# Investment Decision Framework for Infrastructure Asset Management: A Probability-based Approach

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# Executive Summary

Australia's civil infrastructure assets of roads, bridges, railways, buildings and other structures are worth billions of dollars. Road assets alone are valued at around A$140 billion. As the condition of assets deteriorate over time, Queensland Department of Main Roads spends approximately A$1 billion annually in asset maintenance, or the equivalent of A$27 million per day (Queensland Department of Main Roads).

To effectively manage road infrastructures, road agencies firstly need to optimise the expenditure for data collection but, at the same time, not jeopardise the reliability in using the optimised data to predict maintenance and rehabilitation costs. Secondly, road agencies need to accurately predict the deterioration rates of infrastructures to reflect local conditions so that the budget estimates can be accurately estimated. Finally, the prediction of budgets for maintenance and rehabilitation must be reasonably reliable.

A procedure for assessing investment decisions for road asset management has been developed. The procedure includes a:

- method for optimising data collection
- method for calibrating deterioration prediction models
- method for assessing risk-adjusted estimates for lifecycle cost estimates

# 1. A Method for Analysing Optimal Data Collection

A case study was conducted using the developed method for identifying optimal intervals for pavement strength data collection for road asset management. Pavement strength data is usually collected at close intervals of 100 metres or 200 metres, which is an expensive exercise. Road authorities worldwide find it to prohibitively expensive to collect data over the whole road network. The method developed in this project will produce a more cost-effective data-acquisition practice.

The method is used to examine the stochastic properties of road pavement strength data over extensive lengths of road network. The results found that road authorities could reduce strength test sampling rates to 20% and 25% without losing any statistical relevance for network applications. This means a chosen network strength-testing strategy could be achieved at roughly one-quarter of current costs.

## Benefits to the Industry

- For the Queensland Department of Main Roads, a potential 75% savings on pavement strength data collection costs.
- The method is generic and could be used for analysing optimal data collection for other types of physical infrastructures.

# 2. A Method for Calibrating Deterioration Prediction Models

This method is used for calibrating deterioration prediction models for local conditions.

The variability in road condition data may arise from the variability in climatic conditions, soil conditions, user vehicles etc. When the prediction functions do not show a strong correlation or relationship with recorded data, these functions provide less confidence in predicting the deterioration rate for local conditions.

This calibration method is based on probability-based assessment. The method has been used in calibrating pavement deterioration prediction models for road networks of 1688 km for the Bruce Highway, and 1033 km for the Landsborough Highway in Queensland as case studies.

### Benefits to Industry

- There is a worldwide need for an improved model calibration procedure in predicting deterioration rates of road assets for local conditions.
- The method yields calibrated models that closely replicate the actual variability in network condition.
- The method is unique in world practice in that it uses actual variability in asset data in calibrating prediction models.
- The method is generic and could be used for calibrating any types of functions.

## 3. A Method for Risk-adjusted Assessment of Budget Estimates for Road Maintenance and Rehabilitation

Previous methods for risk-adjusted assessment of errors in budget estimates have been difficult to use. The method developed in this study is based on the Latin Hypercube Sampling Technique. This technique can simulate a small amount of input data from input variables. By substantially reducing analysis complexity and input data preparation, this results in a more practical method which overcomes the limitations of previous methods.

Stochastic property of pavement strength at the network level, accurate deterioration prediction models, and the method of risk-adjusted assessment will enable road authorities to reliably assess lifecycle costing for road asset maintenance and rehabilitation.

### Benefits to Industry

- The method can assess the levels of risk associated with the budget estimate. Budget estimates can be refined to 80 to 90 per cent certainty.
- The method can be used for any critical data input to assess risk. Consequently, risk associated with investment decisions also can be assessed.

### Conclusion

The procedures and methods developed in this study will yield affordable, comprehensive, relevant, and high-quality asset data, using accurate prediction models and analysis tools in assessing lifecycle costing for road asset management.