Austroads

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Data to Support the Heavy Vehicle Road Reform Part A

Project Summary

Data to Support the Heavy Vehicle Road Reform Part A: Project Summary

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Abstract

The Council of Australian Governments (COAG) Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

This combined work has identified a number of findings related to the gaps, challenges and opportunities related to developing nationally consistent datasets to provide a basis for heavy vehicle cost recovery and investment, as well as other future applications.

Keywords

Heavy vehicles, cost recovery investment, forward looking cost base, asset register, data standard, infrastructure rating

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About Austroads

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

Summary

This is the final report for the three-year project AAM6068 *Data to Support the Heavy Vehicle Road Reform*, which has investigated a number of different aspects of the requirements, gaps, and opportunities for supplying infrastructure data suitable for supporting a future heavy vehicle cost recovery and investment process. It has continued the work of the previous project (AT1920) and represents a total of seven years of work from 2013 to 2020.

The Parts of the report are as follows:

Part A – Project Summary provides an overview of the Heavy Vehicle Road Reform, the role of the project in the Reform, a summary of each Part (B to H) of the project, and the overall conclusions drawn from the project.

Part B – Heavy Vehicle Infrastructure Rating describes the development of the Heavy Vehicle Infrastructure Rating (HVIR) Framework as a potential measure of how fit-for-service a road is for heavy vehicles. This Part also describes the development, features and processes of the HVIR Tool intended to allow road managers to assemble data and generate HVIR results in a consistent way.

Part C – National Road Asset Register describes the development of standards, tools, and processes for building a nationally consistent database at 100 m intervals containing infrastructure-related information including reference, inventory, operational and condition data. In addition, an investigation was conducted into the requirements for an open data environment through development of open-source code for populating the National Road Asset Register and revising the data specification for the Asset Register to expand its application beyond Australian road agencies.

Part D – Infrastructure Base Map and Data Alignment Guidance presents a discussion of the merits of various mapping platforms, and guidance on how various data elements can be aligned to the base map in a nationally consistent way.

Part E – Traffic Data Analysis reports on an investigation of traffic data, documenting how traffic data is collected, processed, and presented to illuminate the causes of inconsistencies between this data from Australian road agencies.

Part F – Alignment of Expenditure Reporting Data provides the results of a study of the extent and causes of inconsistencies in forecast and actual expenditure data submitted by Australian road agencies to the National Transport Commission (NTC) for the Forward-Looking Cost Base (FLCB) model.

Part G – Stocktake of Pavement Deterioration Modelling is based on a survey of pavement deterioration modelling teams within Australian road agencies to list the models, data, and processes used in the modelling of pavements.

Part H – Investigation of Maintenance Data Records reports on a survey of the nature and extent of record-keeping related to routine and periodic maintenance within Australian road agencies.

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1. Introduction

1.1 Background

1.1.1 The Heavy Vehicle Road Reform

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

The Council of Australian Governments (COAG) Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

Figure 1.1 provides an overview of the policy intent of the Heavy Vehicle Road Reform, detailing some of the issues with the current Pay-As-You-Go (PAYGO) system, how the reformed system would be different and the benefits for road users, industry, government, and the community.

1.1.2 Data to Support the HVRR

Austroads project AAM6068 *Data to Support Heavy Vehicle Road Reform* is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Properly functioning markets require informed users and road providers. In the case of the system of road provision and funding, increased efficiency and fairness can be achieved through greater transparency and accountability to customers; based on more rigorous reporting of road service delivery against agreed standards; which requires improvements to current data availability, accuracy, and timeliness.

The Asset Register, Heavy Vehicle Infrastructure Ratings (HVIR), and investigations of data availability, quality, and structure that were the focus of this project are all part of a package of measures that aim to establish an openly available baseline of information required to transition to the provision of heavy vehicle infrastructure as an economic service over the longer term.

1.2 Purpose

This project maintained the flexibility to address the evolving needs of the HVRR over 3.5 years. The work plan for each year of the project was developed, in consultation with the Commonwealth, to address either emerging priorities or problem statements which had emerged as the broader reform progressed. Overall, the project endeavoured to provide clarity around the availability and quality of road-related data, and answer some of the basic questions for data-driven outcomes.

1.3 Scope

Years 1 and 2 of the project focused on:

- expanding and refining the calculation methods for the HVIR to make them more realistic and accessible for asset managers from both road agencies and local government
- further developing the creation of centralised, harmonised datasets by submitting Asset Register data through online tools
- expanding the Asset Register to include local government roads.

Year 3 of the project focused on:

- developing options for any organisation to generate harmonised data for the Asset Register in an open data environment via source code (Python), consideration of a national base map, guidance for associating data with the base map and data specifications that are compliant with the Austroads Data Standard
- a brief investigation of potential causes of some inconsistencies in expenditure reporting for the NTC's FLCB model
- several data-related investigations across Australian jurisdictions:
  - how traffic data is collected, calculated, and reported
  - the data, models and processes used in pavement deterioration modelling
  - the extent of record keeping for routine and periodic road maintenance.

1.4 Methodology

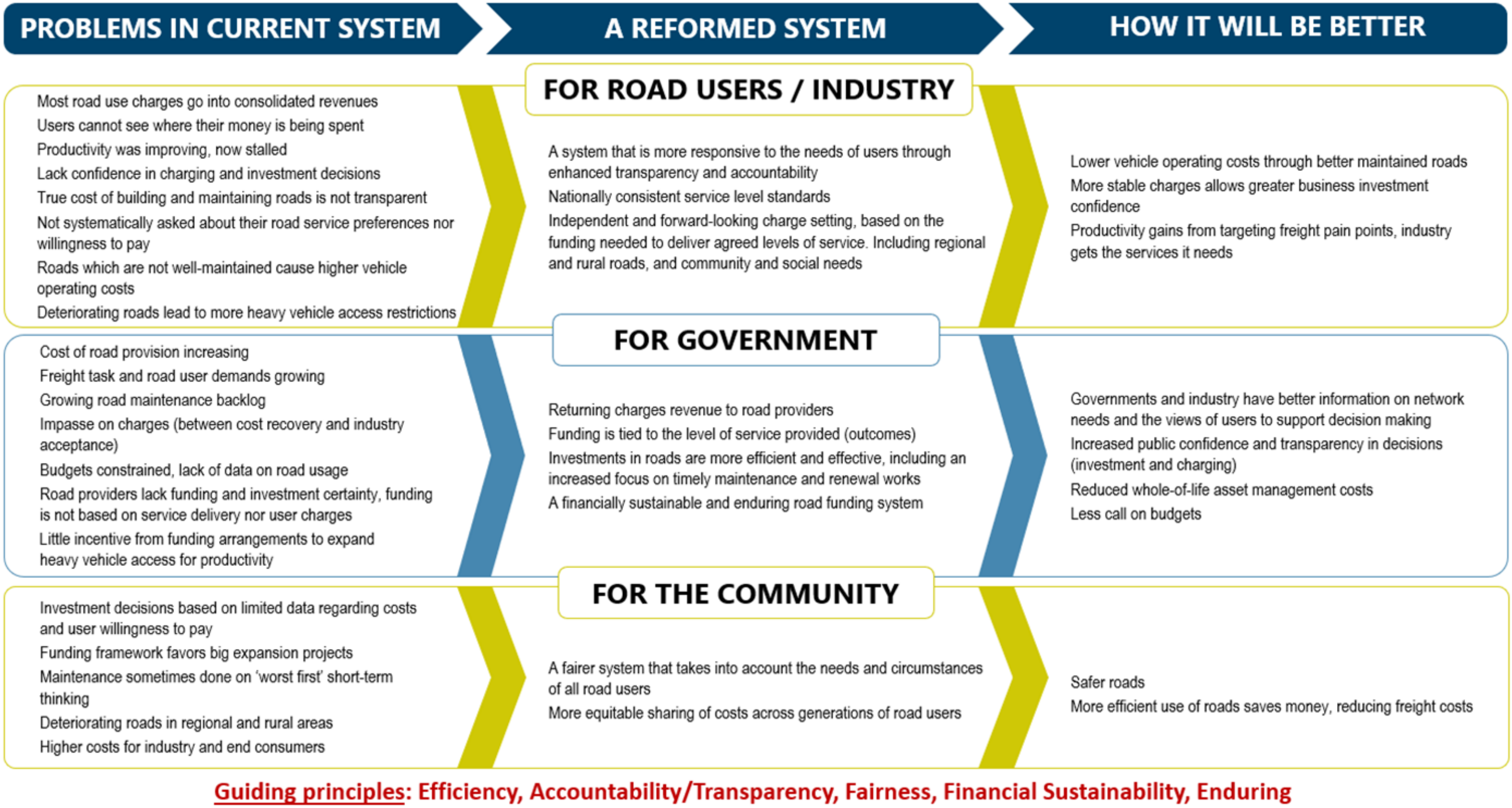
Part A is a concise summary of all of the project outputs together with a brief description of the key findings.

Sections 2 to 8 of Part A contain a description of the inception, summary, and outcomes of each of the Parts B to H, respectively.

Section 9 summarises the key learnings from the project overall.

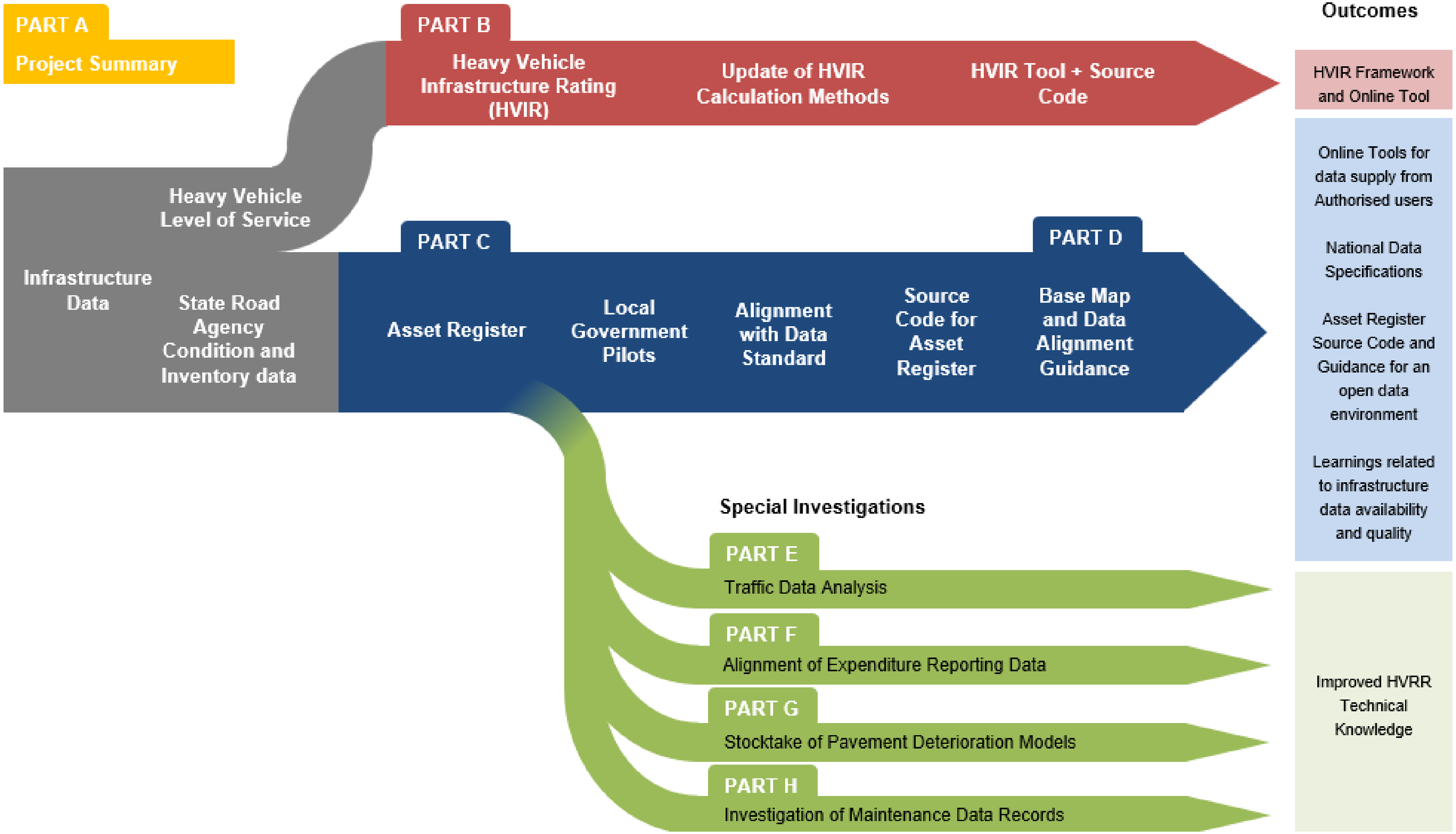
Figure 1.2 shows how each of the Parts B to H fit into the project's objectives and outcomes.

Figure 1.1: Heavy Vehicle Road Reform statement of policy intent



Source: Supplied by HVRR via private email (29/01/2021) – Edited for clarity.

Figure 1.2: Representation of project components in supporting the HVRR, and project outcomes



2. Part B – Heavy Vehicle Infrastructure Rating

2.1 Inception

One of the key outputs of the previous project AT1920 was the Heavy Vehicle Infrastructure Rating (HVIR) for the assessment of the level of service provided by the infrastructure to freight vehicles (focusing on arterial roads managed by states and territories). At the conclusion of AT1920 the HVIR results, as calculated, were based on a provisional method limited by the data that had been previously available. There remained a need to expand the calculation methods to accommodate both state, territory, and local jurisdictions, and for a review of the HVIR Framework as a whole.

2.2 Summary

Further development of the HVIR and the HVIR Tool were key components of the extended project AAM6068.

The first year of the current project saw progress made as follows:

1. The HVIR Tool was developed to increase functionality. It was released to road agencies (RAs) in May 2018 to allow them to be responsible for uploading their data and producing HVIR for internal review before publishing.
2. The Calculation methods for HVIR were updated and expanded to be ready for review and ‘ground-truthing’ by road agencies and HVRR working groups.

In Year 2, the review of the HVIR Framework was conducted, which involved both consultation and a survey, resulting in several improvements to the HVIR Framework. These included:

- a revision of how heavy vehicle access was calculated and interpreted to better represent the actual proportions of the heavy vehicle fleet
- a revision of how ride quality was calculated to provide a more technical grounding
- refining the description of the service attribute of ‘Safety’ to ‘Leeway’, which is more in line with the original basis of the service attribute and how it is calculated (using lane and shoulder width)
- expansion of Calculation methods to be able to account for unsealed roads, and sealed roads without line-markings
- removal of unused and obsolete Calculation methods.

These changes did alter HVIR results for a given dataset compared to the previous methods, but the difference was found to be minimal, and the Framework as a whole was made more technically robust.

2.3 Outcomes

The HVIR Framework presents a means of calculating the level of service provided by the road asset to heavy vehicles, based on key data inputs related to the access level, the ride quality and the leeway or clearance provided to heavy vehicles. The HVIR can provide a performance-based indication of roads across Australia that allows valid comparison of different freight routes for the purposes of setting standards or informing heavy vehicle charges.

The Framework has been designed with basic principles that allow it to be adapted in the future to include additional service attributes and Calculation methods based on new data sources.

The current project has produced the HVIR Framework in three forms:

1. as a documented process that can be implemented in any existing systems
2. as an online tool currently hosted in the Road Managers Tool for authorised users
3. as source code in Python which can be adapted to any dataset to produce HVIR.

3. Part C – National Road Asset Register

3.1 Inception

The key outputs of the previous project AT1920 included an Asset Register containing inventory and condition data for freight routes from state and territory jurisdictions which was developed to determine the nature and extent of data available about freight routes. This Asset Register was in the form of data in Excel spreadsheets and maps as .kml files. This format was unworkable in the long term and the feasibility of an online tool to overcome issues encountered in the data supply process was investigated. This approach was found to be feasible, and the pre-existing Road Managers Toolbox was adopted and a trial conducted with Queensland Department of Transport and Main Roads (TMR). Further development of functionality was required to test the workability of data being submitted and generated through the online tools approach.

3.2 Summary

Components of the extended project AAM6068 included:

- annual road agency data updates of the Asset Register
- extension of the Asset Register to include a growing sample of local government roads
- continued improvement of the Asset Register.

A summary of these project activities is contained in Figure 3.1.

Figure 3.1: Developments and improvements in the Asset Register

	YEAR 1	YEAR 2	YEAR 3
Data Supply	Initial Local Government Pilot	Expanded Local Government Pilot	Assessment of Open Data Sources
Data Consistency	Assessment of Implementation Issues for Data Standard	Harmonisation of Asset Register and Data Standard	Updated Data Specification for Asset Register
Data Updates	Annual Update of Asset Register Data	Annual Update of Asset Register Data	
Functionality	Development of Online Tools	Further development of Online Tools	Development of Open Source Code

The first year of the current project saw progress made in the following two areas:

- Alignment and implementation issues between the Austroads Data Standard and Asset Register were reviewed. Aligning the Asset Register and Data Standard is feasible and has some advantages; however, several issues need to be resolved before this can begin.
- A pilot program to identify and solve the problems encountered by local government using the HVIR Tool commenced in May 2018. An evaluation of the 2017–18 pilot program informed the design of an updated Local Government Pilot Implementation Program for 2018–19.

The main components of work in Year 2 included:

- annual update of the Asset Register and HVIR
- extension of the Asset Register, including a growing sample of local government roads
- assessment of implementation issues related to data.

These are summarised below.

Annual update of Asset Register data

The prolonged process of updating the 2018 and 2019 data in the Asset Register was used to understand and identify issues in the data supply process. Based on these understandings, the groundwork was laid to move to a less centralised process in Year 3 by making available to asset owners open-source code to calculate the HVIR and undertake quality assessments of their data.

Extension of the Asset Register to include local government roads

Through a smaller initial pilot and a more extended pilot, a number of local governments were engaged to explore their potential to supply asset data. Despite improving the engagement process, and adapting data requirements, the general finding of the pilots was that local governments are currently not able to efficiently supply high-quality data about their roads. A follow-up survey was conducted to identify the key challenges, which were: 1) a lack of resources, 2) a lack of expertise in data manipulation, and 3) the data simply not being collected or maintained.

Sourcing of data from Western Australian local governments through the RAMM database was also found to be unfeasible due to both the limits of the RAMM data specification and the amount of data usually supplied by the local governments.

Assessment of implementation issues related to data

An assessment of the similarities and differences between the Asset Register and Austroads Data Standard Prioritised Harmonisation Subsets (PHS) (Austroads 2019a) produced recommendations for improvements that could be made to both the Asset Register Data Specification and the Austroads Data Standard (Austroads 2019b).

An analysis of open data sources was also undertaken and found that while all road agencies have open data platforms, the specific data needed for the Asset Register is often not available or not available at the required level of detail.

3.3 Outcomes

Part C documents a number of efforts to develop methods for asset owners to supply data to the Asset Register, to improve the quality of data in the Asset Register and ensure the Asset Register is in line with other efforts focused on developing national consistency.

The initial data specification of the Asset Register was based on data held by road agencies but has since been adapted to be compliant with the Data Standard, as well as providing potential improvements that could be made to the Data Standard.

Online tools and processes for sourcing data and placing the burden for addressing inconsistencies on the owners of the data were developed, which can provide a means to build an ongoing centralised database of nationally consistent data if supported by the appropriate endorsements and business needs. In addition, all of the functionality of the online tools has been programmed into Python source code to allow diverse organisations to utilise and innovate on this functionality in a harmonised open data environment.

Efforts to source data from local governments have yielded important learnings related to the required incentives, support and approaches needed in the future to successfully generate and obtain data about local government freight routes.

4. Part D – Base Map and Data Alignment

4.1 Inception

To collect and report better road-related data, a common way of identifying the location of road segments is needed. Every bit of information about road usage, asset condition and road expenditure can be linked to the location of a road segment, and then displayed using geospatial mapping.

Earlier work on this project focused on RAs and departments of transport as providers of road-related data. This focus was expanded to consider the feasibility of incorporating road-related data held by other public and private organisations for inclusion in both centralised and harmonised databases like the Asset Register, and in an open data environment.

This generated two key questions that needed to be answered:

- What was the most appropriate candidate for a base map of Australian roads?
- What are the challenges, gaps and opportunities associated with aligning datasets collected for a variety of other purposes with the base road network?

4.2 Summary

Analysis of base map options

For HVRR and other road reporting and visualisations, the lack of a nationally agreed spatial representation of the road network complicates the task of establishing the condition and rate of deterioration of assets on the network at any point in time in a consistent way.

To answer the need for a nationally consistent road network base map (location and segmenting) against which data can be reported for HVRR, one of the national networks is to be selected. To aid in this decision, the advantages and disadvantages of a number of national road network base maps were investigated to provide a strong basis for the choice of a base network for reporting.

Due to the complexity of segmentation and maintaining a consistent road network it is recommended that the Commonwealth use a commercial road network where the provider can provide assistance with segmentation and rolling updates. In particular, a commercial navigation provider has a (beneficial) vested interest in keeping the network base map as up-to-date as possible with significant in-house GIS capability. The commercial provider is also likely to have more complete and consistent road attribute information across the country. Of the commercial providers that meet these requirements, HERE maps is considered superior to the others – although there may be a significant upfront monetary cost associated with this.

If a commercial provider is unaffordable, then OpenStreetMap provides a good alternative network base map. It will, however, require significant resource investment, particularly in segmentation, before it can be used as a national network base map.

Aligning data with the base map

Geospatial data is integral to the management of transport and transport assets across Australia by both government and private organisations. However, there are significant differences in the way geospatial data can be represented, which makes aligning different datasets particularly from different organisations, difficult in a consistent and accurate way.

This challenge is ameliorated slightly in the case of base map alignment, and this document provides some practical guidance for matching and aligning data from different sources to a common road network. This guidance is composed of the following:

- An overview of what the potential data environment is, its requirements and its capabilities. An outline of the network data structure is provided, and properties of the base-map documented.
- Examples of how data should be stored in the potential data environment. The examples show what attributes are required for a HVIR compatible dataset, and how the different datasets can be represented.
- Practical guidance for aligning specific geometric objects with the underlying line segment road network representation. These objects include line segments from other network representations, point locations or trace points (e.g. GPS path), areas, and linearly referenced positions.

4.3 Outcomes

Part D provides some discussion on a number of the issues that need to be resolved in the selection of a national base map that data from multiple sources and organisations can be aligned to. Initial responses to this discussion have made clear that there are diverse opinions about what a single national map ‘should’ be and the ‘best’ way to approach it – usually informed by what individual commenters think the national data base map is intended for. This suggests that further consultation on what a national base map would be used for by different organisations could provide valuable insight into what the properties of the national base map should be.

The selection of a network base map for road-related data is an important step towards building a single harmonised database of road data for Australia. Additionally, the guidance included in Part D provides some direction to organisations wanting to align their data to a harmonised network in the future.

The provision of a national base map and alignment guidance by no means ensures an accurate and transparent national dataset of harmonised road data. However, it does take steps towards enabling the decentralised participation of organisations that produce data to report it in a standardised way in a common environment.

5. Part E – Traffic Data Analysis

5.1 Inception

Data on road usage is perhaps the most fundamental item of information needed to support a more market-like system of road provision and funding. Considerations of traffic data within the reform raised questions about what differences existed between data from different jurisdictions. The processes behind the reported traffic volumes were somewhat of a black box, and so there was a need to understand how each jurisdiction arrived at the traffic volumes they reported, in the interests of understanding whether reported traffic volumes were equivalent and working towards harmonisation.

5.2 Summary

A detailed investigation on the collection, calculation, processing and reporting of traffic volumes between jurisdictions was conducted. Literature on traffic volume collection and reporting was reviewed. A comparison across jurisdictions of their traffic data practices was implemented. The extent and availability of commercial traffic data in a national and open context was explored. A draft data specification for a nationally consistent reporting of traffic volume data was proposed.

The scope of this work was limited to annual average daily traffic (AADT) volume on arterial roads in terms of the Austroads vehicle classification.

Through the investigation on traffic data practices in Australia, it was found that the inconsistencies between jurisdictions arise because of the differences in business need, availability of equipment and processes for calculating the AADT. For example, traffic volume data in NSW is mostly collected from permanent counting stations as there are about 600 permanent stations across NSW. NSW also uses a different method of calculating the AADT.

5.3 Outcomes

In order to increase the consistency in traffic volume data between jurisdictions, it is suggested that a national business need (e.g. public awareness, road design or traffic management) be identified at first. A traffic data specification, including collection, calculation, processing, and reporting, can be determined correspondingly. Stakeholder engagement during the development of a national data specification is important to ensure the required level of practicality and rigour within different jurisdictions is achieved. This could be incorporated into existing initiatives aimed at developing national harmonisation such as the Austroads Data Standard work.

6. Part F – Alignment of Expenditure Reporting Data

6.1 Inception

A more transparent and accountable road system would include easily accessible information about where road-related expenditure is being spent, i.e. what money is being spend on what type of works on which roads. The NTC is responsible for collecting capital, operational, and other expenditure data associated with building and maintaining the road network for the purpose of determining PAYGO-based cost recovery. The NTC has also been charged with development of a Forward-Looking Cost Base (FLCB) model for cost recovery and investment, and accordingly has been collecting expenditure data from jurisdictions to support the developing FLCB model.

However, a number of inconsistencies and other accuracy concerns have been identified in the reported expenditure. An investigation was therefore undertaken within this project to assist the NTC with understanding the causes of these issues.

6.2 Summary

For the past few years, the NTC has requested data from Australian jurisdictions on their forecast and actual expenditure in order to develop an FLCB model. The objective of Part F is to provide an understanding of the issues being experienced in the provision of FLCB data and propose any available solutions for providing improved confidence in FLCB data.

The quality of FLCB-compliant expenditure data provided by states and territories to the NTC has improved year by year since expenditure forecasts were first collected (jurisdictions have provided expenditure data for PAYGO since the 1990s). However, a key concern remains regarding the divergence between forecast and actual expenditure. Additionally, there are concerns related to an inability to explain differences in reported expenditure between the FLCB and PAYGO expenditure categories.

While only two years of FLCB expenditure data was available, an analysis was conducted to indicate the magnitude of the discrepancy between forecast and actual expenditure. Table 6.1 shows the average multiplication factors for the FLCB Actuals exceeding forecast expenditure across all seven participating jurisdictions, demonstrating that the actual Operating expenditure was greater than what was forecast in every category while in most categories actual Capital expenditure was less than forecast.

Table 6.1: Average factors across jurisdictions of difference between actual and forecast expenditure

Financial year	Expenditure category	Operating expenditure		Capital expenditure	
		Average	Std. dev.	Average	Std. dev.
2017–18	Pavement/Surface	1.33	0.41	1.03	0.48
	Bridges/Major culverts	1.14	0.21	0.74	0.51
	Other expenditure	1.15	0.32	0.78	0.47
2018–19	Pavement/Surface	1.08	0.33	0.74	0.30
	Bridges/Major culverts	1.09	0.29	0.86	0.36
	Other expenditure	1.32	0.56	1.31	1.49
	(outliers removed)	(1.09)	(0.23)	(0.71)	(0.29)

To improve understanding of the discrepancy issues, the NTC held discussions with each state and territory road agency during March and April 2019. The format of these discussions was a mix of face-to-face meetings and teleconferences. These discussions were focused on trying to improve the quality of the data provided for the FLCB modelling, including developing a better understanding of the process used to provide data.

Responses from the jurisdictions and other discussions were used to develop a further ARRB survey that endeavoured to:

- gain a greater understanding of the details of how each jurisdiction went about translating expenditure categories
- understand more about the causes of 'unexpected expenditure' that could lead to forecasts not matching actual expenditure.

Overall, the responses received indicated that translating between an organisation's own cost categories and the FLCB expenditure categories was less of an issue for the A, B, and D groups of categories, while most of the problems experienced by the majority of respondents were in category group C, *Renewal, Upgrade and Expansion Expenditure*.

Many respondents reported or provided information that showed that it was not possible to relate the FLCB categories to specific organisational categories due to fundamental differences in how the categories are structured. In these cases, FLCB Expenditure data was determined through a highly manual process.

As each of the road agencies or departments of transport have different internal structures and processes and these are expected to remain different for the foreseeable future, the desired outcome is that despite these differences the forecast expenditure is broadly considered transparent and reliable.

With this outcome in mind, the following approaches are offered as means of potentially increasing confidence in FLCB expenditure forecasts:

- confidence signalling – giving organisations the confidence to invest internally in improved processes for producing FLCB data according to the current guidelines
- alternative categorisation for capital expenditure – responding to organisations' feedback to develop purpose-focused categories
- margin of variance – to communicate expectations of understood and acceptable variance between forecast and actual expenditure.

6.3 Outcomes

This report has investigated the differences between forecast and actual FLCB expenditure with an attempt made to show the magnitude of the inconsistencies. Insufficient data was available to draw any conclusions, but if this analysis was to be extended in the future it could be valuable.

The surveyed road agencies and departments of transport have indicated that providing expenditure data in line with the FLCB Guidelines is achievable, but challenging in two main aspects:

- There is a fundamental difference between the way categories under capital expenditure are structured between the FLCB guidelines and systems within road agencies.
- The consequence of the above point is that manual processes are often required to obtain the required information.

A number of potential solutions have been presented as means of potentially increasing confidence in the FLCB which include: confidence signalling, alternative categorisation for capital expenditure, and developing and communicating a margin of variance.

The key issue arising from the investigation is the same fundamental issue encountered in other areas of this project. That is, developing reliable, nationally consistent data is a long-term process that must begin with enforcing national standards in the reporting of data. This process can only move forward as individual jurisdictions adopt standard systems and processes. This will require strategies that incentivise the necessary internal development within separate organisations to move towards national consistency at the fundamental level.

7. Part G – Stocktake of Pavement Deterioration Modelling

7.1 Inception

Modelling of the deterioration of pavements is a key part of managing road assets. As with other areas of data within the reform, there was a need to understand the data, models and other processes used within jurisdictions to determine to what extent data and the interpretation of data was equivalent between jurisdictions and to work towards harmonisation.

7.2 Summary

Part G aimed to investigate and document the various approaches and software adopted across RAs for pavement deterioration modelling, as well as their data input requirements through using a survey. Further, this survey aimed to gather the opinions of these road agencies on the use of big data in asset management.

Pavement performance and pavement deterioration modelling is an essential part of any pavement management system (PMS), as this type of modelling assists with estimating long-term maintenance investment requirements.

The two main types of models which emerged from the consultation were:

- deterministic models, including Weighted Maximum models and Condition vs Time models
- probabilistic models.

Deterministic modelling

Deterministic approaches predict a single value of the dependent variable from pavement performance prediction models based on statistical relationships to build either empirical or mechanistic-empirical relationships between the dependent and independent pavement performance variables. Deterministic models are used by Department for Infrastructure and Transport South Australia, Department of Transport (DoT) Victoria, Department of State Growth (DSG) Tasmania, Main Roads Western Australia (MRWA), Transport Canberra and City Services Directorate (ACT), Transport for New South Wales (TfNSW), and Queensland Department of Transport and Main Roads (TMR).

Weighted maximum models are based on the calculation of a pavement condition index (PCI). The PCI is a numerical indicator based on a scale of 0 to 100. The PCI measures the pavement's structural integrity and surface operational condition.

Condition vs time models are used by DoT Victoria. These models were developed by DoT Victoria, consequently there is no documentation for these models. These models were developed in Microsoft Excel using surface condition data in a 'shot-in-time' approach.

Probabilistic modelling

Probabilistic approaches inherently recognise the stochastic nature of pavement performance by predicting the distribution of the dependent variable. Probabilistic models are currently being researched by MRWA to model the deterioration of timber bridges.

Some of the noted reasons for the choice of deterministic models included:

- The majority of pavement deterioration occurs in the gradual deterioration phase, which is where deterministic models are most appropriate.
- These models can be simply transferred into a PMS.
- These models are seen to be the best practice option.
- These models can provide a relationship to traffic data which is important to consider with rising traffic volumes.
- The outputs of these models have been shown to reflect observed pavement performance under various loading, environmental conditions, and service level requirements.

The main data types involved in all these models were:

- quality assured, and repeatable, condition survey data from a certified vehicle (such as ARRB's Network Survey Vehicles)
  - this includes roughness, rutting, cracking, surface texture, potholes, skid resistance and deflection
- inventory data
  - including road segment IDs, road hierarchy, dimension information for pavements/seals, last constructed data, and data on traffic counts, geometry, and asset useful life
- environmental information (i.e. climate zones)
- traffic data
- works programs
- other additional datasets where deemed to be relevant.

Big data and asset management

As mentioned previously, when the survey was circulated to RAs it also requested information on opinions on the use of big data in asset management. While most RAs were supportive of big data use as a concept, many said that it is not something which is currently available for implementation. The main benefit identified was that it could improve maintenance practices and response times.

However, several RAs defined the disadvantages and risk of this type of data, with some major themes including:

- the possibility of low-quality data which is not quality-assured where its source is not the traditional one
- issues of bias (unintentional) with crowd sourced data if not set up correctly
- the large requirements for IT infrastructure that is necessary to support big data analytics.

The overall consensus which seemed to emerge, as conveyed clearly by one RA, was that these alternative data sources would be better suited to supplement and enhance data collection as opposed to fully replacing the traditional cyclic data collection using Laser Profilometers and automated conventional road condition data collection devices.

7.3 Outcomes

Part G presents the various approaches adopted across Australian road agencies for pavement deterioration modelling, as part of the HVRR, as well as their data input requirements. This investigation was aimed at providing insight into the drivers for heavy vehicle investment and data requirements to support subsequent phases of the reform, particularly those related to transparency and accountability and heavy vehicle charging models.

Most of the models used by the Australian RAs were seen to be consistent and reliable for the purposes these models were meant for. Further, all data inputs were mostly seen to be fit-for-purpose, with the data being quality assured by either independent data collection organisations or internally within the road agency.

There were limitations noted for each of these models, including that factors which are not considered in the model may have a major impact on the condition of the pavement, such as drainage and local climatic and geological effects. However, it was noted that inclusion of these elements could be an area of further research, including the suitability of models that can be calibrated for local conditions.

8. Part H – Investigation of Maintenance Data Records

8.1 Inception

During the reform, the absence or availability of key datasets has become one of the issues to be addressed. Maintenance data records are an important part of explaining the performance and maintenance costs of road assets, and the absence of this data could potentially limit the usefulness of national asset datasets. As with other investigations undertaken on this project, sufficient understanding to determine equivalence and work towards harmonisation was needed.

8.2 Summary

Part H aimed to investigate and document the various approaches adopted across RAs for recording and sorting completed maintenance and operational works. This included both routine and periodic maintenance data, to understand the potential for gaps in data records, which could be applicable to the FLCB model.

Further, Part H aimed to investigate the road maintenance data perspective of road managers in RAs on the FLCB approach and what improvements could be made. This assessment was completed through a literature review and a survey distributed to project contacts.

The most advanced Australian standard (i.e. nationally consistent standard) for recording maintenance data is the Austroads Data Standard, including the relevant data function groups, and the Priority Harmonisation Subset. The Austroads Data Standard is aimed at providing consistency in assessing the functionality of road network data with respect to the consistency and reliability of the information which is recorded about road networks. This information is critical in achieving consistency for the FLCB model and ensuring it is based on the best available and most appropriate datasets.

Each of the RAs surveyed noted that they recorded both routine and periodic maintenance works. Routine maintenance was generally recorded as individual road segments, or collectively, depending on the intensity of the works at each location. Periodic maintenance was recorded either as individual road segments, or as projects (if multiple works were completed in one project).

Currently, the NTC is responsible for making recommendations to the Infrastructure and Transport Ministers regarding heavy vehicle cost recovery and investment. Recently, reviews have been undertaken of the current PAYGO heavy vehicle charging model scheme. The issue identified with the current charging methodology was mainly that it is outdated, with the cost base not being an accurate reflection of the actual cost base. The representatives of the surveyed road agencies view the FLCB approach as beneficial.

In addition, survey respondents noted additional attributes of completed works which should be recorded to demonstrate further benefits from the FLCB approach. These included road attributes, defect information, historical information, and future data predictions.

Based on the information provided in the consultation on routine and periodic maintenance data records, it seems that most RAs record the required attributes of completed works which are recommended (by the road agencies) for inclusion in the FLCB model. There are, however, improvements which could be made to asset register specifications to ensure that the information recorded is consistent. These outcomes can be achieved through effective collaboration between RAs, Austroads and industry bodies.

8.3 Outcomes

Part H presents the various approaches adopted across RAs for recording completed maintenance and operational works that include both routine and periodic maintenance. The RAs have also provided their opinions on the FLCB model, and on the data requirements for this model.

9. Key Project Findings

This project has significantly built understanding of the challenges and technical constraints in producing the data upon which the HVRR will depend. Other outcomes include an enhanced HVIR and Online Tool to support road managers, and practical learnings that can be applied to data provision under a reformed system.

While this project covered a diverse number of topics, there were nonetheless some important findings. These are listed below in Table 9.1.

Table 9.1: Key project findings

Finding 1	One of the fundamental challenges in building national consistency is that data collected and processed within jurisdictions is often fundamentally linked with the needs and priorities of individual organisations within those jurisdictions. While national standards can be imposed on reported data, the underlying data is potentially very different, leading to accuracy issues when it is transformed to comply with reporting requirements. One of the consequences of this is that reported data that appears the same can have a very different underlying nature, meaning that harmonisation has not really been achieved and there can be a lack of reliability in the outcomes of applications in the national context. An example from this project relates to the Asset Register dataset that was conceived as a collection of important information about roads – this data had to be sourced from multiple departments and teams within organisations that during their day-to-day business do not interact with each other. While starting from reporting consistency is a sensible first step, true harmonisation must ultimately consider and address the original needs and parameters of data collection and processing in sufficient detail to recognise the true nature of data presented.
Finding 2	While the supply of data for the Asset Register was not the first instance of data about road assets being submitted to the Commonwealth, the process in this project was both novel and beyond the normal activities of organisations. The consequences of this were that it is completed by exception and although guidance was provided, it remained an unfamiliar task open to interpretation. The drawbacks of this situation are that it does not allow for institutional knowledge to be built (i.e. each analyst may do things in their own way with differing levels of effort or understanding of the data), with inconsistency in the quality of the data from year to year. The use of the Road Managers Toolbox and the HVIR Tool addressed these issues by providing a guided approach that imposed consistency on the supplied data and provided feedback on gaps and errors in the data back to the organisations, making them responsible for correcting these gaps and errors to achieve a successful submission. Had data supply through these tools been able to continue, it is expected that over time it would not only be a familiar process, but a valuable one for organisations to see and understand their data with a broader view (i.e. across usually separate data types) and how closely the data aligns to the requirements of national applications. Without a nationally endorsed and supported process that places responsibility on the organisations, jurisdictions are not given direct cause to identify and correct inconsistencies in their data as part of their normal business. As indicated in Finding 1, true national consistency of reliable data is unlikely to be achieved through processes that do not impact the normal business of organisations.

Finding 3	Currently, local governments are not well-equipped to maintain or provide data to the extent needed to obtain an understanding of the quality of their freight routes. This is in many cases an issue of resources, where the council does not have the time, tools, and funds to collect data about their roads beyond their own maintenance needs. This is exacerbated by a lack of real and/or perceived value in collecting and maintaining data about the local road network in relation to: • Detailed, high quality data is not needed for undertaking year-by-year maintenance, and therefore local governments can 'get by' without data that would cost more to collect and maintain, and which the value of cannot be seen unless there is sufficient expertise to put the data to use (e.g. modelling deterioration, costing different strategies, etc.). • Local governments are disconnected from any benefits arising from sending off data about their roads to the Commonwealth or RA. A further consequence is that the 'getting by' approach means different things to different local governments, meaning that the lack of consistency is even greater than at the state level. Research elsewhere has long shown that this approach is ultimately more expensive than taking a longer-term view supported by data and modelling – but these kinds of outcomes are currently beyond the capabilities and/or resources of most local governments. Solutions to this state-of-affairs lie in part in linking data submission with funding/revenue to provide a business need for high quality data; but even incentivised, local governments will need an approach that addresses the lack of expertise and resources evident in many local governments.
Finding 4	Bringing together data from diverse organisations on a national map requires far more standardisation and fundamental understandings of both how data is linked to the intent of that data being collected in the first place, and the intention of mapping the data. Different organisations and individuals have diverse ideas about the purpose and nature of a map that brings together road-related datasets. While this is not unexpected, further consultation with the stakeholders likely to participate would allow progress to be made towards an outcome with the most benefit.
Finding 5	Top-down national standards or guidelines for data do not include considerations for how data is developed from the ground-up within jurisdictions. Due consideration should be given to the bottom-up approach such as was developed within the Asset Register to ensure a complete understanding of the nature of data behind reporting requirements. The business case for data within an organisation drives the nature and frequency of the data collection and how it is processed and presented. The intent of the data is therefore reflected in the characteristics of the dataset and if this intent is not understood, the data could be misleading.

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Research Report
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Data to Support the Heavy Vehicle Road Reform Part B

Heavy Vehicle Infrastructure Rating

Data to Support the Heavy Vehicle Road Reform Part B: Heavy Vehicle Infrastructure Rating

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part B details the development of the Heavy Vehicle Infrastructure Rating (HVIR), which was designed as a measure of the Level of Service provided by a road to heavy vehicles. The HVIR can serve as an infrastructure-based indicator of the performance of a route for the purposes of establishing a comparable measure across jurisdictions and as part of the basis for cost recovery and investment.

Keywords

Heavy vehicles, level of service, data standard, infrastructure rating

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About Austroads

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

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

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

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

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

Summary

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads is a critical component of building a more efficient and fairer system for making decisions about road spending.

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services, one that provides clear links between the needs of users, the charges they pay and the services they receive.

Properly functioning markets require informed users and road providers. The asset registers and heavy vehicle infrastructure ratings (HVIR) that are the focus of this project, are part of a package of measures that aim to establish an openly available baseline of information required to transition to the provision of heavy vehicle infrastructure as an economic service over the longer term.

Austroads project AAM6068 *Data to Support Heavy Vehicle Road Reform* is a three-year continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017.

One of the key outputs of the previous project AT1920 was the HVIR for the assessment of the level of service provided by the infrastructure to freight vehicles. At the conclusion of AT1920 the HVIR results, as calculated, were based on a provisional method limited by the data that had been previously available. There remained a need to expand the calculation methods to accommodate both state, territory, and local jurisdictions, and for a review of the HVIR Framework as a whole.

Further development of the HVIR and he HVIR Tool were key components of the extended project AAM6068.

The first year of the current project saw progress made as follows:

1. The HVIR Tool was developed to increase functionality. It was released to road agencies (RAs) in May 2018 to allow them to be responsible for uploading their data and producing HVIR for internal review before publishing.
2. The calculation methods for HVIR were updated and expanded to be ready for review and 'ground-truthing' by road agencies and HVRR working groups.

In Year 2, the review of the HVIR Framework was conducted, which involved both consultation and a survey, resulting in a number of improvements to the HVIR Framework. These included:

- a revision of how heavy vehicle access was calculated and interpreted to better represent the actual proportions of the heavy vehicle fleet
- a revision of how ride quality was calculated to provide a more technical grounding
- a refining of the description of the Service Attribute of 'Safety' to 'Leeway', which is more in line with the original basis of the Service Attribute and how it is calculated (using lane and shoulder width)
- expansion of calculation methods to be able to account for unsealed roads, and sealed roads without linemarkings
- removal of unused and obsolete calculation methods.

The impact of these changes does alter the HVIR results, but the differences in the calculated HVIR results are minimal, and the framework as a whole is more technically robust.

Contents

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1. Introduction

1.1 Background

The project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* objective is to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

1.2 Purpose

The Heavy Vehicle Infrastructure Rating (HVIR) aims to provide accessible information about the current state of heavy vehicle road services on different parts of the network. It has been designed to use readily available data and produce a convenient indicator for use in setting standards or making comparisons.

1.3 Scope

The further development of the HVIR in this project has focused on increasing the robustness and technical basis of the fundamental approach developed in AT1920 (consisting of the selected service attributes, and the principle of setting different expectations of HVIR based on the category of road).

Part B, therefore, includes the improvements made to existing methods for calculating individual service attributes, new calculations methods developed, and ultimately the discontinuation of calculation methods. All these have been undertaken through consultation and trials with asset owners from both state and local government level to identify what is most practical and useful.

1.4 Methodology

Part B describes the development of the HVIR itself and the online HVIR Tool as follows:

- Section 2 summarises the initial development of the HVIR in the original project AT1920.
- Section 3 details the first round of updates to the HVIR calculation methods (additional detail is in Appendix A).
- Section 4 reports on the results of the HVIR Framework technical review and the second round of updates (additional detail is in Appendix B).
- The complete and updated description of how to calculate the HVIR is included in Appendix D, while Appendix E details the data needed to calculate HVIR.

2. Summary of Preceding Project AT1920

2.1 Overview of AT1920

Austroads project AT1920 *Developing the Information to Support the Heavy Vehicle Road Reform* was a multi-year project that commenced in July 2013 and concluded in June 2017. The three primary outputs were road categorisation, the HVIR and the national freight route register.

This section briefly documents the relevant developments (including road categorisation) for the HVIR over the four years of AT1920.

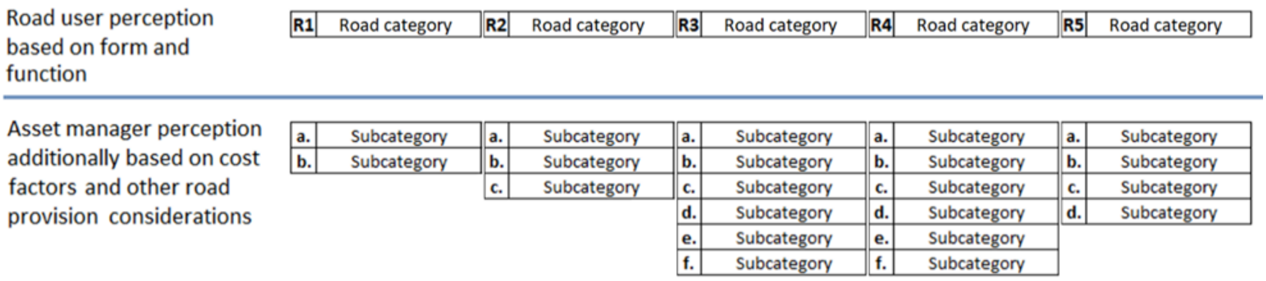
2.2 National Classification of Roads

The first output was a national categorisation of roads as shown in Table 2.1. This was developed after a consideration of road categorisation/classification in all Australian states and territories.

The development of the road categories commenced with a consideration of the key concept that should drive the process. The key concept to be resolved was how best to reconcile the visible characteristics of a road, such as width and condition, with the hidden characteristics such as the structure, materials, environment, and location (remoteness) of the road. When considering levels of service, road users base their judgements on these visible characteristics (often termed the Customer Level of Service, CLoS). However, the cost of providing and maintaining the asset depends to a greater extent on the hidden characteristics (often termed the Technical Levels of Service, TLoS).

After a consultation process through the Assets Task Force, it was decided that a series of categories should be determined based on the functional classifications of roads, with sub-categories used to separate assets by their costs or administrative/structural classes. This approach is represented in Figure 2.1 (note: categories and sub-categories are undefined here).

Figure 2.1: Representation of the category and subcategory approach selected



After the approach was decided, a literature review was undertaken of existing road classification systems in use throughout Australian state and territory jurisdictions. It was generally found that:

- Both freeways/motorways and access roads are well-defined in a very similar way across all jurisdictions and classification schemes.
- Some jurisdictions distinguished between urban and rural roads, but their visible physical characteristics were usually not sensitive to this distinction.
- The greatest variation was in what were variously called feeder, collector, and distributor roads.

Based on the literature review, five categories of sealed and marked roads (i.e. roads with some form of linemarking) were determined to capture the key visible physical points of difference between roads in the network. These are shown in Table 2.1. Consideration was also given to unmarked (i.e. roads with no form of linemarking) and unsealed roads.

Table 2.1: Definitions of road categories in the HVRR

Road category	General description	Definition
R1	Freeways, motorways and tollways	• Divided carriageway sealed multi-lane roads with sealed shoulders on both sides of each carriageway.
R2	Urban highways	• A major sealed road that is not a freeway but may have divided carriageways and 2+ lanes in each direction and sealed shoulders.
R3	Urban arterials and rural highways	• Single carriageway with one sealed lane in each direction; it may have sealed or unsealed shoulders. • Unmarked roads with a seal width of 7 to 15 m. • Unsealed roads with a width of 8 to 16 m.
R4	Collector/distributor roads	• Other sealed roads that are not access roads with no requirement for shoulders. • Unmarked roads with a seal width of less than 7 m. • Unsealed roads with a width of less than 8 m.
R5	Access roads	• Roads that exist to provide property access.

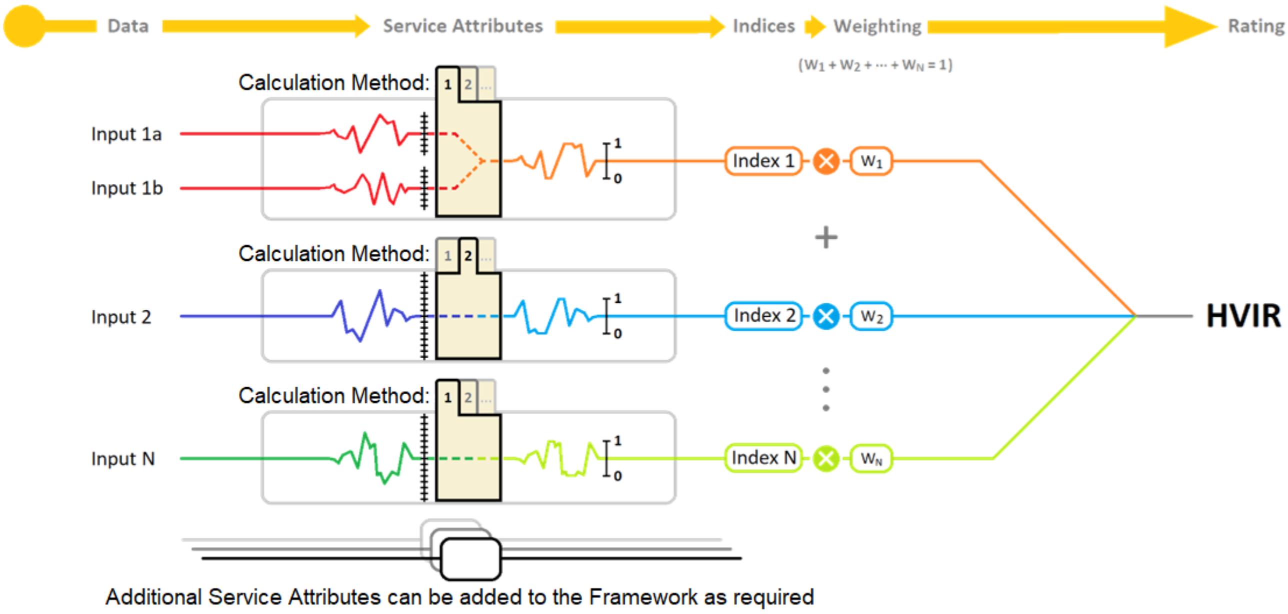
No further consideration was given as to how the subcategories should be determined. Use of these road categories was carried through into the current project (AAM6068).

2.3 Initial Development of the HVIR

One of the key tasks of project AT1920 was to develop a means of measuring the level of service for heavy vehicles provided by a road. The measure was to be linked to the infrastructure, i.e. attributes of the asset that were under the direct control of a road manager. This did not include congestion, which is controlled indirectly through larger operational considerations of traffic on the network.

The HVIR Framework was subsequently developed to produce a measure of the suitability of roads for heavy vehicles, together with an interpretation of this measure based on the heavy vehicle road user expectations for each road category. The HVIR Framework is composed of a number of ‘Service Attributes’ representing the factors of importance to road users, each measured on a scale from 0 to 1. Weighting factors representing the relative importance of the included service attributes to each other are also decided. The framework allows service attributes to be added or removed in the future. They can be based on any quantity that can be turned into a meaningful scale between 0 and 1. The HVIR is produced by summing the weighted service attributes, reported as a percentage. A representation of the HVIR Framework is shown in Figure 2.2.

Figure 2.2: Representation of HVIR Framework



Potential service attributes were nominated after consultation with industry (Ritzinger et al. 2013). A literature review and questionnaire survey were conducted as part of work into levels of service for freight vehicles (Austroads 2016) to identify the key service attributes. These were then subject to an analysis of what was practical to utilise. The final service attributes selected were access, ride quality and what was originally termed ‘safety’ but was later called ‘leeway’.

Once determined, a method was needed to calculate each service attribute from some input parameter(s). The initial methods employed were as follows:

- Access was envisioned to be determined by a formula based on length limits (road geometry) and mass limits (strength of the asset), although this information was not readily available in the early datasets.
- Ride quality was based on International Roughness Index (IRI).
- Safety/Leeway was based on a formula that considered the lane width and the width of sealed shoulder available. This formula was based on surveys of heavy vehicle drivers who reported lane width and the amount of sealed shoulder as contributing to perceptions of safety. Other safety features (such as railings or textured sidelines such as ‘rumble strips’) were not included because the absence of these features may be due to a perceived lack of need rather than unsafe conditions.

The HVIR Framework was designed to allow these service attributes to be determined by a range of methods to accommodate both state, territory and local government road agencies. The formulas and constants are not elaborated on in this section since the methods have been modified in the current project. These changes are discussed in Section 3 and a complete and up-to-date presentation of the calculation methods are presented in Appendix A.

The calculation of the rating did not consider what class of road was being assessed. This was deliberate to provide a consistent measure of the suitability of the infrastructure for heavy vehicle use. However, a means of interpreting the HVIR in terms of the current road class was required since the expectations for a road will vary depending on the function of that road in the network.

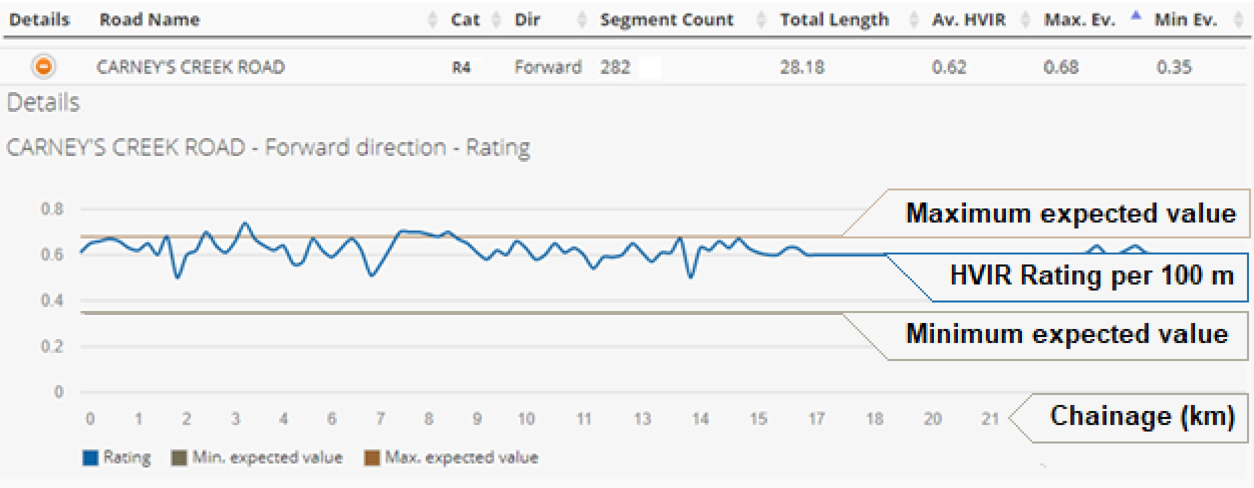
Therefore, for each road category (determined as described in Section 2.2), these expectations were expressed through the following two values:

Minimum expected value – the lowest standard of HVIR expected for this road function.

Maximum expected value – the highest reasonable standard of HVIR expected for a road of this function.

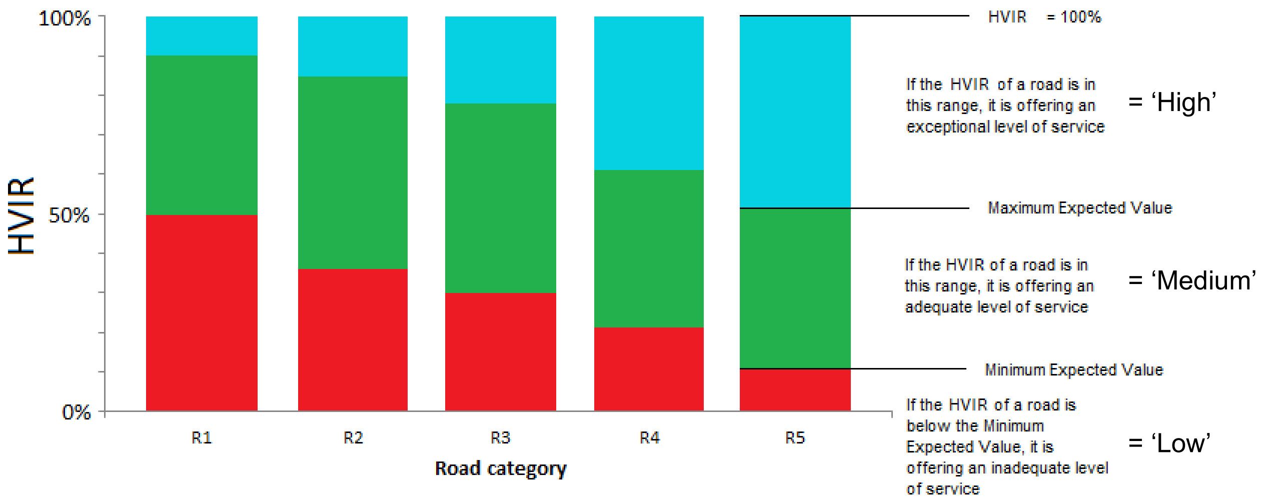
These expected values allow a relative interpretation of HVIR as shown in Figure 2.3. In the case where a road's category is being changed, the expected values, and the way in which they are determined, provide guidance on what features need to be upgraded and to what extent (assuming that the change is to a higher level road category) to maintain an above-minimum standard.

Figure 2.3: Screenshot from the HVIR Tool showing the results for a road plotted against chainage and the minimum and maximum expected values for this road category



The expected values define ranges of low, medium, and high as shown in Figure 2.4, which provides a broad indication of the expected performance of the asset considering its function in the network.

Figure 2.4: Demonstration of interpretation of HVIR based on the road categories



2.4 Transition to the Extended Project

Based on the success of AT1920 and the ongoing needs of the HVRR, Austroads project AAM6068 was commissioned as an extension of the project work achieved in AT1920. The extension project was for three years with 2017–18 being the first year.

The initial aims of the project were to:

- continue annual updates and publication of the Asset Register and HVIR on the Transport and Infrastructure Council web page

- extend the Asset Register and HVIR to include a growing sample of significant local government roads
- align the Asset Register and Austroads Data Standard
- continued improvement of data sharing functions for the Asset Register, and the HVIR Tool and calculations.

These aims were to be reviewed at the completion of each year to ensure the project was still delivering on the needs of the HVRR.

3. First Update to HVIR Calculation Methods

During project AT1920, the concepts of basic and advanced/sophisticated calculation methods for the HVIR were described. Basic parameters were intended to rely on simple data that smaller local governments could collect, while advanced parameters were designed to utilise richer sources of data. However, at the end of project AT1920, the calculation methods used for the HVIR were a mix of these concepts, being determined by the data that was available during the earliest stages of the development of the HVIR with the Queensland Key Freight Route dataset.

During the first year (2017–18) of the extension project AAM6068, the suite of calculation methods was further developed. A description of the rationale for each of the first-round updates is found in Appendix A.

In brief the changes to the calculation suite were:

- turning on the By Limits method for calculating Heavy Vehicle Access as data on vehicle mass and length limits became available
- adding the By Austroads Vehicle Class (AVC) method for calculating Access to accommodate local governments
- adding the By HATI Calculation Method for Ride Quality to provide the option for a heavy vehicle specific measure of roughness in addition to the existing By IRI method
- adding the By Subjective Comfort Speed (SCS) method to accommodate local governments
- revising the way the By Road Geometry method was calculated for 'Safety'
- adding the By ANRAM Calculation Method to allow more sophisticated calculation of Safety.

These changes were an effort to provide calculation methods suitable for datasets from both state and territory road agencies and local governments.

4. HVIR Framework Technical Review

4.1 Purpose of the Technical Review

The technical review of HVIR was focused on gaining input and ultimately agreement on the details of the framework in terms of a number of key aspects such as:

- what data is used to calculate HVIR
- the relative contribution of different types of data
- how the outcomes are interpreted and reported.

The technical review of HVIR was conducted through two major activities:

- General feedback sourced from an Assets Task Force (ATF) session in Hobart on 18 February 2019 and other discussions/correspondence. The discussion within the session at the ATF meeting was structured around three main points:
  - national road classification (see Section 4.2.1)
  - bridges and other structures (see Section 4.2.2)
  - the best use of HVIR results (see Section 4.2.3).
- Responses to an online survey (See Section 4.2.4) that ran from 22 April to 26 July 2019.

The feedback was collected and analysed to produce a number of recommendations on how the HVIR Framework should be amended. These amendments are documented in Section 4.3.

4.2 Technical Review Responses

4.2.1 National Road Classification

The discussion on national road classification was prefaced by a description of the current road categories used to interpret HVIR results, and an example of inconsistent categorisation for roads continuing across state borders, and examples of alternative functional road classification systems.

The need for a national, consistent system of road classes was reiterated – with the additional point made that however roads are classified, the classification needs to be forward-looking to represent what is needed as the network grows based on both modelling of the economic benefits and the strategic priorities of roads.

It was generally agreed that the current approach of using road inventory data (e.g. carriageway description, number of lanes, whether the road is sealed or not, etc.) to categorise the road was not desirable in the long term, instead a functional classification should be used. It was noted that this functional classification should be able to account for the role of the road, e.g. roads in remote areas are important links in the network if they are the sole means of access to otherwise isolated areas, regardless of their structure or traffic volume.

The development of a simple, four-class, functional road classification system by Institute of Public Works Engineering Australasia (IPWEA) (2015) was used, with one of the outcomes being that engineers on the ground need a definitive identification of road assets.

The IPWEA experience provides an example of one of the problems raised with regard to a national classification of roads, which is that roads tend to be classified within state and territory jurisdictions based on the intended use of such classifications, with some jurisdictions having several road classification systems.

It was agreed that whatever road classification system is proposed to be used, the impact of the HVIR ratings need to be able to be reviewed before a final decision is made.

It should be noted that the road categories used in HVIR were developed prior to the November 2018 agreement by Ministers to develop national service level standards for roads. This is now a key part of the HVRR, and these standards will be based on nationally consistent, customer-centric road classification based on the different functions of roads. This will at some point supersede the HVIR road categories.

4.2.2 Bridges and Other Structures

The discussion on bridges and other structures was prefaced by a description of the current lack of any specific assessment of structures in the HVIR with three proposed approaches outlined as follows:

- Treat the structure as a continuation of the road and assess it in the same way.
- Develop alternative calculation methods for structures.
- Do not include structures in HVIR results.

It was agreed that as part of the network, some form of the HVIR result needs to be generated for bridges and structures. However, for this to be implemented, more detailed data about structures than is currently being provided is needed.

The Access level currently used as an input for HVIR is intended to be the Access level by Notice rather than the actual capacity of the asset. This should also be the case for structures to avoid higher access than the road agency wants to be generally allowed being represented through the HVIR (higher access may still be available through application of permits).

4.2.3 The Best Use of HVIR Results

The discussion on the best use of HVIR results was introduced by questions related to the following: the accuracy and reliability of the HVIR results; potential applications of the HVIR results; and the consideration of any risks associated with the use or publication of the HVIR results.

It was agreed that the reliability of the data is critical, especially when the data/ratings are available to the public. To avoid the data/ratings being misunderstood and/or misused, the outputs need to be well-defined and well-understood.

While the HVIR results include access information, the ratings do not represent access for the purposes of route-planning, and therefore may not be of interest to industry. The ratings are, however, intended to inform investment in the road network. It was mentioned that any inputs to investment need to focus on the network as a whole, rather than particular sections in isolation, and allow performance of the asset to be the key driver of investment rather than the type of asset.

If the HVIR results are to inform road investment, there needs to be a clearer or more detailed indication of what the ratings for a road should be (i.e. as determined by performance goals).

4.2.4 Online Survey Results

Respondents were sought from all state and territory road agencies and other organisations with a state or federal role. The response to the voluntary survey was far less than hoped. While limited, the response tended to support the same views as expressed during the ATF meeting.

One important issue was raised in relation to how Access was calculated, with the southern jurisdictions effectively being penalised for not allowing the longer and heavier vehicles that are permitted in northern and central jurisdictions. As a consequence, roads in southern jurisdictions were unable to achieve higher values of the Access Index *A*. This was addressed in the next round of updates (see Section 5).

4.3 Implementation of Updates to the HVIR Framework

4.3.1 Revised Service Attribute Weighting

The survey results seemed to indicate an equal weighting should be implemented. This appeared to be largely based on a perception of the then so-called ‘safety’ service attribute as more than the simple consideration of leeway defined by the amount of transverse space the vehicle can safely manoeuvre in.

While the original justifications for the weightings was not robust, it was decided that the question of weightings should be revisited once changes to service attributes and calculation methods are finalised and well-understood.

4.3.2 Revised Expectations for the Access Index

The feedback on how Access is measured within the HVIR Framework suggested diverse opinions about how it should be approached. The key concern seemed to be that some jurisdictions felt that their roads were rated ‘poorly’ because they did not offer as high a level of access to heavy vehicles as other jurisdictions. While the comparative appearance of the rating is an accurate reflection of the access levels allowed across Australia, it is true that the upper end of the scale accommodates a very small percentage of the heavy vehicle fleet, usually operating in northern and central areas of Australia.

After consideration of all the feedback, the Project Team decided on the following:

- There should be no change to the principle that the measure of access is against the longest and heaviest vehicle combinations as defined by the National Heavy Vehicle Regulator (NHVR).
- All values used within calculation methods and for setting expectations against road categories should be updated to be compliant with the latest limits defined by the NHVR.
- The expectations for Access should be reviewed to better reflect the actual vehicle classification and road use characteristics. For example, 99% of the registered heavy vehicle fleet are combinations with a load limit no greater than 100 tonnes. The consequence of this would be an ‘improvement’ in the interpretation of Access for most jurisdictions.

4.3.3 Revised Calculation of Ride Quality

The HVIR Framework should always be updated to implement any nationally consistent schemes. The interpretation of the Ride Quality Index (R) against road categories is currently largely arbitrary. Therefore, it was recommended that the calculation methods using IRI and HATI should be brought in line with any national pavement construction and intervention standards when they are introduced.

The SCS calculation method was not included in this survey as it was intended for local governments. However, local governments had elsewhere indicated that they are unlikely to collect the additional data this calculation method relies on. Therefore the SCS calculation method was removed from the HVIR Framework.

In the case of unsealed roads, the feedback given was that the HVIR for unsealed roads should include Access and Leeway only, since ride quality as an annually collected measurement is of limited use on an unsealed surface.

4.3.4 Revised Concept for Safety/Leeway

The following changes were designed to improve understanding of this Service Attribute, and to allow it to be able to be calculated for road configurations beyond sealed roads with linemarking.

This includes the deletion of some calculation methods that were included as ‘safety’ indicators, based on the treatment of Leeway as a proxy for Safety. Now that this Service Attribute is being strictly limited to a measure of Leeway, calculation methods based on Safety are no longer appropriate.

It was decided to:

- change the name of the Service Attribute Safety (S) to Leeway (W)
- remove the unused ANRAM-based calculation method from the HVIR Framework
- remove the subjective speed-based comfort calculation method (SCS)
- implement Leeway calculation methods for roads that are:
  - sealed roads without linemarkings
  - unsealed roads
  - remote, low traffic roads with sealed strips that are designed to accommodate a single direction flow at any one place/time (vehicles passing each other utilise unsealed areas) – roads of this nature are present in the Northern Territory (NT) and are being phased out.

The basis for the updates following the technical review is elaborated on in Appendix B, and the final calculation methods for HVIR are contained in Appendix D.

4.4 Alternative Representation of HVIR

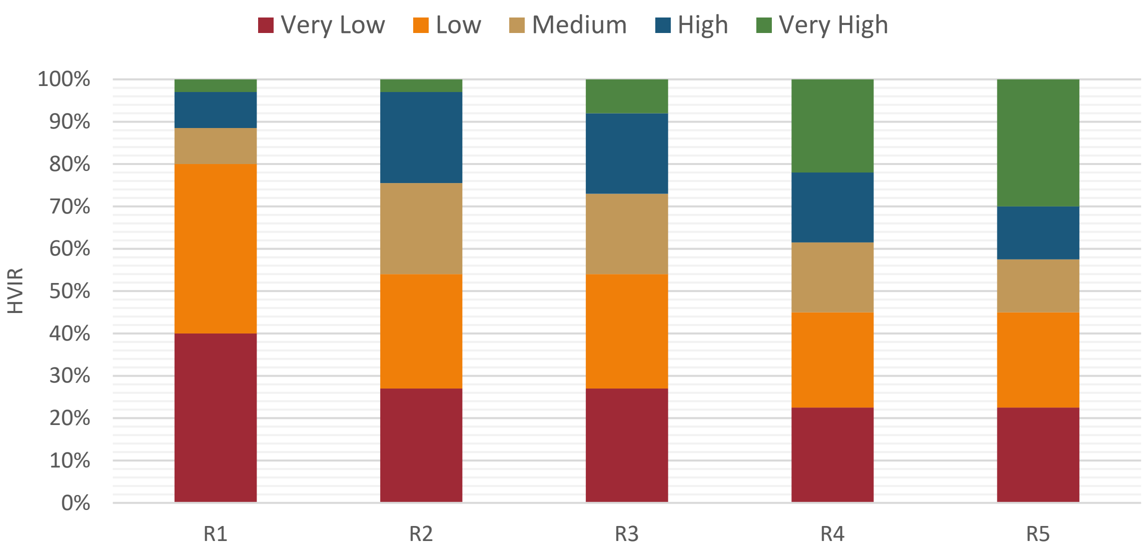
Some feedback was given that expressing the HVIR across a one to five scale could be useful since these scales are commonly used as indicators of infrastructure performance.

Table 4.1 shows a translation of the three HVIR levels into a five-level representation by splitting the ‘Medium’ and ‘Low’ categories into equal halves relative to their limits in each road category. This is shown graphically in Figure 4.1. This is simply an alternative representation that does not require any change to the underlying calculations.

Table 4.1: Interpreting HVIR across 5 levels, linked to maintenance strategy

Current HVIR levels		Five-point levels	
High	Asset is above expectations for its road category	Very high	Asset is performing well above expectations
Medium	Asset is meeting expectations for its road category	High	Asset is performing to a high quality
		Medium	Asset performance is adequate
Low	Asset is below expectations for its road category	Low	Asset performance is inadequate
		Very low	Asset is failing to provide sufficient service

Figure 4.1: HVIR levels if interpreted by the 5 levels linked to maintenance strategy



5. HVIR Calculation Tool and Open Source Code

5.1 Purpose of the HVIR Tool

The HVIR Tool was developed as a proof of concept for a data supply process intended to allow road managers to upload the data required to calculate the HVIR. The tool allows feedback to the road managers of information about gaps and errors in the data for them to address to achieve compliance with the specification. There are two types of users or perspectives on data-sharing within the system. In practice these groups overlap:

- **Asset owners** such as road agencies (RAs) and local governments (LGs) which have direct responsibility of the road assets and related inventory and condition data.
- **National perspective users,** primarily state, territory and Commonwealth officials working on HVRR, using the data to support commitments to open data and transparency under HVRR.

The tool was designed to provide features for the asset owners who each had an account in the Road Manager's Toolbox which hosts the HVIR Tool, to support uploading of data.

5.2 HVIR Tool Feature Updates

During project AT1920, the core functions of the data supply process, uploading and displaying data, had been established. In 2017–18, the main focus of development was on the HVIR Tool features to support supply from state, territory and local agencies. This involved features to support several key activities in the workflow as follows:

- While the default format of data is specified, and the Data Standard, when implemented, should see consistency in the reporting of data, it was anticipated that not all data would always conform to these requirements. This is especially true during the initial stages of this project. Therefore, the ability to map required data to inputs not in the requested format was included.
- A range of calculation methods are provided to accommodate different levels of sophistication in the available data. Additional calculation methods and updates to existing calculation methods for HVIR were implemented, as discussed in the next section. Details of the calculation methods are provided in Appendix D.
- Features related to the interrogation of results were added to allow users to identify causes for the ratings. This includes the ability to track backwards from ratings, to service attributes and to the input data. Users can either start by selecting a section on the main map, or by searching the table of results as these have been made to be interactive and connected.
- In the future it is anticipated that there may be a need to view expenditure and other data on a map alongside the ratings and use potential features that exploit the ratings and expenditure data. In preparation for this, an expenditure data layer was added as a placeholder. The information that it will contain and how it is to be displayed remains to be determined.
- Subsequent to the creation of ratings, it may be desirable to update some of the input data (i.e. new condition data or corrections) rather than repeat the setup of the entire process. A feature was developed to allow input data to be updated within an existing assessment. Ratings then need to be regenerated to overwrite the previous ratings.
- An additional action subsequent to the creation of ratings is to append more locations and feature data. This would be used if data for additional roads became available or new freight routes were identified in the network and needed to be included. This function has also been added.

In addition, there were developments to add help information, ensure browser compatibility and address bugs.

With these developments, the HVIR Tool was made ready to take over from the older Excel-based version of the Asset Register. Further development in the data supply process will rely on feedback from national users, RAs, and LGs. However, these further developments are not intended to create a system that individually accommodates the idiosyncrasies of each asset owner, but rather features that facilitate all users to supply data without issues.

Development to the end of June 2019 was focused on developing and refining features for asset owners, including state, territory, and local government users, as well as expanding the HVIR calculation methods to account for additional data (e.g. data typically collected by local government) and road types (unsealed and unmarked roads).

Table 5.1 contains a summary list of each major update of the HVIR tool since August 2016. There were also numerous bug fixes undertaken as needed. An expanded version of this table is shown in Appendix C.

Table 5.1: Summary of version/feature updates for the HVIR tool

Version	Capabilities	Date completed
V1.0 Demonstration	Online demonstration showing the appearance and workflow: uploading data, calculating HVIR and displaying results.	2 August 2016
V1.1 Core functions	Functional version of online tool that performs calculations (single user only).	30 December 2016
V1.2 Supporting functions	Expansion of supporting functions for a single, state-level user.	28 April 2017
V1.3 Readiness for live trial with Queensland Department of Transport and Main Roads	Support for multiple state-level users (i.e. separate accounts) and minor features for improved workflow.	26 May 2017
V1.4 Readiness for initial release	Features and support for users.	22 December 2017
Project Year 1 pre-release	Improvements to workflow and features for asset owners.	7 March 2018
HVIR tool released to RAs		9 April 2018
Project Year 1 post-release	General user improvements.	19 June 2018
	Features for LG users.	
Project Year 2	Improvements in response to LG technical pilot and implementation of data downloads.	4 December 2018
	Extended capability to handle exceptions, unmarked and unsealed roads, expanded data downloads, and visualisation of data.	14 June 2019

5.3 Development of HVIR Open Code

The HVIR tool was designed for asset owners to submit data related to their roads, but also served as a test bed for more generic processes from other organisations which could not access the online tools designed for authenticated users. A generic process for supplying data to ongoing data supply processes from 2020 onwards in an open, harmonised data environment was required.

Current Asset Register data collection processes require road asset owning organisations to manually prepare and submit data to the HVIR Tool, which is then extracted and sent to the Commonwealth for release on the TIC website. Similar data is also increasingly released separately on jurisdiction open data portals, however:

- Open data released on jurisdiction portals is currently less nationally consistent, with varying levels of completeness and detail.
- Implementation of a national road data standard is in the early stages.

As data management under HVRR and in jurisdictions moves towards being more open and nationally harmonised, the focus is moving to open, accessible data and technical standards underpinning a nationally consistent road asset register that will need to:

- be openly available
- contain sufficient detail and be complete
- include transparent data quality, completeness checks and ratings
- most likely appear in multiple datasets provided by the appropriate organisations, that can be easily 'linked' by end users, rather than a single large spreadsheet with many field columns
- have consistent identification/referencing across the jurisdiction.

Ongoing future processes in support of HVRR need to support jurisdictions to prepare nationally consistent datasets using openly available clear data standards and publish them directly on their own open data portals. This is in line with leading data management practices where data release occurs as close as possible to the data ownership. There is planned be a governance structure with clear roles for RAs as data custodians, and ongoing participation in developing and improving transparent national data standards and definitions.

To support these outcomes, the project progressed to:

- Developing the HVIR as an open source code (in Python), so that any stakeholder with appropriate road asset register data, can download the HVIR code and apply it to their own data, including making innovations and adjustments as desired. This included an associated User Guide explaining the development and application of the HVIR.
- Developing a HVRR road asset register template and technical 'interface specifications' that include clear data standards and definitions for all asset register fields. This would enable any stakeholder with road asset data to prepare a draft road asset register, and perform a simple, transparent check to generate a report on data format, quality, and completeness.

The HVIR code runs through the data according to various criteria and provides an assessment of how valid the data is. The validation checks are detailed in Table 5.2.

Table 5.2: List of validation checks

Statistic	Check	Description
Accuracy	Format	Attribute by attribute check of the format of supplied data (i.e. usable for the intended application)
	Range	Attribute by attribute check if the data content is within the expected range for the variable
Completeness	Number of attributes supplied	Number of attributes supplied compared to the data specification
Timeliness	All fields	Distribution of the 'age' of the data (time since collection) for each field (column) (where applicable)

The outputs of these validation checks include:

- the percentage of blank attributes
- the percentage of supplied but inaccurate attributes
- the percentage of accurate attributes
- distributions of the age of the data for condition and financial data.

The HVIR code and operating guide with the data specification are available on request.

6. Conclusion

The HVIR Framework presents a means of calculating the level of service provided by the road asset to heavy vehicles, based on key data inputs related to the access level, the ride quality and the leeway or clearance provided to heavy vehicles. The HVIR can provide a performance-based indication of roads across Australia that allows valid comparison of different freight routes for the purposes of setting standards or informing heavy vehicle charges.

The framework has been designed with basic principles that allow it to be able to be adapted in the future to include additional service attributes and calculation methods based on new data sources.

The current project has produced the HIVR Framework in three forms:

1. as a documented process that can be implemented in any existing systems (see Appendix D and Appendix E)
2. as an online tool currently hosted in the Road Manager's Tool for authorised users
3. as source code in Python which can be adapted to any dataset to produce HVIR.

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Appendix A First Round Updates to HVIR

A.1 Updates to the Calculation of Access

The By Limits method was devised during project AT1920 to assess the level of access provided by a road section in terms of the gross mass limit of the pavement, and the vehicle length limit imposed by the geometry of the road. It eventuated that most (asset) road managers within road agencies usually did not have access to this type of data, which was instead held by heavy vehicle access groups within the road agencies.

For the current project, the By Limits method was retained as a means of representing the permitted capacity of the network; however, additional methods were included to allow the access level to be determined by simpler means.

The simpler method for setting heavy vehicle access utilised Austroads vehicle classes, which are determined by considering the numbers of axles and axle groups. By entering the highest Austroads vehicle class (AVC) permitted to use the road, an equivalent value of Access (*A*) as would be calculated by the largest vehicle in that Austroads class, is produced. This method of setting Access was considered appropriate for local governments to implement without having to undertake access assessments.

A default value was calculated based on the value of HVIR as calculated by limits for general access. The current value for this limit is $A = 0.35$.

A.2 Updates to the Calculation of Ride Quality

IRI is collected by all RAs across their networks; it is one of the key indicators of pavement condition. Therefore, IRI was initially used as a proxy for ride quality in project AT1920. The issues with the continued use of IRI are that:

- roughness (a quality of the road surface) is not exactly the same as ride quality (the subjective experience of riding in a vehicle)
- IRI is based on a quarter-car model and is therefore unsuitable for heavy vehicles
- collecting IRI is beyond the financial means and interest of most LGs.

To address the first two issues, a heavy-vehicle specific indicator of ride quality was sought. The most accepted indicator of this type seems to be the Heavy Articulated Truck Index (HATI), which is effectively a half-truck model (Hassan, McManus & Cossens 2006). Ride quality, *R*, determined using the HATI method is based on the same concept as the IRI method, where the index (both use m/km) is mapped in the range 0 to 1.

While HATI is an improvement over IRI, it still produces one value to represent the ride quality experienced by all heavy vehicles. Austroads project AAM2106 refined the development of an index intended to capture the range of ride quality experienced by the entire fleet of heavy vehicles. This was called the Fleet Ride Index (FRI), previously referred to as the Heavy vehicle Roughness Band index (Austroads 2012). It endeavours to be an improvement on HATI by offering a more useful and accurate measure. If FRI is accepted as a measure of ride quality for heavy vehicles, then it could be included as a calculation method for the HVIR in the future.

The final issue is that all these measures of roughness, or ride quality, are not usually collected by LGs. Therefore, there was a need to devise an indication of roughness that LGs could collect with limited available resources. The result was the Subjective Comfort Speed (SCS) measure, which allows roads to be assessed by driving in a passenger car and rating the highest safe and legal speed at which the ride remains subjectively comfortable. This speed is compared against the speed limit. If the SCS is less than 80% of the speed limit, then the road is given a value of *R* that is in the middle of the 'low' range of *R* as determined by IRI. If the SCS is greater than 80%, then *R* is set to the middle of the 'medium' range of *R*.

It was later found that LGs were not motivated to collect the data required for this measure to be determined. Therefore, this calculation method was ultimately removed.

A.3 Updates to the Calculation of Safety/Leeway

Based on the findings from previous projects, Safety/Leeway was determined in project AT1920 by considering lane widths and sealed shoulder widths. How this was calculated involved two iterations, with the current method explained in Appendix D. This 'by geometry' method was retained as it is feasible for local government to collect data for their freight routes at the narrowest width.

There are more sophisticated measures of safety, and it was desirable to include one of these at the time of the first review (although this was later retracted – see Sections 4.3.4 and D.4.4). Measures such as star ratings and AusRAP (Australian Automobile Association 2013) were reviewed but considered unsuitable because they are generally limited to National Highways and involve crash data rather than being limited to infrastructure data only. The Australian National Risk Assessment Model (ANRAM) was selected and values of vehicle star rating system (VSRS) for roads mapped to the range 0 to 1. This includes, amongst other infrastructure data, the width of lanes and sealed shoulders (ARRB 2014).

Appendix B Technical Review Updates to HVIR

B.1 Development of the Detailed HVIR Framework Updates

B.1.1 New Calculation Method and Expectations for the Access Index

Updating the mass index calculation

The calculation of the Access index *A*, is based on an underlying calculation of a Mass index *M* and a Length index *L* as shown in Equations A1 and A2:

$$M = \frac{(Vehicle)\ Mass\ limit\ of\ road\ (t)}{HIghest\ legal\ vehicle\ mass\ (t)}\ 0 \leq M \leq 1 \qquad \text{A1}$$

$$L = \frac{(Vehicle)\ Length\ limit\ of\ road\ (m)}{53.5\ m}\ 0 \leq L \leq 1 \qquad \text{A2}$$

Both of these measures are intended to measure the actual limit of the road against a theoretical maximum limit for the road. The previous value of 119 tonnes for the highest legal mass limit was taken from Queensland regulations on mass and dimension limits for heavy vehicles that are now superseded by national limits defined by the NHVR.

While the maximum theoretical limit for a heavy vehicle based on axle spacings is 172.5 tonnes for a 53.5 m vehicle (see: https://www.legislation.qld.gov.au/view/whole/html/inforce/current/sl-2013-0077), it is desirable to use common vehicle configurations to set limits. For this purpose, the General Mass Limit of an 18-axle ABB-quad configuration from NHVR documentation has been used (NHVR 2019, 2020). This sets the maximum limit at 122.5 tonnes.

Using this value creates a new Equation A3 for the calculation of the Mass Index.

$$M = \frac{Mass\ limit\ of\ road\ (t)}{122.5t}\ 0\ \leq\ M\ \leq\ 1 \qquad \text{A3}$$

The Length index is unchanged as 53.5 m remains the maximum length limit under the current NHVR rules.

Changes to the Austroads Vehicle Class (AVC) calculation method

The changes to the By Limits calculations also change the ranges for the Austroads Vehicle Classes, which are based on calculating the Access Index according to the NHVR limits for vehicles matching the description of Austroads Vehicle Classes. The updated table of these values is shown in Table B 1. None of these changes were greater than 0.01 when rounded to 2 decimal places.

Table B 1: Updated Access index when selected by Austroads vehicle class

Austroads class	Previous values of *A*	New values of *A*
3	0.17	0.16
4	0.21	0.21
5	0.22	0.24
6	0.26	0.25
7	0.30	0.29
8	0.34	0.34
9	0.36	0.35
10	0.50	0.50
11	0.75	0.75
12	1.00	1.00

Changes to Assumed Access

Assumed (General) Access is still based on Austroads Vehicle Class (AVC) of 9, which now corresponds to A = 0.35 as shown in Table B 1.

Modifying mass and length limit expectations

The above change has minimal impact on the value of the Access Index calculated. To bring the interpretation of Access more in line with actual road use (i.e. to not be weighted so heavily towards the minority of very long and heavy vehicles), the best way to achieve this is to modify the expectations for Access on each road category.

According to the Australian Bureau of Statistics (ABS 2019) in that year only around 1% of all heavy vehicles nationally were registered to have a total mass greater than 100 tonnes, and at most account for 3.52% of vehicles in Queensland (see Table B 2). This makes a case for limiting the maximum expectation (for road categories R1, R2 and R3) to 100 tonnes. The greater capacity offered by some roads would still be registered in the actual value of the Access Index, but the interpretation of the Access Index would not be skewed by this small percentage of very heavy vehicles.

Table B 2: Heavy vehicle registration numbers for various gross combination mass limit ranges

Jurisdiction	Vehicle gross combination mass range					
	Up to 20 t	20 to 40 t	40 to 60 t	60 to 100 t	> 100 t	% over 100 t
NSW	121 415	29 729	5 529	14 843	1 608	0.93%
Vic	93 060	28 245	7 990	18 037	3	0.00%
Qld	89 986	23 436	4 378	12 119	4 742	3.52%
SA	23 436	7 222	3 141	4 157	1 153	2.95%
WA	54 702	17 556	14 371	190	23	0.03%
Tas	10 659	2 634	590	1 025	36	0.24%
NT	4 272	1 189	112	249	–	0.00%
ACT	2 416	519	46	103	–	0.00%
National	399 950	110 530	36 157	50 723	8 332	1.38%

Source: ABS (2019).

The minimum mass limit expectation for roads R1, R2 and R3 (which also defines the maximum expectation for R4 roads) was previously set at 99 tonnes, also based on the superseded documentation. The current NHVR limit for vehicles up to 36.5 m is 88.5 tonnes (GML).

The lower length limit for R4 roads was previously set to 25 m for a B-double. The NHVR limit for B-doubles is set to 26 m. Therefore, the expectations for the Length limits have been updated accordingly for the minimum expectation for R4 roads (which also defines the maximum expectation for R5 roads).

The summary of the changes discussed above are:

- The maximum expectation for road categories R1, R2 and R3 was changed from 119 to 100 tonnes.
- The minimum expectation for road categories R1, R2 and R3 and the maximum expectation for R4 roads, was changed from 99 to 88.5 tonnes.
- The lower Length limit for R4 roads was changed from 25 m to 26 m.

Table B 3 shows the previous values for the expectations by road category, and Table B 4 shows the updates discussed above.

Table B 3: Previous expected values for the Access Index

Road category	General description of category	Mass limits (tonnes)		Length limits (m)		Access Index (*A*)	
		Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value
R1	Freeways	119	99	53.5	36.5	1.00	0.99
R2	Urban highways	119	99	53.5	36.5	1.00	0.99
R3	Urban arterials and rural highways	119	99	53.5	36.5	1.00	0.99
R4	Collector and distributor roads	99	62.5	36.5	25	0.99	0.81
R5	Access roads	62.5	50	25	19	0.81	0.68

Table B 4: Updated expected values for the Access Index

Road category	General description of category	Mass limits (tonnes)		Length limits (m)		Access Index (*A*)	
		Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value
R1	Freeways	100	88.5	53.5	36.5	0.90	0.70
R2	Urban highways	100	88.5	53.5	36.5	0.90	0.70
R3	Urban arterials and rural highways	100	88.5	53.5	36.5	0.90	0.70
R4	Collector and distributor roads	88.5	62.5	36.5	26	0.70	0.50
R5	Access roads	62.5	55.5	26	19	0.50	0.40

B.1.2 New Calculation Methods for the Ride Quality Index (*R*)

Updating the ride quality index calculation

The previous relationship between IRI and ride quality was based on a straight line drawn between *R* = 1 at IRI = 0 m/km, and *R* = 0 at IRI = 10 m/km. This is defined by the relationship in Equation A4. The range of 0 to 10 m/km was selected to cover a realistic span of IRI values, with these terminals being the theoretical minimum (0 m/km is perfect smoothness) and a level of roughness a road should never be allowed to degrade to (10 m/km).

$R = -0.1 \times IRI + 1$ $0 \leq R \leq 1$ (Note, this equation has been superseded by Equation A5) A4

The basis for the new Ride Quality Index calculation would ideally reference national standards on the smoothness of new road constructions/resurfacings and intervention triggers. However, such national standards currently do not exist.

The Austroads *Guide to Asset Management* (Austroads 2018) does provide indicative roughness levels for different road types as shown in Table B 5.

Table B 5: Indicative levels of roughness

Road function	Typical maximum desirable roughness (IRI m/km) for new construction or rehabilitation (length 500 m)	Indicative level of roughness (IRI m/km)	
		Isolated areas (of the network, i.e. < 500 m)	Length > 500 m
Freeways and other high-class facilities	1.6	4.2	3.5
Highways and other main roads (100 km/h)	1.9	5.3	4.2
Highways and other main roads (< 80 km/h)	1.9	6.1	5.3
Other local sealed roads	No limits defined	No limits defined	No limits defined

Source: Austroads (2018), Page 9, Table 1.2 (edited).

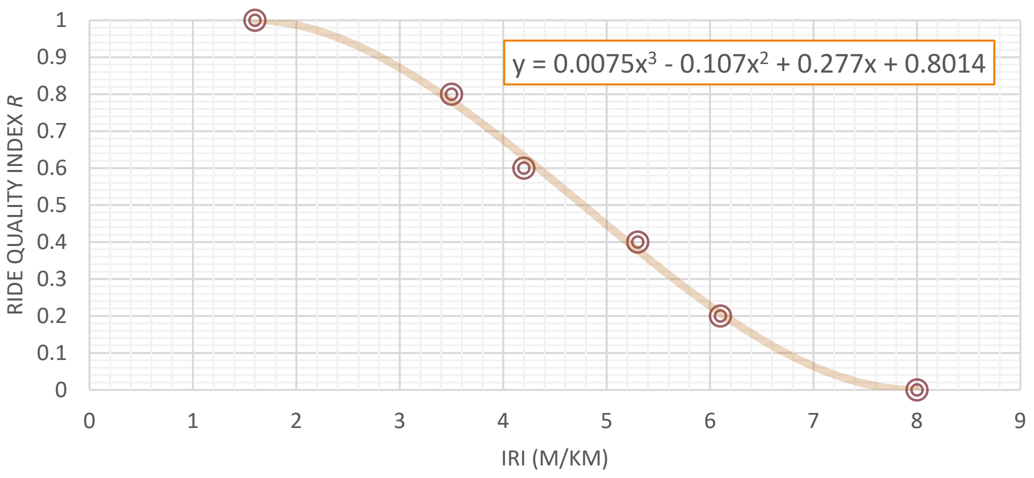
These values represent various standards of roughness, and therefore can be taken as points of significance. To associate these with the Ride Quality Index, they were varied evenly across the full range of *R*: 0.0 to 1.0 as shown in Table B 6. The roughness of 8 IRI corresponding to Ride Quality of zero has been selected by adding 1.9 m/km to the previous value of 6.1 m/km to reflect the 1.9 m/km gap (between 1.6 m/km and 3.5 m/km) at the other end of the scale.

Table B 6: Association of IRI with the Ride Quality Index

Points of significant roughness (IRI, m/km)	1.6	3.5	4.2	5.3	6.1	8
Distributed Ride Quality Index	1	0.8	0.6	0.4	0.2	0

When plotted (see Figure B 1), the third order polynomial of the trendline gives a new relationship between roughness and Ride Quality as shown in Equation A5, which replaces Equation A4 as the formula for calculating the Ride Quality Index from IRI.

Figure B 1: Relationship between roughness and ride quality based on indicative levels of roughness for different road types



$$R = 0.0075 \times IRI^3 - 0.107 \times IRI^2 + 0.277 \times IRI + 0.8014 \quad 0 \leq R \leq 1 \qquad \text{A5}$$

Updating ride quality expectations

The previous expectations for ride quality were based on dividing the 1 to 10 m/km scale of registerable IRI into parts in a largely arbitrary manner, anticipating that these expectations would be reviewed.

Feedback from the technical review of the HVIR indicated that the association of pavement performance measures with Customer Level of Service (CLoS) developed in New South Wales (then Roads and Maritime Services (Roads and Maritime) NSW) has been adopted by South Australia (Roux & Terris 2016) and is therefore a potential national approach.

NSW classifies their state road network with a ranking based on strategic priority, freight use, traffic volumes and travel speed. These classes are accompanied by descriptions of inventory in terms of carriageway and number of lanes (see Table B 7). All this information allows the road categories used in the HVIR to be roughly equated to the NSW road classes. While the NSW road classes are rural rather than urban road classes, the expectations for these roads extend from the highest standards of quality.

Table B 7: Description of Roads and Maritime road classes and equivalence to HVIR Road Categories

NSW Road Class	Daily traffic (average)	Heavy vehicles (average)	Speed limit (km/h)	Description	HVIR Road Category
6R	> 12 000	2 500	100 to 110	Class 6R roads are the principal rural State Roads and are almost entirely comprised of the National Highway Network. They are typified by the highest traffic volumes and serve interstate and strategic inter-regional functions with limited direct access. Typically, they have divided carriageways with 4 or more lanes.	R1
5R	12 000	1 200	80 to 110	Class 5R roads are significant rural State Roads. They are typified by high traffic volumes including freight, commercial vehicles, and public transport travel. They provide a high standard of travel and serve interstate and the inter-regional functions with direct access to abutting land controlled. Typically, they have divided and undivided carriageways with 2 or more lanes with frequent overtaking opportunities.	R2
4R	10 000	1 000	80 to 110	Class 4R roads are important rural State Roads. They are typified by moderately high traffic volumes including freight, commercial vehicles, and public transport travel. They provide a good standard of travel and serve some interstate, inter-regional and intra-regional functions with direct access to abutting land controlled. Typically, they have undivided carriageways with 2 lanes with overtaking lanes.	R3
3R	4 500	500	60 to 110	Class 3R roads typically do not contribute to the National Highway Network. However, they do provide a strategic freight function. They are typified by moderate levels of traffic volumes including freight, commercial vehicles, and public transport travel. They provide an acceptable standard of travel and serve inter/intra-regional functions.	R4
2R	1 500	250	60 to 110	Class 2R roads provide inter-regional and intra-regional connectivity and the strategic needs of freight. They are typified by low levels of traffic volumes. They provide a reasonable standard of travel and serve intra-regional and some inter-regional functions.	R4
1R	500	50	60 to 110	Class 1R roads are typified by very low levels of traffic volumes including freight, commercial vehicles, and public transport travel. They provide a varied but reasonable standard of travel and serve some inter-regional and intra-regional function.	R5

Source: Roux and Terris (2016).

NSW introduces CLoS through a matrix of the road class (implying a traffic volume) and the speed limit, populated with a range of CLoS Categories A to E, as shown in Table B 8.

Table B 8: Customer Level of Service category for various road classes and speed zones

Speed (km/h)	Subnetwork 1	Subnetwork 2	Subnetwork 3	Subnetwork 4	Subnetwork 5	Subnetwork 6
≤ 60	E	E	E	D	D	C
70	E	E	D	D	C	C
80	E	D	D	C	C	B
90	D	D	C	C	B	B
100	D	C	C	B	B	A
110	C	C	B	B	A	A

Source: Roux and Terris (2016).

The ranges of CLoS in Table B 8 can subsequently be equated to each of the HVIR road categories to produce an expected range of CLoS for each road category by considering the descriptions of the Roads and Maritime road classes and the speed limits. These CLoS categories can be used to determine the maximum and minimum expected values for each road category by determining the upper and lower limits of IRI for each CLoS category. These limits are determined by the boundaries of the Preventative Investigation Level and the Unacceptable Condition Level from the NSW approach, which provides the IRI values shown in Table B 9.

Table B 9: Determining expectations for IRI from CLoS categories in the NSW approach

HVIR road category (NSW subnetwork rank)	Highest speed (km/h)	Lowest speed (km/h)	Max. CLoS category	Min. CLoS category	Preventative investigation level IRI (m/km)	Unacceptable condition IRI (m/km)
R1 (6)	110	100	A	A	2.2	3.4
R2 (5)	100	60	A	D	2.2	4.6
R3 (4)	110	60	B	D	2.7	4.6
R4 (3)	80	60	D	E	3.5	5
R4 (2)	80	60	D	E	3.5	5
R5 (1)	50	40	E	E	3.9	5

The above traffic associations, the expected values of IRI and the subsequent calculation of the Ride Quality Index using Equation A5 are shown in Table B 10.

Table B 10: Updated expected values for the Ride Quality Index (*R*)

Road category	General description of category	Indicative traffic level (vehicles per day)	Speed limit range (km/h)	IRI (m/km)		Ride Quality Index (*R*)	
				Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value
R1	Freeways	> 12 000	100–110	2.2	3.4	0.97	0.80
R2	Urban highways	12 000	80–100	2.2	4.6	0.97	0.54
R3	Urban arterials and rural highways	10 000	80–110	2.7	4.6	0.92	0.54
R4	Collector and distributor roads	1 500–4 500	60–80	3.5	5.0	0.78	0.45
R5	Access roads	500	40–60	3.9	5.0	0.70	0.45

Calculation of ride quality index using HATI

The calculation method for *R* by HATI is unchanged due to being developed independent of the IRI method. It is, however, subject to the new expected values for ride quality as these are independent of the calculation method.

B.1.3 Changes to Calculation of Ride Quality Index using Visual Condition Grade (VCG)

Ride quality is affected by surface condition, and local governments often undertake visual assessments of pavement condition. This is usually limited to surface distress (cracks, stripping, potholes, etc.), but does not capture longer wavelength undulations of the surface that are the main cause of roughness at higher speeds. Visual condition inspections are therefore not a measure of roughness by any means but can be considered an indicator of roughness for lower speed roads, which many local government roads are.

The main benefit of these visual inspections is that they are already undertaken by local governments and are therefore a dataset that exists.

The Institute of Public Works Engineering Australia (IPWEA) has published a national uniform code for assessing road pavement condition in their *Practice Note 9* (IPWEA 2015) which describes a 0 to 5 grade scale for visual assessments of pavement condition.

The IPWEA scale was adapted to the HVIR Ride Quality Index (*R*) for roads in Categories R3, R4, and R5 only, and defined relative to the Maximum and Minimum Expected Values for *R* for each road category. The resulting values of *R* and how they are selected are shown in Table B 11, where the ranges of *R* referred to are shown in the last three rows of Table B 10.

Table B 11: Details of the Visual Condition Grade (VCG) Calculation Method

VCG	Condition	*R*			Justification
		R3 roads	R4 roads	R5 roads	
0	Not rated	–	–	–	No result
1	Very good	0.92	0.78	0.74	Top of expected (medium) range for an ‘as new’ road
2	Good	0.73	0.62	0.60	Middle of expected range
3	Fair/Moderate	0.54	0.45	0.45	Lower end of expected range
4	Poor	0.27	0.23	0.23	Middle of below expectations (low) range
5	Very poor	0	0	0	Surface has failed

B.1.4 The Leeway Index Calculation Method

Selection of Leeway calculation method

The Leeway Service Attribute using the By Geometry calculation method is unchanged (apart from no longer being called ‘Safety’). However, this method was intended solely for sealed roads with linemarking, as shown in Equations A6 to A8.

$$W_{Lane} = \frac{Width\ of\ lane\ (m)}{5.8}\ , 0 \leq W_{Lane} \leq 1 \qquad \text{A6}$$

$$W_{Shldr} = \frac{Width\ of\ sealed\ shoulder\ (m)}{3}\ , 0 \leq W_{Shldr} \leq 1 \qquad \text{A7}$$

$$W = \frac{(W_{Lane} + W_{Shldr})}{2} \qquad \text{A8}$$

Processes have since been developed to calculate Leeway for sealed roads without linemarkings and for unsealed roads.

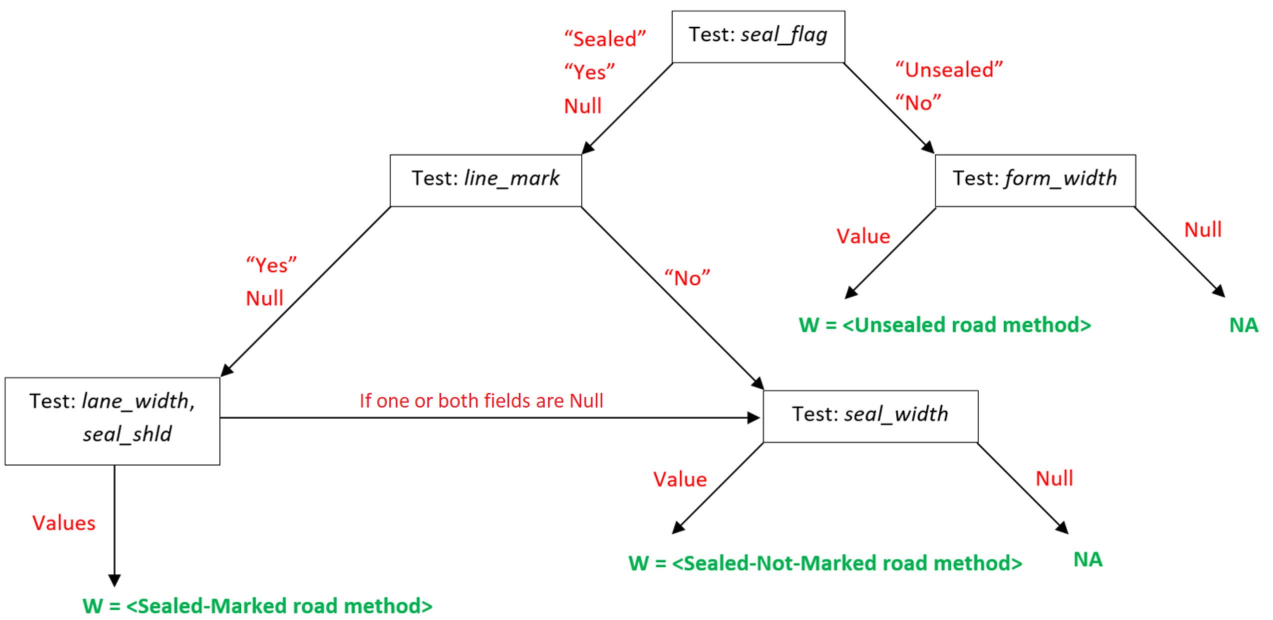
For Asset Register datasets developed elsewhere in this project, the identification of a road is by the use of 'Flag' columns in the dataset as shown in Table B 12.

Table B 12: Road type identification and selection of calculation method for Leeway

Seal flag	Linemarking flag	Road type	Required data
'Sealed'	'Yes'	Sealed road with linemarkings (this is the default road type)	• Lane width • Sealed shoulder width
'Sealed'	'No'	Sealed road without linemarking	• Seal width
'Unsealed'	N.A. *If the road is flagged as Unsealed, any data in the linemarking flag will be ignored.*	Unsealed road	• Formation width

To ensure the HVIR is calculated in the event of road type flags (seal and linemarking) not being populated, although the necessary data is present, a process to arrive at the appropriate calculation method has been implemented. The result will be *Not Available* (NA) only if the user uses flags to point at missing data, or if all data is missing. The default road type (i.e. if no flags are populated) is a sealed road with linemarkings which is the vast majority of the network. This process is illustrated in Figure B 2.

Figure B 2: Tests of data to select Leeway calculation methods



The process for dealing with unmarked and unsealed roads is to generate proxy lane and shoulder widths. The logic in both cases is that proxy lane widths should not be less than 2.9 m, and that at 5.8 m (double this minimum) even without lane markings drivers will tend to start to form two columns of traffic, therefore this is the maximum lane width. Below is a statement of the calculation rules for each case.

Calculating Leeway on unmarked roads

The following method (a variation of By Geometry) is applicable when the Seal flag is 'sealed'/'yes' and the Linemarking flag is 'no'. The input is the total seal width (TSW) in metres.

1. Assume half of the seal width (HSW) is for travel in each direction.
2. Take HSW and allocate up to 2.9 m as the lane width.
3. If there is any HSW remaining, divide it equally between additional lane width and sealed shoulder width, limiting lane width to a maximum of 5.8 m.
4. Add any additional HSW to the sealed shoulder width.
5. Once values for Lane Width (LW) and Sealed Shoulder Width (SSW) have been finalised, calculate Leeway with the By Geometry method.

Expressing these rules mathematically (all values in metres):

Half seal width (HSW) = TSW/2

If HSW ≤ 2.9	*Lane Width (LW) = HSW* *Sealed Shoulder Width (SSW) = 0*
If 2.9 < HSW ≤ 5.8	*LW = 2.9 + ((HSW – 2.9)/2)* *SSW = (HSW – 2.9)/2*
If HSW > 5.8	*LW = 5.8* *SSW = HSW – 5.8*

These values of LW and SSW input into the By Geometry method equation.

Calculating Leeway on unsealed roads

The following method (a variation of By Geometry) would be applicable when the seal flag is 'no'. The input is the total formation width (TFW) in metres.

Half formation width (HFW) = TFW/2

If HFW ≤ 2.9	*Lane Width (LW) = HFW* *Sealed Shoulder Width (SSW) = 0*
If 2.9 < HFW ≤ 5.8	*LW = 2.9 + ((HFW – 2.9)/2)* *SSW = (HFW – 2.9)/2*
If HFW > 5.8	*LW = 5.8* *SSW = HFW – 5.8*

These values of LW and SSW input into the By Geometry method equation.

Calculating HVIR for unsealed roads

The Standard calculation for HVIR is as shown in Equation A9:

$$HVIR\ (\%) = 100 \times (0.4A + 0.4R + 0.2W) \qquad A9$$

where

A = Access Index

R = Ride Quality Index

W = Leeway Index

Since roughness cannot be reliably measured for unsealed roads (the characteristics of the road surface can vary from day to day), feedback was provided to the effect that in the case of unsealed roads, the HVIR calculation should exclude Ride Quality as a Service Attribute and only use Access and Leeway. This alternative calculation would be activated by the Seal flag being set to 'Unsealed'/'No'.

For unsealed roads, the HVIR calculation is as shown in Equation A10.

$$HVIR\ (\%) = 100 \times (0.67A + 0.33W) \qquad A10$$

B.2 Impact of Updates to the HVIR Framework

The updates to the calculation methods and expected ranges of the Service Attributes will have the following key impacts:

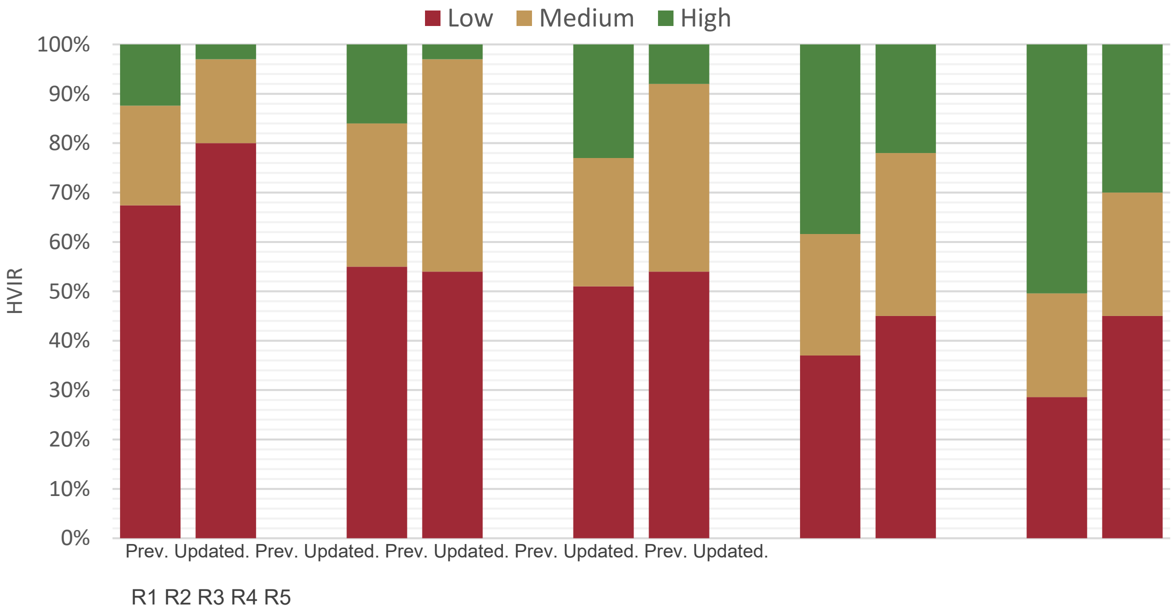
- **Access** – A given pairing of Mass and Length limits will have a slightly lower Access Index (*A*) result, but the expectations for Access on roads have been revised lower based on NHVR information, meaning that southern states with lower access levels (i.e. excluding the top 1% of longest and heaviest vehicles) are not 'penalised' so severely.
- **Ride quality** – The revised calculation methods produce a higher Ride Quality Index (*R*) for lower (smoother) values of IRI, and lower *R* values for higher (rougher) values of IRI. Expectations for Ride Quality have been raised significantly, meaning that 'Low' scores are more likely, potentially driving improvement.
- **Leeway** – The Leeway calculation is unchanged ('By Geometry' method) but has been expanded to handle unsealed and unmarked roads.

Overall, the results are generally to raise and narrow expectations for each road category. The maximum and minimum expected values for HVIR are shown in Table B 13, and Figure B 3 shows the ranges of High, Medium, and Low that are generated from these expected values.

Table B 13: Differences between the previous and new HVIR expected values

Road category	Previous HVIR levels		New HVIR levels	
	Max.	Min.	Max.	Min.
R1	88%	67%	97%	80%
R2	84%	55%	97%	54%
R3	77%	51%	92%	54%
R4	62%	37%	78%	45%
R5	50%	29%	70%	45%

Figure B 3: Differences between the previous and updated HVIR levels



To obtain an understanding of the impact of using an actual dataset, the upgraded framework was used to produce outputs for a state road network and compared to the result from a previous assessment. The dataset for South Australia was used because the dataset was more complete. A fraction of the results where no HVIR was produced was removed for clarity (this left the same number of records in both datasets: 84 337 rows).

The results of the comparison are shown in Figure B 4 and Figure B 5. At a network level, the results are similar as most records are categorised as 'Medium', but with increased numbers being classified as 'High' and 'Low'.

Figure B 4: Comparison of previous and updated HVIR statistics for SA

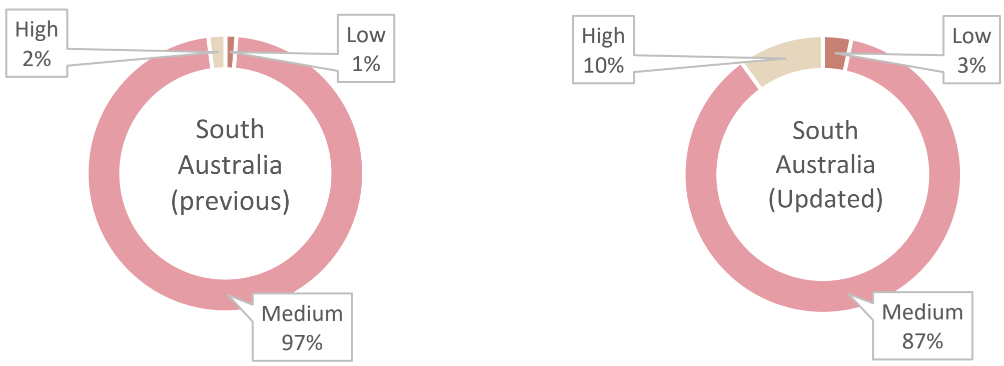
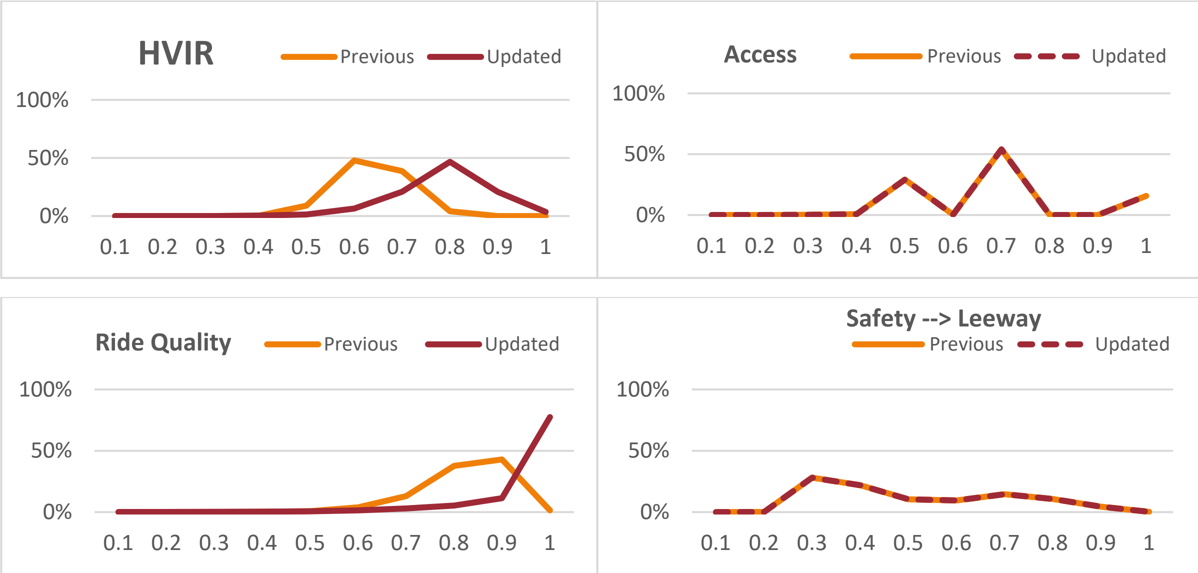


Figure B 5: Changes in distribution of HVIR results and in the contributing service attributes



Appendix C HVIR Tool Development History

Development history of the HVIR Tool is shown in Table C 1. Version numbers for the HVIR Tool were used when Big Cloud Solutions Pty Ltd was used as the developer, each version associated with a work order. Subsequent to December 2017, development of the tool is in-house and therefore largely continuous, especially in response to user feedback. Developments are thereafter grouped by financial year.

Table C 1: Detailed version/feature updates for the HVIR tool

Version	Capabilities	Date completed
V1.0 Demonstration	Online demonstration showing the appearance and workflow: uploading data, calculating HVIR and displaying results. The demonstration website had basic functionality such as displaying data in a grid, communication with a spatial database and other navigation controls. The website was intended to be a rapid prototype and demonstration for subsequent project phases.	2 August 2016
V1.1 Core functions	Functional version of online tool that performed calculations (single user only). Remote calculation capability for generating HVIR ratings was implemented, along with supporting features.	30 December 2016
V1.2 Supporting functions	Expansion of supporting functions for a single state-level user. 1. Design of file formats, network representation and back-end database design. 2. File upload capability that supported HVIR format. 3. Extension to multiple projects. 4. Database import and validation functions. 5. Basic project management functions. 6. Updated new project wizard to allow selection of uploaded files. 7. Mapping publishing functions (to Aperture). 8. Project level URL requests enabled a web location for results that have been generated to be provided.	28 April 2017
V1.3 Readiness for live trial with TMR	Support for multiple state-level users (i.e. separate accounts) and minor features for improved workflow 1. Improved responsive design. 2. Improved store management, deletion checks and lists of dependent projects. 3. Zoom-to button in table, which pans/zooms main map to current row. 4. Map get feature info popup and table highlighting of selected segments on map using nearest neighbour searching. 5. Ability to edit job metadata (name, code, description). 6. Implemented user accounts and security, service security, user permissions. 7. Added attribute filtering control to features table (basic on/off). 8. Local .CSV file download of HVIR segment ratings results table. 9. Shapefile network loading support. 10. Interactive map popups on maps. 11. Setup user accounts (ARRB, TMR test accounts).	26 May 2017

Version	Capabilities	Date completed
V1.4 Readiness for initial release	Features and support for users. 1. Added support for different level user accounts and permissions (national, state reviewer etc.). 2. Added support for multiple user accounts to single user ID (organisation level access). 3. Automated some user account tasks, setup user accounts for states/territories in admin section. 4. Implemented graphical user interface (GUI) help popups/tips for users that can be disabled in global user setting. 5. Additional workflow guidance sections. 6. Improved global error pages (backend general error handling). 7. Improved user visible error messages when importing/creating, import logs/details available for users to review imports and other processes. Also include option to send email to the helpdesk. 8. Ability to cancel creations/imports. 9. Added ability to append additional features to a project after it is created. 10. Added support for displaying expenditure data. 11. Ability to append points/segments to existing networks. 12. Retesting existing dataset imports and appending.	22 December 2017
Project Year 1 pre-release	Improvements to workflow and features for asset owners. 1. Included ability to assign a different field for unique ID in feature data file. 2. Included ability to assign a different field for all location data during Network creation. 3. Implemented ability to filter segments in Segments Table from map, and select segment on map from Segments Table. 4. Implemented new menu structure and button format for improved workflow. 5. Implemented advanced calculation methods for Access (By AVC and By Limits), Ride Quality (By HATI) and Safety (By ANRAM). 6. Updated Calculation Configuration controls. 7. Added Input data to Survey Segments table to allow user preview. 8. Various cosmetic changes in preparation for release. 9. Added button to view inputs when expanded row of Results Table for improved results interrogation.	7 March 2018
HVIR Tool released to RAs		9 April 2018
Project Year 1 post-release	General user improvements. 1. Updated Segment Ratings Table and Road Performance Summary Tables to include Road Category column to improve clarity for users. 2. GUI improvements in response to TMR user feedback. 3. Activated By Limits calculation method for Access and made available in Calculation Configuration box.	19 June 2018
	Features for local government users. 1. Added a downloadable data file. 2. Added a column to the downloaded .CSV dataset template that contains a descriptive string for the user to identify the road (section), i.e. the road name and chainage. 3. Added the ability to remove roads (sections) from the network by clicking on the map after the network creation wizard. 4. When creating a dataset from an uploaded .CSV, removed rows that are unpopulated (apart from a unique ID) and advised the user how many rows were removed.	

Version	Capabilities	Date completed
Project Year 2	Improvements in response to LG technical pilot and implemented data downloads. 1. Modified default Access to A = 0.36 to reflect General Access. 2. Included Ride Quality and Safety calculation methods intended for local government (restricted to R4 and R5 only). 3. Permitted R3 roads in calculation methods for local government based on feedback. 4. Provided a 'download dataset' link on the public share URL page that allowed viewers to download a .CSV of the dataset with ID/contextual information (e.g. road name, road number, etc.). 5. Added link to download a .kml file of HVIR results similar to .CSV downloads.	4 December 2018
	Extended capability to handle exceptions, unmarked and unsealed roads, and expanded data downloads. 1. An additional road category 'R0' included to account for known exceptions where rating will always be low for good cause (e.g. low ride quality on cattle grates). The maximum expected HVIR is 100%, the minimum expected value is 0% i.e. The HVIR level will always be Medium. 2. Added Visual Condition Grade calculation method for local government users. 3. Added calculation methods for Safety in the case of unmarked and unsealed roads. 4. Included all feature data fields in the 'input data' .CSV download, including location data as start and end points. 5. Modified shapefile download to be embedded with all of the feature data. 6. Modified columns to show values for formation and seal widths and removed SCS in HVIR input data table. 7. Included service attributes as displayable (default hidden) layers in HVIR results.	27 May 2019

Appendix D HVIR Calculation Methods

D.1 HVIR Calculation Framework

The equation for the calculation of HVIR on sealed roads is shown in Equation A11:

$$\text{HVIR}(\%) = 100 \times (0.4A + 0.4R + 0.2S) \qquad \text{A11}$$

where

A = access (0.4)

R = ride quality (0.4)

S = safety (0.2)

For unsealed roads, the HVIR calculation is as shown in Equation A12.

$$\text{HVIR}(\%) = 100 \times (0.67A + 0.33\text{W}) \qquad \text{A12}$$

The framework permits other service attributes to be added with appropriate adjustments to weightings to ensure the result always varies between 0 and 100%.

Each service attribute must have the following qualities:

- The outputs are reported on a scale from 0 (bad) to 1 (good).
- The input parameters are based on infrastructure.
- All parameters are to be reported at 100 m intervals.

For each service attribute, a number of calculation methods are permitted based on what data is available. However:

- All of the calculation methods must produce equivalent results, with simpler methods related back to the more advanced/fundamental calculation methods.
- Calculation methods that rely on cruder or less reliable data must have fewer specific outputs compared to other calculation methods.

A number of these calculation methods were developed to address a lack of data in local governments.

The full set of calculation methods (current and discontinued) are shown in Table D 1, with the fundamental Methods indicated by an **F**.

Table D 1: Calculation methods for HVIR service attributes

<table>
<tr><th>Service attribute</th><th>Calculation method</th><th>Parameter</th><th>Unit of measurement</th></tr>
<tr><td rowspan="3">Access</td><td rowspan="2">By limits (F)</td><td>Mass limit</td><td>tonnes</td></tr>
<tr><td>Length limit</td><td>m</td></tr>
<tr><td>By Austroads vehicle class</td><td>Max. permitted vehicle class</td><td>Class number (1 to 12)</td></tr>
<tr><td rowspan="5">Ride quality</td><td>By IRI (F)</td><td>Roughness</td><td>IRI m/km</td></tr>
<tr><td>By HATI</td><td>Roughness</td><td>HATI (m/km)</td></tr>
<tr><td rowspan="2">By subjective comfort speed (DISCONTINUED)</td><td>Speed limit</td><td>km/h</td></tr>
<tr><td>Subjective speed of comfort</td><td>km/h</td></tr>
<tr><td>By VCG</td><td>Visual Condition Grade</td><td>Grade (0 to 5)</td></tr>
<tr><td rowspan="4">Leeway (previously: Safety)</td><td rowspan="2">By road geometry (F)</td><td>Lane width</td><td>m</td></tr>
<tr><td>Sealed shoulder width</td><td>m</td></tr>
<tr><td>By ANRAM risk score (DISCONTINUED)</td><td>ANRAM rating</td><td>Total vehicle SRS</td></tr>
<tr><td>By Assumed Safety (DISCONTINUED)</td><td>Speed limit</td><td>km/h</td></tr>
</table>

Equation A11 allows any road to be given a HVIR score based on its physical characteristics. However, for roads of different categories there are different expectations based on factors such as speed limits, traffic levels and role or importance in the network. These expectations, encapsulated in the HVIR functional road category, provide a context for the interpretation of HVIR values.

A range of expected values is defined for each HVIR road category, stated in Table D 2 and shown in Figure D 1. The range, as indicated by the maximum and minimum expected values, varies according to the road category; they are higher (more demanding of quality and capacity) for higher category roads.

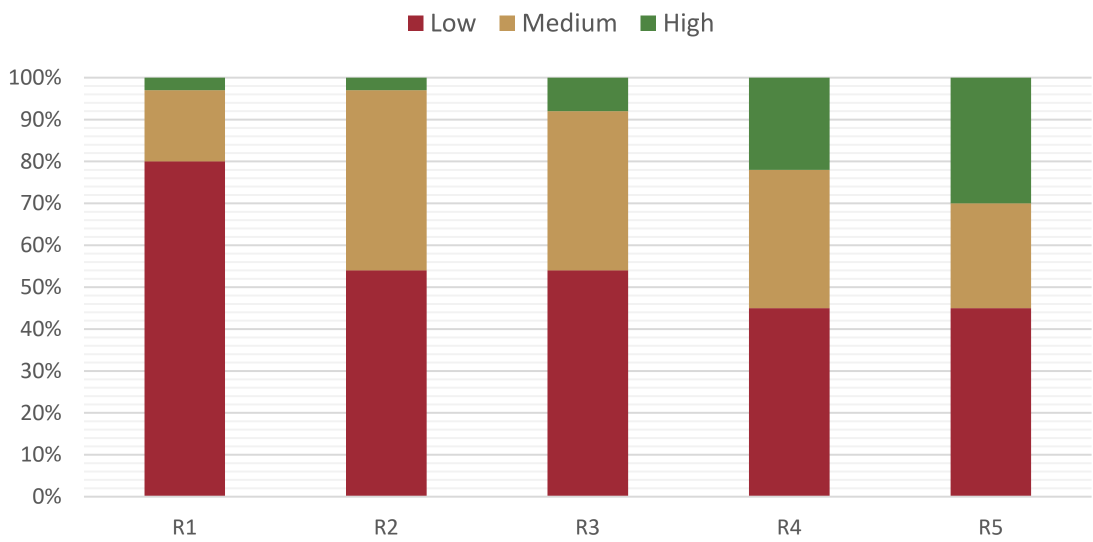
Table D 2: Maximum and minimum expected values for HVIR by road category

Road category	General description of category	HVIR	
		Max.	Min.
R1	Freeways	97%	80%
R2	Urban highways	97%	54%
R3	Urban arterials and rural highways	92%	54%
R4	Collector and distributor roads	78%	45%
R5	Access roads	70%	45%

These expected values divide the range of possible ratings into:

- Low – the HVIR is below the minimum expected value for that road category.
- Medium – the HVIR is between the minimum and maximum expected values for that road category.
- High – the HVIR is above the maximum expected value for that road category.

Figure D 1: Maximum and minimum expected ranges for High, Medium, and Low ratings



The method for determining the expected values is explained in Sections D.2, D.3 and D.4 as part of the explanation of the calculation methods.

D.2 Calculation Methods for Access

D.2.1 By Limits

The calculation of access by limits is based on a consideration of the mass and length limits of a road. The 'amount of access' of a road is measured by comparing these limits against the upper end of mass and length limits present in the vehicle fleet across Australia, as defined by the National Heavy Vehicle Regulator's (NHVR) mass and dimension limits (NHVR 2019, 2020).

For the mass limit, the General Mass Limit of an 18-axle ABB-quad configuration from NHVR documentation has been used. This sets the maximum limit at 122.5 tonnes. The method of calculating the capacity by mass (*M*) is shown in Equation A13:

$$M = \frac{Mass\ limit\ of\ road\ (t)}{122.5\ t} \quad 0 \leq M \leq 1 \qquad \text{A13}$$

For the length limit, the maximum vehicle length of 53.5 m for the longer road trains is used. The method for calculating the capacity by length (*L*) is shown in Equation A14:

$$L = \frac{Length\ limit\ of\ road\ (m)}{53.5\ m} \quad 0 \leq L \leq 1 \qquad \text{A14}$$

The Access Service Attribute (*A*) is then calculated using Equation A15:

$$A = \frac{2M}{1 + \frac{M}{L}} \qquad \text{A15}$$

The maximum and minimum expected values of *M* and *L* considered appropriate for each road category are determined by expectations of the range of vehicles in each road category that are reasonably expected to be accommodated under normal circumstances as follows:

- R5 (access or local roads) – required to accommodate general access vehicles. The minimum expected value is therefore set by inputs of 55.5 t and 19 m. The maximum is defined by the minimum for the next lower level.
- R4 (collector and distributor roads) – required to accommodate the longest B-doubles. The minimum expected value is therefore set by inputs of 62.5 t and 26 m. The maximum expected value is set by the minimum for the next lower level.
- The minimum requirements for the remaining road categories (R3, R2 and R1) are the same since these roads need to offer the same level of access for the network to be used – i.e. a higher level of access on a freeway is pointless as a vehicle requiring the higher level of access would not be able to use lesser roads to enter or exit.
- According to the Australian Bureau of Statistics in 2019 only around 1% of all heavy vehicles nationally are registered to have a total mass greater than 100 t, and at most account for 3.52% of vehicles in Queensland. This makes a case for limiting the maximum expectation (for road categories R1, R2 and R3) to 100 t.

The expected values for the Access Service Attribute when these inputs are used are shown in Table D 3**.**

Table D 3: Expected values for Access Service Attribute

Road category	General description of category	Mass limits (tonnes)		Length limits (m)		Access Index (*A*)	
		Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value
R1	Freeways	100	88.5	53.5	36.5	0.90	0.70
R2	Urban highways	100	88.5	53.5	36.5	0.90	0.70
R3	Urban arterials and rural highways	100	88.5	53.5	36.5	0.90	0.70
R4	Collector and distributor roads	88.5	62.5	36.5	26	0.70	0.50
R5	Access roads	62.5	55.5	26	19	0.50	0.40

D.2.2 By Austroads Vehicle Class

The determination of Access according to Austroads vehicle class is an equivalent calculation to the By Limits method. It uses as input the highest class of vehicle allowed to use the road, and outputs the corresponding access level that would be determined by the longest and heaviest vehicle in that class using the By Limits method.

The access levels associated with each Austroads class are shown in Table D 4.

Table D 4: Access by Austroads vehicle class

Austroads Class	A
3	0.16
4	0.21
5	0.24
6	0.25
7	0.29
8	0.34
9	0.35
10	0.50
11	0.75
12	1.00

The expected values as determined in the By Limits methods are used for this method.

D.3 Calculation Methods for Ride Quality

D.3.1 By IRI

The ride quality of a sealed road is determined by considering various standards of roughness (in m/km) for road maintenance across all road classes. These are associated with the Ride Quality Index, by using a third order polynomial to form a relationship between roughness and Ride Quality. With this relationship, ride quality (*R*) by IRI is calculated using Equation A16:

$$R = 0.0075 \times IRI^3 - 0.107 \times IRI^2 + 0.277 \times IRI + 0.8014 \quad 0 \le R \le 1 \qquad \text{A16}$$

The expected values of ride quality were based on considerations of the strategic priority, speed limit, traffic level and function of roads within the network. The current values are shown in Table D 5.

Table D 5: Maximum and minimum expected values of roughness and the Ride Quality Service Attribute

Road category	General description of category	IRI (m/km)		Ride Quality Index (*R*)	
		Maximum expected value	Minimum expected value	Maximum expected value	Minimum expected value
R1	Freeways	2.2	3.4	0.97	0.80
R2	Urban highways	2.2	4.6	0.97	0.54
R3	Urban arterials and rural highways	2.7	4.6	0.92	0.54
R4	Collector and distributor roads	3.5	5.0	0.78	0.45
R5	Access roads	3.9	5.0	0.70	0.45

D.3.2 By HATI

Determining the ride quality using the Heavy Articulated Truck Index (HATI) (Hassan, McManus & Cossens 2006) is similar to using IRI except that HATI uses profile data collected from the wheel path of heavy vehicles and a half-truck model that is intended to represent the greater ride sensitivity of heavy vehicles.

The linear scale for HATI has been determined as varying between 1.0 and 5.5. This is based on a comparison of IRI and HATI data collected from A, B and C class roads to determine a relationship between these measures.

With the values of 1.0 and 5.5 m/km determining the upper and lower bounds of the linear scale, ride quality (*R*) by HATI is calculated using Equation A17:

$$R = -0.2222 \times HATI + 1.2222 \quad 0 \le R \le 1 \tag{A17}$$

The expected values of *R* for each road category as determined in the By IRI methods are used in this method.

D.3.3 By Subjective Comfort Speed

NOTE: This calculation method has been discontinued due to a lack of resources amongst local governments (for whom it was intended) to collect additional data.

Because local governments often do not have the resources for collecting road roughness data using measurement vehicle surveys, the following method has been included to allow an indication of ride quality to be obtained. Because the input to this measure is far less reliable than the IRI or HATI methods, the output, *R*, is limited to one of two values: the middle of the expected range (medium), or the middle of the below expectations range (low).

The subjective data is collected at 100 m intervals sitting in a passenger car and noting the maximum legal speed at which the road can be travelled and still considered comfortable. The rougher the road is, the slower the vehicle will have to travel to achieve a comfortable ride.

This 'comfort speed' is compared to the speed limit and a value of 80% is defined as the limit of acceptable speed reduction. The calculation method, as demonstrated by Equation A18, and outputs are shown in Table D 6.

Table D 6: Determination of *R* using Comfort Speed method for each road category

Road category	$If\ \frac{Comfort\ Speed\ (km/h)}{Speed\ Limit\ (km/h)} \ge 0.80$ A18	
	Then *R* =	Else: *R* =
R1	0.88	0.38
R2	0.79	0.31
R3	0.69	0.25
R4	0.53	0.13
R5	0.38	0.00

D.3.4 By Visual Condition Grade

The Institute of Public Works Engineering Australia (IPWEA) has published a national uniform code for assessing road pavement condition in their *Practice Note 9* (IPWEA 2015) which describes a 0 to 5 grade scale for visual assessments of pavement condition.

The IPWEA scale was adapted to the HVIR Ride Quality Index (*R*) for roads of Categories R3, R4, and R5 only, and defined relative to the maximum and minimum expected values for *R* for each road category. The resulting values of R and how they are selected are shown in Table D 7, where the ranges referred to are shown in Table D 5.

Table D 7: Details of the Visual Condition Grade (VCG) Calculation Method

VCG	Condition	*R*			Justification
		R3 roads	R4 roads	R5 roads	
0	Not rated	–	–	–	No result
1	Very good	0.92	0.78	0.74	Top of expected (Medium) range for an ‘as new’ road
2	Good	0.73	0.62	0.60	Middle of expected range
3	Fair/Moderate	0.54	0.45	0.45	Lower end of expected range
4	Poor	0.27	0.23	0.23	Middle of below expectations (Low) range
5	Very poor	0	0	0	Surface has failed

D.4 Calculation Methods for Leeway

D.4.1 By Geometry (Sealed Roads with Linemarkings)

This method uses the widths of the (outer) lane and left-hand sealed shoulder. Widths are defined as being measured between the centres of any defining lines and/or seal edges. In the case of wider centrelines used for safety (e.g. on turns or on rural highways to separate high-speed traffic) the lane width is measured from the centre of the line defining the edge of the centreline area, where the width of this line is consistent with other road linemarkings. If there are no separate defining lines, the lane width is measured from the edge of the centreline area.

The calculation of the Leeway benefit of lane width is based on horizontal tracking requirements of vehicles under the Performance Based Standards (PBS) scheme (National Transport Commission 2008), which range from 2.9 m for general access vehicles up to 3.3 m for the longest vehicles. Rather than topping out at 3.3 m, which would not register the increased benefit of wider lanes, the maximum leeway is considered to be conferred by lane widths of 5.8 m, which is double the minimum lane requirement under PBS. The reasoning for this is that, once lanes are effectively double width, traffic tends to drive side-by-side as if there are two, unmarked lanes, thereby eliminating any benefit associated with additional width. This is calculated using Equation A19:

$$W_{LW} = \frac{Width\ of\ lane\ (m)}{5.8}\ , 0 \leq W_{LW} \leq 1 \qquad \text{A19}$$

The leeway benefit of sealed shoulder width is calculated on a linear scale that maximises at 3 m, which provides enough room to park a vehicle out of the lane with additional clearance from roadside barriers and ongoing traffic. This is calculated using Equation A20:

$$W_{SSW} = \frac{Width\ of\ sealed\ shoulder\ (m)}{3}, 0 \leq W_{SSW} \leq 1 \quad \text{A20}$$

These are averaged for the calculation of the Leeway Service Attribute. This is shown in Equation A21.

$$W = \frac{(W_{LW} + W_{SSW})}{2} \quad \text{A21}$$

The values of 3.3 m and 2.9 m are also used for the maximum and minimum expected values for lane widths across all five road categories since vehicles travelling at traffic speeds (50+ km/h) must have suitable width. This is affected to some degree by speed, but since the PBS Guidelines do not include speed, it is also not included here.

The maximum and minimum expected values for sealed shoulder widths were determined by attributes of road types under the M, A, B and C road system, with the following additional justifications:

- R1 roads (e.g. freeways) are required to have a wide sealed shoulder that is often an emergency stopping lane. For this reason, the maximum width of 3 m is used. The minimum width must be able to accommodate the standard heavy vehicle; therefore, it cannot be any narrower than the maximum vehicle width according to the Australian Design Rules (2.5 m.)
- R2 roads (e.g. highways and major arterials) often do not have shoulders in built-up areas. Therefore, the minimum expected value is zero. Where they are present, the maximum width expected is sufficient to accommodate vehicle widths of 2.5 m.
- R3 roads can be urban arterials or rural highways. These are in the same category since they are both important connecting roads; they are usually one lane in each direction. Urban arterials may not have shoulders, or the shoulder area can also be used for parking. Although rural arterials are usually required to have shoulders, these may not be sealed. Therefore, the minimum expected value for R3 roads is zero. The sealed shoulder area of an urban arterial or a rural highway is assumed to not allow a vehicle to pull over, but simply to provide extra clearance. This is important in built-up areas to increase space between a heavy vehicle and the roadside, and on rural highways because it allows heavy vehicles passing each other in opposite directions to move away from the centreline. The maximum expected value for sealed shoulder width on R3 roads is therefore 1 m.
- R4 and R5 roads generally do not have requirements for shoulders; any shoulders that exist are very likely to be used for parking and effectively be unavailable. Therefore, both the maximum and minimum expected values are zero.

The maximum and minimum expected values for all the road categories are shown in Table D 8, along with the resultant maximum and minimum values for the Leeway Service Attribute.

Table D 8: Maximum and minimum expected values for the Leeway Service Attribute

Road category	Lane width (m)		Sealed shoulder width (m)		S	
	Max.	Min.	Max.	Min.	Max.	Min.
R1	3.3	2.9	3	2.5	0.78	0.67
R2	3.3	2.9	2.5	0	0.70	0.25
R3	3.3	2.9	1	0	0.45	0.25
R4	3.3	2.9	0	0	0.28	0.25
R5	3.3	2.9	0	0	0.28	0.25

D.4.2 By Geometry (Sealed Roads without Linemarkings)

The following variation of the By Geometry method is applicable to sealed roads without linemarkings distinguishing lanes and shoulders. The input data is the total seal width (TSW) in metres.

1. Assume half of the seal width (HSW) is for travel in each direction.
2. Take HSW and allocate up to 2.9 m as the lane width.
3. If there is any HSW remaining, divide it equally between additional lane width and sealed shoulder width, limiting lane width to a maximum of 5.8 m.
4. Add any additional HSW to the sealed shoulder width.
5. Once values for Lane Width (LW) and Sealed Shoulder Width (SSW) have been finalised, calculate Leeway with the By Geometry method.

Expressing these rules mathematically (all values in metres):

Half seal width (HSW) = TSW/2

If HSW ≤ 2.9	*Lane Width (LW) = HSW* *Sealed Shoulder Width (SSW) = 0*
If 2.9 < HSW ≤ 5.8	*LW = 2.9 + ((HSW – 2.9)/2)* *SSW = (HSW – 2.9)/2*
If HSW > 5.8	*LW = 5.8* *SSW = HSW – 5.8*

These values of LW and SSW input into the By Geometry method equations (A6, A7, and A8).

D.4.3 By Geometry (Unsealed Roads) Method

The following variation of the By Geometry method is applicable to unsealed roads. The input data is the total formation width (TFW) in metres.

Half formation width (HFW) = TFW/2

If HFW ≤ 2.9	*Lane Width (LW) = HFW* *Sealed Shoulder Width (SSW) = 0*
If 2.9 < HFW ≤ 5.8	*LW = 2.9 + ((HFW – 2.9)/2)* *SSW = (HFW – 2.9)/2*
If HFW > 5.8	*LW = 5.8* *SSW = HFW – 5.8*

These values of LW and SSW input into the By Geometry method equations (A6, A7, and A8).

D.4.4 By ANRAM Risk Score Method

NOTE: This calculation method has been discontinued due to reverting this Service Attribute (Leeway) back to its original intention as a measure of the amount of available area (land and shoulder width) available for manoeuvring.

ANRAM includes a risk score assessment for vehicles based on 14 elements of road infrastructure (ARRB 2014). This score reflects the likelihood of crashes occurring; it ranges from a theoretical zero (no likelihood of a crash) up to maximums in the hundreds.

The road category that has the highest risk factors was R3, which includes rural highways. The average ANRAM vehicle star rating score (SRS) for R3 roads was 18.97, with a standard deviation of 17.52. This average plus three standard deviations is 71.54, representing about 99.7% of deviations from the average. This SRS is rounded to 70 and used to define the upper limit of risk score. This is calculated using Equation A22.

$$S = \frac{(Vehicle\ SRS\ Total\ - 70)^2}{4900}, 0 \leq S \leq 1 \qquad \text{A22}$$

This power relationship better approximates the distribution of risk factors than a linear relationship. The expected values for safety using this method are the same as those calculated using the By Geometry method.

D.4.5 By Assumed Safety Method

NOTE: This calculation method has been discontinued due to reverting this Service Attribute (Leeway) back to its original intention as a measure of the amount of available area (land and shoulder width) available for manoeuvring.

In the absence of any other data, a provisional default value for Safety was devised. The intention was not to allow baseless claims of safety to be made, but rather to recognise that risk is lower on roads with less traffic and lower speed. For this reason, default values are applicable only to R3, R4 and R5 roads.

It would be possible to use traffic levels (e.g. AADT) as an input, however, not all local councils collect traffic counts on all of their roads. Every road will have a speed limit, and coupled with the assumption of low traffic, the speed limit is used to indicate the value of S as shown in Table D 9.

Table D 9: Values of safety (*S*) using the By Assumed Safety method

Rules	R3 Roads	R4 roads	R5 roads
If speed limit ≤ 50 km/h, S =	0.25	0.25	0.25
If 80 km/h ≥ speed limit > 50 km/h, S =	0.13	0.13	0.13
If speed limit > 80 km/h, S =	0	0	0

The justification for these outputs are:

- This method is intended for local governments only therefore it is limited to R5 (Access), R4 (collector/distributor), and R3 (urban arterial) roads only.
- R3, R4 and R5 roads are treated the same since for a local government these categories are intended to indicate a distinction of the role in the network rather than a dramatically different design of road.
- S = 0.25 is the lowest value in the ‘Medium’ range of expected values (for R3, R4 and R5 roads), i.e. it is the minimum safety expected for the road. Roads up to 50 km/h are deemed to be slow enough to be assumed to be (barely) safe at low traffic levels.
- S = 0.13 is the middle of the ‘Low’ range of expected values. Roads in the speed range 50 to 80 km/h are assumed to be unsafe, but not associated with the highest risk on the network due to the low traffic levels.
- If the speed is greater than 80 km/h, the risk is perceived to be high regardless of the traffic level, therefore S = 0.

Appendix E Data Required for HVIR

Table E 1 shows the data needed for location referencing in a shapefile or .CSV. The same unique ID must be used for feature and network road segments.

Table E 1: Data required for network files

Header	Units	Details
unique_id	–	Each 100 m interval must have a unique identifier’ this can usually be generated by concatenating the road number, section name or ID, the direction and the chainage.
road_num	–	Number used as a unique identifier for roads.
road_name	–	Highest level name of road.
sect_num	–	Alphanumeric identifier for roads that are broken into sections.
sect_name	–	Named section of a longer road; this could be a lower-level road name or indicate the locations the road links.
dirctn	Forward or reverse	Please use 'Forward' rather than 'Proscribed' or 'Gazetted' and 'Reverse' instead of 'Counter'.
start_long	GPS coordinate	GPS coordinates of the start of the 100 m interval are vital for mapping to be possible.
start_lat	GPS coordinate	
end_long	GPS coordinate	Providing end points for 100 m intervals increases accuracy of mapping.
end_lat	GPS coordinate	
chain_start	km	Start chainage is used to identify the sequence of intervals.
chain_end	km	The interval's end chainage or length must be included since intervals at road ends may not be 100 m in length.
int_len	km	

Table E 2 contains the data needed for calculating heavy vehicle infrastructure ratings using basic calculation methods. All of this data is intended to be obtainable without special equipment or resources. The same unique ID must be used for feature and network road segments.

Table E 2: Feature data required for basic calculation methods

Header	Units	Details
unique_id	–	Each 100 m interval must have a unique identifier; this can usually be generated by concatenating the road number, section name or ID, the direction and the chainage.
road_cat	R1 to R5	R1 – Freeways.
		R2 – Urban highways.
		R3 – Urban arterials or rural highways.
		R4 – Collector and distributor roads.
		R5 – Property access roads.
lane_width	m	Lane width is an input into the Safety Service Attribute.
seal_shld	m	Sealed shoulder width is an input into the Safety Service Attribute.
speed_lim	km/h	Speed limit at the beginning of the interval.
com_speed	km/h	A subjective assessment of the maximum legal speed the road can be driven and regarded as very comfortable.
avc	–	The highest Austroads vehicle class permitted to use the road.

Table E 3 contains the data needed for calculating heavy vehicle infrastructure ratings using advanced calculation methods. The same unique ID must be used for feature and network road segments.

Table E 3: Feature data required for advanced calculation methods

Header	Units	Details
unique_id	–	Each 100 m interval must have a unique identifier. This can usually be generated by concatenating the road number, section name or ID, the direction, and the chainage.
road_cat	R1 to R5	R1 – Freeways.
		R2 – Urban highways.
		R3 – Urban arterials or rural highways.
		R4 – Collector and distributor roads.
		R5 – Property access roads.
mass_lim	tonne	What is the mass limit of this road according to notices?
len_lim	m	What is the length limit of this road, not including entry or exit manoeuvres?
iri	m/km	International Roughness Index.
hati	m/km	Heavy Articulated Truck Index.
vsrs	SRS	Australian National Risk Assessment Model.

Table E 4 contains other inventory and condition data that is not used in the calculation of HVIR; however, it is requested to allow the Asset Register data to potentially be used by other tools and processes.

Table E 4: Other data requested for asset register

Header	Units	Details
cway	A, B or C	A – Single carriageway.
		B – Divided carriageway, forward.
		C – Divided carriageway, reverse.
line_mark	Yes or No	Unmarked roads are handled differently and so it is important to identify these.
num_lanes	–	Number of lanes is a secondary check on the road categorisation.
unseal_shld	m	
pave_type	SS, or SU, or US, or UU or C	SS = Stabilised base and subbase.
		SU = Stabilised base, unstabilised subbase.
		US = Unstabilised base, stabilised subbase (and/or subgrade).
		UU = Unstabilised base and subbase.
		C = Concrete.
pave_date	dd/mm/yyyy	When was the pavement constructed or rehabilitated?
seal_flag	Sealed or unsealed	Sealed and unsealed roads are handled differently so it is important to identify these.
seal_date	dd/mm/yyyy	When was the surface last sealed or resealed?
traffic	AADT	One-way AADT.
perc_heavy	%	Percentage of heavy vehicles.
climate	CD, or CW, or HD or HW	CD = Cold and dry.
		CW = Cold and wet.
		HD = Hot and dry.
		HW = Hot and wet.

Header	Units	Details
subgrade	S, M, C, X or R	S = Sandy.
		M = Medium.
		C = Light clay.
		X = Expansive clay.
		R = Rock.
cost_maint	$	Annual expenditure on maintenance per 100 m interval (averaged) per lane.
cost_asset	$	Replacement cost per 100 m interval (averaged) per lane.
rutt	mm	Maximum rut depth.
textowp	MPD	Texture of outer wheel path.
textbwp	MPD	Texture between wheel paths.
cracking	%	% area of surface with cracking.
strength	(microns)	Central deflection from Falling Weight Deflectometer (FWD) or Traffic Speed Deflectometer (TSD).

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Research Report
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Data to Support the Heavy Vehicle Road Reform Part C

National Road Asset Register

Data to Support the Heavy Vehicle Road Reform Part C: National Road Asset Register

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part C documents the development of the data requirements and supporting tools and processes of the National Asset Register, a national arterial network dataset containing location, condition, inventory, operational and historical data related to road assets at 100 m intervals. This dataset was updated by state and territory road agencies on an annual basis.

Developing the National Asset Register answered important questions related to data availability and consistency, and demonstrated the feasibility of building national datasets when supported by appropriate data specifications and processes.

Keywords

Asset register, condition data, inventory, data standard

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About Austroads

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

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

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

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

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

Summary

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

The Council of Australian Governments (COAG) Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

Properly functioning markets require informed users and road providers. The Asset Register and heavy vehicle infrastructure ratings (HVIR) that were the focus of the first two years of this project, are part of a package of measures that aim to establish an openly available baseline of information required to transition to the provision of heavy vehicle infrastructure as an economic service over the longer term.

Austroads project AAM6068 *Data to Support Heavy Vehicle Road Reform* is a three-year continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017.

The key outputs of the previous project AT1920 included an Asset Register containing inventory and condition data for freight routes from all state and territory jurisdictions excluding the Northern Territory. This Asset Register was in the form of data in Excel spreadsheets and maps as .kml files. This format was unworkable in the long term and the feasibility of an online tool to overcome issues encountered in the data supply process was investigated. This approach was found to be feasible and an online HVIR Tool with core functionality was built and a trial conducted with Queensland Department of Transport and Main Roads (TMR).

Components of the extended project AAM6068 included:

- annual road agency data updates of the Asset Register
- extension of the Asset Register to include a growing sample of local government roads
- continued improvement of the Asset Register.

The first year of the current project saw progress made in the following two areas:

- Alignment and implementation issues between the Austroads Data Standard and Asset Register were reviewed. Aligning the Asset Registers and Data Standard is feasible and has some advantages; however, several issues need to be resolved before this can begin.
- A pilot program to identify and solve the problems encountered by local government using the HVIR Tool commenced in May 2018. An evaluation of the 2017–18 pilot program informed the design of an updated Local Government Pilot Implementation Program for 2018–19.

The main components of work in Year 2 included:

- annual update of Asset Register and HVIR
- extension of the Asset Register, including a growing sample of local government roads
- assessment of implementation issues related to data.

These are summarised below.

Annual update of Asset Register data

The prolonged process of updating 2018 and 2019 data in the Asset Register was used to understand and identify issues in the data supply process. Based on these understandings, the groundwork was laid to move to a less centralised process in Year 3 by making available to asset owners open-source code to calculate HVIR ratings and undertake quality assessments of their data.

Extension of the Asset Register to include local government roads

Through a smaller initial pilot and a more extended pilot, a number of local governments were engaged to explore their potential to supply asset data. Despite improving the engagement process, and adapting data requirements, the general finding of the pilots was that local governments are currently not able to efficiently supply high-quality data about their roads. A follow-up survey was conducted to identify the key challenges, which were found to be 1) a lack of resources, 2) a lack of expertise in data manipulation, and 3) the data simply not being either collected or maintained.

Sourcing of data from Western Australian (WA) local governments through the Road Assessment and Maintenance Management (RAMM) database was also found to be unfeasible due to both the limits of the RAMM data specification and the amount of data usually supplied by the local governments.

Assessment of implementation issues related to data

An assessment of the similarities and differences between the Asset Register and Data Standard Priority Harmonised Subset (PHS) (Austroads 2019b) produced recommendations for improvements that could be made to both the Asset Register Data Specification and the Data Standard.

An analysis of open data sources was also undertaken and found that while all road agencies have open data platforms, Asset Register data is often not available or not at the level of detail found in the Asset Registers.

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1. Introduction

1.1 Background

The objective of project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* was to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services, one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

1.2 Purpose

The National Asset Register is part of a package of measures that aim to establish an openly available baseline of information required to transition to the provision of heavy vehicle infrastructure as an economic service over the longer term.

The aim was to investigate data availability and consistency, and demonstrate the feasibility of building a national dataset to serve as a resource for future data-driven applications. This included expanding the asset register to include local government roads.

1.3 Scope

Part C includes the development of the data requirements and supporting tools and processes of the National Asset Register, a national arterial network dataset containing location, condition, inventory, operational and historical data related to road assets at 100 m intervals.

A practical approach was taken with the above based on existing data and capabilities of state, territory and local government asset owners.

1.4 Methodology

Part C describes the development of the National Asset Register as follows:

- Section 2 summarises the activities and deliverables from the original project AT1920.
- Section 3 provides documentation of efforts to improve and expand the data in the Asset Register, including:
  - inviting road agencies to upload data through online tools
  - an initial pilot with a small number of local governments to address likely technical issues with use of the online tools by local governments
  - a broader pilot inviting local governments to upload data through online tools
  - learnings from these processes and pilots.

- Section 4 discusses the feasibility of implementing the Austroads Data Standard within the current Asset Register, including a detailed consideration of each data type.
- Section 5 documents an analysis of open and commercial data available in 2018–19 as potential sources for populating the Asset Register.
- Section 6 describes some of the outputs of the open data approach to populating the Asset Register, including some of the processes for assessing data quality. As an example, a quality analysis of data previously submitted to the Asset Register is presented.
- Section 7 documents a review and revision of the Asset Register Data Specification to be more general, and not limited to only the types of data normally collected by road agencies.

2. Summary of Project AT1920

2.1 Overview of Project AT1920

Austroads project AT1920 *Developing the Information to Support the Heavy Vehicle Road Reform* was a multi-year project that commenced in July 2013 and concluded in June 2017. The three primary outputs were road categorisation, the heavy vehicle infrastructure rating (HVIR) and the national freight route register.

This section documents in brief the progress of the National Asset Register and its associated processes over the four years of this project.

2.2 Developing a National Freight Route Asset Register

To provide a data resource for the HVRR, a national freight route Asset Register was developed which contained inventory and condition data at 100 m intervals (supplied by the asset owner), along with calculated HVIR for each of these intervals.

The development of the Asset Register progressed as follows:

1. A survey of jurisdictions was conducted to ascertain what data was collected, the frequency of collection, and the format of the data. It was determined that a national asset register was feasible.
2. Version 1.0 of the Asset Register was built in Microsoft Excel in June 2015. It contained inventory and condition data from key freight routes (KFR) in Queensland, totalling 5566 km of roads. The spreadsheet included macros to calculate HVIR, generate reports (.pdf) for whole roads, and generate a .kml file showing the colour-coded HVIR outputs on a map. Even with data from only one state included, it was noted that an alternative would eventually be needed due to the limitations of Excel.
3. Version 1.1 was released in January 2016 following a request for other state and territory road agencies to provide data on their KFRs. The resulting KFR data (approx. 37 800 km in total) was provided by all road agencies (RA) except the Northern Territory (see Table 2.1), which was due to undertake their first survey of their network in five years. Attempts to combine the datasets from each agency caused the macros to grind to a halt with the .kml files, even if they could be generated, tending to crash Google Earth when attempts were made to launch the maps. Due to these limitations, the Asset Register was required to consist of separate Excel and .kml files for each road agency.
4. Version 1.2, released in January 2017, included additional data on other roads considered to also be freight routes. Point features such as bridges and rest areas were also shown on the map. This provided data for 89 600 km of roads (see Table 2.1). In some cases, Road Agencies (RAs) elected to provide data for their entire networks rather than going through the process of deciding which roads, in addition to KFRs, were considered as freight routes.

Table 2.1: Amount of data in 100 m records, expressed as total km of road per road agency

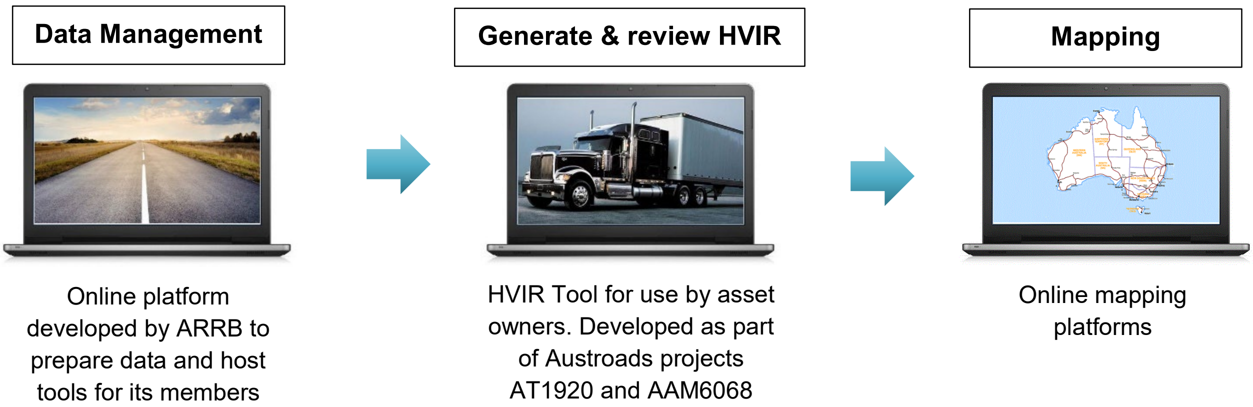
Road agency	January 2016 KFR Asset Register Version 1.0 and 1.1 (km)	January 2017 Jurisdiction Freight Network Asset Register Version 1.2 (km)
ACT	43	28
NSW	4 213	17 721
NT	–	–
Qld	7 450	34 466
SA	5 150	5 807
Tas	471	3 774
Vic	4 472	9 569
WA	12 998	18 198

While Excel was an appropriate tool for the very early development phase, the use of Excel for storing and processing large datasets was neither efficient nor very accessible to review. The .kml map files also presented their own limitations.

There was also feedback from some RAs that their asset managers were not engaged in the process, since data requests were often sent to data managers who then responded without the asset manager necessarily being made aware of this. This meant that the data was not always an accurate representation of the freight route network. The process of generating HVIR results also lacked transparency, relying on the project team to perform the calculation of results, a step in the process that would not continue after the end of the project.

Building on existing plans for data supply and management, the project team investigated the feasibility of building an online tool for generating HVIR results which asset owners could access and use (see Figure 2.1). This would allow asset owners to be responsible for uploading their own data and generating ratings, thus ensuring that an accurate representation of their networks was supplied. ARRB was already developing a platform, called the Road Manager's Toolbox, to take on data collection, storage, and management tasks common to several tools and processes that had been developed, as well as being a consistent and accessible place to host those tools for its members.

Figure 2.1: HVIR Tool as part of a process between data management and mapping tools



The online HVIR Tool was developed in parallel to continued data requests and the Excel-based Asset Register, with the intention that the online tools could take over the data supply process when ready.

By the end of project AT1920 in June 2017, the core functions had been developed and a successful trial had been undertaken with TMR. However, further development would be required before the data supply process could make use of these online tools for additional users (i.e. other jurisdictions and national organisations).

2.3 Transition to Extended Project

Based on the success of AT1920 and the ongoing needs of the HVRR, Austroads project AAM6068 was commissioned as an extension of the project work achieved in AT1920. The extension project was for three years with 2017–18 being the first year.

The original aims of the project were to:

- continue annual updates and publication of the Asset Register and HVIR on the Transport Infrastructure Council (TIC) web page. The data was expected to be presented through a publicly available online mapping platform, linked to the TIC website
- extend the Asset Register and HVIR to include a growing sample of significant local government roads
- align the Asset Register and Austroads Data Standard
- continued improvement of data sharing functions for the Asset Register, and the HVIR Tool and calculations.

These aims were to be reviewed at the completion of each project year to ensure the project was still delivering on the needs of the HVRR.

3. Improving Data Supply for the Asset Register

3.1 Online State and Territory Data Updates

After completing the previous project, AT1920, an Asset Register of freight routes comprised of road segments at 100 m intervals from every state and territory jurisdiction existed, albeit in the form of separate Microsoft Excel files (these files generated the HVIR results and shapefiles through the use of embedded macros). The HVIR Tool which had begun to be developed was at a proof-of-concept stage, but had demonstrated that it could host data, generate HVIR results in a transparent manner, and represent the outputs on maps.

One of the objectives of AAM6068 was to further develop the data supply process by engaging RAs through the centralised HVIR Tool in order to make jurisdictions responsible for providing nationally consistent data of sufficient completeness and accuracy, and for the process to be transparent. This process was also designed to enable inconsistencies and gaps between the provided datasets to be identified through visualisations of the results on a national map – although at that time this capability was not implemented.

Starting in December 2017, RAs were invited to provide an update to the inventory and condition data previously provided under AT1920 with the intention of expanding the data represented within the HVIR Tool to obtain a clearer picture of the state of the data. At that time, the data request was of a similar nature to previous data requests.

A significant effort was made from January 2018 onwards to prompt and assist RAs to supply data for the update of the Asset Register. In May 2018, the HVIR tool was ready for RAs to engage directly with the HVIR Tool themselves. However, response from some RAs was minimal, despite the large effort in prompting and the support provided. This was not unexpected given the departure from traditional data requests which RAs are accustomed to addressing. Supplying data through the HVIR Tool was a new process, as it required participation from 1) the data officers sourcing and supplying the data from their systems; and 2) from asset managers with sufficient authority to sign off on the data being representative of their network up to the date the data was provided. Securing participation on these two levels proved to be challenging and time-consuming.

RAs did update data using their latest surveys over the course of March and April 2019, meaning that the data they provided was in fact accurate at the provided date in early 2019. While the updated 2019 dataset was largely completed, the adjustment of the road agencies to providing data through the new process was less developed.

The challenge of the new process for RAs seemed to be related largely to organisational issues based on reporting/delivery structures and the distribution of data within organisations as described in brief below:

- The task of organising data is handed down through two to three levels of staff (e.g. Asset Manager → Data Manager → Data team member). This increases delays and the chance of miscommunication (or failure to communicate).
- The task of providing data often ends up in the hands of a staff member who has access to asset data, but not necessarily operational data (e.g. speed zones and traffic level) or heavy vehicle access data.
- The above two issues are compounded by the novelty of what is being requested (i.e. asking road agencies to provide their data through an online platform), whereas previously road agencies have simply provided smaller, separate datasets on request.

Some of the RAs started to look to how they could develop processes to supply data in the future which requires both a) the compiling, modifying, and checking of data; and b) the authority to direct the data to be prepared and delivered (through the online tools) as well as signing off on the end result.

3.2 Engagement with Local Government

3.2.1 Introduction

One of the key objectives for the project was to expand data in the Asset Register to include local government freight routes. Given the success of engaging with local governments through the provision of online tools such as the Restricted Access Vehicle Route Assessment Tool (RAVRAT), a similar approach was intended for the HVIR Tool, whereby local governments would be able to log in and provide their data, with the HVIR results being automatically calculated for them.

The HVIR Framework offers a number of different calculation methods for each service attribute, designed to allow different data to be used, depending on what is available and delivers a comparable result. Many of the calculation methods were developed with local governments in mind since it was known that they would not have data of the name and nature or coverage compared with that of the road agencies (i.e. local government data would be much more limited).

The engagement with local governments consisted of four main components:

- a technical pilot where four councils were contacted to work through some of the fundamental technical issues with the submission of data and to test engagement processes
- an implementation pilot that took the learnings from the technical pilot and approached a further seven councils from a shortlist prepared by the Australian Local Government Association
- an investigation of the RAMM dataset to which local governments in Western Australia submit data
- a survey of all 11 councils to identify additional learnings related to the collection, preparation, and submission of data.

The learnings and any outcomes from each of these stages are presented below.

3.2.2 Technical Pilot Learnings and Outcomes

Urban Tasmanian Council

The council experienced no issues with use of the online tool but did have issues with the data requirements.

The first issue was that it was not possible for the council to produce data at 100 m intervals. It is expected that most local governments (LGs) will experience this issue. In this case, the council was asked to provide their data in terms of links between intersections. This was subsequently taken on as the normal approach with local governments.

Issues related to successful use of the data supply process are as follows:

- There is a lack of current data on lane width, sealed shoulder width, Austroads class permitted access, ride comfort measures, safety star ratings and travel direction.
- Visual condition grades are undertaken each year in October and February and cover about 20% of the network, completing the entire network over 5 years. This condition monitoring is done in line with the Institute of Public Works Engineers Australasia (IPWEA) guidelines.
- Data on the physical dimensions of infrastructure are only collected at the time of construction.
- Heavy vehicle (HV) access is restricted by exception (e.g. mass limit or length limit by road category).
- The council stated that they did not have the capacity to undertake additional large scale data collection (such as measuring lane and shoulder widths), and currently did not see the benefit in doing so.

The information about the collection of network data over five-year intervals was in line with previous findings. During the previous project AT1920 a survey of 30 local governments in NSW found that 5 years to survey an entire local government network was typical. Even though the Asset Register is interested only in freight routes, there was no indication that these routes were prioritised for additional scheduled inspections.

For this reason, there should be an expectation that data supplied from local governments may be up to five years old unless agreements under HVRR stipulate prioritised inspections and that these can be practically undertaken.

Two actions were undertaken to address some of the gaps in the data:

1. providing better information about how to identify heavy vehicle access levels
2. utilising existing datasets on visual condition grade as an indicator of ride quality.

The instructions for determining the access level on freight routes seemed to be inadequate, despite desktop solutions for determining the access available. There may have also been a poor understanding of the Austroads vehicle class system which is used in the User Guide but not explained.

The User Guide was updated to include useful information about access and how it can be determined for either By Limits or By Austroads Vehicle Class (AVC). An example of this information is shown in Appendix C.

The Subjective Comfort Speed (SCS) method of determining ride quality (or comfort) was intended as an achievable method for LGs to obtain some indication of ride quality in the absence of any other data. The feedback from the urban Tasmanian council suggested that LGs was unlikely to invest resources in collecting the required input data (a subjective assessment of comfort while driving at the speed limit) and certainly not outside of scheduled inspections of their roads.

Therefore, it seemed prudent to attempt to use data that is already collected to obtain an indication of the ride quality.

LGs usually make visual inspections of their roads. The IPWEA has attempted to create a standardised rating system for this, explained in IPWEA Practice Notes 9 and 9.1 (IPWEA 2015). While the project team was aware of this, the SCS was devised to directly assess ride quality – the IPWEA visual inspection is both subjective and indirect. Regardless, a means of indicating ride quality based on visual condition grade (VCG) inspections was implemented.

First rural Victorian council

Engagement with this council was undertaken cautiously to first ascertain what data was available and then try to identify early any issues with collating data. The statements below summarise the responses received from the council.

> **Location information** is available through MapInfoPro (a commercial, desktop data management system with GIS capability).
>
> **Road categorisation** was mapped to the road classes as shown in Table 3.1.

Table 3.1: Road classification for the first rural Victorian council

HVIR road category	Council road class	Description
R3	Link	Link roads provide a road that supplements the main arterial road network. These roads provide through traffic movement between urban areas, and other places, such as shopping precincts, major sporting venues, industrial areas, agricultural areas, and major tourist attractions.
R4	Collector	Collector roads provide the connection between Access roads and the state arterial road network, other collector roads or population centres. These roads will either have an identifiable origin and destination or have a high proportion of through traffic in conjunction with access for properties abutting the road.
R5	Access	Property access roads.

Heavy vehicle access information is available from a non-asset database.

Road condition data in the form of visual inspections is available, collected every three years for sealed roads and every five years for unsealed roads.

Lane and shoulder widths are available.

Speed limits are available.

Other asset information mentioned were maintenance ratings, segment lengths, surface type, other surface information, pavement information, formation data, presence of kerbs, some traffic counts, and if the road is part of a bus route.

It was established that the council had access to all the data for the minimal dataset. However, the task of collating all the data would have involved assembling data from up to four different systems which was considered as too onerous for them to continue.

Second rural Victorian council

The revised approach with this council yielded the following assessment of the data capability:

Location information is available as shapefiles of the network.

Data management is through AssetFinda – a commercial asset management program.

Road categorisation was mapped to the simplified road classes as shown in Table 3.2.

Table 3.2: Road classification for the second rural Victorian council

HVIR road category	Council road class	Description
R3	Link	Sealed roads with moderate to high traffic volumes that serve as principal routes in major urban areas or significant links between townships or urban areas.
R4	Collector	Sealed roads that carry moderate volumes of traffic to Link roads or state arterials. Unsealed roads identified by residents as high priority.
R5	Local or Laneway	Property access roads and/or those carrying low volumes of local traffic.

Heavy vehicle access information is known but not in electronic records.

Road condition data in the form of visual inspections is available for sealed roads (from 2014) with minimal data for unsealed roads. It was noted that this data is outside their 'roads register'.

Lane and shoulder widths are available only as total surface width.

Speed limits are available from VicRoads, once again outside their 'roads register'.

Other asset information mentioned were surface information, seal type, base material, and the length, width, depth, and area of the asset.

The council was in the process of digitising many of their records (including HV access) and planned to have completed a condition assessment of their network by the end of 2019.

It was established that the council had access to data for the minimal dataset. However, it was anticipated that they would have trouble collating the data.

Urban South Australian council

The revised approach with this council yielded the following assessment of the data capability:

Location information is available as shapefiles of the network.

Road categorisation was mapped to the road classes used by the council as shown in Table 3.3.

Table 3.3: Road classification for a South Australian council

HVIR road category	Council road class	Description
R3	Feeder	Feeder roads provide a road that supplements the main arterial road network. Largely defined by traffic volume.
R4	Collector	Collector roads provide the connection between Access roads and the state arterial road network or Feeder roads. Largely defined by traffic volume.
R5	Local	Property access roads.

Heavy vehicle access is available in electronic format.

Road condition data in the form of IPWEA 1 to 5 visual inspection grading is available.

Lane and shoulder widths are not specifically available, only the road width.

Speed limits are available from the state government.

Based on an assessment that the council possessed all the data required, they were sent Sign In credentials for the HVIR Tool. However, even after establishing that the council had the data to participate, resourcing issues meant that no further action was taken by the council.

General learnings from the technical pilot

This technical pilot engaged with four councils with the following outcomes:

- A minimal dataset that most LGs should be capable of producing was identified and support for this (additional calculation methods) were included in the HVIR Tool.
- A process for approaching local governments was evolved and was used for the next phase of the HVIR pilot program. This approach is elaborated on subsequently.

The experience with the urban Tasmanian council was very successful but proved to be unusual as the majority of LGs are likely to have limited resources to spare, despite a high level of interest.

The experience with the first South Australian council suggested that an alternative style of approaching LG was needed to avoid councils being suddenly confronted with a difficult and complex task that they were not expecting.

A revised approach was used for the subsequent three councils that involved more initial discussion to earn about what sort of data they had, stressing that the primary interest was in identifying and documenting challenges experienced by the councils trying to participate. Once it was ascertained that the required data was available, the councils were provided with access to the online tools.

Despite this softer approach, once the task of organising data was turned over to each council, it seemed the real or perceived resource requirements were still too much for most councils to handle.

Therefore, a further revised approach was developed, composed of three stages:

1. Discussing (via phone or email) what type, format and timing of data is available.
2. Requesting that the raw data is supplied. While this is not feasible in the long term, this seems to be necessary to get the process started and build momentum for the pilot.
3. Presenting the data and HVIR results through the HVIR Tool back to the council to demonstrate the outputs of the process and how the outputs are used in the Reform.

3.2.3 Implementation Pilot Learnings and Outcomes

LGs agreeing to participate in the data pilot were first guided through a discussion of what data they had available. All of the councils initially reported that they did have some form of data for at least some roads that they understood would meet the parameters described.

Rather than making the HVIR Tool available to them, the councils were requested to supply data, so that the project team could undertake an in-depth analysis of the practical applicability of the data. With the exception of an urban Victorian council, the councils engaged were unable to provide data.

Currently, the only councils that have been able to respond successfully to the direct engagement are two councils, one in Tasmania from the technical pilot, and one from Victoria in the implementation pilot. These are both urban centres with medium to very large populations (~65 000 and 195 000 respectively). The only other council of comparable classification was a regional council which did not provide any data (this was complicated by engaging the council through their regional group).

This suggests that more populated councils (with more ratepayers) are more likely to collect and be able to provide requested data about their freight routes; however, the data management capability may vary due to other factors that are not yet well understood.

3.2.4 RAMM Database Learnings and Outcomes

RAMM is a commercially available digital asset and work management program used by Main Roads Western Australia (MRWA) and the Western Australia Local Government Association (WALGA). This program is used to build a centralised database with supported geospatial and data validation features.

Effort was focused on working with WALGA and MRWA to take advantage of existing road asset data submissions by LGs to MRWA. The intention of this was to gain permission to test data that councils have already submitted to the RAMM database to avoid them having to go through two instances of extracting their data and submitting it through two online portals.

An analysis of whether HVIR could be calculated from the data provided in the RAMM database was previously conducted and found that the necessary data to calculate HVIR was present among the 172 fields of data in the RAMM dataset used for that analysis. However, it was subsequently learnt that some of the data in that dataset was volunteered by councils and could not be relied upon to be supplied consistently by participating councils.

The local government interface requirements produced by MRWA specifies a number of outputs that are to be exported from LG systems and sent to MRWA (see Table 3.4). The specified information provides sufficient location referencing for mapping using link and node segmenting, but insufficient detail related to heavy vehicle access, ride quality and parameters used for safety. For this reason, the RAMM database does not seem to offer access to a large and consistent dataset as hoped.

Table 3.4: Data specified by MRWA for submission to the RAMM database

Output	Required information	Description
Database	LG number	The 3-digit Local Government identification number
	Map zone	The 2-digit Map Grid of Australia (MGA) zone number
Road	Road number	7-digit identifier
	Road name	Name of road
	Start terminus	Start point description of road
	End terminus	End point description of road
Element	Road number	7-digit identifier
	Length	Element length (m)
	Carriageway	S = single, L = left, R = right
	Metres start	Starting chainage of element
	Element sequence number	The sequence number of the element along the road length
	Element type	D = distance break, S = other
	Start LG node ID	Unique ID for start node of network element
	Exit leg number	Value of the leg exiting the intersection
	End LG node ID	Unique ID for end node of network element
	Approach leg number	Value of the leg approaching the intersection
	Well known text	Text string defining the spatial representation of the element
Node	LG node ID	Unique ID for the node in the LG system
	IRIS node ID	Unique ID for the node in the IRIS system
	Node description	Identifies the node type, e.g. intersecting road
	Easting	Geographic coordinate position along x axis
	Northing	Geographic coordinate position along y axis
Inventory	Road number	7-digit identifier
	Metres start	Chainage (m) of inventory start location
	Metres end	Chainage (m) of inventory end location
	Carriageway	S = single, L = left, R = right
	Cross-section type	Formation type of the road (7 options)
	Surface type	Surface material type of original seal (9 4-character codes)
	Formation width	(m)
	Pavement width	(m)
	Pavement year	Year of construction or last substantial reconstruction
	Surface width	Sealed surface width
	Original surface year	Year of first surface seal
	Latest reseal type	Surface material type of current seal (9 4-character codes)
	Reseal year 1	Year of the reseal before the latest reseal
	Reseal year 2	Latest reseal year
	Surface treatment	Unsealed road surface treatment (5 3-letter codes)
	Treatment year	Year of the most recent unsealed treatment

Output	Required information	Description
	Drainage left	One of 7 types of surface water channel on the left side of the road (3-letter code)
	Drainage right	One of 7 types of surface water channel on the right side of the road (3-letter code)
	Speed limit	Legal speed limit (km/h)
	Road hierarchy	Road category (6 classes)
	Traffic count	Latest AADT
	Traffic year	Year of the latest AADT
	General terrain	One of 5 terrain types
	Special use	Identifies if road has special use (e.g. bus lane, ramp, etc.) using one of 6 codes
Path	LG number	The 3-digit local government identification number
	Path type	Material type – one of 12 2-letter identifiers
	Length of pedestrian only path – road	Length (m) of path adjacent to road
	Length of pedestrian only path – other	Length (m) of path not adjacent to road
	Length of dual use path – road	Length (m) of path adjacent to road
	Length of dual use path – other	Length (m) of path not adjacent to road
	Area of pedestrian only path – road	Area (m^2) of path adjacent to road
	Area of pedestrian only path – other	Area (m^2) of path not adjacent to road
	Area of dual use path – road	Area (m^2) of path adjacent to road
	Area of dual use path – other	Area (m^2) of path not adjacent to road

3.2.5 Learnings from the Follow-up Survey

To attempt to gain a better understanding of the obstacles facing local governments, a survey was sent to all the responding councils involved in both this round (seven councils) of engagement as well as the previous technical pilot (four councils). This survey sought to ascertain:

- the greatest constraint in meeting data requests (staff availability; staff skills/familiarity with data; or data management systems/processes/software)
- how location information for local roads is stored (e.g. MapInfo, etc.)
- the GIS capability within the council
- the network coverage and timing of any surface condition data collected
- the type of surface condition data collected (e.g. IRI, visual condition rating, public complaints, etc.)
- the nature of any road geometry data records (lane, shoulder and seal widths for sealed roads, and formation widths for unsealed roads)
- accessibility to heavy vehicle access data
- a description of the extent to which HV access, road inventory, and condition or operational data (traffic volumes, speeds, etc.) are linked to local road location data.

Responses were received from seven councils, including an urban locality in Tasmania, five councils in regional New South Wales, and one in regional Victoria. The findings are elaborated on in the following sections.

Constraints in meeting data requests

Councils were asked to rank their greatest constraints in meeting the data requests. The three options for ranking, provided in the survey, were staff availability, staff skills/familiarity with data, and data management systems/processes/software. The results showed that six of the seven councils who responded to the survey were encountering the same constraints, supplying a similar ranking of:

1. staff availability
2. staff skills/familiarity with data
3. data management systems/processes/software.

One council identified that the issue of staff availability, and the ability of staff to meet data requests, is largely affected by the lead times in the data requests. It was suggested that this could be resolved through the negotiation of longer lead times, to allow staff to fit data requests around other commitments. In addition, it was noted that a reasonable lead time, with clear objectives, is also a requirement for councils to ensure they can provide the most appropriate data for the purpose of the request. Lastly, staff turnover was cited as an issue in staff availability.

In regard to data management systems/processes/software, one respondent indicated that the issue did not lie within local councils, but it is an issue caused by inconsistencies between all road agencies, (e.g. it includes VicRoads, councils, and the state government).

Location information software and GIS expertise

Of the councils who responded to the survey, there was a wide variety in the software used to store location information. MapInfo is utilised by four of the seven councils surveyed, the others used ArcGIS, Geocortex and IntraMaps. In many cases use of these mapping programs were incorporated into asset/data management software systems such as Civica’s Authority Software, BizeAsset, TechOne Works and Assets and Reflect.

Most councils indicated that their GIS teams are very experienced, especially in the asset management departments. However, it was indicated by two of the councils that their GIS teams are often very busy, and therefore, need long lead times in requests for data. An additional issue cited by one council was that, although the GIS specialists have the expertise to produce the required information, the constraint is the extent of data which is collected. One council indicated that they do not have a dedicated GIS specialist, however, they have several staff who are familiar with the system and they engage a technology company to provide specialist services.

Surface condition and road geometry data – type and coverage

The councils provided varying responses regarding their network coverage and timing in the collection of surface condition data. Two of the seven councils reported that surface condition data is limited in extent and range and based on outdated visual inspections. However, other councils reported full network coverage over a period of two to five years (differing for sealed and unsealed roads).

These network surveys covered a range of topics across councils including anecdotal data, specialised surveys, visual condition rating, visual maintenance ratings, public complaints, deflection, and roughness (IRI). All councils cited visual condition rating as one of the main forms of collection of surface condition data.

In particular, the urban Tasmanian council completes vehicle-mounted laser surveys once every five years for the whole sealed network. In-vehicle assessments are completed for the entire network over the five-year period, between surveys. Lastly, detailed visual inspections, on foot, are completed where required, including through the public complaint logs.

All councils document the sealed width and formation width for sealed roads, and formation widths for unsealed roads. Commonly, lane and shoulder width are combined into seal width for sealed roads.

Heavy vehicle access and linkage to road location data

Six of the seven councils indicated that they have access to heavy vehicle access notices, largely through the National Heavy Vehicle Regulator (NHVR) portal. However, one council expressed an issue with the NHVR portal data not yet being at a stage where it can be easily translated into heavy vehicle road usage data.

When asked to what extent heavy vehicle access, road inventory, condition, or operational data (traffic volumes, speeds, etc.) is linked to road location data, varying responses were received. Some councils have road inventory and road location data linked, others do not have linkages, and the extent to which these are linked is varied.

One council indicated that, although this linkage is currently limited, it is improving. This council is aware of a need to look at data more broadly than current asset management practices. This council is considering the recommendations for improvement from the Austroads Data Standard for Road Management and Investment (Austroads 2019a). Other councils indicated that heavy vehicle access data and road condition data are linked spatially with GIS data.

Another council indicated that they have the requested road attributes recorded against road segments, in a form that can be easily displayed on a map. However, there were some roads where attributes were lacking.

One council provided a detailed response. Heavy vehicle access data is mapped for all gazetted routes, but not uploaded into the GIS system. Road inventory is held by segment within the asset management system used, which is linked to the GIS system. The condition of assets is also held within the asset management system for each segment, and for individual assets within each segment. Traffic counts are currently held in a separate location to the asset management database and GIS system; however, the council is working on having this integrated.

Summary of survey results

Based on the results of the survey, the key issues for councils in providing requested datasets have been identified as the following:

- the availability of staff to complete data requests
- clarity in the instructions of data requirements
- inconsistencies in data management practices across all types of road agencies
- the ability of staff to extract data
- the extent to which data is collected, stored, and integrated with other datasets.

For the process of requesting LGs to provide effective data, the following list of recommendations has been developed.

Based on the issues identified, the following is suggested for better outcomes in the future:

- Initial discussions with councils regarding data requirements should include negotiations on the lead times required, based on staff availability. This will allow councils to properly plan their resources to provide the data required.
- In addition, these initial discussions should include clear instructions on the requirements of the data being provided, and what is its intended purpose. This will assist councils with providing datasets that are fit for purpose.
- The use of a consistent GIS platform in the storage of data and location information provides a universal platform for the collation of data. If all the councils were using a similar software platform, processes could be adapted to this to streamline uploading of data. Furthermore, it is important that staff within the council not only have the skills to use these GIS and software platforms, but also their availability to meet data requests.

- As a major constraint in data availability is the extent to which data is collected, it is recommended that councils are supported to undertake more in-depth assessments of their networks.
- Datasets collected by councils should all be integrated into either asset management databases or GIS platforms to allow for linkages and cross-pollination in disciplines. By collating data, patterns may emerge which can assist future management.
- Lastly, data management practices should be based on a common standard, such as the Austroads Data Standard for Road Management and Investment. Furthermore, this standard should be used by all road management agencies to ensure consistency across datasets at different levels of government.

3.2.6 Summary of Learnings from Local Government Engagement

The process of direct engagement with local governments has been largely unsuccessful due to three key reasons:

1. Lack of resources across many of the councils to undertake the necessary person-hours to produce the requested outputs. This is complicated in many cases by storing of different types of data in separate databases.
2. Lack of expertise in data manipulation, some of which is normally required to meet the request being made. This again is often complicated by the nature of data management systems, processes and software that is used – all of which are suitable for the normal uses of the council, but not for extracting specific datasets as requested.
3. In many cases the data being sought either does not exist or does not exist in the form needed.

It is worth noting that extensive data about roads is now collected by third-party organisations. This data includes heavy vehicle access, inventory data and road condition data. Currently some of this data is rudimentary, however the quality and coverage of these datasets are sure to improve over time with technological improvements and investment.

These datasets potentially allow a national, consistent, mappable database of road data to be built and provided to local government. While this data may not be as detailed, reliable, and accurate as data collected by traditionally delivered professional road asset surveys, it could potentially provide a much wider coverage of the Australian road network.

In the future, engagement with local government could potentially take the form of making available reporting on data-derived assessments (e.g. HVIR results) for local roads (e.g. freight routes) and providing councils with the ability to update their current data with more recent and reliable data before any results are used for decision-making (e.g. road funding) purposes. This approach would avoid the delays and failure experienced by relying on all councils to have the resources and expertise to supply detailed data about their roads.

It is suggested that future work in this area includes the following:

1. Investigating the feasibility of accessing, combining and pinning to a map suitable data from commercial and open-source providers to calculate the HVIR and populate Asset Register datasets.
2. The formulation of any new calculation methods within the HVIR Framework that are needed in light of either different data or data of different sources/accuracy (e.g. roughness as reported from mobile phones is currently appropriate as an indicator of roughness rather than a measure of it), and a reliability index.
3. A scoping/costing for national scale implementation.

4. Data Standard Implementation in the Asset Register

4.1 Introduction

The Austroads Data Standard:

> *…was developed to provide a common understanding and language for the management and investment in road and associated infrastructure in Australia and New Zealand. It is intended to be used by all road asset owners, managers, road network funding agencies, stakeholders and service providers in the planning, delivery, operation, maintenance, disposal and reporting of asset management functions across the road asset portfolio.*

(from Austroads 2019a)

As part of this approach, a Priority Harmonisation Subset (PHS) of data items was determined in order to:

> *…promote the realisation of two key benefit areas identified by key industry stakeholders. These areas relate to comparative road network performance reporting and data items that are considered a priority for effective asset and maintenance management. The PHS…is confined to roads (pavement and surfacing), structures (bridges and major culverts) and tunnels as these asset types combined represent a significant share of the whole road network portfolio.*

(from Austroads 2019b)

The Asset Register and the HVIR Framework developed within this project will be some of the first practical adoptions of the Data Standard. However, the coverage of the full Data Standard is far wider than the data requirements of the Asset Register, therefore this discussion focuses on a consideration of the fields in the Asset Registers and Data Standard PHS only.

This report provides in Section 4.2 an overview of the Revised Priority Harmonised Subsets (PHS).

Section 4.3 presents an analysis of the alignment between the Data Standard and the Asset Register data and recommends where each could potentially be enhanced.

Section 4.4 presents a summary of the findings from the analysis.

4.2 Overview of the Revised Priority Harmonised Subsets (PHS)

As of January 2019, the Austroads Data Standard contained 987 data items. The PHS as a subset contains a total of 169 data items. Each of these items is associated with a level of varying sophistication of road asset components and management practices, as defined in Table 4.1.

Table 4.1: Asset data sophistication matrix

Level	1	2	3
General description	Network/subnetwork	Asset class	Component
Detailed information	• Information at network/subnetwork level • Level of service (LoS) description • Broad description of asset	• Information at asset level • Detailed asset description and condition data • Relationship of asset to network defined	• Information at component level • Detailed component description and performance data • Relationship of component to asset defined

Source: Table 1.1, page 4, Austroads (2019b).

Table 4.2 shows the references for the PHS dataset from within the wider Data Standard.

Table 4.2: Structure of the PHS

Function groups	Asset type	Data Standard section number	Number of sections
Classification	Road classification	8.2.1	1
Condition	Pavement/bridge major culvert/climate/terrain/soil type/rutting/roughness	8.4.2, 8.4.4, 8.4.9, 8.4.10, 8.4.12, 8.4.20, 8.4.22, 8.4.23, 8.4.31, 8.4.33, 8.4.34, 8.4.35, 8.4.36, 8.4.39, 8.4.50, 8.4.97, 8.4.61, 8.4.74, 8.4.75, 8.4.76, 8.4.77, 8.4.79, 8.4.80, 8.4.81, 8.4.82, 8.4.83, 8.4.84, 8.4.11,8.4.98, 8.4.99, 8.4.100	31
Demand	Population/road use/traffic growth	8.5.3, 8.5.6, 8.5.5, 8.5.7, 8.5.4, 8.5.8, 8.5.11	7
Inventory	General/valuation/bridge major culvert/pavement/ pavement general/pavement surfacing	8.3.0.1, 8.3.0.2, 8.3.0.14, 8.3.0.4, 8.3.0.15, 8.3.0.16, 8.3.0.17, 8.30.0.19, 8.3.0.20, 8.3.0.22, 8.3.0.21, 8.3.3.6, 8.3.3.21, 8.3.3.23, 8.3.3.24, 8.3.3.26, 8.3.14.3, 8.3.14.4, 8.3.14.7, 8.3.15.5, 8.3.15.6, 8.3.15.13, 8.3.31.1, 8.3.31.2, 8.3.31.3, 8.3.31.4, 8.3.31.6, 8.3.3.17, 8.3.3.20, 8.3.20.1, 8.3.14.13, 8.3.14.18, 8.3.14.5, 8.3.15.3, 8.3.15.7, 8.3.15.4	36
Location referencing	Point/polyline/X, Y, Z coordinates	7.1.1.2, 7.1.1.7, 7.1.1.8, 7.1.1.9, 7.1.2.11, 7.1.2.12, 7.1.2.13, 7.1.2.14, 7.1.2.15, 7.1.2.16, 7.1.2.17, 7.1.7.1.3.11	12
Network	Network name/node/road/link section	8.1.1, 8.1.2, 8.1.3, 8.1.4, 8.1.5, 8.1.6, 8.1.7, 8.1.8, 8.1.12, 8.1.13, 8.1.14, 8.1.15, 8.1.39, 8.1.40, 8.1.17, 8.1.18, 8.1.19, 8.1.20, 8.1.21, 8.1.22, 8.1.23, 8.1.27, 8.1.28, 8.1.29, 8.1.30, 8.1.31, 8.1.32, 8.1.33, 8.1.34, 8.1.35	30
Performance (asset)	Asset life/output/asset life	8.10.8, 8.10.15, 8.10.9, 8.10.16, 8.10.19, 8.10.20, 8.10.20, 8.10.21, 8.10.22, 8.10.23, 8.10.24, 8.10.28, 8.10.29, 8.10.25, 8.10.26, 8.10.27, 8.10.14	17
Performance (financial)	Investment	8.11.11, 8.11.12, 8.11.13, 8.11.14, 8.11.15, 8.11.16, 8.11.18	7
Utilisation	Traffic volumes	8.6.12, 8.6.26, 8.6.28	3
Works and costs	Maintenance/FWP2/output	8.14.1, 8.14.2, 8.14.3, 8.14.4, 8.14.5, 8.14.7, 8.14.8, 8.14.9, 8.14.11, 8.14.12, 8.14.14, 8.14.16, 8.14.28, 8.14.29, 8.14.31, 8.14.34, 8.14.37	17
Performance (service)	Road safety/customer experience/travel speed	8.12.10, 8.12.43, 8.12.46, 8.12.72	4
		Total Items =	169

Source: Table 3.1, page 1, Austroads (2019b).

4.3 Asset Register Alignment with the Data Standard

4.3.1 Analysis Approach

This section presents a comparison between the Asset Register and the Austroads PHS Data Standard. The analysis will provide guidance on implementing the Data Standard within the Asset Register as well as illustrating instances where the Data Standard could be modified to be more practical.

This comparison will cover the following common areas of Asset Management data:

- Section 4.3.2 – Identification of network segments
- Section 4.3.3 – Location referencing of network segments
- Section 4.3.4 – Road classification
- Section 4.3.5 – Heavy vehicle access data
- Section 4.3.6 – Road condition data
- Section 4.3.7 – Inventory data
- Section 4.3.8 – Operational data
- Section 4.3.9 – Environmental data
- Section 4.3.10 – Financial data.

4.3.2 Network Segment Identification

The Asset Register includes a unique ID for each 100 m segment of the network, as well as other information that provides contextual identification (see Table 4.3). Since the Asset Register was built on condition data, the field for 'direction' is important as it indicates the direction in which the road was surveyed. Roads are usually surveyed in one direction only, with the other direction (often the same carriageway with a similar level of traffic) expected to be in a similar if not identical condition. Condition data is often collected in the reverse direction when there is a divided carriageway, but state and territory jurisdictions vary in their practice on this. Surveys also typically collect data in the outermost continuous lane only since this lane is usually the most trafficked.

The result is a 'bottom-up' approach where the 100 m segment is the fundamental unit where all information about the network relevant to each 100 m segment is associated with it. The network as a whole is represented as a collection of these highly detailed segments.

Table 4.3: Segment identification data in the Asset Register

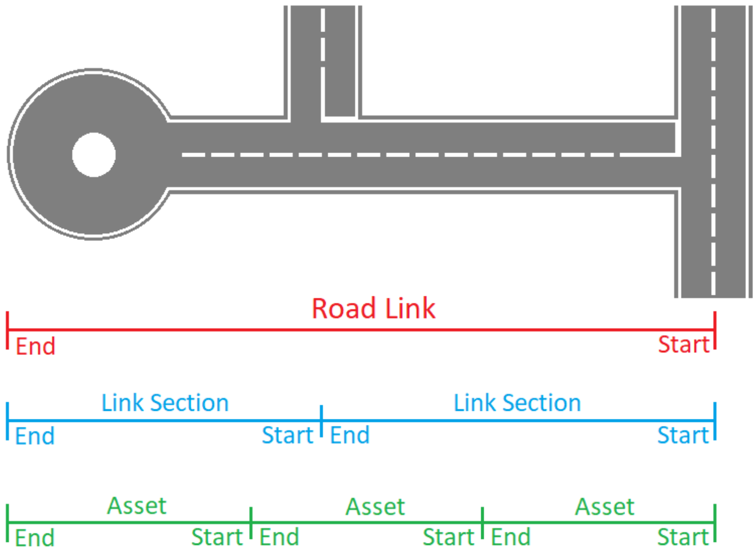
Field header	Field description	Format	Source	Expected range
unique_id	**Unique Id** Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row in the data to be associated with the network must use the same Unique ID as the shapefile.	Alphanumeric string	Road network reference	Non-specific
road_num	**Road number** Number used as a unique identifier for roads.	Alphanumeric	Road network reference	Non-specific
road_name	**Road name** Highest level name of road.	Text string	Road network reference	Non-specific
sect_num	**Section number** Alphanumeric identifier for roads that are broken into sections.	Alphanumeric string	Road network reference	Non-specific
sect_nam	**Section name** Named section of a longer road. This could be a lower level road name or indicate the locations the road links.	Text string	Road network reference	Non-specific
dirctn	**Direction** Please use 'Forward' rather than 'Prescribed' or 'Gazetted' and 'Reverse' instead of 'Counter'.	Text code	Road network reference	'Forward' or 'Reverse'
chain_start	**Chainage start** (km) Start chainage is used to identify the sequence of intervals.	Number to 3 decimal places	Road network reference	Between 0 and 3000
chain_end	**Chainage end** (km)	Number to 3 decimal places	Road network reference	Between 0 and 3000
int_len	**Interval length** (km) Interval lengths should be 0.1 km, except at the end of roads.	Number to 3 decimal places	Road network reference	Between 0 and 10

By contrast, the Data Standard attempts to represent the road network with a top-down approach starting from viewing the network as a whole, and then picking out connections and significant features:

- road links – which are connected at nodes and form the network
- link sections – sections within road links that have homogenous features
- assets – physical assets that are not necessarily confined within a link section.

Figure 4.1 shows how these elements of the network are defined relative to each other. The continuation of assets across multiple link sections requires an appropriate information referencing system.

Figure 4.1: Road link features as described in the Data Standard



'Assets' are the lowest level segmentation of the network under the PHS Data Standard and include unique identification as well as location referencing (see Section 4.3.3). In the Asset Register, network segmentation is in 100 m segments, which can be treated as 'assets' under the Data Standard since they represent distinct condition information.

The PHS Data Standard sets out identification of assets by a unique asset ID as shown in Table 4.4, Data Item 35. The remaining data items in Table 4.4 largely replicate the additional identification information used in the Asset Register.

Table 4.4: Data items that can be used for identification

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
35	Inventory	All – A General	8.3.0.1	Unique asset identifier	The unique asset identifier	All – a general unique asset ID (alphanumeric)
36	Inventory	All – A General	8.3.0.2	Asset class	The asset class or group	All – A general asset class (alpha)
51	Inventory	Pavement all	8.3.14.3	Chainage at start of street segment	Chainage at start of street segment. This is to be the starting chainage of the centreline.	Pavement chainage at start of segment (m) (integer)
52	Inventory	Pavement all	8.3.14.4	Chainage at end of street segment	Chainage at end of street segment.	Pavement chainage at end of segment (m) (integer)
82	Network	Road	8.1.12	Road ID	Unique reference identifier for an existing road.	Road unique reference ID (integer)
83	Network	Road	8.1.13	Road name	Road name spelled in full, no abbreviations for type of road.	Road (alpha)
90	Network	Link section	8.1.19	Link section ID	Link that is broken into more than one part creates a link section.	Link section unique (integer)

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
99	Network	Link section	8.1.31	Separate link sections for traffic flow direction	Identifies if the carriageway for vehicle flow in the opposite direction is separated by a physical barrier (divided), or undivided (no physical barrier).	Link section separate links for traffic flow (divided/ undivided) (alpha)

Source: Selected columns and rows from Table 3.3, Page 16, Austroads (2019b).

Chainage is often used in unique IDs because it is a convenient number generator for customised segmentations of a network, particularly when the segmentation is finer than the records the asset owner keeps for their own purposes. However, the use of chainage in a unique ID creates an issue when the chainage value at a particular point on a road is updated if there are works that change the length to a road by adding or subtracting sections or by altering the alignment of a road. Subsequent to any changes, the chainage of the road is re-calculated from the start point of the road.

To avoid confusion as a result of this, either:

- the unique asset IDs need to be fixed and avoid any reference to the chainage; or
- any changes to chainage and any unique IDs reliant on this information need to be documented.

While avoiding chainage in the unique IDs may be a solution, the presence of a number that is related to the physical position of the asset is advantageous, as the alternative is to generate unique IDs using an abstract number or alphanumeric that is unrelated to the asset.

One aspect of asset identification that can be useful is to know the sequence of assets along the road length. This may or may not be provided within the format of unique IDs. In the Asset Register, this is contained within the chainage (start and end) data, which is provided for each 100 m segment. Chainage provided in the Data Standard for the start and end of 'Street segments' are presumed to be Road or Link Sections rather than assets (the term 'Street Section' is mentioned only in Section 8.3.14). Regardless, this chainage information still adds to the context for the 100 m asset segments.

4.3.3 Location Referencing

In the Asset Register, the location of 100 m segments is specified by using GPS coordinates for the start and end of each segment (see Table 4.5).

Table 4.5: Location referencing for 100 m segments in the Asset Register

Field header	Field description	Format	Source	Expected range
start_long	**Start Longitude** If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Geospatial database	Between 112 and 154
start_lat	**Start Latitude** If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Geospatial database	Between –10 and –44
end_long	**End Longitude** If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Geospatial database	Between 112 and 154

Field header	Field description	Format	Source	Expected range
end_lat	**End Latitude** If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Geospatial database	Between –10 and –44

In the PHS Data Standard under the Location Referencing Function Group, data items for the X and Y coordinates of the start and end points of assets are provided (see Table 4.6). The proposed metrics are GPS coordinates to 6 decimal places. These align with the method used to directly locate 100 m assets in the Asset Registers.

Table 4.6: Location referencing for an asset in the Data Standard

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Format?
67	Location referencing	Polyline	7.1.2.12	X coordinate start	X coordinate locator point at start of asset	X coordinate start at start of asset (degrees) (numeric) to six decimal places
68	Location referencing	Polyline	7.1.2.13	Y coordinate start	Y coordinate locator point at start of asset	Y coordinate start at start of asset (degrees) (numeric) to six decimal places
69	Location referencing	Polyline	7.1.2.14	X coordinate end	X coordinate locator point at end of asset	X coordinate end at end of asset (degrees) (numeric) to six decimal places
70	Location referencing	Polyline	7.1.2.15	Y coordinate end	Y coordinate locator point at end of asset	Y coordinate end at end of asset (degrees) (numeric) to six decimal places

Source: Selected columns and rows from Table 3.3, page 16, Austroads (2019b).

The location information in both the Asset Register and the PHS Data Standard allow the location of the asset to be known, but not the path of the asset. In many applications it is desirable to be able to trace the path of the road rather than drawing straight lines between the start and end points as even over 100 m these may not accurately represent the shape of the asset. The impact of this relates not only to the appearance of the asset when plotted on a map or other graphical representation, but also impacts the interaction with other spatial data such as from vehicles travelling along the road, or other mapped assets located on the roadside.

To address these challenges and take a more modern approach to data management and data architecture, the Asset Register data structure may evolve to hold an underlying network map with accurate road curvatures separate from additional information about the 100 m asset segments. Then a unique identifier that allows the richer asset condition information to be linked with the network map/asset locations will be critically important.

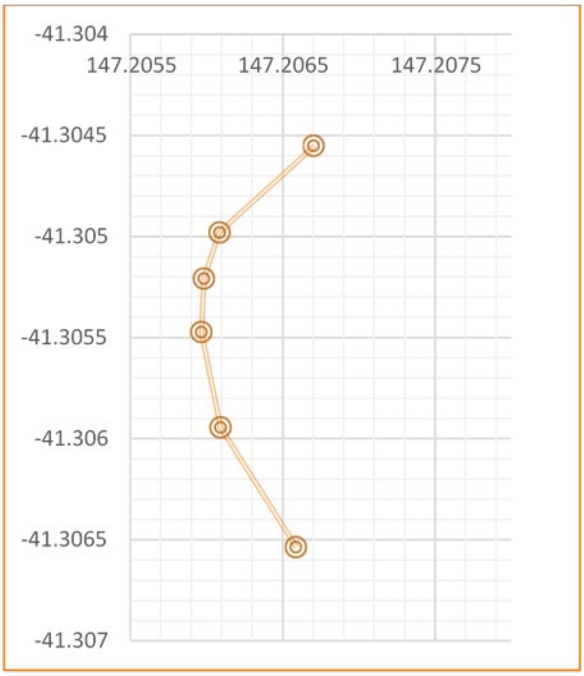
When exporting to other applications that may not have an underlying network map, the shape of the road asset can be represented using Well Known Text (WKT), which provides a string of coordinates in sufficient number to represent the required shape as determined by the rate of curvature (e.g. two points are sufficient for a straight road, but a road with sharper curves, or complicated path, requires a greater number of points). WKT has the advantage of being able to be represented in table outputs (e.g. in .CSV files) using recognisable (GPS) coordinates – as opposed to the same information stored in binary format such as within shapefiles.

Figure 4.2 shows a WKT plot of six coordinate points making up a length of road compared to the same length of road as represented in Google Maps navigation. The plot linking start and end points (red line) is overlaid on the Google Map to demonstrate how this segment would appear without path information.

Figure 4.2: Comparison of a road plotted in Google Maps and a WKT representation of the same road

a. Google maps road section path

b. WKT plot of road section



Source: Google Maps (2019), 'Tasmania', map data, Google, California, USA.

While the Data Standard report (Austroads 2019b) mentions WKT as a data type definition in Table 6.3 (page 33), it does not appear anywhere else in the Data Standard report or at all in the Revised PHS report i.e. there is no data item for WKT or any other path geometry information. The inclusion of a road path data item using WKT in the Data Standard would allow this to be made consistent when applying the Data Standard to applications that do not have an underlying network map or exporting data to other applications.

The Asset Register processes can use shapefiles for sharing and presenting information. However, there is a compatibility issue between the Data Standard and Esri shapefiles since attribute names in shapefiles are limited to 10 characters. This means that 17 data item names in excess of 10 characters in the PHS would be automatically truncated as shapefile attributes, making headers either no longer unique or losing some information. This will need to be addressed if the Data Standard is intended to work seamlessly with Esri shapefiles.

4.3.4 Road Classification

The Asset Register uses the five-level road categorisation system developed as part of AT1920 in the absence of a nationally consistent road classification system. These road categories are shown in Table 4.7.

Table 4.7: Road categories used in the Asset Register

Field header	Field description	Format	Source	Expected range
road_cat	**Road category** R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	Alphanumeric code	Road network reference (adapted)	R1 or R2 or R3 or R4 or R5

The PHS Data Standard includes a single data item for the road classification as shown in Table 4.8. The road classification system ultimately adopted by the Data Standard will be an agreed, national classification of roads.

Table 4.8: Data items related to road classification

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
5	Classification	Road classification	8.2.1	One road classification system (NZ) approach	The road classification for the carriageway section	T.B.A.

Source Table 3.3, Page 16, Austroads (2019b).

The Asset Register will continue to contain and use the R1 to R5 road classification system until a consistent, national road classification system is agreed.

4.3.5 Heavy Vehicle Access Data

Heavy vehicle access is described in two ways in the Asset Register (see Table 4.9): using the Austroads Vehicle Classes (1 to 12), or by the specific mass and length limits of vehicles allowed to use the road section.

Table 4.9: Heavy vehicle access data in the Asset Register

Field header	Field description	Format	Source	Expected range
avc	**Austroads Vehicle Class** This is one option for indicating heavy vehicle access by inputting the highest Austroads vehicle class permitted to use the road section.	Integer code	Heavy vehicle access management data	Integers 1 to 12
mass_lim	**Mass limit for heavy vehicle access** (t) Mass limit indicates the heaviest gross mass permitted to use the road.	Number to 1 decimal place	Heavy vehicle access management data	1 to 150
len_lim	**Length limit for heavy vehicle access** (m) The length limit indicates the longest vehicle permitted to use the road.	Number to 3 decimal places	Heavy vehicle access management data	5 to 100

The Data Standard PHS has four data items in the Access function group as shown in Table 4.10 which can be used to convey access information.

Table 4.10: Data Standard PHS items related to Access

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
1	Access	Identification	8.13.2	Restriction type	The restriction type	Access identification restriction type (alpha)
2	Access	Identification	8.13.3	Restriction reason	The reason for the restriction being applied	Access identification reason for restriction (alpha)
3	Access	Identification	8.13.4	User group restriction applies to	The user group that the restriction applies to	Access identification road user restriction description (alpha)
4	Access	Identification	8.13.5	Restriction unit	Unit for the value dimensioning the restriction	Access identification restriction unit (metres, tonnes) (alpha)

Source Table 3.3, Page 16, Austroads (2019b).

While this allows the heavy vehicle access to be indicated, there can be multiple restriction types. The Data Standard refers to these multiple restriction types and their units in the discussion of access (page 179 of the Data Standard V3 report). The allowed restriction types are shown in the Data Standard V3 report in Table 9.39 on page 196), replicated below in Table 4.11. At any point on the network access could be restricted due to any number of these reasons.

Table 4.11: Restriction types for data item 8.13.2

Code	Description
ACCESS	Access
AGRI	Agricultural machinery
AXLE	Axle limit
DIR	Direction
HAZCHEM	Hazardous material
HEIGHT	Height (vertical) clearance
LENGTH	Length
TOLL	Toll fee application
WEIGHT	Weight
WIDTH	Width clearance

This approach requires that data items be used to define the type, reason, user group and then unit for each individual restriction. For example, describing a restriction by weight and length from the list in Table 4.13 would require the use of two instances of each of the four data items in Table 4.10. This seems to be putting a lot of information around the restriction that is repetitive, but the cost-benefit balance of this will ultimately depend on the application of the data.

The PHS Data Standard does not describe how multiple instances of data items are to be implemented.

4.3.6 Road Condition Data

The Asset Register includes all the typical condition data with the addition of strength (central deflection) which is increasingly efficient to collect with traffic speed deflectometers (TSD). Initially, no survey date was included with the condition data, with the complete dataset expected to be the latest data up to the release date (which could include data from multiple years). Fields have recently been added to include the survey date for all the condition data. Table 4.12 shows the specification for condition data in the Asset Register.

Table 4.12: Road condition data from the Asset Register

Field header	Field description	Format	Source	Expected range
hati	**Heavy Articulated Truck Index** (m/km)	Number to 3 decimal places	Calculated from surveyed condition data	0 to 15
iri	**Lane IRI** (m/km)	Number to 3 decimal places	Calculated from surveyed condition data	0 to 20
lp_date	**Date longitudinal profile data was collected** Longitudinal profile data is used to calculate both IRI and HATI	Date yyyymmdd	Condition survey metadata	After 1960
rutt	**Rutting** (mm) Lane rutting	Integer	Condition survey laser measurement	0 to 250
rut_date	**Date rutting data was collected**	Date yyyymmdd	Condition survey metadata	After 1960
cracking	**Cracking extent** (%)	Percentage integer	Condition survey laser measurement	0 to 100
crk_date	**Date cracking data was collected**	Date yyyymmdd	Condition survey metadata	After 1960
strength	**Central deflection** (microns)	Integer	Traffic speed deflectometer output	0 to 10000
str_date	**Date deflection data was collected**	Date yyyymmdd	Condition survey metadata	After 2010
textowp	**Texture in outer wheel path** MPD	Integer	Condition survey laser measurement	0 to 30
textbwp	**Texture between wheel paths** MPD	Integer	Condition survey laser measurement	0 to 30
tex_date	**Date texture data was collected**	Date yyyymmdd	Condition survey metadata	After 1960
vcg	**Visual condition grade** Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/Moderate 4 = Poor 5 = Very poor	Integer	Manual survey records	0 or 1 or 2 or 3 or 4 or 5

The Data Standard PHS includes data related to the road condition as shown in Table 4.13, including data in much greater detail , such as when the condition data was collected, data for different parts of the lane (i.e. in and between wheel paths), and the source (vehicle/device) of the data collection.

Table 4.13: Data items related to ride quality

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
6	Condition	Subjective condition	8.4.2	Subjective condition survey date-time	Date-time that subjective condition survey was done	Subjective condition of asset survey date dd/mm/yyyy
7	Condition	Visually assessed condition	8.4.4	Visual assessed condition	A numerical rating of the condition based on a visual inspection using a documented guideline with the aim of repeatable results	Visually assessed condition rating (0 to 5) integer
8	Condition	Visually assessed condition	8.4.9	Visual cracking area	Percentage area affected by cracking	Visually assessed condition % area affected by cracking (integer)
9	Condition	Visually assessed condition	8.4.10	Visual measured rutting	Numerical rating of rutting based on visual assessment using a documented guideline to achieve repeatable results	Visual condition of asset (rating) 1–5 integer
10	Condition	Pavement – Cracking	8.4.12	All cracking extent	The percentage affected area of a 100 m section (or defined segment length) where cracking is evident in the traffic lane	Pavement cracking % of surface area 100 m integer
11	Condition	Pavement – Cracking	8.4.20	Cracking survey date-time	Date that cracking survey was done	Pavement cracking survey date dd/mm/yyyy
12	Condition	Pavement – Deflection	8.4.22	Deflection testing vehicle	Type of vehicle used to measure deflection	Pavement deflection testing vehicle type (alphanumeric)
13	Condition	Pavement – Deflection	8.4.23	Pavement deflection d0	Pavement deflection at the test load. As measured using a BB, DEF, FWD or TSD (iPAVe)*. TSD deflection not normalised	Pavement deflection under test load measured (micron) integer
14	Condition	Pavement – Deflection	8.4.31	Deflection survey date-time	Date that deflection survey was done	Pavement deflection survey date dd/mm/yyyy & time hrs min.
15	Condition	Pavement – Roughness	8.4.33	Lane roughness IRI quarter car	Pavement roughness expressed as Lane IRI, reported at 100 m intervals	Pavement roughness lane IRI (m/km) numeric two decimal places
16	Condition	Pavement – roughness	8.4.34	Inner wheel path IRI roughness	Pavement roughness expressed as IRI, reported at 100 m intervals	Pavement roughness inner wheel path IRI (m/km) numeric two decimal places

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
17	Condition	Pavement – roughness	8.4.35	Outer wheel path IRI roughness	Pavement roughness expressed as IRIqc, reported at 100 m intervals	Pavement roughness outer wheel path IRI (m/km) numeric two decimal places
18	Condition	Pavement – roughness	8.4.36	Roughness survey date-time	Date that roughness survey was done	Pavement roughness survey date dd/mm/yyyy
19	Condition	Pavement – rutting	8.4.39	Rut depth inner	Maximum rut depth inner wheel path. Measured using a 2 m straight edge, at the deepest transverse cross-section point, and reported at 100 m intervals	Pavement rutting depth (mm) inner wheel path (integer)
20	Condition	Pavement – rutting	8.4.50	Rut depth outer	Maximum rut depth outer wheel path. Measured using a 2 m straight edge, at the deepest transverse cross-section point, and reported at 100 m intervals	Pavement rutting depth (mm) outer wheel path (integer)
21	Condition	Pavement – rutting	8.4.97 (NEW)	Lane rut depth	Lane rut depth reported at 100 m intervals	Pavement rutting depth (mm) mean of outer & inner wheel path (integer)
22	Condition	Pavement – rutting	8.4.61	Rutting survey date-time	Date that rutting survey was done	Pavement rutting survey date dd/mm/yyyy
23	Condition	Pavement surface – texture	8.4.74	MPD Pavement texture inner wheel path	Pavement texture Mean Profile Depth (MPD) measured in the inner wheel path reported at 100 m intervals	Pavement texture MPD texture inner wheel path (mm) numeric one decimal place
24	Condition	Pavement surface – texture	8.4.75	MPD Pavement texture outer wheel path	Pavement texture Mean Profile Depth (MPD) measured in the outer wheel path reported at 100 m intervals	Pavement texture MPD texture outer wheel path (mm) numeric one decimal place
25	Condition	Pavement surface – texture	8.4.76	MPD Pavement texture between wheel path	Pavement texture Mean Profile Depth (MPD) between the left and right wheel paths reported at 100 m intervals	Pavement texture MPD texture between wheel paths (mm) numeric one decimal place
26	Condition	Pavement surface – texture	8.4.77	Texture survey date-time	Date that texture survey was done	Pavement surface texture survey date: dd/mm/yyyy & time hr

** BB = Benkelman Beam, DEF = Deflectometer , FWD = Falling Weight Deflectometer, TSD = Traffic Speed Deflectometer, iPAVe = intelligent Pavement Assessment Vehicle.*

Source Table 3.3, Page 16, Austroads (2019b).

The inclusion of more types of condition data as described in the Data Standard provides a more complete and authoritative reference for the condition data and should be included in the Asset Register.

4.3.7 Road Inventory Data

The adequate description of road inventory needs to have provision for three main types of roads: sealed roads with line markings, sealed roads without line markings, and unsealed roads. There needs to be a means of identifying which of these types a given road is and then measures of the relevant physical parameters.

For this reason, the Asset Register specification has been expanded to include sufficient information to make this identification, as well as the subsequent information required in light of the road type (see Table 4.14).

Table 4.14: Inventory data from the Asset Register

Field header	Field description	Format	Source	Expected range
road_cat	**Road category** R1 – Freeways R2 – Urban highways R3 – Urban arterials or Rural highways R4 – Collector and distributor roads R5 – Property access roads	Alphanumeric code	Road network reference (adapted)	R1 or R2 or R3 or R4 or R5
cway	**Carriageway code** A – Single carriageway B – Divided carriageway, Forward C – Divided carriageway, Reverse	Letter code	Road network reference	A, B or C
form_width	**Width of formed roadway** (m)	Number to 3 decimal places	Construction data or subsequent survey	Between 1 and 100
seal_flag	**Seal flag**	Text code	Construction data	Sealed or Unsealed
seal_width	**Width of seal** (m)	Number to 3 decimal places	Construction data or subsequent survey	Between 1 and 50
seal_date	**Date of last seal or reseal**	Date yyyymmdd	Maintenance records	Within 20 years
line_mark	**Line marking flag**	Text code	Construction data	Yes or No
num_lanes	**Number of lanes**	Integer	Construction data	1 to 10
lane_width	**Lane width** (m)	Number to 3 decimal places	Construction data or subsequent survey	1 to 10
seal_shld	**Sealed shoulder width** (m)	Number to 3 decimal places	Construction data or subsequent survey	0 to 10
unseal_shld	**Unsealed shoulder width** (m)	Number to 3 decimal places	Construction data or subsequent survey	0 to 10
pave_type	**Pavement type** SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	Text code	Construction data	SS or SU or US or UU or C
pave_date	**Date of pavement construction**	Date yyyymmdd	Construction data	After 1950

The PHS Data Standard does include some data items for the identification of the road type:

- Data item 54 (DS 8.3.15.5) identifies if the road is sealed or unsealed.
- Data item 94 (DS 8.1.23) sets out 'link section average width', (which accounts for seal width if sealed, or formation width if unsealed).

These two together provide for the inventory description of unsealed roads and sealed roads without line markings, although the presence or absence of line markings is not included in the PHS. The Data Standard does include data items related to the description of painted lines for which null values could be used to indicate the absence of lines (e.g. Line type = none, see DS Section 8.3.10 Line Marking).

The Data Standard and the Revised PHS both have data items that are comparable to the content of the Asset Register (often with some more detail) with the exception of shoulder widths (sealed or unsealed). These are shown in Table 4.15.

Table 4.15: Inventory data from the PHS Data Standard

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
53	Inventory	Pavement all	8.3.14.7	Pavement base material	Type of nominal base material description (concrete/granular/ asphalt/other)	Pavement material source name (alpha)
54	Inventory	Pavement surfacing all	8.3.15.5	Road surface status	The status of the current surfacing type	Pavement surfacing status sealed (S) unsealed (U) (alpha)
55	Inventory	Pavement surfacing all	8.3.15.6	Year of current surface installation	The calendar year of the most recent surfacing	Pavement surfacing year current surfacing applied yyyy (integer)
56	Inventory	Pavement surfacing	8.3.15.13	Surfacing material type	A description of the material type of the surfacing layer: sprayed seal; asphalt; concrete; unsealed wearing surface; unsealed no wearing surface	Pavement surfacing material type (alpha)
93	Network	Link section	8.1.22	Link section length	Length of the link section calculated by deducting the link section end displacement from the link section start displacement	Link Section length (m) (integer)
94	Network	Link section	8.1.23	Link section average width	Weighted average width of the link section measured between edge of pavement to edge of pavement for unsealed roads. For sealed roads from edge of seal to edge of seal where no kerb is present, or kerb face to kerb face	Link section average width (m) (numeric) to one decimal place

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
95	Network	Link section	8.1.27	Number of lanes left of centreline	Number of trafficable lanes within the link section, left of the centreline	Link section number of lanes left of centreline (integer)
96	Network	Link section	8.1.28	Number of lanes right of centreline	Number of trafficable lanes within the link section, right of the centreline	Link section number of lanes right of centreline (integer)
97	Network	Link section	8.1.29	Average lane width left of centreline	Average width of trafficable lanes, within the link section, left of the centreline	Link section average lane width left of centreline (m) (numeric) to one decimal place
98	Network	Link section	8.1.30	Average lane width right of centreline	Average width of trafficable lanes, within the link section, right of the centreline	Link section average lane width right of centreline (m) (numeric) to one decimal place
99	Network	Link section	8.1.31	Separate link sections for traffic flow direction	Identifies if the carriageway for vehicle flow in the opposite direction is separated by means of a physical barrier (divided), or undivided (no physical barrier)	Link section separate links for traffic flow (divided/undivided) (alpha)
102	Network	Link section	8.1.34	Type of pavement construction	Type of pavement on the link section	Link section type of pavement construction (alpha)
103	Network	Link section	8.1.35	Ownership organisation	Link section that defines the ownership location of a road	Link section ownership organisation name (alpha)
150	Inventory	Pavement layers	8.3.14.13	Layer material	Type of material for the layer	Description (alpha)
151	Inventory	Pavement layers	8.3.14.18	Layer width	Width of material for the layer excluding the feather edge. Generally, this is the width of pavement underneath the surfacing	Metres (numeric) to two decimal places
152	Inventory	Pavement general	8.3.14.5	Centreline segment length	Centreline segment length between chainages in metres	Metres (numeric) to two decimal places
153	Inventory	Pavement surfacing – general	8.3.15.3	Length of seal	The length of the seal for the layer	Metres (numeric) to two decimal places
155	Inventory	Pavement surfacing – general	8.3.15.33 (NEW)	Number of lanes	Number of lanes	Integer
156	Inventory	Pavement Surfacing – General	8.3.15.4	Width of seal	Width of the seal layer. The seal width is only required for a partial width seal, and will have an offset from the centreline	Metres to two decimal places

Source Table 3.3, Page 16, Austroads (2019b).

The Asset Register data will continue to include: sealed shoulder width (m to 2 decimal places), unsealed shoulder width (m to 2 decimal places), and an indicator for whether the road has painted lines or not (Marked or Unmarked).

For the ability to fully describe inventory, shoulder widths should be included in the PHS dataset.

4.3.8 Operational Data

Operational data refers to data affecting the operation of the road; this can include both imposed conditions on operations (speed limits, time-based restrictions, etc.) and operational statistics (traffic, congestion, average speeds, etc.). In the Asset Register operational data is limited to speed limit, traffic (AADT) and the heavy vehicle percentage as detailed in Table 4.16.

Table 4.16: Operational data collected for the Asset Register

Field name	Description	Unit type	Source	Expected range
traffic	One-way AADT	Integer	Traffic counters	0 to 50000
perc_heavy	% of heavy vehicles	Percentage integer	Traffic counter and/or WIM or similar	0 to 100
speed_lim	Speed limit (km/h)	Integer	Operational database	25 to 130

Table 4.17 shows the same information above as it is specified in the PHS, with the following differences:

- The traffic data is expected to be two-way (i.e. per carriageway).
- There is an inclusion of a data item for reporting the traffic level against the Austroads (1 to 12) Vehicle Classes.
- The formulation of the % heavy vehicles is described as a breakdown of the Austroads Vehicle Classes (assumed to be levels 3 to 12 inclusive) – this same quantity in the Asset Register which does not have its formulation specified.

Table 4.17: Specification of operational (utilisation) data in the PHS

No.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
126	Utilisation	Traffic volumes	8.6.12	Average annual daily traffic (AADT)	Typically, the total volume of traffic (sum of vehicles travelling in both direction on a two-way road) at a location over a period of 365 days divided by 365. Practically, the counting period should be a minimum of 7 continuous days and, if known, seasonal factors should be applied	Use traffic volumes average annual daily traffic (AADT) number vehicles/day (integer)
127	Utilisation	Traffic volumes	8.6.26	Percentage of AADT classified as heavy vehicles	The percentage of the AADT where the traffic volume is classified as heavy vehicles. Australia: classes 3–12	Use traffic volumes % AADT classified as heavy vehicles (integer)

No.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
157	Utilisation	Traffic volumes	8.6.28	Average annual daily traffic per class	Each country has pre-defined classes definition that differ slightly. They are based on the number of axles, axle spacing, weight and length of vehicle. Australia: Austroads specifies 12 classes	Vehicles/day (integer)
165	Performa nce (service)	Travel speed	8.12.72 (NEW)	Posted travel speed	Posted travel speed (speed limit) on rural or urban road or link	Posted travel speed km/h (integer)

Source: Items 126, 127 from Table 3.3, page 42, 43; Item 165 from Table 3.4, Page 50, Austroads (2019b).

4.3.9 Environmental Data

Environmental data provides important information related to the life-cycle of the road pavement. Cracking and other forms of deterioration are accelerated by the persistence of water in the immediate environment of the asset. In the Asset Register environmental data is limited to a broad categorisation of the climate, in terms of the annual temperature range (hot or cold) and the annual precipitation (dry or wet). The subgrade is described in terms of the soil type underlying the road construction. Table 4.18 summarises all the environmental data in the Asset Register.

This data is important as it provides a broad indication of the amount of water typically introduced to the road asset, and the extent to which the water can leave the asset by draining away or evaporating.

Table 4.18: Environmental data in the Asset Register

Field name	Description	Unit type	Source	Expected range
climate	**Climate** CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	Text code	Geographical data	CD or CW or HD or HW
subgrade	**Subgrade material** S = sandy M = medium C = light clay X = expansive clay R = rock	Text code	Geographical data	S or M or C or X or R

When environmental data is used in asset management, it is typically in the form of the Thornthwaite Moisture Index (TMI), which is a more detailed calculation based not only on the climate and soil type, but more precise measures of the precipitation, evapotranspiration, soil water storage, moisture deficit and run off from the asset. While this is a superior representation of the environmental data, two key issues associated with its use are:

- Since the TMI relies on more detailed input data its availability is more limited that broad categorisations of regional climate zones and soil types.
- There are three different methods of calculating TMI (producing different answers) commonly in use.

The PHS Data Standard includes a data item for TMI added in the latest revision (see Table 4.19) but does not specify which calculation method should be used.

Table 4.19: Specification of environmental data in the PHS

No.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
166	Condition	Climate	8.4.11	Thornthwaite Moisture Index	Thornthwaite Moisture Index	Climate Thornthwaite Moisture Index (integer)
167	Condition	Climate	8.4.98 (NEW)	Marine or non-marine	Marine – relevant to coastal areas; Non-marine – non-coastal areas	Description (alpha)
169	Condition	Soil type	8.4.100 (NEW)	Soil (reactive/ non-reactive)	Soil type will influence infrastructure performance and capital and maintenance costs	Description (alpha)

Source: Selected rows and columns from Table 3.4, Page 50, Austroads (2019b).

4.3.10 Financial Data

The Financial data that has been included in the Asset Register is limited to three key considerations: the annual maintenance costs of the asset, the revenue from the asset (placeholder for potential road-user charging), and the replacement cost (value) of the asset (see Table 4.20). These amounts are intended to be sourced from more detailed financial data and analysis hosted elsewhere and provided so that quick comparisons can be made between the performance of the asset and the costs associated with it.

Table 4.20: Financial data in the Asset Register

Field name	Description	Unit type	Source	Expected range
cost_maint	**Annual expenditure** on maintenance per 100 m interval (annual average)	Number to 2 decimal places (AUD)	Budget and expenditure records	0 to 30000000000
cost_asset	**Replacement cost** per 100 m interval (annual average)	Number to 2 decimal places (AUD)	Financial forecasting	0 to 300000000000
revn_asset	**Revenue** per 100 m interval (annual average)	Number to 2 decimal places (AUD)	Placeholder for charging	0 to 30000000000

The cost per 100 m section in the Asset Register is a (proportional) fraction of the costs associated with longer ‘maintenance sections’ which are often several hundred metres in length; likewise, construction costs and any future revenue from charges for use of the road link would be divided between the number of 100 m segments. Therefore, these quantities for the 100 m sections are somewhat artificial. For example, maintenance decisions are usually made based on the condition of the maintenance section rather than a 100 m section (there are exceptions for defects like potholes that need to be addressed as soon as possible to prevent rapid deterioration of the pavement).

The PHS Data Standard includes specification for eight data items that are associated with the cost of assets in the network (see Table 4.21). These express the financial information in slightly more detail than the approach in the Asset Register.

Table 4.21: Specification of asset level financial data in the PHS

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
38	Inventory	All – A general	8.3.0.4	Owner of the asset	Owner of the asset	All – A general name of owner of asset (alpha)
39	Inventory	All – B valuation	8.3.0.15	Construction date	Date the asset was commissioned	All – B valuation construction date (dd/mm/yyyy)
40	Inventory	All – B valuation	8.3.0.16	Construction cost	Construction cost in Australian Dollars.	All – B valuation construction cost $AUD (numeric)
41	Inventory	All – B valuation	8.3.0.17	Operation status	Current operational state of the asset	All – B valuation operational status (alpha)
42	Inventory	All – B valuation	8.3.0.19	Valuation type	Valuation type	All – B valuation valuation type (alpha)
43	Inventory	All – B valuation	8.3.0.20	Assessed cost in Australian Dollars	Assessed cost in Australian Dollars.	All – B valuation assessed cost $AUD (numeric)
44	Inventory	All – B valuation	8.3.0.22	Valuation year	The date the valuation was undertaken	All – B valuation date valuation was made (dd/mm/yyyy)
45	Inventory	All – B valuation	8.3.0.21	Unit cost	Cost per unit of the asset	All – B valuation unit cost of asset $AUD (numeric)

Source Table 3.3, Page 16, Austroads (2019b).

The financial information included in the PHS has a total of seven data items (see Table 4.22) that are focused on total costs (for a network, region, or the nation) rather than the breakdown per road section of the maintenance and replacement costs. Additional data items are related to infrastructure upgrades, and recurrent spending, but taking a whole-of-network view.

The Asset Register has not included this broader scope of total costs, but they are detailed here as a potential future inclusion.

Table 4.22: Specification of network level financial data in the PHS

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
119	Performance (financial)	Investment	8.11.11	Total capital spend	Relatively large (material) expenditure, which has benefits, expected to last for more than 12 months.	Investment total capital spend upgrades/ expansion/ renewals/ replacement of assets $AUD/year (integer)
120	Performance (financial)	Investment	8.11.12	Capital spend – upgrade and expansion	Upgrade capital is expenditure which replaces a previously existing asset with enhanced capability or function.	Investment capital spend on upgrades and expansion of assets $AUD/year (integer)

PHS no.	Function groups	Asset type	Data Standard section	Name	Definition	Proposed metrics
121	Performance (financial)	Investment	8.11.13	Periodic maintenance (capital spend – renewals)	Periodic maintenance and replacement involve expenditure on an existing asset, which returns the service capability of the asset up to that which it had originally.	Investment spend on maintenance or replacement of assets $AUD/year (integer)
122	Performance (financial)	Investment	8.11.14	Total recurrent spend	Recurrent expenditure, which is relatively small (immaterial) or that which has benefits expected to last less than 12 months. Recurrent expenditure is continuously required to maintain an asset or provide a service.	Investment recurrent spend total $AUD/year (integer)
123	Performance (financial)	Investment	8.11.15	Recurrent spend – rroutine pavement-related maintenance	Routine maintenance is recurrent expenditure, which is regularly required as part of the anticipated schedule of works required to ensure that the asset achieves its useful life and provides the required level of service.	Investment recurrent spend maintenance $AUD/year (integer)
124	Performance (financial)	Investment	8.11.18 (NEW)	Recurrent spend – routine Off-pavement-related maintenance	Routine off pavement-related maintenance is recurrent expenditure, which is continuously required to provide a service along the pavement.	Investment recurrent spend routine off pavement maintenance $AUD/year (integer)
125	Performance (financial)	Investment	8.11.16	Recurrent spend – operations	Operations is recurrent expenditure, which is continuously required to provide a service.	Investment recurrent spend operations $AUD/year (integer)

Source: Selected columns and rows from Table 3.3, Page 16, Austroads (2019b).

4.4 Summary of Aligning the Asset Register and Data Standard

4.4.1 General Conclusions

Some of the key differences between the Asset Register and Data Standard specifications arise from the original intent of each of these datasets.

The Asset Register data specification was built from data known to be collected and used by RAs in representing the performance of the road network in terms of the key considerations of heavy vehicle access, surface/pavement condition, and inventory. It has been expanded to accommodate a broader range of road types (i.e. road types other than sealed, marked roads), to include more metadata (e.g. the date and time that data was collected), and financial data.

The Data Standard specification has taken a top-down approach to systematically define and describe every possible aspect of the road network. The consequence of this is that the data items that make up the Data Standard are: weighed towards network-level considerations, are relatively complex, and in some cases are not a match to the actual data reported by road agencies.

There are merits and important reasons for both approaches being the way that they are, and the recommendations in the following sections seek to build more of a middle ground by:

- aligning the Asset Register data specification to the Data Standard to allow the Asset Register to deliver value on a broader scale
- providing feedback to make the Data Standard more practical.

The project team has concluded that beyond these is an appropriate level of alignment between the Data Standard and Asset Register for current practice.

4.4.2 Potential Changes to the Asset Register Data Specification

The following points will more closely align the Asset Register data specification with the PHS Data Standard:

1. Introduce Data Standard terminology to the Asset Register. This will involve:
   a. where the Asset Register and the Data Standard have equivalent fields, adopt the Data Standard field name/description
   b. adopt the Data Standard header names (abbreviations) where reasonable.
2. Include important data items in the Asset Register that are currently absent, in particular:
   a. data items that identify the source/vehicle/device used to collect the data
   b. data items that identify the asset owner/jurisdiction
   c. road path data (e.g. Well Known Text).
3. Do not include additional complex or detailed specifications of data such as access restrictions and extended financial data.

A version of the Asset Register data specification compliant with the Data Standard is shown in Appendix A.

4.4.3 Suggested Changes to the Data Standard

The following suggestions are made for the review of the Data Standard project, considering the analysis contained in this report.

1. Define a process for generating standardised unique IDs for road links and pavement segment assets (100 m condition data will be attached to these). Using chainages is still recommended as it provides a convenient and practical reference for distinguishing both the location and identity of any asset, especially when there are new installations or customised network segmentations are extracted from the data. The use of chainages for this purpose means that there must be processes in place to allow unique IDs to be updated and historically associated when networks are upgraded.
2. To ensure that the path of a road link is accounted for, the Data Standard should either:
   a. add a disclaimer/caveat that geographical location and path information is to be provided by an underlying national map as part of applications, such that all location information provided in the Data Standard is solely for assisting with identification/association with an underlying map; or
   b. add a data item for path information in the form of Well-Known Text (text string).
3. Consider shortening all data item names to be no more than 10 characters if the Data Standard is intended to be compatible with ESRI shapefiles.

4. Consider simplifying heavy vehicle access by allowing multiple restriction units to be grouped under a single restriction type based on the vehicle parameters. Every road link will have a mass, length and height limit for vehicles that can operate on it.
5. Include the paint marking data specification from Section 8.3.10 Line Marking of the Data Standard V3 S in the PHS. 'Line type = none' should be used to indicate the absence of lines (Austroads 2019a, 2019b).
6. Sealed and unsealed shoulder widths should be included in both the Data Standard and the PHS. The absence of this data may be due to the difficulty/expense in collecting lane width data by traditional methods, but this data should be included because:
    a. it is needed to provide a complete picture of the road inventory
    b. emerging technologies are making the reliable acquisition of this data more feasible and affordable.
7. The Data Standard needs to be clear about the requirements for traffic information, specifying Annual Average Daily Traffic (AADT) as one-way or two-way traffic per carriageway. The implications of this decision are:
    a. One-way traffic requires a direction to be identified; while two-way traffic assumes that the traffic in both directions is equal, or that any disparity is inconsequential.
    b. While two-way traffic has traditionally been how traffic data is reported, future applications may benefit from the more detailed quantification of traffic flow in each direction along a road.
    c. AADT calculations are estimates of the true traffic level and different results can occur if the approach is not standardised. The Data Standard should standardise the basis for the calculation of AADT, i.e. the number and distribution of traffic count samples across the week and year.
8. Since the Data Standard reports the Thornthwaite Moisture Index (TMI), one of the three common calculation methods should be selected for the Standard. It is recommended the revised method with assumptions for Australia is used (Method 2 in Austroads 2010).
9. Dates in the Data Standard are currently in the format dd/mm/yyyy (e.g. 29/07/2019). Consideration should be given to formatting dates as yyyymmdd (e.g. 20190729) since this allows this data to be chronologically sorted in numerical order, i.e. without needing to be recognised as date information.

5. Open and Commercial Data Source Analysis

5.1 Introduction

5.1.1 Purpose of Analysis

This section provides a 2019 analysis of the 'useability' of data from open and commercial sources for use in populating the Asset Register. The analysis was limited to data in the Asset Register data specification to define a manageable but diverse set of data quantities to investigate.

The key outcome is an understanding of the type and quality of data generally available from various open data and commercial providers and the potential to automate access and use of this data. These assessments were undertaken for both open and commercial data sources. This was complemented by a more detailed analysis being undertaken in AAM6146 *Next Generation Asset Data Collection* on new and emerging sources of data.

Appendix B outlines the availability of individual Asset Register data items for each open dataset.

5.1.2 Useability of Data

Useability of data in this report is based on the following:

- **Availability** – the data is made available in some form. Data that is unavailable includes both data that does not exist and data that is considered private and confidential by the owner.
- **Accessibility** – whether the data can be obtained freely or at cost.
- **Applicability –** whether the data is in a suitable form for the application – in this case high-resolution data linked to road locations, and if the segmentation of the data is in 100 m records. This is a consideration specific to the Asset Register, although the intention of the Asset Register is to provide a high-detail dataset that can be used for multiple other applications.

The individual data items are assessed by the following useability Grades 0 to 4 (developed for this analysis) to provide an indication of the effort in putting the data to use. This was done by attempting to access each data item from each source and comparing it to the specifications of the Asset Register dataset (i.e. the data format and network segmentation requirements). The criteria for each grade are shown in Table 5.1.

Table 5.1: Grades for measuring the useability of data sources

Grade	Availability	Accessibility	Applicability	Useability
0	No	–	–	–
1	Yes	Commercial	No	**Very low** – this data would need to first be paid for and then processed in order to be of any use.
2	Yes	Free	No	**Low** – this data may be able to be processed into something useful, its value needs to be balanced against the time and effort to process it.
3	Yes	Commercial	Yes	**High** – this data is useful, but its value needs to be balanced against the cost of obtaining it.
4	Yes	Free	Yes	**Very high** – this data is useful and can be readily accessed and included.

Earlier in the analysis, Accessibility also included a secondary consideration of whether it can be accessed directly (i.e. via Application Programming Interface (API) protocols) or if logging in, etc. is required. In the end it was decided not to include this consideration in determining the grade to have a more manageable number of grades, and because the technical means of accessing the data is something that can readily change; whereas whether or not data is collected at all and how useful it is are more fundamental considerations.

5.1.3 Data Analysis Categories

The Asset Register dataset is limited in size, but diverse, and requires data at a fine level of granularity. While this requirement is demanding, it reflects the needs of potential applications that rely on detailed data to produce insights. Therefore, the Asset Register dataset is a suitable case to measure the practicality of sourcing data from open and commercial datasets.

The analysis will be summarised in terms of two categories:

- **Jurisdiction/Sector** – where the *Useability* of the whole dataset is assessed for:
  - national organisations
  - RAs (and/or departments of transport)
  - LGs (selected organisations known to have good open data)
  - selected private companies (HERE Maps is the only private organisation known to have condition data).
- **Data groups** – where the *Useability* of data in the following groups is assessed:
  - climate and environment data
  - condition data
  - financial data
  - heavy vehicle access data
  - inventory data
  - location data
  - operational data
  - reference information
  - road asset data.

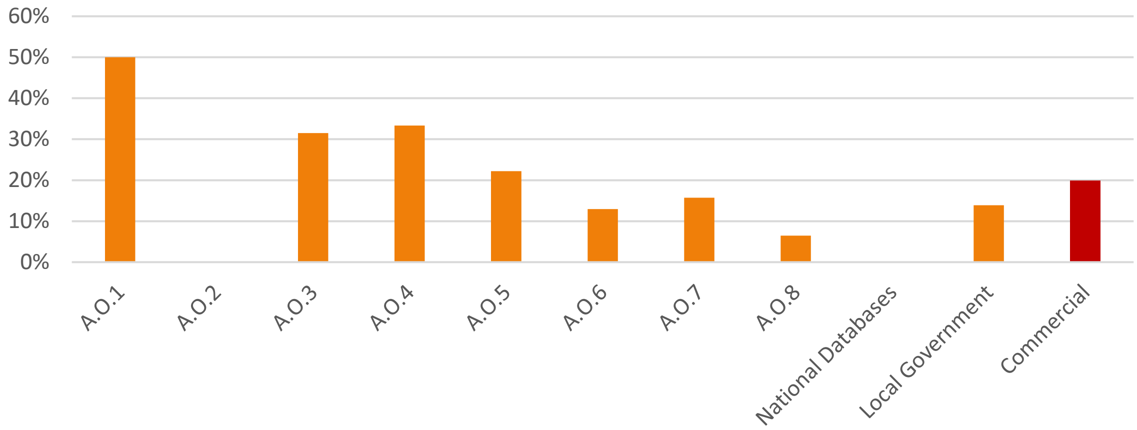
Section 5.2 contains a comparison of the useability of data between jurisdictions and sectors, while Section 5.3 details the useability of the data groups listed above.

A final summary of findings based on the analysis is in Section 5.4.

5.2 Analysis by Jurisdiction/Sector

This section summarises the general data 'performance', that is, the availability and accessibility of high-quality agnostic data. Results such as those shown in Figure 5.1 compare the individual assessments of useability (0 to 4) for each data item against perfect data (useability = 4 for all data items). The useability is expressed as a percentage in Figure 5.1. The results for RAs have been anonymised as the value of this analysis lies in the overall useability of data across Australia.

Figure 5.1: Useability of open data for Asset Register dataset



Note: A.O. = Asset owner, one of the eight Australian states or territories.

In general, the performance of all organisations and sectors is low, but there is significant variation. Asset Owner 2 (A.O.2) has an open data policy, with numerous documents and datasets available via download and API. However, none of these include the detailed data related to any of the data groups in a form that can be accessed easily and linked to geometry, resulting in zero percentage (%) useability across all the data items.

By contrast A.O.1 had the most useable data with a few key datasets at 100 m intervals containing much of the needed information. However, the useability performance for this jurisdiction is still only 50%. One interesting case that contributes to the lower score is that often the data is presented in a way that obscures the data; for example, road condition data (roughness, rutting, texture) is reported in categories (i.e. ranges) for each 100 m segment rather than specific values.

This form of data representation by A.O.1, and the absence of useable condition data from A.O.2 is reflective of the apparent vulnerability many road jurisdictions have around sharing detailed condition data. They are also sensitive to comparisons of road condition between jurisdictions as they can potentially impact funding decisions. Table 5.2 shows a 'heat map' of the useability of data for all the data groups across jurisdictions. Condition data is much more poorly represented than other groups such as operational, reference and location data.

There is also a lack of national open datasets with the level of detail being assessed here. There are some road geometries available at the national level, but these are not without issues, such as the NHVR's approved routes not being downloadable, and Geoscience Australia's roads dataset not including low level access roads as examples.

Table 5.2: Heatmap of the useability of data in data groups across different jurisdictions and sectors

Data items	A.O.1	A.O.2	A.O.3	A.O.4	A.O.5	A.O.6	A.O.7	A.O.8	National databases	Local government	Commercial
Heavy vehicle access data	33%	0%	33%	33%	0%	17%	0%	0%	0%	0%	17%
Road asset data	20%	0%	0%	60%	20%	20%	20%	0%	0%	10%	30%
Climate and environment data	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%
Condition data	15%	0%	15%	0%	0%	0%	0%	0%	0%	0%	2%
Financial data	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Inventory data	59%	0%	18%	36%	18%	0%	18%	0%	0%	18%	36%
Location data	79%	0%	64%	50%	36%	36%	36%	36%	0%	36%	18%
Operational data	67%	0%	67%	67%	67%	0%	0%	0%	0%	17%	25%
Reference data	57%	0%	79%	64%	64%	43%	43%	14%	0%	29%	36%

In general, three jurisdictions are performing the best at providing open, useable data. More detail is available in Appendix B, which contains further information about the availability of every data item.

Commercial data has been shown in the above results for comparison, but it should be noted that the measure of useability includes a consideration of whether the data can be obtained with or without cost – therefore there is an inherent bias in the assessment of commercial data.

There are several commercial data providers within the Australian market that provide mapping applications. Many of these collect their own data, but currently this does not include pavement condition data. A summary of the data products that are available from commercial providers is shown in Table 5.3.

Table 5.3: Data products available from various commercial providers in Australia

Company	Comment and/or data products
Bing	Bing is Microsoft's mapping company and they have been doing some development with machine learning on aerial photography/satellite images. No mention of road condition or inventory data.
Google	Some difficulty was experienced finding reliable information on data products, and no mention of road condition or inventory data. However, given the size and reach of Google it is expected they are working on the same kind of products that other companies are.
HERE	HERE has a high-definition map product which could provide information about lanes, road signs, line marking etc. however, it does not exist in Australia yet. The product is developed largely from LiDAR data which they have collected but the processing required to develop the map is significant and they seem to want to have a client or use-case before they commit to doing it.
nearmap	nearmap is a niche mapping company that provides some physical object reconstruction from photogrammetry but do not seem to collect any road condition information.
TomTom	Broadly speaking, TomTom has some interesting datasets available, though for the most interesting datasets (High Definition and Advanced Driver Assistance Systems maps) coverage for Australia is unmentioned in any product sheets or press releases and hence should be assumed not to exist. Specific data products are related to live and historic traffic statistics, route monitoring, origin/destination analysis, incidents/events, parking availability, electric vehicle services, speed camera locations and maps for various levels of vehicle automation.

5.3 Analysis by Data Group

5.3.1 Climate and Environment Data

The type of climate and environment data in the Asset Register dataset is specific to road asset management and is primarily concerned with how much water is likely to persist in the immediate vicinity of the road structure. Therefore, the climate is specified as one of four data types that consider whether the average annual temperatures are 'hot' or 'cold; and the amount of annual precipitation is 'dry' or 'wet'. Likewise, the soil type is one of five data types that correlate to how well the subgrade soil drains away water. This data is commonly linked to the road location and reported in jurisdictions' pavement management systems.

Since this data is usually used by the road engineers responsible for the asset, the climate and soil type data for each road segment was not found to be available from open data sources.

Using the more detailed climate and soil data that is available from organisations that specialise in these data types and make them available would both provide a richer dataset that could be updated more frequently and easily. Furthermore, the simplified climate and soil codes specific to road engineers can be derived from this more detailed data, such as the Thornthwaite Moisture Index (TMI).

Obtaining this data for the Asset Register through an automated process is a functionality that needs to be developed. The key advantage of incorporating these data into the Asset Register is the link with road asset locations.

5.3.2 Condition Data

Condition data is the main set of information collected to monitor the performance of the road in terms of obligations to road users and integrity of the road structure and surface. The number of condition parameters has increased over time as technology has developed to measure these at traffic speed, which is needed to effectively monitor a network. Condition data also needs to be collected on an ongoing basis, with RAs continually cycling through collecting condition data on their networks (over a frequency of 1 to 3 years).

Given the importance of condition data, highly detailed datasets are collected by RAs. However, condition data is not usually available in openly available datasets, either being absent, or presented in aggregate form such as bins/ranges (e.g. 0.0 – 2.9 m/km, 3.0 – 5.9 m/km, etc.) and/or by longer sections (e.g. 1 km).

Some companies (both mapping companies and smaller app developers) have tried to produce an equivalent of IRI using accelerometers (vehicle-mounted and in smartphones) rather than use specialised road surveying equipment, such as a laser profilometer, that measures the road profile (Wix 2016). While the accuracy and repeatability of roughness data derived from accelerometers is less than that of a laser profilometer, the advantage of accelerometer-based indicators of road condition (specifically in mobile phones) is the potential for the sheer volume of data that can be obtained. While the data may be considered a roughness indication rather than a roughness measure, the high number of samples should provide a statistically reliable representation of the road's surface condition potentially for every day of the year rather than more accurate surveys which are conducted just once a year (at best).

There are examples of asset owners opting to buy data collected from smartphones rather than paying for road condition surveys, which may be entirely appropriate depending on the intended use for the data and the understanding of what it actually represents (e.g. an owner with a small network using the data to flag inspections of parts of the network showing poorer surface condition may be more cost-effective than an annual survey and allow a timelier response to road condition issues).

The potential offered by smartphone-based indications of road surface condition should be tempered by an understanding that for this data to be sourced from the general public, the appropriate applications will need to be installed and active, with costs for storing and uploading data borne by individuals.

Figure 5.2 contains a comparison of the average useability score across the condition data group for different levels of government and the private sector. It shows a very low useability of condition data from all sources.

Figure 5.2: Useability of condition data from different government levels and sectors

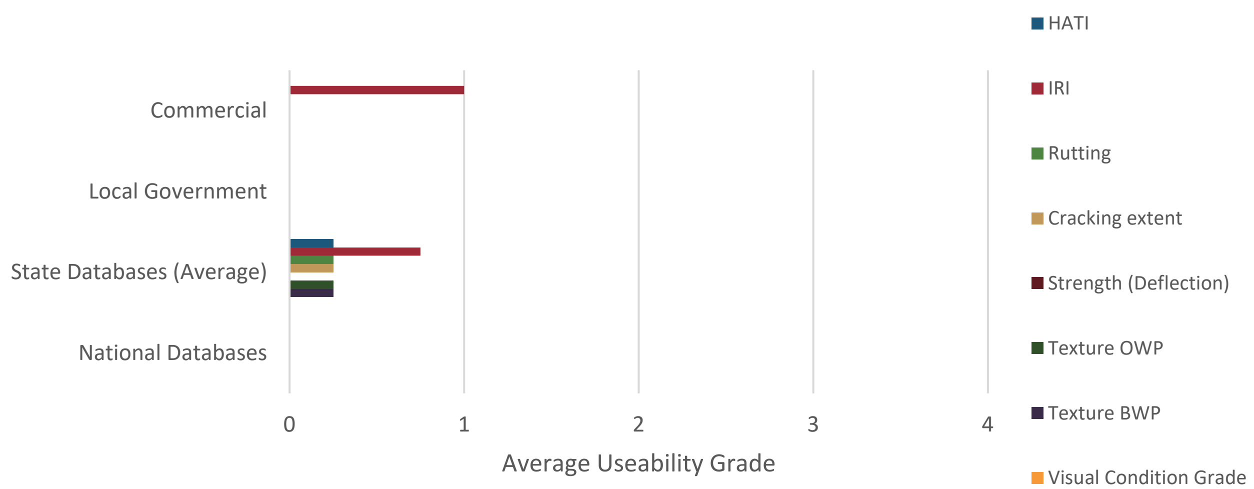
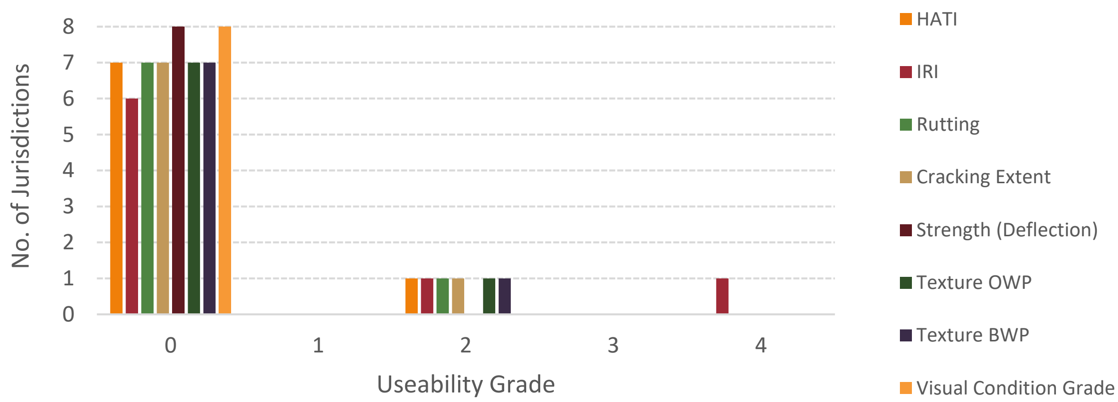


Figure 5.3 provides a further breakdown of the data available from RAs as a histogram of the grades for the data items in the condition data group. It shows that most condition data is unavailable; one jurisdiction (Victoria) has condition data that is of low use (i.e. requiring significant manipulation or lacking precision), and one jurisdiction (Queensland) has IRI roughness in a highly useful form.

Figure 5.3: Histogram of useability of condition data (states and territories)



Generally, some form of metadata for condition data (i.e. survey times and dates) is provided when condition data is provided. However, it was found to be reported for roughness data only, although for RAs it can be safely assumed now that all condition data is collected at the same time. The relative useability of the condition metadata is shown in Figure 5.4 and the histogram of useability grades for RAs is shown in Figure 5.5.

Figure 5.4: Useability of condition metadata data from different government levels and sectors

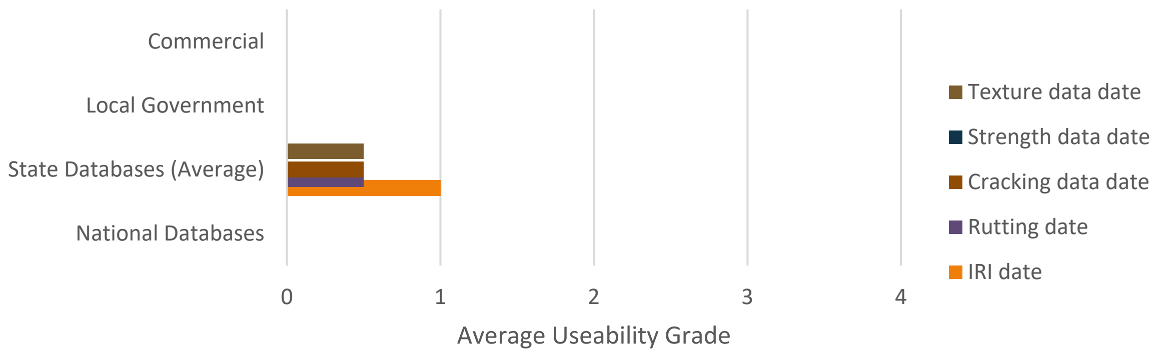
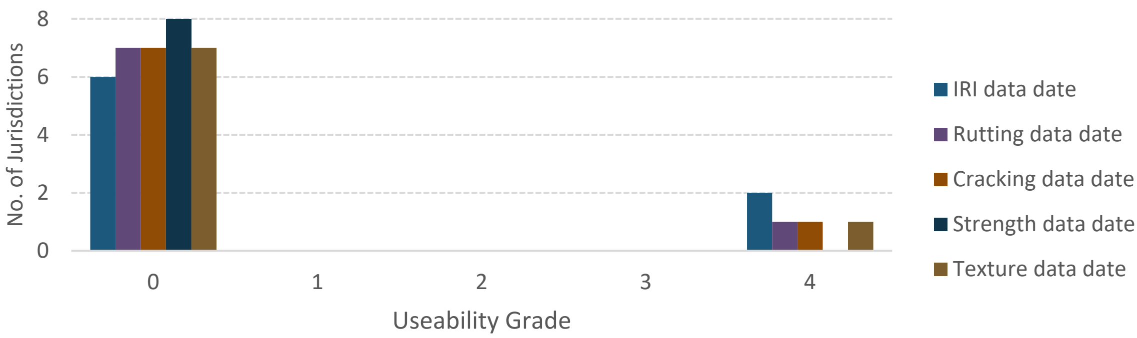


Figure 5.5: Histogram of useability of condition metadata (states and territories)



5.3.3 Financial Data

Financial data is not available through open datasets.

5.3.4 Heavy Vehicle Access Data

Heavy vehicle access data is often reported in very specific ways, such as access for a particular type or access scheme of the vehicle. All of these imply a vehicle mass and length limit, but it does not necessarily follow that all vehicles of equal or lesser mass and length are therefore legally permitted to use the road. This is unavoidable since mass and length limits are the fundamental physical parameters of access and are therefore the best generic measures to use since they span all vehicle types and access schemes.

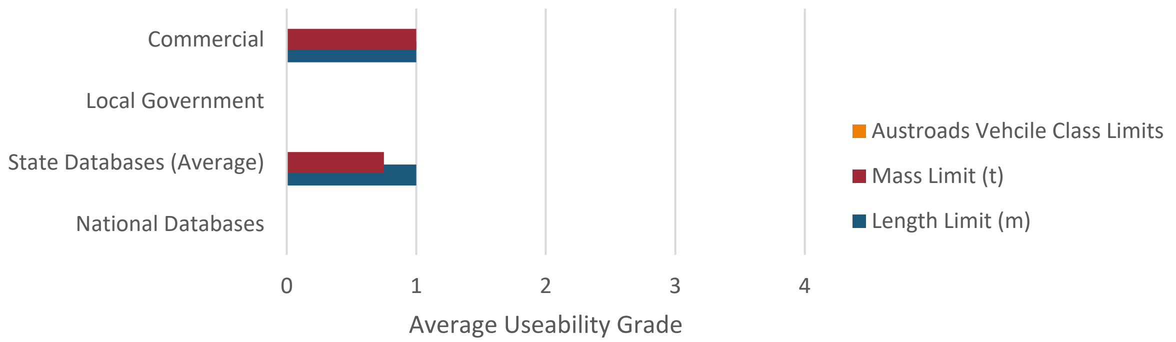
The Austroads Vehicle Classes (AVC) are broad generalisations that are often used in traffic analysis rather than by those making heavy vehicle access decisions within RAs and LGs. But AVC does imply mass and length limits and is therefore useful (as well as being more accessible to those who do not specialise in heavy vehicles). This was the reason for including AVC as an input since the Austroads classes are defined by numbers of axles and axle groups, so the most restrictive vehicle using the road can be identified by simple observation.

Given the above, the useability of open and commercial data is limited where it is available as it is often expressed in different terms to fundamental mass and length limits or AVC.

While there are national maps of heavy vehicle access available from the NHVR, these are not downloadable as a dataset and therefore not available according to the parameters of this analysis.

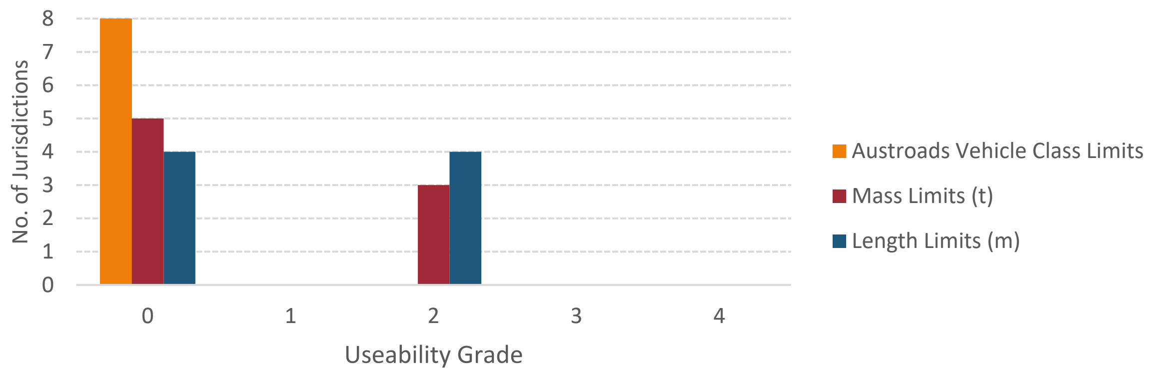
Figure 5.6 shows the comparisons between the various sources of access data, showing low useability overall.

Figure 5.6: Useability of HV access data from different government levels and sectors



The histogram in Figure 5.7 shows there is some mass and length limit data available from three or four of the eight Australian RAs, but this data is in a form that is of low use.

Figure 5.7: Histogram of useability of heavy vehicle access data (states and territories)



5.3.5 Inventory Data

Inventory information, based on physical measurement, has a high level of availability (see Figure 5.8 because it is measurable by anyone who uses the road (albeit with specialised equipment to collect it safely and efficiently). Consequently, the data usually does not need to be updated unless a road is rebuilt or significantly modified (e.g. lane duplication, sealing shoulders, repainting lane configurations, etc.).

Consultation with LGs has found that while they do not have measured inventory information, they do have the design specifications for their roads (these differ from measurements because despite the specifications there may be variations along the length of the road due to construction and damage and/or material loss). Other information such as the road category and the carriageway type (single or divided) is unambiguous and should be reliable. It is this information that was found to be made openly available by some LGs.

By contrast, RAs are known to collect and maintain information on the widths of lanes, shoulders, seals, and formations. However, making this information openly available is less common (see Figure 5.9). Road category and carriageway information was the most commonly available inventory information, but only Victoria made available data on many of the other measurements sought.

No national datasets of detailed road inventory data were found with a 100 m segmentation. However, national datasets for roads such as Geoscience Australia and PSMA do include some information such as carriageway type and number of lanes.

Figure 5.8: Useability of inventory data from different government levels and sectors

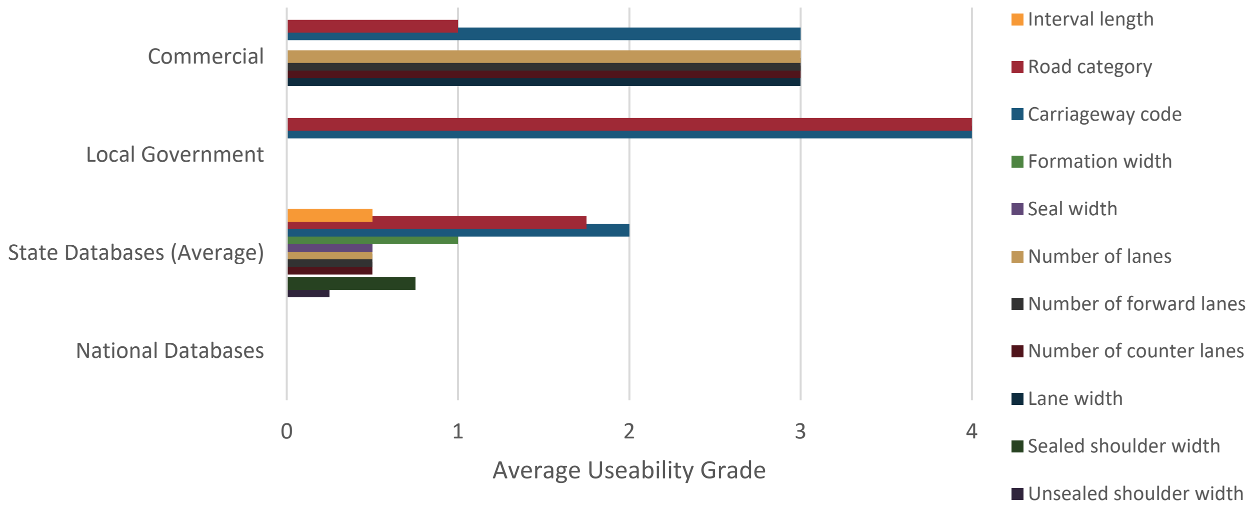
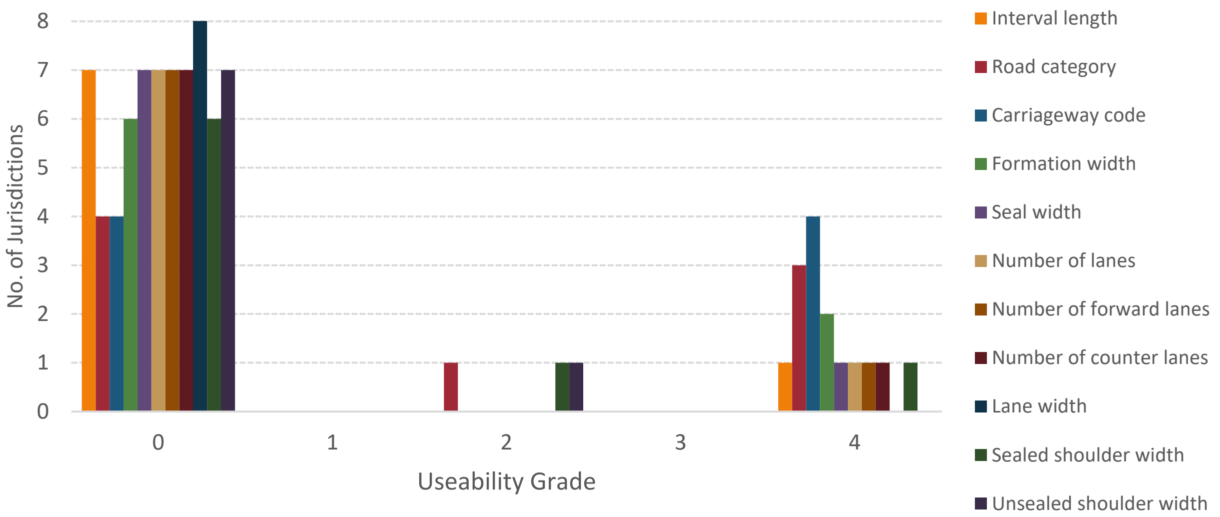


Figure 5.9: Histogram of useability of inventory data (states and territories)



5.3.6 Location Data

Location data for roads is the most commonly available data in some form. In most cases this meant that spatial data such as shapefiles was available that showed the road location on a map. However, these were not usually segmented into 100 m segments. Location data with these issues was found to be available from commercial providers and some LGs. The location data from RAs varied in its useability. No national datasets with open geospatial data were located. These comparative results are shown in Figure 5.10.

RAs also have good location data, however, they make it available to differing extents ranging from not at all, to being available as shapefiles or other forms of geospatial data. Only Queensland and Victoria provided GPS start and end points for 100 m segments of the network. RAs were also the most likely to make available running chainages along roads (see Figure 5.11).

Figure 5.10: Useability of location data from different government levels and sectors

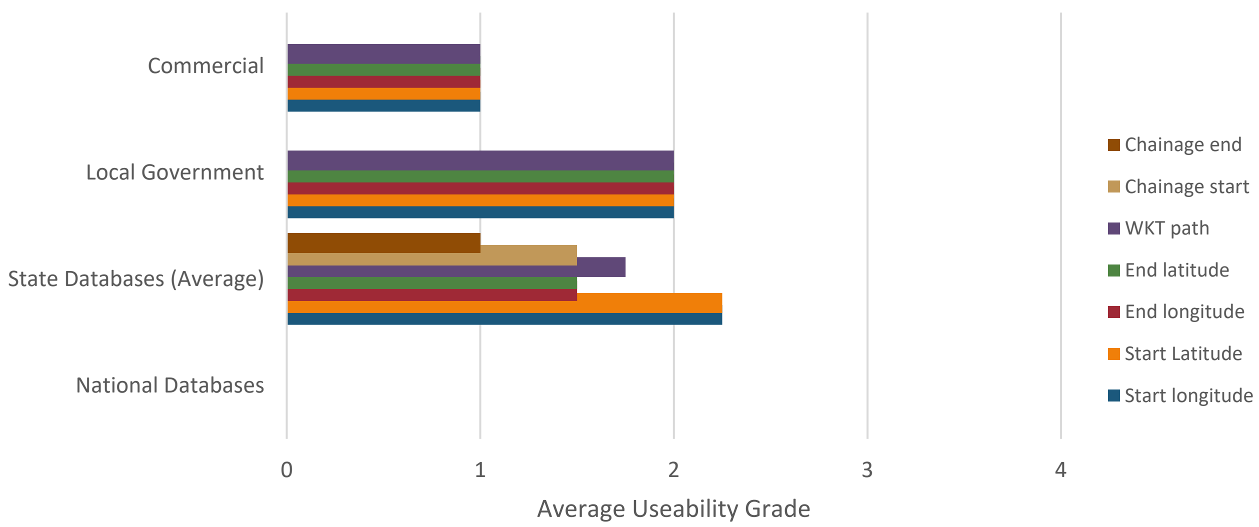
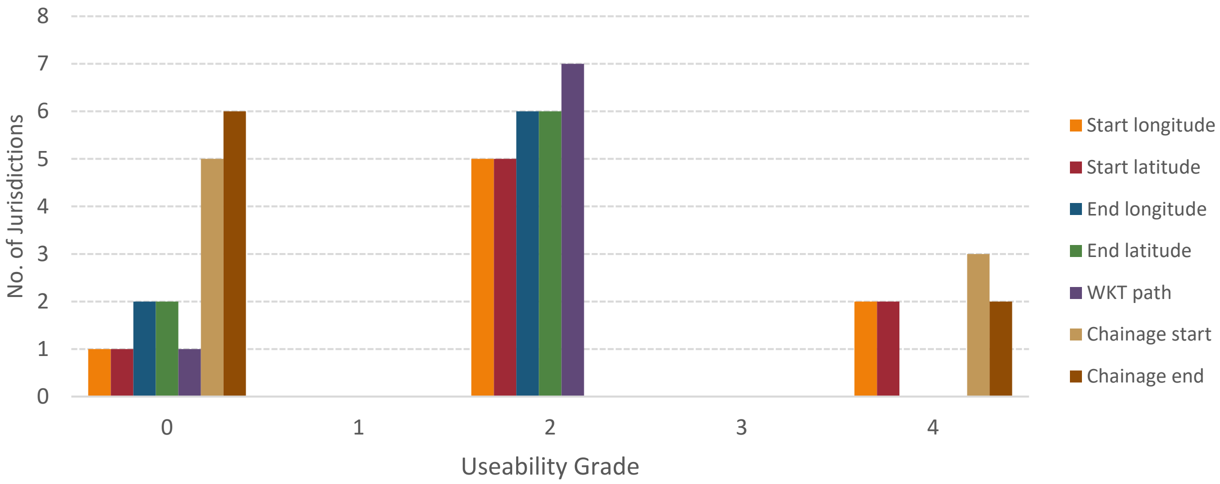


Figure 5.11: Histogram of useability of location data (states and territories)



5.3.7 Operational Data

Speed limit data is readily collected by commercial providers, as this information is publicly posted and able to be surveyed by private companies, if not provided by road agencies, for applications such as maps and navigators. Data from commercial providers is linked to road locations. RAs tend to maintain speed limit data for all roads, including local roads. LGs have access to this data and can make it available in some form for their own network, but usually without location information (apart from referencing the road name). RAs, with one exception, do not make speed limit data available.

Traffic volumes and heavy vehicle percentages are not made available by commercial providers or LGs, although both are known to collect this data. Private traffic count companies make the data available to their clients only, and therefore whether this data is available or not is via the client (road owner). Numerous discussions with LGs over the years have indicated that they undertake their own traffic surveys, but these tend to be sporadic and therefore it is unsurprising that this data is not made available.

RAs do have high quality traffic volume and vehicle classification data sourced from either commercial providers or their own equipment. Half of the road agencies in Australia made this information available in some form, three provided it with 100 m segment granularity.

These results are shown in Figure 5.12 and Figure 5.13.

Figure 5.12: Useability of operational data from different government levels and sectors

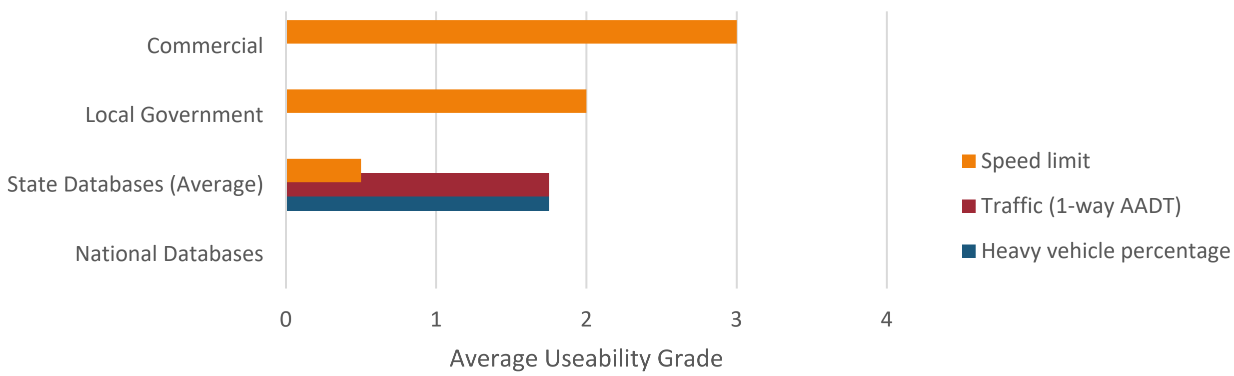
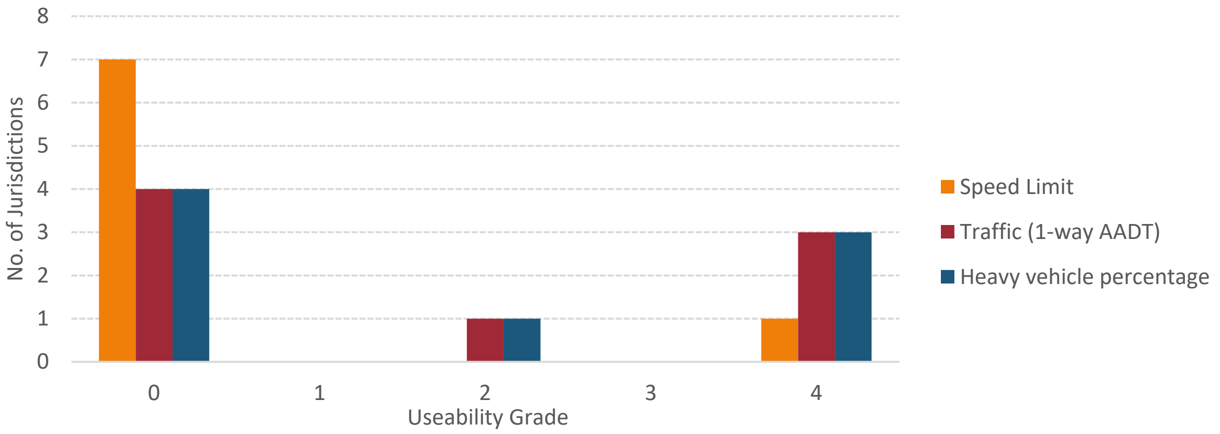


Figure 5.13: Histogram of useability of operational data (states and territories)



5.3.8 Reference Information

Reference information refers to the identification information of roads such as names and numbers. This kind of information naturally accompanies any data that is made available so that roads can be identified, and is therefore present for all commercial, local government and state and territory datasets. As there are no national datasets meeting the requirements of this analysis, there is no reference data at the national level. This is shown in the comparative useability grades in Figure 5.14.

The distribution of the useability grades for reference data across the RAs indicates there is enough information to identify roads by one means or another for those road agencies that do provide data meeting the requirements of this analysis (see Figure 5.15).

Figure 5.14: Useability of reference data from different government levels and sectors

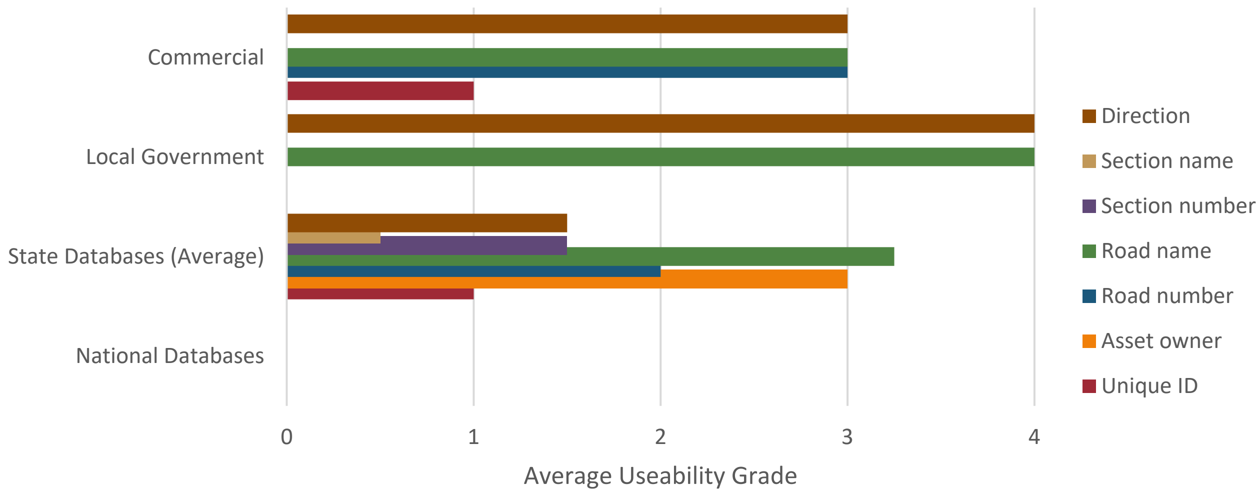
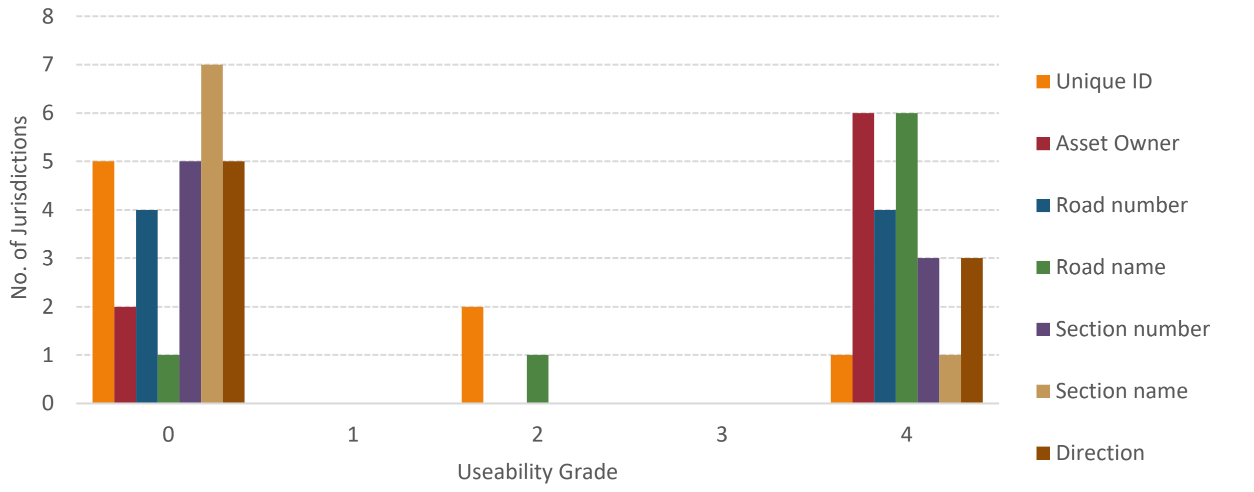


Figure 5.15: Histogram of useability of reference data (states and territories)



5.3.9 Road Pavement and Surface Data

Road asset data provides information about the structure and surface of a pavement. Whether a road is sealed or not, and whether it has line markings or not, is information easily surveyed by commercial companies. There is no barrier to LGs having good data on which of their roads are sealed or not, however, of the local government open databases investigated, less than half made this information available (see Figure 5.16).

Information about what lies under the surface of the road is not widely available, and anecdotally there is often not good information about this, even among road agencies. In terms of open data, only Western Australia has made some structural data available, while data on whether roads are sealed or unsealed is provided by half of the RAs (see Figure 5.17).

Figure 5.16: Useability of road asset data from different government levels and sectors

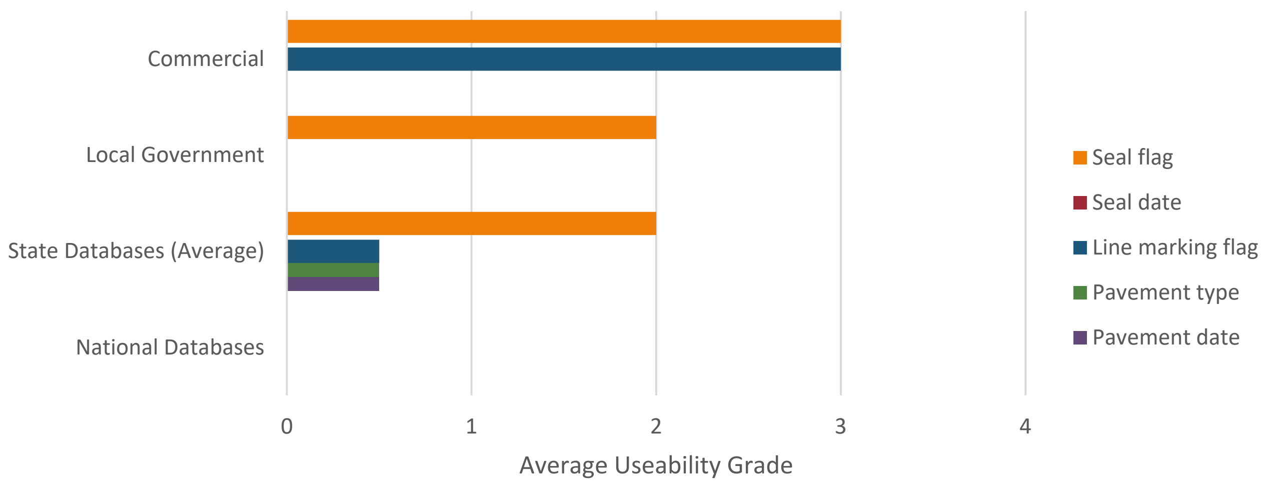
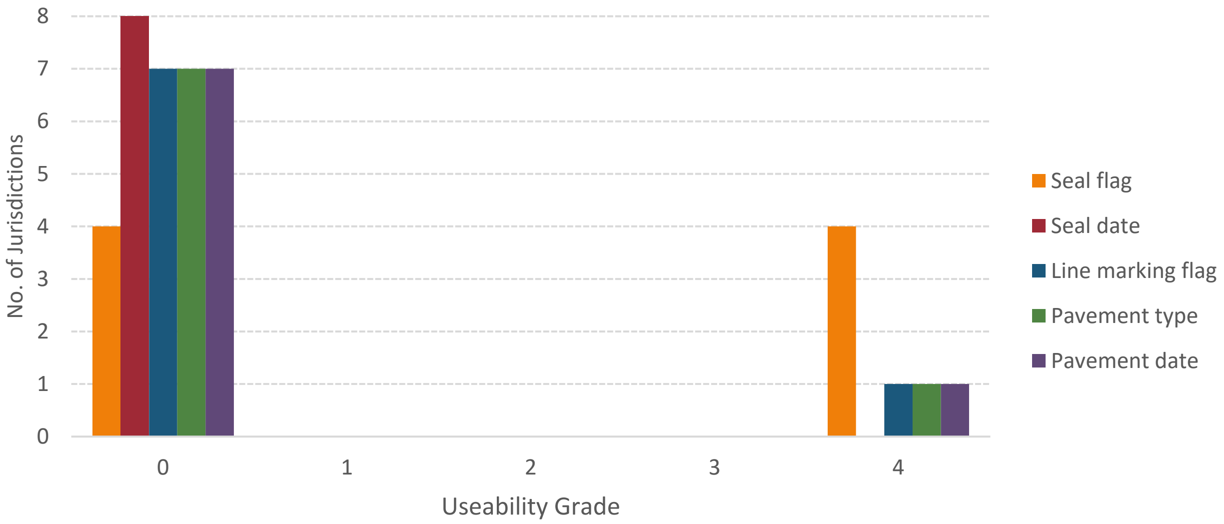


Figure 5.17: Histogram of useability of road asset data (states and territories)



5.4 Summary of Findings

Table 5.4 serves as a heatmap of the useability of data from all organisations in this investigation for every data item in the Asset Register dataset. The numbers in the cells are the useability grades as described in Table 5.1.

Table 5.4: Heatmap of the useability of data items across jurisdictions/sectors

Data item	A.O.1	A.O.2	A.O.3	A.O.4	A.O.5	A.O.6	A.O.7	A.O.8	National databases	Local government	Commercial
avc	0	0	0	0	0	0	0	0	0	0	0
mass_lim	2	0	2	2	0	0	0	0	0	0	1
len_lim	2	0	2	2	0	2	0	0	0	0	1
seal_flag	4	0	0	0	4	4	4	0	0	2	3
seal_date	0	0	0	0	0	0	0	0	0	0	0
line_mark	0	0	0	4	0	0	0	0	0	0	3
pave_type	0	0	0	4	0	0	0	0	0	0	0
pave_date	0	0	0	4	0	0	0	0	0	0	0
climate	0	0	0	0	0	0	0	0	0	0	0
subgrade	0	0	0	4	0	0	0	0	0	0	0
hati	4	0	0	0	0	0	0	0	0	0	0
iri	0	0	4	0	0	0	0	0	0	0	1
iri_date	4	0	4	0	0	0	0	0	0	0	0
rutt	0	0	0	0	0	0	0	0	0	0	0
rut_date	0	0	0	0	0	0	0	0	0	0	0
cracking	0	0	0	0	0	0	0	0	0	0	0
crk_date	0	0	0	0	0	0	0	0	0	0	0
strength	0	0	0	0	0	0	0	0	0	0	0
str_date	0	0	0	0	0	0	0	0	0	0	0
textowp	0	0	0	0	0	0	0	0	0	0	0
textbwp	0	0	0	0	0	0	0	0	0	0	0
tex_date	0	0	0	0	0	0	0	0	0	0	0
vcg	0	0	0	0	0	0	0	0	0	0	0
cost_maint	0	0	0	0	0	0	0	0	0	0	0
cost_asset	0	0	0	0	0	0	0	0	0	0	0
revn_asset	0	0	0	0	0	0	0	0	0	0	0
int_len	0	0	4	0	0	0	0	0	0	0	0

Data item	A.O.1	A.O.2	A.O.3	A.O.4	A.O.5	A.O.6	A.O.7	A.O.8	National databases	Local government	Commercial
road_cat	2	0	0	4	4	0	4	0	0	4	1
cway	0	0	4	4	4	0	4	0	0	4	3
form_width	4	0	0	4	0	0	0	0	0	0	0
seal_width	4	0	0	0	0	0	0	0	0	0	0
num_lanes	4	0	0	0	0	0	0	0	0	0	3
frwd_lanes	4	0	0	0	0	0	0	0	0	0	3
cntr_lanes	4	0	0	0	0	0	0	0	0	0	3
lane_width	0	0	0	0	0	0	0	0	0	0	3
seal_shld	4	0	0	2	0	0	0	0	0	0	0
unseal_shld	0	0	0	2	0	0	0	0	0	0	0
start_long	4	0	4	2	2	2	2	2	0	2	1
start_lat	4	0	4	2	2	2	2	2	0	2	1
end_long	2	0	0	2	2	2	2	2	0	2	1
end_lat	2	0	0	2	2	2	2	2	0	2	1
path	2	0	2	2	2	2	2	2	0	2	1
chain_start	4	0	4	4	0	0	0	0	0	0	0
chain_end	4	0	4	0	0	0	0	0	0	0	0
speed_lim	0	0	0	4	0	0	0	0	0	2	3
traffic	4	0	4	2	4	0	0	0	0	0	0
perc_heavy	4	0	4	2	4	0	0	0	0	0	0
unique_id	0	0	4	2	2	0	0	0	0	0	1
owner	4	0	4	4	4	4	4	0	0	0	0
road_num	4	0	4	4	4	0	0	0	0	0	3
road_name	4	0	2	4	4	4	4	4	0	4	3
sect_num	0	0	4	4	4	0	0	0	0	0	0
sect_nam	0	0	4	0	0	0	0	0	0	0	0
dirctn	4	0	0	0	0	4	4	0	0	4	3

The key findings from this analysis are as follows:

1. There is a lack of detailed condition data being posted on open data sites despite this being the most frequently collected and detailed of datasets. Detailed condition data was released as part of the Asset Register on the Transport and Infrastructure Ministers' Council website.
2. In terms of open data from RAs, the useability of the data provided by jurisdictions is greatest from A.O.1 (50%), with A.O.3 (31%) and A.O.4 (32%), followed by A.O.5 (22%) and then A.O.7 (16%), A.O.6. (13%), and A.O. (8 6%). A.O.2 with 0% useability was an exception. Particular strengths in data provision from some jurisdictions are A.O.1 with condition data, A.O.4 with road asset data (e.g. pavement structure), and the top four jurisdictions all having more inventory and operational data available.
3. The biggest gaps in the Asset Register dataset from open sources is specific forms of climate and environment data and financial data.

The amount of detailed data available from open data sources and commercial providers is not extensive and setting up processes to capture data automatically is not feasible at this time due to the gaps and inconsistencies that exist even in the available datasets.

However, the conclusion of this analysis also indicates that the Asset Register could be adapted to take advantage of existing richer datasets, especially as these evolve into the future. The specification of the Asset Register was initially built from considerations of road asset data held in common across RAs, and therefore is limited by the typical nature and availability of data at that time. While it is recommended that a central focus on practical datasets is retained, the basis for data specification should be shifted from the form of data for a specific end use (i.e. for asset managers within RAs) to a specification that is expanded to include the richer sources of data available (usually specialised organisations). This supports the creation of general and detailed datasets rather than a dataset that is narrowed and simplified by one application.

Based on these findings, it is recommended that fundamental questions about data supply from point of collection to the assembly of national datasets are considered anew. This is because the existing structures and processes of open data supply are built on narrow business cases that exclude consideration of national dataset needs.

Implementation of a national dataset could be by using a nationally focussed data scheme/initiative, such as the Austroads Data Standard, which would need to be linked to the national business need currently embodied by the HVRR, which covers heavy vehicle charging, road funding, etc. This arrangement should incentivise organisations to comply and participate for the greatest chance of a successful national dataset.

6. Supporting an Open Data Environment

6.1 Introduction

Many datasets of road-related data are held by other organisations apart from road agencies (Section 7.2 explains this in more detail). Enabling these other users to participate in generating a data-based Asset Register contributes to an open data environment where numerous applications and approaches can be pursued.

To support these outcomes, the following were developed:

- The functionality of the HVIR Tool related to building the Asset Register was translated in Python code that can be implemented and adapted by any user. The outputs of this code are a compliant dataset and data quality reports.
- A simple analysis tool in Power BI as an example of a comparative analysis of data quality between jurisdictions and over the provided years (datasets).
- Data quality reports for the existing datasets on the TIC website.

The Python code produces three complementary data quality assessment ratings:

- an assessment of the supplied data in terms of 9 data groups (described in Section 5.3)
- an assessment of every provided attribute in terms of a code:
  - 0 = No data
  - 1 = Invalid data (incorrect or out of expected range)
  - 2 = Valid data

  These codes are mapped to the same locations (row and column) as the input dataset
- a log file that contains summarised values of various quality tests, including summaries based on the two previous quality outputs.

This log file is used to produce visualisations in the new Data Quality Dashboard. An example of these data quality reports can be seen in Section 6.2, where reports were generated for the existing Asset Register datasets.

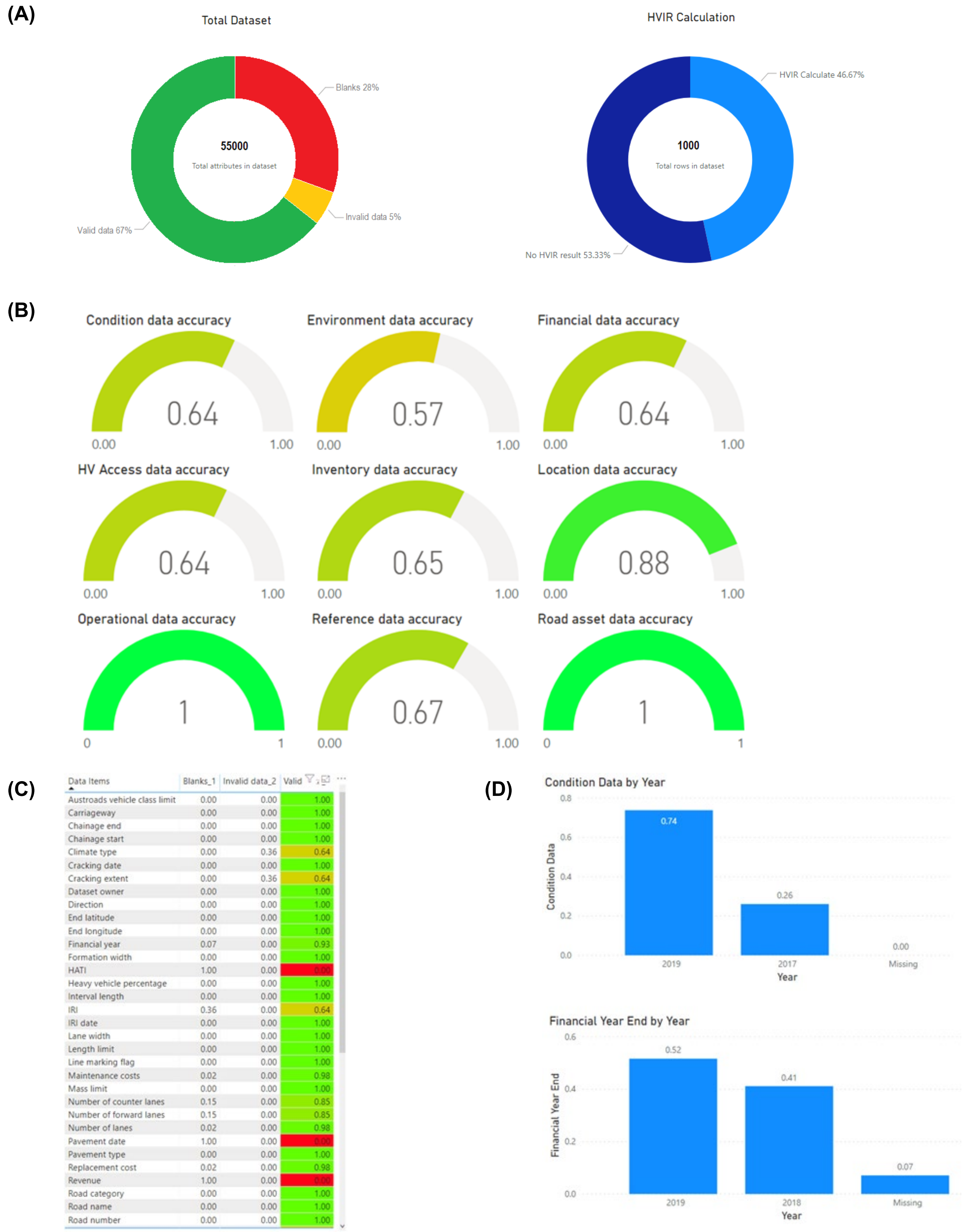
The Data Quality Dashboard was built in Power BI and consists of four groups of visualisations as described in Table 6.1.

Table 6.1: Description of visualisation groups in the Data Quality Dashboard

Visualisation group	Description
General statistics	Reports on the number of total attributes (columns × rows) in dataset, and then the breakdown of these in terms of blanks, invalid data, and valid data to provide an assessment of the completeness and accuracy of the dataset. A similar visualisation is also provided for the HVIR calculation, reporting the number of records (rows), and then the percentages of these for which HVIR was successfully calculated, and for which no result was calculated.
Data group analysis	Reports the percentage of valid data by data group. These assessments of accuracy include rules to account for equivalent data; for example, if vehicle mass and length limits are provided, HV access is reported at 100%, regardless of whether AVC Limits are supplied. The included data groups are condition data, environmental data, financial data, HV access data, inventory data, location data, operational data, reference data and road asset data.
Data item analysis	A table of each data item (column) in the dataset is presented with the percentages of blank, invalid and valid attributes in that column.
Timeliness histograms	The percentage of all condition data attributes (roughness, rutting, strength and texture) within each year are counted, as well as those for which no year is provided. These are then presented as a histogram to show the distribution of dates within the dataset. An identical histogram is displayed for the end of the financial year provided with the financial data items.

Examples of these are shown in Figure 6.1. The source code and the Power BI visualisation file are publicly available.

Figure 6.1: Screenshot examples (A, B, C, and D) of data quality visualisations from the Dashboard



Data Items	Blanks_1	Invalid data_2	Valid
Austroads vehicle class limit	0.00	0.00	1.00
Carriageway	0.00	0.00	1.00
Chainage end	0.00	0.00	1.00
Chainage start	0.00	0.00	1.00
Climate type	0.00	0.36	0.64
Cracking date	0.00	0.00	1.00
Cracking extent	0.00	0.36	0.64
Dataset owner	0.00	0.00	1.00
Direction	0.00	0.00	1.00
End latitude	0.00	0.00	1.00
End longitude	0.00	0.00	1.00
Financial year	0.07	0.00	0.93
Formation width	0.00	0.00	1.00
HATI	1.00	0.00	0.00
Heavy vehicle percentage	0.00	0.00	1.00
Interval length	0.00	0.00	1.00
IRI	0.36	0.00	0.64
IRI date	0.00	0.00	1.00
Lane width	0.00	0.00	1.00
Length limit	0.00	0.00	1.00
Line marking flag	0.00	0.00	1.00
Maintenance costs	0.02	0.00	0.98
Mass limit	0.00	0.00	1.00
Number of counter lanes	0.15	0.00	0.85
Number of forward lanes	0.15	0.00	0.85
Number of lanes	0.02	0.00	0.98
Pavement date	1.00	0.00	0.00
Pavement type	0.00	0.00	1.00
Replacement cost	0.02	0.00	0.98
Revenue	1.00	0.00	0.00
Road category	0.00	0.00	1.00
Road name	0.00	0.00	1.00
Road number	0.00	0.00	1.00

6.2 Quality Assessment of Existing Datasets

Australian road agencies have provided data for the Asset Register in response to requests in 2016, 2017 and 2018. Each one of these requests increased the amount of data specified, as well as in some cases the road agencies improved the completeness of their responses. The most recent data request has seen the highest level of completion of data provided so far, with these datasets being accurate to the first quarter of 2019.

Below are comparative quality assessments for all the jurisdictions. Each assessment is designed to analyse the quality of the data according to varying focuses on completeness, accuracy, and timeliness. All these need to be considered to obtain a complete understanding of the quality of the underlying data.

The first comparison of three completeness statistics shown in Table 6.2 provides an indication of 1) the percentage of blank attributes, 2) invalid attributes with values that are either the wrong format (e.g. text when a number is expected, etc.) or out of range (e.g. wrong data or wrong units), and 3) attributes that are valid. The three completeness statistics total 100%. The table also shows the percentage of rows (100 m segments) where HVIR results were able to be calculated. Even where a low completeness of data was provided, the HVIR can still be calculated in most segments because:

- HVIR relies on a limited subset of the data in the Asset Register dataset
- the HVIR calculation method can automatically select from multiple types of data depending on availability within the dataset.

Table 6.2: Completeness statistics

Jurisdiction	Total rows in dataset	Blanks	Invalid data	Valid data	HVIR calculated
ACT	4 439	60%	0%	40%	97%
NSW	183 590	49%	7%	43%	100%
Qld.	345 494	48%	0%	52%	87%
SA	89 399	46%	0%	54%	94%
Tas.	41 823	38%	0%	62%	100%
Vic	233 691	75%	2%	24%	100%
WA	192 780	35%	0%	64%	85%

Note: Percentages for blanks, invalid data, and valid data total 100%.

Accuracy of data is first presented in terms of data groups as shown in Table 6.3. The data groups are a grouping of similar parameters for the purpose of identifying what areas of data may have issues in being supplied accurately. The percentages in Table 6.3 are the percentage of attributes for all parameters in the data group that are valid, except that of HV access data, condition data, and inventory data groups. This exception considers whether alternative data has been provided for the purposes of calculating HVIR. For example, HV access data is counted as complete if either mass and length limits are supplied, or Austroads Vehicle Class limits are provided since either of these allow HVIR to be calculated using some type of heavy vehicle access data. The consequence of this is that a dataset that provides both mass and length limits and Austroads Vehicle Class limits for each road segment (such as South Australia) is given the same completeness score as a dataset that provides either one, since supply of two is considered to be redundant (this is desirable as it provides multiple ways for access data to be included). There are similar rules for condition data and inventory data which are all explained in the documentation for the Python HVIR code, and users of the code can modify these rules for determining accuracy if this approach does not meet their needs.

Table 6.3: Accuracy of data by data group

Jurisdiction	HV access data	Road asset data	Environment data	Condition data	Financial data	Inventory data	Location data	Operational data	Reference data
ACT	67%	40%	47%	67%	0%	36%	94%	33%	29%
NSW	33%	59%	0%	66%	0%	45%	100%	53%	57%
Qld.	33%	32%	0%	80%	33%	53%	100%	100%	72%
SA	100%	99%	0%	75%	0%	64%	50%	100%	43%
Tas.	67%	99%	0%	63%	67%	63%	100%	70%	86%
Vic	33%	0%	0%	20%	0%	45%	50%	0%	29%
WA	98%	96%	100%	56%	33%	63%	100%	69%	85%

The final comparison in Table 6.4 shows the percentage of valid data for each data item in the dataset. The values tend to be generally high (up to 100%) or zero, showing that in most cases the issue is availability of data, rather than issues with accuracy of the data being provided.

The last six rows of Table 6.4 are the metadata for dates of the condition and financial data. The timeliness of the dataset is expressed as a histogram of the number of segments for which the metadata is provided, including one column for segments where the metadata is missing. For condition data with multiple parameters (strength, roughness, rutting, cracking and texture), the oldest collection date for the data is used. With the introduction of traffic speed deflectometers and automatic crack detection, all these parameters can be collected by survey vehicles at traffic speed at the same time, meaning there is no technical reason why road agencies should not have the same coverage and timing of collection for all these parameters.

Metadata is missing from the datasets in the current analysis because at the time of the data requests, metadata was not included in the specification.

Table 6.4: Percentage of data that is valid for each data item

Data items	ACT	NSW	Qld	SA	Tas	Vic	WA
Dataset owner	0%	0%	0%	0%	0%	0%	0%
Road number	0%	100%	100%	0%	100%	0%	100%
Road name	100%	100%	100%	100%	100%	100%	100%
Section number	0%	0%	100%	0%	100%	0%	92%
Section name	0%	0%	100%	0%	100%	0%	100%
Direction	0%	100%	4%	100%	100%	0%	100%
Start longitude	98%	100%	100%	100%	100%	100%	100%
Start latitude	90%	100%	100%	100%	100%	100%	100%
End longitude	98%	100%	100%	0%	100%	0%	100%
End latitude	90%	100%	100%	0%	100%	0%	100%
WKT path	0%	0%	0%	0%	0%	0%	0%
Chainage start	100%	100%	100%	100%	100%	100%	99%
Chainage end	100%	100%	100%	100%	100%	100%	99%
Interval length	100%	100%	100%	100%	100%	100%	100%
Road category	100%	100%	100%	100%	95%	100%	100%
Carriageway	0%	0%	100%	100%	100%	0%	100%
Formation width	0%	0%	0%	0%	0%	0%	0%
Seal flag	100%	100%	100%	100%	100%	0%	95%
Seal width	0%	0%	0%	0%	0%	0%	0%
Seal date	0%	99%	0%	94%	100%	0%	95%
Line marking flag	100%	0%	60%	100%	100%	0%	100%
Number of lanes	0%	100%	99%	100%	100%	100%	94%
Number of forward lanes	0%	0%	0%	0%	0%	0%	0%
Number of counter lanes	0%	0%	0%	0%	0%	0%	0%
Lane width	100%	100%	88%	100%	100%	100%	95%
Sealed shoulder width	99%	100%	100%	100%	100%	100%	100%
Unsealed shoulder width	0%	0%	0%	100%	100%	0%	100%
Austroads vehicle class limit	0%	100%	100%	100%	0%	100%	100%
Mass limit	100%	0%	0%	100%	100%	0%	97%

Data items	ACT	NSW	Qld	SA	Tas	Vic	WA
Length limit	100%	0%	0%	100%	100%	0%	97%
HATI	0%	0%	0%	0%	0%	0%	0%
IRI	97%	100%	87%	94%	100%	100%	91%
Rutting	98%	100%	85%	94%	100%	0%	91%
Cracking extent	23%	17%	84%	94%	16%	0%	0%
Strength	20%	15%	61%	0%	0%	0%	0%
Texture OWP	98%	100%	85%	94%	100%	0%	100%
Texture BWP	98%	0%	85%	94%	99%	0%	100%
Visual condition grade	0%	0%	0%	0%	0%	0%	0%
Pavement type	0%	0%	0%	100%	100%	0%	92%
Pavement date	0%	97%	0%	98%	94%	0%	97%
Speed limit	100%	52%	100%	100%	100%	0%	99%
Traffic volume	0%	73%	99%	100%	100%	0%	99%
Heavy vehicle percentage	0%	33%	99%	100%	9%	0%	8%
Climate type	95%	0%	0%	0%	0%	0%	100%
Subgrade soil type	0%	0%	0%	0%	0%	0%	100%
Maintenance costs	0%	0%	100%	0%	100%	0%	0%
Replacement cost	0%	0%	0%	0%	100%	0%	100%
Revenue	0%	0%	0%	0%	0%	0%	0%
IRI date	0%	0%	0%	0%	0%	0%	0%
Rutting date	0%	0%	0%	0%	0%	0%	0%
Cracking date	0%	0%	0%	0%	0%	0%	0%
Strength date	0%	0%	0%	0%	0%	0%	0%
Texture date	0%	0%	0%	0%	0%	0%	0%
Financial year	0%	0%	0%	0%	0%	0%	0%

Table 6.2 to Table 6.4 can be produced in a Power BI dashboard for comparison between different datasets with conditional formatting to provide a visual indication of results. Tables of this nature are currently being used as the best way to provide a visualisation of the quality for comparisons between large numbers of parameters or large numbers of datasets.

7. Update to Asset Register Data Specification

7.1 Introduction

With the need for national datasets containing high quality data, the Asset Register dataset must be updated to take advantage of the best available data. Originally conceived as a list of data about roads common to all RAs, the Asset Register is now progressing to obtain data from multiple organisations.

Section 7.2 identifies the organisations or sectors that are likely to be able to provide either better data or provide it more effectively. These considerations include an assessment of the quality, coverage, and spatial resolution of the data and how frequently it is updated. The processes required for data to be obtained from these sources is also discussed.

Section 7.3 contains a brief discussion of location and referencing data being sourced from a yet-to-be-selected base map.

For those data items where a change is recommended, Section 7.4 considers the new data sources and any changes that would need to be made to the type, format, or units of the data.

A summary of the current data specification is found in Appendix A; a comparison of heavy vehicle classes is shown in Appendix B to aid discussion on heavy vehicle access (Section 4.3); and the updated Asset Register data specification is found in Appendix C.

7.2 Review of Data Availability and Accessibility

7.2.1 Sources of Data

The Asset Register dataset includes various data groups for which there are organisations that can provide the data more directly, or a richer alternative to the data used currently. Asset managers within a road agency do remain the best source for information relating to the asset itself (which they either maintain directly or require subcontractors to maintain and provide detailed records). This includes:

- the date of the last reseal
- date of the last pavement construction/rehabilitation
- the design of the pavement construction.

Likewise, the operations areas of road agencies remain the best source for data they collect and maintain themselves, or subcontract to have reported to them on an ongoing basis. This includes:

- speed limits
- traffic volumes
- heavy vehicle percentages.

The heavy vehicle access teams within councils and road agencies are also the most suitable to provide the blanket heavy vehicle access as expressed by Austroads Vehicle Classes. Access is not normally or legally expressed in terms of the Austroads Vehicle Classes, but these classes can be related to access notices and permits and have been included to provide a baseline level of access in the absence of other data. This information is usually defined by policy on a jurisdiction-wide basis.

Although RAs remain the best provider of data for the seven data items mentioned above, the data needs to be sought from the appropriate teams within organisations, rather than using the asset manager as a single point of contact.

For the remaining information there are either alternative or superior sources as indicated in Table 7.1 against the types of data for which they may be a better option.

Table 7.1: List of data groups and the organisations or sectors that may be better sources of data

Data group	Sources (organisation/sector)
Road condition (IRI, rutting, cracking extent, strength, texture, visual condition grade, condition data collection dates)	Road agency – Asset Manager Road survey company
Road inventory (Formation width, seal width, surface type, linemarking, number of lanes, sealed/unsealed shoulder width)	Road agency – Asset Manager Road survey company Autonomous vehicle maps
Location and reference information (Unique ID, asset owner, road & section names, road & section numbers, direction, GPS coordinates (line and path), chainages and length, road class)	Base map provider
Pavement structure/history (Seal date, structure date, structure type)	Road agency – Asset Manager
Heavy vehicle access data (Austroads Vehicle Class, mass limit, length limit)	National Heavy Vehicle Regulator Road agency – Heavy vehicle group
Operational data (Traffic volume, heavy vehicle percentage, speed limit)	Road agency – Operations group
Climate and soil data (Climate type, subgrade material)	Bureau of Meteorology Australian Soil Resource Information System
Financial data (Annual expenditure, replacement cost, revenue, financial year)	State and territory treasuries

7.2.2 Accessing Data from Organisations

Accessing data from preferred organisations or sectors will require one of a set of processes depending on the nature of the organisations involved. These are defined briefly below.

Purchased data

Data from commercial companies can be purchased but must have open licensing to make the data available in the Asset Register. This requires that the data purchased is either customised for the Asset Register, or the data that appears in the Asset Register is derived from the purchased data.

Mandated data supply

Data held by public organisations can be required to be provided under arrangements established by governments.

Data sharing clause in contract

In the case of data collected for public organisations, clauses can be included for the data to be shared directly with the Asset Register as well as the client.

Open data

Some data is publicly available and can be accessed directly.

Data provided by organisations can be required to adhere to a strict specification and could be submitted through an online portal that automatically associates data locations with the base map road segments, thereby allowing the Asset Register to be automatically updated.

Accessed maps (open data or data purchased as-is) would need to be associated in-house with the underlying base map.

7.3 Sourcing Location and Reference Data from the Base Map

While the specification of data format for location and referencing data is generic and is not expected to be revised, there may still be differences that are of necessity dictated by the base map that the Asset Register is built up from.

The greatest difference expected is that the base map may not provide all the data items that are currently included, but it will remain important to retain these, even as placeholders, since none of this information is superfluous. It is also possible that the base map will contain additional data items.

These issues will be resolved once a base map is selected.

7.4 Revised Data Items

7.4.1 Number of Data Items to be Revised

Most data items can be sought from alternative organisations without any change to the type, format, or units of the data as they already conform to common standards. Of the 55 data items in the Asset Register, 50 require no change. The five which are required to be changed are listed in the sections below.

The complete, updated data specification for the Asset Register is in Appendix D.

7.4.2 Road Classes

Nationally consistent road classes will need to be used in the Asset Register. This is currently complicated by a lack of readiness. However, although the classification system is currently unknown, the format of nationally consistent road classes is expected to be a set of alphanumeric codes with associated definitions similar to the current road categories used. Only the codes will need to be included in the Asset Register as a single data item.

Once national road classes are established, this data is expected to be sourced from:

- data included as part of the base map
- asset managers in councils or RAs.

7.4.3 Mass and Length Limits for Heavy Vehicle Access

Heavy vehicle access as part of an assessment of the level of service (LOS) provided by a road is similar but different to access for heavy vehicle routes. The Asset Register is concerned with the former and seeks a level of access as an indication of peak legal capacity and not physical capacity since this is not relevant if it is not being offered to road users. Therefore, the access level sought:

- is **not** for any particular vehicle type or scheme
- is **not** for any particular load type
- is for ‘normal’ access, which means:
  - freight vehicles (not Over Size Over Mass)
  - by notice (not permit)
  - unconditional (not restricted by time of day/season).

It is, in other words, the highest level of access offered by a road section to any freight vehicle at any time.

For this reason, the access level should still be in mass/length limits since this is common to all vehicle schemes and to the pavement capacity or road geometry itself; however, it is understood that LOS access is distinct as described above. Therefore, the dataset is a customised output that considers the maximum mass and length limit of all vehicles that meet the criteria above. As the maximum mass and length limits within a group of vehicles may not be paired (i.e. the maximum mass limit might be from a different vehicle to the maximum length limit vehicle), the rule is that: The maximum mass limit across a group of vehicle classes/schemes is the mass limit of the individual vehicle class with the greatest length.

This rule excludes vehicle classes that are heavier but shorter. Length is treated as the more critical factor because length limits relate to physical geometry and dictate whether a vehicle in every run can navigate the roadway at all, or at least do so safely; whereas the negative consequences of higher mass usually require multiple runs to manifest.

This data can be sourced from the NHVR, by mandating data supply.

Appendix C shows a comparison of mass and length limits for the Austroads Vehicle Classes, NHVR mass and dimension limits, National Road Train Networks, and the PBS Scheme.

7.4.4 Climate and Subgrade

The Thornthwaite Moisture Index (TMI) provides a meaningful interpretation of climate and subgrade material (soil type) for road construction and maintenance considerations. This data can be sourced directly from the RAs that calculate it for their networks, or by sourcing the underlying data to calculate TMI in-house.

This data can be sourced from:

- RAs (as TMI where available)
- the Bureau of Meteorology (temperatures and rainfall to calculate TMI).

A simplified approximation of TMI that relies on mean monthly temperature and total monthly precipitation only was developed in 1972 (described in Austroads 2010). While an approximation, it can be readily calculated from data easily accessible from the Bureau of Meteorology. It is therefore proposed that the approximation of TMI replaces the climate code used previously in the Asset Register.

The method for calculating the annual TMI is as follows in Equations 1 and 2:

$$TMI = \frac{P_{eff} - 48}{0.8} \quad 1$$

where

P_{eff} = sum of $P_{eff\,M}$ for each month, M:

$$P_{eff\,M} = 1.65 \times \frac{Pr_M}{(M_M + 12.2)^{1.1111}} \quad 2$$

where

Pr_M = Total precipitation (mm) in month M

M_M = Mean temperature for month M

While this TMI can be calculated over any 12-month period, meaning it could be updated every month, this level of detail is unlikely to be useful and calculating the TMI at the end of each financial year is sufficient.

The reason that the simplified approach to calculating TMI above is an approximation is that it does not include how well soils shed moisture through drainage and evapotranspiration. Including this information is not recommended because:

- Spatial information about soil types is less available.
- The desired information is usually part of larger datasets that include a lot more detail about soils than is needed.
- The simplified TMI should be sufficient for the purposes of the HVRR.

Information about the subgrade should therefore be considered part of the pavement structure/history data group (along with pavement structure, construction date, and seal/reseal date) and supplied by asset owners (road agencies and local governments).

The specification will therefore be based on the Unified Soil Classification System (ASTM International 2006), the partial list of which consists of the two-letter codes in Table 7.2 (organic soils have been excluded since organic soils are removed to construct the road on the underlying inorganic soils). Due to the likelihood that this information may be limited, the specification will also allow for the first letter only to be used.

Table 7.2: Unified Soil Classification System (inorganic soils only)

First letter	Second letter	Group symbol	Group name
G = gravel S = sand M = silt C = clay	P = poorly graded (uniform particle size) W = well graded (diverse particle size) H = high plasticity L = low plasticity	GW	Well-graded gravel, fine to coarse gravel
		GP	Poorly graded gravel
		GM	Silty gravel
		GC	Clayey gravel
		SW	Well-graded sand, fine to coarse sand
		SP	Poorly graded sand
		SM	Silty sand
		SC	Clayey sand
		ML	Silt
		CL	Clay of low plasticity, lean clay
		MH	Silt of high plasticity, elastic silt
		CH	Clay of high plasticity, fat clay

Source: ASTM International (2006).

8. Conclusion

Part C has documented extensive efforts to source and understand the gaps and opportunities in sourcing road-related data for use in a harmonised, national dataset.

The key challenge is that existing approaches, tools, and processes related to data are focused on the immediate needs of the organisations; and the compatibility and sharing of data beyond the organisation is secondary concern at best and in many cases not a consideration at all.

The Asset Register and associated tools and processes developed in this project have demonstrated that it is feasible to build an annually updated dataset of the state arterial road network in Australia that represents the current extent of national consistency achievable in such a highly detailed dataset.

Unfortunately, this cannot be replicated for local government roads due to 1) a lack of resources, 2) a lack of expertise in data manipulation, and 3) the data simply not being either collected or maintained.

For all asset owners, an incentive to participate is needed that could not be replicated in the current project. However, if supply of high-quality data is linked to cost recovery and investment on the road network, the Asset Register and its associated tools and processes can provide the mechanisms for a national dataset of harmonised road data to be achieved.

National standards such as the Austroads Data Standard or the current Asset Register Data Specification are an important part of defining what nationally consistent data should look like. Establishing a standard would give asset owners the confidence to undertake that changes necessary to produce nationally consistent data at the point of production, especially if this is fundamentally linked to cost recovery and investment for states and territories as well as local governments.

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Appendix A Data Standard Compliant Asset Register Data Specification

Table A 1 contains specifications for a dataset in the Asset Register that is compliant with the Austroads Data Standard (Austroads 2019a) where appropriate. These are the column headers for the data in 100 m intervals.

Table A 1: Asset Register dataset conforming to Data Standard

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
unique_id	Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	Alphanumeric string	8.3.0.1	**asset_id**	The unique asset identifier	All – a general unique asset ID (alphanumeric)	In the asset register all assets are 100 m network segments. In the Data Standard there are additional asset types included as specified by 8.3.0.2.
–	–	–	8.3.0.4	**owner**	Owner of the asset	All – A general name of owner of asset (alpha) Road agency/state/local/private owner description	NEW Owner or jurisdiction identifier will be needed for the national dataset.
road_num	Road number Number used as a unique identifier for roads.	Alphanumeric	8.1.12	**road_id**	Unique reference identifier for an existing road	Road unique reference ID (integer)	
road_name	Road name Highest level name of road.	Text string	8.1.13	**road_name**	Road name spelled in full, no abbreviations for type of road	Road (alpha)	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
sect_num	Section number Alphanumeric identifier for roads that are broken into sections	Alphanumeric string	8.1.19	**link_s_id**	Link that is broken into more than one part creates a link section	Link Section unique (integer)	Section numbers and names were included to allow the inclusion of sections of longer roads with an additional name. Links represent an alternative segmentation of the network.
sect_nam	Section name Named section of a longer road. This could be a lower level road name or indicate the locations the road links.	Text string	–	**–**	–	–	Not needed under Link segmentation (TO BE DELETED).
dirctn	Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter	Text code	–	**–**	–	–	No equivalent in Data Standard.
start_long	Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places	7.1.2.12	**loc_x_s**	X coordinate locator point at start of asset	X coordinate start at start of asset (degrees) (numeric) to six decimal places	
start_lat	Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places	7.1.2.13	**loc_y_s**	Y coordinate locator point at start of asset	Y coordinate start at start of asset (degrees) (numeric) to six decimal places	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
end_long	End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places	7.1.2.14	**loc_x_e**	X coordinate locator point at end of asset	X coordinate end at end of asset (degrees) (numeric) to six decimal places	
end_lat	End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places	7.1.2.15	**loc_y_e**	Y coordinate locator point at end of asset	Y coordinate end at end of asset (degrees) (numeric) to six decimal places	
chain_start	Chainage start (km) Start chainage is used to identify the sequence of intervals.	Number to 3 decimal places	–	**asset_from**	–	–	In the Data Standard, chainages are only provided for street segments (see 8.3.14.3 and 8.3.14.4) but not for assets.
chain_end	Chainage end (km)	Number to 3 decimal places	–	**asset_to**	–	–	
int_len	Interval length (km) Interval lengths should be 0.1 km, except at the end of roads	Number to 3 decimal places	–	**asset_len**	–	–	With the Asset Register containing 100 m segments as assets requires that these chainage values be retained, including the length.
road_cat	Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	Alphanumeric code	8.2.1	**ctype_hvir**	–	–	HVIR road categories to be retained until nationally agreed road classification system.

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
cway	Carriageway code A – Single carriageway B – Divided carriageway, Forward C – Divided carriageway, Reverse	Letter code	8.1.31	**links_div**	Identifies if the carriageway for vehicle flow in the opposite direction is separated by means of a physical barrier (divided), or undivided (no physical barrier)	Link section separate links for traffic flow (divided/undivided) (alpha)	
form_width	Width of formed roadway (m)	Number to 3 decimal places	8.1.23	**link_s_wid**	Weighted average width of the Link section measured between edge of pavement to edge of pavement for unsealed roads. For sealed roads from edge of seal to edge of seal where no kerb is present, or kerb face to kerb face	Link section average width (m) (numeric) to one decimal place	Formation width is provided for by link width. (TO BE MERGED)
seal_width	Width of seal (m)	Number to 3 decimal places					Seal width is provided for by link width. (TO BE MERGED)
seal_flag	Seal flag Sealed or unsealed	Text code	8.3.15.13	**s_mat**	A description of the material type of the surfacing layer.	Sprayed seal; asphalt; concrete; unsealed wearing surface; unsealed no wearing surface	
seal_date	Date of last seal or reseal	Date yyyymmdd	8.3.15.6	**seal_year**	The calendar year of the most recent surfacing	Pavement surfacing year current surfacing applied yyyy integer	
line_mark	Line marking flag Yes or No	Text code	8.3.10.5	**lin_typ**	Type of painted line marking	Line description (alpha)	Needs to include 'none' as a type. Note: This is currently not part of the PHS
num_lanes	Number of lanes	Integer	8.3.15.33 (NEW)	**pave_lanes**	Number of lanes	Integer	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
–	–	–	8.1.27	**links_lanl**	Number of trafficable lanes within the link section, left of the centreline	Link section number of lanes left of centreline (integer)	Inclusion of these fields serves to • eliminate uncertainty about whether one way or two-way lane count has been provided and • provides detail when the number of lanes is not equal in both directions.
–	–	–	8.1.28	**links_lanr**	Number of trafficable lanes within the link section, right of the centreline	Link section number of lanes right of centreline (integer)	
lane_width	Lane width (m)	Number to 3 decimal places	8.1.29	**links_lwl**	Average width of trafficable lanes, within the link section, left of the centreline	Link section average lane width left of centreline (m) (numeric) to one decimal place	Note: PHS erroneously reports header as **links_llr.**
			8.1.30	**links_lwr**	Average width of trafficable lanes, within the link section, right of the centreline	Link section average lane width right of centreline (m) (numeric) to one decimal place	
seal_shld	Sealed shoulder width (m)	Number to 3 decimal places	–	**ssh_wid_l**	–	–	This is not provided for in the Data Standard V3 but is to be retained.
unseal_shld	Unsealed shoulder width (m)	Number to 3 decimal places	–	**ussh_wid_l**	–	–	This is not provided for in the Data Standard V3 but is to be retained.

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
avc	Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	Integer code	8.13	**restr_avc**	–	–	Current specifications for access restrictions in the Data Standard are too complex and unwieldy for the purposes of the Asset Register. The current access restriction reporting in the Asset Register will be retained.
mass_lim	Mass limit for heavy vehicle access (t) The mess limit indicates the heaviest gross mass permitted to use the road.	Number to 1 decimal places	8.13	**restr_mas**	–	–	
len_lim	Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	Number to 3 decimal places	8.13	**restr_len**	–	–	
–	–	–	8.13	**restr_hgt**	**Height limit for heavy vehicle access** (m) The height limit indicates the tallest vehicle/load permitted to use the road	Number to 3 decimal places (1 millimetre)	This needs to be included to provide a more complete description of access.
hati	Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	Number to 3 decimal places	–	**hati_lane**	–	–	The Heavy Articulated Truck Index (HATI) is not mentioned in the Data Standard

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
iri	Lane IRI (m/km)	Number to 3 decimal places	8.4.33	**iri_lane**	Pavement roughness expressed as Lane IRIqc, reported at 100 m intervals	Pavement roughness lane IRI (m/km) numeric two decimal places	
–	–	–	8.4.35	**iri_owp**	Pavement roughness outer wheel path IRI	(m/km) numeric two decimal places	
lp_date	Date longitudinal profile data was collected	Date yyyymmdd	8.4.36	**lp_date**	Date that roughness survey was done	Date dd/mm/yyyy	The Data Standard code is **iri_date**, however it is not correct to refer to IRI here. The survey data that is collected is the longitudinal profile, which is then processed into roughness measures like IRI, HATI and other HV roughness measures that are in development.
rutt	Rutting (mm) Lane rutting	Integer	8.4.97 (NEW)	**rut_lane**	Lane rut depth reported at 100 m intervals	Pavement rutting depth (mm) mean of outer & inner wheel path (integer)	
rut_date	Date rutting data was collected	Date yyyymmdd	8.4.61	**rut_date**	Date that rutting survey was done	Pavement rutting survey date dd/mm/yyyy	
cracking	Cracking extent (%)	Percentage integer	8.4.12	**cr_all_ex**	The percentage affected area of a 100 m section (or defined segment length) where cracking is evident in the traffic lane	Pavement cracking % of surface area 100 m i(nteger)	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
crk_date	Date cracking data was collected	Date yyyymmdd	8.4.20	**cr_date**	Date that cracking survey was done	Pavement cracking survey date dd/mm/yyyy	
–	–	–	8.4.22	**p_df_veh**	Type of device used to measure deflection	Pavement deflection testing vehicle type (alphanumeric)	
strength	Central deflection (microns)	Integer	8.4.23	**p_df_d0**	Pavement deflection at the test load. As measured using a BB, DEF, FWD or TSD (iPAVe)*. TSD deflection not normalised	Pavement deflection under test load measured (micron) (integer)	
str_date	Date deflection data was collected	Date yyyymmdd	8.4.31	**p_df_date**	Date that deflection survey was done	Pavement deflection survey date dd/mm/yyyy & time hrs min.	
–	–	–	8.4.74	**tx_MPD_iwp**	Pavement texture Mean Profile Depth (MPD) measured in the inner wheel path reported at 100 m intervals	Pavement texture MPD texture inner wheel path (mm) (numeric) one decimal place	Inner wheel path was not initially included in the Asset Register since the outer wheel path typically shows the greatest amount of change from trafficking.
textowp	Texture in outer wheel path MPD	Integer	8.4.75	**tx_MPD_owp**	Pavement texture Mean Profile Depth (MPD) measured in the outer wheel path reported at 100 m intervals	Pavement texture MPD texture outer wheel path (mm) (numeric) one decimal place	
textbwp	Texture between wheel paths MPD	Integer	8.4.76	**tx_MPD_bwp**	Pavement texture Mean Profile Depth (MPD) between the left and right wheel paths reported at 100 m intervals	Pavement texture MPD texture between wheel paths (mm) (numeric) one decimal place	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
tex_date	Date texture data was collected	Date yyyymmdd	8.4.77	**tx_date**	Date that texture survey was done	Pavement surface texture survey date: dd/mm/yyyy & time hr	
vcg	Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/Moderate 4 = Poor 5 = Very poor	Integer	8.4.4	**cond_vis**	A numerical rating of the condition based on a visual inspection using a documented guideline with the aim of repeatable results	Visually assessed condition rating (0 to 5) (integer)	Note: the PHS Data Standard on page 17 in the 'Comments' column indicates the scale is from 0 (Very good) to 5 (Very poor) – this is incorrect; 0 represents a lack of rating, 'Very Good' is indicated by 1.
pave_type	Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	Text code	8.1.34	**pave_const**	Type of pavement on the link section	Link section type of pavement construction (alpha) Comments: Pavement base material: unbound granular, bound granular, deep lift asphalt, concrete, other	The PHS does not include any data items for the subbase material; however, subbase is accounted for in the larger data standard item 8.3.13.10. Whether or not the subbase is important depends on the application of the data but is included here to provide consistency with the Asset Register content.
			8.3.13.10	**path_s_typ**	Type of the subbase course material. As per VicRoads Standard Specification	TBA	
pave_date	Date of pavement construction	Date yyyymmdd	8.3.0.15	**const_date**	Date the asset was commissioned	All – B valuation construction date dd/mm/yyyy	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
speed_lim	Speed limit (km/h)	Integer	8.12.72 (NEW)	**pts**	Posted travel speed (speed limit) on rural or urban road or link	Posted travel speed km/h (integer)	
traffic	One way AADT	Integer	8.6.12	**aadt_all**	The total volume of traffic per carriageway in both directions	Average annual daily traffic (AADT) number vehicles/day (integer)	This change is from one-way AADT per carriageway to two-way per carriageway.
perc_heavy	% of heavy vehicles	Percentage integer	8.6.26	**aadt_hcv**	The percentage of the AADT where the traffic volume is classified as heavy vehicles: classes 3–12	Traffic volumes % AADT classified as heavy vehicles (integer)	
climate	Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	Text code	8.4.11	**–**	–	–	The Data Standard uses the Thornthwaite Moisture Index, which considers the climate and how moisture-retentive the subgrade is. The Asset Register will not adopt TMI at this stage due to the data requirements and variation in its calculation.
subgrade	Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	Text code	8.4.11 8.4.100	**–**	–	–	
cost_maint	Annual expenditure on maintenance per 100 m interval (averaged)	Number to 2 decimal places	8.3.0.16 to 8.3.0.22	**–**	–	–	

Existing field header	Existing field description	Existing format	Relevant Data Standard section number	DS compliant field header	DS compliant field description	DS compliant format	Comment
cost_asset	Replacement cost per 100 m interval (averaged)	Number to 2 decimal places	8.3.0.16 to 8.3.0.22	–	–	–	These fields will be retained in their current form as they are intended as financial indicators rather than the more complex financial information presented in the Data Standard.
revn_asset	Revenue per 100 m interval (averaged)	Number to 2 decimal places	–	–	–	–	Not included in the DS.

** BB = Benkelman Beam, DEF = Deflectometer , FWD = Falling Weight Deflectometer, TSD = Traffic Speed Deflectometer, iPAVe = intelligent Pavement Assessment Vehicle.*

Source: Austroads (2019a).

Appendix B Open State Data Analysis Tables

Table B 1 to Table B 7 provide the details of the analysis for the open datasets for each of the RAs (excluding NSW). The links for each of the datasets named is shown in each table.

Table B 1: Analysis of Victorian open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row must use the same unique ID as the shapefile.	No	
Owner of the asset	Yes, all roads in file are assumed to be VicRoads	Pavement condition
Road number Number used as a unique identifier for roads.	Yes	Pavement condition
Road name Highest level name of road.	Yes	Pavement condition
Section number Alphanumeric identifier for roads that are broken into sections.	No	
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	No	
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	Yes	Pavement condition
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Yes	Pavement condition
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Yes	Pavement condition
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	Pavement condition
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	Pavement condition
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, but spatial data option	Pavement condition
Chainage start (km) Start chainage is used to identify the sequence of intervals.	Yes	Pavement condition
Chainage end (km)	Yes	Pavement condition
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads.	No	

Field description	Availability	Dataset
Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	A categorisation provided	Pavement condition
Carriageway code A – Single carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	No	
Width of formed roadway (m)	Yes	Road width and number of lanes
Seal flag Sealed or unsealed	Yes	Road width and number of lanes
Width of seal (m)	Yes	Road width and number of lanes
Date of last seal or reseal	No	
Line marking flag Yes or no	No	
Total number of lanes	Yes	Road width and number of lanes
Number of lanes in the forward direction Data Standard right lanes	Yes, separate record	Road width and number of lanes
Number of lanes in the reverse direction Data Standard left lanes	Yes, separate record	Road width and number of lanes
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	Yes	Road width and number of lanes
Unsealed shoulder width (m) of left/outermost shoulder		
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No but data for restricted access vehicles available as layers	Heavy vehicle restrictions
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	No but data for restricted access vehicles available as layers	
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	Yes	Pavement condition
Lane IRI (m/km)	No	
Date IRI data was collected	Yes	Pavement condition
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	

Field description	Availability	Dataset
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	
Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	No	
Date of pavement construction	No	
Speed limit (km/h)	No	
One way AADT	Yes	Traffic volume
% of heavy vehicles	Yes	Traffic volume
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	No	
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- Heavy vehicle restrictions

  https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/hvr-higher-mass-limit

- Pavement condition

  https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/pavement-condition-data

- Road width and number of lanes
  https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/road-width-and-number-of-lanes/
- Traffic volume
  https://vicroadsopendata-vicroadsmaps.opendata.arcgis.com/datasets/traffic-volume

Table B 2: Analysis of Queensland open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	Yes	Road roughness condition 100 m
Owner of the asset	Yes, by inclusion TMR is owner	Road roughness condition 100 m
Road number Number used as a unique identifier for roads.	Yes	Road roughness condition 100 m
Road name Highest level name of road.	No, exists in other datasets	Queensland Spatial Catalogue
Section number Alphanumeric identifier for roads that are broken into sections.	Yes	Road roughness condition 100 m
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	Yes	
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	No	
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Yes	Road roughness condition 100 m
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Yes	Road roughness condition 100 m
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No	
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No	
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, exists in other datasets	
Chainage start (km) Start chainage is used to identify the sequence of intervals.	Yes	Road toughness condition 100 m
Chainage end (km)	Yes	Road roughness condition 100 m
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads.	Yes	Road roughness condition 100 m
Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	No	

Field description	Availability	Dataset
Carriageway code A – Single carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	Yes	Road roughness condition 100 m
Width of formed roadway (m)	No	
Seal flag Sealed or unsealed	No	
Width of seal (m)	No	
Date of last seal or reseal	No	
Line marking flag Yes or no	No	
Total number of lanes	No	
Number of lanes in the forward direction Data Standard right lanes	No	
Number of lanes in the reverse direction Data Standard left lanes	No	
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	No	
Unsealed shoulder width (m) of left/outermost shoulder	No	
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No but data for restricted access vehicles available as layers	Queensland Spatial Catalogue
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	No but data for restricted access vehicles available as layers	Queensland Spatial Catalogue
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	No	
Lane IRI (m/km)	Yes	Road roughness condition 100 m
Date IRI data was collected	Yes	Road roughness condition 100 m
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	

Field description	Availability	Dataset
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	
Visual Condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	No	
Date of pavement construction	No	
Speed limit (km/h)	No	
One-way AADT	Yes	Traffic census
% of heavy vehicles	Yes	Traffic census
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	No	
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- Road roughness condition 100 m

  www.data.qld.gov.au/dataset/road-condition-roughness-data-and-class-1km-segments/resource/66457d52-79c8-46d6-9e95-d356527a71e5

- Queensland Spatial Catalogue

  http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={6BD377F3-B007-437B-A523-D7B26C07F545}

- Traffic census

  https://www.data.qld.gov.au/dataset/traffic-census-for-the-queensland-state-declared-road-network/resource/e459b36d-31e0-468c-8894-7848096eba77

Table B 3: Analysis of Western Australian open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	No, not 100 m segments	
Owner of the asset	Yes	Road network
Road number Number used as a unique identifier for roads.	Yes	Road network
Road name Highest level name of road.	Yes	Road network
Section number Alphanumeric identifier for roads that are broken into sections.	Yes	Road network
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	No	
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	No	
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, but spatial data option	
Chainage start (km) Start chainage is used to identify the sequence of intervals.	Yes	Road network
Chainage end (km)	No	
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads.	No	
Road Category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	Yes	Road hierarchy
Carriageway code A – Single carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	Yes	Road network
Width of formed roadway (m)	Yes	Pavement detail
Seal flag Sealed or unsealed	No	

Field description	Availability	Dataset
Width of seal (m)	No	
Date of last seal or reseal	No	
Line marking flag Yes or no	Yes	Line marking
Total number of lanes	No	
Number of lanes in the forward direction Data Standard right lanes	No	
Number of lanes in the reverse direction Data Standard left lanes	No	
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	Yes, for some roads, does not specify seal	Pavement detail
Unsealed shoulder width (m) of left/outermost shoulder	Yes, for some roads, does not specify seal	Pavement detail
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No but data for restricted access vehicles available as layers	Heavy vehicle networks
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	No but data for restricted access vehicles available as layers	Heavy vehicle networks
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	No	
Lane IRI (m/km)	No	
Date IRI data was collected	No	
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	

Field description	Availability	Dataset
Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	Yes	Pavement detail
Date of pavement construction	Yes	Pavement detail
Speed limit (km/h)	Yes	Legal speed limits
One-way AADT	No, information on counter sites only	
% of heavy vehicles	No, information on counter sites only	
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	Yes	Pavement detail
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- Road network

  https://catalogue.data.wa.gov.au/dataset/road-network
- Road hierarchy

  https://catalogue.data.wa.gov.au/dataset/road-hierarchy
- Pavement detail

  https://catalogue.data.wa.gov.au/dataset/pavement-detail
- Line marking

  https://catalogue.data.wa.gov.au/dataset/line-marking
- Heavy vehicle networks

  https://catalogue.data.wa.gov.au/dataset?q=heavy+vehicle+network
- Legal speed limits

  https://catalogue.data.wa.gov.au/dataset/legal-speed-limits

Table B 4: Analysis of South Australian open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	Not 100 m sections	
Owner of the asset	Yes	Roads
Road number Number used as a unique identifier for roads.	Yes	Roads
Road name Highest level name of road.	Yes	Roads
Section number Alphanumeric identifier for roads that are broken into sections.	Yes	Roads
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	No	
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	No	
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, but spatial data option	
Chainage start (km) Start chainage is used to identify the sequence of intervals.	No	
Chainage end (km)	No	
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads.	No	
Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	Yes	Roads
Carriageway code A – Single carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	Yes	Roads
Width of formed roadway (m)	No	

Field description	Availability	Dataset
Seal flag Sealed or unsealed	Yes	Roads
Width of seal (m)	No	
Date of last seal or reseal	No	
Line marking flag Yes or no	No	
Total number of lanes	No	
Number of lanes in the forward direction Data Standard right lanes	No	
Number of lanes in the reverse direction Data Standard left lanes	No	
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	No	
Unsealed shoulder width (m) of left/outermost shoulder	No	
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No	
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	No	
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	No	
Lane IRI (m/km)	No	
Date IRI data was collected	No	
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	

Field description	Availability	Dataset
Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	No	
Date of pavement construction	No	
Speed limit (km/h)	No	
One-way AADT	Yes	Traffic volumes
% of heavy vehicles	Yes	Traffic volumes
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	No	
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- Roads

  https://data.sa.gov.au/data/dataset/roads
- Traffic volumes

  https://data.sa.gov.au/data/dataset/traffic-volumes

Table B 5: Analysis of Tasmanian open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	No	
Owner of the asset	Yes, by inclusion	Stateroads (MapServer)
Road number Number used as a unique identifier for roads.	No	

Field description	Availability	Dataset
Road name Highest level name of road.	Yes	Stateroads (MapServer)
Section number Alphanumeric identifier for roads that are broken into sections.	No	
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	No	
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	Yes	Stateroads (MapServer)
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	Stateroads (MapServer)
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	Stateroads (MapServer)
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, but spatial data option	
Chainage start (km) Start chainage is used to identify the sequence of intervals.	No	
Chainage end (km)	No	
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads	No	
Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	No	
Carriageway code A – Single Carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	No	
Width of formed roadway (m)	No	
Seal flag Sealed or Unsealed	Yes	
Width of seal (m)	No	
Date of last seal or reseal	No	
Line marking flag Yes or no	No	
Total number of lanes	No	
Number of lanes in the forward direction Data Standard right lanes	No	

Field description	Availability	Dataset
Number of lanes in the reverse direction Data Standard left lanes	No	
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	No	
Unsealed shoulder width (m) of left/outermost shoulder	No	
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No	
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	Some info but hard to use	Freight_RoadsBridges (MapServer)
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	No	
Lane IRI (m/km)	No	
Date IRI data was collected	No	
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	
Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	

Field description	Availability	Dataset
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	No	
Date of pavement construction	No	
Speed limit (km/h)	No	
One-way AADT	No	
% of heavy vehicles	No	
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	No	
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- Stateroads (MapServer)

  https://data.stategrowth.tas.gov.au/ags/rest/services/PUBLIC/STATEROADS/MapServer
- Freight_RoadsBridges (MapServer)

  https://data.stategrowth.tas.gov.au/ags/rest/services/HVN/FREIGHT_ROADSBRIDGES/MapServer

Table B 6: Analysis of Northern Territory open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	No	
Owner of the asset	Yes, by inclusion	NT government-controlled roads
Road number Number used as a unique identifier for roads.	No	
Road name Highest level name of road.	Yes	NT government-controlled roads
Section number Alphanumeric identifier for roads that are broken into sections.	No	
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	No	

Field description	Availability	Dataset
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	Yes	NT government-controlled roads
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial ata option	
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, but spatial data option	
Chainage start (km) Start chainage is used to identify the sequence of intervals.	No	
Chainage end (km)	No	
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads.	No	
Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	Yes	NT government-controlled roads
Carriageway code A – Single Carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	Yes	NT government-controlled roads
Width of formed roadway (m)	No	
Seal flag Sealed or Unsealed	Yes	NT government-controlled roads
Width of seal (m)	No	
Date of last seal or reseal	No	
Line marking flag Yes or no	No	
Total number of lanes	No	
Number of lanes in the forward direction Data Standard right lanes	No	
Number of lanes in the reverse direction Data Standard left lanes	No	
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	No	

Field description	Availability	Dataset
Unsealed shoulder width (m) of left/outermost shoulder	No	
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No	
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	No	
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	No	
Lane IRI (m/km)	No	
Date IRI data was collected	No	
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	
Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	No	
Date of pavement construction	No	
Speed limit (km/h)	No	
One-way AADT	No	
% of heavy vehicles	No	

Field description	Availability	Dataset
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	No	
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- NT government controlled roads
  https://data.nt.gov.au/dataset/nt-government-controlled-roads

Table B 7: Analysis of Australian Capital Territory open data

Field description	Availability	Dataset
Unique Id Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row here must use the same unique ID as the shapefile.	No	
Owner of the asset	No	
Road number Number used as a unique identifier for roads.	No	
Road name Highest level name of road.	Yes	Transport map layers
Section number Alphanumeric identifier for roads that are broken into sections.	No	
Section name Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	No	
Direction Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	No	
Start longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
Start latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End longitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	
End latitude If a separate shapefile of 100 m sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	No, but spatial data option	

Field description	Availability	Dataset
WKT path Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	No, but spatial data option	
Chainage start (km) Start chainage is used to identify the sequence of intervals.	No	
Chainage end (km)	No	
Interval length (km) Interval lengths should be 0.1 km, except at the end of roads.	No	
Road category Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads	No	
Carriageway code A – Single carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	No	
Width of formed roadway (m)	No	
Seal flag Sealed or unsealed	No	
Width of seal (m)	No	
Date of last seal or reseal	No	
Line marking flag Yes or no	No	
Total number of lanes	No	
Number of lanes in the forward direction Data Standard right lanes	No	
Number of lanes in the reverse direction Data Standard left lanes	No	
Lane width (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane.	No	
Sealed shoulder width (m) of left/outermost shoulder	No	
Unsealed shoulder width (m) of left/outermost shoulder	No	
Austroads Vehicle Class This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	No	
Mass limit for heavy vehicle access (t) The mass limit indicates the heaviest gross mass permitted to use the road.	No	
Length limit for heavy vehicle access (m) The length limit indicates the longest vehicle permitted to use the road.	No	

Field description	Availability	Dataset
Heavy Articulated Truck Index (m/km) Include if calculated from road profile.	No	
Lane IRI (m/km)	No	
Date IRI data was collected	No	
Rutting (mm) Lane rutting	No	
Date rutting data was collected	No	
Cracking extent (%)	No	
Date cracking data was collected	No	
Central deflection (microns)	No	
Date deflection data was collected	No	
Texture in outer wheel path MPD	No	
Texture between wheel paths MPD	No	
Date texture data was collected	No	
Visual condition grade Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	No	
Pavement type SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	No	
Date of pavement construction	No	
Speed limit (km/h)	No	
One-way AADT	No	
% of heavy vehicles	No	
Climate CD = cold and dry CW = cold and wet HD = hot and dry HW = hot and wet	No	
Subgrade material S = sandy M = medium C = light clay X = expansive clay R = rock	No	
Annual expenditure on maintenance per 100 m interval (averaged)	No	
Replacement cost per 100 m interval (averaged)	No	
Revenue per 100 m interval (averaged)	No	

Dataset sources:

- ACT transport map layers
  https://data.actmapi.act.gov.au/arcgis/rest/services/data_extract/Transport/MapServer

Appendix C Heavy Vehicle Classes

Table C 1 shows an equivalence of heavy vehicle classifications based on a comparison of mass and length limits.

Table C 1: Equivalent vehicle classifications for Austroads, NHVR, and Performance Based Standards limits

Austroads				NHVR mass & dimension limits				Existing NHVR national access networks	Performance Based Standards					Vehicle examples
Class	Length	Axles	Axle groups	Length	GML	CML	HML		Level	Length	GML	CML	HML	
0–9	≤ 19 m	axles = 6 and groups > 2 or axles > 6 and groups = 3		≤ 19 m	55.5 t	57 t	57 t	––	1	≤ 20 m	50.5 t	–	–	General access 
10	17.5 to 26 m	> 6	4	19 to 26 m	62.5 t	64.5 t	68 t		2A	20 < L ≤ 26 m	63 t	65 t	68.5 t	B doubles 
11	26 to 36.5 m	> 6	5 or 6	26 to 36.5 m	88.5 t	90.5 t	91 t	32 m road train network	2B	26 < L ≤ 30 m	83 t	85 t	85 t	A doubles 
									3A	30 < L ≤ 36.5 m	103 t	105 t	110 t	B triples  AB triples  Rigid truck with 2 dog trailers 
								36.5 m road train (Type 1) network						

Austroads				NHVR mass & dimension limits				Existing NHVR national access networks	Performance Based Standards					Vehicle examples
Class	Length	Axles	Axle groups	Length	GML	CML	HML		Level	Length	GML	CML	HML	
12	> 36.5 m	> 6	> 6	36.5 to 53.5 m	122.5 t	124.5 t	135.5 t	53.5 m road train (Type 2) network	3B 4A	36.5 < L ≤ 42 m 42 < L ≤ 53.5 m	126.5 t	128.5 t	141.5	A triples  A B triples  Quad combinations 
				–	–	–	–	–	4B	53.5 < L ≤ 60 m	126.5 t	128.5 t	141.5	Quad combinations 

GML = General Mass Limits, CML = Concessional Mass Limits, HML = Higher Mass Limits.

Note: The values shown are the limits of each class and should not be taken as applying in all circumstances to any individual vehicle combinations represented by name or image.

Disclaimer: All images and values shown here are for general guidance only.

Sources: NHVR (2019, 2020).

Appendix D Updated Asset Register Data Specification

The latest version of the data specification for the Asset Register is shown in Table D 1.

Table D 1: Updated data specification for the Asset Register

Header	Field description	Format	Source	Expected range	Use	Examples
unique_id	**Unique Id** Each interval must have a unique identifier. If a separate shape file of 100 m sections is used to define locations, each row must use the same unique ID as the shapefile.	Alphanumeric string	Base map network information	Non-specific	Uniquely identifies each road segment in Australia	24:SmithHighway:A1:0910
owner	**Owner of the asset**	Alphanumeric string	Base map network information	Non-specific	Identifies owner in national database/map	Queensland Brimbank City Council
road_num	**Road number** Number used as a unique identifier for roads.	Alphanumeric	Base map network information	Non-specific	Broad identifier used as backup and recognition for human user	24
road_name	**Road name** Highest level name of road.	Text string	Base map network information	Non-specific	Broad identifier used as backup and recognition for human user	Smith Highway
sect_num	**Section number** Alphanumeric identifier for roads that are broken into sections.	Alphanumeric string	Base map network information	Non-specific	Broad identifier used as backup and recognition for human user	A1

Header	Field description	Format	Source	Expected range	Use	Examples
sect_nam	**Section name** Named section of a longer road. This could be a lower-level road name or indicate the locations the road links.	Text string	Base map network information	Non-specific	Broad identifier used as backup and recognition for human user	Main Street
dirctn	**Direction** Please use Forward rather than Prescribed or Gazetted and Reverse instead of Counter.	Text code	Base map network information	Forward or Reverse	Identifies the side of the road that has been surveyed	Forward
start_long	**Start longitude** If a separate shapefile of 100 sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Base map network information	Between 112 and 154	Mapping	153.403812
start_lat	**Start latitude** If a separate shapefile of 100 sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Base map network information	Between –10 and –44	Mapping	–27.496256
end_long	**End longitude** If a separate shapefile of 100 sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Base map network information	Between 112 and 154	Mapping	153.404291

Header	Field description	Format	Source	Expected range	Use	Examples
end_lat	**End latitude** If a separate shapefile of 100 sections is not used, GPS coordinates of the interval are vital for mapping to be possible.	Number to minimum 6 decimal places (~10 cm)	Base map network information	Between –10 and –44	Mapping	–27.495478
path	**WKT path** Path of the section. This can be provided as an alternative to the start/end coordinates, above. LINESTRING(XXX.XXXXXX YYY.YYYYYY, …)	Set of numbers, each to minimum 6 decimal places (~10 cm)	Base map network information	Between –10 and –44 OR Between 112 and 154	Mapping	LINESTRING(153.403812 –27.496256, 153.404291 –27.495478)
chain_start	**Chainage start** (km) Start chainage is used to identify the sequence of intervals.	Number to 3 decimal places (1 m)	Base map network information	Between 0 and 3000	Identifies position in sequence	1.2
chain_end	**Chainage end** (km)	Number to 3 decimal places (1 m)	Base map network information	Between 0 and 3000	Identifies segment length	1.3
int_len	**Interval length** (km) Interval lengths should be 0.1 km, except at the end of roads.	Number to 3 decimal places (1 m)	Base Map Network information	Between 0 and 100	Identifies segment length	0.1

Header	Field description	Format	Source	Expected range	Use	Examples
road_cat	**Road category/class** INTERIM: Please translate your road classes into the following: R1 – Freeways R2 – Urban highways R3 – Urban arterials or rural highways R4 – Collector and distributor roads R5 – Property access roads FINAL: To be advised	Alphanumeric code	Base map network information OR Asset Manager (RA or LG)	INTERIM: R1 or R2 or R3 or R4 or R5 FINAL: To be advised	Defines expectations for interpretation of HVIR	INTERIM: R2 FINAL: To be advised
cway	**Carriageway code** A – Single carriageway B – Divided carriageway, forward C – Divided carriageway, reverse	Letter code	Base map network information	A, B or C	Potential check on the road category	A
form_width	**Width of formed roadway** (m)	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG) OR Road survey company	Between 1 and 100	Used to assess leeway in HVIR for unsealed roads	11
seal_flag	**Seal flag** Sealed or unsealed	Text code	Asset Manager (RA or LG) OR Road survey company	Sealed or Unsealed	Used to identify if roads are sealed or unsealed, which determines how they are handled. If blank or unreadable, will default to 'sealed'	Sealed

Header	Field description	Format	Source	Expected range	Use	Examples
seal_width	**Width of seal** (m)	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG)	Between 1 and 50	Used to assess leeway in HVIR for sealed but unmarked roads	9
seal_date	**Date of last seal or reseal**	Date yyyymmdd		Within 20 years	Asset Register data	20130912
line_mark	**Line marking flag** Yes or no	Text code	Asset Manager (RA or LG) OR Road survey company OR Autonomous vehicle map	Yes or No	Used to identify if sealed roads are unmarked (no lanes or shoulders), which determines how they are handled. If blank or unreadable, the default is a marked road, unless specified as unsealed	Yes
num_lanes	**Total number of lanes**	Integer	Asset Manager (RA or LG) OR Road survey company OR Autonomous vehicle map	1 to 10	Potential check on the road category	3

Header	Field description	Format	Source	Expected range	Use	Examples
frwd_lanes	**Number of lanes in the forward direction** Data Standard right lanes	Integer	Asset Manager (RA or LG) OR Road survey company OR Autonomous vehicle map	1 to 10	Potential check on the road category	2
cntr_lanes	**Number of lanes in the reverse direction** Data Standard left lanes	Integer	Asset Manager (RA or LG) OR Road survey company OR Autonomous vehicle map	1 to 10	Potential check on the road category	1
lane_width	**Lane width** (m) Where there are multiple lanes that have been measured, this is for the leftmost (outermost) continuing lane	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG) OR Road survey company	1 to 10	Used to assess leeway in HVIR for sealed and marked roads	2.5

Header	Field description	Format	Source	Expected range	Use	Examples
seal_shld	**sealed shoulder width** (m) of left/outermost shoulder	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG) OR Road survey company	0 to 10	Used to assess leeway in HVIR for sealed and marked roads	1
unseal_shld	**unsealed shoulder width** (m) of left/outermost shoulder	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG) OR Road survey company	0 to 10	Asset Register data	1
avc	**Austroads Vehicle Class** This is one option for indicating heavy vehicle access by inputting the highest Austroads Vehicle Class permitted to use the road section.	Integer Code	Heavy vehicle access team (RA or LG)	Integers 1 to 12	Used for the crude assessment of heavy vehicle access	10
mass_lim	**Mass limit for heavy vehicle access** (t) The mass limit indicates the heaviest gross mass permitted to use the road.	Number to 1 decimal place (500 kg)	National Heavy Vehicle Regulator	1 to 150	Used for the fine assessment of heavy vehicle access	67
len_lim	**Length limit for heavy vehicle access** (m) The length limit indicates the longest vehicle permitted to use the road.	Number to 3 decimal places (1 mm)	National Heavy Vehicle Regulator	5 to 100	Used for the fine assessment of heavy vehicle access	32

Header	Field description	Format	Source	Expected range	Use	Examples
hati	**Heavy Articulated Truck Index** (m/km) Include if calculated from road profile.	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG) OR Road survey company	0 to 15	Used to assess ride quality in HVIR	3.541
iri	**Lane IRI** (m/km)	Number to 3 decimal places (1 mm)	Asset Manager (RA or LG) OR Road survey company	0 to 20	Used to assess ride quality in HVIR	2.891
iri_date	**Date IRI data was collected**	Date yyyymmdd	Asset Manager (RA or LG) OR Road survey company	After 1960	Used to check how current the IRI data is	20181123
rutt	**Rutting** (mm) Lane rutting	Integer	Asset Manager (RA or LG) OR Road survey company	0 to 250	Asset Register data	2

Header	Field description	Format	Source	Expected range	Use	Examples
rut_date	**Date rutting data was collected**	Date yyyymmdd	Asset Manager (RA or LG) OR Road survey company	After 1960	Asset Register data	20181123
cracking	**Cracking extent** (%)	Percentage integer	Asset Manager (RA or LG) OR Road survey company	0 to 100	Asset Register data	2
crk_date	**Date cracking data was collected**	Date yyyymmdd	Asset Manager (RA or LG) OR Road survey company	After 1960	Asset Register data	20181123
strength	**Central deflection** (microns)	Integer	Asset Manager (RA or LG) OR Road survey company	0 to 10000	Asset Register data	150
str_date	**Date deflection data was collected**	Date yyyymmdd	Asset Manager (RA or LG) OR Road survey company	After 2010	Asset Register data	20181123

Header	Field description	Format	Source	Expected range	Use	Examples
textowp	**Texture in outer wheel path** MPD	Integer	Asset Manager (RA or LG) OR Road survey company	0 to 30	Asset Register data	7
textbwp	**Texture between wheel paths** MPD	Integer	Asset Manager (RA or LG) OR Road survey company	0 to 30	Asset Register data	15
tex_date	**Date texture data was collected**	Date yyyymmdd	Asset Manager (RA or LG) OR Road survey company	After 1960	Asset Register data	20181123
vcg	**Visual condition grade** Visual condition rating as described in IPWEA Practice Notes 9.0 and 9.1: 0 = Not rated 1 = Very good 2 = Good 3 = Fair/moderate 4 = Poor 5 = Very poor	Integer	Asset Manager (LG)	0 or 1 or 2 or 3 or 4 or 5	Used to assess ride quality in HVIR	3

Header	Field description	Format	Source	Expected range	Use	Examples
pave_type	**Pavement type** AS = thick asphalt over stabilised base AU – thick asphalt over unstabilised base SS = stabilised base and subbase SU = stabilised base, unstabilised subbase US = unstabilised base, stabilised subbase (and/or subgrade) UU = unstabilised base and subbase C = concrete	Text Code	Asset Manager (RA or LG)	AS, AU, SS or SU or US or UU or C	Asset Register data	SU
pave_date	**Date of pavement construction**	Date yyyymmdd	Asset Manager (RA or LG)	After 1950	Asset Register data	19970915
speed_lim	**Speed limit** (km/h)	Integer	Operations team (RA)	25 to 130	Used to assess leeway in HVIR for local roads with no inventory data	100
traffic	**One-way AADT**	Integer	Operations team (RA) OR Traffic counter company	0 to 50000	Asset Register data	5000

Header	Field description	Format	Source	Expected range	Use	Examples
perc_heavy	**% of heavy vehicles**	Percentage integer	Operations team (RA) OR Traffic counter company	0 to 100	Asset Register data	11
climate	**Climate** Simplified Thornthwaite Moisture Index (TMI)	Number	(INDIRECT) Bureau of Meteorology	-60 to 100	Asset Register data	-20
subgrade	**Subgrade material** 1-letter Code: G, S, M, or C OR 2-letter Code GW, GP, GM, GC, SW, SP, SM, SC, ML, CL, MH, or CH	1- or 2-letter text code	Asset Manager (RA or LG)	Listed codes only	Asset Register data	ML
cost_maint	**Annual expenditure** on maintenance per 100 m interval (averaged)	Number to 2 decimal places (cents)	State Treasury OR Asset Manager (RA or LG)	0 to 30000000000	Placeholder for future financial data	500.00

Header	Field description	Format	Source	Expected range	Use	Examples
cost_asset	**Replacement cost** per 100 m interval (averaged)	Number to 2 decimal places (cents)	State Treasury OR Asset Manager (RA or LG)	0 to 300000000000	Placeholder for future financial data	20000.00
revn_asset	**Revenue** per 100 m interval (averaged)	Number to 2 decimal places (cents)	State Treasury OR Asset Manager (RA or LG)	0 to 30000000000	Placeholder for future financial data	1000.00
fin_year	**Financial year** date of financial data reported	year YYYY/YY	State Treasury OR Asset Manager (RA or LG)	After 1950	Placeholder for future financial data	2017/18

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Data to Support the Heavy Vehicle Road Reform Part D:

Infrastructure Base Map and Data Alignment

Data to Support the Heavy Vehicle Road Reform Part D: Infrastructure Base Map and Data Alignment

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part D documents the investigation of issues related to representing transport-related data from multiple organisations on a single map. This is addressed by:

- assessing the suitability of currently available map providers for use as a base map
- developing guidance for representing data from diverse sources on the base map.

Keywords

Transport data, mapping, GIS, map layers

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About Austroads

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

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

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

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

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

Summary

Analysis of base map options

For the Heavy Vehicle Road Reform (HVRR) and other road reporting and visualisations, the current lack of a national spatial representation of the road network complicates the task of establishing the condition and rate of deterioration of assets on the network at any point in time in a consistent way.

To answer the need for a nationally consistent road network (location and segmenting) against which data can be reported for HVRR, one of the national network maps is to be selected. To aid in this decision, an investigation of the advantages and disadvantages of a number of road network maps was conducted to inform the choice of a base network for nationally consistent reporting.

Due to the complexity of segmentation and maintaining a consistent road network it is recommended that the Commonwealth use a commercial road network where the provider can provide assistance with segmentation and rolling updates. In particular, a commercial navigation provider has a (beneficial) vested interest in keeping the network as up-to-date as possible and significant in-house Geographic Information Systems (GIS) capability. The commercial provider is also likely to have more complete and consistent road attribute information across the country.

If a commercial provider is unaffordable, then OpenStreetMap provides a good alternative network. It will, however, require significant investment, particularly in segmentation, before it can be used as a national network.

Aligning data with the base map

Geospatial data is integral to the management of transport and transport assets across Australia by both Government and private organisations. However, there are significant differences in the way geospatial data can be represented, which makes aligning different datasets particularly from different organisations, difficult in a consistent and accurate way.

This challenge is ameliorated slightly in the case of base map alignment, and this document provides some practical guidance for matching and aligning data from different sources to a common network in the context of a road transportation network. This guidance is composed of the following:

- an overview of what the HVRR data environment is, its requirements and its capabilities. An outline of the network data structure is provided, and properties of the base-map documented
- examples of how data should be stored in the HVRR environment. The examples show what attributes are required for a HVRR compatible dataset, and how the different datasets can be represented
- practical guidance for aligning specific geometric objects with the underlying line segment road network representation. These objects include line segments from other network representations, point locations or trace points (e.g. GPS path), areas, and linearly referenced positions.

Contents

Tables

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1. Introduction

1.1 Background

The project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* objective is to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

1.2 Purpose

Currently, there is no nationally consistent spatial representation of the road network, and even within each of the state and territory jurisdictions there are often many different representations designed around their intended purpose.

For the Heavy Vehicle Road Reform and other nationally consistent road reporting and visualisations, this complicates the task of establishing the condition and rate of deterioration of assets on the network at any point in time in a nationally consistent way.

These differences include the way the road network is segmented (both length and reason for dividing into individual road segments), their representation, attributes, data types, naming, labelling and spatial location (the GPS representation of the road centreline or lane). Data from the same organisation can also vary from year to year, meaning that there is no permanent representation of the road network that can be used.

The selection of a base map for Australian road-related data provides the first steps towards multiple providers being able to contribute to an open, harmonised data environment. However, guidance is also required to ensure that data is aligned with the base map in a consistent way.

The purpose of Part D is therefore to:

- provide an assessment of available base map options to enable an informed decision to be made
- develop guidance for representing transport-related data from multiple organisations on the base map.

1.3 Scope

The assessment of base map options included all of the major public and commercial maps available and strategic approaches have been developed for making a decision. No recommendation is offered.

The guidance developed for representing data on a map covers some of the fundamental issues, but it is limited in detail due to the necessity of accommodating the potential for data of any nature and further placing it on a base map that has not yet been selected. It addresses instead the fundamentals of spatial representation which any dataset must comply with to be represented on maps.

1.4 Methodology

This report examines solutions to the challenges described above in the following two sections.

Section 2 documents an analysis consisting of a review of existing candidates for a national base map, defines criteria for making a selection, and finally provides a basis for making a selection based on two strategic approaches.

Section 3 examines the challenge of aligning diverse datasets by a range of different providers using different methods to the base map to create a single, harmonised dataset. This is an extremely challenging task, but the guidance provided enables progress towards this goal to be made.

It should be noted that organisations that collect and process data are best placed to understand and adapt their data for applications, and given the diversity of data in the current scope, this guidance is focused on the harmonised outcomes rather than the details of processes to adapt what is in effect an unknown and infinite dataset (i.e. there is no one solution).

2. Analysis of Base Map Options

This section discusses existing base map options available for national datasets. Base map in this context refers to a digital representation of the Australian road network, not be to be confused with base map 'tiles' which are often constructed from this information.

2.1 Selection of a Base National Road Network

To answer the need for a nationally consistent road network (location and segmenting) against which data can be reported, one of the existing national networks is to be selected. To aid in this decision, ARRB has investigated the advantages and disadvantages of a number of available national road networks to provide a strong basis for the choice of a base network for nationally consistent reporting of transport and infrastructure data.

2.2 Overview of Existing Options

2.2.1 OpenStreetMap

As the name suggests, OpenStreetMap (OSM) is an open source data project and can be used by anyone without licence fees. OSM was created in the UK in 2004 and now has over 6 million registered users who update the map. This is both the biggest strength and weakness of the providers examined, it is as up-to-date and accurate as the contributors make it. This means that there are maps in some locations that are not financially viable for a commercial provider to map, but also there is not a requirement or financial support to update and maintain maps on a regular schedule. Community contributions can also mean that representations and tags are less consistent e.g. some roundabouts circle break at every link and others are a complete circle.

Perhaps the biggest advantage of OSM is that there is a large community of contributors and developers building open source solutions on top of the platform. Data manipulation tools, routing engines and data visualisation tools provide additional functionality required by OSM users and also provide accessible interfaces for editing and improving the OSM network.

Further, the OSM project is a worthwhile and valuable community-driven initiative that government organisations can contribute to which may assist the timeliness of updates. While commercial organisations may need to drive the network to record network changes, government organisations (or construction contractors) could directly update the OSM map when major construction projects or infrastructure works are completed.

Whilst this enables timely updates from a wide range of organisations across the transport, construction, government and community sectors, it introduces additional challenges of shared responsibility – rather than a single organisation being responsible for the quality of a road dataset within its jurisdiction.

2.2.2 HERE Maps

HERE is a commercial map and data provider which traces its map origins from Navteq. The primary focus of HERE Maps is for in-vehicle navigation however they also have associated data products that are aligned to their base maps. HERE have a fleet of survey vehicles that regularly survey the network but also source community contributors to keep their maps up-to-date. They have minor map updates fortnightly and major updates every quarter and annually.

HERE (as with other mapping providers) is also working towards having an Australian HD live map that is updated in real time as information is provided by connected vehicles on the road. The map will be based on their existing road network with the addition of data such as LiDAR to provide additional information about individual lanes and roadside infrastructure. The live portion will be provided from connected vehicles and other Internet of Things (IoT) devices on the network to provide an up-to-date picture of the road at any point in time.

HERE also provides a web and mobile interface to allow map contributions and updates from individuals or businesses. This could provide a mechanism to fast track map updates of key features on the network, although there can be significant time for registered changes to be verified and applied to a map release.

2.2.3 TomTom

TomTom is another well-known commercial map and data provider known for their navigation systems with base maps that originated from Tele Atlas. TomTom is also a traffic data provider, based on probe data, and has a slightly different offering to HERE. They also survey the road network with their own vehicles and are moving towards a live HD map.

2.2.4 StreetPro Navigation (Pitney Bowes)

StreetPro Navigation is a commercial base map offering by Pitney Bowes. Pitney Bowes offer several different levels of information on their maps and both the Classic and Navigation levels offer routable networks however the Navigation level includes extra attributes to do this more accurately.

StreetPro Navigation is used by the Queensland Department of Transport and Main Roads (TMR) as their primary road network although the extent, coverage and accuracy in other jurisdictions is unknown.

2.2.5 PSMA

The PSMA transport network contains data sourced from jurisdictions around Australia combined into a single data layer. It contains 2.7 million kilometres of road centreline information. They do not survey the network but may source data from state and territory road agencies and their partners to enhance the base network. One key attribute that is missing is link direction which is important for road management, data processing and navigation. The PSMA network is not navigable and the released data is often less current and less complete than other mapping providers since there is significant delay and reliance on receiving map data update information.

2.2.6 Road Agency Maintained

Another option is to require jurisdictions to maintain a version of the road network that is nationally consistent. Most major jurisdictions utilise some form of road network map, many of which publish an open data version of these. The advantage of this option would be the highly detailed, road-specific data regularly collected and associated in-house by the road agencies. The challenge is making the networks align where they join and providing consistent attributes.

2.3 Comparison of Base Map Candidates

The four tables in this section provide a comparison on a number of key aspects of base maps.

Table 2.1 provides an overview of key map attributes that are needed for the representation of a detailed road network. If any of these attributes are missing, it can complicate the association of data or require aggregation or downsampling etc. of data to ‘fit’ the representation of the network.

Table 2.2 presents three aspects of the base map related to accuracy:

- how roundabouts are represented and flagged
- how frequently the network representation is updated
- the accuracy claimed by the provider.

Table 2.3 provides a comparison of the road hierarchy or class system used with each base map.

Table 2.4 presents a summary of the advantages and disadvantages of each base map in relation to data considerations, and a note on the cost to obtain the base map for use.

Table 2.1: Overview of fields present in data

Map	Divided	No. lanes	Speed limit	Direction	Sealed	One way	Hierarchy	Name	Z-levels	GDA 2020 option
OpenStreetMap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
HERE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
TomTom	✓*	✓*	✓	✓*	✓*	✓*	✓*	✓	✓*	
StreetPro Nav	✓	✓	✓	✓	✓	✓	✓	✓	✗	In progress
PSMA	✗	✓	✗	✗	✓	✓	✓	✓	✗	✓
Road agency maintained	Varies	Varies	Varies	Varies	Varies	Varies	Varies	Varies	Varies	Varies

** Assume attributes as full specifications were not available.*

Table 2.2: Map representations of roundabouts, update frequency and quoted accuracy

Map	Roundabouts	Update frequency	Accuracy
OpenStreetMap	Type flag. Adjoining links connect to physical representation.	Varies	Varies
HERE Maps	Type flag. Adjoining links connect to physical representation. Roundabout links break at all adjoining connections.	Quarterly	±1 m to ±100 m
TomTom	Type flag. Adjoining links connect to physical representation. Roundabout links break at all adjoining connections.*	Quarterly*	
StreetPro Navigation	Type flag. Adjoining links connect to physical representation. Contains logical lines to central node as well as another type.	Quarterly	±2 m urban, ±10 m rural
PSMA	Subtype flag. Round. Un-named	Monthly release	±2 m urban, ±10 m rural
Road agency maintained	Varies	Unknown	Unknown

** Assume values as full specifications were not available.*

Table 2.3: Overview road classification information

OpenStreetMap (multiple highway tags)	HERE (multiple fields)	TomTom	StreetPro Navigation (Roadclass)	PSMA (Hierarchy)	Road agency maintained
• Road – motorway – trunk – primary – secondary – tertiary – unclassified – residential • Link – motorway_link – trunk_link – primary_link – secondary_link – tertiary_link • Special – living_street – service – pedestrian – track – bus_guideway – escape – raceway – road • Paths – footway – bridleway – steps – corridor – path – cycleway	Functional class: • 1 – high volume, max speed traffic • 2 – high volume, high speed traffic • 3 – high volume traffic • 4 – high volume traffic at moderate speeds between neighbourhoods • 5 – volume and traffic flow are below the level of other functional classes Access vehicle type field e.g. automobile, buses, taxis, trucks, pedestrians Supplementary geometry: • Racetrack • Driveway • Alley • Bicycle path • Walking path • Private road for service vehicles • Mountain biking trail • Hiking trail • Cross-country ski trail • Golf course trail	Functional road class: • 0 – Motorways; freeways; major roads • 1 – Major roads less important than motorways • 2 – Other major roads • 3 – Secondary roads • 4 – Local connecting roads • 5 – Local roads of high importance • 6 – Local roads • 7 – Local roads of minor importance • 8 – Other roads (non-car)	• Freeway • Highway • Roundabout construction line • Private road • Vehicle ferry • Arterial road • Sub-arterial road • Connector road • Local road • Under construction • Proposed road • Closed road • Path/mall/pedestrian access • Pedestrian ferry • Restricted access (closed to public) • Access road • 4WD track	• National or state highway • Arterial road • Sub-arterial road • Collector road • Local road • Access road • Vehicle track • Busway • Ferry	• Varies

Table 2.4: Pros and cons of each base map option

Map	Pros	Cons	Cost
OpenStreetMap	• Updated by millions of people using the roads • Comparable accuracy to other providers • Near instant updates possible	• Road attribution is often inconsistent or missing • No quality checking of data with public editing • Tracking versions and updates can be difficult • Potential for vandalism/nefarious behaviour	Free
HERE Maps	• In-house survey vehicles • Network for most versatile speed data offering • Collect LiDAR • HD map in progress	• Cost • Potentially restricted licences for use and distribution • Metropolitan focus	Commercial
TomTom	• In-house survey vehicles • Collect LiDAR • HD map in progress	• Cost • Potentially restricted licences for use and distribution • Metropolitan focus	Commercial
Street ProNav	• Used by some road agencies	• Do not survey network	
PSMA	• Developed from road agency data	• No link direction • Do not survey network • Lacks key attributes • Cost • Potentially restricted licences for use and distribution	Commercial, but potential for partnership given ownership by states
Road agency maintained	• Closest match to what road managers are using	• No consistency • Non-matching geometry at jurisdiction borders	Cost required to align and standardise networks

2.4 Base Map Key Selection Criteria

2.4.1 Basic Features

The national base map will require a number of attributes to be fit for purpose. For example, it needs to function efficiently with map matching or network conflation algorithms to allow data in other networks to be joined. Also, it needs to allow effective network segmentation and other geoprocessing actions. Therefore, there are a number of key minimum technical characteristics required:

- Routable network
  - This means that routes can be generated from the network, e.g. for navigation. Therefore, links need to be connected at nodes and contain information about access and traffic direction.
  - Map matching algorithms typically require a routable network to produce accurate results. Some workarounds are possible, but they decrease the speed and accuracy.
- Link/segment direction identification
  - A consistent link directionality attribute is a part of being routable, but it is also required for other geoprocessing actions, for example locating a point of interest on a link.
  - The link direction in conjunction with direction of travel can also be used as a workaround where carriageways are not classified.

- Elevation and structures
  - Z-levels or structure attributes enable bridges and tunnels to be distinguished from surface roads in a 2D map representation.
  - Where a network is not represented by nodes and links, elevation information is required to determine intersection locations.
- Accurate and timely network
  - Map data is a digital representation of the physical world and therefore needs to reflect this accurately and in a timely manner. Therefore, having a mechanism to update a newly constructed road quickly and make this accessible to end-users is valuable.

While extensive attribute information is valuable, it is not as important as having a reliable base network with the key attributes mentioned above. This is because additional attributes can be added to the base network if it is in a form that allows for effective map matching and joins to other data sources.

Cost and licensing restrictions on use are another important factor with commercial map providers; however, this will vary depending on the use case. For example, restricting the publishing maps of road geometries to static images is likely to incur a much lower cost than publishing the map data where the road geometries are made available since the commercial intellectual property is made public.

2.4.2 Segmentation

Different types of road network segmentation are used for different purposes, usually based on intersections and when information does (or is likely to) change. In some cases, the network is segmented between major intersections and this is often the minimum level of segmentation available. Others require a more granular approach, so road links are then split into smaller (sometimes as low as 100 m) segments as is often the case for road condition reporting. Navigation networks like the HERE network are typically segmented according to a change in road attributes on top of the intersection segmentation. For example, a posted speed limit change will create a new segment.

Other networks (such as OSM) rely on a less granular (node and ways) representation.

It should be noted that in addition to actual link segmentation, attribute data may be represented via linear distance or geospatial position according to a position along a link.

2.4.3 Supporting Data Alignment

Data alignment between networks is a complex topic with many different methods that vary in accuracy, complexity, computation time and network requirements. The differences between networks and the complexity of this task are the main drivers for the need for a unified and common network representation.

Accepting that not all data will be provided in a common standard, a selected base map network can support data alignment through the following:

1. provide a consistent, segmented network with good attribute data (road names, elevations and structure information, link and traffic directionality, start, end and shape geometry) to the data providers
2. provide good specifications and support documentation of the network and associated metadata
3. ensure that services are available to support data providers without strong in-house GIS capabilities to support alignment of data to a standard base map network
4. provide guidance on linear referencing and mapping of data within and across road links.

3. Guidance for Aligning Data with the Base Map

3.1 Introduction

Geospatial data is integral to the management of transport and transport assets across Australia by both government and private organisations. However, there are significant differences in the way geospatial data can be represented, which makes aligning different datasets particularly from different organisations, difficult in a consistent and accurate way.

One key difference is base map alignment. This document provides some practical guidance for matching and aligning data from different sources to a common network in the context of a road transportation network. In addition to network alignment this report also provides guidance for data translation between aligned networks.

Currently the Asset Register requires that road managers supply data in a shareable and standardised format, although no network is specified and so the supplied data cannot be reported in a consistent way nationally.

Once a base map for road data is selected, the data at a minimum:

1. must be aligned to the agreed road network, and individual data points should contain common identifiers which reference this network
2. (if data was transformed from a different referencing system) must contain the original identifiers for potential reverse transformations and quality assurance
3. (where the data is not attributable to an entire road link/segment) must use a specified linear referencing system for the base network.

If data cannot be represented by the road network, for example the locations of rivers or the flight paths of aircraft then it cannot be imported into the GIS environment used for HVRR and subsequent applications.

For most applications, the benefits of storing data in a standardised network vastly outweighs the error introduced through geometric transformations between source (collected) data and the standardised network. This guidance is intended to be for general use and does not provide advice for mapping specific data collection standards associated with surveying techniques or commercial equipment.

This guidance is composed of three main sections:

1. **Section 3.2 – Data Standard and Structure** provides an overview of what the HVRR data environment is, its requirements and its capabilities. An outline of the network data structure is provided, and properties of the base map documented.
2. **Section 3.3 – Data Storage Standards** provides examples of how data should be stored in the HVRR environment. The examples show what attributes are required for a HVRR compatible dataset, and how the different datasets can be represented.
3. **Section 3.4 – Aligning Data Objects with a Base Map** presents practical guidance for aligning specific geometric objects with the underlying line segment road network representation. These objects include line segments from other network representations, point locations or trace points (e.g. GPS paths), areas, and linearly referenced positions.

The methods outlined in Section 3 consider the heterogeneity of outcomes when using different geospatial alignment techniques, acknowledging that some methods may be more practical to implement than others. Applications which require precise measurements for small distances cannot use alignment techniques intended for aggregation and region-wide reporting. Section 3 assumes a reasonable level of accuracy is required but does not detail methods that approach the accuracy needed for linear referencing system alignment.

This guidance does not explicitly consider elevation geometry information and assumes all data aligns to a 2-dimensional representation of the road network. This, however, does not preclude elevation, height or vertical clearances being included as attributes within the dataset.

Most geospatial coordinate systems represent X and Y datums of the earth's surface. Altitude (z) data is not always stored in base networks but is required in some applications to differentiate bridges, underpasses and tunnels. It is possible to retro-actively embed road height in a road network which lacks it with a high-resolution height map or z-level information. It is worth nothing that there are also several applications that require very high accuracy mapping which must consider changes in elevation along the road; however, they are outside the scope of this guidance.

3.2 The Data Environment

3.2.1 Initial Comments

Both the Asset Register data specification and Austroads Data Standard rely on a digital representation of the road network. The road network is made up of sequences of geo-referenced points forming a line or linestring, and the set of all (non-overlapping) linestrings constitutes the network with all data stored in this format. Data is stored alongside a linestring identifier, allowing data to be associated with a specific road segment. In addition, the data may also contain linear references along a linestring which allows sub-positioning within the segment and nodes representing intersections between linestrings.

The HVRR data structure natively supports linestrings and points where the geometry is on a road. Data represented by more complex geometry such as polygons, fields and 3D structures are not natively supported and must be functionally mapped to linestrings or points (see Table 3.1).

Table 3.1: HVRR supported geometric objects used to represent geospatial data

Geometric object	Support
Linestrings	Supported when representing physical roads
Points	Supported with linear referencing and position along a road or discrete points
Polygons, areas and fields	Not supported, must be mapped to the road network
Elevation data	Partially supported, must be mapped to the 2D road network with height/altitude stored as a data attribute
Geometric data unrelated to the road network	Unsupported

3.2.2 Base Map Requirements

A road network base map has not yet been selected for the purposes of data alignment; however, there are minimum requirements for a usable national base map (see Section 2.4).

The common referencing system or network must be able to store all data pertaining to the road system. The road network base map must:

- be complete, containing all driveable publicly (and privately (for example toll) owned) roads
- be highly accurate
- be routable (with suitable node/intersection and link/road connectivity)
- be able to be dynamically segmented and referenced
- provide a robust and transparent method for road network updates to ensure the network topology remains an up-to-date representation of the infrastructure
- contain no geometric overlap, with every linestring being completely unique
- have consistent segment directionality and direction labelling to allow for linear referencing
- use the WSG84 coordinate reference system and be transformable to Geocentric Datum of Australia 2020 where required. Note, if high precision is required for historical data or long-term applications, the time of recording or generation of the geometry needs to be recorded.

3.3 Data Storage Guidance

This section details how data should be organised for the potential data environment. Data stored in the environment is hierarchical, with individual data points sharing a common parent. In this context, a dataset does not refer to all the data stored in the potential environment but rather a group of records which share a common parent. One example is a list of stop signs in a council area. These positions are grouped together and share a common dataset.

3.3.1 Unique Identifiers

To effectively manage multiple datasets from various sources the HVRR data standard uses several unique identification system or indexes. Each record must contain value representing the following identifiers:

- **Local ID**
  Each record needs to have a unique identifier within its dataset. The local ID will be unique for all records that share a dataset ID, but not necessarily be unique to all records in the potential data environment.
- **Dataset ID**
  This attribute is shared by all records from the same dataset or data source. Dataset IDs are immutable and cannot be changed once set.
- **HVRR Geometric ID**
  This identifies the linestring object the record aligns to. While the set of all geometric IDs are unique, records in the same dataset may share the same geometric ID and are therefore not unique indexes for data points themselves. The geometric ID can be used for spatial filtering and linking datasets together using the common identifier.
- **Source ID**
  All data should possess a HVRR network ID, but also a reference to the original geometric data structure, via an identifier which should also be preserved to allow for quality assessment, or an updated alignment method.

3.3.2 Dataset Requirements

A dataset is a collected set of records, and each record will have the same dataset ID, and a unique local ID. To improve the visualisation and analysis of the dataset some requirements have been specified:

- All data is of the same geometric type. Point and linestring data cannot share the same dataset ID.

- All data must share the same source ID referencing system.
- Records which share a dataset ID should all share the same set of attribute-value pairs. For example, if a record in a dataset contained an asset number attribute then all other records must contain the same attribute, but not the same value. This ensures data can be stored in a tabular structure, as opposed to a JSON or XML style schema.
- Any date/time data should be stored in UTC ISO time (ISO 8601 date and time formats) and converted to the appropriate time zone when needed.

3.3.3 Linearly Referenced Positions

The HVRR data standard supports linear referencing along the road network. The following optional attributes can be used to store a point or segment along a linestring. If these attributes are left empty, the record is assumed to align to the entire linestring.

- **Linear Reference Start (0,1)**
  This value represents the start of a segment of linestring. The value is a fraction of the entire linestring and when interpolated yields the geospatial co-ordinates of segment starting points. It must be less than linear reference end, and the linear reference position field must be empty.
- **Linear Reference End (0,1)**
  This is identical to the previous value but represents the end of the segment. It must be greater than the linear reference start, and the linear reference position field must be empty.
- **Linear Reference Position (0,1)**
  If the record is representing a discrete position or point, this attribute can be used to store the fractional position from the beginning of the linestring. Interpolation of the linestring will then return the position. The previous two attributes must be empty to store a positional value.

3.3.4 Examples of Stored Data

Examples of point and linestring data are detailed in Table 3.2 and Table 3.3. These only show a record, and not an entire dataset. Specifications for area and 3D data are not supported, and no examples are provided. An expansion of the data environment would be required to support these data types.

Table 3.2: Example of point data for a specific position on the road where the linear reference position column is used

Data attribute	Data type	Example value
geom_id	Integer	11484
local_id	Integer	5448
linear_reference_start	Decimal (0,1)	Null
linear_reference_end	Decimal (0,1)	Null
linear_reference_position	Decimal (0,1)	0.69
data_type	Integer	0 (Point)
source_id	Integer	54542
dataset_id	Integer	50
Attribute_1	String	30 cars
Attribute_2	String	80 km/h

Table 3.3: Example of linestring data for a segment of the road where the start and end linear referencing positions are provided

Data attribute	Data type	Example value
geom_id	Integer	11485
local_id	Integer	5442
linear_reference_start	Decimal (0,1)	0
linear_reference_end	Decimal (0,1)	0.45
linear_reference_position	Decimal (0,1)	Null
data_type	Integer	1 (Linestring)
source_id	Integer	54542
dataset_id	Integer	51
Attribute_1	String	30 cars
Attribute_2	String	80 km/h

3.4 Aligning Data Objects with a Base Map

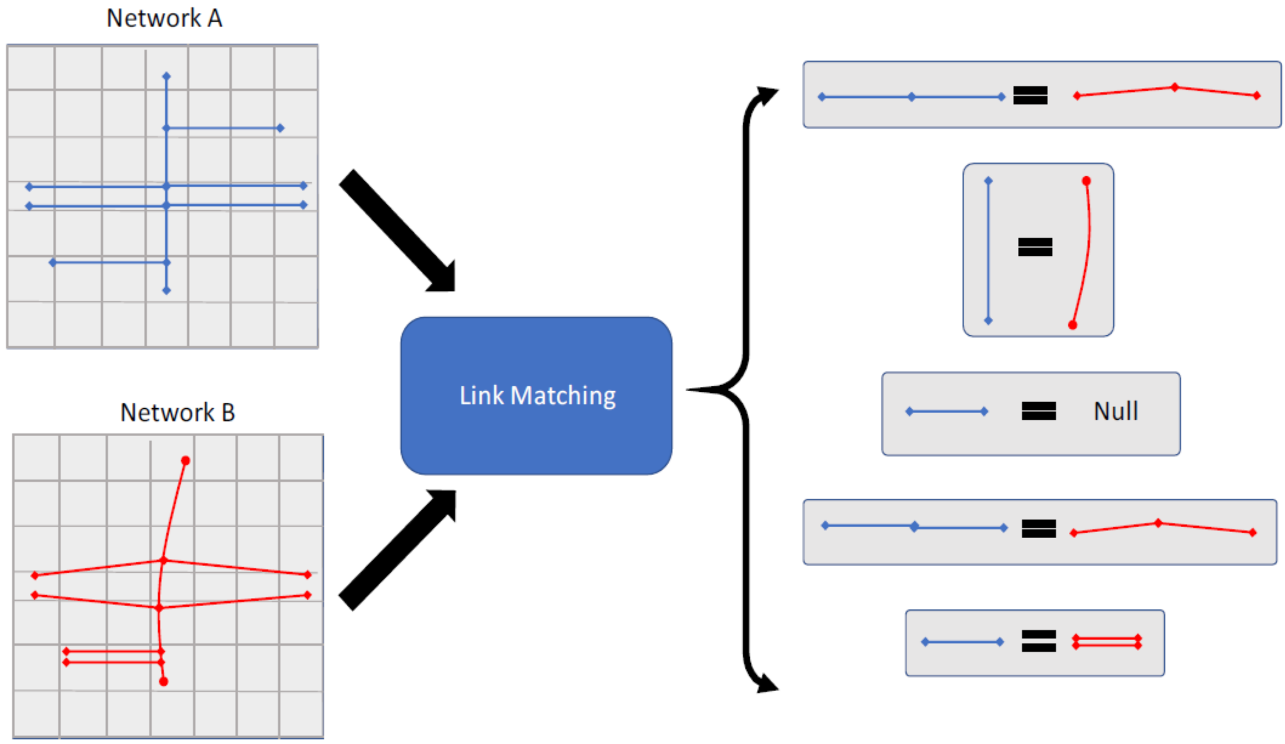
3.4.1 Initial Comments

Geospatial data can be stored in a variety of structures and formats. Each provider will use the format which suits their needs and in fact may not use a road network (just GPS coordinates for example). It is acknowledged that a significant amount of geometric transformation and processing is required to make third party data sources compatible with the HVRR environment. This section considers how geospatial data can be aligned for the purpose of reporting in a common system (sometimes called map matching) and is the process required to enable third party data to be incorporated into the HVRR environment. The following guidance should cover alignment for most applications, but Section 3 is by no means comprehensive, and a GIS user should consider their use case and choose the most appropriate methods available to them.

3.4.2 Reversible Transformations

When aligning or associating geometric data (refer to Figure 3.1), most methods are not reversible. The alignment, or more broadly the transformation is either incomplete or inaccurate when reversed. An example of an irreversible transformation is contained in Section 3.4.3. This is the primary reason a source ID must be provided when importing data into the HVRR environment, as reversing the alignment method will not generate the same relationship.

Figure 3.1: An example of matching network A to network B



3.4.3 Example of an Irreversible Transformation

A set of GPS points can be mapped to a second set of GPS points using the following method:

For each point in *Set A:*

- Find the closest point in *Set B.*
- If the distance between points is less than some threshold, then assign the point in *Set A* to the point in *Set B.*

Every point in *Set A has a match in Set B* so data can be mapped from ***Set A* to *Set B*** (see Table 3.4). A metric could be calculated using the two data sources and a value assigned to points in *Set B*. In this scenario, data is required to be reported using the GPS points from both *Set A* and *Set B*. The calculations have been performed and embedded using *Set B*, and a data mapping from *Set A* to *Set B* now exists. While the obvious step would be to use the previous mapping to go from *Set B* to *Set A*, this transformation is irreversible based on the alignment method and data/accuracy will be lost (see Table 3.5). To report the aggregated metric along points from *Set A*, the same matching procedure must be performed but in reverse. This is because points in *Set B* may have no analogue in *Set A*, and the data will not be mapped appropriately. The method iterates on all points in *Set A*, not *Set B.*

Table 3.4: Data mapping from Set A to Set B

Point in *Set A*	Closest point in *Set B*
A_1	B_3
A_2	B_3
A_3	B_6
A_4	B_2

Note that many points in Set B are not the closest to any points in Set A.

Table 3.5: Data mapping from Set B to Set A

Set B	Set A
B_1	A_1
B_2	A_4
B_3	A_3
B_4	A_1
B_5	A_3
B_6	A_4

Note that here all points in Set A have an analogue in Set B, but point A_2 is not closest to any points in Set B.

3.4.4 Guidance for Linestring Data

Linestring data

Linestrings are sets of ordered geometric positions. As a sequence, linestrings can represent GPS traces of vehicles, road networks or a section of key road infrastructure such as freight routes. Linestrings are not natively routable and must be associated with a network to understand connectivity or routing options related to the sequence. Linestrings also form the basis of linear referencing positioning systems, where a location is determined by a 1-dimensional distance from the start or end of a linestring, rather than GPS co-ordinates or other geodetic datums.

Mapping a set of linestrings to another set of linestrings

When aligning a linestring to a common road network, it is important to consider the direction and physical object the linestring represents. In the case of aligning different road segments, embedded metadata such as direction, road name and speed limit can be used to improve the accuracy of the alignment procedure through a metadata filter. If the linestring represents a GPS trace, time-series data may be leveraged to infer the speed of the vehicle, which may assist in the selection of matching segments. Some common linestring alignment methods include:

- contextualised Fréchet Distance (Fréchet Distance/(difference in line string length))
- average point distance + heading filtering
- map matching.

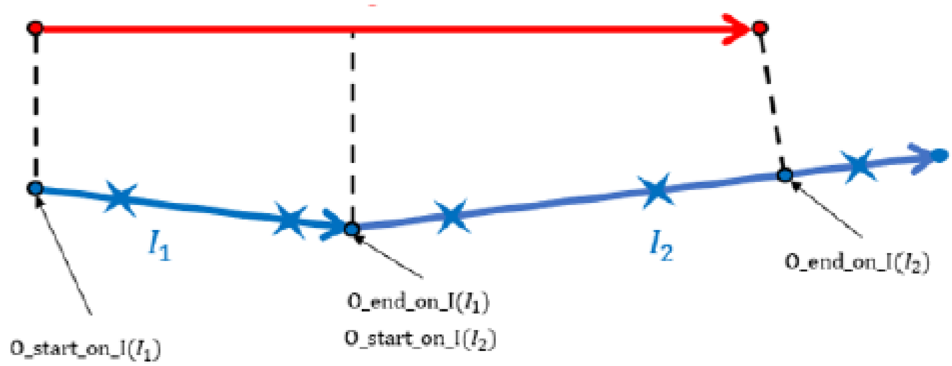
Linestrings typically represent data which describes a section of road, or traverse of a vehicle along a series of roads. In both cases the desired mapping between input linestrings and base networks is typically 1 to many as the input linestring may align to multiple consecutive segments of road. Advances in navigation software have yielded a variety of alignment algorithms focused on snapping moving vehicles to a digital road network. These algorithms can also be used for linestrings which do not represent a vehicle, but the road itself.

Map matching can be technically difficult to implement and computationally expensive when dealing with many millions of linestrings. There are numerous fundamental differences in network representations and other edge cases. Existing map matching algorithms include open source methods like *graph-hopper* or *pgmapmatch*, as well as implementations in commercial software such as *Strava*. Map matching considers the geometry of the entire linestrings, often calculating similarity using a Hidden Markov Model and probability modelling of potential paths. Matching linestrings is also possible through geometric similarity measures. These measures have limitations for curved linestrings and issues with scale but are typically used in more complex alignment algorithms.

Linearly referenced positions or sections on linestrings

Linear referencing (refer to Figure 3.2) can be considered as a location on a linestring. To match a linear referenced data source the position on the line must be evaluated using reference road geometry to produce an X-Y spatial location(s). The resulting X-Y position(s) can then be matched to the target network as a point or linestring data source. This works for discrete positions in a linear referenced system as well as linear sections. If all data is linearly referenced, conversion of linear positions to GPS positions should provide sufficient accuracy for most cases.

Figure 3.2: Linear referencing involves projecting data positions to distances along linestrings



Mapping data in one road network to another road network

If the linestring data is stored as a road network, more robust alignment methods are possible. Road networks contain several invariants which can be leveraged for increased accuracy and enable more complex representations. One example of a network invariant is linestrings overlap. No two linestrings represent the same road geometry and this can be leveraged algorithmically when aligning two road networks. Alignment of one road network to another is challenging and good results require a blend of manual and automated processing. It should be acknowledged that perfect automated map matching under all conditions is impossible and that some manual map matching is inevitable. Two approaches, map-matching, and network conflation exist which can include metadata matching via street names and geometric alignment algorithms. Some networks are incomplete or only contain major roads or use highly simplified road geometry. The large variety in digital representation of the physical roads mandates a nuanced approach when aligning networks.

Linestrings data aggregation

Once linestring data is mapped to the base network, it may be necessary to aggregate the associated data to fit the standard of the network.

An example of this would be translating road roughness from one network (say 100 m surveyed segments) to the standardised HVRR network, which may have different segments and lengths. A roughness result is desired in the HVRR for each segment that has one. The mapping may be many-to-one or many-many or one-many, and the roughness value needs to be weighted in a way that is appropriate for that particular data type. The allocated proportions or weightings to the data are required to calculate values accurately for use in the standard network.

It is important to note that the correct way to align this data will depend on the data being aligned and the geospatial alignment and overlap of the two networks and techniques may vary.

3.4.5 Guidance for Point Data

Mapping point data

Mapping point data is relatively straightforward but can often be error prone due to location offset and quirks in the storage standard. Typically, a single point is to be matched to a single link, but weighted scores can also be applied based on distance from the point. Data embedded in GPS points may also be directional and can be used to increase accuracy during alignment. An example method is outlined below:

1. Create a circular buffer (area) of sufficient size with the GPS position (given GPS error) at its centre.
2. Select all links within, overlapping this area.
3. For all links within the area
   a. Calculate the distance between the point and the line.
   b. If relevant, calculate the heading at this location.
   c. Find the difference between the line heading and point heading.
      i. If lines are bi-directional take the minimum of (heading_difference, –heading_difference).
4. If heading is known and relevant, discard any lines with a difference in heading greater than a desired threshold.
5. Take the line with the minimum distance to the point.
6. If point is less than a threshold distance from the line, then return the match.

This process can be repeated for all points in the set.

When working with GPS traces (being a sequence of points) there are several options to improve point matching accuracy including:

- Take the average of the data if multiple points align to the same link.
- Store the linearly referenced position of the point with the link for later interpolation.
- If GPS points are likely to have a large error, or there is confidence that the data only applies to a single link, convert the point to a circular area before alignment.
- Take into account the order and timing of neighbouring travel points.

The best approach will depend on the specific needs of the application.

Abstractly connected point data

This refers to point data where there may be some nascent association between data in different points. An example is anonymised road data collected at probe site locations. In this example data can be grouped by the GPS position of the probe, but also by an anonymised identifier which indicates a unique vehicle travelling through different probe locations.

Given a vehicle can be traced between probe locations, it is prudent to consider the potential routes this vehicle may have travelled between the probes. Identifying potential routes allows data from probes to be interpolated across specific sections of the road network, instead of being applied to the location and link closest to the probes.

To achieve this, routing algorithms such as A* and Dijkstra could be used. Connected point data which cannot be represented in linestrings can be represented as graphs and routing-based alignment methods in the base network used to infer potential paths.

Offset point data or asset management data

Sometimes data assigned a GPS position may represent road furniture, road signs or other objects not explicitly within the drivable area of the road. Mapping this data to a network heading or direction along the road can be used to improve accuracy. The following considerations should be made when mapping an asset or offset road data:

- If the heading is known, the position can be offset to be closer to the centre of the road.
- Offset from heading can be performed by calculating the normal and offsetting by x metres in the direction of the normal vector, where x should be less than 5 m.
- Offset point data can then be treated in the same way as vehicle GPS data, as positions along the road. The above methods for mapping point data can then be applied.

3.4.6 Guidance for Area Data

Finding geometric objects within an area

Locating objects within an area is supported by almost all GIS programs as well as geospatial libraries and programming packages. Finding out if an object is contained within an area can be used for a variety of mappings. For example, state borders are often defined as geospatial areas. Assigning a road network to a given state is as simple as iterating through a list of states and checking if the object is within the area. Areas can also be generated around points and linestrings to create distance buffers or filters.

Fields

Fields are non-discrete areas, by which data may be mapped based on the field strength at a given location. They can be defined functionally or through a raster. Examples include magnetic fields, distributions of particulates and weather. Mapping data from a field onto a road network can be performed by evaluating the field strength at the location of the geometric object. To increase performance, it may be possible to define an area outside of which the field strength is close to 0, then calculating field strength within this area only. If this is not possible the field can be evaluated on a projected raster map and subsequently interpolated based on the object’s position.

4. Conclusion

The selection of a network base map for road-related data is an important step towards building a single harmonised database of road data for Australia. Additionally, the guidance here provides some direction to organisations wanting to align their data to this harmonised network.

The provision of a national base map and alignment guidance by no means ensures an accurate and transparent national dataset of harmonised road data but does take steps towards enabling the decentralised participation of organisations that produce data to report it in a standardised way in a common environment.

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Data to Support the Heavy Vehicle Road Reform Part E

Traffic Data Analysis

Data to Support the Heavy Vehicle Road Reform Part E: Traffic Data Analysis

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part E presents an investigation of traffic data across Australian jurisdictions aimed at understanding the well-documented inconsistencies. The investigation included a comparison of the data collection, calculations and other processes used.

Keywords

Traffic data, AADT, data consistency, national standards

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About Austroads

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

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

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

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

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

This report has been prepared for Austroads as part of its work to promote improved Australian and New Zealand transport outcomes by providing expert technical input on road and road transport issues.

Individual road agencies will determine their response to this report following consideration of their legislative or administrative arrangements, available funding, as well as local circumstances and priorities.

Austroads believes this publication to be correct at the time of printing and does not accept responsibility for any consequences arising from the use of information herein. Readers should rely on their own skill and judgement to apply information to particular issues.

Summary

A detailed investigation on the collection, calculation, processing and reporting of traffic volumes between jurisdictions has been conducted. Literature on traffic volume collection and reporting is reviewed. A comparison across jurisdictions of their traffic data practices is implemented. The extent and availability of commercial traffic data in a national and open context are explored. A draft data specification for a nationally consistent reporting of traffic volume data is proposed.

The scope of this work is limited to annual average daily traffic (AADT) volume in terms of the Austroads vehicle classification.

Through the investigation on traffic data practices in Australia, it is found that the inconsistency within jurisdictions should not be attributed to a lack of a national specification. It is mainly because of the differences in business need, availability of equipment and processes for calculating the AADT. For example, traffic volume data in NSW are mostly collected from the 600 permanent counting stations across the state. NSW also uses a different method of calculating the AADT to other jurisdictions.

In order to increase consistency in traffic volume data between jurisdictions, it is suggested that a national business need (e.g. public awareness, road design or traffic management) be identified at first. A traffic data specification, including collection, calculation, processing, and reporting, can be determined correspondingly. In addition, stakeholder engagement during the development of a national data specification is important to ensure the required level of practicality and rigour within different jurisdictions.

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1. Introduction

1.1 Background

The project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* objective is to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

Austroads projects AT1920 and AAM6068 have both focused on collecting data related to road assets as part of efforts under the HVRR. This national dataset of road assets at 100 m intervals has included operation data such as traffic volumes, and heavy vehicle percentages.

It was observed that there was inconsistency and uncertainty surrounding the traffic data between and from even within road agencies. The reasons for these inconsistencies were not entirely clear and so this investigation of traffic data was undertaken to obtain clarity around the reasons for inconsistencies in the collection, calculation, processing, and reporting of traffic volume data between Australian jurisdictions.

1.2 Purpose

The purpose of this investigation is as follows:

- to investigate the methods of data collection, processing algorithms (including definition of traffic segments), data coverage and data currency
- to investigate if jurisdictions report traffic volumes network-wide following the Austroads vehicle classification and the methods of data collection
- to develop a national specification in relation to collection, processing, extrapolation and reporting of traffic volume data – in terms of AADT for the 12 Austroads vehicle classes
- to discuss the inconsistencies in traffic volume data and provide suggestions.

1.3 Scope

This investigation is conducted within the following scope:

- limited to annual average daily traffic (AADT) suitable for national specification
- applies network-wide
- includes the six states of Australia
- includes Austroads vehicle classification and/or percentage of heavy vehicles.

1.4 Methodology

Section 2 contains a literature review that has included consultation with traffic teams in state road agencies as well as reviewing their available documentation.

Section 3 is an analysis of how traffic data is collected directly.

Section 4 details the availability of traffic data through open and commercial sources.

Section 5 finishes the investigation with some discussion on a national traffic data specification to achieve national harmonisation of traffic data.

2. Literature Review

2.1 Factors Influencing Traffic Volume

There are a number of general factors that can influence traffic volumes. These are mentioned in Table 2.1.

Table 2.1: Examples of factors influencing traffic volume

Factors influencing traffic volume	Explanation	Examples of traffic volume
Location	Traffic volumes vary in relation to location. This is a representation of traffic on a road network, at a point in time.	AWT, AAWT, ADT and AADT
Time	Traffic volumes demonstrate time variation. Such data discloses short-term fluctuations and long-term trends of road traffic and may relate to an individual segment or a network. This data requires continuous, or frequent and regular collection, and is typified by hourly, daily, and seasonal traffic patterns.	Hourly volume and peak-hour volume
Traffic composition	Traffic volumes vary in relation to traffic composition. This will disclose the constituent characteristics of traffic volumes, such as the proportion of different vehicle classes, the number of bicycles and pedestrians, and possibly their origin and destination.	Traffic composition and classified vehicle counts

Note: AWT = average weekday traffic.
AAWT = annual average weekday traffic.
ADT = average daily traffic.
AADT = annual average daily traffic.

Source: National Association of Australian State Road Authorities (NAASRA) (1982).

2.2 Traffic Volume Data Requirements

The type of traffic volume reported usually relates to the requirements for which the traffic data was sought. Some examples of these are shown in Table 2.2.

Table 2.2: Traffic volume data requirement

Purpose	Types of traffic volume data required
1. Road financing and budgeting	VKT for different classes of road
2. Classification of roads and road network planning	AADT Traffic composition and growth trends
3. Classification of traffic for noise and environment studies	AADT Traffic composition and speed
4. Validation and adjustment of trip data collected in transport studies	AADT AAWT 24-hour or peak-hour volume across cordon or screen lines or at major intersections

Purpose	Types of traffic volume data required
5. Development, maintenance and improvement programs, and economic evaluation of alternatives	AADT VKT DHV Traffic composition and growth trends for important corridors
6. Selection of design standards for road geometry and pavement thickness (1)	AADT DHV Traffic composition and growth trends for a particular road Possibly bicycle and pedestrian data
7. Interchange and intersection design	Turning movements Traffic composition Peak-hour volume and trends Possibly bicycle and pedestrian data
8. Evaluation of Level of Service (LOS)	DHV Hourly flow variation patterns AADT – adequate for low-volume rural roads
9. Supply of exposure data for determining accident rates	AADT VKT Traffic composition
10. Implementation and appraisal of safety programs	VKT on different road sections and areas AADT and peak-hour volumes on particular roads and movements at intersections Possibly traffic composition and pedestrian movements
11. Establishment of warrants for traffic control devices	AADT Peak-hour volumes Possibly traffic composition and pedestrian movements
12. Estimating the loading on pavement and bridges (in the absence of weigh-in-motion equipment)	Classified vehicle counts Axle configurations

1 *The selection of design standards for pavement thickness is now largely determined from weigh-in-motion equipment that provides a direct measure of pavement loading by vehicle types.*

Note: AADT = annual average daily traffic.
AAWT = annual average weekday traffic.
DHV = design hourly volume.
VKT = vehicle kilometres of travel.

Source: Austroads (2017).

2.3 Obtaining Raw Data

2.3.1 Methods of Counting

There are a number of methods for obtaining the raw data of traffic volumes, which are traffic counts. These methods are elaborated on in Table 2.3.

Table 2.3: Methods for traffic counting

Method of counting	Feature	Application
Manual counting		
Hand-counter and PC-based data logger	1. Expensive 2. Experienced persons can record multiple items in a counting program	1. Intersections where turning movement volumes are required 2. Sites where detailed classification data are needed, e.g. number of passengers or vehicle body types 3. Short-period vehicle counting
Automatic axle counting		
Pneumatic tube	1. Above ground 2. Susceptible to damage, and short lifespan 3. Frequent checking for split or breakage	1. Short-period vehicle counting
Piezoelectric cable	1. Set in groove cuts of road surface 2. Durable 3. More expensive than pneumatic tubes 4. Pressure sensitive	1. Permanent vehicle counting 2. CULWAY weigh-in-motion system 3. Detecting pedestrians at zero or low speeds
Automatic vehicle counting		
Inductive loop	1. Most accepted and widely used by Australian road agencies 2. Embedded in the pavement or attached to road surface 3. Change in loop inductance caused by vehicle chassis or engine 4. Size, shape, and positioning are important for accurate counting 5. Not suitable for unsealed roads 6. Microprocessor data recorder can log and store large amounts of traffic data that can be remotely accessed	1. Vehicle counting 2. Traffic surveillance 3. Traffic signal control 4. Vehicle classification
Video image detection	1. Counting and classifying from video recordings 2. Night-time headlight detection algorithms can measure vehicle numbers but not classify vehicles 3. High accuracy 4. Rapid advancement 5. Continuity	1. Vehicle counting 2. Vehicle classification 3. Incident detection 4. Vehicle number plate recognition 5. Enforcement, tolling and monitoring
Microwave radar	1. High-frequency (gigahertz) radio waves 2. Unimpeded by various weather conditions, e.g. rainy, windy, cloudy, snowy, and foggy 3. Able to operate during daytime and at night 4. Able to trace vehicle profiles, allowing vehicle classification 5. Vehicle occlusion may occur, i.e. vehicles being missed because they are partly or entirely occluded by a larger vehicle closer to the detector	1. Vehicle counting 2. Vehicle classification
LiDAR sensor	1. Ultraviolet, visible, or near-infrared light to image vehicles 2. Able to determine physical profiles of vehicles with high resolution 3. Occlusions due to vehicle, terrain or vegetation may occur	1. Vehicle counting 2. Vehicle classification

Method of counting	Feature	Application
Magnetometer	1. Mounted under road pavement 2. Detects the change in the earth's magnetic field caused by vehicle movement 3. Battery powered 4. Connected to roadside equipment wirelessly 5. Same level of accuracy as inductive loops, and easier to install with less pavement damage	1. Vehicle counting 2. Occupancy estimation
Acoustic sensor	1. Monitor vehicle noise, primarily tyre noise 2. More cost-effective than in-pavement sensor 3. Accuracy of vehicle counting and speed measurement may vary 4. Less suitable for non-permanent count applications	1. Vehicle counting and speed measurement across multi-lane roads with high traffic volume
Infrared sensor	1. Detects axles by registering the on and off times of vehicle wheels crossing the path of an infrared beam 2. The Infra-Red Traffic Logger (TIRTL) consists of transmitter and receiver units on opposite sides of carriageway 3. TIRTL has a speed measurement accuracy of less than 1% error at up to 250 km/h 4. TIRTL classifies vehicles on multi-lane highways as per Austroads 12-bin system by measuring the number of axles, axle configuration, wheel width and the ratio of the front-to-back wheel width 5. TIRTL has an expected product life of 20+ years	1. Vehicle counting 2. Vehicle classification 3. Speed measurement

Source: Austroads (2017).

2.3.2 Counting Stations

Roads with similar traffic patterns could be grouped together, and accordingly different types of counting stations can be used to monitor traffic volumes in each group. These groups can remain intact for several years, even though the AADT values for different road sections within the pattern group may vary. Counting stations are categorised as pattern stations and short-term stations in terms of whether counting tasks last long enough to establish seasonal patterns.

Pattern stations

Pattern stations include:

- permanent stations, which are monitored continuously
- seasonal stations, which may be continuously counted or frequently sampled, but usually only for the duration of the survey year in a particular locality.

At permanent stations or continuously counted seasonal stations, the AADT can be measured directly. When the available data is less than a full year, techniques for synthesising missing data are used (CSIRO 2000). However, at seasonal stations where counting is not continuous, AADT is estimated by using appropriate adjustment factors. The adjustment factor is derived from a permanent station representative of the required seasonal station.

It should be noted that seasonal volume variations are much more related to climatic and geographic characteristics than to AADT. Consequently, the use of a seasonal adjustment factor derived at a permanent station in the same AADT stratum, but in a different geographic area, is less likely to yield an accurate result.

Short-term stations

Traffic volumes at short-term stations are measured for short periods (usually less than one week), once during the survey period. At short-term stations, AADT can be estimated by multiplying the ADT obtained at the station by a seasonal adjustment factor derived at a permanent station which exhibits a similar traffic pattern.

The adequacy of this approach depends on the assumption that the short-term station is well represented by the permanent station selected. The selection of the permanent station is therefore very important (Transfund New Zealand 2001). To increase the confidence in the pattern information obtained, it is recommended that the data collection at all short-term stations in a pattern group be made at the same time as the related seasonal adjustment factor is being derived.

Density of counting stations

The accuracy of an AADT estimate depends partly on the grouping of short-term stations with pattern stations. The method of grouping is therefore important. Areas with similar economy, culture and development tend to show similar traffic patterns. The most effective grouping is generally by geographical region.

Pattern stations are best located by randomly selecting the number of sites on roads from each of AADT strata, within each geographical region. As a general rule, the density of pattern stations in each stratum should be proportional to the product of total road length and the square root of the mean AADT in that stratum. This will provide a weighting factor in favour of low-volume roads, which tend to exhibit more daily variations in traffic volumes.

The number of short-term stations is determined by the extent of the road system and the availability of funds. It is usual to count at the following locations:

- each leg of all major intersections
- identifiable locations remote from major intersections, where the difference in AADT from those measured at major intersections could be seen.

The number of pattern stations, and the ratio of pattern stations to short-term stations, cannot be rationally assessed in advance, since it will depend on the regional grouping and the reliability of matched patterns. Thus, the achievement of consistent and specified accuracy levels in AADT estimation is essentially an iterative process that develops over time and experience.

The guidelines for the densities of traffic counting stations are shown in Table 2.4.

Table 2.4: Density of counting stations

Type of road	Counting station density (km/station)		
	Pattern station		Short-term station
	Permanent [1]	Seasonal	
Rural			Up to 25 (usually 13–17) Short-term stations may be characterised by one pattern station
Freeways, arterials	100–200	200–300	
Local roads	5000–9000	1000–2000	
Urban			
Freeways, arterials	20–50	30–50	
Collectors, distributors	100–150	50–100	
Local roads	> 1000	4000–6000	

1 Lower figures (or higher densities) are applicable if few seasonal stations are used.

Source: Austroads (2017).

2.4 Transforming Raw Data

Raw traffic data, such as traffic counts, surveyed from the field will be used for the calculation of traffic volume data. A traffic counting program should be designed so that the following traffic volume data can be derived from raw traffic data at the required levels of accuracy:

- AADT
- VKT.

2.4.1 AADT

Definition

AADT is the average annual daily traffic passing a roadside observation point over the period of a calendar year. It can be either directly measured or estimated from short-term counts.

AADT can be calculated by measuring the total traffic volume passing the observation point over a year and then divided by the number of days in that year, as shown in Equation 1.

$$AADT = \sum_{i=1}^{n} V_i \,/n \qquad (1)$$

where

V_i = total traffic counts on day i

n = number of days in that year, e.g. 365 or 366

The calculation of AADT would be straightforward if the counting stations were to operate without failure of recording daily traffic counts for every day of the year. Some inaccuracies could be present, as a result of instrument counting errors, malfunction, or other causes, but the AADT derived would be relatively accurate.

Estimation

A method of AADT estimation is included in the *Guide to Traffic Management* by Austroads (2017). If traffic was counted on random days in the year, the result would only estimate the AADT. The longer the period during which traffic is counted, the closer the ADT calculated will approximate the AADT. For example, the ADT derived from several short-term counts throughout the year, will more closely estimate the AADT, particularly if the road segment exhibits a high seasonal variation. The AADT at a particular location can be estimated by multiplying the ADT derived from short-term counts by the seasonal adjustment factor derived from a pattern station representative of the required location, as shown in Equation 2.

$$AADT_j = ADT_j \times SAF_i \quad (2)$$

where

$AADT_j$	=	the AADT at the required location j
ADT_j	=	the ADT derived from short-term counts at the required location j
SAF_i	=	the seasonal adjustment factor at a pattern station i representative of the required location

The seasonal adjustment factor can be calculated by dividing the AADT obtained from one-year counts at a pattern station by the ADT derived from short-term counts at the pattern station.

Transfund New Zealand (2001) provides a formula to estimate AADT on the basis of undertaking one-week count surveys, as shown in Equation 3.

$$AADT = WADT \times week\ factor\ \times vehicle\ factor \quad (3)$$

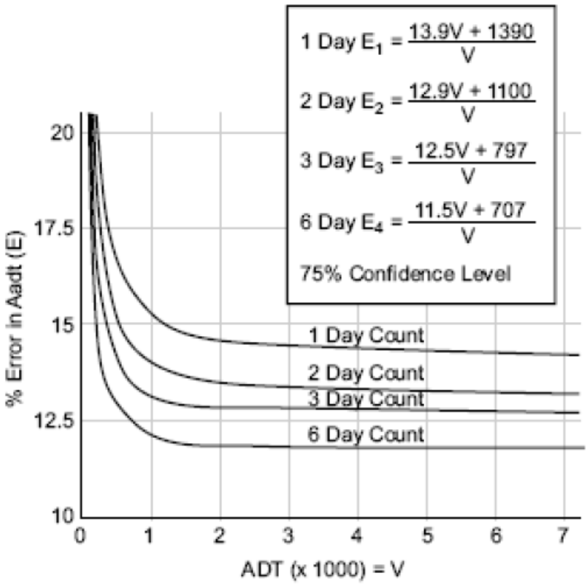
WADT is the ADT for the week counted. Week factor can be determined by the week counted given the week factors are categorised by week of the year, road types and vehicle types. Vehicle factor is calculated as 2.00 divided by the axle factor which is defined as the average number of axles per vehicle. The axle factor can be obtained from a survey.

If a count survey is undertaken for several weeks, the AADT estimates for each week can be averaged to obtain the overall AADT. If a count survey is undertaken for a whole day, the WADT can first be estimated by multiplying the daily volume by the appropriate day factor. If a count survey is undertaken for part of a day, the WADT can be estimated by multiplying the two or three-hour volume by the appropriate part-day factor. Transfund New Zealand (2001) also gives the day and part-day factors in relation to road types, day of the week and time periods of the day. These factors need to be validated by using local data from other places, note that the error in the AADT estimates using part-day factors could be greater than 30%.

Error due to count duration

Based on the *Guide to Traffic Management* (Austroads 2017), errors can be reduced if the number of days for traffic counting increases, as can be seen in Figure 2.1. For all AADTs, percentage error decreases as the number of days counted increases and the six-day count will produce less than 12.5% error for AADT over 1000. While error bands are naturally higher for smaller AADTs, this has to be realistically acceptable and is tolerable in terms of the limited impact on the overall traffic volume.

Figure 2.1: Percentage error in AADT estimation based on short-period ADT



Source: Austroads (2017).

Error due to seasonal adjustment factor

This type of error can be interpolated from the table comprising the intervals of percentage error in estimated AADT, the number of AADT estimates within each interval, and the cumulative percentage of AADT estimates. The cumulative percentage represents the confidence limits corresponding to accuracy. Austroads (2017) gives an example to illustrate the calculation of this type of error.

2.4.2 VKT

As described in the Austroads report (2004), VKT on a network is the vehicle kilometres travelled on a network of road sections, calculated as shown in Equation 4.

$$VKT = \sum_{i=1}^{n} (AADT_i \times L_i) \quad (4)$$

where

VKT = vehicle kilometres travelled on a network of road sections $i = 1,2, \ldots n$

$AADT_i$ = AADT for road section i

L_i = length of road section i

The above defines the daily VKT. The annual VKT can be obtained by multiplying the daily VKT by the number of days in that year.

The commonly used forms of VKT include total VKT, VKT by vehicle class, VKT by route, VKT by road type, and VKT by region.

2.4.3 Accuracy and Rounding

The accuracy of an AADT estimate depends mainly on the period of time during which traffic was counted. It also depends on the accuracy of the seasonal adjustment factor used to convert the ADT to AADT.

Similarly, the accuracy of the estimation of VKT depends primarily on the number of road sections for VKT calculation and the accuracy of the AADT estimation for each road section. If the road sections with similar traffic characteristics cannot be sampled, the accuracy of the VKT estimation also depends on the difference of the sampled road sections. Accuracy can be improved by grouping road sections with similar traffic characteristics, such as geographic regions, functional categories, or volume strata. For example, seasonal variations have the greatest impact on AADT estimates and regional groupings are usually preferable. On the other hand, volume stratification is used to improve the accuracy in estimating VKT.

Accuracy requirements for AADT and VKT are set out in Table 2.5 and Table 2.6.

Table 2.5: Accuracy requirements of AADT for individual sites or road sections

Traffic characteristic	Maximum error requirement at 68% confidence limit(1)
AADT < 100	50%
101 < AADT < 300	35%
301 < AADT < 1100	25%
AADT > 1100	15%
Trend in AADT(2)	10%
Traffic composition in AADT(3)	20%

1 *68% confidence limits represent $\pm$ one standard deviation from the mean.*
2 *Trend in AADT relates to the trend estimation based on the AADTs for multiple periods using statistical methods.*
3 *Traffic composition errors are expressed as percentage errors of vehicle class proportions.*

Source: Austroads (2017).

Table 2.6: Accuracy requirements of VKT for groups of roads

Traffic characteristic	Errors at 95% confidence limits				
	Australia	State	City(1)	Rural area(1)	AADT range(2)
Total annual VKT	3%	5% – 7%	10%	10%	25%
Change in annual VKT	1%	3%	5%	5%	10%
Traffic composition in annual VKT	3%	5%	10%	10%	15%

1 *If these accuracies are achieved, those for jurisdictions and Australia will also be obtained.*
2 *Recommended AADT ranges are given in Guide to Traffic Management (Austroads 2017).*

Source: Austroads (2017).

An appreciation of the accuracy requirements for AADT data permits the rounding of the numbers. Table 2.7 provides some examples of rounding and compares the percentage change in AADT against the maximum error requirements. It shows that, in all cases, rounding is within the permitted error range. The maximum error permitted is based on random sampling and rounding should be carried out only if necessary, e.g. for reporting purposes.

Table 2.7: Examples of rounding AADT

AADT range	AADT data	Rounding	Percentage change	Maximum error requirement
0–100	46	50	8.7%	50%
101–300	157	200	27.4%	35%
301–1100	678	700	3.2%	25%
> 1100	2345	2300	1.9%	15%

Source: Austroads (2004).

2.5 Reporting Traffic Data

Traffic data should be reported in a readily understandable manner to the audience which is unfamiliar with the methods of data collection. Large volumes of data must generally be presented as numerical tabulations. Graphical representations permit very rapid visual interpretation, particularly for variations in time and space, and are sufficiently accurate for most purposes. Modern computer graphics systems can readily generate time profiles and flow maps.

It is important to precisely record and identify the location of counting sites. This can be done either by using a permanent reference system devised for general inventory purposes, by verbal description, or by making a location plan. The availability of GPS devices and GIS software has greatly facilitated data presentation. Unusual variations resulting from weather features, public holidays, crashes, or the like should be recorded on presentations, so that users are made aware of the occurrence of such events.

2.5.1 Estimated AADT

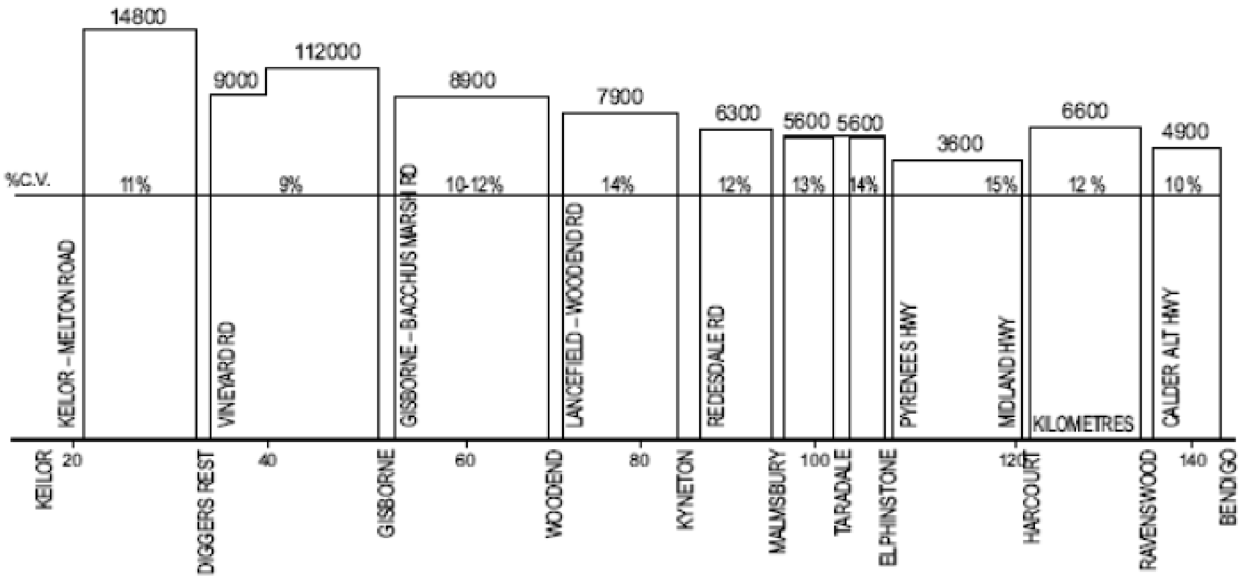
Estimated AADT profiles for road sections are normally obtained from short-term counts and represent the majority of published data, particularly for rural areas. A common method of presentation is to display the estimated AADT at each counting station on a map. The report by Austroads (2017) shows a typical AADT map (Figure 2.2) prepared for the Department for Infrastructure and Transport South Australia. Alternatively, flow bands proportional to the AADT estimates are drawn along the surveyed routes.

Figure 2.2: Typical map presentation of AADT estimates

Source: Austroads (2017).

Another method is to plot AADT profiles for road segments associated with a route, which is particularly useful in urban areas where routes are so close together that numbers or flow bands overlap. The report by Austroads (2017) presents an example showing the typical AADT profile for a route, shown in Figure 2.3. The route is represented schematically by a straight line (the abscissa), and the AADT value for each route segment is shown as an ordinate.

Figure 2.3: Typical AADT profile for a route



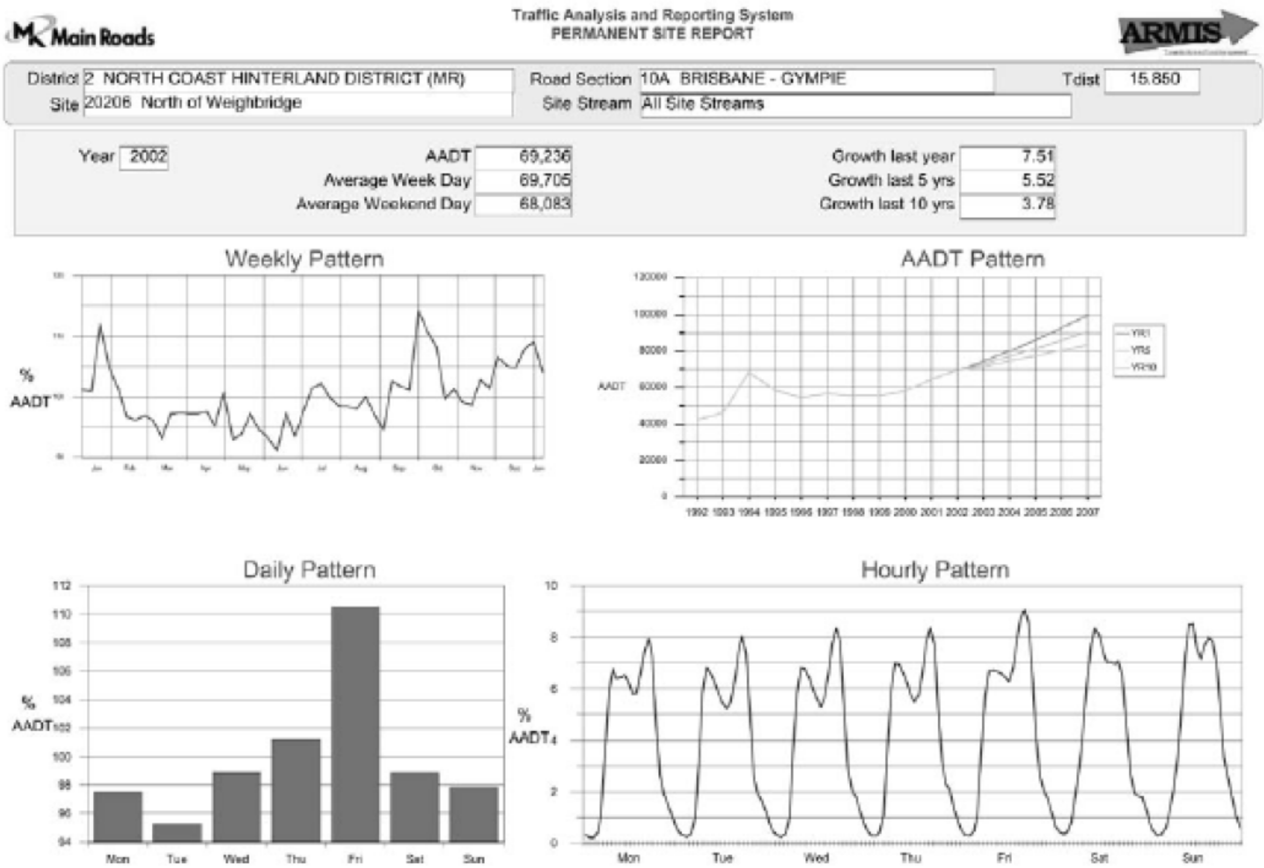
Source: Austroads (2017).

The duration of the counts and the adjustment factors used in the AADT estimation may be of interest to those familiar with traffic counting methods. These data are usually presented in the tabular form.

2.5.2 Traffic Volume Patterns and Trends

Pattern stations provide information on daily and seasonal variations while permanent stations also provide indications of trends. Graphical and tabular presentations are usually used to show daily, weekly, and monthly variation patterns, often illustrated as proportions of the AADT. A typical pattern station report is given by Austroads (2017) in Figure 2.4.

Figure 2.4: Typical pattern station report

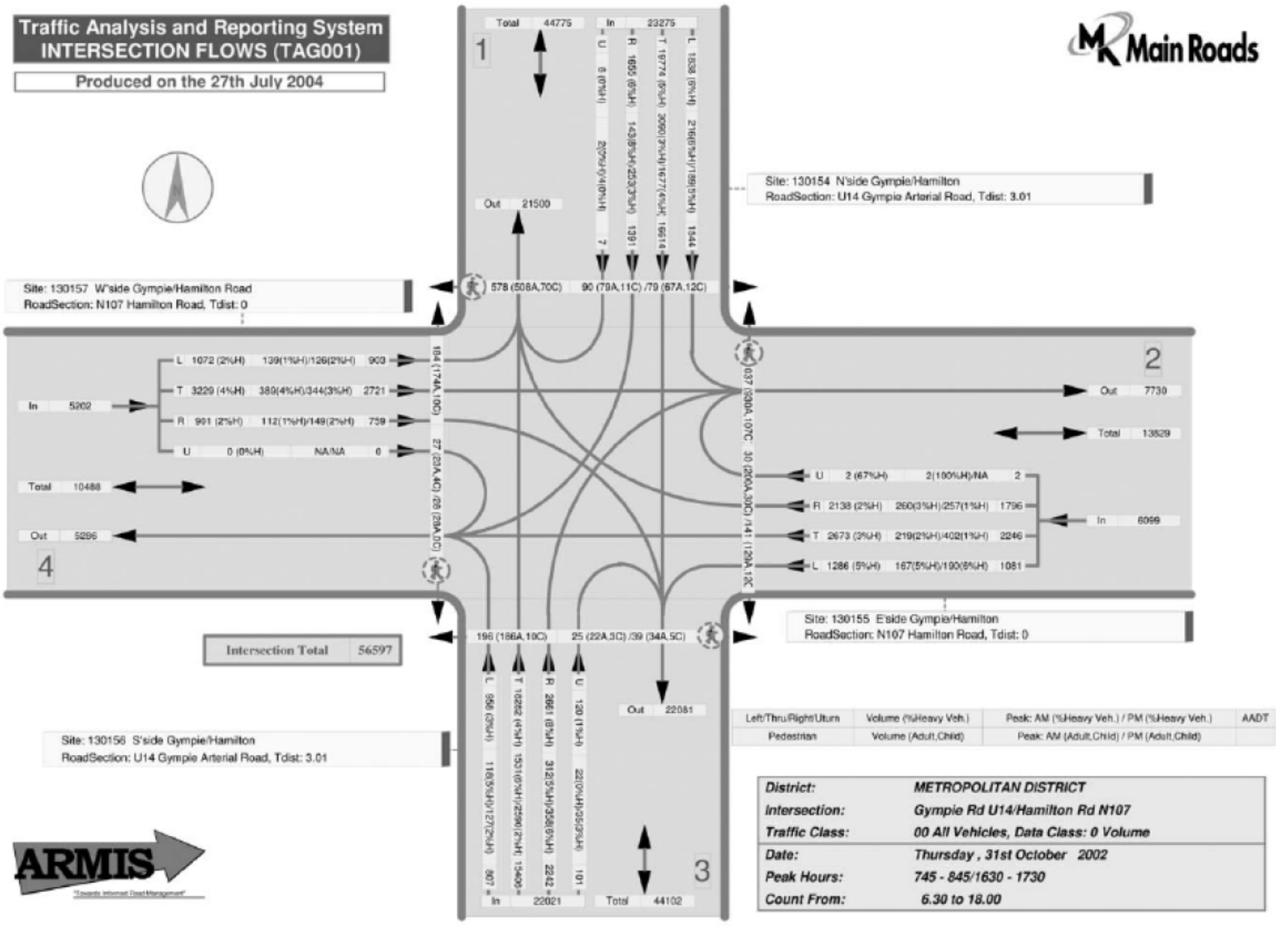


Source: Austroads (2017).

2.5.3 Intersection Flow

Information on intersection movements is usually obtained from manual counts over relatively short periods, typically the peak hour or 12 hours from 7 am to 7 pm. These data are essential for intersection and traffic signal design. Intersection counts may be categorised into two vehicle classes, i.e. cars and heavy vehicles, which are displayed either as the number of vehicles or as the proportion of the total traffic counts. The report by Austroads (2017) shows a typical intersection count report in Figure 2.5.

Figure 2.5: Typical intersection count report



Source: Austroads (2017).

3. Traffic Data Collection Analysis

3.1 New South Wales

3.1.1 Road Traffic Volume Counts API

Through the NSW Road Traffic Volume Counts API (part of Transport for NSW's open data), traffic count data from 2006 is available. There are four datasets that can be queried:

- Traffic collection station reference is a general description of the traffic collection station, e.g. geospatial coordinates, road name, suburb, postcode, device type, road number, road type including the data quality rating (Figure 3.1).
- Annual average traffic count summary is a general description of traffic station, traffic direction, date of recording and the quality of data (Figure 3.2).
- Permanent hourly traffic counts provide an hourly traffic count for each permanent station post 2006 at a daily level (Figure 3.3).
- Sample hourly traffic counts provide an hourly traffic count for each sample station post 2006 at a daily level (Figure 3.3).

Figure 3.1: Traffic collection station reference

Table name: road_traffic_counts_station_reference

Variable Name	Data Type	Length	Value Definition	Domain Values
THE_GEOM	Geometry		WGS84 Point Geometry	
STATION_KEY	Number		Unique Station Key	Refer 5.1
STATION_ID	String	51	The ID of the traffic collection station	
NAME	String	71	Name of the road otherwise specified	
ROAD_NAME	String	8000	Road name	
FULL_NAME	String	152	Road name, cardinal direction from the intersection, and nearest intersecting road	
COMMON_ROAD_NAME	String	100	Common (localised) road name	
SECONDARY_NAME	String	79	Cardinal direction from intersection and nearest intersecting road	
ROAD_NAME_BASE	String	50	Road name without street type	
ROAD_NAME_TYPE	String	20	Street type	
INTERSECTION	String	70	Nearest intersecting road	
DISTANCE_TO_INTERSECTION	Number		Distance in metres to nearest intersecting road	
ROAD_NUMBER	String	7	RMS classified road number	
LINK_NUMBER	String	4	RMS classified road-link number	
MAB_WAY_TYPE	String	20	MAB Road type: A, M, B	
MAB_WAY_NUMBER	String	10	MAB number	
MAB_IDENTIFIER	String	5	MAB Road type and number	
ROAD_FUNCTIONAL_HIERARCHY	String	100	Local, Primary, Arterial, Motorway, Dedicated Bus way, Urban service lane, Sub-Arterial Road, Distributor Road	
ROAD_ON_TYPE	String	50	On Culvert, On Dam Wall, On Bridge, In Tunnel and On Ground	
LANE_COUNT	String	100	Number of lanes of road including Unknown Lanes, One Lane, and Two or More Lanes	
ROAD_CLASSIFICATION_TYPE	String	100	Type of road classification e.g. Freeway, Street, Deviation, Highway, Road	Refer 5.7
ROAD_CLASSIFICATION_ADMIN	String	100	Administration of road classification: Regional, ,Local and State	
RMS_REGION	String	20	RMS region locations: Hunter, Western, Southern, ACT, Northern, South West and Sydney	
LGA	String	40	Local Government Area	
SUBURB	String	40	NSW suburb	
POST_CODE	String	12	Postcode	
DEVICE_TYPE	String	100	Recording device type	Refer 5.8
HEAVY_VEHICLE_CHECKING_STATION	Boolean		0: Non Heavy Vehicle Checking Station 1: Heavy Vehicle Checking Station	
PERMANENT_STATION	Boolean		0: Non-Permanent Station 1: Permanent Station	
VEHICLE_CLASSIFIER	Boolean		0: Non Vehicle Classifier 1: Vehicle Classifier	
LAMBERT_EASTING	Number		NSW Lambert Coordinates System	
LAMBERT_NORTHING	Number		NSW Lambert Coordinates System	
WGS84_LATITUDE	Number		WGS84 Coordinate System	
WGS84_LONGITUDE	Number		WGS84 Coordinate System	
DIRECTION_SEQ	Number		0: BOTH 1: NORTH 3: EAST 5: SOUTH 7: WEST 9: NORTHBOUND AND SOUTHBOUND 10: EASTBOUND AND WESTBOUND	Refer 5.3
QUALITY_RATING	Number		4: One or more years of data for either one or both directions has been excluded for quality reasons 5: No data has been excluded due to quality	

Source: Transport for NSW (TfNSW) (2021).

Figure 3.2: Annual average daily traffic count summary

Table name: `road_traffic_counts_yearly_summary`

Variable Name	Data Type	Length	Value Definition	Domain Values
STATION_KEY	Number		Unique Station Key	Refer 5.1
STATION_ID	String	50	The ID of the Traffic Counter Station	
TRAFFIC_DIRECTION_SEQ	Number		0: COUNTER 1: PRESCRIBED 2: BOTH	Refer 5.2
TRAFFIC_DIRECTION_NAME	String	50	0: COUNTER 1: PRESCRIBED 2: BOTH	
CARDINAL_DIRECTION_SEQ	Number		1: NORTH 3: EAST 5: SOUTH 7: WEST 9: NORTHBOUND AND SOUTHBOUND 10: EASTBOUND AND WESTBOUND	Refer 5.3
CARDINAL_DIRECTION_NAME	String	50	1: NORTH 3: EAST 5: SOUTH 7: WEST 9: NORTHBOUND AND SOUTHBOUND 10: EASTBOUND AND WESTBOUND	
CLASSIFICATION_SEQ	Number		0: UNCLASSIFIED 1: ALL VEHICLES 2: LIGHT VEHICLES 3: HEAVY VEHICLES -9: Masked classifier as counter	Refer 5.4
CLASSIFICATION_TYPE	String	14	0: UNCLASSIFIED 1: ALL VEHICLES 2: LIGHT VEHICLES 3: HEAVY VEHICLES -9: Masked classifier as counter	Refer 5.4
COUNT_TYPE	String	13	TRAFFIC COUNT	
YEAR	Number		Year	
PERIOD	String	15	ALL DAYS: 24 hours AM PEAK: 6-10AM PM PEAK: 3-7PM OFF PEAK: 10AM-3PM WEEKDAYS: Monday - Friday WEEKENDS: Saturday - Sunday PUBLIC HOLIDAY: NSW Public Holidays	Refer 5.6
PARTIAL_YEAR	Boolean		0: Non Partial Year 1: Partial Year	
LATEST_DATE	Date		For incomplete years, this will show the latest date of the partial year	
TRAFFIC_COUNT	Number		Average traffic count for the period	
DATA_START_DATE	Date		The date when data started recording. This usually applies to sample counters.	
DATA_END_DATE	Date		The date when data finished recording. This usually applies to sample counters.	
DATA_DURATION	Number		The number of day's data was recorded. This usually applies to sample counters.	
DATA_AVAILABILITY	Number		Percentage of available data within the recorded duration for a single direction. -1: the total sum of traffic volume in both directions.	
DATA_RELIABILITY	Number		Percentage of useful data of available data for a single direction. -1: the total sum of traffic volume in both directions.	
DATA_QUALITY_INDICATOR	Number		0 Data has passed quality checks to be included in the dataset 1 Data did not pass quality checks and has not been included in the dataset	

Source: TfNSW (2021).

Figure 3.3: Screenshot of TfNSW permanent and hourly sample traffic count

Table names: road_traffic_counts_hourly_permanent *and* road_traffic_counts_hourly_sample

Variable name	Data type	Length	Value definition	Domain values
STATION_KEY	Number		Unique Station Key	Refer 5.1
TRAFFIC_DIRECTION_SEQ	Number		0: COUNTER 1: PRESCRIBED 2: BOTH	Refer 5.2
CARDINAL_DIRECTION_SEQ	Number		1: NORTH 3: EAST 5: SOUTH 7: WEST 9: NORTHBOUND AND SOUTHBOUND 10: EASTBOUND AND WESTBOUND	Refer 5.3
CLASSIFICATION_SEQ	Number		0: UNCLASSIFIED 1: ALL VEHICLES 2: LIGHT VEHICLES 3: HEAVY VEHICLES -9: MISSING	Refer 5.4
DATE	Date	8	YYYY-MM-DD	
YEAR	Number		>2006	
MONTH	Number		1 -12. Numerical value of the month.	
DAY_OF_WEEK	Number		1: Monday 2: Tuesday 3: Wednesday 4: Thursday 5: Friday 6: Saturday 7: Sunday	
PUBLIC_HOLIDAY	Boolean		0: Non Public Holiday 1: Public Holiday	
SCHOOL_HOLIDAY	Boolean		0: Non School Holiday 1: School Holiday	
DAILY_TOTAL	Number		Total sum of traffic volume for 24 hours	
HOUR_00	Number		Traffic volume count for time between 00:00-00:59	
HOUR_01	Number		Traffic volume count for time between 01:00-0:159	
HOUR_02	Number		Traffic volume count for time between 02:00-02:59	
HOUR_03	Number		Traffic volume count for time between 03:00-03:59	
HOUR_04	Number		Traffic volume count for time between 04:00-04:59	
HOUR_05	Number		Traffic volume count for time between 05:00-05:59	
HOUR_06	Number		Traffic volume count for time between 06:00-06:59	
HOUR_07	Number		Traffic volume count for time between 07:00-07:59	
HOUR_08	Number		Traffic volume count for time between 08:00-08:59	
HOUR_09	Number		Traffic volume count for time between 09:00-09:59	
HOUR_10	Number		Traffic volume count for time between 10:00-10:59	
HOUR_11	Number		Traffic volume count for time between 11:00-11:59	
HOUR_12	Number		Traffic volume count for time between 12:00-12:59	
HOUR_13	Number		Traffic volume count for time between 13:00-13:59	
HOUR_14	Number		Traffic volume count for time between 14:00-14:59	
HOUR_15	Number		Traffic volume count for time between 15:00-15:59	
HOUR_16	Number		Traffic volume count for time between 16:00-16:59	
HOUR_17	Number		Traffic volume count for time between 17:00-17:59	
HOUR_18	Number		Traffic volume count for time between 18:00-18:59	
HOUR_19	Number		Traffic volume count for time between 19:00-19:59	
HOUR_20	Number		Traffic volume count for time between 20:00-20:59	
HOUR_21	Number		Traffic volume count for time between 21:00-21:59	
HOUR_22	Number		Traffic volume count for time between 22:00-22:59	
HOUR_23	Number		Traffic volume count for time between 23:00-23:59	

Source: TfNSW (2021).

TfNSW has approximately 600 permanent roadside collection device stations which continuously collect traffic information 365 days per year. There are also numerous sample roadside collection device stations across NSW, which collect information on a short-term basis, usually over a two-week period. The various types of data collection devices are shown in Table 3.1.

Table 3.1: TfNSW device types

Description
Trafficorder loop counter
Trafficcorder tube axle pair counter
Excel LPL (loop-piezo-loop)
Excel LI (loop induction)
Sensys
TIRTL (the infra-red traffic logger)
Metro Count PP (piezo-piezo)

Source: TfNSW (2021).

The AADT provides an estimate of traffic volume on a typical day of the year and is calculated as follows:

1. Calculate the daily total for each traffic collection station (365 figures).
2. Calculate an average for each day of the week for each month (7 days x 12 months = 84 figures).
3. Using the data from Step 2, create an average for each day of the week (7 figures).
4. Average the 7 daily averages from Step 3 to calculate the overall figure for the year, which is the resulting AADT.

The underlying data used to calculate the AADT is the hourly volume from each traffic collection station. This means each traffic collection station is expected to provide 24 observations per day. For the data provided to be considered reliable, it needs to pass through a number of data quality checks. The first check is the regularity of data, quantifiable by at least 19 hourly observations per day. If there are less than 19 hourly observations on a specific day, then that day is excluded from the analysis. The second check relates to the consistency of the volume being recorded:

- At least one figure for each day of the week within each month is required (a minimum of 84 figures per year – 7 days x 12 months).
- The daily volume is then compared to the average for that day of the week in the month. For instance, Monday 3 June 2013 is compared to the average volume figure for all Mondays in June 2013. If the daily volume is greater or less than 20% of the average, that specific Monday is excluded from the analysis, as the figure is considered inconsistent.

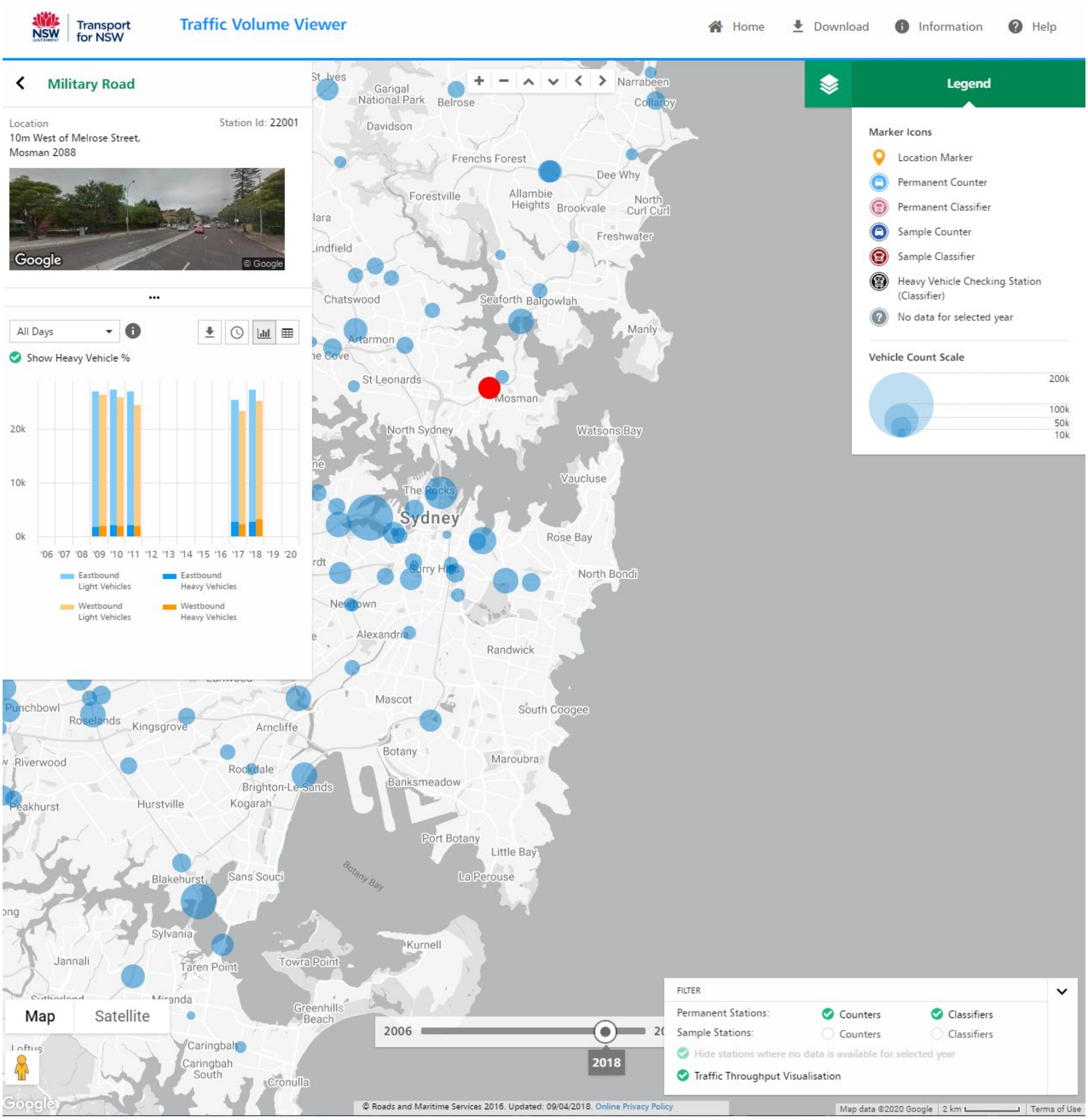
When a traffic collection station is also a classifier, it will provide observations for a variety of different vehicle classes per hour, including light and heavy vehicles. It is possible to not have an observation in every vehicle class for every hour. To provide an indication of the data quality for the traffic collection stations that classify, the data quality check for the number of observations focuses on light vehicles only, as heavy vehicle observations can be intermittent during the day.

Traffic collection stations collect traffic data daily and aggregation of this data to produce the traffic volume viewer datasets is undertaken monthly.

3.1.2 Traffic Volume Viewer

The TfNSW traffic volume viewer is an interactive tool, allowing public users to browse and search for available traffic count data in NSW. Data is available from 2006 up to the current year. The available data includes AADT counts, and also hourly counts. The map shows the locations of traffic count stations, which report the number of vehicles only, and traffic classifier stations, which count the vehicles and differentiate between light and heavy vehicles. The tool enables searching by location, station ID and area, shown in Figure 3.4.

Figure 3.4: TfNSW traffic volume viewer



Source: TfNSW (2021).

3.2 Victoria

3.2.1 Traffic Volume Data

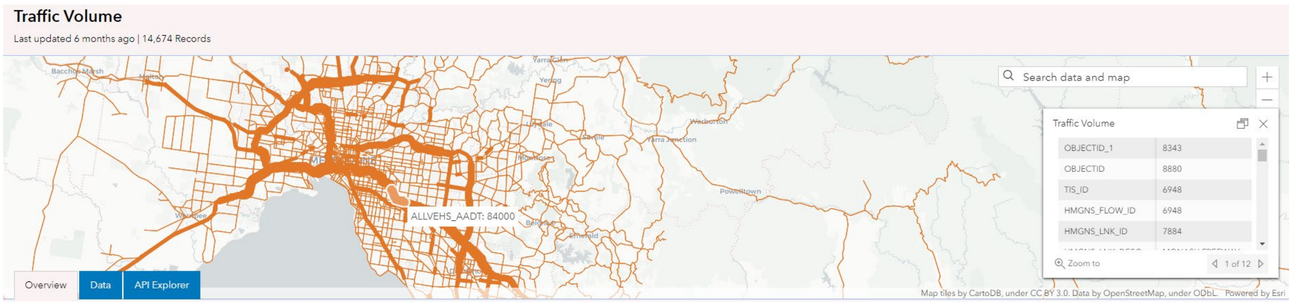
This dataset from VicRoads shows traffic volumes for freeways (excluding toll roads) and arterial roads in Victoria. The AADT count is provided, including the number of commercial vehicles. The data provided is for the current year, with values derived from traffic surveys or estimates. When there is no actual data collected from surveys, the volume estimation uses various data sources, including historical volumes, annual growth rates, volumes from the opposite stream, and upstream/downstream volumes. The two main sources of traffic data are SCATS and STREAM, which consist of more than 80% of the volume data collection. Many other devices, including WIM, TIRTL, inductive loop and pneumatic tube, are also deployed for data collection. The attributes of the data are shown in Figure 3.5. The data can be viewed in a map, illustrated by Figure 3.6.

Figure 3.5: Screenshot of VicRoads data attributes

FIELD NAME	FIELD TYPE	FIELD WIDTH	FIELD DEFINITION
TRUCK_CALC	Text		Calculation type used for truck volume. "A" actual volume; "E" estimated volume
PER_TRUCKS	Text	30	Percentage of Trucks that make up the All Vehicle volume
CI	Text	30	Confidence Interval on the growth rate. E.g. 0.27% Means that the volume on this homogeneous flow is growing at the Growth Rate +/- 0.27%
YR	Number	10	Year data is applicable. This is the current calendar year
LABEL	Text	10	24hr Annual Average Daily Traffic volume for all vehicles and 24hr Trucks.
MIDPNT_LAT	Text	38	LATITUDE OF MIDPOINT OF LENGTH SEGMENT
MIDPNT_LON	Text	38	LONGITUDE OF MIDPOINT OF LENGTH SEGMENT
FLOW	Text	100	Direction of Traffic Flow measured E.g East Bound
LOCATION_I	Text		System generated unique identifier assigned to every planned roadwork or event.
HMGNS_FLOW	Text		Homogeneous flow id eg 1234. An internal reference for Homogenous Flow. Homogeneous flow - The traffic volume information associated with the traffic flow along a link that is representative of all travel along the whole link
HMGNS_LNK_	Number		Homogeneous link ID
HMGNS_LN_1	Text	1000	Homogeneous link description eg BRIDGE ROAD btwn LENNOX STREET & CHURCH STREET
ALLVEHS_MM	Number		24 hour Median Midweek volume for all vehicles over Tues, Wed, Thurs
ALLVEH_CAL	Text		Calculation type used for all vehicle volume. "A" actual volume; "E" estimated volume
ALLVEHS_AA	Number		Yearly volume for all vehicles divided by 365
TRUCKS_AAD	Number		Yearly volume for trucks divided by 365
TWO_WAY_AA	Text	30	Two way yearly volume for all vehicles divided by 365
ALLVEH_AMP	Text		Highest hourly vehicle flow between midnight and midday
ALLVEH_PMP	Text		Highest hourly vehicle flow between midday and midnight.
GROWTH_RAT	Text	30	Logarithmic Annual Growth Rate of Volume at 95% confidence level. E.g 1.9% indicate that the homogeneous volume is growing by 1.9% a year

Source: VicRoads (2017).

Figure 3.6: Traffic volume data



Source: VicRoads (2017).

3.3 Queensland

3.3.1 Traffic Census for the Queensland State-declared Road Network

Queensland Department of Transport and Main Roads (TMR) provides traffic census data for the state-declared road network from 2004 to 2018. Data are collected by roadside traffic counting devices, typically pneumatic tubes and piezoelectric cables, and entered into TMR corporate systems. The average daily traffic (ADT) is directly measured for each site. The AADT is then calculated by the relationships between permanent and short-term traffic counting sites, using seasonal adjustment factors. This process of calculating AADT is defined in the *Guide to Traffic Management* (Austroads 2017) and followed by each road agency in Australia.

Larger roads are broken down into road sections. Road sections are then broken down into AADT segments. Where the road network with an AADT of 4000 or more sees a difference of 10% or more between arterial roads or other state-controlled roads, a traffic counting site is located between those segments. As shown in Figure 3.7, the datasets include:

- a unique identifier for the location of each traffic counter, i.e. SITE_ID
- descriptive details of the location of each traffic counter, i.e. DESCRIPTION
- longitude and latitude of the location of each traffic counter, i.e. LONGITUDE and LATITUDE
- AADT of the segment
- percentage of the AADT that is heavy vehicles (zero or empty where a traffic counter could not classify vehicles), i.e. PERCENT_HV
- through distance of traffic counter measured in kilometres from the beginning of the road section, i.e. TDIST
- start and end through distances of the AADT segment measured in kilometres from the beginning of the road section, i.e. TDIST_START and TDIST_END
- a unique identifier for each road section, i.e. RSECT_ID
- the road name.

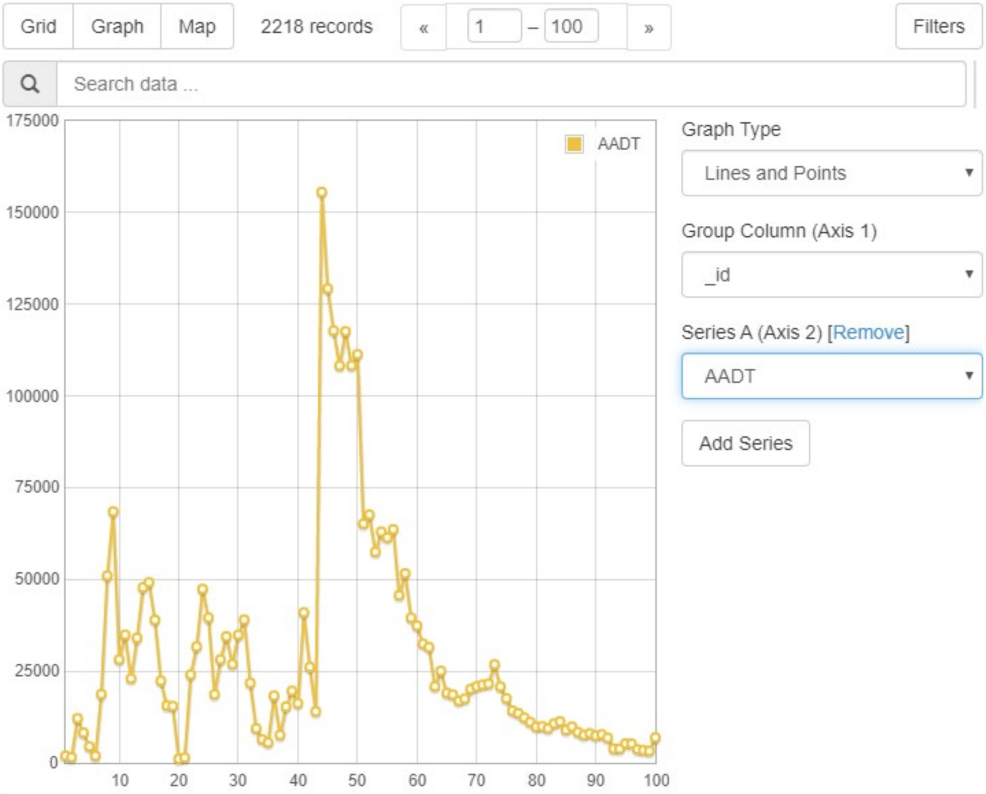
Traffic census data can be viewed online in a graph (Figure 3.8) and a map (Figure 3.9), showing up to 100 records. The data in Google Earth format are also provided to enable data visualisation in Google Earth. For each traffic counting site, the AADT segment and annual volume report are available, as seen in Appendix A.

Figure 3.7: Screenshot of TMR traffic census data

SITE_ID	DESCRIPTION	LONGITUDE	LATITUDE	AADT	TDIST	PERCENT_HV	RSECT_ID	ROAD_NAME	TDIST_START	TDIST_END
131646	Sth of Myora Res- Dunwich	153.4110807	-27.4826895	1942	2.5	13.25	1000	EAST COAST ROAD	0	9.36
131757	North of Beehive Rd	153.4675671	-27.43377	1522	11.4	10.72	1000	EAST COAST ROAD	9.36	16.9
11412	80m south of Hillside Dve	153.2338199	-27.7327266	12134	0.5	22.26	1003	STAPYLTON - JACOBS	0	1.09
12966	400m west of Quinns Rd	153.2415967	-27.7277023	8218	1.45	20.86	1003	STAPYLTON - JACOBS	1.09	1.86
11754	600m east of Alberton Road	153.2658279	-27.7204947	4467	4.15	15.88	1003	STAPYLTON - JACOBS	1.86	7.95
11543	At Behm Creek bridge	153.3385448	-27.7533308	1933	14.4	17.43	1003	STAPYLTON - JACOBS	7.95	19.28
11548	Between Norman St & Scarbor	153.4107765	-27.9610665	18753	0.15	8.88	101	SMITH STREET CONN	0	0.48
11400	Between Kumbari Av & Parklai	153.3892765	-27.9629959	51028	2.39	4.83	101	SMITH STREET CONN	0.48	3.74
11545	1.5km west of Labrador-Carrar	153.3618256	-27.9629008	68524	5.2	3.27	101	SMITH STREET CONN	3.74	7.4
11403	Between Sunlight Dr & Billabo	153.4366728	-28.1014013	28192	2.2	5.63	102	BURLEIGH CONNECTI	0	3.3
10890	630m west of Mattocks Rd	153.4127519	-28.1013169	34886	4.57	9.24	102	BURLEIGH CONNECTI	3.3	5.69
11549	280m north of Nerang St	153.4094246	-27.9673589	23002	0.55	4.3	103	SOUTHPORT - BURLEI	0	1.14
10009	Between Harvest Cl & Brolga A	153.4108836	-27.9795632	34058	1.94	3.87	103	SOUTHPORT - BURLEI	1.14	3.969
11404	700m south of Boomerang Cre	153.4115228	-28.0197926	47845	6.5	4.62	103	SOUTHPORT - BURLEI	3.969	8.2
10035	250m Nth Markeri St Intersecti	153.4067209	-28.04609	49201	9.468	5.65	103	SOUTHPORT - BURLEI	8.2	11.96
11597	700m north of Burleigh Conne	153.4271367	-28.0948653	38967	15.4	6.8	103	SOUTHPORT - BURLEI	11.96	16.09
10568	740m south of Burleigh Conne	153.4237562	-28.1078192	22380	16.88	9.71	103	SOUTHPORT - BURLEI	16.09	17.915
11406	Between Robina Pkway and Pa	153.383979	-28.033151	15655	0.15	5.1	104	GOLD COAST - SPRIN	0	3.533
11555	Between Hinterland Dve and S	153.3615246	-28.0817221	15484	5.142	6.61	104	GOLD COAST - SPRIN	3.533	5.323
11532	At Little Nerang Creek bridge	153.293405	-28.1234192	1095	15.25	4.57	104	GOLD COAST - SPRIN	5.323	23.133
11544	680m east of Nerang-Murwillu	153.2474502	-28.1111487	1408	29.597	7.96	104	GOLD COAST - SPRIN	23.133	30.37
12269	Between Boulton Road and Lal	153.3567474	-27.9987904	24054	1.75	6.85	105	NERANG - BROADBEA	0	3.62
11550	900m east of Ross St	153.3784848	-28.0133281	31712	4.55	6.46	105	NERANG - BROADBEA	3.62	6.973
11578	Boobegan Creek Bridge	153.3967629	-28.0311231	47389	8	7.21	105	NERANG - BROADBEA	6.973	9.3
11559	At Dunlops Canal Bridge	153.4206328	-28.0355968	39580	10.5	6.06	105	NERANG - BROADBEA	9.3	11.545
12268	Between Lather St and Lenneb	153.4153157	-27.9732236	18672	0.5	5.87	106	SOUTHPORT - NERAN	0	0.955
12284	100m East of Bailey Cr	153.3901616	-27.9762926	28191	3.13	7.74	106	SOUTHPORT - NERAN	0.955	4.05
11561	Between Ashmore Rd & Kamh	153.3629606	-27.986087	34461	6.18	7.28	106	SOUTHPORT - NERAN	4.05	8.23
11562	Between Parkridge Dr & Pac M	153.3419471	-27.9844615	26930	8.58	9.64	106	SOUTHPORT - NERAN	8.23	9.39
135783	150m east of Osborne Court	153.1912767	-27.6710819	34894	1.05	11.66	108	BEENLEIGH - REDLAN	0	1.29
136337	175m west of California Creek	153.2005143	-27.6702806	39025	1.99	8.76	108	BEENLEIGH - REDLAN	1.29	2.18
131873	At California Creek Bridge	153.216778	-27.6732985	21799	3.64	13.71	108	BEENLEIGH - REDLAN	2.18	4.84
135776	400m East of Mt Cotton Rd	153.2320688	-27.6768288	9398	5.23	13.07	108	BEENLEIGH - REDLAN	4.84	6.32
134115	430m west of Teviot Road	153.270073	-27.686181	6423	9.29	9.38	108	BEENLEIGH - REDLAN	6.32	10.96
136104	500m north of Lagoon View Rd	153.3000264	-27.6748253	5552	13.29	9.77	108	BEENLEIGH - REDLAN	10.96	16.05
135563	100m west of Link Rd on Colbu	153.2907605	-27.5834854	18289	0.9	3.6	1082	COLBURN AVENUE	0	2.35
131756	East of Holz St	153.3044342	-27.5876537	7613	2.4	6.05	1082	COLBURN AVENUE	2.35	3.73
135651	South of Ross Court	153.266693	-27.5330497	15326	1.015	5.08	109	CLEVELAND - REDLAN	0	1.38
140025	109 at intersec on Island Outlo	153.2668596	-27.5578647	19644	3.78		109	CLEVELAND - REDLAN	1.38	3.8
135655	north of Ziegenfusz Rd	153.2683961	-27.5609294	16235	4.14	5.15	109	CLEVELAND - REDLAN	3.8	6.64
136062	North of Victoria Point Road	153.2808587	-27.5823308	40984	6.9	4.87	109	CLEVELAND - REDLAN	6.64	7.2
135649	430km South of Benfer Road	153.2871708	-27.5998289	26123	8.93	5.68	109	CLEVELAND - REDLAN	7.2	9.56
131875	South of Giles Rd	153.2892674	-27.6146799	14035	10.63	5.85	109	CLEVELAND - REDLAN	9.56	15.36
135995	10A - South of Dohles Rocks Rc	153.0191713	-27.2908822	155602	0.05	11.39	10A	BRUCE HIGHWAY	0	1.9
130050	10A - PTC 1km Nth of Dohles R	153.0181449	-27.2649659	129278	2.994	10.65	10A	BRUCE HIGHWAY	1.9	5.05
135790	10A - 700m Nth of Plantation R	152.9935858	-27.2145659	117823	9.4	11.75	10A	BRUCE HIGHWAY	5.05	9.73
20854	10A - Btw Boundary and Decep	152.9877569	-27.1961543	108284	11.53	7.83	10A	BRUCE HIGHWAY	9.73	13.5
20206	10A - PTC 1km South of Station	152.9777565	-27.1581528	117622	15.85	10.21	10A	BRUCE HIGHWAY	13.5	17.96
20797	10A - South of Buchanan Road	152.9769979	-27.121587	108325	20	11.23	10A	BRUCE HIGHWAY	17.96	21.42
21084	10A - Btw Buchanan and Bribie	152.9753566	-27.0899385	111360	23.28	10.7	10A	BRUCE HIGHWAY	21.42	23.89

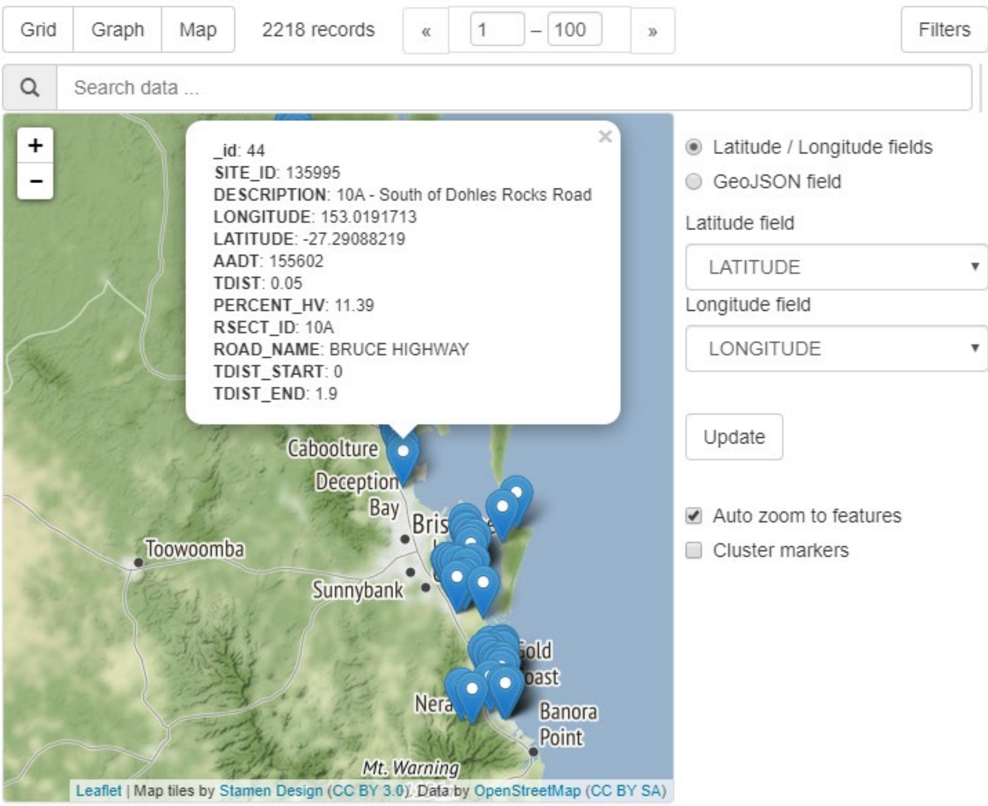
Source: TMR (2018).

Figure 3.8: Traffic census data in graph view



Source: TMR (2018).

Figure 3.9: Traffic census data in map view



Source: TMR (2018).

3.4 South Australia

3.4.1 Traffic Volume Data

The Department for Infrastructure and Transport (DITSA) publishes the dataset of arterial road traffic volumes throughout South Australia. Traffic volume is the sum of traffic travelling in both directions on a two-way road passing a roadside observation point over the period of a full year divided by the number of days in the year, i.e. AADT. The accuracy of observation point and traffic detail is over 95%. The data are updated on a weekly basis. The attributes of the traffic volume data are shown in Figure 3.10. In addition, the data is displayed in a map viewer (Figure 3.11).

The principal means of network-wide traffic data collection on rural arterial roads in South Australia are 7-day classification meter surveys, while in the metropolitan area of Adelaide short-term intersection turning counts are conducted on one weekday (usually from 7 am to 7 pm). Because both of these survey types provide limited traffic data, the AADT is extrapolated using appropriate seasonal factors derived from permanent or continuous counting sites. Approximately 50 permanent or continuous counting sites are located throughout the rural areas of the state and about 20 such sites in metropolitan Adelaide.

MetroCount counters with either pneumatic tube or piezoelectric sensors, along with 8 weigh-in-motion (WIM) facilities (a combination of Culway and Viper units) are used for rural surveys. About a dozen TIRTLs from the company CEOS are deployed at strategic locations around the state. The intersection turning counts are mainly done using MioVision cameras and technology supplemented by on-site staff where necessary.

Because one of the main purposes of permanent counting sites is to obtain data for long-term growth assessment, it is important that the locations of those sites are very stable. In South Australia, most of the permanent sites were established back in the 1960s or thereabouts and are still being used. If opportunities arise or a need is seen to supplement the information about seasonal fluctuations on certain roads, new sites will be occasionally established.

For short-term counting programs in rural areas and metropolitan Adelaide, the arterial road network is broken down into traffic estimate sections (TES). These are sections of roads where traffic volumes do not vary by more than +/− 10% from a notional AADT value.

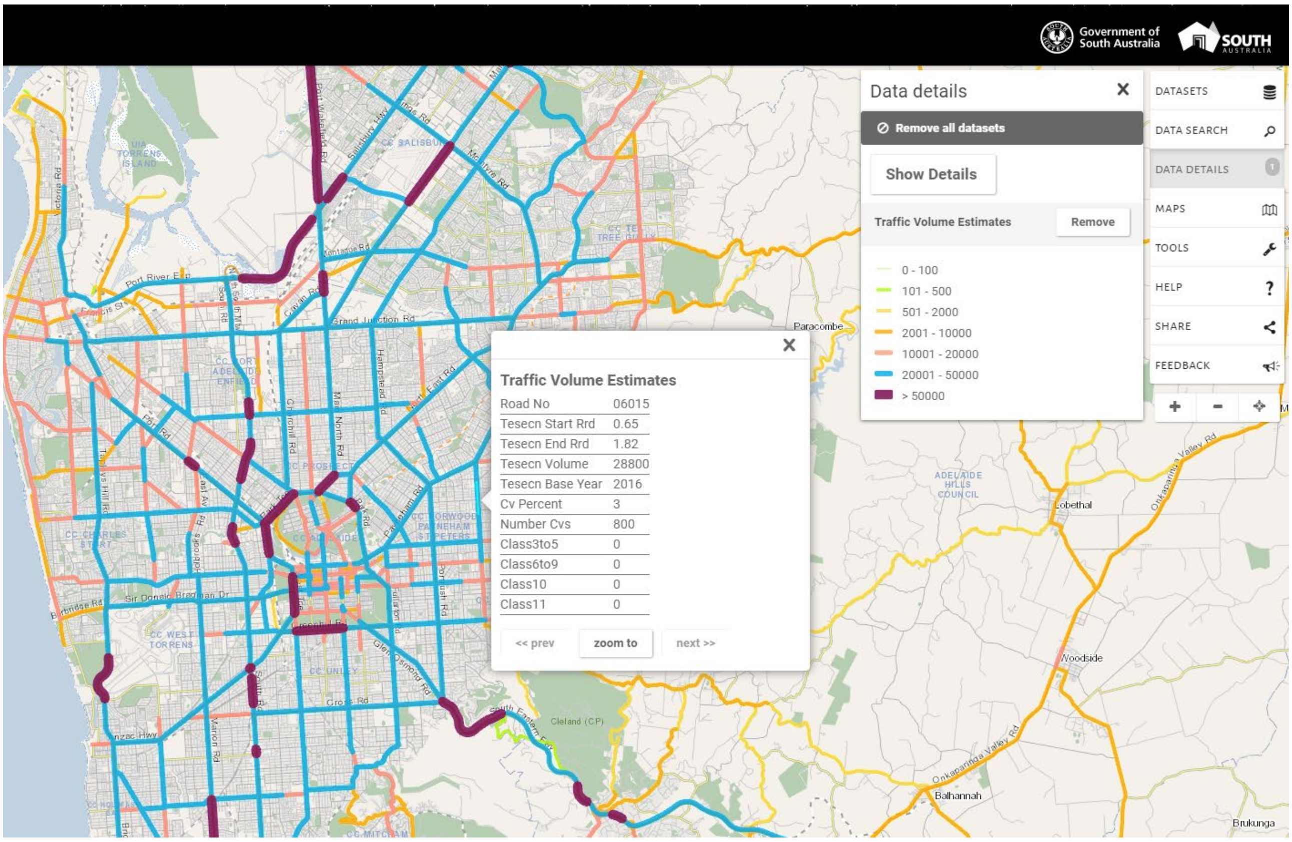
Traffic surveys at all sites are conducted to derive AADT estimates for TESs every 4 to 4.5 years, which is subject to the availability of funding. The routes in the National Land Transport Network and other sites on high-growth roads are desirably being updated about every three years. The data accuracy of approximately +/− 5% for 95% of the time is desired. Rural classification meter surveys provide full Austroads vehicle classification breakdowns.

Figure 3.10: Screenshot of DITSA data attributes

Name	Field Alias	Data Type	Description
ROAD_NO		text	Unique identifier as defined by DPTI, for roads which DPTI are responsible for maintaining or may have in the past, as well roads which may be of interest to DPTI.
SIDE		text	Carriageway/Side for the designated section of road All CRRS roads have a defined direction and the side is defined with reference to the increasing road running distance, not driving direction of the road.
TESECN_START_RRD		Double	Driven length (road running distance) in kilometres from the start of the road to the start of the section for the AADT All roads have a designated start, end and direction in CRRS.
TESCN_END_RRD		Double	Driven length (road running distance) in kilometres from the start of the road to the end of the section for the AADT.
TESECN_ID		Double	Internal unique identifier
TESECN_VOLUME		Long Integer	Traffic volume as defined above (AADT)
TESECN_BASE_YEAR		text	The year in which the traffic volume was counted
TESECN_PROJECTED		text	The year traffic volume (AADT) was last updated
CV_PERCENT		Long Integer	The percentage of AADT for Commercial Vehicles
NUMBER_CVS		Long Integer	Number of Commercial Vehicles
CLASS3TO5		Long Integer	The number of vehicles of this configuration
CLASS6TO9		Long Integer	The number of vehicles of this configuration
CLASS10		Long Integer	The number of vehicles of this configuration
CLASS11		Long Integer	The number of vehicles of this configuration
TRAFFIC_SCORE		Double	Derived figure based on AADT and Commercial Vehicles

Source: DITSA (2021).

Figure 3.11: Traffic volume in map viewer



Source: Data SA (2015).

3.5 Western Australia

3.5.1 Traffic Digest Data

Main Roads Western Australia (MRWA) undertakes traffic counting throughout Western Australia, and openly shares the data. A sample of the data is shown in Figure 3.12. This data provides the average number of vehicles for the latest year of traffic data available. The traffic volumes are expressed as the average number of vehicles at each location on a typical weekday (Monday to Friday) for the metropolitan area, and a typical day (Monday to Sunday) for regions outside the metropolitan area. Although many local government roads are counted, the focus is on providing information about the state road network.

Traffic data are obtained by installing equipment on the road. Counts are either permanent or short term. Permanent counts called Network Performance Sites (NPS) are strategically located on major roads with fixed infrastructure, and monitor traffic 24 hours a day. There are approximately 170 NPS collecting information about the number, type, and speed of vehicles on the road. A further 50 NPS are situated on cycle paths to report on the travel behaviours of cyclists. Short-term counts use portable data loggers with rubber tubes that extend across the roadway and are in place between 2 to 7 days, in some instances longer.

NPS give a good picture of the seasonal behaviour by measuring traffic throughout the year, but it is not practical to install equipment on every road. Using traffic patterns each NPS is categorised into a Seasonal Behaviour Group. These groups are used to generate the seasonal adjustment factors which are applied to short-term counts in order to make them representative of the annual conditions of a typical day, hour or quarter-hour within the year collected.

When a single tube is installed across the road, each axle passing over the tube will be counted. This number is then divided by two, assuming all vehicles have only two axles, to provide an indicative number of vehicles. This form of counting is avoided on freight routes as it will over count. It is typically used at locations where variable speed and congestion make classification counts problematic.

A pair of parallel tubes can determine the actual number of vehicles at a location and their type (in accordance with the Austroads 1994 classification scheme) and are known as classification sites. This is done by detecting each axle and analysing the relationship between their spacing and grouping. Speed information can also be obtained from these collections.

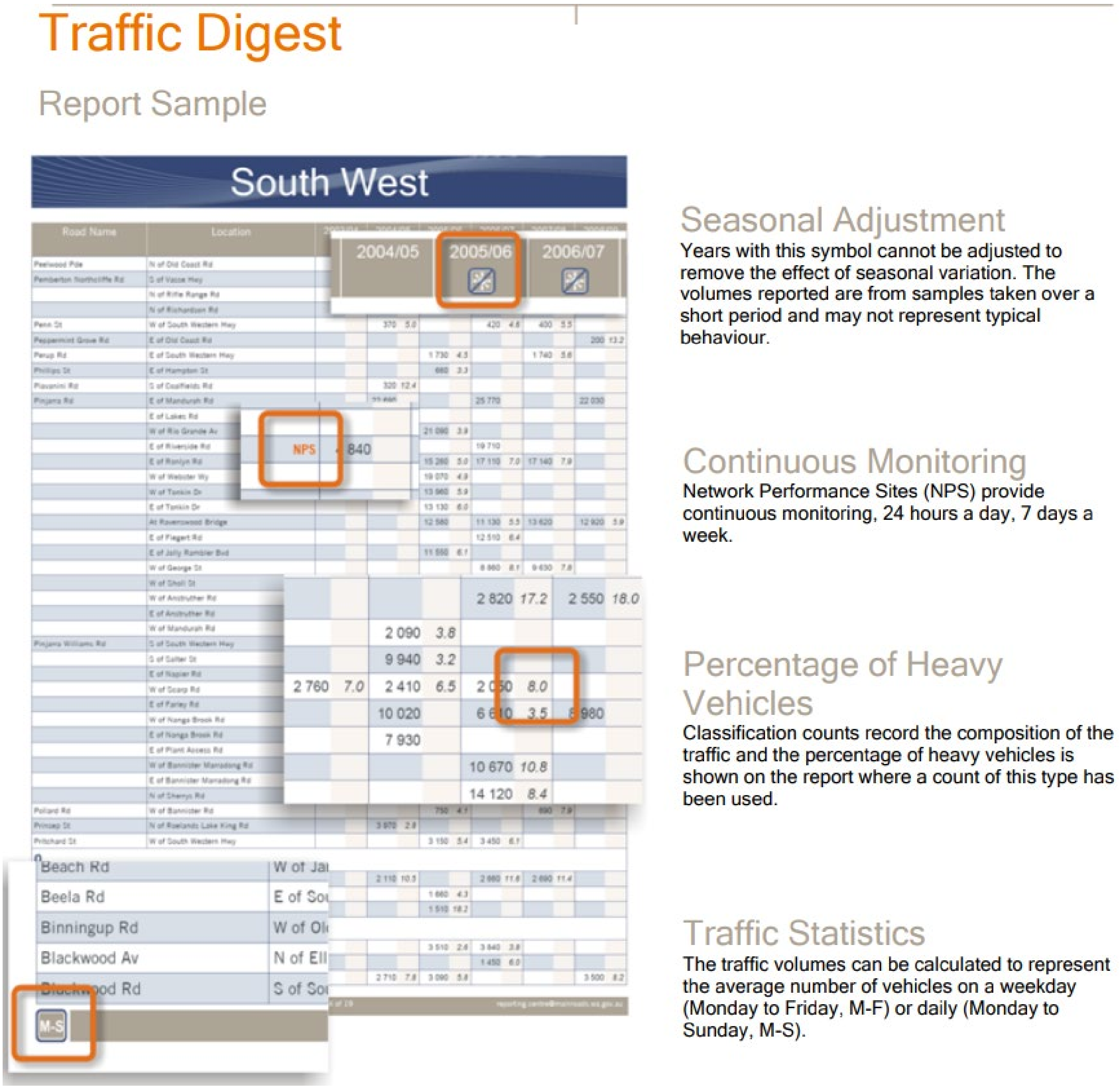
Figure 3.12: Screenshot of MRWA traffic digest data

X	Y	OBJECTID	SITE_NO	ROAD_NAME	LOCATION_DESC	TRAFFIC_YEAR	COLLECTION_TYPE	MON_SUN	MON_FRI	PCT_HEAVY_MON_SUN	PCT_HEAVY_MON_FRI	NETWORK_PERFORMANCE_SITE	LG_NO	LG_NAME	RA_NO	RA_NAME	SAT_SUN	PCT_HEAVY_SAT_SUN
115.717368	-32.279346	202008	7933	Parkin St	East of Bell St	2014/15	Class	8023	8535	7.4	7.4	No	107	Rockingham (C)	7	Metropolitan		
115.931	-31.938468	202009	7938	Great Eastern H	West of Aurum St	2018/19	Volume	51209	56439			No	113	Belmont (C)	7	Metropolitan	38140	
115.851033	-32.109144	202010	7951	Berrigan Dr on	NB N of Berrigan	2014/15	Class	8970	9542	13.3	13.3	No	103	Cockburn (C)	7	Metropolitan		
115.858292	-32.126398	202011	7955	Armadale Rd o	NB N of Armadale	2014/15	Class	11752	12502	9.5	9.5	No	103	Cockburn (C)	7	Metropolitan		
115.857074	-32.155857	202012	7959	Russell Rd on t	NB N of Russell R	2014/15	Class	6571	6990	12.7	12.7	No	103	Cockburn (C)	7	Metropolitan		
115.788159	-31.856782	202013	7976	Reid Hwy	East of Okely Rd	2014/15	Class	19651	19064	5.8	7.9	No	125	Stirling (C)	7	Metropolitan	17919	4.1
115.770907	-31.857674	202014	7977	Reid Hwy	East of Marmion /	2018/19	Class	22912	23885	7	7.8	No	125	Stirling (C)	7	Metropolitan	20772	4
115.755383	-32.373412	202015	7979	Warnbro Sounc	North of Port Ken	2017/18	Class	15387	14624	6.7	7.4	No	107	Rockingham (C)	7	Metropolitan	16776	5.6
115.770626	-32.406524	202016	7980	Anstey Rd (Sec	West of Mandura	2017/18	Class	8228	8934	6.2	7.1	No	107	Rockingham (C)	7	Metropolitan	6792	5.3
115.994092	-31.931775	202017	7982	Abernethy Rd	South of Kalamur	2018/19	Class	14618	17958	19.5	21.7	No	102	Kalamunda	7	Metropolitan	7638	12.2
115.998858	-31.923448	202018	7983	Abernethy Rd	South of Great Ea	2017/18	Class	8825	11580	27	28.9	No	109	Swan (C)	7	Metropolitan	3519	16.9
115.768727	-32.144913	202019	7987	Cockburn Rd	North of Quill Wy	2018/19	Class	9502	10732	12.5	13.7	No	103	Cockburn (C)	7	Metropolitan	6711	8.6
115.778663	-32.146305	202020	7991	Cockburn Rd	South of Russell F	2016/17	Class	6795	8476	11.5	12.9	No	103	Cockburn (C)	7	Metropolitan	3692	7.3
115.82856	-32.3641	202021	7995	Baldivis Rd	South of Sixty Eig	2017/18	Class	3928	3960	12.1	12.1	No	107	Rockingham (C)	7	Metropolitan		
115.826168	-32.361721	202022	7996	Sixty Eight Rd	West of Baldivis F	2017/18	Class	2200	2218	11.9	11.9	No	107	Rockingham (C)	7	Metropolitan		
113.76603	-24.80827	202023	8047	North West Co	North of McGlade	2018/19	Class	959	905	22.3	24.1	No	803	Carnarvon	14	Mid West-Gas	1048	19
117.11205	-20.75985	202024	8048	North West Co	South of Point Sa	2019/20	Class	2043	2181	25.1	26.3	Yes	814	Karratha (C)	11	Pilbara	1699	21.1
118.9974	-20.44694	202025	8050	Marble Bar Rd	South of Great Nc	2018/19	Class	272	298	55.5	54.4	Yes	813	Port Hedland (T	11	Pilbara	247	56.3
113.73177	-24.93327	202026	8060	North West Co	South of Bush Bay	2019/20	Class	754	740	26.7	28.4	Yes	803	Carnarvon	14	Mid West-Gas	787	23.3
113.96469	-23.5542	202027	8061	Minilya Exmou	North of North W	2018/19	Class	305	292	19.3	21.2	Yes	803	Carnarvon	14	Mid West-Gas	337	17.2
115.5443	-22.50127	202028	8062	Nanutarra Rd	East of North We	2018/19	Class	128	132	27.3	28	Yes	811	Ashburton	11	Pilbara	118	23.7
118.45361	-20.63876	202029	8074	Great Northern	South of North W	2019/20	Class	1366	1394	74.7	73.7	Yes	813	Port Hedland (T	11	Pilbara	1295	77.6
113.76523	-24.72777	202030	8078	North West Co	North of Blowhol	2018/19	Class	549	540	27.7	29.1	Yes	803	Carnarvon	14	Mid West-Gas	570	23.9
115.837447	-32.293751	202031	8200	Mundijong Rd	East of Kwinana F	2017/18	Class	5645	5591	12.1	13.7	No	107	Rockingham (C)	7	Metropolitan	5718	9
115.851878	-32.243219	202032	8212	Kwinana Fwy	NB S of Thomas R	2017/18	Class	39784	38777	7.5	10.3	No	105	Kwinana (C)	7	Metropolitan	36219	5.2
115.852214	-32.243175	202033	8213	Kwinana Fwy	SB S of Thomas Rc	2017/18	Class	39368	40079	10.2	13.1	No	105	Kwinana (C)	7	Metropolitan	34489	7.4
115.843094	-32.273767	202034	8214	Kwinana Fwy	NB S of Mortimer	2017/18	Class	36553	35554	4.5	6.8	No	107	Rockingham (C)	7	Metropolitan	33336	2.6
115.84357	-32.273719	202035	8215	Kwinana Fwy	SB S of Mortimer	2017/18	Class	36271	37035	4.8	7	No	107	Rockingham (C)	7	Metropolitan	31691	2.7
115.766874	-32.325353	202036	8222	Ennis Av (Nort	NB N of Safety Ba	2014/15	Volume	2103	2133			No	107	Rockingham (C)	7	Metropolitan		
115.767116	-32.326158	202037	8226	Ennis Av	At Bridge Under S	2019/20	Class	16852	18980	7.2	8	No	107	Rockingham (C)	7	Metropolitan	11875	4.8
115.854131	-32.255308	202038	8229	Mortimer Rd	East of Kwinana F	2017/18	Class	4720	4913	9.4	10.9	No	105	Kwinana (C)	7	Metropolitan	4098	7.4
115.822645	-31.858561	202039	8232	Reid Hwy (East	EB W of Wannero	2015/16	Class	2632	2813	9	9	No	125	Stirling (C)	7	Metropolitan		
115.829648	-31.859664	202040	8233	Wanneroo Rd c	EB E of Wanneroc	2015/16	Class	8407	8984	13	13	No	125	Stirling (C)	7	Metropolitan		
115.822353	-31.858976	202041	8234	Wanneroo Rd c	WB W of Wanner	2015/16	Class	3138	3353	7.2	7.2	No	125	Stirling (C)	7	Metropolitan		
115.829565	-31.86012	202042	8235	Reid Hwy (Wes	WB Off Ramp to V	2015/16	Class	7993	8541	17.5	17.5	No	125	Stirling (C)	7	Metropolitan		
116.00382	-31.917585	202043	8236	Great Eastern H	West of Stirling C	2017/18	Class	25634	28256	16.6	16.6	No	109	Swan (C)	7	Metropolitan		
115.991319	-31.939192	202044	8239	Abernethy Rd	South of Dundas I	2015/16	Class	16740	20429	22.2	23.5	No	102	Kalamunda	7	Metropolitan	8457	15.6
115.977113	-31.982076	202045	8240	Abernethy Rd	East of McDowell	2016/17	Class	19152	25181	16.1	16.7	No	113	Belmont (C)	7	Metropolitan	6279	11.1
115.78252	-31.855235	202046	8245	Okely Rd	North of Reid Hw	2018/19	Class	7196	7683	3.7	3.9	No	125	Stirling (C)	7	Metropolitan	5951	2.6
115.996811	-32.044084	202047	8247	Alcock St	South of Madding	2017/18	Class	4161	4294	6.8	7.6	No	104	Gosnells (C)	7	Metropolitan	3483	5.6

Source: MRWA (2020).

The traffic digest report is also available, summarising the average number of vehicles travelling on a weekday (Monday to Friday) or daily (Monday to Sunday) within Western Australia. Traffic volumes and percentage of heavy vehicles are provided for the latest available six years. A sample of the report can be seen in Figure 3.13.

Figure 3.13: Sample of traffic digest report

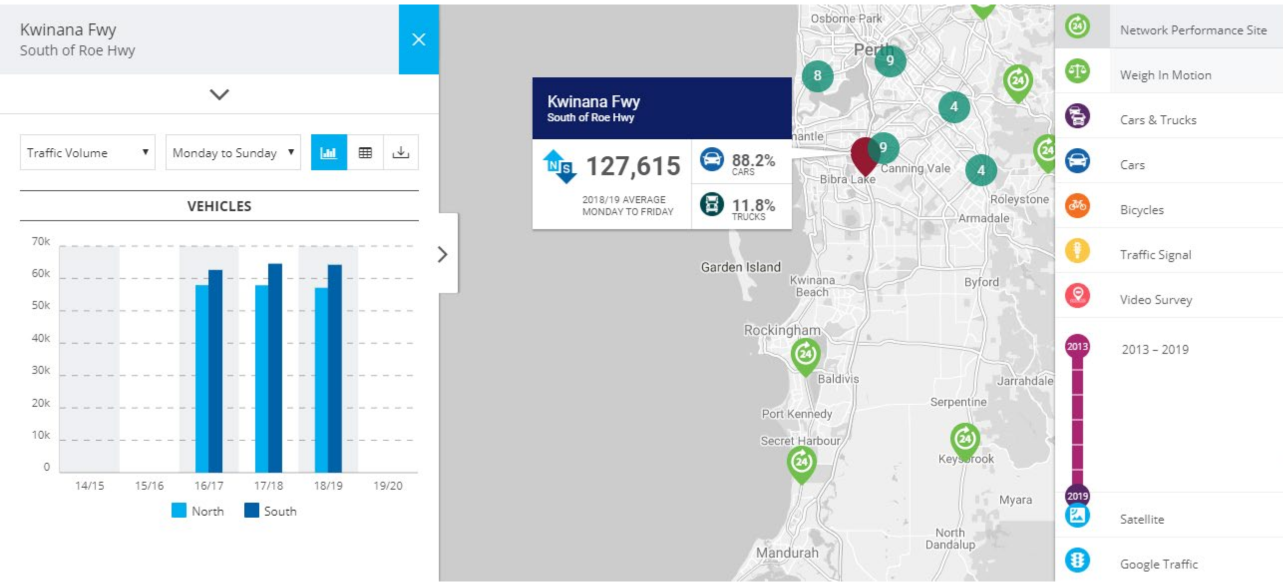


Source: MRWA (2018).

3.5.2 Trafficmap

MRWA Trafficmap provides up-to-date traffic information about vehicles travelling on Western Australian roads. The information includes the number and type of vehicles, speed of travel and at some locations the mass of vehicles. In Figure 3.14, Trafficmap allows users to search for location, quickly view current traffic volumes and speeds, view trends and detailed data from the last five years, filter by year or type of vehicle, and download reports. The detailed volume reports for a location downloaded from Trafficmap can be found in Appendix B.

Figure 3.14: Trafficmap



Source: MRWA (2021).

3.6 Tasmania

3.6.1 RoadsTas Traffic Stats

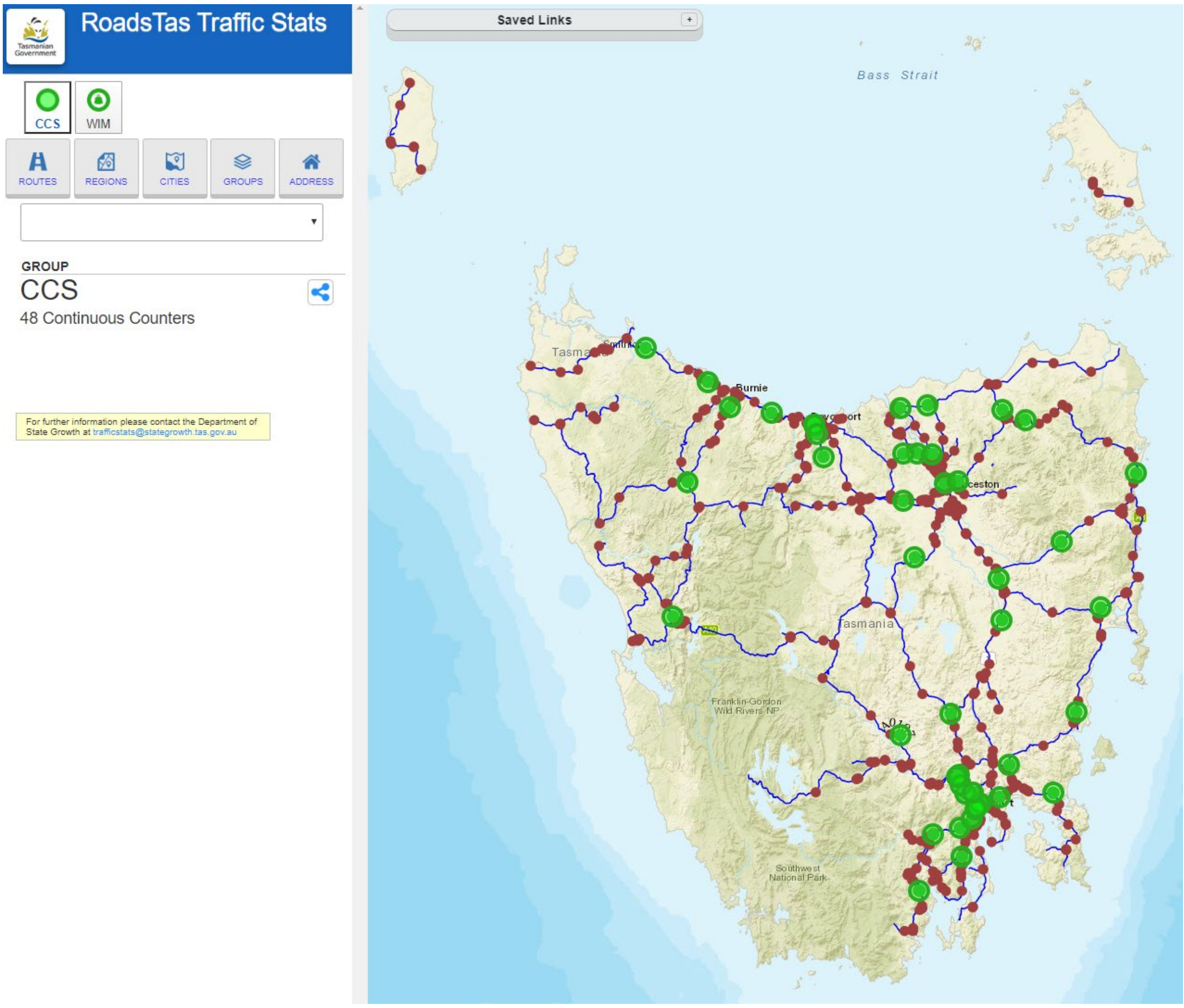
Traffic data for state roads in Tasmania are not openly available. The Department of State Growth currently commissions Transmetric to provide traffic statistics using their Geocounts webviewer (Figure 3.15 and Figure 3.16). The detailed traffic data associated with traffic counters, e.g. AADT, are also provided, as shown in Figure 3.17. These data are accessible to employees of the Department of State Growth and selected traffic consultants. While the Geocounts webviewer can be accessed by any individual, a business decision was made by the Department of State Growth not to make it public for now.

The AADT is calculated directly for the 43 permanent traffic counting sites in Tasmania. These sites are monitored and downloaded remotely. There are also 500 short-term counting sites. For approximately half of these sites, a 7-day tube count is conducted each year. The AADT for the short-term sites is estimated using the 7-day count data and seasonal factors calculated from the permanent traffic monitoring sites.

Various devices are used to collect traffic volume data. For permanent traffic monitoring sites, 35 Metrocount 5710 piezo classifiers, 5 TIRTLs and 3 WIM Vipers are used. There are 484 short-term traffic counting sites which are counted by Metrocount 5600 tube classifiers, and the other 16 sites are monitored by SCATS (an adaptive urban traffic management system).

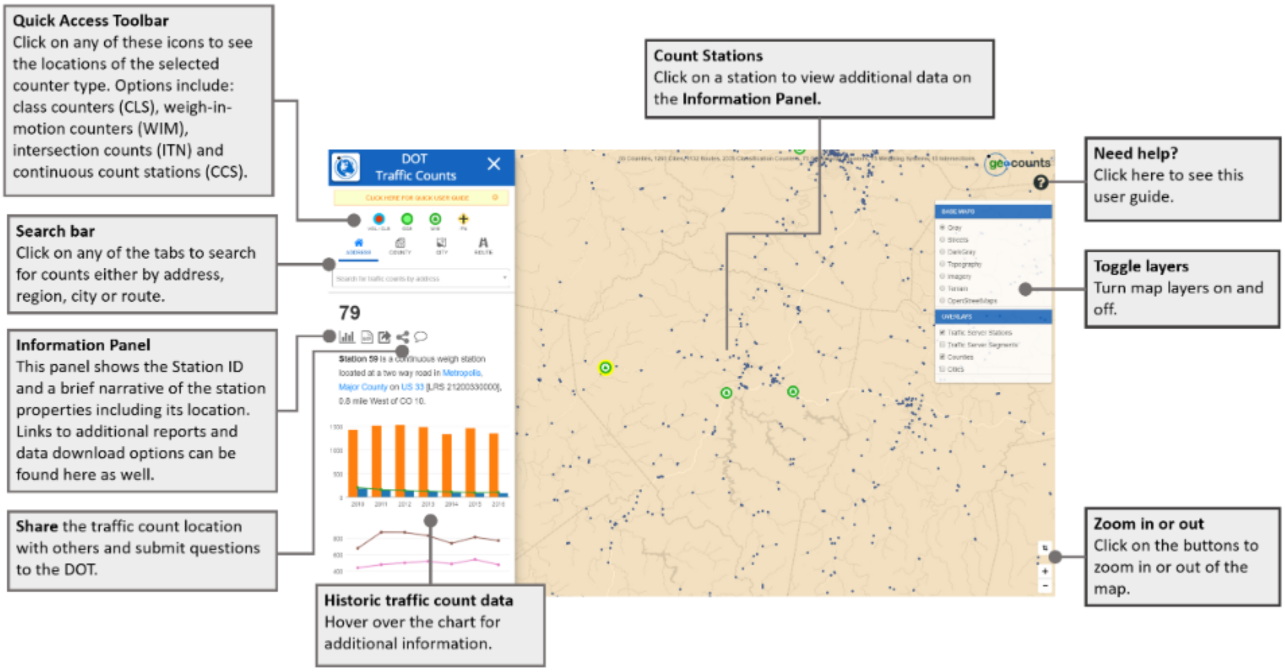
The locations of traffic counting sites are determined by partitioning all the state roads into Uniform Traffic Segments (UTS) based on change in traffic volume over the length of the roads. Where a permanent traffic monitoring station is located in a UTS, the permanent site is used as the UTS site. For each of all other UTS, a suitable short-term counting site is selected based on road geometry, road condition, site distance, speed variability and anchorage point. The same short-term sites are used each time the count is conducted unless there has been a change in one or more of the characteristics at the site that would make it unsuitable as a counting site.

Figure 3.15: Geocounts webviewer



Source: Department of State Growth (2020).

Figure 3.16: Geocounts user guide



Legend

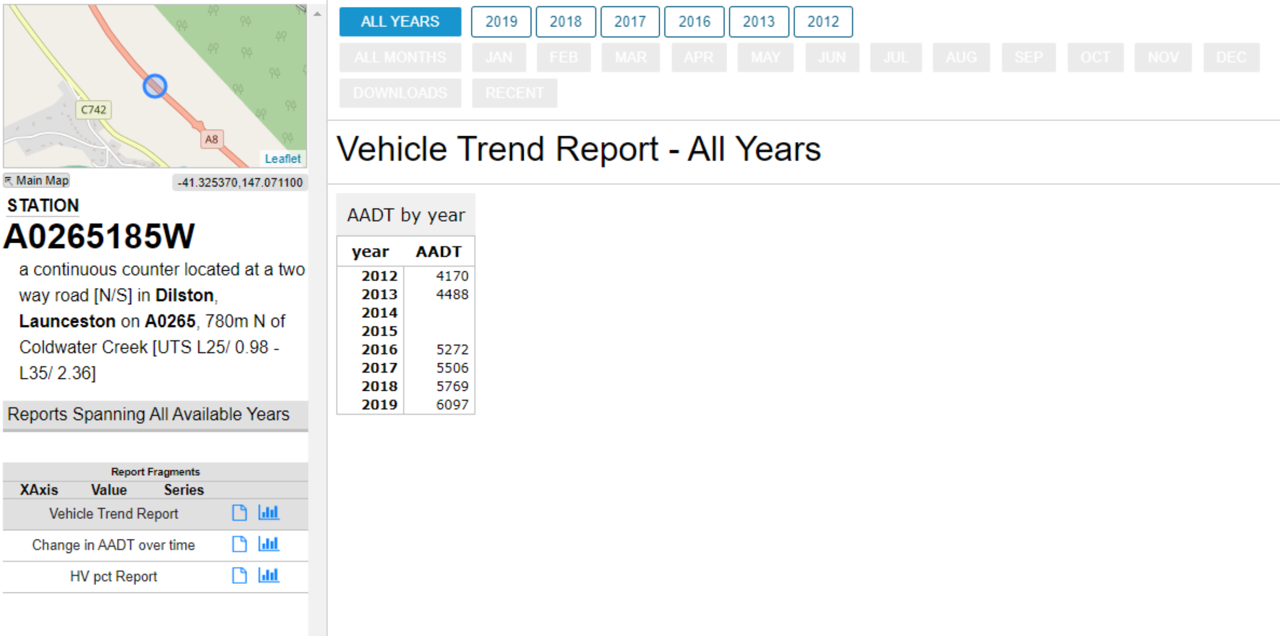
	Description
	Weigh-in-motion (WIM) counter - A station that captures and records axle weights and gross vehicle weights as vehicles drive over a measuring device.
	Intersection (ITN) counter - A station that collects data at a location where two or more roadways cross each other.
	Continuous Count Station (CCS) - A station that collects traffic data 24 hours a day, 365 days a year.
	Volume Station - A station that collects only traffic volume data.
	Class Station - A station that collects both traffic volume and vehicle class data.

Glossary

Term	Definition
AADT	Annual Average Daily Traffic (AADT) is a measure used primarily in transportation planning and transportation engineering. Traditionally, it is the total volume of vehicle traffic of a highway or road for a year divided by 365 days.
AADTT	Average Annual Daily Truck Traffic (AADTT) is the total volume of truck traffic on a highway segment for one year, divided by the number of days in the year.
LRS	Linear Referencing System (LRS) is a system where features (points or segments) are localized by a measure along a linear element. The LRS can be used to reference events for any network of linear features, for example roads, railways, rivers, pipelines, electric and telephone lines, water and sewer networks. Click here for more info.

Source: Department of State Growth (2020).

Figure 3.17: Traffic report from Geocounts



Source: Department of State Growth (2020).

3.7 National Network Performance Indicators

The National Network Performance Indicators (NPIs) have been developed by Austroads and their stakeholders over a number of years. The rationale for NPIs was to provide a consistent basis for comparison of road network performance across Australia. These performance indicators comprise a number of metrics including travel time, journey time reliability and safety. However, the application of the NPIs has been relatively limited.

In order to increase their use across the road agencies in Australia, a recent work (Austroads 2018) has investigated customer and community expectations with respect to the NPIs. It is recommended that the NPIs be revisited to ensure that they are best tailored to guide decision making, particularly investment decisions. This highlights the importance of a national business need which drives national consistency.

4. Open/Commercial Traffic Data

4.1 CEOS

In 1998, the company CEOS began the development of an infra-red based vehicle counter, classifier and speed measurement product that became known as the Infra-Red Traffic Logger (TIRTL). As of today, CEOS has sold TIRTL to state instrumentalities in Australia and New Zealand.

The company can download and warehouse all vehicle data every 1 hour, and transfer to clients as required or to a third party on request of clients. The format of data reporting is determined by clients and includes tables and graphs on a weekly/monthly basis. Figure 4.1 shows the TIRTL data attributes.

Figure 4.1: Screenshot of TIRTL data attributes

Field	Description
date	Human readable date of the first axle in yyyy-mm-dd format.
time	Human readable time of the first axle in hh:mm:ss format.
zone	The offset of the above date and time from UTC in hh:mm format.
timestamp	The time of the first axle represented as the number of seconds since 1970-01-01 00:00:00 UTC.
database_id	A unique identifier for this vehicle (comprising a contiguously increasing number).
lane	The name of the region in which this vehicle was detected.
speed(*units*)	The speed of the first axle of this vehicle.
average_speed (*units*)	The average speed of this vehicle.
heading	The direction (north, south, east, west etc) that the vehicle was travelling.
direction	The direction that this vehicle was travelling, from the perspective of the receiver.
class_number	The number of the class that this vehicle matched from the classification scheme.
class_name	The name of the class that this vehicle matched from the classification scheme.
hv_class_number	The number of the class from the heavy vehicle class scheme that this vehicle matches.
hv_class_name	The name of the class from the heavy vehicle class scheme that this vehicle matches.
toll_class_number	The number of the class from the toll class scheme that this vehicle matches.
toll_class_name	The name of the class from the toll class scheme that this vehicle matches.
trigger_class_name	The name of the class that this vehicle matches from the trigger scheme.
trigger_list	A space separated list of triggers that were generated for this vehicle in the form *XY*, where *X* is 'F' for a front trigger and 'R' for rear trigger and *Y* is the ID of the trigger.
distance(*units*)	The distance from the receiver to the centre of the vehicle.
width(*units*)	The distance from the near side to the far side of the vehicle. This measurement is only accurate in specific circumstances, please discuss its use with your vendor prior to use.
axle_count	The number of axles detected on this vehicle.
wheelbase(*units*)	The distance from the first axle to the last axle.
length(*units*)	The distance from the front to the rear of this vehicle. The front and rear overhangs are calculated based upon the axle configuration.
clearance(*units*)	The distance from the rear of the previous vehicle to the front of this vehicle.
headway (units)	The time from the front of the previous vehicle in the same lane to the front of this vehicle.
spacing(*units*)	The distance from the front of the previous vehicle to the front of this vehicle.
gap	The time in seconds from the rear of the previous vehicle to the front of this vehicle.
axle_speed_#(*units*)	The speed of the axle.
axle_break_speed_#(*units*)	The speed of the leading edge of the axle.
axle_make_speed_#(*units*)	The speed of the trailing edge of the axle.
axle_chord_length_#(*units*)	The length of the chord produced by the beams across the wheel.
axle_edge_count_#	The number of edges detected on this axle.
axle_spacing_#(*units*)	The distance between two adjacent axles.

Source: CEOS (2016).

4.2 Matrix Traffic and Transport Data

Matrix specialises in automatic counting technology to undertake traffic surveys, using MetroCount 5600 data loggers to collect mid-block traffic data. Pneumatic tubes are installed on the survey road and connected to loggers to capture classification, volume, and speed data by direction. Each vehicle is logged individually which allows extensive analysis of the data. MetroCount loggers can classify into Austroads classification bins as well as other classification schemes.

Matrix does not openly share any traffic data for previous projects except some example data.

4.3 Trans Traffic Survey

The company generally uses automatic pneumatic tube counters and induction loop counters to collect traffic volume data. In high-risk traffic locations, tube counters are replaced with radar automatic traffic counters. Computer vision software is also available to automatically and accurately track and count vehicles from collected field video. No traffic data is shared by the company unless on the request of clients.

4.4 AusTraffic

Traffic counting data are typically collated into 15-min blocks for reporting purposes, but this can be customised to suit clients' requirements. Classification categories may be as simple as 'car' and 'truck' or extend up to the full 12 Austroads classifications. Trucks can be further classified into their hazardous goods carry code and other vehicles can be classified based on their public transport functionality. Austroads classes 1–3 may also be classified into limousine, hire car, taxi, car derivative used for commercial purposes, and car with trailer (1, 2 or 3 axles).

For count-only projects of up to three traffic lanes, the most commonly used method is with pneumatic road tube. In multi-lane sites, non-compressible tubes that allow surveying middle and far lanes without the interference of near-side traffic can be deployed for quick temporary data needs. Inductive loop, piezo, fibre optics or treadle sensors can be deployed for long-term applications. Axle sensing is the optimal method for accurately obtaining all 12 Austroads vehicle classifications and speeds.

Austraffic does not share any survey data without the permission of clients.

5. National Traffic Data Specification

5.1 Requirements for National Consistency

The requirements for achieving national consistency in traffic data include the establishment of:

- accepted methods of data collection
- a common approach to data processing and estimation
- a national reporting format.

These requirements are elaborated on in the sections below.

5.2 Data Collection Methods

5.2.1 Permanent Counting Stations

Permanent counting stations are an important source of traffic data. Firstly, they provide daily and all-year-round traffic data that constitute a comprehensive and reliable dataset. Secondly, they show regional fluctuations and trends of traffic. Thirdly, they provide seasonal adjustment factors that feed into the calculation of short-term counts.

The counting techniques for permanent counting stations include TIRTL, piezoelectric detector and inductive loop.

5.2.2 Short-term Counting Stations

In order to supplement permanent counting stations and respond to various business needs, short-term counting stations are established to measure traffic volumes for only a brief period (usually less than a week).

The commonly used counting method for short-term stations is use of pneumatic tube. Where tube counts are not suitable, alternative data sources can be SCATS/STREAM data.

5.2.3 WIM (Weigh-In-Motion) System

A WIM system is used to measure detailed data primarily for heavy vehicles. WIM sites are mainly located on major freight corridors, and many are permanent sites. WIM systems use a combination of mass sensor and vehicle detection sensor that can classify vehicles based on number of axles, axle spacing and axle group configuration. This enables a measurement of classified traffic counts. The counting data can be used to calculate AADT if all lanes of traffic are monitored. The volume data collected by a WIM system can supplement a traffic counting program, although WIM sites may not be at the best representative locations.

5.3 Data Processing and Estimation

5.3.1 AADT Measured from Yearly Counts

AADT can be calculated by measuring the total traffic volume passing the observation point over a year and then divided by the number of days in that year. The calculation of AADT would be straightforward if the counting stations were to operate without failing to record traffic counts for every day of the year. Some inaccuracies could be present, as a result of instrument counting errors, malfunction, or other causes, but the AADT derived would be relatively accurate. Where less than a full year's data is available, techniques for synthesising missing data are used (CSIRO 2000).

5.3.2 AADT Estimated from Short-term Counts

If traffic were counted on a random day in the year, the result would only approximate the AADT. The accuracy of the approximation would depend on the weekly and seasonal pattern for the road segment, the counting day of the year, and the ADT counted. Daily variations tend to decrease with increasing traffic volumes.

The longer the counting period, the closer the ADT obtained will approximate the AADT. The ADT derived from several short-term counts throughout the year will more closely approximate the AADT, especially if the particular road segment exhibits a high seasonal variation. According to the *Guide to Traffic Management* (Austroads 2017), where a broad counting program has been established and seasonal patterns identified, the AADT at a particular location can be estimated by multiplying a sample count (e.g. 2 to 7 days duration) by the seasonal adjustment factor derived from a permanent station representative of the required location.

The accuracy of an AADT estimate therefore depends on the accuracies of both the short-term count and the seasonal adjustment factor. The former relies on counting duration and counting days of the year. The latter depends on the accuracy with which the permanent station reflects the fluctuations at the short-term stations. The estimation errors due to seasonal adjustment factor and count duration are described in Section 2.4.1.

5.4 Data Reporting

A reporting format for nationally consistent AADT data is produced in Table 5.1.

Table 5.1: Reporting format for AADT data

Variable name	Description
Station ID	Counting station unique identifier
Station type	Counting station type, e.g. permanent, short term
Counting start date	Date when counting starts, which applies to short-term counting
Counting end date	Date when counting ends, which applies to short-term counting
Counter type	Counting device type, e.g. inductive loop, TIRTL, pneumatic tube, WIM
Station latitude	Latitude of counting station
Station longitude	Longitude of counting station
Traffic direction	Traffic direction of AADT measured, e.g. southbound
Number of lanes	Number of lanes of AADT measured
Road name	Road name
Road ID	Road unique identifier
Road type	Road type, e.g. freeway/motorway, highway, arterial, collector/distributor, local
Road section ID	Unique identifier of the road section for AADT measured

Variable name	Description
Road section start distance	Driven distance from the start of the road to the start of the road section for AADT measured
Road section end distance	Driven distance from the start of the road to the end of the road section for AADT measured
AADT of all vehicles	Annual average daily traffic volume of all vehicles
AADT of Classes 3 to 5	Annual average daily traffic volume of classes 3 to 5 based on Austroads classification
AADT of Class 6 to 9	Annual average daily traffic volume of classes 6 to 9 based on Austroads classification
AADT of Class 10	Annual average daily traffic volume of class 10 based on Austroads classification
AADT of Class 11	Annual average daily traffic volume of class 11 based on Austroads classification
Year	Year AADT measured

6. Conclusion

The investigation on traffic data practices in Australia found that the inconsistency within jurisdictions arises from the differences in business need, availability of equipment and processes for calculating the AADT. For example, traffic volume data in NSW are mostly collected from 600 permanent counting stations across the state. NSW also uses a different method of calculating the AADT than other jurisdictions.

In order to increase consistency in traffic volume data between jurisdictions, it is suggested that a national business need (e.g. public awareness, road design or traffic management) be identified at first. A traffic data specification, including collection, calculation, processing, and reporting, can be determined correspondingly. In addition, stakeholder engagement during the development of a national data specification is important to ensure the required level of practicality and rigour within different jurisdictions.

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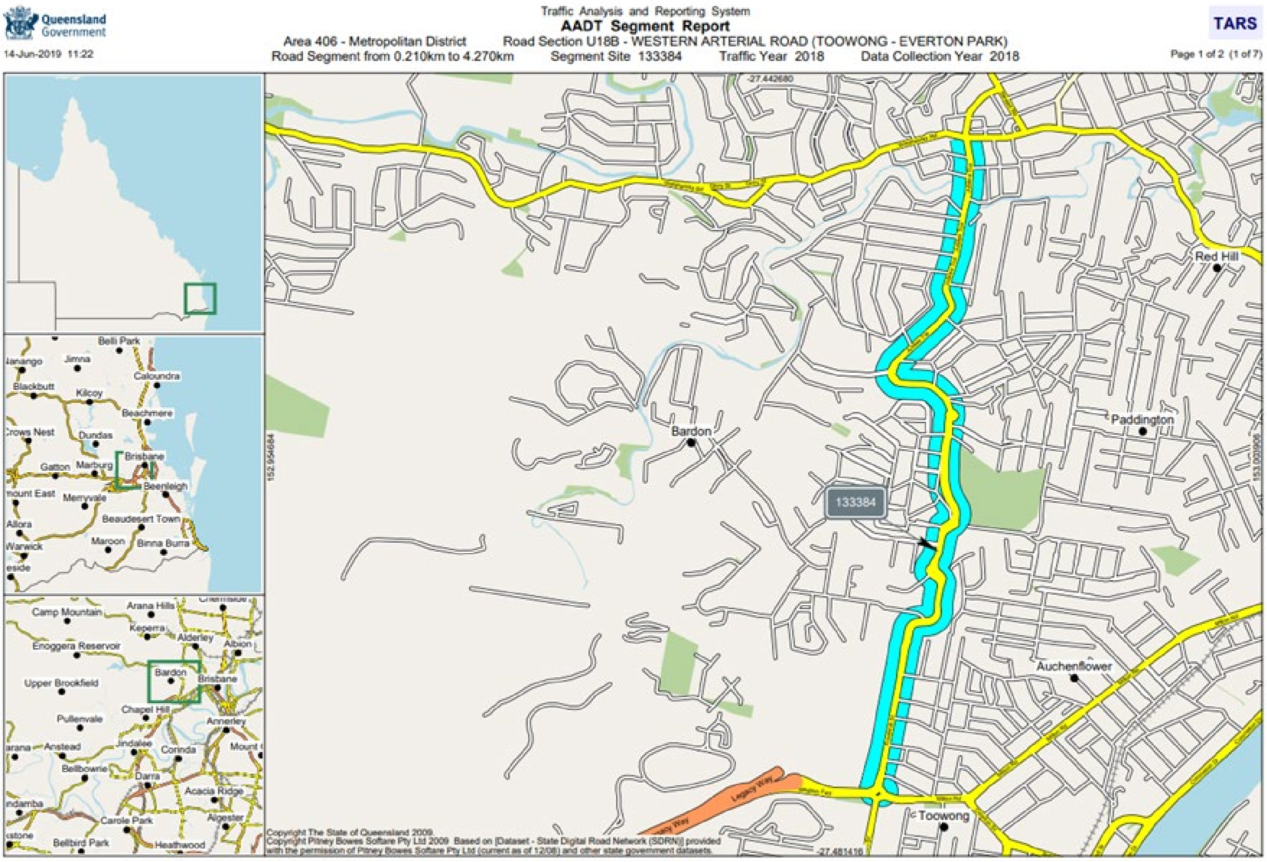
Appendix A AADT Segment and Annual Volume Report

A.1 AADT Segment Report

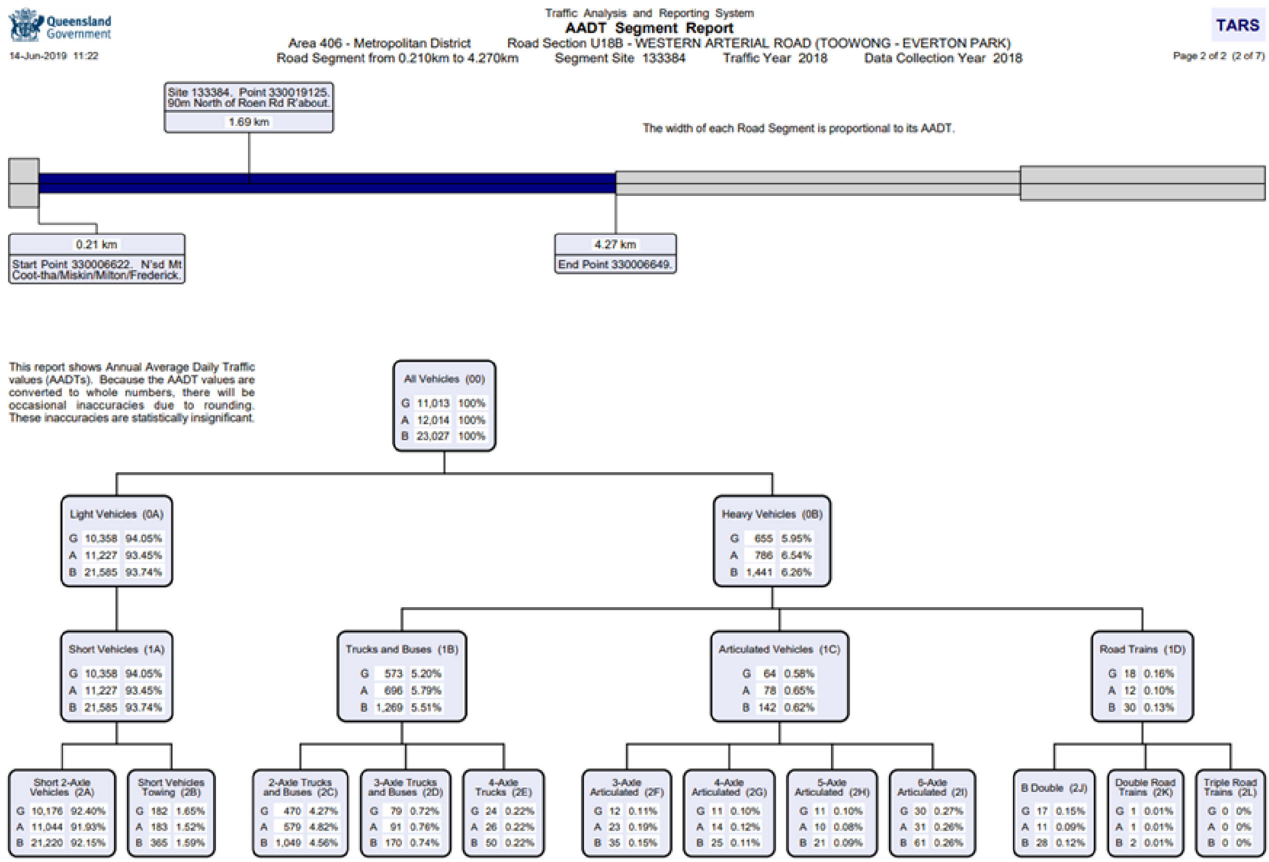
Figure A 1, Figure A 2, and Figure A 3 provide screenshots of TMR's AADT segment report.

Figure A 1: TMR AADT segment report map



Source: Provided by TMR.

Figure A 2: TMR AADT segment report vehicle classification



Source: Provided by TMR.

Figure A 3: TMR AADT segment report notes

Queensland Government

Traffic Analysis and Reporting System
Report Notes for AADT Segment Report

TARS

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AADT Segment Annual Volume Report
Provides summary data for the selected AADT Segment of a Road Section. Summary data is presented as both directional information and a combined bi-directional figure. The data is then broken down by Traffic Class, when available. The report also includes maps displaying the location of both the AADT Segment and the traffic count site.

Annual Average Daily Traffic (AADT)
Annual Average Daily Traffic (AADT) is the number of vehicles passing a point on a road in a 24 hour period, averaged over a calendar year.

AADT Segments
The State declared road network is broken into Road Sections and then further broken down into AADT Segments. An AADT Segment is a sub-section of the declared road network where traffic volume is similar along the entire AADT Segment.

Area
For administration purposes the Department of Transport and Main Roads has divided Queensland into 12 Districts. The Area field in TSDM reports displays the District Name and Number.

District Name	District
Central West District	401
Darling Downs District	402
Far North District	403
Fitzroy District	404
Mackay/Whitsunday District	405
Metropolitian District	406
North Coast District	407
North West District	409
Northern District	408
South Coast District	410
South West District	411
Wide Bay/Burnett District	412

AADT Values
AADT values are displayed by direction of travel as:

G Traffic flow in gazettal direction
A Traffic flow against gazettal direction
B Traffic flow in both directions

Data Collection Year
Is the most recent year that data was collected at the data collection site.

Please Note:
Due to location and/or departmental policy, some sites are not counted every year.

Gazettal Direction
Is the direction of the traffic flow. It can be easily recognised by referring to the name of the road eg. Road Section: 10A Brisbane - Gympie denotes that the gazettal direction is from Brisbane to Gympie.

Maps
Display the selected location from a range of viewing levels, the start and end position details for the AADT Segment and the location of the traffic count site.

Road Section
Is the Gazetted road from which the traffic data is collected. Each Road Section is given a code, allocated sequentially in Gazettal Direction. Larger roads are broken down into sections and identified by an ID code with a suffix for easier data collection and reporting (eg. 10A, 10B, 10C). Road Sections are then broken into AADT Segments which are determined by traffic volume.

Segment Site
Is the unique identifier for the traffic count site representing the traffic flow within the AADT Segment.

Site
The physical location of a traffic counting device. Sites are located at a specified Through Distance along a Road Section.

Site Description
The description of the physical location of the traffic counting device.

Start and End Point
The unique identifier for the Through Distance along a Road Section.

Vehicle Class
Traffic is categorised as per the Austroads Vehicle Classification scheme. Traffic classes are in the following hierarchical format:

Volume or All Vehicles
00 = 0A + 0B

Light Vehicles
0A = 1A
1A = 2A + 2B

Heavy Vehicles
0B = 1B + 1C + 1D
1B = 2C + 2D + 2E
1C = 2F + 2G + 2H + 2I
1D = 2J + 2K + 2L

The following classes are the categories for which data can be captured:

Volume
00 All vehicles

2-Bin
0A Light vehicles
0B Heavy vehicles

4-Bin
1A Short vehicles
1B Truck or bus
1C Articulated vehicles
1D Road train

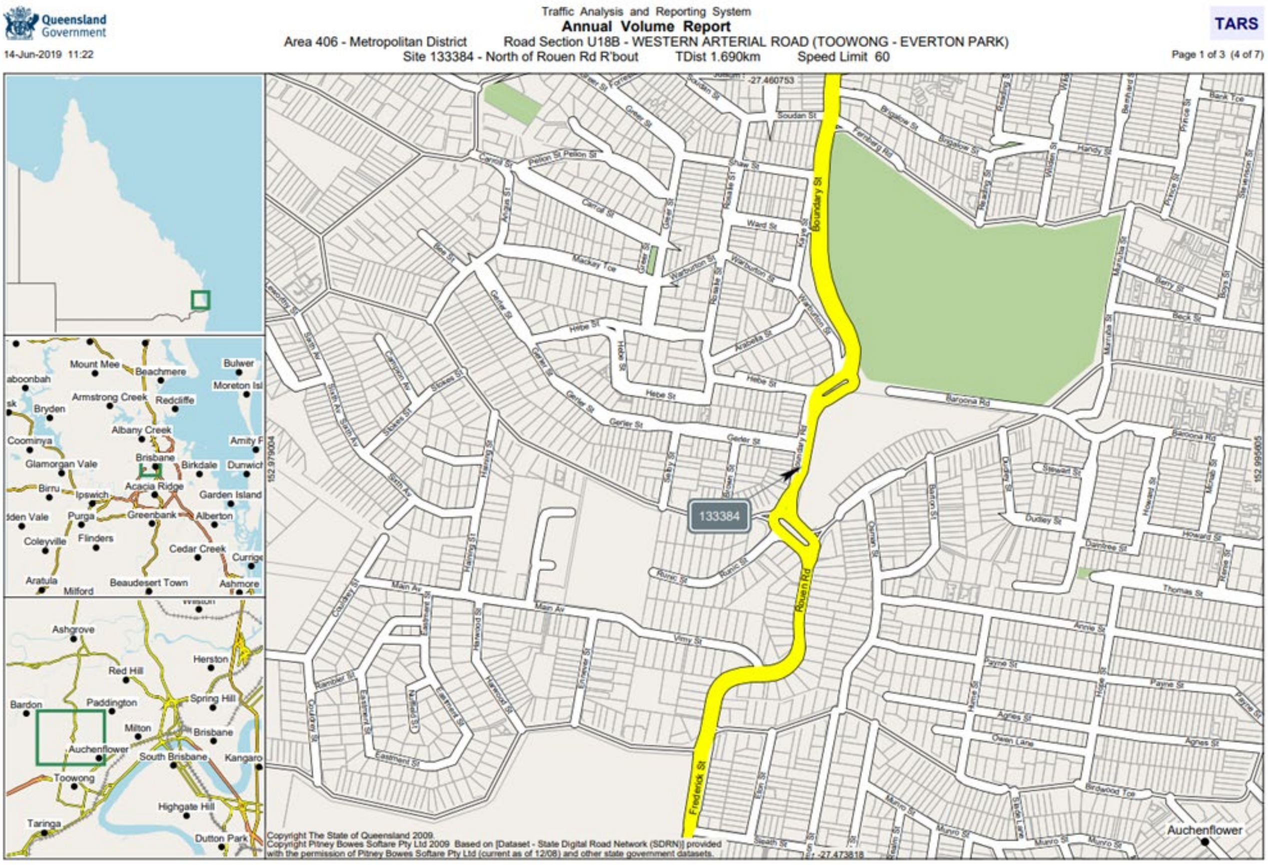
12-Bin
2A Short 2 axle vehicles
2B Short vehicles towing
2C 2 axle truck or bus
2D 3 axle truck or bus
2E 4 axle truck
2F 3 axle articulated vehicle
2G 4 axle articulated vehicle
2H 5 axle articulated vehicle
2I 6 axle articulated vehicle
2J B double
2K Double road train
2L Triple road train

Source: Provided by TMR.

A.2 Annual Volume Report

Figure A 4, Figure A 5, Figure A 6 and Figure A 7 provide screenshots of TMR's annual volume report.

Figure A 4: TMR annual volume report map



Source: Provided by TMR.

Figure A 5: TMR annual volume report site history

Queensland Government

Traffic Analysis and Reporting System
Annual Volume Report

TARS

14-Jun-2019 11:22

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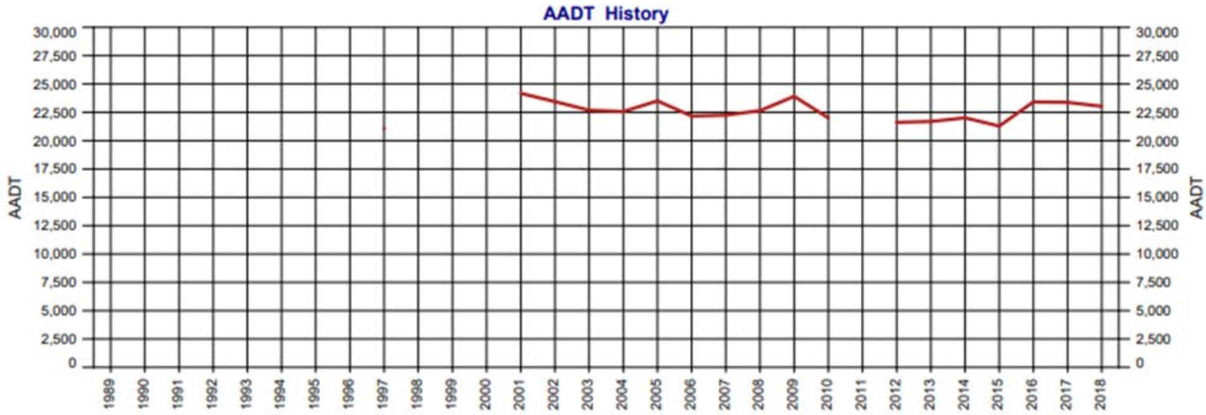
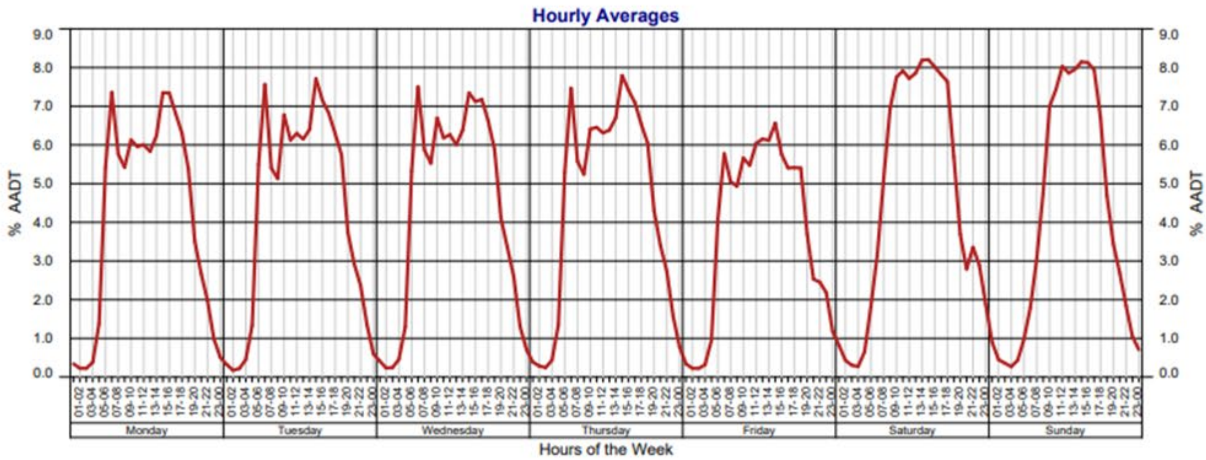
Area	406 - Metropolitan District
Road Section	U18B - WESTERN ARTERIAL ROAD (TOOWONG - EVERTON PAF
Site	133384 - North of Rouen Rd R'bout
Thru Dist	1.69
Type	C - Coverage
Stream	TB - Bi-directional traffic flow

Year	2018	Growth last Year	-1.52%
AADT	23,027	Growth last 5 Yrs	1.22%
Avg Week Day	23,027	Growth last 10 Yrs	0.37%
Avg Weekend Day	23,717		



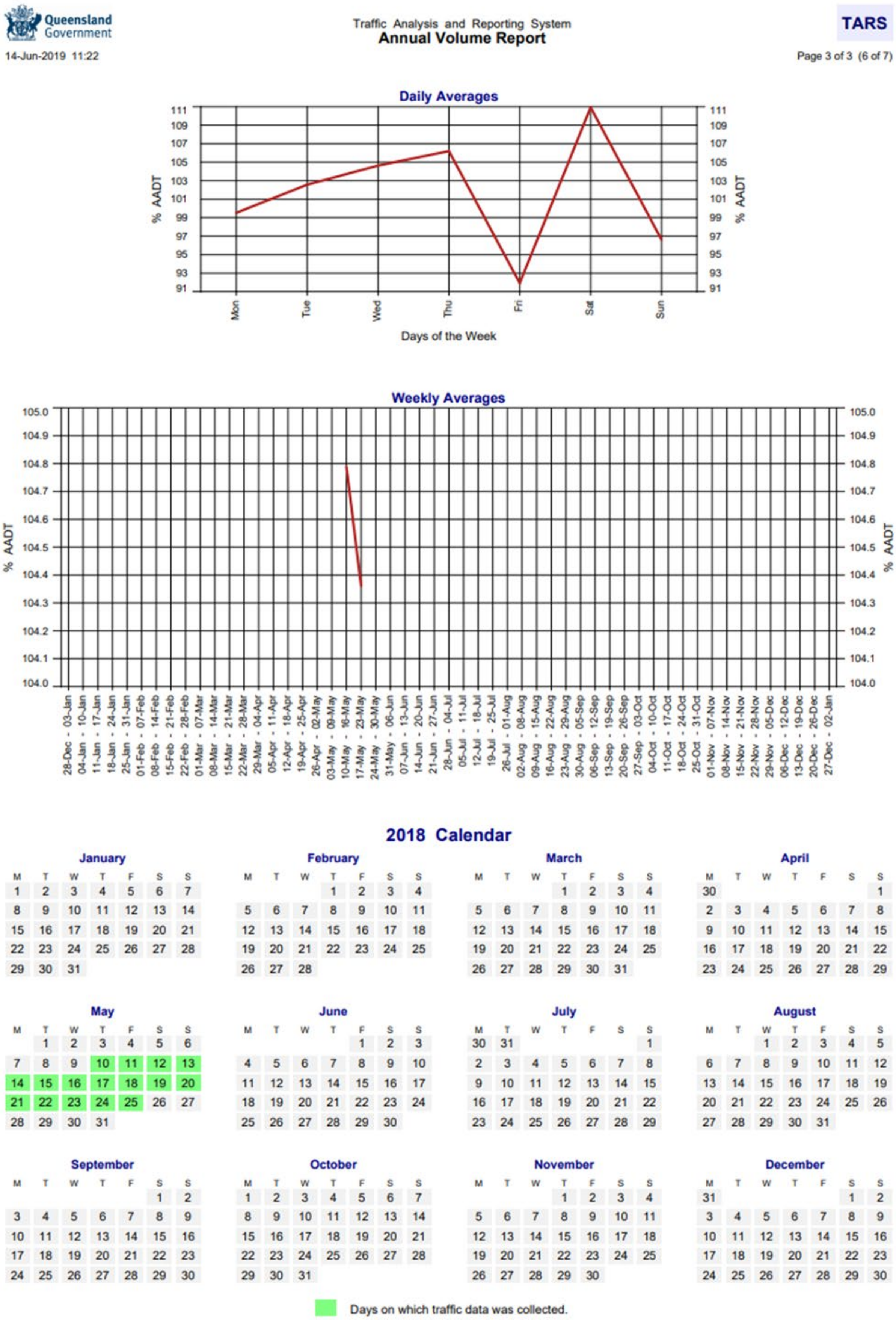
Year	AADT	1-Year Growth	5-Year Growth	10-Year Growth
2018	23,027	-1.52%	1.22%	0.37%
2017	23,382	-0.16%	1.95%	0.60%
2016	23,419	10.01%		0.63%
2015	21,289	-3.29%	-0.72%	-0.84%
2014	22,013	1.48%	-0.78%	-0.40%
2013	21,693	0.36%	-1.25%	-0.63%
2012	21,615		-1.23%	-0.78%
2011				
2010	22,005	-7.96%	-0.97%	
2009	23,909	5.56%	1.43%	
2008	22,649	1.77%	-0.08%	
2007	22,254	0.37%	-0.88%	-0.23%
2006	22,172	-5.68%	-1.48%	
2005	23,508	4.17%		
2004	22,566	-0.53%		

Year	AADT	1-Year Growth	5-Year Growth	10-Year Growth
2003	22,687	-3.24%		
2002	23,447	-3.02%	1.95%	
2001	24,178			
2000				
1999				
1998				
1997	21,077			
1996				
1995				
1994				
1993				
1992				
1991				
1990				
1989				



Source: Provided by TMR.

Figure A 6: TMR annual volume report time series results



Source: Provided by TMR.

Figure A 7: TMR annual volume report notes

Queensland Government

Traffic Analysis and Reporting System

Report Notes for Annual Volume Report

TARS

14-Jun-2019 11:22

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Annual Volume Report
Displays AADT history with hourly, daily and weekly patterns by Stream in addition to annual data for AADT figures with 1 year, 5 year and 10 year growth rates.

Annual Average Daily Traffic (AADT)
Annual Average Daily Traffic (AADT) is the number of vehicles passing a point on a road in a 24 hour period, averaged over a calendar year.

AADT History
Displays the years when traffic data was collected at this count site.

Area
For administration purposes the Department of Transport and Main Roads has divided Queensland into 12 Districts. The Area field in TSDM reports displays the District Name and Number.

District Name	District
Central West District	401
Darling Downs District	402
Far North District	403
Fitzroy District	404
Mackay/Whitsunday District	405
Metropolitian District	406
North Coast District	407
North West District	409
Northern District	408
South Coast District	410
South West District	411
Wide Bay/Burnett District	412

Avg Week Day
Average daily traffic volume during the week days, Monday to Friday.

Avg Weekend Day
Average daily traffic volume during the weekend, Saturday and Sunday.

Calendar
Days on which traffic data was collected are highlighted in green.

Gazettal Direction
The Gazettal Direction is the direction of the traffic flow. It can be easily recognised by referring to the name of the road eg. Road Section: 10A Brisbane - Gympie denotes that the gazettal direction is from Brisbane to Gympie.

G Traffic flowing in Gazettal Direction
A Traffic flowing against Gazettal Direction
B The combined traffic flow in both Directions

Growth Percentage
Represents the increase or decrease in AADT, using a exponential fit over the previous 1, 5 or 10 year period.

Hour, Day & Week Averages
The amount of traffic on the road network will vary depending on the time of day, the day of the week and the week of the year. The ebb and flow of traffic travelling through a site over a period of time forms a pattern. The Hour, Day and Week Averages are then used in the calculation of AADT.

Road Section
Is the Gazetted road from which the traffic data is collected. Each Road Section is given a code, allocated sequentially in Gazettal Direction. Larger roads are broken down into sections and identified by an ID code with a suffix for easier data collection and reporting (eg. 10A, 10B, 10C). Road Sections are then broken into AADT Segments which are determined by traffic volume.

Site
The unique identifier and description of the physical location of a traffic counting device. Sites are located at a Through Distance along a Road Section.

Stream
The lane in which the traffic is travelling in. This report provides data for the combined flow of traffic in both directions.

Thru Dist or TDist
The distance from the beginning of the Road Section, in kilometres.

Type
There are two types of traffic counting sites, Permanent and Coverage. Permanent means the traffic counting device is in place 24/7. Coverage means the traffic counting device is in place for a specified period of time.

Year
Is the current year for the report. Where an AADT Year record is missing a traffic count has not been conducted, for that year.

Source: Provided by TMR.

Appendix B Volume Reports

B.1 Information Sheet

Figure B 1, Figure B 2 and Figure B 3 contain pages 1 to 3 respectively of the Main Roads Western Australia's Trafficmap information sheet.

Figure B 1: MRWA Trafficmap page 1 of information sheet

trafficmap

NOVEMBER 2017

Information Sheet
Network Performance Sites

Network Performance Sites (NPS) collect traffic information continuously, 24 hours of the day, each day of the year. This information sheet is intended to outline the collection of the data, calculation of statistics and reporting.

Network Performance Sites (NPS)

These count locations are fixed infrastructure; installed at strategic locations on major roads. These sites collect data about the number, type and speed of travel for vehicles passing the location.

The duration of the collection allows long term patterns to be studied including seasonal variations and annual growth. This detailed understanding of travel behaviours at sites across the state is used as the basis for adjusting short term traffic counts in order to make them representative of the annual conditions..

NPS data, as it already represents the average of a year, is used as source of information used by the seasonal adjustment process. Public holidays, periods around Easter, Christmas and New Years are excluded from calculations.

The following reports are available for these count locations;

Hourly Volume

Hourly vehicle volumes by direction. Includes peak hour statistics, morning and afternoon peak hour times and volume.

Quarter Hourly Volume

Quarter hourly vehicle volumes by direction. Includes peak quarter hour statistics; morning and afternoon peak hour times and volume.

Hourly Speed

Hourly median and 85th percentile speeds by direction.

Hourly Speed Compliance

Traffic volumes based on speed limit ranges by direction and hour. Shows when speeding occurs and by how much.

Vehicle Type

Freight composition of an average day. Vehicle type is described using the Austroads 1994 Vehicle Classification Scheme.

Daily Volume

An average day of week trend of traffic volumes by direction and time e.g. day of week, weekly, weekday and weekend.

Daily Volume by Month

Daily traffic volumes averaged into months for the latest year.

Monthly Volume

Monthly comparison of weekly, weekday and weekend traffic volumes vehicles for the latest year. Displays seasonal patterns.

Monthly Volume by Year

Yearly comparison of average monthly traffic volumes vehicles spanning a six year period. Displays seasonality and growth patterns.

Daily Vehicle Volume Calendar

Calendar showing daily traffic volumes of vehicles types recorded at a NPS for the latest year available.

Download Data

An excel file containing all the statistics used in the above reports.

Source: https://trafficmap.mainroads.wa.gov.au/.

Figure B 2: MRWA Trafficmap page 2 of information sheet

mainroads WESTERN AUSTRALIA

Hourly Volume

South Western Hwy (H009)
South of Old Bunbury Rd (SLK 66.78)

SITE 15087

2016/17
Monday to Friday

Each traffic report displays the following information about the traffic count location:

Road name (Road Number)

This is the road name, as it should appear on street signs and directories. The road number is an identifier used by Main Roads to describe the road.

Location (SLK)

The site is described in relation to the nearest intersection, town or feature. If there are roads with the same name in the same region a suburb name can be included to distinguish between them.

Straight Line Kilometre is the measurement, used within Main Roads to define the location of events along a road.

Site number

A site number is a unique number used by Main Roads to distinguish between locations and to store information related to that location.

Year

The year shown is financial year, which runs from July to June.

Individual pages in the reports are provided to group information based on:

Average

Three different averages are calculated based on the days of the week counted. Calculations exclude public holidays, periods around Easter, Christmas and New Year's eve.

- **Monday to Friday** is based on the average of each available weekday. A minimum of two weekdays are needed for locations in the Perth metropolitan area and five consecutive weekdays in regional areas.
- **Monday to Sunday** is based on the average of any day collected within the full week.
- **Weekend** is based on the average of any available weekend days. If no collections were taken over the weekend, the average cannot be calculated and no data will be displayed within

Vehicle Type

The type of vehicle data collected is grouped into;

- **All Vehicles**, which are Cars (that includes cars towing a trailer or a caravan) and all trucks.
- **Heavy Vehicles**, which are also referred to in trafficmap as trucks, are vehicles that fall within classes 3 through to 12 of the Austroads 1994 Vehicle Classification scheme.

Direction

Shows each direction that vehicles were heading when they passed the site;

- N Northbound
- S Southbound
- E Eastbound
- W Westbound
- N S / E W Both Directions

Detailed information for NPS location cover:

Vehicle Volumes

Volumes are displayed in a table and as a graph, to identify patterns.

Quarter Hourly Volumes are calculated for each 15-minute increment, i.e. 00, 15, 30 and 45, for each hour over a 24-hour period.

Hourly Volumes shows the volume calculated for each hour over a 24-hour period. The time shown is the start of the hour. The total is the sum of vehicles for that direction (and vehicle type) over the 24-hour period.

Vehicle Type provides volumes and percentages for all vehicles passing the location based on the type of vehicle as determined by the Austroads 1994 Vehicle Classification Scheme.

Daily Vehicle Volume Calendar displays the daily traffic volumes of all vehicles on a calendar by direction.

Daily Heavy Vehicle Volume Calendar displays the daily traffic volumes of heavy vehicles only on a

Source: https://trafficmap.mainroads.wa.gov.au/.

Figure B 3: MRWA Trafficmap page 3 of information sheet

calendar by direction.

Peak

The peak times of day where the highest volume of traffic was recorded.

- **Peak Volumes** are based on quarter hour intervals, for example 00, 15, 30, 45. The peak hour being the four consecutive quarter hours with the highest volume. The peak quarter hour being the highest volume in a single quarter hour period.
- The **Peak Time** is the start of the peak period. For example, a peak time of 08:45 represents vehicles counted between 08:45:00 and 09:44:59.

Speed of travel

Hourly Speed shows average speed of travel by vehicles passing through the location. Speeds reported are the median speed, also known as 50th percentile, and the 85th percentile speed.

Median is the figure used to demonstrate the typical speed of travel for each hour. Median is used in preference to mean, another commonly reported average, as it reduces the influence of outliers.

85th percentile speed is a commonly used statistic to show what speed the majority of vehicles were travelling at or under. Some calculations of this remove any vehicles travelling closer than a certain distance to other vehicles (usually 4 seconds) to ensure that the figure uses only "free-flowing" vehicles. In this report, all vehicles in the sampled period are used to determine this figure, regardless of proximity to other vehicles.

Hourly Speed Compliance provides the total number of vehicles passing through a location. The number and percentage of vehicles that were travelling under or at the speed limit i.e. not speeding and the percentage of vehicles that were travelling over the speed limit.

A further breakdown of speeding vehicles into the following speed intervals;

- Less than or equal to 10 km/h over the speed limit
- Greater than 10 up to and including 20km/h over the speed limit
- Greater than 20 up to and including 30km/h over the speed limit
- Greater than 30 up to and including 45km/h over the speed limit
- Greater than 45km/h over the speed limit

The **speed limit** is shown to give an indication of general compliance at the location, it should be noted that the speed shown is the current speed at that location, which may have changed since the collection took place.

Patterns and Trends

Daily Volumes shows the variation in daily traffic through an average week in the year.

Daily Volume by Month is a breakdown of the **Daily Volume** report into each individual month. This demonstrates the variations in the daily patterns caused by seasonal variation. For example, weekend traffic at a coastal location may be higher in summer than winter. Seasonal colours have been selected for each month to make it easier to see the trends with winter colours shown in shades of blue, spring in greens, autumn in reds and oranges, and summer months in purple.

Monthly Volume provides average weekday, daily and weekend volumes for each month in the latest available year, also referred to as seasonal variations.

Monthly Volume by Year combines the seasonal variation shown in the **Monthly Volume** report with annual changes in volume. Detailing the monthly traffic counts available within the previous six year period each year is shaded, with the oldest years being faintest.

Source: https://trafficmap.mainroads.wa.gov.au/.

B.2 Hourly Volume

Figure B 4: Example of the MRWA Trafficmap hourly volume report for a route

Hourly Volume

2018/19
Monday to Sunday

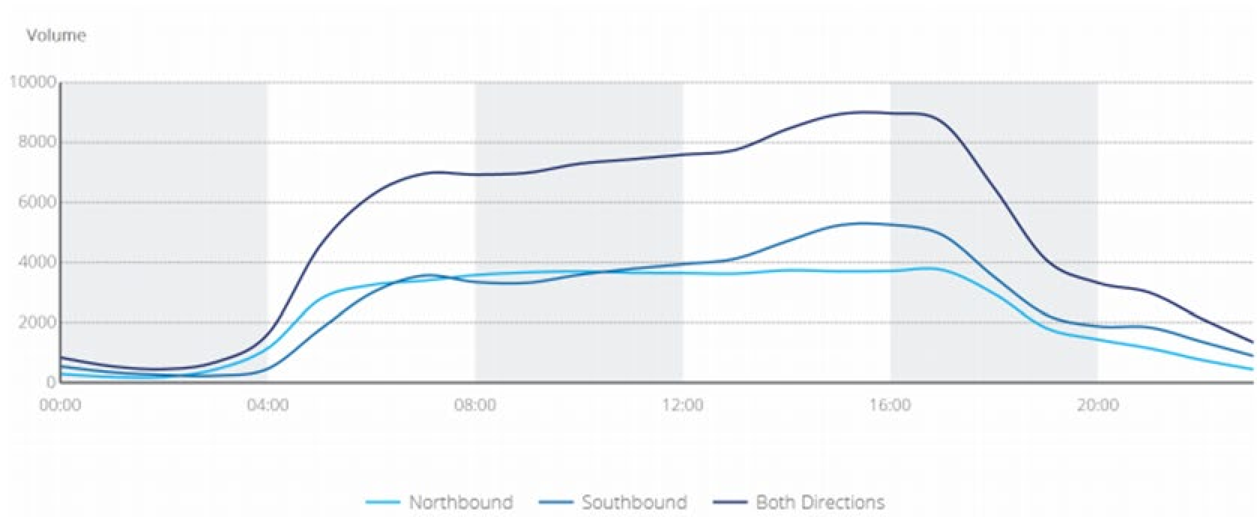
Kwinana Fwy (H015)

South of Roe Hwy (SLK 15.85)

	All Vehicles			Heavy Vehicles			
	NB	SB	Both	NB	SB	Both	%
00:00	295	550	845	27	40	67	7.9
01:00	198	355	553	20	31	51	9.2
02:00	196	263	459	29	31	60	13.1
03:00	458	240	698	60	36	96	13.8
04:00	1164	479	1643	137	73	210	12.8
05:00	2778	1780	4558	305	233	538	11.8
06:00	3254	2989	6243	392	488	880	14.1
07:00	3394	3564	6958	320	511	831	11.9
08:00	3580	3349	6929	346	487	833	12.0
09:00	3669	3321	6990	407	490	897	12.8
10:00	3703	3589	7292	443	518	961	13.2
11:00	3656	3783	7439	450	516	966	13.0
12:00	3648	3945	7593	437	507	944	12.4
13:00	3628	4124	7752	440	505	945	12.2
14:00	3737	4704	8441	421	509	930	11.0
15:00	3704	5236	8940	359	472	831	9.3
16:00	3716	5258	8974	297	380	677	7.5
17:00	3754	4920	8674	217	282	499	5.8
18:00	2963	3524	6487	152	190	342	5.3
19:00	1829	2270	4099	105	124	229	5.6
20:00	1440	1880	3320	78	98	176	5.3
21:00	1150	1843	2993	64	82	146	4.9
22:00	763	1369	2132	46	68	114	5.3
23:00	450	897	1347	38	45	83	6.2
TOTAL	57127	64232	121359	5590	6716	12306	10.1

Peak Statistics

		All Vehicles NB	All Vehicles SB	All Vehicles Both	Heavy Vehicles NB	Heavy Vehicles SB	Heavy Vehicles Both
AM	TIME	10:00	11:45	11:45	10:30	06:30	10:30
	VOL	3703	3913	7559	452	529	974
PM	TIME	16:45	15:30	15:30	13:00	13:45	13:30
	VOL	3786	5315	9016	440	510	946



Source: https://trafficmap.mainroads.wa.gov.au/.

B.3 Quarter Hourly Volume

Figure B 5: Example of the MRWA Trafficmap quarter hourly volume report for a route

Quarter Hourly Volume

Kwinana Fwy (H015)

South of Roe Hwy (SLK 15.85)

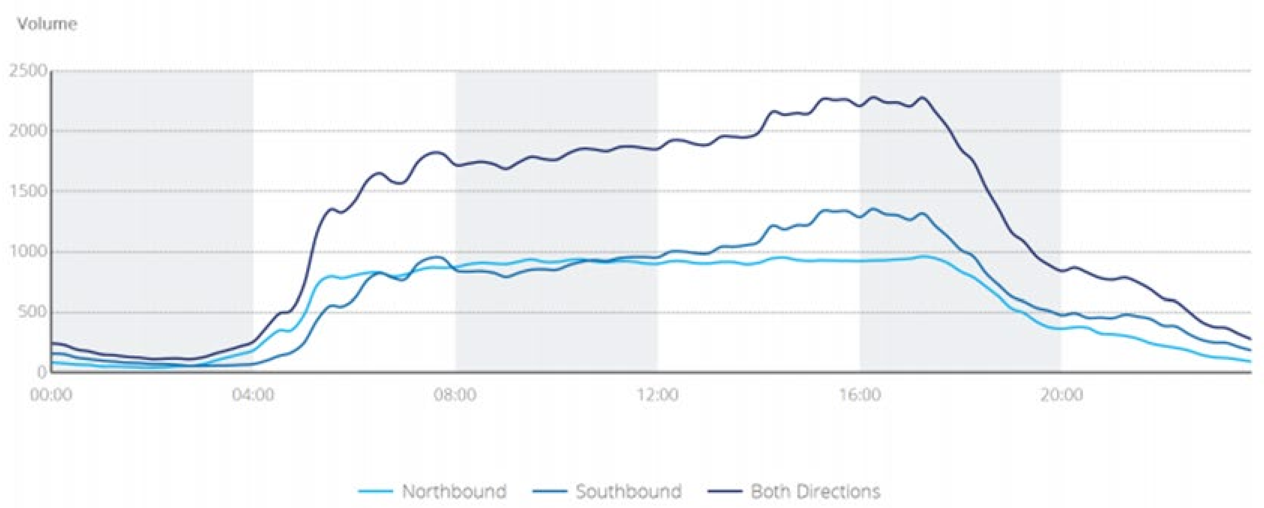
2018/19
Monday to Sunday

All Vehicles

	Northbound				Southbound				Both Directions			
	0	15	30	45	0	15	30	45	0	15	30	45
00:00	86	77	68	64	158	154	125	113	244	231	193	177
01:00	52	53	48	45	100	92	83	80	152	145	131	125
02:00	42	45	53	56	71	71	65	56	113	116	118	112
03:00	71	102	129	156	56	59	60	65	127	161	189	221
04:00	187	274	350	353	72	100	139	168	259	374	489	521
05:00	482	720	795	781	250	432	551	547	732	1152	1346	1328
06:00	805	825	828	796	615	765	824	785	1420	1590	1652	1581
07:00	811	847	869	867	773	898	948	945	1584	1745	1817	1812
08:00	873	896	908	903	848	836	839	826	1721	1732	1747	1729
09:00	898	918	937	916	791	825	851	854	1689	1743	1788	1770
10:00	915	931	938	919	850	890	918	931	1765	1821	1856	1850
11:00	912	922	919	903	924	948	955	956	1836	1870	1874	1859
12:00	901	921	921	905	954	1001	1002	988	1855	1922	1923	1893
13:00	903	915	914	896	987	1041	1041	1055	1890	1956	1955	1951
14:00	909	944	952	932	1084	1214	1186	1220	1993	2158	2138	2152
15:00	924	929	926	925	1227	1337	1334	1338	2151	2266	2260	2263
16:00	923	927	929	937	1288	1355	1313	1302	2211	2282	2242	2239
17:00	943	961	945	905	1266	1318	1214	1122	2209	2279	2159	2027
18:00	836	788	710	629	1016	961	822	725	1852	1749	1532	1354
19:00	534	495	423	377	631	589	537	513	1165	1084	960	890
20:00	365	377	372	326	476	492	455	457	841	869	827	783
21:00	318	306	282	244	452	481	465	445	770	787	747	689
22:00	223	206	185	149	390	383	322	274	613	589	507	423
23:00	128	122	108	92	251	248	213	185	379	370	321	277

Peak Statistics

		Northbound	Southbound	Both Directions
AM	TIME	10:30	11:45	11:30
	VOL	938	956	1874
PM	TIME	17:15	16:15	16:15
	VOL	961	1355	2282



Source: https://trafficmap.mainroads.wa.gov.au/.

B.4 AADT Volume by Vehicle Type

Figure B 6: Example of the MRWA Trafficmap AADT volume by vehicle type report for a route

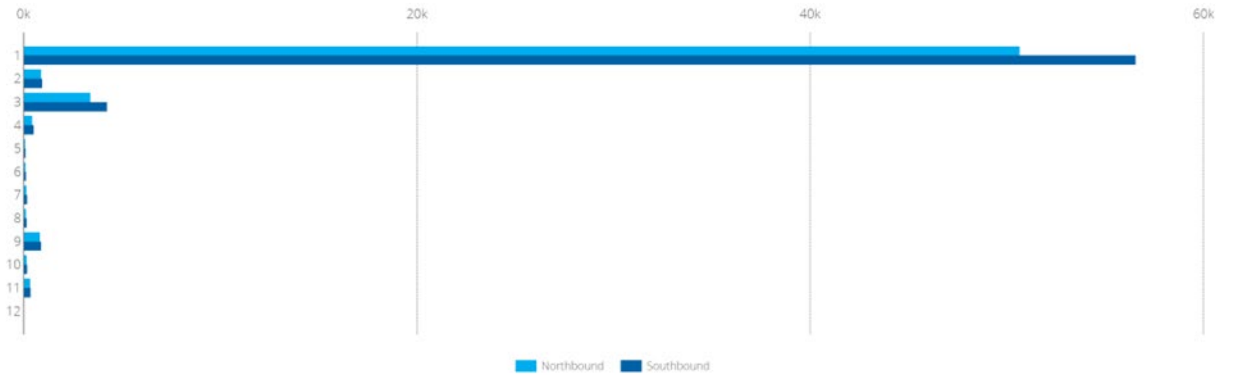
Vehicle Type

Kwinana Fwy (H015)

South of Roe Hwy (SLK 15.85)

2018/19

Monday to Sunday

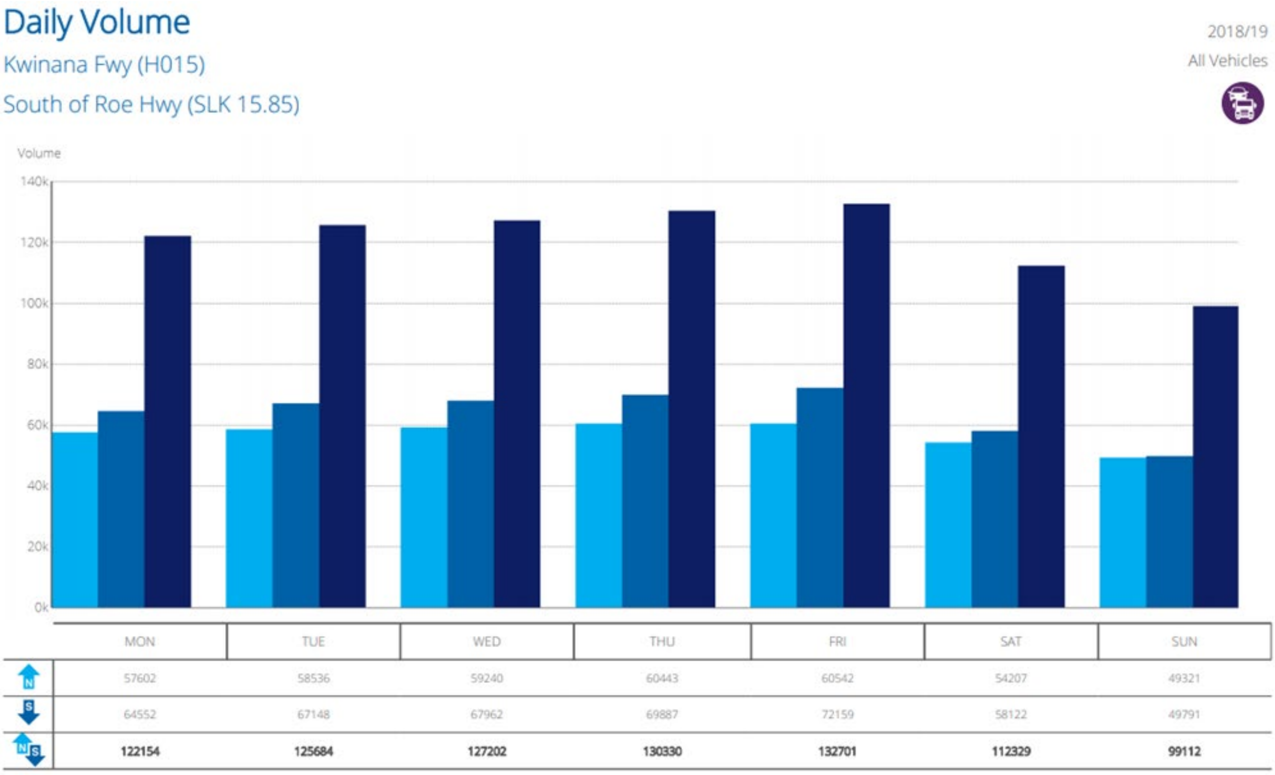


	Austroads Classification Scheme 1994													
	1	2	3	4	5	6	7	8	9	10	11	12	Heavy	Total
↑ N	50653	884	3388	443	86	92	135	127	824	160	331	4	5590	57127
%	88.7	1.5	5.9	0.8	0.2	0.2	0.2	0.2	1.4	0.3	0.6	0.0	9.8	
↓ S	56561	955	4237	517	103	125	169	148	882	174	356	5	6716	64232
%	88.1	1.5	6.6	0.8	0.2	0.2	0.3	0.2	1.4	0.3	0.6	0.0	10.5	
↑↓ NS	107214	1839	7625	960	189	217	304	275	1706	334	687	9	12306	121359
%	88.3	1.5	6.3	0.8	0.2	0.2	0.3	0.2	1.4	0.3	0.6	0.0	10.1	

Source: https://trafficmap.mainroads.wa.gov.au/.

B.5 Daily Volume

Figure B 7: Example of the MRWA Trafficmap daily volume report for a route

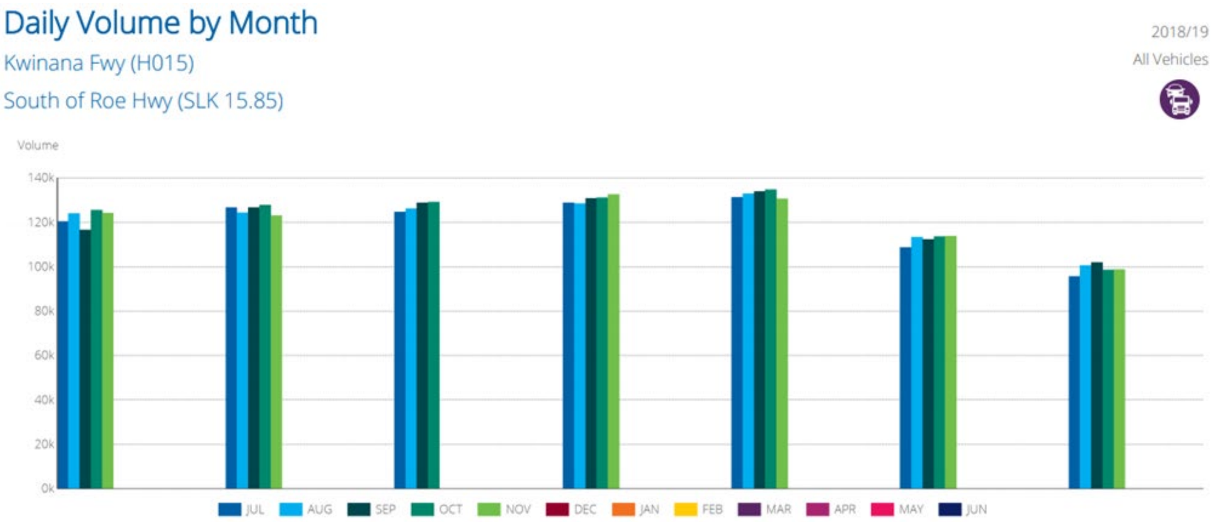


	MON	TUE	WED	THU	FRI	SAT	SUN
N	57602	58536	59240	60443	60542	54207	49321
S	64552	67148	67962	69887	72159	58122	49791
N S	**122154**	**125684**	**127202**	**130330**	**132701**	**112329**	**99112**

Source: https://trafficmap.mainroads.wa.gov.au/.

B.6 Daily Volume by Month

Figure B 8: Example of the MRWA Trafficmap daily volume by month report for a route

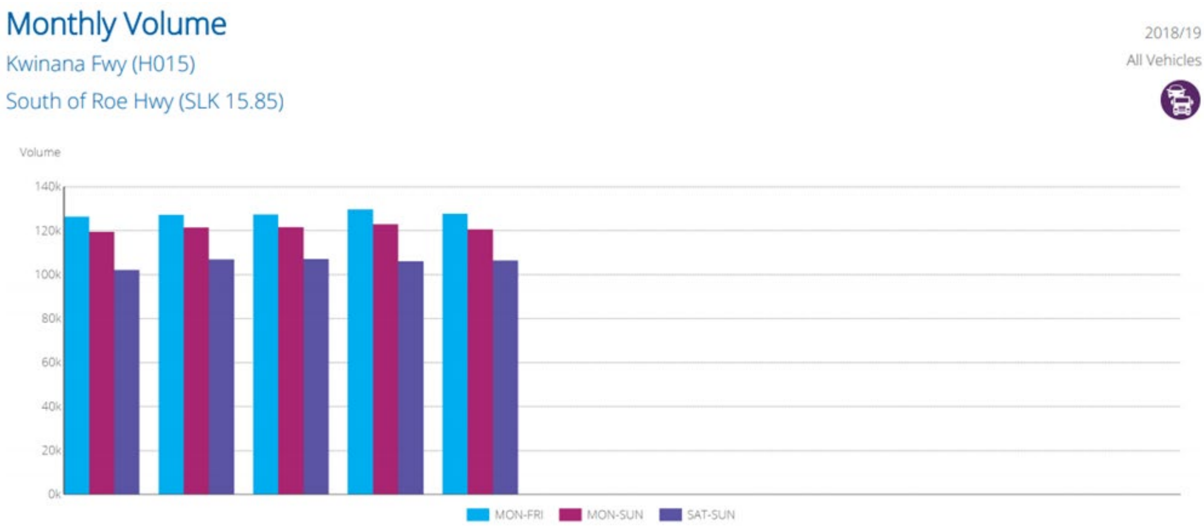


	MON	TUE	WED	THU	FRI	SAT	SUN
JUL	120441	126665	124756	128772	131291	108607	95652
AUG	123987	124304	126125	128503	132996	113246	100640
SEP	116608	126687	128855	130701	133928	112297	101909
OCT	125583	127806	129073	131119	134681	113652	98536
NOV	124153	122959		132559	130612	113841	98822
DEC							
JAN							
FEB							
MAR							
APR							
MAY							
JUN							

Source: https://trafficmap.mainroads.wa.gov.au/.

B.7 Monthly Volume

Figure B 9: Example of the MRWA Trafficmap monthly volume report for a route

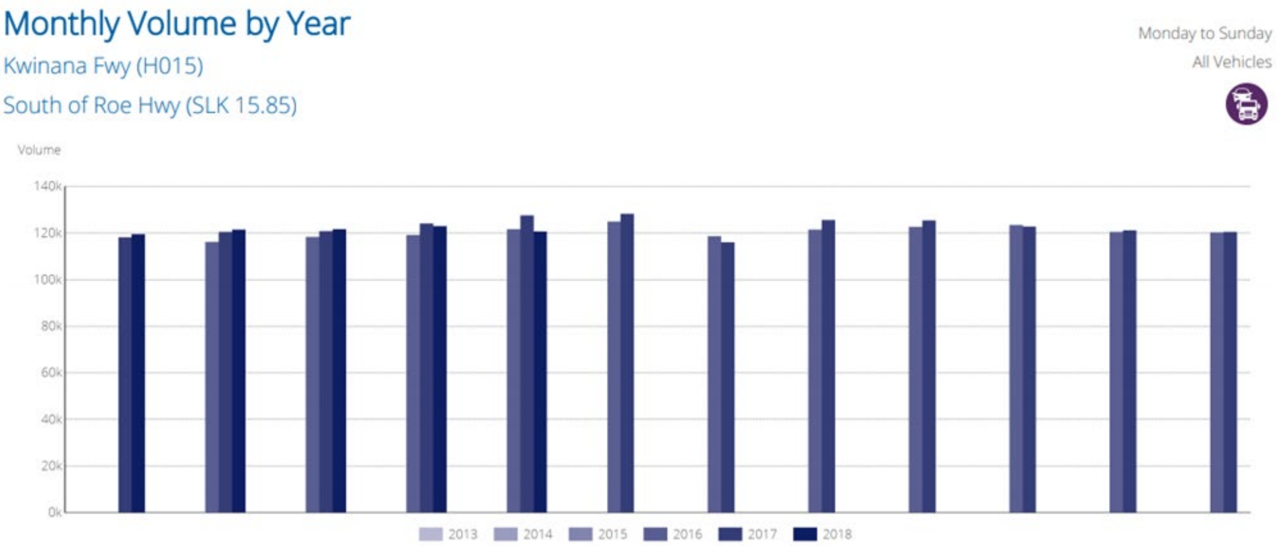


	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
MON-FRI	126385	127183	127356	129652	127571							
MON-SUN	119455	121400	121569	122921	120492							
SAT-SUN	102130	106943	107103	106094	106332							

Source: https://trafficmap.mainroads.wa.gov.au/.

B.8 Monthly Volume by Year

Figure B 10: Example of the MRWA Trafficmap monthly volume by year report for a route

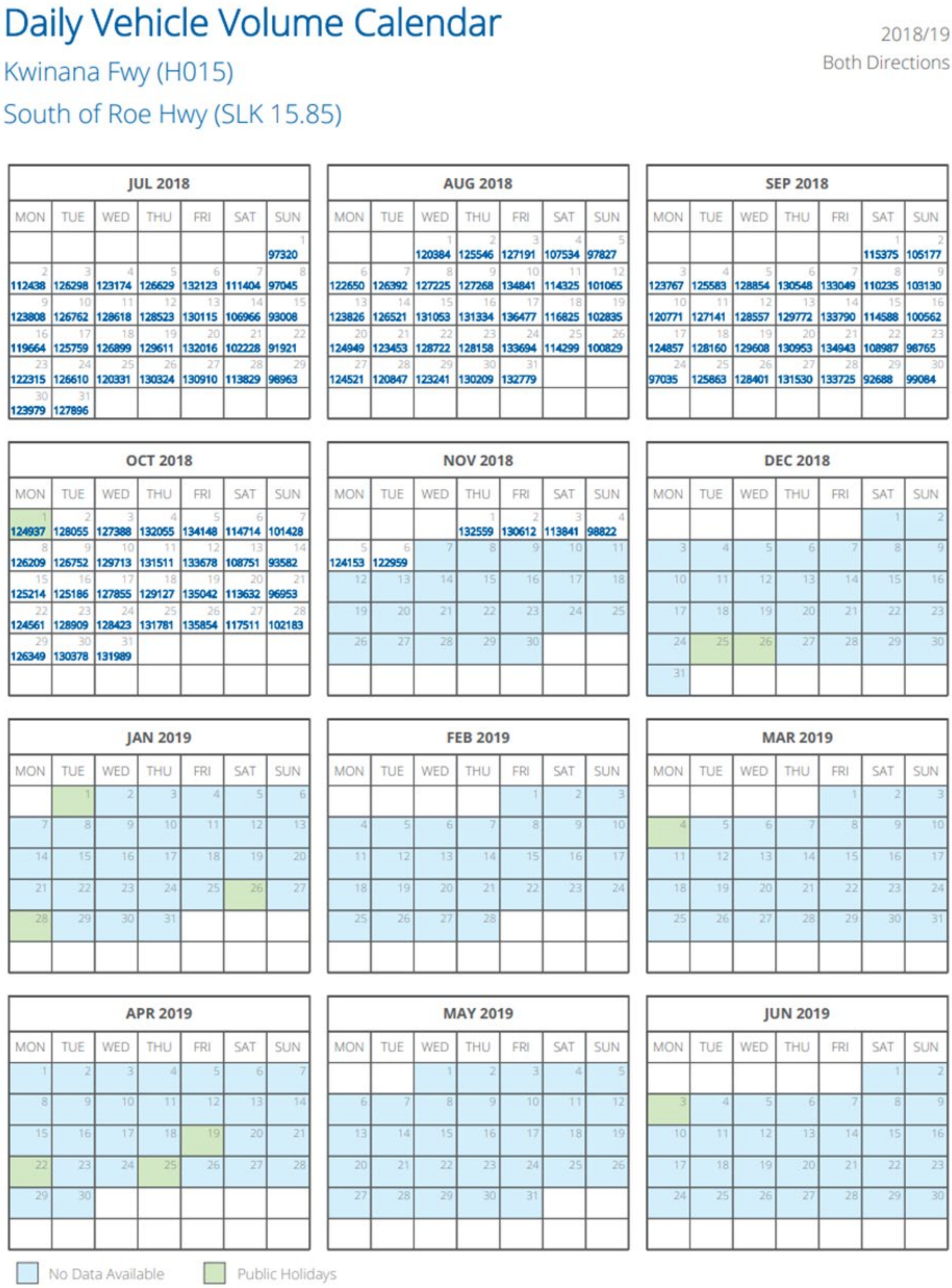


	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
2018/19	119455	121400	121569	122921	120492							
2017/18	118073	120444	120717	123956	127441	128195	115993	125431	125283	122763	121029	120367
2016/17		116073	118207	119140	121519	124831	118658	121424	122593	123403	120384	120301
2015/16												
2014/15												
2013/14												

Source: https://trafficmap.mainroads.wa.gov.au/.

B.9 Daily Vehicle Volume Calendar

Figure B 11: Example of the MRWA Trafficmap daily vehicle volume calendar for a route



JUL 2018

MON	TUE	WED	THU	FRI	SAT	SUN
						1: 97320
2: 112438	3: 126298	4: 123174	5: 126629	6: 132123	7: 111404	8: 97045
9: 123808	10: 126762	11: 128618	12: 128523	13: 130115	14: 106966	15: 93008
16: 119664	17: 125759	18: 126899	19: 129611	20: 132016	21: 102228	22: 91921
23: 122315	24: 126610	25: 120331	26: 130324	27: 130910	28: 113829	29: 98963
30: 123979	31: 127896					

AUG 2018

MON	TUE	WED	THU	FRI	SAT	SUN
		1: 120384	2: 125546	3: 127191	4: 107534	5: 97827
6: 122650	7: 126392	8: 127225	9: 127268	10: 134841	11: 114325	12: 101065
13: 123826	14: 126521	15: 131053	16: 131334	17: 136477	18: 116825	19: 102835
20: 124949	21: 123453	22: 128722	23: 128158	24: 133694	25: 114299	26: 100829
27: 124521	28: 120847	29: 123241	30: 130209	31: 132779		

SEP 2018

MON	TUE	WED	THU	FRI	SAT	SUN
					1: 115375	2: 105177
3: 123767	4: 125583	5: 128854	6: 130548	7: 133049	8: 110235	9: 103130
10: 120771	11: 127141	12: 128557	13: 129772	14: 133790	15: 114588	16: 100562
17: 124857	18: 128160	19: 129608	20: 130953	21: 134943	22: 108987	23: 98765
24: 97035	25: 125863	26: 128401	27: 131530	28: 133725	29: 92688	30: 99084

OCT 2018

MON	TUE	WED	THU	FRI	SAT	SUN
1: 124937	2: 128055	3: 127388	4: 132055	5: 134148	6: 114714	7: 101428
8: 126209	9: 126752	10: 129713	11: 131511	12: 133678	13: 108751	14: 93582
15: 125214	16: 125186	17: 127855	18: 129127	19: 135042	20: 113632	21: 96953
22: 124561	23: 128909	24: 128423	25: 131781	26: 135854	27: 117511	28: 102183
29: 126349	30: 130378	31: 131989				

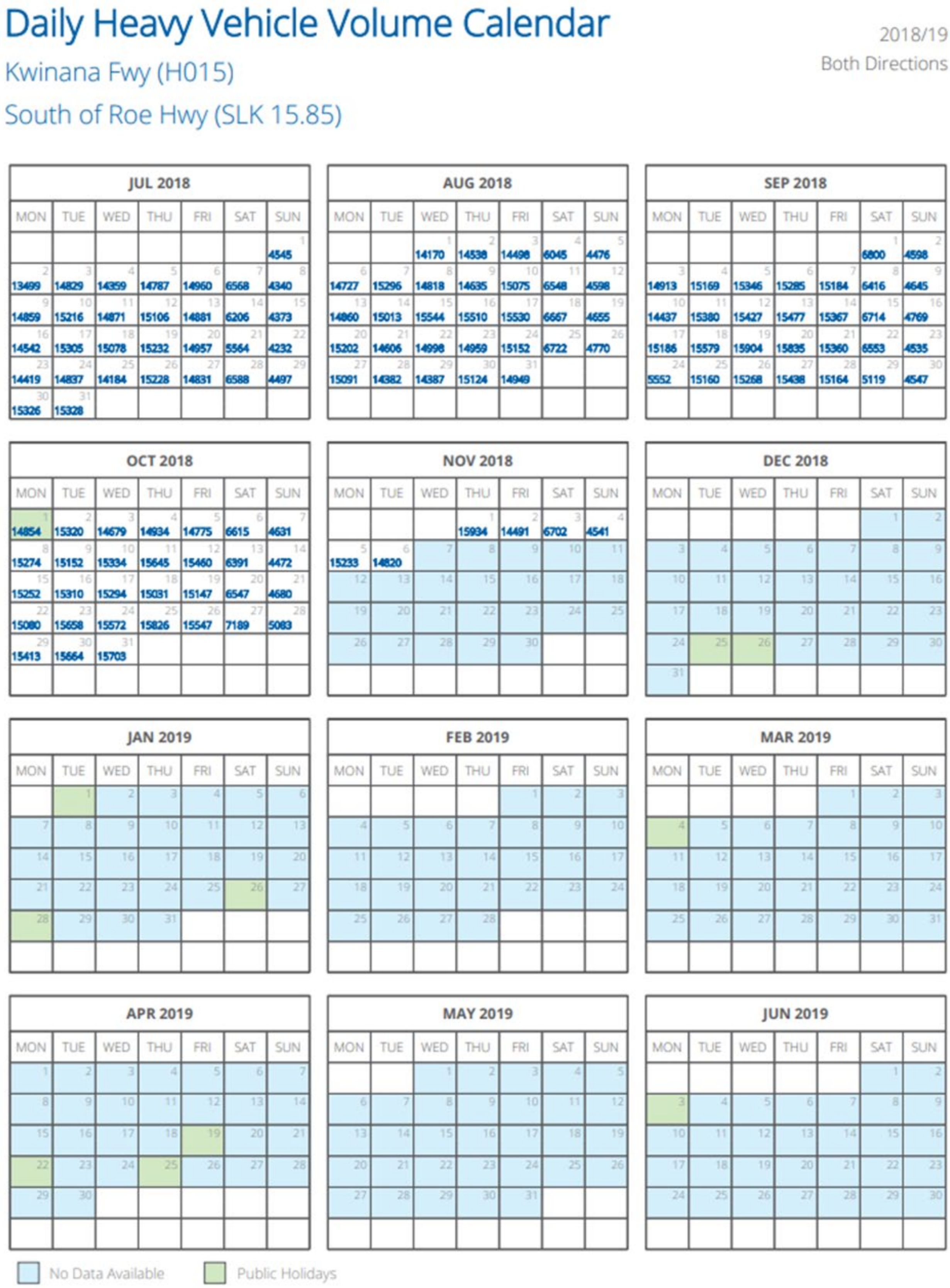
NOV 2018

MON	TUE	WED	THU	FRI	SAT	SUN
			1: 132559	2: 130612	3: 113841	4: 98822
5: 124153	6: 122959	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Source: https://trafficmap.mainroads.wa.gov.au/.

B.10 Daily Heavy Vehicle Volume Calendar

Figure B 12: Example of the MRWA Trafficmap daily heavy vehicle volume calendar for a route



Source: https://trafficmap.mainroads.wa.gov.au/.

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Research Report
AP-R656F-21

Data to Support the Heavy Vehicle Road Reform Part F

Alignment of Expenditure Reporting Data

Data to Support the Heavy Vehicle Road Reform Part F: Alignment of Expenditure Reporting Data

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part F documents an investigation of potential causes in differences between forecast and actual data submitted by jurisdictions to the NTC as part of the development of a forward-looking cost base model.

Keywords

Expenditure, Forecast, Actual, Operational, Capital, Forward looking cost base, FLCB, PAYGO

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About Austroads

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

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

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

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

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

This report has been prepared for Austroads as part of its work to promote improved Australian and New Zealand transport outcomes by providing expert technical input on road and road transport issues.

Individual road agencies will determine their response to this report following consideration of their legislative or administrative arrangements, available funding, as well as local circumstances and priorities.

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Summary

For the past few years, the National Transport Commission (NTC) has requested data from Australian jurisdictions on their forecast and actual road expenditure in order to develop a prototype forward-looking cost base (FLCB) model. The objective of Part F is to provide an understanding of the issues currently being experienced in the provision of FLCB data and to propose any available solutions for providing improved confidence in FLCB data.

The quality of expenditure data provided by states and territories to the NTC has improved year by year since FLCB-compliant expenditure forecasts were first collected (jurisdictions have been providing expenditure data for PAYGO since the 1990s). However, a key concern remains regarding the divergence between forecast and actual expenditure. Additionally, there are concerns related to an inability to explain differences in expenditure between the FLCB and PAYGO expenditure categories.

While only two years of FLCB expenditure data was available, an analysis was conducted to indicate the magnitude of the discrepancy between forecast and actual expenditure. The general finding was that actual operating expenditure was always greater than forecast, while actual capital expenditure was in most cases less than forecast.

To improve understanding of the discrepancy issues, the NTC held discussions with each state and territory road agency during March and April 2019. The format of these discussions was a mix of face-to-face meetings and teleconferences. These discussions were focused on trying to improve the quality of the data provided for the FLCB modelling, including developing a better understanding of the process used to provide data.

Responses from the jurisdictions and other discussions were used to develop a further ARRB survey that endeavoured to:

- gain a greater understanding of the details of how each jurisdiction went about translating their internal expenditure reports into FLCB categories
- understand more about the causes of 'unexpected expenditure' that could lead to forecasts not matching actual expenditure.

Overall, the responses received indicated that translating between an organisation's own cost categories and the FLCB expenditure categories was less of an issue for the A, B, and D groups of categories, while the majority of problems experienced by the majority of respondents were in category group C: *Renewal, Upgrade and Expansion Expenditure*.

Many respondents reported or provided information that showed that it was not possible to relate the FLCB categories to specific organisational categories due to fundamental differences in how the categories are structured. In these cases, FLCB expenditure data was determined through a highly manual process.

As each of the road agencies or departments of transport have different internal structures and processes and these are expected to remain different for the foreseeable future, the desired outcome is that despite these differences the forecast expenditure is broadly considered transparent and reliable.

With this desired outcome in mind, the following approaches are offered as means of potentially increasing confidence in the FLCB:

- Confidence signalling – giving organisations the confidence to invest internally in improved processes for producing FLCB data according to the current guidelines.
- Alternative categorisation for capital expenditure – responding to organisations' feedback to develop purpose-focused categories.

- Margin of variance – to communicate expectations of understood and acceptable variance between forecast and actual expenditure.

The key issue arising from the investigation in Part F is the same fundamental issue encountered in other areas of this project. That is, developing reliable, nationally consistent data is a long-term process that while it must begin with enforcing nationally consistent reporting of data, it can only move towards true national consistency as individual jurisdictions adopt consistent systems and processes. This will require strategies that incentivise the necessary internal development within organisations to move towards national consistency at the fundamental level.

Contents

Tables

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1. Introduction

1.1 Background

The project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* objective is to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

1.2 Purpose

For the past few years, the National Transport Commission (NTC) has requested data from Australian jurisdictions on their forecast and actual expenditure in order to develop a forward-looking cost base (FLCB) model. The data that has been provided so far has had several issues:

- Some datasets have been incomplete.
- There has been a significant difference between the forecast and actual expenditure.
- The underlying causes of inconsistencies are not clear.

What is needed is to establish confidence in the accuracy of the FLCB model. The objective of Part F is therefore to provide an understanding of the issues currently being experienced in the provision of FLCB data and proposing any available solutions for providing improved confidence in FLCB data.

1.3 Scope

This investigation is based on:

- two years of data available (the forecast and actual expenditure for 2017–18 and 2018–19) from seven jurisdictions
- responses from all eight state and territory road agencies to two surveys.

Due to the limited data available, the results of this investigation are considered to be indicative only.

1.4 Methodology

Section 2 summarises the results of the previous NTC survey of the jurisdictions, which served as a background to a new survey of the jurisdictions.

Section 3 presents an analysis of the magnitude of the inconsistencies between the forecast and actual FLCB expenditure in order to quantify the extent of the problem. These results have been anonymised.

Section 4 contains the findings from an analysis of potential sources of inconsistency that can arise within the reporting of FLCB data. This includes an identification of key differences that can exist between jurisdictions and lead to inconsistencies between FLCB data reported from different parts of Australia.

Section 5 presents several potential improvements that could be made in the development and reporting of FLCB data to minimise the inconsistencies identified in Sections 2 and 3.

2. Previous NTC Survey of Jurisdictions

2.1 Background to Previous Survey

The quality of data provided by states and territories to the NTC has improved year by year since FLCB-compliant expenditure forecasts were first collected (jurisdictions have been providing expenditure data for PAYGO since the 1990s). However, a key concern remains regarding the divergence between forecast and actual expenditure. Additionally, there are concerns related to an inability to explain differences in expenditure between the FLCB and PAYGO expenditures.

To improve understanding of these issues, the NTC held discussions with each state and territory road agency during March and April 2019. The format of these discussions was a mix of face-to-face meetings and teleconferences. These discussions were focused on trying to improve the quality of the data provided for the FLCB model, including developing a better understanding of the process used to provide data in 2018. As part of the discussions, high-level comparison of the following four sources of forecast and actual expenditure data were shown to participants:

- actual FLCB expenditure for 2017–18 (provided to the NTC in mid-2018)
- forecast FLCB expenditure for 2017–18 (provided to the NTC in mid-2017)
- actual FLCB expenditure for 2018–19 (provided to the NTC in mid-2019)
- forecast FLCB expenditure for 2018–19 (provided to the NTC in mid-2018).

The key purpose of the discussions was to try to improve the data to be provided later that year (2018–19 actual and 2019–20 forecast expenditure) and any future years. The discussions helped the NTC to better understand the areas of difficulty for states and territories, such as the timing of the request. In response, the timing of the information request was amended by sending it out to states and territories earlier and having a later due date. Greater explanation was also provided about the context in which the various types of data were sought and how it was to be used.

2.2 Findings from Previous Survey

Of the 12 questions asked (see Table 2.1), the responses to five focusing on FLCB data quality are of particular interest to the current analysis.

Table 2.1: Discussion questions from the previous NTC survey

No.	Discussion question	Focus
1	Are the same people at your agency/department involved in preparing the PAYGO and FLCB expenditure returns?	PAYGO-FLCB consistency
2	Is the same underlying expenditure data source used for the PAYGO expenditure and actual FLCB expenditure?	PAYGO-FLCB consistency
3	Is the same broad approach used to translate the data from the format in the source data into the relevant expenditure categories (for example, using a 'representative' project to derive high level proportions)? If not, why are different approaches used, and do you have a view on which approach is likely to be more accurate/reflective of reality?	PAYGO-FLCB consistency
4	Is there any difficulty in translating from the source data into the FLCB's expenditure categories, given the higher number of categories?	FLCB data quality

No.	Discussion question	Focus
5	Did you attempt any sort of check last year to verify the consistency of the PAYGO and FLCB expenditure amounts for 2017–18 (recognising that this was not explicitly requested)? For example, checking that the totals match, and that the allocation to different categories were broadly in alignment?	PAYGO-FLCB consistency
6	To the best of your knowledge, is there any expenditure that is included in the reported FLCB expenditure that is not included in PAYGO (or vice versa)? For example, scope differences such as cycle paths, footpaths, etc.?	PAYGO-FLCB consistency
7	Are the FLCB expenditure guidelines clear and easy to follow? For example, about what expenditure should be included/excluded and whether expenditure should be classified as capital expenditure or operating expenditure?	FLCB data quality
8	Does the timing of the request for information (in 2018, responses were requested by 3 August) limit your ability to provide the information in the requested format? If yes, how much additional time would be required? Is the same situation applicable to forecast expenditure data as well?	FLCB data quality
9	What were the source(s) of your FLCB expenditure forecasts (for example, project pipeline forecasts, budget estimates, etc.)?	FLCB data quality
10	Do you think that there may be some expenditure being included in the FLCB forecasts that is specifically excluded under PAYGO (for example, due to the reduced detail available in the source data for the forecasts, relative to actual expenditure data used for PAYGO)?	PAYGO-FLCB consistency
11	Is the data source used to derive forecasts for the FLCB typically expected to over or under-state actual expenditure? If yes, what are the reasons for this? Do you have an estimate of how much the typical over/underspend is likely to be (dollar or percentage)?	FLCB data quality
12	Do you anticipate any imminent changes/improvements in the availability of forecast data in the future? This could include both changes to the level of detail available (requiring changes to the assumptions needed to translate the data into the common FLCB expenditure categories) or changes to the number of years of data available?	Continued availability & quality of data

Full responses from seven jurisdictions were available for analysis. Responses to the five relevant questions were analysed to identify any common themes that would inform the current analysis. The generalised responses to the questions relating to FLCB data quality are presented below.

Question 4: Translating from source data into FLCB expenditure categories

Jurisdictions generally commented that the difficulty associated with translating data from their own systems into the expenditure categories required by the FLCB Guidelines depended largely on the similarity of categories. Specifically:

- Three jurisdictions reported no difficulty or high manageability when it came to translating expenditure categories; however, the task was noted to be time-consuming.
- Two jurisdictions reported some level of difficulty based on assumptions and other subjective decisions required to determine an answer where expenditure categories did not obviously match.
- Two jurisdictions reported that there was some challenge in translating expenditure categories due to how different they were, with one jurisdiction citing the complexity of the information sought.

Question 7: Clarity of FLCB expenditure guidelines

Six jurisdictions commented that the Guidelines were clear and easy to follow, with only one jurisdiction reporting some degree of challenge. Even so, there were specific suggestions relating to various areas of expenditure where assumptions needed to be made or other subjective judgments. In particular, two jurisdictions raised questions about whether expenditure should be classified by its purpose or by the asset it is invested in.

As noted above, the NTC has addressed some of these issues in subsequent communications.

Question 8: Timing of the FLCB request

The response across all jurisdictions was that August was not an ideal time for them to be obtaining the requested information, suggesting after August would be better. Of concern to this analysis is the situation where data is requested when it is not yet available, and therefore that assumptions or incomplete data may be used to provide answers, thereby leading to later inconsistencies.

Question 9: Source of forecast expenditure

Expenditure forecasts across all respondents are based on budgets and approved funding, which tends to be at a high level and can end up deviating from actual expenditure due to:

- only major projects being identified in any detail, while smaller projects are not
- projects (even larger projects) usually have no breakdown of what the expenditure is per asset type
- additional funding and/or projects may be approved over the course of the year.

Question 11: Typical over- or under-estimation of forecast expenditure

Responses indicated that actual expenditure may be above or below what was forecast between different years, and the amount of this discrepancy is difficult to quantify. There was a variety of reasons given for the discrepancy, which included redistributing funds to different projects/works due to completion delays caused by circumstances such as:

- prolonged delivery of work
- weather preventing work
- delays in the finalisation of promised funding.

These responses from the jurisdictions and other discussions were used to develop a further survey that endeavoured to:

- gain a greater understanding of the details of how each jurisdiction went about translating expenditure categories
- understand more about the causes of unexpected expenditure that could lead to forecasts not matching actual expenditure.

The analysis of the responses is presented in Section 4.

3. Magnitude of Inconsistencies

3.1 FLCB Forecast versus Actual

The following two years of submissions to the NTC from seven jurisdictions were available for analysis:

- FLCB forecast vs actuals for financial year 2017–18
- FLCB forecast vs actuals for financial year 2018–19.

The NTC has amended the guidance and requirements for the FLCB submission each year to allow jurisdictions to improve their forecasting. This means that quantifying the magnitude of inconsistency is an exercise in understanding the features in the broadest possible terms. Extending this analysis with additional data from 2019–20 and subsequent years will yield a better understanding of the magnitude of inconsistencies.

Figure 3.1 and Figure 3.2 show comparisons of forecast vs actual total expenditure for years 2017–18 and 2018–19, respectively. The limited observations that can be drawn from these results are as follows:

- An apparent improvement has been achieved in the 2018–19 financial year for the three larger networks.
- Overall, the discrepancy across all of the seven included jurisdictions was on average a factor of 1.19 in 2017–18, and 1.26 in 2018–19; however, this corresponded to an average discrepancy value of $38.76 million in 2017–18, and $19.83 million in 2018–19.
- Across both financial years, the total forecast expenditure more commonly underestimated the actual expenditure.

Figure 3.1: Forecast vs actual FLCB total expenditure for financial year 2017–18 for jurisdictions (anonymised as numbers 1 to 7)

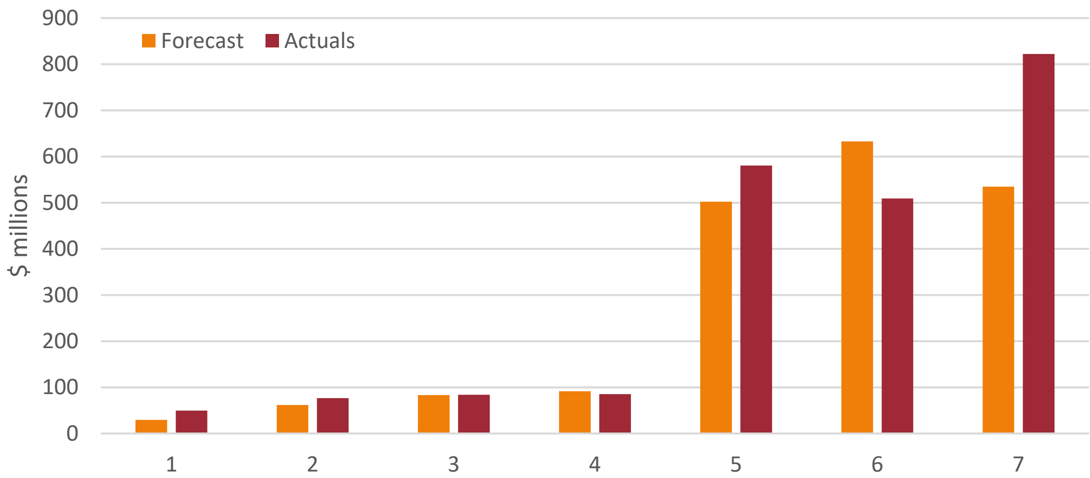
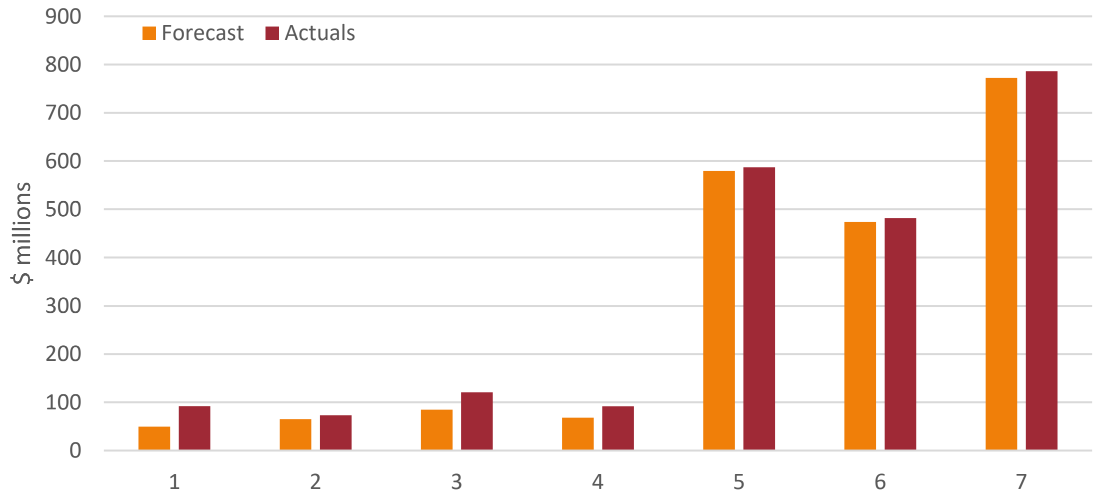


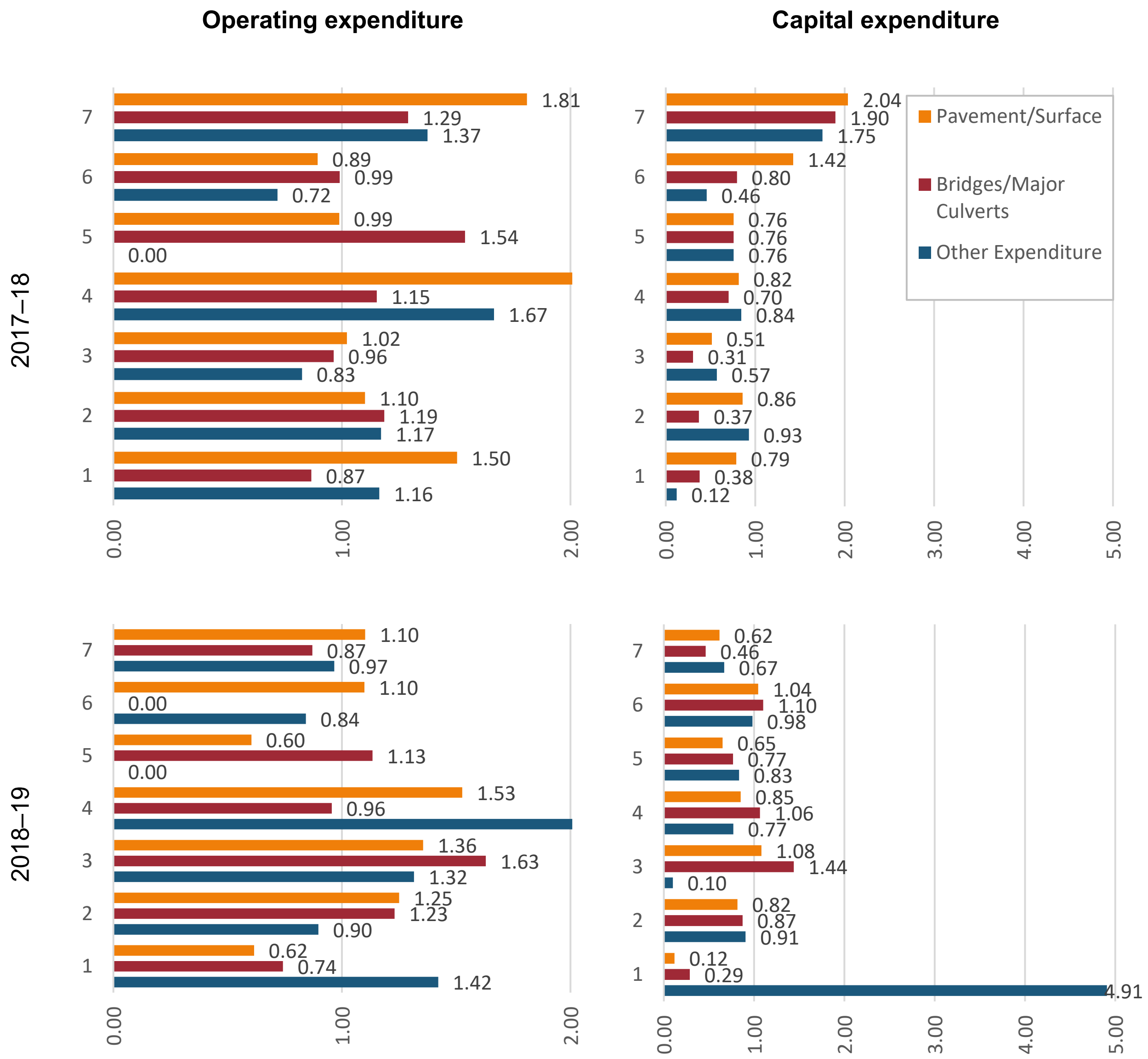
Figure 3.2: Forecast vs actual FLCB total expenditure for financial year 2018–19 for jurisdictions (anonymised)



Examining the difference between forecast and actual expenditure in greater detail, a breakdown of operating vs capital expenditure for roads, structures and other expenditure was undertaken to identify any notable features.

Figure 3.3 shows the difference between the forecast and actual expenditure for each expenditure category area (i.e. roads, structures and other) as multiplication factors, i.e. the actual expenditure divided by the forecast expenditure.

Figure 3.3: Difference (as a multiplication factor) between actual and forecast expenditure by financial year and expenditure type for jurisdictions (anonymised)



Note: A value less than 1 indicates the forecast expenditure overestimated the actual expenditure.

These results show that:

- The 4.91 times actual capital expenditure over the forecast capital expenditure in 2018–19 for one jurisdiction was due to major new capital works and upgrade programs announced within that financial year and is therefore treated as an outlier in this analysis.
- Actual capital expenditure usually did not reach the forecast level, potentially because of delivery delays.
- Jurisdictions, or expenditure areas that show actual expenditure exceeding forecast expenditure were not consistent and likely the result of new projects announced during that financial year.
- There was no consistent over or under forecasting of expenditure for any expenditure area across jurisdictions.
- Actual operating expenditure for each expenditure category generally varied between 0.6 and 2.0 times forecast expenditure.

Table 3.1 averages the data shown in Figure 3.3 across all of the seven featured jurisdictions.

Table 3.1: Average factor across jurisdictions of difference between actual and forecast expenditure

Financial year	Expenditure category	Operating expenditure		Capital expenditure	
		Average	Std. dev.	Average	Std. dev.
2017–18	Pavement/surface	1.33	0.41	1.03	0.48
	Bridges/major culverts	1.14	0.21	0.74	0.51
	Other expenditure	1.15	0.32	0.78	0.47
2018–19	Pavement/surface	1.08	0.33	0.74	0.30
	Bridges/major culverts	1.09	0.29	0.86	0.36
	Other expenditure	1.32	0.56	1.31	1.49
	(outlier removed)	(1.09)	(0.23)	(0.71)	(0.29)

While more in-depth analysis of individual cost category items within each expenditure area is possible, with only two years of data available, the extent of the above analysis is considered to be appropriate. If this analysis is extended in the future, analysis of individual expenditure categories would be warranted and useful.

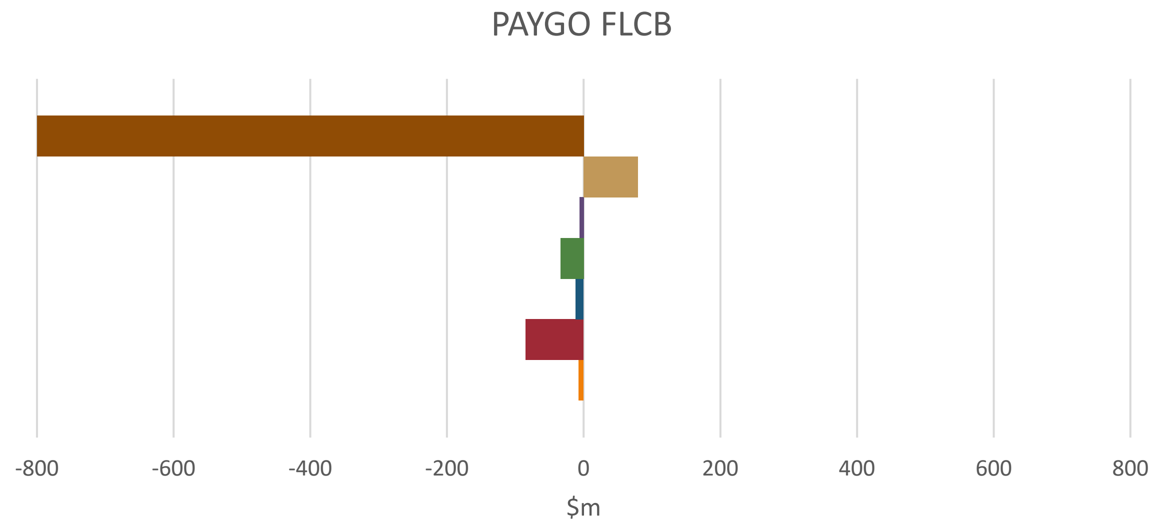
With the limits of the current analysis stated, it appears that while operating expenditure is more likely to have a greater contribution to the forecast-actual discrepancy than capital expenditure, no expenditure area stands out as being a key contributor to said discrepancies.

3.2 FLCB versus PAYGO

While PAYGO is known to have some limitations, it is the established approach, and confidence in the FLCB approach depends to some extent on comparisons of total expenditure under each approach, with any differences being transparent and justified. This section provides a comparison of the magnitude of the total expenditure as determined by PAYGO and the FLCB as a starting point to understanding where differences may lie.

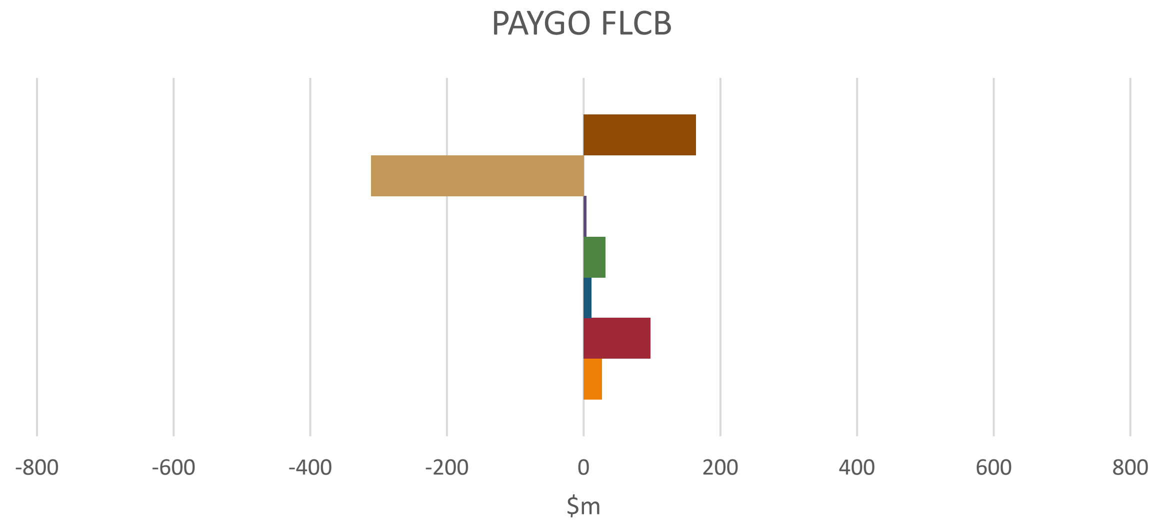
A comparison between the capital, operating and total expenditure actuals for FLCB and PAYGO are shown below in Figure 3.4, Figure 3.5, and Figure 3.6, respectively. Only one year of data was available for the comparison, but the comparison yielded a number of observations that there may be value in determining the validity of as data for additional years becomes available.

Figure 3.4: Difference between PAYGO and FLCB capital expenditure (actuals) in financial year 2018–19 for seven Australian jurisdictions (anonymised)



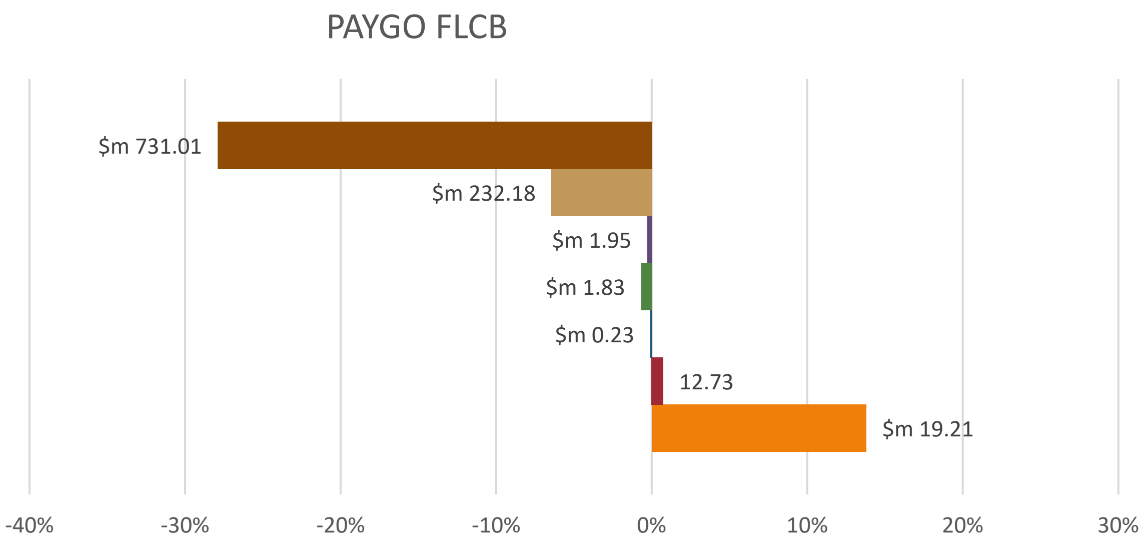
Note: A negative amount indicates how much greater the PAYGO actuals were compared to the FLCB actuals, and vice versa for the positive amounts.

Figure 3.5: Difference between PAYGO and FLCB operating expenditure (actuals) in financial year 2018–19 for seven Australian jurisdictions (anonymised)



Note: A negative amount indicates how much greater the PAYGO actuals were compared to the FLCB actuals, and vice versa for the positive amounts.

Figure 3.6: Difference between PAYGO and FLCB total actuals as a percentage in financial year 2018–19 for seven Australian jurisdictions (anonymised)



Note: A negative percentage indicates how much greater the PAYGO actuals were compared to the FLCB actuals, and vice versa for the positive percentages.

A more detailed analysis of the comparison between the 2018–19 FLCB and PAYGO datasets showed that:

- For capital expenditure, it was more common for the PAYGO actuals to be greater than the FLCB actuals.
- For capital expenditure, across the majority of jurisdictions the greater part of the discrepancy was due to expenditure on pavements and surfaces rather than on structures (by a factor of up to 5).
- For operating expenditure, it was more common for the FLCB actuals to be greater than the PAYGO actuals.
- For operating expenditure, across the majority of jurisdictions the greater part of the discrepancy was due to expenditure on pavements and surfaces rather than on structures (by factors of between 5 and 20).
- There was no correlation between the size/value of the network and the amount of discrepancy between PAYGO and FLCB.
- There was no obvious tendency for ‘other’ expenditure under both operating and capital expenditure – but the amount of discrepancy was usually comparable to both pavements and surfaces, and structures.

4. Cause of Inconsistencies

4.1 ARRB 2020 Survey

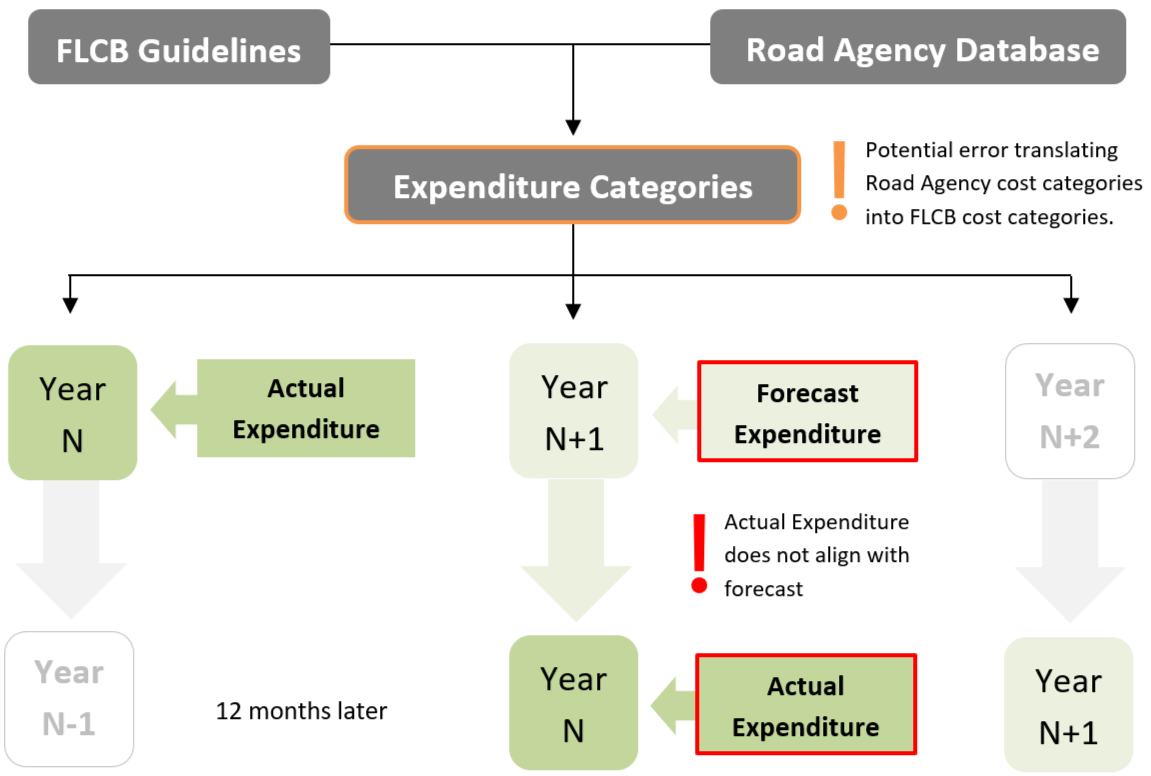
To gain further insight into the processes used by Australian road agencies to produce expenditure reports, a survey of jurisdictions was undertaken in July 2020. Three jurisdictions responded directly to the survey form, two provided explanatory documents and spreadsheets, and two jurisdictions provided their response via online meetings and presentations.

The survey focused on two key areas:

- the methods by which the cost categories are interpreted within each organisation, e.g. if the organisation's own expenditure categories are split or combined to match with the FLCB expenditure categories; and the rationale these methods are based on
- examples of unplanned expenditure that are known to occur, and the typical amount of expenditure.

Based on preceding discussions with the NTC, these areas are regarded as the two key causes of discrepancies arising from the process of developing expenditure data (represented in Figure 4.1). Responses to the ARRB survey on these two key causes are examined in the following subsections.

Figure 4.1: Representation of FLCB processes and locations of potential inconsistencies



4.2 Translation of Expenditure Categories

The expenditure categories provided in the FLCB Guidelines (NTC 2019) are intended to be at a higher level than how categories may be broken down within organisations (in a way that may be unique to that organisation); but when these more detailed categories are grouped the overall expenditure is accurate. Therefore, the extent to which lower-level organisational categories can be grouped within the higher level FLCB categories is important. It should be noted that PAYGO categories are also susceptible to this issue.

Overall, the responses received indicated that translating between an organisation's own cost categories and the FLCB expenditure categories was less of an issue for the A, B, and D groups of categories, while most of the problems experienced by the majority of respondents were in category group C – *Renewal, Upgrade and Expansion Expenditure*.

Many respondents reported or provided information that showed that it was not possible to relate the FLCB categories to specific organisational categories due to fundamental differences in how the categories are structured. In these cases, FLCB expenditure data was determined through a highly manual process.

A number of respondents reported that their organisation's cost categories were split between FLCB expenditure categories because the latter do not exist in their systems. One example of this is from the Queensland Department of Transport and Main Roads, which categorises expenditure based on its purpose rather than the type of surfacing (i.e. rigid, flexible, or unsealed) or structure (i.e. bridge, culvert or retaining wall). This splitting was evident in a number of expenditure categories under C – *Renewal, Upgrade and Expansion*.

Transport for NSW (TfNSW) commented that the current FLCB template does not distinguish between capital maintenance (renewals) and major projects (expansion), and that there are no easy matches between the expenditure categories used by TfNSW and those in the FLCB guidelines, especially in categories C2 *Pavements* and C3 *Surfacing*.

In an example of the manual processes sometimes required, NT provided an example of Category C2-1 *Rigid Pavements*, which do not exist as a cost category within their systems. Rigid pavements are manually identified by reviewing each transaction via its project description, asset type and trade category. Manual processes of this nature were required in the NT for most of the expenditure categories under C – *Renewal, Upgrade and Expansion* as cost data is again not recorded by pavement type.

Main Roads Western Australia (MRWA) also described the need to utilise manual processes to determine expenditure as prescribed by the FLCB categories. MRWA also records works by purpose through a hierarchy of tasks and subtasks where expenditure items are recorded against the lowest level (e.g. the ground level tasks for the project).

MRWA also pointed out that the data for costs incurred through these tasks is far more detailed and extensive than expenditure budgets which are organised by project and resources rather than tasks. This could be a contributing factor to differences between forecast and actual expenditure.

Addressing the issues noted above is a challenge, especially in terms of a methodology (or limited set of methodologies) that could be devised and applied to ensure a more accurate and consistent result from road agencies and departments of transport. These organisations understand their own systems best, and the information provided by respondents showed that the systems and processes in each jurisdiction are very different to each other at the detailed level where a methodology would need to be applied to make a real difference to outcomes. Any higher-level methodology tends to be applied at the reporting level only – a level that is currently already occupied by the FLCB guidelines.

4.3 Unavoidable Inconsistencies

When providing examples of unplanned expenditure, the respondents overall identified three key causes for expenditure to deviate from what was planned (i.e. forecast). These causes are elaborated on below:

- **New project announcements by government.** Additional spending can be ordered by governments for a large variety of reasons, often within short timeframes when in response to events that cause heightened community concern. Examples are safety/congestion/productivity initiatives, economic-based stimulus packages, or new federal infrastructure funding.
- **Rescheduling of projects.** Rescheduling often occurs when planned projects are unable to proceed due to causes beyond the agency/department control, and so other projects which can proceed are brought forward. These causes of delay are most often weather events and contractor availability; but can also potentially be caused by issues like planning obstacles, litigation, community opposition, or industrial accidents.
- **Disaster response**. The timing and extent of natural disasters impacting the road network cannot be predicted year to year and when they occur, expenditure is prioritised to restore the road network to a functional level. These events are usually flooding, but can also include bushfires, collapsing landscape (e.g. major rockfalls, sinkholes, etc.) and extreme storms/cyclones that may cause large-scale blockage or damage to roads.

Respondents were asked to provide historically typical amounts of expenditure for these causes of unplanned expenditure and for their organisation's expectations for how these amounts might change in the future. While some jurisdictions do budget for a disaster response, none were able to offer a consistent or confident estimate of typical additional spending due to the causes listed above. The question on future expectations for the causes of unplanned expenditure seemed to be misunderstood, and rather than commenting on whether the trend of unplanned expenditure was expected to increase or decrease, most respondents simply indicated that the causes would be ongoing.

In general, these three key causes of unplanned expenditure are rooted in events beyond the control of road agencies or departments of transport, and whether discrepancies from these causes lead to a lack of confidence from industry or the community is unknown. Locating historical expenditure based on these causes and undertaking a statistical analysis to quantify the probable magnitude of unplanned expenditure could be a valuable endeavour (beyond the scope of the current project). This could contribute to increased confidence in the FLCB approach by providing a reliable margin of variation with a transparent explanation based on historical trends.

5. Approaches to Increase Confidence in FLCB

5.1 Introduction to Approaches

Survey respondents stated that they complied with the FLCB Guidelines (NTC 2019) by associating in whole or part their existing datasets and expenditure categories with those specified by the guidelines. As each of the road agencies or departments of transport have different internal structures and processes and these are expected to remain different for the foreseeable future, the desired outcome is that despite these differences, the forecast expenditure is broadly considered transparent and reliable.

With this outcome in mind, the following approaches are offered as means of potentially increasing confidence in the FLCB:

- Confidence signalling – giving organisations the confidence to invest internally in improved processes for producing FLCB data according to the current guidelines.
- Alternative categorisation for capital expenditure – responding to organisations' feedback to develop purpose-focused categories.
- Margin of variance – to communicate expectations of understood and acceptable variance between forecast and actual expenditure.

These are elaborated on in the following subsections.

5.2 Confidence Signalling

Based on the information received through the ARRB survey and other discussions; in most cases the currently manual processes are necessary not because it is too difficult for automated processes to exist, but rather that there has been no incentive and/or resources to invest in developing the automated processes. This is likely to be resolved over time if the FLCB model replaces the PAYGO model used for heavy vehicle cost recovery.

This internal investment will likely be prioritised when the FLCB model is announced as the ongoing model for Australia.

The FLCB approach is intending, for the first time ever for roads, to look at categorising road expenditure by asset life, so that road users can be charged for the reasonable annual depreciation of each asset. This necessarily requires expenditure to be broken down into types associated with different lives, which may be tricky at first and will be quite different to how road managers have to date categorised their spending. This issue could potentially be addressed through some averaging or assumptions based on further guidance from the NTC.

5.3 Alternative Categorisation of Capital Expenditure

Several of the respondents indicated that the capital expenditure categories arranged under pavement and surface and structure types are less useful than arranging categories under the purpose of the capital expenditure. Developing this alternative arrangement of categories could allow organisations to provide their expenditure data more readily and accurately.

Feedback from Victoria has indicated that it would be preferable to consider using the agreed work breakdown structure developed for reporting the estimated costs of road projects to the Commonwealth for co-funded road projects. It is suggested that the adoption of this technique would simplify the manner in which capital items are recorded since it would make it feasible to use the cost estimates for projects as the basis for the FLCB returns.

TfNSW have recommended that in their case, an alternative breakdown of categories would be a better representation of their expenditure as shown in Table 5.1.

Table 5.1: Alternative breakdown of categories for renewal and expansion from TfNSW

C1 – Capital maintenance (renewals)	
C1-1	Pavement capital maintenance
C1-2	Bridge capital maintenance
C1-3	Corridor assets (culverts, slopes and other) capital maintenance
C1-4	ITS capital maintenance
C1-5	Other
C2 – Major projects (expansions)	
C2-1	Earthworks
C2-2	Pavement
C2-3	Bridge
C2-4	Corridor assets (culverts, slopes and other)
C2-5	ITS
C2-6	Other

Progressing with this strategy would require another round of extensive engagement with the jurisdictions.

5.4 Margin of Variance

A longer-term additional strategy is to establish a robust margin for unplanned expenditure. This would require sufficient years of data to be able to indicate with confidence the magnitude of the well-explained variation between forecast and actual expenditure. This would be part of a communication strategy to ensure that industry and community understand that some inconsistency is unavoidable due to the ongoing nature of causes such as those discussed in Section 4.3.

This could be based on an analysis of the kind attempted in Section 3 but covering more years of data and including finer detail to identify the precise occurrences and magnitude of the variations. An important part of this would be a departure from terminology like ‘discrepancies’ in favour of terms like ‘variation’ to establish that the differences are expected, understood, and can be justified.

The drawback to this approach is that the amount of confidence in the FLCB approach that this will yield is proportional to the number of years of data it is based on, with several years likely to be required before a reliable variance can be established.

6. Conclusion

This report has investigated the differences between forecast and actual FLCB expenditure with an attempt made to show the magnitude of the inconsistency. Insufficient data was available to draw any conclusions, but if this analysis were to be extended in the future it could be valuable.

The surveyed road agencies and departments of transport have indicated that providing expenditure data in line with the FLCB guidelines is achievable, but challenging in two main aspects:

- There is a fundamental difference between the way categories under capital expenditure are structured between the FLCB guidelines and systems within road agencies.
- The consequence of the above point is that manual processes are often required to obtain the required information.

A number of potential solutions have been presented as means of potentially increasing confidence in the FLCB which include: confidence signalling; alternative categorisation for capital expenditure; and developing and communicating a margin of variance.

The key issue arising from the investigation is the same, fundamental issue encountered in other areas of this project. That is, developing reliable, nationally consistent data is a long-term process that while it must begin with enforcing nationally consistent reporting of data, it can only move towards true national consistency as individual jurisdictions adopt consistent systems and processes. This will require strategies that incentivise the necessary internal development within organisations to move towards national consistency at the fundamental level.

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Austroads

Research Report
AP-R656G-21

Data to Support the Heavy Vehicle Road Reform Part G

Stocktake of Pavement Deterioration Modelling

Data to Support the Heavy Vehicle Road Reform Part G: Stocktake of Pavement Deterioration Modelling

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part G provides an overview of various types of pavement deterioration models and the extent of their use in Australian road agencies.

Keywords

Pavement deterioration, modelling, deterministic, probabilistic

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About Austroads

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

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

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

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

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

Summary

Part G aimed to investigate and document the various approaches and software adopted across Australian road agencies for pavement deterioration modelling, as well as their data input requirements through the use of a survey. Further, this survey aimed to gather the opinions of these road agencies on the use of big data in asset management.

Pavement performance and pavement deterioration modelling is an essential part of any pavement management system, as this type of modelling assists with estimating long-term maintenance investment requirements.

The two main types of models which emerged from the consultation were:

- deterministic models, including weighted maximum models and condition vs time models
- probabilistic models.

Deterministic modelling

Deterministic approaches predict a single value of the dependent variable from pavement performance prediction models based on statistical relationships to build either empirical or mechanistic-empirical relationships between the dependent and independent pavement performance variables. Deterministic models are used by Department for Infrastructure and Transport (DIT) South Australia, Department of Transport (DoT) Victoria, Department of State Growth (DSG) Tasmania, Main Roads Western Australia (MRWA), Transport Canberra and City Services (ACT), Transport for NSW (TfNSW), and Queensland Department of Transport and Main Roads (TMR).

Weighted maximum models are based on the calculation of a Pavement Condition Index (PCI). The PCI is a numerical indicator based on a scale of 0 to 100. The PCI measures the pavement's structural integrity and surface operational condition.

Condition vs time models are used by DoT Victoria. There is no documentation for these models as they were developed by DoT Victoria. The models were developed in Microsoft Excel using surface condition data in a 'shot-in-time' approach.

Probabilistic modelling

Probabilistic approaches inherently recognise the stochastic nature of pavement performance by predicting the distribution of the dependent variable. Probabilistic models are currently being researched by MRWA to model the deterioration of timber bridges.

Some of the noted reasons for the choice of deterministic models included:

- The majority of pavement deterioration occurs in the gradual deterioration phase, which is where deterministic models are most suited.
- The models can be simply transferred into a pavement management system.
- The models are seen to be the best practice option.
- The models can provide a relationship to traffic data which is important to consider with rising traffic volumes.
- The outputs of these models have been shown to reflect observed pavement performance under various loading, environmental conditions, and service level requirements.

The main data types involved in all these models were:

- quality assured, and repeatable, condition survey data from a certified network survey vehicles
  - this includes roughness, rutting, cracking, surface texture, potholes, skid resistance
- inventory data
  - including road segment IDs, road hierarchy, dimension information for pavements/seals, last constructed data, and data on traffic counts, geometry, and asset useful life
- environmental information (i.e. climate zones)
- traffic data
- works programs
- other additional datasets where deemed to be relevant.

Big data and asset management

As mentioned, when the survey was circulated to state and territory road agencies it also requested information on the opinions on the use of big data in asset management. While the majority of road agencies were supportive of this as a concept, many said that it is not something which is currently available for implementation. The main benefit identified was that it could improve maintenance practices and response times.

However, several road agencies defined the disadvantages and risk of this type of data, some major themes included:

- the possibility of low-quality data which is not quality-assured
- issues of bias (unintentional) with crowd sourced data if not set up correctly
- the large requirements for IT infrastructure as it is necessary to support big data analytics.

The overall consensus which seemed to emerge, as conveyed clearly by one road agency, was that these alternative data sources would be better suited to supplement and enhance data collection as opposed to fully replacing the traditional cyclic data collection using laser profilometers and automated conventional road condition data collection devices.

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1. Introduction

1.1 Background

The project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* objective is to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

1.2 Purpose

Part G aims to investigate and document the various approaches and software adopted across Australian road agencies for pavement deterioration modelling, as well as their data input requirements. This investigation will provide insight into the drivers for heavy vehicle investment and data requirements to support subsequent phases of the reform, particularly those related to transparency and accountability and heavy vehicle cost recovery and investment models.

1.3 Scope

The models included in Part G are the models advised as being used in Australia.

This consultation and survey process is limited to Australian road agencies and other contacts as determined by the Pavement Modelling Group assembled for project AAM6214 *Road Deterioration Models Update*.

Opinions offered by survey respondents from organisations are not necessarily the official position of those organisations.

1.4 Methodology

This report provides a summary of the various approaches, used by road agencies for pavement deterioration modelling. This includes:

- an overview of the different models being used by road agencies for pavement deterioration modelling. This includes various types of deterministic models, and probabilistic models (Section 2).
- an overview of which road agencies use these models and how these models are used (Section 3)
- a description of the use of big data and alternative data sources in asset management, and the opinions of the road agencies on this topic (Section 4)
- a summary of the information provided and concluding remarks (Section 5).

In order to gather information on the pavement deterioration models used by each road agency, a consultation survey was circulated. This survey asked questions on both the pavement deterioration models used, and the opinions of the road agencies on the use of big data in asset management.

The survey was distributed to:

- Department for Infrastructure and Transport (DIT) South Australia
- Department of Transport (DoT) Victoria
- Department of State Growth (DSG) Tasmania
- Main Roads Western Australia (MRWA)
- Transport Canberra and City Services Directorate (TCCSD) Australian Capital Territory
- Transport for NSW (TfNSW)
- Queensland Department of Transport and Main Roads (TMR)
- Department of Infrastructure, Planning and Logistics (DIPL) Northern Territory.

The consultation questions are detailed in Table 1.1.

Table 1.1: Consultation questionnaire distributed to road agencies

Consultation category	Questions
Pavement deterioration modelling	What generic type of Road Pavement Deterioration model(s) does your road agency use (e.g. deterministic, probabilistic, hybrid or other)? Please attach any relevant documentation, if available, or model description. Can you provide a brief description of what form of deterioration each model predicts and how it is used (application and methods) in your organisation?
	Why has your road agency selected these models? What are the benefits of these models? That is, history and/or outcomes it best supports.
	How reliable have these models been for your team? Are there any limitations to any of the models? Can these models be successfully calibrated to suit your local conditions?
	What data inputs are required for each model?
	What quality does the data for each model need to have, i.e. field measured or visually rated condition data and measurements vs estimates?
	Are there any limitations in data availability for modelling?
	How are the data flows within each model managed?
	Is there potential for any of these models to be further refined through either machine learning of big data or additional observational and experimental data?
Big-data questions	Has your road agency considered the use of crowd-sourced or commercially sourced big data in asset management? If so, what, and how would the big data be used in deterioration modelling?
	What do you see are the benefits and disadvantages of crowd-sourced, or commercially sourced, big data?
	In an unconstrained world, what additional data collection techniques not currently used do you think would be useful to collect to monitor pavement condition and its associated independent variables? For example, LiDAR ground penetrating radar, vehicle sensors, cameras, dash-cams, etc.
	Do you think any of these alternative data collection techniques would be appropriate to be used in the place of a traditional road condition data collection?

2. Pavement Deterioration Models

2.1 Approaches to Deterioration Modelling

Pavement performance and pavement deterioration modelling is an essential part of any pavement management system (PMS). This type of modelling assists with estimating long-term maintenance investment requirements and the consequences on future pavement condition of budget allocation for maintenance treatments on particular road segments.

Martin (1996) outlined that the two most common approaches for predicting pavement performance were:

- **deterministic** approaches predicting a single value of the dependent variable from pavement performance prediction models usually based on statistical relationships between the dependent and independent pavement performance variables
- **probabilistic** approaches that inherently recognise the stochastic nature of pavement performance by predicting the distribution of the dependent variable.

Table 2.1 provides a matrix summary of these model types which are further discussed in this section. This table details the model types, and their applicable uses.

Table 2.1: Classification of pavement deterioration models

	Types of models					
	Deterministic				Probabilistic	
Levels of pavement management	Primary response: stress, strain, deflection, etc.	Structural & distress: rutting, cracking pavement condition ratings	Function: serviceability index, skid loss, roughness	Damage	Survivor curves	Transition process models: Markov, semi-Markov
National network				✓	✓	✓
State network		✓	✓	✓	✓	✓
District network		✓	✓	✓	✓	✓
Project	✓	✓	✓	✓		

Source: Martin (1996).

As discussed in Section 1.4, each road agency was contacted to determine what pavement deterioration models were in use within their organisation. Four main types of models emerged. These were deterministic models, weighted maximum models, probabilistic models, and condition vs time models. How each of these models is used by the road agencies is summarised in Section 3.

The following sections provide an overview of each of these models.

2.2 Deterministic Models

2.2.1 Definition of Deterministic Modelling

Deterministic models are a relationship which is comprised of the variables which are understood to, or assumed to, affect the performance or rate of deterioration of a pavement. However, the resulting predictions do not take directly into account the stochastic nature of the performance of the pavement (Martin 1996).

There are different types of deterministic models: these include mechanistic models, mechanistic-empirical models, and empirical regression models.

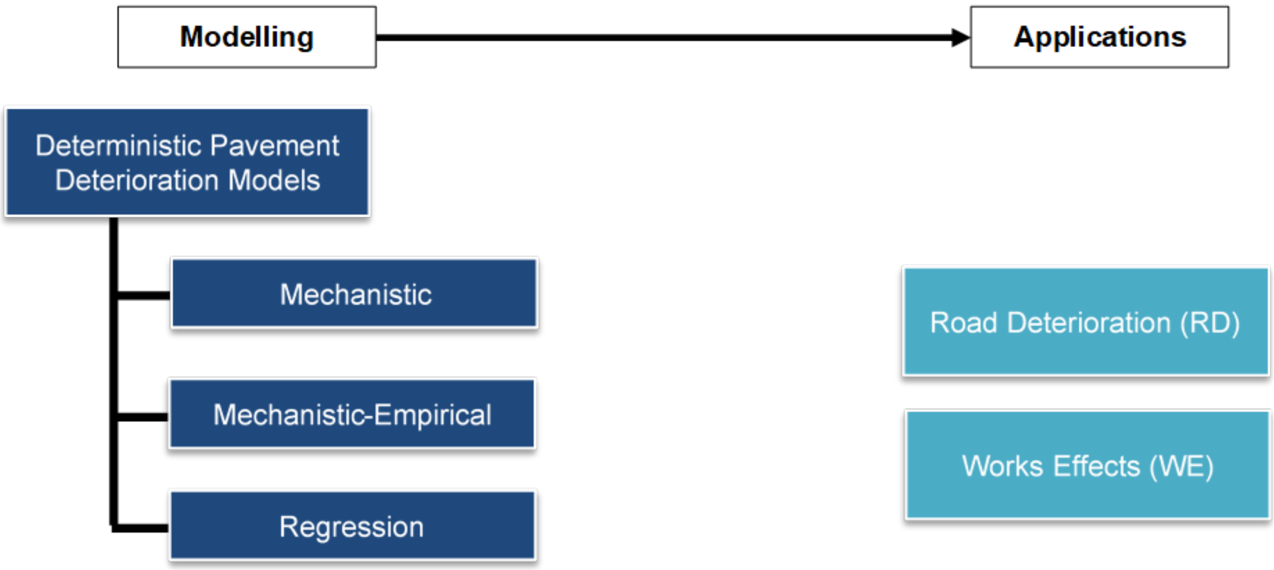
The mechanistic models draw the relationship between response parameters such as stress, strain, and deflection (Li, Kumar & De Silva 2002 cited in Amin 2015). The mechanistic-empirical models draw the relationship between roughness, cracking, and traffic loading. The empirical regression models draw the relationship between a performance parameter (e.g. riding comfort index, RCI) and the predictive parameters (e.g. pavement thickness, pavement material properties, traffic loading, and age) (Li, Kumar & De Silva 2002 cited in Amin 2015).

2.2.2 Mechanistic-empirical and Empirical Models

There are two main types of mechanistic-empirical deterministic models for pavement performance available in Australia: these are road deterioration (RD) models (roughness, rutting, cracking and strength) and deterministic work effects (WE) models (asphalt overlays, granular re-sheeting and mill and replace asphalt). Mechanistic-empirical models are based on theoretical postulations about pavement performance, but are calibrated, using regression analyses, by observational data. These models must adhere to known boundary conditions and physical limits. These models can incorporate interactive forms of distress near the end of pavement life, such as the interaction of rutting with cracking, when these interactions are well understood. These models were developed by the Australian Road Research Board (ARRB) for Austroads with the support of the Institute of Public Works Engineering Australasia (IPWEA) as well as contributions from local government (Martin & Choummanivong 2018).

The deterministic model types described are presented in Figure 2.1.

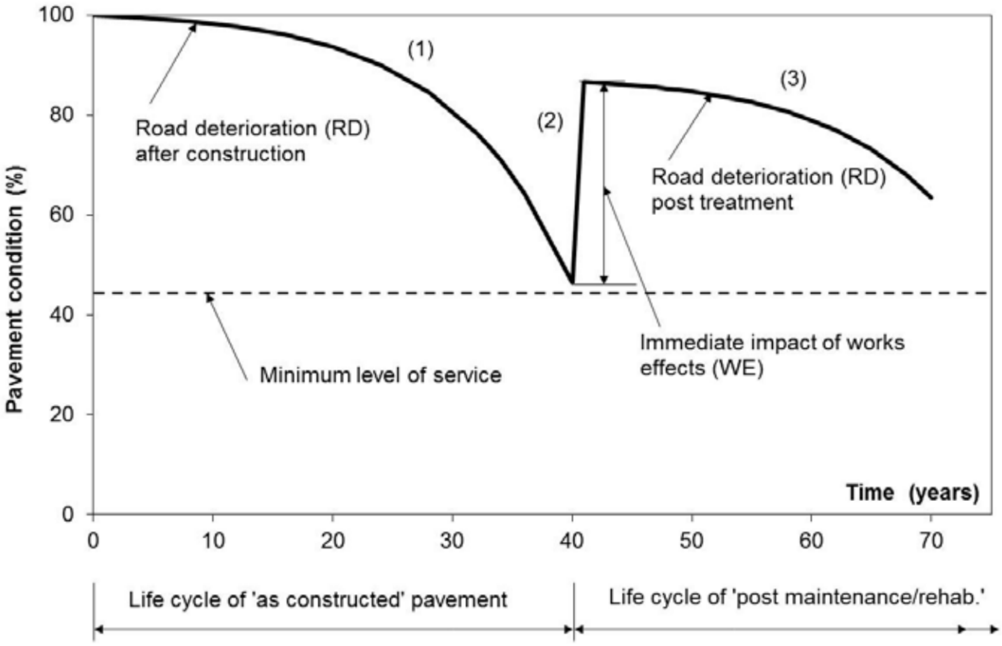
Figure 2.1: Deterministic pavement deterioration models



There are three main stages of in-service pavement performance for which most RD and WE models apply (see Figure 2.2). These are:

1. road deterioration (RD) of pavement condition, both functional and structural, post construction
2. impact of works effects (WE) on pavement condition
3. road deterioration (RD) of pavement conditions post works effects.

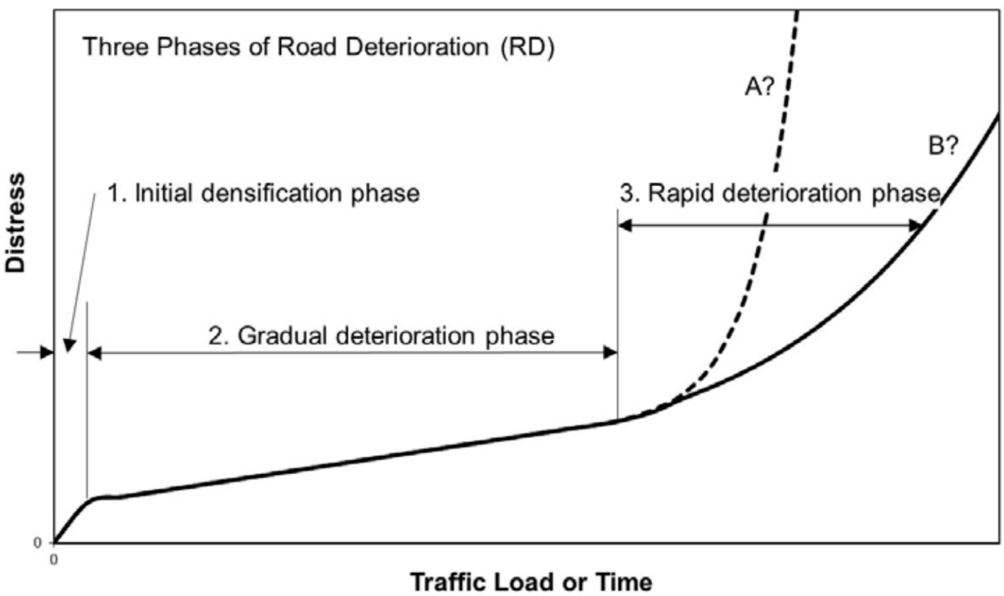
Figure 2.2: Three stages of pavement performance



Source: Martin and Choummanivong (2018).

Furthermore, there are three phases of road deterioration or distress over time. These are initial densification, gradual deterioration, and rapid deterioration. These deterioration phases are shown in Figure 2.3.

Figure 2.3: Three phases of road deterioration



Source: Martin and Choummanivong (2018).

The majority of RD models are confined to predictions in the gradual deterioration phase. There are, however, some models that can be used for the rapid or accelerated deterioration phase. Although these models are not extensively used in practice they do allow for a high-level prediction of distresses beyond the gradual deterioration phase. These models are not based on extensive data, but they can provide an estimation of the outcomes of halted road maintenance.

There are three key Austroads publications which detail deterministic pavement deterioration models, these are:

- AP-T160-10 – *Asphalt and Seal Life Prediction Models based on Bitumen Hardening* (Austroads 2010a)
- AP-T158-10 – *Interim Network Level Functional Road Deterioration Models* (Austroads 2010b)
- AP-T159-10 – *Predicting Structural Deterioration of Pavements at a Network Level: Interim Models* (Austroads 2010c).

Each of these models, and others, including accelerated deterioration models, have been documented in Martin and Choummanivong (2018). Martin and Choummanivong (2018) stated that 'these models have the capacity to improve the decision-making processes of all Australian road agencies under a variety of distresses, distress phases, conditions of climate and traffic loading and maintenance regimes'.

Further, Martin (1996) provides an overview of several deterministic models, including:

- non-roughness based deterministic pavement performance models
  - empirical models for local roads
  - functional performance models (for example pavement condition rating models and pavement serviceability index
  - detailed distress prediction
- roughness based deterministic pavement performance models
  - NAASRA Improved Model for Project Assessment & Costing (NIMPAC) model (1981)
  - Road Transport Investment model (RTIM) (1982)
  - Norwegian model
  - time based models
  - ARRB models (1994)
  - World Bank HDM-111 Model (Paterson 1987) and HDM-4 Model (Morosiuk, Riley, & Odoki. 2001).

Lastly, Martin (1996) detailed the limitations of deterministic models, including multicollinearity and historical erroneous assessment of model fit. Mechanistic-empirical and empirical models have a fundamental problem with multicollinearity, that is, some of the 'independent' variables used in these models can be highly correlated to each other. Therefore, these variables are not strictly independent, and the predictions made using them are of little value, particularly if the variables are used beyond the range of observational data (Robinson 1995; cited in Martin 1996). It is noted that a principal component analysis (PCA), a statistical technique that finds variables that are principal components (PCs) in the dataset, can be used to identify the collinearity among independent variables and those variables can be eliminated to improve the statistical soundness of the model (Jolliffe & Cadima 2016).

2.2.3 Weighted Maximum Models

A version of the deterministic model, weighted maximum models, are based on historical deterioration trends. Weighted maximum models are based on the calculation of a Pavement Condition Index (PCI) which is a functional performance indicator. The PCI is a numerical indicator that is usually based on a scale of 0 to 100. The PCI measures the pavement's structural integrity and surface operation, or functional, condition (Shahin & Kohn 1981).

The PCI is determined by measuring factors of pavement distress, and then using a series of calculations to weight and combine these measures into a single rating for the road section (Shahin & Kohn 1981).

By combining various pavement performance measures (i.e. roughness, rutting, cracking, surface texture, etc.), and weighting each of these measures, the functional performance of the pavement can be assessed. However, the weightings of these measures, when combined to calculate the PCI, can be subjective, and therefore cannot always be used to reliably measure long-term pavement performance (Martin 1996). This can be overcome by using weightings which are specific to the region in which the models are being implemented.

2.2.4 Condition vs Time Models

Condition vs time deterministic models are used by the DoT Victoria. There is no documentation for these models as they were developed internally by DoT Victoria. The models were created in Microsoft Excel using surface condition data in a 'shot-in-time' approach.

2.2.5 Bayesian Models

These models are usually developed from observed data combined with expert experience using Bayesian regression techniques (Pilson, McCullough & Smith 1998). Bayesian regression was developed specifically to deal with small quantities of poor quality observed data and has been applied to the development of pavement deterioration models initially using prior models based on the observed data with posterior models based on the prior model, the observed data and expert experience (George, Rajagopal & Lim 1989).

2.3 Probabilistic Models

2.3.1 Definition of Probabilistic Modelling

As discussed, deterministic models are widely used to predict future pavement performance for managing roads. However, the outcome of these models is a forecast of the average future performance, with a probable distribution of outcomes around the average. This means that 50% of the actual condition could potentially be better or worse than the condition predicted by the model (Austroads 2013). To resolve this issue, research has been undertaken to investigate the use of probabilistic models.

Probabilistic models determine future performance together with the level of uncertainty of the results (Austroads 2013) by assigning various probabilities to the future condition of a pavement (the dependent variable) (Martin 1996). By knowing the associated uncertainties in the model outputs, or the probability of performance, decision makers can enhance their understanding of the probable outcome (Austroads 2013).

2.3.2 Probability Density Function (PDF)

The probability density function (PDF) mathematically defines the variability of the predicted outcomes and is often used in combination with a deterministic model. A PDF can be derived from the slope of the pavement survivor curve. A PDF is usually not normally distributed, and its use may produce unrealistic predictions (Wang, Zaniewski & Way 1994). Often a Weibull distribution is used to define a PDF (Li, Kumar & De Silva 2002). A PDF is often the basis for defining the probabilities of pavement condition for other probabilistic approaches as used in the Markov probabilistic approach.

A PDF can also be used as the basic form for a time to failure model (TFM), assuming pavement age (time) at pavement failure is a random variable (Osman & Hayashi 1995). This approach also assumes that the average life expectancy of a pavement is a good indicator of its performance. A clear understanding of what constitutes pavement condition at failure is needed for this approach to work.

2.3.3 Probabilistic Model Benefits

The benefits of the probabilistic models are:

- the ability to select an acceptable level of risk related to the decisions based on the forecast outcome
- the capacity to focus attention on the most important factors affecting the outcome
- the model enables improvements to the overall reliability of forecasts.

Probabilistic models typically:

- use empirical knowledge in lieu of historical data, such as the Markov Probabilistic Approach (Symons 1985), or
- use deterministic relationships and calculate the associated uncertainties, using a PDF as demonstrated by Kadar et al. (2015).

Austroads (2013) provides a detailed investigation of probabilistic models and shows why these models are beneficial to be used in conjunction with deterministic RD models.

Further, Martin (1996) provides an overview of each type of probabilistic model, including Survivor Curves (Lytton 1987), the Markov probabilistic approach (Haas, Hudson & Zaniewski 1994), the Semi-Markov probabilistic approach (Lytton 1987), and the use of probabilistic pavement condition indices (e.g. pavement condition index, present serviceability index, road roughness).

3. Australian Road Agency Pavement Deterioration Modelling Practice

3.1 Survey Results Summary

This section summarises the pavement deterioration modelling practice of each of the road agencies who provided information via the consultation process. This includes all states and territories except the Northern Territory.

Table 3.1 provides a summary of the practices and opinions of each road agency regarding pavement deterioration modelling. These include: the type of model being used, the benefits of this model, the data inputs, and the limitations.

Table 3.1: Summary of pavement deterioration modelling practices by state road agency

State road agency	Type of model	Data inputs	Benefits	Limitations
Department for Infrastructure and Transport South Australia	Deterministic	• Repeatable, quality-assured data condition survey data • Additional information perceived as relevant	These models were selected as deterioration models that are simple to use and incorporate into the PMS model.	The reliability of this model has been suitable for the DIT's use. However, other components (e.g. works effects) potentially have bigger impacts on the PMS outputs than the deterioration models themselves do.
Department of Transport Victoria	Deterministic (Austroads)	• Pavement condition survey – roughness – rutting – cracking – macrotexture – surface inspection rating (SIR) data – loss of aggregate SIR – loss of texture SIR – maintenance patch SIR • Network information – speed – AADT – climate zone	Deterministic models were selected as the best practice option, as these models provided a relationship to traffic volumes. The selected deterministic models were adopted from Austroads (2010b, 2010c) publications. The key models implemented were the cracking, rut depth and roughness progression models. DoT combine these with models for texture depth and friction, based on HDM4 and Markov chain models. These models were selected based on the Long-Term Pavement Performance (LTPP) study where many Victorian sites were monitored.	The Austroads models are not suitable for assessing areas with high traffic increases. The Austroads models do not predict the fast deterioration phase in failure modes which can be seen on site.
	Deterministic condition vs time	• Condition survey data over time	There was uncertainty, at the time, that the Austroads models could provide a better result than the internally developed condition vs time models. The benefit of this model is that it is based on Victorian data.	This model was developed to ensure that the forecasting was based on a vast history of Victorian data. Therefore, it is specific to Victoria. If the model uses time as a variable to predict condition, it lacks explanatory prediction power when typical changes occur, such as future changes in traffic load and climate.

State road agency	Type of model	Data inputs	Benefits	Limitations
Department of State Growth Tasmania	Deterministic (Roadwise and HDM4)	• Asset inventory – road segment IDs – road hierarchy – dimension information for pavements/seals – last constructed data – traffic count data – geometrical data – asset useful life • Current condition information – cracking – roughness – rutting – surface texture – skid resistance • Climate zones (specific to Roadwise) • Pavement structural number (specific to Roadwise)	HDM4 was considered to be a widely supported tool in Australia at the time it was adopted. It provides detailed deterioration models for various condition indices, which has facilitated benchmarking levels of service related to asset renewal/maintenance across the state network. Roadwise was adopted in 2015, with its primary benefit relating to informing long-term financial planning and providing clear overall condition status of the network.	Concerning calibration, HDM4 has been calibrated for the state network, whereas Roadwise is currently under further development. Reliability for both models are still in early phases, in terms of actual comparisons/reviews of forward predicted outputs with measured field data.
Main Roads Western Australia	Deterministic	• Condition survey data • Inventory data • Environmental information • Traffic data • Works programs	The majority of pavements in MRWA network deteriorate at a slow rate, namely gradual deterioration phase. This phase is where the deterministic models are most suited.	MRWA has employed a continuous improvement process to ensure that any limitations are identified. Additionally, MRWA complete an annual review of the local calibrations. However, human error, and a large quantity of historical records can affect the performance.
Transport Canberra and City Services Directorate	Deterministic Weighted Maximum	• Road condition – cracking – roughness – skid resistance – rut depth – texture depth – deflection	This model allows for customising requirements from averaging the road condition parameters to the weighted maximum method.	Previously intersections were not accounted for in this model, however, this limitation has recently been rectified.

State road agency	Type of model	Data inputs	Benefits	Limitations
Transport for NSW	Deterministic	• Current condition – roughness – rutting – cracking – texture – skid resistance – strength • Pavement ages or surfacing ages • Pavement types • Surfacing types • Levels of service groups	The models were developed based on historical performance trends and local experience. The models seemed to reflect pavement performance observed on the network under various loading, environmental conditions, and service level requirements.	Some of the models cater for various loading and environmental conditions through level of service (LOS) groups, however, the main variable is pavement or surfacing age. There are opportunities to further improve the models to cater for other important parameters such as traffic loading, moisture condition, etc. directly.
Queensland Department of Transport and Main Roads	Deterministic model types used in TMR's pavement management system (SCENARIO)	• Pavement condition data – roughness – rutting – cracking – pavement strength(1) • Road inventory data • Road usage information • Categories (seal type, pavement type, traffic volume, environmental zone are used for grouping homogeneous sections of the larger road network into a smaller number of categories)	The deterministic model types have been selected as only one predicted outcome for a given set of intervention criteria. The main benefit of these models is it is easier to incorporate in PMS.	These models are reasonably reliable. However, it does not consider uncertainties due to any environmental/climate changes. These models can be calibrated to suit local conditions using recent condition data.

1 Work is currently underway to develop pavement strength curves for use in pavement modelling.

3.2 South Australia

DIT in South Australia uses deterministic models, which are sometimes called the family of curves developed in-house. This model completes single parameter deterioration modelling (e.g. roughness, rutting, cracking) in the form of recursive equations. The individual parameter values are converted to performance indices combined into an index (e.g. pavement health index) using advanced maximum criteria described in COST Action 354 report (COST 2008.). These parameters are incorporated into the PMS model setup using the dTIMS application. The PMS model runs provide the basis for multi-year reseal/rehab works programming and establish the backlog on pavement asset renewals.

These models were selected as deterioration models because they are simple enough to use and incorporate into the PMS model. Other components of the PMS model are much more complex (e.g. vehicle operating costs, travel time, crash, environmental cost models). Further, the deterioration trends based on historical values and the current measured values used in the recursive equations produce near enough predicted future parameter values. This model can be calibrated to suit local conditions. The reliability of this model has been suitable for the DIT's use. However, other components (e.g. works effects) potentially have bigger impacts on the PMS outputs than the deterioration models themselves do. Therefore, there may not be much value in refining the models.

In terms of the data inputs for the model, whatever is perceived as relevant information that may influence the performance of the parameter being modelled is considered as a data input. Further, the data used in the model should be repeatable automated measurements from quality-assured data collection equipment (e.g. a network survey vehicle). In order to ensure the quality of the data, new data must first be tested and its comparability with historical data confirmed before it can be used in modelling.

3.3 Victoria

DoT Victoria has three PMS which are used across the business, this includes the corporate sector, the North-eastern region, and the Eastern/South-western regions.

The corporate department uses deterministic deterioration models from Austroads. The selected deterioration models were adopted from Austroads (2010b, 2010c) publications. The key models implemented were the cracking, rut depth and roughness progression models. DoT combines these with models for texture depth and friction, based on HDM4 and Markov chain models. These models were selected based on the Long-Term Pavement Performance (LTPP) study where many Victorian sites were monitored. The major inputs for these models are pavement condition survey data parameters, including roughness, rutting, cracking and macrotexture.

Furthermore, DoT collects condition information using Surface Inspection Rating (SIR). There are seven SIR parameters currently rated by DoT in a scale of 0, 1, 3 and 5, based on the condition of the surface. As a part of the model implementation, three SIR models were implemented in dTIMS. These parameters are loss of aggregate SIR, loss of texture SIR and maintenance patch SIR.

Additional network information which is included in modelling is the average speed of the traffic, the Average Annual Daily Traffic volume (AADT), and climate zone. All relevant data is collected though automated data collection systems and through visual inspection. At this stage, the models do not use TSD data, however, DoT is investigating integrating it into the models. Currently, the outputs of the TSD data are re-estimated for the purposes of modelling.

These models are used to support the business case for the pavement rehabilitation and resurfacing program. Deterministic models were selected as the best practice option, as these models provided a relationship to traffic volumes. The consideration of traffic was important because of the rising traffic volumes on certain parts of Victoria's road network. DoT see the Austroads deterministic models as reliable, however, these models are strongly influenced by calibration. Further, the Austroads models are not suitable for assessing areas with high traffic increases, for example, 10 times the normal traffic loading. In this instance, it was found that the models do not correlate with the field conditions. The Austroads models do not predict the fast deterioration phase in failure modes which can be seen on site. These models require the collection of road condition data, which can be measured using a network survey vehicle or through an accredited visual inspector. One limitation of the data is the cost, data can always be purchased, however, the difficulty is knowing how much you need and how much is reasonable.

DoT corporate department uses condition vs time models for surface aggregate loss and maintenance planning. The DoT North-eastern Region and Eastern/South-western Regions use condition vs time models for all pavement condition parameters. These models are generally used to show a need for maintenance or investigation during internal discussions.

The condition vs time models were selected because, at the time, there were no available Austroads models which fit the required purpose. The North-eastern and Eastern/South-western Regions selected these models, rather than the deterministic models, to ensure that the forecasting was based on a vast history of Victorian data. There was uncertainty, at the time, that the Austroads models could provide a better result than the internally developed condition vs time models.

The data flows are managed within these models by manual uploading of the data into the model. Further, DoT always keeps different datasets in different 'bins' that are linked to the section of the road that the data is relevant to. When needed, DoT converts one data scale (pavement condition score; PCS) into another scale (SIR) using the appropriate conversion factor. Both the PCS and SIR data are merged into the model as two separate tables. A separate column is then created for each data type within the life-cycle costing table for the respective road section. The model then detects the relevant dataset as per instructions coded into the model. For example, a road section identifies the roughness values from one column, which is the PCS value, and texture loss from another column, which is the SIR value. However, each measure has a different scale. For example, IRI has a roughness scale which can vary from 1.5 to 12, while the SIR scale which is used to express texture loss, varies from 0 to 5. Therefore, all values predicted by the models are converted into a five-point scale (very good, good, fair, poor, and very poor) for comparison and aggregation purposes.

The output reliability of these models is still in the testing phase. DoT has successfully calibrated the model using pavement condition data; however, it has not yet been fully implemented.

3.4 Tasmania

DSG utilises two pavement deterioration models, the first is Roadwise, and the second is HDM4. Both of these models are deterministic type models.

Roadwise focuses on the use of PCI and the surface condition index (SCI) deterioration model outputs, that are primarily for strategic network modelling from an overall network condition and financial forecasting perspective. Roadwise is also utilised by DSG to provide initial inputs into the forward resurfacing and pavement renewal programs.

HDM4 focuses on the deterioration of individual condition measures such as cracking, rutting, roughness, as well as age profiles across the network for seals and pavements. This has primarily been utilised by DSG for the development of strategic network KPI measures related to the required levels of service.

HDM4 was regarded as a widely supported tool in Australia, utilised across various road agencies at the time it was adopted by DSG, in the early 2000s. It provides detailed deterioration models for various condition measures, which has facilitated the benchmarking of levels of service related to asset renewal/maintenance works across the Tasmanian state road network.

Roadwise was adopted in 2015 by DSG, with its primary benefit aimed at informing long-term financial planning and providing a clear overall condition status of the network. In practice this information has largely been used to inform forward financial planning and asset management planning development within DSG.

Concerning calibration, HDM4 has been calibrated for the Tasmanian state road network, whereas Roadwise is currently under further development in this area. The reliability assessment of both models is still in the early phases of investigation, when considered in-terms of actual comparisons and reviews of the forward predicted outputs with measured field data.

The models used by DSG, share largely the same data inputs, including the asset inventory, which includes road segment IDs, road hierarchy, dimension information for pavements and surfacings, last constructed data, pavement types, traffic count data, geometrical data, and asset useful life. The data inputs also include current pavement condition information, such as cracking, roughness, rutting, surface texture and skid resistance.

One of the key differences between the two models is that HDM4 has had further calibration specific to the Tasmanian state road network, while Roadwise has not had this calibration. However, Roadwise includes climate zones and the pavement structure number which improves its explanatory power.

DSG's data is primarily field measured through automation; although, there are some minor limitations such as pavement construction age which has been estimated in a few cases, based on the best available historic information.

There are some limitations with DSG's current dataset, primarily relating to a lack of detailed information on the pavement structure which covers the base and subbase details and underlying subgrade conditions. Additionally, DSG collect pavement surface deflection measurements for some parts of the state network (higher category roads), but this is not used for modelling purposes. DSG note that addressing these limitations would provide further opportunities for refinement of pavement deterioration modelling, particularly for the medium-longer term. However, DSG's deflection data is currently in the early stages of being incorporated into the deterioration modelling.

Information on the data flows is primarily derived from DSG's asset information management system, via the development of an input file for the models. The data flow is undertaken using a Microsoft Excel input file.

As noted, further modelling refinement by DSG through improving the continuity of the asset data profile of pavement structural conditions would be beneficial to DSG. Currently the pavement structural profile is only detected by DSG through isolated pavement investigations, or specific design projects, which incur the high costs associated with isolated physical investigation works. There is also potential for DSG to benefit from larger scale more efficient data capture. An example provided by DSG is the possible combination of ground penetrating radar (GPR) and surface deflection measurements to assist in improved modelling of the pavement structure and its impact on performance. However, this has not been investigated by DSG at this stage.

3.5 Western Australia

Deterministic models are the model of choice for MRWA. In addition, MRWA is currently researching probabilistic models for timber bridges.

The MRWA deterioration models, used for roughness and rutting, can be described as the rate of deterioration per year. The models have two phases namely, the gradual phase and the rapid phase. The deterioration rates of the gradual deterioration phase are different for the Metro and Rural regions. MRWA observed that under an appropriate resurfacing regime and minor increase of traffic loading, the majority of pavements in MRWA network deteriorate at a slow rate in the gradual deterioration phase. However, where required resurfacing work is deferred for a prolonged period, the pavement surface starts to distress and lose its integrity. Consequently, this allows the ingress of water to push the pavement into the rapid deterioration phase with the result of ultimate pavement failure, unless maintenance intervention occurs.

The data inputs required for this model are condition survey data (i.e. roughness, rutting, surface texture, cracking, etc.), each of these datasets has its own quality assurance process. However, MRWA did note that there are always limitations and issues with data due to frequency, timing, survey faults, human error, and a large quantity of historical records. By documenting these issues with the data, the users of the model can be informed of the limitations of the model.

This model was developed based on historical data and local experience. The models are incorporated into the MRWA PMS, dTIMS, to support budget forecast and maintenance work planning.

In order to ensure the reliability of these models, MRWA has a continuous improvement process. The models are subject to annual review for local calibration. In addition, MRWA also engages a number of research institutes for the long-term model development works.

MRWA indicated that continuous improvement within these models is the key to success. However, the use of big data or machine learning may require a different approach, in comparison to the traditional data collection and entry methods.

3.6 Australian Capital Territory

TCCSD has implemented a PMS which uses a deterministic weighted maximum pavement deterioration model.

The PCI within this model for the ACT roads is tailored in such a way that every road condition parameter is treated as equally important. This approach was undertaken because it was judged to be closer to real-life practice. This method means that all road condition parameters can be interpreted separately, therefore, allowing maintenance intervention decisions to be based on the road parameters in the worst condition.

Transport Canberra and City Services has made the decision to move away from averaging road condition parameters to customising their requirements by using a weighted maximum method.

The data inputs for this model are all the road condition parameters which are surveyed by Transport Canberra and City Services. These inputs include: cracking, roughness, skid resistance, rut depth, texture depth, and deflection. Transport Canberra and City Services has not identified any current limitations with the data required for this model.

The PMS used by Transport Canberra and City Services recommends annual intervention based on the condition assessment through use of their deterioration model. This is done for each lane of a multi-lane road in discrete sections. This approach aims to optimise the available resources and develop feasible work packages for the delivery of the work. The review of PMS outputs occurs from January to June each year which may require further site visits to identify the combination of areas to form a viable and efficient works program undertaken from January to March.

Transport Canberra and City Services continuously monitor the outcomes of their PMS analyses and the in situ observations of the road condition to confirm the validity of the results. Previous versions of the PMS did not account for the presence of intersections; therefore, these were prioritised based on the public and internal feedback along with visual inspection rather than the PMS outcomes. The updated version of the PMS now considers both intersections and mid-blocks as part of the deterioration modelling process.

3.7 New South Wales

Transport for NSW (TfNSW) also uses deterministic models. These models are a simplistic form of the deterioration models that are used for roughness, rutting, cracking, texture, skid resistance and strength. Pavements assessed by these models are assumed to be in the gradual deterioration phase and time (or pavement age) is generally the main variable. TfNSW's models are tailored to pavement and surfacing types and level of service groups. TfNSW uses these models in their PMS, based on a dTIMS software package, to perform budget analyses and to develop forward works programs.

TfNSW's models were developed based on historical performance trends and local experience. Review of the model predictions have shown that the models reflect pavement performance currently observed on the network under various loading, environmental conditions, and service level requirements.

TfNSW has noted that the models are producing acceptable pavement performance trends at the network level. While some of the models cater for various loading and environmental condition through grouping roads under levels of service, the main independent variable is pavement age or surfacing age. TfNSW noted that there are opportunities to further improve the models to cater for other important independent variables such as future changes in traffic loading, moisture condition and others, directly. These improvements in explanatory power of the deterioration models are essential with the inevitable future changes in traffic and climate that will impact on future pavement performance prediction.

In order to ensure the adequate quality of the condition data, the annual pavement condition data collected by road condition survey, is quality checked. This type of data is considered to be fit-for-purpose for use in the models.

While traffic data, maintenance history, and aggregate size are not directly used in the current modelling, TfNSW has said that future improvements to these models should include better recording and use of such data. Furthermore, deterioration rate information that is more specific to detailed treatments and location is an area that TfNSW identified as one they are looking towards developing.

The current TfNSW models are specific to the detailed performance parameters and are not interrelated to each other. TfNSW uses a separate structural analysis model to process strength data allowing them to estimate the remaining structural life and estimate the thickness of the pavement layers for the design of future rehabilitation work. The structural remaining life estimates are used in the modelling deterioration rather than the measured pavement deflections.

TfNSW has outlined that there are opportunities to refine these deterioration models or adopt a new set of models that reflect, and reliably predict, network performance. In this regard, TfNSW noted that a proposed Austroads project, AAM6214 – *Road Deterioration Models Update*, is currently being developed for active research. TfNSW hopes that big data (i.e. detailed historical pavement performance data, maintenance history, etc.) collected and managed by various road agencies will be taken into consideration along with data collected from long-term pavement performance (LTPP) monitoring sites.

3.8 Queensland

Queensland Department of Transport and Main Roads (TMR) uses deterministic model types within their PMS (SCENARIO). There are two separate deterioration models, one with treatment and one without treatment. These models include an analysis of roughness, rutting and cracking. Further, these models include a linear rate of roughness progression which is used in SCENARIO. These models are used to predict treatment performance and its timing based on the prescribed maintenance intervention levels. In addition, these models enable TMR to predict future performance as the basis of triggering future treatments.

The deterministic model types have been selected by TMR as there is only one predicted outcome for a given set of intervention criteria. The main benefit of this is that it is easier to incorporate this information into SCENARIO. Further, these models are seen to be reasonably reliable and they can be calibrated to suit local conditions using recent condition data. However, the models do not consider uncertainties due to any environmental/climate changes.

The inputs for these models include pavement condition data such as roughness, rutting, and cracking as well as road inventory data. TMR uses ARRB's network survey vehicles (NSVs) and Intelligent Pavement Assessment Vehicle (iPAVe) annually to collect functional and structural road condition data for the entire road network. Therefore, the quality of this data is good as it is validated by ARRB's data experts and TMR. This means that there are no limitations on data availability and adequacy for the current models.

The data flows within each model are managed using the appropriate datasets provided at the required quality for each model, as an input into SCENARIO.

TMR indicated that these models are currently under consideration for a review, to be replaced by machine learning applied to the use of big data for creating updated performance models. This decision is being considered as the current models were developed some time ago.

4. Use of Big Data and New Methods of Data Collection for Asset Management

4.1 Context of Consultation

Part G also aimed to gather the opinion of road agencies on the use of big data in asset management. It has been hypothesised that data from the machine vision systems on connected autonomous vehicles (CAVs) could be used by road agencies to manage their assets.

This component of the project's consultation process was a follow-on from the findings of Austroads project FSP6088 *Infrastructure Changes to Support Automated Vehicles on Rural and Metropolitan Highways and Freeways: Emerging Asset Information Technology (Module 4)* (Austroads 2019). These questions were asked to ascertain any current, planned, or desired use of these datasets in the area of road asset management.

4.2 Considerations

This section aimed to investigate the opinions of road agencies on emerging data sources, such as big data capture from sensors in vehicles, and on how such data could supplement or even replace current practices in asset inventory and condition data collection.

Currently, there are three main ways of collecting road data: these include specialist survey vehicles, fleet-sourcing, and crowd sourcing. The use of specialist survey vehicles to collect asset information is a well-established practice for many road agencies. Fleet-sourced data is based on aftermarket devices mounted into vehicles for example, data collection devices in road maintenance vehicles or telematics devices in a trucking fleet. Crowd sourced data is most likely to come from smartphones or similar devices such as suitably capable dash-cams (Austroads 2019).

Sensor technologies being investigated include: gyroscopes and accelerometers, LiDAR, radar, private vehicle sensors, and on-board mass units (Austroads 2019). These technologies will be able to record various types of road condition data, similar to the lasers and cameras mounted on traditional NSVs. However, the scale at which this data can be recorded, both temporally and spatially will be expanded.

Road agencies currently use specialist survey vehicles, such as NSVs and the Intelligent Pavement Assessment Vehicle (iPAVe), to collect road asset inventory and pavement condition data. These vehicle assessments are generally completed for the entire state-controlled road network every 1 to 3 years, to provide accurate data, but not always at the desirable frequency required for these datasets (Austroads 2019).

The main benefit of this type of big data collection would be the regular frequency and the real-time availability of information. However, compared to the sensors used on specialist survey vehicles, the sensors on general-purpose vehicles and in smartphones and dash-cams have a much lower cost as these sensors are not optimised for collecting information on asset inventory and condition. This means that, although these crowd sourcing and fleet-sourcing methods can generate many measurements at a much higher frequency than those from specialist survey vehicles, each of these measurements is highly likely to be significantly less accurate (Austroads 2019).

Furthermore, crowd-sourced and fleet-sourced data will require different business processes to those used by specialist survey vehicles. This data is also suited to different purposes than the traditionally collected data. These purposes include monitoring conditions where information needs to be detected quickly and often, such as identifying potholes in roads (Austroads 2019).

4.3 Opinions of Road Agencies (RAs)

4.3.1 Department for Infrastructure and Transport

DIT has not yet considered the use of alternative datasets at the road assets section level, including data for deterioration modelling. That said, DIT noted that machine-learning with big data could be useful as an additional data source to detect road features (e.g. road width, line-markings, etc.) not currently monitored. DIT does see a perceived benefit of big data, as this is possibly a low-cost data collection method. However, the perceived disadvantages of the possibly low quality, and not quality-assured, data values have been noted. Alternative data collection techniques will need to prove their worth by producing data of comparable quality to traditionally collected data for them to be considered by DIT.

4.3.2 Department of Transport Victoria

DoT Victoria has considered the use of big data and new methods of data collection in asset management for data types such as cracking, potholes, roughness, etc. However, this investigation did not proceed. DoT Victoria noted that the possible benefit of this data is that it would be at a much lower cost than the current methods of data collection with the potential that it could even be at no cost. If DoT were to use big data, it will be commercially sourced big data, as this is seen to be more reliable.

In an unconstrained world, DoT has recommended research into new technology for collecting cracking data. Currently, DoT is finding only 50% accuracy in the cracking data collection methodology available in Australia especially in sprayed seal roads with high macrotexture. In addition, DoT believes it would be highly beneficial to have GPR data for informed decision making. Lastly, LiDAR could be used to collect detailed information on other road assets, apart from pavements. However, as mentioned, cost is a major factor in decision making.

4.3.3 Department of State Growth

DSG has looked at some commercially sourced data for their traffic analysis and for their congestion modelling, however, it was considered to be too expensive relative to the benefits it provided. Further, DSG has not considered this type of data either for pavement deterioration or pavement performance modelling. On the other hand, DSG has used STRAVAS (crowd sourced data) for their bike counts.

DSG noted that there are several benefits to using this alternative data source which include providing unexpected solutions to problems, allowing for better engagement with stakeholders/industry, and potentially more innovative solutions may be developed, which could streamline some aspects of data collection and allow for more access to current datasets.

DSG also noted that there are several disadvantages of big data, including:

- There are issues of bias (unintentional) with crowd sourced data if not set up correctly.
- Data scientists and big data experts are among the most highly sought after and therefore they can be hard to attract and retain in the public sector.
- There are data quality issues. Before big data can be used for analysis, it needs validation that the information is accurate, relevant and in the proper format for analysis. This can be a resource intensive exercise.
- There are large requirements for IT infrastructure as this is necessary to support big data analytics. There will be a need for storage space to house the data, networking bandwidth to transfer it to and from analytics systems, and computing resources to perform those analytics. These are all expensive to purchase and maintain.

- There may be difficulty in integrating this data into legacy systems. There are many years of 'siloed' data in a variety of different applications and systems throughout road agencies and relevant organisations. To integrate all those disparate data sources and moving data where it needs to be will also add to the time and expense of working with big data.
- Lastly, the information requires space and infrastructure for secure storage for example, using cloud solutions. However, there are security concerns due to government policy regarding cloud storage and security.

As previously mentioned, a focus for DSG would be for further refining the current pavement asset data (i.e. into pavement layers and subgrade conditions). DSG noted that there may be some potential for this to be undertaken by GPR in collaboration with other data monitoring techniques.

DSG hypothesised that vehicle sensors and dash-cams could have some potential for more frequent optimised data collection across the network, as opposed to the periodic 3-year cyclic data collection which is currently undertaken. Although not specifically related to pavements, DSG is looking into LiDAR to further develop the road asset inventory as part of an internal data governance project.

At this stage DSG sees these alternative data sources as better suited to supplement and enhance data collection as opposed to fully replacing the traditional cyclic data collection process using laser profilometers and/or automated conventional road condition data devices.

DSG concluded by saying that big data analytics offers many benefits, but the immediate asset focus does not warrant the need for these types of datasets yet. Currently the DSG considers its data collection fit-for-purpose.

4.3.4 Main Roads Western Australia

MRWA is currently investigating the use of public or crowd-sourced data for use in asset management. However, these trials are in the very early stages and have not yet been used for deterioration modelling. Further, MRWA noted that if defects can be identified using collected visual footage, such as that from dash-cams, it would significantly improve maintenance practices and reduce response times. Although, MRWA did note that this is not in an unconstrained world, and many of the hypothesised data sources are not readily available, therefore, their advantages and disadvantages cannot be considered at this stage.

4.3.5 Transport Canberra and City Services Directorate

Transport Canberra and City Services has not yet considered the use of big data for asset management. Although big data could potentially increase the frequency of data collection, and provide real-time data, Transport Canberra and City Services sees that the challenge will be processing this large amount of data and being able to apply it to practical asset management.

In the opinion of Transport Canberra and City Services, vehicle sensors, cameras, and dash-cams might be useful in collecting various data. However, Transport Canberra and City Services also noted that the data collection technology is changing very rapidly, therefore, Transport Canberra and City Services is expecting in the future that the conventional data collection systems might be quantumly changed to accommodate these new technologies.

4.3.6 Transport for NSW

No data from external sources were considered for pavement deterioration modelling by TfNSW. However, TfNSW has over 20 years of performance data and, as detailed earlier, this is defined as big data in a proposed Austroads project (AAM6214) currently being developed.

At this stage, TfNSW is unsure if any crowd-sourced or commercially sourced data can provide the level of detail, quality and accuracy required for pavement deterioration modelling.

TfNSW noted that predicting pavement performance is an element in a large decision matrix for developing a work program. Available budget, works effects, work benefits, thresholds, treatment selection criteria, etc. all play important roles. Current datasets are considered ‘fit-for-purpose’ for network level planning and budget analysis. Therefore, TfNSW believes it would be more useful if the factors influencing collected data could be detected and explained better. For example, the detection and effect of moisture in TSD deflection data would be very useful.

TfNSW has said that time will tell if any future data collection system is any better than the current data collection approach in terms of quality, repeatability, and reliability, etc.

5. Conclusions

5.1 Pavement Modelling

This report has presented the various approaches adopted across Australian state and territory road agencies for pavement deterioration modelling, as part of the Heavy Vehicle Road Reform, as well as their data input requirements. This investigation was aimed at providing insight into the drivers for heavy vehicle investment and data requirements to support subsequent phases of the reform, particularly those related to transparency and accountability and heavy vehicle charging models.

The two main types of models emerged from the consultation were:

1. **deterministic models**, including weighted maximum models and condition vs time models
2. **probabilistic models**.

The majority of road agencies use deterministic models. Some of the noted reasons for this choice include:

- Most pavement deterioration occurs in the gradual deterioration phase, which is where deterministic models are considered to be most suited.
- These models can be simply transferred into a pavement management system.
- These models are seen to be the best practice option.
- These models can provide a relationship to traffic data which is important to consider with rising traffic volumes.
- The outputs of these models have been shown to reflect observed pavement performance under various loading, environmental conditions, and service level requirements.

The main data types involved in all these models were:

- quality assured, and repeatable, condition survey data from a certified vehicle (such as network survey vehicles)
  – this includes roughness, rutting, cracking, surface texture, potholes, skid resistance
- inventory data
  – including road segment IDs, road hierarchy, dimension information for pavements/seals, last constructed data, traffic count data, geometrical data, asset useful life
- environmental information (i.e. climate zones)
- traffic data
- works programs
- other additional datasets where deemed to be relevant.

The majority of the models used by the road agencies were seen to be consistent and reliable for the purposes these models were being used for. Further, all data inputs were mostly seen to be fit-for-purpose, with the data being quality assured by both independent data collection organisations or internally within the road agency.

There were limitations noted for each of these models. Some of the major themes included factors which are not considered in the model may have a major impact on the condition of the pavement, such as drainage and local climatic and geological effects. However, it was noted that inclusion of these elements could be an area of further research, including the suitability of models that can be calibrated for local conditions.

5.2 Use of Big Data in Asset Management

When the survey was circulated to the road agencies, it also requested information on their opinions of the use of big data in asset management. Road agencies currently use specialist survey vehicles, such as NSVs and the iPAVe, to collect road asset inventory and pavement condition data. The data collected by these vehicles are generally undertaken for the entire state-controlled road network every 1 to 3 years, providing accurate datasets, but not as often as desired (Austroads 2019). The survey asked the road agencies for their opinion on alternative datasets such as fleet-sourced and crowd-sourced data through the use of sensor technologies and other innovative data services.

While most road agencies were supportive of this as a concept, many said that it is not something which is currently practical for implementation. Some of the benefits noted by road agencies included:

- If defects can be identified using footage, such as that from dash-cams, it would significantly improve maintenance practices and response times.
- The use of LiDAR data to collect information on other road assets could provide beneficial additional data.
- Machine-learning of big data could be useful as an additional data source for picking up road features.
- It is possibly a low-cost data collection method.

However, several road agencies defined the disadvantages and risk of this type of data. Some major themes included the possibility of low quality and not quality-assured data; issues of bias (unintentional) with crowd sourced data if not set up correctly; large requirements for IT infrastructure as this is necessary to support big data analytics; difficulty in integrating this data into legacy systems; and security concerns due to government policy regarding cloud storage and security.

The overall consensus which seemed to emerge, and which was conveyed by DSG, was that these alternative data sources are better suited to supplement and enhance data collection as opposed to fully replacing the traditional cyclic data collection via laser profilometers and automated conventional road condition data collection devices.

Pavement performance and pavement deterioration modelling is an essential part of any PMS, as this modelling assists with estimating long-term investment requirements. The use of big data or alternative data methods has the potential to improve the performance and increase the benefit of the outcomes of these models, however, it requires more research and investigation.

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Research Report
AP-R656H-21

Data to Support the Heavy Vehicle Road Reform Part H

Investigation of Maintenance Data Records

Data to Support the Heavy Vehicle Road Reform Part H: Investigation of Maintenance Data Records

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Abstract

The COAG Heavy Vehicle Road Reform (HVRR) is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive.

This project is a continuation of the work undertaken in project AT1920 *Developing the Data to Support the HVCI/HVRR* between July 2013 and June 2017. AAM6068 ran from July 2017 to December 2020. These two projects represent just one part of the larger reform.

Part H documents an investigation into the nature and extent of maintenance data records in Australian road agencies.

A survey was also conducted into whether the current extent of data maintenance record keeping in Australian road agencies supported forward-looking cost base approaches for heavy vehicle cost recovery and investment.

Keywords

Maintenance data, data collection, condition data, forward-looking cost base

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About Austroads

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

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

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

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

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

Summary

Part H of the project aimed to investigate and document the various approaches adopted across Australian state and territory road agencies for recording and sorting completed maintenance and operational works. This included both routine and periodic maintenance data, to understand the potential for gaps in data records, which could be applicable to the Forward-Looking Cost Base (FLCB) model.

Further, Part H aimed to investigate the road maintenance data perspective of road managers in state and territory road agencies on the FLCB approach and what improvements could be made. This assessment was completed through a literature review and a survey distributed to project contacts.

The most advanced Australian standard (i.e. nationally consistent standard) for recording maintenance data is the Austroads Data Standard, including the relevant data function groups, and the Priority Harmonisation Subset (PHS). The Austroads Data Standard is aimed at providing consistency in assessing the functionality of road network data with respect to the consistency and reliability of the information which is recorded about road networks. This information is critical in achieving consistency for the FLCB model and ensuring it is based on the best available and most appropriate datasets.

Each of the state and territory road agencies surveyed noted that they recorded both routine and periodic maintenance works. Routine maintenance was generally recorded as individual road segments, or collectively, depending on the intensity of the works at each location. Periodic maintenance was either recorded as individual road segments, or as projects (if multiple works were completed in one project).

Currently, the National Transport Commission (NTC) is responsible for making recommendations to infrastructure and transport ministers regarding heavy vehicle cost recovery and investment. Recently, reviews have been undertaken of the current heavy vehicle charging model scheme (PAYGO). The issue identified with the current charging methodology was mainly that it is outdated, with the cost base not being an accurate reflection of the actual cost base. Overall, road agencies view the FLCB model as beneficial.

In addition, road agencies noted additional attributes of completed works which should be recorded to demonstrate further benefits from the FLCB approach. These included road attributes, defect information, historical information, and future data predictions.

Based on the information provided in the consultation on routine and periodic maintenance data records, it seems that the majority of state and territory road agencies currently record the required attributes of completed works which are recommended (by the road agencies) for inclusion in the FLCB model. There are, however, improvements which could be made to Asset Register specifications to ensure that the information recorded is consistent. These outcomes can be achieved through effective collaboration between state and territory road agencies, Austroads and industry bodies.

Acronyms

ANRAM	Australian National Risk Assessment Model
DIPL	Department of Infrastructure, Planning and Logistics Northern Territory
DIT	Department for Infrastructure and Transport South Australia
DoT	Department of Transport Victoria
ESA	Equivalent Standard Axles
FLCB	Forward-Looking Cost Base
GPS	Global Positioning System
GVM	Gross Vehicle Mass
LoS	Levels of Service
MMS	Maintenance Management Systems
MRWA	Main Roads Western Australia
NTC	National Transport Commission
PCU	Passenger Car Unit
PAYGO	Pay-As-You-Go
PBS	Performance Based Standards
PHS	Priority Harmonisation Subset
RMIP	Road Maintenance Intervention Parameters
RMPC	Road Maintenance Performance Contracts
RUC	Road User Cost
SCRIM	Sideways-force Coefficient Investigation Machine
TfNSW	Transport for New South Wales
TMR	Queensland Department of Transport and Main Roads

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1. Introduction

1.1 Background

The project *AAM6068: Data to Support Heavy Vehicle Road Reform (HVRR)* objective is to improve the shared understanding of the current condition and level of service of freight route assets and to support agreed Heavy Vehicle Road Reforms (HVRR).

Improving the amount and quality of nationally consistent information about the nature and condition of Australia's roads, is a critical component of building a more efficient, fairer system for making decisions about road spending.

HVRR is a joint reform process of the Commonwealth, state, territory, and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. Properly functioning markets require informed users and road providers.

1.2 Purpose

Part H focuses on the well-known road data gap of operational maintenance records. It aimed to conduct a stocktake of current practices to record completed maintenance, including challenges and opportunities, and review the extent of national harmonisation in this area.

Further, Part H aimed to document the road maintenance data perspective of road managers in state and territory road agencies on the Forward-Looking Cost Base (FLCB) approach, and what the data requirements of this model should be.

1.3 Scope

The scope includes the requirements for operational maintenance data where there is the potential for gaps in record keeping on what works have been done, where and when as opposed to capital works which are expected to be well-documented. Operational maintenance can include both periodic and routine maintenance and potentially rehabilitation works (where no improvements in LoS occur).

The terminology used in this report is:

- Routine maintenance is small mainly reactive works which are normally anticipated within a budget timeframe, but their precise nature, location and timing are not known in advance. Routine maintenance mainly consists of minor activities planned on a short-term basis, usually about two weeks or less (Austroads 2015).
- Periodic maintenance refers to maintenance treatments conducted at regular intervals longer than one year. For pavements, bitumen resealing, asphalt resheeting and gravel resheeting are the most common forms of periodic maintenance. For bridges, replacement of joint seals is an example (Austroads 2015).
- Heavy vehicle charging – Price attached to road use by heavy vehicles in approximate proportion to the damage their loading inflicts on the pavement (Austroads 2015).
- Forward-Looking Cost Base– a model for anticipating cost recovery and investment to maintain levels of service on infrastructure.

1.4 Methodology

This report provides a summary of the various approaches, used in the states and territories for capturing and maintaining routine and periodic maintenance data records, as well as opinions on the FLCB approach. This includes:

- Section 2 – an overview of current national guidelines for detailed attributes of completed works, including the Austroads Data Standard and the accompanying Priority Harmonisation Subset (PHS).
- Section 3 – a summary of the role of the National Transport Commission (NTC), the current cost recovery model, and the heavy vehicle charging determination review.
- Section 4 – a detailed overview of the practices of state and territory road agencies in maintenance data recording and management practices.
- Section 5 – a summary of the opinions of state and territory road agencies on the FLCB model, as well as the recommended attributes of completed works which should be recorded for the model.
- Section 6 – the learnings and conclusions from the above.

Information on the methods for capturing and storing maintenance data records used by each of the state and territory road agencies was obtained via survey. This survey asked questions on the methods for both routine and periodic maintenance, including the types of data recorded in these records, and how these records could potentially influence the FLCB approach. Further, this survey asked respondents about their opinions on the benefits of the FLCB model.

The survey was distributed to all state and territory road agencies, with responses received from :

- Department for Infrastructure and Transport (DIT) South Australia
- Department of Transport (DoT) Victoria
- Department of State Growth (DSG) Tasmania
- Main Roads Western Australia (MRWA)
- Queensland Department of Transport and Main Roads (TMR).

A selection of the consultation questions (those related to maintenance records) is detailed in Table 1.1.

Table 1.1: Summary of survey questions

Questions
Are annual records of routine maintenance kept by your organisation? 1. Completion times and locations (GPS, chainage, lanes, etc.) of the works. State 'yes' or 'no'. 2. Description of the works conducted. State 'yes' or 'no'. If yes, is this recorded in aggregate or individually for road segments? 3. The costs of the works? State 'yes' or 'no'. If yes, can these costs be linked to individual segments of work or are they aggregated?
Are annual records of **periodic maintenance** kept by your organisation? If yes, complete the following: 1. Completion times and locations (GPS, chainage, lanes, etc.) of the works. State 'yes' or 'no'. 2. Description of the works conducted. State 'yes' or 'no'. If yes, is this recorded in aggregate or individually for road segments? 3. The costs of the works? State 'yes' or 'no'. If yes, can these costs be linked to individual segments of work or are they aggregated?
What are the methods used for the recording and storage of routine and periodic maintenance work information? Please list and describe.
Why have these particular methods used for record keeping been selected?
Are other types of data (e.g. pavement type, condition parameters, traffic, road inventory, etc.) included in these datasets? If yes, what types of data are included? Please list and describe.

Questions
What is your organisation's opinion on the Forward-Looking Cost Base Model?
Do you see any direct benefits from these charging models?
If yes, what are these benefits?
In regard to the current Levels of Service (LoS) and maintenance intervention standards used by your organisation, please answer the following: 1. Does the LoS depend on the classification of the road in the network? 2. If yes, apart from road classification, are there other criteria that impact on the LoS. Please describe.
Hypothetically, how would you see these LoS and maintenance intervention standards being used in the Forward-Looking Cost Base Model?
In your opinion, what attributes of completed works (e.g. location, description, cost etc.) need to be recorded and monitored to facilitate the Forward-Looking Cost Base Model?
In your opinion, does your organisation have the capacity to meet all the potential data requirements and operational requirements for the Forward-Looking Cost Base Model? State 'yes' or 'no'. If no, what additional data needs to be collected to support the Forward-Looking Cost Base Model?
Do you have any recommendations for improving future Asset Register data specifications? Please state.
Other comments on this topic. Please state.

2. National Guidelines for Detailed Attributes of Completed Works

2.1 Austroads Data Standard

Research has shown that there is a strong need for harmonisation in assessing the functionality of road networks, and the activities of road managers in maintaining these networks across Australia and New Zealand. Thus, the consistency and reliability of the recorded information about road networks is critical in achieving this aim (Austroads 2019b).

There are several key benefits of having a nationally harmonised dataset, these include:

- allowing for comparative road network performance reporting across jurisdictions (Austroads 2019a)
- allowing for an economic evaluation of comparable datasets (Austroads 2019a)
- the costs and benefits of different road treatments can be more easily compared, allowing for improved maintenance and investment strategies
- a reformed road system more accountable and transparent to customers would have consistent detailed reporting of which road segments have been maintained to what extent. This would allow customer groups to monitor service levels and recent expenditure to hold road agencies to account (e.g. for the charges they pay).

With this in mind, Austroads developed the *Data Standard for Road Management and Investment* (Austroads Data Standard), with the aim of harmonising the way in which data is collected and used by road managers for the planning, delivery, operation, maintenance, and disposal of road assets across all areas of data reporting and asset management (Austroads 2019a). The Austroads Data Standard for Road Management was published in 2018 (Austroads 2018).

This Data Standard was initially developed in 2016 and was based on a strong business case for it to be implemented using harmonised datasets that would actively influence reform and the adoption of emerging technologies for all stakeholders. The benefit cost ratio (BCR) was dependent on how it was to be implemented. It was decided that it would be implemented as a harmonised road asset data standard and the taxonomy would be adopted by road agencies, local councils, road manager partners and service providers. It was a highly detailed document very much based on road agency practice in New Zealand. This work was reviewed in 2017, for its definitions and there were metrics introduced for the Data Standard. The accompanying document, the Prioritised Harmonised Subset (PHS), was also reviewed. This was a reduced version of the Data Standard confined to roads (pavement and surfacing), structures (bridges, major culverts), and tunnel assets which proposed a set of metrics for the PHS. The revised Austroads Data Standard (Version 3.0) and the revised PHS for the Data Standard were published by Austroads in 2019 (Austroads 2019a).

The Data Standard could be of use in the FLCB approach, as it will regulate the way in which data is reported, allowing for national consistency in data reporting to influence heavy vehicle charging. This is discussed further in Section 2.3.

The Austroads Data Standard defined the data requirements for a road Asset Information Management System (AIMS). For reporting purposes, the Data Standard supports the harmonisation of activities for road management and investment purposes. To ensure consistency, a series of data function groups were defined as follows:

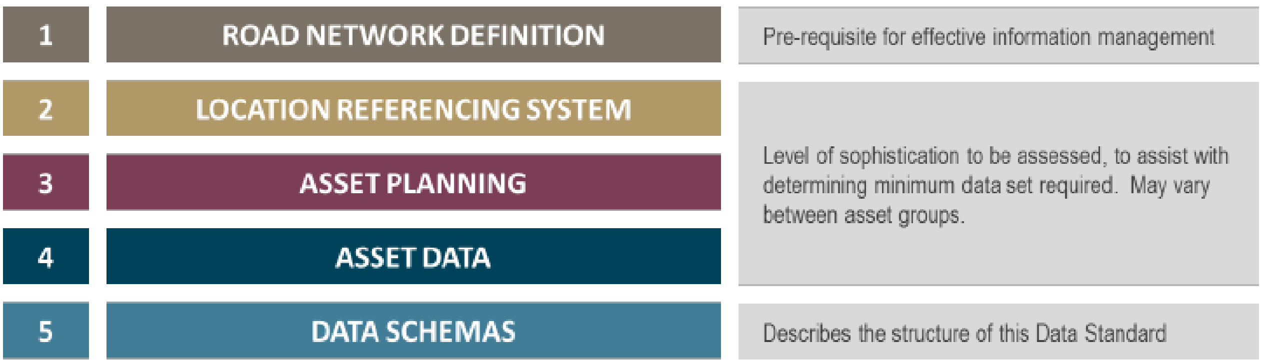
- Network
- Classification
- Condition
- Demand
- Utilisation
- Criticality
- Risk
- Resilience
- Performance (asset)
- Performance (finance)
- Performance (service)
- Access
- Works and costs.

A key aim of the Data Standard is to harmonise the way in which data types are defined into the data function groups. This will assist not only with the consistency of data records, but also the reliability of the data recorded this way for use in heavy vehicle charging models.

2.1.1 Using the Austroads Data Standard

There are five major steps in using the Austroads Data Standard. Figure 2.1 details a series of logical steps for establishing a relationship between an organisation's road management and investment practices, and their relevant data items which are outlined in the Austroads Data Standard.

Figure 2.1: Using the Austroads Data Standard



Source: Austroads (2018).

2.2 Priority Harmonisation Subset and Austroads Data Standard

The PHS of the Austroads Data Standard was developed to promote the benefits of using comparative road network performance reporting. Further, the PHS identifies the data items considered to be a priority for effective asset and maintenance management. The PHS was developed to assist with realising the benefits of harmonised data reporting.

2.3 Importance of Harmonised Data for the FLCB Approach

Current and future heavy vehicle charges are based on appropriate and the best available data, according to the NTC (2020). Therefore, consistency in this data across Australia is of key importance.

The NTC (2020) is currently seeking to make improvements to how data is sourced to improve the quality of the data used for current and future heavy vehicle charging models. These improvements include:

- accurately measuring and reporting road expenditure by state and territory governments over time, including investigating options to improve the reliability and quality of the data
- accurately measuring and reporting local government road expenditure, to improve the reliability and quality of the data
- allocating expenditure between the different vehicle classes, including the cost allocation matrix used in the cost allocation process
- investigation of road use and fuel consumption data and how it is used in the charging model (NTC 2020).

3. Approaches to Heavy Vehicle Cost Recovery and Investment

This section details the requirements for a heavy vehicle charging scheme, including:

- the role of the National Transport Commission (NTC)
- what the current heavy vehicle charging mechanisms are and how they operate
- the *Heavy Vehicle Charging Determination Review* due to be completed in 2021.

3.1 National Transport Commission

The NTC is responsible for making recommendations to the infrastructure and transport ministers on heavy vehicle charging. These charges are intended to be applied nationally and are set to fully recover the share of road construction and maintenance costs attributable to heavy vehicles (NTC 2019).

3.2 PAYGO

Heavy vehicles are classified as vehicles which exceed a gross vehicle mass (GVM) of 4.5 tonnes (NTC 2020).

In the current heavy vehicle charging scheme, the three main components to the charges paid by heavy vehicles are:

- the road user charge (RUC) (otherwise known as the diesel fuel charge), administered by the Commonwealth
- the road component of the registration charge, as applied by state and territory governments
- the regulatory component of the registration charge, which covers the operating cost of the National Heavy Vehicle Regulator (NHVR) (NTC 2019; NTC 2020).

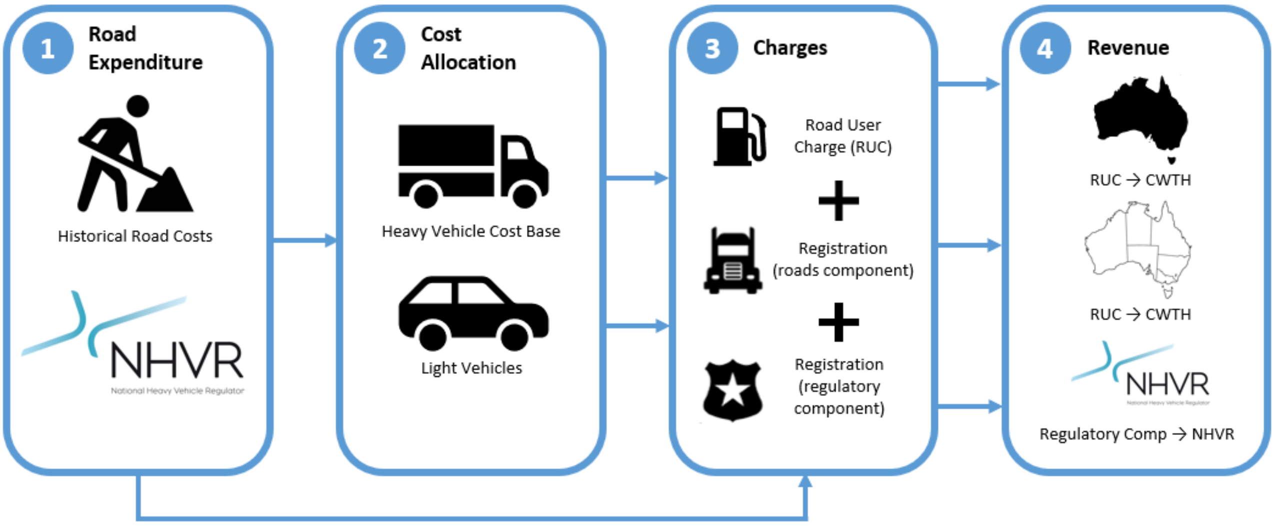
The RUC and the registration charge are designed to recover the costs incurred by governments in building and maintaining roads which are used by, and therefore impacted by, heavy vehicles. The amount of charges used to cover the cost of the NHVR is designed to vary in line with the NHVR's budget, which is approved by the NTC.

These charges are currently implemented by using a Pay-As-You-Go (PAYGO) model. This model calculates the heavy vehicle cost on the basis of historical government annual expenditure and available annual road usage data (NTC 2019, 2020).

Every year, the state and territory road agencies provide the NTC with a completed annual road expenditure template, which reports their most recent year's road building, operating and maintenance expenditure. In addition, data supplied by the Australian Bureau of Statistics Government Financial Statistics Series is used to account for the local government annual expenditures on roads. Using all these sources of information, a cost base is established for the heavy vehicle component of all the costs incurred (NTC 2019).

This is detailed in Figure 3.1.

Figure 3.1: PAYGO system



Source: Adapted from NTC (2019).

3.2.1 Legislation

The RUC is legislated through the *Commonwealth Fuel Tax Act 2006*, and it is implemented through a reduced fuel tax credit. The *Fuel Tax Act 2006* requires the Transport Minister to determine the amount of RUC to be paid by heavy vehicle operators, with a public consultation being required before charges can be increased (NTC 2019).

3.3 Heavy Vehicle Charging Determination Review

In 2020–21, the NTC undertook the *Heavy Vehicle Charges Determination: Scope* (NTC 2020) project to review the current PAYGO methodology to ensure that it is a correct and accurate representation of the cost impact of heavy vehicles.

The issues identified by NTC (2020) with this current methodology, which the determination project aimed to address were:

- The current PAYGO methodology has not been reviewed since the 2014 heavy vehicle charges determination. A thorough review of the methodology will ensure that the methodology and the information used in it are current and as accurate as possible.
- PAYGO is a cost recovery mechanism underpinned by a set of pricing principles which are binding on the NTC. The heavy vehicle cost base identified under the current methodology is higher than the revenue collected by current heavy vehicle charges, but this cost base has been lower in the past. The determination will review the PAYGO methodology with a focus on cost recovery in line with pricing principles. This includes ensuring that the heavy vehicle cost base underpinning future heavy vehicle charges is calculated using appropriate data, assumptions, and calculations.
- To the extent that the determination identifies a gap between the identified cost base and heavy vehicle charges revenue, changes may need to be introduced using a gradual transition process. If required, the determination will develop transition options for consideration by the infrastructure and transport ministers (NTC 2020).

4. Australian Road Agency Maintenance Data Recording and Management Practices

This section summarises the method used by each of the state and territory road agencies who provided information via the consultation process for collecting, recording, and storing routine and periodic maintenance data.

The state and territory road agencies who participated included:

- DIT South Australia
- DoT Victoria
- DSG Tasmania
- MRWA
- TMR.

Table 4.1 provides a summary of the practices and opinions of each state and territory road agency in providing maintenance information. This includes routine and periodic maintenance methodologies, information on LoS, and recommended improvements to Asset Register specifications.

Subsequent to the survey, TfNSW provided some general input on their practices, and this has been added to Table 4.1.

The responses are also discussed in more detail for each organisation in Sections 4.1 to 4.5.

Table 4.1: Summary of survey responses provided by state and territory road agencies

	MRWA	TMR (QLD)	DIT (SA)	DoT (VIC)	DSG (TAS)	TfNSW
Routine maintenance records						
Completion times & location	Recorded	Recorded	Recorded	Recorded	Recorded	Recorded
Description of works	Recorded as individual road segments.	Recorded individually by location or collectively depending on the proximity of the defects.	Recorded individually by GPS, carriageway, and lane. Can be aggregated.	Recorded individually by chainage, lane, and location.	Recorded as individual works.	Recorded individually by location or collectively depending on the proximity of the defects.
Cost of works	Not recorded. Estimates can be made based on assumptions.	Recorded by chainage.	Individual road segments can be aggregated.	For each maintenance record.	Aggregated	Not recorded. Estimates can be made based on assumptions.
Method for storing information	Field based tablets for recording defects and works, which can be synchronised to a central database. This database can be accessed by maintenance planners.	Field based tablet and paper data collection. Recorded in Contractors Maintenance Management Systems (MMS) and TMR ARMIS-RMPC system.	Field-based tablet/device. Uploaded to ArcGIS.	AMMS	Electronic, reflect IMS, and RIMS, (and for Finance, CMS, and Finance 1).	–
Periodic maintenance records						
Completion times & location	Recorded	Recorded	Recorded	Recorded	Recorded	Recorded
Description of works	Recorded as individual road segments.	Recorded exact chainage (can be aggregated for 100 m road segments).	Individual road segments, can be aggregated.	For structures, at the contract level. For pavement, available for segments.	Aggregated	Recorded as individual road segments.
Cost of works	Recorded	Project costs recorded, but not individual works where multiple locations of works were completed.	Currently aggregated due to financial system requirements and cannot be readily linked to individual road segments.	Linked to individual segments.	Aggregated	Currently aggregated due to financial system requirements and cannot be readily linked to individual road segments.
Method for storing information	As above	As above	As above	RAS	As above	–

	MRWA	TMR (QLD)	DIT (SA)	DoT (VIC)	DSG (TAS)	TfNSW
Levels of service						
Classification & criteria	Based on road classification and local knowledge of regional practitioners.	Based on: • road classification • speed environment • defect size and orientation • road geometry and configuration • trafficable width • % heavy vehicles.	Road classification system from an asset management perspective. A new road classification system that will cater for the agency-wide needs is being developed.	Road classification and local criteria such as industry, accessibility, traffic volumes, etc.	Based on road classification.	Based on: • road classification • speed environment.
Using levels of service standards in FLCB model (Would changes to these standards need to be made?)	These standards were not developed for heavy vehicle charging models, therefore, will need to be reviewed.	Current routine maintenance intervention standards and LoS can be linked to heavy vehicle charging models, with additional factors considered such as the delivery of preventive works.	Future data regarding the prioritised works to be undertaken and their components are limited due to the timing and flexibility of decision making.	Not provided	Yes, depending on the final model and resourcing status.	–
Improvements for Asset Register specification						
	Data quality and integration with other information, e.g. cost & defects.	Efficient and cost-effective defect logging techniques and improved back-loggers' defect logging skills.	No improvements	Constantly liaising with Austroads to improve asset data capture and specifications.	No improvements	Data quality and integration with other information, e.g. cost & defects.

4.1 Main Roads Western Australia

MRWA keeps some routine maintenance records, including completion times, locations, and a description of the works conducted as individual road segments. The cost information is not recorded as part of routine maintenance data collection. However, estimates can be made based on assumptions.

MRWA also keeps periodic maintenance records, recording the completion times and locations as individual road segments. Cost information is recorded for periodic maintenance as part of data management.

Both routine and periodic maintenance data is recorded using field-based tablets. These tablets record the defects and the works completed and can be synchronised to a central database which can be accessed by maintenance planners. This method for collection and storage was selected because it provides consistency in collection and analysis.

Any other relevant data which may be needed (e.g. pavement type, condition parameters, traffic, road inventory, etc.) can be accessed through MRWA's other databases. Data can be accessed through the inventory database and RMIP (Road Maintenance Intervention Parameters) for what actions the defined works require.

Regarding LoS, MRWA develops their LoS based on the classification of the road, as well as using the local knowledge of regional practitioners. However, these standards need to be amended for the purposes of heavy vehicle charging as these standards were not developed for this purpose.

Regarding the data requirements, MRWA outlined that current cost data is not readily available in terms of location specific maintenance data. However, routine maintenance funding could be reasonably allocated based on some broad assumptions. Periodic maintenance costs could be estimated by reasonable allocation methods using either estimated unit rates or other methods to apportion more aggregated cost data.

In terms of capital works, MRWA has good location data but it is often difficult to extract the rehabilitation, replacement, and new cost components. Capital projects usually require all these components (e.g. widening works will often encompass all three). Most models require this data to be separated.

To improve future Asset Register data specification, MRWA recommended that data quality and the integration of this information be improved, for both costs and defects.

4.2 Queensland Department of Transport and Main Roads

TMR's routine maintenance delivery is a cyclic process, completed across the entire network throughout the year. Defects are identified, prioritised, and usually fixed during each monthly cycle. This information is to be recorded in the system and paid as a claim where the information must include a location. However, it is usually known that a location may be arbitrary where multiple activities, for example potholes over a section, are repaired. Some data entry staff record provisional items (non-unit rate works) against a single location. Fixed defects are recorded individually or collectively depending on the proximity of the defects and the treatment (maintenance activity) method that was used. This data is recorded against a physical chainage, not a segment.

When cost data is displayed against a 100 m or 1 km segment, it represents the sum of the activities which occurred over that segment. As chainage is recorded for all delivered works, the associated cost can be linked to individual segments unless work has been delivered within two segments. In such a situation, an average cost can be calculated for each segment.

Periodic maintenance records are kept by TMR for surfacing and pavement rehabilitation treatments, although, records of periodic treatments on bridges/major culverts are not recorded. Regular inspections are undertaken on structures and defects recorded in the bridge information system at the structural element level (for example, girder 1 on span 2). When works are completed, defects are removed from the system, but this often occurs when the structure is re-inspected. TMR records the costs of these works.

As with routine maintenance, information on periodic maintenance is recorded based on chainage, lane and pavement layers impacted. The description of works is recorded against the exact chainages impacted. However, when recorded on a 100 m segment, the information is aggregated.

For recording information on routine and periodic maintenance, Smartphones and tablets with the Android operating system are used by most of the contractors to capture defects data. There are two main methods for how this information is then stored. These are the Contractors Maintenance Management Systems (MMS) and the TMR ARMIS Road Maintenance Performance Contracts (RMPC) system. The Contractor’s MMS is the primary storage for defects and maintenance delivery data. The TMR ARMIS-RMPC system is used monthly. The contractors are required to send TMR an ASCII file which contains an extract from their MMS detailing the activities, work quantities and locations of works to be claimed. This information is stored in TMR's RMPC system.

These methods were selected as they achieve efficient, cost-effective, and consistent maintenance delivery. These methods also provide an effective way of monitoring maintenance delivery performance and assist with developing improved reporting frameworks.

There are no additional datasets, other than the routine and periodic maintenance information, recorded and stored with these methods. The routine maintenance is only related to data attributes being used to capture defect data. Inventory information forms part of the core asset management information managed by TMR separately.

TMR has LoS which are based on road classification. Other criteria which impact LoS are the speed environment, the defect size and orientation, the road geometry and its configuration, the trafficable width, and the percentage of heavy vehicles using the network. TMR sees that these LoS could be used in the FLCB model.

In terms of recommendations for improving future Asset Register data specification, TMR believes that there needs to be more efficient and cost-effective techniques for logging pavement defects. There also needs to be an improvement in data loggers’ defect logging skills.

4.3 Department for Infrastructure and Transport, South Australia

Currently, the DIT records routine maintenance information based on location by GPS, carriageway, and lane. The description of works is recorded individually, however, these are aggregated where required. The costs of these works can be linked to the individual road segments and can also be aggregated.

Similarly, periodic maintenance is recorded by location, carriageway, and lane, with road start and end running distances. These works are recorded individually and aggregated where required. The costs are currently aggregated in accordance with DIT’s financial system requirements, and therefore are not readily linked to individual road segments.

For both routine and periodic maintenance, information is captured in the field with tablets, based on GPS location. This information is then uploaded to a centrally located ArcGIS database. Having all the information stored in ArcGIS enables DIT to map and perform a spatial analysis of the data. In addition, it assists with generating consistent reports from a single source.

These datasets include information on the pavement/surfacing type associated with the applied periodic maintenance treatments. This information is captured in the corporate treatment registers. Other condition data, such as roughness, lane shape/rutting, texture and skid resistance are also collected so that it can be directly related to the verification and acceptance requirements when undertaking new, resurfacing and pavement rehabilitation works (i.e. for compliance testing). Network-wide data collection includes traffic data that is measured outside of the maintenance area.

DIT uses a road classification system from an asset management perspective, for determining LoS and maintenance intervention standards. However, this system does not cater for network operations and transport planning needs. A new road classification system that will cater for the agency-wide needs is being developed. In addition to road classification, ANRAM safety ratings, other performance indicators are used to determine LoS. The PBS Network Classification guidelines are considered for trafficable lane and shoulder widths in determining LoS.

4.4 Department of Transport, Victoria

DoT Vic keeps annual records for routine and periodic maintenance. Routine maintenance records provide an overview of the completion times and location of the works by GPS, chainage, and lane. Further, the details of the works are individually recorded on DoT's Asset Management Maintenance Systems (AMMS). . The cost of the works is recorded against each of these maintenance records, as well as the asset class. For periodic maintenance records, the completion time and locations are recorded in the Road Asset System (RAS). These details are available for both pavements and structures. For structures, the contract level description of the works is recorded. For pavements, a description of works is available for segments. The cost of these works can be linked to each individual segment. Other types of information are recorded in these datasets. This includes pavement type, condition, and treatment history.

DoT Vic currently uses a road classification based LoS system for maintenance intervention standards. This system also includes classification based on local criteria such as industry, accessibility, and traffic volumes.

The methods for recording this information have been in use for the past 15 years, as they meet the current needs of the road agency. DoT Vic is constantly liaising with Austroads to develop improved asset data capturing methods and specifications.

4.5 Department of State Growth

DSG keeps annual records of routine maintenance, which cover the completion times and work locations. The description of works conducted is recorded on individual works, however, the costs of these works are aggregated.

DSG also keeps annual records on periodic maintenance. Similarly, these records cover completion times and locations. These records are aggregated for both description and costs of the works.

These datasets include additional types of data such as condition data and skid resistance data (collected by SCRIM). These records are recorded and stored in electronic systems, including IMS and RIMS. The financial elements records are stored with CMS and Finance1. These systems were selected as they are the standard systems for DSG.

DSG's LoS are dependent on classification of the road network, as road maintenance funding is provided based on road category. The expenditure to maintain the required LoS is planned to occur over several years. This information can be used in heavy vehicle charging if heavy vehicle charging is based on the cost to maintain the road to a certain standard.

4.6 Summary of Road Agency Maintenance Data Recording and Management Practices

As outlined in Table 4.1 a variety of methods are used by the state and territory road agencies for recording and managing both routine and periodic maintenance data. However, there are also several similarities.

All road agencies record both routine and periodic maintenance works. Generally, for routine maintenance the data is recorded individually using location data, or the individual works which were completed. This information is commonly recorded by chainage and can be aggregated into road segments.

Cost information is also recorded for both routine and periodic maintenance works. However, the information which is recorded varies for periodic maintenance. Some road agencies aggregate this data for road segments, other road agencies record this information as the cost of the project. For routine maintenance, the majority of road agencies record this information based on road segment.

A variety of methods are used for recording and storing this information. Field based tablets or devices are commonly used for recording the information. This information is then uploaded and stored in a variety of asset management systems, or as spatial data.

Further, the majority of road agencies base their level of service and maintenance intervention standards on road classification. Additional factors which are included are: local knowledge, speed environment, road geometry and configuration, percentage heavy vehicles, traffic volumes, accessibility, etc.

Several road agencies noted improvements which could be made for Asset Register data specifications within their organisations, to assist with the harmonisation of data records for the FLCB approach. These included:

- integration of additional information which may be relevant (i.e. historical costs of defects)
- efficient and cost-effective logging techniques for defects
- improved back-logging
- collaboration with industry bodies such as Austroads.

5. Opinions on Heavy Vehicle Cost Recovery and Investment

This section summarises the opinions of respondents from within each of the state and territory road agencies on approaches to heavy vehicle cost recovery and investment. Further, this section summarises the opinions on what attributes of completed works would need to be recorded in order to achieve the full benefit of any approach. Lastly, this section summarises the opinions on road agencies' ability to meet these data requirements. It should be noted that the opinions included in this text are from the road agency representative who completed the survey.

5.1 Opinions on and Benefits of a Forward-Looking Cost Base Approach

Most respondents consider a FLCB approach to be beneficial. The perceived benefits of an approach of this nature include:

- The FLCB approach is fundamental to setting prices that will reflect the true costs that heavy vehicles impose on the network.
- There is economic efficiency created by the user paying for their true consumption.
- This approach provides a method for cost-recovery in the maintenance and management of a road network in response to the use of heavy vehicles.
- This approach provides improved transparency in the costs of providing the road network for heavy vehicles. This transparency leads to improved decision making about investment in transport infrastructure.

In terms of principles needed to ensure any approach is robust and equitable, respondents noted the following:

- There is a need to ensure that the cost recovery and investment is based on sound assumptions, or an evidence base that the user can see and understand.
- The charges imposed need to be fair and equitable, which are transparent to ensure that there are no subjective assumptions undermining the integrity of the model.
- It is not clear how the forward-looking cost base approach addresses the problem of national averaging of prices. If a particular jurisdiction's forward-looking strategy and funding profile is sustainable, will that jurisdiction receive funding that matches this, or will it be affected by under-funding due to other jurisdictions?
- The model needs to be robust in predicting the future needs of routine and periodic maintenance based on a variety of traffic scenarios.

To facilitate implementation of a more detailed heavy vehicle cost recovery and investment model approach, the respondents noted:

- The need for data reflecting the locations of relevant defects and the associated maintenance costs to be used for future estimation of charges that are aligned with various possible traffic scenarios.
- The need for a harmonised collection of data on completed works, including road ID, carriageway code, lane code, chainage, defect sub-code/s, defect dimensions, defect logged date and fixed date, maintenance activity number, delivered work quantity and cost, and historical defects at the same location which were previously fixed.

- The need to consider heavy vehicle traffic data including their growth rate. This enables a correlation between heavy vehicle use and the observed road deterioration.

5.2 Attributes of Completed Works and Capacity to Meet Requirements

The survey respondents noted that to facilitate more accurate cost attribution, the following attributes of completed works would need to be recorded:

- road classification and road inventory information (including road ID, carriageway code, lane code, chainage)
- locations of relevant defects and the associated maintenance costs
- historical defects at the same location which were previously fixed
- road configuration parameters such as trafficable width and road geometry (this is important because the impact of heavy vehicles can increase due to road configuration parameters such as trafficable width and road geometry. Edge break and shoulder damage are high on narrow roads due to heavy vehicle presence)
- pavement condition levels, such as roughness, rutting and cracking, immediately after treatments, followed by regular condition monitoring to observe the deterioration rates
- traffic data for heavy vehicles should be included, along with their growth rate (this enables a correlation between heavy vehicle use and the observed road deterioration)
- priority of the works to be undertaken, and the components of these works.

It was further noted by one respondent that there are a variety of ways in which heavy vehicles impact roads that are not based on the road classification. Therefore, if there is a lack of delivery of routine maintenance repairs based on road classification, particularly preventative type of works, there can be an increase and subsequent acceleration in pavement deterioration due to the impact of heavy vehicles.

One respondent noted that their organisation does not currently have the capacity to meet all of the potential data requirements and operational requirements for the FLCB model. Currently, data is unavailable for major parts of the network. However, this road agency is exploring avenues to have the data capturing processes extended to cover the entire network.

6. Conclusions

This report has presented the various approaches adopted across Australian state and territory road agencies for recording completed maintenance and operational works that includes both routine and periodic maintenance as well as the opinions of road agencies on the FLCB model, and the data requirements for this model.

Each road agency surveyed noted that they recorded both routine and periodic maintenance works. Routine maintenance was generally recorded as individual road segments, or collectively depending on the intensity of the works at each location. Periodic maintenance was recorded either as individual road segments, or as projects (if multiple works were completed in one project). Generally, road agencies recorded similar information. Therefore, achieving harmonisation in the information recorded will be straightforward. In addition, the data required for the FLCB model will be consistent.

Further, this report aimed to document the road maintenance data perspective of road managers in the road agencies on the FLCB approach, and what the data requirements of this model should be.

Overall, road agencies considered the FLCB model as beneficial, and fundamental in setting prices that will reflect the true costs imposed on the road network from heavy vehicles. The FLCB approach will provide economic efficiency through an ability to recover the costs from the impact of heavy vehicles on the road network. Further, the FLCB approach will create a steady and predictable stream of heavy vehicle funding for roads improving the transparency about the cost of providing and maintaining the road network for heavy vehicles. This will lead to improved decision making about investments in road transport infrastructure. However, to achieve these outcomes road agencies noted additional data attributes of completed works which should be recorded. These include additional road attributes, current and historical defect information, and future predictions of traffic scenarios and deterioration.

Based on the information provided in the consultation on routine and periodic maintenance data records, it seems that all the state and territory road agencies surveyed currently record the required attributes of completed works which are recommended (by the road agencies) for inclusion in the FLCB model. There are, however, improvements which could be made to Asset Register specifications within each of the road agencies to ensure that the information recorded is harmonised for effective inclusion in the FLCB model. These outcomes can be achieved through effective collaboration between state and territory road agencies, Austroads and industry bodies.

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