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Lean Warehousing, 7S and SLP tools to improve productivity in the inspection and storage process in a Spare Parts Warehouse of an Automotive Retail Company.

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Abstract

The research focused on solving the problems of high inspection and storage times in a spare parts warehouse serving as a distribution center for the dealers of an automotive retail company, identifying inefficient distribution and unnecessary transfers as the leading causes. A model based on Lean Warehousing and warehouse management with the lean tools, SLP and 7S, was implemented, which, after simulation in Arena software, resulted in an increase in productivity from 2.11 to 3.12 packages per man-hour and a 17% reduction in waiting times for spare parts packages. In addition, improved inspection and warehousing times were achieved, representing a significant reduction in associated costs, specifically in the expenses for using a support warehouse that amounted to $100,000 per year. This approach promises to be a model for improving warehouse management efficiency in the automotive retail sector.

Keywords
Lean Warehousing, 7S, SLP, storage productivity, storage times

1. Introduction
The automotive industry is one of the largest and most influential worldwide; its importance lies in its turnover, equivalent to the world's sixth-largest economy (Masoumi et al., 2020). In Peru, the automotive sector generates more than 400,000 direct formal jobs and more than one million indirect jobs, totaling more than 1.5 million jobs for the country; tax contributions exceed 15 billion soles annually, equivalent to 14% of government tax revenues, while the sector's share, including related activities, represents 16% of GDP (De la Cruz 2023), automotive trade, has had a strong recovery in the final stretch of the pandemic with a growth of 32. 58% during 2021 (De la Cruz 2022), and an average annual growth of 2.9% during 2022 and 2023 (De la Cruz 2024), so the big car brands increase their presence through the expansion of their dealer networks in charge of the pillars of the sector, car sales, spare parts, and after-sales services. This increase in demand causes the automotive market to be more dynamic; therefore, companies in the sector must focus on competitiveness and productivity (Suárez et al. 2017).

When it comes to ensuring competitiveness and productivity in the automotive sector, good management of the supply chain stands out as a competitive advantage, key for the sale of spare parts and after-sales services because the availability of spare parts and accessories is a primary factor to be taken into account by customers when deciding the automotive company that provides the service, (Merchán and Berrezueta 2018) in addition it is essential to improve service levels by minimizing downtime and maximizing the availability of their products, through good merchandise storage management, in the case of the automotive sector automotive spare parts, allow to play a central role in taking measures to achieve the desired service levels and minimize the costs incurred (Bhalla et al. 2021).

Among the main problems affecting storage management are excessive inspection, storage and order preparation times, which are evidenced in unexpected productivity and can be caused by the inefficient use of space, unnecessary transfers, lack of standards, and disorder, among other waste, therefore, lean tools emerge as an excellent option for its orientation to reduce waste that exists in the environment (Khairunnisa et al. 2020), and for its orientation to optimize distribution, time, costs or specific storage operations (Prasetyawan et al. 2020). Martins et al. (2020) demonstrate that the application of 5S reduces operating times and minimizes human errors and reprocesses; their improvement proposal managed to improve storage capacity by 12%, increase 35 the spaces in the order preparation area, and improve the loading and unloading area of materials, significantly reducing transport distances. Montalvo et al. (2020), faced with the problem of preparation and shipping times of finished products, proposed the implementation of 5S and SLP, thus reducing order delivery times by 54.39%, reducing 8.77 days of lost time plus production time to 4 days. Marmolejo et al. (2016), carried out implemented 5S in the import process, so they had to redesign the positions and the work area, eliminating backtracking, unnecessary transport, and the causes of waste; in addition, the activities to be performed were reduced from 21 to 9; these changes had an impact on efficiency, times that do not add value were decreased by 12%. In this context, companies in the automotive sector must focus on being more efficient in providing a better level of service by using lean tools to achieve their objectives.

Next, the research is divided into five parts: literature review, methods, results and discussions, validation, and conclusions.

1.1 Objectives

The main objective of the research is to improve the review and storage productivity from 2.11 to more than three packages per man-hour by using lean warehousing 7S and SLP tools. It is also sought that this research can help continuously improve warehouse management of automotive companies in the retail sector for better productivity and competitiveness. Finally, the main objective goes hand in hand with secondary objectives that, in turn, are related to improving productivity, such as the reduction of inspection, storage, and spare parts waiting times, the reduction of costs associated with the warehouse, and an improvement in the use of warehouse space.

2. Literature Review

2.1 Warehouse Management

It involves developing and implementing a series of processes to optimize the storage of goods, ensure they move faster through the warehouse, ensure accurate identification, maximize utilization of available space and minimize cargo handling, review precise inventory levels, increase employee productivity, and reduce operating costs (Abushaikha et al. 2018). Five main activities can be classified in a warehouse. It is imperative to document the identification information, unloading procedure, and verification precisely by the accompanying shipping documentation upon the goods' arrival. After identifying the merchandise, it becomes imperative to allocate and relocate it to a designated area within the warehouse according to factors such as volume, weight, and rotation. Inventory control is an essential process that ensures the identification of products in the warehouse, their precise location, and the transfers that affect them. The process of ordering entails the selection and retrieval of products from the warehouse to generate delivery orders. Physical verification is performed during shipping, the process of generating shipment documentation to ensure that the shipping reports correspond to the merchandise being loaded onto the corresponding transport unit. (14% Serrano) The utility of warehouse management can be summed up in two fundamental variables: the execution of accurate storage and picking policies. Properly managing these two processes is a foundation for all aspects of warehouse operations, including order fulfillment, economic profitability, warehouse capacity, and productivity.

2.2 Lean Warehousing

The pursuit of enhanced productivity and cost reduction in warehouse management, coupled with increased competition, has led to a proliferation of research concerning implementing Lean Warehousing. This methodology is adaptable to all warehouse types, irrespective of their unique attributes. Measures are implemented to reduce expenses and boost output to eliminate activities that fail to produce value (Abushaikha et al., 2018). According to Abushaikha et al. (2018), lean warehousing aims to optimize activities and available resources by eliminating waste from the logistics system. Lean methodology substantially enhances cost reduction, staff productivity, and the attainment of superior service quality. Lean philosophy permits the identification and elimination of the seven primary sources of waste in a warehouse organization—ergonomics, overproduction, excessive processing, excess inventory, transportation, waiting, and defects—in the same vein of waste reduction (Salhieh et al. 2019).

2.3 Lean 7S tool

The Lean 7S approach is an extension of the 5S method, which focuses on seven key areas to improve organization and efficiency in any operating environment. The seven areas are sorting, Setting in order, shining, standardizing, sustaining, safety, and spirit. This approach promotes the elimination of waste, continuous improvement, and the creation of a safer and more efficient work environment (Sukdeo et al., 2020). 7S, the new model of the 5S methodology, allows for increasing efficiency, quality, and safety performance in organizations, as demonstrated by an implementation study in a manufacturing company (Sukdeo et al. 2020). In addition, incorporating 6S and 7S improves the organization's competitiveness by promoting a culture of continuous improvement, organizational quality, and sustainability (Carrera et al., 2021).

2.4 Systematic Layout Planning (SLP)

Systematic layout planning (SLP) is a systematic tool to optimally design and reorganize warehouses' layouts. It is based on identifying material flows, work relationships, and space requirements to develop a layout that minimizes movements, reduces bottlenecks, and maximizes operational efficiency (Yang 2021). In a warehouse, it is essential to eliminate non-value-added activities such as unnecessary trips. A Peruvian SME operating in the textile sector successfully attained notable enhancements by implementing the SLP methodology. These included a 54.39 percent reduction in order delivery time, a 24 percent decrease in the number of operations, a 17 percent decrease in transports, and a 19 percent reduction in the number of inspections (Montalvo et al. 2020). In another case, a signal control box company applies the SLP method, achieving a 65% reduction in material handling time, and the material handling distance became 67% shorter, i.e., the labor intensity and operator burden are significantly reduced (Yang 2021).

2.5 Effectiveness of lean warehousing 5S/7S and SLP tools together

Instances of effective 5S and SLP tools integration within warehouse management, specifically lean warehousing, where the overarching goals were enhanced efficiency and waste elimination. The efficacy of Lean Warehousing techniques was demonstrated through the simulation in Arena software of the implementation of 5S and SLP tools. This resulted in a 26 percent reduction in the time required to process a picking order and the elimination of incidents arising from expiration dates. The implementation of Lean methodologies, including but not limited to 5S and SLP, increased the efficiency of the picking and storage operations by 27% and 33%, respectively (Figueroa et al., 2022). By organizing work areas and eliminating unnecessary routes, implementing Lean methodology tools such as 5S and SLP in warehouse management yields positive results for operations; after configuring their model and conducting the simulation, they decreased damaged merchandise by 23.3 percent and merchandise transfer times by 34.7 percent. The optimization increases the organization's financial gains (Echevarría et al., 2023). In summary, Lean Warehousing, 7S, and SLP tools offer positive approaches to effective warehouse management and improved productivity and time. Combining order practices, standardization, and optimal layout design can help companies achieve higher levels of operational efficiency in their warehouse management and thus be more competitive in the marketplace.

3. Methods

After the selected literature review, a model is developed to improve productivity and reduce the merchandise's waiting, inspection, and storage times. This proposed model generates value by applying Lean Warehousing tools to achieve the objectives. Next, the comparison matrix between the causes of the problem developed in the case is shown in Table 1.

Table 1. Comparison matrix of the causes developed in the case of study vs. the state-of-the-art

Causes / Authors	Unproductive times	Unnecessary routing	Inefficient layout areas
Montalvo-Soto et al. (2020)	5S, SLP	5S, SLP	SLP
Yang (2021)	SLP	SLP	SLP

Espinoza-Camino et al. (2020)	5S	5S	
Leon-Enrique et al. (2022)	5S, SLP	5S, SLP	SLP,
Sukdeo et al. (2020).	7S	7S	-
Echeverria-Garcia and Espinoza-Alarcon (2023).	5S	5S	-
Nallusamy and Ahamed. (2017)	5S, SLP	5S, SLP	SLP
Proposal	7S + SLP	7S + SLP	SLP

3.1 Model proposal

After analyzing previous works' results regarding their usefulness in solving the problems identified in this case study, the improvement proposal model, shown in Figure 1, was developed based on three stages to solve the main problem and its root causes.

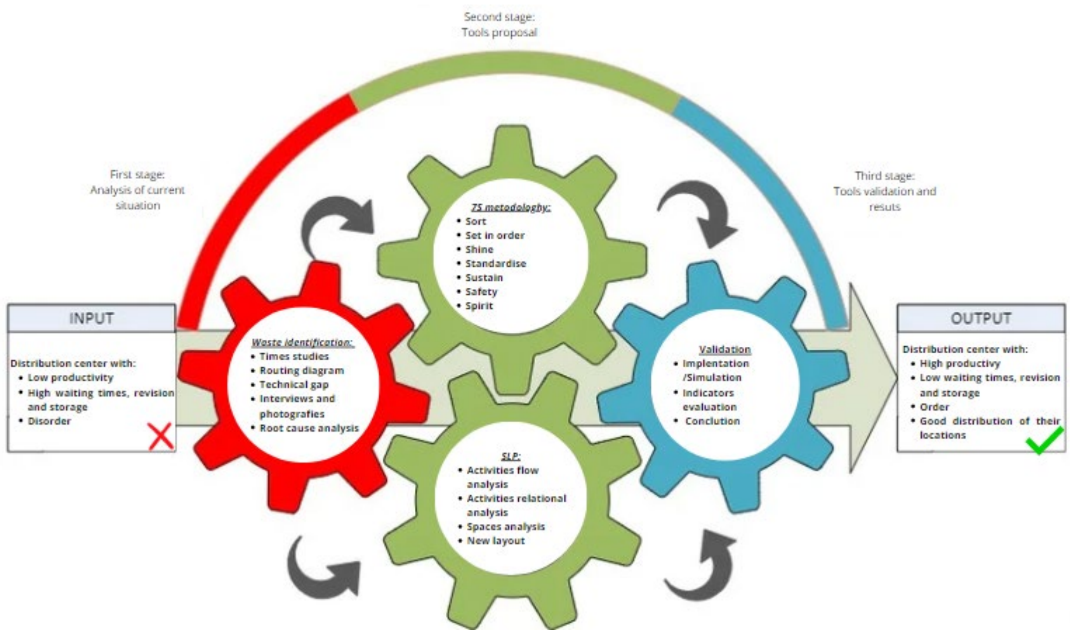

Figure 2. Proposed model

The main innovation of the proposal is the 7S tool in replacement of the classic 5S, taken to warehouse management, providing safety and spirit for work as aspects to be considered for improvement.

3.1.1 Analysis of the current situation

The improvement proposal model begins with the stage of Analysis of the current situation of the spare parts distribution center, which consists of identifying the main problem and technical gap within the sector and, secondly, determining the waste to find the root causes based on the information collected and analyzed, using time studies, route diagrams, technical gap review, interviews with workers, photographs of locations and storage density.

3.1.2 Implementation of proposal tools

The second stage of the model is the proposed implementation of tools, which consists of two steps; the first step is to conduct an internal audit of the 7S to know the current score, with a maximum of 20 points for each "S". To then apply the 7S, the second phase of stage two consists of making the SLP where a new distribution and new spaces for the locations of the distribution center will be proposed, this will be done taking into account the current distribution, the diagram of routes of the center, the diagram of activities and the list of locations that the distribution center needs, once the information is collected, the Analysis of spaces and relational, to have the areas and distribution of spaces that will require each location so it will culminate with a new design of facilities for the Distribution Center.

3.1.3 Validation and results

The third stage will culminate in the research with the validation, a simulation in Arena Software to give the new indicators resulting from the implementation of 7S and SLP, with an analysis of the results, comparing the new indicators with those before the implementation, and the research conclusions.

3.2 Indicators to evaluate

The indicators for the model are presented below.

7S Accomplishment
Objective: To indicate how effective the 7S methodology is in eliminating waste.
Formula:

$$\frac{\mathrm{S1} + \mathrm{S2} + \mathrm{S3} + \mathrm{S4} + \mathrm{S5} + \mathrm{S6} + \mathrm{S7}\ (\mathrm{S7\ Score})}{\mathrm{Perfect\ score\ (84\ points)}}$$

% Layout performance
Objective: To indicate how effective the use of the Distribution Center is in the areas it has; the intention is to reduce the m² because each m² costs the rent paid.
Formula:

$$\frac{\text{Area for activities in the Distribution Center } (\mathrm{m}^2)}{\text{Total area of the Distribution Center } (\mathrm{m}^2)}$$

Operator productivity
Objective: To measure when the goods are received at the warehouse until they are stored.
Formula:

$$\frac{\text{Number of packages}}{\text{effective man} - \text{hour}}$$

Labor cost
Objective: To measure the cost of the operators
Formula:

$$\frac{\text{Man} - \text{hour cost (USD)}}{\text{Productivity } \left(\frac{\text{Package}}{\text{man} - \text{hour}}\right)}$$

% Package inactivity
Objective: To measure the percentage of time that a package of spare parts is in queues until its final storage, concerning the total time of the package from its arrival at the warehouse to its final storage, passing through all the activities.
Formula:

$$\%\ Package\ Inactivity = \frac{Total\ waiting\ time\ for\ a\ package\ in\ the\ process}{for\ a\ package\ in\ the\ process}$$

3.3 Data Collection

The data collection could be carried out thanks to the guided visits that were scheduled to the distribution center and the subsequent non-guided visits where there was the freedom to take the required information. The warehouse manager, supply manager, and related operational and administrative staff were interviewed and surveyed to understand the workflow and their needs and find opportunities for improvement. A time study was carried out on the storage activities, photographs were taken, and measurements of the dimensions of the equipment and defined areas of the warehouse were made. The root cause and path diagrams, such as the Ishikawa diagram and the Value Stream Mapping, were helpful in waste identification. Finally, the information validation meetings with the personnel surveyed and interviewed at the beginning were held to polish the problem statement, objectives, and potential solutions for the research.

4. Results and Discussion

4.1 Numerical Results

After a time study that allowed to know the productivity of inspection and storage of spare parts, the average inspection and storage per part of this distribution center in the last 15 months is compared with the time per part of the sector that according to Leon et al. (2022) is 7 minutes and 30 seconds per part, while that of the company is 8 minutes and 36 seconds per part, having a technical gap of 14.67%, which translates into a 14.67% delay in inspecting and storing spare parts compared to the sector (Figure 2).

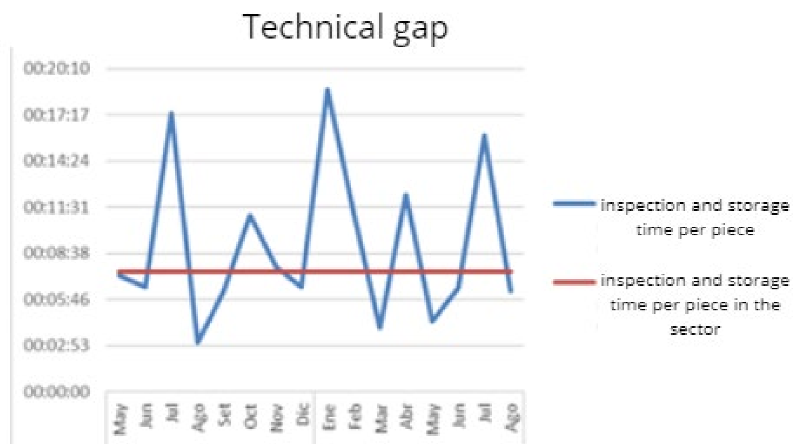

Figure 2. Technical gap inspection and storage productivity in “time/piece."

A study of storage density was also carried out according to the type of rack or mezzanine storage infrastructure. The storage density is an indicator to be taken into account since it measures the amount of space occupied by the spare parts over time, having that the storage density averages less than 50% in the mezzanine storage area and the pallet storage area in racks during the last eight months, it is evident an inefficient use of space in the locations dedicated to storage, being able to gain 50% of their areas in m² for other places that may need more space (Figure 3).

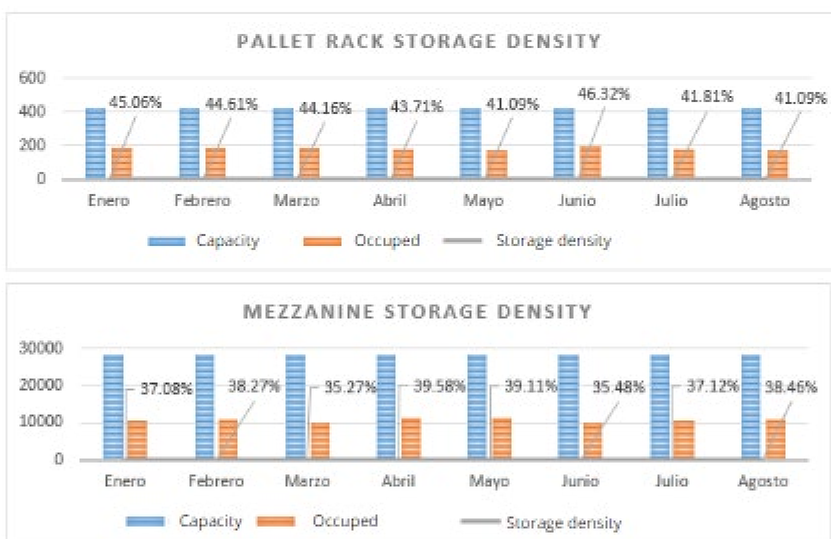

Figure 3. Storage Density

4.2 Graphical Results

Two route diagrams were made to identify the unnecessary routes for the storage activities in the distribution center and to better understand the movement of the spare parts and the operators. The first diagram shows the activities through which the spare parts pass to be stored, and the second diagram shows the activities carried out by the receiving operator to use the storage equipment. From the first diagram, in Figure 4, 12 activities could be determined, half of which were transportation activities, 2 of them being residual, while from the second diagram, Figure 5, 4 unnecessary routes were detected. Both routes could be improved if the SLP were carried out (Micheli et al. 2021).

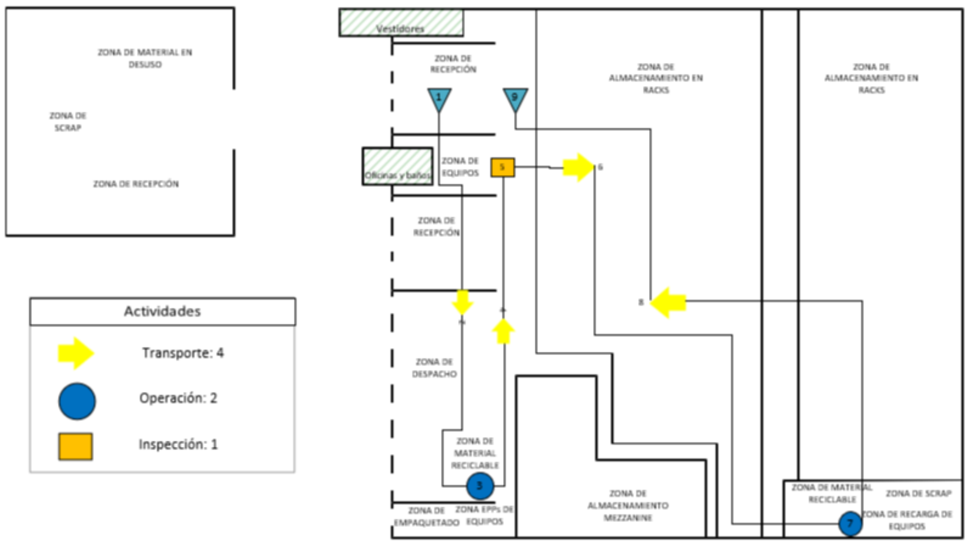

Figure 4. Route diagram for the use of storage equipment

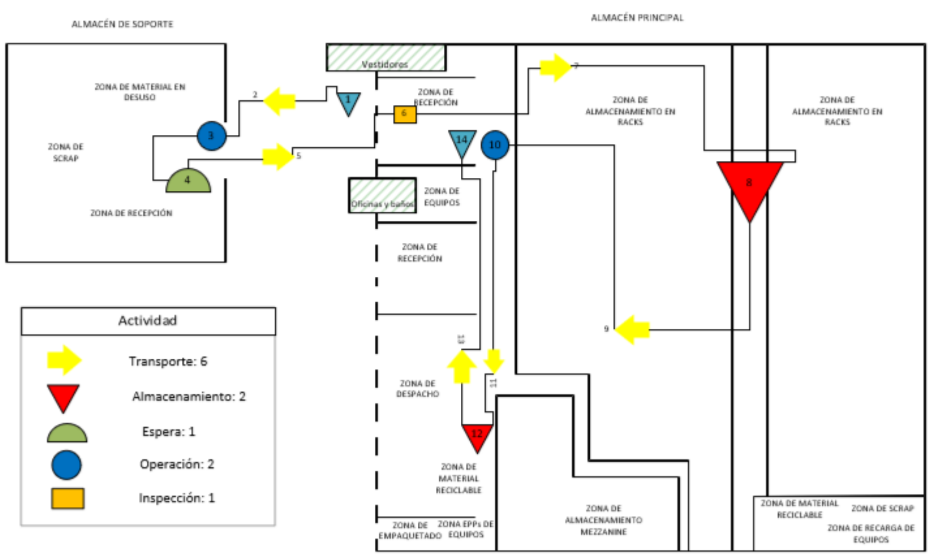

Figure 5. Spare parts package route diagram

4.3 Proposed improvements

Figure 6 shows the implementation process of the 7S and SLP tools, detailing each step to be followed.

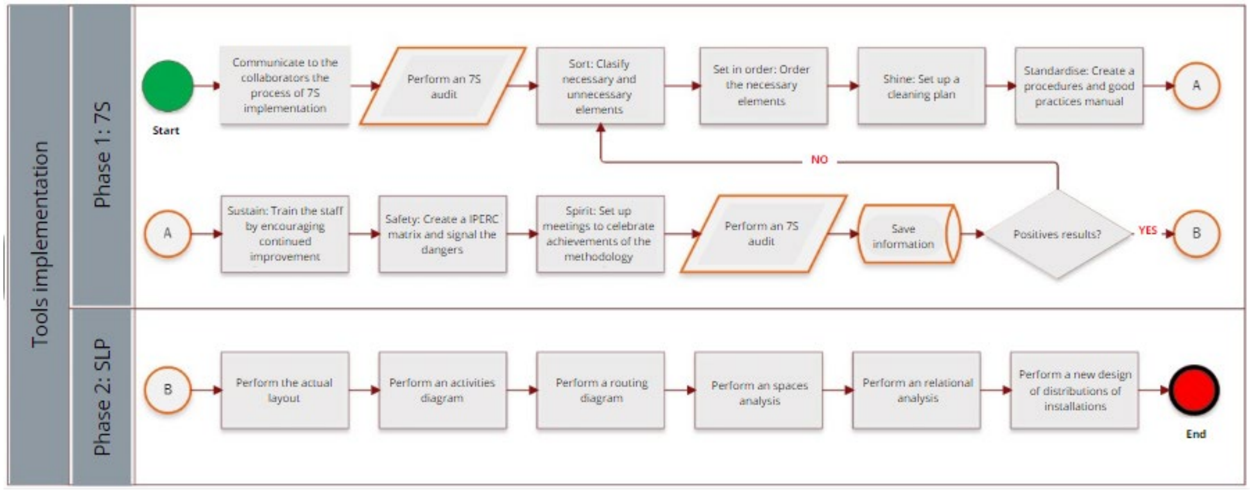

Figure 6. Tools implementation process proposal

5. Validation
5.1 Validation design and comparison with initial diagnosis
For the implementation of the 7S in the distribution center, Figure 7 and Figure 8, the method proposed in Figure 6 was followed with a classification of all the elements of the warehouse according to their need, ordering according to purpose and need, establishing a weekly cleaning plan, reasonable practice procedures, training, an IPRC matrix and signage for safety, and meetings to celebrate achievements in the management of 7S for the working spirit.

Figure 7. Training and implementation of 7S methodology

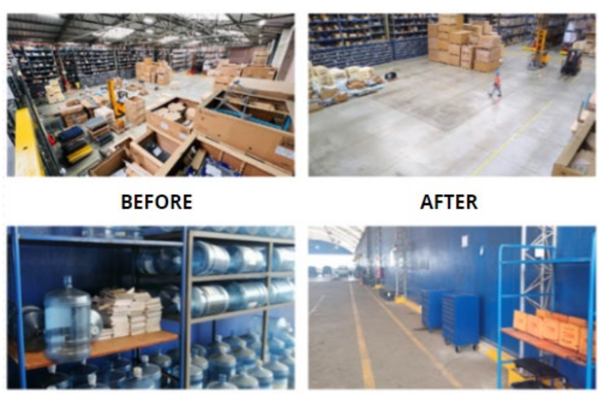

Figure 8. Before and After

The method used to review the tool's validation was comparing the initial and final indicators obtained at the end of the 7S implementation period, as well as the new inspection and storage times per Spare parts package (Table 2).

Table 2. Pilot test validation results

Tool	Indicator	Current	Expected	Obtain
7S	% Package inactivity	19.9%	16%	15.8%
7S	Average inspection time per package of pieces	41.1min	35 min	34.9min
7S	7S Accomplishment	44%	100%	89.2%
7S + SLP	% Layout performance	78.95%	85%	86.55%

5.2 Simulation of improvement proposal

After having performed in the following order, an analysis of the flow of activities, relational Analysis of activities and locations, and space analysis, a new distribution proposal was made, see Figure 9, with the results of the Analysis being helpful for the variables that allow us to introduce in its simulation, although with the consideration that it does not consider external factors that may affect the duration of each activity and the implementation of the model, In addition, the so-called support warehouse of 1000m² is removed from the distribution center, which generates expenses of more than 100,000 USD per year, the purpose of this support warehouse was to store scrap and to serve as a waiting area for the spare parts that had not yet passed inspection and had no space in the receiving area, both purposes of this support warehouse were solved with the 7S methodology that will allow the SLP to optimize the distribution of the warehouse thanks to its results.

Figure 9. Proposed layout location map

5.2.1. Simulation model in Arena software

The Arena software will be used as a validation method for the SLP tool; it should be considered that since it is a simulation software, it has some limitations, such as the accuracy of the data obtained and collected, and does not consider external factors that may affect the duration of the process activities and the implementation itself. The scope of the system begins with the truck's arrival at the distribution center; there are five types of trucks, depending on whether it has 1, 2, 3, 4, or 5 orders. Each order contains packages of spare parts that are unloaded in the reception area. They wait for a quality inspection there, and the packages are assigned according to their characteristics and location.

As a sample, the last eight months of work of the operators in charge of the storage activities of the distribution center were taken; 50% of the data were taken after discarding scattered data from their respective fields, taking a confidence level of 95% and 10% for the margin of error, taking as a factor for the start and end of a replica the 9h45min that lasts a working day. Regarding the probability distributions, these were found according to a data analysis in Input Analyzer of the results of the time study to obtain the appropriate and adjusted distributions to facilitate the simulation of each activity, except for unloading, which took place at a rate of 4 minutes per package, as well as recycling at 4 minutes after package inspection. The distributions obtained and used in the simulator are presented below (Table 3).

Table 3. Fitted distributions used in the simulation

Activity	Distribution	Unit
Time between arrivals	Expo (1.29)	Hour
Order per truck	0.5 + Expo (1.02)	Number of orders
Pieces per package	0.999+Gamm (89.7,0.457)	Amount of pieces
Storage time	163*Beta (0.219,2.52)	Hour
Inspection time	2+Expo (35.3)	Hour
Packages per truck type 1	0.5+Expo (3.68)	Number of packages
Packages per truck type 2	1.5+ Expo (4.49)	Number of packages
Packages per truck type 3	Tria (2.5,5.17.5)	Number of packages
Packages per truck type 4	5.5+8*Beta (1.37, 1.64)	Number of packages
Packages per truck type 5	6.5+7*Beta (0.291, 0.595)	Number of packages

The entity within the simulation system is a dynamic element that moves through each system activity. Thus, we indicate the two entities that interact with the system activities, their attributes, and the resources related to them through the activities. These are the trucks and the packages of spare parts (Table 4 and 5).

Table 4. Interaction of entities in the simulation system

Entities	Atributes	Resources	Activities
Trucks	Time between arrivals	Forklift driver	Arrive to the system
Trucks	Number of orders and packages	Forklift driver	Review truck type and attributes
Package	Amount of pieces	Forklift driver	Unloading
Package	Amount of pieces	Reception operator	Inspection
Package	Amount of pieces	Storage operator	Storage

Table 5. Quantity of resources

Resources	Quantity
forklift driver	1
reception operator	3
storage operator	2

Five replicas were taken as a preliminary sample to calculate the number of replicas needed by the spare parts storage simulation system. They entered the Arena software, giving a half width of 29.4, above the desired 17.6. This value is 10% of the average of the total storage time, giving a total of 14 replicas as the recommended ones (Figure 10 and 11).

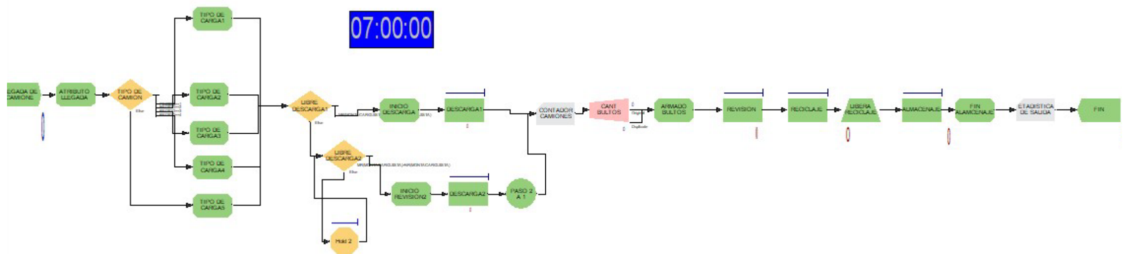

Figure 10. Initial simulation

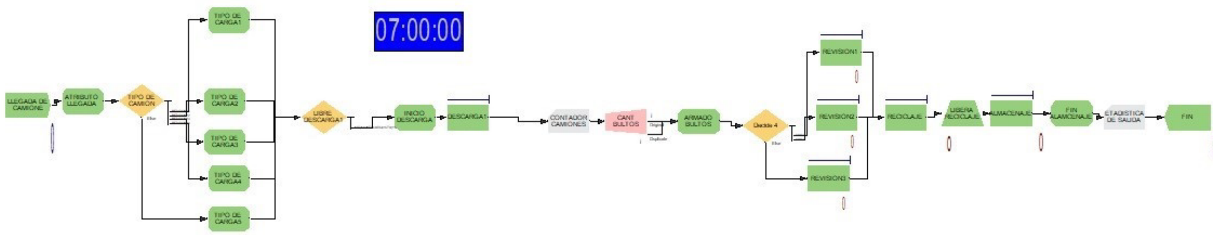

Figure 11. Simulation of the improved situation

We can verify in the results of the indicators that the reduction of inspection time, by the application of 7S, gave more space and order to operators so they could perform their work at a good pace and allowed better manage their tools, the cost of labor reducing the cost by 2.79 USD in turn that productivity increased by 47.86% this coincidence by being both indicators linked through man-hours and spare parts packages that are worked. Also, the storage time was reduced by an average reduction of 12. 6% due to the average inspection time reduced to store products by 15.08% and the total waiting time for inspection and storage by 5.86% due to the improvements in inspection and storage speed (Table 6).

Table 6. Final results after the proposed model simulation

Tools	Indicator	Original Model	Improve Model	Improvement
7S + SLP	% Package Inactivity	19.9% (15.8% with 7S)	14.04%	Waiting time in queues per package was reduced by 5.86%
7S + SLP	Operators productivity	2.11 Packages/man-hours	3.12 Packages/man-hour	Productivity improves by 47.86%
7S + SLP	Labor cost	8.62 USD	5.83 USD	It was reduced by 32.36%
7S + SLP	Average inspection time per package of pieces	41.1 min	34.9 min	Inspection time was reduced by 15.08%
7S + SLP	Average storage time per package of pieces	18.3 min	16.74 min	Storage time was reduced by 12.6%

6. Conclusion

The implementation of 7S and SLP tools in the warehouse management of the spare parts distribution center of a retail company in the automotive sector managed to increase productivity in the inspection and storage activities of spare parts and accessories from 2.11 packages of spare parts/man-hour to 3.12 packages of spare parts (productivity increased by 47.86%). This productivity improvement impacts the labor cost, which is reduced by 32% for operations related to inspection and storage. The 7S methodology is an innovative proposal that seeks a better work environment that prioritizes sustainability and improves cleaning, order and standardization, considering new aspects concerning the classic 5S, both safety and work spirit. The 7S and SLP also reduced 29.45% in the waiting time of a queued package thanks to the reduced inspection and storage times of the spare parts by 15.08% and 12.6%, respectively. Finally, the SLP also improved distribution throughput by increasing by 7.6% while reducing the total area of the distribution center from 7000m² to 6000m², demonstrating that the SLP tool allows more efficient use of the total warehouse area.

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