Risk Assessment in Life-Cycle Costing for Road Asset Management

Noppadol Piyatrapoomi, RMIT University
Arun Kumar, RMIT University
Neil Robertson, Queensland Department of Main Roads
Justin Weligamage, Queensland Department of Main Roads

Background

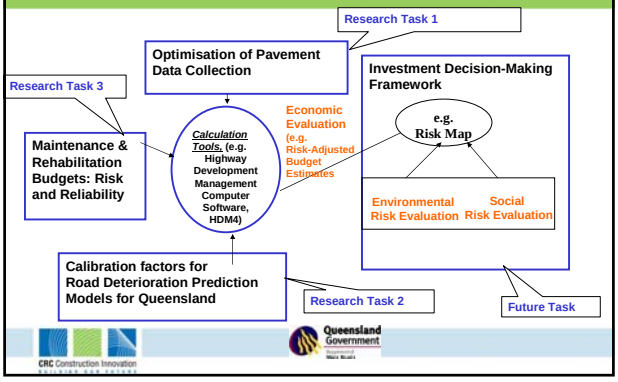
- Australia has billions of dollars worth of civil infrastructure assets as roads, bridges, railways, buildings and other structures. Road assets alone are valued at around A$ 140 billion.
- As condition of assets deteriorate over time, billions of dollars are spent annually in asset upkeep, which amounts to expenditure in the order of A27$ million per day.
- Public demand for greater accountability in using public funds
- Need for risk management approaches that consider both financial and non-financial impacts

QLD Main Roads Road Asset Management

- Main Roads has stewardship of 34,000km of sealed road network in Queensland, Australia (value $27b)
- Investment planning and asset management takes a medium to long term view: 10 to 20 years+
- Investment decision support relies on
  - Comprehensive, relevant, quality asset data
  - Investment modelling tools: agency and user impacts over asset life cycles
- Decision makers expect reliability in forecasting, investment risks understood

Research Tasks

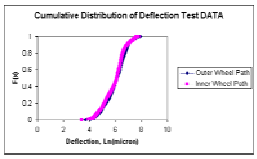
- Task 1: The Development of a Procedure for Optimising Data Collection
- Task 2: Calibrating Pavement Prediction Models
- Task 3: The Development of a Method for Risk-Adjusted Assessment for life-cycle costing

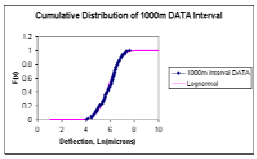


Task 1: The Development of a Procedure for Optimising Data Collection

- Focus on strength testing of pavements – the most valuable, and also the most expensive data we collect on road pavements
- Studied probability distributions of subset of sample population of FWD data (200m interval)
- Interpretation of consequences of wider sample test intervals on the consistency of data population
- This method identified test intervals can be increased up to 1200m without much change in its characteristics

LN(Do) =N(6.05, 0.805) LN(Do) =N(5.913, 0.795)





Task 2 – Calibrating Deterioration Prediction Models

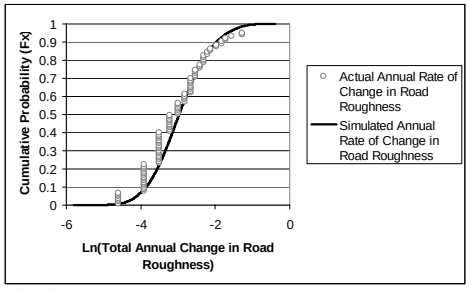
- Adopted HDM4 deterioration model for predicting the rate of change in road pavement roughness developed by The International Study of Highway Development and Management (ISOHDM 2001)
- This study used the probability-based method and Monte Carlo simulation technique
- Measured roughness was modelled for 1400km length on Bruce Highway in Queensland

HDM4 Model for Annual Rate of Change in Roughness

$$\Delta RI = Kgp\ (\Delta RIs + \Delta RIc + \Delta RIr + \Delta RIt) + m\ Kgm\ RIa$$

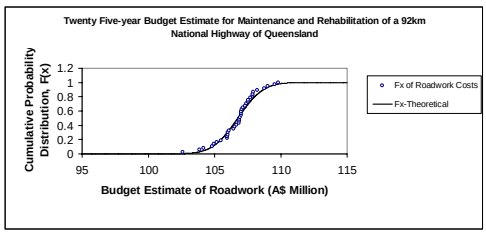
Kgp	=	calibration factor, Default value = 1.0
ΔRI	=	total change in roughness
ΔRIs	=	change in roughness due to pavement strength deterioration due to vehicles
ΔRIc	=	change in roughness due to cracking
ΔRIr	=	change in roughness due to rutting
ΔRIt	=	change in roughness due to pothole

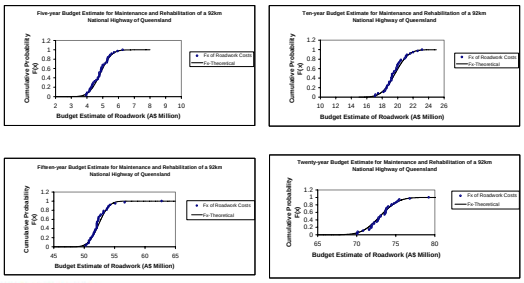
(m kgm RIa = ΔRIe) =change in roughness due to climatic condition



Task 3 – Risk Adjusted Assessment in Life-Cycle Costing

- Road investment tools can predict the life cycle costs for construction and maintenance road projects within a networks.
- Most inputs to such analysis are variable, and consequently the predicted life cycle cost is variable, and demonstrates a probability distribution.
- In this study, critical variable inputs are simulated, in order to assess the variability of the output costs.
- To demonstrate the methodology, only the variability of pavement strength was considered in the analysis.





Conclusions

- Characterisation of the statistical properties of certain road asset data can be used to select an optimal test sampling plan, which is affordable and still statistically relevant.
  - will lower the cost of network level data collection
- Variability properties can be used for calibrating deterioration prediction models in predicting deterioration rates of road infrastructures to suit local conditions.
  - Model calibration is a major component of the investment analysis process and this unique stochastic method closely replicate the actual variability in network condition.

Conclusions

- The risk-adjusted assessment in budget/cost estimates can be used in assessing the variability of budget/cost estimates arising from the variability and uncertainty of critical input variables.
  - will improve confidence in future affordability of investment decisions.