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An Integrated SLP, S&OP, and 5S Approach to Improve Order Fulfillment in a Polyester Fiber Warehouse

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Abstract

This paper analyzes order fulfillment performance in the finished goods warehouse of Gexim S.A.C., a Peruvian company dedicated to the production of plastic monofilaments, where operational inefficiencies were identified related to an inadequate warehouse layout, lack of standardization, and misalignment between demand planning and logistics operations. Based on an initial diagnosis, an OTIF (On-Time In-Full) level of 89.5% was observed, mainly affected by excessive travel distances and long picking times, which resulted in a significant annual economic impact. To address these gaps, this paper proposes an integrated approach combining workplace organization tools (5S), layout design through Systematic Layout Planning (SLP), and aggregate planning via Sales and Operations Planning (S&OP) within a unified methodological framework. The effectiveness of the proposed approach was evaluated using discrete-event simulation in Arena, allowing a comparison between As-Is and To-Be scenarios. The results show a 40% reduction in picking times, compliance levels above 90% in order and cleanliness standards, a substantial improvement in 5S audit results to 72.53%, and a 95% alignment between demand and inventory. The findings demonstrate that the joint and coordinated application of layout, standardization, and planning tools significantly improves order fulfillment performance in industrial environments, highlighting the value of integrated approaches in warehouse management.

Keywords
Warehouse management; Systematic Layout Planning; 5S; Sales and Operations Planning; Discrete-event simulation

1. Introduction
The plastics industry, part of the non-primary manufacturing sector in Peru, has exhibited volatile behavior in recent years due to external factors, including the COVID-19 pandemic, which in 2020 reduced normal sector operations to only 19% of companies (Ministry of Production, 2021). However, the economic recovery process allowed for gradual improvement during 2021 and 2022. According to the National Institute of Statistics and Informatics (INEI, 2022), more than 81% of companies in this sector are concentrated in Lima Metropolitan Area, highlighting a high degree of geographic centralization and significant pressure on the operational efficiency of their logistics systems. Additionally, the plastics industry plays a strategic role by providing essential inputs to sectors such as packaging, construction, and consumer goods (National Society of Industries, 2023).

Despite its economic relevance, the sector faces structural challenges that affect its competitiveness. The trade balance of plastic products has been consistently negative; in 2021, imports reached USD 2,430 million compared to exports of USD 442 million, generating a deficit close to USD 2,000 million (SUNAT, 2022). This dependency on imported inputs, coupled with increasing environmental requirements related to solid waste generation, increases the need to optimize logistics and warehousing processes to reduce costs, improve service levels, and move towards more sustainable operations.

In this context, a diagnosis carried out at the finished goods warehouse of Gexim S.A.C. identified the main gap as the low performance of the OTIF (On Time in Full) indicator. The observed fulfillment level was 89.5%, 4.5 percentage points below the sector standard of 94% reported by Espinoza Freire (2020). This deviation reflects deficiencies in the timeliness and completeness of shipments, mainly associated with excessive travel distances, long picking times, and lack of standardization in warehouse operations. As a result, unnecessary inventory accumulation occurs, order fulfillment is delayed, and logistics flow is less efficient. The impact of these inefficiencies translated into an estimated annual economic loss of PEN 410,587.32, equivalent to 8.8% of polyester fiber sales. This impact includes losses from unfulfilled sales, higher operational costs, and additional expenses resulting from inefficient warehouse management. These findings highlight the need to implement structured solutions to improve order fulfillment performance and reduce associated extra costs.

To address these challenges, this study proposes an integrated approach that combines workplace organization tools (5S), layout design using Systematic Layout Planning (SLP), and aggregate planning through Sales and Operations Planning (S&OP), coordinated within a unified methodological framework. Unlike previous research that applies these tools separately, this study demonstrates their joint application, enabling simultaneous improvements in space organization, operational flow efficiency, and alignment between demand and inventory. This integration creates a synergistic effect, particularly relevant in industrial warehouses with high operational volumes, where isolated improvements may not lead to overall performance gains. The proposed approach is validated through discrete-event simulation in Arena, providing quantitative evidence of its impact on warehouse performance and demonstrating the value of integrated methods for industrial warehouse management.

1.1 Objectives

1.1.1 General Objective

To improve the order fulfillment level (OTIF) and operational efficiency of the finished goods warehouse through the integrated application of 5S, Systematic Layout Planning (SLP), and Sales & Operations Planning (S&OP).

1.1.2 Specific Objectives

- Reduce picking times by reorganizing the warehouse layout using the SLP methodology.
- Enhance orderliness, cleanliness, and standardization of operational activities through the implementation of 5S.
- Improve alignment between demand, inventory, and storage capacity by incorporating the S&OP process.

1.2 Research Questions

- RQ1: To what extent does the integration of 5S, SLP, and S&OP improve order fulfillment (OTIF) and operational efficiency in the finished goods warehouse of the plastics sector?
- RQ2: How does the warehouse layout redesign using Systematic Layout Planning (SLP) impact on the reduction of picking times and the optimization of internal routes compared to the current layout?
- RQ3: Does the implementation of the S&OP process improve forecast accuracy, reduce warehouse congestion, and ensure operational consistency as evaluated through discrete-event simulation in Arena?

2. Literature Review

The specialized literature on warehouse management consistently indicates that operational performance improvements require integrated approaches combining spatial redesign, workplace organization, and collaborative planning. Systematic Layout Planning (SLP) is widely recognized as an effective methodology for optimizing internal flows and reducing operational times. Studies by Bautista and Figueroa (2022) show that layout reconfiguration supported by 5S and discrete-event simulation significantly reduces picking times and improves space utilization, while Pérez-Mata and Romero (2022) reported substantial reductions in occupied area after applying SLP in a work-in-process warehouse. These findings confirm that structured layout redesign can generate significant efficiency gains even in low-technology environments.

The effectiveness of layout redesign is further enhanced when combined with standardization and Lean practices. Quiroz-Flores et al. (2022) integrated 5S, ABC classification, and operational standardization in a hardware distribution center, achieving notable reductions in picking and storage times. Similarly, Montalvo-Soto et al. (2020) demonstrated that combining SLP with Lean diagnostic tools such as Kanban, Pareto, and Ishikawa leads to significant improvements in delivery performance. In parallel, the 5S methodology has been widely validated as a foundational practice for operational stability, with Martínez and González (2021) reporting reductions in search times and inventory errors, and García and Fernández (2019) documenting improvements in material location efficiency and space utilization. Collectively, these studies indicate that 5S acts as an enabling mechanism that supports and sustains layout and process improvements.

From a planning perspective, Sales and Operations Planning (S&OP) plays a critical role in aligning demand, inventory, and production decisions. Castillo et al. (2024) demonstrated that S&OP improves forecast accuracy and reduces inventory costs, while Chumpitaz Martínez et al. (2022) and Viveros et al. (2021) highlighted its positive impact on service levels, order preparation efficiency, and cross-functional coordination. Recent contributions emphasize the adaptability of S&OP when integrated with Lean and 5S practices, as well as its potential integration with emerging technologies such as artificial intelligence and big data (Marcelo-Alfaro et al., 2024; Duque Jaramillo et al., 2019). Despite these advances, limited empirical evidence exists on frameworks that fully integrate 5S, SLP, and S&OP within a single operational model, particularly in plastic manufacturing and Latin American logistics contexts. The present study addresses this gap by proposing and validating an integrated improvement framework through discrete-event simulation, demonstrating measurable improvements in key performance indicators such as OTIF and warehouse congestion.

3. Methods

Gexim S.A.C. faces critical issues in warehouse management and order fulfillment. The company operates three warehouses for finished products, but a lack of organization, classification, and technical criteria has generated significant operational problems. One warehouse exhibits a high level of disorganization, with no defined system for product distribution, resulting in an average utilization of only 83 % of available space. This situation causes unnecessary material accumulation and increases search times by approximately 40 % (Figure 1)

Figure 1. Current operational condition of the finished goods warehouse (2025)

The proposed solution model was structured in three main phases, as shown in Figure 2: initial diagnosis (INPUT), application of improvement tools, and sustainability of results (OUTPUT).

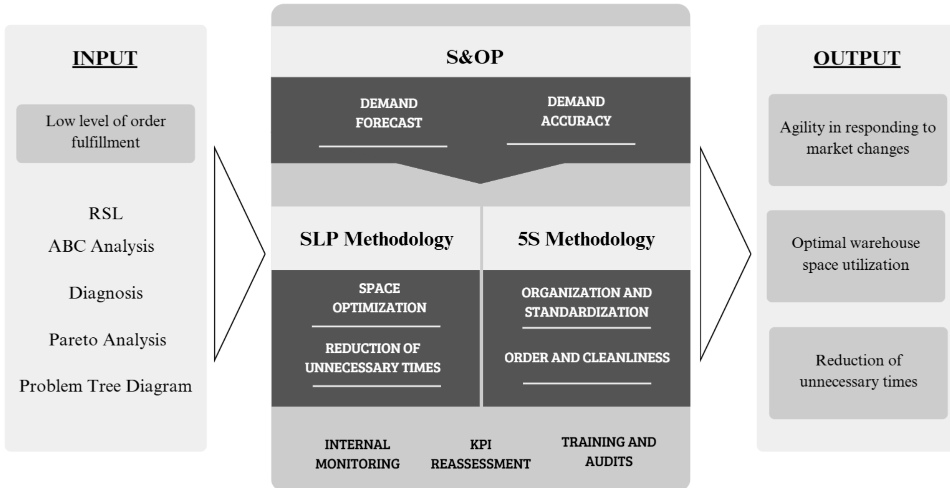

Figure 2. Proposed integrated improvement model based on 5S, SLP, and S&OP. Source: Authors' elaboration (2025).

In the first phase, corresponding to the preliminary diagnosis, both qualitative and quantitative tools were applied to characterize warehouse problems. A problem tree diagram was used to identify critical points of accumulation and disorganization, the RSL (Systemic Location Relationship) methodology was employed to analyze product placement, and ABC classification was applied to determine inventory rotation and priority. This evaluation provided a solid basis for decision-making and prioritization of interventions.

The second phase focused on the application of improvement tools. Systematic Layout Planning (SLP) and 5S methodologies were integrated under a Sales & Operations Planning (S&OP) approach, ensuring alignment with inventory levels, demand, and operational capacity. The objectives were to redesign the warehouse layout, assign strategic zones based on product rotation, reduce unnecessary travel, and establish sustainable practices of organization, cleanliness, and standardization to optimize internal operations.

To provide quantitative support for the proposal, a simulation model in Arena was developed to represent both the current scenario and the proposed scenario after implementing SLP and 5S. The simulation uses historical inventory and operational time data as input parameters, allowing analysis of material flow, space utilization, and order fulfillment efficiency, without assigning arbitrary resource values.

The third phase, focused on the sustainability of improvements, included internal control mechanisms such as periodic audits, continuous monitoring of key performance indicators (KPIs), and ongoing training programs for warehouse staff. These actions aim to maintain achieved standards, foster a culture of continuous improvement, and ensure that the benefits of the reorganization are preserved over time. The selection of KPIs was based on their direct relevance to warehouse operational efficiency and order fulfillment performance. OTIF (On-Time In-Full) was adopted as the primary service-level indicator because it simultaneously captures delivery timeliness and order completeness. Average picking time was selected as a key operational KPI due to its direct relationship with layout efficiency, internal travel distances, and labor productivity. The 5S audit score was used to evaluate the level of workplace organization and process standardization required to sustain improvements, while demand forecast accuracy was included to assess the effectiveness of the S&OP process in aligning demand, inventory, and operational capacity.

From a methodological perspective, the study adopted a mixed-methods approach, combining quantitative tools, such as scenario simulation and efficiency indicators analysis, with qualitative tools, including direct process observation and interviews with supervisors. This methodological design allowed a comprehensive characterization of warehouse problems, measurement of current performance, and projection of operational improvements under a replicable, evidence-based model.

4. Data Collection

The data collection process was designed to obtain detailed information on the internal operations of the finished goods warehouse, aiming to identify the causes of congestion, disorder, and delays in order preparation and dispatch. A mixed-methods research approach was adopted, combining quantitative tools such as scenario simulation and efficiency and capacity indicators analysis, with qualitative tools including direct observation, interviews with supervisors, and internal audits. This methodological design allowed a comprehensive characterization of warehouse deficiencies and the projection of replicable improvements.

Currently, the warehouse has a maximum capacity of 46 products, while the average inventory reaches 57 units, representing 20 % overcapacity. This condition limits operability, particularly as picking is performed manually by a single worker.

A population of 558 orders corresponding to one year was used, based on historical records of finished goods. To determine a representative sample size, the following formula was applied:

$$n = \frac{N \ast Z^2 p \ast q}{d^2 \ast (N-1) + Z^2 \ast p \ast q}$$

The calculation resulted in a sample size of 228 orders, ensuring a 95 % confidence level and a ±5 % margin of error, allowing for statistically representative analysis of the total population.

4.1 Process Diagram (DAP)

To map warehouse operations, a Process Diagram (DAP) was developed representing the current order preparation and dispatch flow. As shown in Figure 3, this diagram enabled the visualization of bottlenecks, unnecessary movements, and areas with overcapacity, facilitating the identification of critical intervention points.

N	Descripción del Proceso	DAP				
		●	➡	■	D	▼
1	Recepción de pedido	X				
2	Asignar cantidad de productos al pedido	X				
3	Evaluar espacio dentro del almacén			X		
4	Transporte al almacén		X			
5	Almacenar productos					X
6	Asignar operario de picking	X				
7	Realizar picking	X				
8	Verificar pedido			X		
9	Despacho de pedido	X				

Figure 3. Process Diagram (DAP) of order preparation and dispatch in the finished goods warehouse. Source: Authors' elaboration (2025).

4.2 Cause Analysis

The first analysis focused on identifying organizational and operational factors affecting order fulfillment. The Ishikawa diagram revealed that the main inefficiencies originate from warehouse congestion with low-rotation products, inefficient inventory control, manual transfers, and a disorganized layout. These causes highlight the interaction of structural and flow-related problems that increase preparation and dispatch times (Figure 4).

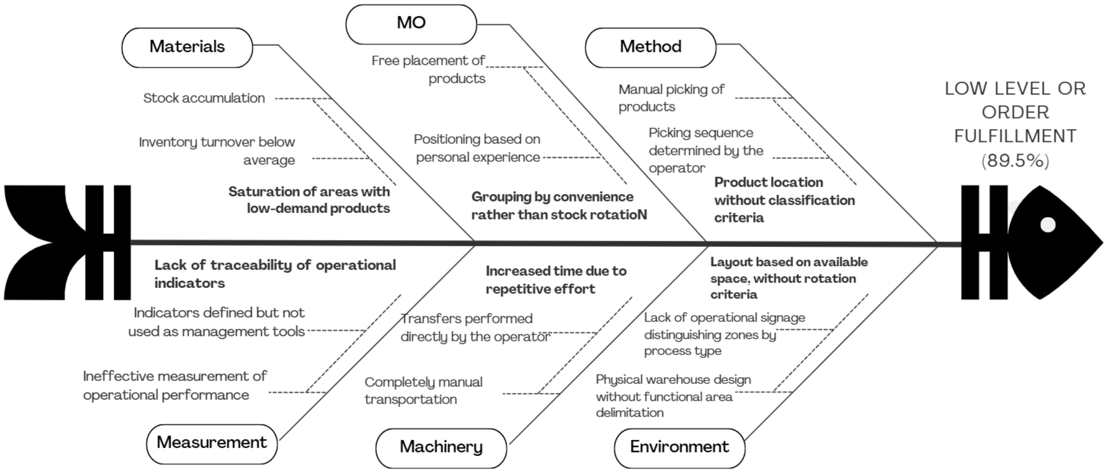

Figure 4. Ishikawa diagram of root causes affecting order fulfillment performance. Source: Authors' elaboration (2025).

The second analysis quantified the contribution of each cause to overall warehouse performance. The Pareto diagram showed that 82 % of the problems affecting order fulfillment are concentrated in three main factors: the use of layout without considering product rotation (36 %), grouping of products according to worker convenience (30 %), and congestion of areas with low-demand products (16 %). These results allow clear prioritization of improvement interventions (Figure 5).

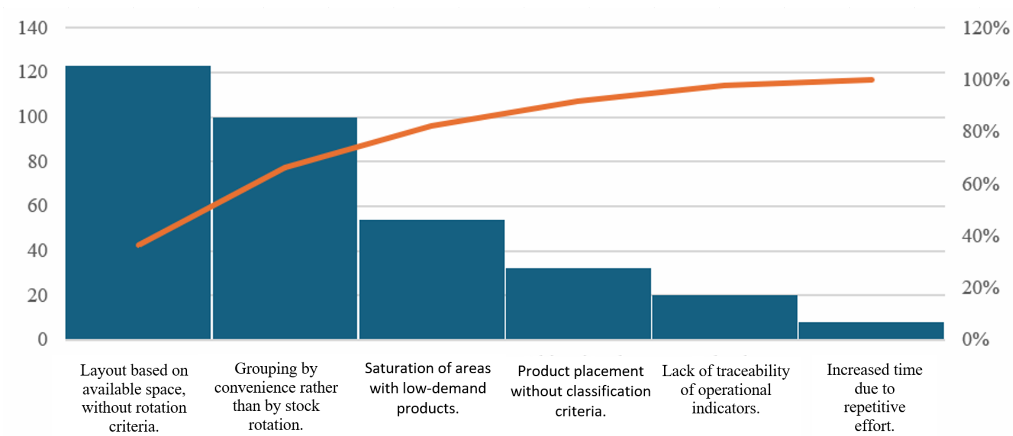

Figure 5. Pareto analysis of the main causes affecting order fulfillment in the finished goods warehouse. Source: Authors' elaboration (2025).

These findings served as the basis for defining an action plan focused on warehouse reorganization, implementation of a systematic product location method, and efficient inventory management, ensuring that future improvements address the critical points identified and are replicable.

4.3 Initial 5S Audit

As part of the diagnosis, an initial audit based on the 5S methodology was conducted, evaluating existing operational, organizational, and cleanliness conditions using a 0–5 scale for each component: Seiri, Seiton, Seiso, Seiketsu, and Shitsuke. The results showed an overall average of 2.15 out of 5 (42.93 %), with standardization (Seiketsu) and discipline (Shitsuke) being the weakest areas. As observed in Figure 6, this indicates the need to establish clear standards and reinforce a culture of order and continuous improvement.

SEIRI	
Components	0-5
Have all unnecessary items been identified and removed from the warehouse?	5
Are there designated areas for storing items that need to be evaluated or repaired?	4
Has a review of the tools, materials, and equipment been carried out to classify what is necessary and what is unneces	4
Are there any stored items that haven't been used in the last 6 months?	4
Has the process of disposal and reassignment of materials been documented and communicated?	2
Total	3.8
SEITON	
Components	0-5
Does each tool or material have a clearly identified designated place?	4
Are the storage areas properly labeled?	4
Are the items stored in a way that allows them to be easily found and used without delay?	4
Have the work routes and storage areas been defined in a way that allows for smooth traffic flow?	3
Are the work teams and maintenance tools organized and accessible without obstructions?	4
Total	3.8
SEISO	
Components	0-5
Are regular cleanings carried out in the warehouse to remove dust, dirt, and other debris?	2
Have specific individuals been assigned responsibility for performing cleaning tasks in designated areas?	3
Are the equipment regularly inspected and cleaned to detect maintenance failures?	2
Are cleaning tools accessible and available in the warehouse?	2
Is the warehouse kept clean throughout the day, or does dirt accumulate at some point?	1
Total	2
SEIKETSU	
Components	0-5
Are there documented procedures for maintaining order and cleanliness in the warehouse?	1
Has the staff been trained to follow these standardized procedures?	1
Have daily or weekly checklists been implemented to ensure compliance with 5S?	0
Are the rules and regulations regarding order and cleanliness in the warehouse clearly visible?	0
Is visual signage (labels, colors, markers) used to help with 5S compliance?	2
Total	0.8
SHITSUKE	
Components	0-5
Does the staff consistently follow the established rules for keeping the warehouse in order?	0
Are periodic audits conducted to verify compliance with the 5S methodology?	0
Has the work team adopted the continuous improvement culture based on the 5S methodology?	1
Total	0.333333333

Figure 6. Results of the initial 5S audit in the finished goods warehouse. Source: Authors' elaboration (2025).

4.4 SLP Data

The physical distribution of the warehouse, covering 100 m² (10m x 10m), was evaluated, identifying deficiencies in space organization and operator routes during picking. To visualize these issues, a current layout flow diagram was developed, as shown in Figure 7, which allowed quantification of unnecessary movements and evidenced the need for redistribution. This information served as the basis for the improvement proposal under Systematic Layout Planning (SLP), prioritizing route optimization, product accessibility, and reduction of dispatch times.

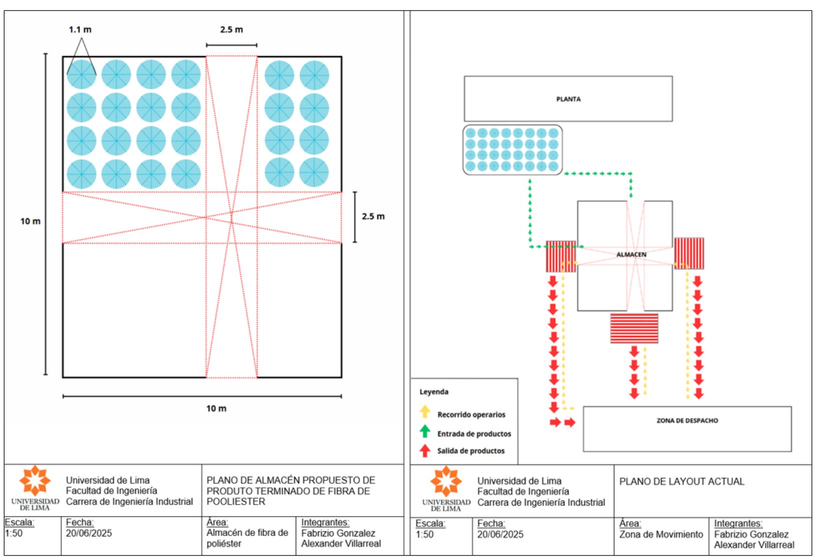

Figure 7. Initial layout diagnosis of the finished goods warehouse. Source: Authors' elaboration (2025).

4.5 S&OP Data

The macro-level solution proposed through the Sales & Operations Planning (S&OP) methodology establishes a structured and collaborative planning process to ensure effective integration across commercial, production, logistics, planning, and management departments. This approach aligns supply with demand through monthly cycles of analysis, review, and consensus, enabling data-driven decision-making based on historical data, forecasts, and actual capacity.

The S&OP process anticipates inventory and production requirements, adjusting operations to optimize inventory flow and increase order fulfillment efficiency. By assigning clear roles, defining key performance indicators (KPIs), and validating plans through simulation, the methodology enhances operational agility and efficiency, while strengthening the organization's responsiveness to demand fluctuations and supporting supply chain sustainability.

To obtain relevant data and evaluate the current situation, actual demand recorded during the first semester of 2024 was compared with the forecast previously used by the company. As shown in Table 1, this comparison revealed significant deviations between projected and actual customer requests, indicating low forecast accuracy. These results were fundamental for identifying the root causes of stockouts and unnecessary inventory accumulation, serving as a baseline for redesigning the planning process within the S&OP framework.

Table 1. Comparison between forecasted demand and actual demand (first semester of 2024).

Month	Forecast (units)	Actual (units)	Absolute Error (%)
January	200	180	11,11%
February	210	230	8,70%
March	250	265	5,66%
April	270	280	3,57%
May	290	295	1,69%
June	305	310	1,61%
Average	—	—	5,72%

5. Results and Discussion

5.1 Numerical Results

The main quantitative results of the proposed improvement are summarized in Table 2, which compares the key performance indicators of the finished goods warehouse before and after the implementation of the integrated model based on 5S, SLP, and S&OP.

Table 2. Warehouse performance indicators before and after the proposed improvement

Indicator	As is	To be	Variation
Demand forecast accuracy	±20%	±5%	75%
Warehouse space utilization	83%	95%	12
Average picking time	5.0	3.0	40%
5S compliance index	42.93%	72.53%	+29.6 pts

` Note. Picking time reduction is based on discrete-event simulation results with a 95% confidence level.

Demand forecast accuracy improved substantially, reducing the error margin from ±20% to ±5%, which represents a 75% improvement. This result reflects a stronger alignment between actual demand and operational planning, contributing to the reduction of stockouts and excess inventory.

In addition, effective warehouse space utilization increased from 83% to 95%, indicating a more efficient use of available space following the layout redesign using Systematic Layout Planning (SLP). From an operational standpoint, the average picking time decreased from 5 to 3 minutes, corresponding to a 36% reduction, mainly due to product reallocation based on rotation criteria and shorter internal travel distances.

Finally, the 5S compliance index increased from 42.93% to 72.53%, with an improvement of 29.6 percentage points, confirming the consolidation of order, cleanliness, and standardization practices required to sustain operational improvements over time.

5.2 Graphical Results

Graphical results complement the numerical analysis by illustrating the behavior of the picking process. As shown in Figure 8, post-implementation picking times exhibit lower dispersion and a stronger concentration around reduced average values compared to the initial scenario.

This decrease in variability indicates improved process stability and more effective operational standardization within the warehouse. The narrower distribution of picking times suggests reduced operational uncertainty and enhanced performance predictability.

These observations are further supported by the Arena discrete-event simulation, which shows a more controlled system behavior and quantitatively validates the operational benefits derived from the integrated implementation of layout redesign, workplace organization, and collaborative planning.

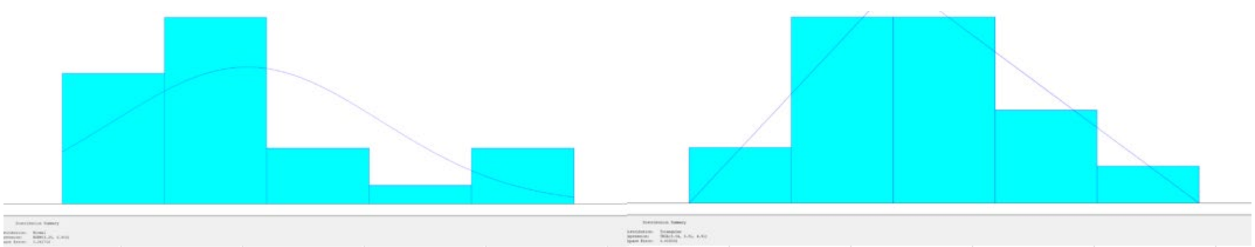

Figure 8. Distribution of picking times before and after the implementation of the integrated 5S–SLP–S&OP model. Source: Authors' elaboration based on Arena simulation results (2025).

5.3 Discussion

The results confirm that the integrated implementation of SLP, 5S, and S&OP has a positive and consistent impact on order management performance at Gexim S.A.C., validating the initial hypothesis that structured improvements in internal logistics processes and integrated planning directly enhance operational efficiency and service levels. The overall improvements observed indicate that addressing layout design, workplace organization, and planning coordination simultaneously generates synergistic effects within warehouse operations.

The layout redesign using Systematic Layout Planning (SLP) led to a 40% reduction in picking times and internal movements, improving material flow and reducing operational bottlenecks. This result is consistent with prior studies that highlight the effectiveness of SLP in minimizing non-value-added activities and optimizing space utilization in warehouse environments (Bautista & Figueroa, 2022; Pérez-Mata & Romero, 2022). In parallel, the application of the 5S methodology strengthened process standardization and workplace organization, as reflected in the increase of the cleanliness index from 70% to 90% and the improvement of 5S audit scores from 42.93% to 72.53%, supporting existing evidence on the role of 5S in reducing operational variability and sustaining performance improvements (Martínez & González, 2021).

From a planning perspective, the implementation of Sales and Operations Planning (S&OP) improved coordination among functional areas and enhanced demand–inventory alignment, leading to an increase in the service level from 75% to 95%. This finding aligns with previous research identifying S&OP as a key mechanism for improving service levels and system stability in logistics operations (Chumpitaz Martínez et al., 2022; Castillo et al., 2024). Furthermore, validation through discrete-event simulation using Arena confirmed reductions in operational times and inefficient space utilization, providing empirical evidence that the integrated application of these methodologies delivers measurable and sustainable improvements in industrial warehouse performance.

5.4 Proposed Improvements

Based on the results presented in Sections 5.1 to 5.3, a set of complementary improvements is proposed to ensure the sustainability of the operational gains achieved and to further strengthen warehouse performance over time. These actions are designed to consolidate the improvements derived from the integrated application of 5S, SLP, and S&OP, while reducing the risk of performance deterioration in the medium and long term.

As part of the reinforcement of the 5S methodology, a visual management board is proposed in a strategic area of the finished goods warehouse (Figure 9). This board will serve as a communication and awareness tool for warehouse personnel, displaying 5S principles, audit results, improvement progress, and best practices. Its objective is to maintain 5S compliance levels above 70% and to sustain the improvements in workplace organization and operational discipline achieved during the implementation phase.

Figure 9. Proposed 5S visual management board to support workplace organization and continuous improvement.
Source: Authors' elaboration (2025)

In addition, a visible weekly cleaning schedule is proposed to support the standardization of cleaning and maintenance activities. This schedule will clearly define assigned responsibilities and execution frequencies, facilitating monitoring and compliance. These actions are expected to contribute to maintaining low process variability and sustaining stable operational performance, as observed in the post-implementation results.

Regarding spatial organization, the proposed layout redesign based on Systematic Layout Planning (SLP) is presented in Figure 10. The layout prioritizes the proximity of high-rotation products to the dispatch area and limits unnecessary internal movements through defined storage zones and circulation paths. This configuration is intended to sustain the 36% reduction in picking time and the 95% space utilization level achieved after implementation.

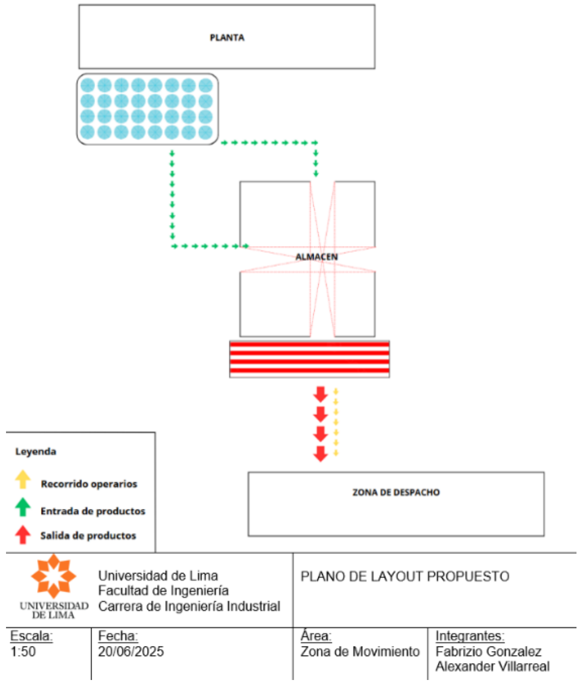

Figure 10. Proposed warehouse layout based on Systematic Layout Planning (SLP).
Source: Authors' elaboration (2025).

Finally, product allocation limitations and visual boundaries are proposed to control storage capacity and avoid over-occupation of critical areas (Figure 11). These measures aim to prevent deviations from the designed layout and to preserve the efficiency gains obtained in space utilization and material flow.

Figure 11. Proposed product zoning and storage capacity limitations in the finished goods warehouse.

Overall, these proposed improvements complement the results achieved by the integrated model and provide a structured framework for sustaining operational efficiency, process stability, and service level performance in industrial warehouse environments.

5.5 Validation

The validation of the proposed integrated improvement model was carried out through a combination of post-implementation audits and discrete-event simulation, following the methodological framework presented in Figure 2. This approach enabled an objective assessment of the impact of the joint application of the 5S, SLP, and S&OP methodologies at organizational, operational, and planning levels.

To validate the effectiveness of the 5S implementation, a post-intervention audit was conducted using a structured checklist based on the five pillars of the methodology. The results show an average score of 3.63 out of 5, equivalent to a 72.53% compliance level, representing an improvement of 29.6 percentage points compared to the initial situation.

These results demonstrate the effectiveness of the implemented actions, particularly in the pillars of order, cleanliness, and standardization, consolidating a more stable and disciplined operational foundation that supports the sustainability of the improvements achieved in warehouse performance. Figure 12 confirms the improvement in 5S compliance achieved after implementation.

SEIRI	
Components	0-5
Have all unnecessary items been identified and removed from the warehouse?	5
Are there designated areas for storing items that need to be evaluated or repaired?	4
Has a review of the tools, materials, and equipment been carried out to classify what is necessary and what is unneces	4
Has the process of disposal and reassignment of materials been documented and communicated?	3
Total	4
SEITON	
Components	0-5
Does each tool or material have a clearly identified designated place?	4
Are storage areas properly labeled?	4
Are the items stored in a way that allows them to be easily found and used without delay?	4
Have the work routes and storage areas been defined in a way that allows for smooth traffic flow?	3
Are the work teams and maintenance tools organized and accessible without obstructions?	4
Total	3.8
SEISO	
Components	0-5
Are regular cleanings carried out in the warehouse to remove dust, dirt, and other debris?	4
Have specific individuals been assigned responsibility for performing cleaning tasks in designated areas?	4
Are the equipment regularly inspected and cleaned to detect maintenance failures?	4
Are cleaning tools accessible and available in the warehouse?	3
Is the warehouse kept clean throughout the day, or does dirt accumulate at some point?	4
Total	3.8
SEIKETSU	
Components	0-5
Are there documented procedures for maintaining order and cleanliness in the warehouse?	4
Has the staff been trained to follow these standardized procedures?	3
Have daily or weekly checklists been implemented to ensure compliance with 5S?	4
Are the rules and regulations regarding order and cleanliness in the warehouse clearly visible?	2
Is visual signage (labels, colors, markers) used to help with 5S compliance?	3
Total	3.2
SHITSUKE	
Components	0-5
Does the staff consistently follow the established rules for keeping the warehouse in order?	3
Are periodic audits conducted to verify compliance with the 5S methodology?	4
Has the work team adopted the continuous improvement culture based on the 5S methodology?	3
Total	3.333333333

Figure 12. Results of the final post-implementation 5S audit. Source: Authors' elaboration (2025).

The statistical validation of the operational impact of the layout redesign based on Systematic Layout Planning (SLP) was conducted using discrete-event simulation in Arena, as illustrated in Figure 13. Model outputs were analyzed using the Output Analyzer add-on, allowing a quantitative evaluation of key process performance indicators.

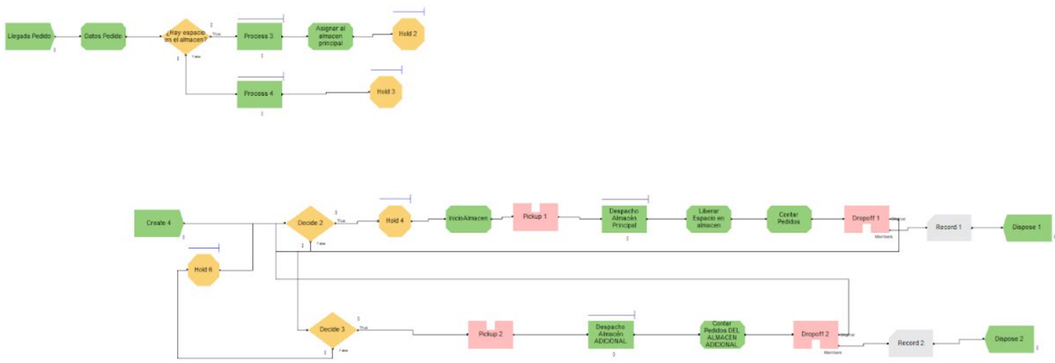

Figure 13. Arena discrete-event simulation model of the proposed warehouse improvement scenario. Source: Authors' elaboration using Arena simulation (2025).

The analysis focused on picking time, due to its direct impact on operational efficiency and order fulfillment. In the initial scenario, the average picking time was 5.0 minutes, with a 95% confidence interval ranging from 4.8 to 5.2 minutes, reflecting inefficiencies associated with warehouse disorganization, poor space utilization, and the absence of an optimized layout.

After implementing the redesigned layout and the proposed reorganization, the average picking time decreased to 3.0 minutes, with a 95% confidence interval between 2.8 and 3.2 minutes. This result represents a 40% reduction in picking time, along with a noticeable reduction in process variability.

In addition, a statistical hypothesis test was conducted using Arena Output Analyzer to compare mean picking times before and after the implementation. A two-sample t-test was performed at a 95% confidence level, yielding a statistically significant difference (p-value < 0.05). This confirms that the observed improvement is not due to random variation, but rather to the proposed layout redesign. Figure 14 shows a statistically significant reduction in average picking time after the layout redesign.

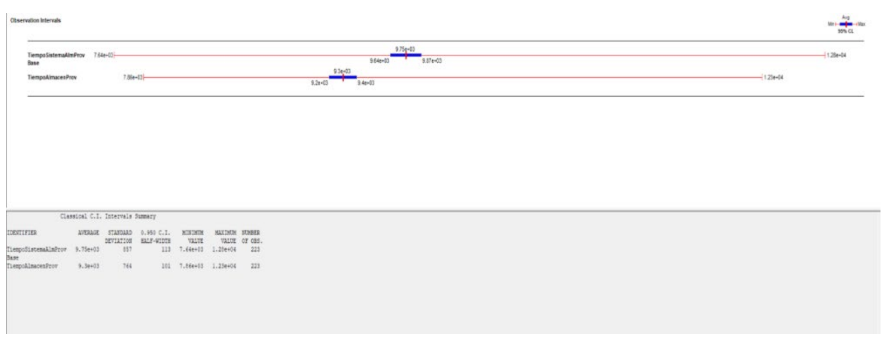

Figure 14. Confidence intervals for picking time before and after the layout redesign. Source: Authors' elaboration based on Arena Output Analyzer results (2025).

The effectiveness of the Sales and Operations Planning (S&OP) process was validated through a comparative analysis between the initial situation and the post-intervention scenario, focusing on the alignment between demand forecasting and inventory management.

For this purpose, a statistical forecasting model was developed in Python, incorporating moving average techniques and Holt–Winters exponential smoothing. The model evaluated forecast accuracy against actual demand, demonstrating a significant improvement in planning performance.

The results indicate that forecast accuracy increased to 95%, while the service level improved from 75% to 95%. Furthermore, simulation outcomes revealed reduced warehouse saturation, improved dispatch coordination, and lower variability in delivery times. These findings confirm that the S&OP implementation contributes significantly to operational stability and enhanced order fulfillment performance.

6. Conclusion

This study demonstrates that the integrated application of 5S, Systematic Layout Planning (SLP), and Sales and Operations Planning (S&OP) constitutes an effective framework for improving warehouse performance in industrial environments. Rather than generating isolated improvements, the coordinated implementation of organizational, spatial, and planning methodologies produces synergistic effects that enhance operational stability, service levels, and overall efficiency.

The results confirm that aligning workplace organization, layout design, and demand planning within a unified model strengthens material flow, reduces process variability, and improves decision-making consistency. The validation through discrete-event simulation further supports the robustness of the proposed framework.

The main contribution of this research lies in empirically demonstrating that operational performance improvements are significantly amplified when these methodologies are integrated rather than applied independently. This integrated approach provides a replicable model for sustainable warehouse improvement, particularly in emerging industrial contexts.

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