Proceedings of the 7th African International Conference on Industrial Engineering and Operations Management
Cape Town, South Africa, May 13-15, 2026

Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AF07.20260121
Published: May 13, 2026

Improvement of Logistics Service Level through 5S, ABC Classification, SLP and LPS in the Real Estate Logistics Area

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Abstract

This study proposes the optimization of the warehouse logistics process in a construction project through the application of Lean Construction tools and discrete-event simulation using Arena software. The initial diagnosis identified inefficiencies related to search times, errors in material selection, and stockouts. Methodologies such as 5S, ABC classification, Systematic Layout Planning (SLP), and Last Planner System (LPS) were applied to redesign the operational flow and improve inventory management. The simulation enabled a comparison between the baseline scenario and the improved scenario, showing significant reductions in process times and rework, as well as an increase in the service level (Fill Rate). The results confirm that the integration of Lean tools and simulation models constitutes an effective strategy, reducing logistics service time by 19.62%.

Keywords
Lean Construction, Discrete-event simulation, Inventory management, Optimization, Planning

1. Introduction
The construction sector in Peru faces significant structural challenges, evidenced by low logistics performance and planning deficiencies that directly affect the continuity and efficiency of projects. Although the sector contributes approximately 7% of the national GDP, it bears cost overruns equivalent to 2% of annual GDP, representing nearly US$ 1.2 billion, mainly associated with planning failures and inadequate logistics management (BCRP, 2025).

At the regional level, the productivity of the construction sector in Latin America remains about 40% below the average of the overall economy. In the Peruvian case, infrastructure projects present cost overruns of up to 30% compared to the initial budget, mainly attributable to deficiencies in scheduling, resource management, and the timely supply of critical materials (World Bank Group, 2023). This situation is reinforced by the contraction of the sector's level of operations by −5.2% during the 2023–2022 bimester, which highlights institutional and planning weaknesses that compromise the efficiency of future investments (CAPECO, 2024).

Likewise, the average physical execution of suspended projects does not exceed 40%, despite more than 60% of the committed budget having been disbursed in numerous cases. By the end of the second semester of 2023, 21 projects had been reactivated and another 14 were in the process of reactivation, with a committed investment of approximately S/ 558.7 million and an estimated impact on 522,924 beneficiaries. This reflects the need to improve management mechanisms and operational control in the sector (MVCS, 2024).

In this context, the present research addresses inefficiencies in warehouse logistics processes within real estate projects, focusing on the optimization of material preparation and service times. A relevant technical gap is identified with respect to industry standards, with the current average service time of 15.80 minutes compared to a reference value of 13.20 minutes, representing a difference of 2.6 minutes per request. The main indicators analyzed include the Fill Rate, average search time, and errors in material selection, which reflect the logistics service level. To address these issues, tools such as 5S, SLP, ABC classification, and Last Planner System are employed, with the objective of increasing operational efficiency and business profitability, from which the corresponding problem tree was constructed (Figure 1- Figure 6).

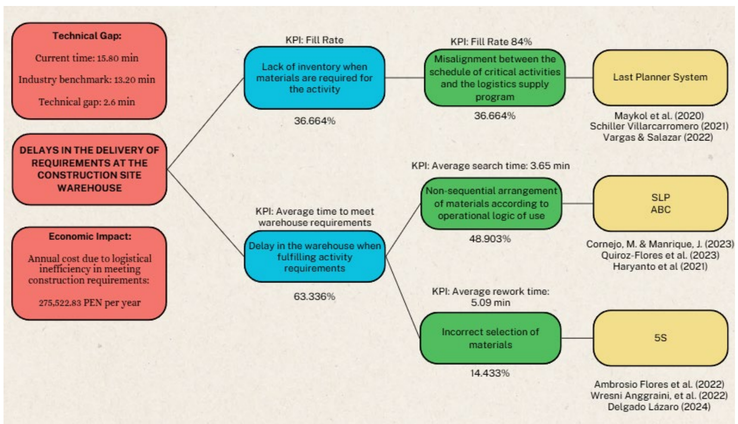


Figure 1. Problem tree

1.1 Objectives

- Improve logistics efficiency in the process of fulfilling warehouse requests, specifically by optimizing the internal lead time of the warehouse to ensure the timely supply of materials for the execution of critical activities.
- Reduce the average number of unscheduled weekly requests through the implementation of the Last Planner System, which will allow the alignment of the schedule of critical activities with the logistics programming of requirements.
- Decrease the average search times for materials in the warehouse by reorganizing their physical arrangement under operational criteria using SLP and 5S tools, ensuring a logical and sequential flow.
- Minimize selection errors and material identification times by distributing inventory according to a logical criterion through the ABC classification model, prioritizing access to high-rotation supplies.

2. Literature Review

In the case of the 5S methodology, empirical results show a direct impact on problem components related to average search time and average rework time derived from incorrect material selection. In the warehouse of a public hospital, Arana Cárdenas et al. (2022) reported that service and dispatch time was reduced from 12.10 to 5.46 minutes, representing an improvement of nearly 55%, following the systematic implementation of 5S. This quantitative variation reflects the elimination of non-productive times associated with unnecessary movements, searching for supplies in unclear locations, and correcting mistaken deliveries. Complementarily, Haryanto et al. (2021) documented that, in an industrial context, the combined application of 5S and layout redesign reduced picking time by 36%.

The literature on ABC classification provides relevant quantitative results both for operational efficiency and for the reduction of rework, aspects related to the lack of inventory at the time of request and errors in order preparation. In supermarket logistics centers in China, the ABC strategy combined with the ANP method increased storage efficiency from 87.7% to 96.5%, optimizing location assignment based on product value and frequency of use, and concentrating handling resources on items with the greatest operational impact. Similarly, Delgado Lázaro (2024) reported that, after implementing ABC classification in the analyzed warehouse, rework time was reduced from 9.7 to 4.92 minutes, implying a substantial decrease in corrections required due to preparation errors and subsequent adjustments.

Regarding layout design, the results of applying the Systematic Layout Planning (SLP) method show a quantifiable influence on the sequential arrangement of materials and, by extension, on average search time. In the study by Haryanto, Hisjam, and Yew (2021), layout reconfiguration through SLP in a manufacturing company reduced material handling costs by 44.7%, from 5.38 to 2.97 million Indonesian rupiah per month, and decreased picking time by 36%. In comparable industrial contexts, improvements of up to 38% in productivity, reductions of 14% in movements, and 33% in cycle times have been documented as a result of reorganizing areas according to flows and usage frequencies.

Finally, the Last Planner System (LPS) addresses the problem from the perspective of schedule reliability and constraint management, with quantitative effects on the number of non-compliant activities and unplanned material requests. In the studies reported by Maykol et al. (2020), Loayza and Guevara (2020), and Schiller Vilcarromero (2021), the implementation of LPS in building and remodeling projects reduced weekly non-compliant activities from a range of 30–18 events to 8–10, as a result of early planning, coordination among specialties, and systematic monitoring of constraints related to materials, information, and resources.

3. Méthod

The present proposal aims to reduce the internal lead time of the construction warehouse, which is currently prolonged by delays in logistics service, selection errors, and stockouts. These inefficiencies originate from inventory disorder, poor physical distribution, and lack of operational standardization. To address them, a model is proposed that integrates continuous improvement tools: 5S, ABC analysis, Systematic Layout Planning (SLP), and Last Planner System (LPS).

The model acts on inventory management through the classification and prioritization of materials (ABC), the redesign of flows and spaces (SLP), order and cleanliness (5S), and the effective coordination of logistics tasks (LPS).

Figure 2. Conceptual Model

The proposed model for improving the logistics system of the construction warehouse begins with the identification of deficiencies in the timely fulfillment of logistics requests. During the initial diagnosis, an average service time of 15.8 minutes was observed, along with a rework time of 5.09 minutes, 3.65 minutes for material search, and an average Fill Rate of 84%. According to the literature, these values are expected to be reduced to an average logistics service time of 13.20 minutes, a rework time of 4.92 minutes, a selection time of 2.30 minutes, and a Fill Rate of 95%.

The proposed model for improving the warehouse logistics system consists of four components, divided into two categories: Planning and Training (5S and Last Planner System) and Organizing and Standardizing (SLP and ABC).

The first component, 5S, is aimed at directly addressing non-productive times associated with material search and rework due to incorrect selection. The starting point is an initial warehouse audit, where service times (15.8 min), rework times (5.09 min), and material selection times (3.65 min) are recorded, along with a checklist of conditions related to order, cleanliness, and signage in the main transit and storage areas. This audit makes it possible to identify sources of disorder, accumulation of unnecessary materials, and ambiguous locations, which are then contrasted with results reported in the literature, such as the reduction of search times from 3.5 to 1.8 minutes in Arroba-Vásquez (2022) or picking times from 4.2 to 2.3 minutes in Escobal et al. (2024), after applying 5S in warehouses with comparable characteristics.

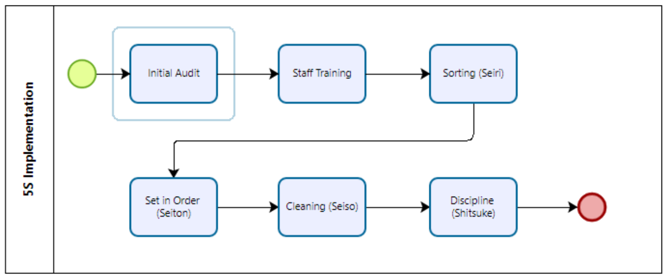


Figure 3. Component 1

The second component, Last Planner System (LPS), focuses on the coordination between the schedule of critical activities and the programming of logistics supply, with a direct impact on the Fill Rate and the frequency of stockouts. The process begins with a theoretical introduction to the LPS framework and the formation of the planning team, composed of representatives from construction, logistics, and key suppliers. Subsequently, a review of the master schedule and activities is carried out, identifying critical milestones and tasks that demand higher volumes of materials. With this tool, material requirements can be forecasted much earlier, thereby reducing the probability of stockouts.

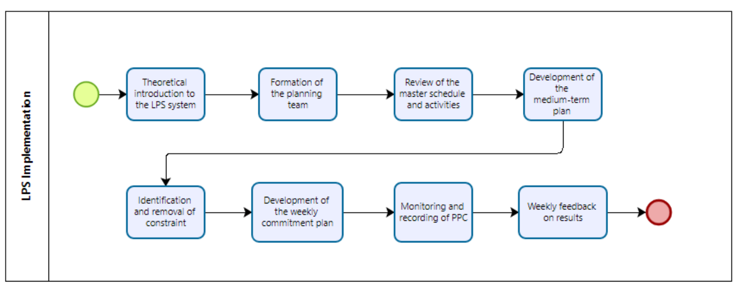


Figure 4. Component 2

The third component, Systematic Layout Planning (SLP), focuses on the coordination between the schedule of critical activities and the programming of logistics supply, with a direct impact on the Fill Rate and the frequency of stockouts. The process begins with a theoretical introduction to the SLP framework and the formation of the planning team, composed of representatives from construction, logistics, and key suppliers. Subsequently, a review of the master schedule and activities is carried out, identifying critical milestones and tasks that demand higher volumes of materials.

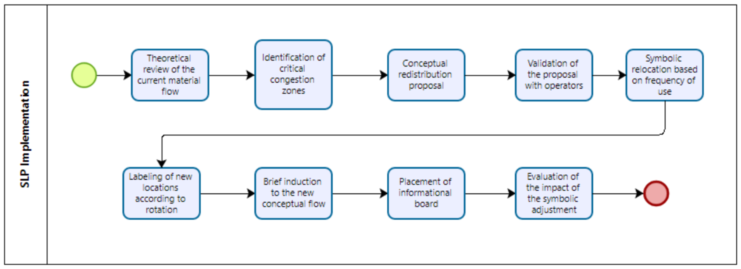


Figure 5. Component 3

The fourth component, ABC classification, focuses on inventory prioritization according to criticality and frequency of use, with the objective of reducing selection and rework times, and contributing to the increase of the Fill Rate by concentrating management on items that generate the greatest operational impact. The process begins with determining turnover by group, calculated from the historical record of requests in the construction warehouse. For each material code, the number of withdrawals and its share in total movements are computed, identifying those that account for the highest percentage of demand. Based on these data, classification into groups A, B, and C is carried out, following criteria consistent with empirical evidence.

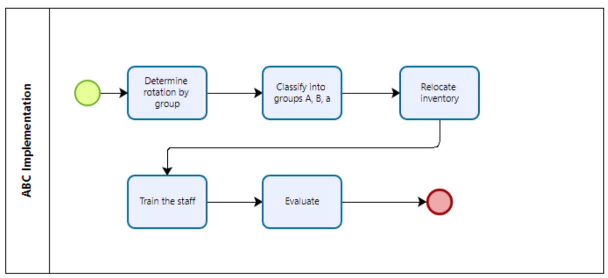


Figure 6. Component 4

4. Recolección de datos

To rigorously validate the proposed design aimed at improving the logistics process of fulfilling on-site requests, discrete-event simulation using Arena Simulation was selected as the validation method.

To rigorously determine the size of the population on which the statistical analysis will be applied, actual records corresponding to a period of six consecutive months were analyzed. It was found that, on average, 258 material requests are made to the warehouse per week.

To determine the required sample size, the formula for finite populations was used.

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

N = 258 population size (weekly requests)
Z = 1.96 (95% confidence level)
p = 0.5 (maximum variance proportion)
q = 1−p = 0.5
d = 0.05 margin of error (5%)

Replacing these values, the following calculation was obtained:

$$n = \frac{258 \: x \: 1.96^2 x \: 0.5 \: x \: 0.5}{0.05^2 x \: (259-1) + 1.96^2 x \: 0.5 \: x \: 0.5}$$

$$n = 155 \: pedidos$$

Our initial data consisted of times measured during an initial site visit. In this first visit, the data obtained were intended to be used for our Arena model of the baseline scenario. For the improvement scenario, we returned to measure the times after training the workers and implementing the improvements in a pilot test. For both scenarios, the Arena tool Input Analyzer was used to obtain distributions of the measured times. The results can be observed in Table 1.

Table 1. AS IS and TO BE Times

Activity	**Distribution**	**Expression**
Interarrival Time	Triangular	TRIA(1, 3.95, 35)
Inventory Review Time	Triangular	TRIA(1.24, 2.04, 4)
Search Time (AS IS)	Triangular	TRIA(2.55, 2.81, 3.78)
Rework Time (AS IS)	Triangular	TRIA(4, 4.37, 5.55)
Transfer Time to Work Area	Normal	NORM(5.61, 0.805)
Search Time (TO BE)	Normal	NORM(2.29, 0.081)
Rework Time (TO BE)	Normal	NORM(1.49, 0.333)

5. Results and Discussion

5.1 Numerical Results

The reduction of service times and the improvement of material flow in a construction warehouse can be effectively analyzed using discrete-event simulation tools such as Arena. This type of modeling makes it possible to represent the actual operation of the warehouse, evaluate different operating scenarios, and detect bottlenecks related to material search, selection errors, and stockouts.

For this study, a comparison was made between the baseline scenario and the improved scenario. As shown in Table 2, confidence intervals obtained from Arena were analyzed for each performance indicator, using the corresponding number of replications. Subsequently, a mean comparison analysis was carried out through the paired T-test in the Output Analyzer. All simulations were performed with 91 replications and a 95% confidence interval in the Output Analyzer.

Table 2. Comparison of AS IS and TO BE Scenarios

Indicator	AS IS	TO BE	Unit
Average Total Time	[16.1; 16.7]	[12.4; 13.1]	Minutes
Average Search Time	[3.1; 3.12]	[2.29; 2.34]	Minutes
Average Rework Time	[3.87; 3.92]	[1.48; 1.53]	Minutes
Fill Rate	[91.1; 91.84]	[93.22; 94.1]	Percentage

First, the average total process time was reduced from 16.4 minutes in the baseline model to 12.7 minutes in the improved model, representing a 22.6% decrease. This reduction reflects greater overall efficiency in the material flow and better coordination between the worker and the warehouse operator.

The average search time decreased from 3.11 to 2.32 minutes, showing a 25.4% improvement. This means that all activities subsequent to the search can begin more quickly. Cornejo, M. & Manrique, J. (2023) achieved a reduction in search time to 2.30 minutes, which is similar to our result.

Likewise, the average rework time decreased from 3.9 to 1.5 minutes, equivalent to a 61.5% reduction. This improvement indicates a shorter duration of corrective activities due to errors in material selection. Delgado Lázaro (2024) achieved a reduction in reprocessing time from 9.7 to 4.92 minutes; compared with our improvement, it has been demonstrated that rework time can be reduced through the use of ABC and SLP tools.

Finally, the Fill Rate indicator, which measures the service level or the percentage of requests fulfilled without stockouts, increased from 91.42% to 93.61%, representing an improvement of 2.19%. In terms of inventory management, this implies a reduction of approximately 17% in stockouts (decreasing from an average of 13.3 to 9.9 occurrences).

5.2 Graphical Results

As mentioned earlier, the improvement test was carried out through a simulation in the Arena software. The design of the Arena model is shown below in Figure 7:

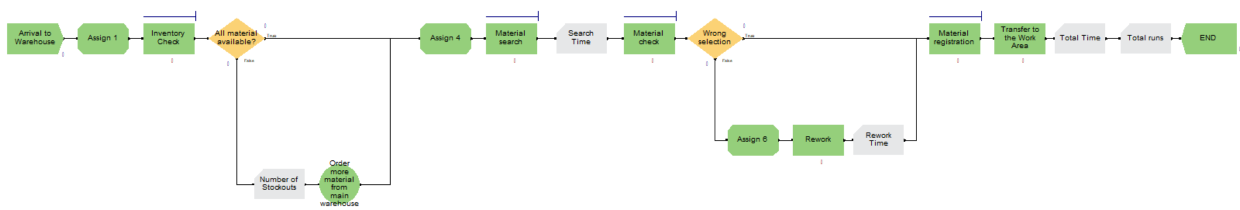
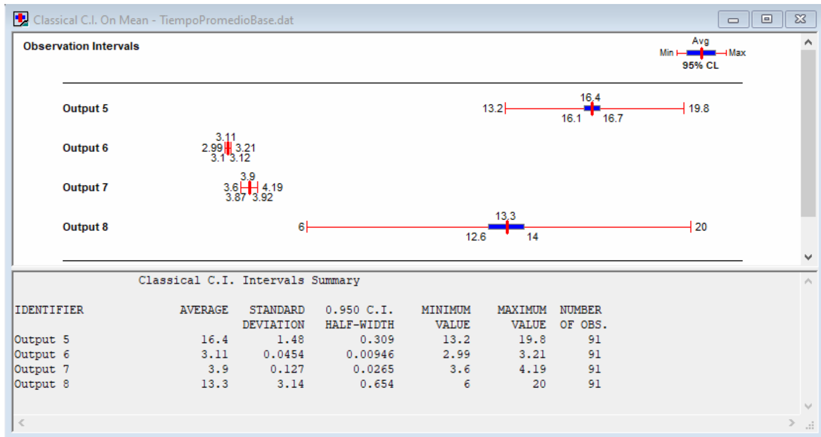


Figure 7. Baseline Arena Simulation Model

This model represents the path that a worker must follow when making a material request to the warehouse. In the simulation, the process begins when the worker arrives at the warehouse to request the materials needed. The warehouse operator receives the request, checks availability, and determines whether the material is in stock. If it is not available, it is requested from another site, generating additional waiting time. When the material is available, the worker enters the warehouse and performs the corresponding search. After collecting the materials, the warehouse operator verifies that the selected items are correct. If an error exists, the worker must return them and repeat the search, generating rework. Finally, once the material is validated, the warehouse operator records the withdrawal in the inventory, and the worker transfers the materials from the warehouse to the work area where they will be used.

The results obtained were processed using Arena's Output Analyzer tool, and these results can be visualized in Figure 8.



IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
Output 5	16.4	1.48	0.309	13.2	19.8	91
Output 6	3.11	0.0454	0.00946	2.99	3.21	91
Output 7	3.9	0.127	0.0265	3.6	4.19	91
Output 8	13.3	3.14	0.654	6	20	91

Figure 8. Graphical Results of the Baseline Model in Output Analyzer

As can be observed, these results coincide with what was mentioned in the numerical results section and also show that 91 replications were used with a 95% confidence interval. The result of Output 8 represents the number of times stockouts occurred in a week; considering 155 weekly requests, the Fill Rate percentage can be calculated.

5.3 Proposed Improvement

The changes made in the improved model were mainly adjustments to time values, so the improvements from 5S, SLP, and ABC classification are represented using the TO BE time distributions. The only structural change in the model is the implementation of the Last Planner System tool. The LPS tool is represented as a preventive action before the material runs out. In the Arena simulation, this is modeled with a Decide node following the material registration activity, as can be seen in the following Figure 9.

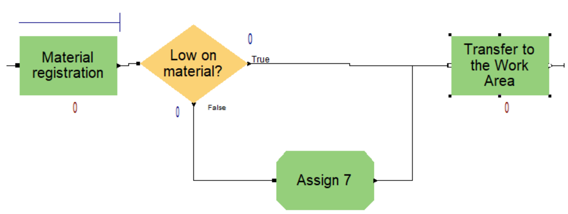
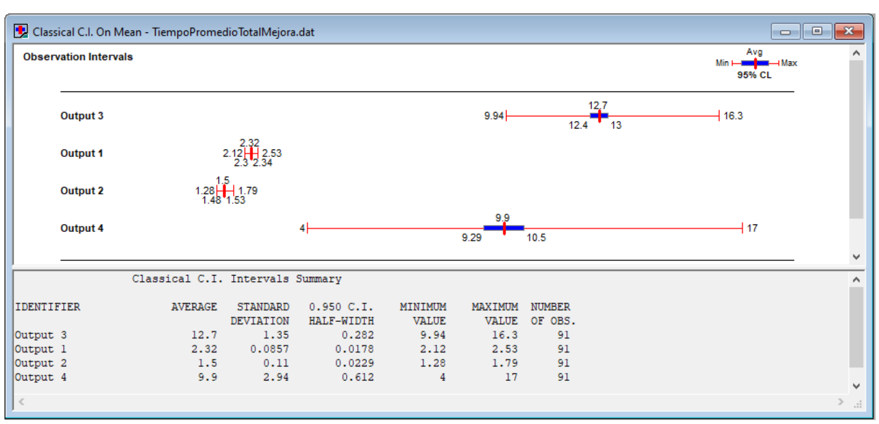


Figure 9. Representation of planned replenishment in the improved model

After making the changes in the improved model and running the Arena simulation, the following results were obtained from the Output Analyzer (Figure 10).



IDENTIFIER	AVERAGE	STANDARD DEVIATION	0.950 C.I. HALF-WIDTH	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
Output 3	12.7	1.35	0.282	9.94	16.3	91
Output 1	2.32	0.0857	0.0178	2.12	2.53	91
Output 2	1.5	0.11	0.0229	1.28	1.79	91
Output 4	9.9	2.94	0.612	4	17	91

Figure 10. Graphical Results of the Improved Model in Output Analyzer

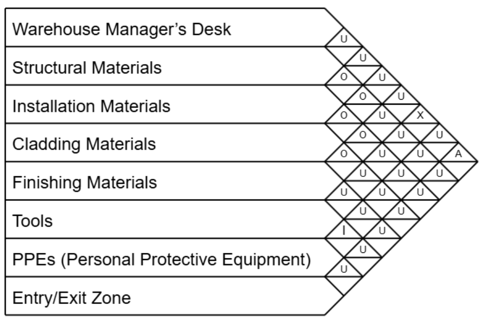
As with the baseline model, these results coincide with those shown in the numerical results section, with the same number of replications and confidence interval. From these results, it can be evidenced that process times were indeed reduced, while weekly stockouts decreased, leading to an increase in the Fill Rate.

These results, together with those of the baseline model, demonstrate that applying the LPS tool increased the project's Fill Rate, while ABC and SLP reduced the average search time, and 5S reduced the rework time. Taken together, all the tools contributed to reducing the average logistics service time.

5.4 Validation

To validate that our implementation of the proposed tools was realistic, we carried out a pilot implementation in order to obtain the times for the improved model mentioned earlier. Using these times, the previous Arena simulation was performed. Below we present the results obtained from this pilot test.

The 5S, ABC, and SLP tools demonstrated significant quantitative impacts on warehouse management. The application of 5S reduced the average material search time from 3.65 to 2.30 minutes and the reprocessing time from 5.09 to 1.48 minutes, aligning with improvements reported in the literature ranging between 36% and 55% following organization and cleaning processes (Figure 11).



Code	Closeness Rating
A	Absolutely Necessary
E	Especially Important
I	Important
O	Ordinary Closeness
U	Unnecessary
X	Avoid Closeness

Figure 11. Route Relationship Diagram

ABC classification and SLP reorganization, in turn, consolidated these improvements by prioritizing critical items and optimizing routes, achieving additional reductions of up to 50% in selection and logistics service times, as well as storage efficiency above 95% reported in recent studies (Figure 12 and Figure 13).

Figure 12. Post-Implementation Warehouse

The integration of the Last Planner System raised the Fill Rate from 84% to 95% and reduced stockout events and logistical emergencies, consistent with reductions of 18% in nonconformities and cuts of seven minutes in associated times, according to specialized literature. These results confirm that the combination of these tools generates substantial improvements in operational efficiency, order, and logistical coordination, with solid quantitative support at both international and local levels.

Figure 13. Lookahead Last Planner System

6. Conclusions

The quantitative comparison between the AS IS and TO BE scenarios confirms the technical feasibility of the proposed model for logistics improvement in construction warehouses. The average total service time was reduced from 16.4 to 12.7 minutes (−22.6%), accompanied by decreases in search time (−25.4%) and rework (−61.5%). The Fill Rate increased from 91.42% to 93.61%, equivalent to an approximate 17% reduction in stockouts. These results, obtained with 91 replications and a 95% confidence interval, reinforce the statistical consistency of the scenario contrast.

The contribution of this work goes beyond the improvement values, by demonstrating the functional integration of Lean tools with differentiated effects: 5S reduces non-productive times and rework; ABC prioritizes critical items to minimize errors; SLP reconfigures the layout to optimize routes; and LPS strengthens supply coordination, raising the service level.

This study constitutes a baseline reference for future research on logistics optimization in construction projects. It is recommended to expand the model by incorporating economic variables (waiting costs, productivity impacts, costs associated with stockouts), conducting sensitivity analyses under uncertainty scenarios, and validating its applicability in projects of different scales and typologies. Finally, the incorporation of low-friction digital supports, such as mobile records or RFID technologies, can strengthen traceability and sustain the service level over time.

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Biographies

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Giacomo Gómez Sánchez Angeldonis, Industrial Engineering student at Universidad de Lima, with practical experience in project management, operations, and process improvement in both the real estate and agroindustrial sectors.

Rodrigo Arcaya Huayamares, Industrial Engineering student at Universidad de Lima, with experience in operational excellence and continuous process improvement, particularly in the construction and real estate sectors.