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Industry Seminar
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Bringing Innovation to Facility Management

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'yes' OPTUS

Decision Framework for Road Development and Maintenance Investments

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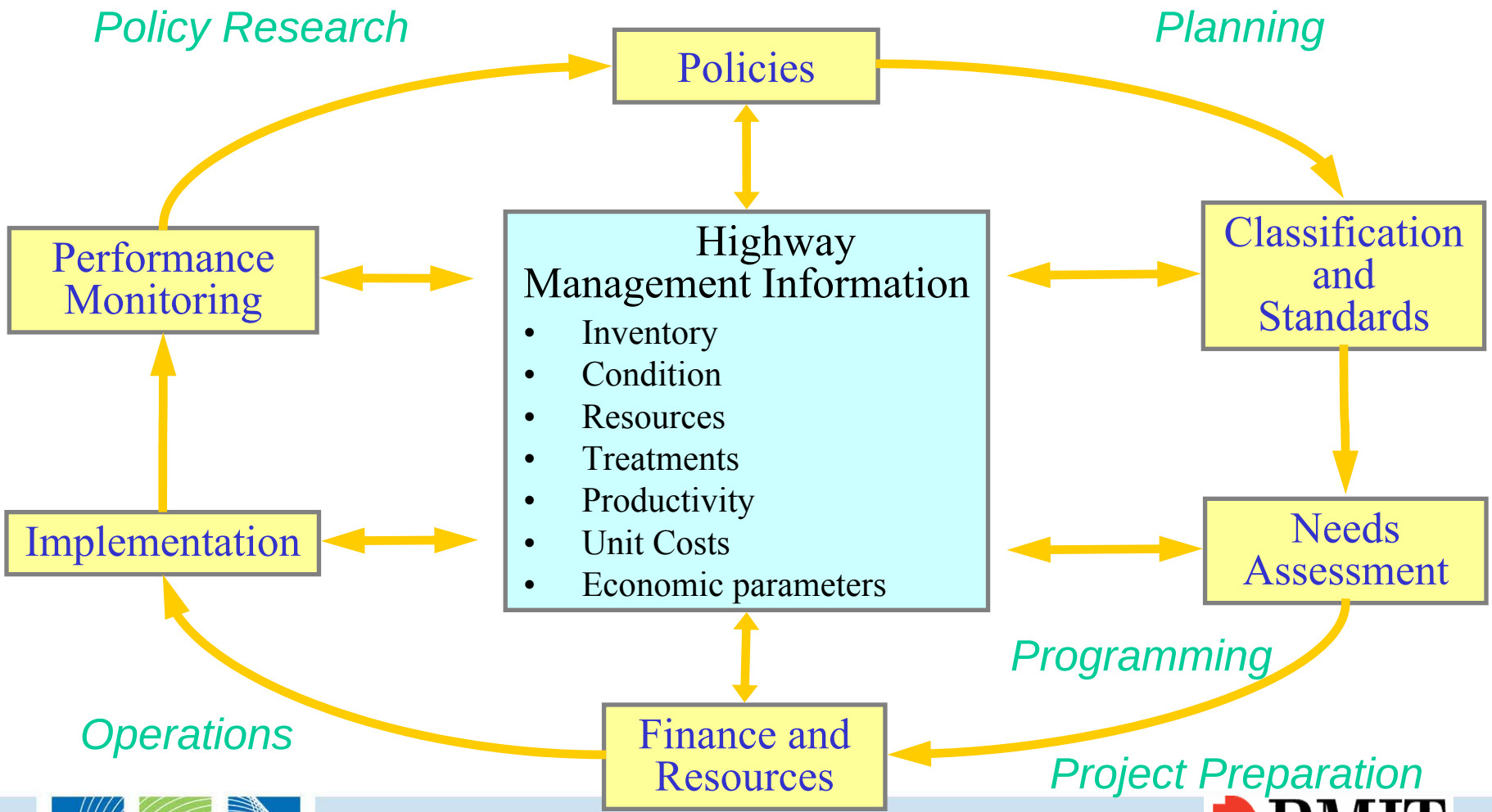
Queensland Department of Main Roads

Investment Decision Framework

- Road system is an important economic asset
- Assets require sustainable business management
- Investment decisions will consider future performance of the investment
- Performance:
    - of the infrastructure (physical & economic)
    - of the vehicle fleet
    - effect (benefits) to road users
- Costs and benefits:
    - to the agency
    - to the road users
- effective decision making requires a network of knowledge and decision support skills

Road Management Cycle



Investment Information

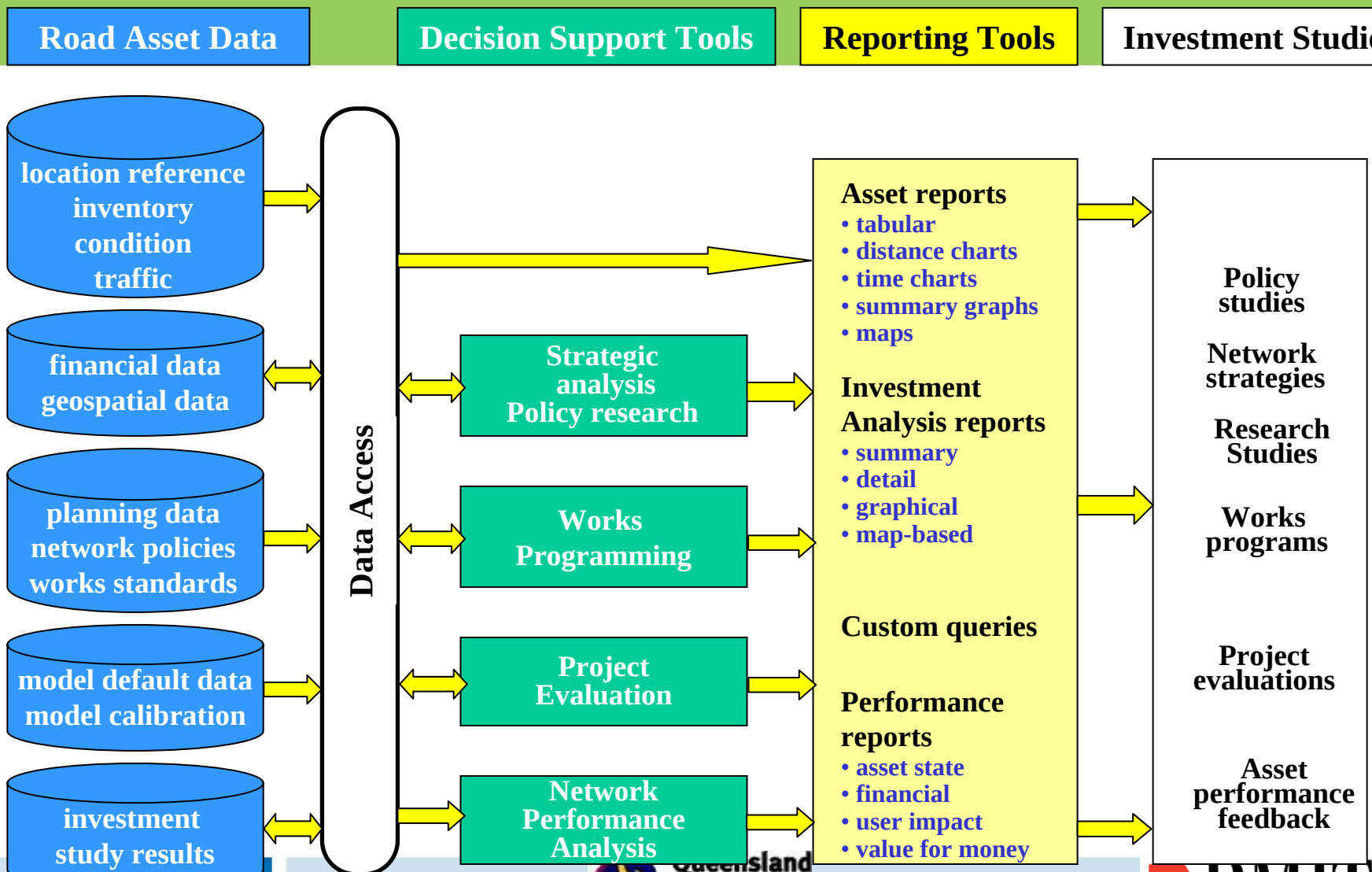
- Identifying deficiencies in the road system
- Predicting future trends in deficiencies
- Developing strategic plans and policies
- Developing forward plans for improvement and upkeep works
- Programming works into budget years
- Conducting appraisals of project proposals
- Predicting impact and consequences of investment options
- Researching local road transportation needs
- Researching future impacts of operational or technological options

Road Asset Decision Support

The decision support system should:

- support Planning, Programming, Preparation and Policy Research functions
- present relevant, reliable, up to date information
- predict future impacts on the transport system and its users
- compare competing investment or policy choices
- consider both the infrastructure and the community
- allow for new work, maintenance and upgrading
- provide a reliable calibrated modeling capability
- assess investment impacts over life cycles
- provide monetary and non-monetary measures of investment effectiveness
- identify optimum choices between alternative investments

Road Asset Management System



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.
- Increasing priority conflicts between capital and recurrent funding needs
- Public demand for greater accountability in using public funds
- Need for risk management approaches that consider both financial and non-financial impacts

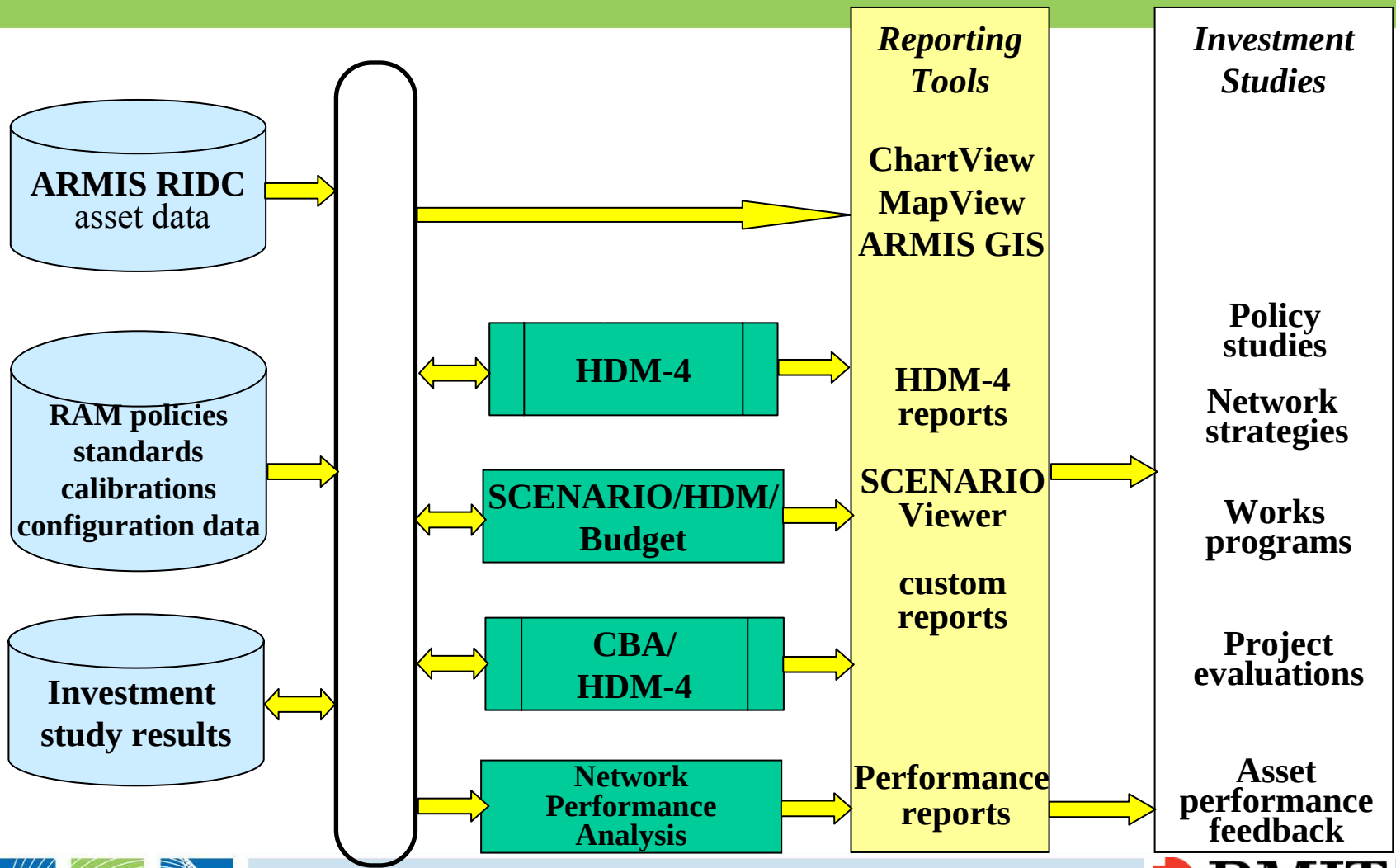
Some QLD Road Investment Statistics

- Road network
  - Total 180,000 km
  - State Controlled 34,000 km
- Replacement value of State Controlled network: $25 billion
- Annual net depreciation: $524 million
- Five year works program (RIP):$5.6 billion

QLD Main Roads
Road Asset Management

- Investment planning and asset management takes a medium to long term view: 10 to 20 years+
- Network management strategies to deliver levels of service consistent with network performance targets
- 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

Main Roads' Road Asset Management System: The Future



CRC Project Aim

Investment Decision-Making Framework for Infrastructure Asset Management

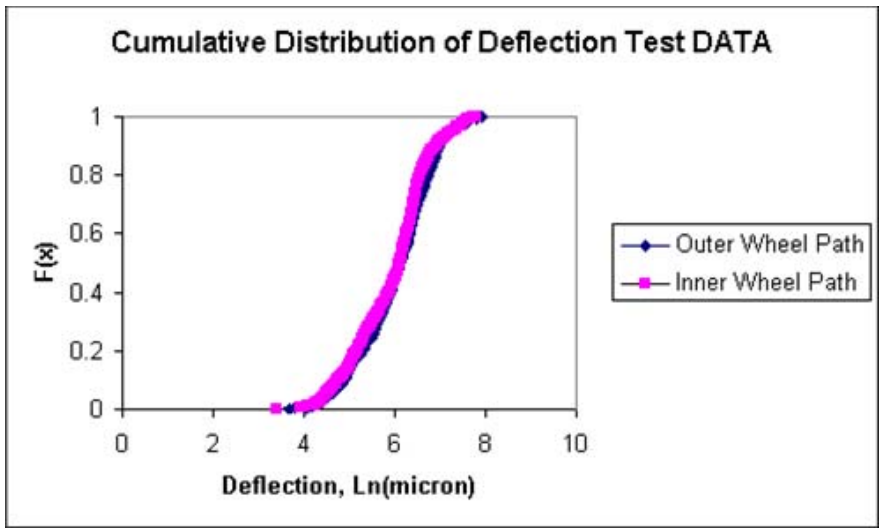
Develop elements of a systematic investment decision-making framework for infrastructure asset management which takes into account economic justification, social and environmental considerations, while incorporating uncertainty and risk assessment.

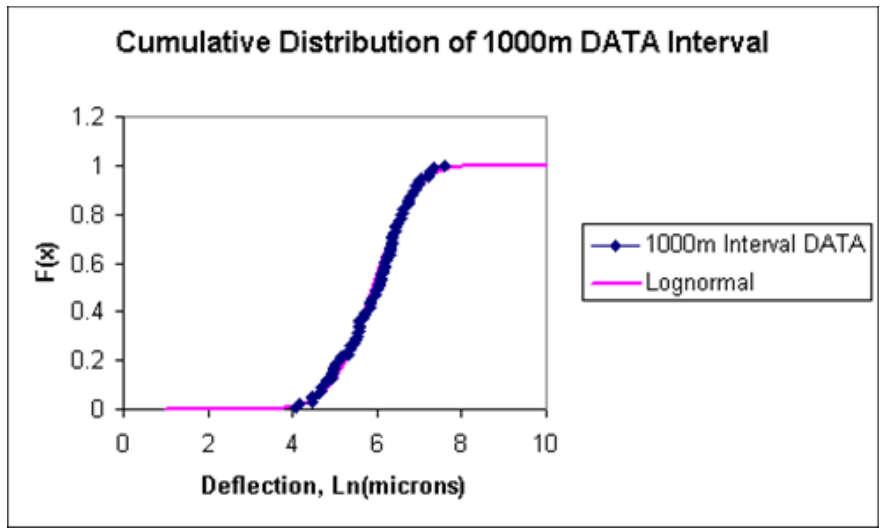
Initial Research Tasks

- **Research Task 1:** ***The Development of a Procedure for Optimising Data Collection***
- ***Research Task 2: The Development of a Method for Risk-Adjusted Expenditure and Reliability Assessment***
- ***Research Task 3: The Development of Pavement Prediction Models of road conditions for Queensland***

Optimising data collection

- Focus on strength te
  also the most expens
- Studied probability di
  FWD data (200m inte
- Interpretation of cons
  the consistency of da
- This method identifie
  1200m without much





LN(Do) =N(6.05, 0.805)

LN(Do) =N(5.913, 0.795)

Optimising data collection

- Potential lower costs for network level data collection

  Example: **Structural data collection**

  Under current practice (200m test intervals), a statewide survey would cost $5million.

  This research justifies 800m test intervals, costing $1.3 million for a statewide survey.

  thus, a potential 75% saving on data collection costs, (approx. $3.7 million annually) or increase data collection length by four times.
- Main Roads WA spends $800,000 annually for structural data collection at 800m intervals.

Calibrated Models for Road Condition Prediction

- Model calibration is a major component of the investment analysis process (in HDM4)
- Global need for an improved model calibration procedure
- Method used here is unique: utilises actual variability in asset data
- Investment simulation using stochastic model inputs based on the actual network asset data
- Results are encouraging
- Method yields calibrated models that closely replicate the actual variability in network condition
- Potential for an auto-calibration method

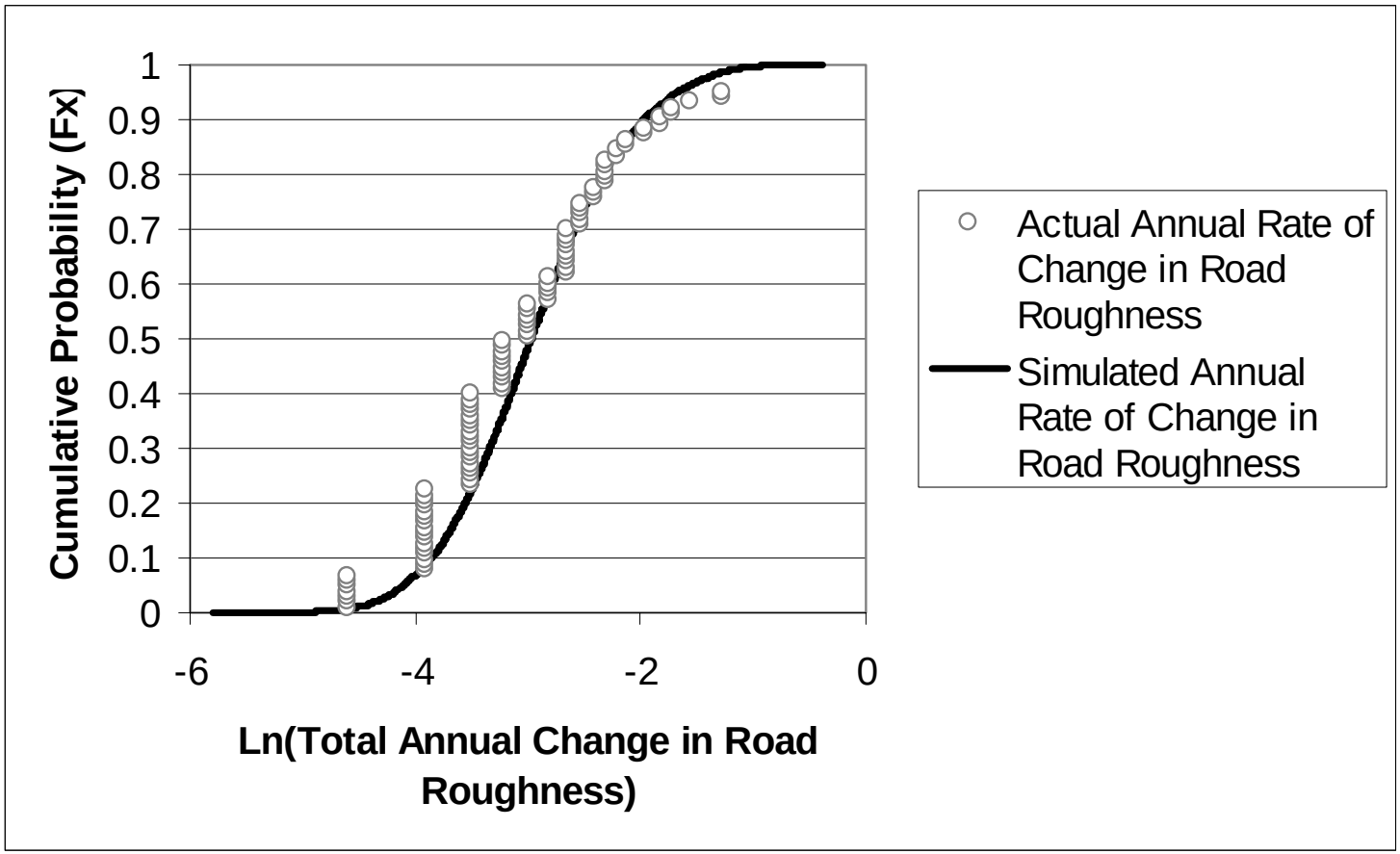
Calibrated Models for Road Condition Prediction

- 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 1700km 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


Cumulative Probability (Fx)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-6
-4
-2
0
Ln(Total Annual Change in Road Roughness)
Actual Annual Rate of Change in Road Roughness
Simulated Annual Rate of Change in Road Roughness

Assessment of Investment Risk

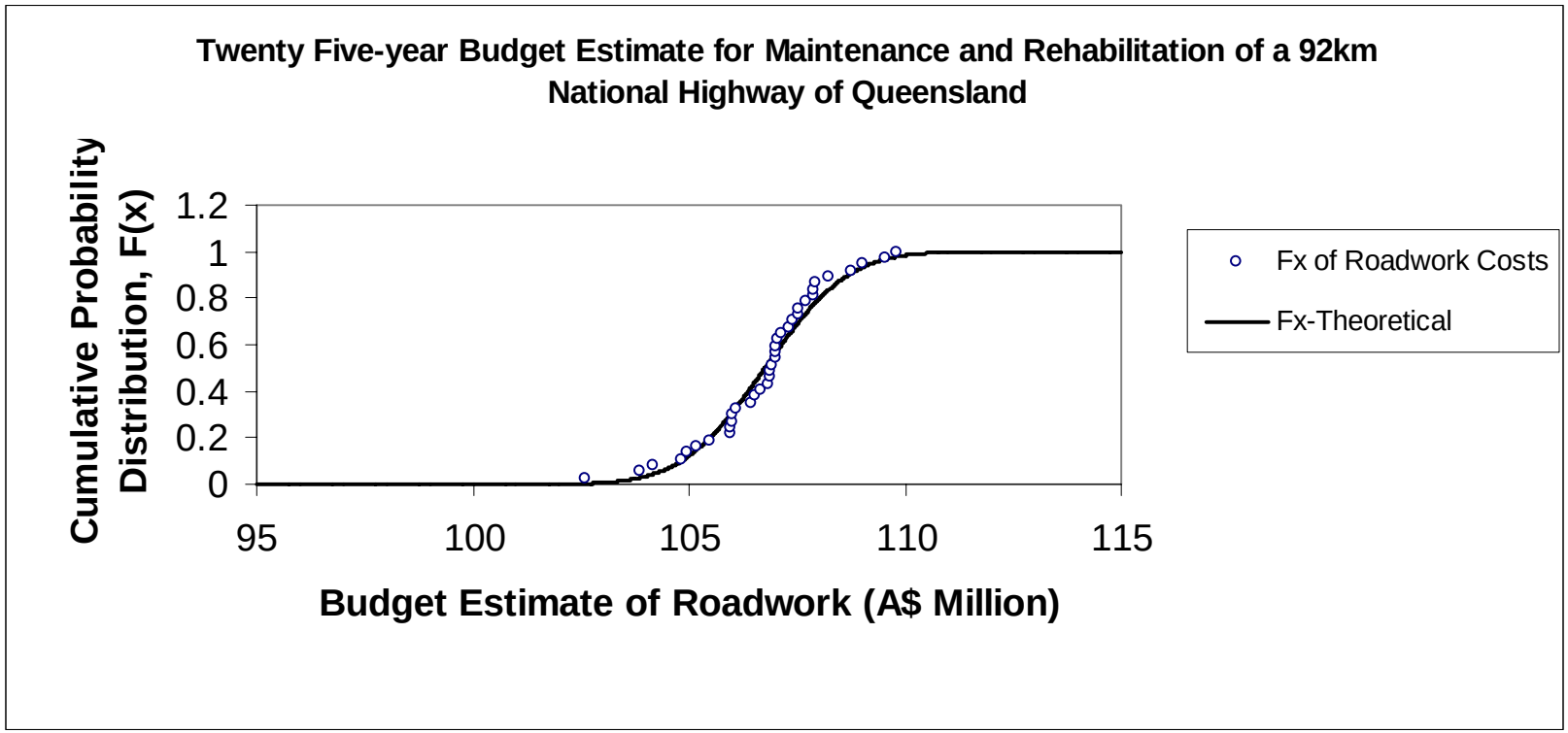
- Road investment tools can predict the life cycle costs for construction and maintenance road projects within a networks.
- Most inputs to such analysis are variable, and consequently the predicted life cycle cost is variable, and demonstrates a probability distribution.
- In this study, critical variable 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.

Assessment of Investment Risk

- Can assess the levels of risk associated with the budget estimate in relation to pavement strength

  eg. Produce budget estimates for a project life cycle cost with 5% probability of exceeding

- This method can be used for any critical data input to assess risk association.
- Consequently risk associated with investment decisions can be assessed


Twenty Five-year Budget Estimate for Maintenance and Rehabilitation of a 92km National Highway of Queensland
Cumulative Probability Distribution, F(x)
1.2
1
0.8
0.6
0.4
0.2
0
95
100
105
110
115
Budget Estimate of Roadwork (A$ Million)
Fx of Roadwork Costs
Fx-Theoretical

Conclusion

- Queensland Main Roads is reviewing and improving its planning and investment decision support processes for road asset management
- Many system improvement opportunities
- CRC project contributes to 3 beneficial outcomes:
  - Cost effective data acquisition practice, with better understanding of data quality
  - Understanding reliability of future budget predictions
  - Improving credibility of predictions of network performance and of future needs for works

Conclusion

- 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.

Conclusion

- 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.