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Service model based on lean tools to improve order fulfillment rate in a SMEs in the commercial sector

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Abstract*– The commercial sector has been growing steadily in recent years. However, there are problems within logistics that are detrimental to customer satisfaction; the objective of companies is to deliver orders on time and avoid large losses. That said, in the present research, the problem that generates the greatest economic losses for the company is the high percentage of unfulfilled orders. The objective is to reduce the technical gap of unfulfilled orders by implementing a model based on the Lean methodology, through the application of 5S, ABC and Kanban; achieving the improvement of the objectives of the proposed indicators. The research focuses on a warehouse where the root causes of the problem are identified and quantified, to subsequently attack them through Lean tools. Finally, through the use of Arena software simulation, it was demonstrated that the proposed model achieves a reduction of 38.8%, 12.32% and 47.23% in picking times, registration to the system and total simulation time, respectively, thus improving the fulfillment of deliveries to the customer until reaching the target of 5%.

***Keywords*—Service Model, Kanban, 5S, ABC, Warehouse, Order Fulfillment, Commercial Sector.**

I. INTRODUCTION

According to a publication of the National Institute of Statistics and Informatics of Peru, the EAP represents 67.8% of the working-age population, males and females over 14 years of age, of which the Commercial Sector concentrates 19.5% of said EAP [1]. Likewise, it is necessary to indicate that the growth of the commercial sector has remained almost uniform from 2012 to the present, approximately 14% [1]. In the operation of warehouses, the activities of returning, reassembling, and reshipping orders could represent between 55% and 65% of the total costs for the company; therefore, an improvement in this process could lead to significant savings in operating costs and, therefore, in the entire logistics cost [2].

For all the above described, we consider that the commercial sector has much to innovate and improve in the logistic aspect because sometimes it presents processes with activities with a Lead Time greater than that of the technical gap, which makes that our management in the supply chain may have delays in the orders, or non-fulfillment of demands, not allowing an agile and dynamic system of internal logistics.

According to [3], "The market has demanded from organizations characteristics that include: efficiency, effectiveness, dynamism, creativity, agility, flexibility and that they have a holistic vision, that they are competitive and, at the same time, have defined strategies seeking sustainability in the business".

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At the continental level, Europe classified companies by level of market segmentation, company size, level of maturity of logistics implementation, and use of resources for production, transportation, or distribution, among others [4]. Research in Mexico set out to analyze ordering orders looking for the best strategies for the picking problem. The indicators reviewed were: travel time between warehouses, time used to search for the products that are part of the order, the collection of the products, and their preparation. The proposed strategies were: employing storage techniques, analyzing a routing method, and avoiding errors in picking [5].

In Peru, the Ministry of Transport and Communications and the Inter-American Development Bank conducted a survey of Peruvian companies in the logistics-commercial sector, with the result that the logistics cost represents 16% of sales revenue; therefore, its importance has been measured and, therefore, there is a need to seek substantial improvements [6]. The problem identified in the literature in scientific articles is the need for a more inefficient administration and the choice of the best tool to solve the problems encountered. Therefore, for our case study, an investigation was carried out in a distribution center of finished products related to the commercialization of industrial supplies, in which a model is proposed to optimize the time of the activities performed in the production logistics to reduce the percentage of non-fulfillment of orders. For this case study, we have focused on finding the solution to the possible root causes, which are concluded from the Pareto diagram, such as disorder in the warehouse, lack of signage in aisles and corridors, inefficient visual management by colors in the locations of shelves and racks, inaccurate classification of stored products and random distribution of stored products according to their rotation. Given this reality, we analyzed a Peruvian SME responsible for supplying industrial supplies to various customers. By studying their inventory management, we evidenced the problem found and decided to propose improvements to solve their problems. We have estimated the economic impact that this problem could generate: the cost of losing a customer; this represents 13.50% of the total annual income received, according to the information provided. Therefore, we have decided to use the 5S, ABC, and Kanban methodologies to fulfill the objective of our improvement proposal. Therefore, this research proposes to implement improvements in production logistics, delivering complete and on-time orders and attacking the root causes that originate the problem found. It is necessary to indicate that although these methodologies mentioned have been used in distribution centers to improve a current situation similar to our case study, there is no research that this set of methods for the proposal of improvement in the commercial sector applied to Peruvian SMEs, this makes the research innovative by the use of the three methodologies and the order of use of these. In addition, using the Arena software will help to demonstrate the achieved goals of reducing the technical gap and the process times in the distribution center.

This scientific article will be divided into six parts: introduction, state-of-the-art, contribution, validation, discussion, and conclusions.

II. State of the Art

A. 5S in warehouses

The 5S consists of sorting, standardizing, ordering, and maintaining good organization in the warehouse. Each S contributes to making operations more efficient within a company, reducing logistics costs, and delivering orders on time to the customer [7]. For the application of the 5'S, an initial observation and inspection of the warehouse area should be performed using a Check List and then dividing the improvement work into four stages: Initial cleaning, application, optimization, and continuity [8]. In the research of [9], the 5S tool was implemented to classify, sort, and clean a warehouse; red cards were also used to classify obsolete products and determine whether they should be eliminated or relocated, with the help of other Lean tools such as ABC and standardization of work, this research obtained good results since picking time was reduced by 55%.

Currently, the competitiveness of companies is high; therefore, they are concerned about retaining their customers from competitors by using Lean methodologies because, over the years, they are becoming more effective in solving problems within companies and thus improving productivity [7]. In the warehouse, the search for products is essential for the order preparation process; for this, it is necessary to have an adequate environment of order and cleanliness. The 5S methodology helps companies to reduce product search times, as in the case of a Peruvian plastics manufacturing company that used the 5S tool in its improvement proposal model, reducing the time spent searching for tools in the machining area from 8.6 to 3.1 hours, achieving a reduction of 36.05%, which was reflected in the 5S audit [10].

B. ABC in warehouses

The ABC classification is used to organize the items in descending order according to the annual consumption or utilization criteria or according to the annual demand or sales [9]. The ABC tool is very effective in warehouses; companies, when they have many items, may not have the policy to be efficiently located within the warehouse; therefore, they classify products with the same importance [11]. Therefore, the ABC tool helps to classify products within the warehouse in order to improve travel times and reduce picking times. It consists of classifying products into three categories, A, B, and C, according to sales profitability criteria [7]. While it is true that the classification consists of categorizing items into three groups, A, B, and C, in descending order according to the value invested in the goods, there are also other classification criteria such as delivery time, obsolescence rate, among others; this is where it is called ABC Multicriteria tool [11].

In the research of [7] the ABC tool is used to reduce the number of routes and thus the picking time is less; also classified into three types of customers where group A belongs to 80%; group B, 15% and group C; 5%; therefore, in the new design the products belonging to group A are placed closer to the dock than the other products belonging to the other groups and as a result the picking time was reduced from 335s to 180s.

C. Kanban in warehouses

The Kanban methodology is a tool that helps in visual management and is appropriate for any type of work team, it helps to improve quality, reduce delivery time and also production costs. Works carried out demonstrate its application and it is shown that it helps the good communication between areas making use of the kanban cards, this makes that there is a reduction of times in the different activities, with the application of this technique it is possible to obtain that the delivered orders decrease in 54.39% and the number of operations go from 54 to 34 units [12]. Other scientific studies detail the adaptability of this tool and its efficiency to achieve results, support agile processes and improve working conditions [13].

Therefore, if there is no good communication between the different areas, there will not be an adequate inventory control. Lack of communication can lead to inaccurate measurements and as a consequence there will be lost merchandise, material in bad condition, disorder in the area and even delays in the delivery of orders. Therefore, kanban cards are helpful as a visual management tool for operators. In addition, the labels with the appropriate and necessary information for each shelf or rack, depending on the items, is a great help to keep a better record of inventory, not only because it provides accuracy, but also because it allows continuous improvement in both the performance of the operators. The delivery of orders on time is key and strategic for many companies with their customers, since reliability is compromised and guarantees a future reward, either with the same customers or with new customers [12].

D. Orders delayed by picking activity

In distribution companies, order preparation (picking) is a very important process and should be carefully analyzed as unproductive picking times in order to have better results within the warehouse [14] [15]. This process involves order preparation, order searching, routing within the warehouse, ordering, inventory recording, and a number of operators, among others [14] [16]. It is important the distribution of the warehouse in terms of layout and routing policies, this could cause congestion problems in the aisles, so it is proposed that

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the design of the warehouse be S-shaped or U-shaped; in this way, we also avoid downtime in the picking process [17]. Order delays occur as a consequence of poor management within a warehouse, and the best way to attack the problem is to verify which are the most important causes. It is necessary to take into account the picking process and apply engineering methodologies to improve the current situation of the warehouse and perform continuous monitoring based on indicators. On-time delivery of orders generates reliability for the company in the eyes of its customers.

Therefore, poor management within the warehouse generates high logistics costs such as labor, loss of customers, product waste, etc. Therefore, companies aim to decrease costs in unproductive operations and satisfy their customers with fast delivery of products [15].

III. Innovative proposal

A. Basic model

Currently, companies in the commercial sector have problems with order fulfillment and inefficient performance in the management of distribution and placement of stored products, which leads to longer search times for picking and generates unnecessary inventory management costs and extra man-hours. To this end, we have prepared a table that summarizes and relates the articles referenced in this research with the tools and causes that, if used incorrectly, would generate inaccuracy in the measurement of our indicators.

Table I summarizes the causes found in the case study and the authors who mention each of them in their research, according to the systematic literature review.

TABLE I
COMPARATIVE MATRIX OF THE COMPONENTS OF THE PROPOSAL VS. STATE OF THE ART

Causes / References	Warehouse clutter	Lack of signage in corridors and hallways	Inefficient visual color management of rack and shelf locations	Classification of stored products	Random distribution of stocked products
[12]			Kanban		
[11]				ABC	ABC
[7]	5S			ABC	ABC
[9]	5S			ABC	
Proposal	**5S**	**5S**	**Kanban**	**ABC**	**ABC**

B. Proposed model

This value proposition is practical for the commercial sector, easy to implement, and very objective in terms of obtaining results aligned with the indicators to be measured.

The tools and optimizations under the Lean methodology have been adopted by companies for a long time, seeking to improve the efficiency and results of their operations, which is why the Lean philosophy is one of the most important in the business world [17].

In the initial phase, visits were made to the warehouse to inspect the area and collect data on the current situation and the procedures being carried out in order to analyze, through root cause analysis and a Pareto diagram, the choice of Lean tools to solve the problems encountered. These were: disorder, lack of signage in aisles, inadequate classification of stored products, and distribution of items without criteria. Therefore, the Lean tools used were: 5S, ABC classification, and Kanban. The first one basically solves the disorder and lack of cleanliness in the aisles and shelves; the second one classifies with descending criteria the ubiquity and position of the items according to sales revenue, classifying the stored products in zones A, B, and C; and finally, the last tool contributes to the visual management in the warehouse, providing the operator with inspection support when storing and picking the products. These three Lean tools manage to reduce search times, and picking times, among others, and therefore the total time spent in fulfilling and delivering an order. It is concluded that the proposed model was based on these three Lean tools to validate the proposed improvements obtaining satisfactory results with the measurement of the indicators shown for this research. The conceptual model of the proposal is shown in Figure 1.

C. Model components

The improvement proposal is divided into three components, which we will mention below.

Component 1: Analysis of the improved situation

The first component of the model is an initial diagnosis, which is necessary to understand the current situation of the area and collect measurable data to later analyze the information obtained. In this step, after analyzing the processed information, we will evaluate which Lean tool, according to the needs of the area, will be necessary to use to find the root causes of the current situation. [13].

After analyzing the information, the root cause diagram and the Pareto chart were made to identify the problems of the case study and finally select the Lean tools to be implemented, according to the needs of this first component, for the improvement proposal: to reduce the percentage of unfulfilled orders.

Component 2: Implementation of methodologies

The first tool to be implemented is the 5S. This tool is used to identify problems of order, cleanliness, and standardization in activities [18]. The 5S tool consists of 5 stages: Seiri is responsible for performing classification in the inspection line of products arriving in the area, verifying the condition of the products: broken, defective, expired, incomplete or dirty. Seiton: is in charge of organizing the workstation in the picking area, placing a plastic tray to better organize the orders that have been taken care of as well as the pending orders to be picked. Seiso consists of keeping the workstation clean, meaning that the corridors are free of obstacles, clear and optimally lit, and signposted. This is to ensure that the aisles and corridors are better organized and that the resources to be used are always clean, tidy, and in good condition. The warehouse must be kept clean. The fourth S: Seiketsu, consists of supporting the fulfillment of the three previous Ss. The cleaning work is carried out by means of cleaning schedules, indicating the person in charge of cleaning, the days and times used for each person in charge, as well as the utensils to be used, and the supervisor in charge will verify what is established is complied with daily, according to the established schedule.

Finally, the fifth S, Shitsuke, refers to this step to discipline the operator to achieve continuous improvement in the activities performed at each stage and thus measure compliance with the objectives set.

The second Lean tool is the ABC classification, which has the importance of classifying products and/or items since this is not the case in the current situation. The placement of the received products is done randomly and without any engineering criteria because as they arrive, they are stored following the SKU or empty space criteria and, therefore, often have duplicate locations. Therefore, we classify by type of family according to sales revenue in the company in descending categories: A, B, and C. These will be the new mega zones in the warehouse, in which the items will be placed once entered from the receiving line.

The last Lean tool is Kanban; with this tool, we seek to reduce picking and search times, which are the basis for the improvement of our problems, using colored sorting cards: green (high rotation), yellow (medium rotation), and red (low rotation).

The complementation of the Lean tools: ABC classification and Kanban contribute to the visual management of the warehouse, achieving not only a greater sense of ubiquity and space for the operator but also the reduction of core times in the picking and packing process of the production logistics area, once the product is identified in the order form, avoiding downtime in the aforementioned processes.

Component 3: Verification and analysis of results

The validation of the proposed model was carried out through a pilot plan for the implementation of the Lean 5S tool, and for the ABC and Kanban tools, the implementation of the Arena software version 16.1 was proposed, which will simulate the scenario of the improvement proposal in the production logistics area for this case study and both will show us results aligned to our objective indicators.

The improvement proposal will be made in the production logistics area warehouse, where the inspection, storage, picking, and order dispatch processes are carried out.

D. Proposed Model Process

In the Figure 2 shows the implementation method of the proposed service model, detailing the step-by-step for its application.

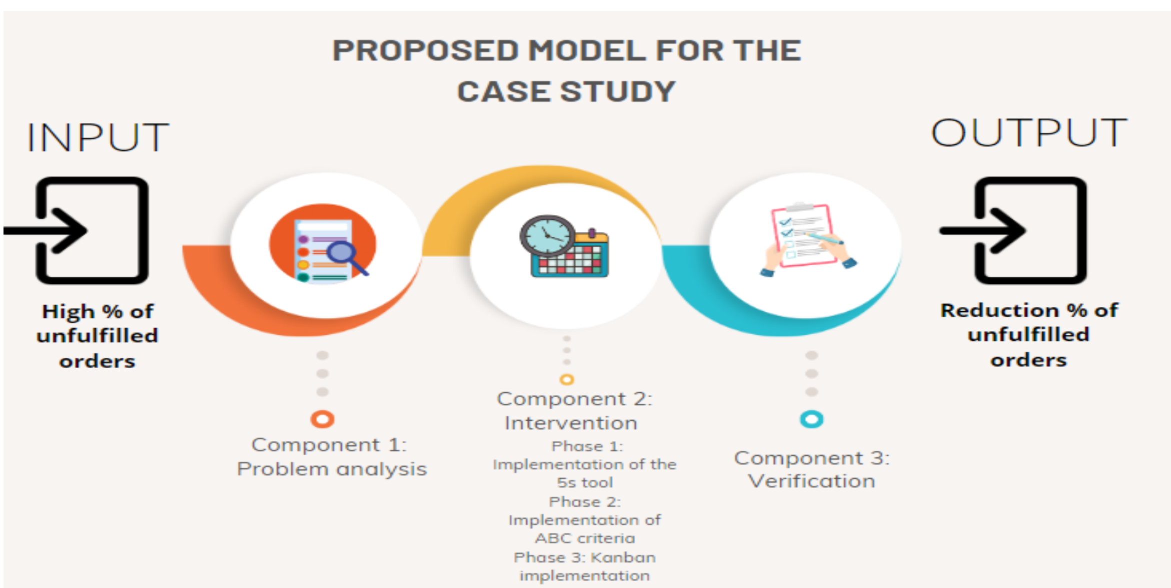

Figure 1. Proposed Model. Adapted from [9], [11], [12]

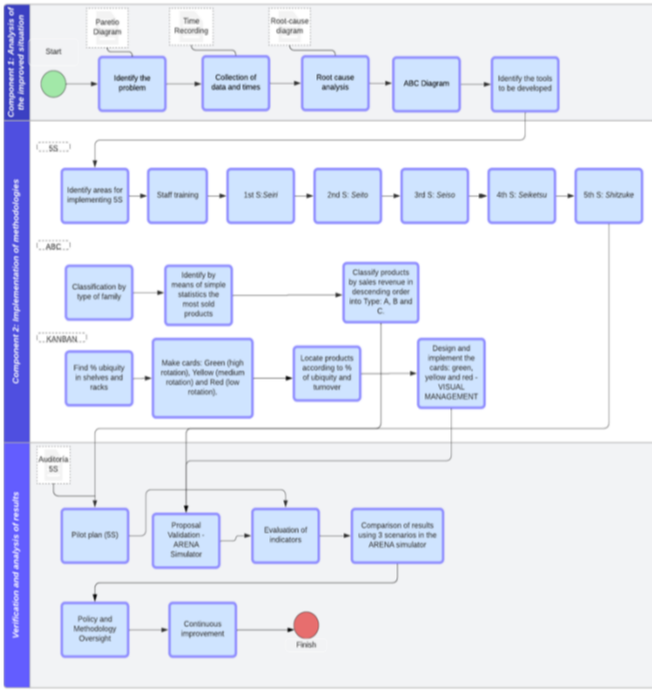

Figure 2: Proposed Model Process

E. Indicators of the Proposed Model

The indicators used to reduce the uptime and thus achieve a reduction in the percentage of unfulfilled orders were as follows:

Percentage of non-fulfillment of orders (%PNFO):
Determine the % of unfulfilled orders.

$$\%PNFO = \frac{Number\ of\ orders\ no\ fullfilled\ and\ not\ delivered\ on\ time}{Total\ orders\ placed} \times 100$$

Average picking time of an order (APT):
Determines the preparation time of an order in minutes.

$$APT = \frac{Picking\ process\ time\ of\ a\ order\ (\text{min})}{Total\ time\ of\ picking\ process\ (min)}$$

Time in the system (TS)
Determines the total time in minutes of an order from the time it is generated until it is placed on the mobile unit for delivery to the customer.

Objective: Decrease system time

$$TS = Improved\ total\ system\ time\ (\text{min}) - Total\ time\ in\ current\ systema\ (min)$$

Average packaging time (APT)
Determine the average time in minutes to pack an order.
Objective: Decrease packing time per order in the packing area.

$$APT = \frac{Time\ to\ pack\ an\ order\ (min)}{Total\ packing\ time\ for\ all\ orders\ (min)}$$

Average time of registration in the system (ATRS)
Determines the average time in minutes to register an order prepared and sent to paking for packing and shipment to the customer.

Objective: Decrease of the time registered in the system per order in the picking area.

$$ATRS = \frac{Time\ of\ registration\ of\ a\ completed\ order\ (min)}{Total\ recording\ time\ of\ all\ completed\ orders}$$

Percentage of improvement in 5S Audit (% 5S):
Determine the improvement in terms of 5S tool implementation in the production logistics warehouse.

$$\%\ 5S\ Audit = \sum Cumplimiento\ de\ cada\ \text{"S"}$$

IV. Validation

A. Initial diagnosis
When analyzing the current situation, the problem was identified as a high percentage of unfulfilled orders. Currently, the case study has an average of 21.05% of unfulfilled orders, exceeding the ideal in the commercial sector, which is 5% generating losses of S/. 281,102.78 per year, which represents 13.5% of annual revenues.

The causes that generate the problem within the warehouse are Disorder in the warehouse, lack of signage in the aisles and corridors, inefficient visual management by colors in shelf and rack locations, inadequate classification of stored products, and random distribution in the warehouse of received products. This is due to two main reasons related to excessive time in two fundamental tasks to attend to order; the first one is the picking time found in the initial situation of 10.97 min/order; due to the causes we have already mentioned. The second is the travel time inside the warehouse, which is used for the purpose of picking, assembling an order, and delivering it; this time is initially 142.34 min/order due to the inadequate classification of the stored products and the random distribution of received products ready to be distributed in the warehouse. Next, the implementation of the improvement proposal in the warehouse of the commercial sector will be explained. Table II shows the indicators of the initial situation.

TABLE II
INITIAL VALUES

Indicator	Initial values
% of non-fulfillment of orders	21.05%
5S Audit	2.35
Average packaging time	27.77 minutes
Average time of registration in the system	3.06 minutes
Total simulation time	142.34 minutes
Picking time	10.97 minutes

B. Validation of the pilot design

Implementing the Lean 5S tool serves to organize the warehouse and keep it clean to improve an improvement in picking time. The initial audit resulted in 2.35 points, and after implementing each S in the warehouse, a gain of 44.68% has been achieved, with a final result of 3.4 points in the 5S audit.

As shown in Figure 3, the improvement after applying the 5S tool shows that by using red cards, the classification, cleaning, order, and good use of spaces within the warehouse are more efficient.

Figure 3: Pilot 5´s before and after

Finally, Figure 4 shows the final result of applying the 5S audit after implementing the 5S tool for the case study through a pilot plan.

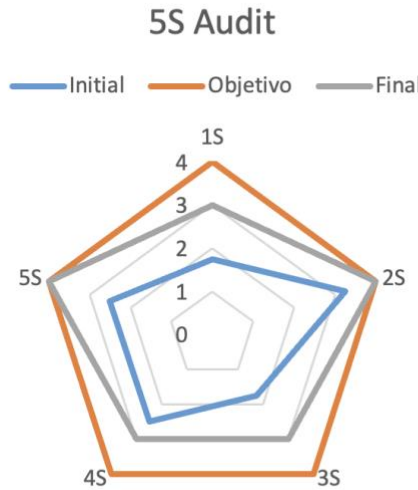

Figure 4: Results from the output 5S evaluation

C. Arena Simulator software validation design

The process of receiving, storing, picking, packing, and shipping products arriving at the production logistics area is modeled using the Arena software simulator. The most critical processes, picking and packing, will be analyzed to quantify, with the help of the simulator, the optimization of the process activities to reduce the non-fulfillment of the orders served.

The application of the Lean ABC tool is developed, where the products are considered with three classifications to be stored when the operator performs the picking activity. With this, time reductions are evidenced, according to the indicators. For example, a 38.08% reduction in the picking time of the current situation compared to the improvement proposal. The initial time was 10.97 minutes, and the improvement resulted in 7.02 minutes, i.e., 3.95 minutes less than in the current situation. Furthermore, the packing time was reduced by 26.36%; this time was initially 27.77 minutes, and with the improvement proposal, we obtained 20.45 minutes, a reduction of 7.32 minutes for this activity.

The implementation of the Kanban tool through the simulation was developed with the use of colored cards to have better visual control of the locations of the stored products and classify them by color according to the rotation criteria; therefore, three cards were developed: green (high rotation), yellow (medium rotation) and red (low rotation). By making these improvements, it was possible to validate that the average run time of the simulation decreased by 47.23%, obtained from an initial scenario of 142.34 min, to achieve a time of 75.11 min in this indicator after using this tool. Also, an improvement in the system registration time, with an initial value of 3.06 min, managed to decrease after the implementation of the cards, 0.37 min; thus, obtaining a final value of 2.69 min meant a time reduction percentage 12.32%.

In conclusion, by applying the Lean tools: 5'S, ABC, and Kanban, we have reduced the non-compliance of orders. Initially, we have gone from having 21.5% of unfulfilled orders to obtaining 5% of unfulfilled orders after the implementation of the Lean tools supported in the pilot plan and the simulation in the Arena simulator, reaching the objective of the technical gap, which was 5% of unfulfilled orders for the commercial sector. In the table III shows the indicators of the final situation.

TABLE III
FINAL RESULTS OF INDICATORS

Indicator	Initial values	Final result
% Of non-fulfillment of orders	21.05%	5%
5S Audit	2.35	3.4
Average packaging time	27.77 minutos	20.45 minutos
Average time of registration in the system	3.06 minutos	2.69 minutos
Total simulation time	142.34 minutos	75.11 minutos
Picking time	10.97	7.02 minutos

V. Conclusions

Lean tools have the purpose of solving problems in non-standardized processes; they do it independently by nature; however, the combination of these tools can become the solution to an improvement proposal for a specific problem as the one presented in this case study and depending on the scope, restrictions, and variables to be analyzed we could achieve solutions to the different root causes that may affect one or several areas of a company. We have used: 5S, ABC classification, and Kanban.

It is necessary to point out the importance of making a good diagnosis of the current situation found to identify the root causes and the problems encountered clearly; otherwise, we could not identify the root causes and therefore find tangential or palliative solutions and not improvement proposals related to improving measurable indicators over time that can be validated through a proposed simulation. The other support tools we used for this case study were the Pareto chart and the cause-and-effect diagram or "Ishikawa", which were of great help for the elaboration of our problem tree in the diagnosis phase.

For this case study, the problem was the high percentage of unfulfilled orders in production logistics; after analysis, we decided to use three Lean tools: 5S, ABC, and Kanban. The 5S tool is responsible for order and cleanliness, ABC for classifying products on the shelves, and Kanban for the visual management of the warehouse. All of them independently help to reduce the lead time in the chain, but the added value is that, in an integrated manner, they achieve the solution to the problem presented: a high percentage of unfulfilled orders. The importance of the improvement proposal for this case study stands out in the integral use of these Lean tools.

We believe that with this research work, we are providing validated and verifiable information to future research related to the commercial sector of SMEs and even other sectors with particular needs and at the same time with some similarity; because, unlike other models of improvement proposal with Lean manufacturing tools, this article postulates the use of a practical and efficient combination to the problem of order fulfillment with the added value that is simulated in the Arena simulator in three scenarios, with the help of the continuous improvement.

Regarding time indicators such as picking time, packing time, or system registration time, we have been able to demonstrate through validation that after applying the Lean Manufacturing tools through the Arena simulator simulation, we have achieved reductions in all these indicators; in parallel, regarding the problem of clutter and inefficient visual management in the warehouse we have obtained a better score in the 5S audit, achieving an improvement of 44.68% after its application through a pilot plan aimed at lifting the observations found in the warehouse management of production logistics. Finally, as an integral result of applying these Lean tools, we have achieved the main objective of reducing the percentage of non-compliance of orders, reaching the goal of 5%, indicated in the technical gap for the commercial sector.

The simulation model was validated in Arena through 3 scenarios in different time periods and favorable results were obtained for the proposal in all of them, reducing the Lead Time in the system time and considering it a viable project for the implementation in this case study.

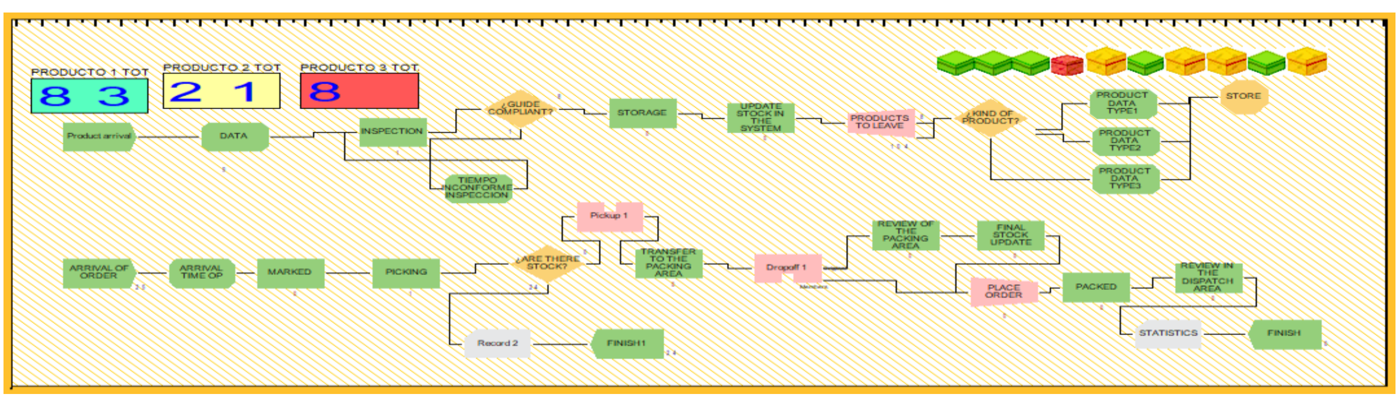

Figure 5: Improved situation simulation in Arena Simulator software

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