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# Modelling of urban transport recurrent and infrastructure expenditure requirements

Stage 1 Report to the Commonwealth Grants Commission

8 September 2017

IA147500

# Modelling of Urban Transport Recurrent and Infrastructure Expenditure Requirements: Stage 1 Report

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Jacobs Australia Pty Limited

Level 7, 177 Pacific Highway
North Sydney NSW 2060 Australia
PO Box 632 North Sydney
NSW 2059 Australia
T +61 2 9928 2100
F +61 2 9928 2500
www.jacobs.com



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## Contents

# Executive Summary

The Commonwealth Grants Commission (CGC) is currently conducting a five-year review of the methods used to calculate States' and Territories' (States') GST requirements, which is due for completion in 2020. The CGC has commissioned Jacobs to provide the following:

- A model or models that can be used to assess States' urban transport recurrent and infrastructure expenditure requirements.
- Assurance for the States that the proposed model/s and data used are reliable and fit for purpose.

The consultancy has been programmed in two stages. Stage 1 will identify drivers of urban recurrent and infrastructure expenditure and to evaluate data availability and reliability. Stage 2 is to apply the proposed model by evaluating alternative and existing CGC models. This report documents the Stage 1 tasks and outputs.

## Recurrent expenditure model

**Output 1**

- "A report that provides a comprehensive understanding of the drivers of net urban transport recurrent spending and expenditure on urban transport infrastructure in Australia, with appropriate international comparisons, and a model/s specification relevant to Australia."

Urban transport recurrent expenditure includes State expenses (net of revenues) in providing passenger transport in urban areas, and subsidies to private providers and local governments for urban passenger transport. It also includes passenger concessions and State government administration expenses. Assessed expenses for urban transport are currently calculated based on a regression model that estimates net per capita expenses by city using the logarithm of city population. These expenses are then adjusted for interstate wage differentials.

Stage 1 has identified key drivers for urban recurrent expenditure, following a review of existing CGC models, States' data returns in the 2015 review, consultant work undertaken in the 2010 review, public transport operating expense data in the public domain and a review of Australian and international literature.

The key drivers and their main effects are:

- **Population served by an urban transport network** – Urban population drives the overall travel demand, which can be met by public transport or car. In Australian capital cities, mass public transport accounts for 10% of passenger kilometres travelled. The proportion of mass transit is higher in the largest cities - Sydney and Melbourne.
- **Employment and journey to work –** Commute trips drive the AM and PM peak travel demand. The average operating cost per passenger km may be lower during these peak periods as occupancy is higher in peak hours compared to the off-peak.
- **Student enrolment and education trips –** Educational trips are heavily subsidised. Typically, primary and high school students travel free, while tertiary students pay half fare.
- **Public transport service provision –** Availability and accessibility of public transport services are pre-conditions for people choosing to use public transport. In particular, availability of train services significantly increase overall public transport patronage in urban areas.
- **Travel cost by car** – Household Travel Surveys undertaken in Sydney suggest that avoiding parking problems is the main reason that people use public transport to travel to work. Fuel

and parking costs and urban congestion also play a role. While the travel cost by car is an important driver, it will not be included in the recurrent model. The cost of parking and road congestion is location based and there is a large variation between CBD, major centres and suburb centres. Consequently, it is difficult to define a measurement to be included in the model.

- **Urban congestion** – Congestion of the road network increases travel time, travel costs and adversely affect travel time reliability. Based on data from the Bureau of Infrastructure, Transport and Regional Economics (BITRE), the most congested Australian cities are Sydney, Melbourne and Perth. Urban congestion incentivises people to use more public transport. However it also has a detrimental impact on bus operating costs.
- **Urban density** – Higher residential density around train stations and in suburban cities, and good accessibility to public transport will attract higher public transport patronage.
- **Urban terrain** – Steep gradients increases bus operating cost and also increases the likelihood of tunnel or elevated rail infrastructure being chosen over at grade solutions. Urban terrain can be measured by road and rail slopes.
- **Emerging trends in public transport use –** In the last 20 years there has been an observed decline in the proportion of young people obtaining a drivers' licence. The advent of car-sharing and ride-sharing services can provide an attractive alternative to car ownership in urban areas. These emerging trends underscore rising public transport patronage. Whilst travel cost by car is an important driver, it will not be included in the recurrent model as it is difficult to define a measurement to be included in the model.

The urban recurrent expenditure models have been tentatively specified with the operating expenses as the dependent variables and key drivers as explanatory variables. The model building process in Stage 2 will search for the most appropriate model specification under the guiding principles that the final model should be simple and transparent with consistent, comparable and reliable data sources. The appropriate control of existing mass public transport modes (train and light rail) in Significant Urban Areas (SUAs) will also be tested. Statistically, a dummy variable, taking the value of either 0 or 1, can be used to control the existence of a particular mode. For example, the dummy variable for train takes the value 1 in Sydney with the service and 0 in Hobart without the service. This will allow control of the existence of train services in SUAs.

### Infrastructure expenditure model

In the existing CGC approach, there are two infrastructure assessments: The depreciation assessment recognises the use of existing infrastructure during the year (depreciation expenses), while the investment assessment recognises the need for extra (or upgraded) infrastructure. In the 2015 review, both depreciation and investment were estimated. In the 2020 review, it is suggested that both depreciation and investment continue to be used in the infrastructure expenditure model.

Key drivers for urban recurrent expenditure are also the drivers of urban infrastructure expenditure as they represent underlying travel demand, patronage and service provision. In addition, the following three key drivers of urban transport infrastructure expenditure have been identified:

- **Population growth** – the population growth drives the need for new public transport infrastructure and expanded capacity. Population growth does not influence depreciation thus the depreciation and investment were separately assessed in the 2015 review.
- **Terrain condition** – the presence of waterways and bridges. This may differentiate the unit construction cost and difficulty of construction in urban centres.
- **Engineering options –** presence of surface, tunnel or elevated rail track. Primarily relevant to heavy rail, this factor introduces significant differences in the unit cost of construction.

As for the urban recurrent expenditure model, alternative infrastructure models have been tentatively specified with the capital charge as the dependent variables and the above key drivers as explanatory variables. During Stage 2, a preferred model will be developed under the guiding principles of simplicity and transparency using data that is consistent, comparable, reliable and easily collected.

**Output 2**

- “An evaluation of whether comparable, reliable and fit for purpose data are available to model urban transport spending for Australian cities using the model/s specifications from Output 1.”
- “A discussion of whether sufficiently robust data are likely to be available to justify the consultancy proceeding to Stage 2.”

## Data sources

Data informing the key drivers of urban public transport expenditure have been identified. Data will be sourced from:

- **Australian Bureau of Statistics** (ABS) – Underlying travel demand data including population, population growth, employment, student enrolment and journey to work collected from Census. Residential density can be derived from ABS data.
- **Bureau of Infrastructure, Transport and Regional Services** (BITRE) – Urban congestion cost will be used to derive an urban congestion index. This index will be available for Australian capital cities only.
- **Geoscience Australia** – Geographical data containing terrain condition, rail / road slopes, waterways and bridge lengths.
- **Data collection via State Treasuries** – operating expenses, net expenses, depreciation, capital investment, public transport revenue kilometres, physical infrastructure assets (track kilometres, dedicated bus lane kilometres, ferry wharves), number of boardings, number of journeys, average journey length in kilometres.

## Data availability

All required data items, sourced from ABS, BITRE and CSIRO, were available for analysis in Stage 1. These data items are reliable and comparable between States. They fulfil part of the data needs for developing the urban transport recurrent and infrastructure models.

The Stage 1 data assessment was based on the 2015 data returns of States Treasuries provided by CGC. The data is not ideal for model development as many of the required data items were not supplied by the States.

As part of the Stage 1 consultancy, a Draft State data request for the 2020 review was developed. The scope of data collection covers recurrent expenditure and revenue; physical assets; asset value and depreciation; capital investment; size of the transport task; average journey length; inter-city trips between potential satellite cities and their principal city, and rail construction engineering options (surface, underground and elevated rail). States were required to indicate the availability of the data requested by mid-June and return the data by mid-August. States have indicated that:

- The required data is generally available.

- Timing of data collection in July / August could be an issue as States are typically preparing the end of year financial statements in the same period.
- Data splitting on SUAs could be a problem for some States, for example Tasmania
- Clarification of data requirements may be required by some States

The assessment of States' data return in 2010 by the Institute for Sustainable Systems and Technologies for the 2010 review indicated that data items provided were broadly comparable between States. The data returns in the 2015 review also indicate that most data items are comparable.

The underlying issues with current CGC assessment models and initial indication of data availability and comparability justify the Stage 2 consultancy.

## Selection of geographic boundaries for assessment

**Output 3**

- "A report on the most appropriate urban area geography / boundaries for the assessment of the spending requirements of urban areas."

The current CGC recurrent model is based on the log of population while the infrastructure model is based on population squared with a discount factor of 50%. All other factors being the same, both models will give a higher share of GST revenue as city population increases. The Queensland Government has argued the conceptual case for amalgamating cities.

In Stage 1, additional modelling approaches have been attempted to develop GST revenue neutral models. In such a model, the States' GST requirements would be the same whether or not satellite cities were amalgamated to their principal city. Crucially, it has been shown that revenue neutral models may be valid if the recurrent or infrastructure expenditure models are largely based on public transport patronage that can appropriately capture inter-city trips. However, if the GST assessment models are mostly based on patronage, other key drivers could be missed and the model would overly favour those cities with already well-established public transport infrastructure. Such models do not adhere to the principle of Horizontal Fiscal Equalisation (HFE). It is thus essential to set out clear criteria to test if a satellite city should be amalgamated in the GST assessment.

In Stage 1, two quantitative criteria were identified:

1) **Public transport travel time threshold of 120 minutes between the principal and satellite city centres in AM peak hours.**

   This threshold indicates the maximal limit of commute travel time between the principal and satellite cities.

2) **Proportion of inter-city commute trips is greater than 5 percent of satellite intra-city commute trips.**

   This criterion indicates a minimum level of labour market integration between the principal and the satellite city.

Data for assessment of the two criteria are available from public transport timetables and ABS Journey To Work (JTW) data, which is reliable and comparable between States.

# 1. Introduction

## 1.1 Objective of the project

Commonwealth Grants Commission (CGC) is currently conducting a five-year review of the methods used to calculate the States' and Territories' (States') GST requirements, which is due for completion in 2020. The CGC commissioned Jacobs to provide the following:

- A model or models that can be used to assess States' urban transport recurrent and infrastructure expenditure requirements.
- Confidence for States that the model/s and data used are reliable and fit for purpose.

The consultancy is being undertaken in two stages. Stage 1 of the study is aimed at identifying the drivers of urban recurrent and infrastructure expenditure and to evaluate the availability and reliability of data. Stage 2 of the study is aimed at developing a proposed model by evaluating alternative and existing CGC models.

This report documents the Stage 1 tasks and outputs as set out below[1]:

**Output 1**

- *A report that provides a comprehensive understanding of the drivers of net urban transport recurrent spending and expenditure on urban transport infrastructure in Australia, with appropriate international comparisons, and a model/s specification relevant to Australia.*

**Output 2**

- *An evaluation of whether comparable, reliable and fit for purpose data are available to model urban transport spending for Australian cities using the model/s specifications from Output 1.*
- *A discussion of whether sufficiently robust data are likely to be available to justify the consultancy proceeding to Stage 2.*

**Output 3**

- *A report on the most appropriate urban area geography / boundaries for the assessment of the spending requirements of urban areas.*

This review will apply the principal of Horizontal Fiscal Equalisation (HFE) to the urban transport models. HFE is defined so that

*State governments should receive funding from the pool of goods and services tax revenue such that, after allowing for material factors affecting revenues and expenditures, each would have the fiscal capacity to provide services and the associated infrastructure at the same standard, if each made the same effort to raise revenue from its own sources and operated at the same level of efficiency[2].*

## 1.2 Approach

To fulfil the above tasks and produce the required outputs, Jacobs have undertaken the following research and analysis:

- Review of existing models in use by the CGC and approaches in the 2015 review. The review focused on the fundamental principles of recurrent and infrastructure expenditure models, States' concerns regarding the models, and methods developed in the 2015 review.

[1] Commonwealth Grants Commission Consultancy Brief
[2] https://www.cgc.gov.au/index.php?option=com_content&view=article&id=258&Itemid=536, What is fiscal equalisation

- Review of the States' data return for the 2015 review, including the items requested and the resulting data return. We recognise that those data items that were omitted in States' data return can be used as an approximate indicator of the data availability for the 2020 review data request.
- Review of the consultancy report for the 2010 review. The review provided a good understanding of the historical background and consideration of urban transport recurrent and infrastructure models.
- Review of International and Australian literature considering urban transport operating cost and public transport patronage. In particular, we reviewed some of the publically available data from the NSW Independent Pricing and Regulatory Tribunal (IPART) to understand how public transport fares are set and public transport operating efficiency in NSW. We also reviewed States' Household Travel Surveys to understand public transport patronage and time of day and day of week travel patterns. We reviewed Bureau of Infrastructure, Transport and Regional Economics (BITRE) urban passenger transport trend and associated dataset. The International literature review was undertaken to understand how transport costs are modelled.

Development of simple and transparent urban transport models requires detailed data on transport service provision, operating expenses, infrastructure cost, travel demand and patronage, and systematically testing the model specifications. Collection and assessment of this data will form the main task of Stage 2 of the study.

## 1.3 Definition of urban centres

In the 2015 review, only those centres with a population greater than 20,000 were included. As such, the number of Urban Centres / Localities (UCLs) included in the urban transport assessment has increased from 68 in 2015 to 389 in 2020. These UCLs have been aggregated to 106 Significant Urban Areas (SUAs) and capture around 86 percent of Australian residents. The list of SUAs is provided in Appendix B.

The proposed geographic coverage of the urban transport assessment is UCLs contained within SUAs as defined by the Australian Bureau of Statistics (ABS) for the 2011 Census. Data has been analysed at the level of SUAs; where an SUA contains more than one UCL, the data from each UCL within the SUA has been combined. Where an SUA crosses state boundaries (for example, Gold Coast – Tweed Heads spans Queensland – New South Wales), the portion of the SUA in each state has been considered separately. All UCLs that are contained within SUAs have been included, regardless of population.

In the 2015 review, States' data was collected on SUAs. The use of SUAs as the geographic boundaries for assessment is appropriate. States will be able to provide the input data as SUAs had been used in the 2010 and the 2015 reviews. SUAs can also identify each city individually to avoid splitting input data where a service is provided in two or more UCLs within a city.

## 1.4 Organisation of the report

The remainder of this report is organised as follows:

- **Section 2** – discusses drivers of urban transport recurrent expenditure and preliminary model specifications.
- **Section 3 –** discusses drivers of urban transport infrastructure expenditure and preliminary model specifications.

- **Section 4** – discusses data needs for estimating urban transport expenditure models and provides a preliminary assessment of the data availability, comparability, reliability and fit for modelling purpose.
- **Section 5** – discusses the treatment of satellite cities in urban transport expenditure analysis.
- **Section 6** – assesses whether the Stage 2 component of the should proceed, based on the outcomes of the Stage 1 analysis
- **Section 7** – summarises the conclusions of the Stage 1 analysis

# 2. Urban transport recurrent expenditure

This section identifies the main drivers of urban transport recurrent expenditure, and considers how these driving factors can be specified in the urban transport recurrent models. This section, together with Section 3, fulfils the Output 1 component of Stage 1 of the study.

## 2.1 Drivers of urban transport recurrent expenditure

The following nine factors have been identified as the main drivers of urban transport recurrent expenditure:

1) Population serviced by an urban transport network
2) Employment and journey to work
3) Education enrolment and educational trips
4) Public transport service provision
5) Travel cost by car
6) Urban congestion
7) Urban density
8) Urban terrain
9) Emerging trends of urban public transport use

### 2.1.1 Population serviced by urban transport network

The urban transport task is a derived demand, as travel occurs because people want to undertake specific activities at different locations in an area. Thus the transport activity only occurs because of some other underlying demand[3]. The underlying demand is driven by the desire of a city's population for commuting, education, business, leisure and recreational activities.

Table 2-1 summarises the urban passenger transport tasks in Australian capital cities in 2013[4]. The motorised transport task, measured in passenger kilometres travelled (pkm), was 12,297 km per capita for all Australian capital cities. Compared to the Australian average, residents in Canberra travelled the most (11 percent higher than average), while people in Darwin travelled the least (25 percent lower than the average), followed by Adelaide (13 percent lower) and Hobart (6.6 percent lower). Other cities, namely Sydney, Melbourne, Brisbane and Perth, are generally within a ±5 percent range of the average.

The key observation is that the urban transport task is driven by population. However, we think that the 2015 Review model could be improved by including other influences that explain the variation in travel demand between cities, which include travel distance to work, education and other social and cultural activities. This means that the transport assessment would be based on population, with adjustment for other factors such as travel distance.

[3] Australian Transport Council (2006) National Guidelines for Transport System Management in Australia
[4] BITRE 2015 Urban public transport: updated trends, information sheet 59

**Table 2-1 : Urban passenger transport tasks in Australian capital cities, 2013**

| Passenger transport task | Sydney | Melbourne | Brisbane | Adelaide | Perth | Hobart | Darwin | Canberra | All Capital Cities |
|---|---|---|---|---|---|---|---|---|---|
| Motorised transport task (pkm per annum per capita) | 12,356 | 12,890 | 12,338 | 10,671 | 11,906 | 11,482 | 9,252 | 13,642 | **12,297** |
| Compared to Australian Capital City Average | 0.5% | 4.8% | 0.3% | -13.2% | -3.2% | -6.6% | -24.8% | 10.9% | **0.0%** |
| Passenger transport task by mass transit (pkm per annum per capita) | 1,725 | 1,397 | 1,045 | 637 | 913 | 403 | 575 | 573 | **1,227** |
| Compared to Australian Capital City Average | 40.5% | 13.8% | -14.9% | -48.1% | -25.6% | -67.2% | -53.2% | -53.3% | **0.0%** |
| % travel undertaken by mass transit | 14.0% | 10.8% | 8.5% | 6.0% | 7.7% | 3.5% | 6.2% | 4.2% | **10.0%** |

*Source: BITRE 2015 Urban public transport: updated trends, information sheet, 59*

It is worth noting that the broad urban transport task includes all motorised travel made by car, train, bus, ferry and light rail, not merely public transport alone. Modal share of mass transit is significantly different among Capital cities. On average for all Australian capital cities, public transit (train, bus, ferry and light rail) accounts for only 10 percent of the total urban passenger transport task, while 90 percent of the transport task was made by car, motorcycle and light commercials. On average, Australian capital city dwellers travelled 1,227 km on public transport in 2013. By comparison, people in Sydney travelled most at 1,725 km, followed by those in Melbourne, who travelled 1,397 km. Hobart residents recorded the lowest public transport usage, with annual passenger kilometres travelled 67 percent less than the Australian average. This is followed by Canberra (53 percent lower), Darwin (53 percent lower) and Adelaide (48 percent lower).

In the 2010 Review, the Commission used a model based on the relationship between urban city size and net per capita operating expenses to calculate States' GST requirements. In the 2015 Review, this method was retained and modified to:

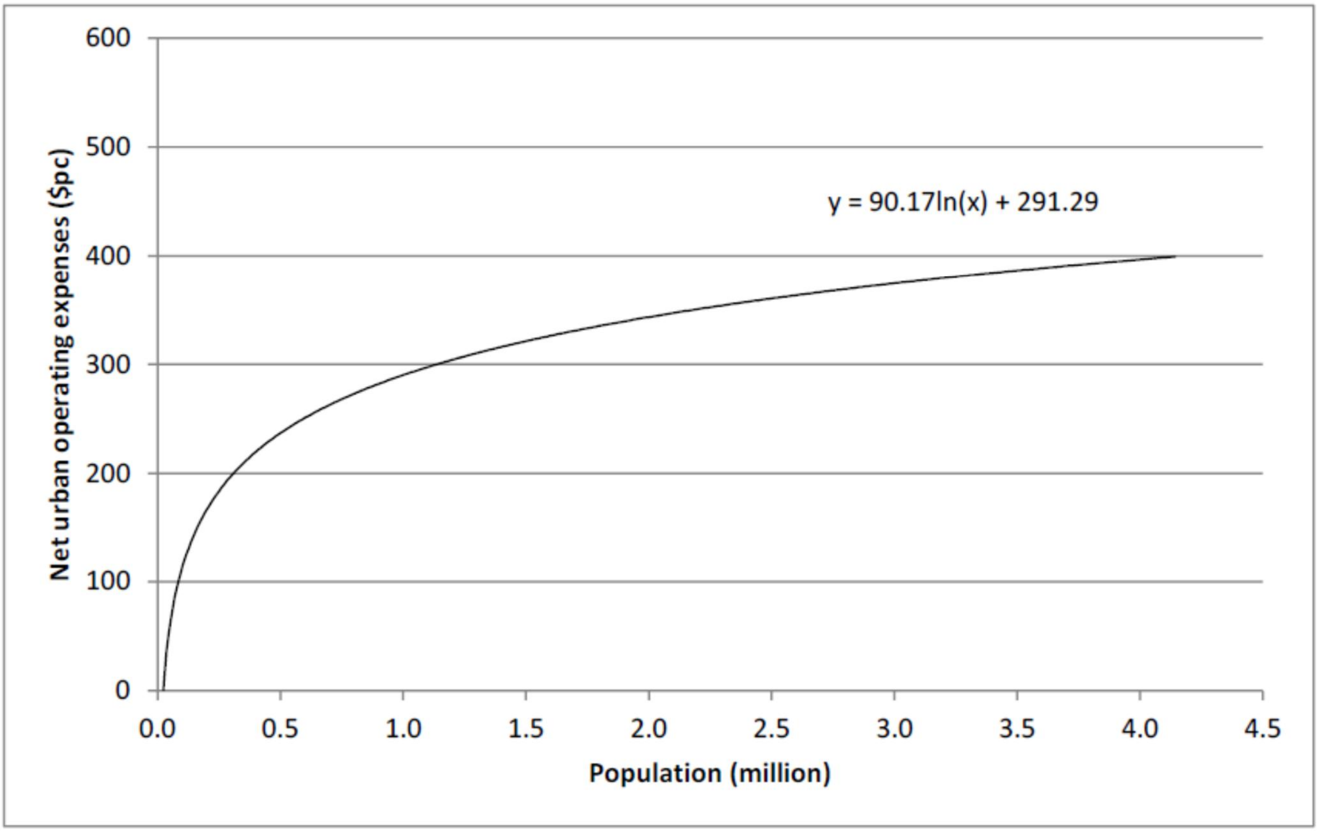
- include all urban centres with population over 20 000, instead of only those where a public transport service was provided
- weight net expenses by population, instead of using unweighted expenses.

The model estimated net per capita urban transport expenses by city using the logarithm of city population, as shown below.

$$Per\ capita\ net\ expenses_i = \beta_0 + \beta_1 \times ln(Population_i)$$

where i is the index of all urban centres with a population over 20,000. The relationship is illustrated in Figure 2-1.

**Figure 2-1: Modelled per capita net expenses by urban population size**




*Source: CGC Transport Consultancy Brief, 2017*

The figure indicates that the per capita net expenses rise as city population increases. Three main reasons were offered to explain this model[5]:

- There is greater per capita use of public transport in larger cities.
- Traffic congestion rises as city size increases, leading to more resources (e.g. crew time and fuel) being needed to operate a given level of service by road-based public transport. This is likely offset to an extent by the greater intensity of public transport usage in larger cities.
- Potentially, diseconomies of scale, with more resources needed to perform the same transport task as city size increases. However, in reviewing the international literature, the CGC report cautiously concluded that there does not appear to be a strong case for intrinsic diseconomies of scale in public transport operating expenses with regard to city size.
- In the 2015 review, some States had argued the case for economies of scale. Queensland presented analysis showing that as total population increases, total operating expenses per passenger-kilometre decreases. In reviewing literature on economies of scale in bus services, Cubukcu (2008)[6] discussed findings in support of all three possible cases (i.e. for the presence of economies of scale, diseconomies of scale and constant returns to scale) and concluded that a U-shaped curve may be most appropriate. As the city size increases, the operating expenses per passenger kilometre will initially decrease, supporting a case of economics of scale. However, as the city size increase further, the operating expenses per passenger kilometre will increase, supporting a case of diseconomies of scale. Optimum operating expenses at the bottom of the U-Shape are difficult to establish in reality. In the

[5] CGC 2009 Consultancy Advice: 2010 Review of State Government Subsidised Urban Public Transport Service. Page 13
[6] Cubukcu, K. M. (2008) Examining the cost structure of urban bus transit industry: does urban geography help? Journal of Transport Geography, 16(4), 278-291.

2020 review, the States data questionnaire has been designed to collect operating cost and passenger kilometre travelled. The economies of scale factor can be further examined in Stage 2 with the receipt of States data returns.

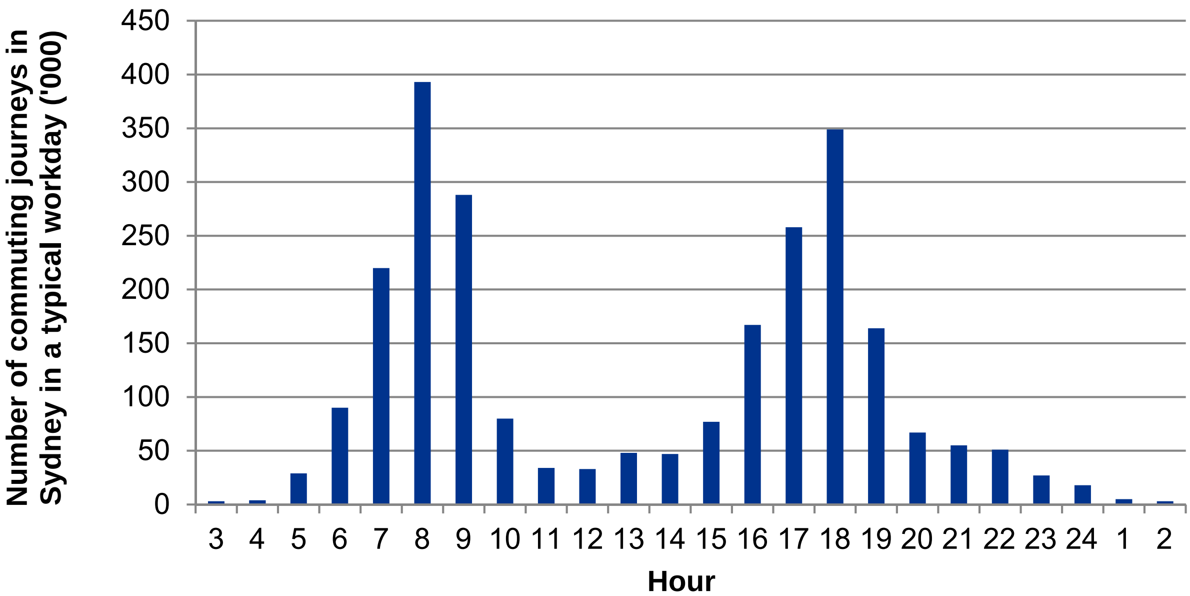
It was noted that the use of population as the sole driver for modelling urban public transport can be problematic. In the 2010 and 2015 reviews, Queensland and Western Australia said that using population as the sole driver of net urban operating expenses ignored other important influences on expenses.

### 2.1.2 Employment and Journey to Work

Public transport trip generation by employed person is different from other trip purposes. The most evident pattern for commuting trips is the dual peaks in the morning and evening. For example, Figure 2-2 shows the number of commuting journeys by time of day in Sydney. Trips during the AM peak hours (6– 9am) account for 36 percent of daily trips, while trips in PM peak hours (4 – 7pm) account for a further 31 percent. Equivalent data from Queensland shows a similar pattern as presented in Figure 2-3. Due to the intensity of demand, public transport has to be provided at a level that can accommodate peak hour journeys, which affects public transport recurrent and infrastructure costs.

In transport demand modelling, the place of residence is used for trip generation while the place of work is used for trip attraction. At the aggregate level, trip generations are equal to trip attractions thus there is no preference whether the place of residence or work is used[7]. Commuter and student trips predominantly occur in peak hours. Transport provision and capacity is planned to meet the peak hour demand while there will be excessive capacity in off-peaks.

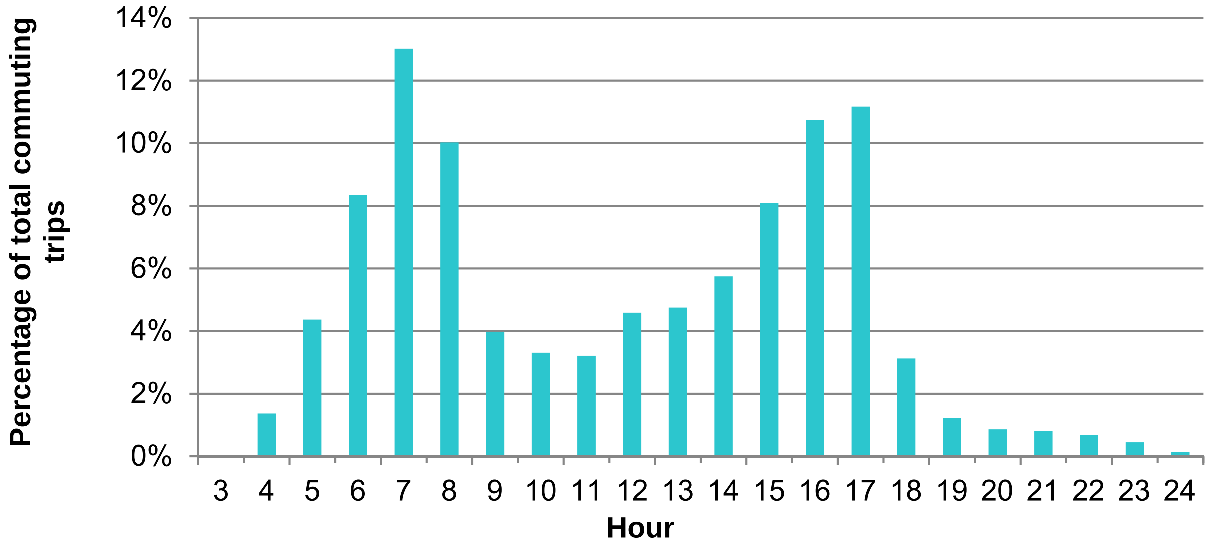
**Figure 2-2 : Commuting trips by time of day, all modes, Sydney**




*Source: Household Travel Survey data 2014/15, Sydney, website: https://public.tableau.com/shared/JJTQM32WP?:toolbar=no&:display_count=yes, accessed on May 14, 2017*

[7] Taylor 92009) Critical review of transport modelling tools (implementation options), national Transport Modelling Working Group; Bureau of Transport Economics (1998): Urban transport models: a review

**Figure 2-3 : Commuting journeys by time of day, all modes, South-East Queensland**




*Source: South East Queensland Travel Survey (SEQTS), 2009-12 datasets*

### 2.1.3 Student enrolment and educational trips

Education-related trips are one of the important drivers of urban transport expenditure. The education trip category represents the largest trip purpose, based on the Sydney Household Travel Survey in 2012/13. Table 2-2 shows that Education / childcare trips represent 24 percent of all train trips and 48 percent of all bus trips in Sydney. Combined, they represent 36 percent of all bus and train trips. Educational trips tend to occur in the morning peak hours 7-9am, and in the afternoon around 3-5pm. However, most available trip data did not distinguish between trips made by primary, secondary and tertiary students.

**Table 2-2 : Percentage of Train and Bus trips by purpose, Sydney, 2012/13**

| Trip Purpose | Train | Bus | Train and Bus |
|---|---|---|---|
| Commute | 39% | 17% | 27% |
| Work related business | 9% | 4% | 6% |
| Education/ childcare | 24% | 48% | 36% |
| Shopping | 7% | 11% | 9% |
| Personal business | 12% | 12% | 12% |
| Social/ recreation | 8% | 7% | 7% |
| Serve passenger – eg, drive a child to a school / a train station | 2% | 2% | 2% |
| **Total** | **100%** | **100%** | **100%** |

*Source: Household Travel Survey, 2012/13, Sydney*

### 2.1.4 Public transport service provision and the transport task

It is capital intensive to construct heavy and light rail lines and stations, and these modes are also expensive to operate. Based on CGC data from 2004/05 to 2006/07, the operating cost for train services was between $17.40 per Vehicle-Kilometre (vkm) in Adelaide and $46.33 per vkm in Sydney, as shown in Table 2-3. In comparison, bus is significantly less expensive than rail. However, if the operating cost is measured in passenger kilometres travelled (pkm), the difference between train and bus is marginal on the Australian average.

**Table 2-3 : Public transport operating cost in Australian capital cities ($2006)**

| City | Operating cost ($/Vehicle-Kilometre) | | | Operating cost ($ / Passenger-Kilometre) | | |
|---|---|---|---|---|---|---|
| | Train | Bus | Light Rail / Tram | Train | Bus | Light Rail / Tram |
| Greater Sydney | $46.33 | $4.41 | | $0.28 | $0.30 | |
| Melbourne | $31.25 | $8.34 | $12.93 | $0.18 | $0.58 | $0.05 |
| Brisbane | | | | $0.38 | $0.25 | |
| Perth | $21.96 | $3.94 | | $0.64 | $0.55 | |
| Adelaide | $17.40 | $4.30 | $24.83 | $0.43 | $0.43 | $1.22 |
| **Average** | **$29.24** | **$5.25** | **$18.88** | **$0.38** | **$0.42** | **$0.64** |

*Source: CGC 2009 Consultancy Advice: 2010 Review of State Government Subsidised Urban Public Transport Service, pp. 67-68, Table B.12. Values were as at FY2004/05 – 2006/07)*

The presence of train services should be controlled in developing urban transport recurrent and infrastructure models. Among eight Australian capital cities, five major cities have train services and four have light rail / tram services, as shown in Table 2-4. Their presence will be controlled in developing urban transport expenditure models in Stage 2 of the study. Statistically, a dummy variable, taking the value of either 0 or 1, can be used to control the existence of a particular mode. For example, the dummy variable for train takes the value 1 in Sydney with the service and 0 in Hobart without the service. This will allow the control of existence if train services in SUAs in the models.

**Table 2-4 : Presence of public transport mode in Australian capital cities**

| City | Train | Bus | Light Rail / Tram | Ferry |
|---|---|---|---|---|
| Sydney | ✓ | ✓ | ✓ | ✓ |
| Melbourne | ✓ | ✓ | ✓ | ✓ |
| Brisbane | ✓ | ✓ | ✓ | ✓ |
| Adelaide | ✓ | ✓ | ✓ | |
| Perth | ✓ | ✓ | | ✓ |
| Hobart | | ✓ | | |
| Darwin | | ✓ | | |
| Canberra | | ✓ | | |

*Source: States data return to Commonwealth Grants Commission for the 2015 review. The presence of a transport mode is judged by the presence of physical assets of the mode.*

### 2.1.5 Travel cost by car

In Australian capital cities, only 10 percent of the total motorised transport task was undertaken by public transport. Reasons for using public transport are diverse; Based on the Sydney Household Travel Survey in 2012/13, shown in Table 2-5, the top reasons given for taking public transport were to avoid parking problems, save money (compared with driving), faster, less stressful, not owning a car or the respondent lives or works close to public transport.

Cars and motorcycles represent the bulk of trips undertaken, with convenience / independence of driving cited by over half of respondents who travel to work by car. Often, public transport is indirect, slow, has limited coverage, and services may be infrequent or unavailable. There is potential for increasing urban public transport mode share if the quality of the services provided was improved.

The travel cost of cars can be modelled by well-established Vehicle Operating Cost models[8], which capture the costs for fuel, oil, tyre, repair and maintenance. The cost is varied by travel speed. There are so many different roads in a city thus we would not be able to accurately specify the average speed to differentiate the car cost among urban centres. Parking cost can be added on top of the estimated vehicle operating cost.

**Table 2-5 : Reasons for travelling to work by public transport or car**

| Travelling to work by public transport | | Travelling to work by car | |
|---|---|---|---|
| **Reason for travelling to work by public transport** | **Percent of respondents (%)** | **Reasons for travelling to work by car** | **Percent of respondents (%)** |
| Avoids parking problems | 48% | Prefer convenience/independence of car | 54% |
| Cheaper | 36% | PT services are indirect | 38% |
| Faster | 34% | PT services are too slow | 28% |
| Less stressful than other forms | 26% | PT doesn't go where required | 18% |
| Do not have a car | 23% | PT timetable constraints | 16% |
| Live or work close to public transport | 19% | Employer provides/subsidises car/parking | 15% |
| Arrives closer to destination | 15% | Use car for work trips | 14% |
| Enjoy time to read and relax | 15% | Use car for other non-work trips | 12% |
| Don't drive/no licence | 13% | PT is unavailable here | 9% |
| Car used by someone else | 7% | PT services are too infrequent | 10% |
| Environmental reasons | 5% | Carpooling arrangements | 6% |
| Other | 5% | PT services are unreliable | 4% |
| Employer assistance in public transport costs | 2% | Other | 5% |
| | | PT uncomfortable | 3% |

*Source: Household Travel Survey, 2012/13, Sydney*

In transport planning, mode choice for public transport is a function of the generalised costs[9] of car, train, bus and ferry that captures the costs of public transport fare, travel time, comfort, security, car operating cost including fuel and parking. In the CBD areas of the Australian capital cities, parking costs could be a main determinant of people's choice of a public transport option[10]. Road toll and fuel cost are also important determinants in these areas[11]. While travel cost by car is an important driver, it will not be included in the recurrent model. The cost of parking and road congestion is location based and there is a large variation between CBD, major centres and suburb centres. Thus, it is difficult to define a measurement to be included in the model.

### 2.1.6 Urban congestion

Bus operating costs will be affected by urban congestion. The urban congestion index has been developed using input data from Bureau of Infrastructure, Transport and Regional Economics (BITRE) traffic and congestion data (see Table 2-6). Given that the total congestion cost and VKT in

[8] Transport and Infrastructure Senior Officials' Committee (2016), Australian Transport Assessment and Planning (ATAP) Guidelines, Transport and Infrastructure Council, Canberra, www.atap.gov.au

[9] NSW Government Transport and Infrastructure (2002) Sydney Strategic Travel Model, technical report

[10] Hay, A. & Shaz, K. (2012) Parking and Mode Choice in Sydney: Evidence from the Sydney Household Travel Survey, 35th Australasian Transport Research Forum 2012 Perth, Australia, Shaping the future; Connecting Research, Policy and Outcomes

[11] Australian Transport Council (2006) National Guidelines for Transport System Management in Australia

Australian capital cities are known, the congestion cost per Vehicle-Kilometre Travelled (VKT) can be calculated. The highest congestion cost occurs in Sydney, estimated at $0.15 per VKT. Congestion costs in Hobart, Darwin and Canberra are relatively low at less than 5 cents per VKT. Melbourne, Brisbane, Adelaide and Perth have the same estimated congestion cost of $0.11 per VKT.

From the estimated congestion costs, a congestion index is developed such that the average Australian capital city has a congestion index of 1. For each city, the ratio of congestion cost per VKT to the Australian average is defined as the congestion index. Using the passenger car equivalency (PCE) factors, (2 axle rigid bus = 2 and 3 axle articulated bus =3), the congestion cost per bus kilometre travelled is also estimated and presented in Table 2-6.

**Table 2-6 : Congestion Index (BITRE)**

| City | VKT (billion KM) | Congestion cost ($b) | Congestion cost ($/VKT) | Congestion index | Congestion cost for rigid bus ($/VKT) | Congestion cost for articulated bus ($/VKT) |
|---|---|---|---|---|---|---|
| Sydney | 40.81 | $6.12 | $0.15 | 126% | $0.30 | $0.45 |
| Melbourne | 40.38 | $4.62 | $0.11 | 96% | $0.23 | $0.34 |
| Brisbane | 21.6 | $2.29 | $0.11 | 89% | $0.21 | $0.32 |
| Adelaide | 10.39 | $1.11 | $0.11 | 90% | $0.21 | $0.32 |
| Perth | 17.8 | $1.99 | $0.11 | 94% | $0.22 | $0.34 |
| Hobart | 1.98 | $0.09 | $0.04 | 37% | $0.09 | $0.13 |
| Darwin | 1.05 | $0.03 | $0.03 | 24% | $0.06 | $0.09 |
| Canberra | 3.9 | $0.19 | $0.05 | 41% | $0.10 | $0.15 |
| **Total Metropolitan** | **137.9** | **$16.45** | **$0.12** | **100%** | **$0.24** | **$0.36** |

*Source: VKT and congestion cost were sourced from Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2015, Traffic and congestion cost trends for Australian capital cities. The PCE factors were sourced from Transport for NSW 2016 Principles and Guidelines for Economic Appraisals of Transport Initiatives, Appendix 4, Table 18.*

The level of urban congestion has a significant impact on bus operating costs, particularly where bus routes share road space with general traffic for part or their entire route. Direct impacts of congestion include increased wear and tear on vehicles and tyres, from repeated stopping and starting in traffic, and reduced fuel efficiency. Traffic congestion and peak-spreading also drive demand for public transport and additional bus services, leading to additional vehicle costs (purchase, registration, maintenance, storage and depreciation), and personnel costs (recruitment, training, salaries and overtime). It is estimated that over 90 percent of bus operation costs relate to the number of vehicles in the fleet and the total bus kilometres travelled[12], and a recent study of bus routes in New Jersey, USA found that approximately 6.5 percent of bus operating costs were due to vehicle maintenance and purchase costs induced by traffic congestion[13].

Indirectly, urban congestion contributes to persistent late-running services and unreliable travel times. Buses not only experience intersection and mid-block delays faced by general traffic, but also delays entering and exiting bus stops. The result is 'bus bunching', where regularly scheduled services instead run near-simultaneously. This can lead to poor utilisation of the existing services while incurring the same operational costs. Late running services also affect fleet and driver logistics and further drive demand for new vehicles in order to maintain spare capacity. Higher fleet utilisation may also reduce the opportunities for routine maintenance and increase the likelihood of break-downs.

[12] World Bank, 'Cities on the move: A World Bank urban transport strategy review - Urban Transport Pricing and Finance'
[13] McKnight C et al 2003, 'Impact of Congestion on Bus Operations and Costs', Region 2 University Transportation Research Centre

Some of these impacts are mitigated by the implementation of bus-priority schemes such as dedicated bus lanes.

Conversely, urban congestion and the deterioration in the level of service provided by bus operators may deter passengers from the bus network. Longer dwell times, unreliable travel times and over-crowding may cause passengers to switch to alternative modes such as private vehicles. However, this is heavily dependent upon the travel and population characteristics of the urban area.

Urban congestion will reduce bus travel speed which will lead to an increased bus operating cost. The Australian transport national guidelines[14] provide a model showing how the travel speed will affect the vehicle operating cost:

$$VOC = BaseVOC * (k_1 + k_2/V + k_3*V^2 + k_4*IRI + k_5*IRI^2 + k_6*GVM)$$

where:

*VOC* = vehicle operating cost (cents/km)

*BaseVOC* = lowest VOC point in curve from raw HDM-4 output

*V* = vehicle speed (km/hr)

*IRI* = International Roughness Index (m/km)

*GVM* = gross vehicle mass (tonnes)

*k1 to k6* = model coefficients

In this model, the bus operating cost is a function of travel speed, road surface roughness and vehicle weight (including weight of passengers). The bus operating cost follows a U-Shape with the most efficient operating cost occurring at a speed around 60 - 70 km/h. With road congestion, as the speed is reduced below 60 km/h, bus operating costs will increase.

Congestion costs will also affect Government's decision making for capital investment. In economic appraisal and business case development, a marginal congestion cost is included with indicative values shown in Table 2-7:

**Table 2-7 : Marginal urban congestion cost, Sydney, dollar values as at March 2016**

| Road category | Marginal congestion cost, Sydney ($/vkt) |
|---|---|
| Freeways | $0.21 |
| CBD streets | $1.01 |
| Arterial roads (inner) | $0.34 |
| Arterial roads (outer) | $0.11 |
| Average | $0.36 |

*Source: Transport for NSW (2015)*[15]

In project business cases, a transport initiative or project that reduces road congestion is attributed to a congestion reduction benefit. A public transport project (rail, metro or busway) is projected to reduce road congestion.

The effect of road congestion on bus operating cost can be incorporated into the urban transport recurrent model using the congestion index as the independent variable. However, congestion data is only available for capital cities and it is generally assumed there is no road congestion outside

[14] Transport and Infrastructure Senior Officials' Committee (2016), Australian Transport Assessment and Planning (ATAP) Guidelines, PV2, road transport.

[15] Transport for NSW, 2016, Economic parameter values for valuation methodologies, Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives

Australian capital cities. The effect of road congestion on capital investment is indirect which cannot be directly captured in the urban transport infrastructure model.

### 2.1.7 Urban density

Average density is calculated simply as the total population divided by the area of an urban centre. There is other measurement of urban density that includes an urbanised area but excludes non-urban land uses (e.g. nature reserve. This will require a GIS package to model all SUAs). We anticipate that there is a relationship between urban density and the uptake of public transport. Table 2-8 shows the population of urbanised areas (defined as Urban Centres / Localities) located within Australian capital cities. This measure helps to avoid under-estimation of population density where the capital city also encompasses large non-urbanised areas and results in less variability between cities. We find that the urban density of Sydney, Melbourne, Perth and Adelaide is approximately double that of its overall density, while urban Hobart is almost four times as dense as Hobart overall.

**Table 2-8 : Urban population density and public transport mode share in Australian capital cities**

| Capital City (2011 SUA) | Population (2011 Census) | Urban Population (2011 Census) | Total Area (sqkm) | Total Urban Area (sqkm) | Population density (pp/sqkm) | Population density in Urban Areas (pp/sqkm) | Public Transport Mode Share[16] |
|---|---|---|---|---|---|---|---|
| Sydney | 4,196,432 | 4,142,579 | 4,064 | 2,184 | 1,033 | 1,897 | 14% |
| Melbourne | 4,000,286 | 3,934,172 | 5,679 | 2,734 | 704 | 1,439 | 11% |
| Brisbane | 2,025,384 | 1,984,433 | 5,065 | 2,134 | 400 | 930 | 8% |
| Perth | 1,776,983 | 1,720,610 | 3,367 | 1,626 | 528 | 1,058 | 8% |
| Adelaide | 1,223,452 | 1,210,819 | 2,024 | 1,021 | 604 | 1,186 | 6% |
| Hobart | 192,013 | 190,856 | 1,213 | 315 | 158 | 606 | 4% |
| Canberra | 370,090 | 363,845 | 482 | 443 | 767 | 821 | 4% |
| Darwin | 111,778 | 110,418 | 295 | 219 | 379 | 504 | 6% |

The public transport mode share is plotted against both the overall population density (Figure 2-4) and the urban population density (Figure 2-5). We see that the density of urbanised areas is a better predictor of public transport mode share, with an $R^2$ value of 76% compared to 46% for a linear fit. However, this relationship appears to be largely driven by high public transport mode share in Sydney and Melbourne, and implies only that public transport mode share increases with urban density, with all other factors being equal. As we can see in Figure 2-5, cities in Australia do not always adhere to this trend. It is possible that other factors- such as the coverage and frequency of the public transport network – contribute to lower than expected take-up in cities like Hobart, Canberra and Adelaide. While urbanised population density is more accurate to reflect public transport patronage, its calculation usually involves the use of Geographic Information System (GIS). The simple population density is straight forward to calculate. In many cases, infrastructure projects in high density areas mean more property acquisition and high land value. It can trigger to choose a tunnel or elevated rail track option which will increase capital cost.

[16] BITRE UPT Patronage, accessed 20 May 2017, <https://bitre.gov.au/publications/2014/files/is_059-060.xlsx>

**Figure 2-4: Population density and public transport mode share in Australian Capital Cities**

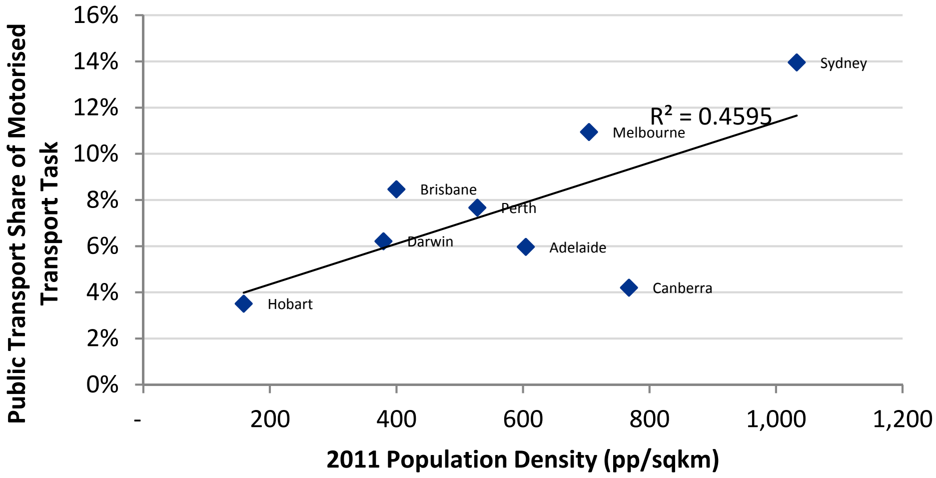
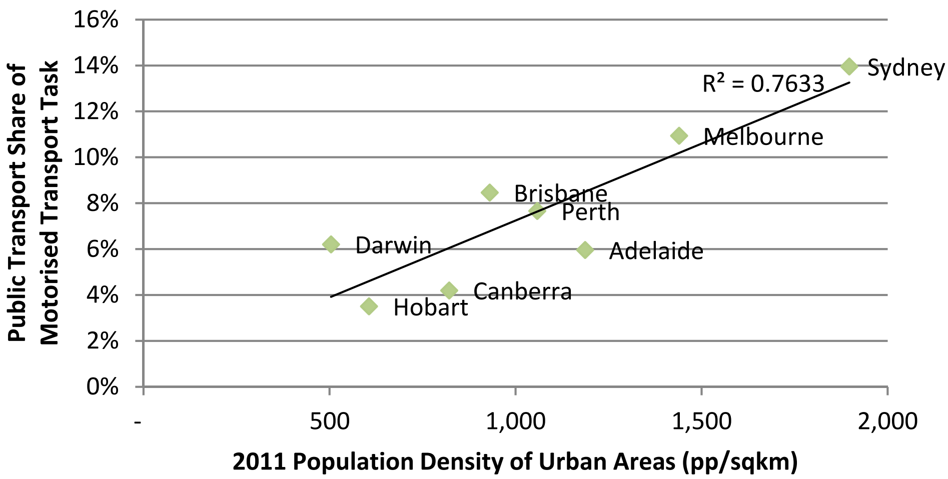



**Figure 2-5 : Population density and public transport mode share of urban areas in Australian capital cities**




### 2.1.8 Urban terrain

Urban terrain is likely to cause variation in bus operating costs. The Australian Transport and Infrastructure Senior Officials' Committee (TISOC)[17] recommends a Bus Operating Cost model:

$$BUSVOC = a_1 * (1 + a_2 * NRM + a_3 * Rise\&Fall + a_4 * Curvature + a_5 * Load)$$

Where *BUSVOC* is the bus vehicle operating cost in cents per kilometre travelled; *NRM* is road surface roughness counts per KM; *Rise&Fall* is a measure of road slope (metres in rise and fall in one kilometre road section); *Curvature* is a measure of road curviness; and *Load* is a measure of number of passengers carried. The $a_1$ to $a_5$ are equation parameters provided in the TISOC guidelines. This model clearly shows that, as road slope increases, bus operating costs also increase. The CGC has obtained the slope (in degrees) for road and rail segments in Australia. This data is used to represent the terrain conditions in each UCL.

[17] Transport and Infrastructure Senior Officials' Committee (2016), Australian Transport Assessment and Planning (ATAP) Guidelines, Transport and Infrastructure Council, Canberra, www.atap.gov.au

### 2.1.9 Emerging trend of urban public transport use

In recent years, there is a growing debate about the potential for new technologies to affect travel demand. In particular, changes in digital technologies, telecommunications and media could materially affect prospective travel patterns and locations (for example through telecommuting and arguments that 'the workplace is anywhere').

In recent decades, young adults in Australia and much of the developed world are becoming less likely to obtain a driving licence. Research into this trend is only recently emerging yet it is likely to have important impacts on public transport. Delbosc and Currie (2013)18 surveyed over 200 young adults in Melbourne, Australia. The survey explored the relationship between car licensing and demographics, life stage, use of social media and attitudes as well as exploring reasons why some young adults do not have a licence. Although most young adults saw a car as providing independence, they also saw it as a big responsibility. Car ownership and car use have declined in recent decades, translating to increased public transport use.

## 2.2 Recurrent expenditure model specification

### 2.2.1 Gross operating expense and net expense

In specifying the urban transport recurrent expenditure models, the immediate question is what should be the dependent variable to be modelled. Historically, CGC has used the net expense as the modelling dependent variable. The alternative dependent variable that has been considered for the 2020 review is the gross operating expenses.

The gross operating expenses are defined as the recurrent costs of operating public transport, excluding capital costs or capital charges. The net expenses are expenses minus all revenue other than government subsidies.

It has been difficult to obtain the gross operating expenses for private operators. The proportion of public transport services provided by the private sector varies between States. This means that the use of gross operating expenses as the dependent variable is unlikely to be possible because the data across States will not be comparable. If gross operating expenses were to be used, a separate estimate of fare revenue at average standards would need to be made. Currently CGC has no proposal to measure States' capacity to raise revenue from fares. The net expense is thus the preferred dependent variable for the recurrent expenditure model.

The principle of the CGC's advice on GST revenue distribution among the States and Territories ('States') is horizontal fiscal equalisation (HFE)[19]. Therefore, the recurrent expenditure model must be independent of the policy of individual governments (policy neutral) and reflect what States do on average. It determines how total recurrent spending on urban transport in a year would be needed by States if they were to provide the average level of service, given their circumstances. This is the most important principle in developing the urban transport recurrent and infrastructure models in this project. The HFE principle requires that all independent variables used in urban transport model be policy neutral while the policy neutral requirement is not relevant to the dependent variable.

### 2.2.2 Preliminary assessment of policy neutrality and data availability

Table 2-9 provides a preliminary assessment of policy neutrality and data availability. Net expenses have been used as the modelling variable in past years, which would still be available. Population was the sole explanatory variable used in the 2010 and 2015 reviews. Population and its sub-groups, including employed persons, tertiary students, and primary and secondary school students are

[18] Alexa Delbosc and Graham Currie (2013) Exploring attitudes of young adults toward cars and driver licensing, Australasian Transport Research Forum 2013 Proceedings, Brisbane, Australia
[19] https://www.cgc.gov.au/index.php?option=com_content&view=article&id=258&Itemid=536

considered policy neutral in the assessment of GST requirements. (Strictly speaking, population is not entirely policy neutral in the long-term. A State's economic policies can affect its population and employment; however, such interactions should be out of the scope of the CGC assessment). Reliable and transparent data is available from the ABS and it is likely that States will have confidence in these data items.

**Table 2-9 : Dependent and explanatory variables for an urban transport recurrent expenditure model**

| Recurrent expenditure and main drivers | | Policy neutral? | Data likely to be available for all States? |
|---|---|---|---|
| **Candidate for dependent variable** | | | |
| 1 | Operating expense | Yes | To be assessed from States data return |
| 2 | Net expense | No | Yes |
| **Candidates for explanatory variables**<br>***Population and sub-groups***[20] | | | |
| 1 | Population | Yes | Yes |
| 2 | Number of full-time equivalents (FTE) | Yes | Yes |
| 3 | Student enrolment: tertiary | Yes | Yes |
| 4 | Student enrolment: Secondary | Yes | Yes |
| 5 | Student enrolment: Primary | Yes | Yes |
| 6 | Student enrolment: All | Yes | Yes |
| ***Urban transport tasks*** | | | |
| 7 | Number of public transport users | No | To be assessed from States data return |
| 8 | Number of journeys: Commute | No | To be assessed from States data return |
| 9 | Number of journeys: Education | No | To be assessed from States data return |
| 10 | Number of journeys: Others | No | To be assessed from States data return |
| 11 | Number of journeys: All purposes | No | To be assessed from States data return |
| 12 | Passenger kilometre travelled: Commute | No | To be assessed from States data return |
| 13 | Passenger kilometre travelled: Education | No | To be assessed from States data return |
| 14 | Passenger kilometre travelled: Other | No | To be assessed from States data return |
| 15 | Passenger kilometre travelled: All purpose | No | Yes – BITRE data |
| 16 | Number of journeys to work by train | No | Yes – ABS Journey to Work data |
| 17 | Number of journeys to work by bus | No | Yes – ABS Journey to Work data |
| 18 | Number of journeys to work by light rail / tram | No | Yes – ABS Journey to Work data |
| 19 | Number of journeys to work by ferry | No | Yes – ABS Journey to Work data |
| 20 | Number of journeys to work by car and other modes | No | Yes – ABS Journey to Work data |
| 21 | Public transport mode share | No | Yes - Calculated from ABS Journey to Work data |
| ***Urban transport operations*** | | | |
| 22 | Revenue kilometre travelled: Train | No | To be assessed from States data return |
| 23 | Revenue kilometre travelled: Bus | No | To be assessed from States data return |

[20] In transport demand modelling, the place of residence is used for trip generation while the place of work is used for trip attraction. At the aggregate level, trip generations are equal to trip attractions thus there is no preference whether the place of residence or work is used. Commuter and student trips predominantly occur in peak hours. Transport provision and capacity is planned to meet the peak hour demand while there will be excessive capacity in off-peaks.

| Recurrent expenditure and main drivers | | Policy neutral? | Data likely to be available for all States? |
|---|---|---|---|
| 24 | Revenue kilometre travelled: Light Rail / Tram | No | To be assessed from States data return |
| 25 | Revenue kilometre travelled: Ferry | No | To be assessed from States data return |
| ***Other exogenous variables*** | | | |
| 26 | Urban congestion index | Yes | Yes, based on BITRE data |
| 27 | Urban terrain variable | Yes | Yes, based on CSIRO elevation data |
| 28 | Average trip length | Yes | Based on States data return |
| 29 | Urban density | Yes | Based on population density calculation |
| ***Treatment of satellite cities*** | | | |
| Individual urban centre model specification | | Yes | N/A |
| Amalgamated urban centre model specification | | Yes | N/A |

*Source: Jacobs' assessment*

Urban transport tasks reflect the underlying demands. However, the transport task is influence by the level of service and therefore is policy influenced. An examination of the States' 2015 review return indicates that the data is incomplete or partially missing with respect to transport tasks for most States. It is doubtful whether the required data would be available within the 2017 data collection. However, the aggregate data at the Australian capital cities level is available from BITRE[21], which provided partial modelling information on the transport task.

In assessment of urban transport tasks, it is important that the data is consistent among States. An important issue is the definition of public transport boardings, trips and journeys. The data from the 2010 and 2015 reviews, if provided at all, are likely to be a mix of journeys and boardings. A 'boarding' occurs when a person gets onto a public transport vehicle, while a 'journey' includes all travel from an origin to a destination. However, for the public transport expenditure assessment, it would be reasonable to exclude access and egress travel regardless of whether they were made by car, walking or cycling. A single journey may involve several boardings if people use two modes of transport or change to different vehicles of the same mode. For example, a transfer between two different train services may be still counted as one boarding as the traveller would not be required to exit the station. A 'trip' is usually not well defined as it could mean either a boarding or a journey and thus should be avoided if possible.

In this project, we prefer to use journey instead of boarding. However, information on the number of journeys may be available only where a city has an integrated ticket system that registers where people board a second or subsequent public transport service (usually recorded when the subsequent boardings occur within a given time period). Only the cities of Sydney, Melbourne and Brisbane have an electronic ticketing system.

The average journey length in kilometres can be calculated if both passenger kilometres travelled and number of journeys can be provided by States. The average trip length would be useful to analyse whether the journey distance increases as city size increases.

Urban transport options can be measured by train, bus, light rail and ferry vessel kilometre travelled. It is preferable to use revenue kilometres which exclude any dead running. Dead running is defined as kilometres travelled when a revenue gaining vehicle operates without carrying or accepting passengers, such as when coming from a depot or a garage to begin its first trip of the day.

[21] Bureau of Infrastructure, Transport and Regional Economics, Information Sheet 59, and associated datasets, accessed 20 May 2017, < https://bitre.gov.au/publications/2014/is_059.aspx>.

Crucially, urban transport operations are considered as not policy neutral. A State Government can determine the service frequency and public transport coverage. Frequent and better coverage services mean more vehicle kilometres and high customer satisfaction but can suffer from poor economic performance, known as technical efficiency in the previous CGC reviews. Less frequent services mean public transport overcrowding, reduced customer satisfaction but improved technical efficiency.

### 2.2.3 Urban transport recurrent expenditure model specifications

The urban transport recurrent expenditure model can be specified in the following general form:

$$Recurrent = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon$$

Where

*Recurrent* = Urban transport recurrent expenditure either measured in operating expenses or net expenses

$\beta_0, \beta_1, \beta_2, \ldots\ldots, \beta_n$ = Coefficients to be estimated

$X_1, X_2, \ldots\ldots, X_n$ = Explanatory variables in Table 2-9.

$\varepsilon$ = Random error term

This is the theoretical recurrent model with potential independent variables presented in Table 2-9. The proposed / recommended model will be driven by data. When all required data is collected, the proposed model will be tested with data. The best theoretical model will give the best goodness of fit to the data. However, the recommended model will be different to the theoretical model. The recommended model will need to consider some subjective factors such as simplicity and reliability as required by CGC. The following four core models will be tested as part of the Stage 2 analysis:

- **Demand model**: The model uses the operating cost as the dependent variable and population, employment, student enrolment, number of public transport users, number of journeys and passenger kilometres as possible explanatory variables. The demand model is policy neutral as it is driven by people's needs to get to work, education and other activities. This is an improvement to the current model that is driven by the population only. However, the demand model can accommodate neither the different cost structure of bus, train, light rail and ferry, nor the effects of urban congestion and trip length caused by city size.
- **Supply model:** Explanatory variables can include urban transport revenue kilometres by mode (train, bus, light rail and ferry). Urban congestion index can be entered into the model as an explanatory variable. Urban transport revenue kilometres are not policy neutral. The service intensity, frequency and coverage can be decided by States.
- **Urban centre model:** The model will be built at SUA level as all input data will be collected at this geographic coverage. Public transport is not provided to all SUAs. If there is no public transport in a SUA, it should still qualify for GST distribution. On the other hand, a State can choose to provide public transport outside SUAs, which should be ignored in GST distribution as it is the State's policy choice.
- **Amalgamated model:** The principal city and its satellite cities will be amalgamated for dependent and explanatory variables. The urban centre model and amalgamated model will be compared to find out whether the modelled GST requirement is neutral to the specification either based on individual centres or amalgamated centres.

The presence of statistical correlation between the explanatory variables will be dealt with in the model selection. All possible subsets of explanatory variable will be systematically explored however the final recommended model should be simple and transparent. It is anticipated that the adopted model will be a combination of linear, log-linear and polynomial relationships. Data obtained from the ABS will take precedence for its comparability and reliability.

# 3. Urban transport infrastructure expenditure

This section identifies the main drivers of urban transport infrastructure expenditure, and considers how these driving factors can be specified in the urban transport infrastructure models. This section, together with Section 2, fulfils the Output 1 component of Stage 1 of the study.

## 3.1 Review of existing CGC infrastructure expenditure model

In the current infrastructure expenditure model, the Commission decided to assess the investment[22] in urban transport infrastructure in much the same way as other investments. It recognises:

- Larger cities require more urban transport infrastructure per capita than smaller cities to deal with their larger transport task
- Population growth is an important driver of investment
- Interstate differences in the cost of infrastructure affect investment.

The CGC had adopted a quadratic function of the population and applied a 50 percent discount. This simple population based model has been used to assess each State's share of the national urban transport infrastructure expenditure. The CGC observed that urban transport infrastructure grows at a constant rate as cities get bigger.

The population based model for urban transport infrastructure rests on the view that larger cities need much more stock per capita than smaller cities. The conceptual case was presented in the findings of the consultants employed in the 2010 Review to advise on the Transport assessment methods. A high correlation between the annual cost of capital charges and the population of each of the cities was found and two reasons were provided:

- The number of trips per capita and trip length rise as city population increases and more assets are needed to carry the greater number of users.
- Diseconomies of scale mean larger cities need more capital than smaller cities to undertake the transport task. For example, more buses may be needed because of the slower average travel time in larger cities, or rail systems may be required to meet high levels of demand. Such effects may, however, be partly offset by greater productivity of the assets in larger cities, for example with higher average vehicle occupancy.

The regression analysis suggested that per capita asset values increase linearly with city size and have an intercept that is close to the origin. States had concerns about this approach. While New South Wales, Victoria and the Northern Territory broadly supported that analysis, the other States did not:

- Queensland submitted that the outcome of the regression analysis could not be assumed to represent average policy. It said there is no way to ascertain whether observed differences in the actual stock values of large cities represented differences in policies, technical efficiency or an underlying need for different levels of stock.
- Western Australia was concerned the regression analysis may have been driven by differences in State policies and the timing of investment. This was in the context of a large planned expansion of the Perth urban transport system to be completed in 2031 to accommodate predicted future population growth. It also noted that the analysis was not sufficient to show whether the relationship for small urban centres differed from that for capital cities.

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[22] Investment is equivalent to 'net acquisition of non-financial assets' in the ABS Government Finance Statistics operating statement, which is defined as gross fixed capital formation less depreciation plus changes in inventories plus other transactions in non-financial assets.

- In their final submissions for the 2015 review, all States except New South Wales and Victoria expressed reservations with or opposition to the proposed population model. New South Wales and Victoria considered that the conceptual case that larger cities require more assets per capita to deliver urban transport services had been established and is supported by the available data.

## 3.2 Development of new urban infrastructure expenditure model

States have reservations on the existing urban transport infrastructure model. Namely the model is too simplistic; there were too few observations; the fitted line was driven by a few important observations (especially for Sydney), and the data were not sufficiently reliable (for example the asset values were not comparable across States or cities). Furthermore, a discount factor of 50 percent appears arbitrary, introduced simply to alleviate concerns from the six States and Territories other than NSW and Victoria. The existing model also tends to a greater allocation of GST requirement for larger cities, which results in States' argument that some satellite cities should be amalgamated to produce a more favourable GST allocation.

It is important that the urban transport infrastructure model captures the following features:

- **Maintenance of the appropriate capacity to meet ongoing travel demand.** This reflects the fact that existing physical assets need to be maintained, refreshed or replaced at the end of economic life. The indicators for this need may include population or value of the existing asset base.
- **Ability to build new capacity to meet the increased demand.** The increased demand is driven by population growth, employment and economic activities and household income. People with higher incomes tend to travel more than those with lower incomes.
- **Ability to meet peak hour demand.** Transport capacity is designed to meet peak demand. Employed persons generally travel in the AM or PM peaks which put additional demand on urban transport capacity. Reliable time of day travel data is only available in Sydney, Brisbane, Melbourne and Perth. Thus, the peak demand data is not likely to be used in the Stage 2 model.
- **Capture of construction cost adjustment.** The construction cost for one track kilometre in different Capital Cities and urban centres will be different due to a range of factors such as terrain, land value, utility adjustment. Ideally, the unit cost in each urban centre can be used as an indicator of the construction difficulty factor, but such data is unlikely to be available. In recent years, tunnels and bridges have been selected as engineering options. The indicator of transport construction unit cost can be the intensity of structures, bridges and tunnels. CGC has obtained urban waterways and bridge statistics that could potentially be used as a variable representing urban construction cost.

The urban transport infrastructure expenditure model can be specified in the following general form:

$$Capital = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon$$

Where

*Capital*= Urban transport infrastructure expenditure

$\beta_0, \beta_1, \beta_2, \ldots\ldots, \beta_n$ = Coefficients to be estimated

$X_1, X_2, \ldots\ldots, X_n$ = Explanatory variables in Table 2-9.

$\varepsilon$ = Random error term

This is the theoretical infrastructure model with potential independent variables presented in Table 2-9 for 29 potential independent variables and Table 3-2 for additional 7 independent variables. In Stage 2, the proposed / recommended model will be driven by data. When all required data is collected, the proposed model will be tested with data. The best theoretical model will give the best goodness of fit to the data. However, the recommended model will be different to the theoretical model. The recommended model will need to consider some subjective factors such as simplicity and reliability as required by CGC.

## 3.3 Capital charge

The capital charge will be used as a dependent variable in the urban transport infrastructure model. Capital charge can be defined as the sum of the depreciation and capital investment. As state capital investment in new public transport infrastructure is likely to fluctuate from year to year, an average of the three previous years will be taken.

## 3.4 Drivers of urban transport infrastructure expenditure

The following factors have been identified previously as the main drivers of urban transport recurrent expenditure but also drive the urban transport infrastructure expenditure:

1) Population serviced by the urban transport network
2) Employment and journey to work
3) Education enrolment and education trips
4) Public transport service provision
5) Urban density

These variables have been discussed in Section 2.1. The following variables have been identified as additional drivers of infrastructure expenditure

1) Population growth
2) Unit cost of infrastructure provision - terrain condition

### 3.4.1 Population and growth

The 2015 review assessment is based on a simple population model, in which assessed asset values were calculated as the square of urban centre populations. To allow for concerns about the shape of the relationship and whether there were other drivers of infrastructure requirements that had not been captured, the Commission discounted the results by 50 percent.

In the current review, the population growth, defined as the net annual increase of the population in an urban centre, will be used as a driver of urban public transport infrastructure provision.

Table 3-1 presents the annual population growth in Australian capital cities. In the most recent three years, Melbourne recorded the strongest population growth, followed by Sydney, Brisbane and Perth. The population growth would indicate the need for new public transport infrastructure in Australian capital cities and other urban centres.

**Table 3-1 : Annual population growth in Australian capital cities**

| Capital City | Annual population growth rate | | | | | Population in 2016 |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | |
| Sydney | 1.3% | 1.6% | 1.8% | 1.8% | 1.7% | 4,492,189 |
| Melbourne | 1.7% | 2.0% | 2.2% | 2.2% | 2.1% | 4,349,149 |
| Brisbane | 2.1% | 2.1% | 1.7% | 1.5% | 1.5% | 2,169,674 |
| Perth | 3.3% | 3.8% | 2.4% | 1.5% | 1.2% | 1,939,716 |
| Adelaide | 1.0% | 1.1% | 1.0% | 1.0% | 0.8% | 1,272,615 |
| Hobart | 0.6% | 0.2% | 0.6% | 0.5% | 0.7% | 195,899 |
| Canberra - Queanbeyan | 1.7% | 1.8% | 1.4% | 0.9% | 0.8% | 388,483 |
| Darwin | 1.2% | 3.1% | 2.2% | 0.4% | 1.2% | 119,694 |

### 3.4.2 Terrain condition

Unit construction cost for urban rail will depend on urban terrain conditions. Costs associated with constructing bridges and tunnels would be considerably higher than at-grade infrastructure. The CGC has obtained urban waterways and bridge statistics for road and rail from Geoscience Australia. Road and bridge length, adjusted by the population in an urban centre, will be used as an explanatory variable.

### 3.4.3 Engineering options – surface, tunnel and elevated rail

Recent rail projects in Australia have faced a choice between traditional surface, tunnel or elevated rail. While tunnel and elevated rail offer benefits in improved service reliability, safety, automation and potential land-use opportunities along the rail corridor, they are more expensive to construct. In particular, tunnel construction incurs significantly greater capital costs over other options.

**Figure 3-1 : Indicative median per-kilometre cost of rail construction types (2016 A$ million)[23]**


In the last twenty years, tunnelled rail has been applied to new rail projects in urban areas, particularly in Sydney. These include the Sydney Airport Rail Link (2000), Epping – Chatswood Railway Line (2009) and the Sydney Metro Northwest from Bella Vista to Epping (tunnelling completed 2016). A tunnel solution has also been chosen for Sydney Metro City and SouthWest between Chatswood and Sydenham. On a smaller scale, the Perth-Mandurah Railway included almost 2km of tunnelled railway (a combination of bored and cut and cover) was constructed near the Perth city centre in

[23] Woodcock I. & Martin S. 2016, 'Of Skyrails and Skytrains – Elevated rail in the Australasian urban transport environment', *Australasian Transport Research Forum 2016 Proceedings*, Melbourne, Australia.

2007. In such areas, tunnelled rail options offer savings associated with property acquisition and land rehabilitation.

Entrenched rail has been constructed in Brisbane (2009) and Melbourne (2012, 2014), but has largely been restricted to relatively short segments less than 2km) for the purposes of grade-separating existing lines. In contrast, entrenched rail has been applied internationally for medium distance freight lines, such as the 16km Alameda mid-corridor trench in California.

There has been increasing movement towards elevated, or ‘skytrain’ options for both grade separation and new rail line projects, particularly on the outskirts of capital cities. These include the 8.5km Brisbane – Airport ‘AirTrain’ (2000) and the15.5km Sydney Metro NSW ‘Skytrain’ (under construction). In addition, almost 20km of elevated rail has been proposed along the Caulfield – Dandenong Line in Melbourne to remove a number of level crossings on the existing rail line. These projects have also included construction of new elevated rail stations.

Elevated rail offers several advantages over tunnels; construction costs are reduced as there is less conflict with existing utilities and services and fewer groundwater issues. There are also fewer construction impacts, as the new rail line can be constructed over an existing line without the need for extended closures and there are fewer truck movements to dispose of tunnel spoil.

Furthermore, compared to entrenched options, elevated rail allows for greater economic and social opportunities around the station precincts, retention of heritage structures at ground level, and re-purposing land underneath the corridor for public space and active transport, while retaining the cost savings of non-tunnel construction. Elevated rail also offers an improved experience for passengers in way-finding and views, and allows greater flexibility for future interchange arrangements.

However, there are strong arguments against the implementation of elevated rail, as seen in community opposition to proposals for elevated rail in Melbourne. These arguments include the visual impact of the rail structure, noise from train services (particularly freight), shadowing of the rail corridor and perceived impacts on property prices. Careful design of the elevated structures is required to mitigate these concerns.

Decision of surface, tunnel or skytrain options is assessed under well-defined national, state and professional guidelines. Infrastructure Australia[24] divides the investment assessment into five stages:

- Stage 1: Problem identification and prioritisation
- Stage 2: Initiative identification and options development
- Stage 3: Business case development
- Stage 4: Business case assessment
- Stage 5: Post completion review

The options for surface, tunnel or skytrain are interactively developed, examined, reviewed and refined in Stages 2-4. An examination of four recent Metro and urban rail link project business cases in Sydney, Melbourne, Brisbane and Perth[25] revealed that the full costs and benefits of all available options have been estimated and compared to provide the maximal net benefits to public transport users and transport agencies. Techniques used for option analysis include cost benefit analysis, Multi Criteria Analysis, Value Management workshops and Strategic Merit Tests[26]. Reasons for tunnel or

[24] Infrastructure Australia (2017) Assessment Framework for initiatives and projects to be included in the infrastructure priority list (IPL)
[25] These business cases are confidential to States’ cabinet thus the details cannot be released.
[26] The methodology details are provided in Transport and Infrastructure Senior Officials’ Committee (2016), Australian Transport Assessment and Planning (ATAP) Guidelines, Transport and Infrastructure Council, Canberra, www.atap.gov.au

skytrain include terrain conditions such as harbour or river crossing. Costs for property acquisition and utility adjustment (moving telecommunication cables, water pipes) were high in CBD or other high density areas. Hence, a tunnel option typically provides the best value for money option. Land availability and high acquisition costs for commercial buildings constrain the station locations. In many cases it is unfeasible to have a surface rail track option near a CBD. In the outskirts of capital cities, a skytrain option is more often selected, mainly to remove level crossings and to avoid building more overpass and underpass bridges.

### 3.4.4 Preliminary assessment on policy neutrality and data availability

Table 3-2 provides a preliminary assessment of policy neutrality and data availability of the proposed variables. In previous years, the capital charge (dependent variable) has included the depreciation costs of existing infrastructure and investment cost for new infrastructure. Once a physical asset is built its depreciation generally follows a defined schedule based on the age and value of the asset. As evidenced by previous returns, this data is certainly available from States; however there may be issues with data comparability- in the 2015 review, some States asserted that “asset values were not comparable across States or cities”.

Alternatively the capital charge can be defined as depreciation plus capital investment. This model would capture both the effects of maintaining existing capacity and building new capacity. The amount of capital investment should be available for at least the capital cities from the States’ budget.

**Table 3-2 : Dependent and explanatory variables for an urban transport infrastructure expenditure model**

| Recurrent expenditure and main drivers | | Policy neutral? | Data likely to be available for all States? |
|---|---|---|---|
| **Candidate of dependent variable** | | | |
| 1 | Capital charge – depreciation cost | No | To be assessed from States data return |
| 2 | Capital charge – depreciation + capital investment cost | No – States can decide the level of capital investment | To be assessed from States data return |
| **Candidates of explanatory variables**<br>***Population and sub-groups*** | | | |
| 1 | Population | Yes | Yes |
| 2 | Population growth | Yes | Yes |
| 3 | Number of full-time equivalents (FTE) | Yes | Yes |
| 4 | Physical asset valuation ($m) | No | Yes |
| 5 | Urban waterways – rail bridge length | Yes | Yes |
| 6 | Average trip length | Yes | Yes – States data return |
| 7 | Engineering options – at grade, tunnel and elevated | Yes | Yes – States data return |

*Source: Jacobs’ assessment*

# 4. Data strategy

This section fulfils the Output 2 component of Stage 1 of the study.

## 4.1 Preliminary datasets

The following data have been collected in the Stage 1 review. The main data sources were ABS, States' return in 2015 review and other published reports from BITRE.

**Potential dependent variables**

- Net expenses 2010 -2012
- Capital charge – depreciation and investment 2010 - 2012

**Potential explanatory variables**

- Population, 2009-2016
- Population growth 2010-2016
- Number of employment full time by place of work 2011
- Number of employment part time by place of work 2011
- Number of employment full time by place of usual residence 2011
- Number of employment part time by place of usual residence 2011
- Number of tertiary student place of enrolment 2011
- Number of high-school student place of enrolment 2015
- Number of primary-school student place of enrolment 2015
- Number of tertiary student place of usual residence 2011
- Number of high-school student place of usual residence 2015
- Number of primary-school student place of usual residence 2015
- Journey to work 2011 Train (Train mode used at least once)
- Journey to work 2011 Bus (Bus mode used at least once, no train mode)
- Journey to work 2011 Light Rail / Tram (Light rail only)
- Journey to work 2011 Ferry (Ferry only)
- Journey to work (Car and all others)
- Journey to work 2011 Work at home / not work
- Average rail segment slope (degrees)
- Average road segment slope (degrees)
- Total rail bridge length (m)
- Total road bridge length (m)
- Population density (population / hectare in 2011)

**Other explanatory variables investigated but data was incomplete**

- Operating expenditure 2010-2012
- Number of passengers – student concession

- Number of passengers – other concession
- Number of passengers – total
- Public transport vehicle kilometres
- Number of public transport vehicle journeys
- Public transport route kilometres
- Public transport passenger kilometres
- Number of visiting tourists

## 4.2 Proposed data collection for developing urban transport recurrent and expenditure models

A draft data request has been jointly prepared and agreed by CGC and Jacobs. The data collection covers the items below.

**Table 4-1 : Data requested from States**

| Data item | |
|---|---|
| **Recurrent expenditure and revenue** | |
| 1 | Revenue kilometres travelled |
| 2 | Operating expenses |
| 3 | Fare revenue by mode |
| 4 | Concession revenue foregone by mode |
| **Physical assets and capital investment** | |
| 1 | Track kilometres |
| 2 | Dedicated bus lane kilometres |
| 3 | Number of ferry wharves |
| 4 | Number of rolling stock |
| 5 | Number of bus fleet vehicles |
| 6 | Number of ferries |
| 7 | Total asset value by mode |
| 8 | Capital charge - Depreciation by mode |
| 9 | Capital charge - Capital investment by mode |
| **Transport task** | |
| 10 | Number of boardings by fare type (students, other concessions and regular fares) |
| 11 | Average distance travelled per boarding |
| 12 | Number of journeys |
| 13 | Average journey length |
| **Inter-centre public transport journeys** | |
| 14 | Number of intercity trips between principal and satellite cities.<br>This data will be used to determine appropriate geographic boundaries for the expenditure assessment. |
| **Heavy rail infrastructure** | |
| 15 | Heavy rail track kilometres by surface, underground or elevated.<br>This data will be used to understand the drivers to the choice of tunnel or skytrain engineering options over surface rail. |

States were requested to give an indication of data availability by mid-June 2017. Table 4-2 summarises States' indications

**Table 4-2 : Data availability from States' initial indication**

| States | Comments |
|---|---|
| New South Wales | • Not expect any substantial gaps in the data availability |
| Victoria | • Not necessarily be impossible to provide the information, but that it may not be able to be done to the exact request. i.e., it might be difficult to break everything down by the 22 non-urban Significant Urban Areas.<br>• PTV is still looking at the draft data request but may not be able to make much progress at the moment as they are involved in end of financial year reporting.<br>• In regards to the inter-city journeys, you may want to include the Gippsland corridor which would cover Warragul-Drouin. There are also significant inter-city flows on the northern corridor (Seymour), but none of the towns involved are SUAs. |
| Queensland | • Not expect any substantial gaps in the data availability |
| South Australia | • Should be able to provide the data but the timing is a problem as transport agencies will be focused on preparing end-of–year financial statements in July and early August. |
| Western Australia | • Our main questions relate to that the data request does not appear able to pick up capacity of States' urban transport systems. You ask for data about boardings, length of track and busways, number of cars per train, and asset values. But there are no questions regarding the number of trains, buses and ferries, or their passenger-carrying capacities. How would you determine systems' capacities and therefore deduce a standard of service (additionally, some questions on usage at different times of the day would determine, for example peak-hour congestion)?<br>– In relation to the question on the number of cars per train, were you interested in the average number, or modal number, or both?<br>– Similarly, for the question about revenue kms (vehicle km travelled), in relation to trains, is a vehicle a car, or the whole train? Is this all kms the vehicle has travelled, or just kms travelled collecting fares (e.g. not trips between depots).<br>• The Perth Transport Authority (PTA) also had some questions/comments:<br>• Most of the tables can be completed by SUA, however:<br>– Ellenbrook cannot be separated from Perth;<br>– Mandurah has been removed as a separate SUA; and<br>– it is unsure whether the Busway kilometres can be accommodated.<br>• Clarification is required with regard to:<br>– There is a reference to Total Revenue (page 3) and Fare Revenue (table 5), is this the same definition or different?<br>– What is the definition of 'student'? Is it school students or all students (our school and university students receive substantially different concession rates).<br>– The PTA is not funded for depreciation, so the tables will not identify that as such as it is assumed that the Operating subsidy is the balance between total cost and revenue (Note on page 8).<br>– What is the definition of dedicated busway? PTA keeps a valuation record of busways owned by the PTA, not of the other Bus Priority lanes (page 9). |
| Tasmania | • The dataset will be applicable to Burnie only, as Wynyard is not part of the Burnie urban area. It is proposed that Ulverstone be excluded, as it does not receive urban services<br>• No urban passenger rail, ferry and light rail in Hobart<br>• Bus kilometres will be contractually-required kilometres, not necessarily contractually provided kilometres, which may vary slightly.<br>• Data split on SUAs can be problematic - Data only available for Metro (Hobart, Launceston and Burnie), not Merseylink (Devonport) or Legana (Manions). Also, Metro dataset will be overstated as (i) it is statewide and not able to be split by SUA; and (ii) the data will include non-urban services, as these are also unable to be disaggregated from the total. Any disaggregated data would need to be sourced from Metro.<br>• Concession subsidies - Urban services are paid on a km basis, not on a concessional top-up basis. |

| States | Comments |
|---|---|
| | The km payment is set in acknowledgment that concessional fares are offered, which reduces operator revenue. However there is not a direct linkage between the number of concessional passengers at any given time and the level of subsidy provided.<br>• Physical assets - The Tasmanian Government owns some infrastructure that is semi-suitable for ferries (via Tasports as an SOC), however it is not currently used for urban passenger ferry purposes. The Government also owns rail track through Hobart but has no current plans to put in place light or heavy passenger rail services. It has been assumed that none of these are applicable for purposes of this table, given that relevant services do not currently operate. Further advice required if this assumption is incorrect.<br>• There is only one dedicated bus lane in the state, which is located on the Southern outlet. Further advice will need to be sought internally on whether it is possible to notionally attach an asset value and/or depreciation schedule.<br>• It is unlikely that data would be available on the value of bus stops/shelters/pullovers on state roads.<br>• As the table only mentions dedicated busways, an assumption has been made that bus stop infrastructure is excluded. Further advice required if assumption is incorrect.<br>• Metro asset value: The Department of State Growth does not hold data on Metro asset value or depreciation.  This data would need to be sought from Metro, however it is by no means clear that it would be available or complete.<br>• Data not held for Merseylink or Manions.  The Metro dataset held by State Growth will be overstated as (i) it is statewide and not able to be split by SUA; and (ii) the data will include non-urban services, as these are also unable to be disaggregated from the total.  Any disaggregated data would need to be sourced from Metro. |
| Norther Territory | • Data can be populated for Tables 2, 3, 4 and 8 for both Alice Springs and Darwin |
| Australian Capital Territory | • Not expect any substantial gaps in the data availability |
| Overall | • General data availability has been indicated by States<br>• Timing of data collection in July  / August can be an issue as States are preparing the end of year financial statements in the same period.<br>• Data splitting on SUAs can be a problem for some States<br>• Other general clarifications may be required from States |

## 4.3 Preliminary assessment of data availability, reliability and fitness for purpose

The data items to be used in the urban transport infrastructure expenditure model have been assessed in terms of availability, reliability and fitness for purpose. The assessment criteria are presented in Table 4-3 and the preliminary assessment is presented in Table 4-4.

**Table 4-3 : Criteria used for assessing data availability, reliability and fitness for purpose**

| Data Item | High | Moderate | Low |
|---|---|---|---|
| Availability | Required data is published by ABS or other Federal and State Government agencies | The 2015 States return shows that data is likely to be available | Data item was missing in the 2015 review for 4 or more Sates |
| Reliability | Required data is published by ABS or other Federal Government agencies (e.g. BITRE) or renowned research organisations (e.g. CSIRO) | It is questionable whether the definition is exactly the same among States.<br>Data items published by a State government agency thus the comparability between States is questionable. | Data is inconsistent between States. |
| Fitness for purpose | For a dependent variable, it can represent well urban transport recurrent or infrastructure expenses.<br>For an independent variable, data is reliable and highly statistically significant (for example, at 95% of significance level) with a high explanatory power. The statistical significance will be assessed in Stage 2. | For a dependent variable, it can represent urban transport recurrent or infrastructure expenses.<br>For an independent variable, data is moderately reliable or statistically significant (for example, at 90% of significance level) with some explanatory power. The statistical significance will be assessed in Stage 2. | For an independent variable, data is unreliable or statistically insignificant (for example, less than 90% of significance level) with some explanatory power. The statistical significance will be assessed in Stage 2. |

**Table 4-4 : Preliminary assessment of data requirements**

| Data Item | Data source and purpose | Availability (Low, Moderate, High) | Reliability (Low, Moderate, High) | Fitness for purpose (Low, Moderate, High) |
|---|---|---|---|---|
| Gross operating expenses | States Treasury<br>Dependent variable for urban transport recurrent expenditure model | Moderate | Moderate | High |
| Net expenses | States Treasury<br>Dependent variable for urban transport recurrent expenditure model | High – used in previous years | Moderate | High |
| Depreciation by mode | States Treasury<br>Dependent variable for urban transport infrastructure expenditure model | High - used in previous years | Moderate | Moderate |
| Depreciation + Capital Investment | States Treasury<br>Dependent variable for urban transport infrastructure expenditure model | Moderate | Moderate | High |
| **Travel demand** | | | | |

| Data Item | Data source and purpose | Availability (Low, Moderate, High) | Reliability (Low, Moderate, High) | Fitness for purpose (Low, Moderate, High) |
|---|---|---|---|---|
| Population | ABS | High | High | High<br>Any data from ABS has credibility and will likely be agreed by States |
| Population growth | ABS | High | High | High<br>Any data from ABS has credibility and will likely be agreed by States |
| Employment | ABS | High | High | High<br>Any data from ABS has credibility and will likely be agreed by States |
| Student enrolment | ABS (primary and secondary)<br>Australian Department of Education and Training, Higher Education Statistics (tertiary) | High<br>Data for tertiary enrolments limited to Public Universities | High | High |
| Journey to work trips | ABS | High<br>Available by 2011 Travel Zone | High | High<br>Any data from ABS has credibility and will likely be agreed by States. Some aggregation required to assign Travel Zone data to urban centres. |
| Urban congestion index | BITRE | High | High | Moderate – only available for capital cities |
| Urban residential density | ABS | High | High | High<br>Any data from ABS has credibility and will likely be agreed by States |
| Road slope | CGC | High | High | High – Subject to statistical significance test |
| Rail slope | CGC | High | High | High – Subject to statistical significance test |
| Road bridge length | CGC | High | High | High – Subject to statistical significance test |
| Rail bridge length | CGC | High | High | High – Subject to statistical significance test |
| **Revenue kilometres** | | | | |
| Train | States Treasury<br>Independent variable for urban transport recurrent expenditure model | Moderate | High | Moderate – not policy neutral |

| Data Item | Data source and purpose | Availability (Low, Moderate, High) | Reliability (Low, Moderate, High) | Fitness for purpose (Low, Moderate, High) |
|---|---|---|---|---|
| Bus | States Treasury<br>Independent variable for urban transport recurrent expenditure model | Moderate | High | Moderate – not policy neutral |
| Light Rail / Tram | States Treasury<br>Independent variable for urban transport recurrent expenditure model | Moderate | High | Moderate – not policy neutral |
| Ferry | States Treasury<br>Independent variable for urban transport recurrent expenditure model | Moderate | High | Moderate – not policy neutral |
| **Network infrastructure** | | | | |
| Train (Track Kilometres) | States Treasury<br>Independent variable for urban transport infrastructure expenditure model | Moderate | High | High – controlled variable as suggested by CGC |
| Bus (Track Kilometres) | States Treasury<br>Independent variable for urban transport infrastructure expenditure model | Moderate | High | High – controlled variable as suggested by CGC |
| Light Rail / Tram (Track Kilometres) | States Treasury<br>Independent variable for urban transport infrastructure expenditure model | Moderate | High | High – controlled variable as suggested by CGC |
| Ferry (Number of wharves) | States Treasury<br>Independent variable for urban transport infrastructure expenditure model | Moderate | High | High – controlled variable as suggested by CGC |
| Total asset value | States Treasury<br>Independent variable for urban transport infrastructure expenditure model | Moderate | High | Low – Correlation with depreciation |
| **Number of boardings / journeys** | | | | |
| Train | States Treasury<br>Independent variable for urban transport recurrent expenditure model | High | High | High |
| Bus | States Treasury | High | High | High |

| Data Item | Data source and purpose | Availability (Low, Moderate, High) | Reliability (Low, Moderate, High) | Fitness for purpose (Low, Moderate, High) |
|---|---|---|---|---|
| | Independent variable for urban transport recurrent expenditure model | | | |
| Light Rail / Tram | States Treasury<br>Independent variable for urban transport recurrent expenditure model | High | High | High |
| Ferry | States Treasury<br>Independent variable for urban transport recurrent expenditure model | High | High | High |

## 4.4 Comparability of net expenses collected in the 2015 review

In the 2015 review, CGC collected States' financial data on expenses, revenue, capital expenditure, value of physical assets and amounts of depreciation in 2009/10, 2010/11 and 2011/12. This section assesses the comparability of net expenses of the States' data.

Methods of assessing data comparability:

- A process review of data collection and States' data return in the 2015 review
- Compare net expenses per capita by State by SUA
- Compare net expanse per passenger kilometre travelled

### 4.4.1 The process review

In the 2015 review, States were requested to provide the following financial data:

- General Government Sector (GGS) expenses and revenue per UCL, including general government expenses, revenue (excluding fare box revenue) and government contributions received.
- GGS subsidies and dividends, including general government subsidies, dividends and other payments to and from Public Non-Financial Corporations (PNFCs).
- PNFC sector expenses and revenue
- PNFC sector subsidies and dividends
- Physical assets - GGS and PNFCs non-financial assets
- Transport tasks – passenger numbers, vehicle kilometres, passenger kilometres etc.

The examination of States' data return indicates various level of data availability. Five indicators have been selected to check the consistency of the data returns as show in Table 4-5.

**Table 4-5 : States' data return in the 2015 review: the assessment of data availability**

| Jurisdiction | Net expenses | Physical assets | Depreciation | Transport tasks: Vehicle kilometre | Transport tasks: Passenger kilometre |
|---|---|---|---|---|---|
| NSW | Yes | Yes | Yes | No | No |
| VIC | Yes | Yes | No | Yes | No |
| QLD | Yes | Yes | No | Yes | Not complete |
| WA | Yes | Yes | No | Yes | Yes |
| SA | Yes | Yes | No | Yes | Not complete |
| TAS | Yes | Yes | No | No | No |
| ACT | Yes | Yes | No | No | No |
| NT | Yes | No | No | Yes | No |

The key observations are:

- Data on net expenses was generally available and consistent.
- Data on the value of physical assets was generally available except NT
- Only NSW provided depreciation data
- Vehicle kilometre travelled data is available for 5 States only
- Passenger kilometre data was largely unavailable.

The process review indicates that the net expense variable is comparable among States. Data was requested and returned from the same template. There is no reason to suggest that the data returns are incomparable between States. The comparability of other data items is difficult to assess due to various levels of data availability between States.

### 4.4.2 A comparison of net expenses per capita

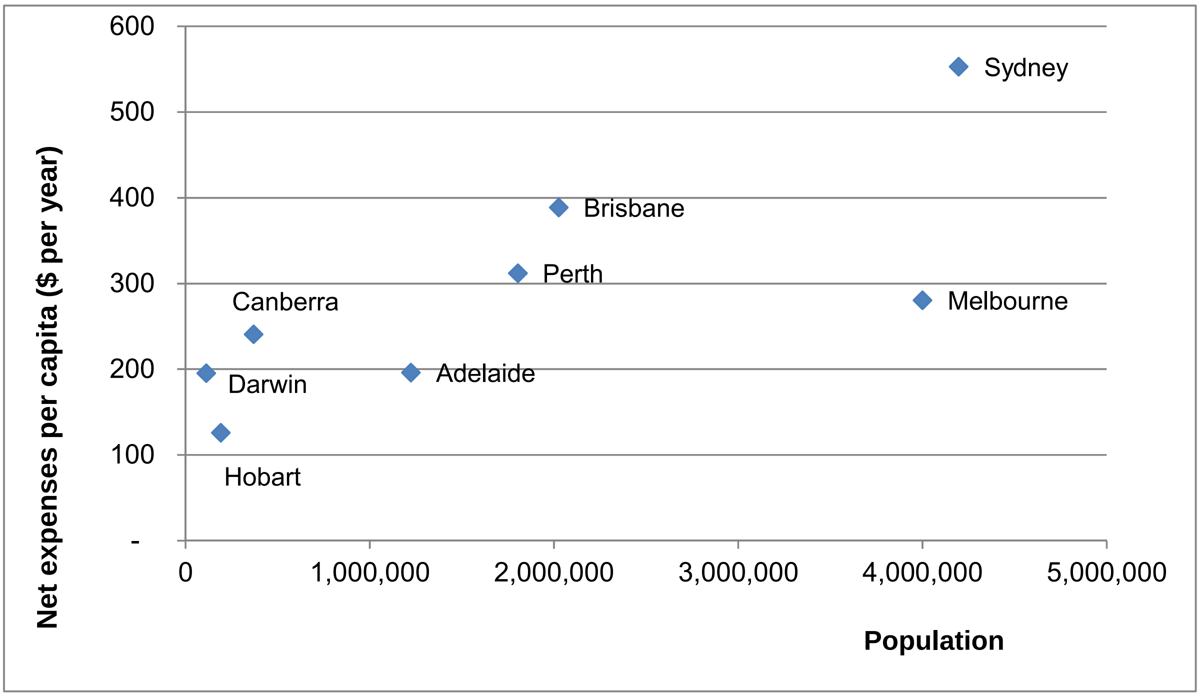
Table 4-6 presents the net expenses per capita by States in capital cities and other UCLs. Net expenses of capital cities are also shown in Figure 4-1. The key observations are:

- In capital cities, net expenses per capita in Sydney, Brisbane and Perth are higher than the Australian average while the expenses in other capital cities are below the average.
- In other SUAs, net expenses per capita are systematically lower than in Capital cities. The net expenses in smaller centres with less population are lower than in large centres.
- The comparison of net expenses per capita mask the fact that the public transport use is lower in small centres.

**Table 4-6 : States' data return in the 2015 review: the assessment of data availability**

| Jurisdiction | Capital City | UCLs with population 100,000 and above, but not capital city | UCLs with population 50,000 - 100,000 | UCLs with population 20,000 - 50,000 |
|---|---|---|---|---|
| NSW | $553 | $178 | | |
| VIC | $281 | $163 | $101 | $92 |
| QLD | $389 | $124 | $24 | $23 |
| WA | $312 | | $72 | $47 |
| SA | $196 | | | $17 |
| TAS | $126 | | $68 | $53 |
| ACT | $241 | | | |
| NT | $195 | | | $36 |

**Figure 4-1 : Net expenses per capita in Australian capital cities**




To further explain the phenomenon that net expenses are generally higher in large centres, capital cities and particularly higher in Sydney, the net expenses per passenger kilometre have been estimated. The passenger kilometre (pkm) data was incomplete in the 2015 review, hence, the BITRE data[27] has been identified as the alternative data source which is considered accurate and reliable. The BITRE data on passenger kilometre travelled is only available for Capital cities but unavailable for other UCLs/SUAs. The estimated net expenses per pkm are presented in Table 4-7 and shown in Figure 4-2. The key observation is:

- Net expenses per passenger kilometre are much more consistent among Capital cities than net expenses per capita. The coefficient of variation of net expenses per capita is 47% which is reduced to 19% when measured in expenses per pkm.

- Melbourne has the lowest net expenses per pkm. The reasons for the low value in Melbourne cannot be explained in the 2015 States data return. In the absence of any other evidence-

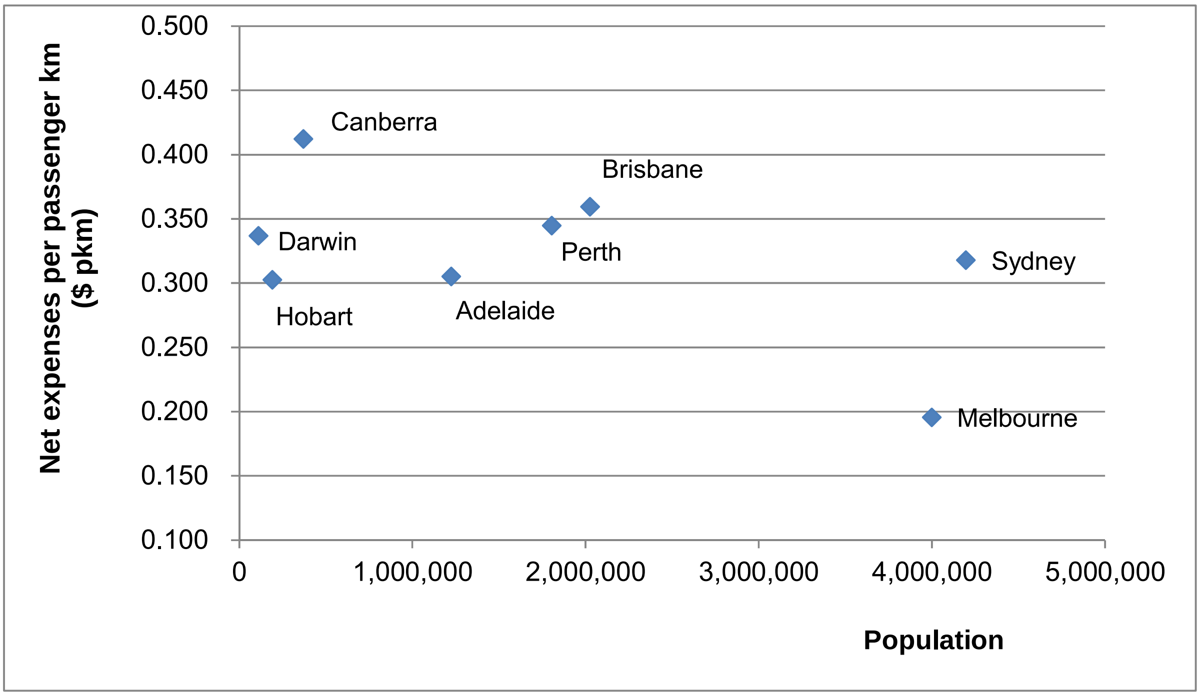
[27] Bureau of Infrastructure, Transport and Regional Development, Information Sheet 59, Urban public transport updated trends.

based reasoning, the only explanation is the high technical efficiency of public transport services in Melbourne.

**Table 4-7 : Net expenses per pkm**

| Jurisdiction | Net expenses ($000, average 2010-2012) | Net expenses per capita ($) | Passenger kilometres per capita per annum | Net expenses ($ per pkm) |
|---|---|---|---|---|
| Sydney | 2,320,101 | 553 | 1740 | 0.32 |
| Melbourne | 1,122,260 | 281 | 1435 | 0.20 |
| Brisbane | 787,393 | 389 | 1082 | 0.36 |
| Adelaide | 239,980 | 196 | 643 | 0.31 |
| Perth | 563,087 | 312 | 905 | 0.34 |
| Hobart | 24,226 | 126 | 417 | 0.30 |
| Darwin | 21,840 | 195 | 580 | 0.34 |
| Canberra | 89,067 | 241 | 584 | 0.41 |
| Mean | | 287 | | 0.32 |
| Standard Deviation | | 134 | | 0.06 |
| Coefficient of variation | | 47% | | 19% |

**Figure 4-2 : Net expenses per pkm in Australian capital cities**



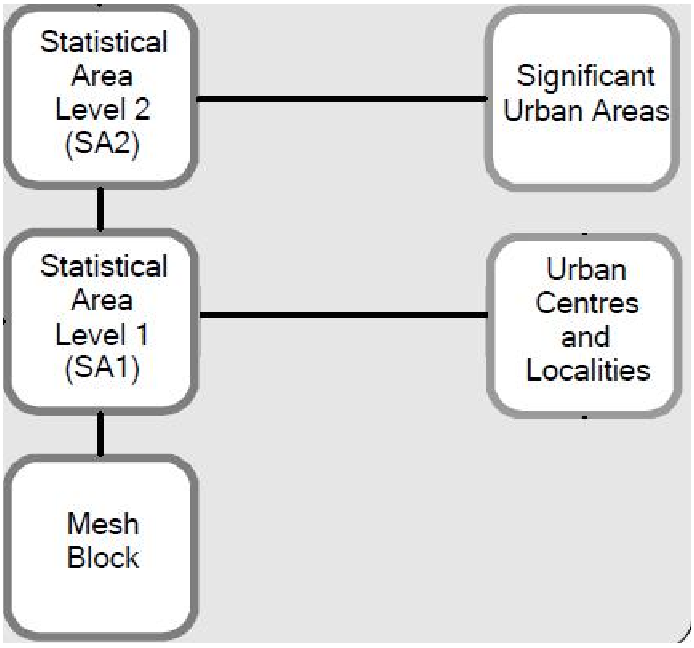
# 5. Urban centre boundaries and treatment of satellite cities

## 5.1 Assessment of the most appropriate urban are boundaries

The boundary of an urban centre can be defined from a number of geographic classifications used by Federal and State governments for statistics, urban planning and reporting purposes. The widely used definitions are UCLs, SUAs and GCCSAs:

- The UCL structure provides a definition of urban areas. These regions are constructed from whole Statistical Areas Level 1 (SA1s).
- The SUA provides a geographical standard for the publication of statistics about concentrations of urban development with a population of 10,000 people or more. The regions are constructed from whole Statistical Areas Level 2 (SA2s). It may combine one or more related Urban Centres. The relationship between UCL and SUA is illustrated in Figure 5-1.

**Figure 5-1** : **Relationship between UCL and SUA**[28]




In the 2015 review, only those UCLs with a population greater than 20,000 were included. In the 2020 review, it is proposed to expand the number of UCLs by also including UCLs with a population less than 20,000. The list of SUAs is provided in Appendix B. The numbers of UCLs and SUAs recommended for the 2020 review by States are shown in Table 5-1.

**Table 5-1 : Number of UCLs and SUAs proposed for the 2020 review**

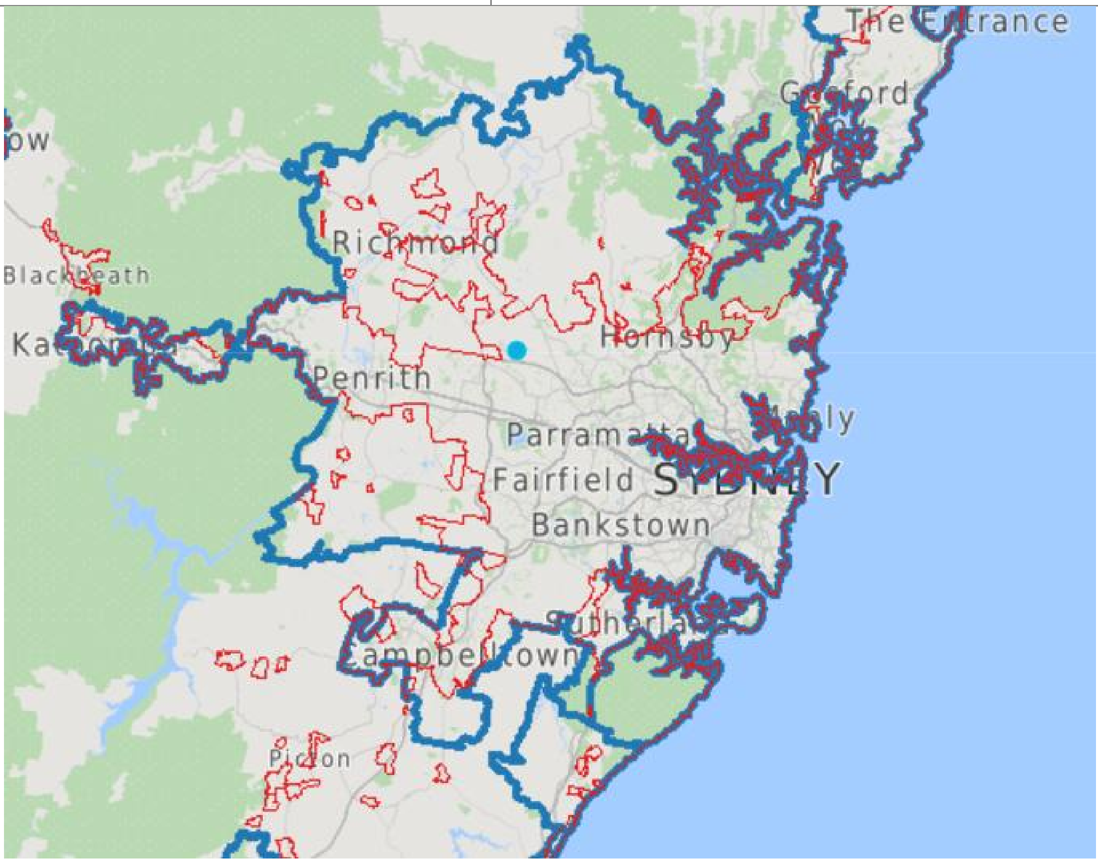
| | NSW | Vic. | Qld | SA | WA | Tas. | NT | ACT | Australia |
|---|---|---|---|---|---|---|---|---|---|
| UCL | 150 | 73 | 86 | 28 | 24 | 23 | 4 | 1 | 389 |
| SUA | 39 | 23 | 18 | 8 | 10 | 5 | 2 | 1 | 106 |

[28] Australian Bureau of Statistics, 2011 Australian Statistical Geography Standard (ASGS): Volume 4 – Significant Urban Areas, Urban Centres and Localities, Section of State.

Greater Capital City Statistical Areas (GCCSAs) are geographical areas that are designed to represent the functional extent of each of the eight state and territory capital cities. They replace the current Capital City Statistical Divisions and will provide a stable definition for these cities which will be used for the output of a range of social and economic survey data. GCCSAs have been created using aggregations of whole SA4s. The GCCSAs reflect the labour market of each capital city. The labour market is sometimes used as a de-facto measure of the functional extent of a city since it contains the majority of the commuting population. The GCCSAs will exclude many cities of interest and will cover substantial areas with no public transport network. Thus, it has been decided that GCCSAs do not fit the purpose for the urban transport recurrent and infrastructure models.

States also have geographic boundary definitions for planning and other purposes. For example, Greater Metropolitan Areas (GMR) of Sydney includes Sydney, Wollongong and Newcastle. For the purpose of urban transport models, the preference has been given to ABS definitions for data consistency among States. Thus, the geographic boundary assessment is focused on comparing UCLs and SUAs for eight Australian capital cities as detailed in the following Tables 5-2 – 5.9.

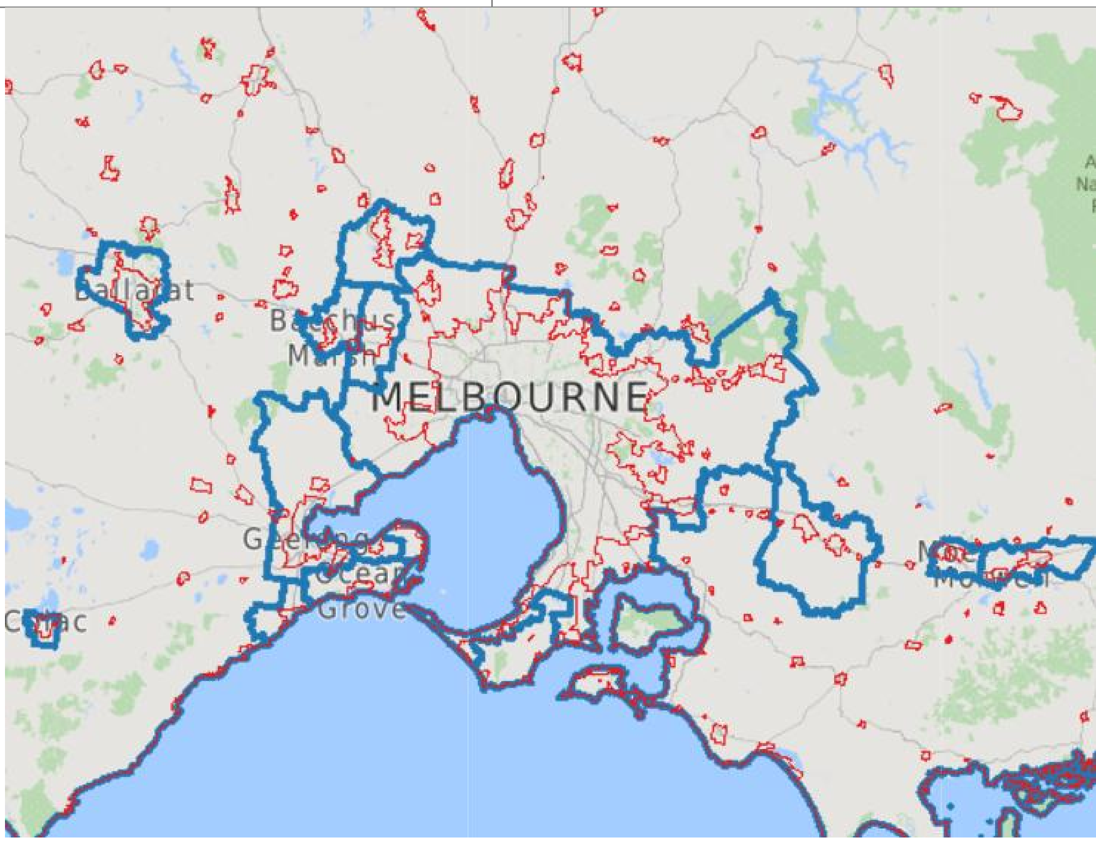
**Table 5-2 : Comparing boundary of UCL and SUA - Sydney**

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Sydney | Sydney<br>Contains 31 UCLs including Sydney, Blue Mountains, Bowen Mountain, Richmond North etc. |
| Population (person) | 3,908,642[(A)] | 3,847,570[(A)] |
| Area (KM$^2$) | 2,037 | 4,046 |
| Public transport services | Public transport service extends beyond the UCL and SUA boundaries. It covers as far north as Newcastle and the Hunter valley, south to the Illawarra, west to Lithgow and north-west to Richmond | |
| Data availability | Would require separating transport financial, asset and patronage data for 31 UCLs which may be very difficult | Would require separating transport financial, asset and patronage data for Sydney and other SUAs. Data would be more likely to be available |
| Fitness for urban transport recurrent and infrastructure modelling | | Preferred |
| Indicative map [(A)]<br>(Blue line = SUA<br>Red line = UCLs) |  | |



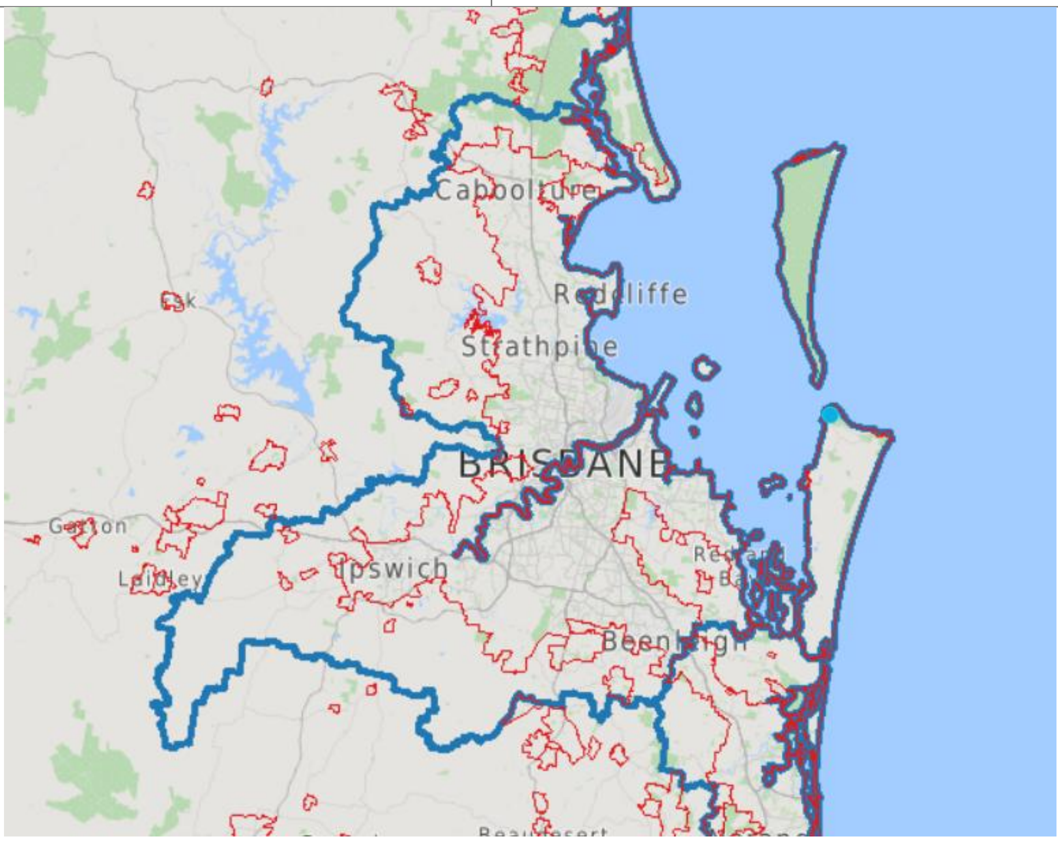
(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

**Table 5-3 : Comparing boundary of UCL and SUA - Melbourne**

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Melbourne | Melbourne<br>Contains 28 UCLs - Arthurs Seat, Balnarring - Balnarring Beach, Beaconsfield Upper, Blind Bight, Bulla , Cannons Creek , Clyde , Diggers Rest, Don Valley , East Warburton , Gembrook , Little River , Melbourne, Millgrove, Officer , Pakenham, Rockbank , Seville, Seville East , Sunbury, Tooradin , Warburton, Warneet , Werribee South , Wonga Park, Wonga Park - South , Woori Yallock - Launching Place, Yarra Junction - Wesburn |
| Population (person) | 3,707,530(A) | 4,028,524(A) |
| Area ($KM^2$) | 2,543 | 5,679 |
| Public transport services | Public transport service extends beyond the UCL and SUA boundaries. It extends west to Melton and Bacchus Marsh, north to Sunbury, and south-east to Pakenham. | |
| Data availability | Would require separating transport financial, asset and patronage data for 28 UCLs which may be very difficult | Would require separating transport financial, asset and patronage data for Melbourne and other SUAs. Data would be more likely to be available |
| Fitness for urban transport recurrent and infrastructure modelling | | Preferred |
| Indicative map (A)<br>(Blue line = SUA<br>Red line = UCLs) |  | |

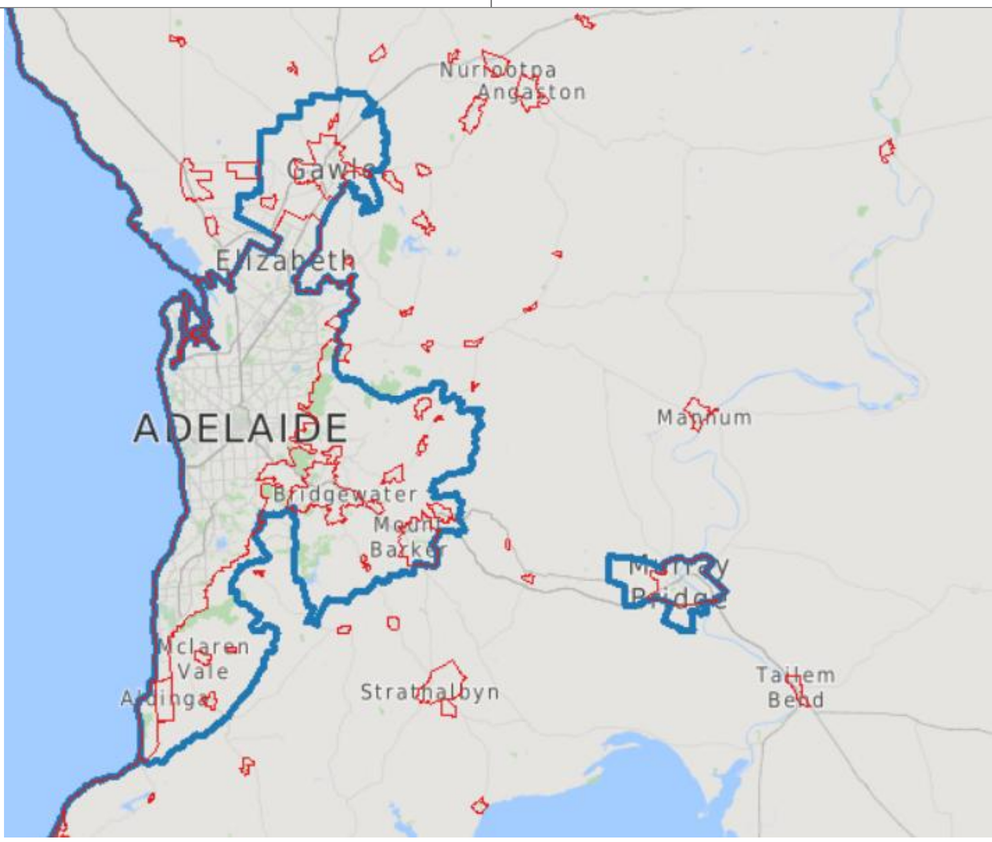
(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

**Table 5-4 : Comparing boundary of UCL and SUA - Brisbane**

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Brisbane | Brisbane<br>Contains 25 UCLs – Amity Point, Beachmere, Bongaree – Woorim, Brisbane, Coochiemudlo Island, Dayboro, Deebing Heights, Donnybrook, Dunwich, Lamb Island, Logan Village, Macleay Island, Marburg, Mount Cotton, Mount Nebo, Point Lookout, Ripley, Rosewood, Russell Island, Samford Valley – Highvale, Samford Village, Sandstone Point – Ningi, Thagoona, Toorbul, Walloon |
| Population (person) | 1,874,427(A) | 1,977,315(A) |
| Area (KM$^2$) | 1,972 | 5,065 |
| Public transport services | Public transport service extends beyond the UCL and SUA boundaries. TransLink extends north to include the Sunshine Coast, west to Helidon, and south-east to include the Gold Coast. | |
| Data availability | Would require separating transport financial, asset and patronage data for 25 UCLs which may be very difficult | Would require separating transport financial, asset and patronage data for Brisbane and other SUAs. Data would be more likely to be available |
| Fitness for urban transport recurrent and infrastructure modelling | | Preferred |
| Indicative map (A)<br>(Blue line = SUA<br>Red line = UCLs) |  | |

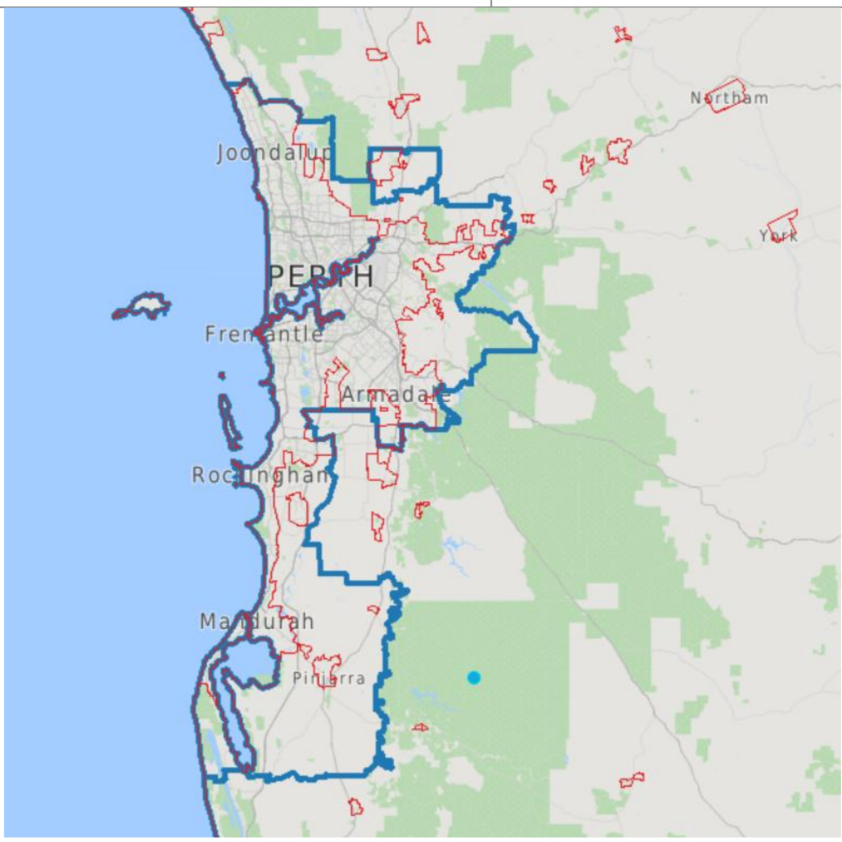
(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

### Table 5-5 : Comparing boundary of UCL and SUA - Adelaide

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Adelaide | Adelaide<br>Contains 19 UCLs – Aldinga, Angle Vale, Balhannah, Charleston, Crafers – Bridgewater, Echunga, Gawler, Hahndorf, Houghton, Lobethal, McLaren Flat, McLaren Vale, Mount Barker, Nairne, Roseworthy, Uraidla - Summertown, Willunga, Woodside |
| Population (person) | 1,103,979[(A)] | 1,198,468[(A)] |
| Area (KM$^2$) | 852 | 2,204 |
| Public transport services | Public transport service extends beyond the UCL boundary but within SUA boundary. It extends south-east to Mount Barker and north to Gawler. | |
| Data availability | Would require separating transport financial, asset and patronage data for 19 UCLs which may be very difficult | Would not require any SUA data separation |
| Fitness for urban transport recurrent and infrastructure modelling | | Preferred |
| Indicative map [(A)]<br>(Blue line = SUA<br>Red line = UCLs) |  | |

(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

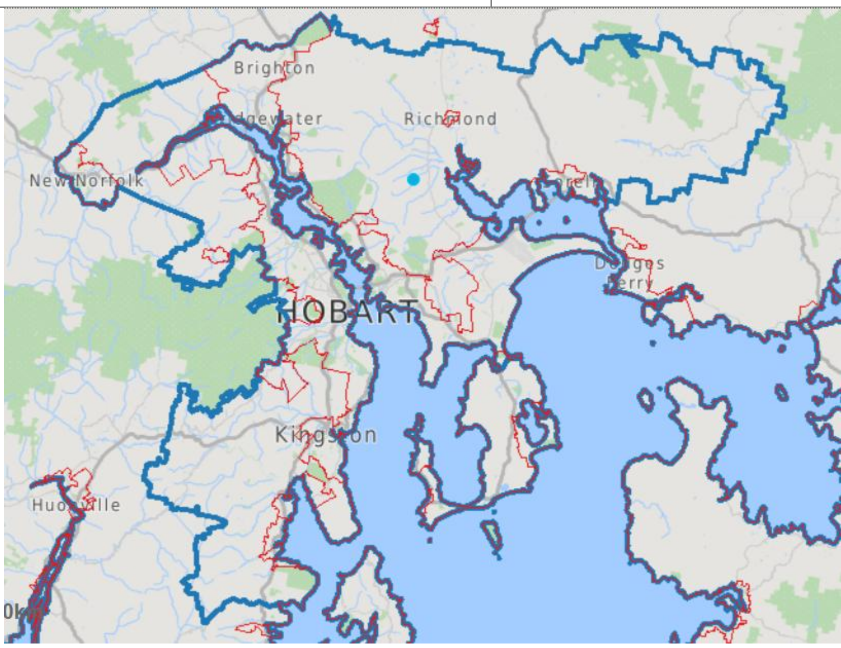
### Table 5-6 : Comparing boundary of UCL and SUA - Perth

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Perth | Perth<br>Contains 10 UCLs – Baldivis, Bickley, Carmel, Herne Hill, Hilbert, North Dandalup, Pinjarra, Rottnest Island, West Swan |
| Population (person) | 1,256,036(A) | 1,670,953(A) |
| Area (KM$^2$) | 1,566 | 3,367 |
| Public transport services | Public transport service extends beyond the UCL and SUA boundaries. It extends further north to Yanchep, east to Eastern Highway towns and south to Mandurah. | |
| Data availability | Would require separating transport financial, asset and patronage data for 10 UCLs which may be very difficult | Would require separating transport financial, asset and patronage data for Perth and other SUAs. Data would be more likely to be available |
| Fitness for urban transport recurrent and infrastructure modelling | | Preferred |
| Indicative map (A)<br>(Blue line = SUA<br>Red line = UCLs) |  | |



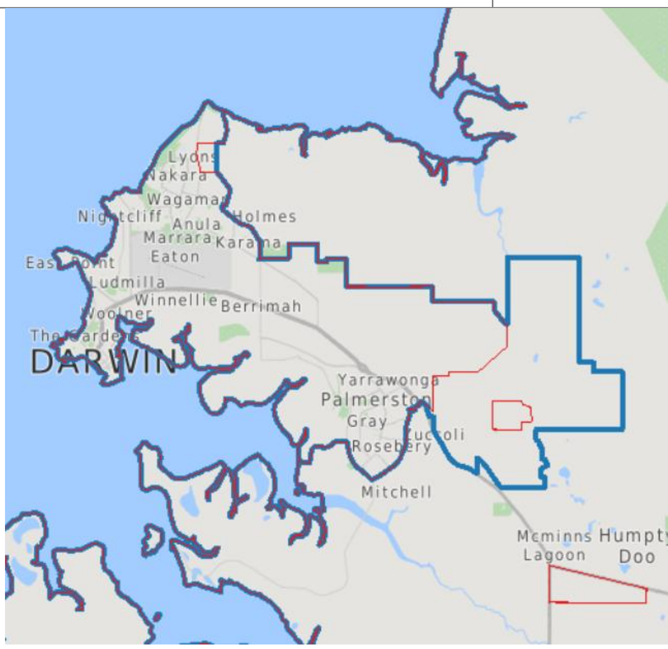
(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

### Table 5-7 : Comparing boundary of UCL and SUA - Hobart

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Hobart | Hobart<br>Contains 10 UCLs – Collinsvale, Electrona, Fern Tree, Hobart, Howden, Lower Snug - Coningham, Margate, Midway Point, New Norfolk, Richmond, Snug and Sorell |
| Population (person) | 170,975[(A)] | 200,501[(A)] |
| Area (KM$^2$) | 269 | 1,213 |
| Public transport services | Public transport service extends North to Bridgewater, south to Kingston, and east to Lauderdale. It is largely within UCL and SUA boundaries. | |
| Data availability | Would not require data separation | Would not require data separation. SUA covers a large area where there is no public transport. |
| Fitness for urban transport recurrent and infrastructure modelling | Preferred | Population of UCL and SUA is close thus the urban expenditure assessment using a population based model would be similar. SUA definition is acceptable. |
| Indicative map [(A)]<br>(Blue line = SUA<br>Red line = UCLs) |   | |

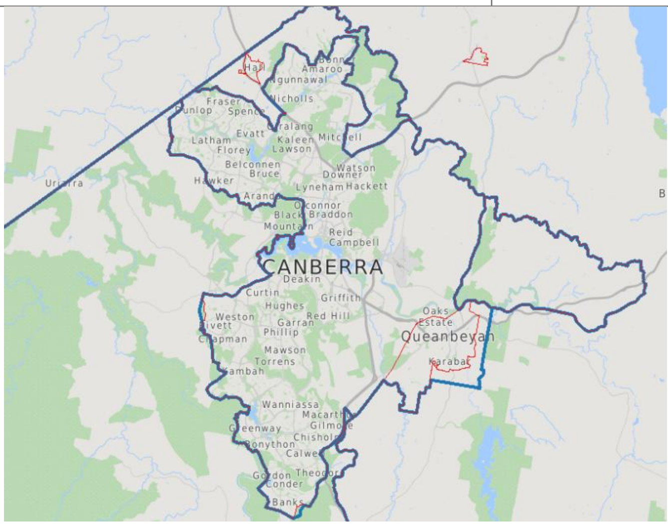
(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

**Table 5-8 : Comparing boundary of UCL and SUA - Darwin**

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Darwin | Darwin<br>Contains 2 UCLs – Darwin and Howard Springs |
| Population (person) | 103,016(A) | 106,255(A) |
| Area ($KM^2$) | 216 | 296 |
| Public transport services | Public transport service extends south-east to, and includes local services in, Palmerston. It is largely within UCL and SUA boundaries. | |
| Data availability | Would not require data separation | Would not require data separation |
| Fitness for urban transport recurrent and infrastructure modelling | Preferred | UCL and SUA are similar however UCL is slightly better in defining the public transport service. SUA is acceptable. |
| Indicative map (A)<br>(Blue line = SUA<br>Red line = UCLs) |   | |

(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

**Table 5-9 : Comparing boundary of UCL and SUA - Canberra**

| | UCL | SUA |
|---|---|---|
| UCL / SUA in capital city | Canberra | Canberra<br>Canberra - Queanbeyan |
| Population (person) | 355,596[(A)] | 391,645[(A)] |
| Area (KM$^2$) | 443 | 482 |
| Public transport services | Public transport service is provided in Canberra UCL | |
| Data availability | Would not require data separation | Would not require data separation |
| Fitness for urban transport recurrent and infrastructure modelling | Preferred | UCL and SUA are similar however UCL is slightly better in defining the public transport service. SUA is acceptable. |
| Indicative map [(A)]<br>(Blue line = SUA<br>Red line = UCLs) |  | |

(A) Data and indicative map were sourced from ABS 2011 Census (http://www.censusdata.abs.gov.au) and ABS maps (http://stat.abs.gov.au/itt/r.jsp?ABSMaps)

The above assessment indicates that SUA is preferred for Sydney, Melbourne, Brisbane, Adelaide and Perth. The UCL is slightly preferred in Hobart, Darwin and Canberra although SUA is acceptable in these three cities. The recommended geographic boundaries of the urban transport assessment are UCLs contained within SUAs as defined by the Australian Bureau of Statistics (ABS) for the 2011 Census. Data can be aggregated at the level of SUAs where an SUA contains more than one UCL. Where an SUA crosses state boundaries (for example, Gold Coast – Tweed Heads spans Queensland – New South Wales), the portion of the SUA in each state has been considered separately. All UCLs that are contained within SUAs have been included, regardless of population.

## 5.2 Treatment of satellite cities

The per capita GST adjustment models are:

**Urban transport recurrent expenditure model:**

$$Per\ capita\ net\ expenses_i = \beta_0 + \beta_1 \times ln(Population_i)\,,$$
$$= 291.29 + 90.17 \times \ln(Population_i)$$

**Urban transport infrastructure expenditure model:**

$$Per\ capita\ asset\ values\ for\ urban\ area\ i = (Population_i)^2 \times 50\%.$$

These models generally favour large cities. If satellite cities are amalgamated into its principal city, the per capita factor would always be higher than the case when the principal city and satellite cities are assessed separately. This arrangement had incentivised States to argue a case that satellite cities should be amalgamated –for example, Queensland argued that the Gold Coast should be treated as part of Brisbane in the submission of the 2015 review.

In this consultancy, modelling approaches were adopted to develop "GST requirement neutral models". The intent was to develop models for recurrent and infrastructure expenditure such that the GST allocation disability factors would be the same (or nearly the same) regardless of whether satellite cities are amalgamated into the principal city, or assessed separately. It proved that such models may work only if the GST model is purely based on travel demand (for example, predictions made on passenger kilometres travelled), or if it simply uses an "equal per capita" allocation. Neither method is ideal as they do not reflect the fundamental drivers of urban transport recurrent and infrastructure expenditure and the HFE principle.

It is necessary to develop a systematic approach to be equally applied in Australia to determine satellite cities that can be amalgamated into their principal city for the purposes of assessing GST revenue allocation. Generally, it is considered that

*"Satellite cities are smaller cities that are near to a large city that is the centre of a metropolitan area. They are different from suburbs, subdivisions and bedroom communities because they have their own centre. Satellite cities could be separate cities outside of the larger metropolitan areas[29]."*

However, this general definition of satellite cities is not helpful for the purposes of GST revenue assessment. Qualitatively, the following criteria could be used to determine whether a satellite city should be amalgamated in GST assessment:

- The principal city and satellite city are both contained with an SUA (as defined by the ABS for the 2011 census)
- Accessibility of the labour market between the principal and satellite cities, measured by the distance and travel time between the principal and satellite cities (by car and public transport)
- Existence of a certain level of market integration, measured by proportion of inter-city commute trips of total commute trips in a satellite city
- Satellite city has its own CBD centre
- Existence of good public transport exists between the principal and satellite city

Preliminary assessment using the above criteria identified eight cities that may be considered as satellite cities:

- Newcastle, Central Coast and Wollongong (Sydney)
- Geelong, Ballarat and Bendigo (Melbourne)
- Sunshine Coast and Gold Coast (Brisbane)

Gawler (Adelaide), Mandurah and Rockingham (Perth) have some features of satellite cities. However, both are contained within the same SUA as their principal city in the 2011 Census. As such, these centres have been automatically amalgamated into their principal city in the urban transport assessment and no special treatment is required.

[29] Online Wikipedia, https://simple.wikipedia.org/wiki/Satellite_city, accessed on May 19, 2017

The following two quantitative criteria are recommended to decide whether those eight cities should be amalgamated in the urban transport assessment. The criteria are applied to the eight satellite cities in Table 5-10.

**1) Public transport travel time threshold of 120 minutes between the principal and satellite city centres in AM peak hours.**

This threshold indicates the maximal limit of commute travel time between the principal and satellite cities. The typical threshold is in the range of a 40 to 180 minute one way trip in international literature[30]. The 40 minute trip length represents local market access; In the USA, a 40 minute trip represents the 80th percentile of average commute time. A 180 minute trip represents the limit that a business can make same day outbound and inbound deliveries. The urban transport assessment focuses on public transport. A threshold of 120 minute travel time between two Centres is considered the maximum for commute trips. With allowance for access and egress time, this threshold corresponds to a 3 hour outbound trip time or 6 hour return trip per work day.

This criterion is tentatively measured with travel time of public transport services assuming a commute trip starts at 7:00 AM on a workday. It is noted that this criterion can be influenced by State governments who choose to provide faster or slower public transport services. However, the CGC should be able to accept that if States provide faster services for social-economic reasons the adoption of a revenue allocation model that does not discourage this practice is reasonable. Using this criterion, Newcastle-Maitland, Wyong, Bendigo and Sunshine Coast would be disqualified for amalgamation for GST revenue assessment purposes (see Table 5-10).

**2) Proportion of inter-city commute trips is greater than 5 percent of satellite intra-city commute trips.**

This criterion indicates a minimum level of labour market integration between the principal and the satellite city. This criterion is measurable using ABS Census journey to work data which is considered reliable and acceptable by States. Receipt of this data is outstanding and will be assessed in Stage 2.

[30] Transportation Research Record, 2012, the relationship of transportation access and connectivity to local economic outcomes: a statistical analysis, by Brian Alstadt, Glen Weisbrod and Derek Cutler.

**Table 5-10 : Assessment of satellite cities for modelling of urban transport GST requirement**

| Satellite city | Principal city | Population* | Distance to the principal city (km) by public transport | Public Transport Travel Time in AM Peak (h:mm) | Car Travel Time in AM Peak (h:mm) | Inter-city commute trips as proportion of total commute trips** | Amalgamate satellite city?*** |
|---|---|---|---|---|---|---|---|
| | | | | Criteria: < 2 hours | | Criteria: > 5% | |
| Newcastle - Maitland | Sydney | 407,897 | 164 | **2:30** | 2:30 | **TBA** | No |
| Central Coast | Sydney | 312,609 | 101 | **1:45** | 1:40 | **TBA** | TBA |
| Wollongong | Sydney | 278,324 | 83 | **1:40** | 1:50 | **TBA** | TBA |
| Geelong | Melbourne | 167,756 | 73 | **1:15** | 1:30 | **TBA** | TBA |
| Ballarat | Melbourne | 86,965 | 119 | **1:15** | 1:45 | **TBA** | TBA |
| Bendigo | Melbourne | 83,232 | 155 | **2:00** | 2:00 | **TBA** | No |
| Sunshine Coast | Brisbane | 252,963 | 105 | **2:30** | 1:40 | **TBA** | No |
| Gold Coast | Brisbane | 497,018 | 85 | **1:20** | 1:20 | **TBA** | TBA |

* - Total population from 2011 Census of all Urban Centres / Localities contained within the named Significant Urban Area

** - Information will be collected from States Treasury data collection

*** - Final recommendation will be made when data returns from State Treasuries to be analysed in Stage 2.

## 5.3 Specific issues:

This consultancy is also required to address the following specific issues:

- *The role of congestion on the level and cost of urban transport services and infrastructure.*

  Section 2.2.6 provides details of how urban road congestion affects bus operating cost and infrastructure investment decision making.

- *The factors affecting decisions to provide underground or raised rail infrastructure instead of above ground. Some States have suggested that these factors could include population density and land values.*

  Section 3.4.3 provides details on construction costs of surface, tunnel and skytrain options, and analyses how these options were selected in the project development phase.

- *Whether the urban transport task, however measured, is a superior variable to urban population size to estimate urban transport expenditure requirements.*

  Section 2.1.4 gives urban transport services provision and Section 2.2.2 provides variables for measuring urban transport tasks. An assessment of these variables suggests that urban transport tasks are State policy influenced. In Stage 2, statistical models will be developed to draw conclusions upon whether the urban transport task gives better statistical fit than urban population.

- *Whether there is a conceptual case that larger cities, such as Sydney and Melbourne, can achieve economies of scale in the provision of urban transport services, compared the smaller cities.*

  Section 2.1.1 analysed possibility of economies of scale (for smaller urban centres), diseconomies of scale for large centres such as Sydney and Melbourne or constant returns of scale. In the 2010 review, it was concluded that the case for diseconomies of scale should be rejected. It is possible for public transport to be managed to permit the optimum scale of service provision to be achieved (e.g. through use of contracts of appropriate size and allowing operators to divide their operations into suitable size units). Cubukcu (2008)[31] suggested the operating cost per passenger kilometre will initially decrease as the city population size increases, supporting a case of economics of scale. However, population thresholds of economies of scale or diseconomies of scale have not been established in existing literature. Due to lack of empirical evidence, the assumption of constant returns of scale is still the best option. In the Stage 2, possible of economies or diseconomies of scale will be examined from the 2020 data return by fitting a regression between operating cost per passenger kilometre with population size and trip length to revealing any statistically significant relationship, if data permits.

[31] Cubukcu, K. M. (2008) Examining the cost structure of urban bus transit industry: does urban geography help? Journal of Transport Geography, 16(4), 278-291.

# 6. Conclusions

Conclusions to Stage 1 of the consultancy are outlined below.

**1) Net expense is the preferred dependent variable for recurrent expenditure model**

Urban transport recurrent expenditure can be measured by gross operating expenses or net expenses. In the 2010 and 2015 reviews, CGC used net expenses in the recurrent expenditure model. It is difficult to obtain gross operating expenses for private operators. The proportion of public transport services provided by the private sector varies between States, means the use of gross operating expenses as the dependent variable is unlikely to be possible because the data across States will not be comparable. If gross operating expenses were to be used, a separate estimate of fare revenue at average standards would need to be made. There is currently no proposal to measure States' capacity to raise revenue from fares. The net expense is thus the preferred dependent variable for recurrent expenditure model.

**2) The capital charge in infrastructure expenditure model should capture the need for maintenance and replacement of existing public transport capacity and building new capacity to accommodate population and employment growth**

In the 2015 review, the CGC used depreciation and investment as the capital charge. It reflects the need for maintaining, refreshing and replacing the existing physical assets, and providing appropriate public transport capacity to meet ongoing travel demand. As the urban population grows, new infrastructure is needed which is not reflected in the depreciation costs. It is appropriate that the capital charge – being the dependent variable in the infrastructure expenditure model – include both depreciation and new infrastructure costs.

**3) Drivers of recurrent and infrastructure expenditures are diverse and the final model form requires systematic tests of various specifications**

An examination of the past and existing CGC approaches, publically available data of public transport operations and international literature indicates that urban transport recurrent expenditure is driven by a range of underlying demand factors. These include passenger travel costs (both public transport and car), operator costs for public transport provision, and local characteristics relating to urban congestion and terrain conditions.

The key driver for infrastructure expenditure is the underlying travel demand, which is itself a function of population, employment and education trips, and increased demand driven by population growth. People living in dense and urban cities tend to use public transport more, while the terrain condition affects the unit cost of infrastructure provision.

All potential explanatory factors will need to be systematically tested during the model specification / model estimation process. The level of statistical significance and correlation between explanatory variables will be analysed in Stage 2. It is intended that the final recommended models should be simple and easy to understand and use. The input data will need to be reliable, readily available, comparable and consistent between States to fulfil the requirements of both the CGC calculations and State's confidence in the data and process.

**4) Data from ABS or other authoritative sources is preferred for explanatory variables**

All data for identified main drivers are available in one form or another. Stage 1 has identified the main data sources as the Australian Bureau of Statistics (ABS), Bureau of Infrastructure, Transport and Regional Economics (BITRE), Geoscience Australia and State Treasury data returns.

Input data from the ABS or BITRE takes precedence in the expenditure model development due to its availability, comparability, reliability and transparency. The data items from ABS include indicators for underlying travel demand such as population, employment, student enrolment and journey to work data collected in the Census; it is intended to use the most recent available Census data. Data from BITRE relates to urban congestion and public transport share in Australian capital cities. Data from Geoscience Australia includes terrain conditions (road and rail slopes) and a potential indicator of construction difficulty measured by the road and rail bridge length. These data sources have followed national systematic and consistent approaches in data collection and data processing. Therefore, they are the preferred data sources.

### 5) Minimum datasets on public transport operating expenses and capital charge are recommended

Jacobs recommends CGC establish a Minimum Data Sets (MDS) on Urban Transport for GST assessment. This idea can be initiated for urban transport but can be extended to other assessments. The MDS is a well-established practice in collecting Commonwealth-State Report on Government Services and typically there is a well-developed and accepted data dictionary. This approach could greatly improve data availability and reliability.

The 2010 review consultancy report and 2015 review data return have clearly indicated various issues in data collection. One of the issues is comparability and consistency between States.

Data items on operating expenses, net expenses and capital charge are the minimal data requirement for use in the urban transport expenditure models. These data items must be provided for all urban centres where public transport is provided by the Government.

The 2020 review data collection should prioritise these items to ensure their availability and consistency. The CGC may consider some form of incentives. For example, if a data item in the minimum dataset is missing, CGC could propose the use of an estimated indicator reflecting the minimal public transport service standards with a lower than average cost. Consequently, States would be incentivised to put in more effort to collect and provide the required minimum data.

### 6) Data quality on patronage and public transport service provision may still be an issue

Many data items relating to public transport patronage and service provision (for example vehicle kilometres by mode) were missing in the 2015 review data return, as shown in Table 6-1. There were significant data missing for NSW, Northern Territory, Victoria and Queensland, while data completion was better for SA, WA and ACT. The extent of data missing suggests the possibility of data unavailability for the current review.

**Table 6-1 : Transport task data collection in the 2015 review, Missing data**

| Transport task | NSW | Vic | Qld | SA | WA | Tas | NT | ACT |
|---|---|---|---|---|---|---|---|---|
| **Passenger numbers** | | | | | | | | |
| Student concessions | × | × | | | | × | × | |
| Other concessions | × | × | × | | | × | × | |
| All other passengers | × | × | × | | | × | × | |
| Total passenger number | × | | × | | | | × | |
| Service population | × | × | × | | × | × | × | |
| **Transport task** | | | | | | | | |
| Vehicle KM | × | | × | | | × | × | × |

| Transport task | NSW | Vic | Qld | SA | WA | Tas | NT | ACT |
|---|---|---|---|---|---|---|---|---|
| Route KM | × | × | × | | | | × | × |
| Passenger KM | × | × | × | | × | × | × | |
| Vehicle journeys | × | × | × | | × | × | × | |

× - Indicates data missing in the 2015 review

**7) Two tests are recommended to decide whether a satellite city should be amalgamated in urban transport assessment**

In determining whether a satellite city should be amalgamated with its principal city for the urban transport assessment, two tests are recommended:

- Commuter travel time by public transport between a satellite city and its principal city in AM peak hours is less than 120 minutes.
- Inter-city commuter trips are more than 5% of all commuter trips in the satellite city.

Two cities are considered accessible and integrated to some degree that warrants their amalgamation for GST assessment requirements.

**8) Stage 2 consultancy is recommended**

The stage 2 consultancy is recommended based on the following considerations:

- Existing models are overly simplified by using population for the recurrent expenditure assessment and population squared for infrastructure expenditure assessment. While population is the most important driver for urban transport expenditure, using a single population variable is problematic as it cannot capture other driving factors.
- Current approach incentivises States to argue for the conceptual case of amalgamating the principal and satellite cities to get a larger slice of GST distribution.
- Current capital charge, defined as depreciation of existing physical asset, does not include the need for new infrastructure due to population and economic growth.
- Data for potentially improved models is largely available. Much of the data can be collected from authoritative data sources such as ABS publications and the recent Census.
- Whether patronage can be used as explanatory variables will be dependent on the data collection from States.

The Stage 2 consultancy will include data process of States data return, model building for urban transport recurrent and infrastructure expenditures and final model recommendations.

# Appendix A: Acronyms

| Acronym | Meaning |
|---|---|
| ABS | Australian Bureau of Statistics |
| BITRE | Bureau of Infrastructure, Transport and Regional Economics |
| CGC | Commonwealth Grants Commission |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| FTE | Full-Time Equivalent |
| FY | Financial Year |
| GST | Goods and Service Tax |
| HFE | Horizontal Fiscal Equalisation (HFE) |
| IPART | NSW Independent Pricing and Regulatory Tribunal |
| JTW | Journey To Work, part of ABS Census data collection |
| PCE | Passenger car equivalency |
| PKM | Passenger kilometres travelled |
| SEQTS | South East Queensland Travel Survey |
| States | Australian States and Territories |
| SUAs | Significant Urban Areas, defined by ABS |
| UCLs | Urban Centres / Localities, defined by ABS |
| Urban Centres | Urban Centres / Localities (UCLs) contained within Significant Urban Areas (SUAs) as defined by the Australian Bureau of Statistics (ABS) for the 2011 Census. |
| VKM | Vehicle-Kilometre |
| VKT | Vehicle-Kilometre Travelled |

# Appendix B: List of Urban Centres for recurrent and infrastructure expenditure modelling

| State Name Abbreviation | SUA Name (2011 Census) | Estimated Residential Population (2011 Census) | Included in 2015 Review | Included in 2020 review |
|---|---|---|---|---|
| NSW | Albury - Wodonga | 47,488 | Yes | Yes |
| NSW | Armidale | 20,820 | Yes | Yes |
| NSW | Ballina | 24,238 | Yes | Yes |
| NSW | Batemans Bay | 15,817 | No | Yes |
| NSW | Bathurst | 32,711 | Yes | Yes |
| NSW | Bowral - Mittagong | 34,255 | Yes | Yes |
| NSW | Broken Hill | 19,179 | No | Yes |
| NSW | Camden Haven | 14,283 | No | Yes |
| NSW | Canberra - Queanbeyan | 38,029 | Yes | Yes |
| NSW | Central Coast | 315,310 | Yes | Yes |
| NSW | Cessnock | 20,765 | Yes | Yes |
| NSW | Coffs Harbour | 63,025 | Yes | Yes |
| NSW | Dubbo | 34,362 | Yes | Yes |
| NSW | Echuca - Moama | 4,900 | No | Yes |
| NSW | Forster - Tuncurry | 20,380 | Yes | Yes |
| NSW | Gold Coast - Tweed Heads | 65,829 | Yes | Yes |
| NSW | Goulburn | 22,334 | Yes | Yes |
| NSW | Grafton | 18,552 | No | Yes |
| NSW | Griffith | 18,497 | No | Yes |
| NSW | Kurri Kurri - Weston | 15,799 | No | Yes |
| NSW | Lismore | 28,628 | Yes | Yes |
| NSW | Lithgow | 11,928 | No | Yes |
| NSW | Mildura - Wentworth | 3,970 | No | Yes |
| NSW | Morisset - Cooranbong | 20,489 | Yes | Yes |
| NSW | Muswellbrook | 11,511 | No | Yes |
| NSW | Nelson Bay - Corlette | 24,705 | Yes | Yes |
| NSW | Newcastle - Maitland | 413,280 | Yes | Yes |
| NSW | Nowra - Bomaderry | 31,761 | Yes | Yes |
| NSW | Orange | 37,151 | Yes | Yes |
| NSW | Parkes | 10,431 | No | Yes |
| NSW | Port Macquarie | 43,303 | Yes | Yes |
| NSW | Singleton | 14,551 | No | Yes |
| NSW | St Georges Basin - Sanctuary Point | 13,075 | No | Yes |
| NSW | Sydney | 4,196,432 | Yes | Yes |

| State Name Abbreviation | SUA Name (2011 Census) | Estimated Residential Population (2011 Census) | Included in 2015 Review | Included in 2020 review |
|---|---|---|---|---|
| NSW | Tamworth | 38,793 | Yes | Yes |
| NSW | Taree | 24,009 | Yes | Yes |
| NSW | Ulladulla | 14,590 | No | Yes |
| NSW | Wagga Wagga | 52,002 | Yes | Yes |
| NSW | Wollongong | 280,979 | Yes | Yes |
| Vic | Albury - Wodonga | 34,040 | Yes | Yes |
| Vic | Bacchus Marsh | 15,900 | No | Yes |
| Vic | Bairnsdale | 12,099 | No | Yes |
| Vic | Ballarat | 88,734 | Yes | Yes |
| Vic | Bendigo | 84,698 | Yes | Yes |
| Vic | Colac | 11,714 | No | Yes |
| Vic | Drysdale - Clifton Springs | 11,169 | No | Yes |
| Vic | Echuca - Moama | 12,872 | No | Yes |
| Vic | Geelong | 170,285 | Yes | Yes |
| Vic | Gisborne - Macedon | 14,206 | No | Yes |
| Vic | Horsham | 15,581 | No | Yes |
| Vic | Melbourne | 4,000,286 | Yes | Yes |
| Vic | Melton | 47,075 | Yes | Yes |
| Vic | Mildura - Wentworth | 35,159 | Yes | Yes |
| Vic | Moe - Newborough | 15,673 | No | Yes |
| Vic | Ocean Grove - Point Lonsdale | 20,648 | Yes | Yes |
| Vic | Sale | 14,009 | No | Yes |
| Vic | Shepparton - Mooroopna | 44,844 | Yes | Yes |
| Vic | Torquay | 13,850 | No | Yes |
| Vic | Traralgon - Morwell | 39,463 | Yes | Yes |
| Vic | Wangaratta | 17,808 | No | Yes |
| Vic | Warragul - Drouin | 24,495 | Yes | Yes |
| Vic | Warrnambool | 31,497 | Yes | Yes |
| Qld | Brisbane | 2,025,384 | Yes | Yes |
| Qld | Bundaberg | 66,991 | Yes | Yes |
| Qld | Cairns | 140,495 | Yes | Yes |
| Qld | Emerald | 13,422 | No | Yes |
| Qld | Gladstone - Tannum Sands | 42,999 | Yes | Yes |
| Qld | Gold Coast - Tweed Heads | 507,048 | Yes | Yes |
| Qld | Gympie | 17,855 | No | Yes |
| Qld | Hervey Bay | 50,301 | Yes | Yes |
| Qld | Highfields | 13,847 | No | Yes |
| Qld | Mackay | 78,397 | Yes | Yes |
| Qld | Maryborough | 23,759 | Yes | Yes |

| State Name Abbreviation | SUA Name (2011 Census) | Estimated Residential Population (2011 Census) | Included in 2015 Review | Included in 2020 review |
|---|---|---|---|---|
| Qld | Mount Isa | 21,617 | Yes | Yes |
| Qld | Rockhampton | 73,501 | Yes | Yes |
| Qld | Sunshine Coast | 257,151 | Yes | Yes |
| Qld | Toowoomba | 106,012 | Yes | Yes |
| Qld | Townsville | 167,776 | Yes | Yes |
| Qld | Warwick | 13,822 | No | Yes |
| Qld | Yeppoon | 16,334 | No | Yes |
| WA | Albany | 29,712 | Yes | Yes |
| WA | Broome | 13,530 | No | Yes |
| WA | Bunbury | 67,694 | Yes | Yes |
| WA | Busselton | 27,344 | Yes | Yes |
| WA | Ellenbrook | 27,505 | Yes | Yes |
| WA | Geraldton | 34,820 | Yes | Yes |
| WA | Kalgoorlie - Boulder | 32,451 | Yes | Yes |
| WA | Karratha | 17,279 | No | Yes |
| WA | Perth | 1,776,983 | Yes | Yes |
| WA | Port Hedland | 14,605 | No | Yes |
| SA | Adelaide | 1,223,452 | Yes | Yes |
| SA | Mount Gambier | 25,803 | Yes | Yes |
| SA | Murray Bridge | 16,385 | No | Yes |
| SA | Port Augusta | 13,990 | No | Yes |
| SA | Port Lincoln | 14,875 | No | Yes |
| SA | Port Pirie | 14,118 | No | Yes |
| SA | Victor Harbor - Goolwa | 24,164 | Yes | Yes |
| SA | Whyalla | 22,572 | Yes | Yes |
| Tas | Burnie - Wynyard | 25,971 | Yes | Yes |
| Tas | Devonport | 27,349 | Yes | Yes |
| Tas | Hobart | 192,013 | Yes | Yes |
| Tas | Launceston | 83,299 | Yes | Yes |
| Tas | Ulverstone | 13,316 | No | Yes |
| ACT | Canberra - Queanbeyan | 370,090 | Yes | Yes |
| NT | Alice Springs | 28,054 | Yes | Yes |
| NT | Darwin | 111,778 | Yes | Yes |
| **Total** | | **18,780,129** | **68** | **106** |
| **Whole Australia Population** | | **20,691,491** | | |
| **Percentage of Australian Population** | | **91%** | | |