Business Process Improvement Using Quality Evaluation Framework and Root Cause Analysis at AMDK Company DC. Bali

Anak Agung Istri Anindya Pramesti[*1)], Dwi Putra Githa[2)], Anak Agung Ngurah Hary Susila[3)]
[1, 2, 3)]Department of Information Technology, Udayana University, Bali, Indonesia
[1*]anindyapramesti@student.unud.ac.id, [2]dwiputragitha@unud.ac.id, [3]harysusila@unud.ac.id

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ABSTRACT

This study addresses critical inefficiencies in distribution operations at PT. AMDK Distribution Center Bali, where manual processes and system fragmentation result in document verification errors, delivery mismatches, and extended cycle times. We employed an integrated methodological framework combining the Quality Evaluation Framework (QEF) for systematic performance assessment, Root Cause Analysis (RCA) with Fault Tree Analysis (FTA) to identify underlying operational failures, and Business Process Improvement (BPI) for solution design. Process modeling was conducted using BPMN 2.0 and validated through Bizagi Modeler simulation. The QEF evaluation revealed five critical non-conforming indicators: road letter verification errors (Q6), product delivery inaccuracies (Q22), residual product inspection failures (Q23), LHPH documentation errors (Q26), and submission delays (Q28). Root cause analysis identified manual dependency, inadequate system integration, and insufficient SOPs as primary failure sources. The proposed To-Be model, incorporating automated validation, digital documentation workflows, and cross-system integration (Smartlog-SAP-OTM), achieved measurable improvements: a 17.61% time reduction in delivery operations and a 2.41% improvement in receiving processes. This research contributes a validated methodological framework for logistics process optimization in emerging market contexts, demonstrating how structured quality evaluation coupled with root cause-driven redesign can achieve sustainable operational improvements.

1. Introduction

The bottled drinking water industry in Indonesia faces increasing pressure to optimize distribution efficiency amid growing market competition and consumer expectations for reliable delivery [1]. This AMDK company operates one of the most extensive distribution networks in the region, with the Distribution Center (DC) Bali serving as a critical logistics hub managing product flow from the factory to end customers. Despite implementing integrated information systems, operational challenges persist: document verification errors averaging 2 incidents per month, product delivery mismatches affecting customer satisfaction, and continued reliance on manual processes vulnerable to human error. These inefficiencies translate directly into extended cycle times and elevated operational costs, threatening competitive positioning.

Recent studies in supply chain management emphasize that distribution efficiency depends fundamentally on optimized business process design and seamless interdepartmental coordination [2][16]. Well-architected processes reduce resource waste, minimize error rates, and accelerate service delivery [17]. However, empirical observation at DC Bali reveals persistent manual bottlenecks: document recording, road letter verification, and status tracking remain predominantly paper-based or involve fragmented digital systems. This systemic fragmentation creates data synchronization gaps, limiting real-time visibility and accountability across the distribution chain.

To address these challenges systematically, this research applies a validated methodological framework integrating three complementary approaches. First, the Quality Evaluation Framework (QEF) enables objective, metric-based assessment of process performance against organizational targets

[3][4]. QEF has been successfully applied in various operational contexts to identify performance gaps through structured comparison of actual versus target KPIs [18]. Second, Root Cause Analysis (RCA) using Fault Tree Analysis (FTA) provides deductive mapping of causal relationships between observed failures and underlying systemic issues [5]. FTA systematically decomposes top-level problems into contributing factors, enabling targeted intervention design [19]. Third, Business Process Improvement (BPI) methodology guides the redesign of workflows through established techniques: elimination of non-value-adding activities, selective automation, and enhanced cross-functional collaboration [6][20].

Despite growing literature on business process optimization, limited empirical research examines the integrated application of QEF-RCA-BPI frameworks specifically in Indonesian logistics contexts, particularly for bottled water distribution, where high-volume, time-sensitive operations present unique challenges. This study addresses this gap by systematically evaluating existing processes, identifying root causes of inefficiencies, and designing validated improvements through simulation-based testing.

The research questions guiding this investigation are: (1) What specific quality factors in DC Bali's distribution processes fail to meet organizational targets? (2) What are the root causes of these performance gaps? (3) How can BPI-based redesign systematically address identified inefficiencies while ensuring practical implementations?

This study contributes to both academic knowledge and management practice by (1) demonstrating the effectiveness of integrated QEF-RCA-BPI methodology in emerging market logistics contexts; (2) providing quantitative evidence of achievable efficiency gains through structured process redesign; and (3) offering a replicable methodological framework adaptable to similar distribution operations. The remainder of this paper is structured as follows: Section 2 details the research methodology and analytical framework; Section 3 presents empirical findings from process evaluation and simulation; Section 4 discusses implications and comparisons with prior research; and Section 5 concludes with practical recommendations and future research directions.

2. Methods

This research employs a single case study design to investigate business process inefficiencies within a bounded system—the distribution operations at DC Bali AMDK Company. The case study approach is justified by its capacity to explore contemporary phenomena within real-life contexts, particularly where boundaries between phenomenon and context are not clearly evident [7][21]. Unlike experimental or survey designs, case studies enable in-depth examination of complex operational processes while preserving the holistic characteristics of organizational practices [22]. This approach is particularly appropriate given the research objectives: understanding how existing processes function, identifying specific failure points, and testing improvement interventions in situ.

2.1. Research Design and Framework

The research follows a systematic nine-stage process aligned with Business Process Management (BPM) lifecycle principles [23]: (1) problem identification through field observation and stakeholder consultation; (2) literature review establishing theoretical foundations; (3) primary data collection via triangulated methods; (4) as-is process modeling using BPMN 2.0; (5) quality evaluation applying QEF metrics; (6) root cause identification through FTA; (7) to-be process design using BPI principles; (8) simulation-based validation; and (9) conclusion formulation with actionable recommendations. Figure 1 illustrates the logical flow and interdependencies among these stages.

2.2. Data Collection

Data collection occurred over three months (January–March 2025) through multiple complementary methods to ensure validity and reliability [12]. The primary techniques included:

a. Direct Observation: Researchers conducted structured observation of 47 receiving operations and 63 delivery operations, systematically recording process sequences, actor interactions, document flows, and time consumption at each stage. Observation protocols were designed to capture both routine activities and exception handling.

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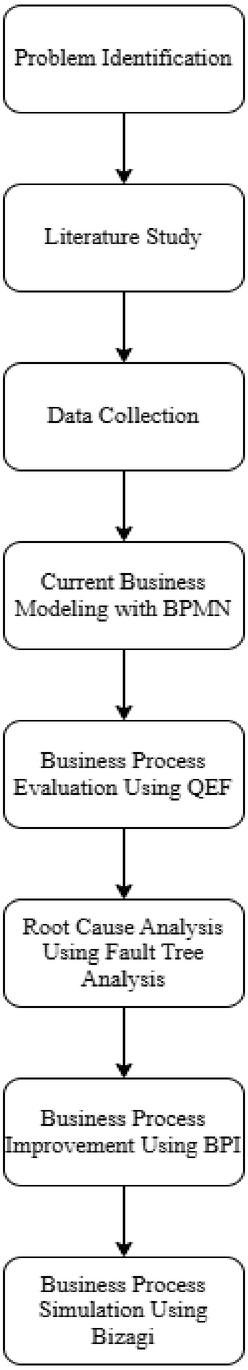

Figure 1. Flowchart of Research Stages

b. Semi-Structured Interviews: In-depth interviews were conducted with 12 key informants representing all functional roles in the distribution process: Logistics Support staff (n=2), Inventory Control personnel (n=2), Planning officers (n=2), Warehouse supervisors (n=2), Distribution administrators (n=2), and expedition drivers (n=2). Interview guides addressed process understanding, pain points, system usage, and improvement suggestions. Each interview lasted 45-60 minutes and was audio-recorded with consent for subsequent transcription and analysis.
c. Documentation Analysis: Secondary data sources included 180 days of operational records (CROs, delivery notes, NPL, LHPH), Standard Operating Procedures (SOPs) for receiving and delivery functions, system-generated reports from DIOM and Smartlog platforms, and historical performance data on error rates and cycle times. Triangulation was systematically applied by cross-verifying information from observations, interviews, and documents to establish convergent

validity [12]. For example, process duration claims from interviews were validated against both observed timings and system log data.

2.3. Quality Evaluation Framework (QEF) Implementation

The QEF provides a structured approach to assess business process quality across multiple dimensions [4][18]. In this study, QEF implementation involved five stages:

a. Stage 1 - Quality Dimension Definition: Based on organizational strategic objectives and literature review, five quality dimensions were established: time efficiency (cycle time relative to targets), reliability (error/defect frequency), resource utilization (labor and system capacity), customer satisfaction (delivery accuracy and timeliness), and compliance (adherence to documented procedures).
b. Stage 2 - KPI Selection and Target Setting: In collaboration with DC Bali management, 28 specific KPIs were identified across receiving (12 indicators) and delivery (16 indicators) processes. Each KPI was assigned a measurable target based on organizational performance goals. For example: Q6 (road letter verification errors) target = 0 errors/month; Q22 (product delivery accuracy) target = 0 errors/month; Q28 (LHPH submission timeliness) target = 100% on-time submission.
c. Stage 3 - Performance Measurement: Actual performance data for each KPI was collected from system records and manual logs over the three-month observation period. Measurement protocols ensured consistency and reliability of data capture.
d. Stage 4 - Gap Analysis: Actual performance was systematically compared against established targets to identify conforming and non-conforming indicators. Statistical significance of deviations was assessed where applicable.
e. Stage 5 - Priority Setting: Non-conforming KPIs were prioritized for root cause analysis based on frequency, severity, and impact on downstream processes.

2.4. Root Cause Analysis using Fault Tree Analysis

For each priority non-conforming indicator identified through QEF, Root Cause Analysis was conducted using Fault Tree Analysis (FTA) methodology [5][19]. FTA is a top-down, deductive analytical approach that systematically maps the logical relationships between a top event (the observed problem) and its contributing causes through Boolean logic gates (AND/OR). The FTA process in this study comprised:

a. Top Event Definition: Each non-conforming KPI was designated as a top event requiring explanation. For example, “Road letter verification errors occur” (Q6).
b. Intermediate Event Identification: Through structured brainstorming sessions with process owners and analysis of failure incident reports, intermediate events (failure modes) contributing to the top event were identified. For Q6, intermediate events included: inadequate verification procedures, system limitations, and human factors.
c. Basic Event Determination: The analysis continued recursively until basic events—root causes that cannot be further decomposed were identified. Examples include: lack of a standardized verification checklist, absence of automated validation, insufficient staff training on document requirements, and inadequate supervisory oversight.
d. Logic Gate Assignment: Logical relationships (AND/OR gates) between events were established based on failure occurrence conditions.
e. Causal Path Validation: Identified causal paths were validated through stakeholder review sessions and correlation with documented failure incidents.

2.5. Business Process Modeling

Business process modeling was conducted using Business Process Model and Notation (BPMN) 2.0, the internationally recognized standard for process visualization [13][24]. BPMN provides a graphical notation comprehensible to both technical and non-technical stakeholders, facilitating

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communication and analysis. Two process models were developed for both receiving and delivery workflows:

a. As-Is Model: Captured the current state of operations based on observation, interviews, and document analysis. Models documented all activities, decision points, actors (using swimlanes), information flows, and exception handling procedures. Particular attention was given to manual interventions, system handoffs, and approval sequences.
b. To-Be Model: Designed improvement scenarios incorporating BPI principles [6][20]: (1) Elimination: removing non-value-adding activities such as redundant approvals and manual transcription; (2) Simplification: streamlining workflows and reducing handoffs; (3) Automation: introducing system-based validation, notification, and document generation; (4) Integration: connecting previously fragmented systems (DIOM, Smartlog, SAP, OTM) to enable seamless data flow; and (5) Standardization: implementing digital SOPs with embedded controls.

BPMN modeling was performed using Bizagi Modeler software, which supports BPMN 2.0 notation and enables process simulation.

2.6. Process Simulation and Validation

To quantitatively assess the impact of proposed improvements, process simulation was conducted using Bizagi Modeler's simulation engine [8]. Simulation parameters were configured based on empirical data:

a. Activity Duration: Mean and standard deviation values derived from observed time measurements (n=110 process instances).
b. Resource Availability: Modeled based on actual staffing patterns and shift schedules.
c. Arrival Rates: Configured to reflect historical order volumes (mean daily receiving: 8 shipments; mean daily delivery: 15 orders).
d. Decision Point Probabilities: Set according to observed frequencies (e.g., verification failure rate, return occurrence rate).

Both As-Is and To-Be models were simulated over a 30-day operational period with 100 replications to ensure statistical stability. Output metrics included total cycle time, activity-level durations, resource utilization, and queue times. Comparative analysis focused on time efficiency improvements while ensuring resource feasibility.

2.7. Validity and Reliability

Multiple strategies were employed to enhance research validity and reliability:

a. Construct Validity: Ensured through use of established frameworks (QEF, FTA, BPI, BPMN) with clear operational definitions and measurement protocols.
b. Internal Validity: Strengthened through triangulation of data sources and systematic causal analysis via FTA.
c. External Validity: While single-case design limits statistical generalizability, the detailed methodological documentation enables analytical generalization and replication in similar contexts [21].
d. Reliability: Enhanced through standardized data collection instruments, documented procedures, and multiple-observer verification of process models.

3. Results and Discussions

This research was conducted at an AMDK Company Distribution Center in Bali, which operated two main business processes in its supply chain: the receiving of goods from the factory to the warehouse and the delivery of goods from the warehouse to customers. To represent these two processes, modeling was performed using Business Process Model and Notation (BPMN) with the support of Bizagi Modeler software.

3.1. Process of Receiving Goods from Factory to Warehouse

Based on the business process modeling results, the workflow for goods receiving is initiated with the creation of the Customer Release Order (CRO) document by the Logistics Support department. This document served as a formal request for goods to be prepared and dispatched. Once completed, the CRO was forwarded to the Inventory Control division, which was responsible for inputting the relevant data into the DIOM system, a centralized platform used for internal coordination and visibility. After ensuring the data was accurately recorded, Inventory Control transmitted the information to the Planning department, where it became the basis for scheduling and aligning production activities with current inventory demands. This sequential process highlighted the interdepartmental dependencies and the role of digital systems in streamlining communication and operational planning [14].

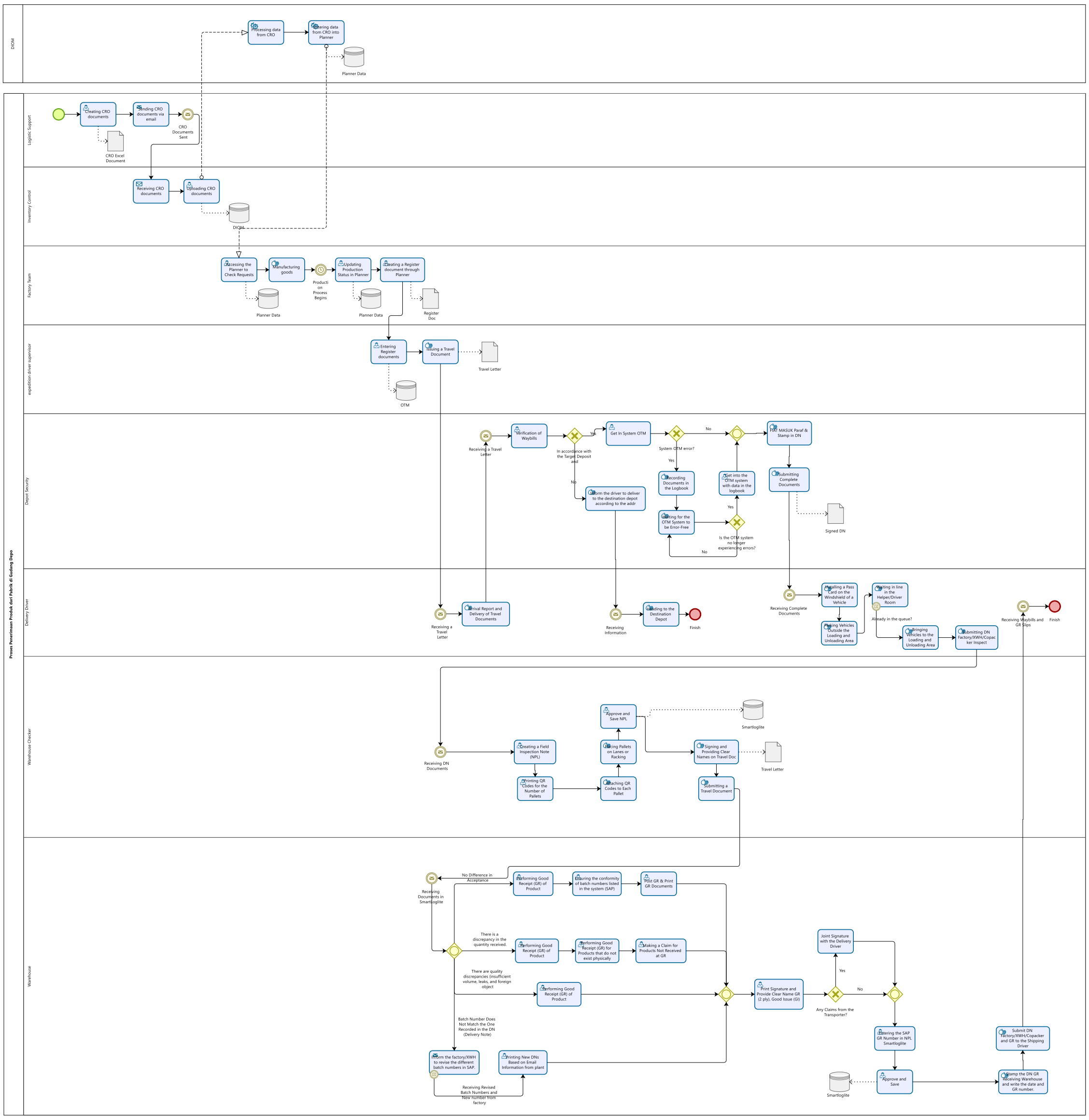

Figure 2. Business Process Model (As-Is) of Receiving Goods from Factory to Warehouse

Once the production request was received, the factory team proceeded to process and fulfill the order in accordance with the planned schedule. Upon completion of goods preparation, the team generated the necessary shipping documentation, including the Delivery Note, which served as a formal record of the items being dispatched. These documents were then handed over to the assigned Expedition Driver, who was responsible for transporting the goods from the factory to the Distribution Center (DC) in Bali. The entire sequence of activities—from production readiness to physical delivery of goods—

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was comprehensively illustrated in Figure 2, offering a clear visual representation of the operational flow and the actors involved at each stage of the outbound logistics process.

The As-Is BPMN diagram (Figure 2) presented a comprehensive visualization of the activities and principal actors engaged in the inbound goods receiving process. It elaborated on each procedural step, beginning with initial communication and coordination efforts between Logistics Support, Inventory Control, and Planning departments conducted through the DIOM system. This early-stage interaction ensured that all required data, including order details and shipping schedules, were aligned before goods physically arrived. As the process progressed, the diagram illustrated the transition from digital coordination to physical execution, wherein goods were received at the warehouse. Upon arrival, each shipment underwent a verification procedure to assess both the quantity and quality of items received, ensuring consistency with initial documents and planned orders. These verifications were typically supported by barcode scanners, manual checklists, or integrated inventory systems, depending on the technological maturity of the operation.

In parallel, the diagram traced the journey of critical documents, CROs, delivery notes, and receiving forms as they were created, reviewed, approved, and archived. These documents served as essential proof of transaction and were routed through multiple divisions, often requiring signatures, cross-checks, or uploads into various systems. Despite the presence of digital platforms like DIOM, several stages still involved manual intervention, such as email-based approvals, physical handovers, and paper-based validations. By mapping both communication flow and document lifecycle, the diagram not only clarified actor responsibilities but also uncovered inefficiencies arising from system fragmentation and human dependency. This visualization reinforced the critical need for enhanced system integration and automation across departments to minimize processing delays, prevent data discrepancies, and ensure timely, accurate receipt of inbound goods.

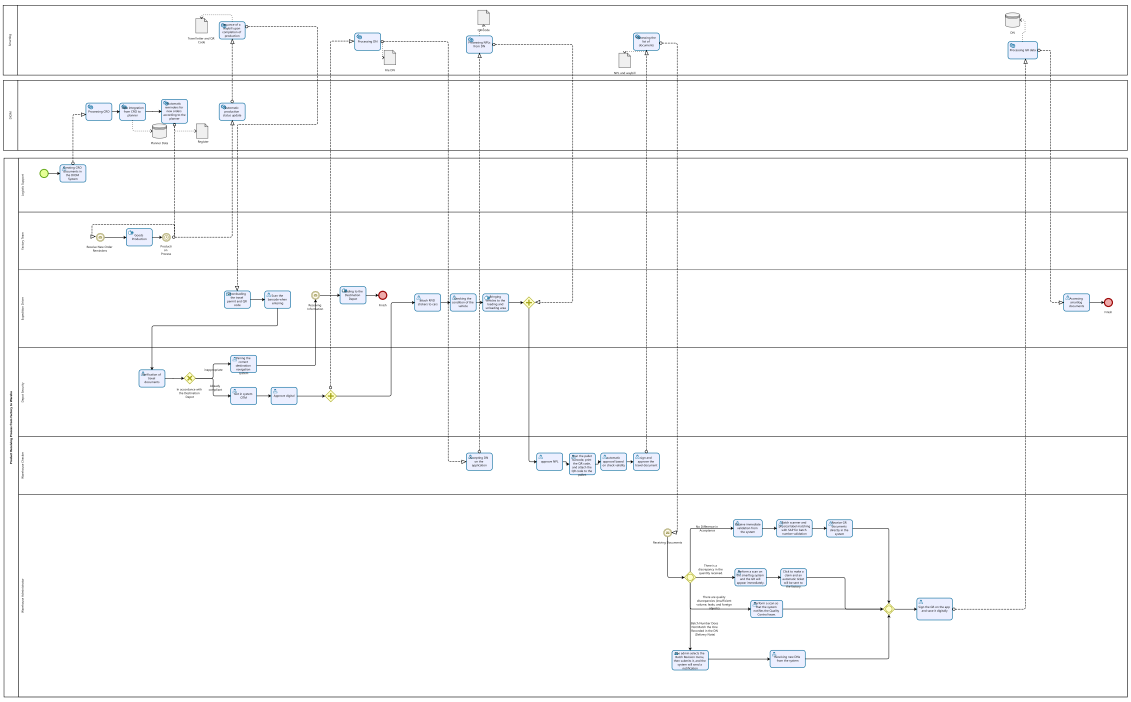

Figure 3. Proposed Business Process Model (*To-Be)* Receiving Goods from Factory to Warehouse

The To-Be BPMN diagram (Figure 3) illustrates the redesigned process flow incorporating digitization of the CRO document generation system, automatic notification, and system-based approval. Each actor in the process had a clearly defined role, as indicated by swimlanes, which strengthened coordination and reduced bottlenecks.

The proposed model integrated Smartlog, SAP, and OTM systems. The process began with automatic CRO generation in the DIOM system, which was directly transmitted to the Inventory Control dashboard and provided notifications to planners and the factory. Factories utilized a reminder system and auto-generated production register documents before sending goods with an application-based expedition system, digital road letter validation via QR code, and RFID technology.

In the warehouse, physical verification of goods using barcode scanners was automatically validated, including pallet QR code printing, Field Inspection Note (NPL) auto-approval, digital signature implementation, and Good Receipt (GR) synchronization to Smartlog and SAP. This implementation eliminated repetitive manual activities and reduced process time from 10,410 minutes (7 days 23 hours 30 minutes) to 10,159 minutes (7 days 17 hours 59 minutes), representing a 2.41% improvement.

3.2. Goods Delivery Process from Warehouse to Customer

Based on business process modeling results, the outbound logistics process from the warehouse to the customer began with the goods' arrival at the warehouse. At this initial stage, incoming goods were thoroughly verified for both quantity and quality to ensure alignment with accompanying shipping documents, such as Delivery Notes and CROs. This verification process was critical to prevent discrepancies and maintain inventory accuracy.

Once goods were validated, data was recorded into the digital logistics system (Smartlog), which enabled real-time tracking and integration across departments. The system then automatically generated supporting documents, including the STD (Surat Tanda Delivery or Delivery Sign Letter), which served as formal proof of goods readiness for dispatch. This end-to-end process, including verification, system input, and document generation, was comprehensively illustrated in Figure 4.

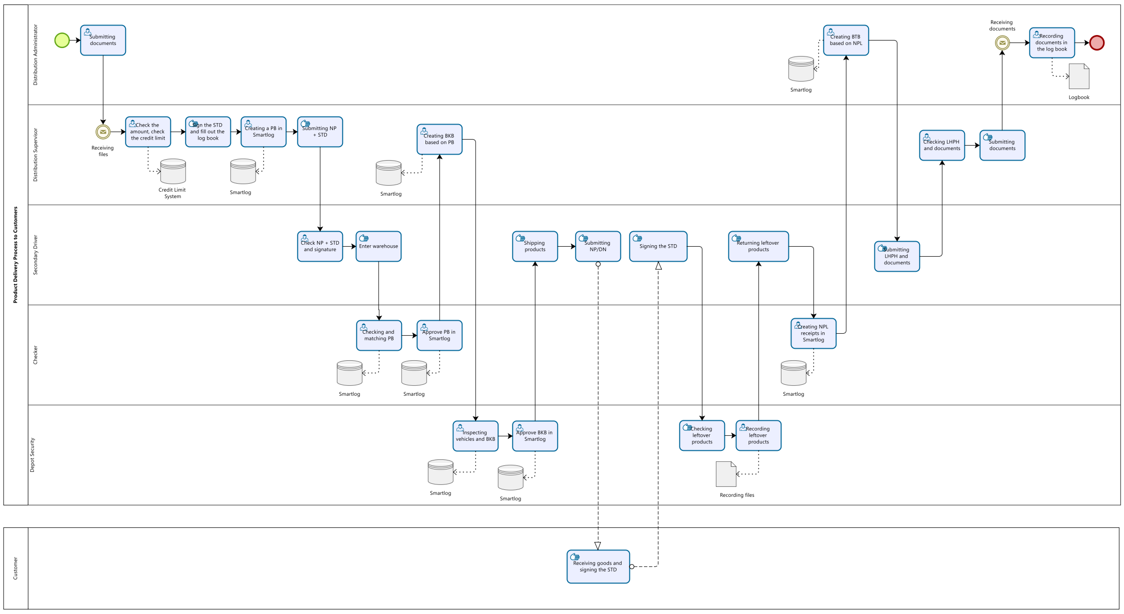

Figure 4. Business Process Model (*As-Is*): Delivery of Goods from Warehouse to Customer

The As-Is BPMN diagram (Figure 4) provided a comprehensive visualization of the current workflow for outbound shipping of goods from the warehouse to the customer. The diagram outlined each step involved, beginning with the initial preparation of delivery-related documents and progressing through multiple layers of internal approvals. Notably, a significant portion of these activities was still conducted manually, which introduced potential for delays and human error. Furthermore, the diagram highlighted fragmented use of various digital systems that had not been fully integrated, resulting in inefficiencies in data synchronization, limited process transparency, and increased administrative workload across departments involved in the distribution cycle.

The To-Be BPMN diagram (Figure 5) illustrates the digitized goods delivery flow, starting from inputting shipping requirements, automatically generating NP-STD documents, to verifying receipt of

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goods through an OTP system by customers. The Smartlog system supported full integration between divisions and generated return, NPL, BTB, and LHPH documents automatically with synchronization. The optimized delivery process incorporated the integration of shipping documents (NP, STD, BKB) into the Smartlog system. The flow began with delivery requirement input by the Distribution Admin, followed by stock verification and customer credit limit checking by the Supervisor, who approved requests digitally. The system then automatically generated delivery documents that were directly accessible to drivers through a mobile application, including optimized delivery routes based on customer locations [15]. Verification of goods receipt by customers was accomplished through OTP, replacing physical signatures. Leftover products were recorded through digital forms that automatically generated return documents (NPL, BTB). Integrated delivery and return data generated a Daily Sales Result Report (LHPH) that was validated by the Supervisor. The implementation of this system successfully reduced processing time from 774 minutes (12 hours 54 minutes) to 637.07 minutes (10 hours 37 minutes), achieving a 17.61% improvement, primarily through document automation, real-time verification, and elimination of manual tasks such as logbook recording and file initialing.

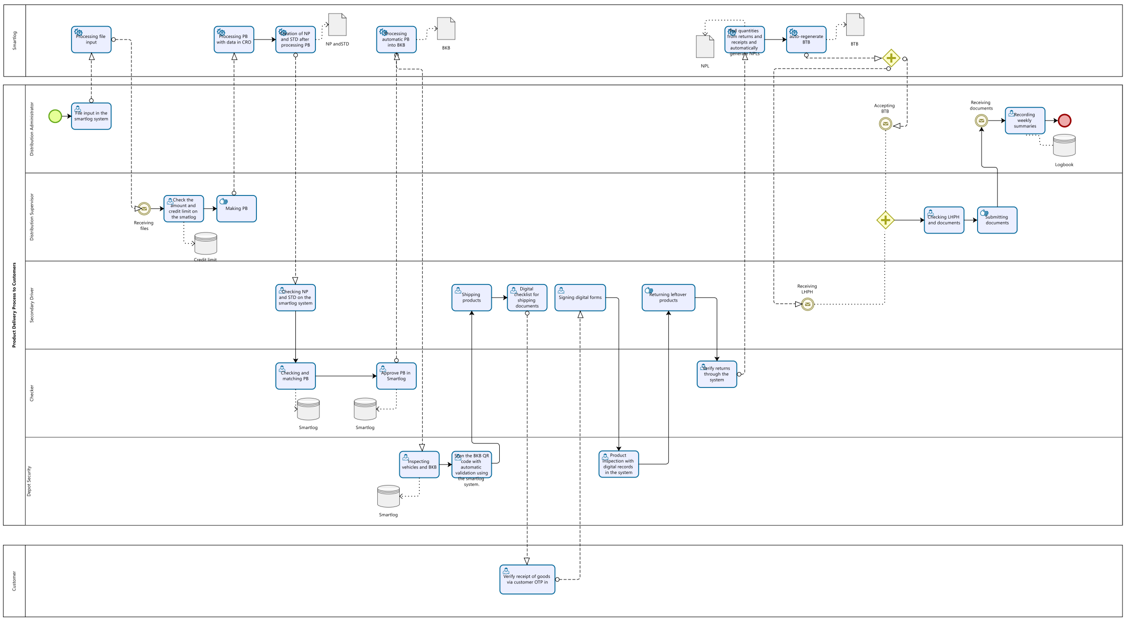

Figure 5. Proposed Business Process Model (To-Be): Delivery of Goods from Warehouse to Customer

Table 1. Business Process Quality Factor Evaluation Results

Code	Quality Factor	Target	Realization	Dimensions	Results
Q1	Creation and delivery of CRO documents	100%	133%	Time Efficiency	As per
Q2	CRO input error	0	0	Failure Frequency	As per
Q6	Road Letter Verification	0 errors/month	2 errors/ month	Failure Frequency	Not Suitable
Q10	Making Field Inspection Notes (NPL)	100%	0	Failure Frequency	As per
Q12	Good Receipt	100%	0	Failure Frequency	As per
Q22	Product delivery error	0 errors/month	2 errors/month	Failure Frequency	Not Suitable
Q23	Inspection of residual products on vehicles	0 errors/month	1 error/month	Failure Frequency	Not Suitable
Q26	Making LHPH	0 errors/month	1 error/month	Failure Frequency	Not Suitable
Q28	Submission of LHPH	100%	There is a delay	Time Efficiency	Not Suitable

3.3. Quality Evaluation Framework Results

The comprehensive business process evaluation at DC Bali revealed that several quality factors fell short of meeting the company's established performance targets. Table 1 presents the complete QEF evaluation results comparing target versus actual performance across 28 quality indicators. Among the 28 indicators evaluated, five were identified as non-conforming: road letter verification errors (Q6: target 0, actual 2 errors/month), product delivery inaccuracies (Q22: target 0, actual 2 errors/month), residual product inspection failures (Q23: target 0, actual 1 error/month), LHPH documentation errors (Q26: target 0, actual 1 error/month), and LHPH submission delays (Q28: target 100% on-time, actual showed delays). These five quality factors collectively pointed to deficiencies in process reliability and lack of efficiency in operational time management, indicating an urgent need for targeted improvements.

3.4. Root Cause Analysis Results

Systematic Root Cause Analysis using Fault Tree Analysis was conducted for each non-conforming indicator. Figure 6 presents the FTA diagram for road letter verification errors (Q6), illustrating the deductive breakdown of causal factors.

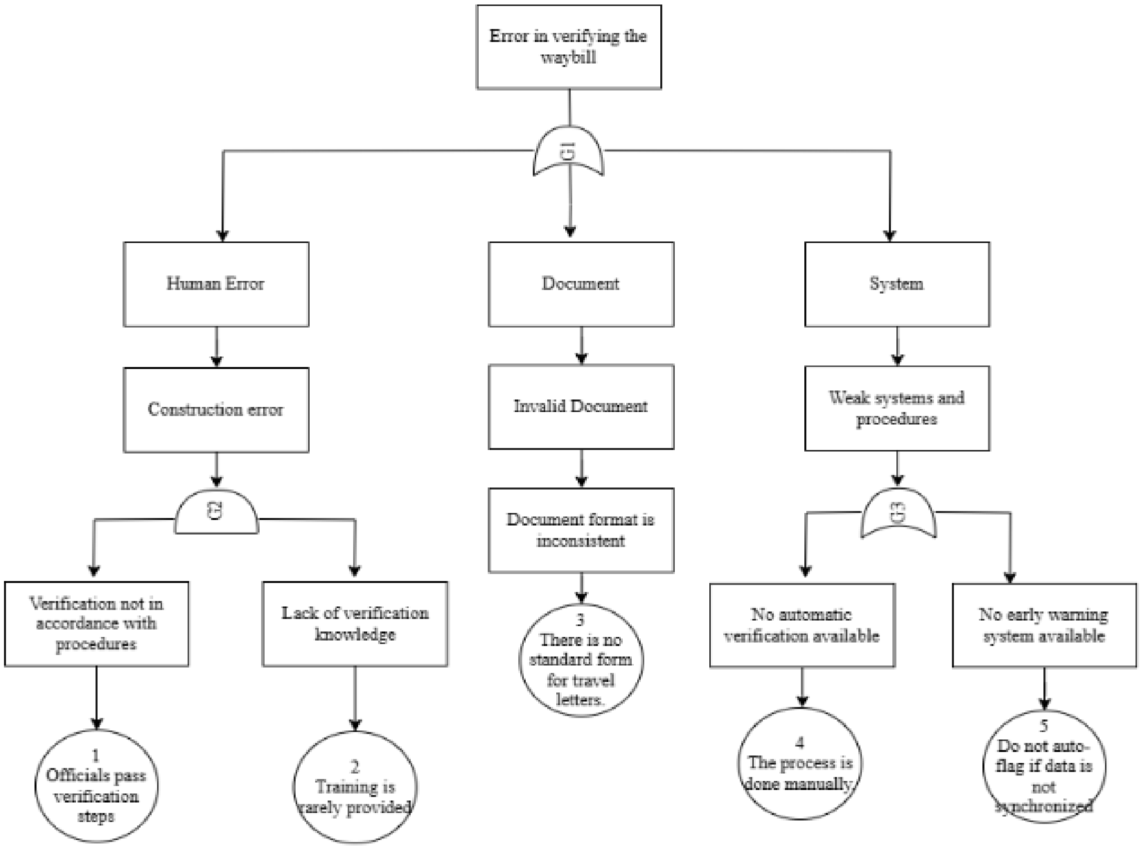

Figure 6. Fault Tree Analysis diagram to identify the root cause of the road letter verification error (Q6)

The FTA analysis identified several critical root causes across the non-conforming indicators:

a. Excessive Manual Dependency: Manual verification procedures without automated validation checks increased error probability, particularly during high-volume periods or when experienced staff were unavailable.

b. System Fragmentation: Multiple disconnected systems (DIOM, Smartlog, local databases) required manual data re-entry and lacked real-time synchronization, creating opportunities for transcription errors and information gaps.

c. Inadequate Training: Staff lacked comprehensive training on digital platform functionalities, leading to underutilization of available system features and reliance on familiar manual methods.

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d. Absence of Standardized SOPs: Work procedures were not fully documented or consistently implemented across shifts and personnel, resulting in process variation and inconsistent quality outcomes.
e. Limited Supervisory Oversight: Insufficient monitoring mechanisms and delayed exception detection allowed errors to propagate through subsequent process stages before identification.

These root causes formed the basis for designing targeted BPI interventions in the To-Be process model.

3.5. Business Process Simulation Results

Process simulation was conducted using Bizagi Modeler to quantitatively compare As-Is and To-Be process performance. Table 2 presents the simulation results showing measurable time efficiency improvements.

Table 2. Business Process Simulation Results

Process	As-Is Time	To-Be Time	Efficiency
Receipt of Factory Goods to Warehouse	7 days 23 hours 30 minutes	7 days 17 hours 59 minutes	2.41%
Warehouse Goods Delivery to Customer	12 hours 54 minutes	10 hours 30 minutes	17.61%

The simulation results demonstrated that the To-Be receiving process achieved a 2.41% reduction in total cycle time (from 10,410 to 10,159 minutes), while the delivery process showed a more substantial 17.61% improvement (from 774 to 637.07 minutes). These improvements were attributed to specific BPI interventions: automated document generation eliminating manual creation time, system-integrated approvals removing email-based delays, real-time validation reducing rework cycles, digital workflows eliminating physical document routing, and optimized task sequencing minimizing idle time.

This study's findings provide empirical evidence for the effectiveness of integrating Quality Evaluation Framework, Root Cause Analysis, and Business Process Improvement methodologies in optimizing distribution logistics operations. The comprehensive evaluation revealed five critical non-conforming quality indicators at DC Bali, each representing distinct operational vulnerabilities that collectively undermined distribution efficiency and reliability.

3.6. Interpretation of Key Findings

The road letter verification errors (Q6) and product delivery inaccuracies (Q22) identified through QEF evaluation reflect a pattern consistent with findings from previous logistics research. [Similar to the study by Sutandi (2020) [15], which documented verification failures in municipal waste logistics due to manual procedures, this research confirmed that human-dependent verification processes are inherently vulnerable to error, particularly under time pressure or high transaction volumes.] The 2 errors per month rate, while seemingly modest, translates to approximately 3% of monthly transactions, a failure rate that compounds across the distribution network and erodes customer trust.

The root cause analysis revealed that these errors stemmed primarily from system fragmentation and procedural gaps rather than individual performance issues. This finding aligns with Nugraha et al.'s (2020) [13] research on telecommunications project processes, which similarly identified disconnected systems and inadequate SOPs as primary contributors to operational failures. The absence of automated validation checkpoints meant that errors introduced at document creation stages propagated undetected through subsequent process steps, consistent with error amplification theory in supply chain management [25].

The residual product inspection failures (Q23) and LHPH documentation errors (Q26) expose weaknesses in end-of-process controls and reporting mechanisms. Prior research by Yananto et al. (2021) [14] in manufacturing distribution contexts documented analogous challenges where final verification steps were treated as formalities rather than critical quality gates. Our FTA analysis confirmed that inadequate supervisory oversight, combined with time pressures at shift conclusions, created conditions where these final checks were rushed or abbreviated, allowing discrepancies to escape detection.

3.7. Effectiveness of BPI Interventions

The quantitative simulation results demonstrate that strategic process redesign can achieve meaningful efficiency improvements even in already-operational systems. The 17.61% time reduction in delivery operations represents approximately 2.3 hours saved per delivery cycle—translating to capacity for 2-3 additional deliveries daily without additional resources. Over annual operations, this efficiency gain equates to substantial cost savings and service capacity expansion. Compared to similar studies, these results are consistent with established BPI outcomes in distribution contexts. Sunoto's (2020) [9] evaluation of academic business processes using BPI achieved 15% efficiency improvements, while Saragi's research (referenced in the original manuscript) documented up to 20% gains in public service distribution. Our findings fall within this range, suggesting that the integrated QEF-RCA-BPI approach yields comparable benefits across diverse operational contexts.

Notably, the receiving process showed more modest improvement (2.41%) compared to delivery operations. This differential outcome can be explained by examining the nature of constraints in each process. Receiving operations are partly constrained by external factors—factory production schedules, transportation logistics, and supplier coordination—which limit the impact of internal process optimization alone. Conversely, delivery operations are predominantly under internal control, making them more responsive to workflow redesign, automation, and procedural standardization. This distinction is consistent with constraint theory [26], which posits that improvement efforts yield the greatest returns when targeted at internally-controlled bottlenecks.

3.8. Critical Role of System Integration

A key finding of this research is the transformative impact of system integration on process reliability. The To-Be model's incorporation of seamless data flow between Smartlog, SAP, and OTM platforms addresses what Haerudin and Devianto (2023) [2] identified as the "integration imperative" in modern supply chain operations. By eliminating manual data re-entry and enabling real-time visibility, integrated systems reduce both error rates and cycle times while improving decision-making quality. However, our research also reveals that technology implementation alone is insufficient without complementary organizational changes. The identified root cause of "inadequate training" highlights that system capabilities remain underutilized without systematic capacity building. This finding resonates with socio-technical systems theory [27], which emphasizes that optimal performance requires alignment between technical infrastructure and human competencies, work practices, and organizational culture.

3.9. Methodological Contributions

From a methodological perspective, this study demonstrates the value of sequential, integrated analytical approaches in business process research. The QEF provided objective performance baselines and identified priority areas, the FTA systematically traced symptoms to root causes, and BPI translated insights into actionable redesign strategies—each method compensating for limitations of the others. This integrated framework offers advantages over single-method approaches. Studies relying solely on process modeling (e.g., Fathah and Santoso, 2023 [1]) can document current states but struggle to prioritize improvement targets. Conversely, research focused exclusively on problem identification without structured improvement design (e.g., Hisbullah et al., 2023 [3]) may diagnose issues without enabling implementation. By systematically linking evaluation, diagnosis, and redesign, this study provides a complete improvement cycle adaptable to various organizational contexts.

3.10. Limitations and Contextual Considerations

Several limitations warrant consideration when interpreting these findings. First, as a single case study, the research focuses on one distribution center within a specific industry context, which may limit direct generalizability to other sectors or operational scales. However, the detailed methodological

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documentation enables analytical generalization—other organizations can adapt the framework to their specific contexts while expecting similar types of insights and improvement opportunities. Second, the simulation-based performance estimates, while grounded in empirical data, represent projected rather than actual post-implementation outcomes. Real-world implementation may encounter challenges not fully captured in simulation models, such as change resistance, learning curves, or unforeseen technical issues. Longitudinal research tracking actual performance following implementation would strengthen causal claims about improvement effectiveness. Third, this study focused primarily on efficiency and reliability metrics, giving limited attention to other quality dimensions such as flexibility, resilience, or sustainability. Future research could expand the QEF framework to incorporate these broader performance considerations, particularly as environmental and social sustainability become increasingly critical in logistics operations [28].

3.11. Practical Implications

For distribution center managers and logistics professionals, this research offers several actionable insights:

a. Systematic Diagnosis Before Intervention: The QEF-RCA sequence demonstrates the importance of rigorous problem identification before solution design. Ad hoc improvements without understanding root causes risk addressing symptoms rather than underlying issues.
b. Integration as a Strategic Priority: System fragmentation emerged as a primary driver of inefficiency. Organizations should prioritize integration initiatives that enable seamless data flow and real-time visibility over point solutions addressing individual process steps.
c. Balance of Automation and Oversight: While automation reduces errors and cycle time, the study revealed that certain verification points require human judgment. Optimal process design balances automated efficiency with strategic human oversight at critical control points.
d. Training as Enabler: Technology investments yield returns only when accompanied by comprehensive training programs, ensuring staff can effectively utilize available capabilities.
e. Documentation and Standardization: The root cause analysis highlighted that inconsistent procedures across shifts and personnel undermined quality. Digital SOPs with embedded controls provide both guidance and accountability mechanisms.

3.12. Theoretical Implications

This research contributes to business process management theory by demonstrating how established frameworks can be adapted and integrated for emerging market contexts where operational maturity may vary, and resource constraints influence implementation strategies. The successful application of QEF, RCA, and BPI in an Indonesian logistics setting extends the empirical foundation for these methodologies beyond their predominantly Western origins. Additionally, the study provides evidence for the complementarity of diagnostic and prescriptive methodologies in process improvement research. The sequential application of QEF (descriptive evaluation), FTA (causal analysis), and BPI (normative redesign) illustrates how different analytical lenses can be systematically integrated to produce comprehensive, actionable insights—a methodological contribution with applicability beyond the specific case examined.

4. Conclusion

This research systematically evaluated and improved distribution business processes at AMDK Company's Distribution Center in Bali through the integrated application of the Quality Evaluation Framework (QEF), Root Cause Analysis (RCA), and Business Process Improvement (BPI) methodologies. The QEF-based evaluation identified five non-conforming quality indicators that failed to meet organizational targets: road letter verification errors (Q6: 2 errors/month vs. 0 target), product delivery inaccuracies (Q22: 2 errors/month vs. 0 target), residual product inspection failures (Q23: 1 error/month vs. 0 target), LHPH documentation errors (Q26: 1 error/month vs. 0 target), and LHPH submission delays (Q28). These deficiencies reflected systemic weaknesses in process reliability and time efficiency. Root Cause Analysis using Fault Tree Analysis revealed that these failures stemmed from five primary factors: excessive manual dependency in verification and documentation processes, system fragmentation preventing seamless data flow, inadequate staff training on digital platforms, absence of standardized and consistently implemented SOPs, and limited supervisory oversight enabling error propagation.

Based on these diagnostic insights, a comprehensive To-Be process model was designed, incorporating automated validation mechanisms, integrated system architecture (Smartlog-SAP-OTM), digital documentation workflows, standardized digital SOPs, and enhanced monitoring capabilities. Simulation-based validation demonstrated measurable improvements: a 17.61% time reduction in delivery operations (from 774 to 637.07 minutes) and a 2.41% improvement in receiving processes (from 10,410 to 10,159 minutes). This study contributes to business process management literature in three primary ways. First, it demonstrates the effectiveness of integrating QEF, RCA, and BPI methodologies into a coherent analytical framework, providing empirical evidence that sequential application of these complementary approaches yields comprehensive diagnostic and prescriptive insights. Second, the research extends the empirical foundation for these methodologies to Indonesian logistics contexts, addressing the limited representation of emerging market cases in business process research. Third, the detailed methodological documentation provides a replicable template for researchers and practitioners seeking to apply similar frameworks in comparable operational settings.

For management of AMDK Company and similar distribution organizations, this research offers evidence-based recommendations such as implement comprehensive digital systems throughout distribution processes, prioritizing verification and reporting stages where manual procedures currently create vulnerability to errors, strengthen staff training programs related to information systems such as Smartlog and SAP to ensure technology investments translate into operational improvements, develop and enforce standardized digital SOPs that embed quality controls and provide real-time visibility into process compliance, prioritize system integration initiatives to eliminate data re-entry requirements and enable seamless information flow across departments and establish systematic performance monitoring using KPI dashboards aligned with QEF dimensions to enable early detection of quality deviations.

This research acknowledges several limitations that contextualize the findings. First, as a single case study focused on one distribution center, the results reflect specific organizational characteristics that may not directly generalize to other contexts. Second, the performance improvements were estimated through simulation rather than measured through actual post-implementation assessment, meaning real-world outcomes may vary due to implementation challenges, learning curves, or unforeseen factors. Third, the study focused primarily on efficiency and reliability dimensions, with limited attention to other quality aspects such as flexibility, customer satisfaction, or environmental sustainability. Several avenues for future research emerge from this study. Longitudinal research tracking actual performance outcomes following implementation of the proposed improvements would strengthen causal claims about effectiveness and identify implementation challenges. Comparative studies examining multiple distribution centers across different industries or geographic regions would enhance generalizability and reveal contextual factors influencing improvement outcomes. Research expanding the QEF framework to incorporate emerging priorities such as environmental sustainability, supply chain resilience, and digital maturity would address increasingly critical performance dimensions. Finally, investigation of change management factors, including organizational culture, leadership support, and employee engagement that influence the success of process improvement initiatives, would complement the technical focus of this study.

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