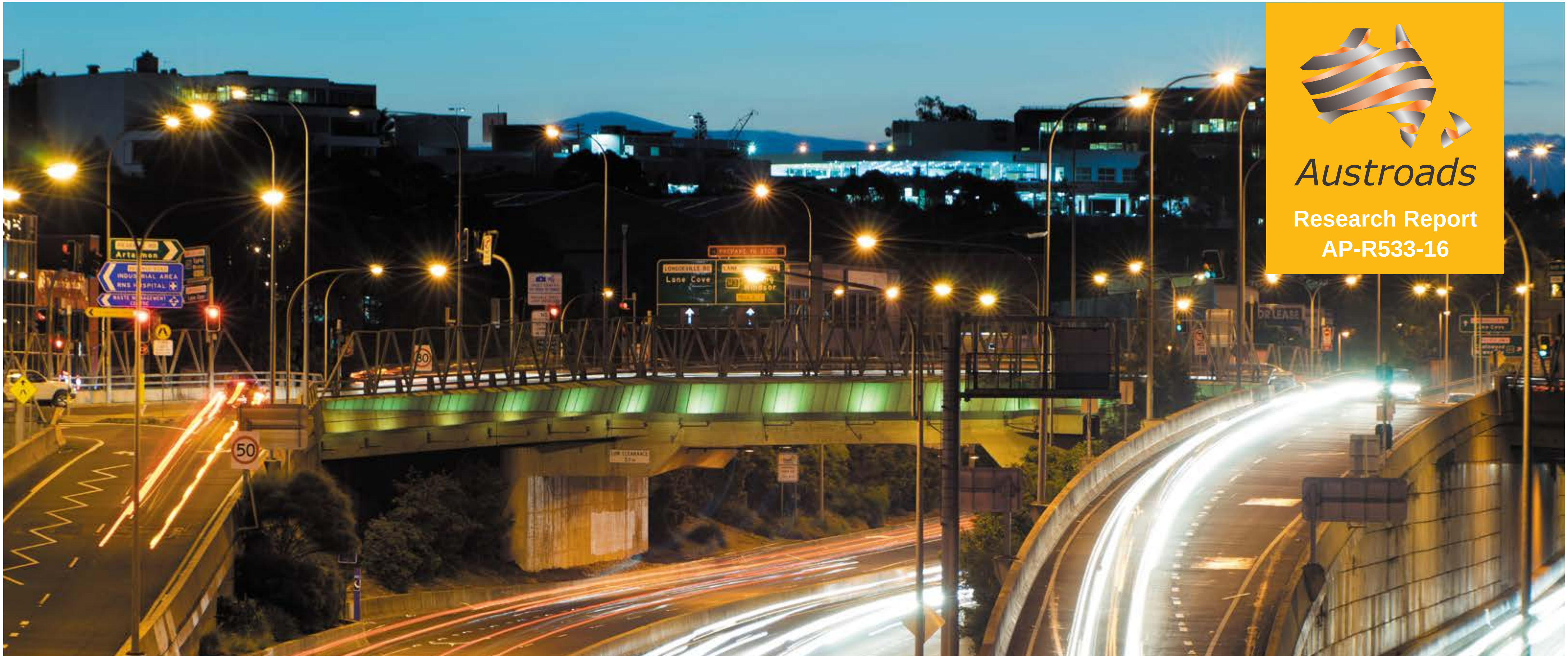

Austroads

Research Report

AP-R533-16

Congestion and Reliability Review

Summary

Congestion and Reliability Review: Summary

Prepared by

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Project Manager

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Abstract

This summary provides an overview of the *Congestion and Reliability Review* which measures levels and identifies key causes of congestion across major cities in Australia and New Zealand.

The Review proposes an approach to identifying and assessing congestion interventions and overlays the key areas of focus for road and transport agency capability development in order to assist agencies in developing a congestion mitigation roadmap.

Keywords

traffic congestion, population growth, urban land use, road network performance, travel time, transport demand, road investment, road user satisfaction

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Austroads

About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Australian Government Department of Infrastructure and Regional Development
- Australian Local Government Association
- New Zealand Transport Agency.

Acknowledgements

We would like to acknowledge the assistance of Google in providing access to their Maps and Traffic datasets. This unique and rich data has allowed this report to measure and compare congestion across Australian, New Zealand, and international cities. Google's data, coupled with Deloitte's analysis, has enabled this evidence-based assessment to be undertaken at an unprecedented scale, using data that is aligned to road users' personal experience.

We would also like to thank Craig Moran and Bryan Wiley for their exceptional leadership and unwavering commitment throughout the Review and the substantial contributions from the cross-jurisdiction CRR Working Group, Professor David Hensher, Founding Director of the Institute of Transport and Logistics Studies in The University of Sydney Business School and Nick Patchett, Partner of Pillar Strategy UK.

FOREWORD

Traffic congestion is a major problem for urban Australia and New Zealand. While some of this reflects Australia's unprecedented economic success and growing population, congestion has also increased where infrastructure provision has lagged growth, and where land use, public transport and road developments have not been integrated into city plans.

Congestion is, of course, not a new problem. To resolve the traffic problems of ancient Rome, Julius Caesar outlawed the use of private vehicles on the city streets during the first 10 hours of the day. This early demand management intervention appears to have been successful, with Roman populace adjusting their travel patterns.

Though our leaders today rarely enjoy the same freedom of action as the Roman dictator, technology is driving a new revolution in transport management, and will become increasingly embedded in our lives over the next 20 years. For example, consumers today can use a smart phone to select the best route for their journey and access congestion and road closure data in near real-time. In future, autonomous vehicles will access this information directly, and execute a journey without human intervention.

Austroads commissioned this Congestion and Reliability Review to leverage the data provided by Google to allow road agencies to understand road network performance and the causes of congestion, using a consistent methodology across Australia and New Zealand. In addition, the available interventions to road agencies have proliferated and new capabilities will be required in future to continue the evolution from the traditional role of road builder to a manager of the future road network and regulator of the embedded technology.

The Review has, with purposeful intent, taken a customer-centric view of congestion with measures that are most relevant to their lives and journeys. This includes a time scheduling budget that includes the actual travel time and the additional buffer that must be allowed due to the uncertainty on how long a trip will actually take. We have also noted that consumers are as interested in public transport alternatives as driving on new roads, are using cars less, and only our population growth is delaying the 'peak car' effect.

Zero congestion is not a realistic goal for a modern city in Australia or New Zealand. The technology that will become embedded in vehicles, roads and the road network will, however, help optimise the use of limited road corridors to both reduce the burden of congestion and make journeys safer. This report provides a baseline for how our road networks perform today, and practical frameworks to help road agencies to improve that performance in future.

Austroads congratulates the whole extended team on this work, and we particularly thank Google for providing their data as a pro-bono contribution to helping Australasia tackle congestion.

CONTENTS

Executive Summary

Road congestion diminishes the quality of life for the residents in Australian and New Zealand (ANZ) cities and costs the ANZ economies over $17bn per year. Urban road supply is constrained by the coastal geography of our cities and is becoming more expensive to deliver with tunnels, bridges and bypasses. Meanwhile, aggregate demand for transport continues to increase in line with a growing population, albeit at a declining rate as inner city living and working changes travel patterns.

Different road users have different travel needs with commuters, commercial and freight users requiring access at different times, with different economic costs and benefits. Reliability is a particular concern for all users that ultimately impacts the liveability of a city. 'Acceptable' congestion is therefore a subjective concept that includes absolute and stability of commute times, scheduling considerations and efficient investment in road supply that delivers the desired benefit.

The ANZ city congestion performance has been determined using massive Google data extracts for the 600km of arterial roads that comprise the backbone of the urban network. Congestion performance is correlated with population, so that the biggest cities, Sydney and Melbourne, perform worst overall. In these cities, road users need to allow an average 50% more time than free flow to complete their journeys during peak hours, when average speeds are as low as 29 km/hr and 34 km/hr respectively. Brisbane (52 km/hr) and Perth (58km/hr) have better performance, while Auckland congestion performance is similar to Melbourne, despite having a lower population. Adelaide has the slowest average travel speed, but higher reliability, reflecting a road network with fewer motorways. Darwin, Hobart and Wellington have low levels of congestion, with Canberra the best performing city overall, achieving average speeds over 60 km/hr. While weekday morning and afternoon peaks exhibit time delays up to 40%, weekend travel also faces congestion with delays up to 30% at the mid-day peak in Sydney.

ANZ cities perform in line with comparable cities in the US and Europe for time delay and reliability, with Melbourne exhibiting the best relative performance, and Auckland the worst. These international comparisons are challenging due to individual geographic and historic road planning constraints. ANZ cities with similar populations are in fact the closest comparator cities for each other.

Most ANZ urban congestion is due to recurring imbalances between supply and demand, with up to 12% due to identified non-recurrent causes, primarily traffic incidents. For many cities, better data collection is required to develop a deeper understanding of the drivers of congestion to ensure the investments are likely to deliver the desired benefits.

Road and transport agencies should invest in a portfolio of interventions including integrated land and transport planning, as well as relatively low cost, high benefit cost ratio "no regrets" interventions such as smart ramp metering and optimising traffic signals. For each road corridor, both demand and supply interventions are important, and a program of multiple intervention projects tailored to the specific congestion problem is most likely to optimise the investment in new road capacity. In particular, detailed pre-investment metrics, and post-implementation analytics are required to ensure that the multi-billion dollar investments are made wisely.

ANZ road agencies are shifting their purpose from just road-building to a more holistic concern for safe, reliable customer journeys. This typically requires a greater focus on strategic planning, delivery performance, technology and data-driven operational capabilities. Particular focus should be given to:

- Strategy and program planning that integrates land use and major infrastructure with the road network plan
- Leveraging data and new technology to optimise investments and the operational management of the road network

Congestion mitigation strategies are on the cusp of major change over the next 10 years, due to increasingly intelligent technology embedded in vehicles and road infrastructure. ANZ road agencies should provide a platform of regulation and technology that can support adoption of this innovation from the private sector. This needs relatively rapid action to support intelligent vehicles and new policy intervention as the most potent platforms for innovation that will mitigate urban congestion.

Effective action on road congestion is needed to avoid it becoming a drag on the economy, living standards or quality of life. Each jurisdiction must develop a strategic plan and investment roadmap for our cities, using an iterative end-to-end process starting from the needs of citizens. No doubt our cities could all be better had past generations implemented their visionary transportation plans. Similarly, the benefits of more focused investment will flow to future generations, and we hope this work triggers a commitment to embrace the potential of the next wave of transportation innovation.

1. Background

ANZ Road and Transport Demand

Vehicle kilometres travelled in Australia and New Zealand (ANZ) continue to rise, albeit at a slower pace than previously, at 1% per annum (see Exhibit 1). BITRE's forecasts suggest that by 2030, kilometres travelled could be a further 40% higher than current levels in Australia[1], while maintaining current growth trajectories will result in kilometres travelled increasing a further 14% in New Zealand.

Growth in demand has two impacts:

a) it is more difficult to develop the supply of road infrastructure (and public transport alternatives) in advance of demand

b) the imperative to have good planning of infrastructure is increased

Demand Drivers

New Zealand and Australia are highly vehicle-dependent, ranking 7th and 8th internationally in vehicle ownership per capita in 2010[2], and now sitting as high as 0.81[3] and 0.76[4] per capita respectively in 2015. This has increased 1% per year since 2004. Australia and New Zealand growth in demand (+1.0% p.a.) is increasing at a slower rate than population growth (+1.3% p.a.) due to a reduction in kilometres travelled per vehicle (-1.0% p.a.).

1 BITRE, (2015), Metropolitan Transport Task Estimates – Australia
2 World Bank, (2010), Motor Vehicles (per 1,000 people)
3 New Zealand Ministry of Transport, (2015), Transport volume: Fleet information, Vehicle ownership per capita 2014 TV035
4 Australia Bureau of Statistics, (January 2015), Motor Vehicle Census 9309.0

Vehicle Kilometres per Capita and 'Peak Car'

ANZ vehicle utilisation per capita has been decreasing since 2004[5], as shown in Exhibit 2. This can be explained by the concept of 'peak car', a hypothesis that motor vehicle distance travelled per capita has peaked and will now continuously fall into the future. This could be due to a decline in driver licencing[6,7], as well as a result of a change in the lifestyles of young citizens who are more likely to attend tertiary studies, work part-time, live with their parents and delay marriage than previous generations. 'Peak car' has been observed in countries around the world including France, Germany, Japan, Sweden and the United Kingdom.

Customer Demand

Customers can be grouped into three types, each with different growth and demand dynamics.

A – Personal. Consumers represent 76% of road users in Australia[8] and 78% in New Zealand[9]. Since 2006, they have become an increasing proportion of overall road users in Australia and a decreasing proportion in New Zealand.

B – Commercial. Light commercial vehicles that are owned by a company or a sole trader and are generally driven for business purposes are used as a proxy. They represent 15% of road users in Australia[10] and 13% of all vehicles in New Zealand[11]. They are decreasing as a proportion of overall road users in Australia and are an increasing proportion in New Zealand.

5 It is important to emphasise that these figures are for 'all vehicles', whereas 'passenger vehicle' ownership per capita is lower at 0.56 and 0.59 (licensed) respectively
6 New Zealand Transport Agency, (2015), Motor Vehicle Registration Statistics
7 Australian Bureau of Statistics, (2015), Vehicle and Driver Statistics
8 Australian Bureau of Statistics, (2015), Motor Vehicle Census 2006-2011
9 New Zealand Ministry of Transport, (2015), Annual Vehicle Data Fleet 2011-2014
10 Australian Bureau of Statistics, (2015), Motor Vehicle Census 2006-2011
11 New Zealand Ministry of Transport, (2015), Annual Vehicle Data Fleet 2011-2014

C – Freight. Freight vehicles represent 3% of road users in Australia[12] and 4% in New Zealand[13]. These vehicles are primarily used to transport goods. Freight has remained a consistent 4% of total vehicle-kilometres travelled on Australian roads from 2000 to 2014[14]. For New Zealand, road is the dominant mode of freight transport in terms of both tonnes and tonne-kilometres, accounting for 91% of tonnes moved and 70% of tonne-kilometres (18.5bn tonne-kilometres in 2012)[15]. This represents a year-on-year increase of just 0.7% in tonnes transported by road from 2006/7 to 2011/2012, and a year-on-year decrease in tonne-kilometres of 0.3%.

The remaining customer group is largely comprised of motorcyclists, making up 4% of road users in Australia and 4% in New Zealand.

ANZ Road and Transport Supply

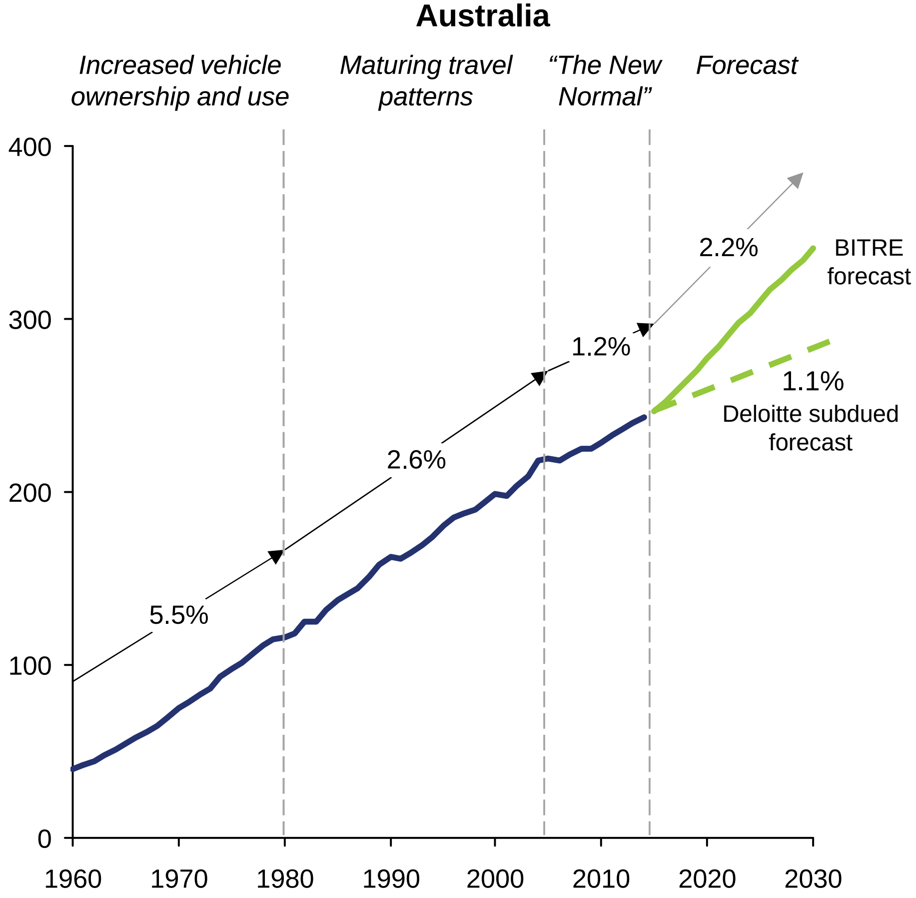
Road and transport agencies in ANZ have met growing population and road demand by building road and alternative infrastructure. This has the highest impact where it is planned alongside land use decisions in integrated urban plans. As a continental nation, Australia spends more of its GDP on transport infrastructure than any other developed nation. In 2014 this proportion was 1.4%, compared to New Zealand's 0.5%, the UK's 0.5% and Sweden's 0.6%[16].

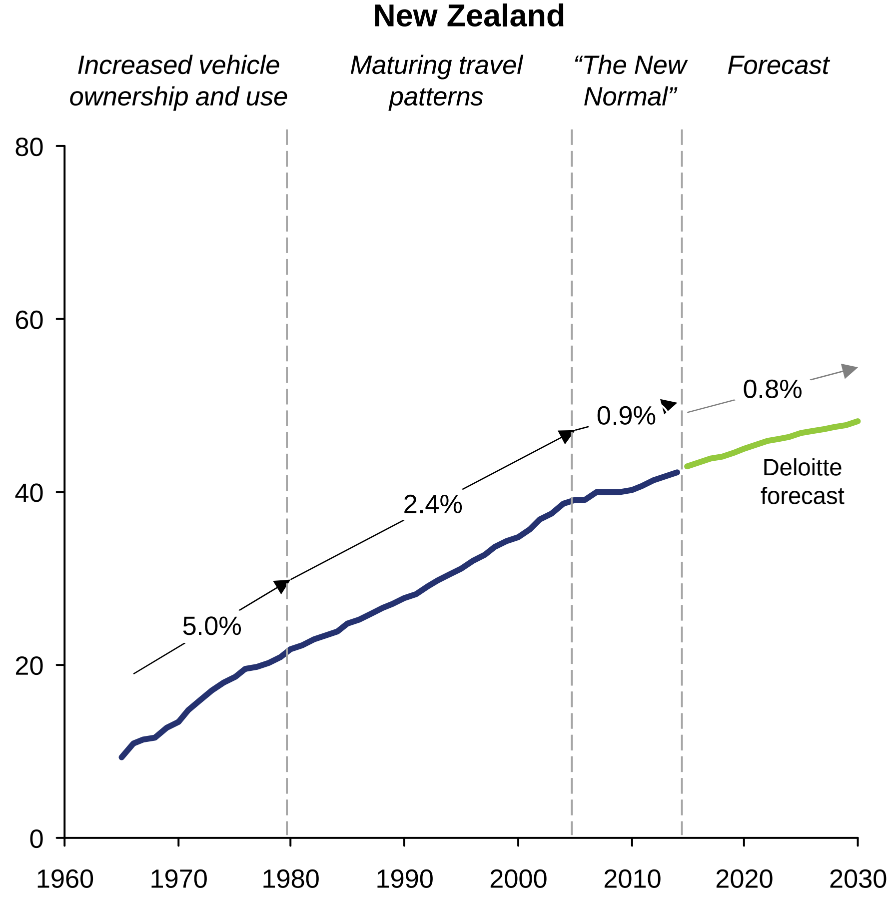
12 Australian Bureau of Statistics, (2015), Motor Vehicle Census 2006-2011
13 New Zealand Ministry of Transport, (2015), Annual Vehicle Data Fleet 2011-2014
14 BITRE, (2007), Working Paper No. 71 'Estimating Urban Traffic and Congestion'
15 Transport NZ, (2012), National Freight Demand Study 2014
16 World Bank, (2013/14), International Transport Forum

Exhibit 1

Growth in total vehicle travel has slowed over the last 30 years

Vehicle Kilometres Travelled
Billion km



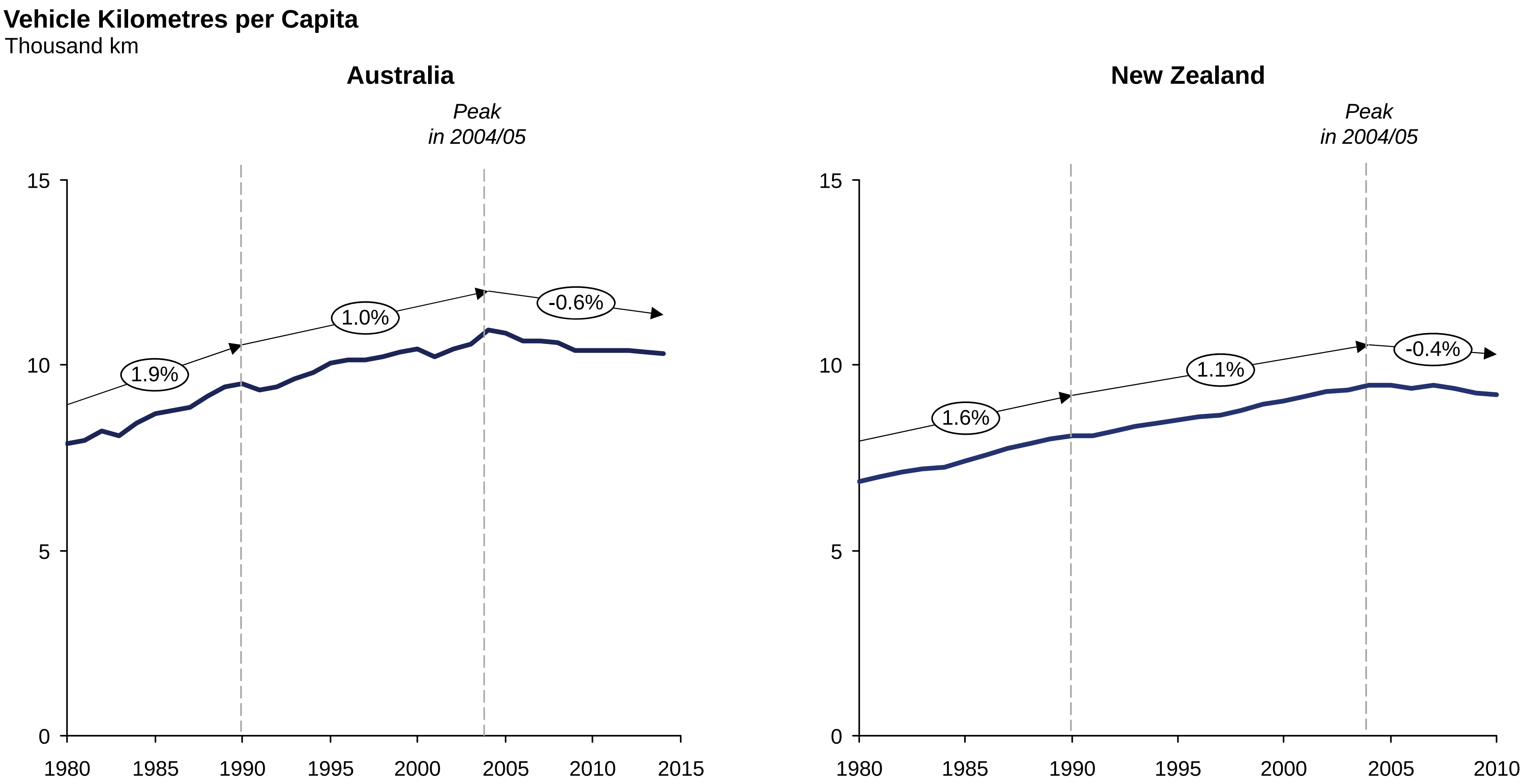


x% Compound Annual Growth Rate (CAGR), i.e. the mean annual growth rate

Note: 'Vehicles' includes cars, LCVs, rigid trucks, articulated trucks, buses and motorbikes
Source: BITRE 2015 Estimates; New Zealand Ministry of Transport

Exhibit 2

Vehicle kilometres per capita peaked for both Australia and New Zealand in 2004



x% Compound Annual Growth Rate (CAGR), i.e. the mean annual growth rate

Note: 'Vehicles' includes cars, LCVs, rigid trucks, articulated trucks, buses and motorbikes
Source: BITRE 2015 Estimates; New Zealand Ministry of Transport

Road Supply and Investment Trends

In Australia, the urban road network supply (+0.7% p.a.)[17] is increasing at a slower rate than demand. Similarly in New Zealand, total road supply (+0.2% p.a.)[18] is not keeping pace with demand. In both Australia and New Zealand, expenditure on roads is greater than specific transport taxes. In Australia, total public road expenditure was 26% higher than funding from roads in 2014[19]. Similarly in New Zealand, total expenditure ($9.2bn) from national funding sources has been above revenue ($9.0bn), in total, for the last three years[20].

Alternative Transport Supply and Expenditure

The demand for road space by personal and commercial vehicles is influenced by the supply and relative attractiveness of alternative forms of transport. For personal consumers, the alternative consists of modes of public transport, i.e. trains, buses, ferries, and light rail, as well as taxis. For road freight, alternatives are largely via rail or sea. For many light commercial vehicles, there is no realistic alternative to the traditional utes and white vans. The different dynamics should be factored into demand management decisions.

For Australian urban mass transit systems the percentage of public transport costs recovered through user payments is around 25-30%[21] while in New Zealand it is 45-55%, well below the level recovered in a number of transport systems internationally, such as 70% in San Francisco, 80% in Washington and 125% in Singapore.

For freight, a shift of freight transportation from road to rail reaps more than just congestion-related benefits. Deloitte Access Economics estimates that a modest increase in rail's modal share of the freight task would result in the current $92m in benefits derived from the Australian North-South corridor growing to $227m by 2030[22].

Interactions of Supply and Demand

Road agencies are aware that demand can be induced by increasing the supply of road space. Building new roads is not always the solution to decreasing congestion. Braess's Paradox shows how more roads can lead to more congestion – if new road supply leads to a faster route and all vehicles take the new fastest route, all of the traffic is slowed.[23]

Definitions of Congestion

This report leverages traffic data provided by Google, which allows travel time along different road segments to be determined. The data can provide near real-time information on travel times for corridors and across cities. Therefore, modified congestion definitions have been developed, which can fully leverage insights from the Google data.

Existing Congestion Definitions

Definitions of congestion centre on both 'absolute travel time' and 'travel time reliability':

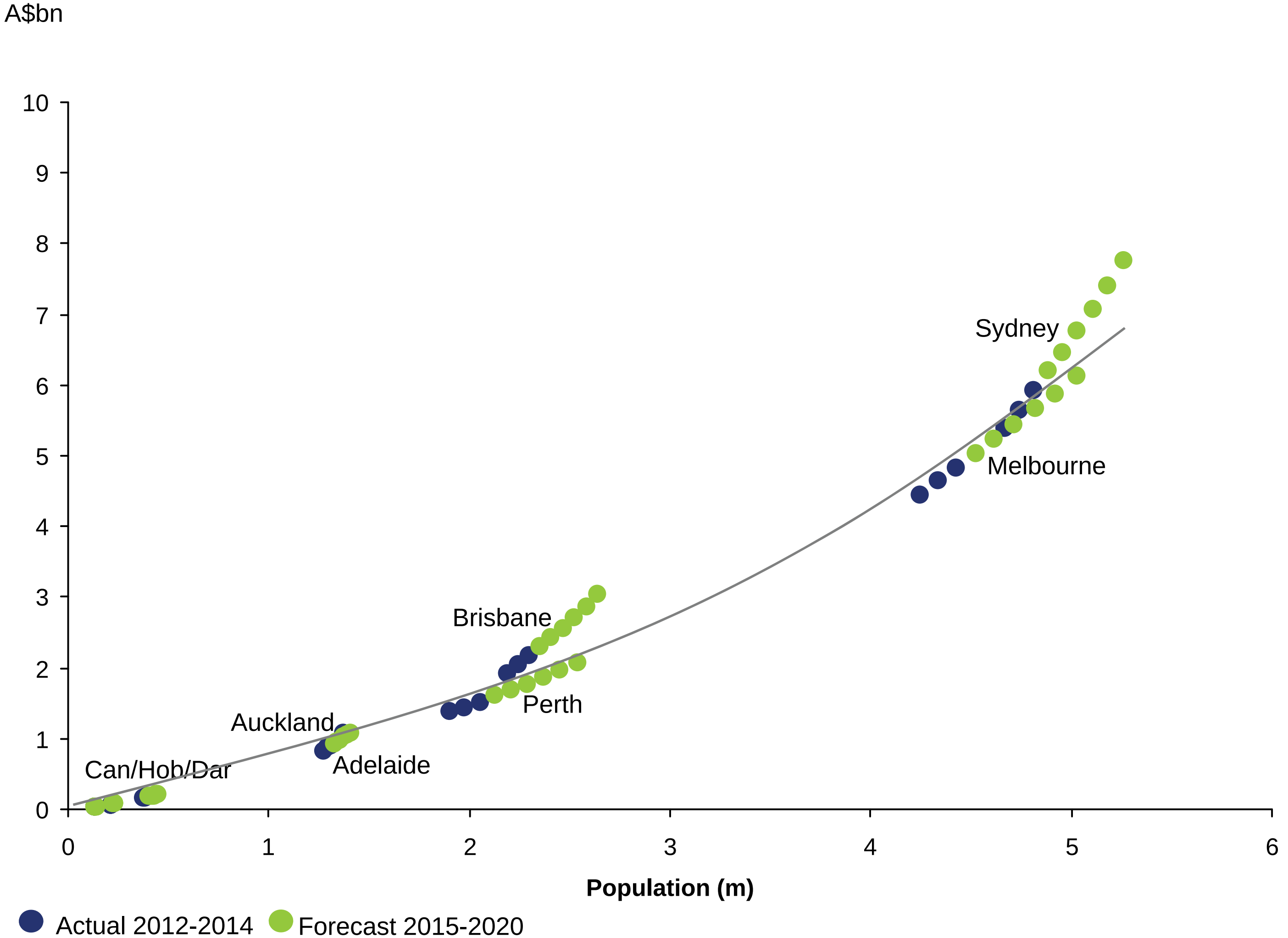
- **Congestion.** The National Performance Indicator definition of urban congestion (Austroads, 2015)24 defines congestion as actual travel time less minimum travel time
- **Reliability.** Travel time reliability measures the variation of average travel time

17 BITRE, (2014), Australian Infrastructure Yearbook
18 New Zealand Ministry of Transport, (2015), Transport Data
19 BITRE, (2014), Australian Infrastructure Statistics Yearbook
20 New Zealand Ministry of Transport, (2014), Future Funding Summary Report
21 Australian Department of Infrastructure and Regional Development, (2011), Trends: Infrastructure and Transport to 2030
22 Deloitte Access Economics / The Australasian Railway Association, (2011), The True Value of Rail
23 Reverse Braess Paradox explains that closing a road can actually lead to less congestion, as found in New York with the closure of 42nd Street in 1990
24 Australian Department of Infrastructure and Regional Development, (2011), Trends: Infrastructure and Transport to 2030

Exhibit 3

There is a positive correlation between congestion cost and population

Congestion Cost and Population[1]



	Congestion Cost CAGR '12-'14	Congestion Cost CAGR '14-'20
Sydney	4.7%	4.6%
Melbourne	4.2%	4.0%
Brisbane	5.9%	5.8%
Perth	5.4%	5.3%
Adelaide	3.5%	3.4%
Darwin	3.8%	3.8%
Hobart	1.6%	1.5%
Canberra	3.5%	3.1%

Note: No New Zealand data on congestion costs;; Auckland has one measurement for 2013, NZ$1.25bn= A$1.1bn using 2013 rate

Source: BITRE Australian Infrastructure Statistics Yearbook 2014, New Zealand Transport Agency 2013

Congestion Definitions Used

The six measures used in this report are those that are both relevant to road users, and can be determined with Google data[25]. The six definitions are illustrated in Exhibit 4. It is acknowledged that the metrics differ from the National Performance Indicators.

Impact of Congestion

The costs of congestion for the Australian economy are estimated to be A$16.3bn in 2015 and are forecast to grow by 5.5% per year between 2016 and 2030. No estimates exist for New Zealand, however Auckland's congestion cost was estimated at over NZ$1.25bn in 2013[26]. Congestion is correlated with population size, but is systematically lower in some cities (see Exhibit 3).

The impacts of congestion fall into four main categories:

- **Economic impact** – This form of impact is a result of non-productive waiting time in traffic, which leads to decreases in overall productivity and results in opportunity cost and negative impact on economic growth. The value of such impact was estimated by BITRE to be worth $8.9bn in Australia by 2020[27], defined as the business time costs of congestion (trip delay plus reliability). Analysis by Sweet from 88 of the most congested metro areas in the United States between 1993 and 2008[28], suggested that high levels of congestion are initially associated with faster economic growth. However above a certain threshold, congestion starts to become a drag on growth
- **Social impact** – The socialised cost shared by all people, is a result of the combined cost of delays for all vehicle passengers involved in congestion. This, for example, can be the cost of blocked traffic interfering with access for emergency vehicles, or additional vehicle operating costs
- **Environmental impact** – An often mentioned, but comparatively low value cost is that of environmental impact (BITRE), where air pollution and carbon dioxide emissions rise given worse traffic flow. Such environmental costs will have negative, uncertain long-term consequences on the environment
- **Health impact** – For Australia, BITRE (2005) estimated the health costs associated with air pollution from vehicles to be worth $3.3 billion each year[29]. Increased air pollution as a result of extended vehicle operation and emissions will continue to increase this cost

25 Due to the sample size of two months' data, combined 'weekday', rather than individual days of the week, is used for outputs. Engineering definitions of trip variability (reliability) are commonly based upon 85th percentile travel times (i.e. approximately 1.44 standard deviations from the mean)
26 Wallis, I., (2013), The costs of congestion reappraised
27 COAG, (2006), Review of Urban Congestion Trends, Impacts and Solutions
28 Sweet, M., (2012), Does traffic congestion slow the economy?
29 Bureau of Transport and Regional Economics (2005), Health Impacts of transport emissions in Australia: Economic costs

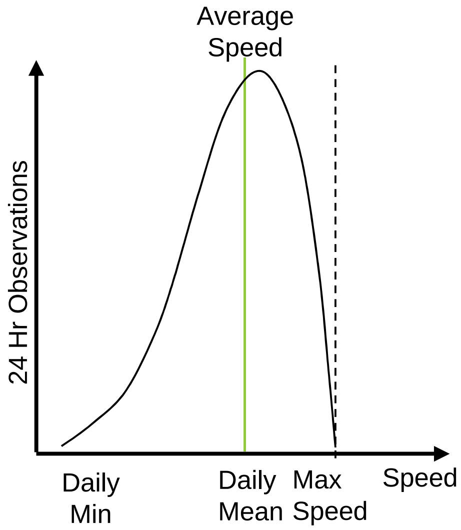
Exhibit 4

Congestion can be measured in different ways, since ‘absolute travel time’ and ‘travel time reliability’ are both important to customers

Congestion Measures Used

1 Average Speed

How fast does traffic in the city travel?

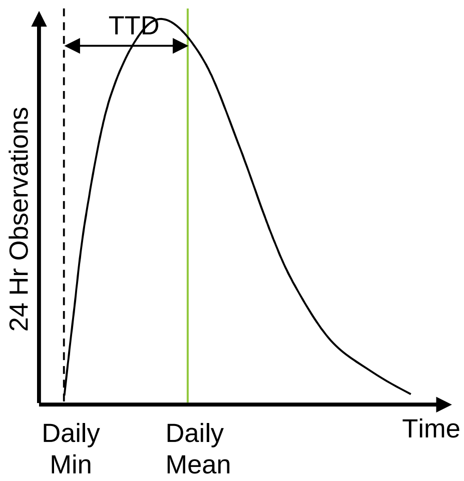


$$\frac{\text{Distance}}{\text{Time}}$$

If you drive in the city at any time of day, on weekdays, what is your average speed?

2 Travel Time Delay (TTD)

How much is traffic delayed from free-flow conditions?

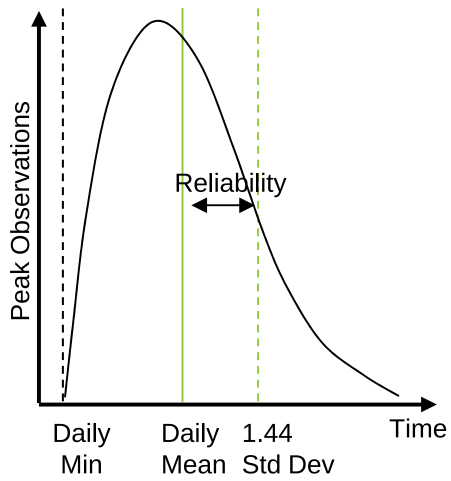


$$\frac{\text{Mean Travel Time for 24hrs}}{\text{Min Travel Time for 24hrs}} - 1$$

The average travel time is x% more than the travel time in free-flow traffic

3 4 Morning / Afternoon Peak Reliability

What is the statistical reliability of travel times in the peak periods?

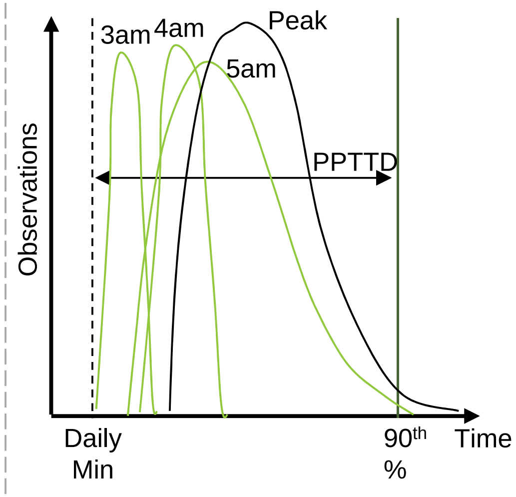


$$\frac{\text{1.44 Standard Deviations of Travel Time for Peak}}{\text{Mean Travel Time for Peak}} - 1$$

If you drive in the morning peak every weekday, your range of travel times are x% more or less than your average travel time, with a greater range indicating a more unreliable journey

5 6 Morning / Afternoon Peak Period Travel Time Delay

How much time does a consumer need to budget during the peak periods, relative to free-flow?



$$\frac{90^{th}\text{ Percentile for Peak}}{\text{Min Travel Time for 24hrs}} - 1$$

If you drive in the morning peak every weekday, you would need to increase your travel time by x% more than your minimum travel time to ensure you arrive on time, 9 times out of 10

2. Customer Perspectives

Road User Satisfaction

Road agencies are increasingly seeking to serve road users as 'customers'. These 'customers' are most concerned with the reliability of their journeys:

A – Personal: Several jurisdictions have studied customer preferences and behaviour, all finding that customers desire 'reliable' journey times and often make their own adjustments to ensure reliability.

B – Commercial: For light commercial vehicle deliveries, drivers normally operate within delivery windows. Businesses could forego earnings if they are late for appointments. Unreliable businesses are a drag on overall productivity.

C – Freight: Freight road users place high value on the arrival speed of goods to ensure efficient production. Heavy goods freight is often scheduled by 'windows' of port delivery times, where trucks are incentivised to queue at ports so as not to be late for their allocated arrival slot.

Information and Forecasting

Regardless of road user type, accurate and timely information is important to mitigate the effects of congestion: time delay, reliability and scheduling. Customers are more likely to find congestion acceptable if they know likely travel times and are kept informed of delays. This information is now available in real-time on smartphones.

Congestion and Liveability

Congestion impacts the 'liveability' of ANZ cities through loss of personal time, late arrival for employment and education, inability to forecast travel time (and resulting travel budget increase), reduced health levels and higher chance of collision.

Comparing road congestion levels with Mercer's Quality of Living rankings[30], there appears to be some correlation between congestion levels and liveability ranking (see Exhibit 5). There appears to be a strong decline in quality of living rankings when congestion reaches a threshold of 35-40%, which Sydney and Auckland are approaching. This suggests that there is potential for improving the relative attractiveness and liveability of a city by improving its congestion levels.

Acceptable Congestion

The 'acceptable' level of congestion is a subjective concept influenced by both urban planning and customer expectations, with five defining factors, defined as follows:

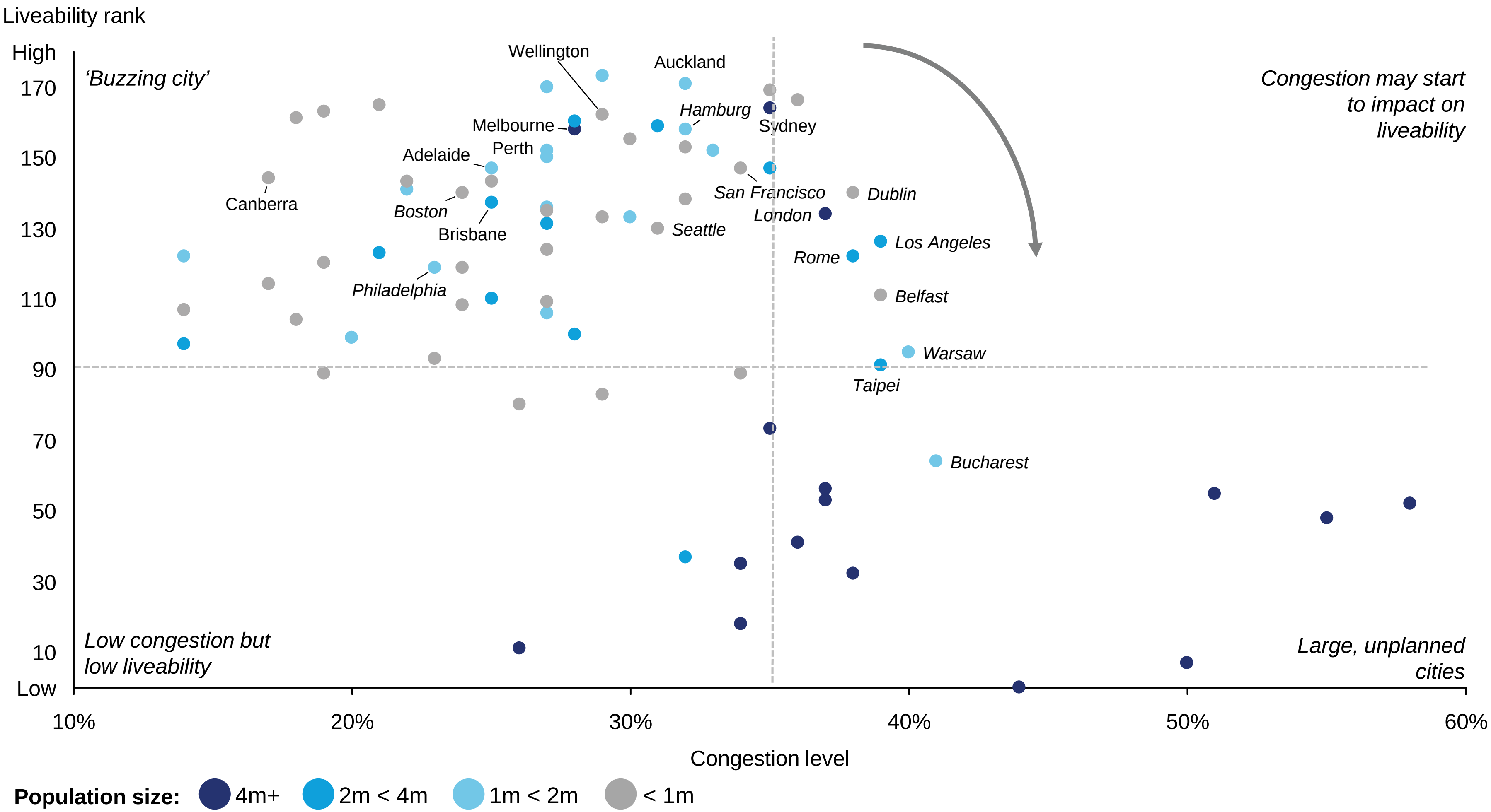
1. **Commute Time** – Marchetti's Constant posits that although forms of urban planning and transport may change and although some live in villages and others in cities, people gradually adjust their lives so that average travel time stays approximately constant. Behavioural drivers of congestion are complex; interactions between both supply and demand side influences impact on journey decision-making. Exhibit 6 indicates that Australians have a tolerance band for commuting that is between 50 to 80 minutes per day, regardless of travel mode (i.e. in 1900-1930, travel was on foot, horse, tram, train and boat).
2. **Stability of Commute Time** – From a customer perspective, the acceptable level of commute time is driven by broader choices around lifestyle, including spend on housing relative versus commute time, location of housing versus transport mode and job location. When road users decide to live in a specific area, they are doing so with the presumption that commute time will either remain static or improve if they stay in that area, and as such a worsening of commute time will not be seen as acceptable.
3. **Reliability and Scheduling** – The effect of reliability is particularly felt when unreliable journeys cause disturbances to road user plans. This effect is captured in 'scheduling models' of road user behaviour. Indeed, poor reliability means that road users may add 'buffer' travel time onto a trip which effectively extends the duration of a trip and is therefore in some ways equivalent to longer travel times. Road users are likely to consider it acceptable that their 'buffer' time will ensure that nine times out of ten they will arrive on time.
4. **Productivity** – Roads operating a productive flow, in line with the speed-volume relationship. Austroads NPIs consider this to be 100% when speed is 80% of posted speed for freeways and 65% for arterials, and flow is 2000 passenger cars per hour per lane for freeways and 900 passenger cars per hour per lane for arterials. Speed stays relatively constant with increases in volume until a given point, where the minimum feasible headway (or close to it) is reached. If there are available substitutes (such as public transport) for the route travelled, the speed-volume relationship will not reverse past the point of 'mathematically optimal' volume.

30 Mercer, (2015), 2015 Quality of Living Rankings

Exhibit 5

Population growth influences both congestion and liveability; congestion must be managed to mitigate the negative results

City Congestion and Quality of Living Rankings

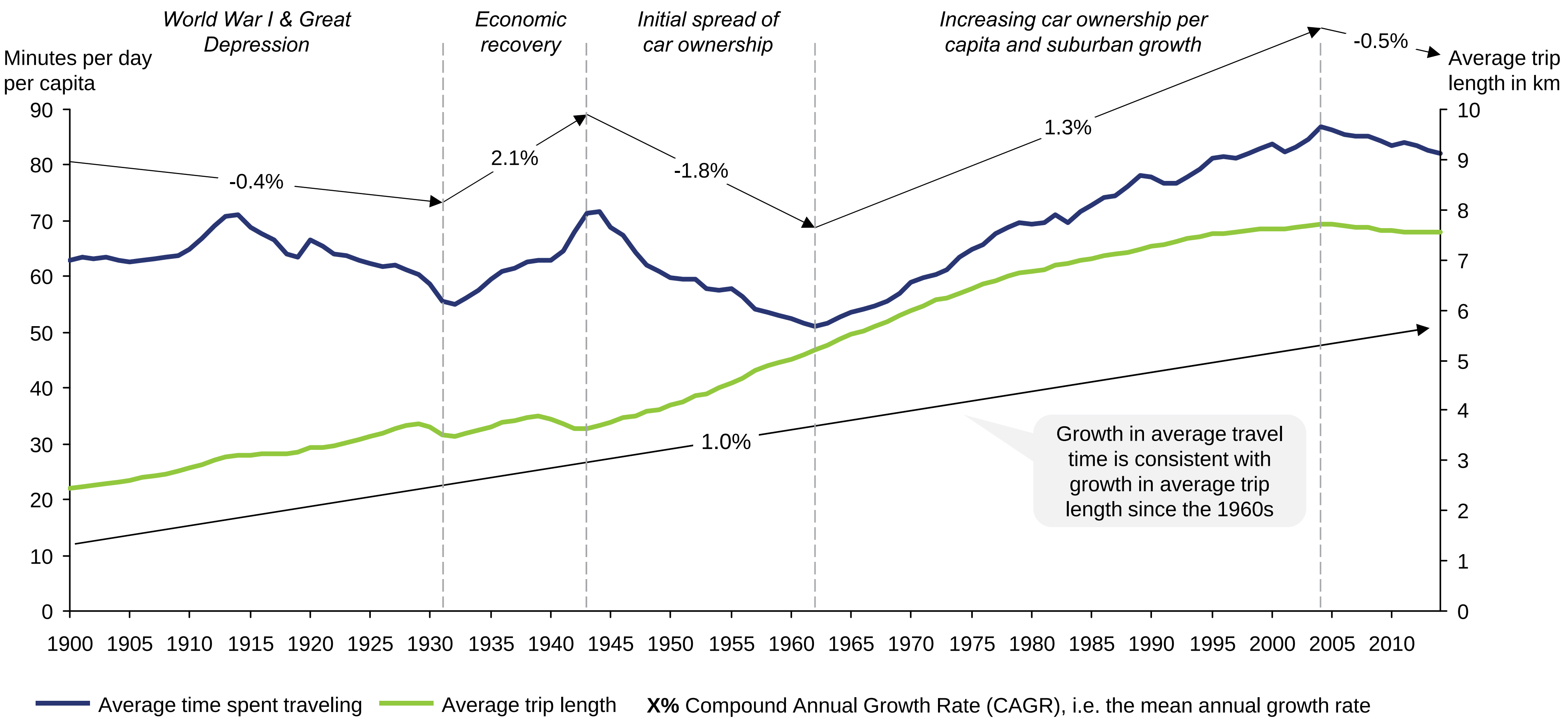


Source: Mercer Quality of Living Rankings, 2015, based on consumer goods, economic environment, housing, medical and health considerations, natural environment, political and social environment, public services and transport, recreation, schools and education, socio-cultural environment; TomTom congestion data

Exhibit 6

Time spent travelling to and from work has not changed significantly in Australia since the start of the 20th century

Implied Average Time and Distance Travelled[1]
Minutes per Day per Capita and Average Trip Length in Km



Note: 1. Includes time and distance travelled to and from work
Source: BITRE 2015 Estimates

5. **Economic** – Acceptable congestion is where the marginal cost of an additional 'unit' of congestion is lower than the marginal cost of intervention to prevent that 'unit'. Given this, if the Benefit-Cost Ratio of a given intervention is greater than 1, then the intervention should be invested in. Due to the topographical and idiosyncratic design of cities, acceptable congestion should be assessed over time, rather than across comparators, with the level of change acting as a proxy for the acceptability of congestion. Additional research is required to identify city and route-specific acceptability.

3. Congestion Performance

The congestion performance analysis is based on Google data collected from 9 September 2015 to 26 November 2015[31]. Observations over this period include weekdays, weekends, school holidays, public holidays and special events (e.g. sporting finals) and so are reasonable representations of normal conditions over a full year.

ANZ Weekday Congestion Performance

For each ANZ city, the six measures of congestion are detailed in Exhibit 7. Group 1 cities (i.e. the largest cities by population) have comparatively high levels of congestion and Group 3 cities (i.e. the smallest cities by population) have comparatively low levels of congestion.

The key findings of comparative ANZ congestion performance measurement include:

- **Sydney and Melbourne** have similar congestion metrics across the analysis, highlighting their similarity as Group 1 cities and as comparators for each other. Melbourne performs better in Travel Time Delay (23% compared to 31%), likely a reflection of its planned road network. In the afternoon peak, Sydney and Melbourne road users need to budget 50% and 41% of additional travel time respectively in order to arrive at their destination on time 9 times out of 10
- **Adelaide** has a slow Average Speed (28 km/hr), in part due to the nature of the slow speed limits on its road network; however it has comparatively high afternoon peak Reliability (3%), given its city size
- **Perth, Brisbane and Wellington** have high Average Speeds (at least 50km/hr), average Travel Time Delay (10-14%) and good Morning and Afternoon Peak Reliability (6-9%); all three have similar congestion measure outputs, despite the differences in their size, topography and historical development
- **Auckland** has low Reliability (10-12%) and road users need to budget 45% additional travel time in order to arrive on time 9 times out of 10 in the afternoon, a likely consequence of the geographical impediments and land use
- **Darwin and Hobart** have high Afternoon Peak Reliability (2-4%) and low Travel Time Delay (4-8%), a likely consequence of their city size and lower demand
- **Canberra** has the fastest Average Speed of ANZ cities (61 km/hr); its morning peak has poorer Reliability (7%) and Travel Time Delay (15%) than its afternoon peak (4% and 14%)

Average Speed

Exhibit 8 shows the Average Speed of roads in each of the jurisdictions. Canberra has the fastest average travel speeds of Group 3 (61 km/h), largely reflecting a number of high-speed roads and major motorways with high speed limits and low congestion, as well as low density. Perth and Brisbane have the highest average travel speeds for Group 2 (58km/h, 55km/hr and 52km/hr respectively) which reflects the makeup of their road networks[32]. The slow average speed of Adelaide (28km/hr) is explained by its high proportion of roads with free-flow speeds of less than 50km/hr (see Exhibit 9).

Exhibit 10 shows the fastest and slowest roads in the ten ANZ cities[33]. Unsurprisingly, the fastest roads in the analysis are motorways, freeways and expressways with high speed limits and significant excess capacity. Often, the slowest roads were designed to be traffic thoroughfares but are now used for other purposes such as commercial streets or as main arterial routes into the city, resulting in excess demand.

Travel Time Delay

Sydney has the highest Travel Time Delay of Group 1 cities (measured as mean travel time relative to minimum travel time) at 31% higher than the minimum travel time recorded over the study period. Auckland has a Travel Time Delay of 22%, significantly higher than the other Group 2 cities. Travel times are more consistently close to the minimum travel time in the Group 3 cities, with mean travel times less than 10% the free flow travel time in Wellington, Canberra, Hobart and Darwin.

When comparing Travel Time Delay across the day, most weekday delay occurs during peak periods, when commuters are travelling to and from work. This is qualified in Exhibit 11. Wellington has the highest proportion of Travel Time Delay during peak periods (79%) and Darwin the least (64%). In general, Travel Time Delay is worse in the afternoon peak than the morning peak. Despite accounting for almost half of the hours of the day, the hours of 7pm to 6am represent 4% to 7% of total Travel Time Delay for each city.

31 Data for ANZ cities were collected in September and October, with data for international comparator cities collected in November.

32 Road selection, street types and infrastructure in the sample provided by road agencies have a significant impact in the Average Speed measure. For example in Adelaide, only 4% of the observed kilometres of road are motorways (defined as roads with free flow speeds in excess of 80km/h), while 45% of the road sample in Auckland, and 58% of the sample in Canberra are motorways

33 It should be noted that only a selection of roads in the major cities themselves have been considered, that is, there may be roads outside the sample that are either faster or slower than those identified above

The most delayed times of day are similar to the periods where Average Speed is lowest. Travel Time Delay exhibits a morning peak at approximately 8am and an afternoon peak at approximately 5pm. The afternoon peak has a larger spread than the morning peak. Darwin shows little relationship between time of day and Travel Time Delay. Exhibit 12 shows that Sydney has the largest number of roads in the 'most delayed' top ten.

Reliability

Reliability is the variation in travel time relative to the average, measured over the morning peak. A greater standard deviation suggests a greater range of travel times, and hence greater unreliability. Exhibit 13 shows that Sydney, Auckland and Wellington have the most unreliable roads of their respective groups, in the morning peak period, while Auckland and Wellington exhibit the lowest level of reliability of their groups, over the afternoon peak period.

Morning and Afternoon Peak Scheduling

Morning Peak Scheduling shows that commuters in Sydney, Wellington and Auckland must allow the greatest buffer time during the morning peak relative to free flow traffic, in their respective groups, to ensure they arrive at their destination on time (see Exhibit 13). Travel in the morning peak in Darwin, on the other hand, is around 5% longer than minimum recorded travel times. A similar pattern is evident in the afternoon peak, though for most cities, slightly longer buffer times are required in the afternoon to ensure commuters arrive at their destination on time.

ANZ Weekend Congestion Performance

Despite congestion being associated with weekday peak periods, as commuters travel to and from work, there is a difference in Average Speeds by time of day at weekends too. Similarly, depending on the time of day, Travel Time Delay also varies at weekends.

Average Speed

For weekends, Average Speeds are lowest in the middle of the day, at approximately 12pm. Average Speeds start to slow at approximately 6am to 7am and do not return to near free-flow speeds until approximately 8pm. Some cities experience a second 'slowing' of speeds at approximately 5pm.

Travel Time Delay

Weekend Travel Time Delay peaks at approximately 12pm and is longest in Sydney for Group 1 and Auckland for Group 2 (see Exhibit 14). Weekend Travel Time Delay is is shorter on weekends than weekdays for all cities. Larger cities tend to have higher weekend Travel Time Delay.

Congestion Performance in ANZ Cities and International Comparators

Roads analysed for the purpose of international comparison focus on major roads and highways, to help ensure consistency and comparability[34]. ANZ cities perform in line with international comparators on the three key measures of Average Speed, Travel Time Delay and Reliability (Exhibit 15). Cities with larger populations (Megacities and Group 1) have lower Reliability and Travel Time Delay performance, however Group 2 and 3 cities have comparable performance to international cities of similar population sizes.

Group 1: Sydney and Melbourne have lower Travel Time Delay, similar Average Speeds and similar Reliability as the comparators of Boston, Philadelphia and Seattle

Group 2: Auckland has significantly higher levels of congestion than its international and local comparators in Group 2; **Brisbane and Perth** have similar delays to Las Vegas, but with lower Reliability; **Adelaide** has low Travel Time Delay compared to most Group 2 cities

Group 3: All ANZ cities have relatively high Reliability; **Wellington** performs worst, but like Brest & Le Havre; **Canberra, Hobart and Darwin** are similar to each other and to Ottawa

34 The analysis in this section considers roads with free-flow of speeds over 80km/hr (and below 130km/hr), for both ANZ cities and international cities. These roads have higher speed limits than the overall network and therefore higher Average Speeds and differing associated congestion measures than those detailed in Section 3.1

Exhibit 7

Sydney, Auckland and Wellington are the worst performing cities in their respective groups

Key Congestion Measures – By City, Weekdays

City	Average Speed (Km / Hr)	Travel Time Delay (%)	Reliability (%)		Scheduling (%)	
			Morning Peak (6am to 10am)	Afternoon Peak (3pm to 7pm)	Morning Peak (6am to 10am)	Afternoon Peak (3pm to 7pm)
	How fast does traffic in the city travel?	*How much is traffic delayed from free-flow conditions?*	*What is the statistical reliability of travel times in the morning peak period?*	*What is the statistical reliability of travel times in the afternoon peak period?*	*How much time does a consumer need to budget during the morning peak period, relative to free-flow?*	*How much time does a consumer need to budget during the afternoon peak period, relative to free-flow?*
Sydney	29	31%	14%	9%	49%	50%
Melbourne	34	23%	11%	8%	34%	41%
Brisbane	52	12%	8%	6%	23%	23%
Perth	58	14%	7%	6%	22%	25%
Auckland	42	22%	12%	10%	37%	45%
Adelaide	28	11%	7%	3%	16%	17%
Canberra	61	9%	7%	4%	15%	14%
Hobart	42	8%	6%	4%	12%	15%
Wellington	55	10%	9%	9%	21%	20%
Darwin	36	4%	1%	2%	5%	6%

City Group: Group 1 (Sydney, Melbourne), Group 2 (Brisbane, Perth, Auckland, Adelaide), Group 3 (Canberra, Hobart, Wellington, Darwin)

Note: As analysis was based on 600km of the most congested roads, comparisons are better drawn among cities within the same group based on population size.

Exhibit 8

Sydney, Auckland and Wellington are the worst performing cities in their respective groups

Average Speed vs. Free-flow Speed – By City, Weekdays
Speed, Kilometres per Hour

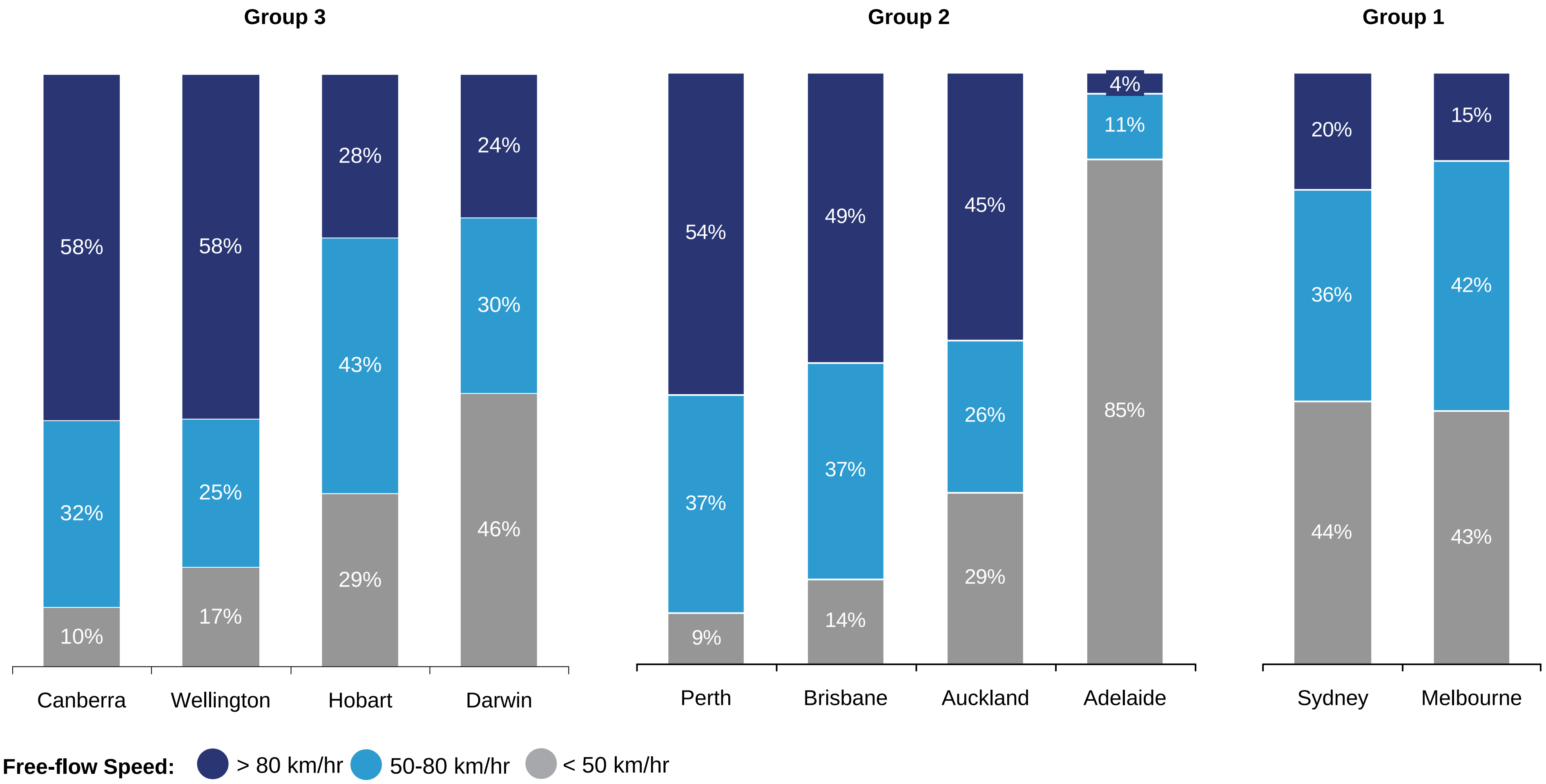
Note: As analysis was based on 600km of the most congested roads, comparisons are better drawn among cities within the same group based on population size.

Exhibit 9

Adelaide has the highest proportion of roads with free-flow speeds slower than 50km/hr

Proportion of Roads in Sample, by Free-Flow Speed

Kilometres of Road, by Free-flow Speed (Kilometres per Hour)



Note: As analysis was based on 600km of the most congested roads, comparisons are better drawn among cities within the same group based on population size.

Source: Road distribution, as per those selected by Austroads jurisdictions

Exhibit 10

The slowest roads in the sample are traffic thoroughfares, which are often used for purposes other than their intended design

ANZ Slowest Roads[1]

Kilometres per Hour

Rank	Road	City	Average Speed
1	King William St	Adelaide	14
2	Harris St	Sydney	15
3	Punt Rd	Melbourne	16
4	North Terrace	Adelaide	16
5	Cleveland St	Sydney	17
6	South Dowling St	Sydney	17
7	Stacey St	Sydney	18
8	Military Rd	Sydney	19
9	Lane Cove Rd	Sydney	19
10	Church St	Sydney	20

ANZ Fastest Roads[1]

Kilometres per Hour

Rank	Road	City	Average Speed
1	Northern Gateway Toll Rd	Auckland	99
2	Federal Highway	Canberra	98
3	Hume Highway	Sydney	98
4	Upper Harbour Mtwy	Auckland	95
5	Northern Expressway	Adelaide	94
6	Eastlink	Melbourne	94
7	Warrego Highway	Brisbane	91
8	Logan Mtwy	Brisbane	91
9	Western Freeway	Melbourne	91
10	Cunningham Highway	Brisbane	90

Road Type: Motorway Traffic Thoroughfare Commercial Street

Note: 1. For roads longer than 5km, in a view to remove the effect of local roads which may have lower speed limits (and therefore appear to be slow but otherwise have freely flowing traffic), as well as limiting the effect of very short roads which are not representative of a city's overall network and congestion.

Source: Google maps data (2015-09-09 to 2015-10-29)

Exhibit 11

Travel Time Delay peaks at ~8am in the morning peak period and ~5pm in the afternoon peak period

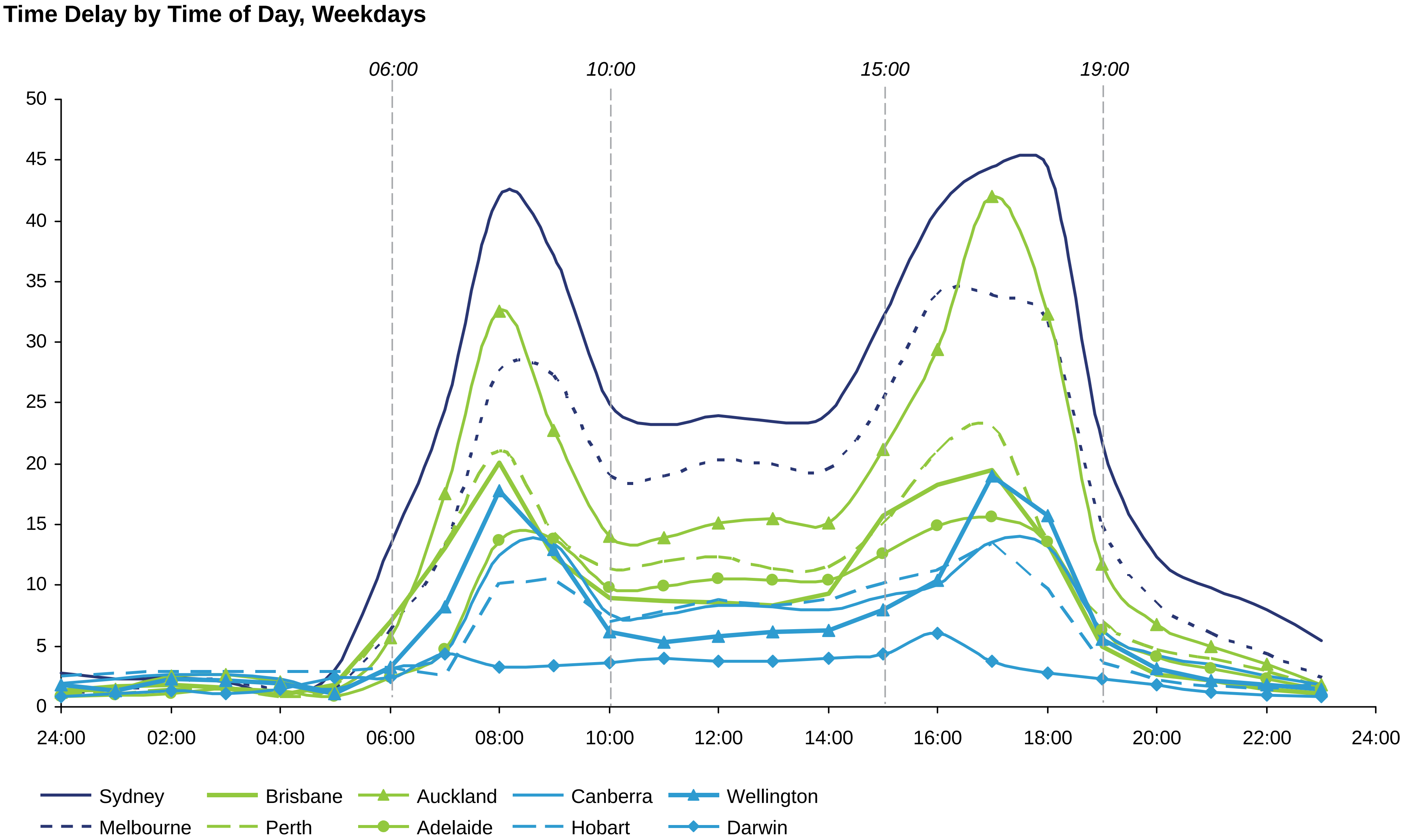


Exhibit 12

Seven of the ten 'most delayed roads' are located in Sydney, while Brisbane has the most entries into the list of 'least delayed roads'

ANZ Most Delayed Roads[1]

% of Minimum Time

Rank	Road	City	% Delay
1	Burke Rd	Melbourne	80
2	Centenary Drive	Sydney	77
3	Punt Rd	Melbourne	71
4	M5 East Freeway	Sydney	69
5	Toorak Rd	Melbourne	67
6	Lane Cove Rd	Sydney	65
7	Epping Rd	Sydney	64
8	Homebush Bay Drive	Sydney	63
9	Eastern Distributor Mtwy	Sydney	60
10	Cahill Expressway	Sydney	59

ANZ Least Delayed Roads[1]

% of Minimum Time

Rank	Road	City	% Delay
1	Richmond Rd	Hobart	0.0
2	State Highway 53	Wellington	0.1
3	Acton Rd	Hobart	0.3
4	Kaipara Coast Highway	Auckland	0.6
5	Northbrook Parkway	Brisbane	0.7
6	Cox Peninsula Rd	Darwin	0.8
7	Mount Glorious Rd	Brisbane	1.0
8	Ipswich-Rosewood Rd	Brisbane	1.2
9	Kings Highway	Canberra	1.2
10	Forest Hill-Fernvale Rd	Brisbane	1.2

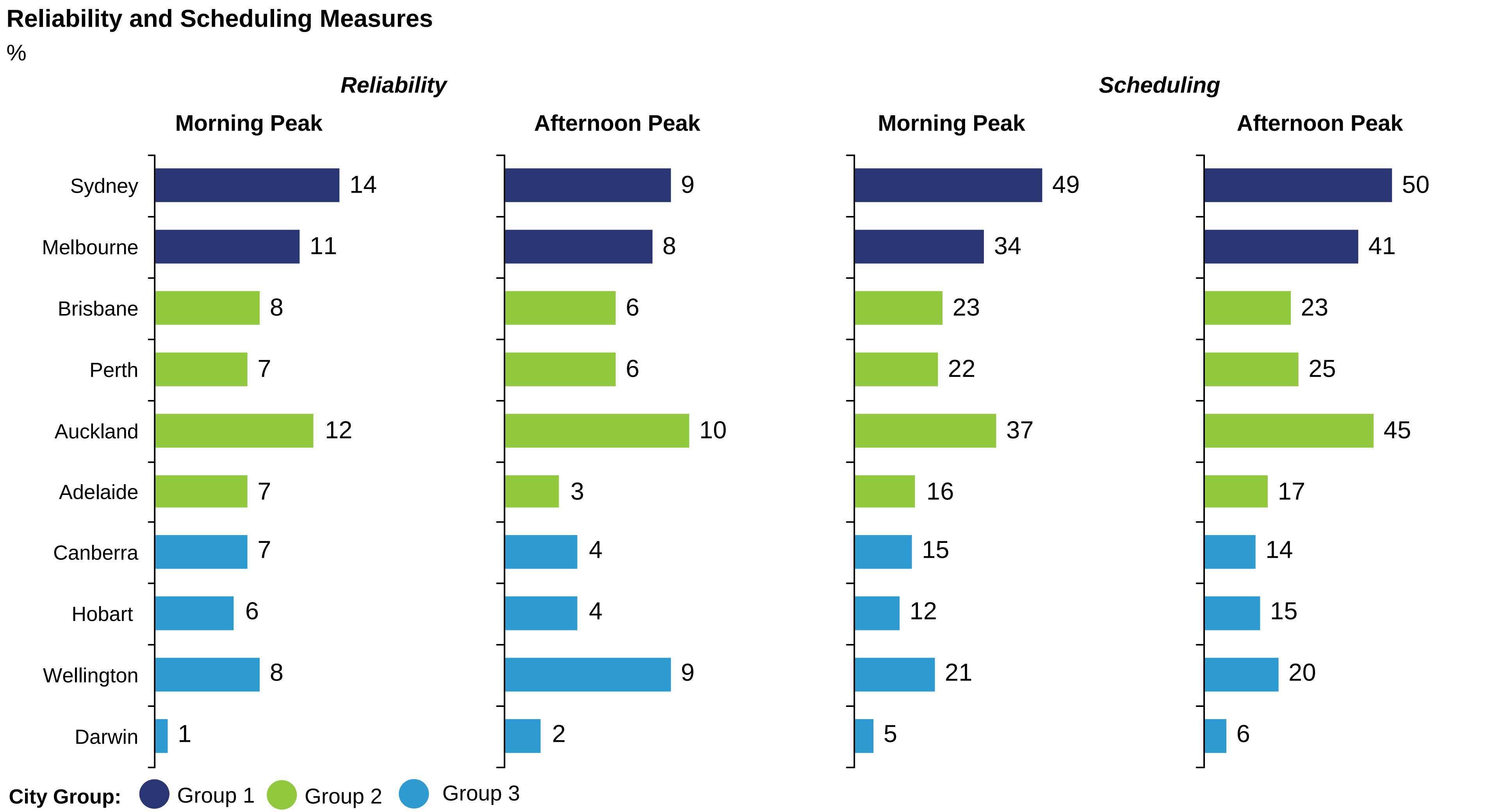
Road Type: Motorway Traffic Thoroughfare Commercial Street

Note: 1. Delay defined as (mean travel time for 24 hours/minimum travel time for 24 hours) -1

Source: Google maps data (2015-09-09 to 2015-10-29)

Exhibit 13

Sydney, Auckland and Wellington exhibit the greatest unreliability within their groups



Notes: 1. Morning Peak = Weekdays 6am to 10am; Afternoon Peak = Weekdays 3pm to 7pm
2. As analysis was based on 600km of the most congested roads, comparisons are better drawn among cities within the same group based on population size.

Exhibit 14

Travel Time Delay peaks at ~12 midday at weekends; with the highest delays observed in cities with larger populations

Time Delay by Time of Day, Weekends

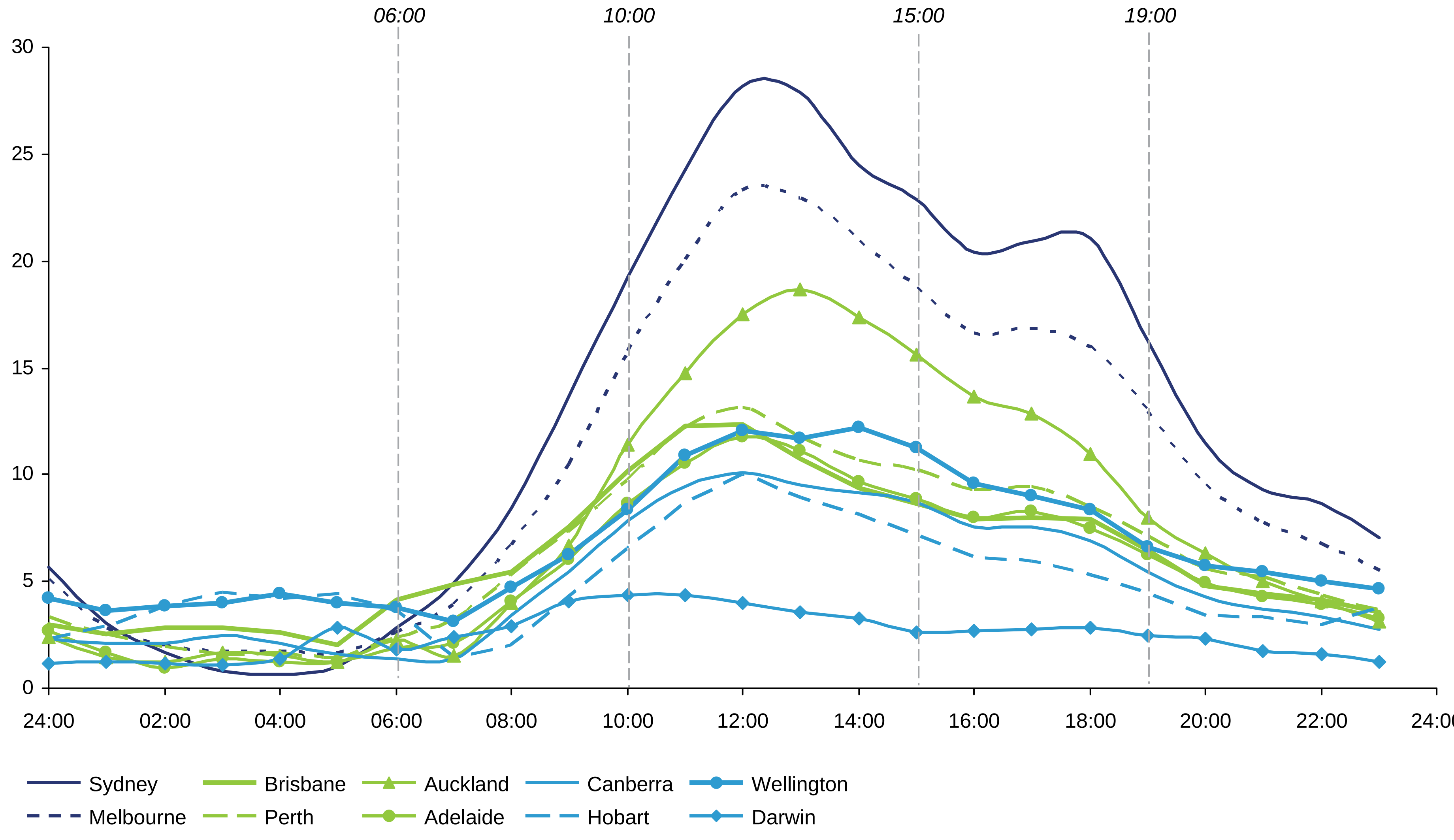
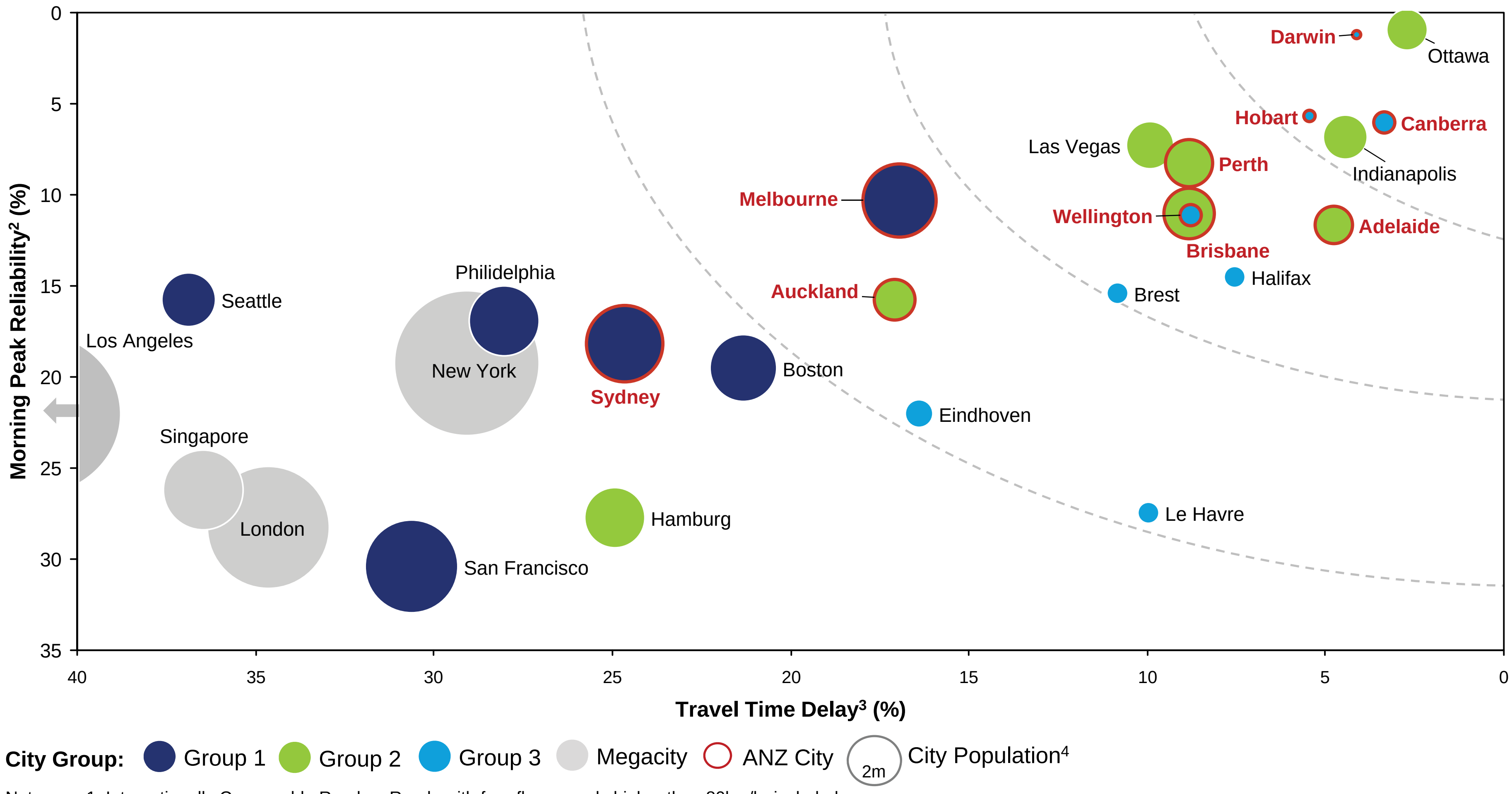


Exhibit 15

ANZ cities perform in line with international comparators on Reliability and Travel Time Delay

Key Congestion Measures, Internationally Comparable Roads[1]



Note: 1. Internationally Comparable Roads = Roads with free-flow speeds higher than 80km/hr included
2. AM Peak Reliability. The statistical reliability of travel times = 1.44 Standard deviation of travel time for 6am to 10am / Mean Travel time for 6am to 10am
3. Travel Time Delay. Traffic delay from free-flow conditions = (Mean travel time for 24hrs / Minimum travel time for 24hrs) -1
4. City Population, as per OECD Data (2014)

4. Causes of Congestion

Causes of Congestion Overview

The quantitative analysis considers a number of potential causes of congestion that could impact overall travel times. These have been categorised into recurrent and non-recurrent causes of congestion, and are summarised below. This approach leverages existing international work, as well as data available from jurisdictions.

Recurrent causes of congestion include:

- **Demand and Supply Imbalance:** The number of vehicles on a road at a given point in time, given the road capacity. For a particular road with a fixed vehicle capacity, increased traffic volumes tend to result in greater congestion and travel times.
- **Weekday Effects:** There are several factors that systematically vary between weekdays and weekends, that are not captured by the number of road users. This can include traffic management tools that are used to manage congestion, such as clearways and traffic light signals.

Non-recurrent causes of congestion assessed are:

- **Traffic Incidents:** Incidents, such as traffic accidents or signal failures, are unplanned and therefore unpredictable in nature.
- **Maintenance and Special Events:** Planned events such as road closures due to roadworks or other scheduled maintenance.
- **Weather:** Precipitation which can impact on the speed of traffic, as drivers manage the risks of low visibility and road traction by reducing their speed. The secondary effect can increase the likelihood of road accidents which can further compound congestion.

In this section, congestion is examined by using travel time data from Google for a sample of road segments in each jurisdiction. An aggregate view is presented below, followed by analysis of the causes of congestion individually for each city.

ANZ Congestion Causes

For Australia and New Zealand, recurrent causes of congestion have the largest impact on explained variations in travel time, explaining 91% of variations for the September and October sample data. For the individual cities recurrent causes explain between 87% and 98% of variation (see Exhibit 16). Non-recurrent causes explain between 2% and 13% of variations in travel time.

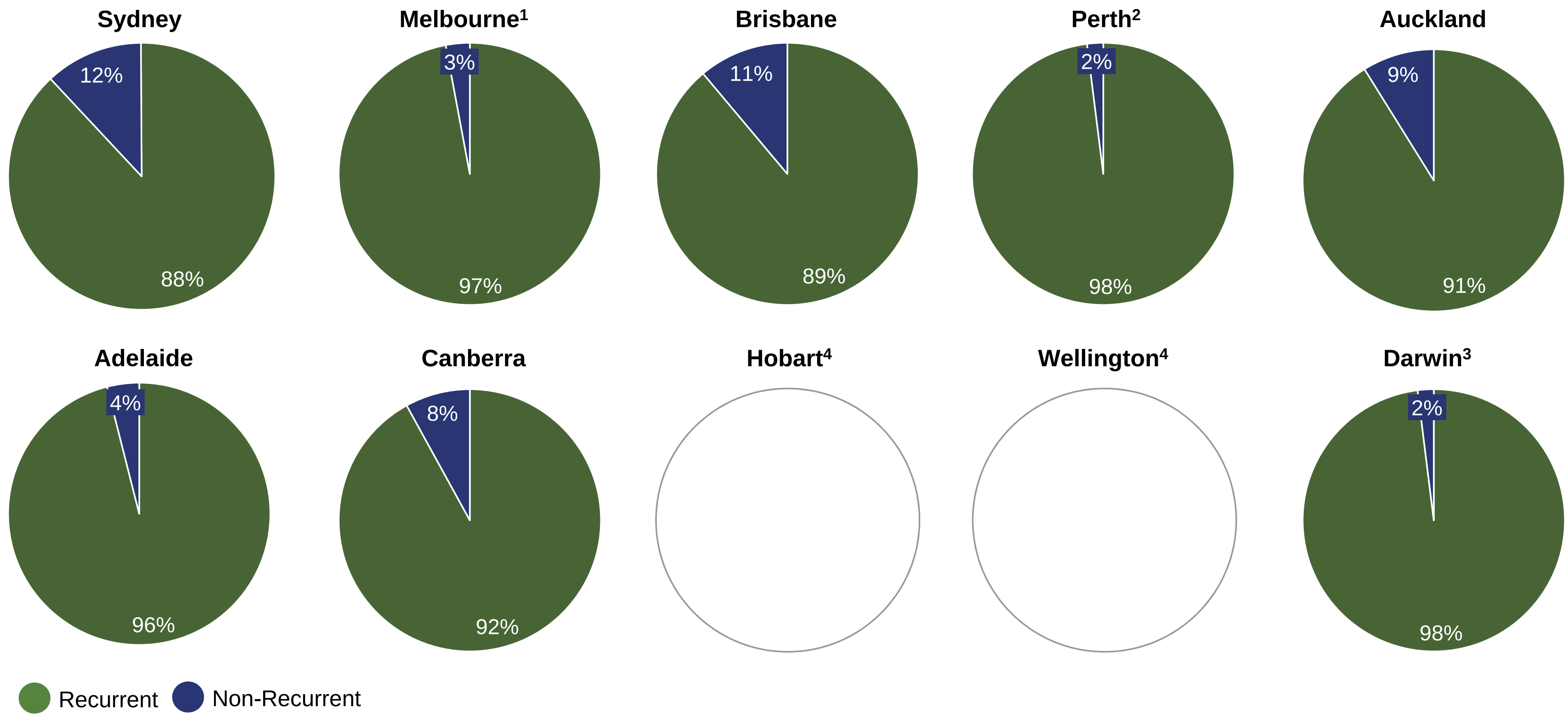
As shown in Exhibit 17, incidents are the non-recurrent cause with largest impact (on average), explaining between 1% and 10% of variation where data exists. Weather (1% to 5%) and planned road maintenance and special events (1%) have relatively small impacts.

It is important to note that under our methodology, only non-recurrent causes where data were available could be analysed, so the analysis may underestimate the impact of non-recurrent causes on travel time congestion in jurisdictions with limited data availability. Where these data limitations have been encountered, they have been noted in the analysis that follows. It is therefore recommended that further research be conducted with a larger, more complete (including GPS coordinates) and consistent data is collected across jurisdictions.

Exhibit 16

The majority of ANZ urban congestion is a consequence of recurrent causes of congestion

ANZ Causes of Urban Congestion - Recurrent vs. Non-Recurrent



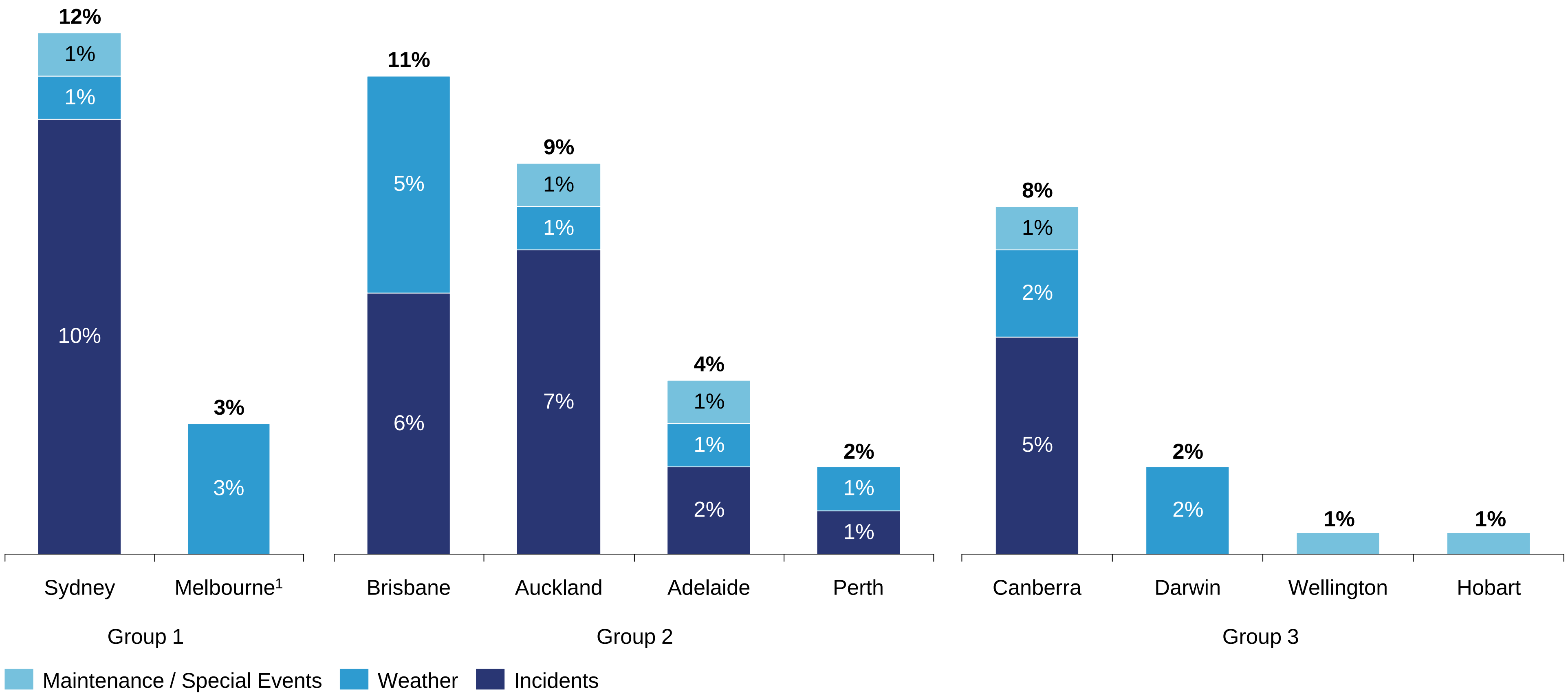
Note: 1. Due to data limitations, there were no maintenance/special events and only a limited number of incidents (0.01% of total observations) recorded around the road segments used in the analysis; 2. Due to data limitations, maintenance/special events could not be mapped to the road segments used in the analysis; 3. Due to data limitations, there were no maintenance/special events or incidents recorded around the road segments used in the analysis; 4. Insufficient traffic counter data to determine causes of congestion
5. As analysis was based on 600km of the most congested roads, comparisons are better drawn among cities within the same group based on population size

Source: Google data, September and October 2015; Jurisdictional data on volume of road users, maintenance/special events, incidents; Australian Bureau of Meteorology; New Zealand National Institute of Water and Atmospheric Research

Exhibit 17

Of the non-recurrent causes of congestion, 'incidents' have the greatest impact on congestion

ANZ Causes of Urban Congestion – Non-Recurrent



Note: 1. Due to data limitations, there were no maintenance/special events and only a limited number of incidents (0.01% of total observations) recorded around the road segments used in the analysis; 2. Due to data limitations, maintenance/special events could not be mapped to the road segments used in the analysis; 3. Due to data limitations, there were no maintenance/special events or incidents recorded around the road segments used in the analysis; 4. Insufficient traffic counter data to determine causes of congestion 5. As analysis was based on 600km of the most congested roads, comparisons are better drawn among cities within the same group based on population size

Source: Google data, September and October 2015; Jurisdictional data on volume of road users, maintenance/special events, incidents; Australian Bureau of Meteorology; New Zealand National Institute of Water and Atmospheric Research

5. Congestion Interventions

Intervention Framework

There exists a wide range of potential interventions that can be applied to mitigate congestion in ANZ cities. Successful selection and application of interventions requires a uniform method for considering each and analysing their relative pros and cons.

Exhibit 18 provides a framework for classifying interventions that are currently used in many developed cities. This framework builds upon the 2006 Council of Australian Government's 'Review of Urban Congestion'[35].

There are also a number of emerging technologies, not included in the framework that may allow for congestion to be managed in new ways over the coming decade. These are discussed in Chapter 7.

Benefit-Cost Analysis

It is important to undertake benefit-cost analysis for all individual congestion intervention projects and programs; it provides decision-makers with an understanding of the relative return on investment, particularly when different metrics may be used across different types of intervention. A comprehensive analysis should also consider feasible alternative projects to inform decision makers which option has the greatest net benefits.

The intervention landscape in Exhibit 19 details the relative cost to implement each intervention and the associated benefit-cost ratio[36]. The analysis demonstrates that, while there is a significant range of costs and benefits for each intervention, interventions can be broadly classified into six categories:

1. **Strategic interventions.** There is a general correlation between longer term projects ('improve planning') and those with high benefit-cost ratios (8:1 and above). Such interventions consider traffic management in the broader context of land use, population growth and integration with economic policy over time periods of more than 20 years.

2. **'No regrets'.** Many of the lowest cost interventions, such as those relating to optimising capacity and operating effectively, have relatively high benefit-cost ratios. These interventions are termed 'no regrets' due to their low levels of investment required.

3./4./5. **Low budget / Medium budget / High budget.** The remaining interventions are categorised by their cost of implementation.

6. **Marginal payoff projects.** Interventions with benefit-cost ratios of less than 1.5:1 are susceptible to execution risk. Agencies should only consider proceeding with such interventions if they are strategically required to mitigate congestion. However, many projects with low BCRs are implemented successfully and sustainably, so they should not be discarded.

Intervention Application

Within each segment of the framework there are a number of interventions, each of which are applicable to different congestion mitigation circumstances. Interventions can be filtered according to their characteristics to be relevant and effectively mitigate congestion causes.

Location-Specific Filtering

Certain interventions are only applicable to specific types of road or specific land-use areas due to the nature of the infrastructure, speed limits, vehicle types and congestion issues facing certain roads.

Filter A. Type of road and land-use

- Motorways – limited-access roads with separation from surrounding land use which move people and goods over long distances
- Traffic thoroughfares –primary purpose as 'movement corridors' which provide safe, reliable and efficient movement between regional centres and within urban areas
- Commercial streets –act as a centre for commercial operations (e.g. shops or businesses), combine high demand for movement and high pedestrian activity with often limited road space
- Local roads – the fabric of suburban neighbourhoods, facilitate local community access
- People-centred spaces - combine higher pedestrian activity and low levels of vehicle movement, creating places of value for local communities and visitors

35 Council of Australian Governments, (2006), Review of Urban Congestion: Trends, Impacts and Solutions

36 While each intervention will have range of BCRs depending on project characteristics, the exhibit details the average, or relative, BCR given analysis of a sample of past projects.

Exhibit 18

The framework groups interventions by approximate timeframe, from long-term strategic change to short-term operational management

Congestion Intervention Framework

Strategic ⟷ *Operational*

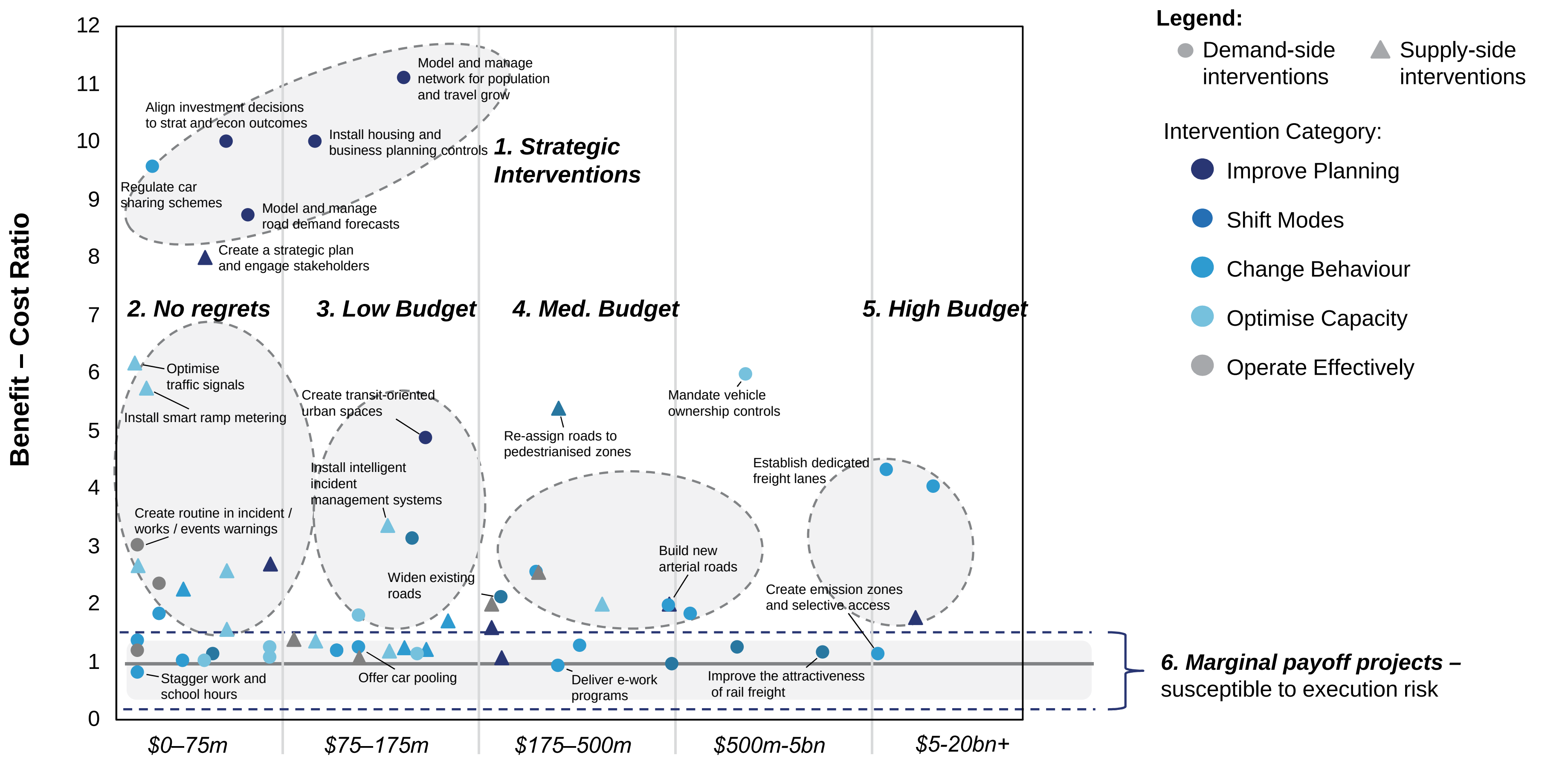
	Improve planning	Shift Modes	Change Behaviour	Optimise Capacity	Operate Effectively
Approximate Timeframe	10-30 years	5-10 years	2-5 years	1-2 years	<1 year
Demand Interventions	Plan urban land use Set economic Policy	Improve public transport reach Incentivise public transport use Road freight to rail Create walking / cycling initiatives	Modify travel demand Substitute travel Manage freight Implement policy measures	Aid travel planning Enforce vehicle restrictions	Manage events
Supply Interventions	Formulate strategy and governance Design networks Build road capacity	Re-allocate road space	Manage freight Control destination choice	Manage road space dynamically Actively manage capacity Enhance road capacity	Manage events Actively manage traffic

Exhibit 19

Investment should be focussed on ‘Strategic’ interventions, as well as relatively low cost, high BCR ‘No Regrets’ interventions

Intervention Benefit-Cost Analysis[1]

ILLUSTRATIVE – BASED ON SAMPLE



Notes: 1. Some data points are extrapolated based on relationships and discussion with stakeholders; 2. Costs are also measured in A$ and converted with year-end exchange rates

Source: International and national analysis of interventions with information from transport agencies, reports and further research

Cause-Specific Filtering

Filtering interventions by the causes of congestion that impact ANZ cities aids road and transport agencies in decision-making when they are considering options for congestion management.

Filter B. Type of cause

- Recurrent – volume of road users, infrastructure
- Non-recurrent – weather, incidents, events

Filter C. Nature of impact

- Time delay (from free-flow speed)
- Reliability of travel time

Filter D. Time of day

- Peak – weekdays: 6am to 10am and 3pm to 7pm (differs by city)
- Non-peak – weekdays: All other times of day, Weekends: All day

The only selection that is mutually exclusive is 'type of cause' - recurrent or non-recurrent. The other criteria are not mutually exclusive, for example weather can affect both time and reliability, at all times of day. This allows for interventions to be tailored to specific causes.

City-Specific Considerations

There are also a number of considerations that influence a city's ability to implement congestion interventions. City-specific criteria allow for further filtering.

City-specific considerations include:

Filter E. Budget

Filter F. Population density

Filter G. Stage of Development

Other factors may also inhibit implementation. These include but are not limited to: strategy, community support, political and policy considerations, legal and institutional issues, planning and performance management, procurement, technology, operations, ability to enforce, outreach and communications.

Combining Interventions

It must also be noted that there is no single 'solution' for improving road congestion. In fact, combining a carefully selected number of interventions may have a greater combined impact than the individual parts. For example, the 2007 OECD report on Managing Urban Traffic Congestion[37] highlighted the benefit-cost evaluation of improved traffic operations and traffic management centres in France in 2004. Benefits were found to be greatest when the different measures were combined, for dense urban areas of high congestion Automatic Incident Detection (AID), Variable Message Signs (VMS) and Dynamic Speed Control (DSC) had BCRs of 1.8-2.6, 1.5-1.7 and 2.1 respectively, but AID + VMS + DSC had a BCR of 3.2-3.7.

Combinations of interventions need not only be centred on one mode of transport or one location. The 2009 Australian Transport Council study, 'Australian Capital City Congestion Management Case Studies'[38] concluded that interventions that are integrated across relevant transport modes, rather than operated independently, tend to be more attractive to users and also deliver better outcomes.

Implications

Given the causes of congestion investigated in Chapter 4, which determined that most congestion is recurrent, appropriate interventions can be prioritised for each ANZ city.

Group 1 Cities (Sydney and Melbourne): Group 1 cities are currently investing in building road capacity. Given this, they can focus future efforts on their developed road network demand management, including interventions relating to 'shifting modes', 'changing behaviour' and 'operating effectively'.

Group 2 Cities (Perth, Brisbane, Adelaide and Auckland): These cities can use 'planning' interventions to determine appropriate investments, considering their populations are likely to grow to that of larger Group 1 cities. This will ensure they invest in providing new capacity and appropriate infrastructure in advance of growth.

Group 3 Cities (Darwin, Wellington, Hobart and Canberra): Smaller cities can focus on operating their road network effectively if high-cost supply-side investments are not determined feasible. Due to likely financial constraints, they should focus on 'strategic', 'no regrets' and 'low budget' investments. They can also use planning interventions to determine and plan future budget for appropriate investments, considering their populations are likely to grow to that of larger Group 2 cities

When considering the non-recurrent causes of congestion, unplanned incidents were the most prominent for most cities, compared to maintenance/special events and weather. Therefore, for 'Operate Effectively' interventions, investment should be focussed on managing incidents, rather than enhancing interventions that target events.

In general, demand-side interventions may be most useful in the short-run to slow down the rise in the use of vehicles. The budget and program for demand-side interventions can be separated from supply-side interventions, to ensure appropriate focus is placed on both.

37 OECD / Transport Strategy Group (2007), Managing Urban Traffic Congestion

38 Australian Transport Council, Urban Congestion Working Group, (2009), Australian Capital City Congestion Management Case Studies

6. Capability Requirements

Capability Maturity Framework

The Capability Maturity Framework identifies the **capabilities required to mitigate congestion** and priority areas of improvement for ANZ road agencies based on their current state and goals:

A. Strategy & Program

B. Delivery Framework

C. Project Delivery

D. Business As Usual Operations (BAU)

The aim of the Capability Maturity assessment is to both evaluate the **current capabilities** of the road agencies and determine the required **'goal' capabilities** to effectively implement interventions and manage congestion. The goal is to provide a baseline to frame discussion on the appropriate level of maturity required, depending on the size, funding and needs within a jurisdiction, and the resulting steps required to build these capabilities.

Each of the above core capabilities has a number of supporting capabilities, with the outcomes of the assessment shown in Exhibit 20.

Relevant Capabilities for Interventions

Cross-referencing capabilities against the interventions framework allows agencies to identify priority capability gaps that require investment. Following this, an assessment of the relevant capabilities for the prioritised interventions can be undertaken. Interventions with a high benefit cost ration (BCR) should be prioritised, however these may have strong or weak supporting capabilities. Agencies should focus investment in:

a) capabilities, where a high-BCR intervention has weak supporting capabilities

b) interventions, where a high-BCR interventions has strong supporting capabilities

Key priority areas of investment in capabilities are shown in Exhibit 21.

For all jurisdictions, as identified in the benefit-cost analysis in Chapter 5, 'Strategic' interventions should be actioned first, followed by 'No Regrets' interventions. Several demand-side 'Change Behaviour' interventions have relatively high BCRs. To ensure these are implemented effectively, focus should be placed on 'Strategy & Program' and 'Delivery Framework' as a first priority.

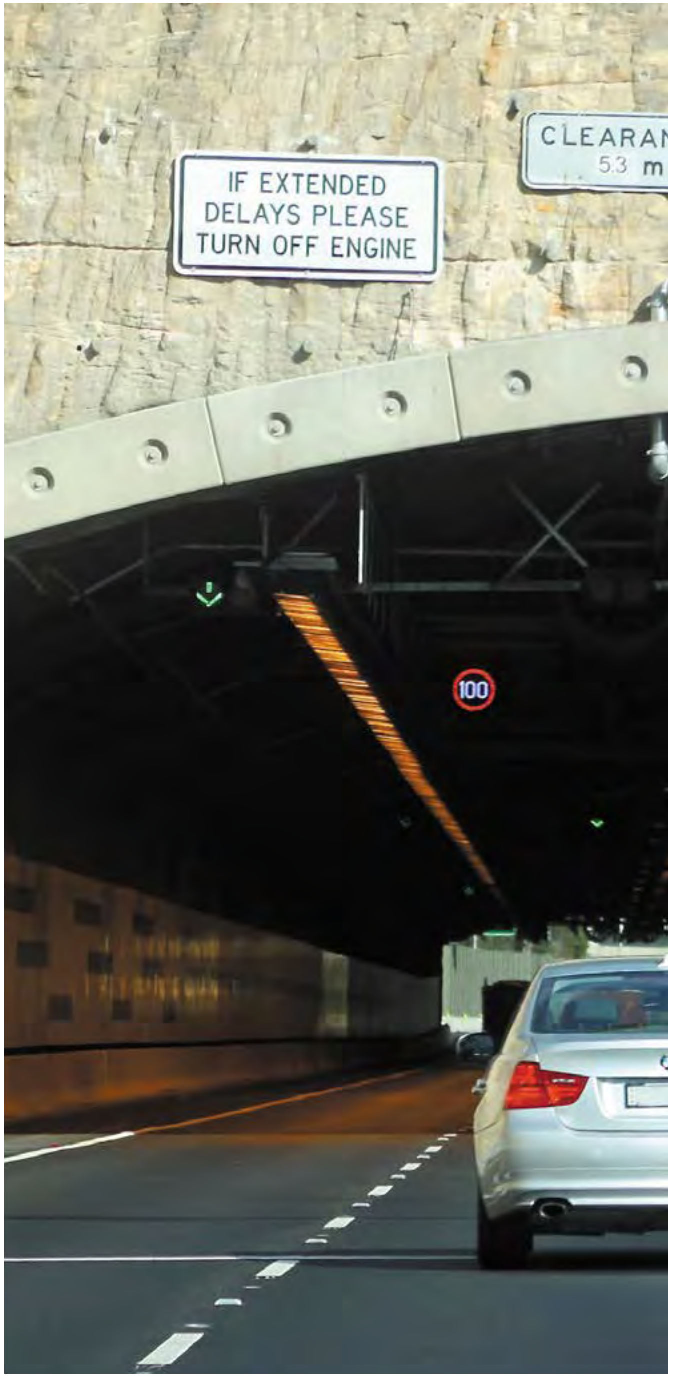
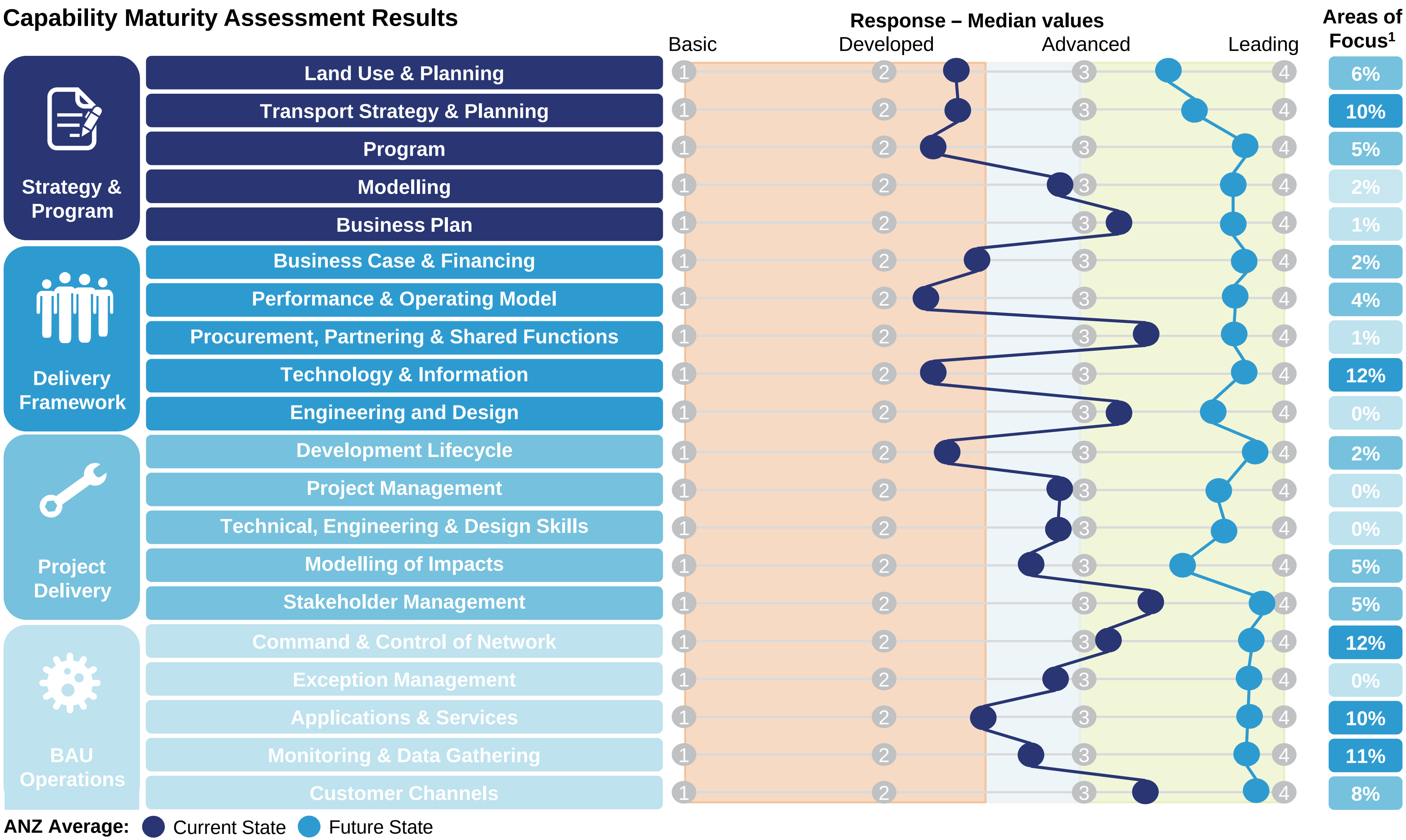


Exhibit 20

The maturity assessment has identified areas of improvement in ‘Performance & Operating Model’ and ‘Technology & Information’

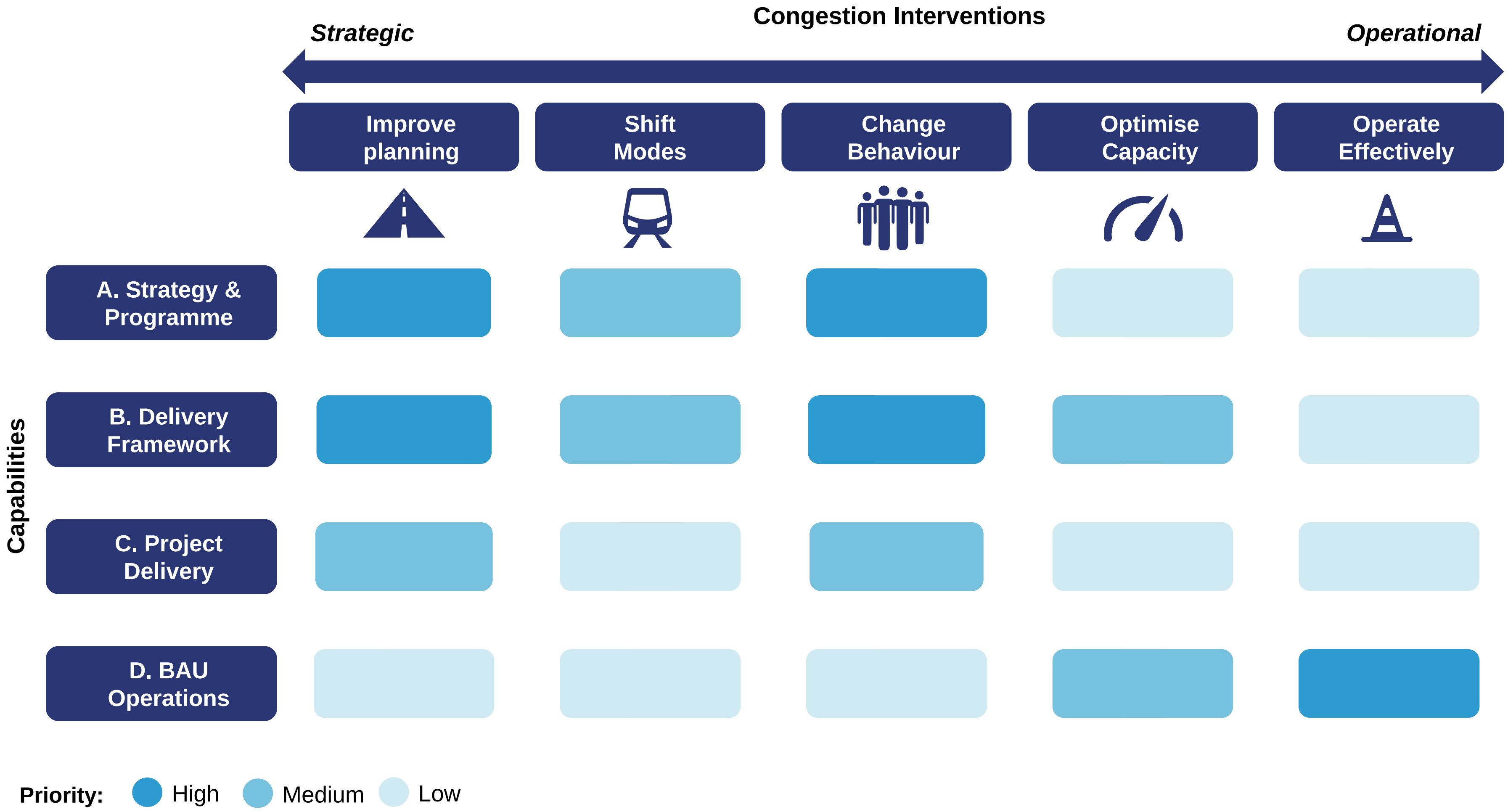


Note: 1. Desired area of investment focus, as specified by jurisdictions

Exhibit 21

Road agency capabilities are more relevant for certain congestion interventions

Interventions–Capability Matrix



Note: 1. Participants prioritised 10 points across the capability areas, with the resulting percentages showing the distribution of investment prioritisation

7. The Future of Congestion Mitigation

Exhibit 22 provides an overview of the four horizons of likely and required changes to vehicle transportation management to enable technological advances in transport which can drive national productivity.

Enhanced ITS Infrastructure

Austroads has developed an 'ITS Strategic Directions' roadmap of supporting technologies[39], to facilitate a coordinated and integrated national transport and infrastructure system that is efficient, sustainable, accessible and competitive, with priority action areas. By coordinating such activities, Austroads can improve the timing and efficiency with which Australia and New Zealand can adopt emerging technology, integrate developments into present systems and align to international practice and standards.

Regulatory Framework

Establishing an appropriate regulatory framework will guide transport innovation, both promoting private sector investment in transportation technology and reducing the risk of post-implementation conflict. ANZ jurisdictions require the appropriate regulatory structures to support such adoption of technology for both major reform (e.g. demand management) and incremental reform (e.g. ride sharing).

National Reforms:

- **Intelligent vehicles.** Consistent regulation on the use of intelligent vehicles is required. Regulation may provide a framework for maintaining the driver 'experience' while mandating certain actions to ensure network efficiency. The safety of drivers, passengers, cyclists and pedestrians will likely be the driver of regulation.
- **Demand management.** Due to finite land supply for urban roads, broader and more sophisticated forms of demand management will eventually be required.

Incremental Reforms: In general, stifling innovation reduces productivity growth, therefore jurisdictions should seek policy reform themselves and be supported by national assistance. A national policy framework should guide decision-making but, primarily, governments should listen to innovators and allow innovators to lobby when they face barriers, otherwise Australia and NZ will lag advances made in other countries.

Congestion Relief Innovation

Given such regulation, private sector innovators will innovate with capability, offerings and new business models to drive value to customers. Exhibit 23 details the four key categories of transportation technology.

Blue Sky…2025 onwards

Looking ahead, road and transport agencies need to hypothesise the likely characteristics of road and transportation management in the future. The below points are intended as a basis for framing further discussions within road and transport agencies, state and federal governments and externally with overseas jurisdictions.

Hypotheses: 10+ years

- **Cost of Data Services** – Data generation, processing, transmission and storage costs will continue to fall in price and physical space requirements, until reaching a theoretical minimum level
- **Value of Time** – The value of time and life will continue to increase relative to goods and services, and as a result:
  - The cost of congestion will increase
  - The safety premium will increase
- **Land Supply** – Urban land supply will not materially increase in Australia and New Zealand (e.g. large scale land reclamation as seen in Singapore or the Middle East is unlikely to cope with rising populations) and therefore:
  - Denser housing will be required
  - Patterns of living and working may change
  - There will be limited space for new roads
  - The cost of land will rise, particularly where required to be acquired from private owners

39 Austroads, (2015), ITS Strategic Directions – A roadmap of ITS activities in Australia and New Zealand

Exhibit 22

The full impact of technology and innovation will be enabled by a platform of regulation and infrastructure

The Future of Congestion Management

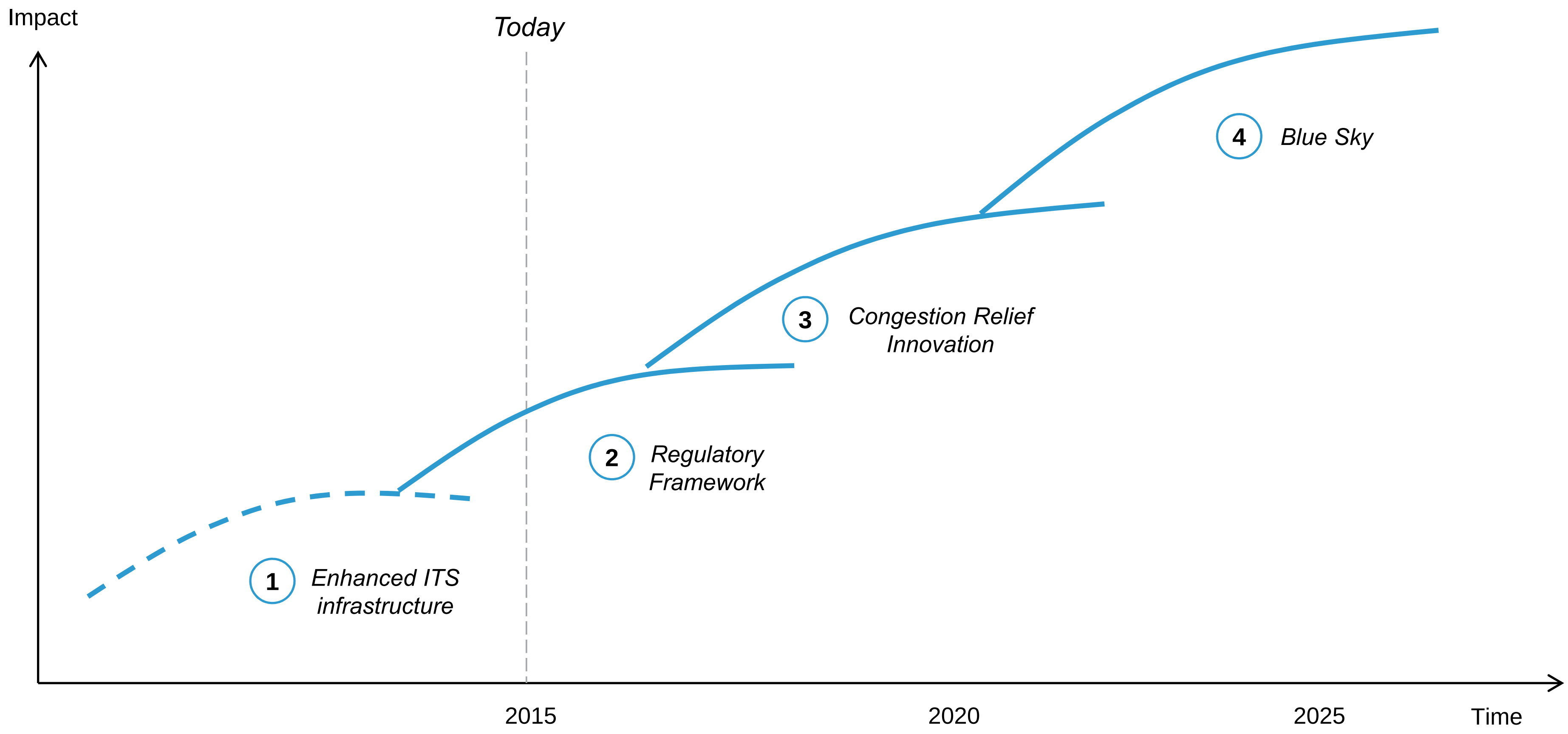
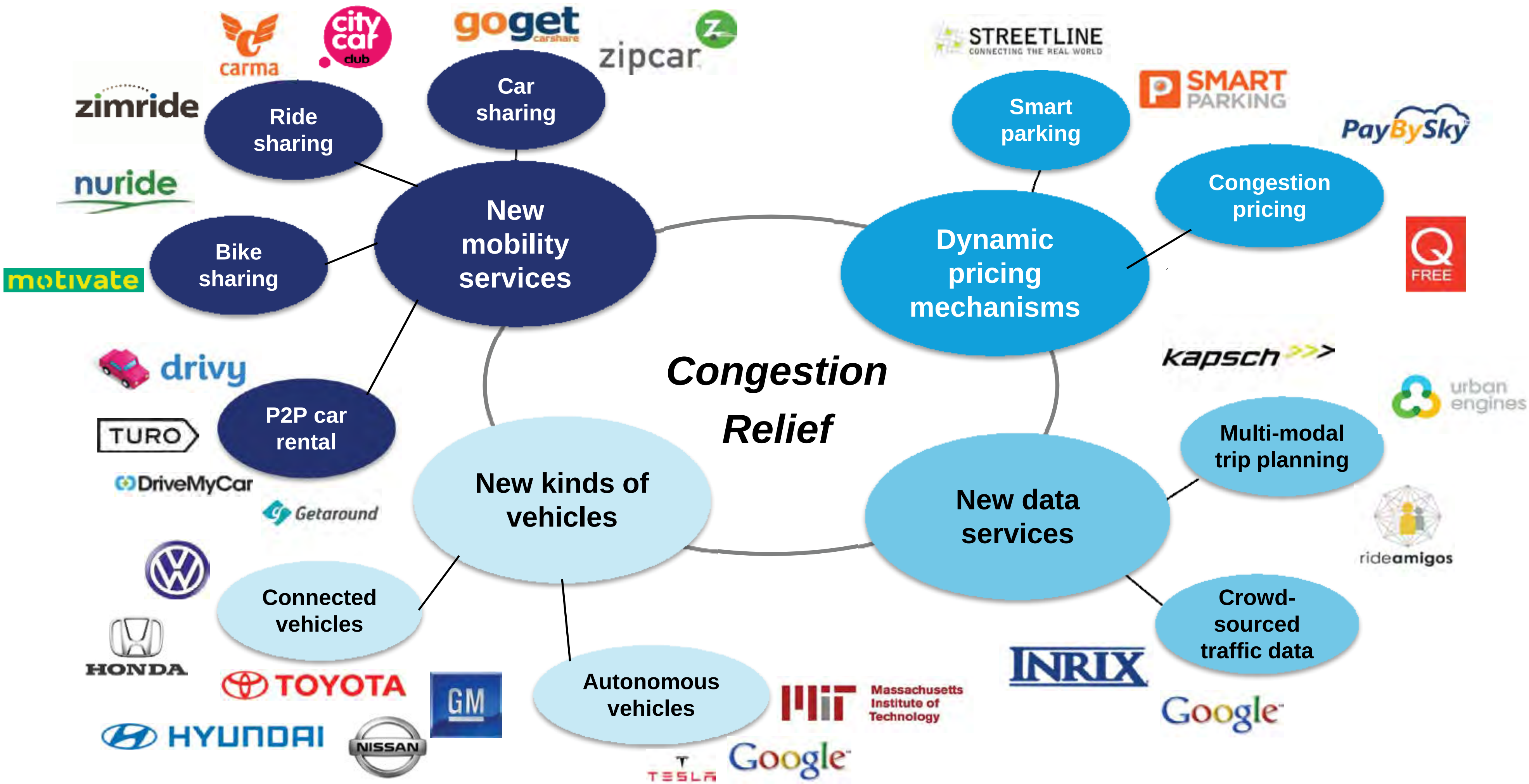


Exhibit 23

New technologies are being introduced around the world to reduce congestion and improve reliability

Emerging Congestion Relief Innovations



Source: Deloitte, The Solution Revolution – Traffic Congestion

Major Implications

The above hypotheses will interact, with a number of consequences for transportation:

1. **Value of time and land supply trade-off** – The existing trade-off in journey (commute) time and the proportion of income spent on housing will intensify, unless business locations adapt to be nearer to corresponding residential areas (including working from home). The increase in the value of time will reinforce increases in the demand and resulting value of land in city centres, followed by the suburbs of cities.
2. **Value of time impact on cost of data services** – Increased value of time will cause greater reliance on data services to mitigate delays and reduce travel time.
3. **Cost of data services impact on value of time** – Data services will support the effective processing of real-time information to ensure that road users' decisions are optimised to maximise network productivity.
4. **Land supply impact on cost of data services** – Increased value of land will cause greater reliance on data services to optimise limited travel corridors, reduce travel time and increase travel reliability from outer-residential areas.
5. **Cost of data services impact on land supply** – Data services will support effective decision-making governing where to place new roads, housing and associated public services, with the ability to model the impact of major infrastructure and property developments on the transport network.

Technology provides an opportunity to solve these consequences. Sophisticated planning to ensure investment decisions are made both efficiently and effectively is required to ensure mitigation decisions do not result in high costs to cities and road networks. As the cost of data services falls it can, in turn, be increasingly used to facilitate decision-making, both in real-time and retrospectively.

8. Congestion Mitigation Roadmap

Congestion Mitigation Goals

Without a well-planned intervention program, the cost of congestion will continue to outpace population growth. The associated congestion will impact the performance of the road system, road user satisfaction and the liveability of cities, and hence be a drag on both economic performance and the wellbeing of the population in ANZ urban areas.

Governments should seek to limit growth in congestion costs (currently 5% p.a. over the last 4 years) in cities to less than the rate of population growth (1-2% p.a.), in order to maintain or improve quality of life. As 'acceptable' congestion is more often defined by the 'reliability' of journey times, this should be the focus of congestion mitigation actions.

Impact of Technology

Road agencies should not only investigate how technology will affect ANZ roads and associated infrastructure in the future, but they should consider how their current investments can be best built to ensure that technology can be 'added' to them in the future, without need for complete re-design. In addition, ANZ cities have significant spare road capacity during non-peak times of day – technology could be used to better consider how this capacity can be utilised, with temporal rearrangement of some activities.

Roadmap for the Future

Mitigating congestion is an iterative process, with multiple stages that can be applied at a city, corridor or road level, as shown in Exhibit 24.

Such a holistic, continuous improvement approach is commonplace in many other industries leading to rapid innovation cycles spanning mobile phones to automobiles. In this case, the objective is not to increase profits, but to improve a scorecard of congestion measures that increase public good, with a flow through into the urban economy.

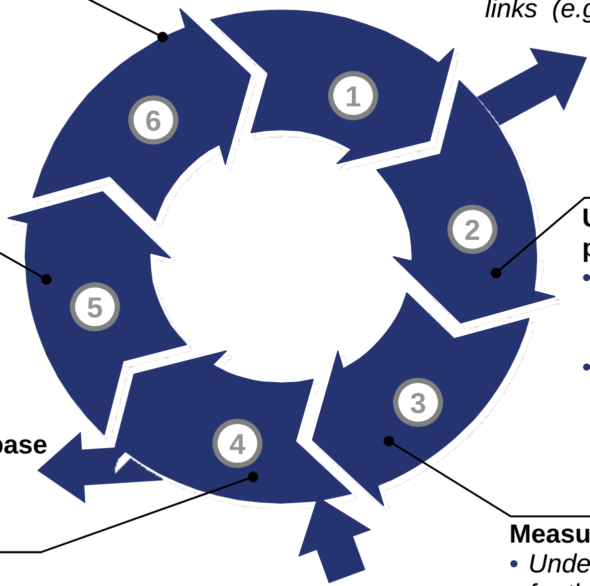
Given that a long term, strategic approach is required, stakeholder support and an agreed policy framework across Government and Opposition is essential. Otherwise, it can be politically appealing for Oppositions to campaign against projects that have diffuse gains, but concentrated losses, and for Governments to prioritise short term projects that deliver benefits within an election cycle over long term planning. Both our major cities have depleted hundreds of millions of dollars in potentially productive investment with such antics.

Our research has shown that congestion management is a journey, rather than a destination, with focused ongoing investment required to maintain the liveability of cities as they grow. Often, the benefits of this investment will flow to future generations, and we can only ponder how improved some of our cities could be if past generations had implemented some of the visionary transportation plans that have fallen by the wayside. We hope this work triggers a commitment to embrace the potential of the next wave of transportation innovation.

Exhibit 24

All cities can tailor this iterative process to their own road user, congestion and road network characteristics

Congestion Mitigation Roadmap – Sydney Example



Profile road customers
- *Understand mix of freight, commercial and commuters on key links (e.g. Parramatta Road)*

Update understanding based on intervention impacts

Understand current network performance
- *Map hot spots of key times / places around the SHB corridor*
- *Provide as a resource for commercial users' scheduling*

Measure the causes of congestion
- *Understand demand characteristics for the 88% recurrent congestion on the SHB at different times of day*

Consider future technology

Prioritise interventions
- *Develop a long-term SHB corridor plan*
- *Determine mode shift goals and limitations (e.g. parking)*
- *Focus on consumer behaviour with high BCR mix:*
  - *Time shift freight and commercial with higher peak tolls*
  - *Reduce commuter demand with park & ride from North Sydney or St Leonards*
  - *Increase CBD parking premium*

Influence policy base on findings

Enhance capability
- *Improve planning interfaces with Sydney Trains & North Sydney Council*

Implement interventions
- *Implement in waves*
- *Pilot, measure and refine*

Agree policy framework
Align all decision-making to the agreed policies and regulations

Seek stakeholder support
Continuously communicate with stakeholders and update decisions based on their views

Source: Deloitte experience

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