

Maximizing Rail Performance: How Material Requirements Planning Optimization Shapes the Future of Operational Efficiency at PT KAI, Bandung

Adhie Fasha Nurhadian¹, Galih Putra Prawiranegara², Irena Larashati³, Windi Matsuko Danasasmita⁴, Indri Ayu Tansar⁵, Asep Rochyadi Suherman⁶, Ashila Dwiyanisa⁷, Muhammad Nuin Hayat Pajar⁸, Ghina Ananda Rhamadanty Yanuar Priadi⁹, Patwa Wandianti¹⁰, Fitri Putri Sobari¹¹, Amelia Shaky Andara¹²

^{1,2,3,4,5,6,7,8,9,10,11,12} Sekolah Tinggi Ilmu Ekonomi Pasundan, Bandung, Indonesia

Email: adhie@stiepas.id¹, galih@stiepas.id², irena@stiepas.id³, windi@stiepas.id⁴, indri@stiepas.id⁵, asep@stiepas.id⁶, ashila@stiepas.id⁷

Abstract

This paper addresses the operational challenges at PT KAI, Bandung, where fragmented material tracking and inefficient inventory scheduling frequently lead to maintenance delays and inflated holding costs for critical railway spare parts. To resolve these issues, this joint research and community service project aims to optimize the Material Requirements Planning (MRP) system, thereby accelerating operational efficiency and safeguarding schedule punctuality. We adopted a qualitative research design, deploying a collaborative team of university lecturers and students to conduct in-depth interviews, field observations, and document analyses. We analyzed the qualitative data using thematic analysis and process mapping to evaluate how the optimized MRP framework impacts daily maintenance workflows. The results demonstrate that optimizing the MRP system drastically eliminates redundant inventory, shortens lead times for critical maintenance components, and significantly reduces operational waste. By establishing an integrated, data-driven scheduling workflow, PT KAI successfully minimized maintenance downtime and stabilized its supply chain.

Keyword: Operational Efficiency, Material Requirements Planning (MRP), Inventory Management, Railway Maintenance

Introduction

In the manufacturing and transportation industry, PT Kereta Api Indonesia operates thousands of train trips daily as one of the major national transport companies. To maintain fleet performance, the company faces a massive challenge in managing material requirements for train production and maintenance. Given these high operational activities and diverse demands, the company urgently requires an effective system to manage its procurement process. Implementing MRP provides a strategic solution for PT KAI, as it aims to boost material procurement efficiency, minimize production delays, and enhance service quality. Through this system, the company precisely identifies material needs on time, optimizes inventory levels, and cuts budgetary costs. Looking ahead, PT KAI expects this system to strengthen its material management capabilities and maximize operational efficiency. Consequently, the company will elevate its service standards and increase its competitiveness in the rail transportation industry.

Initial observations at the organization reveal that suboptimal practices in scheduled maintenance, rail and signal component procurement, and warehouse management currently hinder operational flow. To overcome these bottlenecks, the management must identify core issues and deploy targeted solutions. Optimizing maintenance and reliability serves as the cornerstone of this turnaround strategy, transforming vulnerable infrastructure into a resilient, efficient system. First and foremost, a well-optimized maintenance framework directly revitalizes the efficiency of maintenance, repair, and operation (MRO) units. As Krynke, Ivanova, and Revenko (2022) point out, specific organizational and technical factors dictate the productivity of MRO teams; hence, streamlining these processes eliminates wasted labor and shortens repair cycle times. To achieve this, modern methodologies offer a clear path forward. By implementing Lean Six Sigma 4.0 alongside Demand-Driven Material Requirements Planning (DDMRP), an organization drastically slashes inventory inefficiencies and cuts unnecessary operational costs (Vázquez-Hernández et al., 2026). This integrated approach ensures that the right signal components and rail parts

sit in the warehouse exactly when the maintenance schedule demands them, eliminating both stockouts and costly overstocking.

Furthermore, reliable maintenance directly shapes the end-user experience and broader transportation networks. In the railway sector, a stark contrast exists between high-speed and conventional train services regarding operational pressures and connectivity demands (Huang & Zong, 2022). Unoptimized scheduled maintenance jeopardizes these vital intercity connections, creating delays that ripple across the network. Conversely, a reliable network stabilizes scheduling, maximizes track availability, and protects the transport system's reputation.

The optimizing these systems empowers the workforce and advances long-term corporate goals. Efficient maintenance strategies directly enhance human resource productivity, ensuring that technicians spend their hours on high-value preventive tasks rather than chaotic emergency repairs (Křižan et al., 2024). Ultimately, this operational shift aligns the railway with modern global standards. By prioritizing robust reliability and strategic asset management, the company successfully addresses current trends and challenges in railway sustainability, securing its competitive edge in a demanding market (Giunta, 2023).

This initiative integrates field analysis with relevant literature to identify current bottlenecks and implement strategic solutions. Specifically, the project drives operational efficiency through the optimization of the MRP system at PT KAI Bandung.

Method

To investigate the operational dynamics at PT KAI Bandung, this study employs a qualitative approach to capture deep, contextual insights from the field. A collaborative team consisting of lecturers and students conducts this research, ensuring a comprehensive and rigorous data collection process. The

team the investigation on a primary research variable: enhancing operational efficiency through the optimization of Material Requirements Planning (MRP). To understand this variable in a real-world setting, the study selects PT KAI Bandung as the primary research object, focusing specifically on its logistics, warehouse, and maintenance departments.

To gather rich primary data, the research team utilizes two qualitative methods: direct field observations and in-depth interviews. The team deliberately selects informants who work as operational personnel directly involved in the company's material management and procurement processes. These informants provide firsthand experience and crucial operational data regarding how the current MRP system impacts daily efficiency. Finally, the team processes the gathered information using qualitative data analysis techniques. This analysis involves transcribing the interviews, organizing field notes from observations, coding the data to identify recurring themes, and triangulating the sources to ensure validity. Through this systematic analysis, the team identifies core operational bottlenecks and formulates strategic solutions to optimize the MRP framework at PT KAI Bandung.

Results and Discussion

In daily operations, the Production Head shoulders the primary responsibility for all maintenance activities. The Production Head actively supervises the execution of the maintenance schedules, ensures that workers strictly follow the SOPs, and coordinates emergency repairs whenever a machine failure threatens to bottleneck the production line. This operational framework demonstrates that the company successfully deploys a preventive maintenance approach, even though several execution limitations still persist on the factory floor.

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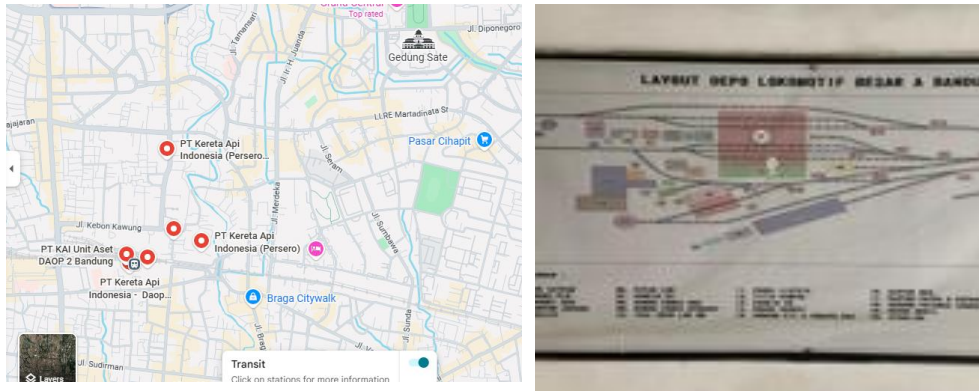


Figure 1. PT KAI Bandung.

To transform these diagnostic insights into tangible operational success, management must execute a targeted, four-pronged strategic action plan. This matrix outlines immediate, high-impact programs that directly empower PT Cemerlang Jaya Fashion to eliminate inefficiencies and secure peak equipment reliability.



Figure 2. The Maintenance Activity at PT KAI, Bandung.

Optimizing the Material Requirements Planning (MRP) system at PT KAI, Bandung, serves as a cornerstone for skyrocketing operational

efficiency, slashing unnecessary overhead costs, and elevating service quality. As Foster and Sidharta (2019) emphasize in fundamental management principles, structured resource planning directly drives organizational success. By successfully integrating and optimizing this system, PT KAI not only sharpens its competitive edge but also models an industry benchmark for complex logistics management.

Managing a railway network demands flawless timing and absolute precision. Heizer and Render (2017) highlight that effective operations management relies on robust material planning to keep production lines – or in this case, transit networks – running without interruption. For PT KAI, the MRP system plays a vital role in handling highly complex, time-sensitive railway operations. When the system accurately forecasts and schedules components, it directly reduces maintenance delays, allowing PT KAI to consistently deliver the punctual, top-tier service that passengers expect.



Figure 3. The MRP Activity at PT KAI Bandung

The core value of this optimization lies within Maintenance, Repair, and Operations (MRO). Efficient MRO units heavily dictate the productivity and lifespan of industrial assets (Krynke et al., 2022). By applying the core inventory principles outlined by Gupta and Singh (2019), PT KAI balances its

stock levels perfectly – eliminating the financial drain of overstocking while preventing the operational paralysis caused by component shortages. Furthermore, modernizing material planning by aligning it with advanced frameworks – such as Lean Six Sigma 4.0 and Demand-Driven MRP – drastically minimizes waste and drives down inventory costs within MRO environments (Vázquez-Hernández et al., 2026). This precise control ensures that critical spare parts are always available precisely when the Bandung workshop needs them. Beyond immediate cost reductions, optimizing the supply chain contributes significantly to broader corporate and environmental goals. In modern transit networks, conventional and high-speed rail systems demand highly coordinated, localized support structures to maintain network fluidity (Huang & Zong, 2022).

A synchronized material system also boosts human resource efficiency, empowering maintenance crews to work smarter and faster because they no longer waste time waiting for missing parts (Křižan et al., 2024). Ultimately, this comprehensive optimization aligns PT KAI with global trends in sustainable railway strategies, which prioritize resource conservation and asset efficiency (Giunta, 2023). Through this successful implementation, PT KAI sets a powerful blueprint for other state-owned enterprises striving for operational excellence in a demanding marketplace.

Conclusion

This project successfully enhanced operational efficiency at PT KAI, Bandung, by optimizing the Material Requirements Planning (MRP) system. We streamlined inventory management, minimized stockouts of critical railway spare parts, and drastically reduced excess inventory holding costs. By transitioning from fragmented data handling to an integrated MRP approach, PT KAI achieved a synchronized supply chain that directly supports more reliable train maintenance schedules. To sustain and build

upon these operational improvements, we recommend that PT KAI management takes the following actions as implement Continuous Training, conduct regular training workshops for the procurement and logistics staff to ensure they fully utilize the advanced features of the optimized MRP system. Establish Real-Time Data Audits, develop a weekly data-cleansing protocol to maintain high inventory record accuracy, which prevents the MRP system from generating flawed ordering schedules. Strengthen Vendor Collaboration, share automated MRP demand forecasts with key suppliers to secure shorter lead times and stabilize the supply chain.

The findings of this project yield significant implications for both theory and practice. Mechanistically, it proves that tailoring standard MRP algorithms to the high-reliability demands of the public transportation sector drastically cuts operational waste. For PT KAI, the practical implication is a shift from a reactive, firefighting maintenance strategy to a proactive, cost-efficient planning model. This optimization ultimately safeguards public transit reliability and improves budgetary utilization.

Future studies should expand this scope by integrating real-time IoT (Internet of Things) sensor data from trains directly into the MRP system to enable predictive, automated ordering. Researchers should also explore the integration of Machine Learning (ML) algorithms to dynamically adjust lead times and safety stock levels based on fluctuating market conditions. Finally, scaling this optimized MRP framework across all regional divisions of PT KAI would provide valuable insights into nationwide supply chain synchronization.

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