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Operational Performance Improvement Analysis Through Six Sigma Approach (Case Study at PT. Freight Express Surabaya)

Pramudya Audrey Prienycha Islamey[1], Slamet Riyadi[2]*, Fausta Ari Brata[3]
[1,2,3] Universitas 17 Agustus 1945 Surabaya. Jl. Semolowaru No. 45, Menur Pumpungan, Sukolilo District, Surabaya, East Java 60118*

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Correspondence Email:
slametriyadi10@untag-sby.ac.id

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ABSTRACT

This study aims to address operational inefficiencies at PT Freight Express Surabaya, specifically focusing on document delays and inter-divisional coordination issues. Employing the descriptive qualitative method with a case study approach through the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) framework, data was collected via observations, in-depth interviews, and historical shipment documentation. The results of the Measure phase indicate the company's baseline performance is at the 3.89 Sigma level with 8,241 Defects Per Million Opportunities (DPMO). The dominant issue identified through Pareto analysis is the lack of inter-divisional coordination. Root cause analysis (Analyze) using Fishbone and 5 Whys reveals that the primary failures stem from systemic failures in information transfer management and the absence of data validation at the source (quality at source). In the Improve phase, a Digital Gatekeeping strategy and formalization of communication protocols were formulated, projected to enhance performance to the 4.14 Sigma level. The Control phase emphasizes digital-based SOP standardization and real-time monitoring to ensure the consistency of improvements.

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi profil kinerja operasional, menganalisis akar penyebab inefisiensi, dan merumuskan strategi perbaikan pada Divisi Operasional PT Freight Express Surabaya. Metode penelitian yang digunakan adalah deskriptif kualitatif dengan pendekatan studi kasus melalui kerangka kerja Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control). Data dikumpulkan melalui observasi, wawancara mendalam, dan dokumentasi historis pengiriman. Hasil fase Measure menunjukkan kinerja perusahaan berada pada level 3,89 Sigma dengan DPMO sebesar 8.241. Masalah dominan yang teridentifikasi melalui diagram Pareto adalah kurangnya koordinasi antar divisi. Analisis akar masalah (Analyze) menggunakan Fishbone dan 5 Whys menemukan bahwa penyebab fundamental adalah kegagalan sistemik dalam manajemen transfer informasi dan ketiadaan validasi data di hulu (quality at source). Pada tahap Improve, dirumuskan strategi Digital Gatekeeping dan formalisasi protokol komunikasi yang diproyeksikan mampu meningkatkan kinerja ke level 4,14 Sigma. Tahap Control menekankan pada standarisasi SOP berbasis digital dan monitoring real-time untuk menjaga konsistensi perbaikan.

INTRODUCTION

Global trade demands that logistics and freight forwarding companies provide fast, accurate, and reliable services. As a crucial hub in East Java, Surabaya plays a vital role in Indonesia's export-import ecosystem. However, logistics performance in Indonesia still faces efficiency challenges, as reflected in the World Bank's Logistics Performance Index (2023), which ranks Indonesia 61st out of 139 countries. This macro-level constraint is mirrored at the micro-level, where many forwarding companies struggle with process inefficiencies, customs hurdles, and shipment tracking issues that hinder business growth.

PT Freight Express Surabaya faces significant operational constraints that necessitate urgent management intervention. Major recurring issues include delays in export document processing due to data unpreparedness, frequent customer complaints regarding shipment delays, and inefficient inter-divisional coordination involving shipping lines, trucking, and warehouses. Furthermore, the emergence of "hidden costs" such as demurrage and detention indicates substantial waste in current workflows. These defects, ranging from schedule delays to non-SOP cargo handling, risk eroding market share as modern customers demand high transparency and speed.

To address these systemic issues, the Six Sigma approach was selected as the intervention methodology. Utilizing the DMAIC (Define, Measure, Analyze, Improve, Control) framework, Six Sigma allows the company to move beyond fixing symptoms to tracing root causes through quantitative performance measurement. While previous research by Antony (2015) and Vinodh & Swarnakar (2018) confirms Six Sigma's benefits in services, a significant gap remains regarding its application in integrating document and physical flows within Indonesian freight forwarders.

Previous research, such as that conducted by Antony (2015) and Vinodh & Swarnakar (2018), confirms the benefits of Six Sigma in improving service flexibility and reliability. However, a significant literature gap remains regarding the specific application of this method to the integration of document and physical flows within Indonesian freight forwarding companies. Most existing studies focus predominantly on the manufacturing sector or isolated warehouse management, leaving a void in understanding how Six Sigma can optimize the complex, paper-intensive coordination of international logistics.

Therefore, this research carries high urgency to fill that gap. The primary focus is to identify the current operational performance profile, analyze the root causes of dominant problems, and design priority improvements. This study aims to answer several main research questions: what is the current operational performance profile, what are the main root causes of inefficiency, and what are the effective improvement designs and control mechanisms.

Beyond addressing these questions, this research offers a distinct contribution by conceptualizing "Digital Gatekeeping" as a form of Quality at Source specifically tailored for export-import document flows in freight forwarding. Furthermore, it demonstrates how the strategic combination of Six Sigma and lean digitalization can effectively eliminate the "hidden factory" the undocumented rework and invisible costs within forwarder operations, providing a replicable model for improving service reliability in the Indonesian logistics context.

RESEARCH METHOD

This study employs a qualitative approach with a single case study method at PT Freight Express Surabaya. This approach was selected to explore operational phenomena in depth, where the qualitative design is enriched by Six Sigma quantitative analysis as an instrument to strengthen the interpretation of field realities. A descriptive qualitative method (Creswell, 2018) serves as the primary framework to dissect operational inefficiencies and bottlenecks that may not be fully captured by statistics alone. The research subject is the Operational Division, with informants selected through purposive sampling. The key informants consist of 7 individuals, including 1 Operational Manager, 1 EMKL (Freight Forwarding) Manager, 3 documentation staff, and 2 field operational staff, ensuring data relevance and validity.

Primary data were collected through direct observation and semi-structured face-to-face interviews lasting 45–60 minutes per session. Secondary data were sourced from the company's historical documents over the last 18 months, identifying 89 validated defect units. These defects were classified into three categories: documentation delays, data entry errors, and additional costs (demurrage). The research instruments include interview protocols, observation sheets, and operational documentation.

Data analysis follows the DMAIC (Define, Measure, Analyze, Improve, Control) cycle of the Six Sigma methodology (Monday, 2022). The application of performance metrics such as

DPMO, Sigma Levels, and Risk Priority Number (RPN) in this stage provides objective measurement to standardize process effectiveness within the qualitative framework. The analysis phase begins with SIPOC mapping, DPMO measurement, and root cause analysis using Fishbone diagrams and the 5 Whys technique, followed by solution formulation via FMEA and the development of a control plan. Data validity is maintained through source triangulation, cross-verifying information from management with data from executive staff and written documentation. The final analysis process refers to data reduction, data display, and conclusion drawing (Miles et al., 2014) to generate practical and applicable improvement recommendations.

RESULTS AND DISCUSSION

Operational Performance Profile (DPMO and Sigma Level) and Dominant Problems

SIPOC Mapping and CTQ Identification

The initial analysis phase began with the Define phase to map business processes and define problems. Process mapping using the SIPOC (Supplier, Input, Process, Output, Customer) diagram shows that the workflow at PT Freight Express Surabaya involves complex interactions between internal and external parties. Information Suppliers include customers and trucking partners, who provide inputs in the form of shipping instructions and initial documents. The core Process includes document creation (PEB, B/L), field coordination, to output in the form of shipped goods and legal documents. Customers demand timeliness and accuracy as the main quality parameters or Critical to Quality (CTQ).

CTQ identification revealed that the most critical quality attributes for customers are shipping timeliness, document accuracy, and cost efficiency (minimizing hidden costs). Failure to meet these CTQs is categorized as a defect. Based on interviews and historical data, various types of failure risks were identified, ranging from document delays, data input errors, to a lack of inter-divisional coordination. This list of risks serves as the basis for classifying problems whose frequency will be measured in the next phase.

The Measure phase aims to establish the current performance baseline. Problem frequency data was collected from the period June 2024 to November 2025. From this data, a total of 89 defect incidents were found spread across various categories. To determine handling priorities, a Pareto analysis was conducted. The Pareto chart shows that the problem "Lack of Inter-Divisional Coordination" (Code A5) occupies the top rank with a frequency of 11-12 incidents, followed by slow customer response and vessel schedule delays.

The dominance of internal coordination issues (A5) in the Pareto diagram indicates that the company's main obstacles are organizational, not just technical. The high frequency of this problem confirms the existence of a "silo mentality" or barriers between departments that hinder the flow of information. The Pareto 80/20 principle is clearly visible, where approximately 50% of total problems stem from just a few vital categories: coordination, customer response, and vessel schedules (Juran & Godfrey, 1999). Focusing improvements on these vital few is expected to have the most significant impact on overall performance.

Process stability analysis using a Control Chart shows that the current operational process is statistically out of control. There is high variation in the number of defects per period, especially those caused by coordination factors and external variables. This fluctuation indicates that the process is immature and highly vulnerable to disruption (Montgomery, 2019). Without process stabilization, efforts to increase capability will be difficult to achieve.

DPMO and Sigma Level Calculation (Baseline)

To measure performance objectively, Defects Per Million Opportunities (DPMO) and Sigma Level were calculated. The average monthly shipment volume is 120 shipments, with a total observation period of 18 months, making the total units (U) 2,160. The number of defect opportunities per unit (O) is set at 5 critical points (Document, Time, Physical, Cost, Communication). Total defects (D) recorded are 89.

The DPMO calculation is performed using the following formula:

$$DPMO = \frac{D}{U \times O} \times 1000000$$

$$DPMO = \frac{89}{2160 \times 5} \times 1000000$$

$$DPMO = \frac{89}{10800} \times 1000000$$

$$DPMO = 8241$$

A DPMO value of 8,241 indicates that in one million opportunities, there are approximately 8,241 probable failures. Based on the Six Sigma conversion table, this value is equivalent to a 3.89 Sigma Level. This achievement places PT Freight Express Surabaya at the national industry average position but still has not reached the world-class standard targeting 6 Sigma (3.4 DPMO).

The following table presents a summary of risk data and event frequencies that form the basis of the calculation:

Table 1. Dominant Problem Categories and Average Frequencies

Code	Dominant Problem Category	Average Frequency
A5	Lack of inter-divisional coordination	11-12 times
A14	Customer does not respond quickly	9-10 times
A16	Schedule vessel delay	7-8 times
A17	DO late release	7-8 times
A2	Shipment delay	6-7 times
A12	Trucking issues	6-7 times

Source: Processed Internal Company Data (2025)

The 3.89 Sigma level implies that the company's operational process has a success rate (yield) of approximately 99.18%. Although it looks high, the remaining failure of 0.82% in the high-volume logistics industry can have serious financial impacts. These failures often manifest as hidden Cost of Poor Quality, such as overtime costs for revisions, customs fines, or storage costs at the port (Feigenbaum, 1991).

Further analysis highlights that although the sigma value is close to 4, process consistency remains an issue. Performance variability is strongly influenced by workload and external factors. During peak seasons, the tendency for defects to occur increases, indicating that the existing system is not robust enough to handle volume surges without sacrificing quality. Overall, the operational performance profile shows that the company has a reasonably good foundation but needs fundamental improvements in coordination and information management aspects (Bowersox et al., 2013). The DPMO value of 8,241 is a clear indicator of a hidden factory producing errors and rework. Subsequent Six Sigma interventions must focus on closing this inefficiency gap to increase the sigma level towards a more competitive target.

Main Root Causes of Operational Inefficiency

Fishbone Findings: The 4M+1E Perspective

After determining the magnitude of the problem quantitatively, the Analyze phase aims to dissect the root causes of the problem qualitatively and in depth. The focus of the analysis is directed at the dominant problem found in the previous phase, namely Lack of Inter-Divisional Coordination. To map this complex cause-and-effect relationship, the Fishbone Diagram (Ishikawa) instrument with 4M+1E categories (Man, Method, Material, Machine, Environment) was used.

The Fishbone Diagram reveals that the Man factor plays a central role in coordination inefficiency. Strong indications of a silo mentality were found, where each division (Marketing, Operational, EMKL) works with its own target orientation without adequate synchronization (Lencioni, 2002). Additionally, fatigue factors due to multitasking during peak seasons cause a decline in staff attention to detail, so work instructions are often missed or not conveyed intact. Reliance on staff's personal memory, rather than the system, exacerbates the risk of human error (Reason, 2000).

The Method factor highlights the absence of standardized communication procedures. Inter-divisional communication is currently dominated by informal channels such as instant messaging or verbal communication, which are prone to distortion and difficult to track (low traceability). The absence of a daily routine briefing mechanism (morning huddle) causes work priorities not to be synchronized from the start of the day. Furthermore, the absence of a data handover checklist allows the information transfer process to proceed without a quality filter.

In the Material (Material/Information) factor, data input quality issues were found. Instruction data from customers is often incomplete, ambiguous, or subject to sudden changes. The Garbage In, Garbage Out (GIGO) phenomenon is very relevant here; when initial information from marketing is already defective, downstream processes in operations will inevitably face issues. Supporting documents that are misplaced or non-standardized in format also frequently hinder the customs document creation process (PEB).

The Environment factor contributes through high work pressure and external disruptions. The work atmosphere during peak seasons, full of pressure, creates a high-pressure environment that triggers reactive and emotional communication. External disruptions such as customs systems being down or port congestion add uncertainty, forcing internal teams to constantly change work plans abruptly, which often triggers coordination chaos.

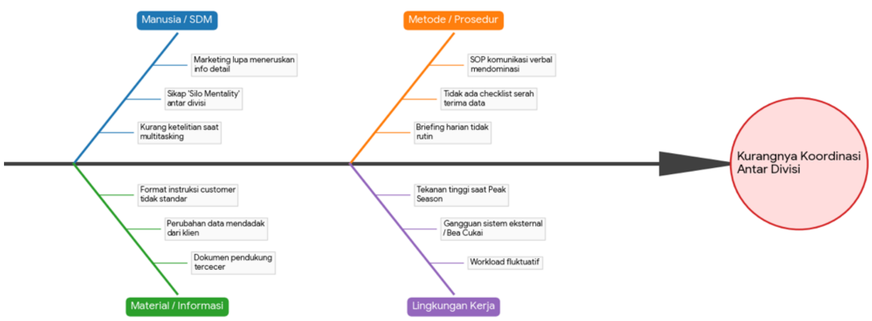

Figure 1. Schematic of Fishbone Diagram Analysis for Coordination Issues

Source: Researcher Analysis (2025)

The following is a schematic overview of the Fishbone Diagram mapping these root causes:

1) Man: Silo Mentality, Excessive Multitasking, Lack of attention to detail, Reliance on memory.
2) Method: Informal communication (verbal/WA), No handover checklist, Absence of routine briefing.
3) Material: Incomplete customer data, Sudden instruction changes, Non-standard data format.
4) Environment: Peak season pressure, External system disruptions, Work environment distractions.
5) Head of Bone (Effect): Lack of Inter-Divisional Coordination.

Whys Analysis: Systemic Failure

Analysis continued with the 5 Whys method to trace root causes to the deepest level in method and human factors. Why questions were asked repeatedly to dig into the reasons behind work instruction miscommunication.

1) Why 1: Why do instruction errors occur? -> Because information from Marketing is not received intact by Operations.
2) Why 2: Why is information not intact? -> Because it is conveyed informally or data is forwarded without a filter.
3) Why 3: Why without a filter? -> Because there is no standard form or data validation checklist.
4) Why 4: Why is there no checklist? -> Because the SOP assumes organic communication is sufficient.
5) Why 5 (Root Cause): The management system has not applied the Quality at Source principle; validation depends on people, not the system.

These 5 Whys findings confirm that the main problem is a systemic failure in information transfer management. The company does not have a gatekeeping mechanism or data quality gatekeeper. As a result, garbage data is allowed to flow from upstream to downstream, burdening operational processes with rework. Reliance on tacit knowledge (knowledge in employees' heads) instead of explicit knowledge (systems/procedures) is a fundamental weakness.

This analysis also shows that internal coordination issues directly impact the company's ability to respond to external variables. Internal asynchrony makes responses to customers slow and field problem handling (such as truck breakdowns) ineffective. Silo mentality worsens the situation because each division tends to blame each other rather than seeking joint solutions when problems arise (Chopra & Meindl, 2016).

From a Lean perspective, this condition creates waste in the form of waiting time, unnecessary movement (back-and-forth confirmation), and product defects (wrong documents). This inefficiency provides no added value to the customer but absorbs company resources. Therefore, the required solution must be able to break down silo walls and build a solid information bridge.

In conclusion, the main root cause of operational inefficiency at PT Freight Express Surabaya does not lie in individual technical competence, but in the weak design of communication and data validation processes. The current work system allows input variability to enter without a filter and relies on a fragile coordination mechanism. The implication of this analysis is the need for a transformation from people-dependent management to system-dependent management. Improvement is not enough with just appeals to be more careful, but must occur through structural interventions that force compliance with data quality standards from the beginning of the process.

Priority Improvement Plan and Projected Performance Increase
FMEA Priorities: Targeting High-Risk Failure Modes

Based on the root cause analysis, the Improve phase formulates an improvement strategy focused on eliminating fundamental causes: information variability and informal communication. The proposed main strategy is the implementation of Digital Gatekeeping and an Integrated Communication Protocol. This approach aims to apply the Poka-yoke (mistake-proofing) principle in the company's information flow (Liker, 2004).

The Digital Gatekeeping solution is realized through the creation of a digital-based Data Handover Form. This form is designed with mandatory field features, where the system will reject submissions if mandatory data (such as HS Code, Contract No., Truck Type) is not fully filled. This mechanism forces the Marketing division as the data supplier to verify the completeness of information before forwarding it to the Operational division. This is an application of the Quality at Source concept, preventing defective data from entering the service production process.

In addition to technological solutions, the institutionalization of a Morning Huddle or cross-divisional operational briefing every morning is proposed. This short 10-15 minute meeting aims to align perceptions regarding priority shipment status and identify potential daily obstacles. This ritual is designed to break down silo mentality and build shared situational awareness, making coordination more fluid and proactive.

Risk analysis of the proposed solutions was conducted using Failure Mode and Effect Analysis (FMEA) to prioritize actions. The Risk Priority Number (RPN) calculation shows that the data handover process has the highest risk of failure before improvement.

Table 2. Failure Mode and Effect Analysis (FMEA)

Process	Potential Failure Mode	Effects of Failure (Severity)	Potential Causes (Occurrence)	Current Controls (Detection)	S	O	D	RPN	Proposed Priority Improvements
Handover of Marketing Data to Documentation	Incomplete shipping instruction data (e.g., wrong HS Code, missing contract no.)	Repeated document revisions, customs fines, delayed manifest submission	Marketing in a rush, lack of initial filtering	Manual checking by documentation staff (often missed)	8	9	7	504	Mandatory Digital Form with "mandatory field" features and automated validation
Trucking Schedule Coordination	Truck arrives but goods are not ready or shipping documents are not yet printed	Waiting costs (truck demurrage), complaints from transporters	Changes in stuffing schedule information do not reach field staff	Communication via group chat (messages get buried)	7	8	6	336	Visual stuffing schedule board updated in real-time and accessible via mobile
Data Entry into PEB System	Incorrect alphanumeric input on draft PEB (Export Declaration)	PEB rejected by system, clearance delays	Human error due to fatigue, misreading handwritten notes	Self-review (often biased)	8	5	5	200	Double Check procedure by a peer (peer review) before the

	submit button is pressed

Source: Researcher Analysis (2025)

The high RPN in the data handover process (504) validates the urgency of implementing Digital Gatekeeping. With this solution, the Occurrence value is expected to drop drastically because the system prevents incomplete data, and the Detection value improves because validation is done by machine. This RPN reduction will have a significant impact on reducing the overall operational risk profile (Pyzdek & Keller, 2014).

In addition to technical aspects, the improvement design also includes a Visual Management System. The use of visual boards (physical or digital) to display shipment status in real-time will reduce staff memory load and minimize the frequency of repetitive questions. Data transparency increases accountability and accelerates managerial decision-making when problems occur (Slack & Brandon-Jones, 2019).

Projected Performance Increase

The implementation of these solutions is projected to have a significant quantitative impact on company performance. Estimation is made with the assumption that improved communication systems and data validation will reduce the frequency of coordination defects (A5) and input errors (A6) by 50-60%. The new performance projection calculation is as follows:

a) Total Defects (D) are projected to drop from 89 to 45.
b) Total Units (U) and Opportunities (O) remain (2,160 units, 5 opportunities).

$$DPMO_{baru} = \frac{45}{2160 \text{ X } 5} \text{ x } 1000000 = 4.166$$

The DPMO value is projected to drop from 8,241 to 4,166. Converting this value to Sigma Level shows a performance increase from 3.89 Sigma to 4.14 Sigma.

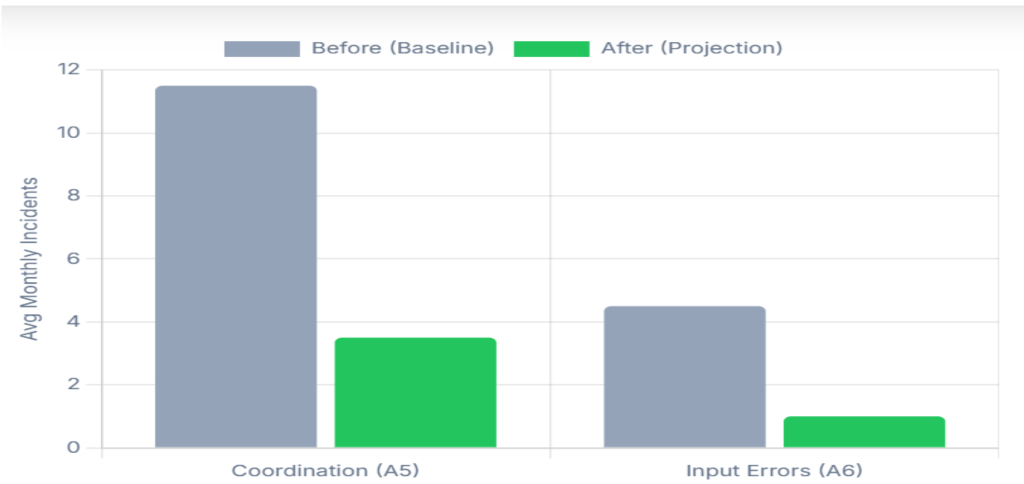

Figure 2. Projected Defect Reduction

Source: Processed Data (2025)

The projected increase to the 4.14 Sigma level serves as a strategic scenario if the proposed recommendations are fully implemented, marking the company's potential transition into a high-performance zone. At this projected level, operational processes are expected to become significantly more stable and predictable. This scenario, which envisions a nearly 50% reduction in DPMO, aims to halve the recurring problems currently burdening the company, such as repetitive document revisions and delay fines.

The financial impact of this projected improvement is the potential reduction of Cost of Poor Quality (COPQ). Efficiency in this model is created not through budget cuts, but through the systematic elimination of non-value-added activities like rework. Consequently, staff time previously spent fixing errors can be diverted to productive activities that enhance customer service.

Qualitatively, this proposed design aims to shift the work culture from reactive to preventive. Under this system, employees would no longer be occupied with "firefighting" daily problems but would instead operate within an organized, planned framework. Customer satisfaction is projected to increase in alignment with improved service accuracy and speed.

Performance Control Mechanism Analysis

Standardization and Real-time Monitoring

The Control phase is a crucial phase to ensure that improvements achieved are permanent and do not revert to old habits. The main control mechanism applied is Process Standardization through the issuance of new SOPs integrating Digital Gatekeeping procedures. These SOPs are not just documents but rules embedded in daily work systems, mandating the use of digital forms and the execution of morning briefings as an inseparable part of operational routines (Gaspersz, 2002).

Control is also carried out through Real-time Performance Monitoring using visual dashboards. These dashboards display key performance indicators (KPIs) such as document completeness status and vendor timeliness. Data transparency allows managers to intervene early if performance trends start to deviate from targets, changing supervision patterns from post-problem inspection to preventive process monitoring.

Periodic Quality Audit mechanisms are applied to verify compliance with new standards. Weekly or monthly audits are conducted to check whether data validation procedures are carried out correctly and whether communication protocols are adhered to. Audit findings become evaluation material in management review meetings, ensuring the improvement cycle continues to rotate (continuous improvement).

The aspect of Human Resource Competence Improvement becomes a pillar of cultural control. Routine training on digital literacy, communication management, and customs is provided to close competence gaps among staff. Skill development is important so that employees can adapt to new work systems that are more structured and technology-based.

The implementation of a transparent Reward and Punishment system is also recommended to reinforce positive behavior. Incentives are given to teams or individuals who consistently achieve zero defect targets and administrative discipline, while educative sanctions are applied for repeated procedural violations (Deming, 1986). This builds personal accountability for work quality.

Technology is utilized as a Control Enabler, for example, through automated notification features that remind of document closing deadlines. The use of technology reduces reliance on human memory and ensures time standards are consistently adhered to without the need for excessive micro-supervision from superiors. Overall, this control mechanism is designed to create a system that is robust and self-correcting. By binding behavioral changes into standard systems and procedures, PT Freight Express Surabaya can maintain operational performance consistency at the new Sigma level, ensuring customer satisfaction and cost efficiency are maintained in the long term.

CONCLUSIONS

Based on the analysis of performance improvement at the Operational Division of PT Freight Express Surabaya using the Six Sigma approach, this research identifies a clear gap between the current baseline performance of 3.89 Sigma (DPMO 8,241) and a projected performance leap to 4.14 Sigma. The initial profile reveals that dominant issues such as inter divisional coordination gaps, slow customer response, and document delays indicate a process operating in a statistically "out-of-control" condition due to special cause variability.

The root causes of these inefficiencies stem from systemic failures in information transfer and the absence of Quality at Source validation. An informal communication culture and "silo mentality" create information distortion gaps that trigger chain errors. These findings confirm that inefficiency is not merely a result of individual negligence, but rather the absence of preventive Poka-Yoke (error-proofing) mechanisms.

The theoretical and practical contribution of this study lies in the validation of "Digital Gatekeeping" and formalized communication protocols as essential tools for synchronizing document and physical flows. By integrating Six Sigma with simple yet disciplined digital interventions, this research proves that significant performance leaps do not always require massive capital investment, but rather a fundamental shift from reactive "firefighting" to a proactive Quality at Source culture. This study provides a strategic blueprint for other freight forwarders to reduce "hidden factory" costs the invisible expenses of rework and corrections and strengthen their competitiveness through structured process transformation.

Based on these findings, it is highly recommended that the management of PT Freight Express Surabaya prioritize the immediate implementation of the Digital Gatekeeping system to halt the flow of invalid data from upstream to downstream. This technical intervention must be supported by visual infrastructure, such as real-time performance dashboards, and the reinforcement of a collaborative culture through routine cross-functional briefings (morning huddles).

Furthermore, human resource development should extend beyond technical customs knowledge to include digital literacy and effective communication skills. To ensure the sustainability of these improvements and prevent the organization from reverting to inefficient patterns, these new standards must be integrated into a transparent reward and punishment mechanism, underpinned by consistent management audits and a long-term commitment to continuous improvement.

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