P3.48 Sustainable asset management

Selecting optimal maintenance strategies based on multi-criteria decision making

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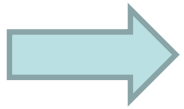


Industry values

Implementations

Background

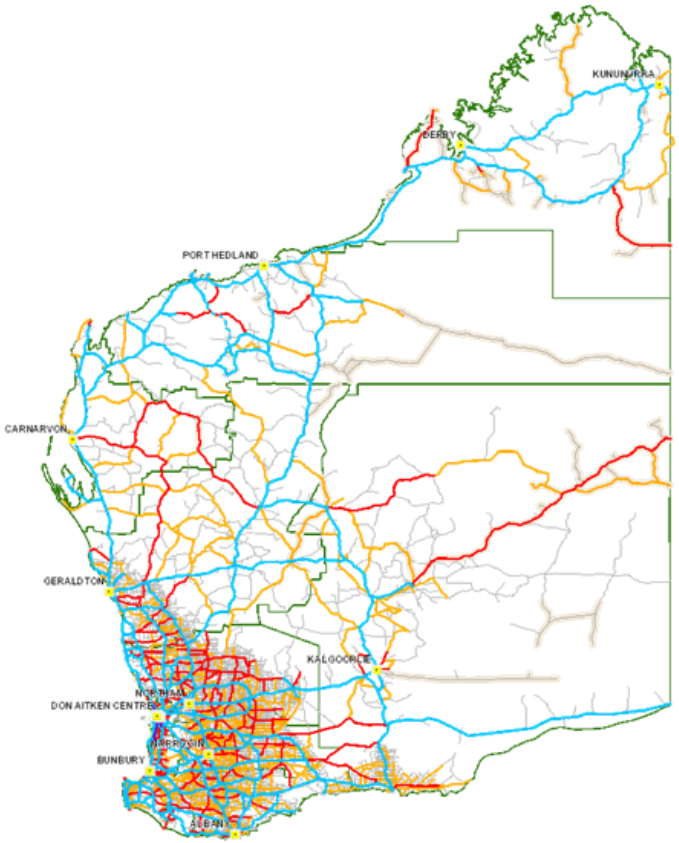
Infrastructure maintenance

Infrastructure maintenance is one of the largest maintenance sectors in Australia. For instance, according to the Department of Infrastructure and Transport (2015), the market value of road maintenance activities is $7.8 billion in 2013, accounting for 5.2% of the total road network value of $150 billion.

Shortfall of maintenance fund

According to the Australian Local Government Association (2013), there is a forecasted shortfall of $17 billion for maintenance and renewable expenditure for local roads across Australia between 2010 and 2024, representing 39% above the estimated funding availability for the corresponding period.

Industry problems



Problem

Given the large number of road sections that need to be maintained under limited budget, how to select the road sections to maintain to achieve cost-effectiveness and sustainability?

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Current practices

Life cycle costing

Existing life cycle costing (LCC) method is mainly based on an evaluation of the present worth cost (PWC) or equivalent uniform annual cost (EUAC) of asset management strategies.

Direct cost of maintenance activities

Pavement performance

Performance means the effect of the maintenance strategy. The optimal timing over the life cycle to schedule PM activities and major rehabilitation on road pavements needs to be assessed.

Pavement performance improvement

Future practices

Road user costs

Road user cost includes all the opportunity cost of travel rather than simply financial cost. Usually, road user cost includes travel time cost, vehicle operating cost and accident cost.

Value of time (VOT)

Vehicle operating cost (VOC)

Accident cost (AC)

Sustainability

How environmental impacts, such as emissions and waste generated from asset management plans can be integrated into the asset management model.

Global warming (CO_2)

Solid waste

Project aim and objectives

Given the large number of road sections that need to be maintained under, how to select the road sections under different scenarios?

Some typical scenarios include:

Limited budget

How do you manage road maintenance when resources are limited and money is tight?

Performance focused

How do you manage road maintenance to achieve maximum network performance?

End user focused

How do you manage road maintenance to achieve maximum end user benefits?

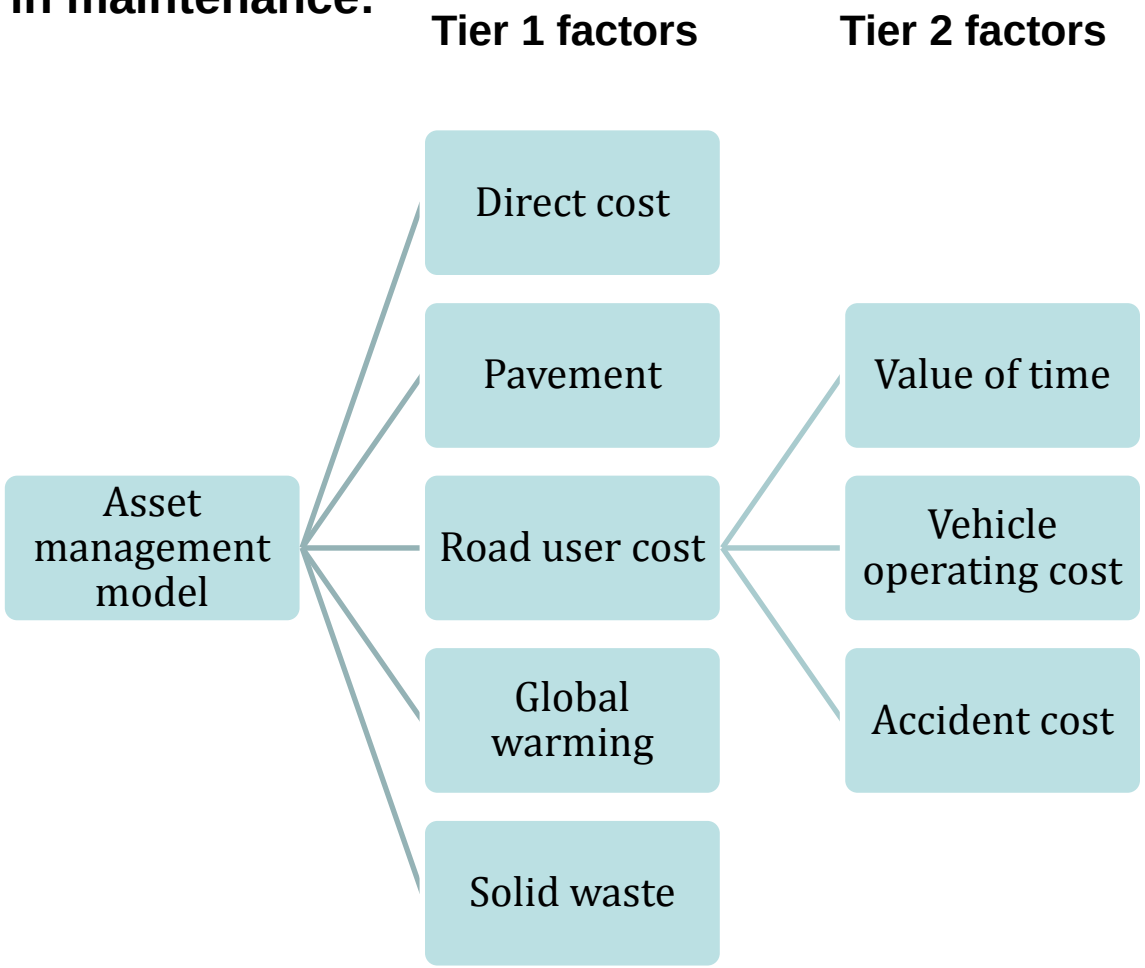
Sustainability focused

How do you manage road maintenance to achieve maximum sustainability?

Or, just a **balanced** approach

Research method

Key considerations in maintenance:



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Research method

Three-step approach:

Step 1:

Weighting process

This step involves a weighting of all factors.

The end results are the weights of each factor.

Step 2:

Rating process

This step involves a rating performance of all road sections on the five tier 1 and three tier 2 factors.

The end results are performance rating scores for each road section.

Step 3:

Aggregation process

This step involves an aggregation process of Step 1 and Step 2.

The end results are scores for the maintenance of each road section.

Processes and outcomes

Step 1: Weight process

Analytic Hierarchy Process (AHP) Technique

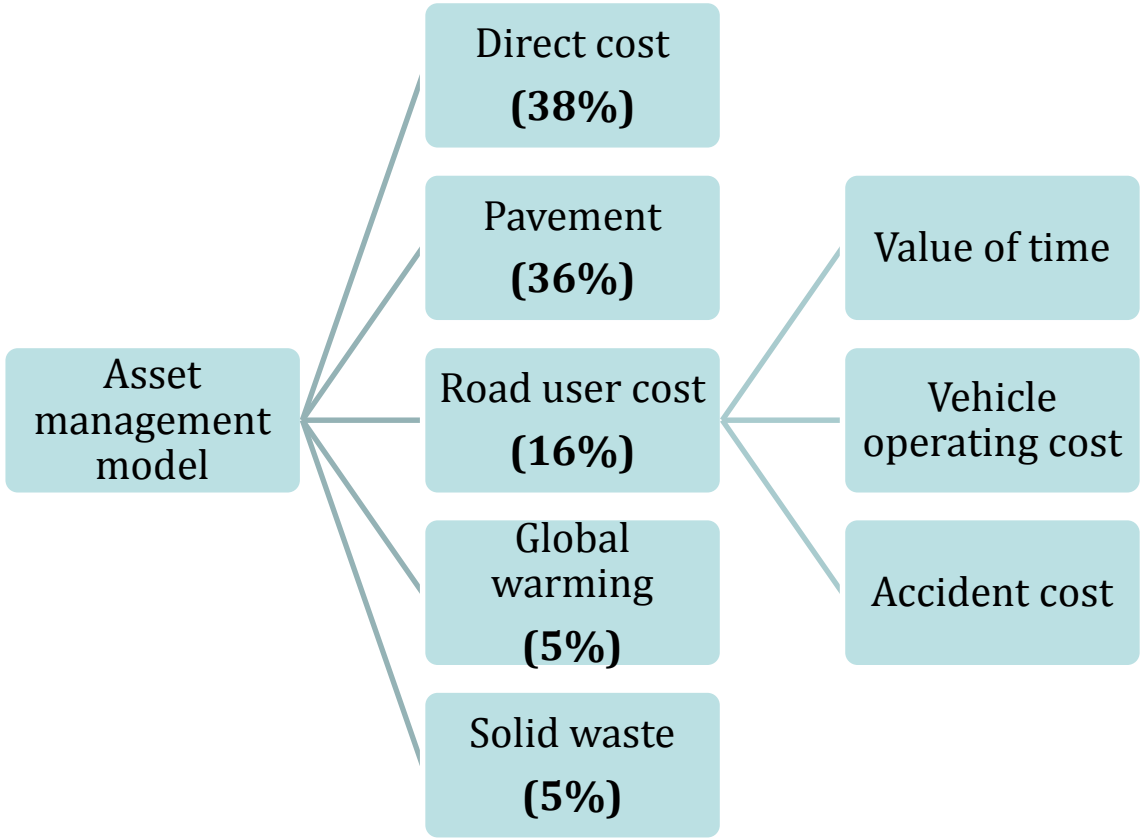
	Direct cost	Pavement performance	Road user cost	Carbon emissions	Solid waste	Priorities
Direct cost	1	1	7	7	6	0.38
Pavement performance	1	1	7	6	5	0.36
Road user cost	0.143	0.143	1	7	6	0.16
Carbon emissions	0.143	0.167	0.143	1	1	0.05
Solid waste	0.167	0.200	0.167	1	1	0.05

Please note that the priorities score may vary significantly in the future. This is the advantage of this project to reflect changing requirements on road maintenance.

Processes and outcomes

Step 1: Weight process

Analytic Hierarchy Process (AHP) Technique



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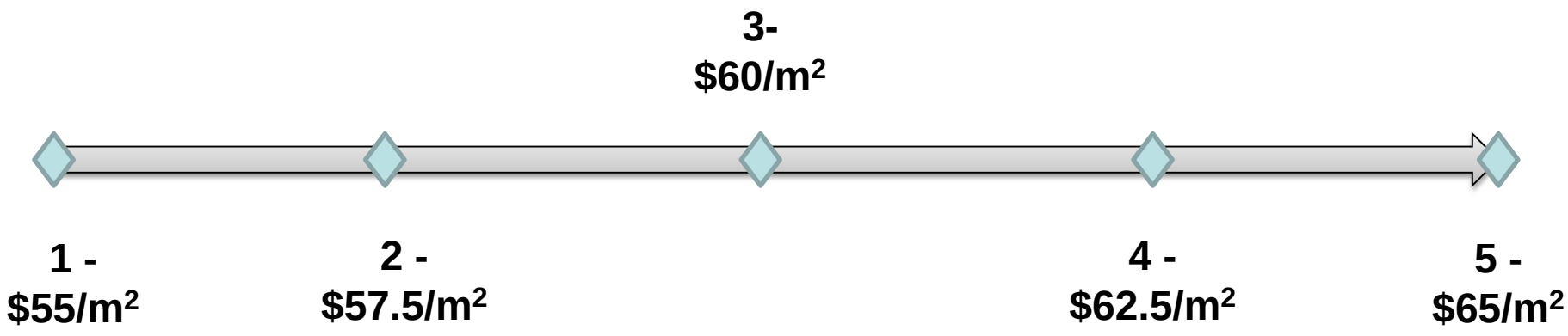
Processes and outcomes

Step 2: Rating process

Quartiles/Hinges – Using direct cost as an example



Assuming maintaining a new road section will cost $63.5/m², its performance rating on direct cost will be 4.4.

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Processes and outcomes

Step 2: Rating process

Quartiles/Hinges

Pavement performance – severity index / urgency of the maintenance

Road user cost – value of time, vehicle operating cost, accident cost

Value of time

$$VOT = L \sum_{c=1}^{n} \Delta Hc * ADTc$$

Vehicle operating cost

$$VOC = \Delta D \sum_{c=1}^{n} ADT_c * C_c$$

Carbon emissions – life cycle assessment

Solid waste – life cycle assessment

Processes and outcomes

Step 2: Rating process

Hinges	Direct cost	Pavement performance	Road user cost	Carbon emissions	Solid waste
	$/m^2		$/m^2	Kg CO_2-eq.	m^3 / m^2
1					
2					
3					
4					
5					

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Processes and outcomes

Step 3: Aggregation process

Projects	Direct cost	Pavement performance	Road user cost	Carbon emissions	Solid waste	Aggregated score
	38%	36%	16%	5%	5%	
1	4.5	3.3	1.6	2.2	1.1	3.32
2	2.1	4.1	2.2	4.3	3.4	3.01
3	xx	xx	xx	xx	xx	xx
4						
5						
… …						

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Industry values and impact

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1. New agile asset management model for road infrastructure. This research focuses on establishing a new asset management model for road infrastructure, which can capture the constantly changing requirements on economic, performance and environmental considerations. The proposed new model is expected to achieve a new maintenance management paradigm which can establish maintenance strategies that fit real behaviours and conditions of roads, achieve cost-effective maintenance and deliver environmental benefits.

Industry values and impact

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2. The project addresses the government's strategic direction, Optimising Maintenance Investment, by providing reliable and accurate maintenance strategies. During an economic downturn, infrastructure stakeholders have to face intense pressure to strategically allocate maintenance resources so that optimal results can be achieved.

As the maintenance plan generated from this project is based on improved life cycle cost and benefit analysis and calibrated prediction of performance using historical and local data, only the right amount of maintenance resources will be allocated to the right maintenance activities at the right location and time.

Industry values and impact

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3. Truly low-cost maintenance activities. According to the Australian Local Government Association (2013), there is a forecasted shortfall of $17 billion for maintenance and renewable expenditure for local roads across Australia between 2010 and 2024, representing 39% above the estimated funding availability for the corresponding period.

The approach that will be developed in this project will significantly fulfil this national vision that asset management can and will be carried out with truly low life cycle cost.

Industry values and impact

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4. Benefits and solutions for MRWA. The proposed approach will be validated through various road segments provided by MRWA, who can achieve accurate performance prediction and effective maintenance budget allocation based on varied economic, performance and environmental considerations.

There is evidence of significant maintenance deficit when there is a 15% per annum reduction in road maintenance expenditure over the three years from 2014-2017 (Government of Western Australia, 2014). Selecting effective maintenance strategies when having tight budget is important and imperative to improve the whole life cycle asset management processes.

Implementation in MRWA

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The project outputs can be implemented in MRWA in a few ways, e.g.:

1. **Evaluate the life cycle cost of maintenance activities;**
2. **Evaluate the environmental performance of maintenance activities, thus enhancing the sustainable performance of MRWA;**
3. **Decision making in selecting maintenance activities based on cost, performance and environmental considerations; and**
4. **Decision making in selecting maintenance activities in varied circumstances, e.g. tight budget vs comfortable budget.**

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