

A Time-Series Forecasting Model for the Reliability Assessment of Railway Maintenance Depot Systems in Tanzania

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ABSTRACT

The reliability of railway maintenance depot systems is critical for operational efficiency and safety in developing transport networks. In many regions, systematic assessment tools are lacking, leading to reactive maintenance and unplanned downtime. This study aimed to develop and validate a time-series forecasting model to quantitatively assess the reliability of railway maintenance depot systems, with the objective of providing a predictive tool for maintenance planning. A methodological framework was developed using historical failure and repair data from multiple depots. The core model is an autoregressive integrated moving average (ARIMA) formulation, specified as $X_t = \mu + \phi_1 X_{t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t$, where system state X_t is a function of prior states and error terms. Model parameters were estimated using maximum likelihood, and forecast uncertainty was quantified with 95% confidence intervals. The model demonstrated a strong predictive capability for system failure rates, with a mean absolute percentage error of 12.7%. Forecasts indicated a significant negative trend in system reliability over a six-month horizon, with a predicted decrease in mean time between failures of approximately 15%. The proposed time-series model provides a robust, data-driven method for forecasting depot system reliability, enabling a shift from reactive to condition-based maintenance strategies. Implementation of the forecasting model within depot management systems is recommended for proactive maintenance scheduling. Further research should integrate real-time sensor data to enhance model accuracy. reliability engineering, maintenance forecasting, ARIMA modelling, transport infrastructure, predictive maintenance This paper presents a novel application of ARIMA time-series forecasting to the reliability assessment of railway maintenance depots, a previously unquantified area in the region, and provides a validated tool for infrastructure managers.

Keywords: Time-series forecasting, Reliability assessment, Railway maintenance depots, Sub-Saharan Africa transport, Infrastructure systems engineering, Predictive maintenance

Article Highlights

- Develops a novel ARIMA model for forecasting railway depot reliability in a Sub-Saharan context.
- Quantifies a significant negative trend in system reliability with 12.7% mean absolute error.
- Provides a validated, data-driven tool to enable a shift from reactive to predictive maintenance.
- Recommends integration into depot management systems for proactive scheduling.

Core Methodological Contribution

An autoregressive integrated moving average (ARIMA) model, specified as $X_t = \mu + \phi_1 X_{t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t$, was developed and validated using historical failure data from Tanzanian depots.

This study presents a quantitative framework for predictive maintenance planning in critical transport infrastructure.

ABSTRACT-ONLY PUBLICATION

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