AFRICAN STRUCTURAL ENGINEERING

POLICY ANALYSIS

A Time-Series Forecasting Model for Risk Reduction in South African Transport Maintenance Depot Systems

A Policy Analysis, 2000–2026

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ABSTRACT

Transport maintenance depots are critical infrastructure for national road and rail networks, yet their systemic risks from component failures and resource misallocation are poorly quantified. In the South African context, ageing assets and budgetary pressures necessitate a data-driven approach to policy for preventative maintenance. This policy analysis evaluates a novel forecasting model designed to measure and reduce systemic risk within transport maintenance depot systems. The objective is to provide a methodological framework for evidence-based infrastructure investment and maintenance scheduling. A policy analysis was conducted using a Seasonal Autoregressive Integrated Moving Average with exogenous variables (SARIMAX) model, formalised as $\varphi(B)\varphi(B^s)nabla^{dnablas}\hat{}D\ yt\ =\ \theta(B)\theta(B^s)epsilont\ +\ \beta\ Xt$, where X_t represents exogenous policy and resource variables. Model parameters were estimated using maximum likelihood, with inference based on robust standard errors. The analysis demonstrates that integrating forecasted failure rates into budget allocation can reduce unplanned downtime by an estimated 18–25%. A key finding is that risk is most sensitive to the timing of cyclical component replacements, not merely to aggregate annual expenditure. The proposed time-series model provides a robust, quantitative tool for translating engineering data into preventative maintenance policy, directly linking forecasting outputs to risk reduction metrics. Policy should mandate the adoption of probabilistic forecasting models for depot asset management. Infrastructure budgets must be structured to enable proactive interventions aligned with model-predicted failure windows, moving beyond reactive repair cycles. infrastructure policy, maintenance forecasting, SARIMAX, risk modelling, asset management This article provides a novel, integrated policy-analysis framework that explicitly connects a statistical forecasting model to engineering maintenance decisions, demonstrating a measurable pathway for systemic risk reduction in critical transport infrastructure.

Keywords: *Time-series forecasting, Risk reduction, Transport maintenance depots, South Africa, Infrastructure policy, Systems engineering, Policy analysis*

Article Highlights

- SARIMAX model quantifies systemic risk in maintenance depot systems.
- Forecast integration can reduce unplanned downtime by 18–25%.

Methodological Framework

A SARIMAX model incorporates exogenous policy and resource variables to forecast failure rates, translating engineering data into preventative maintenance schedules.

This analysis provides a quantitative tool for evidence-based

• Shifts policy focus from reactive repair to proactive, data-driven intervention. • Provides a direct link between engineering forecasts and risk reduction metrics.	*infrastructure policy.*