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ANNUAL SUMMARY REPORT

Project Title: A26: Incorporation of the Pavement Risk Score into the Pavement Condition Index (Year 1 - 2015/16)

Project No: 010564

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SUMMARY

TMR has developed a Pavement Risk Score (PRS) to reflect the risk to pavement preservation/failure and safety. The PRS relies on measured condition data and information on the operating environment to assess the likelihood and consequence of current asset conditions, i.e. it aims to consider future risks.

Since the initial development of the PRS, a new pavement management system (PMS) was introduced together with the pavement condition index (PCI). The PRS was also implemented in the PMS as a trial with only limited calibration and review, but was not integrated into the PCI.

Whereas a number of common elements exist between the PCI/PMS and the PRS, including the adoption of a suite of individual condition indices and the aggregation of these following the recommendations and methods developed in the European COST 354, differences also exist. The main difference is the PCI/PMS employs formal life-cycle costing (LCC) models and a quasi-economic analysis to determine future treatment needs and priorities, whereas the PRS is built around judgement based estimates of risk and accounts for both likelihood and consequence in a single index, with prioritisation based on a risk/cost ratio (RCR).

The first year of the project has seen the completion of a review of the PCI and PRS methods, and the development of a number of executable computer programs to compute various indices either using MS Excel or in the PMS. Field assessments of a representative range of road sections have also been gathered from across the state road network by TMR's regions.

The plan for the second, and final, year of the project has been developed. The plan reflects progress to date, and acknowledges the need to complete a number of tasks, including: extending the PRS to include pavement strength (TSD derived), cracking data (ACD derived) and potentially RMPC backlog data; sensitivity testing and calibration of the PCI and PRS; and finalisation of their incorporation in the PMS and stand-alone user tools. The aim is to continue to offer two solutions, where: a) formal LCC analysis is retained in the PMS; b) a simple but calibrated PRS/RCR approach is available for corporate analysis, with the outcomes calibrated and producing reasonably consistent results.

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1 INTRODUCTION

1.1 Background

TMR has developed a Pavement Risk Score (PRS) to reflect the risk to pavement preservation/failure and safety (Department of Transport and Main Roads 2012). The PRS relies on measured condition data and information on the operating environment to assess the likelihood and consequence of current asset conditions, i.e. it aims to consider future risks.

Since the initial development of the PRS, a new PMS was introduced together with the pavement condition index (PCI) (Kadar 2014). The PRS was also implemented in the PMS as a trial with only limited calibration and review, but was not integrated into the PCI.

The PCI and associated individual Condition Indices (CI) were introduced into the new PMS following the recommendations and methods developed in the European COST 354 study completed in 2008 (Litzka et al. 2008). The PCI is an aggregate of the individual condition indexes based on the concept of the 'weighted maximum', i.e. instead of the average of CIs the maximum (worst) dominates the overall index.

This is a significantly different approach as opposed to using averages, and lacks any previous local experience or numerical guidance. It could be interpreted as addressing the most serious emerging distress in a preventative manner, and it is paramount that the content and the magnitude of this parameter is calculated and interpreted correctly. The calibration will provide a sound basis for interpreting and explaining the PCI as well as it's relation to other measures, particularly the PRS.

The PCI and the individual CIs are calculated for future years by utilising the predictions from the PMS's road deterioration models and ultimately applied in selecting the treatment strategies which are used, whereas the PRS attempts to accommodate future risk through its formulation. That is, it aims to substitute the more complex PMS predictions with its own predictions of the consequences of current conditions, and the priority which should be afforded using a risk-based approach. Consequently the indices used should have realistic values and be consistent as they have a major impact on future outcomes and therefore for program and budget development.

1.2 Scope

The study is aimed at reviewing, calibrating and incorporating the Pavement Risk Score developed by TMR into the Pavement Condition Index implemented in TMR's pavement management system (PMS).

The study has been designed to be delivered in two phases over two consecutive years, as follows:

1. Phase 1:
   (a) **Standardise the CI and PCI calculation**. Currently the PCI and CIs are calculated either in the PMS or using spreadsheets. To avoid potential errors, the calculation of the CIs and PCI is done in separate subroutines. The subroutine (DLL) will be built in a manner that can be used independently, or both in MS Excel and a PMS platform. This makes it possible to explore a large number of combinations and permutations of the possible values.
   (b) **Desktop study – sensitivity analysis**. The purpose of the desktop study is to explore the sensitivity of the weighting factors in the aggregation of the CIs and thus ultimately on the PCI. The data for the purpose of the sensitivity analysis will be obtained from the RAMC PMS (dTIMS) database, where the condition indices are readily available.

(c) **Field validation**. The field validation is a reality check on the results – do they truly reflect the condition and are they indicative of the maintenance requirements?

2. Phase 2:

   (a) Review of the PRS and its constituents; the life-cycle cost risk (pavement condition aspect), and safety risk factors, integrate into the PCI and ensure that the parameters are consistent with the PCI constituents.

1.3 Purpose and Structure of the Report

This report describes the background to the original PCI and PRS, and documents progress achieved in the first year of the study, and focuses primarily on Phase 1 activities a) and c).

Following this introduction, this report is structured as follows:

- Section 2 summarises the basis and application of the Pavement Condition Index (PCI) and the Pavement Risk Index (PRS).
- Section 3 describes the study approach and progress made in the first year of the project.
- Section 4outlines the objective and scope of tasks in the second and final year of the project.
- Section 5 describes the key conclusions to date.

2 GENERAL DESCRIPTION AND INTENDED APPLICATION OF THE PCI AND THE PRS

2.1 General

The basis and application of the PCI and the PRS differ, although there is some commonality between them. Details of their structure and intended application are given below.

2.2 Pavement Condition Index

2.2.1 Description and Application

The need for representing the overall condition of an asset in a succinct and effective manner has always been recognised from the early days of asset management. The overall condition has been widely used in management and technical reports as well as supporting funding requests.

The PCI described here represents a formulation of a general descriptor of the asset condition based on the combination of local experience and the European Cooperation in Science and Technology (COST) Study 354 (Litzka et al. 2008).

The condition of an asset may be described by a number of parameters. These can be physical measures or index (typically rated) values. In order to compare or aggregate the various parameters, they must be on the same scale, which is best achieved by normalising or formulating index values. To distinguish the normalised index parameters from measured parameters, they will be referred to as condition indices (CI).

The condition index offers several advantages, such as:

- It is easily understandable by non-expert stakeholders: a simple scale or even a ‘star rating’ conveys the condition clearly without demanding any subject knowledge.
- The index value can be converted back to a physical measure, so the content remains accessible for the technically minded.
- The index value expresses the desired and actual LOS; hence it is a vehicle for measuring performance.

In a PMS it can be used for setting trigger levels; hence it can have a direct impact on the treatment selection. This is the most direct way to link agency policies to work program development. At the same time the budget necessary to achieve the desired LOS can be easily determined.

The combined index (in this case the PCI) can be used as an optimisation target, e.g. to deliver the best overall condition with the available budget.

The following is a brief summary of the key steps in the development and implementation of the PCI incorporated within the Deighton’s Total Infrastructure Management System (dTIMS) (Deighton Associates Limited 2014) established for the Department of Transport and Main Roads (TMR) in South East Queensland.

The scale adopted is consistent with the International Infrastructure Maintenance Manual (IIMM) (IPWEA 2015), and the overall approach is also consistent with the review of network performance indicators for Austroads (Austroads 2011), where both individual and combined performance indicators are considered.

2.2.2 Formulation of a Condition Index

Definition: Condition index (CI): one property (e.g. roughness) expressed as an index number on a fixed scale.

A CI is calculated by converting the measured parameter to an index value. There are several ways to transform a measured value from one scale to another. For the purpose of the CI, a series of linear transformations was selected, to reflect the value judgement of both the asset manager and the asset owner.

Performance indicators may be formed by using measured or rated parameters, and ought to meet the following requirements:

- All condition indicators should be on the same scale; the identical scale assists in interpreting and communicating the condition.
- All condition indicators should go in the same direction, e.g. the maximum representing the worst and the minimum representing the best condition.
- A CI should express a value judgement suitable for the given circumstances and parameters, e.g. what is ‘good’ in one instance may only be ‘fair’ under different conditions.
- A CI should have a direct link from top management level to operational level, i.e. it must exercise real control over performance. If the outcome of an operation (e.g. maintenance work) cannot be controlled or influenced by a CI, the CI is ineffective as a management tool.

The selected scale of the CI and PCI for South East Queensland dTIMS is 1–5, where 5 represents a very poor condition and 1 represents a very good condition.

2.2.3 Value Judgement

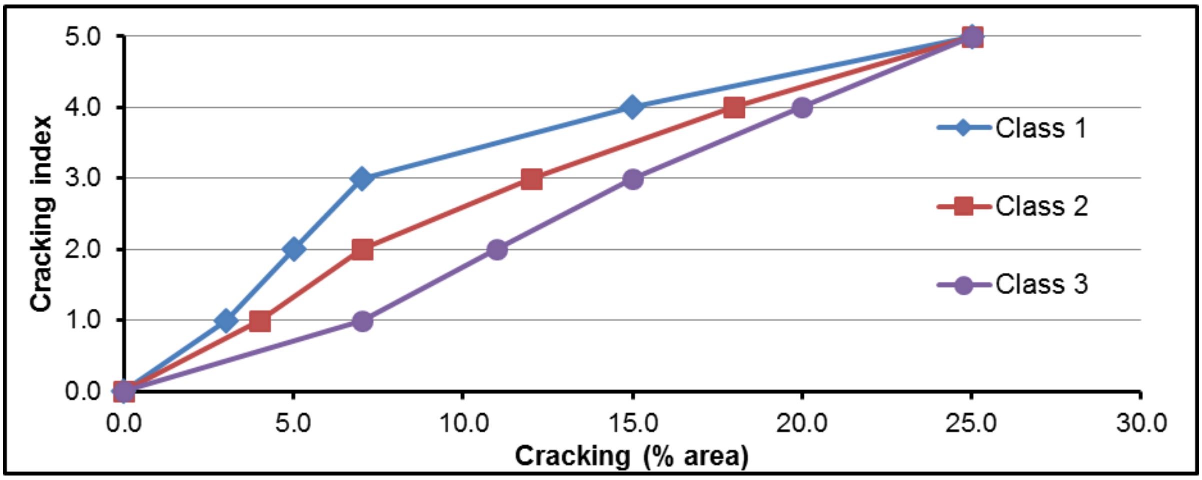
Measured values alone convey an absolute number, without any judgement. Value judgement, i.e. what is considered good, fair, poor, etc., is required for practical asset management, as the value judgement reflects the level of service (LOS) the asset owner desires to achieve. The value judgment presented in Table 2.1 shows the cracking ranges assigned to each condition class for a single asset (or road) class.

Table 2.1: Condition classes

Class name	Very good	Good	Fair	Poor	Very poor
Index range of class	0-1	1-2	2-3	3-4	4-5
% cracking – Class 1 roads	0-3	3-6	6-10	10-15	>15
% cracking – Class 2 roads	0-4	4-7	7-12	12-18	>18
% cracking – Class 3 roads	0-7	7-12	12-15	15-20	>20

The defined ranges or condition classes lend themselves to graphical presentation as straight lines (Table 2.1). The straight line representation allows a large degree of flexibility and it is easy to model in any software. It should be noted that, although the range of the classes is 1–5, for practical reasons the chart starts at zero.

Figure 2.1: Cracking index



The asset manager must define the ranges (bands) for each parameter and asset class. A LOS may be defined for different situations, such as different road classes, pavement types or other circumstances. Figure 2.1 shows the LOS for three road classes; the per cent cracking that is still 'good' for class 3 roads is 'poor' for class 1 roads.

In a further example, Figure 2.2 shows the structure of roughness categories used to report the condition of national roads for the Commonwealth Department of Transport and Regional Services as advised by Geoff Clarke (geoff.clarke@dotars.gov.au) of the Department in 2007. This has been adapted to produce condition ranges and indices for application by TMR, and which also take account of the speed zone, as shown by the example in Figure 2.3.

Figure 2.2: Roughness categories

		Traffic range (vehicles per day)					
Roughness range (IRI)	Roughness range (NRM)	0-500	501-1500	1501-3000	3001-5000	5001-10000	>10000
		VL	LL	BM	AM	HH	VH
0-2.8	0-75	Good	Good	Good	Good	Good	Good
2.8-3.2	75-85	Good	Good	Good	Good	Good	Mediocre
3.2-3.6	85-95	Good	Good	Mediocre	Mediocre	Mediocre	Mediocre
3.6-4.0	95-105	Good	Mediocre	Mediocre	Mediocre	Mediocre	Poor
4.0-4.6	105-120	Mediocre	Mediocre	Poor	Poor	Poor	Poor
4.6-5.2	120-135	Mediocre	Poor	Poor	Poor	Poor	Very Poor
5.2-5.7	135-150	Poor	Poor	Very Poor	Very Poor	Very Poor	Very Poor
5.7-6.3	150-165	Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor
>6.3	>165	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor

Figure 2.3: Roughness categories for slow speeds (<80 km/h)

		Traffic range (vehicles per day) for slow speed (<80 km/h)						
Roughness range (IRI)	Roughness range (NRM)	0-500	500-1500	1500-3000	3000-5000	5000-10,000	10,000-30,000	>30,000
		T1	T2	T3	T4	T5	T6	T7
0-2.3	0-60	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
2.4-2.7	61-70	Very Good	Very Good	Good	Good	Good	Good	Good
2.8-3.1	71-81	Very Good	Very Good	Good	Good	Good	Good	Fair
3.2-3.6	82-94	Good	Good	Good	Fair	Fair	Fair	Poor
3.7-4.0	95-105	Good	Good	Fair	Fair	Poor	Poor	Poor
4.1-4.2	106-110	Fair	Fair	Fair	Poor	Poor	Poor	Poor
4.3.-5.0	111-131	Fair	Fair	Poor	Poor	Poor	Poor	Poor
5.1-6.8	131-180	Poor	Poor	Poor	Poor	Poor	Poor	Poor
>6.8	>180	Poor	Poor	Poor	Poor	Poor	Poor	Poor

From the structure of Figure 2.3 it is also clear that the measured condition values and ranges to which they are assigned are reasonably consistent with a typical hierarchical LOS structure, and economic criteria.

2.2.4 *Transformation of the Physical Parameter to an Index*

The measured values are converted into index values by using the transformation functions between two index ranges. It is possible to use a single transformation function covering the full range from 0 to 5. However, no single function can fit the individually defined transition points from one band to another. Consequently, a series of linear functions have been used that can easily be fitted to the transition points. The generic form of each of the straight lines is represented by Equation 1, as follows:

$$Y = ax + b \qquad (1)$$

where a is the slope of the line and b is the intercept:

$$a = \frac{(y_2 - y_1)}{(x_2 - x_1)} \quad \text{and} \quad b = y_i - a \times x_i$$

and x_1, y_1 and x_2, y_2 represent transition points

The calculation can easily be implemented in a PMS, in this case dTIMS, or in a spreadsheet.

2.2.5 *Aggregation of Indices*

Definition: Pavement condition index: a composite index expressing the overall or combined property as a number on a fixed scale. It is typically a combination of several CIs.

In order to express the overall condition of an asset in terms of a PCI, several condition indices have to be aggregated. In the past, the weighted average was used for this purpose, where the weights expressed the relative importance of the given property. However, averaging does not reflect the extreme values and it tends to convey a reasonably moderate condition. In extreme cases, the very worst and best properties neutralise each other, creating the false impression that the asset is in a reasonable condition.

Engineering decisions are usually made on the basis of the worst condition, e.g. a structurally very weak but perfectly smooth road would have an average (say 2.5) pavement condition index. Treatments, however, would be decided on the basis of the worst condition, in this case the structural weakness. The proposed PCI is shaped by the engineering decision-making approach and consequently it gives greatest weight to the worst condition, whilst the other condition indices are also taken into account as minor adjustments.

The PCI is calculated by applying Equation 2, as follows:

$$PCI = MAX(w_i \times Index_i) + p(\frac{SUM(w_i \times Index_i) - MAX(w_i \times Index_i)}{\sum(w_i) - Avg(w_i)}) \quad 2$$

where:

PCI = pavement condition index

w_i = weight for individual condition criteria, including cracking, roughness, rutting and surface age

$Index_i$ = index value for individual condition criteria, including cracking, roughness, rutting and surface age

p = condition factor (the current value is 0.1)

It should be noted that the weights (w_i) must be relatively small to avoid significant distortion of the index.

2.2.6 Current Composition of the TMR PCI

The current composition of the PCI includes the six attributes listed and defined in Table 2.2.

Table 2.2: Composition of the TMR PCI

Attribute	Description
Roughness (NRM)	Counts per km, with separate limits defined by traffic level and speed zone (<= or > 80 km/h)
Rutting	Mean rut depth (mm), with separate limits defined by traffic level, climate and speed zone
Cracking	Area (%) of all cracking
Remaining useful life (RUL)	RUL of the road pavement in years
Surface age	Age of the latest surfacing in years
Skid deficiency (%)	% less than investigatory skid resistance level

Detailed tables showing the specific ranges of physical parameter values by attribute which correspond to each condition class, and the corresponding range of index values, are contained in Kadar (2014).

2.2.7 Current Application of the QTMR PCI

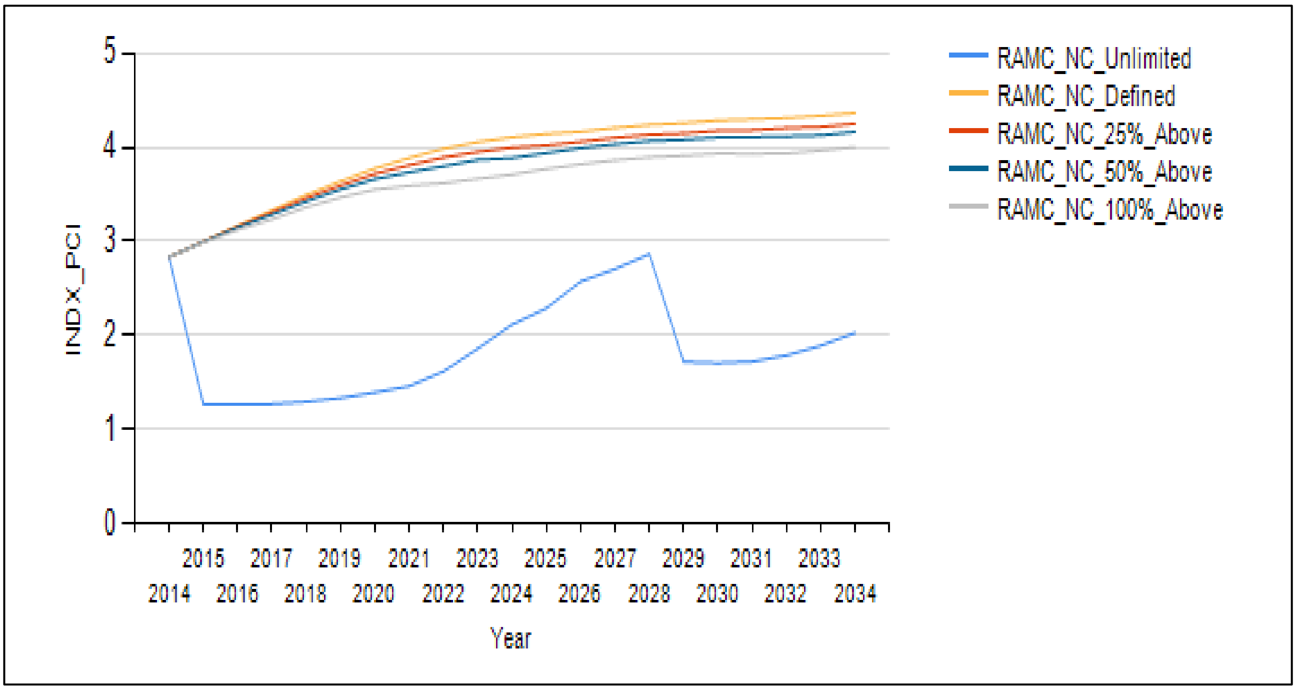
Whereas the individual CI are used for setting trigger levels, and have a direct impact on the treatment selection, the combined index (or PCI) is used as an optimisation target, e.g. to deliver the best overall condition with the available budget.

Within the PMS, the individual attributes are first entered (Year 1 stating condition), and then each attribute is modelled for the full life-cycle of each treatment strategy, using the in-built road deterioration (RD) and works effects (WE) models. This allows a PCI to be reported for each analysis year, and a single PCI to be reported for the full analysis period, as an effective (discounted when benefits are considered) PCI, herein termed PCI_{pv}.

For optimisation purposes, the incremental benefit is represented by the numerical difference between two strategies. This then allows an incremental benefit cost ratio to be determined with the denominator representing the difference in discounted road agency costs.

An example PCI trend is shown in Figure 2.4, where a comparison is made between the effect of having unlimited funds, meaning the works on all sections are triggered at the trigger point, and the effect of a series of alternative, constrained budgets which are significantly less.

Figure 2.4: Average annual PCI by budget scenario

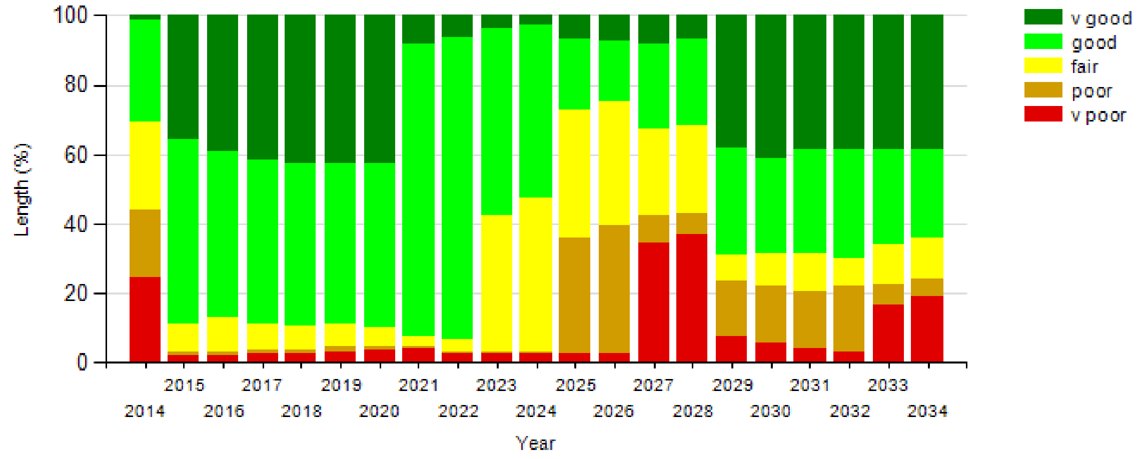


Source: SEQ RAMC 2015 North Coast DTIMS analysis.

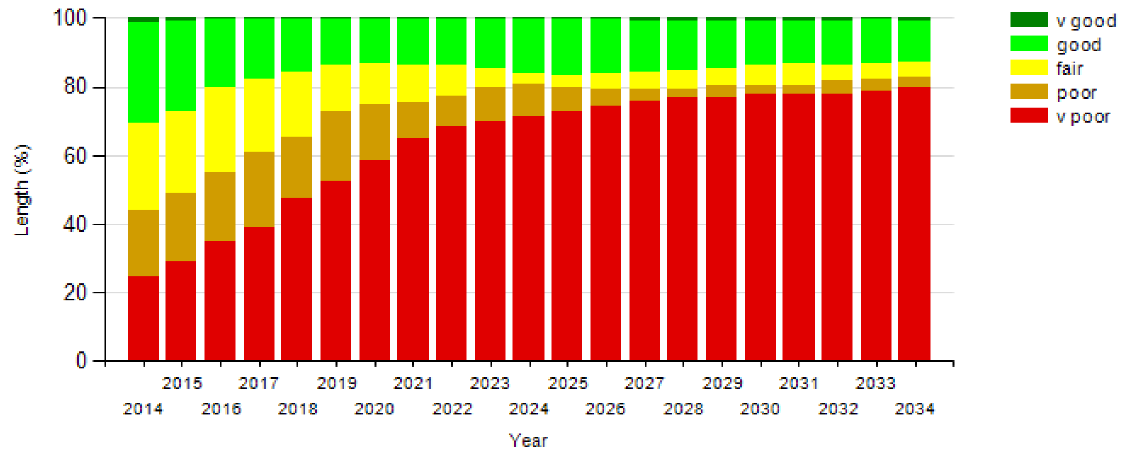
In further illustrating the use of the PCI, the distribution of the PCI by year for two budget scenarios is illustrated in Figure 2.5. This provides a true representation of the condition section-by-section, where some will have been treated and maintained in an acceptable (very good to fair) condition whereas others will not. The underlying data can also be filtered by road class, traffic level etc., or be presented in map form to illustrate the geographical distribution of condition (by year).

In summary, the PCI is a composite index which can be produced for each unique combination of road section, treatment strategy and budget scenario for each analysis year. Because it is comprised of a range of attributes whose values account to some extent for economic efficiency and risk, and the parameter for use in optimisation is determined from a life-cycle analysis, it accounts for both likelihood and consequence.

Figure 2.5: Annual distribution of PCI for two budget scenarios



a) Unlimited budget



b) Defined budget

Source: SEQ RAMC 2015 North Coast DTIMS analysis.

2.3 Pavement Risk Score

2.3.1 General

Risk is assessed in the following form (Equation 3), in alignment with the Department's Guide to Risk Management (Department of Transport and Main Roads 2008).

$$\text{Risk} = \text{Likelihood} * \text{Consequence} \qquad 3$$

where

Likelihood = Possibility * Exposure

The individual components of overall risk are defined as follows:

- Consequence is the outcome or impact of an event or failure.

- Likelihood (or probability) is the chance that a set of circumstances will arise which will result in an event or failure occurring.
- Possibility is the chance that an event will occur for a given set of circumstances.
- Exposure is the frequency with which that set of circumstances occurs.

Ratings for Likelihood (Rare, Unlikely, Possible, Likely and Almost Certain) and Consequence (Negligible, Minor, Moderate, Major and Severe) have been replaced by dimensionless scores 1 to 5, (with 5 being Almost certain or Severe), to enable normalisation and combination of individual attributes.

Road safety consequences relate directly to road user risk and are considered severe. The consequences for agency life-cycle costs can be expressed in terms of the strategic importance of TMR's road assets, and therefore the assessment focuses on the consequence for life-cycle cost (LCC) risks

2.3.2 Attributes and Factors included in the PRS

The PRS developed by TMR (2012) assesses pavement risk from the perspective of both road user safety and road agency life-cycle costs. The PRS is currently based on the measured pavement attributes listed in Table 2.5

Table 2.3: Attributes included in the PRS

Attribute	Safety	Life-cycle costs
Rutting (80th percentile, mm)	✓	✓
Roughness (IRI, m/km)	✓	✓
Linear rutting progression rate	–	✓
Linear roughness progression rate	–	✓
Surface age	–	✓
Routine maintenance costs	–	✓

For each of the attributes, the risk is assessed in terms of likelihood of an event or failure, and provides a normalised score between 1 and 5. TMR are also keen to include the Traffic Speed Deflectometer (TSD) deflection estimates (ARRB Group n.d.a.) in the pavement condition attributes as it has an influence on remaining structural life, automatic crack detection (ARRB Group n.d.b.) and routine maintenance performance contract (RMPC) backlog.

The current factors considered in developing a risk score for each attribute are listed in Table 2.4.

Table 2.4: Factors included in the PRS

Attribute	Application	Likelihood		Consequence weighting
		Possibility	Exposure	
Rutting (80th percentile, mm)	Safety	Rut depth limit Posted speed	AADT Environment zone	Very high
	LCC	Rut depth band	AADT Environment zone	See notes
Roughness (IRI, m/km)	Safety	Roughness band	AADT	Very high
	LCC	Roughness/AADT	Environment zone	See notes
Linear rutting progression rate	LCC	LRutPR band	Environment zone	See notes
Linear roughness progression rate	LCC	LRPR band	Environment zone	See notes

Attribute	Application	Likelihood		Consequence weighting
		Possibility	Exposure	
Surface age	LCC	Surface age quality	Environment zone	See notes
Routine maintenance costs	LCC	RMPC cost band	Environment zone	See notes

Notes: Four alternatives have been proposed, namely: 1. Priority Road Network Consequence Weighting; 2. Strategic Network Consequence Weighting Route; 3. Traffic Volume Consequence Weighting; 4. Heavy Vehicle Volume Consequence Weighting.
Alternative 1 is preferred and has been applied in corporate analysis.

2.3.3 Determination of Individual and Combined Risk Scores

Individual ratings (for Likelihood possibility and Likelihood exposure) are detailed in the PRS documentation. These are multiplied and then weighted according to the consequence of the event and summed to provide an individual Pavement Risk Score for each attribute.

Combined Risk Scores are determined by combining individual scores. Several methods can be used, but the preference is to employ the 'Advanced Maximum Criteria' method, similar to that employed for the PCI (Section 2.2.6) based on COST 354 (Litzka et al. 2008). The recommended formulation comprises the maximum weighted attribute plus the average of all other attributes multiplied by a factor. This factor is named the 'Influence Factor' and it should be between 10% and 20%.

The resulting combined PRS should be further classified according to Table 2.5 to provide a PRS rating.

Table 2.5: Summary of PRS score and rating

Bands– description	Pavement risk score (PRS)	PRS rating
Very good	0< PRS< 4	1
Good	4=< PRS< 10	2
Fair	10 =<PRS< 16	3
Poor	16=< PRS<20	4
Very poor	20=<PRS	5

Source: TMR (2012).

2.3.4 Application of the PRS in Prioritising Candidate Rehabilitation Sections

The prioritisation of candidate rehabilitation sections is assessed based on the PRS and the estimated cost of work. This assessment takes the form of a ratio of Risk on Cost, i.e. the Risk-Cost Ratio (RCR) defined by Equation 4, and is based on the assumption that the selected treatment reduces the pavement risk at that location to zero.

$$RCR = PRS * 102/Cost \quad (4)$$

where

PRS = the combined Pavement Risk Score

Cost = treatment cost in $/m^2

3 STUDY APPROACH AND YEAR 1 PROGRESS SUMMARY

3.1 General

In order to undertake a sensitivity analysis of the weighting factors used in the aggregation of the CIs in estimating PCI and the weightings of the road condition attributes in estimating the PRS and their impact on the estimates of PCI and PRS, road condition data on defined road lane segments was collected from 12 Districts throughout Queensland (see Table 3.1).This road condition data will allow independent estimates of PCI and PRS and their comparison with each other and the field assessment of the PRS rating. The comparisons will also allow adjustment of the weighting factors used in the CIs in estimating the PCI and adjustment of the weighting of the attributes used in calculating the PRS.

The approach and tasks undertaken this year to progress the project are described below, and include:

(a) field assessment of road section conditions and performance

(b) standardising the calculation of PCI.

Due to delays in initiating the field component of the study, the sensitivity testing and calibration of the PCI and PRS were not undertaken as planned, and this will be undertaken in Year 2.

3.2 Field Assessment of Road Section Conditions and Performance

The road condition data on the defined segments was obtained from the 2015Traffic Speed Deflectometer (TSD) survey which included measurements of roughness, rutting, texture, cracking and deflection. This data was made available from the TMR's ARMIS corporate database.

Each of the 12 nominated Districts identified 16 road segments which they rated in terms of the PRS (1–5) (see Section 2.3), making a total of 192 segments for analysis. The key contact in each District was the TMR representative at the Element 17 and 18 Reference Group Meeting of April 2016 (see Table 3.1) who was responsible for identifying and visually rating the segments in terms of the PRS. Data on all 192 segments have now been identified, rated and received.

Table 3.1: Summary of Districts and TMR representatives

District	TMR representative
Northern	Christopher Byrne
Far North	Alan Andersen
North West	William Reed
Central West	Rodney Adams
Mackay	Chris Herring
South West	Manoj Mudiyanselage
Fitzroy	Domitianus Budiono
Darling Downs	Sheikh Alam
Wide Bay/Burnett	Mitchell Curd
North Coast	Kevin Reason
Metro	Shan Sivagurunathan
South Coast	Emad Tadros

Guidance was provided to each District making the PRS ratings for each road lane segment they identified. Table 3.2 shows the approach used for roads with three broad functional levels of traffic (high, medium and low). Table 3.2 shows that as the traffic levels decrease there are more road condition attributes that come into play for potential intervention.

Table 3.2: Rating guide relationship to condition and intervention (roads of three functional levels)

Rating (overall)	Rating name	Description	Road functional level	Dominant attribute(s) triggering potential intervention				
				Cracking	Rutting	Roughness	Surface age	Limited structural life
1	Very good	Excellent condition	High	No	No	No	No	No
2	Good	Good condition	High	No	No	No	No	No
3	Fair	Possible preservation intervention	High	No	Maybe	Maybe	No	No
4	Poor	Remedial level	High	Yes	Yes	Yes	Yes	No
5	Very poor	Unsustainable level	High	Yes	Yes	Yes	Yes	Yes
1	Very good	Excellent condition	Medium	No	No	No	No	No
2	Good	Good condition	Medium	No	No	No	No	No
3	Fair	Possible preservation intervention	Medium	Yes	No	Maybe	Yes	No
4	Poor	Remedial level	Medium	Yes	Yes	Yes	Yes	Yes
5	Very poor	Unsustainable level	Medium	Yes	Yes	Yes	Yes	Yes
1	Very good	Excellent condition	Low	No	No	No	No	No
2	Good	Good condition	Low	No	No	No	No	No
3	Fair	Possible preservation intervention	Low	No	Maybe	Maybe	No	No
4	Poor	Remedial level	Low	Yes	Yes	Yes	Yes	Yes
5	Very poor	Unsustainable level	Low	Yes	Yes	Yes	Yes	Yes

Notes:

- No means intervention is not triggered
- Yes means some form of intervention is triggered.
- Maybe means intervention maybe triggered.

3.3 Standardising the Calculation of PCI

Currently the PCI and CIs are calculated either in the PMS or using a spreadsheet, whereas experience shows that early automation and streamlining of calculations in a purpose-built tool brings substantial benefits in terms of efficiency and reliability of the work.

In response to this requirement, the following tasks were undertaken:

- reviewing and preparing the algorithms for the calculation of individual CIs and the PCI
- preparing a set of configurable direct link libraries (DLLs) for executing calculations
- testing the DLLs in both an MS Excel and PMS environment.

The calculation of the condition indexes employed in the PCI was automated by creating DLLs (an executable program which can be employed in the PMS or standalone). Consequently, the time and effort required to create the DLLs is reasonably well known, and can be extended to computation of the PRS. The use of the automated and standardised calculation of CIs will ensure consistency and makes the calculation tamperproof.

To avoid potential errors, the calculation of the CIs and PCI is done in separate subroutines. The subroutines are built in a manner that can be used independently, i.e. in either MS Excel (as an XML file) or the PMS platform, dTIMS. This makes it possible to explore a large number of combinations and permutations of the possible values.

4 YEAR 2 TASKS

4.1 General

The objective of the second year of the project is to:

- Review the PRS and its constituents, including an extension to include pavement strength (TSD derived), cracking data (ACD derived) and potentially RMPC backlog data.; the life–cycle cost risk (pavement condition aspect), and safety risk factors; and integrate all PRS constituents into the PCI and ensure that the parameters are consistent with the PCI constituents.

With the completion of the software tools in the first year of the project, the essential infrastructure for the analytical work is ready. The acquisition of the current condition data, and the design and implementation of the field review exercise with the cooperation of all Regions was also completed. The team is also more aware of the intent of the PRS approach, described in Section 2.3, and TMR's corporate need to use a simpler calibrated PRS approach in prioritising funding across asset types and program components.

The remaining tasks therefore include:

- sensitivity testing
- calibration of the PCI and PRS.

Prior to the initiation of each task, a workshop will be held to discuss and finalise the definition/calculation of CIs, and to present the results of the study to date.

4.2 Sensitivity Analysis

The purpose of this desktop activity is to explore the sensitivity of the weighting factors in the aggregation of the CIs and thus ultimately on the PCI and PRS. The data for the purpose of the sensitivity analysis will be obtained from the ARMIS and RAMC PMS (dTIMS) databases, where the input data required for the determination of the condition indices are readily available.

4.3 Calibration of the PCI and PRS

The calibration will aim, for each rated road segment, to make separate adjustments to the weighting factors used in the aggregation of the CIs in estimating PCI and the weightings of the road condition attributes in estimating the PRS so that for the same road conditions the PCI and PRS estimates are similar to each other and the visual PRS rating. The separate adjustments to the PCI and PRS weightings ratings are also expected to be the same within each traffic level.

The calibration will be performed having extended both the PCI and PRS to reflect pavement strength (derived from TSD data), and automated cracking data and RMPC backlog data. Prior to this being undertaken, modifications will be made to the existing DLL.

However, a distinction needs to be made for application purposes, and it is with respect to the consequence weighting and prioritisation that the use of the two indices differs. This is because:

- The PCI is employed within a PMS environment which predicts future consequences (using predictive RDWE models) in response to different road preservation treatment strategies, and selects preferred strategies based on a benefit cost analysis. The calculated benefit is based on the improvement in pavement condition, and cost.
- The PRS system is intended as a simplified tool applied at a corporate level and uses judgement to assign risks, both likelihood and consequence.

It is important, however, that both approaches are broadly consistent in the allocation of risks, and priorities, hence the need for calibration.

5 CONCLUSIONS AND RECOMMENDATIONS

It is important for TMR to have confidence in the way their network condition is managed, and a key requirement is to assess risks and, consequently, priorities in a consistent manner.

The PCI introduced into the Department's new PMS, including the manner in which it is applied, aims to address life-cycle cost risks through its application in a life-cycle based quasi-economic analysis.

The intent of the PRS in many respects is similar to the PCI/PMS suite, however, it aims to incorporate both likelihood and consequence in a single index, with prioritisation based on a risk/cost ratio.

The first year of the project has seen the completion of a review of the PCI and PRS methods, the development of a number of executable computer programs to compute various indices either using MS Excel or in the PMS. Field assessments of a representative range of road sections have also been gathered from across the state road network by TMR's regions.

The plan for the second, and final, year of the project has been developed. The plan reflects progress to date, and acknowledges the need to complete a number of tasks, including extending the PRS to include pavement strength (TSD derived), cracking data (ACD derived) and potentially RMPC backlog data; sensitivity testing and calibration of the PCI and PRS; and finalisation of their incorporation in the PMS and a standalone user tool.

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