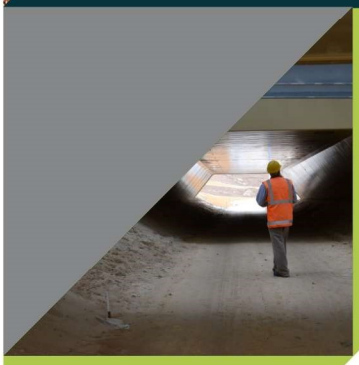
WARRIP

WESTERN AUSTRALIAN ROAD RESEARCH AND INNOVATION PROGRAM

Towards Best Practice in Management of Road Pavement Assets Stage 1

Final Report



AN INITIATIVE BY:

THE GOVERNMENT OF WESTERN AUSTRALIA

mainroads WESTERN AUSTRALIA

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Towards Best Practice in Management of Road Pavement Assets Stage 1
2017-006

for Main Roads Western Australia

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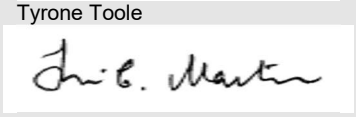
Quality Manager	 Dr Tim Martin

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SUMMARY

Main Roads Western Australia (Main Roads) has embraced and led in the development and application of sound asset management (AM) processes over many years. With the introduction of new data collection technology and recently-published research outcomes on the development of pavement deterioration models and best practice in asset management as reported in the newly-updated Austroads Guide to Asset Management (GAM) (2018 edition), there is an opportunity to review and benchmark the organisation's current processes related to the management of its pavement assets.

By undertaking such a review over two stages, Main Roads has an opportunity to establish a continual program of improvement work across its systems and processes that will ensure the agency is applying current best practice and establishing a solid foundation for its future pavement asset management practice.

The review also aims to assess Main Roads as it progresses towards alignment with ISO 55001, and associated major national initiatives.

This report documents the background to the project and its findings. This work extends earlier work involving initial interviews of regionally-based and centrally-based staff and senior managers aimed at assessing AM practice in Main Roads. An in-depth review of AM systems and processes, as described in draft and current Corporate documents demonstrates substantial progress. Updates to asset managing planning documents and guidelines have also been made with this providing a more comprehensive basis for the review and updated region-specific Ten-Year Network Development Plans (TYNDP).

The key findings address the following topics:

- Consistency and alignment with ISO 550001.
- Consistency and alignment with the Austroads GAM in adopting best practice in the management of roads and transport.
- Quality and comprehensiveness of pavement management modelling, planning and guidance at a corporate level.
- Quality and comprehensiveness of pavement management planning and practice at a regional level.

In conclusion there is a need to:

(a) Address internal capability on a sustainable basis, including the deployment of hired-in mentors and specialist staff to build capability in depth throughout the regions and centrally, although the latter is reasonably well resourced.

Focus on overall asset management system improvements which deliver the best economic return to Government and the Community, with this in need of distinguishing between different regions and focusing on practical whole of life cycle treatments which maximise the return on investment.

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1 INTRODUCTION

1.1 Background

Main Roads Western Australia (Main Roads) has embraced and led in the development and application of sound asset management (AM) processes over many years. With the introduction of new data collection technology and recently-published research outcomes on the development of pavement deterioration models and best practice in asset management, as reported in the recently updated Guide to Asset Management (GAM) (Austroads 2018a, b, c and d), there is an opportunity to review and benchmark the organisation's current processes related to the management of its pavement assets.

By undertaking such a review over two stages, Main Roads has an opportunity to establish a continual program of improvement across its systems and processes that will ensure the agency is applying current best practice and establishing a solid foundation for its future pavement asset management practice.

The review also aims to assess progress towards International Organization for Standardization (ISO) 55001 (ISO 2014a) alignment, and major national initiatives.

1.2 Key tasks and project approach

The tasks being undertaken in this research project are split over two stages. Stage 1 (the subject of this report) includes the following tasks aimed at providing a current status assessment and proposed improvements to Main Roads processes and tools:

- Benchmarking current Main Roads practice against national and international best practice in AM frameworks, systems, KPIs, knowledge capture, use of models, etc.
- Recommend how Main Roads may incorporate pavement modelling and condition data in its business process to provide line-of-sight across strategic and operational levels.
- Recommend alternative strategies to effectively communicate funding needs with Government and the community.
- Identify additional capability requirements across other areas of Main Roads' operations to ensure an integrated consensus of proposed improvements across all departments.

Stage 1 of the project was initiated by:

(a) Information gathering, including:

- How has road (pavement) asset management in Main Roads changed in recent years?
- Reviewing progress against internal and external reviews including the 2007 *Performance audit of state roads* (ARRB 2007), the Main Roads AM Accountability Framework (Main Roads 2008), the Operational Asset Management (OAM) framework studies (ARRB 2009a, 2009b and 2009c) the lessons learned from the Term Network Contracts (TNCs) (Main Roads 2009a), and the Auditor General (WAAG) reviews (Western Australian Auditor General 2009 and 2016).

(b) Initial interviews and assessment of Main Roads practice, how well it is embedded, and its relation to best practice covering questions related to a series of topics tailored to account for different groups and needs.

(c) Follow-on actions post initial interviews, including:

- summarising the initial findings
- the supply by Main Roads of documentation and information sources covering business processes and their application, and a review of these
- undertaking a more in-depth investigation of AM processes and practice and drawing conclusions and recommendations
- documenting the project findings
- responding to feedback and preparing and delivering a Project Workshop to further disseminate the project learnings for Main Roads.

The full suite of tasks is presented in Table 1.1.

Table 1.1: Project tasks

Task no.	Task description
1a	Inception meeting
1b	Scope of interviews
2a	One-on-one/team interviews
2b	Benchmark current practice
2c	Inception report
3a	Detailed dTIMS review with relevant Main Roads dTIMS users
3b	Whole of asset management process review with all departments
4a	Draft report outlining findings and proposed alternative strategies to transition Main Roads to best practice
4b	Main Roads feedback and submission of final report
4c	Final workshop to discuss findings and scope Stage 2

1.3 Limitations of the review activities and changes in the scheduling of tasks

The review commenced with an inception meeting to agree the approach to the project and scope the basis for the interviews (Tasks 1a and 1b in Table 1.1), and continued with one-on-one and team interviews (Task 2a in Table 1.1).

This was followed by the supply and initial review of Main Roads documentation covering strategic direction and AM policy, the Main Roads AM framework (see Figure 1.1) and customer facing levels of service.

An initial review of AM system documentation and tools and the set-up, network plans and application of the Deighton Total Infrastructure Management System (dTIMS), which is applied in determining pavement preservation needs at a state-wide level (Task 3a in Table 1.1), was also undertaken.

However, the task of benchmarking practice required a rescheduling to allow a review of published and draft procedures, instructions and guidelines, templates and forms, reference documents and operational documents to be undertaken, with this task timed to follow the completion of Task 3b, *Whole of asset management process review*.

These changes in schedule were ultimately advantageous as progress in substantially completing a number of key documents and plans was achieved by Main Roads, and the completion of other documents, including the response to the Parliamentary sub-committee on Transport in relation to the Western Australian Auditor General (WAAG) findings (WAAG 2016).

In addition, an inconsistency was identified between the findings of the WAAG report of June 2016 and the information communicated through the various meetings and interviews that the preservation needs of the network are much better understood and are being addressed. Proof of this through the presentation of more factual data was required, with a gap analysis against appropriate measures and criteria being an important input.

1.4 Scope and content of this report

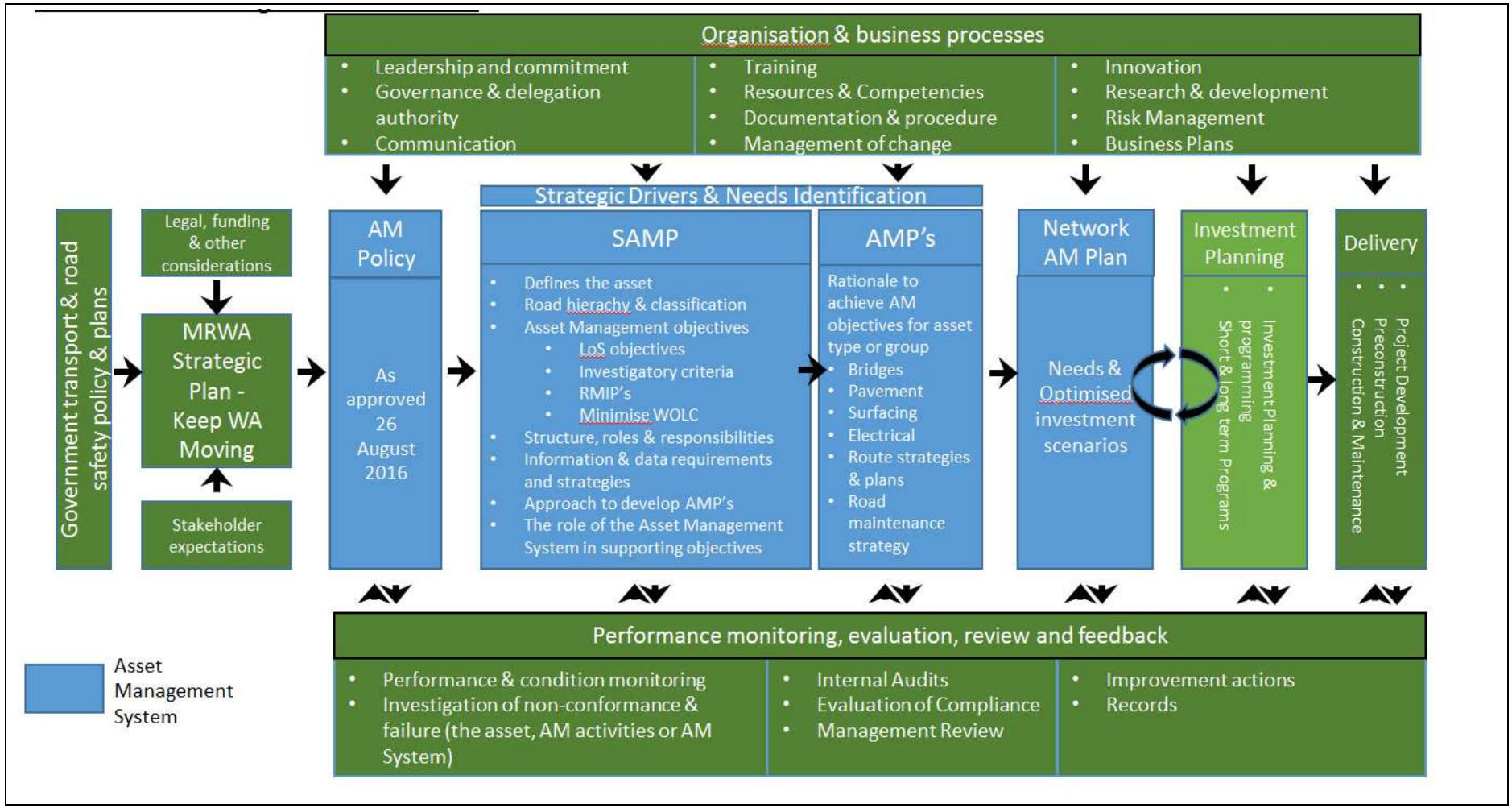
Following this Introduction, this report is structured as follows:

- Section 2, *A basis for best practice asset management*, provides a brief introduction to ISO 55001, and how best practice has been adapted for roads and transport and incorporated into the Austroads GAM.
- Section 3, *Initial interviews and assessment of Main Roads practice*, describes the scope and approach to the interviews, and summarises the results of the interviews and initial findings.
- Section 4, *Detailed dTIMS review*, describes and reviews the modelling framework, life cycle cost analysis procedure, performance models, optimisation, data requirements, treatments and data presentation and reporting employed within Main Roads' dTIMS set-up.
- Section 5, *Whole of asset management process review*, covers the core tasks of the project and documents the status of asset management within Main Roads. It builds on the initial interviews, and documented evidence of the application of policies, plans and processes and tools, and associated ongoing improvement actions.
- Section 6, *Key findings and overall assessment*, reports the results of this review covering the scope of topics and investigation undertaken, including an overall assessment of compliance with best practice.

The report is also accompanied by the following appendices:

- Appendix A, *Abbreviations, acronyms and definitions*.
- Appendix B*, List of formal documents, systems and tools*, noting the full set of documents are in different stages of completion with a number published, in progress or yet to be started.
- Appendix C, *Roadmap to ISO 55001*, which presents summary documentation on Main Roads' 'Roadmap'.
- Appendix D, *Main Roads Network Management Branch RACI MATRIX*, which summarises the roles played by different parts of the organisation across the AM phases, functions and activities.
- Appendix E, *Review details of the Ten-Year Network Development Plans (TYNDP)* for each region.

Figure 1.1: Asset management framework



Source: Main Roads Western Australia (2018a),

2 A BASIS FOR BEST PRACTICE ASSET MANAGEMENT

2.1 General

This section describes the basis for best practice AM, including a brief introduction to ISO 55001, and how best practice has been adapted for roads and transport and incorporated into the GAM.

2.2 Introduction to ISO 55001

ISO 55001 employs a high-level structure which is a common framework for all new management system standards. The aim is to help maintain consistency, align different management system standards, and offer matching text and a common language to aid organisations to incorporate their asset management system (AMS) into core business processes, make efficiencies, and get more involvement from senior management.

ISO 55001 applies the Plan-Do-Check-Act (PDCA) principle to all processes and recommendations its application to any corporate AMS as a whole to support continuous improvement.

The standard specifies key requirements in a series of clauses are as follows:

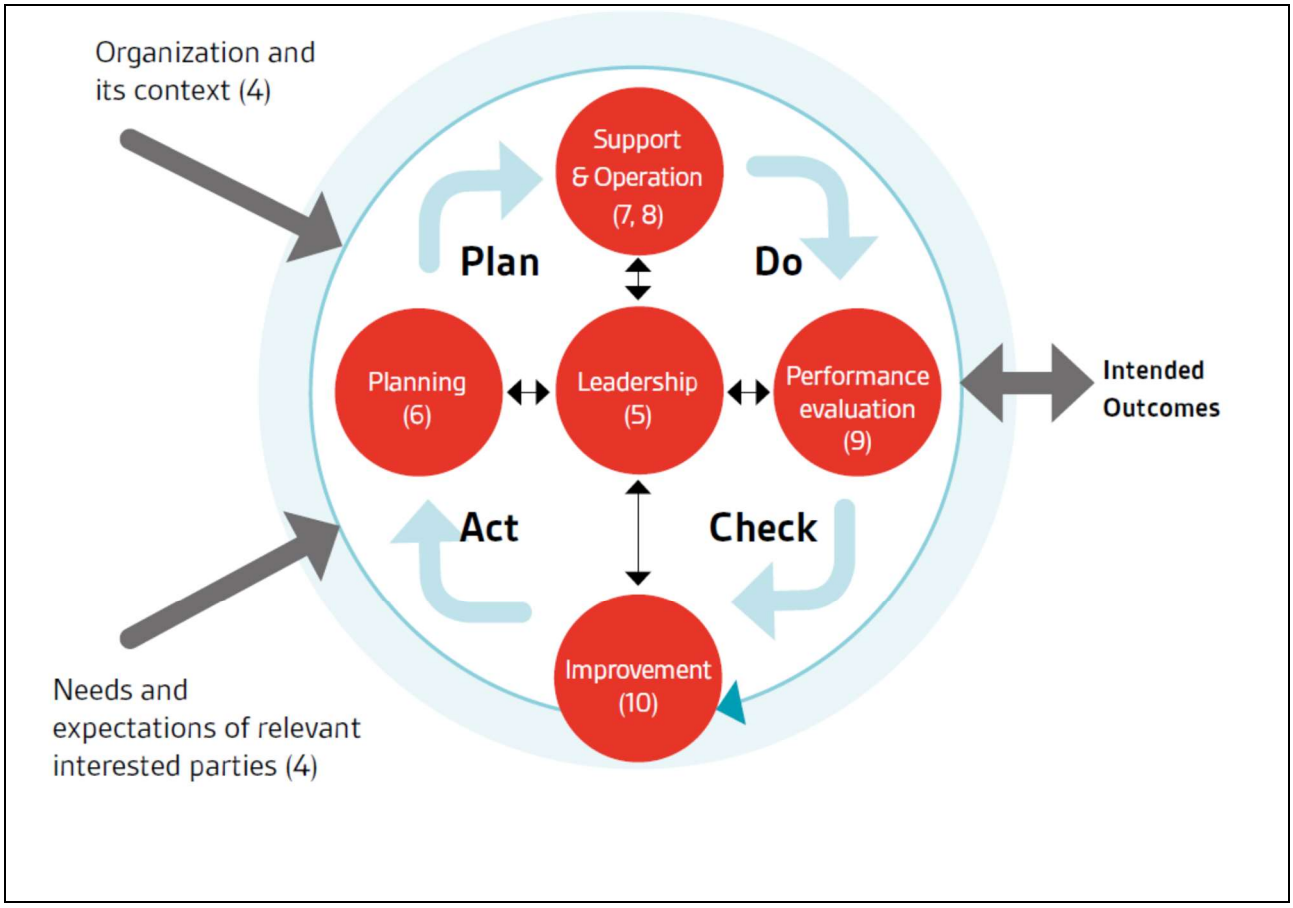
- Clause 1: Scope – details the scope of the standard.
- Clause 2: Normative references – refers to the normative references contained in the standard ISO 55000 (ISO 2018a), Asset management – Overview, principles and terminology.
- Clause 3: Terms and definitions – describes where the terms and conditions given in ISO 55000 apply.
- Clause 4: Context of the organization – the starting point for the standard as it requires the respective organisation to decide on the context of their AMS and how the organisation's strategy supports this. The organisation needs to identify its: position and relation to other organisations and departments, both internal and external; any relevant laws and regulations; and obligations to stakeholders in relation to their AMS. It should also describe how the Strategic Asset Management Plan (SAMP) should be developed and maintained, including:
  - the objectives and scope of the AMS and the organisation's objectives
  - the availability of supporting documents, and the risk and relevant legal and regulatory requirements for the organisation and its register of assets.
- Clause 5: Leadership – requires roles and responsibilities of the senior managers who direct and control the organisation in relation to its use of the AMS. This includes ensuring the AMS supports the strategic direction and that AM requirements are integrated into business processes. This requires a strong culture of collaboration, alignment and continual improvement to be actively supported by top management as well as ensuring that the right resources are made available. Other requirements include:
  - an asset management policy
  - assigned responsibilities for:
    - the planning, establishment, implementation and performance monitoring of the AMS
    - maintaining and updating the SAMP

- continually improving AM.

- Clause 6: Planning – the issues and requirements identified in Clause 4 are considered as well as the risks and opportunities these present. AM objectives should align with organisational goals, and how these address objectives, stakeholder needs and requirements, and risks and opportunities should be described. The SAMP should address whole of life-cycle needs.
- Clause 7: Support – the need to consider the resources and competencies required to establish, improve, maintain and continually improve the AM system. The emphasis is on competent people, with a need to prove awareness, knowledge, understanding, skills and experience. An analysis of training needs should have been undertaken. Communication is also a fundamental need, making sure that the right information is shared with the right people inside and outside the organisation at the right time, including on the assets being managed. Documents relating to AM should be controlled, developed, approved, and maintained.
- Clause 8: Operation – encourages measurement of the effectiveness of the system to achieve its intended outcomes. Change management processes should exist and be communicated. Outsourcing should also be addressed, noting that this does not relinquish the organisation of its responsibilities and requires effective risk management.
- Clause 9: Performance evaluation – the effectiveness of the AM system is quantified against performance indicators including physical performance and financial performance. The clause also requires evidence of internal audits and management reviews and documentation of these.
- Clause 10: Improvement – an emphasis on continual improvement to drive performance with documentation kept to record conformity/non-conformity and corrective actions.

Figure 2.1 illustrates how Clauses 4 to 10 of ISO 55001 can be grouped in relation to the PDCA principle.

Figure 2.1: Operation of ISO 55001 in relation to the Plan-Do-Check-Act principle



Source: British Standards Institution (BSI) (2018).

2.3 Differences between asset maintenance and asset management

Modern AM differs from traditional approaches to managing assets as illustrated in Table 2.1.

Table 2.1: Differences between the traditional approach and modern asset management

Perspective	Asset maintenance	Asset management
Colleague focus	▪ Asset data, location and condition assessment ▪ Current KPIs ▪ The Department's budget	▪ Information-supported decisions (strategic context and related to customer needs) ▪ Strategies to select and manage assets over their lifecycle to support business aims ▪ Collaboration across the Department to optimise resources allocated and activities
Stakeholder focus	▪ Costs ▪ Current performance ▪ Response to failures/maintaining function	▪ Triple-bottom-line and value ▪ Clarity of purpose of the organisation ▪ Focus on impact of activities on organisation's objectives
Top management focus	▪ Short-term gain loss ▪ Department/individual performance ▪ Savings, especially OPEX	▪ Long-term value for the organisation ▪ Developing competence and capability across the workforce ▪ Business risk understood and mitigated

Perspective	Asset maintenance	Asset management
Supplier focus	▪ Short-term contracts and performance ▪ Service level agreements focussed on contract specifications	▪ Long-term contracts and/or partnering relationships in support of client value and objectives ▪ Understanding client strategies and needs in 5 – 10 years

The differences evident from the examples above reflect the maturing of AM over a considerable period; examples exist of this dating back over the last two decades, including in Main Roads' approach to AM.

Practices have therefore been evolving and are reflected in earlier roads-specific national publications. For example, the *Integrated Asset Management Guidelines for Road Networks* (Austroads 2002) was developed to help promote a consistent approach throughout Australia for establishing best practice AM for road networks. One of the important messages was that AM should be seen as a 'process-driven approach'. In a similar manner to the National Guidelines for Transport System Management in Australia (Department of Infrastructure and Regional Development (DIRD) 2015), the Guide proposed an approach which linked:

- AM strategic planning
- AM actions
- AM feedback.

Main Roads developed its approach to AM along similar lines. The main message is AM in Main Roads is not new, but the ISO 55001 sets additional, more comprehensive requirements than has previously been the case.

2.4 Adaptation of best practice to roads and transport based on the GAM

2.4.1 Scope

The latest GAM, published in 2018, was produced to provide guidance to road agencies on the application of contemporary 'whole of organisation' AM practice to road networks. Developed largely by ARRB with special input by AECOM, the GAM is divided into 15 parts, with the order of these parts flowing from high level to detailed technical level providing the following:

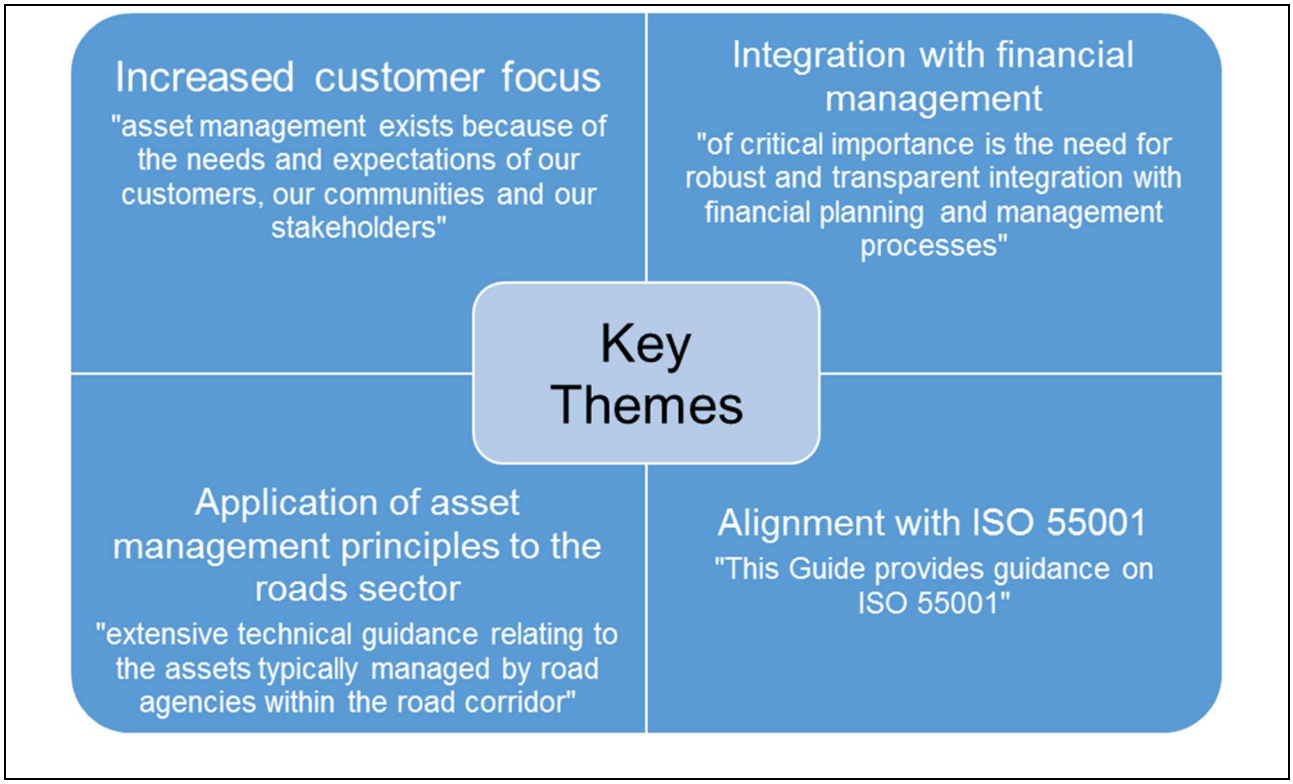
- a management overview
- a description of asset management processes
- detailed technical information.

2.4.2 Key themes

Key themes that flow through the GAM differentiate it from other publicly-available AM resources. Whilst other manuals, such as the International Infrastructure Management Manual (IIMM) (Institute of Public Works Engineering Australasia (IPWEA) 2015), are useful and complementary to the GAM, they do not cover all the relevant technical aspects or provide the local focus needed by road agencies in Australia and New Zealand. The GAM builds on the best practice principles described in ISO 55001, the IIMM and other more generic references; it also references the application of research to solving asset management problems.

These key themes are summarised in Figure 2.2, and are further explained below.

Figure 2.2: Key themes addressed in the GAM



Source: Austroads (2018a).

The themes in the GAM are as follows:

- Increased customer focus

  For a road agency, customer needs and expectations, such as what level of service they require, need to be understood in the context of both community and stakeholder requirements and aligned with the agency's objectives. It recognises that the AM process is a comprehensive and structured approach to the long-term provision and maintenance of infrastructure. AM uses sound engineering, economic, business and environmental principles to facilitate the effective delivery of community benefits.

  This can be taken further, with a more customer-centric view which places the customer at the beginning of this statement. In other words, AM exists because of the needs and expectations of customers, communities and stakeholders. Contemporary AM begins with questions such as 'what are the services being provided and to whom?' and 'what do we need from our assets in order to deliver those services?'

- Integration with financial management

  Clearly, AM involves making decisions about levels of service and associated asset provision. However, of critical importance is the need for robust and transparent integration with financial planning and management processes. This includes not only the expected forward work program, budget development and budget approval processes, but also properly accounting for the very significant and complex capital base that exists in typical road networks.

- Alignment with ISO 55001.

As already discussed, the ISO has published a standard for AM. The intention of this section is to provide an understanding of what to expect should an organisation decide to progress along an alignment or certification path to the ISO Standard.

ISO 55001 is likely to have a significant influence on future AM practice. While it is not mandatory to adopt the Standard, agencies may find it useful to align their practices with ISO 55001 in order to achieve the benefits that improved practice can deliver. Using a risk-based approach is a feature of contemporary AM practice reinforced in ISO 55001. Certification to the Standard may become important in the future as stakeholders and funders seek formal assurance that an agency's practices align with a global standard.

ISO 55001 and the IIMM together provide comprehensive resources, which the GAM complements. ISO 55001 requirements are described in more detail in Section 2.4.

- Application of AM principles to the roads sector

  In deciding how AM should be conducted in their jurisdictions, road agencies need to consider:

  — the nature and scale of the network

  — traffic densities and mix

  — rural versus urban issues.

2.4.3 Definition and purpose

AM has been described in a variety of ways, including as a strategic discipline covering all facets of asset development through to disposal. Other definitions are confined to the preservation or maintenance of existing assets, and the current Austroads definition (Austroads 2015) is:

> *'A systematic process of effectively maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing the tools to facilitate a more organised and flexible approach to making decisions necessary to deliver optimal community benefits.'*

This definition is consistent with ISO (2014b), which specifies requirements for an asset management system within the context of an organisation. It can be applied to all types of assets and by all organisations.

In reinforcing the Austroads definition, the purpose of AM used in the GAM, which is supportive of the above definition is:

To provide the required levels of service at the lowest life-cycle cost to present and future road users and customers, using a 'whole-of-agency' approach to the acquisition and management of physical assets.

It is important to remember that the key focus should be on conducting AM well, i.e. as good business practice. While compliance with regulations and standards may often be a benefit, it should not be the primary driver of good AM practice.

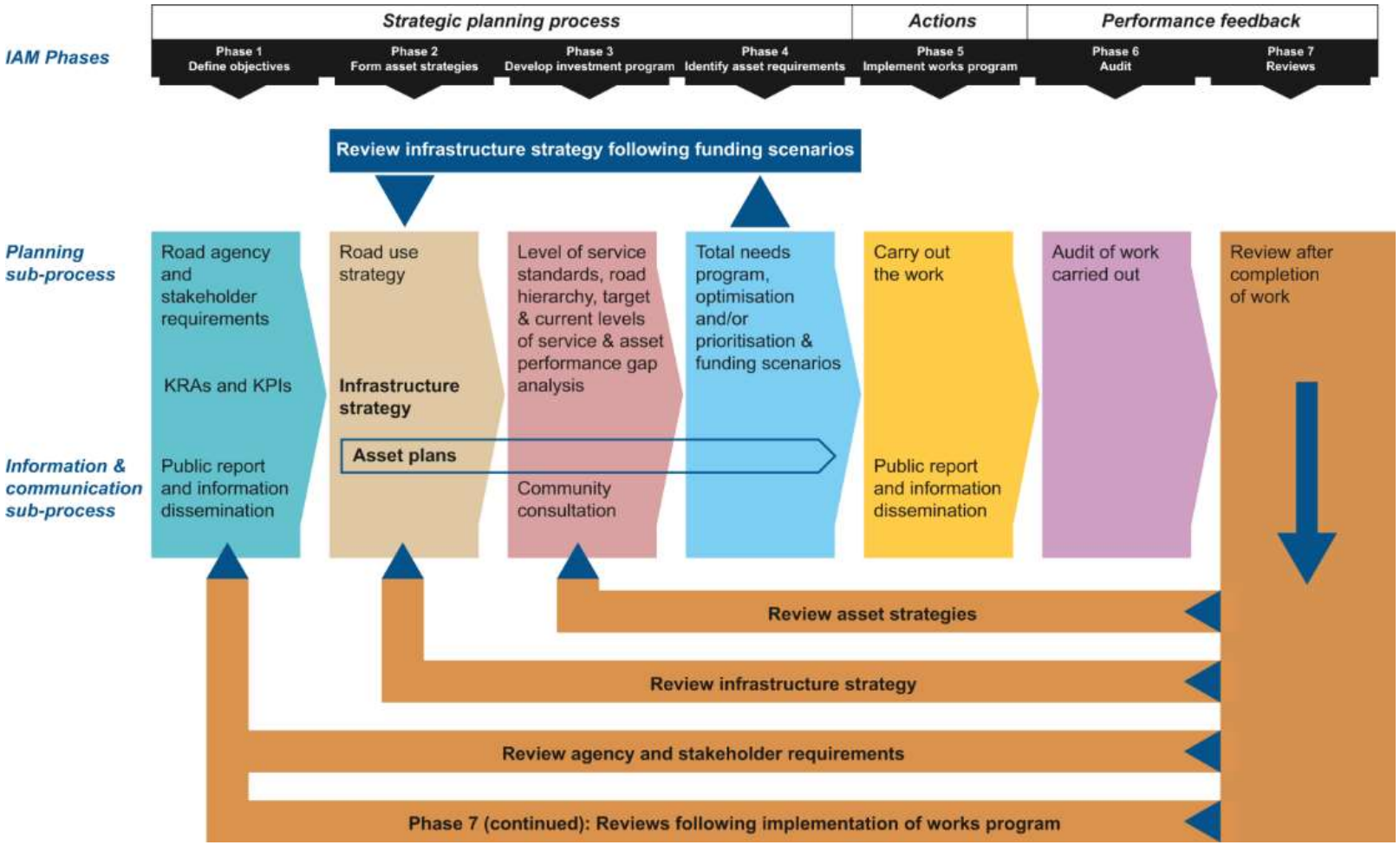
The use of AM principles by road agencies in New Zealand and Australia has developed significantly over the past two to three decades. There has been a significant shift from an AM focus to a service focus, a trend which is also reinforced in the GAM.

2.4.4 Framework

The overall framework for asset management is illustrated in Figure 2.3. It is defined as the Integrated Asset Management Framework (IAMF). This framework has been developed further and personalised by a number of road agencies in Australia and New Zealand as part of their internal AM practice. Many organisations have systematised this process, establishing corporate procedures and complementary information systems and decision support tools, and have sought to embed the following key principles within their organisations:

- the adoption of a rigorous and cyclic process-based approach
- the development of clear business processes and organisational accountabilities
- the continuous improvement in AM practices and human resource skill development.

Figure 2.3: Integrated asset management framework (IAMF)



Source: Austroads (2002).

2.4.5 Relationship to ATAP

The GAM also complements the Australian Transport Assessment and Planning (ATAP) Guidelines (DIRD 2016) which represents an infrastructure planning and decision-support framework applied to transport. They outline best practice for transport planning and assessment in Australia across all land transport modes. They replace the original *National Guidelines for Transport System Management* which remain accessible (DIRD 2015) by providing a comprehensive framework for overall transport system management, focusing primarily on planning, assessing and developing land transport systems and related initiatives. Good transport system management starts with good planning and decision-making, followed by good decisions about individual initiatives. The ATAP Guidelines are a key component of processes to:

- ensure that proposals to improve transport systems in Australia (through policies, strategies, plans and specific initiatives) achieve jurisdictional goals and objectives
- provide maximum net benefit to the community and represent value for money.

They therefore represent a companion set of documents to the GAM and provide specific guidance, e.g. on benefit-cost analysis, which replaces the earlier Austroads Project Evaluation series (Austroads 2012). They contain eight categories of information which cover the following AM-related topics:

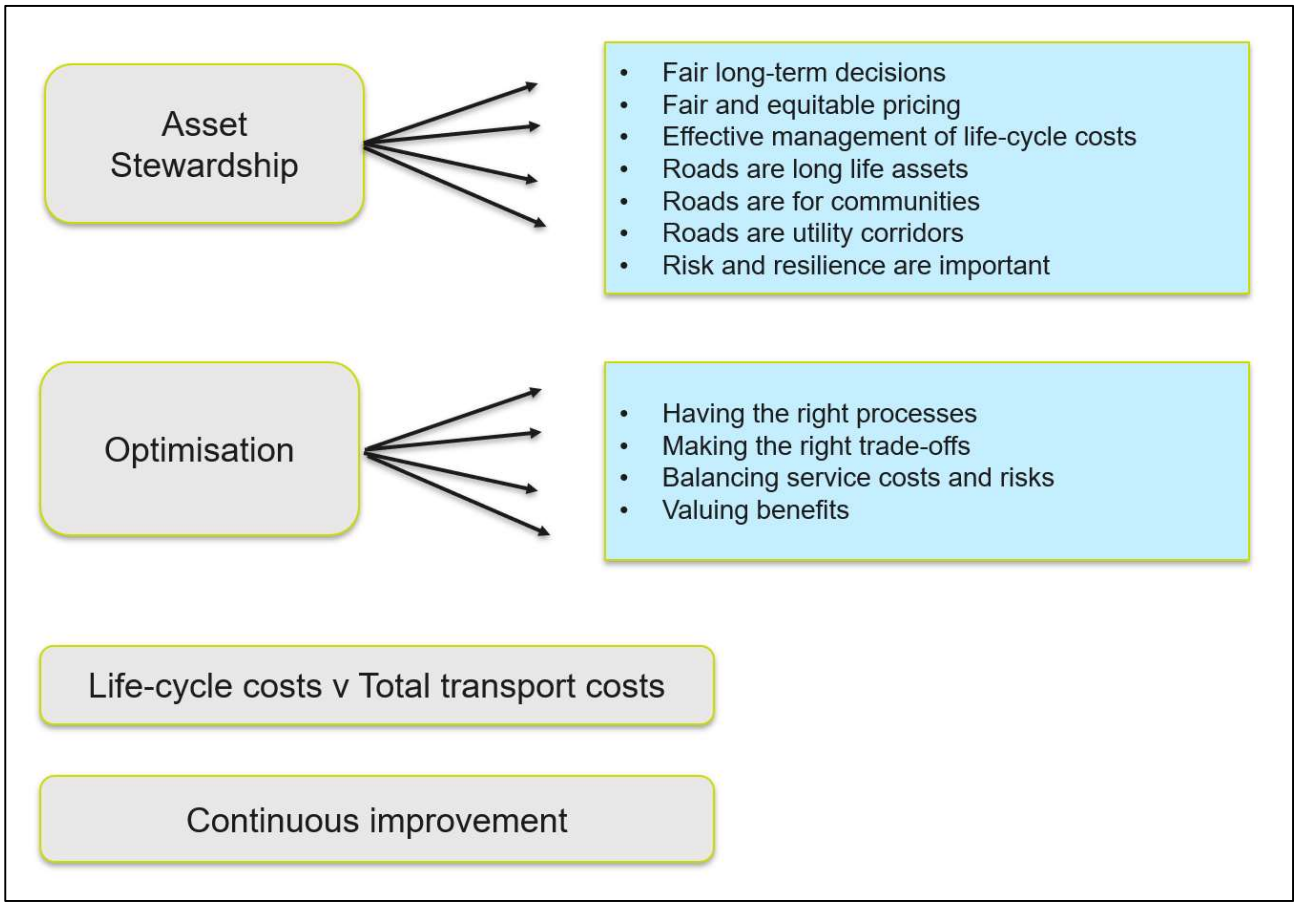
1. About – introduction, purpose, principles.
2. User guide – overview, website, document structure.
3. Framework – policy, integrated transport and land use planning, business cases, prioritisation and program development, delivery.
4. Tools and techniques – travel demand modelling, cost-benefit analysis, equity, etc.
5. Parameter values – public transport, road transport, rail transport, environment.
6. Mode-specific guidance – transport for the public, road, and rail, active transport, travel behaviour change.
7. Worked examples – across all land transport modes.
8. Technical support library.

2.4.6 Key concepts

The GAM also supports the following concepts, elaborated in Figure 2.4:

- asset stewardship
- optimisation
- life cycle costs (of the physical assets) versus total transport costs (including road user costs and externalities)
- continuous improvement (in practice and organisational capacity).

Figure 2.4: Key asset management concepts



Source: Adapted from Austroads (2018a).

2.4.7 Understanding the challenges

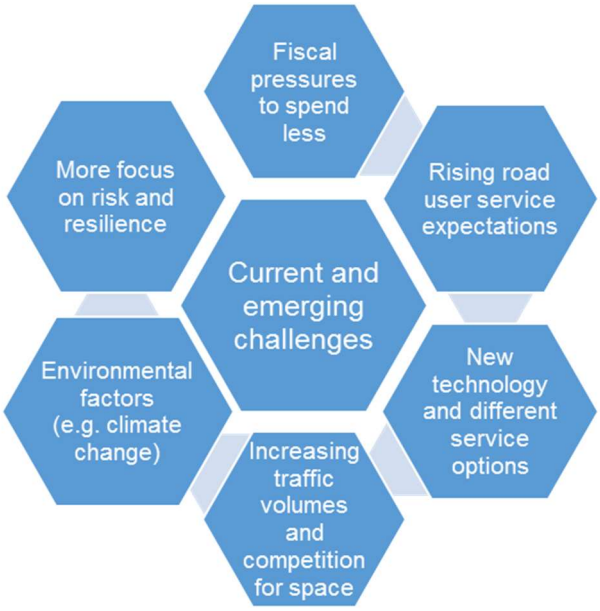
Road agencies can expect to continue to face a myriad of external challenges in relation to changing customer and key stakeholder expectations, as well as managing risk, funding issues, macro-economic issues and global environmental issues.

It is very important that the wider social and economic benefits of good asset management are recognised, including:

- roads and associated infrastructure are vital links providing access and mobility for communities and industry
- roads provide a means for safely and efficiently moving goods and services, enabling economic growth and prosperity
- the substantial investment in infrastructure justifies robust, long-term management practices.

The evolution of asset management is influenced by both contemporary and emerging challenges such as those illustrated in Figure 2.5, as well as other external factors such as legislation, commercial, economic and environmental challenges that should be addressed by asset managers.

Figure 2.5: Challenges influencing the development of asset management



Source: Austroads (2018a).

2.4.8 Asset management benefits

Many benefits can be achieved by adopting a structured, agency-wide approach to asset management. A summary of benefits is presented in Table 2.2.

Table 2.2: Benefits of asset management

Better alignment of service delivery goals with wider organisational goals
Improved financial performance through better return on investment in assets
Informed asset investment decisions – by considering the costs and benefits of alternative solutions, prioritisation of investments, interventions and programs
Better managed risk – through applying a structured risk mitigation framework for assessing, quantifying and mitigating risks
Improved services and outputs
Benefits realised by customers and clients
Demonstrated social responsibility
Demonstrated compliance
Demonstrated duty of care
Demonstrated credibility, such as smoothing the tension between funder and agency
Enhanced reputation
Improved organisational sustainability
Improved efficiency and effectiveness

Source: (ISO 2014b).

Not all benefits will be relevant to a particular agency. The realisation of the most importance benefits will depend on the agency's current situation, its strengths and weaknesses, the expectations of key stakeholders, and the challenges the agency is facing. Any improvement or change management program should be prioritised following an assessment of how well the actions are expected to achieve the benefits sought.

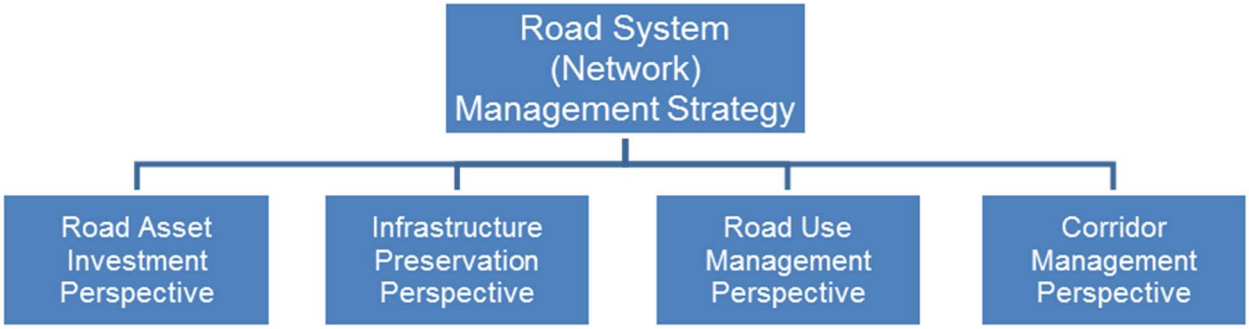
Over the last 20 years, considerable private sector attention in Australia and New Zealand has focussed on improving financial performance using AM processes and practices. The returns have been substantial for organisations beginning with no AM practices in place. Operational expenditure (OPEX) and capital expenditure (CAPEX) budget activities typically consume at least 85% of annual expenditure in most infrastructure-based organisations.

While there is little publicly-available survey data that measures the fiscal impact of implementing AM, many practitioners in Australian and New Zealand organisations have suggested an impact on agency cost savings of 15 to 40%. In some cases, these percentages represent actual expenditure reductions, whereas in other cases reductions were estimated by organisations in terms of what costs they would have incurred without a strategy.

2.4.9 Develop strategies for managing the road network

Road networks should be managed in an integrated and holistic manner. Deciding on the most appropriate strategic approach is a key starting point for any road agency. There are many aspects to consider, including road safety and interactions with land-use, which need to be addressed. Agencies aligning with ISO 55001 also need to consider the relationship between the strategic asset management plan (SAMP) and, should they choose to adopt it, the strategic model illustrated in Figure 2.6. This use of this model is recommended and is consistent with the GAM and the principles set own in the IAMF (Austroads 2002) which continue to apply. It also allows for all the competing issues and demands to be coordinated and addressed together and provides a foundation for developing customer levels of service. Coordination is essential for an effective and efficient strategy to be realised.

Figure 2.6: Strategies for road networks



Source: Austroads (2018c).

The purpose of each of these strategies is as follows:

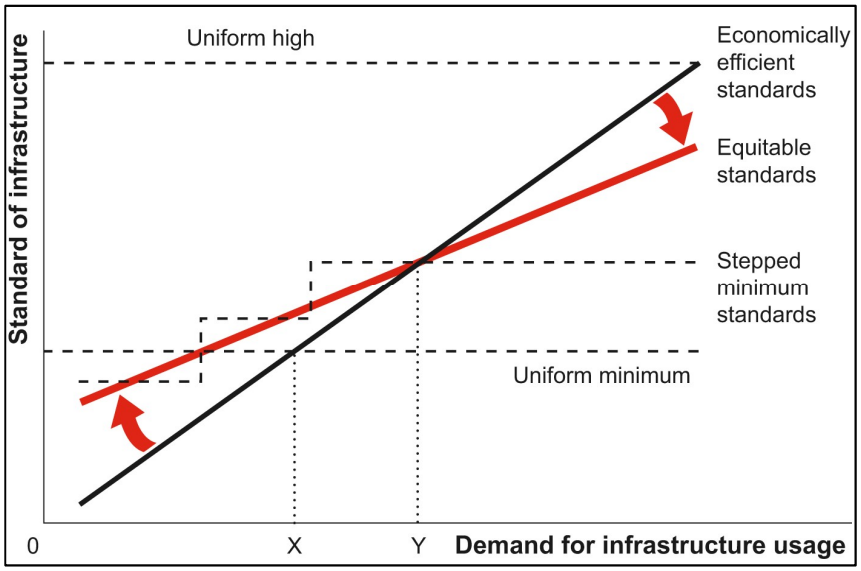
- Road system management strategy (RSMS) – the overarching approach to managing all aspects relating to the road network.
- Road investment strategy (RIS) – new capital investment strategies in assets associated with the expansion and upgrading of the asset base.
- Infrastructure preservation strategy (IPS) – strategies focussed on preserving existing assets in an optimised and cost-effective manner over their life-cycle.
- Road use management strategies (RUMS) – strategies associated with the management of traffic of all forms and modes on the road network.
- Corridor management – planning for and ensuring protection of the road corridor for its intended functions.

Agencies may choose to have separately-documented strategies or perhaps combine strategies in a single document. The approach to aligning these strategies with ISO 55001 and the SAMP should be made explicit in this process.

Finally, the following two key aspects require consideration:

1. Levels of Service – these should be appropriate to the agency's organisational goals and resource constraints, and consistent with the perceived needs of the community and road users. Access is fundamental: it promotes productivity and is an essential catalyst to economic and social growth. Customer-focussed levels of service typically vary depending on the role and importance of the asset within the road system. They need to strike a balance between being uniform across a network and economically efficient. This is represented by the changes in the slope of the line illustrated in Figure 2.7. The flatter the gradient of this line, the less that standards are economically efficient and the more they are uniform or equitable. 'Stepped minimum standards' can often achieve a comparable result forming an 'economic base case' for investment programs. Assignment of standards should account for future demand, i.e. the standard for a particular road may change over time as demand changes.

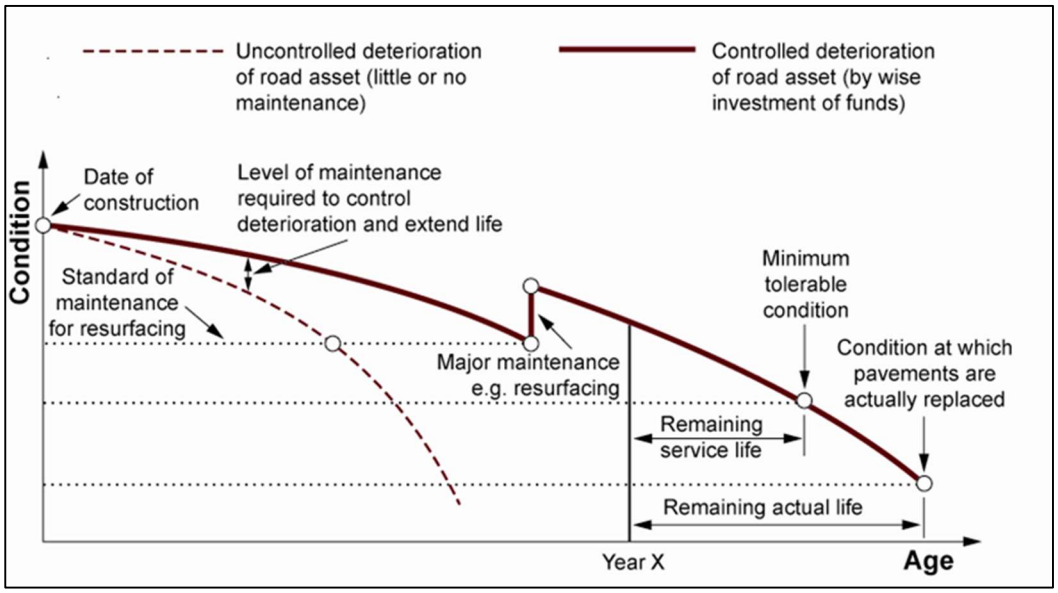
Figure 2.7: Equitable vs economically efficient standards



Source: DIRD (2015).

2. Asset condition – which should measure the asset's physical integrity and condition information to inform the development of proactive maintenance and rehabilitation programs. Asset condition is also critical for risk management due to its linkage to likelihood of failure, with timely interventions being important to extending asset lives and optimising maintenance and renewal as shown in Figure 2.8.

Figure 2.8: Typical pavement condition deterioration with time



Source: South African Development Community (2003).

With respect to the management of pavement- and surfacing-related assets, which this review addresses, both general and specific questions need to be addressed and these are elaborated in the following sections. An overall assessment of Main Roads high-level asset management objectives, policies, systems and tools is also described and assessed.

3 INITIAL INTERVIEWS AND ASSESSMENT OF MAIN ROADS PRACTICE

3.1 General

The initial interviews were planned and structured to allow the project delivery team to understand the role(s) played with respect to primarily pavement AM by the various groups and individuals in the organisation, and the interactions which take place across the organisation. The aim was to receive information on AM practice, with a focus on consistency in approach and understanding specific issues, e.g. within individual regions, and to document the breadth and depth of experience.

A set of questions (Table 3.1) were developed based on the GAM, with the intent that these would offer a starting point to guide discussions, with more specific information being presented and recorded during the interviews. An important concept that was investigated across all groups related to the 'line of sight' which seeks to link and align actions at all levels to corporate targets.

Table 3.1: General questions posed during the interviews

Perspective	Questions	Target group(s)
1. Introduction/context	▪ Describe your role in relation to asset management at Main Roads. How does this interact with other areas of the organisation?	▪ All groups
2. Organisation/governance	(a) What is the value you get from strategic asset management? (b) Can you demonstrate effective/efficient management of public assets? (c) What barriers/constraints exist in achieving more cost-effective management of pavement assets?	▪ Strategy Group ▪ Budget and Investment Planning Group ▪ Network Management Group
3. Outcomes/objectives/KPIs	(a) How do you manage the different focus of 'achievable' vs 'aspirational' targets, considering performance measures and targets? (b) How does your performance framework cater for the different uses of KPIs? (c) How do you link objectives, KPIs and program/project planning to ensure a 'line of sight'? (d) How does your asset investment contribute to broader transport outcomes?	▪ Strategy Group ▪ Budget and Investment Planning Group ▪ Network Management Group
4. Funding and prioritisation	(a) How is limited funding distributed between asset classes, regions, etc.? (b) What level of funding is required to maintain the network to a given Level of Service? (c) How do you demonstrate that your recommended funding is required and the consequences of a smaller programmed spending? (d) How do you justify your decision-making process on funding needs and prioritisation?	▪ Budget and Investment Planning Group ▪ Network Management Group ▪ Regions

Perspective	Questions	Target group(s)
	(e) How does asset management help make (or inform) portfolio-wide investment decisions? (f) Can you demonstrate confidence in your future pavement needs forecasts and proposed programs?	
5. More technical	(a) In relation to pavement assets, how do you use condition data to assist in decision-making, and what data improvements would help you and why? (b) What role does traffic forecasting and demand estimates play in your decision making? (c) For pavement assets, what critical factors/data is needed to better inform decision making in the future, and why? (d) What works best to ensure the smooth delivery of pavement maintenance programs? (e) What practical examples of well-founded pavement treatments exist which provide significant cost savings and have been communicated and accepted in practice? (f) Why do people want to do/not want to do what your work shows they should? (g) Do you have any practical examples of implementing pavement asset management theory?	▪ Network Management Group ▪ Regions ▪ Materials Engineering Group ▪ Asset and Geospatial Information Group ▪ Finance Group
6. Close-out	▪ Do you have any other comments regarding asset management not covered above?	▪ All groups

Source: Adapted from Austroads (2018c).

The interviewer also advised their willingness to accept written or oral contributions to further amplify or clarify any answers or provide added information by extending the scope of the questions. The intent was also to identify potential 'case studies' and areas/issues which would benefit from more in-depth investigation by the project team later in the project.

The interviewees were also advised that they could choose to respond to questions not assigned to their group where relevant.

3.2 Formal documents, systems and tools

Both preceding and during the interviews a number of documents were supplied, and these provided additional and detailed information on policy issues, processes, systems and tools, and technical issues. A list of those made available to the team or viewed during the review is provided in Appendix B. However, not all of these documents were available at the beginning of the review as they were still under development.

3.3 Summary of initial findings

3.3.1 General

A summary of findings is presented below, with this reported separately based on responses from the regions and from a central perspective. The operational setting is also described, and the main

strengths and challenges are discussed, including areas where quick wins (identified by interviewees) could be gained. In each case the findings reflect the views of the respective groups and, as stated earlier, are not the opinion of the review team.

3.3.2 Regions

The operational setting and challenges in managing the regional networks were articulated by each group. They included:

- ageing assets, including structures as well as pavements
- increased freight task due to the closure of the Tier 3 rail line, resulting in concentrated haulage under concessional loading from harvest locations to ports/distribution centres and the haulage of mining equipment and mine inputs and outputs
- many narrow seals exposed to road trains, resulting in significant pavement failures
- flooding/climatic impacts posing a significant risk
- growth of the network, with new roads being constructed to meet demand, e.g. in the south-west
- the lack of quality pavement materials in certain areas of the state, and the overall diversity in conditions.

A summary of the strengths and opportunities, and key challenges faced from a regional perspective are presented in Table 3.2.

Several regions also articulated areas where quick wins could be gained, including the following:

- greater certainty of capital funds – to better match maintenance needs, and a more uniform annual funding profile to take out peaks and troughs
- greater use of interim treatments, e.g. 7 mm seals rather than 14 mm, and rejuvenation sprays (enrichments), to extend coverage as holding treatments
- materials – greater understanding and more strict specifications needed on heavily-loaded roads
- need for the training of inspectors to maximise the use of data as currently everyone comes up with a different interpretation of the data.

Overall, from an organisational perspective the relationship between the regions and central groups was viewed as being very good, and supportive. Consistency in the approach to planning is also evident, and areas for improvement – including to the current state-wide dTIMS model and in data – are well recognised and are being shared. Funding levels have also increased and have apparently contributed to a better managed network from an asset preservation perspective, though quantitative evidence of this is required.

Table 3.2: Summary of strengths, opportunities and challenges for a regional perspective

Perspective	Strengths/Opportunities	Challenges
Organisation/governance	▪ Network Management Branch strongly supporting regions in building capabilities ▪ Good alignment with Budget and Investment Planning (BIP) and Network Management (NM) ▪ Overall satisfaction with NM support and direction	▪ Operating with a new maintenance provider under the Road Network Contract (RNC), and shortage of experienced staff, from supervisors to operators ▪ Change in maintenance operations staff with RNC, and lack of continuity of maintenance managers ▪ Complexity of planning and operations in Metro Region
Outcomes/objectives/KPIs	▪ KPIs and process established	▪ Need for more strategic direction and clarity on key performance indicators (KPI) going forward
Funding and prioritisation	▪ Funding linked to justification ▪ Planning employs the dTIMS model, then field validation, adjustment to treatments, reviewing Maintenance Management Information System (MMIS), high-speed condition data (HSD) and Falling Weight Deflectometer (FWD) data with datasets presented using a reporting/graphics tool named Tableau ▪ Year 1 road maintenance plans are detailed, with reasonable confidence up to year 4. Less specific in outer years, but reported in the Ten-year Network Delivery Plan (10YNDP) for each region ▪ Outputs of planning informs review of reseal program and strategic projects, e.g. combining projects ▪ Level of backlog on seals reducing and now being managed well, with funding considered fair from a maintenance perspective	▪ dTIMS model outputs of variable usefulness, from 80% (i.e. very good) to almost unusable ▪ Modelling of carriageways (not lanes) limits usefulness in Metro Region ▪ Rehabilitation estimates not yet consistent, but potential to improve with supply of Traffic Speed Deflectometer (TSD) data
More technical	▪ Good understanding of issues, including axle loadings, and oxidation of seals, and consideration of the integrity of the pavements rather than solely the age of seals ▪ Extensive use of high-speed data (HSD), modelling, surface condition assessment and validation ▪ Good quality laboratory and MMIS data and local knowledge helping with pavement rehabilitation solutions ▪ Examples of considerable savings in reseal costs by bulking of works, and greater certainty in funding ▪ Trying to flatten out reseal spike in some regions, e.g. through greater use of enrichment sprays ▪ Trialling different solutions, including asphalt/sealed shoulders, Polycom stabilising agent, etc.	▪ Data collection and use of data is biggest issue in Metro Region, with need to capture all lanes and understand 3-dimensional pavement construction ▪ Weigh-in-motion needs to be implemented as assumptions on axle loading may be unreliable, and increased concessional loading is impacting performance – seasonal factors are not available ▪ Drainage maintenance/provision has lost focus, yet it may be the long-term solution ▪ Shoulder sealing is saving a lot of future maintenance and gravel supply, but needs to be employed more widely ▪ Environmental issues – significant road reserve management issues. Also provides a road safety challenge. ▪ Access to suitable materials is a key issue, and further work on developing marginal materials specifications is needed. ▪ Cement stabilisation has been overused, with regions moving towards foamed bitumen solutions.

In addition to the challenges of the operating environment, the main challenges include:

(a) weaknesses in the availability of experienced staff, from managers to operators

(b) the transition from the previous Integrated Service Arrangements (ISA) to the new Road Network Contracts (RNC)

(c) adequate funding for pavement replacement, where appropriate

(d) a need to address complex treatment issues in urban conditions, and the availability of comprehensive data

(e) variable use of solutions which promote significant cost savings including the use of:

- appropriate holding treatments
- shoulder sealing
- bulking of works to reduce contract rates

(f) specific issues on:

- treatment costs and the suitability and availability of effective and efficient solutions, with cases of very expensive solutions with extremely long haulage distances of pavement materials
- evidence of a lack of adequate drainage maintenance or provision.

3.3.3 Central groups

The operational setting and challenges of managing the networks were also articulated by the central groups, with an emphasis on meeting customer needs rather than starting with constrained funding. The need for consistency was emphasised, as was the justification of needs.

A summary of the strengths and opportunities, and key challenges faced from a central perspective are presented in Table 3.3.

Table 3.3: Summary of strengths, opportunities and challenges for a central perspective

Perspective	Strengths/Opportunities	Challenges
Organisation/governance	▪ Greater central coordination with success in addressing earlier lack of consistency across regions: getting funding in the right places and adjusting to meet needs ▪ Investment Planning Steering Committee looks at holistic decision-making process ▪ Recognition that there is a skills gap ▪ Director of Network Management (NM) getting out to each region, as well as other team members and verifying backlogs	▪ Overall human resource capacity and understanding of pavements in regions is a risk
Outcomes/objectives/KPIs	▪ Shift from $ focus to an outcome focus ▪ KPI 1 baseline establishment of financial establishment, monitoring and performance ▪ KPI 2 10YNDP formation, MMIS, knowledge transfer ▪ Previous strategy based on historical constrained budget –now asking funding to support the needs	▪ Drop-off in recent times in the asset management area, with focus on investment planning ▪ Need to focus on Customer Levels of Service ▪ Impacts on corporate strategic direction, performance measures and reporting ▪ Asset management is a subset of the sustainability area and movement and a 'line of sight' building on practical asset management-driven actions is not clear ▪ Need to align the different asset classes together, and ultimately integrate road asset management within the broader transport portfolio ▪ Unclear process regarding strategic route plans and interlinking with other strategic documents ▪ External reporting – funded on six programs and must be reported to each

Perspective	Strengths/Opportunities	Challenges
Funding and prioritisation	▪ Continuous improvement process to get feedback from regions on what should be included in the dTIMS model ▪ Now creating corporate suite of maintenance practices and procedures ▪ Generating a large amount of data, and now need to optimise use to identify trends, outcomes ▪ Resurfacing strategy now in place to reduce backlog ▪ Valuation of infrastructure important role, with surfacing assets now isolated and capitalised	▪ Some regions use dTIMS more than others; therefore greater use and improvements needed ▪ Concern still about what the needs are in the ITS area ▪ Have not been able to clearly demonstrate the impact of changing funding levels ▪ Issue with depreciation becoming an additional expense due to some assets currently being fully depreciated
More technical	▪ Standard treatments, regions decide; complex treatments, MEB consulted ▪ MEB gets involved with Metro Region where service life not met	▪ Austroads (2011) *Guide to Pavement Technology Part 5* – no reference in SWTC documents (no Main Roads supplement); hence empirical/local methods used ▪ Underutilisation of IRIS data ▪ There will be a massive cost and leap when IRIS needs replacing (3-8 year period) ▪ MMIS largely separate from IRIS, and therefore sustainability needs consideration

A number of quick wins were also shared, including:

- Baseline competency for personnel has been addressed through an internal review, with this also considering turnover of staff/loss of knowledge. It is now intended to develop strategies to address the gaps and to implement in 2019 and beyond. This and other organisation plans form part of the Roadmap to ISO 55001 (reproduced in Appendix C) which was presented to the Main Roads Asset Management Steering Committee in February 2018.
- Electronic-based visual inspection data recording to inform works program development, e.g. using a 'Tablet' system.
- Link between pavement life and asset valuation.
- KPIs – disconnect between corporate targets and operational (regional) targets – with actions aimed at creating a line of sight and with these incorporated into the Pavements Asset Management Plan (PAMP).
- Use of Asset Condition Profiles (ACP) to monitor network health, rather than single values such as smooth travel exposure with data presented in the 'Tableau' system.
- Constrained treatments, e.g. holding treatments, to match constrained funding, with a need to continue to encourage better knowledge sharing and to evaluate benefits through appropriate case studies.
- Separating drainage out from pavements for valuation purposes, with Finance taking the lead.
- More focus on pre-seal treatments and surfacing treatments that have a high likelihood of success, although quantifying progress will need consideration with the possibility that such data could be better recorded in and extracted from the MMIS.
- Use of data and better awareness of data, with an expectation amongst many that the availability of TSD data will provide significant benefits, noting also that the value of such data is being investigated in a parallel WARRIP project (*Improving decision making and works program development with continuous network strength and condition data*).

Overall the responses on a formal budgeting and planning process and close working between regional and central groups mirrored regional feedback, whereas the level of detail on KPIs and objectives was less detailed at a regional level. Close working between central groups is also evident from joint tasks, and the overall responses.

4 DETAILED dTIMS REVIEW

4.1 General

Main Roads has been using dTIMS (Deighton Associates 2018) as its main pavement modelling tool to inform its road pavement preservation program since the early 2000s. From 2014, the models used in dTIMS have been replaced or refined with this fully documented in Main Roads (2018a).

This section introduces an analytical framework which is generally accepted as the basis for best practice, e.g. as documented in the GAM, and uses this and an overall assessment of the model from an ISO 55001 perspective as a basis for reviewing the set up used by Main Roads.

The assessment is made based on the available information and the scope of the modelling and does not at this stage define a better quality set up. However, examples of the scale of differences which can result through more refined modelling are illustrated. These compare predictions using the latest Main Roads model and a selection of alternative models, including the most recent Austroads models (Austroads 2010a, b & c). This is reported by Noya and Toole (2018) and discussed later in this section.

4.2 Pavement modelling framework

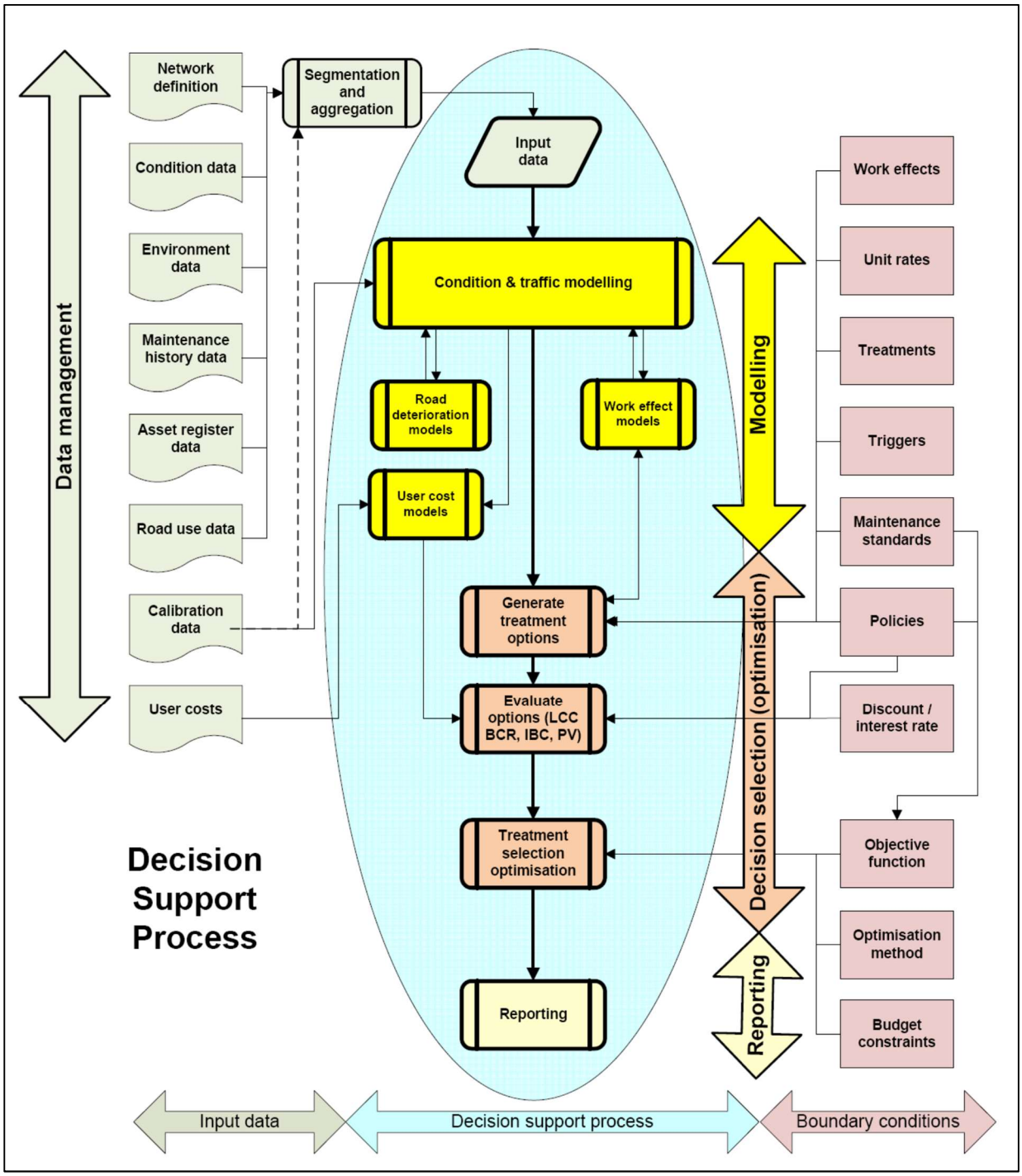
4.2.1 Analytical framework and life cycle cost analysis procedure

Performance modelling is the central component of decision support processes and systems – commonly known as pavement management systems (PMS) when used for managing pavement assets. The full system components are shown in Figure 4.1 (Austroads 2018d). It comprises the following main elements:

- data management
- modelling
- decision selection (including optimisation)
- reporting.

The choices and most common options for the different parts of a pavement management system (PMS) are listed in Table 4.1, with these discussed further below, noting that the presence or absence of specific data, or modelling techniques can only be fully evaluated through comparisons made using case studies. Furthermore, use of anecdotal evidence is problematic given the wide variety of conditions in WA. It is for this reason the Austroads models are of the deterministic type which use mechanistic principles to establish models based on empirical evidence with parameters included based on their significance. The inclusion of such parameters aims to increase the transferability of a model. Transferability in this case means the model's ability to represent different conditions, e.g. climatic and drainage conditions, pavement and surfacing types, traffic levels and mix, etc.

Figure 4.1: Central role of modelling in a pavement management system



Source: Austroads (2018d).

Table 4.1: Example user choices and options for pavement management systems

Elements	Components	Type	Choices	Options
Data management	Network definition	Input	Mainly fixed, although details can differ	Not applicable
	Condition data	Input	User defined	Multiple, but predominantly direct measures of roughness and rutting, with surface distress and strength common
	Environment data	Input	User defined	Various measures, including annual rainfall, TMI, general climate, etc.
	Construction and maintenance history data	Input	User defined	Treatment types, quantities, costs, dates by location, layer, etc.
	Asset register data	Input	Mainly fixed, although details can differ	Not applicable
	Road use data	Input	Mainly fixed, although details can differ	Various levels of detail depending on vehicle classification employed, with dates of survey, type, duration, directions, etc.
	Calibration data	Input	User defined	Whether models are calibrated or not using local/regional evidence
	User costs	Input	Mainly fixed, although details can differ	Use of (national) standard or region/state specific data
	Segmentation and aggregation	Process	User defined	Segmentation/aggregation method, attributes, and detail
	Input data	Input	User defined/selected	Combination of the above, and level of detail, e.g. segment length and whether unique or representative/non-physical
Modelling	Condition modelling	Model	User defined/selected	Type of model (regression or mechanistic-empirical) and level of detailed (incremental, multiple components or aggregate)
	Traffic modelling	Model	User defined/selected	Simple link or section-based projections, or sourced from multi-stage traffic model
	Road deterioration models	Model	User defined/selected	As condition modelling, including parameters such structural data, environment, traffic etc.
	Works effects models	Model	User defined/selected	Mainly whether evidence based, including estimate of impact on resetting multiple condition, structural and age attributes
	User cost models	Model	User defined/selected	Type of model and source, e.g. general vehicle operating cost models as per ATAP guidelines (DIRD 2015), or more detailed HDM type
Decision selection	Generate treatment options	Process	User defined/selected	Standard sets of rules
	Evaluate options	Model	User defined/selected	Combination of treatment options (including limits) and timing
	Treatment selection optimisation	Model	User defined/selected	Ranking or optimisation criteria (in combination with objective functions)
Boundary conditions	Works effects	Model	User defined	Response resulting from application of treatments to current/future condition

Elements	Components	Type	Choices	Options
	Unit rates	Input	User defined	For individual or combinations of treatment, including repairs, or as rolled up rates on a km basis with different rates usually applied based on location
	Treatments	Input	User defined	As individual or combination treatments, depending also on type of model
	Triggers	Input	User defined	As individual or combinations of attributes based on measured data, or as condition states/ratings
	Maintenance standards	Input	User defined	Combination of sets of treatment types and triggers associated with different applications, e.g. by road hierarchy, traffic level/category, etc.
	Policies	Input	User defined	High-level basis for maintenance standards, including associated levels of service, targets and objectives, general priorities, etc.
	Discount/interest rate	Input	User defined	Usually defined by funding agency
	Objective function	Model	User selected	Various, including: a) maximisation of net benefits (typically based on total transport costs) b) minimisation of agency costs to achieve a target condition c) maximisation of condition within budget constraints
	Optimisation method	Process	User selected	Combination of above with ability to determine full program under budget constraint
	Budget constraints	Input	User defined	Unconstrained or budget constrained based on user defined budgets and periods with or without user defined base case (and minimum standards)
Reporting	Condition, traffic, treatments, costs, financial and economic parameters	Output	User defined	Multiple choices

4.2.2 Data management and provision

The following are a few examples of data which typically have a significant impact on pavement performance predictions and benefit estimation:

- Condition data – high-quality data, including road profile, surface condition and strength data. Traffic Speed Deflectometer (TSD) data, including structural information and 'laser-based' crack detection is eagerly awaited for use on the full network. The use of the full suite of data is being examined under a parallel project.
- Environment data – recognised as having a significant impact on surfacing performance (durability) and age-soil and moisture-related deterioration.
- Maintenance history – reflects the cost of upkeep. It is valuable in identifying sections which demand frequent, often expensive, repairs which may be indicative of a more fundamental performance issue. Not accounting for such data means the cost of the 'base case' is underestimated, and the benefits of a proactive strategy can be undervalued.
- Calibration data – time-series information on condition and other data is an important input to ensuring any performance models reflect actual local conditions. The possible inappropriateness of performance estimates was identified as a factor in the initial interviews.
- Segmentation and aggregation – details of actual condition can be identified or lost depending on the level of aggregation used. This can impact works program estimates and benefit estimation, particularly where too much averaging results.

4.2.3 Modelling

The following considerations represent critical choices in terms of modelling:

- Condition modelling, including road deterioration (RD) models – the main considerations are whether it is based on a comprehensive mechanistic-empirical structure with model terms and coefficients determined based on time-series observations, or whether it is based on regression-style models. The latter models are simpler in form, and may prove useful, they are limited because they contain few explanatory variables. For example, whilst they may be useful for a single region and physical environment (climate, soil, etc.) for a specific pavement type, the effect of traffic and other variables may be absent. Model availability may also be an issue, i.e. a model exists for roughness progression, but is unavailable for other condition measures, e.g. rutting, cracking, strength, etc. The absence of such models means only very general modelling can be done, with little benefit to modern decision-support analysis in the context of pavement asset preservation where the timing of a treatment may be critical. This is illustrated by the common phrase 'stich-in-time', representing early and timely intervention.
- Works effects (WE) models – the post-works condition is estimated, e.g. roughness reduction, rut depth correction or impact on strength. A number of models exist for this purpose which account for the type of treatment, and its overall composition, including the thickness and strength of component layers. WE models act in conjunction with RD models, the treatments and the traffic applied, resulting in a condition profile over time. This is the basis for comparing impacts on traffic and therefore user costs (see below).
- User cost models – these estimate the absolute vehicle operating costs (VOC) and other components of road user costs (RUC), e.g. travel time. They are employed where a full economic analysis is undertaken to estimate the total transport cost savings of a particular strategy. They are often reported as the net present value (NPV) of a particular initiative relative to an alternative such as business-as-usual, current funding level, etc.

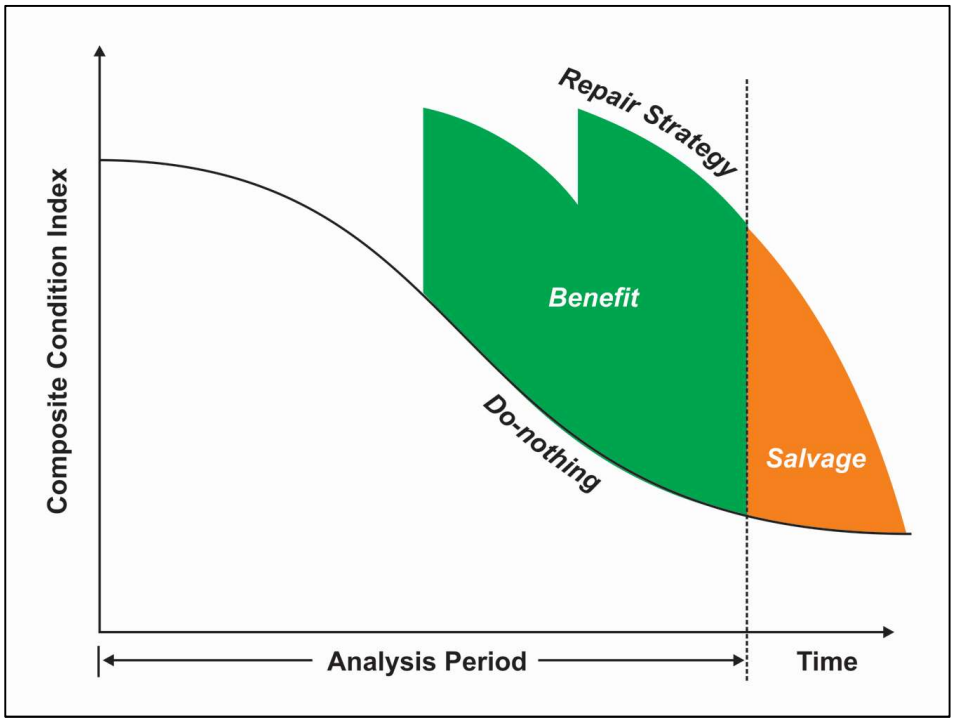
- Generate treatment options – a set of rules are typically defined which allow a treatment to be triggered. These are usually based on condition measures or may employ a condition rating (a formulation which combines a single measure or a number of measures). However, for surfacing treatments, age may be used as a surrogate condition measure, particularly for high-level analysis. The complexity of the rules used differs, with some allowing little or no overlap between generic treatments, such as routine maintenance, resurfacing and rehabilitation, whereas others compute a very large combination of treatment strategies with almost all combinations. Whether the latter approach is efficient needs consideration as it can be wasteful in terms of computing time and may generate options which are later judged to be unworkable. This happens where treatments are applied beyond a certain condition, in which case a dis-benefit needs to be applied as they will most likely have a short life. A major issue, which is often ignored, is the need to run an analysis with the starting point for different treatments delayed in time. This is essential if budget optimisation is to be performed correctly: the ideal timing of a treatment will vary as the budget is tightened. A number of modern systems incorporate such options directly, whereas others do not and rely on the experience and skills of the user. The balance is often between what may constitute a black-box solution, or a more transparent and reasonably pragmatic solution.
- Evaluate options – the full modelling is applied to each analysis alternative (termed a treatment strategy) and for each analysis section. The time-series condition profile of each road section is produced, and agency costs and, where necessary, road user costs determined. Certain systems also report condition as a benefit, i.e. in comparison with a do-minimum or relative to other strategies, in which case it would be reported as an incremental benefit. Measures such as NPV, and NPV/cost may be reported. Other, more complex options, may also be employed, including sensitivity or risk analysis as this helps inform the choices made by decision makers.
- Treatment selection optimisation – the results of the options evaluation are employed to select a single treatment strategy per analysis section. The ideal strategy, based on unconstrained/unlimited funding, is one that maximises benefits, whether these are expressed in monetary values or in terms of condition. The complexity of this step increases where a budget constraint is applied, with the aim typically being to maximise the net monetary benefit or condition benefit per unit of investment. Where a condition-based optimisation method is employed, it is wise to state the economic total transport cost savings associated with such a scenario as this can assist in communication, including any sensitivity/risk analysis.

4.2.4 Boundary conditions

Boundary conditions represent specific user-defined rules applied during analysis and are therefore an integral part of the modelling process. A selection of these is now discussed.

- Works effect – the time-series impact of a treatment (repair) strategy is determined and compared with a do minimum or do-nothing option as shown in Figure 4.2. The difference is represented in this example by the ‘area under the curve’ (less the salvage value if a short analysis period is chosen. As the magnitude of the works effects is reflected by the work item and the quality of workmanship, it can have a significant impact on the forecast condition and funding requirements. Overly optimistic works effects predictions results in a better pavement condition predicted over the analysis period, lower whole-of-life costs and therefore an underestimate of actual budget requirements. At a segment level, exaggerated work effects will also result in higher benefits which in turn will distort priorities and most likely cause earlier selection of the work item over others. It is for these reasons that the quality of models is essential, and that the minimum operating conditions allowable are well defined.

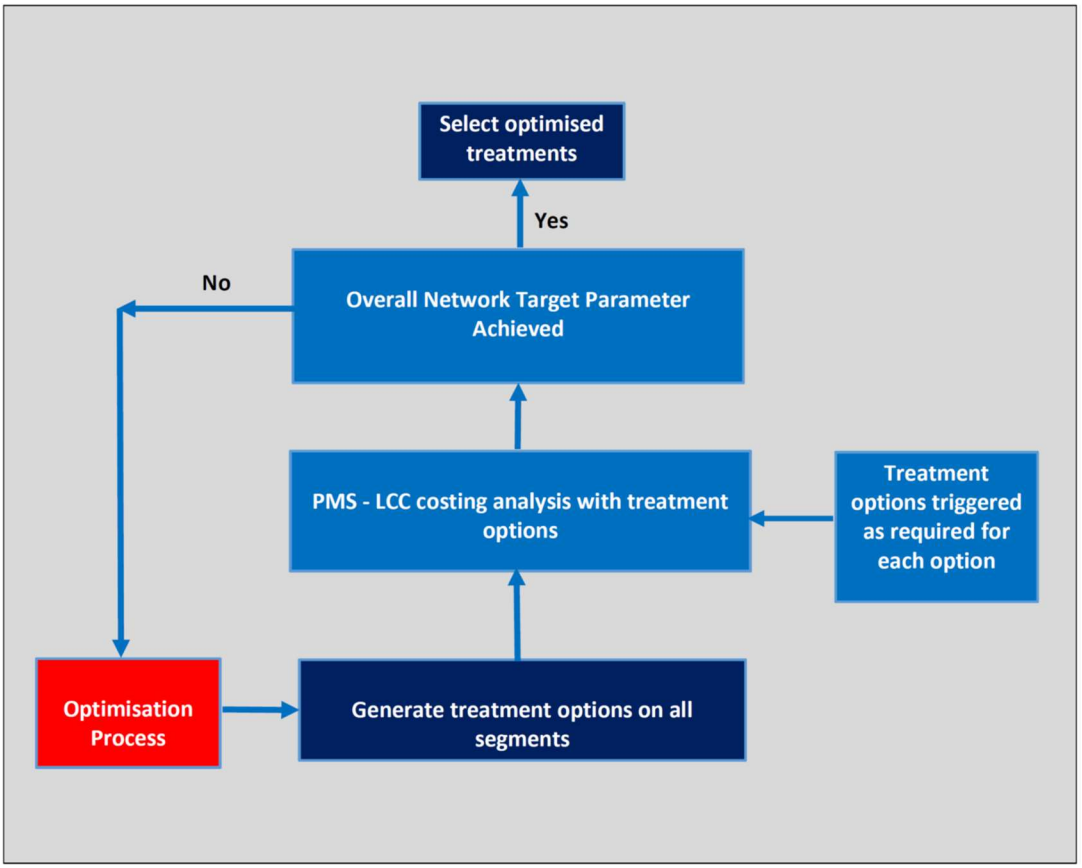
Figure 4.2: Works effects



Source: Deighton Associates (2018).

- Maintenance standards – these describe the desired outcome of the road maintenance investment in specific and quantified terms. Maintenance standards are also used to reflect the different expectations relating to different road classes in the road hierarchy. For example, the maximum roughness would be restricted to a much lower value on a major high-speed freeway than on a residential street, where travel speed is not a major contributing factor to the comfort of the ride or safety. They may also be implemented at two different points in a road asset decision support system (DSS). The trigger condition is formulated to ensure that appropriate treatments are available to achieve the maintenance standard. During the optimisation stage, the priorities can be defined and refined in such a manner that higher priorities are directed towards achieving the overall desired maintenance standards. Figure 4.3 is a schematic of this process.

Figure 4.3: Optimisation process to achieve maintenance standards (level of service)



Austroads (2018d).

- Objective function and optimisation method – these are often considered together along with budget constraints, since with modern, more complex PMS the overall process is somewhat integral, and iterative in nature. The aim of the optimisation process is to reduce the full set of available treatment options into one set of treatment options that produce the best value within given restraints. The target parameter is described and calculated using the objective function which may comprise a single parameter or a combination of multiple parameters (such as a composite Pavement Condition Index), e.g.
  - maximisation of net benefits (typically based on total transport costs)
  - minimisation of agency costs to achieve a target condition
  - maximisation of condition within budget constraints.
- Where a condition-based target is employed various examples exist, with roughness frequently used, particularly when it is in the form of a roughness deterioration function that encapsulates cracking, rutting, traffic, environment, etc. Other parameters, such as asset value and surfacing age, may also be used, or a combination of parameters may be used to produce a Pavement Condition Index (PCI) whose formulation has been agreed. The latter approach is preferred, and examples exist based on the European COST study (Litzka et al 2008) which has been widely adopted for such applications. However, users need to be careful to avoid cases where the optimisation target is only one parameter, or it is dominated by a single parameter or multiple parameters which produce either an imbalanced outcome, or what may be judged an inappropriate outcome. For example, if the optimisation target is surfacing age, very few overlays, which are effective roughness-reducing treatments, will be

selected, as they are more expensive than sprayed sealing. Similarly, if the optimisation target is reduced roughness, overlays will be preferred by the process over sprayed sealing because sealing does not reduce roughness appreciably. It may be more appropriate to achieve a more balanced outcome where a mix of different treatments is selected on the basis that each one selected is the best suited for the prevailing conditions. A suitable mix of parameters would consider the standards to be delivered by the road which take account of surfacing/pavement types and traffic level so that the best strategy under budget constraint is selected. This helps ensure a link with performance outcomes, i.e. that planning supports the targets which the agency is aiming to achieve.

4.2.5 Reporting

Reporting is the means to communicate the results of an analysis. For pavement management applications, it includes the following:

- Current status analysis, and the reporting of historical data.
- Projections of future conditions and traffic, and treatment needs in relation to unconstrained and constrained funding, including the presentation of data in a summary of detailed form to inform network-wide needs or road- and section-specific needs.
- Projected outcomes in relation to maintenance standards and benefits, including the reporting of performance against KPIs.

Reporting may take the form of tables, graphs and spatial presentation, with the format selected to best support the reason for the output. This varies considerably from an overview of the entire road network, a region or a road corridor, to a more detailed view of a road link, or project.

Most importantly, reporting should be designed to meet the needs of the intended users of the information. Whereas it is often considered a final step in the implementation of a management system, it is arguably the main reason a system exists and should form the basis for its design.

Finally, with respect to current and projected performance, these are increasingly reported as the distribution of conditions on the network (as a measure of network health) whereas more general values, e.g. no worse than a stated value, or average values, are less used. Specific examples include a preference for reporting asset conditions profiles (ACP) rather than smooth travel exposure (STE), with the latter representing the proportion of the network below a stated value. The case against the latter from a PMS perspective is that it masks the build-up of a backlog of works which is shown by a bow-wave of conditions with a risk of significant change in the immediate future.

4.3 Review findings

4.3.1 General

The review findings have been developed considering the components of a best practice decision support system (DSS) as described above. The current analytical framework is comprehensive, and its status has been assessed with comments made with respect to the extent it fulfils the requirements of a modern DSS. The scope of different components is also illustrated and discussed, and deficiencies are identified where they exist, with a preliminary rating assigned based on the following:

- 0 – substantially below requirements
- 1 – meets requirements but improvements possible
- 2 – substantially above requirements.

4.3.2 Data management

The status and preliminary rating with respect to data management is recorded in Table 4.2.

Table 4.2: Status and preliminary rating of Main Roads pavement management system: Data management

Components	Options	Status	Preliminary Rating
Network definition	Not applicable.	Comprehensive data	2
Condition data	Multiple, but predominantly direct measures of roughness and rutting, with surface distress and strength common.	Long history of comprehensive functional data, using profilometer, collected annually with video capture of include strength data using the FWD in past years and the TSD for a sample of 900 km (in 2017) with a full TSD survey in 2018.	1 moving to 2 (post TSD)
Environment data	Various measures, including annual rainfall, TMI, general climate, etc.	Climate data available, with use made of temperature (seal lives) and rainfall (pavement deterioration) data, but other data such as TMI required.	1
Construction and maintenance history data	Treatment types, quantities, costs, dates by location, layer, etc.	MMIS data, including comprehensive details since approximately 2014, with improvements possible in Metro Region to representing reportioning of roads/lanes.	1
Asset register data	Not applicable.	Comprehensive data.	2
Road use data	Various levels of detail depending on vehicle classification employed, with dates of survey, type, duration, directions, etc.	To be confirmed (TBC)	
Calibration data	Whether models are calibrated or not using local/regional evidence.	Set of state-wide road deterioration models available for Metro and Rural Regions based on time-series trends. See also Section 4.3.3 and Table 4.2	1
User costs	Use of (national) standard or region/state specific data.	Not employed; see also Section 4.3.3 and Table 4.3	0
Segmentation and aggregation	Segmentation/aggregation method, attributes, and detail.	TBC	
Input data	Combination of the above, and level of detail, e.g. segment length and whether unique or representative/non-physical	TBC	

Highlights include the soon-to-be-available network-wide TSD data with respect to road functional and structural condition. Improvements which are easily achievable include more comprehensive climatic data (TMI), and historical data. Improvements in 'calibration' would require significant resources and its importance is discussed under Section 4.3.3.

A major deficiency discussed further in Section 4.3.4, is the absence of road user cost data and modelling.

4.3.3 Modelling

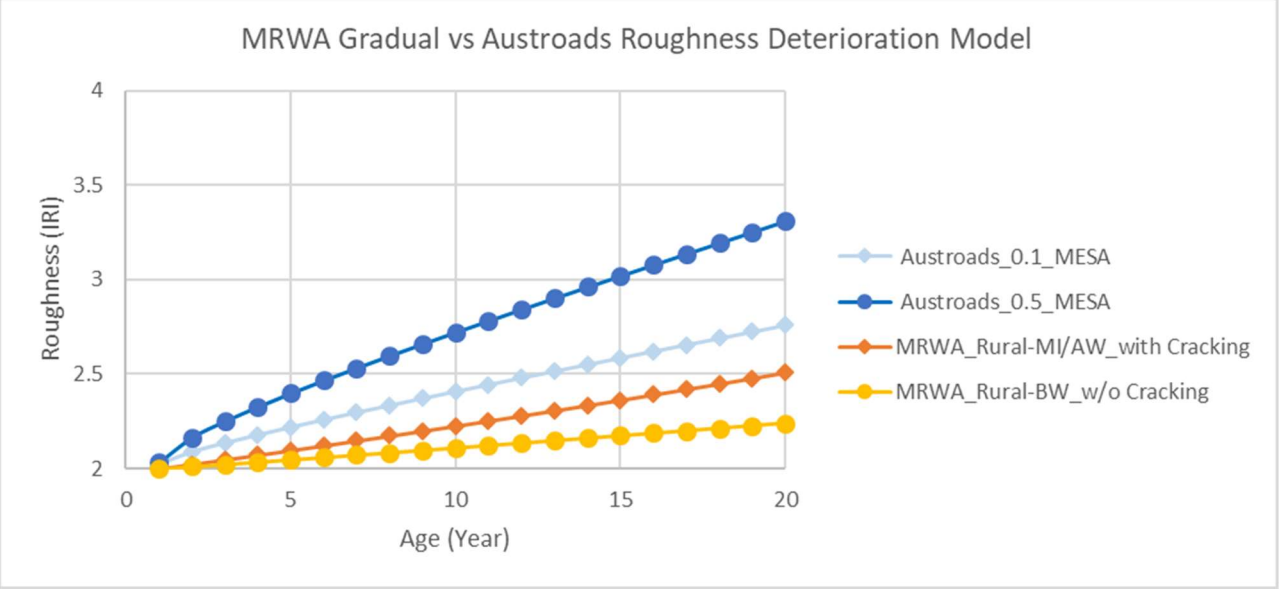
The status and preliminary rating with respect to modelling is recorded in Table 4.3.

Table 4.3: Status and preliminary rating of Main Roads pavement management system: modelling

Components	Options	Status	Preliminary Rating
Condition modelling	Type of model (regression or mechanistic-empirical) and level of detailed (incremental, multiple components or aggregate).	Regression-type model for roughness and rutting with annual (%) change in condition by road class for gradual and rapid deterioration phases.	1
Traffic modelling	Simple link or section-based projections, or sourced from multi-stage traffic model	Predominantly simple projections. Traffic model available for Perth but use in AM unknown.	1 (TBC)
Road deterioration models	As condition modelling, including parameters such structural data, environment, traffic, etc.	Simple models by road class with no structural, environment or direct traffic components, with rapid deterioration estimates only applied to regions with rainfall >300 mm p.a.	1
Works effects models	Mainly whether evidence based, including estimate of impact on resetting multiple condition, structural and age attributes.	Simple resets available by treatment type.	1
User cost models	Type of model and source, e.g. general vehicle operating cost models as per ATAP guidelines (DIRD 2015), or more detailed HDM type.	Not used. Major omission restricting ability to compute economic benefits.	0

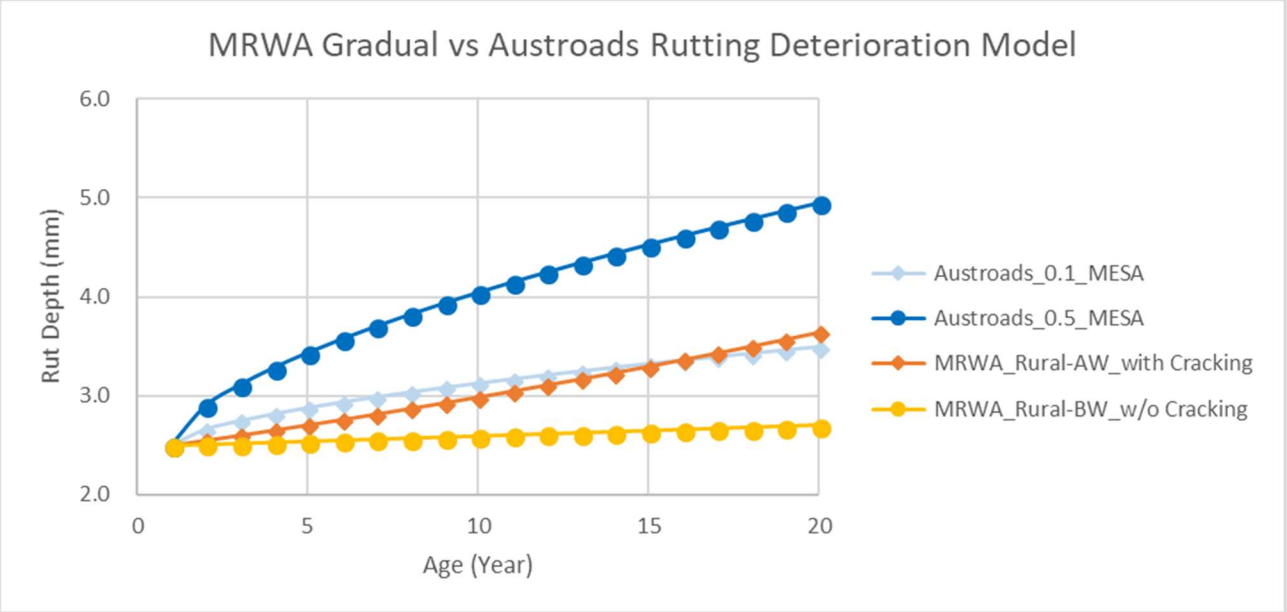
Improvements, which on the basis of the comparisons made require significant inputs, include those to RD and WE models. The differences between RD trends from applying Main Roads' and the Austroads models for road roughness is illustrated in Noya & Toole (2018), with this sourced from the analysis made under the *Improved decision-making* project. Whereas the single comparison is unlikely to be representative, it supports the need for model projections to be tailored on a regional basis (Figure 4.4 and Figure 4.5). An improved calibration could be informed by measured strength data with this supplied from the ongoing TSD survey.

Figure 4.4: Main Roads Gradual versus Austroads Roughness Deterioration Model



Source: Noya & Toole 2019

Figure 4.5: Main Roads Gradual versus the Austroads Rutting Deterioration Model

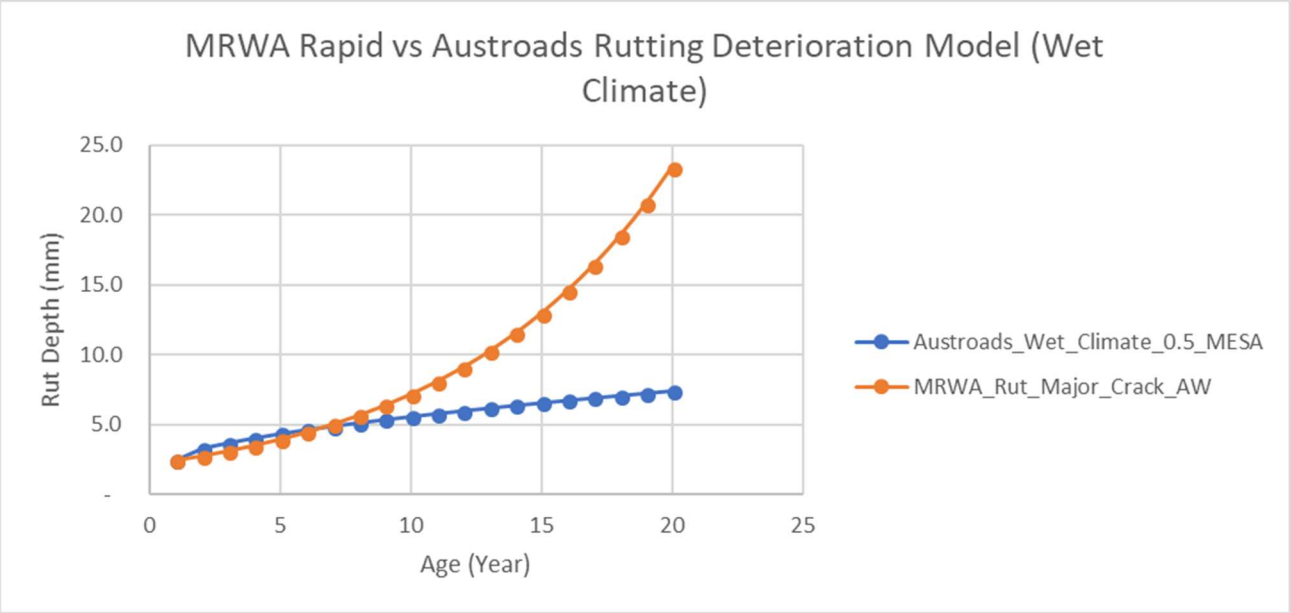


Source: Noya & Toole 2019

An aspect of the current modelling that demonstrates the importance of the input into the model is the definition of a gradual and rapid deterioration phase, with the latter being initiated once the surface of the pavement is more than 1.3 times its target age – based on the Oliver (2006) version of the ARRB oxidation model[1]. This draws on the full suite of knowledge from Austroads studies, and both initiative and judgement has been used in its application. Its effect is illustrated in Figure 4.6. It demonstrates the need for the Austroads model to fully apply the results of the research which underpins its development, including the results of Accelerated Loading Facility (ALF) trials as reported by Martin (2011).

[1] Whereas the Main Roads model introduces the rapid deterioration phase based on the age of the surfacing, the Austroads research in this area is based on a function of IRI (Martin 2011; Martin & Choummanivong 2018).

Figure 4.6: Comparison of the Main Roads model estimates and the Austroads rutting models for the rapid deterioration phase



Source: Noya & Toole 2019

A major deficiency is the absence of road user cost modelling. This is a critical omission as it means any argument for increased funding is unlikely to be supported by a strong economic case.

4.3.4 Decision selection

The status and preliminary rating with respect to decision selection is recorded in Table 4.4.

Table 4.4: Status and preliminary rating of Main Roads pavement management system: decision selection

Components	Options	Status	Preliminary Rating
Generate treatment options	Standard sets of rules	Specific triggers and limits associated with different treatment types, with example decision tree shown in Figure 4.7 covering functional condition, age and structural measure.	2
Evaluate options	Combination of treatment options (including limits) and timing	Employs dTIMS functionality, including delays in treatment timing to allow sufficient strategies to be generated and evaluated under budget constraint. Further clarification needed on 'do-minimum' options to deliver minimum LOS.	1
Treatment selection optimisation	Ranking or optimisation criteria (in combination with objective functions)	Ranking/optimisation based on incremental BCR using internal dTIMS optimisation engine.	1

Whereas dTIMS produces a comprehensive set of treatment strategies, including timing, for analysis from which the best is selected, whether the final optimisation is realistic and efficient depends on the following factors:

- Is the selected option implementable and does it support a minimum level of service which is acceptable to road users?
- Is the analysis duration of a sufficient length to ensure both the benefits and costs of treatments are fully captured?

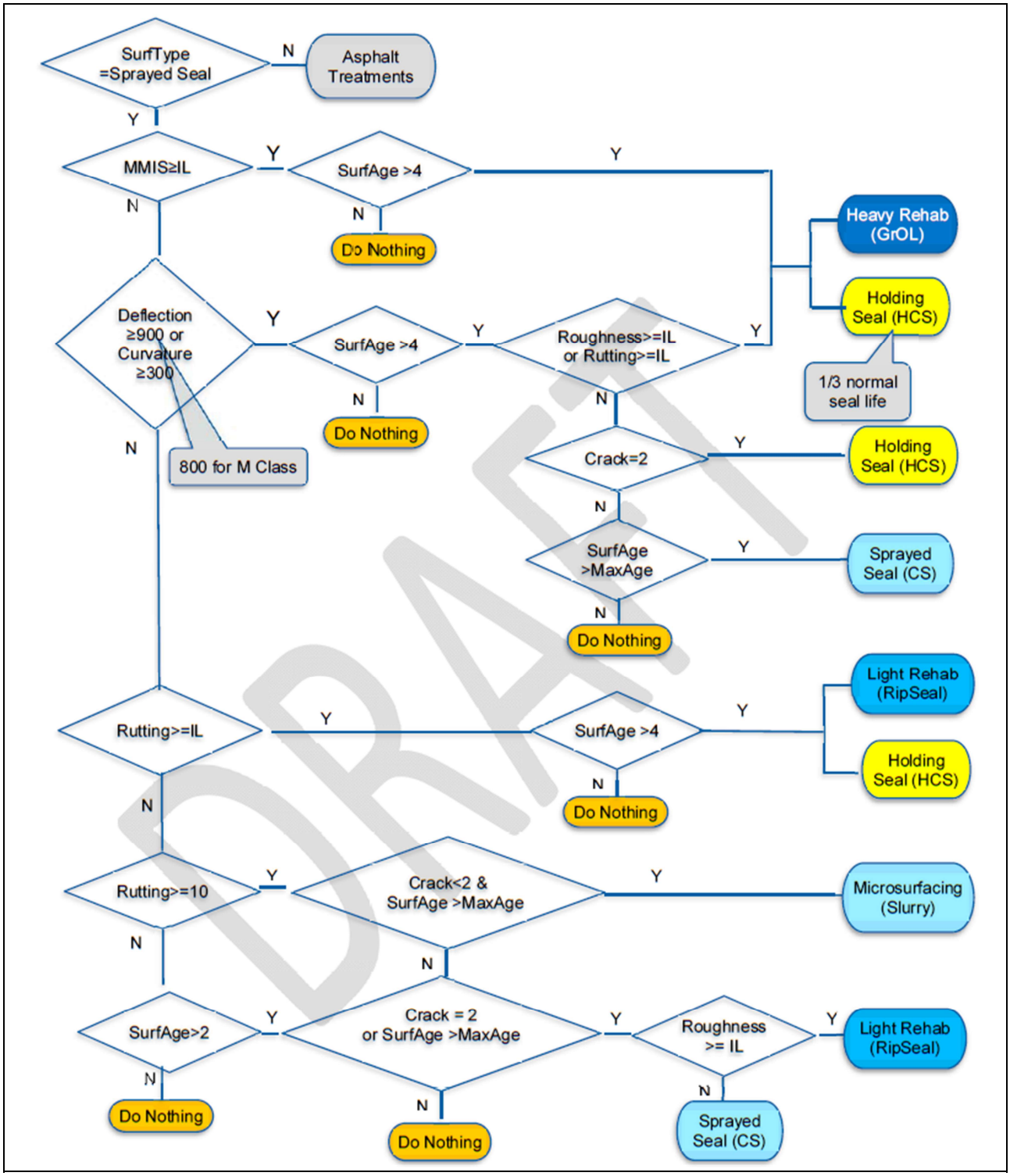
The first question is critical to both ranking and benefits estimation. A mistake on the latter is often made by using the 'do nothing' as a reference, whereas such a strategy rarely, if ever, applies.

The second question relates to circumstances where the analysis period is too short. In such cases the treatment cost is incurred but the benefit may only be partly accounted for. Therefore, the need is to either extend the analysis period or calculate a salvage (or residual) value at the end of the analysis period. When applied as a negative cost, this substitutes as a benefit from using the particular strategy. Where not applied, preservation treatments may seem advantageous, yet they will struggle to perform adequately under increasing traffic.

A further question is whether economic benefits are determined. If this does not happen then it could be addressed as a reporting function post-analysis, i.e. total transport costs (TTC) could be estimated for a number of budget scenarios and the difference (relative to a base case of current funding) reported as a benefit.

A further consideration is the best use of strength data; this an important data input as it heavily influences pavement performance prediction and therefore the timing and selection of suitable treatments.

Figure 4.7: Treatment selection chart for sprayed sealed granular pavements



Source: Main Roads (2018a).

4.3.5 Boundary conditions

The status and preliminary rating with respect to boundary conditions is recorded in Table 4.5.

Table 4.5: Status and preliminary rating of Main Roads pavement management system: boundary conditions

Components	Options	Status	Preliminary Rating
Works effects	Response resulting from application of treatments to current/future condition.	Accounted for in LCC analysis using combination of RD and WE models per treatment strategy. Deficiency arises from the use of simple regression models which are understand not to fully represent differences between regions.	1
Unit rates	For individual or combinations of treatment, including repairs, or as rolled-up rates on a km basis with different rates usually applied based on location.	Available by individual treatment and combinations.	2
Treatments	As individual or combination treatments, depending also on type of model.	Individual and treatment combinations incorporated in each unique strategy (by analysis section).	2
Triggers	As individual or combinations of attributes based on measured data, or as condition states/ratings.	Individual and combinations (with limits) applied to measured data.	2
Maintenance standards	Combination of sets of treatment types and triggers associated with different applications, e.g. by road hierarchy, traffic level/category, etc.	Intervention levels vary by road class, with associated treatments. Possible extension to include traffic ranges.	2
Policies	High level basis for maintenance standards, including associated levels of service, targets and objectives, general priorities, etc.	Available by road class.	2
Discount/interest rate	Usually defined by funding agency.	Standard rate applied.	2
Objective function	Various, including: a) maximisation of net benefits (typically based on total transport costs) b) minimisation of agency costs to achieve a target condition c) maximisation of condition within budget constraints.	Maximisation of condition under budget constraint applied using Pavement Health Indicator (based on the advanced maximum method) as the target under budget constraint. Deficiency arises from the possible use of a 'do nothing' case as a realistic 'base' treatment strategy for ranking and benefit estimation.	1
Optimisation method	Combination of above with ability to determine full program under budget constraint.	Utilises dTIMS functionality combining multiple treatment strategies per analysis section and optimisation function. Same comment as 'objective function'.	1
Budget constraints	Unconstrained or budget constrained based on user defined budgets and periods with or without user defined base case (and minimum standards).	Unconstrained (termed unlimited) and budget constrained possible. Clarification required on base case and minimum LOS.	1

The main deficiencies relate to model calibration, meaning the life-cycle performance trend is potentially poorly estimated, and the adoption of a 'do-nothing' option in the optimisation process, with this discussed in Section 4.3.4.

4.3.6 Reporting

The status and preliminary rating with respect to reporting is recorded in Table 4.6.

Table 4.6: Status and preliminary rating of Main Roads pavement management system: reporting

Components	Options	Status	Preliminary Rating
Condition, traffic, treatments, costs, financial and economic parameters.	Multiple choices	Multiple examples available with examples provided in dTIMS documentation, and through use of the Tableau software (presentation of line graphs, etc.). Determination, and therefore reporting, of economic benefits unavailable (TBC).	1

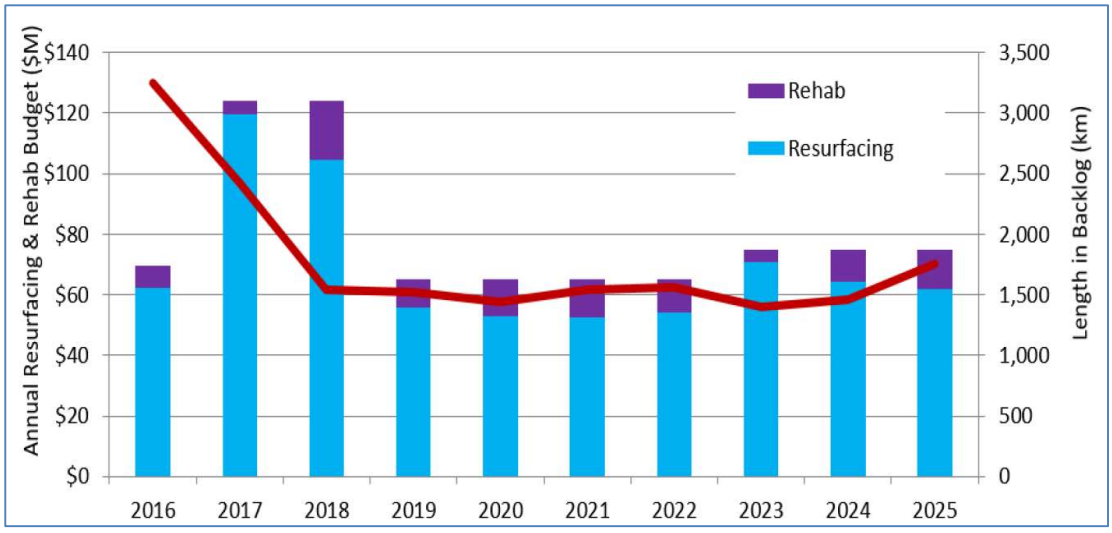
The dTIMS suite offers a comprehensive set of reports, including:

- construction (work) program
- treatment length and cost
- program cost
- average condition
- length of backlog.

In addition, Main Roads have also produced its own specific set of reports with examples which present overall needs at a strategic level including:

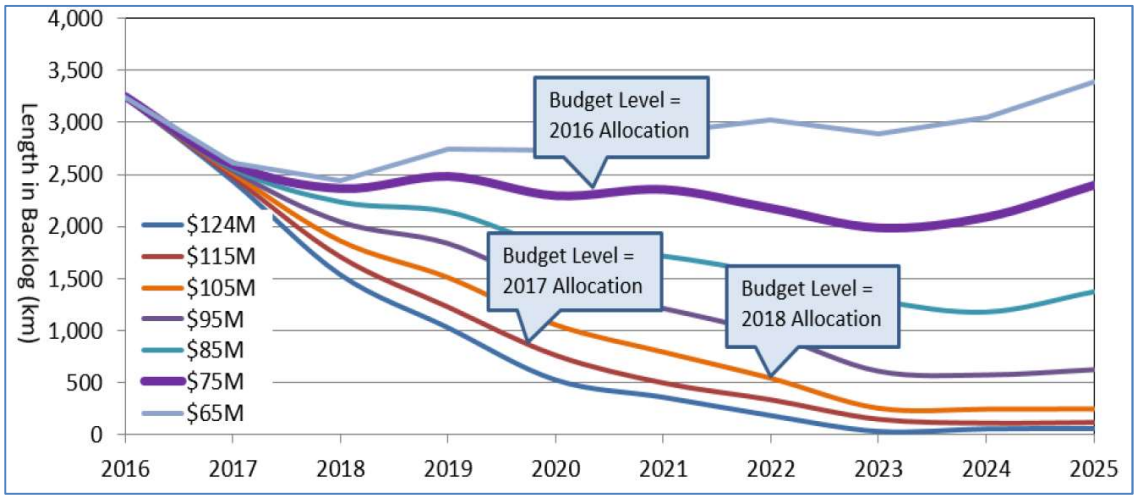
- medium- to long-term forecasts of funding requirements for specified target road maintenance standards (Figure 4.8)
- forecasts of long-term road performance under varying levels of funding (Figure 4.9)
- optimal allocation of funds according to defined budget categories, e.g. resurfacing versus rehabilitation
- optimal allocation of funds to sub-networks, by functional road class or by region.

Figure 4.8: Maintenance budget requirements for holding a 1,500 km backlog



Source: Main Roads (2018a).

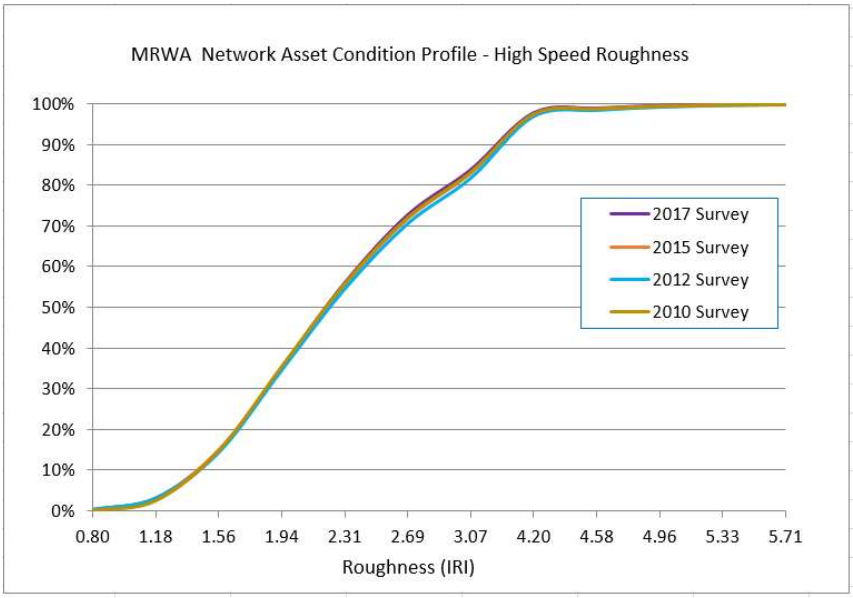
Figure 4.9: Budget scenario analysis versus backlog projections 2016 – 2025



Source: Main Roads (2018a).

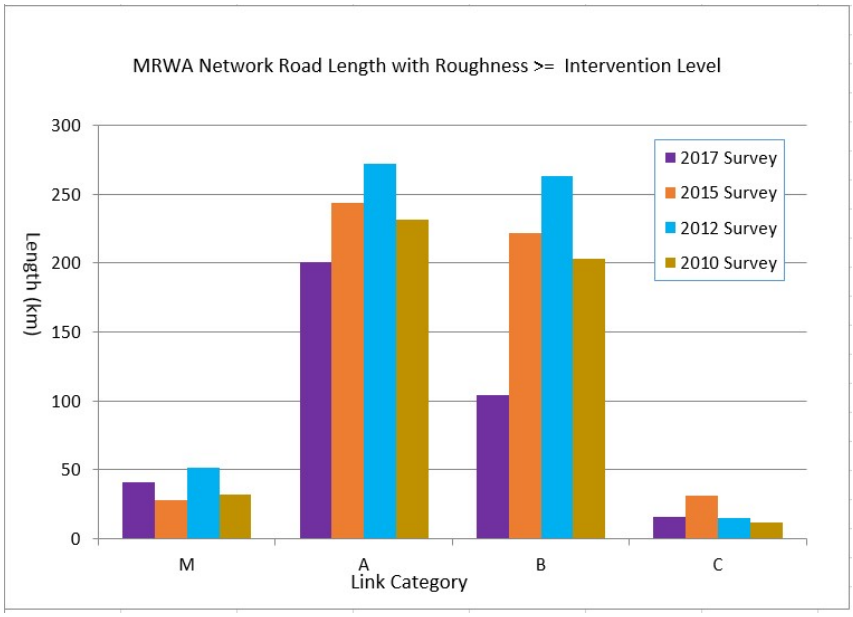
In addition, asset condition profile (ACP) reports have also been produced which show the current and projected distribution of condition by selected attributes (roughness and rut depth), see example in Figure 4.10. These provide a more comprehensive basis for quantifying the overall health of the network from a user perspective, as opposed to reporting a single value which represents, say, roads in a rough or very rough condition but omits to report the proportion of roads in, say, a very good, good or fair condition. However, the latter presentation can still be useful, and an example is illustrated in Figure 4.11, where the length of network (in km) exceeding a specified intervention level by link category is presented.

Figure 4.10: Example asset condition profile of Main Roads regional roads as a cumulative frequency distribution



Source: Main Roads (2018a).

Figure 4.11: Length of regional network exceeding roughness intervention levels



Source: Main Roads (2018a).

Purpose-built reports can be produced using a variety of tools which typically include the use of the dTIMS database and the setting up of queries to report the results within MS Excel or MS Access, or within SQL.

The available reports are comprehensive but could be augmented.

The main area of weakness relates to the reporting of economic indicators, this having been highlighted under various areas. This could be rectified by augmenting the reporting stage with an estimate of the economic costs (as Total Transport Costs) of the alternative scenarios that have been investigated. The main task would involve introducing road user cost models available from the ATAP guidelines (DIRD 2016) and applying these to the dTIMS analysis outputs. This would allow the TTC savings associated with different budget constraints to be reported, for example as a marginal benefit-cost ratio (MBCR) to demonstrate the economic benefit of an increased budget (as an economic gain per additional $ of expenditure).

4.4 Comparative results from case studies

The parallel project, *Improved decision making*, included comparing different dTIMS setups, namely the Main Roads setup and an ARRB setup, with the latter also informed by different structural data. This drew on the estimates of remaining structural life (RSL) derived from a range of methods, including:

- The Austroads SNC ratio method (Austroads 2010b), which involves determining the initial modified structural number (SNC_0) immediately post construction and:
  - applying this in the associated Austroads road deterioration models to predict future performance
  - predicting the change of SNC with time (as the variable SNCi)
  - employing a selected value of SNC ratio ($SNC_i/SNC_{0)}$ as a trigger on its own or in combination with condition-based triggers to select a treatment.

- A Notional Structural Life (NSL) method which involves the adaptation of the deflection-curvature based Austroads pavement rehabilitation procedure (Austroads 2011) to determine the allowable traffic and therefore the RSL of a 'notional' treatment, defined as a minimal surface correction and reseal to a sprayed seal granular pavement, or a nominal 50 mm asphalt overlay to an asphalt pavement
- A simplified version of the ARRB STEP Procedure (Roberts 2017) which involves determining the maximum deflection and curvature parameters for a pavement and estimating the RSL for the particular pavement type having standardised the deflection values including adjustments for temperature, seasonal variation, etc.

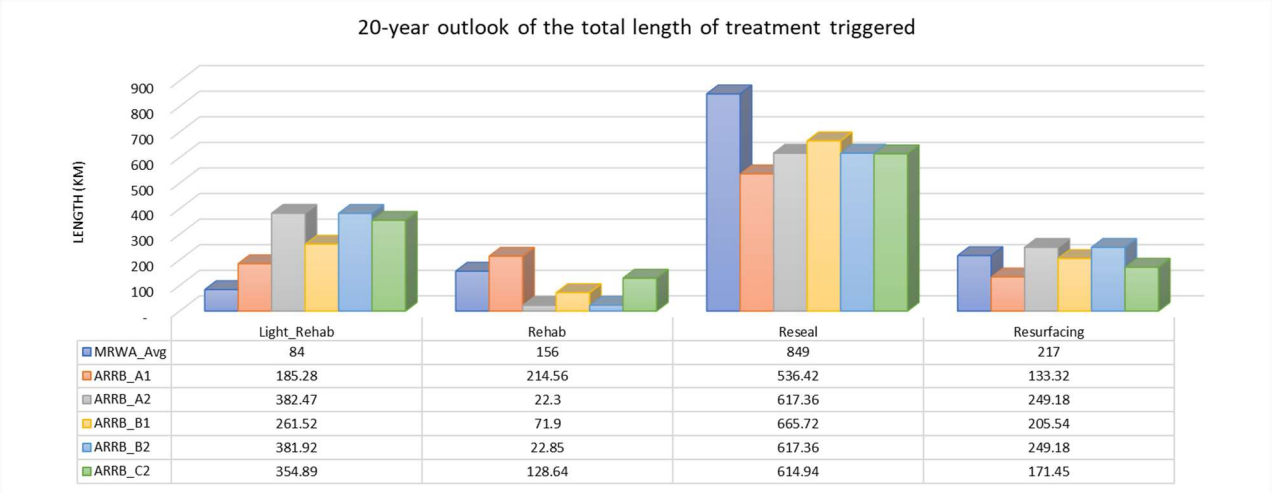
The introduction of structural parameters was aimed at testing the use of the available TSD data. The Austroads road deterioration models, which were employed in the ARRB setup, are also known to be sensitive to changes in structural strength, and the availability of structural data allows more robust estimates to be produced and provides an alternative for triggering treatments. This is particularly important in cases where 'band-aid' type treatments have been employed and there is a need to better understand the true rate of structural deterioration and its associated costs.

A summary of the total treatment cost for each setup (covering a single Main Roads setup and five ARRB setups) and the total length of treatment triggered for each dTIMS setup for a 20-year analysis period based on a sample of approximately 900 km of network subject to TSD testing, is provided in Table 4.7 and Figure 4.12 respectively.

Table 4.7: Total spending in various treatment classes for each setup

Treatment	Main Roads maximum deflection only	ARRB_A1 Austroads SNC Ratio (estimated SNC_i)	ARRB_A2 Austroads SNC ratio (back-calculated SNC_i)	ARRB_B1 Austroads NSL (estimated SNC_i)	ARRB_B2 Austroads NSL (back-calculated SNC_i)	ARRB_C2 ARRB STEP (back-calculated SNC_i)
Light_Rehab	$33,815,407	$72,963,363	$151,469,824	$101,274,041	$151,292,963	$140,431,584
Rehab	$110,067,366	$194,785,016	$13,093,429	$67,676,889	$13,352,611	$118,105,337
Reseal	$34,897,660	$17,980,019	$20,922,685	$22,517,936	$20,922,685	$20,854,969
Resurfacing	$66,889,682	$53,511,570	$105,309,126	$86,106,946	$105,309,126	$73,285,995
Total	$245,670,116	$339,239,968	$290,795,064	$277,575,812	$290,877,385	$352,677,886

Figure 4.12: A 20-year outlook of number of treatments triggered



	Light_Rehab	Rehab	Reseal	Resurfacing
MRWA_Avg	84	156	849	217
ARRB_A1	185.28	214.56	536.42	133.32
ARRB_A2	382.47	22.3	617.36	249.18
ARRB_B1	261.52	71.9	665.72	205.54
ARRB_B2	381.92	22.85	617.36	249.18
ARRB_C2	354.89	128.64	614.94	171.45

Observations on the results are as follow:

- For the set of analysis undertaken, the relative value of resurfacing and rehabilitation costs is between 0.7 and 1.24 and between 1.14 and 1.86 times the Main Roads estimate. The total cost of all preservation and renewal treatments is between 1,.13 and 1.44 times the Main Roads estimate.
- The results of setup ARRB_A1 and ARRB_C2 and ARRB_A2 and ARRB_B2 are almost identical in terms of the total cost as well as the proportional split between asset preservation (reseal and resurfacing) and asset renewal (light and full rehabilitation).
- In a more detailed examination of the results, on a year-by-year basis, the ARRB_A1 setup produces the highest lengths of rehabilitation treatment not only in the first year but also in later years, notably in 2027 onwards. The need for more rehabilitation generated from the ARRB_A1 setup in the later years is driven by the remaining structural life expectation on certain pavement types, with asphalt on stabilised pavement giving the shortest remaining life expectation followed by sprayed seal on unbound pavements.
- The Main Roads setup and ARRB_C2, although not as much as ARRB_A1, also generates significant lengths of rehabilitation in the later years. The rehabilitation needs in the first year appears to be warranted, i.e. poor functional condition with high deflection and curvature. A field validation is needed to confirm needs.

Given the significance of the differences, it is important that the results are validated with an initial focus on the recommended works programs in the immediate two to three years with a view to establishing whether the quantum of the backlog makes sense. Consideration also needs to be given to the calibration of both the Main Roads and Austroads models across all regions. In the longer term a long-term performance monitoring program is recommended for refined calibration of road deterioration modelling.

5 WHOLE OF ASSET MANAGEMENT PROCESS REVIEW

5.1 Overview

Main Roads has embarked on an initiative to comprehensively fulfil the requirements of ISO 55001. To this end Main Roads has developed its own 'Roadmap' aimed at covering all aspects of the standard (Appendix C); it has a long-established approach to asset management. It is therefore not starting afresh but ensuring compliance by updating and extending existing processes and systems, including supporting documents, and extending and adding to them as necessary.

This 'Whole of asset management process review' begins by first listing the components and sub-components of the overall process (Table 5.1) as documented by Main Roads in their Roadmap (Appendix C), the status with respect to existence, the timing of completion and updating plans, and an initial opinion on their scope and content.

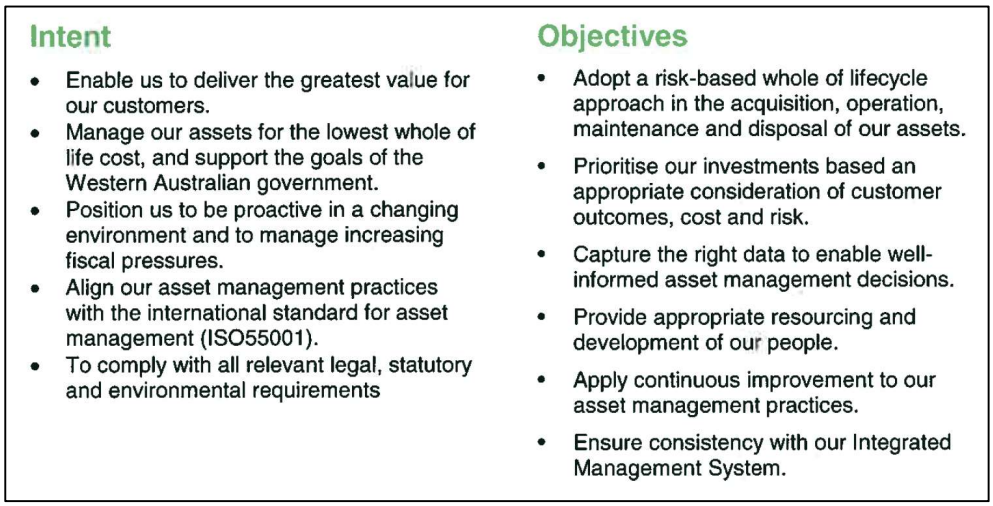
The comments made are primarily focused on pavement asset management, and related assets, whereas general comments are made on other aspects of the overall process and the Roadmap where these are considered relevant, e.g. with respect to route plans. Opinions are later offered on the 'Line of sight' linking specific plans lower in the overall hierarchy and the AM Policy.

Whereas this review makes observations on (human-resource) capacity and capability it does not do this in-depth. This, however, is perhaps the most serious concern from this review and is deserving of further investigation as the issue has been a priority for a considerable time, having between identified through the various WAAG reviews and other internal and external review.

5.2 Asset Management Policy

Main Roads' AM Policy (Main Roads 2017a) is reproduced in Figure 5.1. It is a high-level document which emphasises the management of life-cycle risks, investment prioritisation with a customer and risk focus, capturing the right data, the right people, continuous improvement and delivery.

Figure 5.1: Extract from Main Roads Asset Management Policy



Intent

- Enable us to deliver the greatest value for our customers.
- Manage our assets for the lowest whole of life cost, and support the goals of the Western Australian government.
- Position us to be proactive in a changing environment and to manage increasing fiscal pressures.
- Align our asset management practices with the international standard for asset management (ISO55001).
- To comply with all relevant legal, statutory and environmental requirements

Objectives

- Adopt a risk-based whole of lifecycle approach in the acquisition, operation, maintenance and disposal of our assets.
- Prioritise our investments based an appropriate consideration of customer outcomes, cost and risk.
- Capture the right data to enable well-informed asset management decisions.
- Provide appropriate resourcing and development of our people.
- Apply continuous improvement to our asset management practices.
- Ensure consistency with our Integrated Management System.

Table 5.1: Whole of asset management process review

Title	Sub-title	Reported Status/Target	Next action(s)	Status confirmed by review team	Preliminary opinion
ASSET MANAGEMENT POLICY (AMP)		Completed 16 August 2016 Revised 21 December 2017	Review 2020	Confirmed	High-level document emphasising management of life-cycle risks, investment prioritisation with a customer and risk focus, capturing the right data, the right people, continuous improvement and delivery. Line-of-Sight to this is possible if the other (lower level but more specific components) build towards an integrated approach. A 'funnel' type hierarchical diagram is required to convey this. In the benchmarking task it is important to identify continuity/linkages, and address from intent to delivery.
STRATEGIC ASSET PLAN (SAP)	SAP Overall document	First edition by mid-2018	Review 2019	Confirmed (no date)	Comprehensive document which forms a sound basis for AM, and as a basis for reviewing regional compliance. Reliance on supporting documents and State-wide asset management plan (SWAMP) for details.
	CLOS (Customer Levels of Service)	Completed October 2017		Confirmed	Comprehensive document, noting that asset sustainability measures lack a quantitative basis, i.e. what quantitative measures define when a resurfacing or rehabilitation is required.
	RMIP's (Road Maintenance Intervention Parameters)	Review complete 2017		July 2016 version	Comprehensive document with clear Intervention levels (MIL), response times (MRT) and maximum defective condition (MDC) as a performance measure.
	AMO (Asset Management Objectives)	Completed Oct 2017	Report due mid-2018	May 2018	The objectives in Table 3.1 of the SWRMP are comprehensive but actual targets are not provided, and the list is not consistent with the CFLOS. On further investigation the new AMO-PMM is substantially more comprehensive and complete, with targets offered in the 'Sustainability' area including for resurfacing and pavement rehabilitation. Measures such as Preventative Maintenance Indicator (PMI) and Asset Condition Profiles (ACPs) are discussed and should be investigated further. Clarification required: Objectives are stated in the SWAMP and are elaborated elsewhere in the AMO-PMM
	Confirm measures	mid-2018	Report October 2018	Confirmed (as per SWAMP)	
	Finalise targets	end of 2018		May 2018 (as per AMO)	These are critical as they provide a basis for asset planning, with a need to be realistic and time-based accounting for budget availability. See also above comments under Asset Management Objectives. The main issue will be affordability, i.e. budget availability, and delivery. Trend improvements over time are reported in the SAMP, and these are projected to improve further.

Title	Sub-title	Reported Status/Target	Next action(s)	Status confirmed by review team	Preliminary opinion
	Responsible, Accountable, Consulted, and Informed (RACI) matrix				The previous Asset Management Accountability Framework, which could be updated based on the extensive set of documentation/procedures now available would be a good starting point, even if interim.
	Scope of AM System				A key opinion is there is a risk of substantial duplication, and a document hierarchy is required and a structure showing how all fit in the total AMS.
AUDIT		WAAG 2016	Internal reviews 2018, 2019 and 2020	Evidence in report to WA Parliament Public Accounts Committee	
CAPACITY & CAPABILITY					
ASSET MANAGEMENT PLANS	State-wide Road Maintenance Management Plan (SWRMP)		Develop strategies end 2018 Implement 2019 onwards	February 2018	
	Regional Maintenance Plans	Complete January 2018		February 2018	Provides the most comprehensive and clear links to ISO55001 and best practice AM, with linkage in Table 3.1 between Policy (Keeping WA moving) and AM objectives, including measures.
	Resurfacing Asset Management Plan	Due mid-2018			
	Pavement Asset Management Plan	Completed July 2017	Annual updates	June 2018	
	Visual assessment	Review & update mid-2018	Review & update 2019	June 2018	
	PMS Modelling review	Visual review April 2018	Assess & Program end 2018 (RED)	Ongoing or complete	
	TSD Data collection		Update ex-TSD and annually		
	Electrical Asset Management Plan	Review deterioration October 2018	Refine & update incl. TSD, MMIS from 2018	May 2018	See detailed review and comments in Section 4.

Title	Sub-title	Reported Status/Target	Next action(s)	Status confirmed by review team	Preliminary opinion
	Bridge Asset Management Plans	Draft completed 2016	Review & update end 2018 and end 2019	Ongoing	Outside scope of review
	Route Plans	Timber Completed 2016	Other groups & individual structures end 2018		Outside scope of review
NETWORK VIEW	State wide Network View of route plans		Refine & update from 2019		
	Road Maintenance Procedures	9 Strategic routes completed June 2017	Other links mid 2018		Detail outside scope of review
	Structure Review Network Management Branch	Passing lanes mid-2018	Update with all links mid-2019		Detail outside scope of review

The scope of the AM policy is consistent with best practice. Line-of-Sight to this is possible if the other (lower level but more specific components) build towards an integrated approach. However, a 'funnel' type hierarchical diagram is required to convey this and to identify continuity/linkages and address all aspects from intent to delivery. Specific aspects related to pavement AM include a life-cycle costing (LCC) focus, appropriate prioritisation, capturing the right data and applying continuous improvement practices. This is evidenced by the earlier review and discussion of Main Roads' dTIMS in Section 4, and other aspects as discussed later in this section.

5.3 Strategic Asset Management Plan

5.3.1 General

The Main Roads Strategic Asset Management Plan (SAMP) comprises a series of documents which covers the following:

- Strategic Asset Plan (SAP)
- Customer Levels of Service (CLOS)
- Road Maintenance Intervention Parameters (RMIPs)
- Asset Management Objectives (AMO)
- Scope of the AM System (AMS).

The main contents of these and their relationship to pavement asset management are described below. However, the documents exist in isolation, i.e. they are not part of a suite prefaced by an introductory text and are not described as a hierarchy of related documents. Clarification is therefore required to confirm the latter statement, with the absence of an overarching document being a potentially significant gap.

5.3.2 Strategic Asset Plan

The Main Roads Strategic Asset Plan (SAP) (Main Roads n.d.a) is a corporate document which outlines the organisation's current and future investment needs and highlights issues that facilitate and challenge the achievement of strategic outcomes. It describes Main Roads' Asset Investment Program, the delivery of which involves eight regional responsibility areas, incorporating projects considered from a whole-of-network perspective. These are influenced by the strategic direction of the WA Department of Transport, in keeping with an integrated, multi-modal approach to transport planning.

The 2018/19 SAP sets the strategic context for the organisation's 10-year investment needs. It includes capital works projects which reflect the highest priority needs recommended as part of Main Roads proposed 2018/19 budget submission, including asset expansion and enhancement activities. Projects that remain a priority for Main Roads also form part of the ten-year network plan and will be submitted for funding consideration in future years.

Main Roads' current/y approved Asset Investment Program (AIP) is recorded in the State Budget papers. It comprises major regional and metropolitan road projects for the period 2017/18 – 2020/21. It includes new roads, road upgrades (including sealing of unsealed roads), realignment, duplication, reconstruction and other major works.

From a pavement management perspective, the SAP provides input to the medium-term planning of asset preservation and renewal works by alerting asset managers to major works. However, AM practitioners also need to be conscious of the status of the proposed works as they include ongoing works as well as proposed new works and political commitments with the latter two potentially subject to change.

5.3.3 Customer levels of service

A Customer Facing Levels of Service (CFLOS) Framework (Main Roads 2017b), which is owned by the Network Management Branch, has been developed and applied. It describes what levels of service (LOS) are, the purpose of the framework and how its various elements relate to corporate outcomes.

The aim is to enable Main Roads to assess the outcomes provided to the community from a road user perspective, with the framework linking Main Roads Outcomes, and Level of Service Objectives with Performance Indicators and Technical Measures.

Detailed information about the performance indicators, the associated technical measures and the scoring system utilised to determine the LOS indicators is described. Whereas the model described can be applied to both rural and metropolitan networks, it has only been applied for the rural and outer metro network noting that the metropolitan road network may require the addition of new parameters to reflect the specifics of a high-traffic urban environment.

The LOS parameters have been applied in the route planning process, with potential improvements also identified based on this experience. A distinction is made between indicators of relevance to the public, including safety, customer satisfaction, quality, quantity, capacity, reliability, responsiveness, environmental acceptability, cost and availability, and technical LOS measures such as roughness and rutting, etc.

The framework notes that LOS requirements for non-freight users have been developed by many jurisdictions. They are very similar and include: road conditions; road safety; mobility (efficiency) and accessibility; and social/environmental responsibility. Whilst the framework developed by Main Roads has been based on an internal view of required outcomes, it does provide a strong alignment between the outcomes developed by the NZTA and the frameworks being developed in other jurisdictions in Australia.

The CFLOS model is applied through the route planning process, and its results are utilised in the investment planning process to identify investment initiatives/candidates at the link, route and network level. In a funding-constrained environment decision need to be made on relative funding priorities between routes. Therefore, understanding the need for investments from a customer perspective and the consequences of investment deferral is an important component in prioritising and optimising an investment program. The model aims to inform:

- the prioritisation of asset improvement activities (such as seal widening, improving delineation, or constructing overtaking lanes)
- the prioritisation of planned maintenance activities (such as resurfacing and rehabilitation)
- the funding allocation process for these activities across the network, and between regions.

The framework utilises corporate data from IRIS, and Main Roads' assessment methodologies, and its results are designed to support decision-making such as identifying the required investments or allocating investment priorities. The model has been refined through its application to nine strategic routes. Its ability to depict outcomes at the route level using a consistent set of technical measures has shown that the model is equally applicable at a link, route and network level.

Of the outcome areas under the CFLOS – comprising Safety, Reliability and Efficiency, Accessibility, Amenity, Travel Experience and Sustainability – the latter is most directly associated with pavement asset management, with the specific text quoted below:

'*Key assets on the routes including surfaces, pavements and structures are preserved to extend the assets remaining life at the optimal total cost*'.

An example of the LOS for roughness by link category is shown in Table 5.2. The full set of measures are presented in Figure 5.2, with the travel experience outcome area also having relevance to pavement asset management. Further review of whether asset sustainability measures have a comprehensive quantitative basis, i.e. what quantitative measures define when a resurfacing or rehabilitation, is required.

Table 5.2: LOS for roughness by link category

Level of Service	Link Category	Roughness - IRI (m/km)
Low	MI, MFF	>3.4
	AW+, AW	≥ 3.8
	BW+, BW	≥ 4.2
	CW	≥ 5.3
Medium	MI, MFF	>2 and <=3.4
	AW+, AW	> 2.2 AND < 3.8
	BW+, BW	> 2.6 AND < 4.2
	CW	> 3.0 AND < 5.3
High	MI, MFF	<2
	AW+, AW	≤ 2.2
	BW+, BW	≤ 2.6
	CW	≤ 3.0

Main Roads calculates a Service Indicator Score for each Outcome area, at link and route level, as follows:

(a) Calculate the Service Indicator across all parameters within an outcome area, in each category (High, Medium and Low) by multiplying the percentage in each of the category High, Medium or Low, by a LOS value and calculating a link length weighted average for each category (High, Medium and Low).

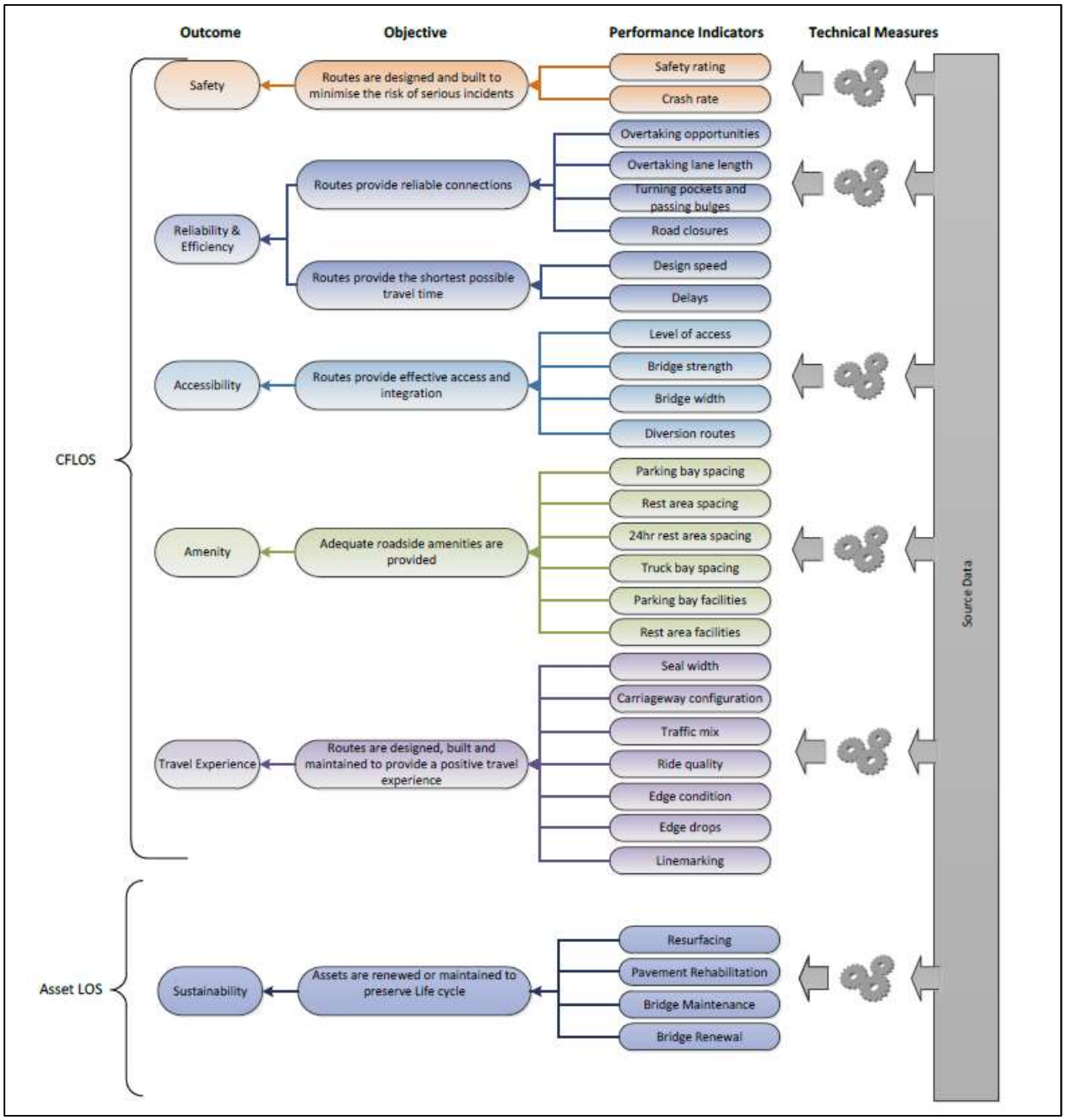
(b) The LOS adopted values are:

- Low = 1
- Medium = 2
- High = 3.

(c) Calculate the overall Service Indicator Score for a link and Outcome area by adding the three Service Indicators calculated for each category of High, Medium and Low. The resulting Service Indicator Score is a number between 1 and 3 where:

- < 1.75 = Low
- 1.75 – 2.25 = Medium
- > 2.25 = High.

Figure 5.2: Relationship between Main Roads Outcomes and CFLOS technical parameters



Source: Main Roads (2017b).

5.3.4 Road maintenance intervention parameters

A comprehensive document on Road Maintenance Intervention Parameters (RMIP) exists (Main Roads 2016) in which clear maintenance intervention levels (MIL), maintenance response times (MRT) and maximum defective condition (MDC) as a performance measure are stated. They differ in relation to road use, including more frequent inspection for higher-traffic roads, and the recording of reports from the public and other organisations with this also used to trigger responses.

Guidance is also provided on the role of the Regional Manager in specifying appropriate intervention parameters where they differ from those published. This may occur to meet regional

needs due to differences in conditions, climate, traffic patterns and road user experience. Advice is provided which aims to limit changes to the MRT and MDC rather than the MIL, as the latter is based on road safety and asset preservation considerations. Examples are quoted of typical circumstances which require a variation in response to address regional needs (and available resources) including the following:

- where a primer seal has been applied, and there is a need to preserve the surface in good condition by applying more stringent standards
- where a section has been programmed for improvement, less-stringent standards may be appropriate provided adequate 'safety-related' warnings are provided.

Guidance is also provided on the following:

- Scheduling of works, including targeting repairs in the lead up to the wet season, prior to resurfacing and to benefit from delivery teams being in the vicinity.
- Considerations in deferring/not deferring remedial works.
- Intervention priorities, with safety ranked highest, then asset preservation, road user comfort and amenity. Guidance is given on addressing drainage defects and water-related issues early and taking a preventative approach and exercising judgement and local knowledge, particularly in emergency situations.

It is understood that more comprehensive guidance on prioritisation and treatments is in preparation.

5.3.5 Asset management objectives

Main Roads have recently produced a comprehensive set of performance measures and targets which are described in the following document *Asset Management Objectives – Performance Measures Manual* (AMO-PMM) (Main Roads 2018b). They address all outcome areas under Main Roads' strategic direction – *Keeping WA Moving* – including:

- safety
- movement
- sustainability
- customer
- other.

In the 'Sustainability' area, which is most closely related to pavement management targets include targets for resurfacing and pavement rehabilitation. A summary of the AM objectives is provided in Table 5.3, including:

- capability
- minimise whole-of-life cycle costs
- well maintained road network.

For each of the AM Objectives, there are one or more measures to monitor Main Roads performance and guide its focus. Where appropriate, a target is given (e.g. 97% meets or exceeds the requirement). In some cases, a target is not given, however, the AM Objective is still measured and changes to the result, i.e. from year-to-year, are compared to monitor progress.

Table 5.3: Summary of Main Roads Asset Management Objectives related to pavement management: Sustainability

Objective	Measure	Target	Scope	Methodology	Reporting
Capability	Adequate capability and knowledge	▪ Strategy to implement all 12 recommendations from *Network Management Capability Review* (NMCR) completed by end of 2018.	▪ Includes the 12 recommendations from NMCR. Excludes implementation and/or developing a strategy for any additional AM recommendations.	Prepare strategy and document as per reporting requirements.	No. and % of recommendations completed, reported at Quarterly intervals.
	Develop an ISO 55001 aligned Asset Management System	▪ December 2018: Complete all Asset Management Plans (AMPs). ▪ June 2019: Complete Internal Audit against ISO 55001.	▪ Includes SAP, SWRMP (and associated regional plans), RAMP, PAMP and Route Plans.	AMPs completed upon approval by Director of NM or AMSC.	Quarterly progress.
Minimise WOLCC	Reduce the level of resurfacing backlog	By end of 2022-23: ▪ Zero backlog on sprayed seal, asphalt surfacing and micro surfacing. ▪ Defined quantity of deferred works on sprayed seal, asphalt surfacing and micro surfacing.	▪ Includes all sealed roads on the Main Roads network. ▪ Excludes all unsealed roads on the Main Roads network.	Extract backlog and deferred information from TYNDP, and report as detailed in reporting requirements.	Annual reporting of State-wide totals for combined backlog and deferred (dollars and m^2), and individual totals by surfacing type for backlog and/or deferred (dollars and m^2).
	Pavement rehabilitation backlog	By end of 2022-23: ▪ Pavement rehabilitation backlog 0 carriageway km. ▪ Sprayed seal deferred <500 carriageway km.	▪ Includes all sealed roads on the Main Roads network ▪ Excludes all unsealed roads on the Main Roads network.	Extract backlog and deferred information from TYNDP, and report.	Annual reporting of total carriageway kilometres replaced, and length funded under maintenance or capital works
	Kilometres of pavement rehabilitation/annum	▪ Average of 100 carriageway-km of pavement rehabilitation completed/annum.	▪ Includes all pavement rehabilitation undertaken on rural sealed roads. Excludes urban roads, unsealed roads, new roads, additional lanes and realignment where the original road is retained as an asset.	To be developed.	Annual reporting of total carriageway kilometres replaced, and length funded under maintenance or capital works.

Objective	Measure	Target	Scope	Methodology	Reporting
	BCR of pavement rehabilitations	▪ All pavement rehabilitation projects have a BCR ≥1.	▪ Includes all sealed roads funded through maintenance program. ▪ Excludes all capital works and unsealed roads.	▪ Extract from TYNDP (locations and costs) and historical costs for last 3 years. ▪ calculate BCR in Main Roads' road evaluation system (WARES) (incorporating actual maintenance costs) for each pavement rehabilitation section and combined program.	Annually as percentage of pavement rehabilitations with BCR ≥1, and BCR of total pavement rehabilitation program.
Well maintained road network	Maintenance Management Information System (MMIS) based rating (RMIPs)	▪ To be developed.	▪ All RMIPs in MMIS.	Extract defects exceeding MIL, MRT and MDC from MMIS, and report.	Report number of defects exceeding MIL, MRT and MDC at monthly intervals.
	Roughness of reseal sites	▪ Pre-reseal – monitor influence of treatment only. ▪ Post-reseal – ensure substantial works are not required during the life of a surfacing (i.e. roughness ILs).	▪ All sealed roads.	Detailed methodology available.	Pre-reseal: ▪ Average IRI for all proposed sites and for each link category. Post reseal: Annual measure, though presented approximately biennially once new data available: ▪ Average roughness (IRI) for all completed reseal sites. ▪ Average roughness (IRI) for all completed reseal sites for each link category. ▪ Percentage of completed reseal sites (by length) meeting the 'target IRI following reseal'. ▪ Percentage of completed reseal sites (by length) for each link category meeting the 'target IRI following reseal'.

A mapping exercise has been undertaken to align each of the AM Objectives to *Keeping WA Moving*, the Funding Programs and the Investment Planning Outcomes. For a number of the AM objectives and measures detailed in this manual, the outcome of each measure will be reported separately for each link category. It is not intended that the AM objectives and associated measures will be reported corporately for each region or responsibility area (RA). Instead, the intent is to make results available to allow regions to monitor their individual performance and/or contribution to the AM Objectives.

Pavement management is also reflected in a number of other objectives including the following:

- safety
  - well-maintained roads, including seal texture (% & ACP)
- movement
  - positive return on investment
- other
  - Pavement Health Index, with a version of this used as a target objective function in the dTIMS pavement management system
  - ISA/RNC KPIs
  - per cent of unsealed network resheeted.

Reference is also made to measures such as the Preventative Maintenance Indicator (PMI)[2] and ACP's but details are not provided, and the intent with these should be investigated further. A possible reason is because reporting is at an early stage and therefore evidence of progress is not available.

Finally, the following comments are also relevant:

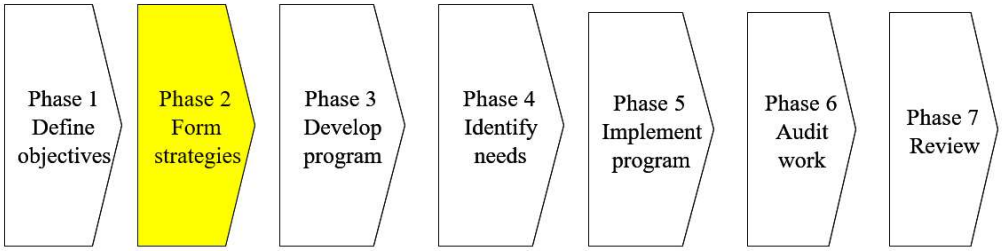
- Whereas the objectives in Table 3.1 of the SWAMP are comprehensive, actual targets are not provided, and the list is not consistent with the CFLOS. In this respect the AMO-PMM is substantially more comprehensive and complete as described above. Addressing inconsistencies is therefore important.
- Final targets are also important as these are critical because they provide a basis for asset planning, with a need to be realistic and time-based and to account for budget availability. See also comments in Section 5.3.5 (Asset Management Objectives). The main issue will be affordability, i.e. budget availability and delivery. Trend improvements over time are reported in the SAMP, and these are projected to improve further.

5.3.6 RACI

The acronym RACI (*responsible, accountable, consulted and informed*) describes the participation by various roles in an organisation in completing tasks or deliverables for a business process or activity; it is used to clarify roles and responsibilities across an organisation. Main Roads' earlier Asset Management Accountability Framework (AMAF) (Main Roads 2009b) is an example of such. It was structured to support the various tasks in the AM framework adopted by Main Roads which adopted the Austroads framework (Austroads 2002). An example of this is illustrated in Figure 5.3, taken from the Operational Asset Management Framework review of 2009 (ARRB 2009a).

[2] Preventative Maintenance Indicator (PMI), being a measure of the current age of a sprayed seal surface against its target age.

Figure 5.3: Example of participation of various groups within the 2009 AM accountability framework



Strategic asset management

Responsibility	Undertaken by	
	COEOAM	Region
Asset maintenance strategy	✓	
Asset maintenance guidelines & plans	✓	
Asset link, corridor & regional network plans/processes		✓
Construction and cost data		✓

Main Roads' Network Management Branch (NMB) has developed a RACI matrix[3] (Appendix D) which assigns responsibilities and accountabilities in some detail. It is structured by the AM phase, and covers a range of functions with specific more detailed activities and roles identified and assigned to the Executive Director, the central NMB team, the regions, other groups and delivery units.

Within NMB two phases are covered, with the main functions being as follows:

- Identifying asset requirements (5 functions, 21 activities)
  - optimisation and prioritisation (3 activities)
  - works program development (8 activities)
  - operational asset management (6 activities)
  - revised TYNDP and AWP reflecting funding allocations (2 activities)
  - identify financial needs to the Department of Treasury and Finance (DTF) via SAMF (2 activities)
- Program implementation (8 functions, 30 activities)
  - deliver high cost/complex projects $10 m plus (Category D) (3 activities)
  - deliver mid-size projects $3 - $10 m range (Category C) (5 activities)
  - deliver minor works $50 k to $3 m (Category B) (9 activities)
  - deliver urgent works (1 activity)

[3] Main Roads employ the acronym Accountable, Responsible, Engaged (replacing Consulted) and Informed.

- deliver maintenance program (RO&DS 5) (5 activities)
- deliver rural network operational services & support rural operational services (3 activities)
- deliver Perth Metro network operational services (3 activities)
- public report & disseminate information (1 activity).

The owner stakeholders within Main Roads are also identified, including from the following groups which have accountability:

- Budget and Programming
- IDD
- Network Operations
- Environment
- Strategy and Communications.

The assignment of roles includes the following positions, divided into two:

- Metropolitan and Southern Regions
  - Executive Director
  - Regions
  - Electrical Asset Management
- Central and Northern Regions
  - Executive Director
  - Regions
  - Network Management Branch
  - Term Contracts.

The majority of roles under Accountability are held by the respective Executive Director, with the Regions assuming the majority of responsibilities with some exceptions. Examples of exceptions include the following, the last two being particularly important to pavement management:

- the regions hold accountability and responsibility for urgent works where defects and hazards need an immediate response
- the NMB is responsible for analysing and preparing the state-wide road maintenance program including allocations between asset/work types and regions
- the NMB shares responsibility with the regions for the 10 Year Road Maintenance Planning, and they share accountability with the Executive Director.

The full matrix is reproduced in Appendix D.

5.3.7 Scope of the asset management system

The overall Asset Management System (AMS) is described in a System Manual (Main Roads undated) which remains under development. The AMS is essentially all the components described in the RoadMap and covered in this section.

Whereas this section of this report has been located in order of its appearance in Main Roads' Roadmap, it needs to be relocated because, from a hierarchy point of view, it describes where components sit in relation to each other.

5.4 Audit

Main Roads aims to conduct internal audits at planned intervals to provide information to assist in the determination on whether the asset management system conforms to:

- the requirements of its asset management system
- the requirements of the International Standard
- is effectively implemented and maintained.

The need is for a comprehensive audit program which considers the importance of the processes concerned and the results of previous audits, with a need to define criteria and scope, select auditors and conduct audits, report the results and retain documentation as evidence.

External-led audits have also been performed by the WA Auditor-General (WAAG 2009 & 2016). The 2016 audit was a follow-on and in areas relevant to pavement management it made recommendations in a number of areas noted in Table 5.4, and the observed progress noted from this review is also noted.

Overall, significant progress has been made and key improvements are imminent, e.g. through the use of network-wide TSD strength data. However, important exceptions exist including the:

- lack of completeness and consistency in Regional Maintenance Plans (RMP)
- development and implementation of asset management and maintenance practices, and their achievement of the required outcomes (on a sustainable basis)
- development of a strategy (including justification) for pavement rehabilitation and ongoing rehabilitation allocation
- need for senior staff review of the RMP, including the backlog of shoulder, drainage and surface repairs.

A constant theme running through the actual practice of pavement management (including surfacings and related assets) is the reliance on senior, usually centrally-based, staff. Whilst this offers a basis for consistency, and the advice and moderation offered is supported, it demonstrates an ongoing weakness in the capability and capacity of the regions to undertake their full responsibilities.

Positive aspects include the extent to which the surfacing is being addressed, and the forthcoming availability of TSD data which is eagerly awaited by the regions. This will contribute to the future rehabilitation strategy and justifiable levels of funding. The forthcoming focus on drainage and shoulders is also welcome.

Table 5.4: Review of WA Auditor General findings and progress related to pavement management

Auditor general recommendations	Progress summary	Specific completed actions	Specific uncompleted and planned actions
Formalise guidance to regions on assessing and prioritising maintenance needs (WAAG Follow-on Audit Finding 1)	Completed in most areas with main concern around the need for the centrally-based NMB team playing a central role in field reviews and finalising state-wide plans. Variable quality evident in region generated plans, e.g. the 10YRMP and TYNDP.	▪ Senior staff visit and review 10-year maintenance plans and priorities. ▪ Verification of resurfacing needs, endorsement by AMSC and communication of 4-year plan to regions. ▪ Central assessment of pavement rehabilitation needs and ongoing tasks in place. ▪ Completion of state-wide visual assessment by experienced resources as input to Auditor-General Finding 2 and ongoing planning. ▪ Bi-annual knowledge sharing conference implemented and ongoing, including emphasising consistency and completeness. ▪ Document and review processes for – 10-year RMP procedure – TYNDP practitioners guide – State-wide maintenance plan – updated regional maintenance plans. ▪ Intranet page on procedures and processes and link to records system.	▪ Document and review processes for: – updated regional maintenance plans (completeness and consistency – significant variability still evident)

Auditor general recommendations	Progress summary	Specific completed actions	Specific uncompleted and planned actions
Establish a consistent basis for calculating backlog to allow comparison over time (WAAG Follow-on Audit Finding 2)	Completed or in progress in all areas, including the initiation of network wide TSD surveys which should improve the identification of needs and strengthen budget proposals.	▪ Formal procedures on TYNDP as per WAAG Finding 1. ▪ Visual assessment by experienced engineers as per WAAG Finding 1. ▪ Better use of available data as input to pavement asset management plan (PAMP) and TYNDP and backlogs including: – condition data – MMIS data. ▪ Improved data collection implemented through acquisition of traffic speed data collection of deflection, profile and condition. ▪ Trial utilisation of sample 900 km of TSD data.	▪ Completion and utilisation of full network TSD data in updated PAMP, RMPs and TYNDPs.
Identify the maintenance knowledge and skills needed by Main Roads and plan for how current and future gaps will be addressed (WAAG Follow-on Audit Finding 5)	Whereas actions have been substantially completed, the key is realising a significant improvement in capability, particularly at a regional level. This is evident from the fact that the Central NMB team continue to undertake the majority of the inspections which feed into the state-wide surfacing asset management plan and the pavement asset management plan.	▪ Skills needs assessment completed. ▪ Develop and award NM support contract to replace ISA support. ▪ Knowledge sharing forums introduced. ▪ Full NM capability review and recommend actions undertaken. ▪ Strategies to implement recommendations developed.	▪ Developing and implementing asset management and maintenance practices, and achieving the required outcomes (on a sustainable basis).

Auditor general recommendations	Progress summary	Specific completed actions	Specific uncompleted and planned actions
Implement a consistent strategy to address maintenance backlog focused on minimising whole of life costs of the network (WAAG Follow-on Audit Finding 6)	Most required actions implemented, with further actions ongoing related to pavement rehabilitation needs which will be better informed by TSD data.	▪ Use of data and analysis: using MMIS and TSD data to assess needs across regions, including demonstrating value of early intervention. ▪ Resurfacing backlog strategy: – Significance of contribution to risks to LCC and safety (68%) and high priority backlog of works. – Senior staff network wide review (as above). – Knowledge sharing (as above). – Central review of needs and endorsement (as above) (good diagram). – Allocations (with justification) supporting backlog reduction. ▪ Pavement rehabilitation strategy: – Contributes to highest priority backlog (24%). – Identified inputs to future update of PAMP using MMIS and highspeed data, and network wide strength data. – Central estimate completed, including senior staff site visits and review, with significant BCR of proposed program.	▪ Initial strategy on pavement rehabilitation and final strategy using new high-speed strength data. ▪ Ongoing rehabilitation allocation. ▪ Senior staff review of RMP including backlog of shoulder, drainage and surface repairs.

5.5 Asset Management Plans

5.5.1 General

Main Roads' asset management plans fit within a suite of asset planning documents which form part of a hierarchy of documents as shown in Figure 5.4, with the AMP and SAMP having been discussed earlier in Section 5.2 and Section 5.3 respectively. This section summarises the content of the following documents which have direct relevance to pavement management, and presents information on Main Roads' improvement plans for these documents:

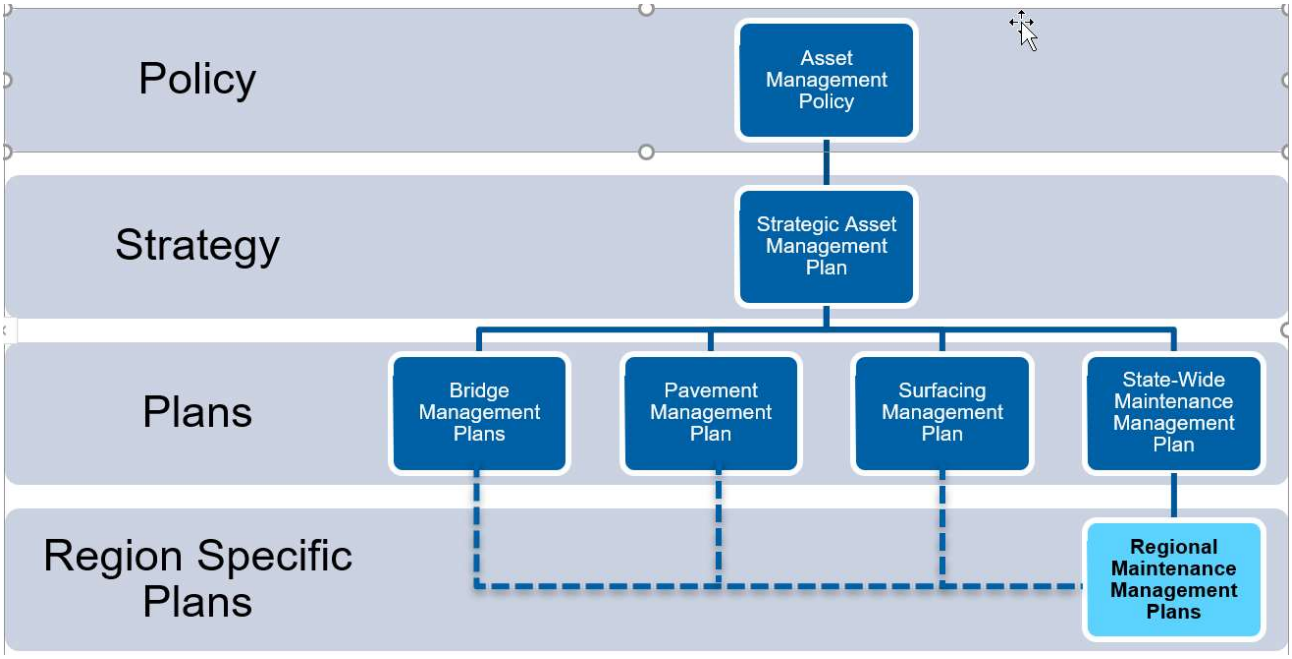
- Resurfacing Asset Management Plan (RAMP)
- Pavement Asset Management Plan (PAMP).

A review of the regional ten-year network delivery plans is also presented, with these also of relevance since surfacing and pavement works (and related works) comprise a significant part of the plans.

The State-wide Road Maintenance Management Plan (SWRMP) is referenced as it describes the following, noting that it also draws on the more detailed documents:

- Main Roads' overall objectives for maintenance management
- factors influencing maintenance of critical assets which are common across the state
- elements of the maintenance approach which are uniform across the state.

Figure 5.4: Main Roads' suite of asset planning documents



5.5.2 State-wide Resurfacing Asset Management Plan and Pavement Asset Management Plan

General

Both the RAMP and PAMP are structured similarly and set out to demonstrate a strong fit with ISO 550001. They show the line of sight between the bottom-up planning and operational focus of

asset management practitioners and corporate asset management objectives. The structure employed is summarised as follows:

- Purpose and context –describes where the RAMP and PAMP fit in the context of the organisation.
- Asset scope, description and current statistics – describes the scope of the asset, as follows:
  - the RAMP applies to the vast majority of surfacing assets, including all spray seals, asphalt surfacing and microsurfacing
  - this PAMP applies to the largest category of pavement assets, being rural granular material pavements; it does not at this stage consider all pavement types including urban roads and asphalt and concrete pavements, or unsealed roads
- Strategic alignment – demonstrates the alignment to the Main Roads strategic direction and Asset Management Policy
- Stakeholders and expectations – details the stakeholders that have a role in implementation and what the expectations of the road user are in relation to the surfacing asset
- Asset objectives and strategy – outlines the asset objectives and the criteria for asset management decision making
- Approach – details the management of risk, the processes, tools and capability required to manage the asset
- Program – outlines the backlog and the funding required to ensure the asset is adequately managed
- Delivery – details the various processes involved with delivering the asset
- Operations and maintenance – summarises the processes involved in operating and maintaining the asset
- References and related documents – lists key documents relevant to this RAMP
- Appendices – provide detailed information of topics discussed within the RAMP, including surfacing statistics, regional profiles, funding information and improvement opportunities.

Both the RAMP and PAMP describe the physical attributes, levels-of-service requirements and life cycle management activities required for the safe and effective operation of each asset.

While the focus is on ensuring that resurfacing and pavement treatments are effectively and efficiently implemented, it also acknowledges that, in order to ensure that the whole-of-life costs of managing the surfacing asset are minimised, other aspects must be considered. These include the relationship between surfacing and pavement assets and other asset groups.

Both plans also acknowledge that there are still improvements that can be made; they provide an outline of a range of proposed improvements that will be implemented over the next two to three years. In fact, the outline represents a combined requirement which acknowledges the need to integrate surfacing and pavement management within overall asset management.

Identified improvements include improvements to predictive pavement modelling and other data interrogation tools and systems, integration of asset and financial management processes, and the adoption of a ‘useful remaining life’ approach rather than a focus on surfacing and pavement age.

Resurfacing Asset Management Plan

The RAMP acknowledges the fundamental relationship that the surfacing has with other assets, and notes the following:

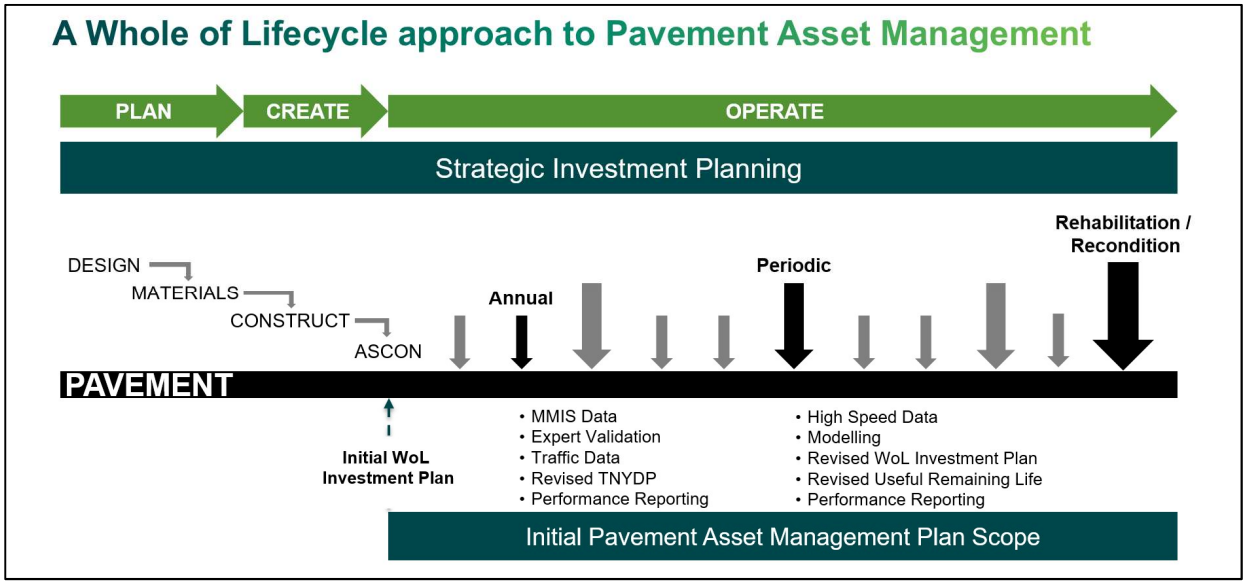
- the primary role of the spray seal surfacing being to waterproof the underlying pavement and reduce the risk of failure
- the need to undertake pavement repairs, edge break repairs and shoulder maintenance prior to undertaking resurfacing activities; this represents good asset management practice, and allows for costs associated with repairing the pavement condition as part of the resurfacing strategy
- consideration of pavement marking assets (longitudinal line marking, transverse line marking and other pavement markings such as arrows, etc.) when a resurfacing action is undertaken.

To ensure a holistic view of the surfacing asset, the RAMP considers and references the following:

- planning of new surfacing assets, including seal design, asphalt mix design and material selection
- construction of new surfacing assets, including construction processes/methodology and provision of as-constructed information
- the operation of the surfacing asset, including inspections, monitoring and maintenance activities (with detailed information included in the SWRMP)
- the renewal of the surfacing asset through reseal, enrichment or replacement (e.g. 'mill and fill') of the surfacing due to the surfacing reaching the end of its useful life (primary focus of this RAMP)
- retirement/disposal of the surfacing asset by either realigning or closing the road or the transfer of the road to another organisation (such as Local Government).

This approach is summarised in Figure 5.5 and is applicable to both surfacings and pavements.

Figure 5.5: A Whole of Lifecycle approach to Surfacing Asset Management



In managing its surfacing (and pavement) assets Main Roads demonstrates its understanding of the:

- age distribution of the surfacings in the Main Roads network, and the likely replacement timing (and cost)
- replacement value (and 'written down' value) of its assets
- alignment of the RAMP with its Asset Management Policy, with this illustrated in Table 5.5
- need for decision-making criteria to determine whether resurfacing is warranted, how these criteria should be considered and how other considerations should be addressed (Table 5.6) with this accounting for the components in Figure 5.6, noting the following:
  - Main Roads takes a 'maximum benefit' strategy when prioritising resurfacing. This means that the 'worst' section of surfacing on the network may not be the first to be resurfaced.
  - Where the condition of a surface impacts road user safety or results in the risk profile of a particular road increasing to an unacceptable level, it may be necessary to undertake a resurfacing treatment on this 'worst' section of seal, rather than resurfacing the road that will achieve the largest benefit to the overall network.
- impact on the costs of delaying resurfacing – this is informed by data from its Maintenance Management Information System (MMIS) (Figure 5.7).

Table 5.5: Alignment of RAMP with Asset Management Policy

Policy Principles	Strategic Alignment to this PAMP	Refer to RAMP Section
Apply a risk-based whole-of-lifecycle approach in the acquisition, operation, maintenance and disposal of our assets	▪ Risk assessment undertaken as part of this RAMP	7.1 Risk Management
Prioritise our investments based on appropriate consideration of customer outcomes, cost and risk	▪ Asset management decision making criteria established	6.2 Criteria for Asset Management Decision Making
Capture the right data to enable well-informed asset management decisions.	▪ Data requirements have been identified and processes and tools in place to ensure capture	7.2 Processes and Tools
Provide appropriate resourcing and development of our people	▪ Resourcing and competency requirements for management of pavement assets has been identified	7.3 Capability
Apply continuous improvement to our asset management practices	▪ RAMP includes number of improvement activities to be implemented	12 Appendix 3: Summary of Improvement Activities
Ensure consistency with our Integrated Management System	▪ Risk management approach aligns with Risk Management Policy	7.1 Risk Management

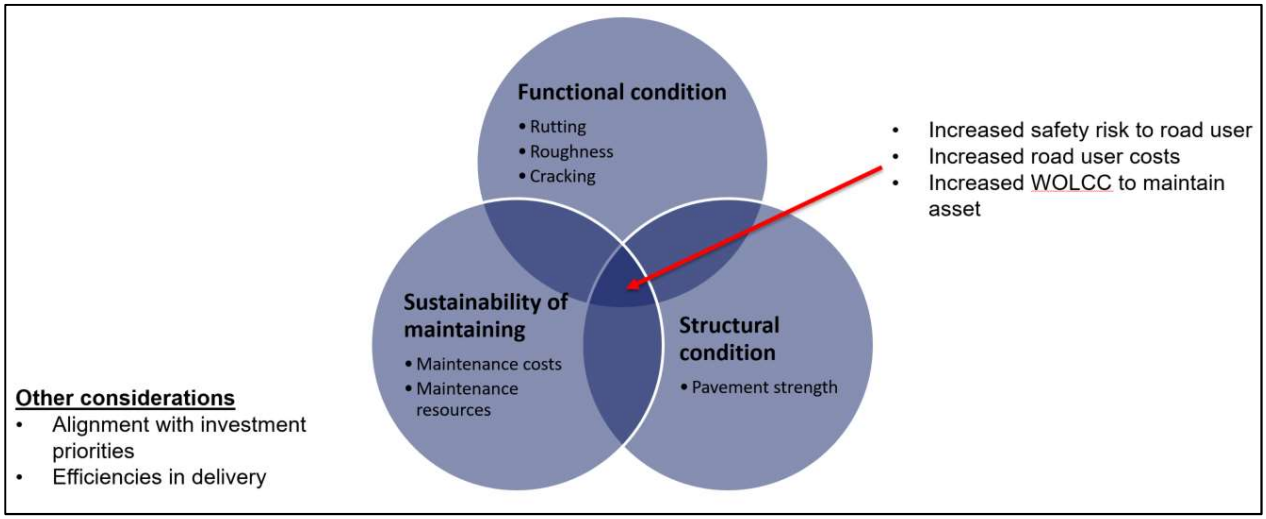
Source: Main Roads (2018b).

Table 5.6: Asset management decision criteria for determining when to resurface

Existing surfacing type	Primary criteria for determining need to resurface	How criteria are considered	Other considerations
Sprayed seal	▪ The existing surfacing is likely to let water into the underlying pavement ▪ The existing surfacing provides inadequate skid resistance ▪ The existing pavement maintenance is not sustainable	▪ Binder condition ▪ Aggregate embedment ▪ Aggregate retention ▪ Surface texture ▪ Surface cracking ▪ Extent of patching	▪ Alignment with investment priorities ▪ Efficiencies in delivery ▪ Strategic importance of road
Asphalt	▪ The existing surface is likely to pothole or rut and become a hazard to road users ▪ The existing surfacing provides inadequate skid resistance ▪ The existing surface maintenance strategy is not sustainable	▪ Surface ravelling ▪ Surface rutting ▪ Surface cracking ▪ Extent of patching ▪ Targeted SCRIM testing	▪ Alignment with investment priorities ▪ Efficiencies in delivery ▪ Strategic importance of road
Microsurfacing			▪ Alignment with investment priorities ▪ Efficiencies in delivery ▪ Strategic importance of road

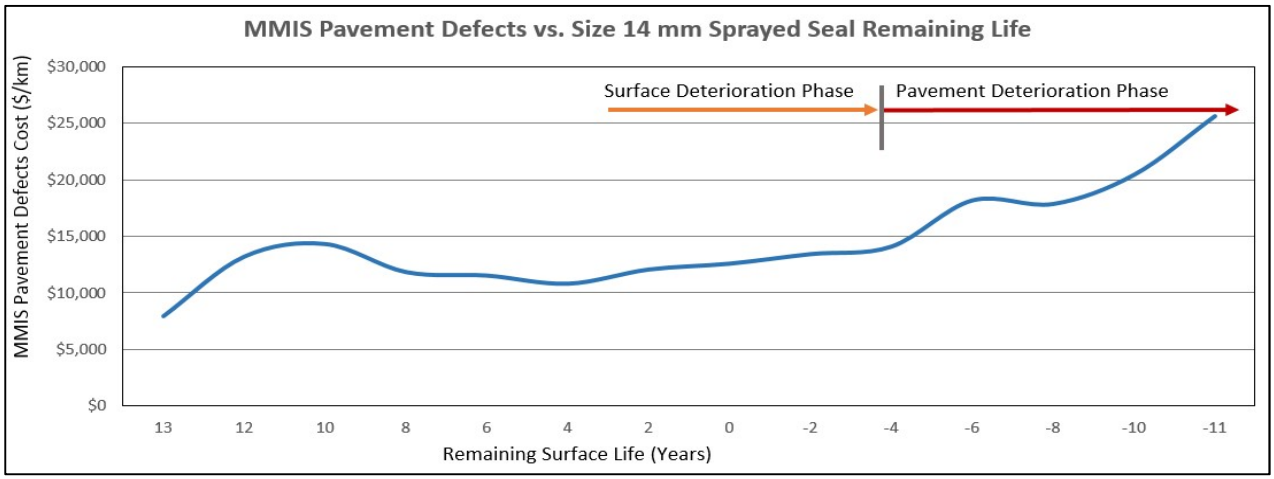
Source: Main Roads (2018b).

Figure 5.6: Criteria for asset management decision making



Source: Main Roads (2018b).

Figure 5.7: Cost of repairs versus remaining surface life



Source: Main Roads (2018b).

Once a decision has been made that resurfacing is required, consideration is given to a comprehensive set of factors in order to determine the new surfacing treatment type, including its suitability in relation to:

- existing surfacing type
- traffic volumes/type
- extent of turning movements
- skid resistance requirements
- condition of underlying pavement
- condition of existing surfacing
- road noise
- timing of treatment (season)
- climate conditions
- risk of treatment failure
- availability of materials
- maintenance requirements
- alignment with investment priorities
- efficiencies in delivery.

A number of technical guidelines exist on the Main Roads website in support of the above, whereas more specific guidance on pre-seal activities is acknowledged as being a gap.

Main Roads also accounts for the following in its decision making:

- The different functional pavement condition parameters that it monitors, including roughness, rutting, texture and cracking. Depending on the severity of these functional conditions and the presence of other criteria and considerations, it may be possible (and sustainable) to restore the pavement to an acceptable functional condition without rehabilitating the pavement.

- Specific quantitative criteria reported in its *Investigatory Criteria Guidelines* and the *Skid Resistance Management Plan*, and guidance on accounting for the structural condition of pavement is also available, with current modelling considering the deflection (D_0) and curvature ($D_0 – D_{200}$) values to determine the treatment level.
- The sustainability of maintaining (surfacing) and pavement assets, e.g. as a result of:
  - maintenance costs
  - resource allocation requirements
  - susceptibility to water ingress
  - availability of materials.
- Risk of failure – the likelihood and consequence of the pavement deteriorating and the benefits of treating a section.
- Accounting for the timing of investment decisions, including the remaining useful life of the asset.
- Use of asset visualisation tools such as Tableau (and Power BI), which allows for a road to be represented as a series of strip diagrams (Figure 5.8), with each strip showing a selected attribute. The data for these each of these attributes can then be analysed by an experienced asset management practitioner who can then make more informed decisions on treatment options and prioritisation. The attributes viewable include:
  - inventory information
  - traffic and safety information
  - work planning information (TYNDP needs)
  - pavement defect information
  - high-speed condition data (TSD)
  - Falling Weight Deflectometer data
  - overall condition index.

Figure 5.8: Example of Tableau display

Source: Main Roads (2018b).

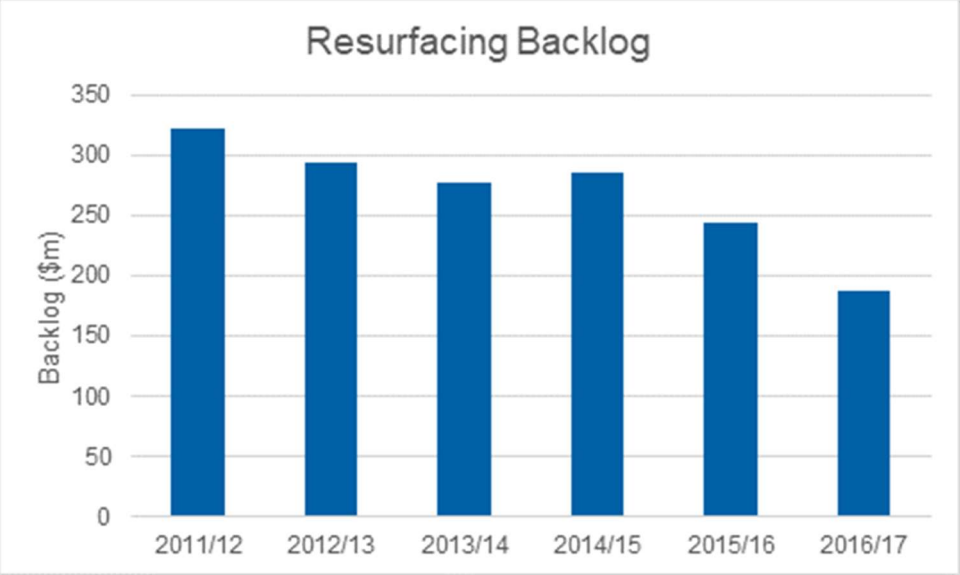
Although not fully developed, the potential exists to estimate the net benefits (and benefit cost ratio) of different strategies, including accounting for:

- the travel time savings to road users
- the reduction in vehicle operating costs
- accident reductions
- reduced road maintenance costs.

In an example quoted for pavement rehabilitation an economic analysis generated a BCR of 2.46, this being substantial and consistent with similar independent studies.

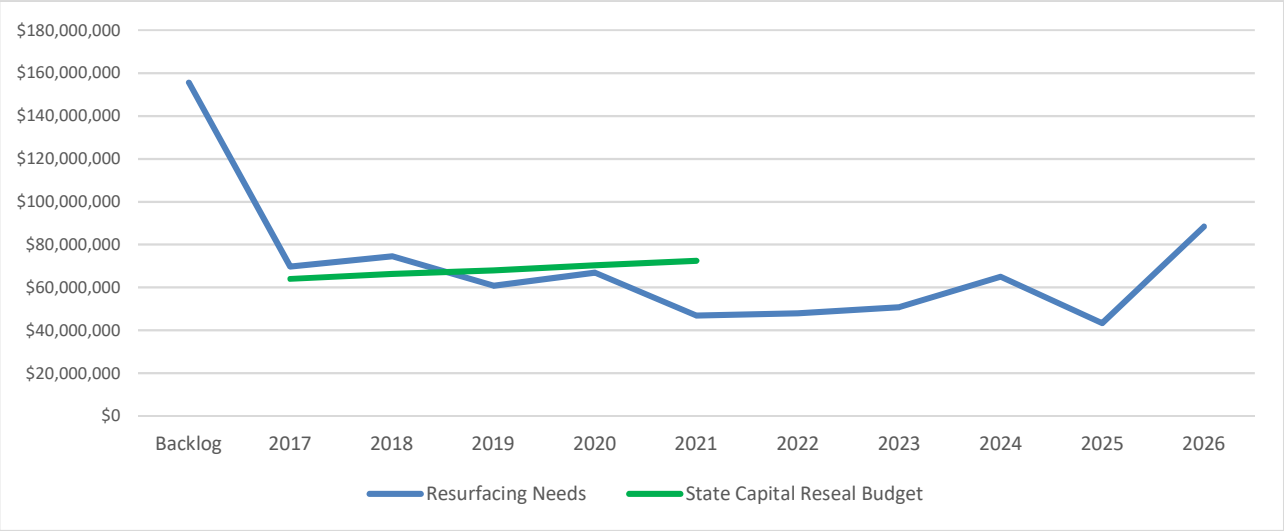
Using its various modelling tools, and historical records, Main Roads is also able to estimate its resurfacing backlog (combined backlog and deferred) and how this has trended over time (Figure 5.9), and how this is projected to trend in the future (Figure 5.10).

Figure 5.9: Past trend in resurfacing backlog



Source: Main Roads (2018b).

Figure 5.10: Projected trend in resurfacing backlog against state budget



Source: Main Roads (2018b).

Pavement Asset Management Plan

As noted earlier, the PAMP has a similar structure and scope to the RAMP, although differences exist in relation to:

- visual assessment
- dTIMS modelling
- future use of TSD data.

The PAMP covers the full life cycle of the pavement asset, with a particular focus on pavement rehabilitation. It has also been developed to align with ISO 55001 and the Main Roads Asset Management Policy. Due to the close interrelationships between the pavement and its surfacing, the PAMP also has strong alignment with the Resurfacing Asset Management Plan (RAMP).

The PAMP supports the development of an optimised pavement rehabilitation strategy to be implemented within available budgets, while also providing robust justification as to budget requirements. As a result of applying its modelling capabilities and following review by experienced practitioners, and whilst acknowledging that there is still further work to be completed, it is believed that in the order of 1,000 km of pavement assets will need to be rehabilitated over the next 10 years. This will require a budgetary allocation over this period of approximately $462.5 million (2017-18 dollars).

The PAMP also outlines a number of improvement opportunities that will facilitate a more strategic approach to the management of pavement assets. This includes improvements to Main Roads' pavement modelling capabilities; the collection and use of additional pavement data; and a shift towards a 'remaining useful life' philosophy. With the implementation of these improvements, Main Roads will be well placed to ensure that its pavement assets both meet the needs of the road user and are their whole of life cycle cost is minimised.

Main Roads' also recognises that its pavement asset can be described as an 18,500 km 'mosaic' of varying age, condition and use. This high level of granularity greatly complicates the asset management process, and WOLCC analysis at very granular levels will not necessarily provide strategic 'best for network' outcomes.

RAMP and SAMP improvement opportunities

Main Roads have identified 25 improvement opportunities, of which 19 apply to surfacings and the full 25 to pavements, covering asset management practices including decision criteria, data, models and tools (Table 5.7). The identified improvements confirm Main Roads is both serious and coordinated in its review. Many improvements coincide with the assessment made by the review team in Section 4, and are consistent with some of the initial observations also reported in Section 3.

With respect to a number of proposed improvements, the following information amplifies the issues to be addressed:

- Timing of investment decision, which is critical to achieving the least WOLCC for the pavement asset and road network in general. Central to this is determining the remaining useful life of the pavement asset.

  For example, if the remaining useful life of the pavement is determined to be five years and the surfacing has a remaining useful life of only one year, then, in order to ensure the least WOLCC, consideration should be given to either:

  — bringing forward a pavement rehabilitation to align with the proposed reseal date (thereby accepting a lower life of the pavement)

  — altering the surfacing treatment to minimise expenditure and ensure the resurfacing more closely aligns with the life of the pavement (e.g. resurface with a 7 mm spray seal with a lower capital cost but anticipated life of 7-8 years, rather than 15 years of a 14 mm reseal).

  Such considerations and guidance are critical for a practical and pragmatic system to work.

- Future Pavement Model, with a view that the existing model can best be described as a ‘strategic model’ which seeks to identify the quantum of pavement rehabilitation and reseal needs. It is not sophisticated enough to accurately identify pavement rehabilitation locations or optimise treatments.

  In the future, it is intended that, in addition to being a ‘strategic model’, the dTIMS model will also provide an ‘operational model’. The strategic level modelling will be utilised to inform Main Roads and relevant stakeholders of the future needs and therefore funding profile. The Operational Level Model will allow for sites to be programmed for treatment. This will include optimisation to assist in prioritising section of pavement to be treated and determining treatment types that best align with the available funding levels, including changes to the treatment strategy for various funding scenarios.

Table 5.7: Review of improvement opportunities related to SAMP and PAMP

Issue	Surfacing asset management plan	Pavement asset management plan
Scope of assets	▪ Improvement Opportunity 1 – Update RAMP to consider other surfacing assets including concrete and segmental paving assets, PSPs and DoT facilities.	▪ Improvement Opportunity 1 – Update PAMP to consider all pavement types including urban roads and asphalt and concrete pavements, as well as unsealed roads.
Replacement value		▪ Improvement Opportunity 2 – Capture pavement asset value and drainage asset value separately
Definition		▪ Improvement Opportunity 3 – Embed definition / intent for pavement rehabilitation (and associated definitions) into Main Roads business
Alignment to Strategic Asset Management Plan	▪ Improvement Opportunity 4 – Update RAMP when SAMP completed to ensure alignment.	▪ Improvement Opportunity 4 – Update PAMP when SAMP completed to ensure alignment.
Stakeholders	▪ Improvement Opportunity 5 – Update RAMP once SAMP completed to ensure alignment of stakeholders.	▪ Improvement Opportunity 5 - Update PAMP once SAMP completed to ensure alignment of stakeholders.
	▪ Improvement Opportunity 6 – Update RAMP to incorporate feedback from stakeholders.	▪ Improvement Opportunity 6 - Update PAMP to incorporate feedback from stakeholders.
Structural condition of pavement	▪ Improvement Opportunity 8 – Determine acceptable deflection and curvature values for different pavement and subgrade materials.	▪ Improvement Opportunity 8 – Determine acceptable deflection and curvature values for different pavement and subgrade materials.
Pavement useful remaining life		▪ Improvement Opportunity 7 – Embed the 'Remaining Useful Life' approach to pavement assets in Main Roads and investigate ways of reliably measuring this.
Pavement Health Index (include consideration of the pavement functional condition, structural condition and maintenance costs. The PHI would be utilised to optimise pavement rehabilitation programs.)	▪ Improvement Opportunity 9 – Establish Pavement Health Index to monitor overall condition of Main Roads pavement assets and to assist in the prioritisation and optimisation of treatments.	▪ Improvement Opportunity 9 – Establish Pavement Health Index to monitor overall condition of Main Roads pavement assets and to assist in the prioritisation and optimisation of treatments.
Road user costs	▪ Improvement Opportunity 10 – Embed approach to include road user costs into pavement treatment decision making process.	▪ Improvement Opportunity 10 – Embed approach to include road user costs into pavement treatment decision making process.
Timing of investment decision	▪ Improvement Opportunity 11 – Compile case studies relating to 'resetting of asset' prior to reseals.	▪ Improvement Opportunity 11 – Compile case studies relating to 'resetting of asset' prior to reseals.
Progress towards implementation of criteria for asset management decision making	▪ Improvement Opportunity 12 – Improve Pavement Rehabilitation Proposal Template to ensure detailed analysis and consistent approach.	▪ Improvement Opportunity 12 – Improve Pavement Rehabilitation Proposal Template to ensure detailed analysis and consistent approach.
Progress towards implementation of criteria for asset management decision making	▪ Improvement Opportunity 13 – Update dTIMS pavement model to align with key asset management decision making criteria.	▪ Improvement Opportunity 13 – Update dTIMS pavement model to align with key asset management decision making criteria.

Issue	Surfacing asset management plan	Pavement asset management plan
		▪ Improvement Opportunity 14 – Analyse historic rutting and roughness data for pavement in poor condition.
Collection of condition data (does WA TSD include digital cracking?)	▪ Improvement Opportunity 15 – Following the collection of additional cracking data, review how this data can be utilised to better optimise the resurfacing program.	▪ Improvement Opportunity 15 – Following the collection of TSD data, review how this data can be utilised to better predict the remaining useful life of pavement assets.
Collection of traffic data	▪ Improvement Opportunity 16 – Develop a strategy outlining Main Roads' approach to the collection and management of traffic data	▪ Improvement Opportunity 16 – Develop a strategy outlining Main Roads' approach to the collection and management of traffic data.
Asset visualisation tools	▪ Improvement Opportunity 17 – Configure Tableau to allow automated update of information displayed, direct from data sources.	▪ Improvement Opportunity 17 – Configure Tableau to allow automated update of information displayed, direct from data sources.
Surfacing trial sites	▪ Improvement Opportunity 18 – Review need for specific LTPP sites once a number of years of TSD data is available and changes in data understood.	▪ Improvement Opportunity 18 – Review need for specific LTPP sites once a number of years of TSD data is available and changes in data understood.
External review of pavement model	▪ Improvement Opportunity 19 – Review dTIMS model and incorporate greater degree of information including findings from external reviews.	▪ Improvement Opportunity 19 – Review dTIMS model and incorporate greater degree of information including findings from external reviews
Future pavement model	▪ Improvement Opportunity 20 – Expand purpose of dTIMS model from 'strategic model' to also provide greater 'operational modelling' capability and allow for optimisation of the program to meet various funding scenarios.	▪ Improvement Opportunity 20 – Expand purpose of dTIMS model from 'strategic model' to also provide greater 'operational modelling' capability and allow for optimisation of the program to meet various funding scenarios.
Pavement valuation		▪ Improvement Opportunity 21 – Review the current approach to depreciating pavement assets to align with the remaining useful life of the pavement.
Resurfacing backlog	▪ Improvement Opportunity 22 – In addition to reporting reseal backlog as a dollar value, also report reseal backlog by length or road or area.	▪ Improvement Opportunity 22 – Review approach to determine pavement rehabilitation backlog to ensure consistent and accurate reporting.
10 year funding to address needs		▪ Improvement Opportunity 23 – Update 10-year funding needs once TSD data available and pavement model is updated.
Four year program		▪ Improvement Opportunity 24 – Compile detailed four-year list of pavement rehabilitation sites. ▪ Improvement Opportunity 25 – Compile detailed four-year list of pavements that will be replaced (rehabilitated, reconstructed or realigned) by proposed capital works.

5.5.3 Regional Maintenance Plans

Regional Maintenance Management Plan

Each Regional Maintenance Management Plan (RMMP) supplements the State-wide Plan with details that are region specific. Capital projects are not discussed in maintenance plans except where holding treatments can be integrated/coordinated/reprogrammed due to impending capital works.

The RMMP are intended to be supported by a range of documents including:

- Regional Road Digest
- Regional Network Plan
- Route Plan(s)
- Link Plan(s) (including information on capital projects)
- Ten Year Network Development Plan (TYNDP) for the region
- Annual Works Program (AWP) for the region

Links to other relevant reference documents are provided throughout this document.

RMMPs are intended to be reviewed annually in accordance with the investment planning cycle, with this led by the region, and with the intended audience for this plan being:

- Regional team – regional manager, network manager, asset manager, maintenance manager and their staff
- Main Road's maintenance delivery partners, proponents and contractors
- Director Network Management and Executive Directors
- Budget and Programming Branch
- External auditors and funding bodies.

The contents of the RMMPs are comprehensive; they are summarised in Table 5.8.

Table 5.8: Contents of the Regional Maintenance Management Plans

Instructions to the Regions (from NMB)	Section 3: The Road Network ▪ Network Extent and Composition ▪ Road usage ▪ Critical routes ▪ Key network issues ▪ Maintenance agreements and concessional loading payments	Section 6: Maintenance management approach ▪ Organisational structure, roles and responsibilities ▪ Supply and procurement – delivery arrangements ▪ Crew and plant capacity ▪ Materials management ▪ Process
Section 1: Overview ▪ Purpose ▪ Link to State Maintenance Plan and other documents ▪ Audience	Section 4: Assets ▪ Asset condition ▪ Critical assets ▪ Surfacing ▪ Pavement ▪ Shoulders ▪ Drainage ▪ Roadside stopping places ▪ Vegetation ▪ Signs and lines ▪ Guardrails and barriers ▪ Unsealed roads	Section 7: Programming ▪ Developing the program ▪ Annual works program ▪ Deferred maintenance and backlog
Section 2: Regional outlook, and context: ▪ Seasonality/climate/storms/flooding/ cyclones ▪ Customer (public, local government or industry) expectations ▪ Network demand ▪ Mining/petroleum activities ▪ Agricultural activities ▪ Tourism; ▪ Freight/port uses ▪ Local environmental issues such as dieback, rare flora/fauna, SEAs ▪ Population movement	Section 5: Maintenance objectives and service levels ▪ Objectives ▪ Level of Service – Road Maintenance Intervention Parameters (RMIPs) ▪ Risk and opportunity management ▪ Maintenance priorities by road and asset type	Section 8: Maintenance works codes ▪ Network management (Work Code 10) ▪ Network operations (Work Code 11) ▪ Routine maintenance (Work Code 12) ▪ Pavement rehabilitation (Work Code 20) ▪ Pavement repairs (Work Code 21) ▪ Shoulders (Work Code 22) ▪ Unsealed roads (Work Code 23) ▪ Re-surfacing – asphalt (Work Code 30) ▪ Re-surfacing – spray seal (Work Code 31) ▪ Surface repair (Work Code 32) ▪ Drainage (Work Code 40) ▪ Vegetation control (Work Code 41) ▪ Roadside and miscellaneous (Work Code 42) ▪ Miscellaneous structures (Work Code 43) ▪ Principal shared paths (Work Code 44) ▪ Traffic devices (Work Code 50) ▪ Electrical (Work Code 60) ▪ Structures – bridge maintenance (Work Code 70)

Ten-year network development plans

For the purposes of this review, the Ten-Year Network Development Plan (TYNDP) for each region was reviewed as it is intended to address the specific needs of each region, accounting for the characteristics of each. It also has a very strong surfacings and pavements focus, although it does cover other assets.

The structure of the TYNDP is specified and is shown in Table 5.9.

Table 5.9: Structure of the TYNDP

Section 1: Purpose (including current focus)	Section 3: Current inventory implications ▪ Replacement lifecycle ▪ Growth in inventory ▪ % of pavement being replaced every year ▪ Changes in 10-year planning based on consumption
Section 2: Planning assumptions ▪ Resurfacing ▪ Rehabilitation ▪ Surface/pavement repair ▪ Shoulder re-conditioning ▪ Drainage ▪ Vegetation ▪ Routine maintenance ▪ Other significant activities	Section 4: 2018/19 Budget Bid ▪ Current backlog deferred at October 2017 ▪ Total needs for 2018/19 ▪ Maintenance backlog delivery ▪ Year 1 Program by top tier task and priority ▪ Rationale for prioritisation ▪ Top tier budget for 2015/16, 2016/17, 2017/18 and 2018/19 ▪ Deferred maintenance management strategy outcomes

A review of the completeness of the TYNDPs and comments on the strengths and weaknesses are provided in Appendix E.

The main observation regarding the TYNDPs is the variability in completeness with a general assessment revealing the following:

- two regions were considered to fully fulfil the requirements (Metropolitan and Wheatbelt)
- two regions were considered to substantially fulfil the requirements (Mid-West – Gascoyne and South West)
- one region provided a moderate amount of information
- three regions provided significantly lower documentation than required (or no documentation was available).

6 KEY FINDINGS AND OVERALL ASSESSMENT

This section summarises the key findings of the review.

6.1 Consistency and alignment with ISO 550001

1. At an organisational level Main Roads demonstrates substantial progress in achieving consistency and alignment with ISO55001. This is evidenced by the overall AM policy and objectives, and the comprehensive focus on Strategic Asset Management including supporting plans, processes and systems.
2. Strong alignment is also demonstrated through commitment to human resource capability development, noting, however, that significant variation in capability exists, particularly within and between the regions, meaning that they place substantial reliance on central teams in the overall management of the network.

6.2 Consistency and alignment with the Austroads GAM in adopting best practice in the management of roads and transport

1. The overall direction and practice of pavement AM is consistent with the Austroads GAM and for the most part borders on best practice. This is evidenced by the comprehensive approach to whole-of-life cycle evaluation and costing of roads assets, including in budget estimates and prioritisation. Further improvements are also ongoing in informing better modelling and decisions, through the use of modern technology from data acquisition (such as the TSD and data acquisition system) to plans for further improvements in modelling to better reflect regional needs. The priority areas for improvements are largely consistent with the options of the review team.
2. Asset preservation concepts and whole-of-life costs (primarily from an agency view) are well embedded and demonstrated in decision making, and in budget allocation, with surfacings assets in particular now the subject of a well-funded strategy. However, improvements in the overall funding and strategy for pavement assets remain a work in progress with this likely to be better informed through the recent investment in traffic speed strength and condition, However, there is a need to consider a broader whole of economy view by accounting for the costs and benefits to road users and the wider community in determining the best network strategies.

6.3 Quality and comprehensiveness of pavement management modelling, planning and guidance at the corporate level

1. The quality and comprehensiveness of pavement modelling at the corporate level, and its application in planning and guidance to the regions, is high. Where weaknesses exist, these are recognised by the team and are the subject of a comprehensive list of improvement actions including in developing regional models, improved estimates of total benefits (to Main Roads and the community) and in the provision of better data and visualisation/user tools for use at a corporate and regional level.
2. Guidance and involvement in planning and decision making in support of the regions is high, with this compensating for the variation in capability evidenced at a regional level.

6.4 Quality and comprehensiveness of pavement management planning and practice at a regional level

1. Whereas Main Roads' overall management of its surfacing and pavement assets has been demonstrated to be improving, and in relation to targets is amongst the highest of its peers, a major concern is the lack of consistency in capability at a regional level and the continued reliance on significant central support. The lack of consistency is highlighted in the variable documentary evidence which sets the scene and justifies regional plans, and the extent of central involvement in reviewing/moderating priorities. The various delivery models employed over the last two decades may have contributed to this, as a solid human resource base, with the exception of a limited few, is judged to be lacking.

6.5 Conclusions

In conclusion there is a need to urgently:

(a) address internal capability on a sustainable basis, including the deployment of hired-in mentors and specialist staff to build capability in depth throughout the regions and centrally, although the latter is reasonably well resourced

(b) focus on overall AM system improvements which deliver the best economic return to Government and the community; there is a need to distinguishing between different regions and focus on practical whole-of-life cycle treatments which maximise the return on investment.

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APPENDIX A ABBREVIATIONS AND ACRONYMS

ACP – asset conditions profile(s)

AM – asset management

AMAF – Asset Management Accountability Framework (of Main Roads)

AMO – asset management objectives

AMS – asset management system(s)

AMSC – Asset Management Steering Committee (of Main Roads)

AWP – annual works program

ARRB – Australian Road Research Board

ATAP – Australian Transport Assessment and Planning (guidelines)

BCR – Benefit-cost Ratio

BIP – Budget and Investment Planning (Branch of of Main Roads)

CAPEX – capital expenditure

CLOS – customer levels of service

DSS – Decision Support System

dTIMS – Deighton Total Infrastructure Management System

DTF – Department of Treasury and Finance

GAM – Guide to Asset Management (of Austroads)

FWD – Falling Weight Deflectometer

HDM – Highway Development and Management tools (of World Roads Congress/PIARC)

HSD – High -speed data

IAMF – Integrated Asset Management Framework (of Austroads)

IIMM – International Infrastructure Management Manual (of Institute of Public Works Engineering Australasia (IPWEA))

IPS – Infrastructure Preservation Strategy

IRIS – Integrated Road Information System (of Main Roads)

ISA – Integrated Service Arrangements

ISO – International Standards Organisation

KPI – Key Performance Indicator(s)

LTPP – long-term pavement performance (study)

MBCR – marginal benefit-cost ratio (see also BCR)

MDC – maximum defective condition

MEB – Materials Engineering Branch (of Main Roads)

MIL – maintenance intervention level(s)

MMIS – Maintenance Management Information System (of Main Roads)

MRT – maintenance response time(s)

NMB – Network Management Branch (of Main Roads)

NPV – net present value

NSL – notional structural life

OAM – operational asset management

OPEX – operational expenditure

PAMP – Pavement Asset Management Plan (of Main Roads)

PCI – Pavement Condition Index

PDCA – Plan-Do-Check-Act (of ISO 55001)

PMI – preventative maintenance indicator

PMS – pavement management system

RACI – responsible, accountable, consulted and informed

RAMP – Resurfacing Asset Management Plan (of Main Roads)

RD – road deterioration (model(s))

RIS – Road Investment Strategy

RMIP – Road Maintenance Intervention Parameters (of Main Roads)

RMMP – Regional Maintenance Management Plan(s) (of Main Roads)

RMP – Regional Maintenance Plan(s) (of Main Roads)

RNC – road network contract

RSL – remaining service life

RSMS – Road System Management Strategy

RUC – road user costs

RUMS – road use management strategies

SNC – Modified Structural Number

SNCi – Modified Structural Number at time i

SNCo – Initial Modified Structural Number

STEP – Structural Evaluation of Pavements (a specific tool)

SCRIM – Sideways force Coefficient Routine Investigation Machine

STE – smooth travel exposure

SWRMP – State-wide Road Maintenance Management Plan (of Main Roads)

SAP – Strategic Asset Plan (of Main Roads)

SAMP – Strategic Asset Management Plan

TMI – Thornthwaite Moisture Index

TNC – term network contract

TTC – total transport costs

TYNDP – Ten-Year Network Development Plans (of Main Roads)

VOC – vehicle operating costs ( )

WAAG – Western Australian Auditor General

WARRIP – Western Australian Road Research and Innovation Program

WOLCC – whole of life cycle costing (also abbreviated to LCC)

WE – Works effects (models)

APPENDIX B FORMAL DOCUMENTS, SYSTEMS AND TOOLS

The following list of asset management system documentation is intended to support all aspects of asset management undertaken by Main Roads.

Document Type	Ref	Title	Status
System Manual	SM1	Asset Management System (AMS)	In Progress
Procedures	P2	Pavement, Surfacing and Roadside Inspection	Complete
	P3	Ten Year Maintenance Planning	Complete
	P5	Maintenance Programming, Management and Delivery	Not Started
	P6	Performance, Monitoring and Reporting	Not Started
	P7	Operational Asset Management Capability and Training	Not Started
Instructions / Guidelines	I2	Pavement Modelling Specifications	Complete
	I3	MMIS Use, Review and Update	In Progress
	I4	Surface Condition Assessment Guideline	In Progress
	I8	Inspection Planning and Scheduling	Complete
	I13	Asset Need based funding Distribution	In Progress
	I15	Annual Works Program (AWP) Change Management	Complete
	I16	Preparation of Regional Maintenance Plans	In Progress
	I17	Defect Management	Complete
	I19	Maintenance Process Compliance Review	In Progress
	I21	Treatment Review	In Progress
	I23	CNR-MSR Financial Management Guidelines	Complete
	I24	Work Performance Management System - Practitioners Guide	In Progress
	I25	Designing for Maintenance	In Progress
	I26	Maintenance Performance Reporting	In Progress
	I27	Pavement Repair Optimisation Sheet - Instructions	In Progress
	I28	Ten Year Network Delivery Plan - Practitioners Guide	In Progress
Templates and forms	T1	Sprayed Seal Condition Assessment Form	In Progress
	T2	Asphalt Surfacing Condition Assessment Form	In Progress
	T4	Network Inspection Plan Template	In Progress
	T5	AWP Change Register	Complete
	T6a	Regional Maintenance Plan Template (Without Examples)	Complete
	T6b	Regional Maintenance Plan Template (With Examples)	Complete
	T7	State Maintenance Plan Template	Complete
	T8	Change Register Template - State Maintenance Budget	Complete
Reference	R1	MMIS user guide	Complete
	R2	Road Maintenance Intervention Parameters Guideline	Complete
	R3	Network Inspection Guidelines	Complete
	R5	Maintenance Work Codes & Treatment Selections	Complete
	R6	Improvement Register	In Progress
	R7	Asset Management - Glossary of Terms	In Progress
	R8	Maintenance Standards	Complete
	R9	Surfacing Condition Assessment – Visual Assessment Guide	In Progress
	R10	Maintenance Practices (Roads)	In Progress
Tools	T1	Pavement Repair Optimisation Sheet	In Progress
Operational Documents	OG106	Abandoned Vehicles	Complete
		Operational Procedure – Bushfire Risk Management and Mitigation	Complete
		Factsheet - Bushfire Risk Management and Mitigation	Complete
		Roadside Trading Policy	In Progress
		Roadside Trading Guideline	In Progress
		Operational Procedure - Verge Maintenance Agreements with Local Government - Published	Complete
		Verge Maintenance - Agreement Template	Complete
		Procedure for Organisations or Individuals Seeking to Undertake Works within the Road Reserve – Complex Works - Draft	In Progress
		Procedure for Utility Service Providers & Local Governments Seeking to Undertake Works within the Road Reserve – Low Complexity Works - Draft	In Progress
		Procedure for Organisations or Individuals Seeking to Undertake Works within the Road Reserve – Low Complexity Works - Draft	In Progress

In addition, various other documents have been provided including:

- Keeping WA Moving – Our strategic direction, Main Roads, 1 September 2017.
- Main Roads Asset Maintenance Policy, 26 August 2016.
- Main Roads Asset Management Framework, March 2017.
- Customer facing levels of service – Rural and outer metro road network, Main Roads Network Management Directorate, September 2017.
- Road Maintenance Intervention Parameters, Main Roads Network Management Directorate, 29 July 2016.
- Guidelines for Creation of New Links and Review Existing Link Categories and Extents, Main Roads Road Asset Planning Branch, January 2013.

Access has also been provided to the 'Tableau' reporting tool, and data files from the MMIS and other tools such as dTIMS.

APPENDIX C ROADMAP TO ISO55001

The status of key documents related to the roadmap is summarised in Table C 1, and extracts of the roadmap are presented in Figure C 1 and Figure C 2. Table C 2 provides a summary of Main Roads' Asset Management Objectives.

Table C 1: Status of key plans and documents related to the Roadmap to ISO55001 and review team confirmation and comments

Title	Sub-title	Reported Status/Target	Next action(s)
ASSET MANAGEMENT POLICY		Completed 16 Aug 2016 Revised 21 Dec 2017	Review 2020
STRATEGIC ASSET MANAGEMENT PLAN		First edition by mid-2018	Review 2019
	CLOS (Customer Levels of Service)	Completed Oct 2017	
	RMIP's (Road Maintenance Intervention Parameters)	Review complete 2017	
	Asset Management Objectives	Completed Oct 2017	Report due mid-2018
	▪ Confirm measures	Mid 2018 (RED)	Report Oct 2018
	▪ Finalise targets	End 2018 (RED)	
	RACI	Draft under review – due mid-2018 (RED)	
	Scope of AM System	Mid 2018 (RED)	
AUDIT		OAG 2016 Internal mid-2018 (RED)	Internal reviews 2018, 2019 and 2020
CAPACITY & CAPABILITY		Assess Capability by April 2018	Develop strategies end 2018 Implement 2019 onwards

Title	Sub-title	Reported Status/Target	Next action(s)
ASSET MANAGEMENT PLANS			
	State Road Maintenance Plan	Complete Jan 2018	
	▪ Regional Maintenance Plans	Due mid-2018 (RED)	
	Resurfacing Asset Management Plan	Completed July 2017 Review & update mid 2018	Annual updates
	Pavement Asset Management Plan	Due end 2018 (RED)	Review & update 2019
	▪ Visual assessment	Visual review April 2018 (RED)	Assess & Program end 2018 (RED) Update ex-TSD and annually
	▪ dTIMS Modelling review	Review deterioration Oct 2018 (RED)	Refine & update incl. TSD, MMIS from 2018
	▪ TSD Data collection	ARRB Contract end 2018 (RED)	
	Electrical Asset Management Plan	Draft completed 2016	Review & update end 2018 and end 2019
	Bridge Asset Management Plans	Timber completed 2016	Other groups & individual structures end 2018 Refine & update from 2019
	Route Plans	9 Strategic routes completed June 2017	Other links mid 2018
NETWORK VIEW		Passing Lanes Mid 2018 (RED)	Other end 2018 Update with all links mid 2019
	State wide Network View of route plans	Widening Mid 2018 (RED)	Update with all links mid 2019
	Road Maintenance Procedures	Some completed Feb 2018 - ongoing	
	Structure Review Network Management Branch	Mid-2018 RED)	

Figure C 1: Roadmap to ISO55001 (Page 1)

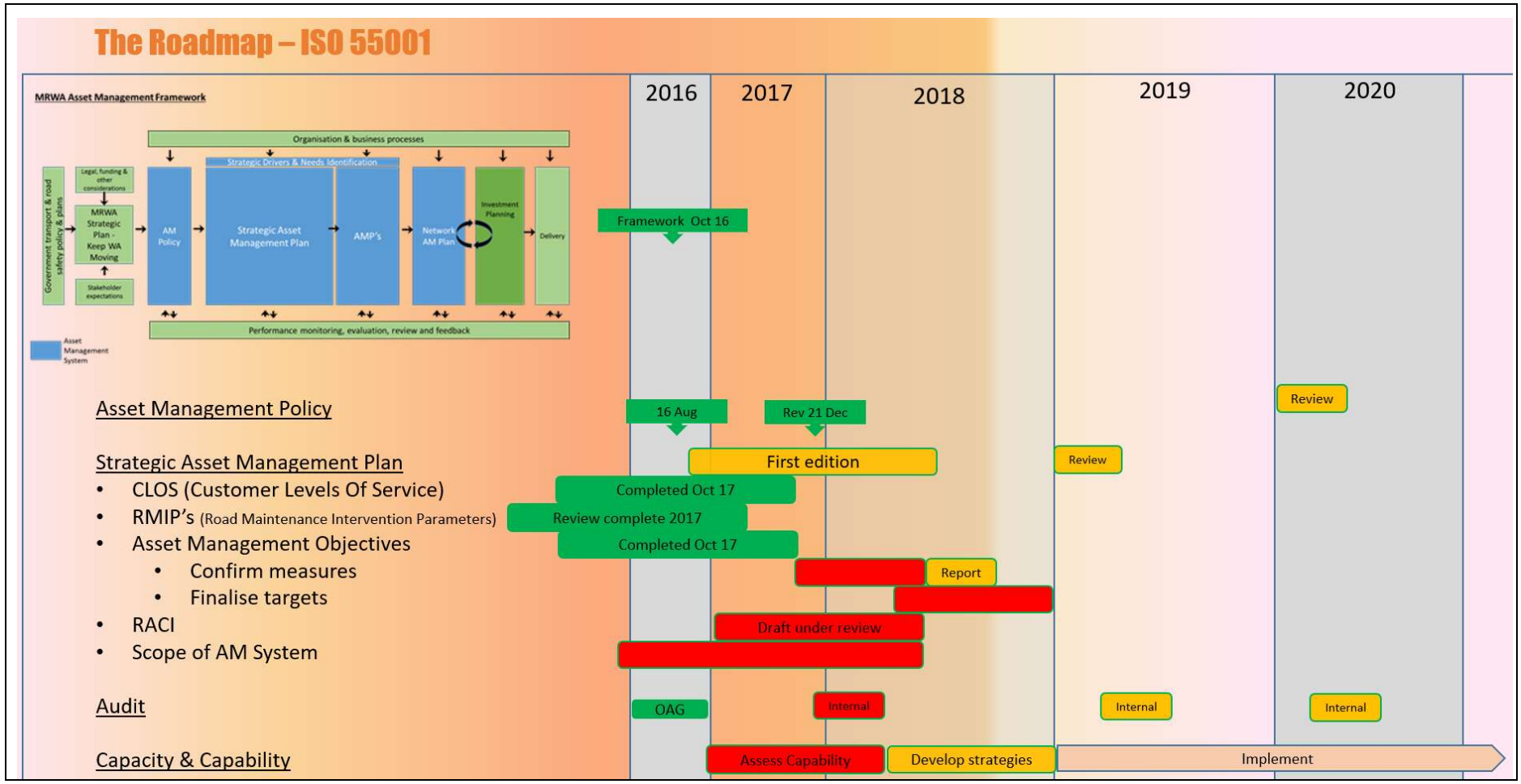

Figure C 2: Roadmap to ISO55001 (Page 2)

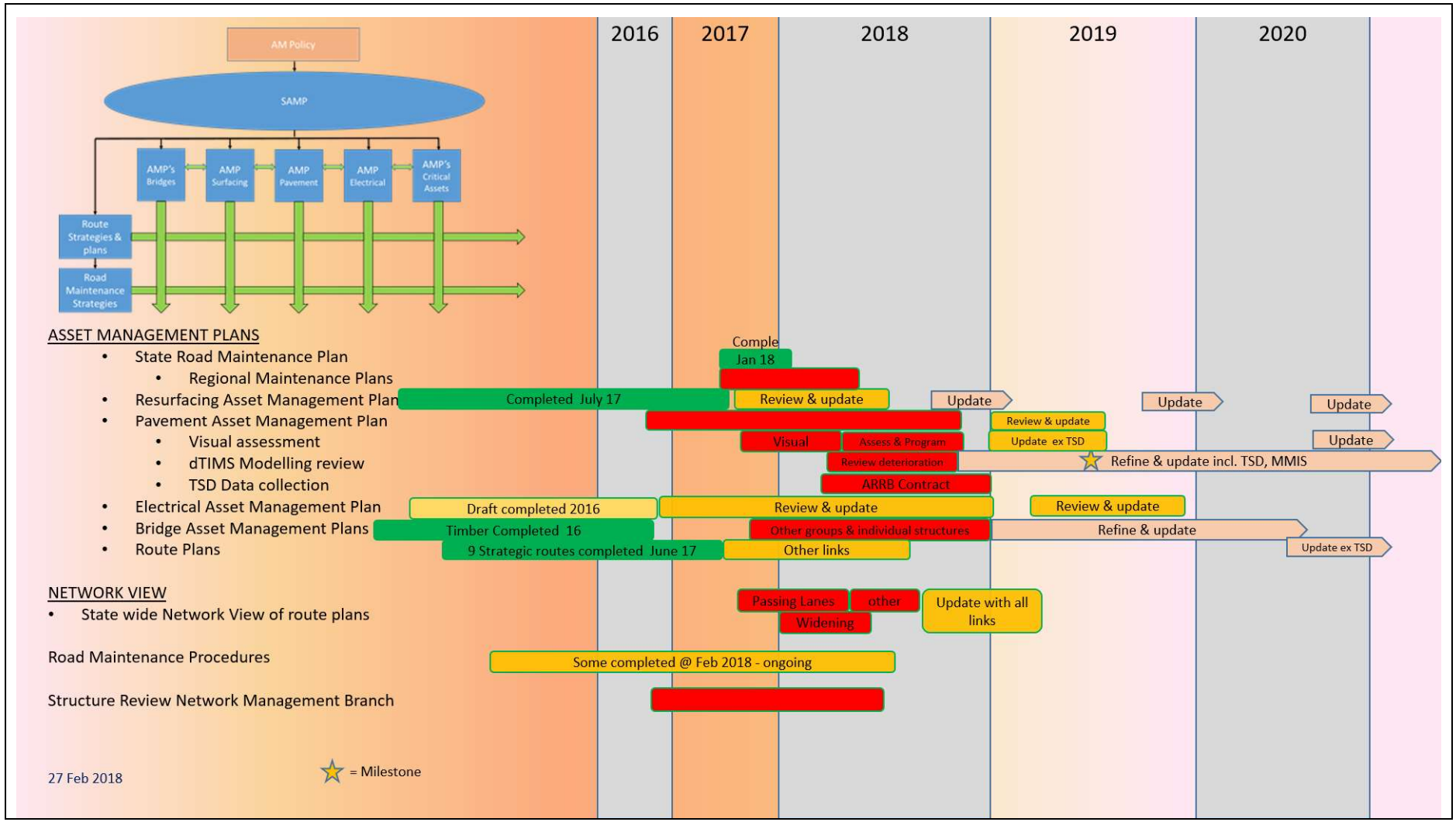

Table C 2: Main Roads Asset Management Objectives

Keep WA Moving	Funding Program	Investment Planning	Primary Asset Management Objectives	Asset Management Objectives	Measure	Current Value	Target
Safety – Provide improved safety outcomes for all users of the transport network	Road Safety	Road Safety	Minimise the likelihood of road trauma to all road users (ROSMA objective)	▪ Safer roadside ▪ Improved Network Configuration (current KPI is total network configuration and not broken into width, geometry and road class as proposed for asset purposes) ▪ Well maintained roads ▪ Reduce livestock on road	▪ ***Rural KSI Crash rate*** ▪ ***Road safety satisfaction*** ***Corporate survey*** ▪ ANRAM/AusRap rating (under development) ▪ ***Seal width (M, A, B & C)*** ○ ***% Minimum (*Corp KPI = total network configuration)*** ○ % Desirable ○ % Interim ROSMA ○ % Ultimate ROSMA ▪ ***Bridge width*** ▪ ***Road geometry design / safe speed (M, A, B, & C)*** ○ Horizontal ○ Vertical ▪ Passing opportunity ▪ % Network edge lined ▪ Seal texture (% & ACP) ▪ Visibility of white lines (possible measure as part of contract) ▪ Pastoral fencing %	***90*** ***90**** ***96*** ***90****	***Monitor 90*** ***90**** ***96*** ***90****

Keep WA Moving	Funding Program	Investment Planning	Primary Asset Management Objectives	Asset Management Objectives	Measure	Current Value	Target
Movement – Improve mobility of people and efficiency of freight	Road Efficiency	Efficiency & Reliability	Improve Journey time reliability	▪ Improve Metro Journey Time Reliability ▪ Improve Metro intersection LoS ▪ Rural – improve closure due to flooding ▪ Complete Route and Link strategies ▪ Complete Metro strategic network plan (to be confirmed with NP&D)	▪ Refer to Network Operations (dashboard) ▪ Refer to Network Operations ▪ ***Network availability/closure due to flooding (Corp KPI = all closure)*** ▪ % completion of route & link plans ▪ Completion of the Metro strategic network plan??	***97***	***85*** 100
	Road Management	Freight Access & Productivity	To provide an accessible road network for freight	▪ Provide appropriate RAV Access ▪ Adequate Bridge Strength ▪ Provide adequate Passing Opportunity ▪ Provide adequate Truck Bay spacing / facilities	▪ ***% road with RAV access*** ▪ ***27.5 m/36 m/53 m*** ▪ ***% bridges ok strength*** ▪ % adequate ▪ % adequate	***97 / 80 / 45*** ***90***	***96 / 78 / 44*** ***91***
	State Develop	State Development	Positive Return on Investment	▪ Positive Return on Investment	▪ ***Return on investment - Current corporate KPI***	***4.5***	***?***

APPENDIX D MAIN ROADS RACI MATRIX

Main Roads' RACI matrix is reproduced in Table D 1.

Table D 1: Main Roads Net Work Management Branch RACI Matrix

AM Phase	Function	Activity / Role	Metro and South			Central and North				Owner
			ED	Reg	Elec	ED	Reg	NM	TC	
Identify Asset Requirements	Optimisation & Prioritisation	Extract & Compile Needs data EPM						E		**Budget and Programming**
		Review Annual Program (Major Projects, ITS, Structures, Pavement & Roads)		R	A/R		R	A		
		Optimise, prioritise and plan: Major Projects, ITS, Structures, Pavements, and other Asset projects.	A	R	A/R	A	R	A/R		
	Works Program Development	Forecast and analyse revenue	A	R		A	R	I		
		Comply with requirements of Corporate Risk management process and Policy	A	R		A	R	I		
		Develop and manage Risk Register	A	R		A	R	I		
		Road Asset risk management	A	R		A	R	I		
		Annual **Bridge** Works Program - Develop and Endorse		R			R	A		
		Develop ITS & Electrical Maintenance Program			A/R					
		10 Year Road Maintenance Planning - Select, allocate, develop & endorse	A	R		A	R	A/R		
		Develop State Maitenance Plan				A		R		
	Operational Asset Management	Develop and maintain regional AM Plans e.g. Road Maintenance, Structures	A	R		A	R	E		
		Develop and implement asset inspection schedules & monitoring plan	A	R		A	R	E		
		Log asset defect and condition data - MMIS & Visual	A	R		A	R	E		
		Assess performance gaps (LOS, IC, RMIP) and select treatments	A	R		A	R	E		
		Optimise investments and prepare programs - TYNDP, AWP, Work Packages.	A	R		A	R	E		
		Analyse and prepare statewide road maintenance program including allocations between asset / work types and regions		E			E	A/R		
	Revised TYNDP & AWP reflecting Funding Allocations	Document revised TYNDP and AWP with agreed funding levels & outcomes of prioritisation		R			R	A		
		Finalise preliminary business cases: ITS, Structures, Road and other Projects	A	R	A/R	A	R	A		
	Identify Financial Needs to DTF via SAMF	Strategic Asset Plan (SAP) for DTF (incl Capital, Maintenance & Disposal) incl bridges		E			E	E		**Budget and Programming**
		Strategic future Roads, Electical and Structures needs.		E			E	E		**Budget and Programming**

Program Implementation	Deliver High Cost/ Complex Projects $10m plus (Category D)	Project Definition & Scope	A	R	E	A	R	E		IDD
		Road & Bridge Technical Design Review		E			E	E		IDD
		Project Definition & scope: ITS, Electrical Assets, metro operational functionality	A		R					IDD
	Deliver Mid Size Projects $3 - $10m Range (Category C)	Project Definition & scope: **Civil road Assets**		E	E		E	E		IDD
		Road & Bridge Technical Design Review		E			E	E		IDD
		Project Definition & scope: **ITS, Electrical & Metro Ops**	A		R					IDD
		Close out & handover. As Cons & IRIS	A	R		A	R			
		Bridge data entry of As Cons into IRIS		R			E			
	Deliver Minor Works $50k to $3m (Category B)	Project Definition & scope: Rural Traffic, Safety and Access Improvements	A	R		A	R	E		
		Road & Bridge Technical Design Review						E		
		Project Definition & scope: Metro Traffic & Safety and Operational Improvements		E						Network Ops
		Community Consultation (at Project Level)	A	R		A	R			
		Clearances & preconstruction	A	R		A	R			Environment
		Prepare Project Mgt Plan - Full scope & design & cost estimates	A	R		A	R			
		Delivery arrangements (including project and contract management) including Quality	A	R		A	R			
		Project close out & handover to asset owner. As Cons & IRIS		R			R			IDD / PM
		Bridge data entry of As Cons into IRIS		E			E			Structures Engineering
	Deliver Urgent Works[x]	Deliver Urgent Road & Bridge Works		A/R			A/R	E		
	Deliver Maintenance Program (RO&DS 5)	Confirm Annual Maintenance Program -				A		A/R		
		Allocate Budgets		I		A	I	A/R		
		Define Project	A	R		A	R	E		
		Delivery arrangements		R			R	E	A	
		Develop and approve Regional Maintenance Plans		R			R	A		
	Deliver **Rural** Network Operational Services & Support Rural Operational Services (RO&DS 5)	Establish & maintain partnerships with Stakeholders in planning and co-ordinating delivery of Network Operational Services	A	R		A	R	E		
		Operational Guideline: Maintain & Develop OG and initiatives		E		A	E	R		
		Manage Strategic Relationships		E			E	A/R		
	Deliver **Perth Metro** Network Operational Services (RO&DS 5)	Establish & maintain Stakeholders partnerships in planning & co-ordinating delivery of Network Ops Services		E						Network Ops
		Deliver real-time operational services in Metropolitan area & SWR in peak periods. Traffic & Network Operations		R	E					Network Ops
		24/7 customer contact and support (CCC) & Traveller Information State-wide		I	I		I	I		Strategy and Comms
	Public Report & Disseminate Information	Review Performance Measurement (PIs) - PI 1, Annual Repord, Austroads and Regional Digest		E	E	A	E	R		Strategy and Comms

Legend

Organisation	Matrix entries
▪ ED – Executive Director ▪ Reg – Region ▪ Elec - Electrical Asset Management ▪ NM – Network Management Branch ▪ Term Contractors	A – Accountable R – Responsible E – Engaged I – Informed

APPENDIX E REVIEW DETAILS OF REGIONAL 10YNDP

A review of the completeness of the TYNDPs and comments on the strengths and weaknesses are provided in Table E 1 and Table E 2.

The level of completeness is indicated by a 0 (lacking detail) or a 1 (significant detail).

Table E 1: Review of TYNDP Overview Reports: Goldfields-Esperance, Great Southern, Kimberley and Metropolitan

Region	Goldfields-Esperance	Great Southern	Kimberley	Metropolitan
Overview (report	▪ Final GER Ten Year Network Delivery Plan Overview Report March 2018	▪ Not available	▪ Overview Report on 10 Year Network Delivery Plan – Kimberley 2018	▪ Metropolitan Region 10YNDP Overview Report ~ Mar 2018
Supporting documents	▪ Proposed Pavement Rehab Sites - Goldfields Esperance Region 2017-18	▪ Pavement rehabilitation proposal ▪ Great Southern Region 2018/19 financial year	▪	▪ Metro Region 2018-19 Pavement Rehabilitation Program
Overview (scene setting and focus)	▪ TYNDP validated using sound, detailed data for years 1 to 4 and concerted effort made to populate years 5 to 10, using only P1. ▪ Well-developed TYNDP with modifications and improvements to be made based on budget advice, with revalidation in later years based on condition ratings, capital projects and change of delivery model.	▪	▪ Updates progress for 17/18 and the development of the 18/19 TYNDP following advice on the proposed budget allocation for 2018/19. Items not funded have been reprogrammed to outer years, with need to refine following analysis of MMIS, site inspection and significant flood damage. ▪ Current Focus on maintenance delivery model and direct managed of specific maintenance. Cost coding issues.	▪ 1
Planning assumptions	1		1	1
Current inventory implications	1		1	1
2018/19 Budget Bid	1		0	1
Current Backlog/Deferred at October (current year)	1		0	1
Total Needs			0	1
Plan for Delivery of existing Backlog	1		0	1

Region	Goldfields-Esperance	Great Southern	Kimberley	Metropolitan
Year 1 Budget Bid by Top Tier Task and Priority			0	1
Justification for any Backlog carried over to future years			0	1
Justification for low priority works			0	1
Table detailing Top Tier budget for last 4 years	1		0	1
Outcome of Backlog Delivery Plan	1		0	1
Brief discussion on Delivery Capacity constraints and strategy			0	1
Funding levels required over the 4-year period			0	1
Brief explanation/overview of reasons for any change in amount of backlog			0	1
Assessed strengths and opportunities (by reviewer)	▪ Region has established long term pavement performance (LTPP) sites; the deterioration of these sites will be repeatedly measured and the ongoing tenure of these sites will assist with pavement life assumptions. The region also has historical records to identify trends and expected asset life. Pavement repairs are expected to have a life of 15 years. ▪ Region also justifies carrying over backlog so that new and upcoming needs can be addressed to ensure that more backlog is not introduced. Smoothing or normalising the current backlog through the years also creates a consistent cash flow and capacity	▪	▪ Planning works to increase the lengths of reseal sections and removing peaks and troughs to enable a consistence level of funding. This is being achieved by selections of different treatments such as enrichments or holding seal treatments (7 mm seals) to group sections of roads in line with predicted funding allocation.	▪ Recognition of limitations. ▪ The Region operates annually under a constrained budget (i.e. the maintenance component of the Available Funds identified in the Annual Works Program). ▪ Recognition that there is a difference between i) ideal/idealistic 'unconstrained' funding, ii) more realistic 'needs' funding - and the actual Available Funds. ▪ The Road Maintenance Intervention Parameters are absolute for safety related issues/defects and are a guide, subject to funding availability and priorities, for other defects ▪ The general rationale is to allocate funding initially to: ▪ The non-discretionary and safety related activities undertaken by the in-house routine maintenance crews ▪ Other safety related activities,

Region	Goldfields-Esperance	Great Southern	Kimberley	Metropolitan
	demand in the future when replacement is next required.			▪ Resurfacing (to protect the pavement) ▪ Management and administration support. ▪ Overall, the maintenance budget is considered to be adequate to meet current service levels although growth is placing increased pressure on operational delivery areas. Where maintenance expenditure levels are such that they will result in a lesser level of service, the service consequences and service risks have been identified and service consequences highlighted, and service risks considered in the Regional Maintenance Strategy. ▪ The 10YNDP resurfacing/rehabilitation program (and backlog) include sections where dTIMS and visual validation data suggest that rehabilitation may be justified. A pragmatic position has been adopted – rehabilitation is only included in an AWP where a formal investigation (via MEB) confirms a WOLLCC benefit. There is no annual target
Assessed weaknesses and challenges (by reviewer)	▪ Lack of discussion on prioritisation	▪	▪ The 2018/19 program is a work in progress. The correlation between visual assessment and the latest HSD is poor. Large areas of pavement have failed where the modelling data has assessed the pavement as fair to good. ▪ Overall limited in content. ▪ The regional assessment of pavement does not align with modelling data – requires further investigations	▪ Structure varies from prescribed template. ▪ This is addressed in the 'pavement life assumptions' above. However, there are significant sections of Kwinana Freeway and Tonkin and Roe Highways where the performance of the existing Hydrated Cement-treated Crushed Rockbase (HCTCRB) has resulted in an asphalt surfacing lifecycle significantly less than normal. ▪ It is difficult to estimate asset expansion over the next 10 years. Many potential improvement projects are currently unfunded, and even committed significant projects are not fully scoped and/or are impacted by delays. Using corporate data, the region has identified a 15% increase in lane km of surfacing over the period 2002-2012 – while the increase in all other regions over the same period was 3%.

Table E 2: Review of TYNDP Overview Reports: Mid-West – Gascoyne, Pilbara, South West and Wheatbelt

Region	Mid-West - Gascoyne	Pilbara	South West	Wheatbelt
Overview (report	▪ Ten Year Network Delivery Plan (TYNDP) - Overview Report – Mid West Gascoyne Region – 29 03 2018	▪ Pilbara Region – TYNDP Overview Plan – April 2018	▪ Overview Report On 10 Year Network Delivery Plan – South West Revised2 – March 2018	▪ D17#863711 TYNDP Overview Report October 2017
Supporting documents	0			▪ Pavement Rehabilitation Proposal Wheatbelt Region ▪ 2018/19 Financial Year Wheatbelt Regional ▪ Maintenance Management Plan Financial Year, 2018-2019
Overview (scene setting and focus)	0	0	1	▪ Emphasis on accurate data Alignment with budgets and WPMS baseline ▪ Unit rates and outputs ▪ Priorities and budget bids ▪ Discussions with NMB and ISA ▪ Accounting for repairs ▪ On-site validation ▪ Recognition of staff shortages
Planning assumptions	0	0	0	1
Current inventory implications	0	0	0	1
2018/19 budget bid	1	0	1	1
Current backlog/deferred at October (current year)	1	0	1	1
Total Needs	1	0	1	1
Plan for Delivery of existing backlog	1	1	1	1
Year1 budget bid by top-tier task and priority	1	0	1	1
Justification for any backlog carried over to future years	1	0	1	1
Justification for low priority works	1	0	1	1

Region	Mid-West - Gascoyne	Pilbara	South West	Wheatbelt
Table detailing top-tier budget for last 4 years	1	0	1	1
Outcome of Backlog Delivery Plan	1	0	1	1
Brief discussion on delivery capacity constraints and strategy	1	1	1	1
Funding levels required over the 4-year period	1	0	1	1
Brief explanation/overview of reasons for any change in amount of backlog	0	0	1	1
Assessed strengths and opportunities (by reviewer)	▪ Simple well illustrated presentation, with a useful tabular commentary	▪ Few details provided	▪ Quantitative statements as per template requirements	▪ 4-year reseal program aims to exceed average replacement rate ▪ Rehabilitation candidates programmed accounting for risks to asset and road users, with sites consistent with state-wide pavement rehabilitation strategy using 10YNDP, MMIS & dTIMS modelling and defect data. ▪ Surface/pavement repair linked to following year's resurfacing program, and identified through MMIS data, visual inspection and pavement modelling with distinction made between need for minor surface defects and structural defects.
Assessed weaknesses and challenges (by reviewer)	▪ Structure and details vary from prescribed template ▪ Detail lacking, including assumptions of information on planning assumptions and implications of current inventory	▪ Structure and details vary significantly from prescribed template ▪ No quantitative statements as per template requirements, or planning assumptions or documentation of inventory implications	▪ Structure and details varies from prescribed template, with no description of planning assumptions or documentation of inventory implications	▪ Unsuccessful request for additional funds to manage an upsurge in pavement defects in 2016/17, which were further exacerbated by record rainfalls.