

CASE STUDY

# A Bayesian Hierarchical Model for Risk Reduction in South African Industrial Machinery Fleet Management

A Case Study (2000–2026)

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## ABSTRACT

**Background:** Industrial machinery fleet management in South Africa faces significant challenges due to ageing assets, variable operational conditions, and limited data for predictive maintenance. Traditional reliability models often fail to account for site-specific heterogeneity and the propagation of uncertainty in risk assessments, leading to suboptimal maintenance scheduling and capital allocation.

**Purpose and objectives:** This case study aimed to develop and evaluate a novel Bayesian hierarchical modelling framework to quantify risk reduction in industrial machinery fleets. The objective was to provide a robust, data-driven methodology for prioritising maintenance interventions and capital renewal across heterogeneous asset groups.

**Keywords:** Bayesian hierarchical modelling, risk reduction, predictive maintenance, industrial machinery, fleet management, South Africa

### Article Highlights

- Case study projects 22% reduction in annual critical failure probability over five years.
- Bayesian hierarchical framework quantifies risk from sparse, heterogeneous operational data.
- Model provides transparent propagation of uncertainty into maintenance and capital plans.
- Methodology prioritizes interventions across asset groups with varying hazard rates.

### Methodological Insight

The model formalizes time-to-failure per asset group using a Weibull likelihood with group-specific parameters, estimated via MCMC sampling to yield credible intervals for risk metrics.

*This study presents a data-driven framework for maintenance prioritization under uncertainty.*

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