Evaluation of the Quality Performance of A Batangas-Based Manufacturing Company: Basis for Improvement and Management Initiatives

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ABSTRACT

Quality performance management remains a critical challenge in high-mix, low-volume (HMLV) aerospace manufacturing due to product complexity, process variability, and stringent customer requirements. This study examined the quality performance of a Batangas-based aerospace manufacturing company over two years (2023–2024) using four key performance indicators (KPIs): Defects per Unit (DPU), First Pass Yield (FPY), Customer Rejection Rate in Parts per Million (PPM), and Nonconformity Closure Rate measured through Turnaround Time (TAT). An explanatory sequential mixed-method design was employed, wherein quantitative trend analysis was conducted first to identify performance patterns, followed by qualitative inquiry to explain the observed trends. Quantitative results revealed a declining trend in DPU and PPM, indicating improvements in internal and external quality outcomes, while FPY showed gradual improvement with intermittent instability linked to supplier-related issues. In contrast, TAT exhibited an increasing trend, reflecting delays in nonconformity resolution. Qualitative findings, derived through inductive thematic analysis of focus-group discussions with quality manager, quality supervisor, quality engineer, and quality inspector, identified product and process complexity, documentation gaps, compliance-driven use of quality tools, supplier dependency, and unclear defect ownership as key challenges influencing quality performance outcomes. The integration of quantitative and qualitative findings demonstrated that while preventive quality controls contributed to defect reduction, systemic constraints within governance, supplier coordination, and cross-functional accountability limited responsiveness in resolving nonconformities. Based on these findings, the study proposed an integrated quality performance enhancement and sustainability framework grounded in the philosophies of Total Quality Management (TQM), Theory of Constraints (TOC), Organizational Development (OD), and the CIPP evaluation model to support sustained quality improvement. The study contributes managerial insights for improving quality performance in HMLV manufacturing environments by emphasizing the importance of data-driven analysis complemented by contextual, human-centered understanding.

Keywords: Quality performance, HMLV manufacturing, explanatory sequential mixed methods, DPU, FPY, PPM, turnaround time TAT, aerospace manufacturing.

INTRODUCTION

Quality performance is the key to attaining high product quality. According to Pitagorsky (2022), in achieving quality performance and results, the value of performance or the work essential to deliver results

and the quality of the upshot or a service or a produce are closely linked. Every result is the outcome of performance or a process. High-quality presentation delivers high-quality products. The method is the key, if it is a decent one, its kinds sure that quality is distinct and commonly understood by stakeholders and that "critical assessment" is finished with positive defiance. Performance excellence can be demarcated in terms of error or defect rates and productivity. Product quality, in terms of measurable attributes such as flexibility, duration, reliability, and customer satisfaction. Service quality can be stated with parameters for response time, customer satisfaction, etc.
According to Coleman, L. B. Sr. (2020), Quality Assurance (QA) and Quality Control (QC) are two terms that are often used interchangeably. QC can be defined as "part of quality management focused on fulfilling quality requirements." While QA relates to how a process is performed or how a product is made, QC is more the inspection aspect of quality management. An alternate definition is "the operational techniques and activities used to fulfill requirements for quality." QC is a systematic process of inspection aimed at ensuring products meet specified requirements and are free from nonconformities.

Research Questions

1. What is the trend of the Quality performance of the Batangas-based Manufacturing company for the past two years in terms of:
   a. Defect per Unit (DPU)
   b. First Pass Yield (FPY)
   c. Customer rejection rate in terms of Parts per Million (PPM)
   d. Nonconformity closure rate in terms of Turnaround Time (TAT)
2. What are the challenges encountered by QC inspectors in achieving a quality performance target in terms of:
   a. Defect per Unit (DPU)
   b. First Pass Yield (FPY)
   c. Customer rejection rate in terms of PPM
   d. Nonconformity closure rate in terms of TAT
3. What improvement initiatives can be proposed to achieve enhanced quality performance?

METHODOLOGY

This study employed an ***explanatory sequential mixed-method*** research design. In this approach, quantitative data analysis is conducted first to identify performance patterns and trends, followed by qualitative investigation to explain and contextualize the quantitative findings. The mixed-method design enables the development of actionable insights and improvement initiatives based on both measurable outcomes and qualitative insights. This design is appropriate when numerical trends require further interpretation to understand underlying causes, particularly in complex organizational settings (Creswell & Plano Clark, 2017).

Research Design

A quantitative data analysis is conducted first to identify performance patterns and trends, followed by qualitative investigation to explain and contextualize the quantitative findings. The design was selected because quality performance indicators provide objective measurements of operational outcomes, but they cannot fully explain the organizational or process-related factors contributing to these outcomes. The qualitative phase therefore allowed deeper exploration of the challenges experienced by quality personnel.

Research Locale

The study was conducted in a **Batangas-based aerospace manufacturing company** specializing in aircraft cabin monument production under an HMLV manufacturing environment.

Data Analysis

The approach begins with quantitative data analysis, which provides an objective foundation by evaluating key performance indicators (KPIs) such as DPU, FPY, Customer Rejection Rates, PPM, and Nonconformity Closure TAT. These quantitative findings are then followed by a qualitative analysis phase, where focus-group discussions with key data sources are conducted to interpret and explain the quantitative results.

For the quantitative data analysis, historical performance metrics DPU, FPY, customer rejection rates PPM, and Nonconformity Closure TAT are extracted from the company's repository for the past two years. Trending analysis is employed to identify trends and problematic areas affecting quality performance. This analysis establishes the foundation for the subsequent qualitative phase by identifying which areas need further exploration.

The qualitative phase seeks to explain why certain quality issues (identified in the quantitative phase) have emerged. Key stakeholders – manager, supervisor, engineer, and inspector – provided in-depth insights through focus-group discussion. The discussion outcome undergoes ***inductive thematic analysis*** to extract common themes. These themes focused on operational challenges, process inefficiencies, and constraints that contribute to the high defect rates, lower yields, or extended nonconformity closure times identified during the quantitative analysis.

The qualitative findings were integrated into the quantitative results to provide a rounded explanation of how and why certain quality challenges exist (refer to Table 1). The focus group discussion helps interpret anomalies and offer practical, experience-based issues. Themes emerging from the qualitative data lead to the formulation of concrete improvement initiatives aimed at optimizing quality control processes, reducing DPU, improving FPY, and minimizing TAT for the new products. It ensures that the study gathers contextual explanations and actionable improvements from those directly involved in production and quality control.

Table 1: Data Analysis Matrix

Research Question	Data to be Gathered	Method of Analysis	Research Type
RQ1: What is the trend of the quality performance of Batangas-based Manufacturing Company over the past two years in terms of DPU, FPY, Customer Rejection Rate, and Nonconformity Closure Rate (TAT)?	Secondary Data: Historical performance metrics (DPU, FPY, customer rejection rate, TAT) from the repository over the past two years.	Trend Analysis	Quantitative
RQ2: What are the challenges faced by QC inspectors in achieving quality performance targets in terms of DPU, FPY, Customer Rejection Rate, and Nonconformity Closure Rate (TAT)?	Primary Data: Focus-group discussion data from key data sources (quality manager, quality supervisor, quality engineer, and QC inspector.	Inductive Thematic Analysis	Qualitative
RQ3: What improvement initiatives can be proposed to enhance quality performance?	-	-	-

RESULTS AND DISCUSSION

The study presents quantitative results derived from the trend of key quality performance indicators, namely DPU, FPY, Customer Rejection Rate in terms of PPM, and Nonconformity Closure Rate in terms of TAT. The trend from 2023 to 2024 represented per quarter of the year; data was taken as the average per quarter to summarize and downsize the analysis. Trend analysis makes it possible to translate empirical data and past behaviors into actionable knowledge, so that businesses can make decisions grounded in evidence rather than intuition and conjecture (Schwarz, 2024). In practice, the KPI target is provided by the top management team, generated from the yearly goal alignment. The aim is to improve its KPI's at about thirty percent year-on-year – some of the KPI targets vary depending on the agreed possible target that can be attained for the year.

The study presents the qualitative findings obtained through ***inductive thematic analysis*** from focus-group discussions. These phases focus on identifying operational, human, and organizational challenges that explain the observed trend. The use of inductive thematic analysis allows themes to emerge directly from data source experiences, thereby providing contextual depth and explanatory insight into quality performance variations. This analysis is grounded in the data, which means that the themes emerge directly from the data set without being influenced by the researcher's preconceived notions or theoretical commitments. This approach ensures that the analysis remains closely connected to the data, yielding nuance and insights (ATLAS.ti, n.d.).

The study concludes with integration and discussion of findings, where quantitative results are examined collectively and interpreted using established quality and management frameworks, including TQM, TOC, CIPP evaluation model, and OD intervention. This integrative discussion supports the development of evidence-based, management-oriented quality improvement initiatives directly addressing the study's research questions.

The Trend of the Quality Performance of a Batangas-Based Manufacturing Company Over the Past Two Years

The result was analyzed using trend analysis, in line with the study's objective to identify performance patterns and assess the company's progress in meeting quality targets. According to Schwarz (2024), trend analysis is a systematic process that uses statistical techniques to identify historical patterns and project future outcomes based on that data. It provides an overview of the company's operational efficiency, process stability, and capability to meet internal and customer quality expectations. Tabulated and presented in a bar graph to provide a ***time-series in a linear trend*** (Schwarz, 2024).

(a) The trend of the quality performance of a Batangas-based manufacturing company over the past two years in terms of DPU.

DPU quantifies the average number of defects present in a sample of produced goods, providing a clear and concise representation of the quality and consistency of a manufacturing process (SixSigma.us, 2024). DPU is the defect detected on the cabin monument assembly upon quality inspection. These are nonconformities in terms of not meeting the intended design, cosmetic issues, and other imperfections.

Quarterly average shows that the process experienced fluctuations in DPU performance during the two-year period of operations. The first half of 2023 reflected higher DPU values Upon verification of the issues encountered in the areas where the DPU target was not met, which are Q1 and Q2 of the year 2023 (refer to Table 2 and Figure 2), it was found to have multiple constraints. Process complexity due to high product variety; the missed-out process was rooted in not incorporating a detailed process in work instruction, and the incorrect sequence in assembly. This complexity reduces process stability, increases inspection difficulty, and heightens the likelihood of defects, rework, and longer turnaround times (Build AM Tech., n.d.). Documentation complexity causes lack of standardization; the transaction was not executed as the system allows assembly to pass through, which was only detected upon inspection of the assembly on succeeding process. Documentation complexity increases inspection time, delays approvals, and contributes to the defect count as the assembly cannot be validated in accordance with design requirements. Lack of standardized work further exacerbates process variability (Juran & Godfrey, 1999). A vigorous downward trend was observed toward 2024, signifying improvements in process accuracy, standardizations, and operators' proficiency. According to Schwarz (2024), A downward trend can signal improved efficiency and cost management within a company, potentially leading to higher profit margins. The decreasing DPU trend implies continuous improvement actions, the EWI team's initiation to update work instructions and generate an assembly sequence that mitigates multiple assembly processes as a corrective action. QC line inspection, check sheet provision, MES data collection, and standardization of work order closure were initiated through CAB Report discussion. The reduction over time signifies the growing effectiveness of Quality management interventions, aligned with Lean Manufacturing's focus on minimizing waste and variability (Kumar et al., 2022). The company's effort contributed to fewer reoccurrences of nonconformities, reflecting Garza-Reyes et al. (2018), who found that continuous quality improvement directly correlates with improved profitability and customer satisfaction. Despite this improvement, occasional occurrences indicate that other types of variations still exist.

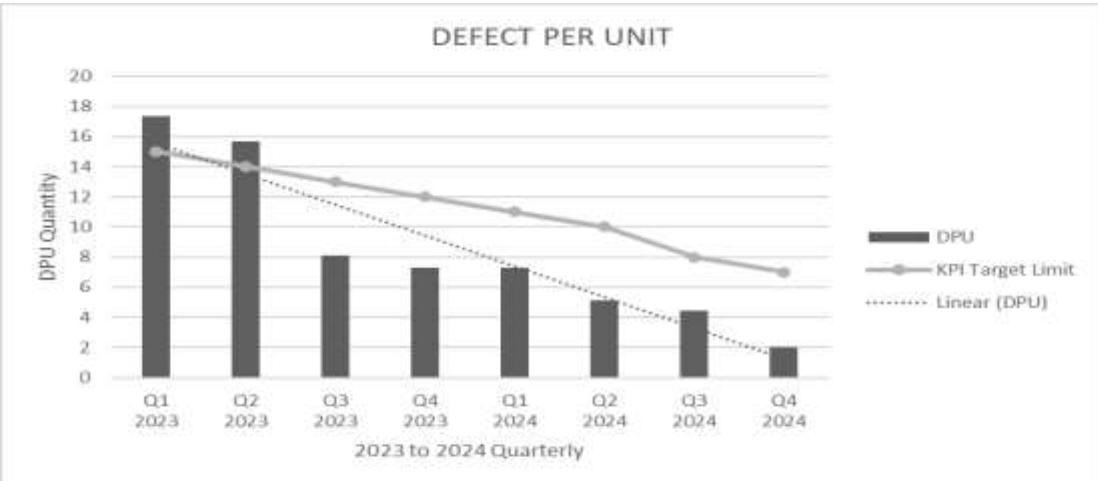

Figure 2: Defect per Unit

Table 2: Defect per Unit

2023 to 2024	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024
DPU	17	16	8	7	7	5	4	2
Target Limit	15	14	13	12	11	10	8	7
Remarks	Target Not Met	Target Not Met	Target Met	Target Met	Target Met	Target Met	Target Met	Target Met

(b) The trend of the quality performance of a Batangas-based manufacturing company over the past two years in terms of FPY.

FPY calculation is a key manufacturing metric that quantifies the efficiency and quality of production processes, calculated FPY as the ratio of the number of products that passed quality control the first time to the total number of units produced (ProcessNavigation Team, 2024). It is a key performance indicator of process efficiency and effectiveness, directly reflecting the capability of the production process to deliver conforming units on the first attempt. A higher FPY corresponds to fewer defects and a reduction in rework processing. Higher FPY translates to improved productivity and lower manufacturing costs. The FPY trend shows quarterly performance results that illustrate the manufacturing status toward meeting its KPI. The FPY data is taken from the assemblies that undergo the Acceptance Test Procedure (ATP) after the manufacturing process. This test is being carried out to verify that the assembly is compliant with electrical and mechanical functions, such as pin-to-pin electrical connectivity, plumbing system, and ventilation test. This type of test serves as a critical checkpoint for product conformance and operational validation.

The FPY data revealed a gradual upward trend from early 2023 to late 2024 (refer to Figure 3 and Table 3). Upon verification of the issues encountered on the areas where FPY target was not met – Q4 of year 2023 and Q3 of year 2024, it was found to have a common issue pertaining to supplied parts which equates to reactive quality culture, as this parts nonconformity only detected on the ATP where already installed and being tested. This relates to organizations lacking a continuous improvement mindset struggle to achieve sustained improvements (Aljubiri, 2019). These recurring issues contribute to the gradual upward trend – slow improvement. An upward trend shows a sustained increase in the value of a variable over time (Schwarz, 2024). Although improvement is slow, still considered an improvement in first-time quality rates.

FPY improved due to some improvements to sustain the process, such as the provision of a jig for pin location checking and the coordination of a supplier quality representative as an effort to improve succeeding deliveries. Apparently, due to high product variety, some of the issues recur in other program models. In an HMLV manufacturing environment, these instances reduce process stability, increase inspection difficulty, and heighten the likelihood of defects, rework, and longer turnaround times (Cosentino, n.d.). Lean Manufacturing principles emphasize that improving FPY through defect prevention reduces rework and scrap, thereby enhancing operational efficiency and lowering the CoPQ (Garza-Reyes et al., 2019).

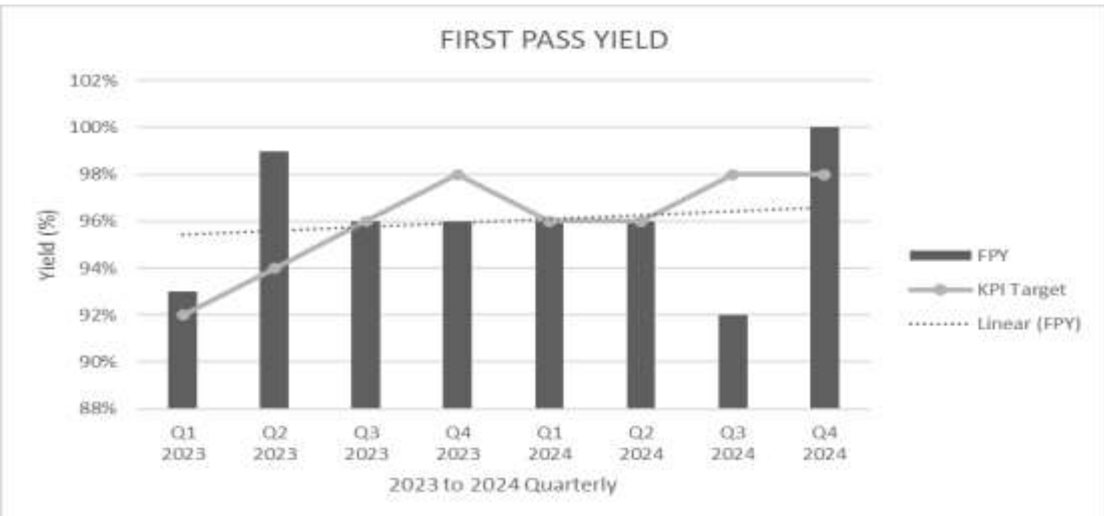

Figure 3: First Pass Yield

Table 3: First Pass Yield

2023 to 2024	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024
FPY	93%	99%	96%	96%	96%	96%	92%	100 %
Target	92%	94%	96%	98%	96%	96%	98%	98%
Remarks	Target Met	Target Met	Target Met	Target Not Met	Target Met	Target Met	Target Not Met	Targ et Met

(c) The trend of the quality performance of a Batangas-based manufacturing company over the past two years in terms of PPM.

The Customer Rejection Rate, expressed in PPM, measures the number of defective parts or products identified by the customer per one million units delivered. It serves as a critical indicator of external quality performance and reflects the effectiveness of the company's quality control processes in ensuring that only conforming products reach customers. According to Sohoify (n.d.), PPM is a simple unit of measurement that describes how many parts of a certain element (such as defects, or quality errors) exist in one million parts of the entire product or batch. It is important for manufacturing in maintaining high quality as it monitors and reduces defects – even a small defect rate can have major consequences in large-scale production. It set and met customer expectations; many industries require suppliers to stay within strict PPM limits. A lower PPM value signifies better quality performance and higher customer satisfaction.

Improvements observed during the second year (refer to Figure 4 and Table 4) are attributed to the establishment of Manufacturing Process Review (MPR), where the process is being audited and validated for its readiness. The Process Flow Diagram (PFD), Process Failure Mode and Effects Analysis (PFMEA), and Control Plan (CP) are being validated in the actual process. A key indicator of external quality performance requires a preventive, process-based quality approach rather than reliance on end-of-line inspection (Juran & Godfrey, 1999). The drastic downward trend continued through 2024, where PPM reached its lowest recorded value within the observed period. This improvement indicates the effectiveness of actions implemented.

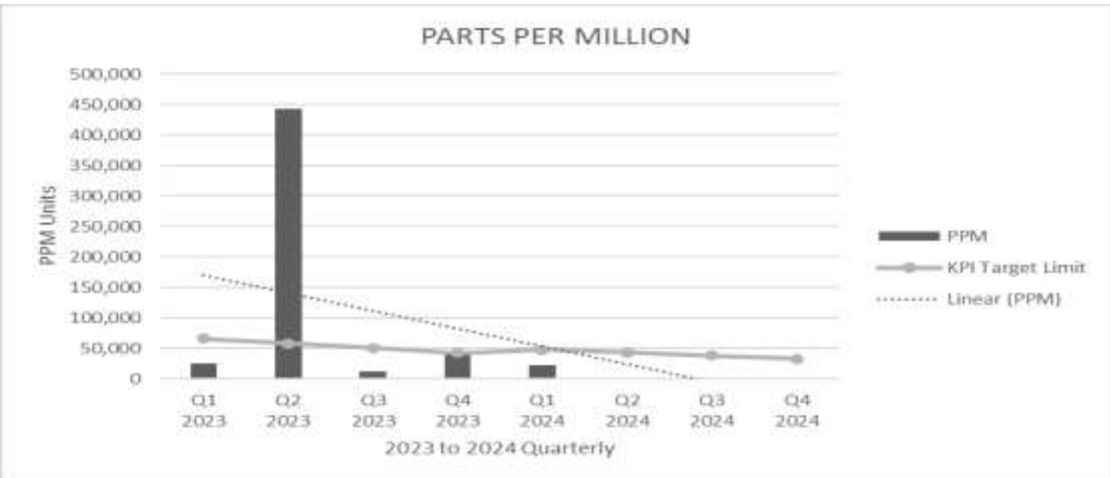

Figure 4: Parts per Million

Table 4: Parts per Million

2023 to 2024	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024
PPM	24,972	443,747	12,130	43,531	21,739	0	0	0
Target Limit	66,065	58,295	50,521	42,748	48,000	43,000	38,000	33,000
Remarks	Target Met	Target Not Met	Target Met	Target Not Met	Target Met	Target Met	Target Met	Target Met

(d) The trend of the quality performance of a Batangas-based manufacturing company over the past two years in terms of Nonconformity closure rate, TAT.

The Nonconformity Closure Rate, measured through TAT, refers to the average time taken to resolve and close quality nonconformities from the date of detection to final disposition. The date of detection is taken from the Quality Notification (QN) initiated date until its closure. The computation is the date of closure minus the date of detection in the average data. According to SixSigma.us. (n.d.), TAT is a measure of the duration between the initiation of the process and its completion. It encompasses the entire life cycle of a task; from the moment a request is submitted until the desired outcome is achieved.

The first quarter of the year 2023 doesn't contain data until May 2023, due to the implementation of TAT metrics starting at the time of SAP. The quarterly TAT data shows an alarming increase in time from Q3 of 2023 until Q3 of 2024. The early of 2023 is the SAP implementation which every user is still navigating the potential of the system. It came to maturity that the system is being utilized appropriately from Q3 of 2023 (refer to Figure 5 and Table 5). The major contributor issue identified from the data that exceeds the target is supplier issues. The average closure time was relatively long due to delays in coordinating with suppliers that resulted in poor cross-functional coordination and communication. These inefficiencies caused prolonged containment and delayed implementation of corrective actions. Delayed responses, unclear accountability, and siloed decision-making prolong issue resolution and contribute to recurring quality problems (Aziz et al.,2018).

The alarming increase in TAT indicates a weaker quality management system and poor accountability in addressing nonconformities. The action and initiatives, such as coordination with suppliers (refer to Appendix 15), proved ineffective in reducing the average resolution time. Spikes in TAT were recorded during peak production months and when a new product or model is running. Some of the issues that contribute to this peak are those parts that require external validation (supplier issues). These cases highlight the inherent challenge of maintaining rapid closure cycles in a highly customized manufacturing environment. A shorter TAT enhances overall operational efficiency by minimizing production disruptions and preventing the recurrence of known issues (Juran & Godfrey, 1999).

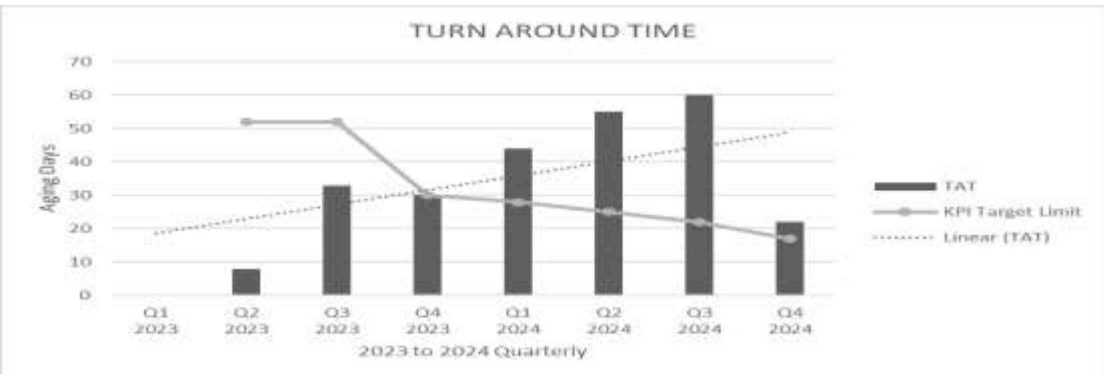

Figure 5: Turn Around Time

Table 5: Turn Around Time

2023 to 2024	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024
TAT	-	8	33	30	44	55	60	22
Target Limit	-	52	52	30	28	25	22	17
Remarks	-	Target Met	Target Met	Target Met	Target Not Met	Target Not Met	Target Not Met	Target Not Met

(e) Synthesis of the quality performance trend of a Batangas-based manufacturing company over the past two years in terms of its identified KPI, which are DPU, FPY, PPM, and TAT.

The trend analysis revealed an uneven but generally improving quality performance across three out of four KPI's examined. The findings indicate that the Batangas-based manufacturing company achieved substantial improvements in both internal and external quality performance, particularly in terms of DPU, FPY, and PPM. The sustained reduction in DPU and PPM reflects the effectiveness of quality management interventions, such as process standardization, enhanced inspection controls, and application of preventive action, such as MPR (refer to Table 6). Previous studies emphasize that defect prevention and process control are more effective in improving quality outcomes than reliance on post-production inspection, especially in complex manufacturing environments (Juran & Godfrey, 1999). The gradual improvement in FPY further suggests increased process capability and reduced rework, aligning with the literature that links first-pass quality to operational efficiency and cost reduction (Garza-Reyes et al., 2019).

Despite these gains, the study revealed that nonconformity closure rate in terms of TAT remains a critical weakness. Prolonged closure times were predominantly driven by supplier-related nonconformities, delayed CFT coordination, and dependency on external validations, indicating that improvements in defect prevention were not matched by equivalent enhancements in issue resolution processes. This finding is consistent with quality management literature, which cautions that ineffective corrective action systems can undermine overall quality performance by allowing known issues to persist and recur (Juran & Godfrey, 1999). From a systems perspective, these delays represent a process constraint that limits overall quality system responsiveness, as articulated in the TOC (Pacheco et al., 2018).

Table 6: Summary of Findings

KPI	Issues	Actions	Assessment
DPU	Process Complexity	Update of Work Instructions	Good vigorous downward trend
DPU	Documentation Complexity	Line Inspection and Data Collection	Good vigorous downward trend
FPY	Reactive Quality Culture	Test improvement through fixtures and coordination to supplier for improvement	Good, gradual upward trend
PPM	Documentation Complexity	Establish MPR	Good, drastic downward trend
PPM	High Product Variety	Documentation Validation	Good, drastic downward trend
TAT	Poor CFT Coordination and Communication	Coordination to supplier for improvement	Not a good upward trend

These contrasting performance patterns underscore the value of integrating quantitative trend analysis with qualitative examination of operational challenges. While trend analysis effectively identified performance improvements and emerging weaknesses across KPIs, qualitative insights were essential in explaining the underlying causes of the trends, particularly those related to organizational processes and supplier interactions. This complementary use of methods validates the adoption of an explanatory sequential mixed-method design, which is widely recommended when quantitative results require contextual explanation to inform actionable managerial decisions (Creswell & Plano Clark, 2018).

The Challenges Encountered by QC Inspectors in Achieving a Quality Performance Target in Terms of DPU, FPY, PPM, and TAT

Qualitative data gathered from QC management to identify patterns of challenges that influence quality performance. Inductive thematic analysis allows themes to emerge directly from the data rather than being imposed by pre-existing theoretical categories (ATLAS.ti, n.d.). Making it particularly suitable for exploring underexamined operational issues in complex manufacturing environments. This approach enables a deeper understanding of how direct experiences explain variations observed in quantitative quality metrics.

By integrating derived themes with the observed trends in DPU, FPY, PPM, and TAT, it provides a contextual explanation of the quantitative results and supports the study's explanatory sequential mixed-method design. This integration aligns with the methodological recommendations that qualitative insights should be used to explain performance patterns and inform actionable quality improvement initiatives (Creswell & Plano Clark, 2018). The qualitative data is translated to a universal language (English) due to the mix of languages used to achieve information and issues naturally from the data source.

1. **Challenges encountered by QC Inspectors in achieving a quality performance target in terms of DPU.**

a. Inspectors are not familiar with the new product.
b. There are assemblies that are almost equivalent to two assemblies.
c. Work instruction creation cannot catch up with scheduled operations.
d. Connecting the dots logic.
e. Hard tolerance settings make it difficult to measure and attain required acceptance.

2. **Challenges encountered by QC Inspectors in achieving a quality performance target in terms of FPY**

a. FMEA was only made to comply for audit purposes, not made to resolve issues.
b. Control Plan is also not used, only provided to comply with documentation needs.

3. **Challenges encountered by QC Inspectors in achieving a quality performance target on Customer rejection rate in terms of PPM.**

a. Chemical traceability expiration and torque issues remain unresolved.
b. Lack of deep understanding of the Process Specification due to it connect the dot logic.
c. Inspection time was not followed for conformity, becoming parallel inspection.
d. Lapses in material enablement due to shortages of parts that, when installed, transactions were neglected.
e. Manufacturing Engineers are dependent on quality inspectors for disposition instead of providing it themselves.

4. **Challenges encountered by QC Inspectors in achieving a quality performance target in Nonconformity closure in terms of TAT.**
   a. QN details are incomplete, resulting in repeated back-and-forth.
   b. Defects are not identified by manufacturing engineers as truly defects.
   c. Repeated issues from suppliers.
   d. For the sake of shipment, transactions are being closed.

Synthesis of Quality Performance (DPU, FPY, PPM, and TAT)

The integrated analysis of DPU, FPY, PPM, and TAT reveals that quality performance within the Batangas-based manufacturing company is shaped by a common set of systemic, process, and organizational factors. While the quantitative data indicate substantial improvements in defect-related outcomes (DPU, FPY, and PPM), persistent inefficiencies in nonconformity resolution (TAT) highlight structural constraints within the quality management system.

Improvements in DPU, FPY, and PPM were achieved through localized process and documentation enhancements, while sustained improvements in TAT require structural and managerial interventions addressing accountability, supplier governance, and corrective action consistency. Consistent with the Theory of Constraints, the nonconformity management process functions as the system's limiting constraint, restricting overall quality responsiveness despite improvements in defect prevention (Pacheco et al., 2018). This integrated understanding validates the use of an explanatory sequential mixed-method design, wherein quantitative trends identifying performance outcomes and qualitative insights explain the underlying causes, enabling more targeted and effective quality management decisions (Creswell & Plano Clark, 2018).

Table 7: Integrated Quality Performance

KPI	Emergent Theme (Inductive)	Impact on Quality Performance
DPU	Product and Process Complexity	Increased defect occurrence due to inspector unfamiliarity, complex assemblies, and high variability during early production stages
DPU	Documentation Gaps and Unclear Work Instructions	Inconsistent inspection interpretation, missed defects, and a higher defect count.
FPY	Compliance-Driven Use of Quality Tools	Failure modes are not effectively mitigated, resulting in defects being detected after the first pass.
FPY	Non-Operational Control Plans	Weak process monitoring and late defect detection, increasing rework, and lowering FPY
FPY	Supplier-Related Nonconformities	Reduce first-pass acceptance due to incoming parts defects detected during testing.
PPM	Lack of Standardized Inspection	Customer detected defects due to parallel inspection and skipped control points.
PPM	Weak Process Specification Clarity	External quality escapes caused by the inconsistent interpretation of acceptance criteria
PPM	Ineffective Feedback Loop from FAI	Recurrence of known defects in succeeding builds, increasing customer rejection rate.
TAT	Incomplete QN Details	Delayed investigation and corrective action due to repeated clarification cycles
TAT	Unclear Defect Ownership and Decision Authority	Prolonged disposition and approval delays across functions
TAT	Supplier Dependency	Extended closure cycles due to external coordination and validation requirements
TAT	Premature Administrative Closure	Recurrence of unresolved issues, inflating average TAT

The Proposed Improvement Initiatives to Achieve Enhanced Quality Performance

Based on the integrated analysis of time-series trend and inductively derived themes, several targeted improvement initiatives are proposed to enhance overall quality performance. These initiatives are designed to address the root causes of quality performance gaps while sustaining observed gains. These initiatives are aligned with the TQM principles and TOC, ensuring both operational feasibility and managerial relevance.

1. The proposed improvement initiatives to achieve enhanced quality performance in terms of DPU.

Table 8: DPU Improvement Proposal

Issues	Improvement Initiatives	Benefit
Product and Process Complexity	Modularization and Process Decomposition	Reduced missed or late defect detection Improved process stability Lower cumulative defect occurrence per unit
Documentation Gaps and Unclear Work Instructions	Standardization and Simplification of Work Instructions	Improved compliance with process requirements Reduced variability in assembly and inspection outcomes Fewer defect attributed to misinterpretation

(a) The improvement initiatives proposed to achieve enhanced quality performance in terms of FPY.

Table 9: FPY Improvement Proposal

Issues	Improvement Initiatives	Benefit
Compliance-Driven Use of Quality Tools	Transition from Compliance-Based to Risk-Based Application of Quality Tools	Reduction in repeat defects during first-pass inspection Improved alignment between process risks and control actions Increased proportion of assemblies passing inspection without rework
Non-Operational Control Plans	Activation and Shop Floor Integration of Control Plans	Improved process discipline and consistency Reduced variability at critical control points Higher first-time acceptance rates
Supplier-Related Nonconformities	Strengthening Incoming Quality and Supplier Process Validation	Reduction in late-stage rework caused by defective supplied parts Improved material readiness and process continuity Increased stability in first-pass outcomes

(b) The improvement initiatives proposed to achieve enhanced quality performance in terms of PPM.

Table 10: PPM Improvement Proposal

Issues	Improvement Initiatives	Benefit
Lack of Standardized Inspection	Standardized Inspection Criteria Method	Reduce variability in inspection outcomes Improved detection of nonconformities before shipment Lower customer rejection rate
Weak Process Specification Clarity	Clarification and Simplification of Process Specification	Improve conformance to design intent Reduced assembly and inspection misinterpretation Lower incidence of customer-detected defects.
Ineffective Feedback Loop from FAI	Institutionalized Closed Loop Feedback Mechanism	Elimination of recurring customer rejection causes Improved process of learning and knowledge retention Enhanced consistency between prototype and production builds

(c) The improvement initiatives proposed to achieve enhanced quality performance in terms of TAT.

Table 11: TAT Improvement Proposal

Issues	Improvement Initiatives	Benefit
Incomplete QN Details	Standardization of QN Content and Submission Requirements	Reduced back-and-forth clarification cycles Faster initiation of corrective actions Shorter average closure time
Unclear Defect Ownership and Decision Authority	Clear Assignment of Defect Ownership and Decision Authority	Faster decision-making Reduced approval bottlenecks Improved accountability for issue closure
Supplier Dependency	Supplier Escalation and Response Time Agreements	Reduced waiting time for supplier feedback Improved predictability of closure cycles Enhanced supply chain accountability
Premature Administrative Closure	Elimination of Premature Administrative Closure Practices	Prevention of repeat nonconformities Reduced long-term TAT through true root cause elimination Strengthened the integrity of the quality management system

Proposed Improvement Initiatives to Achieve Enhanced Quality Performance

To sustain quality performance and drive continuous improvement, the researcher proposed a Quality Performance Enhancement and Sustainability Strategy, an integrated strategy derived from the principles of OD Interventions, TOC, TQM, and CIPP Evaluation Model. This strategy provides a comprehensive roadmap for diagnosing performance gaps, optimizing operational processes, developing workforce capabilities, and sustaining improvements that lead to long-term organizational effectiveness (refer to Figure 6). This activity is run through an OD intervention.

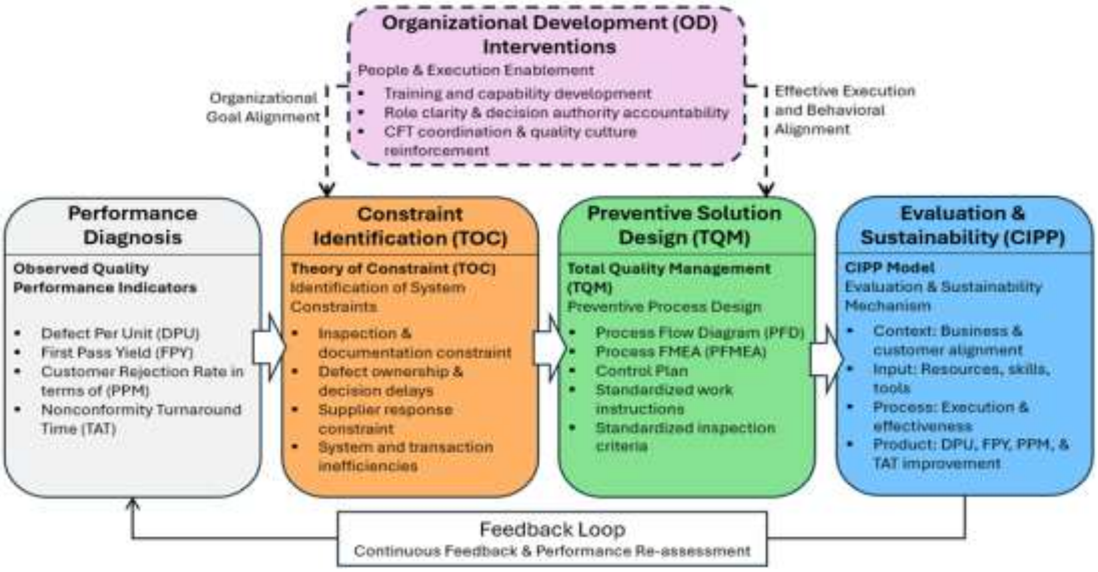

Figure 6: Quality Performance Enhancement and Sustainability Strategy

The Integrated Quality Performance Enhancement and Sustainability Strategy demonstrates that improving quality goes beyond correcting defects after they occur and instead requires strengthening the entire management system. By using performance data and trend analysis, organizations can clearly identify where quality issues exist and how they evolved over time (Schwarz, 2024). The application of

TOC focuses improvement efforts on the most critical factors limiting performance, ensuring that resources are directed where they create the greatest impact (Pacheco et al., 2018). TQM principles embedded preventive controls into processes to reduce variability and defect occurrence, while OD interventions ensure that stakeholders are aligned, capable, and accountable for executing quality systems effectively (Juran & Godfrey, 1999). Continuous evaluation through the CIPP model then ensures that improvements are monitored, aligned with organizational goals, and sustained over time (Roeder, 2020). Together, the integration of TOC, TQM, OD, and CIPP enables organizations to achieve improved quality performance in the short term while maintaining long-term operational excellence.

RESEARCH IMPLICATIONS

An explanatory sequential mixed-method design was employed, wherein quantitative data subjected to time-series trend analysis established performance patterns, followed by qualitative inductive thematic analysis to explain the underlying operational challenges experienced by QC. The integration of findings informed the development of Quality Performance Enhancement and Sustainability Strategy anchored on TOC, TQM, OD interventions, and the CIPP evaluation model.

Summary of Significant Findings, Conclusions, and Recommendations

1. **Trend of the Quality Performance of the Batangas-Based Manufacturing Company Summary**
   The trend analysis confirmed that while internal defect prevention and external customer quality improved over time, the organization's efficiency in resolving nonconformities weakened, revealing an imbalance between prevention performance and corrective response capability (Schwarz, 2024).

- Conclusion: The organization achieved measurable improvements in both internal and external customer quality, as evidenced by declining DPU and PPM values over the two-year period. Improvements in FPY were not consistently sustained, indicating residual process instability influenced by supplier-related quality variability. While TAT deteriorated, as reflected by an increasing trend, signaling the presence of governance, coordination, and decision-making constraints within the quality management.
- Recommendation: The organization should sustain and reinforce preventive quality controls that contributed to the observed reductions in DPU and PPM, particularly through continued standardization of processes and inspection practices consistent with preventive quality management principles (Juran & Godfrey, 1999). Also, strengthen supplier quality management mechanisms, including upstream validation and monitoring, to stabilize FPY performance and reduce variability caused by incoming material nonconformities. For the TAT, the organization should prioritize the reduction as a critical system constraint. Applying TOC principles to clarify governance, improve decision authority, and eliminate bottlenecks in nonconformity resolution processes (Pacheco et al., 2018).

2. **Summary of Challenges Encountered by QC Inspectors in Achieving Quality Performance Target in Terms of DPU, FPY, PPM, and TAT**
   QC faced systemic constraints rooted in process complexity, weak documentation discipline, ineffective use of quality tools, and fragmented CFT coordination. These challenges hindered the consistent achievement of quality performance targets (Juran & Godfrey, 1999).

- Conclusion: QC's ability to control DPU and PPM was constrained by product complexity and unclear inspection and process documentation. While FPY performance was undermined by non-operational use of preventive quality tools, limiting their role in defect prevention. TAT performance deteriorated due to unclear accountability, incomplete defect information, and dependence on supplier response validation. The challenges encountered were systemic rather than individual, indicating process and governance weaknesses within the quality management system.

- Recommendations: Simplify and standardize inspection related documentation, including work instructions and quality criteria, to reduce ambiguity and inspection variability. Repositioning PFMEA and control plan as operational tools, ensuring their active use in identifying and mitigating defect risks rather than serving purely for compliance purposes (Juran & Godfrey, 1999). Also, clarifying defect ownership and decision authority, particularly for supplier-related nonconformities, to reduce delays and improve TAT performance. Strengthening the CFT coordination mechanism between quality, manufacturing engineering, and supply chain to address recurring issues more effectively (Aziz, 2018).

3. **Summary of Improvement Initiative Proposed to Achieve Enhanced and Sustainable Quality Performance**
   Effective quality improvement requires an integrated approach that combines process control (TQM), constraint management (TOC), organizational alignment (OD), and continuous evaluation (CIPP) to ensure both short-term performance gains and long-term sustainability.

- Conclusion: Quality performance improvements are most effective when preventive controls are embedded at the process level, as evidenced by declining DPU and PPM. Sustainability of FPY improvements requires upstream stabilization, particularly in supplier quality and risk management practices. TAT represents a system-level constraint that limits overall quality performance and must be addressed to balance prevention and correction capabilities. A fragmented improvement approach is insufficient; an integrated quality performance strategy is necessary to sustain gains over time.
- Recommendations: Institutionalize preventive quality practices, including validated PFD, PFMEA, and control plans, to further reduce DPU and stabilize FPY (Stamatis, 2019). Apply TOC to identify and elevate TAT as a critical bottleneck, ensuring focused improvement efforts where system impact is greatest (Roeder, 2020). Enhance organizational alignment through OD interventions, such as role clarification, capability building, and accountability reinforcement, to improve CFT execution (Cosentino, n.d.). Adopt the CIPP evaluation model to continuously assess the context, inputs, processes, and outcomes of quality initiatives, ensuring that improvements remain effective and relevant over time (Stufflebeam, 2023).

Ethical Considerations

The researcher obtained ethical approval from the company's management to ensure that the study aligns with the company's policies and standards. Data sources in the qualitative phase of the study are provided with a consent form that includes a clear explanation of the study's goal and what the research aims to achieve. To protect data source information, privacy, and to ensure that personal and sensitive information is not disclosed without permission. The study considered assigning codes to data sources instead of using their real names in data records and reports.

Results were presented in aggregated form, avoiding any specific details that could potentially reveal the identities of the data source. Data was retained only for the duration necessary to achieve the research objectives. Researchers regularly review and adhere to ethical guidelines and seek advice from ethics committees or oversight bodies if ethical issues arise. The citations were updated considering the works of the other authors. APA style was used in this research.

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