or used to boost participants' odds in

online games or raffles (with prizes up to SG$100). Some 20,319 participants applied and were admitted to the programme in its first six months.

Pluntke and Prabhakar (2013) studied INSINC's first six-month trial for the Land Transport Authority Academy. They commented that 'a large conclusion of our work is that it is possible to shift peak demand with relatively modest amounts of incentive money' (Pluntke and Prabhakar 2013). They found the INSINC pilot programme induced a 7.5% shift in peak MRT trips, with a greater than 10% shift among INSINC users. Figure 8.1 highlights the shift in peak-period trips.

Figure 8.1 Shift in commute times from INSINC programme (Pluntke and Prabhakar 2013



INSINC's social component has appeared critical to its success. Participants sent 98,834 emails inviting their friends to join the programme. Some 62% of participants had friends registered, and these participants were significantly more likely to shift their travel behaviour.

Gamification appears to have contributed to greater participation in the programme, with INSINC site usage increasing after a 'Magic Box' programme was introduced, through which participants earn credits for learning INSINC facts or reaching weekly targets. The Magic Box programme appeared to have a significant effect on INSINC participation. The number of INSINC participants who visited the site weekly increased from 27% to 40% after the Magic Box was introduced, and the overall peak-shift increased from 7.5% to 9.3% in the months before and after its introduction (Pluntke and Prabhakar 2013).

Singapore launched the Travel Smart Rewards programme, modelled after the INSINC pilot, in 2012. The programme has continued in subsequent years. According to the Straits Times, 300,000 commuters were registered to the Travel Smart Rewards programme in 2016, and about 5% had shifted to off-peak travel (Min 2016).

A 2013 LTA survey suggests these results may be lasting. It found that 95% of commuters who shifted their travel after free or discounted off-peak fares were introduced, would continue to use the shifted travel times (Poon 2016).

8.8.2 Employer partnerships

The LTA began a new Travel Smart programme in 2012 to partner with employers to support their employees engaging in off-peak and sustainable transport. It was launched as a two-year pilot. As described by Poon (2016), LTA provided consultants to help participating businesses introduce 'such flexi-

work arrangements as staggered work hours, IT facilities for telecommuting, and locker and shower facilities for their employees who chose to walk or cycle to work'. Public officers were also offered flexibility to report to work early. According to a 2013 survey, 8% of public officers shifted their work start time (Poon 2016).

In 2014, LTA launched the Travel Smart Network, which targeted employers near MRT stations with more than 200 employees. It offered monetary incentives to employers who offered flexible travel arrangements (Poon 2016).

TDM efforts to shift public transport use have continued. In 2015, the government launched a two-year trial of an off-peak monthly travel pass. The pass offered a one-third discount and allowed unlimited travel on bus and train services at all times except for the morning and evening peak.

8.9 Key insights

Singapore's authoritarian, single-tier governance system has likely enabled more coordinated and aggressive TDM policy implementation, though cities worldwide can learn from its TDM successes and shortcomings.

Singapore has aggressively prioritised long-term transport and land use integration since its 1971 Concept Plan. In some cases, high density public housing has been developed in areas expected to be serviced by rapid transit infrastructure in subsequent years or decades.

A combination of car restriction policies has limited car ownership and use. Fees, taxes, duties and the vehicle quota system have limited growth in car ownership, while a congestion pricing scheme has managed traffic in busy areas.

The number of car trips fell by 12.5% between 2012 and 2016. This may reflect improved bus services, increased investment in rail infrastructure, and reductions in the vehicle quota in the past decade.

Taxi and ride-hailing vehicles are highly used but not exempt from the congestion-charging scheme. The scheme provides a mechanism by which Singapore can limit increased traffic from ride-hailing vehicles - a growing problem in many cities.

Innovative incentive programmes have influenced public transport riders' behaviour. Singapore's experience suggests that programmes involving financial incentives, gamification and social interaction can contribute to changing public transport users' trip times.

Singapore's TDM policies have been focused on minimising congestion, possibly to the detriment of other potential TDM goals. TDM policies have targeted efficient traffic flow for private vehicles, particularly during peak periods. This goal has often superseded pedestrian, cycling and broader liveability considerations, though TDM goals appear to be evolving.

A reluctance to subsidise bus operations has created lower bus frequencies than might be expected, given Singapore's car restraint policies. Improvements to the regulatory framework and services has been met with increasing ridership in past decade.

9 Sydney case study

9.1 Introduction

Sydney as an Australasian jurisdiction has a similar history of settlement and factors shaping the use of metropolitan land transport systems to New Zealand. Sydney is recording significant, and growing, traffic congestion problems. Projected travel demands are beyond the transport system's current capacity. As with New Zealand, government agencies are facing challenging fiscal pressures serving a growing and ageing population's transport, welfare and health needs.

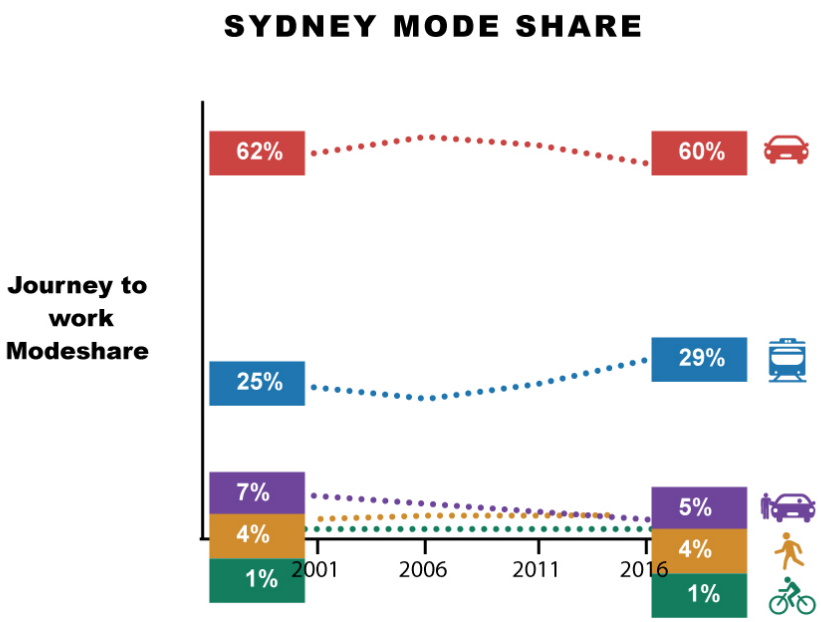
9.2 City snapshot

According to the 2016 Census, the population for Greater Sydney was 4.82 million. Greater Sydney is one of the top 10 fastest growing regions in the Western world and by 2036 is projected to be home to another 1.7 million people (Greater Sydney Commission 2018b). Sydney ranks within the 30 most congested cities worldwide (TTF and LEK 2018)

The Atlas of Urban Expansion estimates Sydney's 2014 urban extent at 1,625.27 km^2. For comparison, it estimates Auckland's 2014 urban extent at 488 km^2. It estimates Sydney's built-up area density at 25 persons per hectare. Using slightly different methodologies, various sources estimate Auckland's 2013 built-up area density and population-weighted density at 38–43 people per hectare, respectively (Atlas of Urban Expansion 2019).

According to the 2016 Census, nearly 60% of Greater Sydney residents travel to work by car. Figure 9.1 shows Sydney mode share changes over the past 16 years based on census data. The Australian census categorises journey to work by one, two or three modes. Journeys made up of more than one mode have had each leg counted for the purposes of this research. For example, a journey by train and bus will be counted in both categories.

Figure 9.1 Sydney journey to work mode share census data (Australian Bureau of Statistics 2016)



Public transport in Sydney is provided by an extensive network of modes including suburban rail, light rail, buses and ferries. The network now includes the new fully automated Sydney Metro, which opened in late May 2019. Buses are a key public transport option with nearly half of these services provided by Transport for New South Wales (TfNSW).

Sydney Trains runs the suburban passenger network for Sydney and manages 1,643 km of track across Sydney and 178 stations (Sydney Trains 2018). In March 2019, there were 36.5 million trips made on Sydney's trains (all operators, including outside of the city core) (TfNSW 2019a). In 2017/18 there were 264.3 million journeys taken on Sydney's bus network.

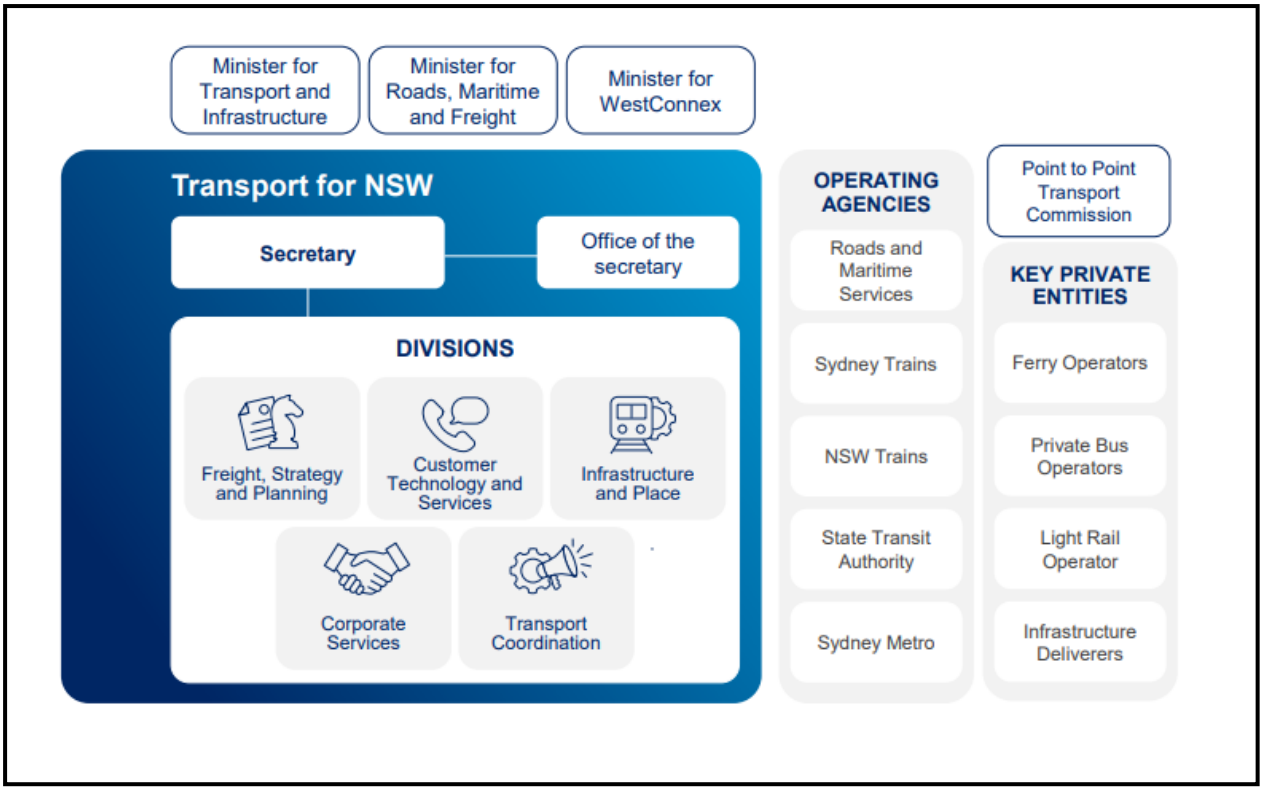
9.3 Governance framework

In Sydney, transport directions have varied since the formal adoption of the TDM concept in 1995. Although the Labour party was first elected in 1995 and continued to govern for 16 years until 2011, there were three different Premiers in the last six years along with six different Ministers of Transport and eight different Ministers of Roads in this period. In total, during Labour's time in office, there were four strategic transport plans (Mulley and Claudine 2015).

9.3.1 Transport bodies

Transport for New South Wales (TfNSW) is the lead agency of the NSW Transport cluster (refer to figure 9.2), established in November 2011 to 'lead the development of a safe, efficient, integrated transport system that keeps people and goods moving, connects communities, and shapes the future of our cities, centres and regions' (TfNSW 2016). TfNSW is responsible for strategy, planning, policy, regulation, funding allocation and other non-service delivery functions for all modes of transport in NSW including road, rail, ferry, light rail, point to point, regional air, community transport, cycling and walking.

Figure 9.2 NSW Transport Cluster (TfNSW 2019b)



TfNSW works closely with the Greater Sydney Commission (established in 2016 in an endeavour to streamline and coordinate infrastructure and strategic planning) and Infrastructure NSW and has established both formal and informal cross-government working groups. It also works with the Department of Planning and Environment, and the Department of Primary Industry.

TfNSW employs techniques across the travel demand management spectrum. The Transport Coordination Division of TfNSW is responsible for the management and delivery of the main Travel Choices TDM programme. Other demand management elements rest more broadly across the organisation, as well as within the Health and Education Departments and local councils. Programmes targeting active and safe travel objectives are predominantly conducted at the local council level, with assistance from Active Living NSW, established in April 2017 as a partnership between NSW Ministry of Health and the National Heart Foundation, and the Education Department.

The Transport Coordination Division reports that its key objectives are 'to achieve more consistent journey times for our customers, minimise the impact of unplanned and planned disruptions on the transport network and enhance communication to help customers choose the best way to reach their destinations' (TfNSW 2019b). The Transport Coordination Division comprises the following:

- Sydney Coordination Office, which manages traffic and transport changes and incident planning in major precincts to support major road and public transport projects as well and the implementation of a large-scale travel demand strategy known as Travel Choices.
- Transport Management Centre, whose purpose is to coordinate proactive real-time management of the transport network.
- Transport Security and Emergency Planning.

The Sydney Coordination Office was established in June 2015 as a single coordination point to manage the impact of the significant development and construction projects within the Sydney CBD. Its responsibilities were expanded in September 2016 from managing disruption to traffic and transport within the Sydney CBD and South East, to managing disruption related to the delivery of major infrastructure projects across the Sydney metropolitan area including light rail.

The current definition of TDM used by TfNSW for the Travel Choices Programme, detailed below, is 'the application of a focused, data led strategy that seeks to change demand on transport networks by redistributing journeys to other modes, times, routes, or by removing the journey altogether. It is most effectively applied when there is an impetus or catalyst for behaviour change'.

The TfNSW Household Travel Survey (HTS) collects information on personal travel behaviour. The area covered by the Sydney Greater Metropolitan Area includes Sydney, Illawarra and the Hunter (TfNSW 2019b). The proportion of private vehicle mode share has not changed significantly over the past decade. Train mode share has increased. Bus mode share has been reasonably stable. Walking mode share has increased very slightly across the GMA. Over the last 15 years, there has been a slight reduction in private vehicle (driver and passenger) travel mode share, according to the HTS, from 71% to currently 69% (Bureau of Transport Statistics 2014).

The Australian Automobile Association reported that average speeds have declined in Sydney over the last five years by 3.5% (Australian Automobile Association 2018). According to the TomTom Traffic Index, Australian cities have experienced rising congestion levels of between 25% and 40% of extra travel time, and this has been growing at around 2% to 4% per annum. Within the global context, while more people are travelling by public transport, Sydney ranks within the top 30 most congested cities.

9.3.2 Funding model

TfNSW is the lead agency of the NSW transport cluster which plans and delivers infrastructure and services across all modes of transport, including road, rail, bus, ferry, light rail, cycling and active transport. The State Government budget allocation for the transport cluster (including roads and maritime services and Sydney Metro) for 2018/19 is $13.4 billion for recurrent expenses and $12.4b for capital expenses (NSW Government 2018). The government has committed significant recurrent expenditure in 2018/19 towards improved public transport services and infrastructure.

TfNSW's budget allocation for 2017/18 was $13 billion for recurrent expenses and $11.3 billion capital expenditure. Key highlights included:

- $10.4 billion for services and operations
- $10.0 billion to enhance road and public transport networks
- $3.6 billion for capital maintenance of road, freight and public transport assets.

In December 2016, the Sydney Coordination Office joined with the Transport Management Centre to form the Transport Coordination Division as it is currently structured. The Transport Coordination Division of TfNSW, responsible for the delivery of the Travel Choices TDM programme, had a reported recurrent expenditure budget allocation of $197 million in 2017/18 (TfNSW 2018a). Disaggregated expenses by individual function or programme under the Sydney Coordination Office are not published.

9.4 Overall approach to TDM

The earliest forms of TDM in Sydney date to the mid-1970s with the concept of TSM, which was a policy in response to the energy crisis of that decade. A key outcome of this is the internationally recognised Sydney Coordinated Adaptive Traffic System (SCATS) traffic management and control system (Black et al 1999). A major contributor to progressing TDM, as separate from TSM, was the *Road transport future directions* report in 1991 undertaken for the NSW Roads and Traffic Authority. Since the formal adoption of the TDM concept in 1995, an extensive range of different measures and initiatives has been developed.

However, it is interesting to note here has not been a long history of coordinated outreach programmes to effect voluntary travel behaviour change in Sydney. Prior to the current TfNSW Travel Choices programme, there was limited attention to delivering specific and targeted behaviour change programmes beyond some travel blending and individualised marketing pilots (TravelSmart Australia 2006).

Currently, the NSW Government's *State infrastructure strategy 2018–2038* sets out the government's priorities for the next 20 years. Combined with the *Future transport strategy 2056*, the *Greater Sydney region plan - a metropolis of three cities* and the *Regional development framework*, it brings together infrastructure investment and land-use planning for the Greater Sydney region. TDM strategies are woven throughout these strategies in numerous ways. It should be noted that the approach to TDM in Sydney is mixed, with lots of different initiatives and approaches being used. Not all of them are covered in this case study, instead key policies and projects that have resulted in different and sometimes successful ways to manage travel demand are outlined.

Sections 9.5 to 9.8 review key strategies Sydney has undertaken to manage travel demand. Strategies are organised into four major categories defined by Litman (2014):

- outreach and implementation programmes
- improve transport options

- financial incentives
- land use planning and development.

9.5 Outreach and implementation programmes

TfNSW employs techniques across the TDM spectrum. Its flagship programme focuses on behavioural change initiatives under the banner of TfNSW's Travel Choices travel behaviour change programme. Prior to 2015 there was no area within the state government transport agency mandated with the responsibility to deliver behaviour change campaigns.

9.5.1 Travel Choices programme in Sydney

The current Travel Choices programme was established in 2015 by the Sydney Coordination Office to support the construction of the CBD and South East Light Rail and maintain a high level of awareness of the need to change travel behaviour to minimise the effects of disruptions. It has contributed to a 9% reduction in cars during morning peak in the CBD to date and its key aims are to:

- enable commuters to make informed choices about their daily commute
- shape long-term, sustainable travel behaviour aligned to future workplaces.

Travel Choices utilises the following principles to engage with customers and influence travel behaviour change, notably these are the same areas the London Olympics TDM policy was shaped around:

Remode – customer message: Use public transport, as driving may no longer be your best option.

Retime – customer message: Avoid travel during the peak, especially between 8 am and 9 am and 5 pm and 6 pm.

Reroute – customer message: Use the city's preferred driving routes where possible.

Reduce – customer message: Minimise the number of times you have to travel, especially by car.

The Travel Choices programme has largely been implemented to manage disruption and traffic congestion and focus on assisting impacted workplaces and reducing private vehicle travel around impacted sites during major construction projects. The Travel Choices website provides a range of planning tools to assist workplaces in general, with implementing behaviour change strategies (TfNSW 2018b). There is a range of free resource to help individuals, businesses and organisations prepare for and adapt to the changes to Sydney's transport network.

The Travel Choices team provides support for those making the shift to more sustainable ways of moving into, out of and around Sydney. This support comes in many forms including:

- For businesses with over 500 employees, dedicated specialist travel advisors are provided to work with the company to provide tailored solutions.
- For businesses with less than 500 employees, free workshops were hosted for them to adapt their existing travel plans to encourage staff to switch to alternative modes or more flexible work hours.
- Extensive information on the construction timeframes and stages were provided to all of those impacted by the works including regularly updated maps to help plan for disruptions.
- Communications were essential with regular email updates, newsletters etc, which were also distributed throughout organisations.

To date, Travel Choices has worked with over 640 businesses and organisations across Sydney and reports contributing to a significant decrease in vehicles entering the CBD and a significant increase in public transport trips during the morning peak. Businesses employing over 500 staff are entitled to a dedicated specialist travel advisor who will work with them and provide tailored solutions 'to manage any impacts of works' (TfNSW 2018b). Since 2015, there has been a 12% reduction in the number of vehicles entering the Sydney CBD in the morning peak and a corresponding 11% increase in public transport trip into the Sydney CBD in the morning peak. Despite this there seems to be much more limited reporting on the success of individual case studies. While several examples of businesses that have been engaged in the programme are listed on the Travel Choices website these are more descriptive and lacking in detail. Potentially, this is because the construction works are still on-going.

9.5.2 Travel Choices 'Innovation Challenges' campaigns

To explore new products and ideas that can influence customer travel behaviours, TfNSW's Sydney Coordination Office (SCO), in conjunction with Future Transport, recently launched the Travel Choices Innovation Challenge. Entries in the Travel Choices Innovation Challenge need to address two inter-related mandatory challenges (TfNSW 2019c):

- How can we develop a product to provide information to our customers that persuades and enables them to remode, retime, reroute and reduce their journeys by promoting the financial, social, environmental and health benefits for our commuting customers and the costs of private vehicle use?
- How can we use open data (and other existing tools and products) to make it easier for customers to obtain and interpret travel information which is specific to their needs?

Additional challenges include: how to connect commuters with local businesses along corridors and alert them to local events and activities to promote increased public transport use, and walking and cycling for longer journeys; and, encourage car-sharing and ways to collect data on how customers are travelling.

Public transport and Live Traffic data have been made available under the TfNSW Open Data program. TfNSW has been actively making travel data open since 2012 and all data supporting the Innovation Challenge initiative is made available via the TfNSW Open Data Hub (TfNSW 2019d). Challenge winners receive endorsement as the TfNSW Travel Choices preferred product. This means promotion to more than 600 CBD businesses already engaged with the Travel Choices programme and the 170,000 customers that form part of the programme's audience.

9.5.3 Mobility as a service

TfNSW currently promotes a suite of mobility apps to assist travel choices. These may be considered a progression of TfNSW's pathway towards MaaS to assist with the management of travel demands and to effect behavioural change (TfNSW 2019e). MaaS was also the subject of the first innovation challenge of TfNSW's digital accelerator, established to explore future technology applications around public transport services in collaboration with the private sector (TfNSW 2019e).

NSW's potential pathway to MaaS is articulated in the *Future transport strategy 2056* (TFNSW 2018c):

- A unified mobility account – integrated payments across modes.
- Utilise apps and application programming interfaces (APIs) to support MaaS and make APIs available through open data for 3rd party app developers to integrate into their products.
- Upgrade the open data portal to enable licensed, non-contracted operators to feed into the journey planner API.

- Build a dashboard for the transport management centre and the open data portal to show customer journey demand and pass on to operators the most efficient real-time journey.

9.6 Improve transport options

The following sub-sections discuss a range of infrastructure- and service-related TDM strategies to improve and create more efficient mobility options. This list is by no means exhaustive due to the broad range of different initiatives rolled out. The list focuses on those that have emerged since 2017 and those with a technology focus. The following may thus be considered a selection of some of the initiatives that are discussed in the key planning documents as key TDM strategies.

9.6.1 Cycling initiatives

TfNSW published *Sydney's cycling future – cycling for everyday transport* in December 2013 (TFNSW 2013). In 2016–17, an investment of more than $40 million helped to deliver more than 290 walking and cycling improvement projects across NSW. This delivered an additional 39 km of cycleway along with 74 walking infrastructure improvements.

In order to promote cycling, City of Sydney Council staff are at key locations each week with information and advice on bike riding in Sydney, including route planning and bike purchase. The city also offers bike advice courses. The City of Sydney's Give Yourself a Lift behaviour change campaign, with funding assistance from the NSW Government, recently won a Greater Sydney Commission Planning Award in 2018 (Greater Sydney Commission, 2018a)

9.6.2 Responsive passenger information systems

Responsive PI systems are a new class of passenger information system working to optimise network performance by using robotic sensor and digital information technologies to inform, influence, and coordinate user behaviour. They are a step up from static and dynamic PI systems. They provide a communications feedback loop between public transport customers and operators in real time.

With new sensing technologies, TfNSW measures crowding levels on rail station platforms and pedestrian movements through concourse areas. This provides frontline staff more information on what is happening across the entire station complex. Staff then communicate with customers about crowding and service conditions before they reach the station.

A scoping study has been developed that seeks to combine these two technologies and others through a new class of passenger information system called responsive passenger information systems (University of Technology Sydney 2016). The scoping study was undertaken by the University of Technology Sydney in partnership with Sydney Trains. The intent of the study was to find ways of using new technologies to influence customer decisions to overcome passenger congestion at key points in the rail network. The study looked at how technology could meet the needs around passenger congestion management at Town Hall and Parramatta stations, and by extension other stations across the Sydney Trains network.

9.6.3 Facilitating the take up of shared services

Ride-hailing services in NSW are a growing part of the point to point transport market. Since its legalisation in December 2015, ride-hailing services have expanded into different locations across NSW. A new regulatory framework for point-to-point transport began in November 2017, following a reform process that began in mid-2015. The Point to Point Transport Commission within TfNSW assists the

NSW Government's Point to Point Transport Commissioner as the regulator for taxis, hire cars, ride-hailing and similar services.

Phillip Boyle and Associates reports that 10 to 14 vehicles are removed from the road for every carshare vehicle added. It was also claimed (in 2015) that

> *the impact of the service on the City of Sydney (with a network of 700+ vehicles) has removed roughly 10,000 vehicles from the road (equivalent to a line of parked cars on both sides of George Street running from the Central Station to Circular Quay five times over), as well as removing up to 37 million Vehicle Kilometres Travelled (VKT) from the LGA per year, as carshare members typically reduce their overall VKT by half after joining carshare.* (Phillip Boyle and Associates 2016).

9.6.4 Trialling connective technologies

Vehicles that are connected and automated, including driverless vehicles, are viewed by the NSW government as bringing significant opportunities for safer travel, lower costs, more transport choices and less congestion on our roads. The NSW Government recently passed legislation to enable the Minister for Roads, Maritime and Freight to approve trials of automated vehicles, to assess their ability to meet policy objectives of improving safety, boosting service frequencies and reducing congestion. The legislation allows government to partner with industry, researchers and universities for automated vehicle trials.

TfNSW has recently published a connected and automated vehicles (CAVs) plan that will include a policy framework and action plan designed to maximise the transport and social benefits from the introduction of CAVs. It includes measures to:

- promote automated technologies that improve safety outcomes
- integrate CAVs with public transport; anticipate infrastructure requirements
- encourage the deployment of CAVs by service providers, particularly in the form of shared and innovative public transport
- extend mobility options to regions and community groups that currently lack transport options (TfNSW nd).

The NSW Transport Management Centre is currently developing a system under the Intelligent Congestion Management Programme that will use the most up-to-date and predictive data to monitor and manage performance in real time across all modes and networks. The NSW Government is investing $470 million to upgrade the M4 to a 'smart' motorway (ANZIP 2019).

9.7 Land use planning and development

Like many Australasian cities, Sydney has significant urban sprawl. There has been an increasing focus on addressing this issue by focusing on creating more compact and integrated environments. This includes optimising infrastructure, integrating land use and transport more effectively and ensuring key design principles around different modes and travel plans are in place.

9.7.1 30-minute city

The Greater Sydney Region Plan (*Metropolis of three cities*) aspires to a 30-minute city (Greater Sydney Commission 2018b), where jobs, services and quality public spaces are in easy reach of people's homes.

A place-based and collaborative approach throughout planning, design, development and management is recommended that will:

- prioritise a people-friendly public realm and open spaces as a central organising design principle
- recognise and balance the dual function of streets as places for people and movement
- provide fine grain urban form, diverse land use mix, high amenity and walkability in and within a 10-minute walk of centres
- integrate social infrastructure to support social connections and provide a community hub
- prioritise opportunities for people to walk, cycle and use public transport.

Within the region plan, two key strategies relate directly to TDM. The first is to optimise infrastructure use, i.e. before implementing new infrastructure responses, the demands on existing infrastructure need to be evaluated and managed. This can be achieved by exploring opportunities including adopting new smart traffic technologies, co-locating services, and developing travel plans to alter and encourage sustainable transport choices.

The second strategy is integrated land use and transport to create walkable and 30-minute cities. Addressing the capacity challenges of the transport network is not limited to investment in new services and infrastructure, or fine-tuning management of the existing networks. Changes to how businesses, education facilities and other activities are operated, together with behaviour changes, can enable customers to use the transport network differently. Clear legislation and a good governance system will be important to ensure this is implemented in a way that achieves the desired goal of a 30-minute city.

9.7.2 Commuter car parking at public transport hubs

Commuter car parking (CCP) facilities are located close to many public transport hubs throughout NSW. There are currently over 36,000 dedicated off-street CCP spaces at train stations in NSW on the Sydney trains and Intercity network. There are also many other free off-street CCPs operated by local councils. The NSW Government has made 5,700 new CCP spaces available since 2011. These have primarily been at train stations. It should be noted that in other jurisdictions reviewed for this report this type of facility is commonly is referred to as park and ride.

In June 2017, the Committee on Transport and Infrastructure resolved to conduct an inquiry into CCP in New South Wales. The inquiry terms of reference required the committee look at current state policies covering CCP, the potential for restricting access to car parks and alternative methods for accessing stations such as point-to-point transport and on-demand buses (Legislative Assembly Committee on Transport and Infrastructure nd).

The committee found that commuter parking was widely supported as a useful service. It commended Transport for NSW for making use of the Opal card to ensure genuine commuters had access to commuter parking. The committee found a lack of consistency between state and local government guidelines specifically regarding CCP guidelines. It recommended that the state parking guidelines include specific guidelines for CCP in consultation with local governments.

9.7.3 Travel plans as part of development consents

The City of Sydney's Development Control Plan (DCP) contains guidelines around when applicants are generally required to prepare and submit a travel plan as part of the development application (DA) process. The guidelines outline what is required in order to prepare, submit and implement a travel plan. In particular, the guide covers:

- the benefits of travel planning
- the elements required to satisfy council's travel planning requirements
- the processes that will need to be undertaken to prepare, submit, implement and review a travel plan (City of Sydney nda).

The council also encourages existing developments to prepare and implement travel plans to better manage travel demands. These are not subject to the same approval process as a travel plan required under a development consent condition. The City of Sydney requires that end-of-trip facilities be provided within new developments.

A good example of a workplace travel plan (WTP) implemented under this policy was the Optus Sustainable Transport Strategy (OSTS). This is one of the few examples where the travel plan was monitored, and results reported. This was an issue with the overall approach in that such WTP were required as a consent condition, but the monitoring and reporting was not. The Optus WTP was developed to help manage staff travel when Optus employees from nine sites across Sydney were relocated to one newly built campus (Optus City Centre - OCS), called Macquarie Park, with 6,500 employees and 2,000 employee car spaces.

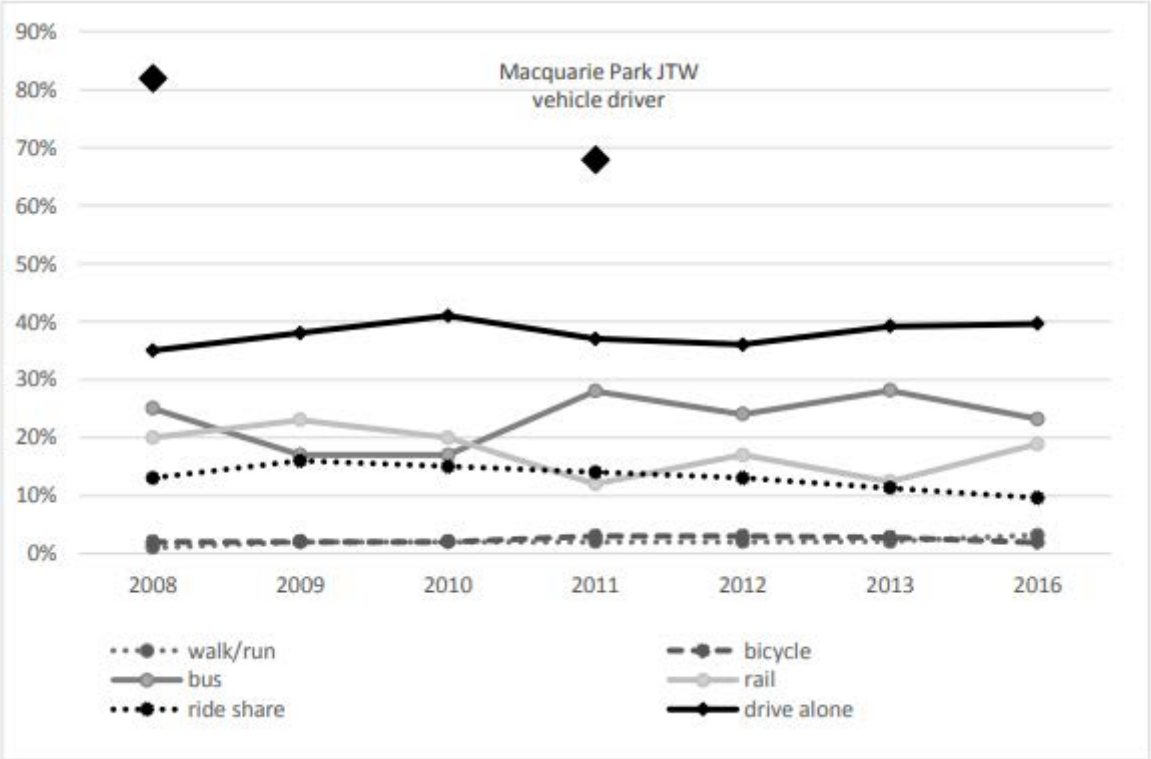
The relocation in mid-2007 to one new campus in Macquarie Park included the imperative for developing a comprehensive green travel plan. Early analysis of baseline data by Optus showed a significant transport infrastructure gap existed. The driving question was, simply, 'How do we get over 6,000 people to work at a new site in a suburban business park with 2,002 employee car parking spaces?'

The transport strategy was designed to increase travel choices for employees to commute to OCS, with an emphasis on improving access by sustainable modes of transport. An important element of this was employee participation. It was recognised as critical for the success of the strategy and included the Optus Personalised Journey Planner, face-to-face travel 'clinics' and travel forums. To ensure that changes were appropriate and long lasting there was a focus on 'empowering employees with sufficient knowledge and information with which to make informed decisions. Particular care has been taken to ensure employees receive information that is honest and straightforward' (NSW Government Premier's Council for Active Living 2011).

A travel plan was developed and included a new employee bus service, financial support for public transport services, a charging mechanism to allocate parking according to need, on-site active transport facilities, and extensive employee engagement. The development approval also required the owner of the site, Stockland, to fund a rail transfer bus for Optus employees, which attracted 1,700 employees per day. To encourage employees to use public transport to travel to Optus Centre Sydney, Optus offered a one-off 30% reimbursement for the cost of 12 months of public transport travel.

The campaign is now self-funding, using revenue raised through charging for car parking spaces. The mode share of Optus Centre Sydney since occupation of the site is more sustainable than the background Macquarie Park journey to work mode share as illustrated by figure 9.3.

Figure 9.3 Mode share Optus Macquarie Park 2008 – 2016 source: Mackay et al (2017)



Key learnings, as reported by the Premier's Council for Active Living include:

- the need for an in-depth understanding of the problem
- clear objectives to guide design of the transport strategy and selection of intervention measures
- the need for a unique combination of measures tailored to the specific needs of Optus
- continuous employee engagement, dedicated staff resources and hard compulsory targets (Premier's Council for Active Living 2011).

9.8 Financial incentives

Initiatives to reduce driving in Sydney predominantly focus around different types of pricing. Infrastructure Australia's report Australian Infrastructure Audit 2015 identified congestion management as the most significant transport management issue facing Sydney. It noted that seven of the eight most congested corridors in Australia were in Sydney and that by 2031 demand on these corridors is projected to 'significantly exceed current capacity' (Infrastructure Australia 2015).

9.8.1 Road pricing via tolls

The NSW Premier signalled the need for new thinking on dealing with road congestion by including it in the Premier's Innovation Initiative in 2015 (City of Sydney nd).

In 2017, the NSW Government Portfolio Committee No. 2 – Health and Community Services reported on matters relating to tolling regimes for roads in New South Wales (New South Wales Parliament 2017). The Committee endorsed the 'use of private sector arrangements for the construction and operation of major arterial roads, where appropriate, and the tolling arrangements that are required to finance them'.

Interestingly, the Committee for Sydney in a 2016 report expresses concern that 'road pricing via tolling has become a way of paying for roads and of inducing rather than shaping demand' (The Committee for Sydney 2016). Currently, the government's position is not to introduce a congestion 'tax' – rather a targeted approach to encouraging people onto public transport (SBS 2017). It seems that road pricing via tolling has not been very effective in alleviating congestion, with average speeds declining in Sydney over the last five years and travel times increasing, as previously noted. In June 2019, the NSW Transport Minister identified a shift from road pricing to mobility pricing stating that he envisaged:

> *a subscription service for transport – like Netflix. You sign up for a nominal fee each week or month and all the different pricing for public or private providers is built into it – whether that be an Uber, a ride-share car, a bicycle or a Metro* (Wiggins and Evans 2019).

This pay as you go approach is starting to be viewed internationally as a different way to manage congestion especially given that revenues from fuel taxes are likely to decline over time as the shift to electric vehicle/hydrogen vehicles and other yet-unknown technologies replace fossil fuels.

9.8.2 Parking space levy in key business districts

In addition to tolling and modest road pricing initiatives, the parking space levy is one of the NSW Government strategies to reduce congestion in the key business districts of Sydney CBD, North Sydney, Bondi, Chatswood and Parramatta, to encourage the use of public transport and improve air quality. An annual levy introduced in 1992 must be paid by owners of liable residential and non-residential off-street parking spaces located in two specific districts:

- $2,440 per space in Sydney's CBD, North Sydney/Milsons Point (Category 1 districts).
- $870 per space in Bondi Junction, Chatswood, Parramatta, and St Leonard's (Category 2 districts) (Transport for NSW 2019g).

The levy contributes around $110 million of funding for infrastructure such as commuter car parks and interchanges.

9.9 Key insights

Congestion management is the most significant transport management issue facing Sydney. This is the key objective underlying the state government's TDM strategies. The proportion of private vehicle mode share has not changed significantly over the past decade. Uncompetitive travel times for public transport, especially in comparison to private vehicles are continuing to drive relatively low bus public transport mode shares in Sydney.

Top down leadership is key to getting actions implemented but only part of the picture. Many of the TDM initiatives rolled out in Sydney are almost exclusively top down and this has been viewed as the driving force for change. However, the current shift towards different approaches, such as MaaS, requires more focus on creating value for the user, and using that value to incentivise behaviour change. This requires a greater amount of co-design of solutions with users.

Greater cross government coordination and integrated transport and land use planning is required to meet the challenges facing Sydney (especially population growth). The NSW Government has acknowledged this, and the Greater Sydney Commission was established recently to facilitate integration across different levels and portfolio areas of government. The Government's Future Transport 2056 strategy alongside the release of the Greater Sydney Commission's Greater Sydney Region Plan was the first time long-term planning and transport were undertaken in direct collaboration.

Transport management strategies should not be considered 'in isolation'. Packaged approaches should combine 'carrots and sticks': where 'carrots' encourage alternatives to driving private motor vehicles and 'sticks' to discourage driving, are introduced concurrently to increase their acceptability.

Parking management is often referred to explicitly as a central component of site level travel demand management.

Strategies to encourage alternative forms of travel to car driving are considered important to offset strategies to discourage driving, such as parking restrictions, parking, price increases. This is the key platform of TfNSW's Travel Choices programme - TfNSW officers work with individuals, businesses and organisations to deliver advice, support and information on transport modes, travel times, preferred routes and alternatives to travel.

Mandatory requirements for travel plans for new developments are viewed as key but it is also important to ensure that they are monitored and results reported. A Travel Behaviour Change toolkit and resources are provided online and, in addition to targeted campaigns, can work well.

10 Vancouver case study

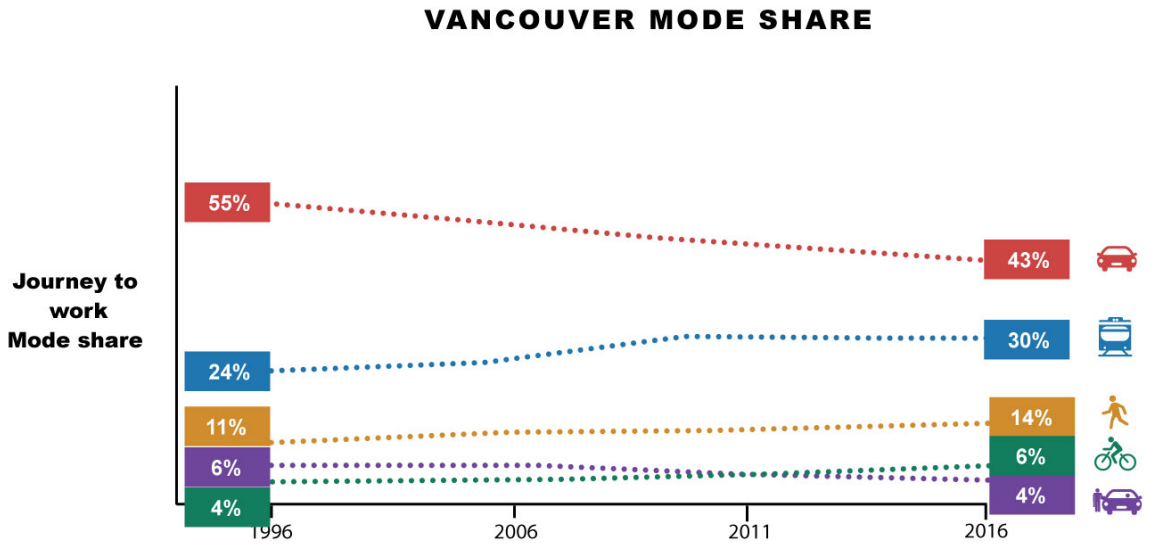
10.1 Introduction

Vancouver, Canada has been internationally profiled as a city with substantial success when it comes to transport mode share. The city achieved its 2020 mode share target of 50% of trips completed by sustainable modes four years ahead of time. The city is now seeking to substantially add to an already strong active and public transport mode share.

10.2 City snapshot

Vancouver City had a 2016 population of 631,486 according to the Canadian Census. Figure 10.1 shows the mode shift in Vancouver since the mid-1990s, with a reduction in private motor vehicle commutes from 55% in 1996 to 45% in 2016. Vancouver's current transport profile is the result of some key initiatives stretching as far back as the 1970s, with substantial movement towards a demand management approach first introduced in the 1990s.

Figure 10.1 Vancouver modal shift 1996–2016 (Canadian Census 1996-2016)



Vancouver mirrors Auckland in some geographic perspectives. As a coastal, seaport city, Vancouver is built on a peninsula with the Burrard Inlet to its north, and the Fraser river to its south. As a result, access to the city's north is either made over one of two bridges, or by using the city's Seabus ferry service. The city's history, founded on First Nations territory and built by immigrants from a range of nations, also holds similarities to the founding of New Zealand cities.

Vancouver's urban area is estimated at 685 km^2 (OECD 2014). For comparison, Auckland's 2014 urban extent was estimated at 488 km^2. Vancouver's 2011 population-weighted density was estimated at 47 persons per hectare (Charting Transport 2016). Using slightly different methodologies, various sources estimate Auckland's 2013 built-up area density and population-weighted density at 38 to 43 people per hectare, respectively (Atlas of Urban Expansion 2019).

Under the umbrella of a series of both region-wide and city-level policies, Vancouver has set itself the goal of having two-thirds of its journeys made by active transport or public transport by the year 2040. In addition, from 2007 to 2040, the city aimed to achieve a 20% reduction in VKT (to 4,760 km per person). This has already been achieved.

Some of Vancouver's main challenges are equally reflected in New Zealand. These include a growing population, with limited road space (particularly relevant for both Auckland and Wellington), concern about the financial burden of sedentary lifestyles, a high cost of housing, an aging population, with the number of Vancouver residents aged over 60 expected to double in the next 30 years, and rising fuel prices.

The City of Vancouver's population is expected to grow by 130,000 new residents and 90,000 new jobs in the next 30 years.

In Vancouver, the issue of overcrowding on public transport is believed to discourage new riders. For this reason, the city's land use development now has a strong focus on active transport, especially developing cycleways (Peacocke, Senior Transportation Engineer, City of Vancouver, pers comm, 28 November 2018).

10.3 Governance framework

The City of Vancouver is one of 23 local authorities that make up the political body of Metro Vancouver, formerly known as the Greater Vancouver Regional District (GVRD). This body is designated as a regional district of British Columbia. The city is incorporated under the Vancouver Charter, which gives the city more powers than other British Columbia communities.

10.3.1 Transport bodies

The City of Vancouver is responsible for the city's roads and local transport infrastructure, while public transport, major roads outside of the city, and bridges are managed by TransLink a transportation authority that spans the whole Metro Vancouver region.

A 21-strong Mayors Council guides the decisions of TransLink, and Vancouver City must negotiate with the council in terms of any transport decisions affecting TransLink. This balance between city and wider regional transportation needs can be difficult to navigate (Peacocke, pers comm, 28 November 2018).

The two pieces of policy which most influence the region and city's TDM work are TransLink's 10-year investment plan and Vancouver City's (2012) *Transportation 2040,* which was developed in collaboration with TransLink. Contained within those plans are the city's most recent TDM plans and proposals, some of which are already in place, while others are only just being established now.

The city's metro system is called SkyTrain and has nearly 80 km of track throughout the city (and beyond in some directions). The system is fully automated, has 53 stations, and carries approximately 470,000 passengers per day. The city was originally built around a streetcar network, the layout of which has been maintained in the city and is now serviced by buses.

10.3.2 TDM responsibility

The City of Vancouver does not have a dedicated TDM team, instead TDM is embedded in the region and city's wider planning at all levels, with a 'TDM lens' put on all transport-related projects (Peacocke, pers comm, 28 November 2018).

In the wider Metro Vancouver, TransLink has a dedicated TDM team, called TravelSmart. The TravelSmart programme focuses on behaviour change initiatives for specific groups, like employers, across the wider Metro Vancouver region.

Managing travel demand in Vancouver is defined as accommodating 'our tremendous growth in trips in the next 20 years by sustainable modes' (Peacocke, pers comm, 28 November 2018).

Key milestones in the city's history of TDM include:

- Protests in the late 1960s and early 1970s led to a decision not to build freeways within the city limits.
- The Greater Vancouver Regional District (now Metro Vancouver) 1993 long-range plan, Transport 2021, recommended TDM approaches for the region – including both incentives: telecommuting, employer travel reduction encouragement, high occupancy vehicle lanes; and disincentives: 50% increase in parking charges in the city, increased fuel prices, bridge tolls.
- The City Council's City of Vancouver Plan: Transportation 1997 agreed to build no new road capacity in the city (City of Vancouver 1997).
- The reordered hierarchy of modes in the 1997 plan put pedestrians, active and public transport modes ahead of cars in terms of planning and design priority.
- The City of Vancouver's (2012) *Transportation 2040* plan further built on the TDM-centred policy of the 1993 and 1997 plans.
- The 2010 Winter Olympics, with its substantial coordinated TDM programme, alongside significantly improved infrastructure and service of both public transport and streets, saw a 34% decrease in car mode share for the duration of the games.

The main measures of TDM success are the same as the city's overall measures of transport success – mode share and VKT.

10.3.3 Funding model

Under the City of Vancouver's 2019-2022 Capital Plan, CAN$310 million of CAN$2.8 billion of capital expenditure is earmarked under the category of 'Transportation and street use' (City of Vancouver 2018).

Capital investments are funded from property tax, development contributions (such as development cost levies), partner contributions from provincial and federal governments, TransLink, non-profit agencies, and philanthropists.

Interestingly, the city notes that philanthropy is particularly relevant in the area of transport (alongside childcare and affordable housing).

Three quarters of the city's operating revenue of CAN$1,516 million comes from property taxes and utility fees. Parking revenue is not included in this, but also makes up 5% of the city's operating revenue.

As TDM is integrated across and embedded within the City of Vancouver, rather than having its own department, there is not a clear financial structure for funding TDM strategies.

In 2018, TransLink operated with a CAN$185 million surplus. Its revenue primarily came from taxation (CAN$819 million) including a fuel tax, public transport fares (CAN$638 million), Government funding (CAN$246 million), and other sources including investment income and 'miscellaneous revenue'. TransLink's 2018 annual report lists expenditures as bus operations, corporate operations, rail operations, roads and bridges, public transport policy, amortisation of tangible capital assets and interest.

Explicit expenditure on the organisation's TDM Programme TravelSmart is not publicly available (TransLink 2018).

10.4 Overall approach to TDM

As outlined above, TDM in the City of Vancouver is considered as a 'lens' that applies to all policy and transport planning, particularly in the City of Vancouver. As a result, the term 'TDM' is not often used in city policy, despite numerous policies fitting the definition of TDM applied to this research.

Transportation 2040, as Vancouver's long-term transportation and land use plan, is one of the greatest influences when it comes to TDM work and includes several elements that can be considered TDM.

The plan is split into six categories: walking; cycling; public transport; motor vehicles; goods, services and emergency response; and encouragement, education and enforcement. Within each category, certain policies can be considered as having a TDM focus, while others focus on providing an enhanced network or improved service.

Transportation 2040's targets are for at least half of all trips to be by foot, bike or public transport by 2020 (this was achieved early, in 2016), and at least two-thirds by 2040. *Transportation 2040* also includes an aim to reduce VKT per person by 20% from the 2007 levels by 2020, to a target of 4,760 km per person. Vancouver has already surpassed this target, with the current VKT being 4,060 km per person.

Transportation 2040 is a fundamental driver of many of the initiatives that this section will now review as it outlines the key strategies that Vancouver has undertaken to manage travel demand. The strategies are organised into four major categories defined by Litman (2014):

- land use planning and development
- financial incentives
- improve transport options
- outreach and implementation programmes.

10.5 Land use planning and development

Land use development is the area in which the City of Vancouver has the most influence over travel demand, particularly its strong integration of land use and transport. City planners have had a strong focus on TOD development in Vancouver, and 90% of people living in Vancouver are within a 10-minute walk or cycle from a frequent public transport stop.

10.5.1 TDM in developments

In 2019, the City of Vancouver implemented a by-law called *Transportation demand management for developments in Vancouver* (City of Vancouver 2019). This is a policy for the management and funding of TDM in new developments in the city. Under this policy, TDM plans are now compulsory for the following developments:

- projects in the Downtown, except residential strata and non-social housing rental in the West End and Robson North Permit Area
- large sites, with a total site area of 8,000 m2 or more, or containing 45,000 m2 or more of new floor area.

Developments are assessed on a TDM scoring system, for which the city has defined how many points various TDM strategies are awarded. The minimum required score to obtain consent is dependent on the type of development. The TDM strategies include: public transport passes; bicycle fleets, parking and facilities; walking improvements; parking pricing; reduced parking spaces; carshare membership, facilities or vehicles; shuttle services; travel planning resources; and signage/wayfinding initiatives. Under this programme, developers pay Vancouver City CAN$2 (approximately NZ$2.20) per square metre of new gross floor area, and city-wide, developers pay CAN$280 (approximately NZ$309) for each vehicle parking space being relaxed. The revenue goes toward the city's TDM monitoring programme. The policy is so new it does not yet have quantifiable results; however, it is a key part of the City of Vancouver's TDM work.

10.5.2 New parking policy for Vancouver

As of 1 January 2019, Vancouver City's parking by-law was amended to meet actions in *Transportation 2040.*

The parking by-law indicates which new developments must have a TDM plan. The plan allows for parking to be reduced by up to 30% in some cases, and up to 60% in some rental residential cases, when satisfactory TDM plans have been put in place.

Additionally, the by-law has removed parking minimums from the city's parking requirements (in most cases). It is now only required that minimum parking requirements be met for accessible parking spaces. The by-law has, in many cases, added maximum parking requirements for new developments. In non-residential uses this is a maximum of one parking space per 115m^2 of floor area. Residential uses have more varied rules, but generally minimum parking requirements have been removed for developments closest to the city.

The policy also updates minimum bicycle parking for developments, making requirements more specific, and increasing the number of bicycle parks required. Minimum requirements for end-of-journey facilities for both offices and retail/service facilities have also been mandated under the by-law.

New developments are required to have automatic door openers for all doors connecting bicycle parking to the outside, requirements for the installation of stacked or vertical bicycle parking (preventing the need for bicycles to be lifted entirely off the ground), a minimum number of bicycle lockers, and the requirement for bicycle racks. As these changes are new to Vancouver, their direct impact has not yet been analysed. However, the changes have been developed to allow the city to comply with *Transportation 2040*, and it is expected they will contribute to long-term reduction in VKT and to achieving mode share goals.

10.5.3 Complete Streets

In 2017, the City of Vancouver used its street design framework and related by-laws to adopt a city-wide Complete Streets policy (City of Vancouver 2017). This is the policy sitting behind the introduction of several visible TDM strategies required by *Transportation 2040*, such as:

- Make streets safer for walking.
- Improve pedestrian connectivity.
- Enable and encourage creative uses of the street.
- Provide generous, unobstructed sidewalks on all streets.
- Make streets accessible for all people (City of Vancouver 2012).

The Complete Streets proposal has changed requirements within Vancouver's Street and Traffic By-Law, allowing the following changes, which were previously not possible:

- Reallocate public rights-of-way for different modes and uses.
- Divert general motor vehicle traffic from streets.
- Reroute public transport routes onto different streets, with the support of TransLink (City of Vancouver 2017).

10.6 Improve transport options

Significant investment has been made in Vancouver to expand the city's public transport network. This includes opening new lines of the city's SkyTrain network, extensions to the network, and a move towards designing streets that are accessible for all users.

10.6.1 Public transport fare review

A TransLink public transport fare review was completed in 2018 as part of *Transportation 2040*. This review suggests a new way of pricing public transport in Metro Vancouver.

The aim of the review, which was started in 2016, was to change the fare structure of Metro Vancouver's public transport to grow ridership but also to reduce overcrowding, particularly in peak times. As a result of the review, the fare structure is set to change this year.

The previous TransLink zoning systems for fares were adopted in 1984 and involved three zones. The system had been a source of complaint for many customers, as it left some riders paying high fares for substantially shorter journeys compared to other passengers.

The most substantial recommendation from the fare review is to change the funding structure to one based on distance, rather than zones. This sought to address the disparity in fare costs across zones for customers and can be considered a TDM strategy in the sense of making the public transport service more appealing and financially viable to users. Bus fares were already changed in 2015, and zone-based fares replaced with a flat rate, regardless of journey distance.

The other significant TDM-related finding from the review was the recommendation to explore the potential of charging different fare rates at different times of day. The aim of this recommendation was to address the problem of (peak period) overcrowding on public transport, which is already a significant issue in Vancouver (Peacocke, pers comm, 28 November 2018). This recommendation is now being used as the basis for further investigation as to how to implement such a plan. The report suggests options like rewards or discounts only at very particular times of day, to ensure the desired outcome is met and that the discounts do not detract from TransLink's fare revenue.

10.6.2 Carshare

Carshare culture plays a significant role in Vancouver, with the city having more carshare vehicles per capita (4.22 per 1,000 people) than any other North American city. A 2018 report by Vancouver City Savings Credit Union looked at carshare uptake in the city, including details about the financial advantages of taking part (Vancity 2018).

There is a carshare fleet of about 3,000 cars in Vancouver, and the growth of the fleet has been aided by encouragement from the City of Vancouver. This has included allowing carshare vehicles to use permit-

only car parking spaces, and relaxing car parking requirements in new developments if carshare is provided instead.

A survey of 4,000 carshare members found more than half of users belonged to more than one carshare scheme and the prevalent reason for taking part was convenience. More than a quarter of participants in the survey had got rid of at least one private vehicle, replacing it with carshare. Forty percent of respondents had avoided buying a vehicle because they were a member of a carshare scheme (Vancity 2018).

Reasons cited for Vancouver's high uptake of carshare include: the high urban population density; a limited supply of taxis and an absence of ride-hailing services (see section 10.6.3); good public transport networks in the city; and support from the City of Vancouver by providing parking for the carshare services. The general attitude of young people in Vancouver, cited as more likely to value inner-city living over car ownership, is also believed to contribute (Price 2015; Vancity 2018). There is evidence of attempts to introduce peer-to-peer carsharing to Vancouver, but the success of such schemes has not yet been reported.

10.6.3 Ride-hailing and Uber

Several commentators have attributed Vancouver's mode share success to the fact that British Columbia laws have meant it is not possible to operate ride-hailing services (such as Uber) in the region (Peacocke, pers comm, 28 November 2018; Price 2019).

This is expected to change with the election of a new government for British Columbia in 2017, promising to bring ride-hailing to the region. Progress on state-wide legislation and regulation allowing ride-hailing services is still being worked through by government but the work is expected to be completed this year (Vancouver Sun 2019). The City of Vancouver and TransLink are both expecting the arrival of ride-hailing services.

Reports from council staff indicate concerns that ride-hailing could reverse the city's trend toward its VKT goals and increase congestion (Zipper 2019). Similarly, there is concern among planners in Vancouver that the presence of ride-hailing services will have a detrimental effect on progress made within the public transport realm in the last several years (Peacocke, pers comm, 28 November 2018; Price 2019).

The City of Vancouver has proposed charging fees to ride-hail companies for each trip, in a form of congestion charging for ride-hailing services only.

10.7 Financial incentives

10.7.1 Congestion pricing report

In May 2018, Metro Vancouver's Mobility Pricing Independent Commission released a report into mobility pricing, in which they discuss:

> *Coordinating some of the ways we pay and paying differently to make it easier for everyone to get around. This is done by using price signals in a way that can manage congestion and encourage the use of different modes of transportation. If done in the right way, it can be fairer and can raise money for investment in the transportation system (*Mobility Pricing Independent Commission 2018*).*

The group's objectives were to reduce traffic congestion, promote fairness and support transportation investment.

A series of topics were investigated in their report, with the topics of congestion point charging and distance-based charging chosen for further investigation.

The commission came up with two potential ways to implement congestion charging in Vancouver.

- A regional congestion point charge, with charge points at, or close to, some or all the regionally important crossings, complemented by further point charges at locations within the Burrard Peninsula.
- A distance-based charge with two or more zones with varying charge rates throughout Metro Vancouver (Mobility Pricing Independent Commission 2018).

Further research is being conducted into the possibility of implementing these options. It is expected that a congestion charge will be introduced to Vancouver at some point and would be the most significant next step for demand management in Vancouver (Peacocke 2018). Congestion charging, however, is considered politically difficult to implement and, in other jurisdictions, alternatives are being considered.

10.8 Outreach and implementation programmes

10.8.1 TravelSmart

The wider Vancouver region has a dedicated TDM programme, called TravelSmart. The programme falls under the leadership of the regional public transport authority, TransLink. As outlined previously TransLink is responsible for operating the region's public transport services, including in the City of Vancouver.

The TravelSmart programme was originally developed under the 1993 GVRD Transportation 2021 plan. It was initially started in 1996 as an internal programme called the Employee Trip Reduction Programme (for employers). It was later expanded to the whole region as the Go Green Choices programme, which then changed to the OnBoard programme in 2002. Since 2009, the programme has been called TravelSmart.

Under the Employee Trip Reduction programme, the key incentive was a discount of 15% on public transport passes. The programme eliminated a 60% parking subsidy that had been available to employees of the City of Vancouver and then used this as a blueprint for private employers - removing an incentive for employees to drive. The programme also used a carpool ride-matching programme and parking incentives for carpooling were introduced. A full-time coordinator was employed for the Employee Trip Reduction programme and promotional activities were undertaken (D Lewin, Senior TravelSmart Specialist, TransLink, pers comm, 23 January 2019).

When the programme was expanded regionally as OnBoard, the key initiative was also a discounted public transport employer pass. It was facilitated through payroll reductions and pass holders could take up to five family members on public transport on Sundays and holidays at no extra charge. Additionally, funding was provided for a rideshare network and corporate carshare programmes. The remainder of the OnBoard programme was based on encouragement of active transport and telecommuting, including information packages, face-to-face interviews, advertising in business papers, and advertising in elevators, billboards on highways and banners in train stations.

The OnBoard programme Employer Pass ended in January 2014 following a review of all fares offered by TransLink. It was determined that the programme was no longer fair on other riders. TransLink stated that public transport use had increased by 84% from 1994 to 2014, and therefore the purpose of the employer pass programme had been fulfilled.

TravelSmart now focuses on target groups, including businesses, schools, new residents and the elderly. The department is made up of six full-time staff, working across all 21 regions in the greater Vancouver area. The department is broken into specialty portfolios, one of which is youth engagement and events (D Lewin, pers comm, 23 January 2019). Success is measured by mode share figures for the region, captured in a five-yearly travel diary as part of the Canadian Census.

10.8.2 Winter Olympics 2010

The Winter Olympics was TravelSmart's biggest success in running a city-wide programme of behaviour change. The programme took four years of planning and the development of an 'integrated game plan', involving changes to the city's streets and the operation of public transport services as if it was rush hour for 12 hours a day. A significant part of the planning was the TravelSmart 2010 challenge, a public awareness campaign challenging the public to reduce car travel by 5% each week for the six weeks leading up to the Olympics.

Businesses were asked to submit their travel plans for the Olympic period to go into a draw to win a six-week 2010 Olympic Games Travel Pass. The businesses which took part were named in full-page newspaper spreads.

Additionally, special Olympic travel passes were available for anyone to purchase, to cover all travel for the duration of the games.

The Vancouver Olympics Organising Committee attributed the mode-shift success of the games to the enhanced public engagement programmes, increased levels of service of public transport, and improved infrastructure, including the trialling of a 1.8 km, two-station tram, and the introduction of an 'Olympic Lane' for official traffic during the games.

The team interpreted the mode-shift message as a sign that Vancouver residents were willing to shift their travel behaviour, but the city needs to provide the right service and infrastructure to allow this to happen.

The Olympic event had a TDM goal of reducing traffic by at least 30% (TravelSmart 2010).

TDM strategies for the Olympics included:

- directly engaging businesses downtown
- outreach to schools and community associations
- general community awareness
- integrated media and communications.

During the Olympics, the city saw increases in all public transport service ridership when compared to a normal weekday. On average this increase was 18%, and on one train line (the Canada Line), the increase was 118% (TravelSmart 2010).

10.8.3 Active transportation promotion and enabling plan

In 2016, the City of Vancouver released its *Active transportation promotion and enabling plan*, outlining two marketing campaigns and seven pilot projects the city will be undertaking to promote cycling and waking in order to help meet the city's *Transportation 2040* targets (City of Vancouver 2016).

Under *Transportation 2040*, the following measures fall under the category of 'promotion and enabling'. They are:

- Develop and implement a programme to promote walking and cycling as fun, practical, and healthy transportation choices, and a normal part of everyday life.
- Produce and regularly update a citywide cycling map, including a digital version.
- Expand and maintain a pedestrian wayfinding system that is consistent, legible and user friendly.
- Educate all road users on the proper use of crosswalks (marked and unmarked), sidewalks, lane crossings, driveways, signals, traffic calming circles, and other infrastructure.
- Develop and implement a long-term strategy to support cycling education and skills development, including identifying partners and potential resource allocations.
- Advocate for making cycling skills training a core part of the school curriculum or widely available to youth through other means.
- Address inconsistencies with established safe riding behaviour

The report pits itself as the other side of the city's vision for walking and cycling, beyond the required changes to infrastructure and land use.

The campaign seeks to find ways for Vancouver to 'establish ourselves as leaders in the field' to promote and enable active transportation. The main goals are marketing cycling and walking.

A series of pilot projects are now being run or developed from this plan. These include active school travel, education, and promotional events

10.8.4 University of British Columbia TDM strategy

The University of British Columbia (UBC) is seen as a strong example of TDM success within the region.

By 1978, traffic problems on the campus had become intolerable and nine surface parking lots around the academic core were built to house the volumes of cars coming to campus every day. In 1997, the Greater Vancouver Regional District (now known as Metro Vancouver) adopted an Official Community Plan by-law policy for UBC, mandating a TDM programme.

Following on from this, the university started its own TDM programme via a Community Plan, a Strategic Transportation Plan and, most significantly, the formation of TREK – the university's Trip Reduction, Research, Education, and Knowledge centre, which implemented a TDM programme for the university.

The goals of the programme were to reduce solo driving by 20% over a five-year period and increase public transport ridership by 20%.

The most successful part of the programme has been the U-Pass, a mandatory pass included in student fees, giving students unlimited access to public transport in Metro Vancouver. The pass has been offered at a rate calculated by TransLink as being cost neutral, while not preventing the agency from making revenue from the addition of new student riders on public transport services.

The cost for students is currently $41 per month, an increase from the original $20 per month when the system was first set up in 2003. In the first year of the U-Pass programme, public transport ridership increased 53% from the previous year, and between 1997 and 2006, public transport trips to the campus increased by 118%. At the same time, single occupant vehicle trips decreased by 12%, and there was a 28% increase in students.

10.9 Key insights

TDM is not named explicitly by the City of Vancouver as policy, but the concept of travel demand management is woven throughout the city's land use and transport planning documents. This approach is believed to encourage a 'TDM lens' on all transport thinking in the city.

Much of the city's transport success is believed to be accounted for by its history of protest against freeways and car-based development, as well as land use development centred around historic tram routes.

Vancouver's TDM approach is predominantly dominated by the city's land use and transport planning guidance: *Transportation 2040.* This document sets clear mode share and vehicle kilometres travelled targets for the city, and has been the driving force behind policy that can be defined as TDM

The city's planners are highly motivated to continue its reputation as a strong transport city.

While the city has met its transport goals so far, the most recently available data (for 2017) showed some small reduction in sustainable mode share. Some of this may be accounted for by changes in survey participants for the city's data collection. The city has only been gathering its own, more comprehensive, travel data for the last five years, so it is important to continue to review this data to determine whether new policies are working.

The 2010 Winter Olympics was a successful TDM behaviour change initiative for the city. Planners have taken this success as a message that the city's residents are willing and able to change their travel behaviour, given the right circumstances.

11 Focus area - Beter Benutten

11.1 Focus area: Beter Benutten Programme

The Beter Benutten (Better Use) programme in the Netherlands was a comprehensive accessibility programme with the goals of reducing congestion and providing an efficient transport network. The first stage of the programme ran from 2011-2014 with the goal of reducing peak congestion by 20% in the busiest regions. A second stage ran from 2014-2017 with the goal of reducing door-to-door travel times by 10% in the busiest regions. This goal was exceeded with an estimated 13% reduction in travel times. The programme ended in 2018; however, the Ministry of Infrastructure and the Environment still has a dedicated group of staff working on a follow up programme which will build on the lessons learned from Beter Benutten.

It has been suggested that the three major innovations offered by the programme are its customised regional packages with national coverage; the regional decision-making mechanisms in which business, and local and regional governments are represented; and the strong emphasis on travellers' behavioural change (Gironés and Vrscaj 2016).

11.2 Background

In early 2010, the Dutch government was considering a road pricing scheme to address congestion in major centres. The government recognised three potential options for addressing congestion and mobility issues:

- pricing
- infrastructure expansion
- optimising use of existing infrastructure.

Pricing options including congestion charges in major cities, a rush hour charge and per-kilometre pricing had been considered starting in the late 1980s, but were dismissed due to a lack of public support (Jongman 2010). With a change of government in 2010, road pricing was no longer considered a viable policy option. Therefore, the focus turned towards optimising use of the existing infrastructure to address congestion and mobility issues. A senior manager within the Ministry of Infrastructure and the Environment was given a budget and the flexibility to experiment and create a programme to optimise use of the existing infrastructure with a TDM focus which became 'Beter Bennuten'.

11.3 Organisational structure and funding

Within the ministry, a discrete project team was established to manage the Beter Benutten programme. They were tasked with creating a framework to guide and evaluate regional project development. Twelve regions were selected as partners for the programme. Within each of the regions there was a governance team comprising the Minister of Infrastructure and the Environment, an elected official from local government such as a governor or mayor, and a CEO of a major employer in the region. This group would typically meet three times per year and set the strategy for the region in line with the central government's goals for the programme.

The central government was responsible for coordinating the programme, collecting and sharing information and lessons learned, and evaluating the programme's measures. At the regional level, there

was a wide range of stakeholders as partners including local and regional government, the national road and water authority, regional business associations, and individual businesses. Each region was responsible for establishing their own organisational/governance structure and these varied. However, there was a programme manager for each region to manage the interventions.

Rens Dautsenberg was part of the Beter Benutten project team at the ministry from 2015–2019. He notes that some regions chose to have a dedicated programme team at a project office. This was generally more successful than having project team members located within their respective agencies or businesses. It meant that regions were able to create their project plans faster and generally deliver better results.

The funding structure was also a collaboration between central and local governments and the private sector. A total of €1.7 billion was invested by the participants with 50% of funding coming from the central government and the remaining 50% a combination of regional government and business (Ministry of Infrastructure and the Environment 2017). For context, the government has committed to investing €88 billion in road infrastructure by 2028. Government funding is often seen as an important way to unlock industry matching funds.

11.4 Programme approach

In each region, congested corridors or 'bottlenecks' were identified and a set of context specific interventions chosen. The programme focused on customisation for each region to be successful. Interventions were classified into three groups: supply, demand and intelligent transport systems and services (ITS)/dynamic traffic management measures.

The programme had four key elements:

1. Problem analysis – A wide group of stakeholders collaborated to identify an accessibility problem and the key target group contributing to it (eg people travelling at rush hour). A behavioural analysis is then undertaken, and programme interventions are designed around the target group.
2. Develop cost-effective solutions – Stakeholders identify innovative and smart measures, centred around the target group to solve accessibility problems. These are then assessed for cost-effectiveness to estimate their impact.
3. Collaboration – Including regional and business partners identifying both accessibility problems and solutions to ensure buy-in. Cooperation with these stakeholders also harnesses their ability to influence traveller behaviour.
4. Monitoring and evaluation – Information is collected on programme cost effectiveness and shared across the regions to identify successful and replicable interventions.

11.5 The toolkit

To capture the lessons learned from the approach, the ministry developed a toolkit known as the 'wegwijs' or 'guide' (Ministry of Infrastructure and the Environment 2019). This provides a knowledge base for project managers seeking to replicate the approach. It is separated into projects under nine programme themes:

1. Behaviour – applying behavioural principles to improve project outcomes
2. ITS – to improve traffic flows, reduce congestion and improve safety

3 Cycling – e-bike promotion and ‘park and bike’ for commuters

4 Avoiding rush hour – off-peak travel rewards

5 Encouraging public transport use – employer-based passes and communication

6 Reducing peak trips on public transport and collaboration with the education sector

7 Parking – capacity and price interventions as well as park and ride

8 Logistics – trip reduction through collaboration with business

9 Integral mobility management architecture – procedures and agreements for public private partnerships to develop rush hour avoidance and cycling promotion ITS projects.

11.6 Strategies

As shown in the toolkit above, there was a wide range of programme themes which encompassed the strategies selected for implementation in each of the different regions. Between 2011 and 2014, 354 projects were implemented across the 12 regions with another 400 implemented between 2014 and 2017. Through collaboration with stakeholders, innovative responses were developed to address accessibility problems. For example, one jurisdiction was facing overcrowding on buses during rush hour. Consultation between schools, the carrier and the local government led to class times being changed. This reduced travel demand by students during peak hour and meant no increase in service was required (Stroeker 2016).

Employer outreach was an important part of the Beter Benutten programme focusing on reducing peak trips by commuters. Approximately 2,100 employers participated in the programme and over 176,000 employees. Two employer networks or TMAs were established: Breikers in Amsterdam and U-15 in the central Netherlands (for more information on TMAs please refer to the focus area of the same name). They focused on sustainable mobility to reduce emissions, increase accessibility and improve the attractiveness of their members to employees. Both networks have remained in operation after the completion of the programme.

Employer strategies included:

- mobility budgets – employees earn money commuting by active modes or public transport and lose money by driving to work
- improving connections between public transport stations and business parks
- e-bike trials and incentive schemes.

Further, 10% of all Beter Benutten projects also focused on logistics to reduce commercial vehicle trips and increase efficiency. In the Brabant region, the railway was electrified between an industrial park and the main line to enable international trains to access the city of Tilburg without transferring cargo to road vehicles. Electrification meant the railway was competitively priced and attractive to businesses.

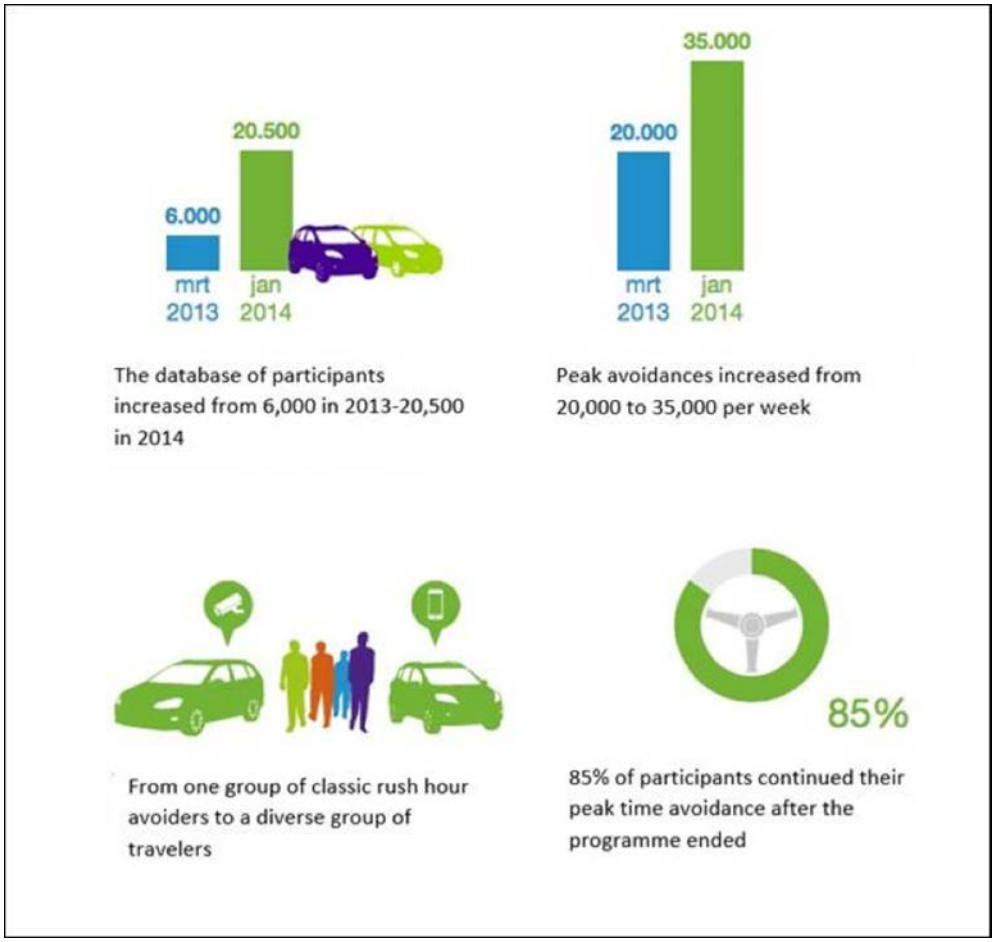
11.7 Programme example – rush hour avoidance

In the Arnhem-Nijmegen region, the ‘SLIM uit de spits’ (SLIM) project shows how an innovative reward system can reduce peak car trips and create durable results (Ministry of Infrastructure and the Environment 2019). The largest rush hour avoidance project in the Netherlands, SLIM has helped commuters avoid an average of 35,000 trips per week.

Motorists who typically drove during rush hour were targeted to avoid making these trips by car for which they were rewarded with loyalty points that could be spent at an online project shop. The project used a free app and website and all participants received weekly feedback about their travel behaviour. This became a multi-year loyalty programme with more than 20,000 participants. Approximately 60% of participants used the app which tracked their travel behaviour.

Within the programme, specific groups were given customised challenges. For example, participants could earn extra points by traveling particularly early or avoiding specific routes with roadworks for a prescribed length of time. Initially, the reward per peak avoidance was set at €4.00 but this was reduced to €0.40. Results indicate that the behaviour change is sustained with 80% to 90% of participants continuing to avoid rush hour trips after the rewards have stopped as shown in figure 11.1 below.

Figure 11.1 Results from the Slim uit de spits programme



11.8 Programme example – cycling promotion

B-Riders was a successful Beter Benutten e-bike cycling promotion project targeting commuters in the Brabant region with approximately 10,000 people participating over five years.

The programme offered three different app-based methods to encourage riders: group one received a financial reward per kilometre cycled; group two received coaching and encouragement by the Online Bicycle Coach app; and, the third group received both a reward and coaching. Results showed that

coaching alone was not sufficient to start people cycling, but it did encourage them to cycle further and more often.

In the first B-riders programme, 2,300 people participated, and an estimated 1,025 peak trips were avoided per workday. A study by the University of Utrecht showed that 'health' (both physical and mental) was the most common reason for joining the programme (Kruijf and Hopmans 2015).

The programme was continued and scaled up as B-Riders 2 and B-Riders 3. In 2017, the programme initiated an employer-based approach with approximately 15 employers across the region joining as partners to promote cycling to their employees. Throughout the three programmes an estimated 1 million car trips have been avoided and approximately 4,100 fewer cars are on the road in the Brabant region every day (Provincie Noord-Brabant 2017). At the end of the Beter Benutten programme in 2018, the B-riders project continued as a commercial operation, taken over by two companies offering slightly different packages, RingRing is open to the public, while employers can participate through GoVelo.

Offering a trial to encourage people to sign onto the programme was seen as one reason for success. The rewards coupled with the online coaching motivated people to join the programme and develop an intrinsic motivation for cycling. One of the additional benefits of the programme was that the provincial government was able to use information gathered from the app to improve cycling infrastructure and to address bottlenecks.

11.9 Measurement and outcomes

Monitoring and evaluation were integral to the Beter Benutten programme as a whole and each of the region's package of interventions was monitored during implementation to track time, funding and outputs and evaluated on conclusion. This allowed the ministry to identify which projects had been most successful and share this knowledge across the regions. While quantitative measures were important for evaluation, the programme also incorporated qualitative measures. In 2015, an online survey of road users was implemented to measure familiarity and satisfaction with Beter Benutten projects with 10,000 respondents.

The Ministry also developed a comprehensive framework for project selection within the regions based on cost effectiveness. While this allowed a systematic approach to project selection, participants felt that it would have been beneficial to have more collaboration with the regions in establishing this framework.

Although emissions reductions were not central to the programme's goals, they are viewed as a positive side effect and were monitored as shown below. Measures implemented as part of Beter Benutten resulted in the following outcomes across the 12 regions:

- 19% reduction of traffic congestion in specific areas during morning and evening rush hour
- 48,000 times per average working day that the rush hour commute was avoided
- traffic lights optimised
- traffic management schemes introduced
- 17,000 new bike parking lots
- five multimodal travel information services created
- reduction of more than 70,000 tonnes of CO2 annually
- reduction of 150 tons of NOx annually.

11.10 Key insights

Combining supply and demand elements was seen to have a positive effect on project outcomes, for example, the use of newly constructed bike paths was much higher when businesses encouraged employees to use them.

Collaboration between the different partners was also seen as an important factor. This was particularly relevant for the Netherlands as a densely populated country with a large number of municipal governments responsible for planning. The regional approach meant that measures could be implemented across municipal boundaries to support TDM goals.

Applying behavioural principles to the interventions was seen as a key element of success. The first step was identifying and analysing the target group for an intervention. By understanding a target group's motivations, programmes could be tailored for success. Projects where behavioural principles were applied avoided nearly twice as many rush-hour trips per participant than those without. Key behavioural principles contributing to success included the use of social influence and trial programmes for projects. Internal evaluation showed that where a trial programme was implemented, projects were likely to reduce almost twice as many rush-hour trips while the effect of programmes using social influence techniques was estimated to be 1.5 times greater than those without.

12 Focus area – persuasive technologies

12.1 Description

There are several real-world concepts in the application of technologies and smart city demonstrations to achieve sustainable development, including managing transport and travel demand objectives. This includes making better use of network capacity, variable road pricing, peak/off peak public transport pricing, parking management and pricing, real-time information, dynamic way finding and expanded modal choices enabled by technologies (shared services etc).

This focus area discusses various examples of the use of persuasive technologies to incentivise travel behaviours.

There are limited details on some applications especially in terms of performance reviews and longitudinal evaluations of effectiveness due to their recent development. The purpose of including these applications is to highlight the greater reach and personalisation of nudging to effect behaviour changes, enabled by new and emerging technologies. Consequently, only some general insights from the literature are provided rather than detailed evaluations of particular initiatives.

12.1.1 Nudging and persuasive technologies

Thaler and Sunstein (2008) define the term nudge as ‘any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives’. More recently, Andersen et al (2018) define nudging as a way of ‘influencing decisions and behaviour using suggestions, positive reinforcement and other non-coercive means, so as to achieve socially desirable outcomes’.

The advantage of nudges is they are simple to deploy and their costs in reaching greater numbers of the population are comparatively low (especially now enabled by technologies). They do not force people to make choices they do not want to make, but also do not assume that people should be left to make their own choices free of outside intervention. Persuasive strategies, built on the principles of nudging, include:

- self-monitoring – individual challenges, personalised information and messaging and goal setting to provide capability and motivation
- social comparison – peer pressure/team encouragement to provide motivation
- gamification – social comparison via leader boards, points for credit, peer challenges and rewards to incentivise desired travel behaviours and choices.

12.1.1.1 Apps for feedback and self-monitoring

TDM programmes commonly provide information, journey planning, coaching and personalised feedback to reinforce behaviours. These aim to raise greater awareness of individuals’ choices on impacts caused by the way they travel. The metrics used are often relatively simple, such as cost, time, calories, distance and carbon footprint. Technology now enables personal coaching online and instant feedback, reinforcement and peer comparisons.

There currently exists a range of walking and cycling ‘apps’ such as Strava (and supporting devices such as FitBit and Smart Watches) that assist users to set their own targets for travel, such as calories burned and distance cycled, and help users to achieve them through tips and monitoring.

These applications and devices can also effect ‘persuasion’ by encouragement and competition. Others have progressed the idea further by asking participants to collect data, for example San Francisco’s CycleTracks app (San Francisco County Transportation Authority 2019). The city can then monitor and use this information to make improvements for cyclists etc.

12.1.2 Social networking and peer persuasion

Facilitating connections into, and awareness of, social networks and social messaging are fundamental features of the smartphone app ecosystem, whether transportation focused or otherwise.

Examples of transportation apps which encourage behaviours via status-seeking competitions such as leader points or team-based challenges to drive change, or simply via crowd sourced alerts about travel conditions and peer-to-peer recommendations of best routes to travel, are provided below.

- Moovit is a real-time journey planner mobile and web app, developed in Israel and available in 2,900 cities across 92 countries, including six cities in New Zealand (Moovit 2019). The application differs from traditional public transport applications as it is community driven and integrates official public transport data from operators with real-time data collected from users via crowdsourcing. Traffic conditions, satisfaction with public transport drivers etc are then shared with the user community.
- Transit App is a journey planning app developed in Montreal, Canada and available in more than 200 cities worldwide, including seven in New Zealand (Transit App 2019). It now features crowdsourced data which allows public transport passengers to report service issues to one another and directly to a public transport agency. Transit app is currently testing this feature in Pittsburgh (PA). Other features include departure alarms, stop announcements, push notifications for service alerts, public transport and bikeshare integration, and real-time trip planning.
- Kowo is a business-based app that companies can use to encourage employees to motivate and organise carpooling. It is based in Belgium and not currently active in New Zealand. Focused on improving commuting in an ‘ecological, economic and stress-free way’, Kowo allows employees to connect with each another in their area and manage carpooling itineraries and rotas. Other benefits of the app include an emission saving calculator, real-time driver tracking and cost-saving analysis.
- Bike Angels are Citi Bike (a bikeshare scheme in New York City) riders who improve the availability of bikes and docks for fellow riders and earn rewards in the form of points which can then translate to bike share discounts, gift cards or physical money. Angels earn points for taking bikes from crowded stations expected to soon become empty. The more crowded the initial pickup station and the emptier the final drop off station, the larger the point payoff. There is a leader board where angels can keep track of their progress compared to other angels.
- Hytch rewards is a free app available in the United States that helps people track shared rides with their contacts, earning ‘trees saved’ whenever they carpool, rideshare, or use public transport. People who live in sponsored areas or work for an employee sponsor can also earn cash rewards for each qualifying mile shared and tracked using Hytch rewards.
- Cycle Atlanta is an app assisting with the planning and maintenance of cycle paths by using a phone’s GPS to record routes in real time, allowing the City of Atlanta, Georgia, United States to know which routes cyclists prefer. The app also allows users to report problems along their route such as potholes, obstructed bike lanes etc.

12.1.3 Gamification – rewards and points

Gamification is the 'use of game design elements in non-game contexts'. Participants become 'players' who can win individual or group rewards if they adjust their behaviour via the use of competition as the persuasive nudge. A user might receive points or rewards for sustainable transport behaviours, such as using public transport instead of driving alone or 'riding to work' one day etc. By employing these techniques, gamification uses the social aspects of competition, achievement, and status to encourage players to compete (Anagnostopoulou et al 2018).

Some research has been undertaken recently on the effectiveness of these types of initiatives for facilitating behaviour change in the short and long term, indicating that game-structured campaigns are an effective tool at facilitating behaviour change (Weber et al 2018). The literature also suggests peer pressure and social connectiveness keeps people more engaged and changes behaviours more-so than individual 'incentives' (Gallani 2017).

The effectiveness of rewards is still a subject of debate; rewards can lead to effective results but may be only for a short period of time (Poslad et al 2015).

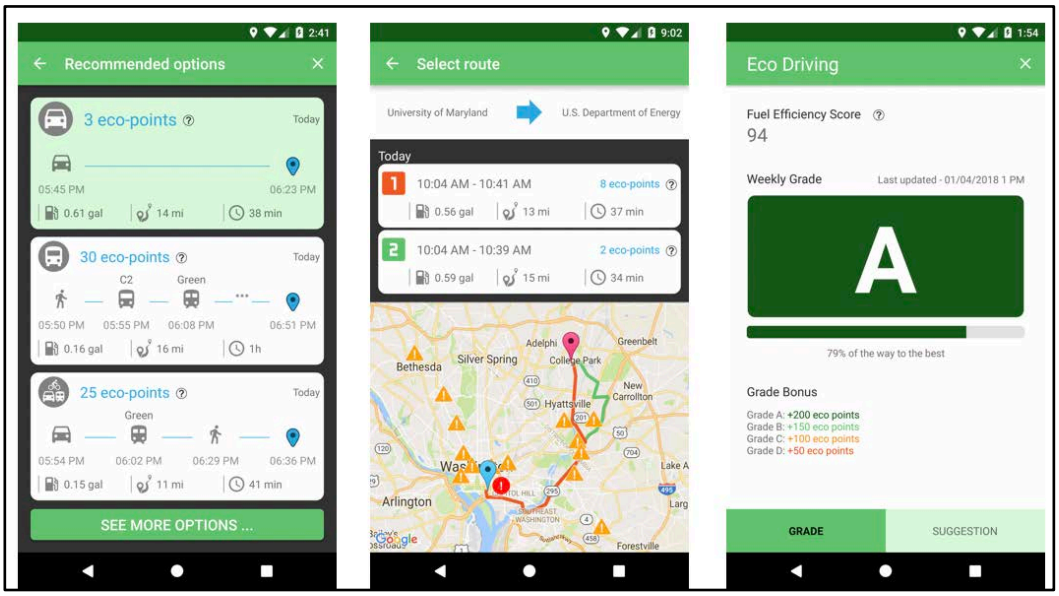
12.2 Examples of persuasive technology applications for TDM

12.2.1 United States – IncenTrip

IncenTrip is part of a current $4.5 million research project funded by the US Department of Energy, the National Science Foundation and the US Department of Transportation's Federal Highway Administration to predict traffic and reduce congestion. Currently being piloted in Washington DC and Baltimore, it turns the commuting experience into a game. Around 35,000 app users earn reward points for sharing their location and travel information while receiving recommendations on the best travel mode, departure time and/or route recommendations. It incentivises users to adopt sustainable travel behaviours. Points may be exchanged for public transport credits, bikeshare and Uber rides, gift cards, charity donations, or cash.

Société de transport de Montréal (STM) Quebec set a target to increase passenger volume 40% by 2020. In 2013, it launched a pilot loyalty scheme also using IncenTrip to attract new customers, provide added value for existing customers, and increase the frequency of public transport use and transform the user experience. By registering with the STM Merci app, holders of an STM OPUS card receive special cultural, sporting, and entertainment event offers via alerts to their mobile phones.More than 240 partners offered a variety of goods and services. An example from the app is shown below in figure 12.1.

Figure 12.1 An image of the IncenTrip interface (incenTrip 2018)



Interestingly, STM Quebec has moved away from the use of the app. However, public transport card holders can now redeem special offers such as retail discounts, event tickets etc via the public transport agency's website. This is discussed further in section 12.2.5 below.

12.2.2 UK – Beat the Street (active travel)

While this initiative is largely based on active travel for health objectives, it is an example of a local community-based programme that can potentially encourage people to undertake more walking and cycling to complete their travel requirements rather than rely on the use of the private vehicle – thus achieving key objectives of managing travel demands and promoting healthy and sustainable travel behaviours.

The Beat the Street initiative is a 12-month community active travel scheme managed by Intelligent Health conducted in a number of towns in the UK. The initiative turns the whole town into a game where people earn points as they walk and cycle around town. In 2016, more than 300,000 people in Reading participated in this initiative.

Beat the Street initially targeted children's physical activity and was designed to encourage participants to walk and cycle in their neighbourhoods by linking walk-tracing technology to a reward scheme.

Rather than use mobile phones, they use radio frequency identification systems with electronic sensors which encourage public recognition of behaviours. Participants receive immediate confirmation of their 'reward' by a signal of flashing lights and buzzing.

In the game, participants need to 'tag-on' to these readers to record that they have undertaken travel at specific places, at specific times. Participants are awarded a point each time they tag-on. Reward points are competed for by the groups or teams and/or individuals. For example, schools win vouchers for sports equipment, books or crafts. Community teams receive vouchers for sports and fitness equipment.

Intelligent Health (2017) reports:

> *On average, across all Beat the Street projects, the proportion of people meeting the physical activity guidelines increased from 40% to 50%. In 2015, 1 out of every 7 adults said*

> *they were inactive at the start of Beat the Street. By the end of Beat the Street, 78% of these people reported that they had become more active. After about 6 months, we estimate that about half of the people who became more active continued to be more active.*

There also appear to be good returns on investment from these Beat the Street initiatives. Evaluations using the National Institute for Health and Care Excellence (NICE) investment calculator for physical activity, and actual project costs, have resulted in the following return on investment (ROI):

- In 2017 Beat the Streets Milton Keyes reported a ROI within two years. Every pound spent on the campaign equated to £13.08 in health benefits and £3.28 in transport cost savings (Intelligent Health 2017).
- In 2014 Beat the Streets, Thurrock reported a ROI within two years. Every pound spent on the campaign equated to £19.63 in health benefits and £4.76 in transport cost savings (Mott MacDonald nd).

12.2.3 TripZoom – Enschede, Gothenburg, Leeds

The TripZoom platform was used in three European cities as part of a European Commission research and innovation project to identify mobility behavioural patterns of citizens and reward gamified personalised mobility solutions that improve CO2 emissions, and travellers' health and travel times. The cities were Enschede (The Netherlands), Gothenburg (Sweden) and Leeds (UK), with the project commencing in 2013.

The research focused on ascertaining whether travel behaviour could be influenced by personalised nudging, ie by providing incentives that match their motivations and preferences in the right place and at the right time.

Interestingly, around one-quarter of the respondents indicated they were willing to commute after peak hours, ie only a minority had a predisposition to reducing congestion. The project anticipated better outcomes at the commencement of the Living Lab trials, as evident in the initial research briefings (Sunset Project nd). Toward the end of the trials, the researchers reported:

> *The main conclusion concerning the outcome of experiments to evaluate the use of a challenge and rewards type incentive is that travellers have the potential to change behaviour, but this needs to be individualised and context-based. The level and use of non-tangible rewards does not seem to influence users much to shift their behaviour to act greener. The level of personalisation is an important characteristic for the effectiveness of an incentive. It is feasible to make car drivers change their departure time. It is hard to induce car drivers to change to public transport. It is feasible to induce public transport users to change to cycling. Social network concepts are rated best when these provide information useful for the individual; sharing information and experiences does not seem to contribute to shifting travel behaviour.* (Poslad et al 2015)

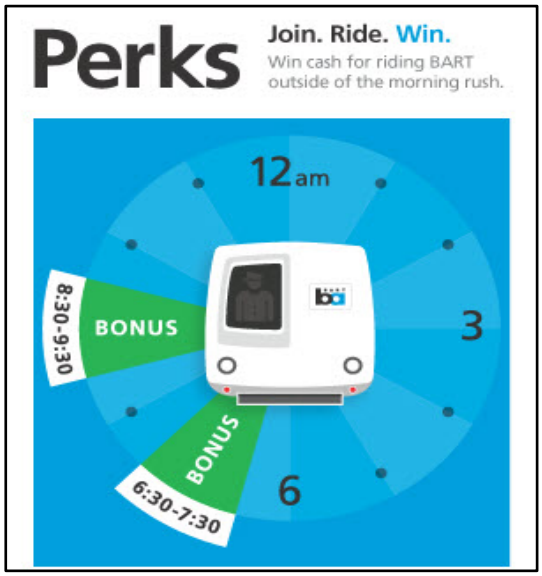
It should be noted that a range of incentives were used for these trials. Along with non-tangible rewards such as avoiding congestion by delaying their departure time, other incentives included tangible rewards such as food, which appeared to be more successful even if the food was never collected.

12.2.4 San Francisco – BART perks

In the San Francisco Bay Area BART offered rewards to commuters who shifted their morning commutes away from the peak rush. The incentive model was based on the Singapore rewards scheme (section

8.8.1). The six-month trial programme concluded in February 2017 (example of the trial promotion is shown in figure 12.2 below) with mixed results.

Figure 12.2 Example of the BART Perks Trial Promotion (Railway Pro 2016)



Around 18,000 people participated in the BART Perks initiative, earning points whenever they rode the train that could be exchanged for cash. In effect, participants took home only an average of $3 a month. However, only 10% of the participants switched to avoid the peak rush period – which was the whole purpose of the scheme.

> *To achieve even greater levels of rider shifting,* the agency adds, *future travel incentives programs for BART would need to be designed to better target individuals who are frequent riders during the busiest periods on the transit system.*

Reported reasons for the lacklustre outcomes included complicated conditions of the game and quite minimal payouts.

Reports also recommended that the risks in partnering with a start-up company be considered. The Perks platform was developed by a local Bay Area technology start-up. When a start-up is successful, it is common for it to be acquired by a larger company. This was the case with Perks, and the parent company decided not to continue to provide the platform as a service moving forward. When start-ups are not successful, there is also a risk that they could dissolve and thus can no longer provide services.

12.2.5 Montreal's Merci

In 2013, the Société de transport de Montréal (STM) established a mobile app-based loyalty programme, Merci, built with SAP. The aim of the mobile app was to alert individual riders of immediate delays or other issues on their usual routes, using geo-location tools. It can also offer an alternative means of transport, for example using the metro instead of a bus, or recommend the best times to arrive at a bus station to get a seat on the next bus. Merci rewards users via the earning of virtual trees instead of points to highlight the agency's environmental objective and provide what it considers as 'instant gratification'.

STM partners with local retailers and entertainment entities to increase the value to customers. Offers from approximately 1,300 partners are pushed to riders, and individuals can also search for relevant offers. Rewards are based on individual public transport usage. For example, while a light user might get a 20% discount, someone who uses public transport more often will receive a two-for-one offer.

STM reported that 24% of Merci participants increased their use of public transport during the six-month pilot. It is interesting though, that the scheme (and app) was discontinued and only a journey planner app is now in play (Montransit). One of the challenges that STM had to overcome revolved around Quebec's strict privacy laws and this is probably the key reason why it now simply links 'special offers' to users of STM's public transport card.

12.3 Key insights

Technology will assist in extending the reach and frequency of behaviour incentivisation campaign components as well as facilitating better targeting, in real time, and personalisation of incentives. The strength of the technology appears to lie in the fact that it can be personalised to the needs of each user. Developments from other industries, in particular the entertainment industries use of pay-as-you-go methods, such as Netflix or Spotify, may provide examples for the transport industry to learn from.

Incentivisation schemes are only successful if the infrastructure is in place to support change.

Infrastructure for the alternative transport modes does not need to be new or necessarily improved, as long as it is available, reliable and easy to access.

Personalised persuasive approaches can be more successful than 'one size fits all' approaches.

Contextualisation is important – provide the right information at the right time and location, and not too many nudges that may put off the participant. This should involve co-design with users and consideration of how to identify value. Research indicates that the more personalised something can be, the more likely it is to be adopted.

Longer-term studies/trials are needed to evaluate the impacts on sustained behaviour change. The greater granularity of data and data mining enabled by ICTs should provide more detailed insights – via 'revealed preferences' in real time rather than relying on stated preference sample surveys. More research is also required on impacts on different travellers' profiles as currently the studies tend to suggest that short-term temporary behaviour changes are easier to achieve than longer-term sustained and meaningful shifts.

The new mobile apps can be both a loyalty and marketing platform. If apps can track a person's location, they can relay offers that are location specific. Some people might find this useful, but others may find the push notifications intrusive.

There are some key challenges to overcome in the deployment of technology solutions to TDM, including:

- Security – personal and corporate (proprietary data) concerns. Protecting data, while still enabling information sharing with other apps and services is a continual challenge confronting developers. Industry-wide security standards, data sharing practices, and common computer languages may assist in addressing this challenge. Increasing public awareness is also important so that people understand the benefits and risks associated with sharing their personal information
- Open data and standardised data – open data is important for aggregation and shaping behaviours. There is a need to find incentives for companies to share data either voluntarily or through legislation. The standardisation of data is also vital to providing integrated and aggregated services, and inter-operability between systems. This is challenging in the context of data sharing between governmental organisations and the private sector.

13 Focus area – urban logistics

13.1 Introduction

Cities are increasingly seeking to apply TDM principles in the area of urban logistics to meet congestion reduction, and environmental and liveability goals. Worldwide, logistics vehicles account for roughly 6% to 18% of traffic in cities (Ros-McDonell et al 2018).

They also account for a major source of energy use and CO2 emissions, and pose challenges in dense environments with heavy competition for scarce street and kerbside space.

Accommodating urban logistics vehicles (both for service provision, such as waste management, and for deliveries) is becoming increasingly challenging for cities. The rise of e-commerce has increased the quantity of goods being delivered, and this trend is expected to continue. Changing consumer expectations also require more just-in-time deliveries and shorter delivery time windows. The need to accommodate just-in-time deliveries can make it more difficult for delivery vehicles to maximise capacity per trip. This is particularly true in urban areas, where delivery vehicles are rarely full.

While demand management has typically focused on personal trips, similar principles can be applied to the efficient movement of goods, through better use of existing services and infrastructure and a shift to more sustainable modes. This can help cities achieve broader environmental, congestion and liveability goals.

13.2 Tools for policy makers

Cities are employing a range of tools to manage negative impacts from urban logistics vehicles. Table 13.1 identifies some of the key strategies being implemented and the TDM goals that they support. The subsequent section will provide an overview of how some of these strategies have been implemented and their project outcomes.

Because of the commercial nature of urban logistics, demand management strategies can require significant stakeholder engagement with the private sector. The relevant stakeholders include shipping firms, operators (drivers), and receiving businesses. However, given the right public sector support and incentives, many private sector stakeholders are willing to engage in demand management strategies, recognising the benefits of cost saving and efficient distribution.

Table 13.1 Urban logistics demand management strategies (adapted from (Browne et al 2012; Ambrosino 2015; Barbosa et al 2017)

Possible TDM goal	Category of initiative	Example initiative
Congestion/VKT reduction	Consolidation	Urban consolidation centres
	Street infrastructure	Third party warehouses
	Access restriction measures	Reserved lanes
		Limited traffic zone
		Time window and off-peak deliveries
		Automated access control system
Per capita vehicle travel reduction	Pricing	Congestion charging
		Parking management systems

Possible TDM goal	Category of initiative	Example initiative
Health, safety, and environmental improvements and emissions reductions.	Access restriction measures Vehicle technology promotion	Low emissions zone Limited access based on vehicle type Vehicle weight and type restrictions Public usage or procurement of low or zero emission vehicles, including electric vehicles or cargo-bikes

13.3 Urban logistics demand management strategies

Cities are increasingly implementing the strategies outlined in table 13.1 to manage urban logistics demand. Some emerging strategies are reviewed in more depth in this section, including freight consolidation, the use of cargo bikes, retiming deliveries to off-hours, delivery lockers and new apps to manage delivery infrastructure. The section also includes an overview of London's (2019a) Freight and Servicing Action Plan which offers an example of how these strategies, and others, can be incorporated into planning processes.

13.3.1 Urban consolidation centres

As delivery vehicles account for a relatively high share of urban congestion, cities are investigating methods to reduce goods vehicle traffic, particularly in high traffic areas. The use of urban consolidation centres (UCCs) aims to reduce delivery vehicle traffic in busy urban areas and other sites, like airports. A UCC is a logistics facility near the site or urban area. Large vehicles with high load factors can drop off goods at consolidation centres, where they are distributed to smaller vehicles to more efficiently complete the 'last-mile' of the delivery journey. This can ensure the last-mile portion of a journey is made using a vehicle more appropriate for a specific place (Allen et al 2012).

UCCs can lead to significant improvements in load factors (a measure of freight load compared to capacity) and reductions in greenhouse gas emissions. Allen et al (2012) evaluated 114 UCC projects that had been the focus of a feasibility study, trial, or became a fully operational scheme. These projects were across 17 countries worldwide, 12 of which were in the EU. Drawing from 24 evaluation studies, they found UCCs have improved vehicle load factors between the UCC and delivery point by a range of 15% to 100% and reduced greenhouse gas emissions from these transport operations by a range of 25% to 80%. They also found that the centres typically led to a reduction in VKT of between 60% and 80%.

In some cases, UCCs also allowed delivery vehicles to occupy less urban space and for shorter periods of time. In Monaco, a UCC led to a 42% reduction in space used by vehicles for delivery. In Tenjin, delivery times were shortened by 7% due to a UCC (Allen et al 2012).

Allen et al (2012) found the success of a UCC can depend on the degree of influence over goods carriers and receivers from a governing organisation. In other words, UCCs are more successful when used by all deliverers to a site or urban area. They observed that this occurs more easily for UCCs serving construction sites or sites with individual landlords, rather than urban areas. Public transport agencies can implement a variety of restrictions in busy urban areas to encourage the use of a UCC, for example by limiting loading zone times or restricting zones by vehicle type or weight.

While UCCs can effectively reduce negative externalities from delivery vehicles, their sustainability can often rely on government funding. Allen et al (2012) state ‘it is apparent that, without some initial funding from the central or local government to pay for feasibility studies and trials, any form of UCC that is not related to a major new development is unlikely to proceed, let alone succeed’.

UCCs can also have complex implications on costs to freight companies. UCCs have the potential to increase delivery costs by requiring double handling, while the subsequent shorter journey times and increased load factors can reduce costs.

13.3.2 Cargo bikes

Cargo bikes, particularly e-bikes, are increasingly being used for last-mile delivery in cities around the world to address congestion, access and sustainability goals. While there are limitations on the effectiveness of cargo bikes to replace vans due to smaller carrying capacity and range, researchers have noted that they could replace up to 10% of existing van deliveries within a 2 km delivery area (Melo and Baptista 2017).

In a recent webinar, Tom Madrecki, UPS Director of Urban Innovation and Mobility argued that the business model to make cargo bike deliveries work is a more critical innovation than the cargo bike itself (Madrecki 2019). UPS has more than 30 bike logistics pilots worldwide. He highlighted several factors to consider when deciding whether e-cargo bikes are appropriate. These include neighbourhood typology, existing demand for deliveries, traffic and congestion, and transport infrastructure. Delivery density must be high enough that the bike does not need to travel long distances. If the density of deliveries is too high, however, much of a deliverer’s time will be spent within a large building. This negates the advantages of cargo-bikes (quickly navigating between buildings) and potentially makes larger vehicles that can carry more goods more suitable.

In Amsterdam, for example, the city has found that the volume of deliveries made by cargo bike has created safety concerns on existing bike lanes. The city is piloting wider shared bike lanes which can accommodate these larger bikes (N Verveen, Programme Manager - Smart and Sustainable Mobility Rijkswaterstaat West-Nederland Noord, pers comm, 10 April 2019).

Micro-hubs, also called ‘staging areas’, are used to move goods from a larger vehicle to a cargo bike. These stations must be close to delivery areas so they can easily be reached by the cargo bikes. Finding appropriate locations may require coordination between cities and private partners. Cities may also be required to establish legal frameworks to make such stations possible (Madrecki 2019).

The City of Gothenburg in Sweden provides an example of the use of cargo bikes in an urban environment. The city helped launch Stadsleveransen (the City Delivery) run by businesses, real estate owners, and the city, to pool deliveries for shops and businesses within a specified zone in the central city (Widegren 2017).

The programme was developed in three stages, beginning in 2012. It allows delivery carriers to drop goods at a nearby consolidation terminal, from which Stadsleveransen handles last-mile delivery using an electric car or cargo bike. In 2015, over 500 businesses were taking part in the scheme and more than 350 packages were being delivered daily. The programme accounted for the majority of deliveries, and 20% of the goods by volume in the area in which it operated. The programme does highlight that businesses often have complex and varied delivery requirements based on their operating model and this can create challenges when designing urban logistics demand management programmes. Figure 13.1 shows the complexity of delivery needs within the relatively compact area covered by the Stadsleveransen programme. In 2017, the programme won the Swedish Quality Innovation Award in the category of ‘Innovations within the public sector and non-profit organisations’.

Figure 13.1 Business delivery requirements for the Stadsleveransen Programme (Widegren 2017)

Red: Not able to receive goods before 10:00 A.M.
Yellow: Limited possibilities to receive goods before 10:00 A.M.
Green: Receives the majority of the goods before 10:00 A.M. In general dedicated personnel and space for goods reception, handling and storage
White: Handling of food and perishable goods. Not relevant at present.

In the New Zealand context, current e-bike regulations may impact on the growth of this mode. In most jurisdictions, e-bikes are governed by a speed restriction. In New Zealand, there is no speed restriction in the regulations, rather a power restriction; 'power assisted cycles' must not exceed a power output of 300 W (NZ Department of Internal Affairs nd). Most e-cargo bikes designed for commercial delivery currently have a power rating of 250 W to comply with EU law and would therefore comply with existing New Zealand regulations.

However, given New Zealand's hilly terrain and the higher load capacities for cargo bikes, this may not provide adequate power for commercial e-cargo bikes. A research report on 'low power vehicle' regulations undertaken for the NZ Transport Agency found that, for cargo e-bikes specifically, there may be a need to increase the maximum allowable power output. For example, a 500 W power output would allow a fully loaded cargo bike reasonable ability to negotiate New Zealand's hilly terrain such as the Port Hills in Christchurch (Lieswyn et al 2017).

13.3.3 Shifting deliveries off-hours

TDM strategies have historically included efforts to shift travel times to avoid peak congested times. For freight and logistics, this translates into shifting deliveries to times when infrastructure is underutilised, notably evening, overnight, or early morning. The off-hours time frame can vary, but typically covers from 7 pm to 6 am. While some cities have attempted to move freight distribution off-peak through strategies such as congestion pricing and traffic restrictions, research shows the most effective method to date is the use of specifically tailored programmes led by the public sector (Sanchez-Diaz et al 2016).

In 2009, New York City implemented an 'Off-Hour Truck Delivery Pilot Programme' (Holguin-Veras et al 2010). The project focused on urban deliveries, estimated to comprise 80% of urban freight traffic. Twenty-five business partners and eight carriers shifted their distribution networks off-peak for a month. Receivers were each given US$2,000 on completion of the pilot and carriers were given US$300 for each truck participating. This was funded by the US Department of Transportation at US$1.2 million, with project partners contributing US$640,000 in matching funds. The goals of the project were to:

- shift truck traffic off-peak (potential for up to 20% of local daytime truck traffic)
- improve congestion and environmental conditions

- increase the competitiveness of New York City for businesses via tax deductions to local businesses, productivity increases from improved traffic conditions, and significant reductions in parking fines (frequently exceeding US$1,000 per month).

The project used GPS-enabled mobile phones to track and predict travel times and delays, calculate and verify rewards, and facilitate data sharing among participants. Results showed improved travel times for deliveries occurring off-peak and feedback received from companies was generally positive. Reported benefits for receivers included more productive staff with less time spent on deliveries during opening hours, and reduced wait time for deliveries. Benefits to carriers included faster delivery times, lower fuel costs, and savings generated by fewer parking tickets from double parking.

The success of the pilot led New York City to implement a permanent programme to move deliveries off-hours (between 7 pm and 6 am) in areas with a high volume of pedestrian traffic and limited kerb space. The city has also developed toolkits for receivers and carriers on how to make the move to retiming deliveries as well as a guide to noise mitigation (New York City 2019).

13.3.4 Delivery lockers

Delivery lockers are an emerging tool to reduce traffic from delivery vehicles in busy urban areas that may also have several benefits for customers. Delivery lockers facilitate reliable parcel storage, off-peak deliveries, and convenient pick-up for customers. Several thousand have been implemented globally, but most are operated by, and often restricted to, individual delivery companies as opposed to common carrier locker systems (CCLS). In Auckland, New Zealand Post has set up ‘ParcelPod’ delivery lockers in Albany, Botany, Newmarket, and on Victoria Street in central Auckland, though they can only be serviced by New Zealand Post.

Few CCLS exist, but their early results are encouraging. They can be located in a variety of urban areas such as residential or office towers, convenience stores, public spaces and transport hubs. They allow tenants or residents to use the locker address for online deliveries. Recipients receive an email or text when the delivery arrives, with a code to unlock their locker and retrieve their parcel.

A study of a CCLS in a 62-storey office tower in Seattle, US, found the locker reduced delivery vehicle dwell time by 78%, as deliverers could stop at a single location rather than travel to multiple floors. In the 10 days before and after the locker was implemented, failed deliveries fell from seven to zero.

13.3.5 App-based and load share technologies

Though still in early stages, technology applications are also supporting emerging solutions to more efficiently manage kerbside infrastructure. MobileDOCK, for example, enables loading dock sharing, scheduling and monitoring. It lets carriers book appointments through the website or mobile application. MobileDOCK has facilitated more than two million appointments in recent years in Melbourne and Sydney (Anon 2019c).

PARKUNLOAD is a Barcelona-based company that integrates smart street signs with a mobile application to regulate restricted parking spaces and loading zones. Upon parking, drivers open the app to receive the current price and maximum parking time, which can vary based on time of day, space location and vehicle type. The app provides cities with data on kerbside use and allows them to flexibly manage kerb infrastructure (Anon 2019a).

FreightShare Lab is a research project in the United Kingdom which aims to reduce emissions through more efficient asset utilisation. Many companies already utilise routing and scheduling software to reduce the number of kilometres trucks spend travelling empty. The FreightShare project is building a platform to

enable collaboration across companies, to reduce this even further by combining loads and destinations across companies and regions (Anon 2018).

13.4 London Freight and Servicing Action Plan summary

TfL recently released a new Freight and Servicing Action Plan (the Freight Plan) that incorporates many of the strategies discussed in the preceding sections (Transport for London 2019). This plan grew from public-private collaboration to manage freight movement during the 2012 Olympics – one of the major triggers for TDM planning in the city. After the event, industry leaders were the driving force to continue the collaboration to manage freight and service demand. Freight management is seen as one of the TDM efforts that has had the most durable impact (Sheffield 2019).

The Freight Plan supports the Mayor's Transport Strategy of 80% of trips in London to be made on foot, by cycle, or using public transport by 2041. It sits alongside the walking, cycling, and vision zero and public transport plans. The city is also planning regulatory and pricing incentives to support the transition to the use of ultra-low emission vehicles in London.

Congestion, safety and environmental concerns are some of the key issues prompting the plan. The movements of goods vehicles in London have increased by around 20% since 2010, contributing to poor air quality, congestion and safety issues. Small goods vehicles comprise around one fifth of road traffic in London and about one third in central London during the morning peak. TfL research shows that heavy goods vehicles are involved in 63% of fatal collisions with cyclists and 25% of fatal collisions with pedestrians, despite only making up 4% of the overall mileage driven in the capital.

One of the plan's major goals is to reduce the number of lorries and vans entering central London in the morning peak (7 am to 10 am) by 10% by 2026.

Key initiatives include:

- Delivery and service consolidation. TfL is considering using a planning authority to require the use of preferred suppliers for multi-tenanted buildings.
- Working with property managers of multi-tenanted buildings is a high impact and efficient strategy to achieve consolidation of services and deliveries.
- Delivery lockers in public spaces and transport hubs.
- Area freight management plans will be developed in conjunction with boroughs, local stakeholders and businesses to address context specific concerns.
- Promote cycle freight. For example, the city is partnering with the London Bridge BID to subsidise businesses moving to delivery by cargo bikes with their 'Bikes for Businesses' programme. This will be supported by the national eCargo Bike Grant Fund which covers 20% of the cost of an electric cargo bike (up to £1,000) for interested businesses and non-profits.
- Implementing ultra-low emissions zones in select busy areas for all vehicles.
- Electrification of delivery vehicles. The city's plan for supporting electric transport infrastructure is due in 2019.
- Smart delivery interventions to mitigate the impact of home deliveries for an increasing urban population such as options to bundle deliveries, delivery time windows, and real-time updates.

To support the implementation of the plan, TfL has created efficient freight delivery toolkits to support boroughs in the areas of retiming deliveries, reducing personal deliveries, and waste management. TfL

has also established a ‘Healthy Streets’ business fund to assist Business Improvement Districts’ efforts to reduce their delivery and servicing impact. London’s broader Healthy Streets approach is discussed in more detail in the London case study.

13.5 Key insights

Delivery vehicles account for a significant share of congestion in busy urban areas worldwide. Their use is growing due to the rise in e-commerce and demand for just-in-time deliveries. Cities can employ a wide variety of urban logistics management strategies to meet overall congestion, environmental and liveability goals.

Close coordination between the public sector and a variety of private sector stakeholders is critical to applying demand management strategies to urban logistics. Understanding the complex delivery requirements and decision-making processes of businesses within an urban setting is essential for effective management. For example, coordinated public sector programmes have been shown to be more effective in shifting deliveries off-hours than more blunt instruments such as congestion pricing.

Urban consolidation centres have shown promising results in reducing delivery vehicle traffic near specific sites or in busy urban areas. However, they can require significant public subsidy and present several governance challenges including sourcing available land.

The market share for small sustainable delivery vehicles, such as electric cargo bikes, is quickly growing. This is an opportunity for these emerging solutions to support TDM goals. The public sector can support the growth of this trend through regulatory changes, considering the specific infrastructure needs of these vehicles, and promoting their use.

Innovative delivery management strategies warrant further investigation including delivery lockers, and smart interventions such as options to bundle deliveries, delivery time windows and real-time updates. New technology applications also show promise to more efficiently manage kerbside infrastructure.

The London Freight and Servicing Action Plan provides a promising example of how a city has employed a range of tools to manage urban logistics in support of its congestion, environmental and liveability goals.

14 Focus area – Massachusetts Institute of Technology

14.1 Description

This focus area has been selected to demonstrate a successful workplace behaviour change programme initiated by a major university campus. It also highlights the city's role in influencing the employer's decisions. The introduction of enhanced commuting benefits for the Massachusetts Institute of Technology (MIT's) employees and 'travel blending' approach may be considered a success in effecting a mode shift away from single-occupancy vehicles and to reduce parking demand by close to 10% in its first two years.

Overall this initiative serves as a promising case study for other employers, particularly large campus-based employers (tertiary institutions, airports, business parks etc) to emulate. Figure 14.1 illustrates how successful the programme was estimated to be financially.

Figure 14.1 Estimated financial impact of MIT behaviour change programme. Adapted from Rosenfield (2019)

14.2 Key objectives

The MIT, located in Cambridge, Massachusetts, has a campus population of 22,000 students, faculty and staff.

MIT's overarching goal in implementing TDM programmes was to reduce the amount of land dedicated to parking by providing attractive alternatives to driving, along with improving commuter awareness and incentivising new behaviours. MIT was largely influenced, not just from a desire to avoid the expense of providing more parking space for a growing campus population base, but also strongly by the historic

policies of government at federal and local level. Back in 1973 the Federal Clean Air Act constrained the number of spaces that MIT could provide to no more than 36% of its commuting population. In 1973, the City of Cambridge also enacted a parking freeze (now replaced by a Parking and Transportation Demand Management Program), which prohibited the creation of new parking spaces. Subsequently, Cambridge also modified its zoning code in 2000 in which a limit was placed on the number of parking spaces that institutions could provide without being subject to implementing additional demand management measures.

Environmental sustainability is another core objective of MIT's TDM effort (also strongly influenced by government vision and policies as discussed below). In 2001, MIT's Academic Council approved a comprehensive Environment, Health and Safety Policy that committed MIT to embracing strong environmental stewardship and pollution prevention. In 2006, the new MIT President also initiated a significant 'Walk the Talk' programme to support programmes that reduced energy usage and mitigate the production of the pollutants that cause climate change. This has grown to include significant test bed research and trial collaborations with government and industry (MIT Energy Initiative 2009).

14.3 Local government influence and collaboration

The City of Cambridge has played a significant role in encouraging MIT's TDM efforts. The Cambridge PTDM Ordinance was enacted in 1998 as a tool to manage growth in vehicular traffic and as a response to air quality concerns. It requires small developments with at least five new parking spaces, or large developments with at least 20 new spaces, to take measures to promote alternatives to SOV commuting and negotiate a contract with the city on specific mode share requirements. The PTDM Ordinance requires mitigation by MIT of any increase in net travel demand for employers in excess of allowed parking spaces.

Further, the monitoring and reporting to show whether the SOV mode split commitment has been achieved is a requirement of all plans. This includes annual reports submitted to the city outlining demand measures, employee survey results on travel behaviour including SOV mode share and biennial counts of car and bike parking (Cambridge Community Development Department 2011). The PTDM Ordinance does not mandate specific measures, but rather provides a toolkit outlining options.

MIT has a long history of partnering with government to progress campus and city-wide sustainability issues. A joint Green Ambassadors Programme promotes more sustainable practices at MIT. MIT also serves on the City of Cambridge' Climate Protection Action Committee, Green Building/Zoning Task Force and Climate Congress. MIT is also working with the City of Cambridge to advance a regional programme to support electric vehicle charging infrastructure. MIT also worked with the City of Boston to expand the city's local commercial bikeshare programme and has installed bikeshare stations on campus. The City of Cambridge, Harvard University and MIT founded the Cambridge Compact for a Sustainable Future in 2013 (MIT 2013). The compact is a community partnership now with almost 20 members. Every member signs the compact and agrees to 'work to create broader collaboration among themselves and with other community partners in order to leverage the combined capacities in research, teaching, innovation, entrepreneurship and programme development to create a more healthy, liveable and sustainable Cambridge' (Cambridge Compact nd). The compact held its first educational event, Commuter Benefits Innovation: Collaborating to Expand Employee Choices, in December 2016.

Examples of the City of Cambridge, Harvard University and the MIT collaboration include:

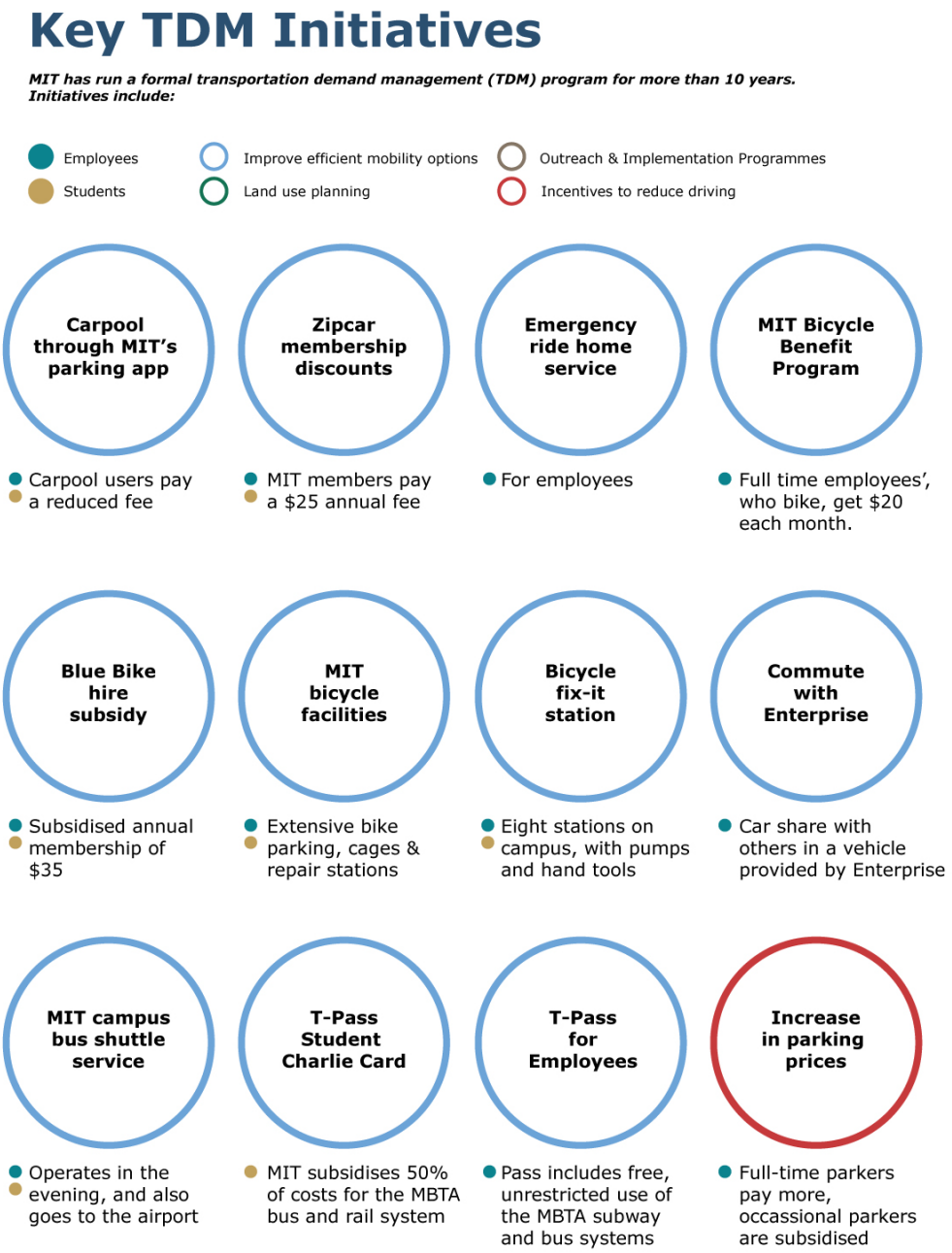
- Representatives from MIT and Harvard serve on a number of city committees including the Cambridge Climate Protection Action Committee, Green Building Task Force, Pedestrian and Bike Committees.

- Government employees are regularly invited to participate at university sustainability events, such as the Walk to Work Breakfast, Harvard Thinks Green (faculty speakers on energy and environment), Green Your Scene events, MIT Efficiency Forward workshops, Earth Day fairs and curricular classes.
- Harvard and MIT are major supporters of the City's hubway bike share scheme. Harvard and MIT support 11 stations in Cambridge and Boston.

14.4 Key TDM initiatives

Figure 14.2 below outlines key TDM initiatives as part of MIT's strategy to change travel behaviour on campus.

Figure 14.2 Significant TDM initiatives in place at MIT. Adapted from Massachusetts Institute of Technology (2016)



14.5 Access MIT programme

The Access MIT programme was launched in 2016 to further reduce parking demand by 10% per year, reduce congestion, increase campus sustainability and reduce single-occupancy vehicle trips to campus. New Access MIT commuter benefits include:

- free, unrestricted use of the MBTA subway and local bus systems for benefits-eligible Cambridge campus MIT faculty and staff with the Access MIT pass (embedded in staff ID)
- in an agreement with the public transport agency, MIT only pays for public transport trips taken, thereby avoiding the expense of monthly passes for non-riders while providing universality of coverage
- a 60% commuter rail subsidy
- a 50% subsidy for parking at MBTA stations, up to $100 per month, for employees
- students continue to receive a 50% subsidy on their monthly Link Pass. Students also now have a Charlie Chip in their ID
- a shift from annual to daily pay-per-day parking plans at MIT gated lots
- integration with existing programmes (carpools, bike benefits etc)
- online commuter dashboard (incentives and gamification)
- rider tools available on the MBTA website, including a journey planner.

These were implemented in addition to the suite of existing commuter benefits including subsidised bike share and carshare memberships, an emergency ride home programme, campus shuttles and others.

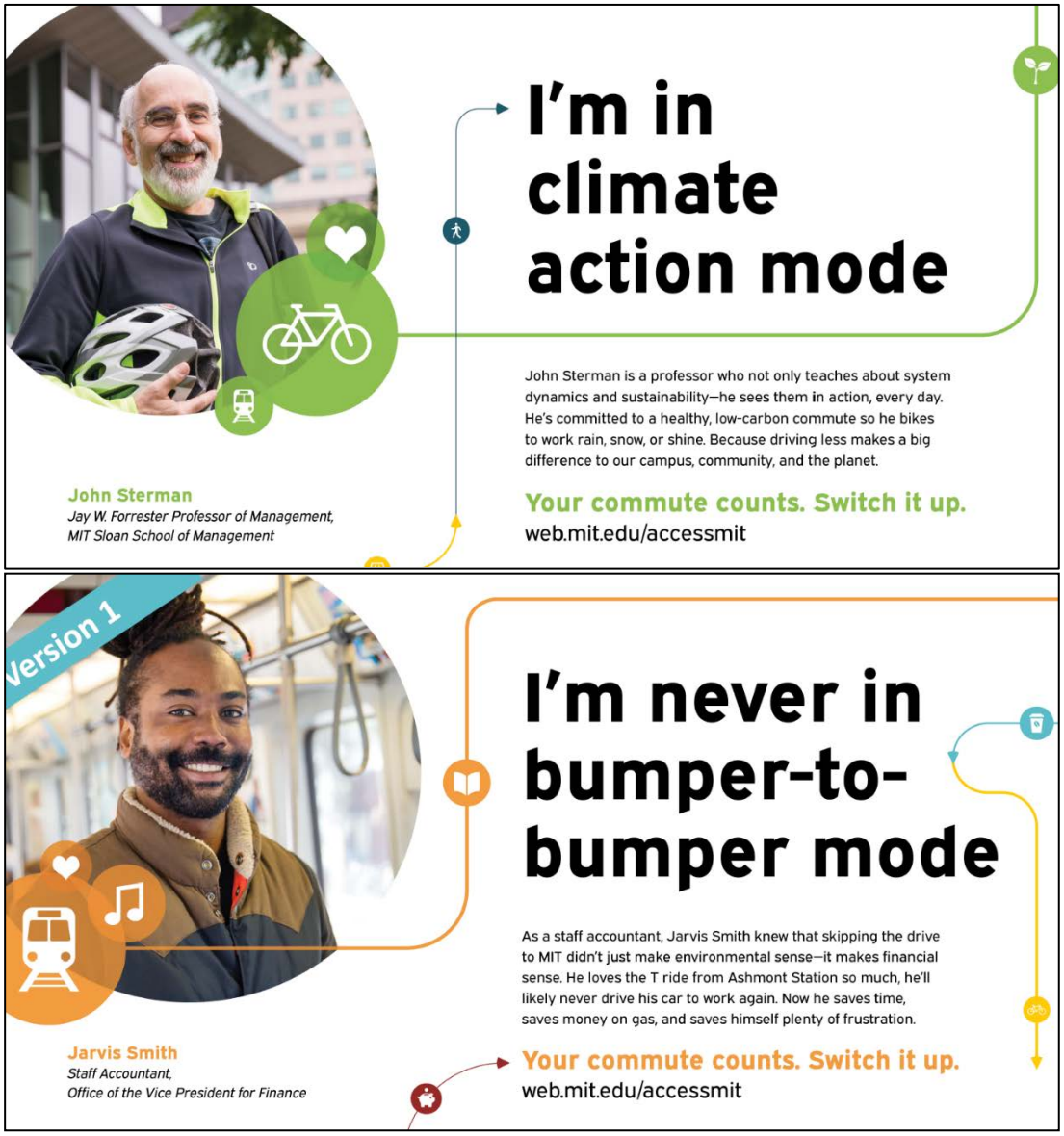
The initial focus was on providing a universal access pass, in collaboration with the public transport agency (MBTA). A key initiative was the shift from voluntary to mandatory participation by employees (previously employees could opt in to the public transport benefits or remain with a subsidised annual parking permit) and a shift from annual unlimited parking to daily parking rates (yet remaining capped to a maximum fee) to encourage staff to be more aware of the cost of their parking choices, to park less and save.

The rationale behind changing from annual to daily parking pricing was primarily to eliminate the ‘sunk cost’ associated with parking. Annual or monthly permits lead to a psychological motivation to ‘get your money’s worth’ out of the parking permit, whereas a daily charge rewards the commuter each day he or she chooses not to drive. That is, daily pricing introduced a non-zero marginal cost. However, the annual cap on fees was introduced in recognition that a number of drivers may not be able or willing to reduce their parking significantly (this may be reconsidered in the future, but MIT was keen to balance TDM objectives with ‘employee satisfaction’ levels). In negotiations to set the 2017–18 parking rates, it was decided that the daily rate would remain fixed at $10, while the cap would increase from $1,760 to $1,900.

14.6 Supporting marketing campaign

An overarching branding and marketing (public awareness and education) campaign was designed – promoting integrated, multimodal transportation options by use of testimonials from employees. The testimonials highlighted quality of life benefits from the choice of their commute. The communications consultancy (43,000 feet) designed a set of verbal and visual guidelines for consistency thereby enhancing reach and frequency of message over the longer term. Figure 14.3 has examples.

Figure 14.3 Examples from the 43,000 feet MIT Marketing Campaign (Young 2019)



14.7 Online commuter dashboard

Another initiative was the development of an *AccessMyCommute* dashboard website, developed by RideAmigos, which featured the following elements (RideAmigos nd). For further information Tucker (2016) outlines the development and implementation of the dashboard in full detail.

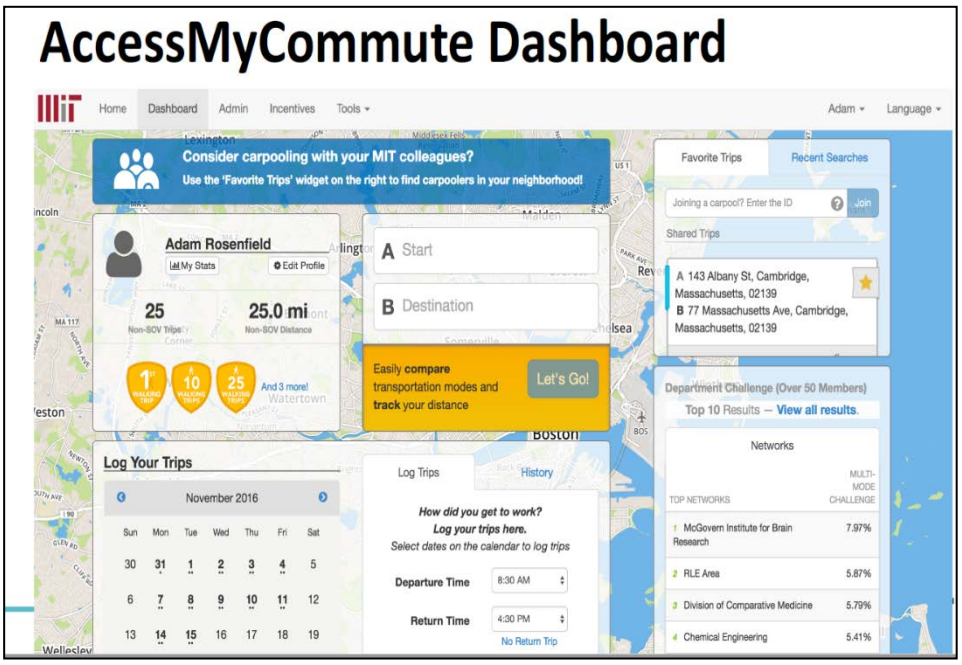
- Multimodal trip planning, cost, directions and carbon emissions associated with different travel modes.
- Carpool matching tool, allowing MIT employees to search for and contact colleagues to form a car-pool (filtering by schedule and driver/passenger preferences).
- Trip logs – automatically populated with public transport trips (through the ID-integrated Charlie Card), driving trips (through the gated lot data interface) and walking or cycling trips (through the Moves app).

- Points-based incentive system for MIT to administer points programmes and competitions to promote its TDM programmes using the travel log as a means for employees to track their trips.

Rosenfield reports the ongoing expense of subscriptions to RideAmigos for the dashboard as a challenge (Rosenfield 2018). While 1,200 users logged on to the Commuting Contest in the spring semester of 2016, the site today only attracts single digit views per day. The incentives campaigns would need to be regularly refreshed to maintain momentum, and this requires coordination and ongoing resourcing.

The surveys also highlighted that the key drivers of travel choice were the public transport, rideshare, and bike subsidies, rather than the dashboard tool, an example of which can be seen in figure 14.4 below, and campaign incentives (MIT 2016).

Figure 14.4 Example of the AccessMyCommute Dashboard (Tucker 2016)



14.8 Programme approach

The programme has largely centred on faculty staff and employees, traditionally provided with a generous benefits package including unlimited parking, but also in recognition that employees were the key segment with a propensity for SOV travel to/from the campus.

A key approach by Access MIT has been to take a 'modal agnostic' approach and, rather than expecting single mode shift (ie driving to public transport), encouraging its population to 'drive alone' on fewer days per week. Rose and Ampt (2001) refer to 'achievable behaviour change' that does not require transformative changes in lifestyle, but rather incremental reductions in car use. They refer to 'travel blending' (the concept behind NRMA's Clean Air 2000 campaign prior to the Sydney Olympics) as: (1) thinking about activities and travel in advance; (2) blending modes; (3) blending activities on a single tour; and (4) making sustainable changes over time.

Many of MIT's most recent initiatives have centred around progressively raising staff and students' awareness of the full cost of their transportation choices. It has retained generous capped annual parking permits but incentivised its employees to reduce the number of days of driving and parking.

14.9 AccessMIT campaign results

Findings show that annual registration for permission to park on a daily basis has decreased by 15% and overall parking transactions have dropped by 10% (Rosenfield 2019). Drive-alone mode share declined from 30% in 2014 to 25% in 2016. It enabled the institute to remove 810 parking spaces.

For drivers, MIT eliminated annual parking permits in favour of daily, pay-as-you-park pricing to encourage multi-modality. The net result was an 8% reduction in parking demand in the first year, at a net cost to MIT of about $200 per employee (Schmitt 2013).

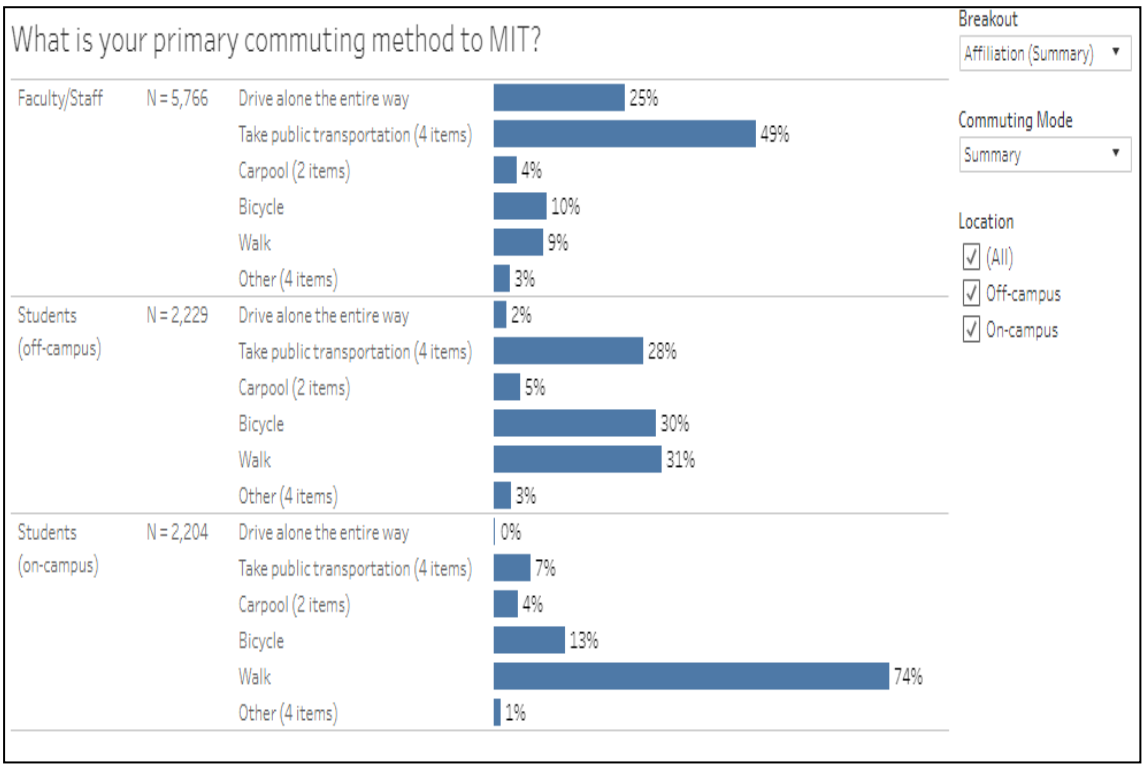
In terms of cost, MIT is estimated to save $1.4 million annually after accounting for the averted capital costs of future parking garages (Rosenfield 2018b).

MIT researchers report that free public transport for employees, subsidised public transport for students, daily parking rates instead of annual, and free parking at train stations have had the most influence on travel behaviours (Brutti et al 2016).

Walking has reduced but MIT transportation staff believe most walkers shifted to cycling or public transport. Those who do drive are now more likely to be occasional drivers, using ridesharing and public transport modes at least one day per week (MIT 2016).

Employee mode choice is measured in the biennial survey (Institutional Research Office of the Provost 2019). Trends indicate a marked decrease in SOV mode share, the first appreciable drop since 2008. Drive-alone mode share has declined from 41% in 2004 to 25% in 2018 as shown in figure 14.5 below.

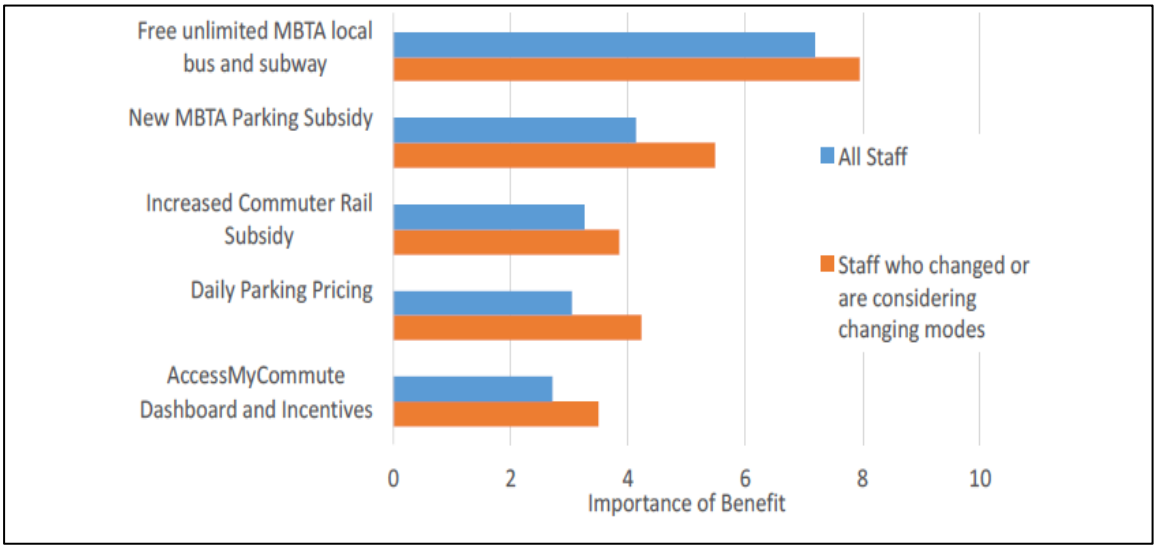
Figure 14.5 Breakdown of primary commuting methods to MIT 2018 (Institutional Research Office of the Provost 2016)



In the biennial survey conducted in 2016, respondents were also asked to rank the five new elements of the programme on a slider from 0 to 10 according to how much each influenced their travel patterns. As

figure 14.6 below highlights, the free public transport pass was by far the most important new benefit, especially among staff who recently switched modes or are currently considering switching modes. The subsidy for parking at MBTA stations for drivers to connect with public transport, as well as the increase in subsidy for commuter rail, were ranked as the next two most important elements, while daily parking pricing was seen as less influential. The online dashboard and incentives were consistently ranked least important.

Figure 14.6 2016 respondents' rankings of the five elements of the AccessMIT programme (Institutional Research Office of the Provost 2016)



14.10 Lessons learned as reported by MIT

MIT noted several campaign challenges and learnings:

- A wide range of stakeholders with varied interests need to be engaged in co-designing and co-creating the campaign.
- The project required a significant financial outlay (public transport subsidies in particular) although it was expected this would be recovered in the longer-term savings of reduced parking requirements.
- It has been challenging to sustain active involvement in the marketing campaign and gamification activities – they noted interest in the dashboard initiative waned significantly after the initial few months.
- Staffing and resources are required to administer the programme.
- Collecting user feedback to find and address shortcomings in programme design is important.
- Long-term success appears dependent on building a constituency of support for such strategies among employer, commuter and government stakeholders. A balancing act is required between:
  - containing the environmental objectives and values of Walk the Talk
  - fulfilling the desire of MIT to be viewed as a benevolent provider for its employees and students
  - providing competitive benefits in excess of the institute's competitors
  - meeting the evident requirement for equality of costs

  - being optional, and
    - increase cost recovery from providing parking, all while –
    - ensuring it is revenue positive in both the short and long term (Block-Schachter 2009).
- Researchers noted that 'nudges' are only as effective as the things people are being nudged towards. For example, nudging commuters toward public transport only works if the public transport system is efficient and reliable (Rosenfield 2018). Public transport subsidies and parking pricing closer to its true costs will lead to greater reductions in car use than gamification.
- Partnerships with local public transport agencies can yield benefits of customised subsidy programmes and/or service provision (MBTA now only charge MIT for public transport trips taken, according to smart ticketing records).
- Integration of mobility options into a single package can ensure that benefits are not perceived to favour a particular mode or geography.
- Regional, state and local policies and partnerships provide important context upon which TDM programmes should be designed.

14.11 Key insights

Universities possess tremendous capability to impact on travel behaviour and modes through travel behaviour change programmes and smart growth policies. These can generate travel benefits for students and staff and are also highly likely to generate substantial positive changes on a university's environmental impacts. Changes also extend beyond the campus. Students learn from their experiences, share their experiences in the wider community, and continue to demonstrate sustainable travel choices beyond their learning days. International students also pass on new learned behaviours to other countries.

Local agencies can also work collaboratively with schools, hospitals and other large institutions to improve public transport services, install new infrastructure like bike lanes, and support bike sharing, ridesharing and carsharing schemes. The practices and principles discussed as part of this focus area are equally applicable to industrial parks, hospital and health campuses, airport precincts and workplaces in general.

The PTDM Ordinance in Cambridge, Massachusetts is an interesting model to review and consider for applicability in other jurisdictions. It requires employers to implement TDM measures to mitigate and ultimately reduce the number of SOV commuters. It also puts in place a framework for mandatory data collection on employee travel behaviour (stated preference surveys as well as revealed data in the form of traffic counts). These datasets are most useful in tracking the effectiveness of workplace-based and regional programmes over time and ensure that TDM initiatives remain grounded in solid evidence.

No one size fits all approach. While MIT's programme has been successful, it should be noted that TDM programmes should be designed in context. A successful programme is one that is tailored to the geographic context, the socio-economic context of its population, the maturity of the private and public transport networks, as well as the administrative structure and culture of the workplace. Geographic context will impact strongly on outcomes. A highly public transport-accessible workplace can pursue the 'stick' of stronger parking management and pricing strategies which are often needed to balance (and fund) the 'carrot' of subsidised public transport. Some universities are also recognising the importance of self-containment to reduce travel demands, with the provision of residential housing, child-care facilities, retail and health services on campus (Rotaris and Danielis 2015).

‘Don’t get distracted by ‘gamification dashboards’ The AccessMyCommute dashboard was initially well-received and was useful in raising awareness and interest. However, the use has not been sustained, and continuation of the expense of maintaining dashboard subscription and management via RideAmigos is possibly difficult to justify.

A blended multi-modal approach. The best opportunities for shifting private vehicle users to public and active modes of transport are encouraging occasional users to become more frequent users not only through pricing incentives/disincentives but also the provision of better reliability, frequency, convenience and customer information relating to public and active transport options.

Behaviour change programmes do not *replace* transportation supply measures (such as new public transport services and stations, pedestrian paths, bicycle lanes and end-of-trip facilities) or land use policies (such as parking zones and ordinances). They *complement* these measures in a cost-effective manner to raise the population’s awareness and understanding, motivation and capability to deliver a holistic solution which leads to more sustainable travel choices. Such programmes cannot replace the provision of alternative transport modes but they can be powerful agents of change to enhance how different modes are accessed and used.

15 Focus area – MaaS

This focus area outlines the latest evidence on whether MaaS can help reduce car ownership and use and increase sustainable transport use. It also explores the public sector's role in supporting MaaS offerings.

MaaS refers to a digital product, typically a smartphone app, which combines transport options from public and private providers into a single platform that facilitates real-time travel planning and payment. Through a subscription or pay-per-use model, customers can access a range of transport services often including several public transport services, carshare and car rental, and bikeshare.

MaaS offerings are generally mode neutral, can incorporate new transport technologies, and can be responsive to a user's personalised mobility preferences. The business model is still evolving and may develop in many forms.

15.1 Could MaaS be a TDM solution?

MaaS may support a city's TDM goals through several mechanisms, including:

- Making multimodal trips more competitive to car transport. MaaS platforms aim to help users more seamlessly plan and book trips using several transport modes, making first-mile last-mile connections simpler and supporting public transport use (Durand et al 2018).
- Reducing car ownership. By combining several transport offerings into a single subscription service, including taxi/ride-hailing and car rental, MaaS platforms aim to provide the perceived freedom and reliability associated with car ownership to non-car owners (Durand et al 2018)
- Providing a mechanism to influence trip behaviour through incentives (share car trips, travel off-peak, etc) (Hazel 2019).

Conversely, MaaS *could* counteract TDM goals by increasing the number of car trips and decreasing sustainable mode share. Risks include:

- MaaS could shift trips from mass transport to taxis/ride-hailing vehicles or car rental by making such trips less expensive. This concern partly stems from early research indicating that ride-hailing services may increase car congestion (Schaller 2018).
- Flat rate subscriptions could induce additional trips (Rowson 2018). Some additional trips may be off-peak or in uncongested areas, though flat-rate subscriptions could also reduce the incentive to avoid peak-time travel.
- Creating a new intermediary between customers and public transport agencies could weaken the agency's brand (Zipper 2018).

15.2 Early evidence on the impact of MaaS

MaaS is in the early stages of development and implementation, and it is too early to draw firm conclusions about its overall impact on travel behaviour. Still, several studies shed light on some possible implications. MaaS platforms are being tested in several cities worldwide.

The 'Whim' app, operated by private Finnish company MaaS Global, represents the most developed MaaS offering. Whim's full commercial launch came in November 2017 in Helsinki, Finland. Whim offers

two subscription plans and a pay-as-you-go option. The subscription options, shown in figure 15.1 below, include discounted rates for several forms of transport, including public transport, taxis, and car and bike rental. Each service can be booked and paid for within the app. MaaS Global raised €12.2 million in venture capital seed funding in 2016 and 2017, and another €9 million in venture funding in 2018.

Figure 15.1 Whim's subscription options as presented in the Whimpact report from early 2019 (Ramboll 2019)

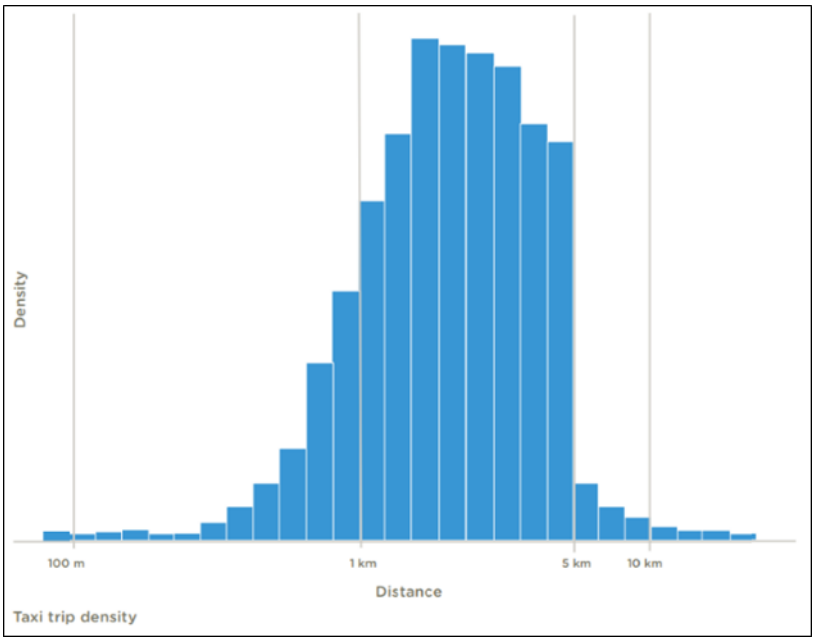
TIER:	WHIM TO GO	WHIM URBAN	WHIM UNLIMITED
Subscription Fee:	0 €	49 € per month (99 € for extended Helsinki Region)	499 € per month
Includes:	• No monthly free • Pay as you go • Public Transport tickets, taxi rides, and rental cars can be all bought from Whim App	• Unlimited number of public transport tickets • All taxi trips within 5 km radius for max 10 € • Fixed 49 € daily rental car fee • Unlimited city bike trips up to 30 minutes at a time	• Unlimited number of public transport tickets • Unlimited number of taxi rides within 5 km radius • Unlimited rental car use • Free to use city bikes for 30 minutes at a time

Whim's user base in Helsinki grew rapidly following its full launch in November 2017, reaching 70,000 registered users in late 2018. The Whim app also launched in the West Midlands, UK in April 2018 and Antwerp, Belgium in October 2018. Some one million trips were taken via the app in all cities by July 2018 and two million by October 2018. For context, 375 million journeys were made on Helsinki Regional Transport services in 2017 (Helsinki Regional Transport 2017). MaaS Global plans to launch the app in 12 more cities across Europe, the US, and Asia in 2019 (MaaS Global 2019).

A 2019 study reviewing Whim use in Helsinki provides encouraging, albeit preliminary, indications about MaaS' use. The key findings from the study included:

- Public transport formed the backbone of Whim users' journeys. When using the Whim app, 95% of trips were made by public transport. When including Whim users' trips where they did not use the app, users estimated public transport modal share was 73%. This compares to 48% among general Helsinki residents with similar demographics.
- Taxi use rose among Whim users, though taxis still accounted for a small mode share and appeared to provide a first-mile last-mile solution. Whim users were found to use taxis at more than twice the rate of non-Whim users, though taxis still accounted for only 2.4% of trips. When using taxis, Whim users combined trips with public transport for 9% of trips, compared to 3% among typical Helsinki residents. This reflects that Whim may have influenced users to be more multi-modal, perhaps by easing the processing of planning, booking and paying for multi-modal trips.
- Whim did not appear to meaningfully increase overall trips. The study found that Whim users averaged 3.4 journeys per day, while the control group averaged 3.3.
- Whim subscription pricing impacted on travel behaviour. Some 97% of users' bike share trips were less than 30 minutes, corresponding to the 30-minute free use period in Whim subscription plans. Similarly, 87% of taxi trips were less than 5 km, after which additional fees applied. Figure 15.2 shows the significant drop in the number of taxi trips beyond 5 km (Ramboll 2019).

Figure 15.2 Taxi trip lengths by 2018 Whim users (Ramboll 2019)



The study did not attempt to explain the reasons why Whim users had higher public transport use than non-users with similar demographics. More generally, however, it argued that MaaS products could reduce the complexity of navigating competing transport services and separate payment accounts, while helping solve the first-mile last-mile problem.

It should be noted that the study had several data limitations and represents behaviour among early adopters, who are likely not representative of the average Helsinki traveller. The results should thus be interpreted with caution.

Other research into the MaaS concept has also found promising early findings. This includes results from a 2017 UbiGo pilot in Gothenburg, Sweden, and a 2015 SMILE pilot in Austria. UbiGo's pilot lasted from November 2013 to April 2014 and included 195 participants. Participants used an app with subscription services that included public transport, taxi, car rental, car sharing and bike sharing services (Karlsson et al 2016). SMILE provided a similar service for 1,000 pilot users (200 of whom participated in a survey of the service) from 2014 to 2015.

In each pilot, the MaaS service appeared to have a significant impact on users' travel behaviour. A study by Karlsson et al (2016) compared the results of the UbiGo and SMILE pilots. The research identified that among UbiGo pilot participants:

- 46% reported greater bus/tram use.
- 44% reported less private car use.
- Substantial shares of participants reported more positive attitudes toward bus, tram, carsharing, car rental, taxi and bike sharing, while 20% expressed less positive attitudes toward private car use.

Results from SMILE participants showed some similar trends:

- 48% stated their mobility behaviour changed through use of the app.
- 55% stated they combined different transport modes more often.
- 48% stated they used public transport more frequently.

- 21% stated they reduced use of their private car.

In each case, participants reported using sustainable modes more frequently and private cars less frequently. While a significant share of UbiGo participants reported greater use of carsharing services (51%), only 4% of SMILE of participants reported increased use.

It should be noted that these pilots had relatively small user bases and were conducted in cities with significant public transport infrastructure and modal share. In partnership with IT supplier Fluidtime, UbiGo is now undergoing a larger trial in Stockholm (Hazel 2019).

These pilots, along with other MaaS surveys and studies, shed some light on MaaS's potential to reduce car ownership. In a literature review of MaaS research, Durand et al (2018) found that researchers believe MaaS will allow for a decrease in car ownership. Karlsson et al (2017) argue that MaaS may be an especially good option to replace households' second car. Meanwhile, some researchers worry that easier access to car-based services through MaaS platforms could 'lead to the cannibalisation of public transport modal shares', partially due to these services' profitability compared to public transport (Durand et al 2018). According to Hazel, who is a board member and strategic advisor to MaaS Scotland (2019), new technologies including ride-hailing and demand responsive transport already threaten public transport ridership. He suggests this is one reason why governments and public transport agencies should be involved in managing the MaaS market framework to ensure that it supports public goals.

In a survey of Londoners, 36% of non-car owners stated they would delay purchasing a car and 40% stated they would not purchase a car if MaaS were available. Among car owners, a quarter said they would be willing to sell their cars for unlimited access to car sharing for the next couple of years (Kamargianni et al 2018). These perspectives may differ in cities with less robust public transport options.

In their literature review, Durand et al (2018) state that autonomy, flexibility and reliability are important conditions for MaaS to compete with car ownership. UbiGo pilot participants overestimated their car use by 30% on average, which Durand et al (2018) state reflects the desire for a 'just in case' option. Focus group participants in smaller Finnish cities and towns 'often mentioned their need for flexibility and autonomy of a private car for trip chaining (combining multiple stops during a single journey)'. An Australian study found that people prefer not having to book shared cars in advance, rather they prefer last-minute availability; every 15-minute increase in advance booking was estimated to decrease willingness to pay by AU$1 (Durand et al 2018).

15.3 The public sector's role in supporting MaaS

Governance may be a greater challenge with respect to the MaaS concept than technology (Sipe 2018; Sørensen 2018). Professor of Urban and Regional Planning at the University of Queensland, Sipe (2018) argues that MaaS 'requires a willingness by private and public transport providers to work with the creators of MaaS platforms' allowing the MaaS operator to 'collect a reasonable and fair commission for each ticket sold'. Sørensen, founder of smart mobility and MaaS consulting company SFMCON also argues that the 'MaaS market relies completely on… mobility actors to open access to plans, available inventory, bookings and payment' (Sørensen 2018). He states that it may be particularly challenging to get private operators to participate if they expect to lose customers in the short term, with the long-term goal of customer growth as users own fewer cars. Agreeing upon ownership and data sharing issues between players is a key issue to establishing MaaS. Giving MaaS providers access to data and APIs can be a major concern for transport operators who may see MaaS as a threat, instead of an opportunity to grow their market (MaaS Global 2019).

In Helsinki, Whim was bolstered by the Act on Transport Services (known as the 'Transport Code') that took effect in 2018. According to Finnish group HPP Attorneys (2018), the code aims to create a growth environment for MaaS, partly by allowing transport data to be shared between customers, service providers and authorities 'as openly as possible'. The code also requires transport providers to make full ticketing functionality available to a third party (Zipper 2018). According to Sipe (2018), this made Finland the 'first country in the world to create an open market for mobility services'. In contrast, MaaS Global had difficulty in the UK getting bus companies to share their data and customers (Hazel 2019).

Government funding may also be important to support MaaS platforms. A 2018 report from the UK Parliament comments that 'several witnesses' noted that 'financial investment will be crucial for [MaaS] to progress beyond small-scale pilots in a way that realises many of the benefits and mitigates potential costs', and 'it is likely that government investment will be required to stimulate this new market' (Transport Committee 2018). Initial government investment may give the private sector confidence to co-invest in MaaS (Hazel 2019).

Governments are showing increasing interest in exploring MaaS to support transport goals. The Scottish Government, for example, committed to a £2 million investment fund to support MaaS testing in Scotland. The fund is part of a broader effort to develop national and international partnerships that make Scotland a leading location for MaaS development (MaaS Scotland 2019). MaaS Scotland now has over 70 fee paying members from the public and private sectors.

The appropriate role for government involvement in scaling MaaS is a key area for further investigation, and varying viewpoints exist among researchers and industry stakeholders. Public sector partnership with the private sector, and leadership to establish an enabling regulatory framework are likely important initial steps. According to Hazel (2019):

> *There is general agreement across the MaaS community that the role of Government should be to enable innovation and delivery of MaaS, not to act as the MaaS aggregator or provider. A major part of this role is ensuring that regulation and legislation support MaaS delivery.*

15.4 Key insights

MaaS offerings are expanding and their growth is expected to accelerate. A market research report from BIS Research forecasts the global market will reach US$1.75 trillion by 2028 (BIS Research 2018). A key portion of this market opportunity is likely to come from offering value added services around MaaS that target individual users (Hazel 2019).

The MaaS concept is in early stages and its overall impacts on travel behaviour are uncertain.

Early pilots suggest MaaS may have the potential to decrease car ownership and use while increasing public transport use and multi-modal trips. Importantly, this evidence comes from cities with already well used public transport systems.

Key risks of the MaaS concept include additional ride-hailing and taxi trips, leading to more overall vehicle journeys.

Pilots suggest that MaaS's pricing models can impact travel behaviour. Data from Whim's 2018 users, for example, suggests that subscription pricing influenced taxi trip lengths and the time period for which bikes were rented.

Governance is a critical challenge for scaling MaaS, including ensuring that public and private transport providers collaborate and share data.

16 Focus area – demand responsive parking pricing – SF*park*

This focus area discusses the outcomes of the largest example of sensor-based demand responsive parking carried out to-date, San Francisco's SF*park.* The programme presents an interesting case study as, while it has achieved its desired outcomes according to the project's evaluation, the overall programme was expensive and had some limitations. The programme, however, gives further insight into what types of technology are best used to implement demand-responsive parking pricing.

Parking policy, in particular its pricing, is considered an influential tool to influence motorists' travel behaviour (Litman 2018b). Transport economists argue that 'cruising' or circling for parking will be increased when parking is provided too cheaply (Shoup 2006; Vickrey 1954; Chatman and Manville 2014). Appropriately pricing parking is considered a solution to such problems, with flow-on effects of improved public space, reduced VKT and reduced congestion. Shoup (2006) found the portion of traffic cruising for parking to vary significantly from city to city, depending on the era – with cruising making up 8% of traffic in New York in 1993, while comprising 74% of traffic in Freiburg in 1977. In Stuttgart in 2018 it was found to make up 15% of traffic. The average percentage of traffic cruising for parking is often cited as 30% (Shoup 2006).

Dynamic parking pricing, where prices react to the demand for spaces, has been discussed as an alternative to congestion pricing for cities unable or unwilling to put congestion charges in place (Pierce and Shoup 2013). Congestion pricing has been successful in cities like Singapore and Stockholm, but politically difficult to implement in other places (Chatman and Manville 2014; Harsam and Quigley 2010).

One method to initiate a dynamic parking programme, is via the use of sensors and parking technology to monitor and adjust parking pricing (Pierce and Shoup 2013). In essence, prices increase in high-demand areas, and decrease in low-demand areas, encouraging drivers either to park in less congested areas or consider other modes.

In 2011, the Municipal Transport Agency of San Francisco (SFMTA), launched SF*park*, a pilot programme testing demand responsive parking technology at 25% of the city's metered parking spaces and 75% of the city's parking buildings. The programme ran as a pilot from 2011 to 2014, making use of parking sensors and data analysis to develop a formula to allow the city to adjust parking rates based on demand. The pilot has generally been reported as a success by the city. As a result of the pilot, dynamic parking pricing is now being rolled out city-wide. Despite this, there have been difficulties with the programme, including the high cost and functionality of the sensors, public opposition to parking pricing, and restrictions on the level of pricing increase allowed by city regulations (Bialick 2015; Parking Today 2013).

16.1 Main objective

San Francisco has city-wide TDM goals in place since 2014 and a city climate action strategy, which calls for 80% of trips made by environmentally sustainable modes by 2030 and an 80% reduction in 1990s level greenhouse gas emissions by 2050.

The chief goal of SF*park* was to increase the amount of time that parking was available on every block, in other words – the occupancy would be set to the appropriate rate. Higher prices in high-demand areas would discourage drivers from parking in those places, particularly for long durations, while lower prices in low-demand areas would encourage drivers toward those places. The general theory behind demand-

responsive pricing is drivers are given information about the true price of their parking space, and this will guide the decision about whether to park in a particular area. Parking occupancy and turnover were expected to improve, allowing parking to be found more quickly for people who still wanted to park in that area. This was believed to have several knock-on effects: drivers would circle less, lowering VKT and creating safer streets. The motivation was also to reduce the number of slow-moving cars on the road, delaying buses.

The main measure used in the pilot was the number of blocks meeting occupancy targets, between 60% and 80%, depending on the day.

The time taken to find a park was initially measured using intercept surveys and parking search time surveys, usually conducted by planning staff on bicycles. Occupancy was measured using the sensors installed as part of the project.

Hank Wilson, parking policy manager for SFMTA, describes the importance of parking measures to achieve San Francisco's overall TDM goals:

> *One of the chief findings or bases of SFpark is that parking is really probably the chief driver of travel demand, you can't do TDM without considering parking, and that was the innovation: recognising that if a car is driving somewhere, in the absence of the ability to do congestion parking, it is something else to make it more expensive to drive.* (Wilson 2019)

It should be noted that SF*park* did not have mode share goals relating to sustainable transport. The scheme is profiled in this focus area based on the assumption that it would be utilised in conjunction with other TDM strategies that focus on sustainable transport uptake.

16.2 Organisational context of SF*park*

SFMTA manages, plans and operates San Francisco's transportation system. This includes public transport, walking, cycling, roads and parking supply. The agency runs 19 parking buildings and 19 parking lots, but there are also a significant number of privately run parking buildings in the city.

SFMTA does not have an accurate count of all off-street parking, due to the high number of private car parks, but it almost has a monopoly on the city's on-street parking supply of 280,000 parking spaces.

In 2008, legislation was approved by the SMFTA board of directors specifying SF*park* pilot areas and the ranges for rates, time limits and parking availability targets.

The programme has been described as 'the biggest price reform for on-street parking since the invention of the parking meter' (Pierce and Shoup 2013).

The SF*park* programme was sponsored by the US Department of Transportation, as part of a Value Pricing Pilot Programme as a way of testing demand-responsive pricing for managing parking. The department also wanted to enhance parking regulation and investigate new parking information systems.

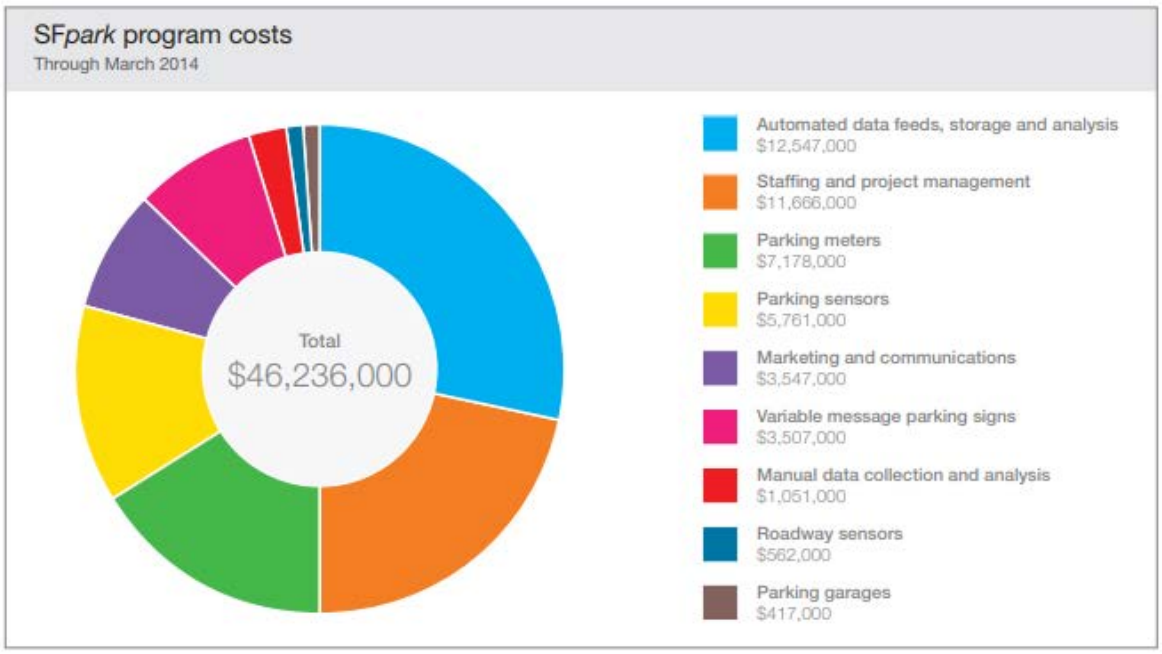
SFMTA has a TDM team with three strategic focus areas: land use and policy co-ordination, citywide parking demand management, and customer-oriented travel choice marketing, education and outreach.

The SF*park* programme fits into the parking demand management category, although the team running SF*park* is not part of the direct TDM team (Wilson 2019).

16.3 Costs of SF*park*

SF*park* was primarily funded through a US$19.8 million grant from the US Department of Transportation, a US$22 million loan from the Bay Area Metropolitan Transportation Commission and local funds of US$4.95 million. This gave the whole programme a total cost of US$46.24 million. Figure 16.1 provides a breakdown of the programme costs associated with SF*park*.

Figure 16.1 SF*park programme costs broken down* (SFMTA 2014)



16.4 The SF*park* pilot

The SF*park* pilot established seven pilot areas with new parking policies, sensors and data collection. Additionally, two control areas where no new policies or technology were used.

The pilot covered 6,000 metered spaces, which accounts for 25% of the city's total parking. It also covered 12,250 off-street spaces, which makes up 75% of the off-street parking managed by the city.

Surveys were undertaken to measure occupancy levels prior to the start of the programme. From there, ideal occupancy rates were determined, parking costs set, and occupancy monitored via sensors on an ongoing basis. This allowed parking prices to be adjusted to meet desired occupancy rates.

16.4.1 On-street pricing

The dynamic meter rates were set to vary based on time and day (eg weekend or weekday). Meters in the city were split into rate periods. The majority operate on a 9 am to 6 pm schedule, mostly divided into the rate periods of: 9 am–noon; noon–3 pm and 3 pm–6 pm, with some exceptions for particular areas like the port.

Drivers pay the metered amount in the time period they are in – even if it changes. So, if a driver parks at 2 pm, and leaves at 4 pm, they will pay different rates for the first and second hour of their stay. Rate changes are made once a month and respond to demand recorded the previous months. The goal was

one available car parking space per block/no more than 80% occupancy. Occupancy data was measured using in-ground sensors.

The rates adjustment formula was:

- When occupancy is 80%–100%, the hourly rate is raised by $0.25.
- When occupancy is 60%–80%, the hourly rate is not changed.
- When occupancy is 30%–60%, the hourly rate is lowered by $0.25.
- When occupancy is less than 30%, the hourly rate is lowered by $0.50.

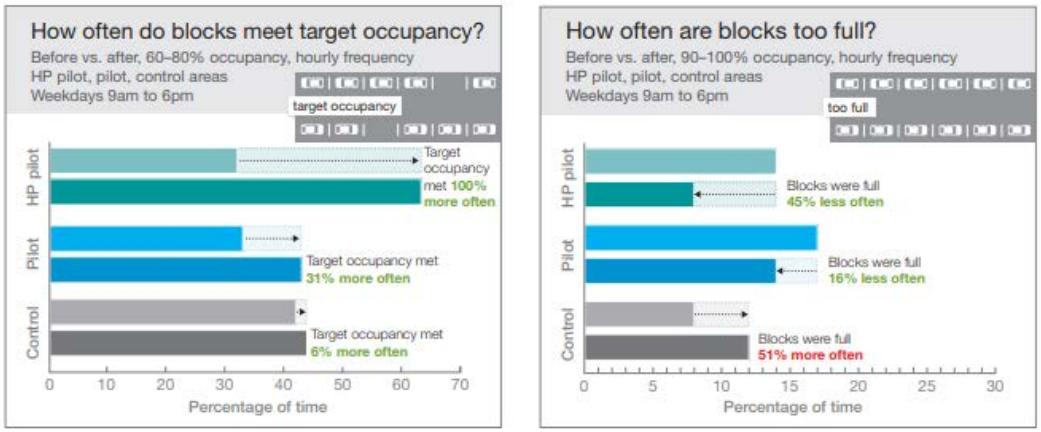
16.4.2 Pilot outcomes

During the pilot, from July 2011 to January 2014, 13 demand-responsive rate adjustments were made at SF*park* meters. On average, the price of parking at these meters was reduced by $0.30 per hour.

On average, in the pilot study areas, target occupancy was met 31% more often compared to the baseline, while in areas where data showed payment compliance was high (people paid their parking fees), occupancy was met 100% more often than the baseline figure 16.2.

Manual surveys showed drivers could find spaces three and a half minutes more quickly after the introduction of SF*park* (SFMTA 2014). SFMTA estimated the effects on VKT and the effect on greenhouse gas emissions. This was calculated using meter payment transaction data, compliance data, manual surveys and comparing this to California Air Resource Board 2011 emissions rates for San Francisco. Greenhouse gas emissions were calculated to be reduced by 30% after SF*park*, as did VKT (SFMTA 2014).

Figure 16.2 Target occupancy results of SF*park* pilot (SFMTA 2014)



Traffic counters from roadway sensors showed that areas with improved parking availability had a 7.7% decrease in traffic volume, compared to 4.5% increase over the same time in non-pilot areas. Traffic speed also decreased in these areas (SFMTA 2014).

Despite these results, one of the most interesting findings, was stated by the programme's policy manager that 'we did all this work, and collected all this data, tried our best to get the price exactly right… and it worked. But we also looked at where we just installed parking meters, where there hadn't been any before, and we also lobbied for pricing on Sundays. These were two examples where we said it wasn't getting the price right, it was just putting a price on something that was previously free – we were much more successful there' (Wilson 2019).

Some critique has come from other research into the programme. A review by Chatman and Manville (2014) found that, although increased parking prices in San Francisco appeared to improve occupancy rates, they did not necessarily increase overall availability of parking. The study argued that the policy was hindered by being unable to make significantly large changes to pricing (pointing to both London and Singapore as examples of places which have done just that via a congestion charge). The incremental nature of change, the removal of parking time limits and a price ceiling implemented as part of SFpark were also criticised.

Despite this criticism, other researchers have, and SF*park*'s monitoring, have concluded that cruising, VKT and emissions have all reduced as a result of the programme (Pierce and Shoup 2013) (SFMTA 2014). Ngo and Krishnamurthy (2017) also found a modest impact on congestion and public transport usage from the programme.

16.5 Next steps

Since the end of the pilot, SFMTA has evaluated the results and continued the policy. In early 2018, the policy was extended from the pilot areas to all 28,000 city-run on-street parking spaces and 14 city-operated parking buildings. Delay to this being carried out immediately appears to be the result of political pushback against priced parking in general.

The sensors are no longer used. Instead, part of the SF*park* evaluation involved developing an algorithm to accurately determine demand based on parking meter data.

16.6 Challenges

Two key challenges arose within the pilot of SF*park.* The first relates to early bird parking rates. Part of the initial S*Fpark* pilot involved changing the hours that early bird parking rates were available in city-run parking buildings, making the time criteria more stringent and outside the peak travel time. Early bird rates for SFMTA controlled parking buildings changed from 'in by 9 am, out by 6 pm', to 'in by 7.30 am' and out after a specified time. The times chosen were influenced by peak bus times in the areas chosen.

The policy was unsuccessful, believed to be due to the limited amount of parking buildings the city has control of (estimated to be 10%). Due to this, drivers did not change their behaviour, instead using privately run parking buildings still offering the original in by 9 am, out by 6 pm discount. The city relies on the revenue from the parking buildings, so relaxed the policy after finding it did not alter driver behaviour.

The second challenge related to the vandalism of parking meters. This has been an ongoing problem for the city, which in some cases means the data being collected for a block is not sufficient and, therefore, parking rates cannot be changed.

On top of these challenges, the project has received criticism from some observers. In particular, the programme has been accused of being too expensive and complicated (Parking Today 2013). The city's US$5.7 million spend on sensors appears to have proved that demand-responsive pricing works, but many cities are carrying out similar parking initiatives without the heavy data investment (Barter 2018). The fact that the city has now ceased using the sensors and replaced them with smart meters adds to this critique.

16.7 Key insights

The SF*park* project has been considered successful enough to expand city-wide. As a large-scale, nationally funded trial of demand-responsive pricing SF*park* has, by internal measures, achieved its objectives of making it faster to find a park on San Francisco's blocks.

Feeding into the city's TDM goals, the project is reported to have decreased VKT, reduced greenhouse gas emissions and redistributed parking uptake in the city.

The pilot's complicated use of sensor data has been criticised. Indeed, while the pilot has proved the effectiveness of demand-responsive pricing, other jurisdictions may not require such heavy investment as seen in SF*park*.

Parking pricing works. The most significant effect of this policy has, in fact, been the installation of parking pricing in areas where it was previously free and not the need for these prices to be dynamic.

17 Focus area – transport management associations

This focus area outlines the definition, purpose and capabilities of transport management associations (TMAs), as well as providing some examples of where the concept of TMAs has been used in the coordination and delivery of TDM strategies.

Historically there has been confusion between *travel* management association and *transport* management association. In the context of this research the correct terminology, as historically adopted in New Zealand, from the UK and USA is *transport* management association.

A TMA is a non-profit making and member-controlled organisation that provides transportation services in a particular area. They are also legal entities. A TMA provides an institutional framework for the implementation of coordinated TDM initiatives. It can be more cost effective than individual organisation travel plans and can influence commuter travel patterns, public transport services and the provision of sustainable transport infrastructure. The TMA facilitates TDM strategies so they can be made easily available to small and medium size enterprises as well as larger organisations, thereby benefiting all TMA members (Philbin 2007).

The Association for Commuter Transport's definition of a TMA is 'an organised group applying carefully selected approaches to facilitating the movement of people and goods within an area. TMAs are often legally constituted and frequently led by the private sector in partnership with the public sector to solve transportation problems' (Association for Commuter Transport 1994). It is this public/private sector partnership that provides the TMA with a foundation for achieving outcomes that satisfy a potentially diverse membership.

TMAs provide an institutional framework for TDM programmes and services. They can be more cost effective than programmes managed by individual businesses. TMAs allow small employers to provide commute trip reduction services comparable to those offered by large companies. They can also provide a variety of services that encourage more efficient use of transportation and parking resources (Litman 2016).

TMAs originated in the USA in the early 1980s, in response to a variety of needs. These included: for organisations to advocate for local transport issues; to save money through cooperative delivery of TDM solutions; and, for developers to mitigate trips as a condition of planning consent agreements. As the 1980s progressed, government agencies started to support the development of TMAs with public grants. Some of these evolved into public/private sector partnerships. Their common goal was trip reduction and environmental sustainability.

In the 1990s, the US government supported the formation, and funding of TMAs through three important legislative acts: The Energy Policy Act of 1992; the Taxpayer Relief Act of 1997; and the Transportation Equity Act for the 21st Century (TEA-21) 1998. In 1999, the federal government's Commuter Choice Initiative enabled employers to implement programmes to incentivise employees to exercise sustainable travel choices in selecting their commute mode (Association for Commuter Transport 1994). The US legislation enabled government funds to be leveraged to promote TDM programmes through TMA coordination.

In the late 1990s, the UK provided similar government guidance to that of the USA in the form of the white paper, *A new deal for transport – better for everyone*, which supported sustainable transport solutions

over and above road building schemes and set the policy context needed to legitimise and accelerate TDM activity in the UK.

Many of the early US TMAs that were established as a result of the needs of the business community, survive to this day. However, the ones that were established as a result of a public agency 'push' have struggled to survive or ceased to exist (Association for Commuter Transport 1994). Business community buy-in (business-led) along with public sector support, particularly ongoing financial support, appears to support successful outcomes.

Many international TMAs, particularly those in the UK and USA operate on a large scale. They are set within expansive geographical areas and service a large working population. This enables them to leverage substantial funding from membership contributions and through matched funding grants. However, this is not the case in New Zealand or the UK which are discussed in the TMA examples below. In both those contexts industrial/commercial areas are set within a smaller geographical context and have correspondingly smaller working populations. They therefore cannot apply the same economies of scale that apply to large TMAs, hence the need for public sector financial support.

TMAs can be established to achieve any number of goals, the most common being advocacy, education, the provision of TDM services, coordination of TDM activity, consent building, brokerage (eg parking brokerage) and the implementation of area-wide TDM initiatives. TMAs are controlled by a board of directors who are elected by member organisations. They are led by a chair/president and include a secretary and treasurer.

TMAs need a clear vision, mission statement, strategy, aims, objectives, goals and a continuous assessment/reflection programme. It is important that to be officially recognised, TMAs are set up legally. In the case of countries such as the UK and New Zealand, where the following two examples are from, this would be as associations through Articles of Association (UK) or Rules of Incorporation (New Zealand). Such TMAs also need to adhere to a defined strategic direction as laid out in the rules and adopted by the board. The rules dictate the operational functions of the TMA and are legally binding.

17.1 Sowton and Wynyard Quarter TMA examples

Two examples of TMAs based on business-led models are the Sowton TMA in the UK and the Wynyard Quarter TMA in Auckland. Both of these TMAs were the first business-led TMAs to be established in their respective countries and included public sector (non-voting) directors. Figure 17.1 summarises the key elements of both the Sowton and Wynyard Quarter TMAs including their scale, how they operate and their key visions and goals.

Figure 17.1 The key aspects of the Sowton and Wynyard Quarter TMAs. Adapted from Philbin (2019)

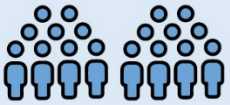
Sowton TMA, UK

The Sowton TMA in entirely **business led.**

Sowton: over **200** Businesses | **15,000** Employees

Sowton TMA:

40 Members | **6,000** Employees



The Sowton TMA was set up as a **not-for-profit company** limited by guarantee and established to deliver **sustainable transport solutions and mitigate congestion and parking problems for the business communitiy.** It sat under the umbrella of the Sowton Industrial Estate Business Association which provided coordination and secretariat support. Legal and accounting support was provided by member solicitors and accountants.

The Sowton TMA had clearly defined aims, to:

- implement and overarching long term sustainable travel plan for the area in and around the Sowton Industrial Estate;
- reduce congestion during the am and pm peak by 10%; and,
- engage businesses in the area to produce travel plans that locked into the overarching travel plan and helped to achieve the objectives for the area.

Wynyard Quarter TMA, NZ

Wynyard Quarter: 2018 **7,000** Employees | 2028 **30,000+** Expected employees

The Wynyard Quarter TMA was developed in 2011 as a condition of consent for the development of the area.

The Wynyard Quarter TMA steering group was to be established to help **mitigate trip generation** and **promote sustainable transport to workers and residents alike.** As it needed to be established at the onset of development, Auckland City Council (as it was then) took the initiative to set up the steering group which. A group of representatives from Auckland City Council, Auckland Transport, Waterfront Auckland, Viaduct Harbour Holdings Limited and the NZTA met periodically to try and frame the structure for the TMA but without the cooperation of the businesses it was not possible to set up a formal TMA.

December 2015
A meeting of 40 businesses and stakeholders, led by Auckland Transport, elected **13 directors** for an interim board to establish the TMA as an incorporated society.

2016 - Vision, Values and Goals
The first TMA business plan was produced with **this vision:** "our vision is of an efficient, networked and highly connected transport system supporting a diverse and vibrant Wynyard Quarter community" (WQTMA, n.d.).

The TMA **values** included: open dialogue and transparency; honesty and integrity; taking ownership of decisions; inclusiveness and equity.

The **goals** included: improving accessibility; providing advice; effective communication; advocacy; support and enhance economic vitality; setting up a robust TMA (financially independent and representative of the community); improving transport related safety, and; making efficient use of limited parking.

The Wynyard Quarter TMA is particularly interesting as it is the first TMA of its kind in New Zealand. The Wynyard Quarter TMA steering group was set up in 2011 as a condition of the planning consent and environment court order which stipulated that a 'voluntary' TMA was to be established in Wynyard Quarter to help mitigate trip generation and promote sustainable transport to workers and residents alike. As it needed to be established at the onset of development, Auckland City Council (now Auckland Council) took the initiative to set up the steering group which, although referred to as a TMA, was *not* a formal TMA organisation. A group of representatives from Auckland City Council, Auckland Transport (AT), Waterfront Auckland, Viaduct Harbour Holdings Limited and the NZ Transport Agency met periodically to try to frame the structure for the TMA but without the cooperation of the businesses it was not possible to set up a formal TMA. By 2015 enough businesses had relocated to Wynyard Quarter to form a groundswell of support for the formation of a formal TMA.

Over the next 18 months, subsequent to the incorporation of the TMA in December 2015, the directors determined the vision, mission, values, objectives and goal for the TMA through a collaborative process of workshops. By 2016 the first TMA business plan was produced which detailed the continued process of TMA development and implementation. The vision stated: 'our vision is of an efficient, networked and highly connected transport system supporting a diverse and vibrant Wynyard Quarter community' (WQTMA nd).

In June 2017 the interim board elected its first 'official' board of directors, chair, vice chair, treasurer and employed a TDM coordinator. The Wynyard Quarter TMA is part funded by membership fees and a contribution allocated to business associations from AT. The business association funding is dependent upon the TMA meeting specific trip reduction targets (that were originally set by Auckland Council) and supporting TDM initiatives which are coordinated by AT. These targets help AT to achieve its own statement of intent for the reduction of single occupant trips in the morning and afternoon peak traffic flows.

By mid-2018 the TMA produced a strategic plan for 2018-2021 (WQTMA 2018). As part of the plan it outlined the outputs of the TMA from its inception in 2016. These included:

- Advocating for public transport improvements and safer speeds in Wynyard Quarter. The TMA is in discussion with AT on the best routes for public transport in Wynyard Quarter. The TMA has supported and opposed reduction in speed limits in the area to reflect the needs of businesses. This resulted in no traffic calming measures being introduced into the Brigham and Hamer Street industrial area.
- Carpooling. A new Wynyard Quarter web-based scheme has been launched. This is based on the carpool scheme that AT currently supports. Wynyard Quarter TMA is working with public and private sector to get dedicated carpool spaces in the area. Wynyard Quarter TMA continues to look for car and vanpooling sites to alleviate traffic congestion at peak times.
- Communication. The Wynyard Quarter TMA has its own website and news bulletins are circulated to businesses in the quarter. A Facebook page and networking channels have also been established.
- Cycleways. Wynyard Quarter TMA members voiced safety concerns over proposed routes for cycle ways. AT took on board the comments, which influenced the route and construction of the cycle paths.
- Parking management and brokerage. The TMA supported AT in increasing pricing for short stay spaces in Wynyard Quarter to improve car park turnover. The Wynyard Quarter TMA Board is keen to look at ways to open up private car parks in the quarter through a brokering scheme to improve parking efficiency in the area.

- Research. Three independent strategic reports have been produced by the Wynyard Quarter TMA. These include the 2016 Parking Plan, Construction Workers and Contractors Access Plan, and draft Business Plan for 2017/18.
- Setting up a robust TMA. The Wynyard Quarter TMA was set up as an Incorporated Society in March 2017. The Board of Directors was formally elected in June 2017. The board meets on a monthly basis to steer the direction of the TMA.
- Advocacy. The Wynyard Quarter TMA acts as an advocacy group for the business community and made formal submissions on the America's Cup Resource Consent, the Auckland Council 10-year budget and the Draft Auckland Plan 2050.
- Travel planning. The TMA works with AT and major employers to review current parking arrangements and staff travel modes. Employees are encouraged to look at sustainable travel options. Businesses are responding well to independent advice and guidance (WQTMA 2018).

17.2 Guidelines for establishing TMAs

The establishment of both the Sowton and Wynyard Quarter TMAs was based on study tours of Groningen in 1997 and 2002 to investigate and learn from the establishment of the Groningen Transport Coordination Centre, and a study tour in 2005 of 10 TMAs in Atlanta, Georgia and Tallahassee, Florida informed the model for setting up the Sowton TMA (Philbin 2004). As a result, a set of guiding principles for the establishment of area-wide TMAs was produced and published first in conference papers delivered in Europe and the USA and then in the Victoria Transport Policy Institute on-line TDM Encyclopedia (S Philbin pers comm, 15 May 2019.) These were further adapted for publication in the 2007 Auckland Region Transport Authority (ARTA) guidelines for establishing TMAs, see figure 17.2 (ARTA 2007).

Figure 17.2 Guidelines for establishing TMAs in Auckland (ARTA 2007)

	Existing Area	Greenfields Site
1	Set up an interim board of directors from interested parties (local councillors, local authority officers, public transport operators and local business representatives)	Establish a board of directors from interested parties (local councillors, local authority officers, public transport operators, business representatives and community representatives from the new residents)
2	Directors must agree to the business plan prior to the launch of the TMA and prior to registration as a not-for-profit company	Directors must agree the business plan prior to the launch of the TMA and prior to registration as a not-for-profit company
3	Write Memorandum and Articles of Association to establish the operating principles of the company	
4	Elect Chairman, Vice Chair, Secretary and Treasurer	
5	Vote to agree business plan and budget	
6	Write job description for transport management coordinator and supporting staff	
7	Establish line management and transport management coordinator accountability	
8	Launch the TMA and raise awareness through local media	
9	Establish database of businesses and organisations in defined geographical area with information regarding size, location, parking availability, whether or not they have a travel plan in place, etc.	Establish database of all participating organisations in the new development area with information regarding size, location, and parking availability (this list is not exhaustive)
10	Contact the businesses, sell the TMA concept – undertake staff travel surveys of those without travel plans in place	
11	Seek further funding opportunities to ensure the continuity of the TMA	
12	Prepare travel plans for all participating organisations (including residential developments)	
13	Liaise with existing travel plan coordinators, local authorities and public transport providers to make best use of demand management measures already in place	Liaise with existing travel plan coordinators, local authorities and public transport providers to make best use of demand management measures already in place within the vicinity of the development area
14	Continue awareness raising campaigns coordinated with local authority programmes and nationwide events	
15	Monitor effect of travel plans and sustainable transport measures through annual automatic traffic count data and travel to work staff surveys and residential travel surveys.	

17.3 TMA funding

There are a variety of services that a TMA can provide, from an advocacy role through to actively operating TDM programmes. The level and type of funding that TMAs receive will depend on the type of service they provide. It is estimated that if a TMA's business plan is to solely provide advocacy, then the level of funding required to support the secretariat and administrative functions would be approximately NZD$150,000 (S Philbin pers comm, 15 May 2019.). However, if the TMA is performing a wider range of services such as awareness raising programmes, guaranteed ride home schemes, parking brokerage schemes, as well as undertaking data collection and analysis, then funding requirements will depend on the scope of the TDM interventions being delivered.

Funding for TMAs can also come from a variety of sources. In the UK, they often fall under the umbrella of an existing business association and therefore a percentage of the broader association's fees will be apportioned to the TMA to fund TDM-related activities. In the US, TMAs are often at least partially funded

from government or regional grants. In the Seattle region, TMAs on average receive 5% of their funding from federal Congestion Mitigation and Air Quality funds, 13% from the state-wide Commute Trip Reduction programme, 12% from regional mobility and other grants, 37% from public partnerships and 33% from private partnerships for a total of USD$2.4 million across three TMAs in 2018 (Moore 2018).

In the UK, the USA and in New Zealand, most TMAs typically charge some form of membership fees which support the activities of the TMA. However, this can be a challenging factor when this fee is in addition to other rates and fees already being paid by organisations. For example: in Wynyard Quarter in Auckland, TMA members are already paying council rates, business rates, developer contributions (the developers only) and membership fees for the Heart of the City Business Association. Therefore, requesting an additional TMA fee was seen as problematic. However, without a membership fee, the TMA lacked the gravitas associated with the 'value' added by paying to be a member. To overcome this, the decision was made to set a minimal membership fee at $1 per employee (Wynyard Quarter Transport Management Association 2015). This fee contributed to funding the administrator who coordinated the meetings and activities of the TMA. In addition, AT provided a grant in both the first and second years of operation, commensurate with grants that had been paid to other business associations for the implementation of TDM interventions. In order to be eligible for the grant, the TMA and the business associations had to achieve certain goals relating to outreach. Currently, the Wynyard Quarter TMA provides a range of services from advocacy and outreach, to operating carpool and van pool programmes. It is estimated that without the additional grant funding provided by AT, the Wynyard Quarter TMA would be unable to provide its current level of services and would likely become an advocacy only organisation.

17.4 Key insights

TMAs need a clear vision, mission statement, strategy, aims, objectives, goals and a continuous assessment/reflection program. TMAs can be established with the aim of achieving various goals: advocacy, education, the provision of TDM services, coordination of TDM activity, consent building, brokerage and the implementation of area wide TDM initiatives. It is therefore important to ensure the vision, strategies and goals for the TMA are clearly articulated and relevant.

TMAs are legal entities. TMAs are controlled by a board of directors who are elected by member organisations. They are led by a chair/president and include a secretary and treasurer. They adhere to a clearly defined set of rules which are legally binding.

TMAs require a robust planning and funding model. The most common arrangement is a public private partnership based on membership fees and public funding contribution.

There are well established guidelines for TMAs including in New Zealand. The guidelines for the development of TMAs used to establish the Sowton TMA were adopted for the AT TMA guidelines which, in turn, helped guide the development of the Wynyard Quarter TMA. These guidelines can be further adapted and modified for site-specific development of TMAs.

18 Focus area – San Francisco's TDM ordinance

In 2016 San Francisco introduced an ordinance (or city policy) requiring the implementation of a TDM for the majority of new developments with over 10 residences and commercial sites that are 10,000 square feet or larger (929 m^2).

This was inspired by a similar model used in Cambridge, Massachusetts, adopted in 1998 and made permanent in 2006. That project required large developments to create project TDM plans.

These plans have been developed for 40 projects in Cambridge, with 35 completing a monitoring report. They cover 17,045 parking spaces and 30 of 35 projects have exceeded their non-drive along mode share commitments.

At the state level the San Francisco ordinance was adopted following the Californian Senate Bill 743, signed into law in 2013. It changed development transportation impact analysis from evaluating level of service (LOS), which measures vehicle travel delay and favours efforts to accommodate automobile traffic, to vehicle miles travelled (VMT), which favours efforts to reduce total vehicle travel. Similarly, California's already existing state Congestion Management Law also supports local efforts to reduce motor vehicle travel (San Francisco Planning Department 2018). These state legislation changes provided further impetus for San Francisco's TDM efforts.

The TDM ordinance reviewed in this focus area is part of San Francisco's wider TDM Programme. The City describes TDM as 'a layer of policies, programmes, information, services and tools that work with the transportation infrastructure and operations to support the use of sustainable modes for all trips'.

According to San Francisco Municipal Transportation Agency, the key functions of TDM programmes are to:

- provide easy-to-understand information about all travel choices
- use marketing and incentives to shift trips to more sustainable modes
- influence land use to improve viability of sustainable modes
- use market pricing to balance transportation demand.

San Francisco previously encouraged (but did not actively legislate for) a range of distinct TDM programmes, including those related to bike parking, showers, carshare parking, unbundled parking. San Francisco's TDM ordinance uses a more integrated approach toward new developments.

The goal of San Francisco's TDM ordinance is to reduce VMT. Since this can be achieved through several mechanisms, including shifting modes or reducing vehicle trip frequency and distances, the plan views VMT as a more appropriate indicator of programme performance than mode share.

18.1 Structure of the ordinance

San Francisco's TDM ordinance for new developments splits developments into one of four land use categories. The categories are:

- category A – primarily retail
- category B – primarily office
- category C – primarily residential
- category D – rarer uses generating fewer vehicle trips than other categories.

Before applying for building permits, the San Francisco Planning Department categorises new developments into one of these land uses and analyses its expected parking volumes. The development is required to achieve a certain level of TDM 'points' based on its level of parking – the more parking the more TDM points are required (San Francisco Planning 2019).

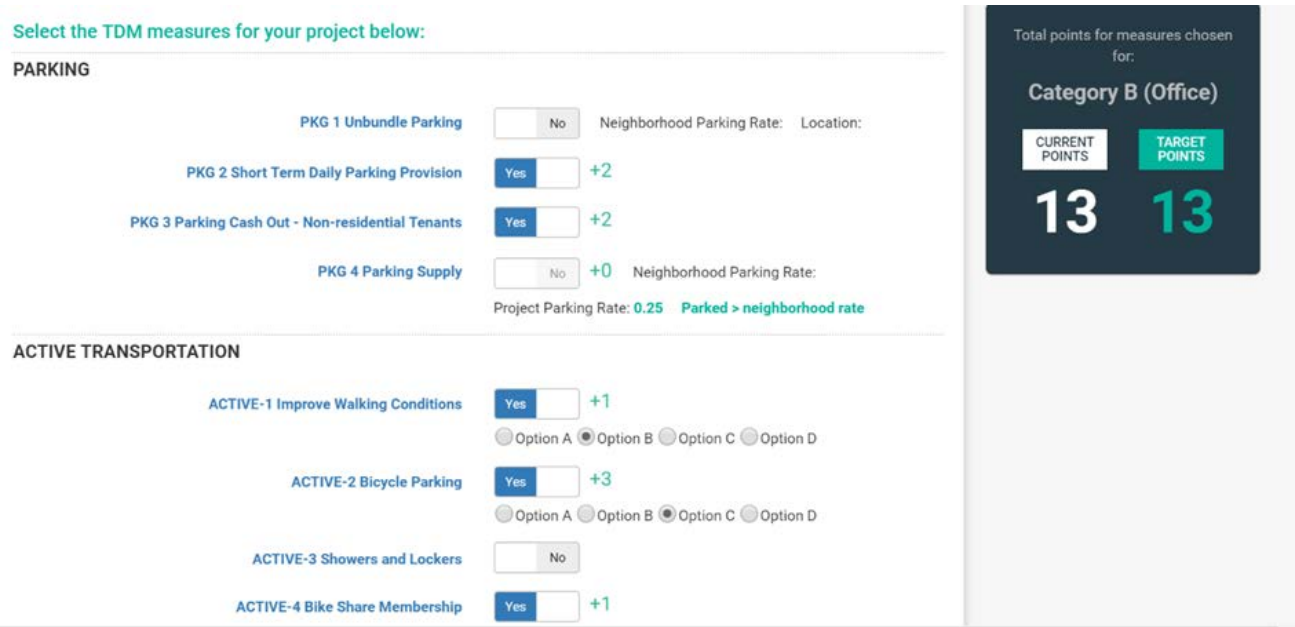
Developments can achieve TDM points by committing to TDM measures along eight categories. They are:

- parking, eg unbundle parking, parking cash out, reduce parking supply
- active transportation, eg improve walking conditions (provide streetscape improvements consistent with the Better Streets Plan and any local streetscape plan so that the public right-of-way is safe, accessible, convenient and attractive to persons walking (SFMTA 2016); provide bicycle parking, showers and lockers, bike share membership, bicycle repair station, bicycle maintenance services, employee bicycle fleet and bicycle valet parking for special events
- carshare, eg carshare parking
- delivery, eg delivery support amenities, provide delivery services
- family, eg on-site childcare
- HOVs, eg subsidies for public transport or bicycle purchase, shuttle bus service, vanpool programme
- communications and information, eg multimodal wayfinding signage on-site, real-time transportation displays on site, tailored transportation marketing services
- land use, eg healthy food retail in underserved area.

In total, there are 26 potential options available in the TDM menu. Not all options are suitable for all developments as some are size or land use category dependent. Some TDM measures provide more points than others, and some can be implemented to various degrees of intensity. Building permits will not be issued until developments create a TDM plan that reaches its required point total.

A comprehensive online tool shows developers various options for meeting their TDM point requirements please refer to figure 18.1.

Figure 18.1 Screenshot of San Francisco's TDM in development online tool. On the right, the number of points required is shown. The 'current points' change as different TDM options, shown on the left, are selected or deselected.



The main goal of the ordinance is to reduce VMT, so parking supply reductions give developers the greatest number of points. San Francisco TDM performance manager Audrey Harris explains that 'if [parking spaces] aren't there, those trips won't happen. As opposed to one of the more programmatic TDM measures that might cost more but don't guarantee those trips won't happen' (A Harris, pers comm, 31 January 2019).

Each TDM point represents approximately a 1% reduction in VMT. This was calculated based on data generated by the California Air Pollution Control Officers Association (CAPCOA) in the 2010 report *Quantifying greenhouse gas mitigation measures,* and analysis carried out by a private consultancy.

The 26 measures available were selected via literature review, local data collection, best practice research and professional transportation opinion.

18.1.1 Strategies rejected from TDM menu

Some TDM options were not included in the menu due to such reasons as failure to meet the city's definition of TDM, being too difficult to implement, or being too large scale for single developments.

Examples of excluded options include:

Does not meet definition of TDM measure for development projects:

- flexible hours; peak period parking fees
- transportation network company and taxi measures
- transportation sustainability fee
- joint parking; remote/satellite parking, parking for non-shared motorcycles, mopeds, scooters; off-street loading space
- spaces for non-shared electric vehicles

- bicycle parking in existing buildings
- pre-tax election for transportation.

Measures related to area-wide vehicle miles travelled

- Generally, the projects being given TDM plans in this context are not large enough to influence land use, density or diversity, so related measures are left out. In special cases this is reconsidered.

Difficult to monitor or implement

- bike share station (contracting between two private entities).
- telecommuting, compressed work weeks, flexible hours, carpool programme, guaranteed ride home.

18.1.2 Exemptions

The following development projects are exempt from taking part in the TDM ordinance:

- residential projects with nine units or less
- less than 10,000 square feet of use other than residential
- 100% affordable housing projects
- parking garages and parking lots.

18.2 Costs

Initial research for policy development was funded by both the San Francisco Planning Department and the San Francisco Municipal Transportation Agency.

The programme itself is funded through application fees – just over US$6,000 (approximately NZ$8,870) per application initially (A Harris, Senior planner transportation demand management, San Francisco Planning, pers comm, 31 January 2019).

Following initial set up, there are two phases of monitoring: an annual report in the first year, at a cost of US$1,000 (approximately NZ$1,480) and a US$1,300 (approximately NZ$1,920) charge to amend the TDM plan after it has been already approved.

18.3 Programme evaluation

As of January 2019, 150 TDM plans had been filed and were either being reviewed or waiting for the project to be given their "entitlement" to build. About 25% of those 150 projects now have the TDM plans recorded on the deed of the property, which means the plan has been accepted by the city's planning department and the project will soon have a building permit issued (A Harris, pers comm, 31 January 2019).

Planning staff have conducted stakeholder outreach and gathered feedback about the programme. Feedback indicated that developers wanted more flexibility around which TDM measures they can use, and how they can be altered. As a result of the feedback, the TDM ordinance was updated, with the wording in the law altered to be clearer about which TDM measures can be used in which development situation, and how they can be altered to suit particular development needs.

Implementing the law resulted in a planning code change, which was a challenging process.

To date, the department has had feedback from developers about the scalability of projects. Developers have concerns about the viability of some measures, for example the measure awarding points for a one-to-one substitution of car parks to bike parks. In large developments, this may be unsuitable.

According to the planning department, the programme is designed to deal with such issues. Not all measures will be appropriate for each development site, but there are several different measures available to suit different development needs, "It's a menu of choosing your own TDM measures as long as [you] meet the points" (A Harris, Senior planner transportation demand management, San Francisco Planning, pers comm, 31 January 2019).

As development is believed to be highly profitable and desirable in the city of San Francisco, it is not believed the programmed is likely to discourage development in the city, or drive it elsewhere (A Harris, pers comm, 31 January 2019).

18.3.1 Future programme evaluation

As it is new, San Francisco's TDM ordinance and tool has not yet been fully evaluated. However, it will be evaluated using the following indicators:

- Number of TDM plans filed, and compliance. Once the projects with TDM plans in place are built, the city's planning department will be monitoring their implementation and on-going compliance.
- Citywide vehicle travel (measured as VMT).

The city is expecting to use the TDM ordinance as a way to determine what TDM initiatives work in particular areas, so those initiatives can then be rolled out in other parts of the city (Bliss 2016).

18.4 Other jurisdictions:

In January 2019, the City of Vancouver introduced a by-law similar to San Francisco's legislation, mandating that new developments are required to have a certain number of 'TDM points' before they can get consent. This is part of the city's *Transportation 2040* and *Greenest city* targets of having walking, cycling and public transport trips making up at least 66% of all trips by 2040, reducing VKT per resident by 20% from 2007 levels, and reducing community-based greenhouse gas emissions by 33% from 2007 levels.

TDM measures for new developments include: financial incentives (eg carshare membership; public transport passes); active transportation (eg access to bike parking, shared bicycle fleet, walking improvements); alternative commute services (eg carshare spaces, shuttlebus service); support, promotion and information (eg transportation marketing services, real-time information); and parking management (paid parking for users, reducing parking supply).

Developers are also allowed to add their own 'innovative strategies' into their TDM plan, subject to approval by the city and suitable justification.

Data to measure the success of this programme is not yet available.

18.5 Key insights

San Francisco's TDM ordinance for developments is acting as a testing ground for understanding the viability of TDM strategies for the city more widely.

The ordinance allows developers to select from a 'menu' of TDM options, adding to a total score.

The programme is funded by application fees from developers, handing some responsibility to developers to take part in TDM research in the city.

The TDM ordinance was implemented after reviewing other, successful, programmes undertaking similar work elsewhere.

It has been deemed unsuitable to include affordable housing projects in the TDM ordinance due to a limited contribution to mode share from such developments.

San Francisco has been careful to exclude TDM strategies from its list of available options that do not meet the city's wider definition of TDM or would be too difficult to implement or monitor.

19 Conclusions and critical insights

The six case study cities described in this report (chapters 5 to 10) apply a wide range of TDM policies, programmes and activities. Additionally, the 10 focus areas (chapters 3 and 4, and 11 to 18 outline examples of particular TDM strategies and methods for developing or analysing these programmes.

This research has reviewed examples of TDM programmes and strategies being implemented around the world, with the intention of providing a useful reference document for any organisations considering managing transport demand. The critical insights outlined in this section demonstrate the opportunities and complexities of implementing TDM programmes, and how they depend on programme context, including goals, resources, governance frameworks, demographics and geographic conditions.

TDM goals, objectives and targets need to be clearly defined and communicated

To maximize benefits, short-term planning decisions should be consistent with strategic, long-term goals. It is therefore important for any planning process to clearly define goals (what communities ultimately want to achieve), objectives (specific ways to achieve goals) and targets (measurable outcomes to be achieved). This allows different jurisdictions and agencies to align plans and investments, including TDM programmes. The clarity and consistency of TDM goals at all levels of governance, is important for the formation of clear policy and strategy. This then enables clear communication to all parties, and generates understanding and buy-in.

This research has shown a range of different transport demand goals for different jurisdictions. In some cases, TDM goals, objectives or targets were established by higher levels of government or defined in a city's strategic vision or plan. Objectives and targets usually included changes in mode share, VKT, congestion reductions, parking cost savings (parking infrastructure savings provided by reductions in vehicle ownership and use caused by TDM strategies), emission reductions, physical activity or other outcomes.

In the case of Singapore, the goals primarily concerned increasing vehicle traffic efficiency, with little consideration of community liveability or the pedestrian and cycling environment. This very clear and focused approach resulted in a significant reduction in traffic congestion, vehicle ownership and VKT.

Vancouver has a wider range of goals, which resulted in a broader set of objectives related to improving and encouraging sustainable mode share and reducing VKT. These goals support a variety of TDM programmes and strategies including integrated land use and transport policy, the *Transportation 2040* plan, and investments to improve walking, cycling and public transport.

In Washington State, clear state-wide TDM goals are in place. Because the state covers a large area with a diverse set of jurisdictions within it, lower-level jurisdictions are allowed to set their own, relevant, TDM targets to meet these larger-scale goals. This structure is designed to allow flexibility in meeting large-scale TDM goals across differing jurisdictions.

The term 'TDM' is used inconsistently.

The term 'TDM,' and variations such as 'vehicle travel reduction' and "mobility management,' are defined and interpreted differently between different jurisdictions, and sometimes even within organisations. This has an impact on the way TDM is understood, implemented and funded.

'TDM' is sometimes used to describe city- or region-wide policies to pursue broad transportation goals. In others, it refers to a discrete programme or strategy.

Both London and Vancouver integrate what can be called 'TDM' goals into their long-term strategic planning, and this is considered part of their success toward those goals. Interestingly, both cities have a smaller scoped TDM-specific team, whose work generally focuses on behaviour change programmes.

The Lake Washington Urban Partnership example outlined in the leadership and business model focus area is an example of the potential disconnect that can arise from inconsistent terminology. The project aimed to reduce congestion on a key corridor through the four T's – transit, tolling, technology and telework. However, only teleworking was considered a TDM strategy. The evaluation, therefore, indicated limited TDM success while the overall project had good outcomes.

This disconnect in usage of the term 'TDM' indicates that it may not always be the most suitable term to refer to city-wide transport goals. This finding also indicates the need to carefully assess the level within an organisation at which a TDM team sits, and whether their scope includes wider transport goals.

The inconsistent use of TDM can also create confusion among the general public. While most people are familiar with things such as carpooling, efficient parking pricing, or active transportation promotion to achieve health and environmental goals, there is less understanding about the full scope of strategies and programmes and their diverse benefits.

To maximise effectiveness, it is important to integrate and prioritise TDM principles into all relevant policies and planning activities.

A trend observed among the case study cities is the practice of integrating TDM goals and objectives into relevant policies and strategies, rather than implementing it as a special programme added afterwards. In the case of Vancouver, Singapore and Amsterdam, this approach appears to have been successful. In many cases, these programmes are named to emphasise health, affordability, sustainability or liveability benefits, rather than called TDM.

Vancouver evaluates all land use and transport planning through a TDM 'lens' based on the city's integrated transport and land use planning strategy (*Transportation 2040*), focused around the city's sustainable mode share targets.

Similarly, Amsterdam's TDM approach is integrated throughout transport and land use planning documents and policies, rather than delivered by a dedicated group. Planning for a liveable, sustainable and accessible city and reducing car trips is seen to be 'in the city's DNA', so is incorporated throughout planning and programme delivery.

In Seattle, TDM efforts have generally been centred around a state-mandated employer-based Commute Trip Reduction Programme. However, at the state level Washington State Department of Transportation is now actively trying to incorporate TDM principles throughout wider transport strategy. This is reflected in the most recent state-wide TDM strategic plan, which for the first time moves beyond the scope of employer-based programmes. This approach has been extended to both regional and local government.

For outreach and implementation programmes to successfully change travel behaviour, alternative mode supporting infrastructure and services must be in place.

Cities with successful outreach and implementation programmes have also provided supporting infrastructure and services that improve the convenience, comfort, integration and affordability of sustainable modes.

The most successful TDM programmes generally include a combination of improvements to appropriate travel options and incentives to use the most appropriate option for each trip. These tend to have synergistic effects; together they achieve greater travel changes and benefits than if implemented individually. Without appropriate travel options, incentive strategies may have little impact and cause

frustration. Investments in alternative modes will have a higher economic return if travellers have incentives to use them.

London's revitalisation of its overground network is a success story. The change involved substantial rebranding and marketing of the service, as well as cheaper journeys. This marketing was accompanied by significant improvements to the overground's actual service, with improved timing and revitalised infrastructure.

The University of British Columbia's successful TDM programme came from an agreement between the university and the district transport provider. The university would reduce drive alone rates by 20% if the transport provider (GVRD) increased bus services to the campus. The increased public transport offering allowed the university to offer the U-Pass to students, with unlimited public transport ridership, partly funded by increased parking frees. The success of the programme relied on the availability of public transport. Campus public transport ridership increased by 168% between 1997 and 2008.

MIT also implemented a workplace behaviour change programme in 2016. The programme has been successful at reducing the drive alone rate on campus. This has been a result of a series of behaviour change initiatives and incentives, including a free public transport pass for employees and a discounted pass for students. This pass was ranked as, by far, the most important benefit of the programme. Such a pass relies on the provision of public transport services to encourage uptake, and the campus locations, serviced by two metro stations has made this strategy effective.

MaaS is an emerging tool that can support TDM goals. Pilot schemes have so far shown success in cities that already have alternative mode supporting infrastructure in place, such as public transport provision in Stockholm, where UbiGo has been tested. The impact of MaaS without such infrastructure has yet to be fully tested and could increase urban traffic problems if implemented without suitable incentives to favour use of shared vehicles.

There are no silver bullets when trying to change travel behaviour on a large scale.

Most individual TDM measures have limited effectiveness on their own; the full effect of TDM can be realised with an integrated programme of appropriate strategies. Most TDM programmes only affect a small portion of total travel – such as city centre commute trips, travel by residents of a particular area, or freight transport – so a variety of TDM programmes are generally needed to achieve broader goals such as reducing local or regional traffic congestion, crashes and pollution emissions.

Many of the most effective TDM strategies evaluated in this research also had substantial financial costs. Some strategies, such as increased fuel taxes, parking fees, road tolls and distance-based vehicle insurance and registration fees, have minimal public costs or generate revenue, but face substantial political opposition.

Some car restraint policies, such as congestion pricing and parking pricing, have proven to be very effective at reducing traffic problems, and their political acceptability tends to increase after citizens experience their benefits. Just three months after congestion pricing was implemented in Singapore for example, traffic into the restricted zone fell by 44%. In San Francisco, implementing the SF*park* pilot programme to more dynamically manage parking prices also appeared to quickly reduce traffic in the area. Car volumes decreased by 7.7% after programme implementation, compared to a 4.5% increase in non-pilot areas. However, such strategies often face institutional and political obstacles which must be addressed to build support. For example, in the Netherlands several governments pursued the idea of congestion charging and found that it was simply too politically unpalatable.

Appropriate infrastructure investments are critical to the success of TDM programmes. Improving public transport infrastructure and service tends to increase ridership and reduce private automobile travel on

affected corridors, and transit-oriented development tends to significantly reduce vehicle ownership and use by residents and workers. However, this often requires significant public investments and can be slow to implement.

Seattle's public transport improvements helped achieve substantial mode shift away from private car use. While this has come at considerable financial cost, this programme has broad public support. Seattle residents generally understand that the strategy is part of a greater vision for the city's transport system. The investment has been funded through three voter-backed measures to enact a sales tax and city vehicle registration fee to pay for public transport improvements. The most recent measure, Sound Transit 3, approved $154 billion (about $35,000 per capita) to expand the light rail system by adding 37 stations to the 41 already built or planned. In 2015, an estimated 25% of residents lived within a 10-minute walk of a frequent service and this jumped to 64% in 2017.

Major events or construction projects are an opportunity to trial TDM strategies and can lead to long-term travel behaviour change.

Major disruptions can cause major changes in travel behaviour. Disruption to regular travel provides an opportunity for travellers to try new modes in a more understanding environment where disruptions and delays are expected. Reluctance to try a new mode is considered a key barrier to change.

Both Vancouver and London used the Olympics as an opportunity to implement both temporary and permanent TDM initiatives. Each saw substantial short-term behaviour change as a result of new TDM strategies, in particular behaviour change strategies. Local goodwill has been pointed to in both examples as a driver of this change.

More substantially, the London Olympics had some significant long-term benefits for managing travel demand. For example, the Olympic freight management strategy was so successful that after the games ended the freight industry pushed for it to continue. This formed the basis for the city's overall freight TDM strategy. Conversely, employer support of flextime and teleworking declined after the games, which may reflect a lack of public concern about 'normal' traffic congestion problems

Construction disruptions can also be an opportunity for behaviour change. For example, when the Velser tunnel crossing in the Amsterdam region was closed for expansion, regional planners instituted a cycling promotion and provided a replacement ferry across the canal. Upon project completion, an estimated 3,500–5,000 people continued cycling and the ferry was retained despite a reduction in car travel times following the tunnel expansion.

In Sydney, the CBD Coordination Office was established in June 2015 as a single coordination point to manage the impact of the significant development and construction projects within the Sydney CBD including light rail and bus network changes. This resulted in the initiation of the Travel Choices Programme, which is now the centrepiece of TDM in Sydney and has expanded from dealing solely with construction disruptions.

Persuasive technologies can influence travel behaviour and come with both benefits and challenges.

Examples of key technologies identified to influence travel demand include MaaS, personalised persuasive technologies, social networking and gamification, and other app-based projects.

Persuasive technologies make use of data collection to offer personalised and targeted incentives for travel behaviour change. In comparison to traditional approaches, these technologies can cast a wider net (contacting users on a large scale), and then use data to personalise incentives more effectively.

Singapore's Travel Smart Rewards Programme (formerly 'INSINC') demonstrated the effectiveness of reaching a wide range of users through social media and technology and utilising smart card data to develop personalised reward schemes. This resulted in a clear shift in the timing of people's journeys.

There are still challenges associated with persuasive technologies, particularly concerning data security and data sharing. Many transport related technologies are being developed by the private sector. Public governance has been identified as a key requirement to ensure public and private interests do not conflict. For example, scaling MaaS requires resolving ownership and data sharing issues between public and private stakeholders. Helsinki, the capital of Finland, has the most advanced MaaS offering worldwide and this was recently bolstered by a national law requiring transport data sharing between customers, transport service providers and authorities.

Other aspects to be aware of with persuasive technologies include the importance of equity of access and the opportunities for technology to complement and enhance already-existing tools, rather than replace them.

TDM policies need to account for emerging mobility trends and services.

Emerging mobility trends and services include ride hailing, the sharing economy, e-commerce and associated deliveries, MaaS, integrated navigation and payment apps, and autonomous vehicles. Managing them requires an understanding of consumer demands and preferences, so facilities and services are designed to respond to changing demands, and are effectively integrated with TDM programmes and strategies.

Ride hailing, such as Uber has emerged as a popular mobility service in cities worldwide. However, early research suggests it may lead to increased congestion. In Singapore, the congestion charging scheme has provided a mechanism to manage the rise of ride hailing as such vehicles have always been subject to the congestion charge. This has meant that Singapore has not experienced the same congestion effects as other cities. Unlike Singapore, ride-hailing vehicles were initially exempt from London's congestion charge. This has meant that growing ride hailing and private hire vehicle use is undermining the success of the city's congestion charge. To combat this, these vehicles lost their exemption from the congestion charge in April 2019.

Planners in Vancouver are concerned about the anticipated arrival of ride-hailing services in the city. Until recently, provincial law prevented these services, so Vancouver has not experienced the traffic problems resulting from ride-hailing services.

Car sharing is another example of the sharing economy applied to urban transport. In Vancouver, car sharing has been very popular and is believed to have reduced car ownership. However, in Amsterdam planners have concerns about greater uptake of car sharing services as previous pilots were shown to cannibalise sustainable transport mode share. As a result, the city is considering establishing neighbourhood-specific electric vehicle sharing stations which would include cars, e-bikes, e-cargo bikes and e-scooters.

The trend toward e-commerce and increasing demand for just-in-time deliveries has increased delivery vehicle traffic in urban areas. City governments are working with private sector stakeholders to implement TDM principles to manage this growth and mitigate the negative impacts. Strategies include encouraging off-peak deliveries, consolidating deliveries, and a move to sustainable modes such as electric cargo bikes.

A trend of preference for sharing or subscription-based services, such as Netflix, is also emerging in transport. This may provide new methods for charging for services and weighting prices based on desired outcomes or TDM goals.

19.1 Future research areas

This research has detailed a range of international examples of TDM strategies through the six case studies and 10 focus areas. In reporting on these strategies, this research has also identified areas where future investigations are warranted. These areas relate to the speed of technological change, the need to ensure that certain groups are not overlooked, and recognition of the fact that the changes may result in unforeseen complexities, both positive and negative, for the transport system. Below is a list of areas of potential future research.

- The issue of access to technology, especially regarding internet access and smartphone apps is important. There is a risk that those in lower-income households and unbanked users (people without a bank account or credit/debit card) may not be catered for very effectively with the advent of these technologies. For instance, many smartphone apps require payment facilitated through credit/debit cards or mobile/internet banking. App-based services with a payment component, eg electronic fares and ticketing, may be difficult or impossible. This can also lead to households that cannot afford to have a credit card or bank account (due to insufficient funds, bad credit history, etc) being excluded.
- Another aspect that requires further consideration is the need to ensure technologies are accessible to all users. Accessibility requires apps to be usable by people with various health conditions (primarily older adults), as well as disabled individuals who need assistance. Although the smartphone apps of today have improved tremendously in design, user interface and power, there has been less progress toward making these apps available for the visually impaired or users with learning disabilities.
- Autonomous vehicles, if or when they become widespread, have the potential to significantly impact on urban mobility patterns. They may bring several benefits, including increased safety, increased mobility and convenience, and reduced emissions. They may also pose additional complexities to cities' TDM goals. For example, by reducing travel costs, autonomous vehicles may increase demand for private vehicle travel. They may also further increase overall VKT by circulating to pick-up and drop-off passengers compared with traditional vehicles that park at their destinations (MRCagney 2017). Ensuring the emergence of autonomous vehicles supports urban TDM goals will likely require a range of regulations and public management. Connected and autonomous vehicle technology may also provide opportunities to update public parking management and provision, including through new pricing enforcement mechanisms and by allowing some existing parking infrastructure to be repurposed. There are many uncertainties regarding consumer responses to autonomous vehicles and the speed of technology developments (MRCagney 2017). Given their potential impact on cities' transport and land use goals, national and urban governments will play an important role in managing their development.
- The rise of micro-mobility, ie a personal vehicle that carries one or two people, such as e-scooters, skateboards, e-bikes and other vehicles that run on small rechargeable batteries, have the potential to transform urban transport by offering non-car alternatives for local trips and public transport access trip legs. The requirements of users of these devices are often the same as those of people walking and cycling due to their speed of travel, size of the vehicle and user combined and the absence of physical protection from injury in collisions. This makes micro-mobility users 'human-scaled' and has implications both for how to cater for the 'the first and last mile' aspects of travel which are often challenging for TDM strategies and for infrastructure both in terms of what space they should operate in and also the need for places to recharge.

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Appendix A: Glossary

ALS	area licensing scheme (Singapore)
API	application programme interface
ARF	additional registration fee (Singapore)
ARTA	Auckland Region Transport Authority
AT	Auckland Transport
ATAP	Auckland Transport Alignment Project
CAPCOA	California Air Pollution Control Officers Association
CAV	connected and automated vehicle
CCLS	common carrier locker systems
CCP	commuter car parking
CMAQ	congestion mitigation and air quality
COE	Certificate of Entitlement (Singapore)
CTR	commute trip reduction (Seattle)
DA	development application
DCP	development control plan (Sydney)
DLR	Docklands Light Railway
ERP	electronic road pricing (Singapore)
FHWA	Federal Highway Administration
GMA	Growth Management Act (Washington State)
GVB	Gemeentelijk Vervoerbedrijf (Amsterdam Public Transport Authority)
GVRD	Greater Vancouver Regional District
HOV	high occupancy vehicle
HTS	household travel survey
INSINC	Incentives for Singapore's Commuters
ITS	intelligent transport systems & services
LEZ	low emission zone
LTMP	Land Use and Transport Masterplan (Singapore)
LTA	Land Transport Authority (Singapore)
MIT	Massachusetts Institute of Technology
MaaS	mobility as a service
MIMPs	major institution master plans (Seattle)
MRA	Amsterdam metropolitan area
MRT	mass rapid transit (Singapore)

NSW	New South Wales
NTU	Nanyang Technological University
OMV	open market value
ORCA	one regional card for all (Seattle)
OSTS	The Optus Sustainable Transport Strategy (NSW)
PSRC	Puget Sound Regional Council
PTDM	parking and transportation demand management
SCO	Sydney Coordination Office (Travel for New South Wales)
SOV	single occupancy vehicle
SeaTac	Seattle-Tacoma International Airport
SDOT	Seattle Department of Transportation
SFMTA	Municipal Transport Agency of San Francisco
STM	Société de transport de Montréal
TDM	travel demand management
TfL	Transport for London
TfNSW	Travel for New South Wales
TMA	transport management association
TSM	transport system management
UCC	urban consolidation centre
UPA	urban partnership agreements
UK	United Kingdom
URA	Urban Redevelopment Authority (Singapore)
VMT	vehicle miles travelled
VKT	vehicle kilometres travelled
VQS	Vehicle Quota System (Singapore)
WSDOT	Washington State Department of Transportation
WTP	workplace travel plan

Appendix B: Additional performance evaluation information

Table B.1 TDM Programme economic evaluation tools

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Transportation Benefit-Cost Analysis. Transportation Economics Committee, Transportation Research Board. http://bca.transportationeconomics.org

TRB Performance Measurement Community of Practice website. www.trb-performancemeasurement.org

TREDIS Multimodal benefit-cost analysis tool. http://tredis.com/mbca

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