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Research Paper

Project Delay Management Model for Projects Adjacent to the IKN Mega Project (Case Study: Central Workshop Construction of PT. IHM)

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ABSTRACT: *Construction projects around the development area of the National Capital City (IKN) face unique challenges including resource competition, material supply pressure, and workforce dynamics due to the national mega project. Delays have become a dominant risk impacting cost, time, and quality performance.*

This research aims to identify dominant factors causing delays and to develop a control model based on Six Sigma using the DMAIC (Define, Measure, Analyze, Improve, Control) approach for the Central Workshop Construction Project of PT. IHM in Sepaku, East Kalimantan.

The research uses a descriptive qualitative approach with a case study method. Data were collected through a two-stage questionnaire survey (expert validation and main survey) involving 10 respondents from the Owner and Contractor sides, field observations, and documentation studies. Data analysis was conducted using descriptive statistical techniques, validity-reliability tests, and systematic application of the DMAIC framework.

Three dominant delay-causing factors were identified: (1) Insufficient number of workers (average score 4.20), (2) Delay in material delivery (4.20), and (3) Contractor's financial difficulties (4.10). Root cause analysis revealed the significant impact of the IKN project's attractiveness on skilled labor migration and material supply priority. The application of DMAIC yielded strategic solutions including workforce forecasting with multi-source recruitment, a multi-vendor system and buffer stock for critical materials, and optimization of contractor cash flow. The control plan includes measurable KPIs, SOPs, and a digital monitoring system to ensure the sustainability of improvements.

The DMAIC-based delay management model proved effective in diagnosing problems systematically and providing solutions adaptive to external dynamics in the IKN supporting region. This research contributes to the development of construction project management literature in national strategic areas and provides a framework that can be adopted for similar projects.

KEYWORDS: Project Delay, Six Sigma, DMAIC, IKN, Construction Management, Lean Construction

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I. INTRODUCTION

The development of the National Capital City (IKN) as a national strategic mega project creates a multiplier effect, including on construction projects in its surrounding areas. These "supporting" projects often face delays due to resource competition, distortions in the material supply chain, and the migration of skilled labor to the core IKN project (Nurjaman et al., 2024). Delays in construction projects not only cause cost

overruns but also disrupt the project owner's operational plans and damage the contractor's reputation (Messah et al., 2013).

Previous studies have widely identified general causes of delays, but few have specifically addressed the unique context of projects around national mega projects like IKN, where external factors have a very large influence. Reactive and conventional approaches are often less effective in handling this complexity. Therefore, a systematic and data-driven approach is needed for delay risk management.

Six Sigma with the DMAIC (Define, Measure, Analyze, Improve, Control) framework offers a structured methodology for process improvement and variation reduction. In a construction context, this approach can be integrated with Lean principles to eliminate waste and improve value streams (Gaspersz, 2007; Al-Aomar, 2012). This research takes the case of the Central Workshop Construction Project of PT. IHM in Sepaku, East Kalimantan, located approximately 40 km from the IKN zero point and experiencing significant delays.

The research objectives are: (1) To identify dominant factors causing project delays in the IKN area, (2) To apply the DMAIC method to analyze root causes, and (3) To develop and test an effective and sustainable delay control model.

II. RESEARCH METHODOLOGY

This research uses a descriptive qualitative case study design. The research location is the Central Workshop Construction Project of PT. IHM in Sepaku District, East Kalimantan. The population is all project stakeholders, with a purposive sample of 10 respondents consisting of project managers, site engineers, and supervisors from the Owner and Contractor sides.

Data collection was carried out through:

1. Literature Study: to compile initial delay-causing variables (55 variables).
2. Preliminary Survey: validation questionnaire to 3 experts to filter variables relevant to the case study project context.
3. Main Survey: questionnaire with a 1-5 Likert scale (1=Not Significant, 5=Very Significant) to 10 respondents to measure the influence level of each variable.
4. Observation and In-depth Interviews: to complement and deepen quantitative findings.

Data analysis follows the DMAIC stages:

- Define: Identification and screening of variables.
- Measure: Measurement of variable significance level, validity test (Pearson Correlation) and reliability test (Cronbach's Alpha).
- Analyze: Descriptive statistical analysis (mean, ranking), Pareto diagram for dominant factor identification, and Fishbone diagram (Cause-and-Effect) for root cause analysis.
- Improve: Formulation of strategic solutions and development of Future State Mapping.
- Control: Development of a control plan with KPIs, SOPs, and monitoring mechanisms.

III. RESULTS AND DISCUSSION

3.1. Identification of Dominant Factors (Define & Measure)

From 55 initial variables, expert validation results yielded 28 relevant variables. The main survey results and statistical tests (all items valid, α=0.97) showed three variables with the highest average scores as the most dominant causes of delay (Table 1).

Table 1. Three Dominant Factors Causing Delays

Code	Variable	Average Score	Category
X4	Insufficient number of workers	4.20	Very Significant
X7	Delay in material/goods delivery	4.20	Very Significant
X27	Contractor's Financial difficulties	4.10	Very Significant

3.2. Root Cause Analysis (Analyze)

In-depth analysis of the three dominant factors revealed a close connection with IKN development dynamics:

1. Lack of Workforce (X4): Caused by the migration of skilled workers to IKN projects offering higher incentives, exacerbated by difficulties in mobilizing workers from outside the region and the limited skills of local workers.

2. Material Delays (X7): Caused by the scarcity of aggregate materials (concrete stone/sand) and truck mixer capacity, where suppliers prioritize deliveries for IKN projects. The delay in ready-mix concrete caused a domino effect on all structural work.
3. Contractor's Financial Difficulties (X27): Resulting from the surge in material prices and mobilization costs, worsened by lengthy payment administration processes from the owner, leading to hampered cash flow and delayed material/equipment purchases.

The Pareto diagram (Figure 1) confirms that these three factors contribute to 20.83% of the cumulative causes of delay, in line with the 80/20 principle. Analysis of the project schedule data showed a difference between actual progress (21.736%) and planned progress (30.485%), indicating the real impact of these delays.

3.3. Formulation of Solutions and Improvement Model (Improve)

Based on root cause analysis, strategic solutions were formulated for each dominant factor:

1. For Workforce: Implement Workforce Forecasting based on schedule, multi-source recruitment (local & outsourcing), retention programs through incentives, and cross-skill worker rotation.
2. For Materials: Implement Early Procurement, a Multi-Vendor system, On-site Buffer Stock for critical materials, and real-time logistics tracking.
3. For Financing: Develop realistic cash flow projections, prepare a cash buffer, negotiate flexible payment terms with vendors, and prioritize fund allocation for critical materials and labor.

Future State Mapping was designed to illustrate the improved process flow, eliminating waste such as waiting and transportation identified in the Current State Mapping.

3.4. Sustainable Control Plan (Control)

To ensure the sustainability of improvement results, a control plan was established including:

- Key Performance Indicators (KPIs): Worker attendance (%), material delivery lead time, stock level, operational fund adequacy.
- Monitoring System: Digital dashboard, online timesheet, weekly coordination meetings.
- Standard Operating Procedures (SOPs): For recruitment, material procurement, and payment invoicing.
- Person in Charge (PIC): Assigned for each control area (HR, Logistics, Finance).

IV. CONCLUSION

This research concludes that :

1. Construction projects in the IKN supporting region are highly vulnerable to delays triggered by external factors, especially resource competition with the core mega project.
2. The three dominant delay factors in the case study are: workforce shortage, material supply delays (especially concrete), and contractor financial difficulties.
3. The DMAIC framework from Six Sigma proved effective as a systematic approach to identify root causes, design measurable solutions, and build a sustainable control system in managing project delays.

Recommendations:

- For Practitioners: Implement early planning principles and collaborative supply chain management with other stakeholders in the IKN area for joint risk mitigation.
- For Future Researchers: Test this model on projects with different typologies around IKN and integrate Lean tools such as the Last Planner System for model refinement.

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