Lean model to reduce picking time delays through Heijunka, Kanban, 5S and JIT in the construction sector

Haydeé de la Cruz[1], Ernesto Altamirano[1] and Christian del Carpio, Msc[2]
[1]Industrial Engineering, Universidad Peruana de Ciencias Aplicadas (UPC), Lima - Peru, u201311457@upc.edu.pe, pcinealt@upc.edu.pe
[2]Direction of research, Universidad Peruana de Ciencias Aplicadas (UPC), Lima – Peru, pcelcdel@upc.edu.pe

***Abstract*– Delays in the time of preparation of orders in a warehouse of materials and construction tools affect delivery times, which affects the level of service and consequently the loss of customers. This, due to the waste in the existing system such as the lack of planning of the process inputs, inefficient procedures, lack of organization and total cleaning. Therefore, this document proposes the application of a Lean Model of picking based on Heijunka, Kanban, 5S and JIT techniques, to eliminate waste (time, movement and inventory). After proposing the improvements, support was made in a stochastic tool to validate the changes with respect to the current situation. Consequently, significant improvements were observed, particularly in the collector's load, reducing its load by 56.29%, eliminating the waiting times for requirements and increasing the orders served. This leads to the improvement of the productivity of the picking operation at 47.07%, resulting in timely deliveries.**

***Keywords*—Lean, picking, Heijunka, Kanban, 5S, JIT, construction.**

I. INTRODUCTION

Currently, technological advances and new logistics management methods used by companies in various sectors are generating revolutionary changes and whose goal is to improve profitability. Therefore, one of the great changes that occurs in the world market is storage; which is considered an important part in the logistics chain of any company [1]. In the construction sector, the cost of a project can be increased up to 10%, due to poor logistics that has an important impact on the margins of the work and the company [2]. Also, in [3] it is mentioned that, in medium and small works, the cost of materials represents 54.51% of the total direct costs. From all this, that the utility of a construction company is largely determined by the effectiveness with which these resources are managed.

The organization under study has a strong presence in Latin America carrying out the construction of prefabricated wooden housing modules, whose useful life is 5 years. This type of project represents approximately 68% of its income that is generally executed outside the urban area; Therefore, the importance of pre-project planning. The public and private sector (corporate alliances) are involved in the business model, who, when financing the module, starts the deployment for construction.

For the execution of the project you must have the structure of the module, which is manufactured and delivered by the supplier at the project site. As for the materials, tools and supplies are provided by the organization, whose level of service based on delivery time is 23%. This causes delays in the start of execution and completion of emergency housing, and even loss of funders.

This problem of late deliveries is due to delays in the time of preparation of orders; which, are transferred the same day of the work. From the diagnosis made, the lack of planning requirements has been identified, generating additional transfers to the project site due to quantity errors. As well as, stock breakage in the preparation of orders. In addition, it is considered the lack of organization of the inventory that is in the warehouse, and the cleaning in the stocks; which are obsolete (spoiled, dirty or expired) that increase the duration of the picking. In addition to this, inefficient procedures that contribute to the collector to carry out activities that do not add value to the process, but rather make a slow and discontinuous flow.

Therefore, the importance of eliminating and / or mitigating waste in terms of movement, times and inventories. The literature mentions that logistics and supply chain management (SCM) is a fundamental part of organizations because it represents 80% of their budget [4]. Therefore, the application of Lean techniques is proposed to improve the productivity of the picking process with the final objective of satisfying customers with perfect deliveries (time, quantity and place).

The research proposes a model of improvement of the picking operation. To do this, many studies focused on the problem and identify the most appropriate techniques have been reviewed. Thus, adopt the most recent trends and contribute with the improvement of the indicators of the organization and valuable information on the subject. Consequently, a control board based on Heijunka principles has been designed that not only plans the requirements of the orders; but also, it allows to control the times of each activity carried out in the picking. In this way, level the load of orders to the collector, plan the resources for availability during the picking and make visible adjustments to guarantee the fulfillment of the orders.

The organization of the article begins with the previous studies of the picking process and the techniques used to solve the problems, in section 2. Then, in section 3 a brief description of the diagnosis of the case study, the foundation of the techniques is made used, the Lean model proposal for the picking process and the indicators. Then, in section 4 the results of the simulation will be obtained. And in section 5, the results obtained will be discussed and continuity proposals will be described to enrich the study. Finally, section 6 will provide the conclusions.

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II. REVIEW OF THE LITERATURE

On the efficiency of the picking operation there are numerous articles focused on problems mentioned above and logistics through the application of different techniques.

Among the philosophies to be used by the present investigation is the Lean principle. Therefore, the authors show the effects of context on the implementation of Lean Supply Chain (LSC) practices; since, it provides evidence to understand why some LSC initiatives may encounter larger barriers than others, compromising their success in implementation. Among the variables the authors consider the level of implementation of Lean practices; that is, the context of the supply chain such as level, size, the company's experience with the technique and the level of suppliers on the ground. As well as, the four contextual variables that underlie said implementation that may affect the study [5].

In that sense, the application of the Lean principles allows to eliminate waste in picking operations. According to Baby, the tools used for short-term implementation are 5S, Kanban and Kaizen; as well as the value flow map (VSM) that identifies processes that do not add value. This application of the Lean methodologies allowed considerable improvements in the time of order preparation, the loading time of the vehicle and the use of space; which, increased the efficiency of warehouse operations by at least 40% [6].

In [7] it is mentioned that reconfiguring and administering an old-fashioned warehouse is achieved by implementing a JIT part feeding system, optimizing the sequence with which stores and workstations are visited to reduce work in process (WIP). In this sense, they propose two policies: Kanban (Cl-K) and JIT; which, are based on the picking. To eliminate waste, the implementation of 5S and Kanban is proposed. Where, the first consists of 5 steps such as eliminating, ordering, cleaning, standardizing and improving; This guarantees the promotion of productivity and reduction of inventory. Regarding the second, it allows visually identify the maximum and minimum signals by means of cards or colored devices; which avoids excess orders adding to the reduction of waste [8]. Another Lean tool that has been studied in a refrigerated warehouse is 6 sigma, where it is considered that prior quality control of inputs improves picking. It identifies the bottlenecks, guarantees the reliability of the orders, highlights the importance of planning and the use of a simulator to analyze the current situation with the proposal [9].

Even Lean methodologies are being applied in medicine; where the authors examined the impact of the Heijunka technique to minimize waiting times according to the needs of the patients. This, through a system that remains flat for the distribution of the level load and schedule of appointments; in this way, avoid the peaks and valleys of patients in waiting times [10]. In the automotive sector the different types of components that are used for the production line of the types of products are considered. Where, the authors mention Heijunka's application for coordination of production on many production lines to establish a standard time per product and reduce installation costs [11]. The workload forecast is established for the collection of zone orders; which, contributes to the efficient process of picking. This benefits in increasing the level of delivery service to end customers and avoids unnecessary labor costs [12]. Heijunka is also used as part of the improvement in environmental performance. This objective was based on having an assembly line without waste (change and time). It was established upstream through a supplier that provides inputs for availability along a continuous flow to produce one product at a time [13].

Other solutions that contribute to solving the problem are related to the reduction of distances. In [14] have focused their research on tracking transport sustainability opportunities in narrow aisles established in warehouses. From this, they provide a new methodology to identify waste processes in warehouse operations using the pyramid method. These processes are opportunities for activity-based improvements, produce guidelines on how to make internal deposits, more sustainable operations, batch selection, use of vehicles for movement and routing algorithms. All this contributes significantly to the efficiency of logistics processes and energy savings. Additionally, it is considered to establish a storage policy based on three classes of a comparable vertical selection distance that impacts the distance of the trips and allows to take advantage of the warehouse dimensions, a complete billing policy in a range of demand biases and forms Warehouse studied. It was obtained that the continuous model is easier to analyze because it suffers less than 2.45% error in the exact discrete model, from the validations [15]. In addition to the above, Rao proposes a new hybrid policy based on turnover that is a combination of storage policies inside and outside the aisle. These analytical travel distance models are developed for business volume storage and are very accurate compared to simulation results. Where, it is obtained as a result that class-based storage significantly reduces selection travel distances over random policy and at the same time is easier to implement than total rotation policy offering good benefits to achieve low travel distances [16].

Regarding the collection, the criteria are established according to the weight, fragility and category restrictions; The authors mention the complex selection, distances and routes. Therefore, they establish the separation of food and non-food categories; as well as, the adaptation of the S-shape, the largest gap, the midpoint and the combined heuristics can provide viable solutions within very short computation times [17]. Another article mentions a modified algorithm for batch order collection (size and structure). This optimizes the routing of collectors on the different lines, divides the orders in batches, improves the order fulfillment time and the waiting time [18]. In [19] the theory was contributed by combining and expanding two previous models by developing an effective optimal solution algorithm that integrates quality control and inventory control. Optimal solution procedures were used in the supply chain through supplier management, inventory inspection, consignment and quality errors.

This allows the proper selection of orders; however, other authors consider, in addition, ergonomic risks. Therefore, they propose workplace designs quantifying the risks in the storage cycle. Where, the objective is to minimize the maximum ergonomic load for a given workforce of order pickers and reduce the unproductive travel time of the pickers; since, otherwise ergonomic risks are much greater than labor [20]. As well as, establish procedures to reduce or eliminate direct or indirect human effort, promoting ergonomic environments [21].

The support to validate the solutions are the stochastic tools that allow defining the strategies to improve the logistics cost without affecting the customer service. In [22] it was demonstrated that integrated simulation - based optimization is a well-founded decision-making tool. Where information technologies facilitate the application of complex techniques such as simulation and statistics applied quickly and efficiently by the middle and / or higher administration with the application of predefined models.

Finally, it should be considered that new technologies must be incorporated according to the needs of companies accompanied by purchasing power. Or if possible to automate operations, this is where inventions are born as mentioned in [23], where the best practices in the management of warehouses and distribution centers are reinforced with the use of technology such as: Google glass for scanning the barcode of incoming stocks, the ASN software that identifies the barcode scanned for shipments, optimization of warehouse systems, not neglecting security, people and sustainability approaches; and reinforce good storage practices.

III. INPUT

To know the current status and identify the main problem of the case under study, the work model used by the organization has been considered. Then, it has been broken down into the key processes and subprocesses to identify the most critical as shown in Fig. 1. It should be noted that for the collection of information on the detail of the processes, segregation of the people involved in the organization. Thus, to consider the information of the actors that have directly intervened in the work model and enrich the diagnosis.

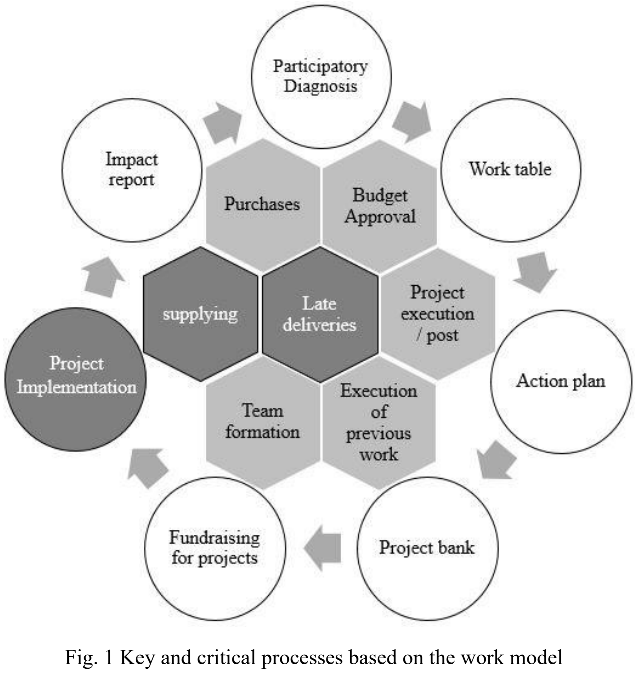

Fig. 1 Key and critical processes based on the work model

From this, it was identified in the matrix of project incidents that late deliveries have the greatest impact and greatest occurrence, where, 77% of orders are late for the construction of housing and 61% are among the 15 min and 30 min. This generates delays in the beginning of the construction, incomplete completion of the construction, exposure of the people involved in the construction to the hours and unknown areas, and even more lost of the construction of the houses.

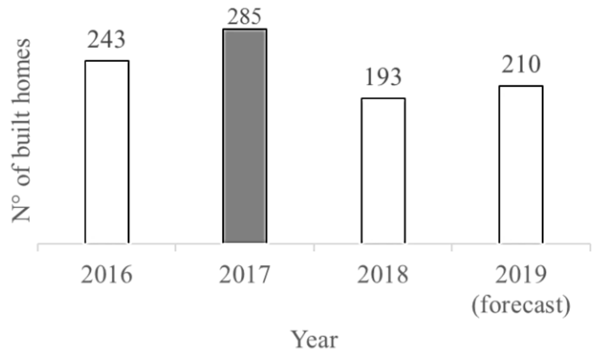

Fig. 2 Constructions made in the last 3 years

Each prefabricated wooden housing module is valued at S/. 5,000.00. In Fig. 2 the variation between 2017 and 2018 of 92 homes that were not built is observed; that is, S/. 460,000 in losses.

Considering the above, the application of engineering tools such as the 5 's and the fish diagram was carried out to determine the problem that results in late deliveries. Thus, it was obtained that the delays in the time of the preparation of the orders is the main problem; which is caused by quantity error (28%), stock breakage (26%), waste stock (34%) and low turnover stock maintenance (12%). This problem belongs to the internal logistics of the company that is involved in the storage cycle (reception, storage, preparation of orders (picking), dispatch and stock control).

For the choice of Lean philosophy techniques, a table of qualitative confrontations has been carried out considering important factors, according to the papers mentioned in the literature according to the case under study. In Table I, you have the techniques selected for implementation that match the particularities of the organization. Because of the size of the company, taking into account which organization is medium; the cost of implementation considered low is less than S / 10,000, average between S / 10,000 to 25,000 and high above S / 25,000; technology is defined as low when performing manual processes, medium by including basic operating systems and high when using ERP to automate processes; the inventory policy is linked to the objective that is expected with the technique that can be to control (apply actions), classify (segregate stocks by criteria), eliminate (zero excess stocks) or plan (internal resources); the type of demand is determined by the internal (dependent) or external (independent) decisions of the organization; in the type of article the particularity of the picking is placed in the case study, which focuses on the technique as materials and tools; the level of implementation defined by the difficulty of introducing the technique to the procedure; the deficiencies are those problems that the techniques can present according to the papers consulted in the literature; and the effects of the implementation that are the outstanding benefits obtained with the chosen technique.

TABLE I. QUALITATIVE MATRIX OF LEAN TECHNIQUES

	5S	KANBAN	JIT	HEIJUNKA
Company size	Small, medium and large	Small and medium	Small, medium and large	Small and medium
Cost	Low cost	Low cost	Medium cost	Low cost
Technology	Low	Low	Medium	Low
Inventory policies	Control	Classify	Eliminate	Planning
Type of demand	Dependent	Dependent	Independent	Dependent and Independent
Item type	Materials and tools	Materials and tools	Materials and tools	Materials and tools
Difficulty level	Low	Low	Medium	Medium
Deficiency	It focuses only on the effects	Diversity of visual objects	Delay and suspension due to lack of supply Periodic	Verification of new orders
Effects	Organized, clean and standardized workplace	Productivity	Reduces inventory levels	Levels the workload to achieve a constant flow of various items

Next, a matrix of criticality of the techniques was made according to the factors that have been described. Where, the numbering from 1 to 5 is considered, whose legend is related to total, partial or null compliance with the criteria. From Table II, the selected Lean techniques will be obtained to be applied in the solution proposal of the picking process. It should be noted that Table I and II show only the Lean techniques chosen.

TABLE II
QUANTITATIVE MATRIX OF TECHNIQUES

1	Does not meet the criteria
2	Partially meets the criteria
3	If it meets the criteria

Standard	5S	Kanban	Heijunka	JIT	Other (7)
Size of the company	5	5	5	5	25
Cost of implementation	5	5	3	5	18
Technology	1	1	3	1	18
Inventory Policies	5	5	3	3	18
Type of demand	5	3	1	1	14
Item Type	3	3	5	5	16
Implementation level	5	5	5	4	16
Shortcomings	5	3	5	5	14
Implementation effects	3	3	5	5	14
TOTAL	37	33	35	34	153
292	13%	11%	12%	12%	52%

Then, have obtained the techniques of Lean philosophy that will be applied; The Lean Model of the picking process will be defined, consisting of the following stages in Fig. 3.

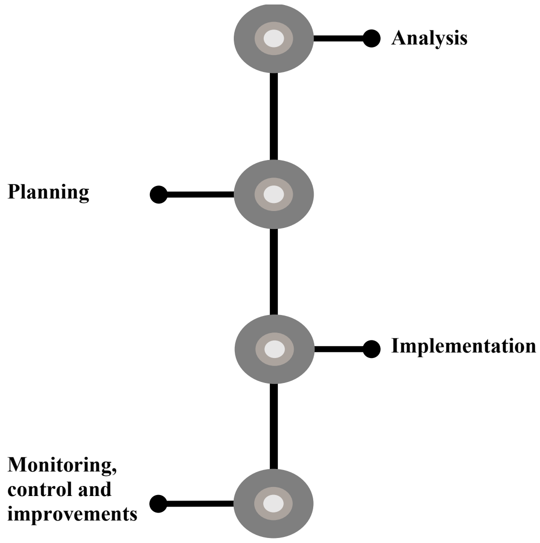

Fig. 3 Stages of the proposal

Analysis

This stage is based on analyzing the current situation of the picking process. Then, identify the resources (people and teams) that the organization has, define the necessary inputs to execute the process and what are the expected outputs. In addition, indicate the budget that will be invested in the implementation of the proposal.

Planning

Planning is carried out according to the established period of time, through the objectives of what you expect to achieve, scope of the proposal, training to be carried out, additional resources necessary to implement the proposal and define the indicators. For this stage we rely on [9].

Implementation

At this stage the integration of the chosen techniques must be carried out; as well as, the deployment in each one of the activities that are carried out in the picking.

1) Plan: To meet the requirements, the collection of the projects to be carried out in a certain period of time, execution dates, place of execution, duration of the project and resources (tools, materials and supplies) to be used is carried out.

For this, we will use the Heijunka board that allows you to plan and minimize waiting time [24]; thus, it will be possible to balance the workload for the picker and the volume of variety of requirements per order [25]. This will achieve leveling through Kanban cards both in project orders and in inventory quantities, where demand is managed by the Heijunka board [26].

It should be noted that from the proposed improvements a linear and constant flow is expected when collecting the requirements; thus, control the increase in orders requested on a normal day and plan the workload of the assistant in charge of preparing the order [27].

To start with the proposal of the Lean board, we will determine the takt time (T_{time}) that will allow us to measure the target time in minutes to guarantee the fulfillment of orders on time and establish the picking rate. For this, the data in Table III is required.

TABLE III
QUALITATIVE MATRIX OF LEAN TECHNIQUES

INFORMATION	DESCRIPTION
• Labor Day	8 hours a day per shift
• Lunch time	1 hour per day per shift
• Number of shifts	1 daily shift
• Business days per month	20 days per month
• Monthly order	16 orders per month
• Requerimiento por pedido	17 requirements per order

The formula for takt time (T_{time}) in (3) is the ratio of available time (T_d) in (1) and the daily requirement (R_d) in (2). Where, the diversity of requirements for orders have been considered.

$$Td\left(\frac{min}{shift}\right) = Workday - Lunch\ time \tag{1}$$

$$Td = 8\left(\frac{hr}{shift}\right) - 1\left(\frac{hr}{shift}\right)$$

$$Td = 7\left(\frac{hr}{shift}\right) \times 60\left(\frac{min}{hr}\right)$$

$$Td = 420\left(\frac{min}{shift}\right)$$

$$Rd\left(\frac{req}{day}\right) = monthly\ order \times daily\ requirement \tag{2}$$

$$Rd\left(\frac{req}{day}\right) = \frac{16\left(\frac{order}{month}\right) \times 17\left(\frac{req}{order}\right)}{20\ \left(\frac{day}{month}\right)}$$

$$Dd\left(\frac{req}{day}\right) = 14\ \left(\frac{req}{day}\right)$$

$$T_{time} = \frac{Available\ time\left(\frac{min}{day}\right)}{Daily\ requirement\ \left(\frac{min}{day}\right)} \tag{3}$$

$$T_{time} = \frac{420\left(\frac{min}{day}\right)}{14\ \left(\frac{req}{day}\right)}$$

$$T_{time} = 30\left(\frac{min}{req}\right)$$

The organization has 125 suppliers, of which 15 are responsible for the manufacture of the housing module and deliver in the exact amount 1 week in advance at the project site. In addition, 15 suppliers are responsible for supplying the warehouse of materials and tools, which are requested by the Purchasing and Supply Coordinator and are delivered within 24 hours of the request. This type of supply is adapted to the case study; however, it must be guaranteed that the tools, materials and supplies are transferred by the organization 1 day in advance of the construction. Thus, they move to the peripheral warehouses of the rural areas where the organization is present

To do this, you must have the perfect orders on time in the dispatch area. The Heijunka board will allow you to plan and control the picking process, this board must have at the top the weeks of the month and include an additional week corresponding to the following month; So, orders would be ready in advance. In addition, the board has been adapted to the particularities of the case study, placing on the left side vertically the types of requirements per order. These requirements may be tools, materials or supplies; which, in turn have an individual or group classification, this has been established to reduce the large number of items per order.

TABLE IV
TYPE OF REQUIREMENT AND CLASSIFICATION ON REQUEST

ORDER		
Tool	Pallas	Individual
	Peaks	
	Measuring tape	
	Hammer	
	Saw	
	Screwdriver	
	Hose (10 mt.)	
Material	Helmets Gloves (pairs) Protection glasses	Grouped
	4 "nails 3 "nails 2 1/2 "nails 2 "nail Cement nails Calamineros Ridge	
	Screw hinge Bolt bolt Door hinge Window hinge Triple advance door lock	
	Serpentine Balloons Bicolor Tape (m)	
	Wood putty	Individual
	Moldimix	
	Candlewick	
Input	Foods	Grouped
	First aid kit	
	Remaining	

Kanban cards must be contained in the boxes on the board; They are represented by colors according to the activity to be executed during the picking process. These colors should be changed every time the wizard changes activity; and put the start and end time to control how long it takes in each one to take the respective means and be able to control the process. Although, planning is currently considered as part of the order preparation activities, this will no longer be necessary; Because the planning is done in the previous month and prior to the preparation of the order. Also, the activity of classifying and ordering that are activities that do not add value and have been eliminated by the techniques that will be detailed in this research work is discarded. Consequently, the activities to be controlled in the picking process are to collect, package, verify and transfer. In addition, the card must contain the description and quantity of each type of requirement classified in Table IV, the date when the order should be perfect (place, time and quantity), the start and end time label for each activity.

The Heijunka board can be digital or made on a blackboard that will identify the weeks with the highest workload and distribute them to avoid order peaks, contribute to the planning of purchase orders for the types of requirements and arrive on time to the picking; This will avoid waiting times, stock breakage, and not perfect orders. In addition, to have the people and equipment available. The Kanban card is shown in Fig. 4 and the board model in Fig. 5.

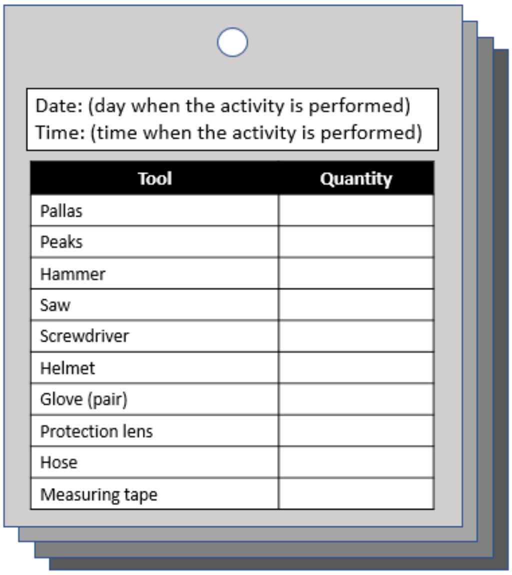

Fig. 4 Kanban process control cards

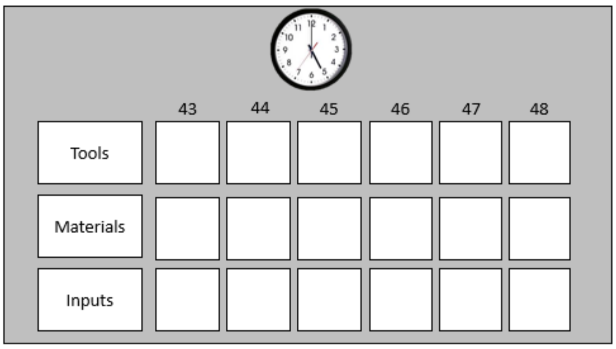

Fig. 5 Heijunka board by type of requirement according to process

2) Remove: This phase includes eliminating obsolete stocks, these tools have been classified into 3 types: damaged or broken, dirty and expired. At this point, it is intended that by executing the picking, the obsolete requirements can be visually identified. Thus, avoid spending time in performing segregation, which is currently done every time orders are entered. The phase is done by placing a red label to those obsolete requirements. In addition, place them in the area outside the route of the picking to avoid errors in the collection and take up space in the warehouse. Additionally, the unnecessary efforts made by the staff to transfer orders and generate ergonomic environments should be eliminated avoiding occupational diseases; Therefore, you must have a cart that allows you to store the requirements during collection and then be transferred to the dispatch area [20], [21].

3) Sort: Next, we propose sorting the requirements vertically, taking advantage of the warehouse space and reducing the collector's paths. Thus, avoid locating horizontally causing obstacles to the transfer of orders to the dispatch area. Also, it should be considered that the items must be placed within reach of the picking assistant, so that accidents during the process are avoided. This also relates to the size of the shelves and the design of the warehouse. For this phase, it has been supported in [15].

4) Clean: This phase contemplates obsolete stocks of the dirty type that upon returning from the project a cleaning plan must be executed. This, mainly with the paintbrushes that come back stained with paint and due to the carelessness of the logistics team, end up being discarded. As well as, gloves that are refused for each activity, but not taking the cleaning measures generate fungus and wear. Therefore, it is proposed to establish in the warehouse the area called "cleaning" where these stocks will be placed for a maximum period of 2 days the cleaning day. In this way, they will have these requirements on time and will be available in the correct state and avoid the error of quantity of orders when arriving at the project site.

5) Standardize: In this phase, we seek to group each of the requirements based on the ABC category that coincides with the assembly of orders, size, weight and groups (individual and grouped). The warehouse has been divided into two parts favoring both doors with which it has; tools and materials are considered in the warehouse called 2; and in warehouse 1 the inputs (food) and remaining. This will allow a continuous and constant flow, avoiding the unnecessary paths to locate the items [17], [20].

Monitoring, control and improvements

For the success of the application, the proposal must be monitored to prevent and solve the problems that arise in a timely manner. It should be noted that this step is part of the implementation so that it is maintained over time that will allow an overview of the established proposal and its application. This, through formats and tools that allow maintaining the proposal within the established limits and that guarantee the correct functioning. Also, the opening to possible adjustments that the proposal requires or to incorporate other measures that are necessary to minimize or mitigate the problem and consequently the effect is mentioned.

1) Improve: This phase has been referred to as the continuous control that must be performed to the process; Mainly inventory control. Therefore, a template has been developed to control the inputs and outputs of the requirements; thus, avoid the verification of quantities and states each time the orders are entered. This query is carried out automatically, where the code, description, available units, price (we will have the valued inventory), entry movement (initial balance, purchases, return to the supplier, entry from another warehouse, adjustment of excess inventory and return) are considered of project) and exit (obsolete, loss, transfer to another warehouse, adjustment of inventory by default and exit by project).

Also, a planning record is established where order requirements are established throughout the year; which will be placed later the Heijunka board. This format must contain the pre and post picking processes. The table contains the projects that will be carried out throughout the year and the requirements are updated automatically; since these are standardized and should only be prepared when the requirements are out of the standard. In addition, those responsible for the functions, place of execution of the projects and the states to be considered for compliance will be placed: done, canceled and pending.

2) Knowledge: It must be ensured that the people who enter to manage the logistics area must have prior knowledge to propose improvements that guarantee the maintenance of the proposal and solutions to the different problems that arise in the area. The profile must include the functional competences according to the functions, this with valuations and additional to the general requirements that are requested.

3) Maintain: To maintain the proposed model, policies to follow, procedures, set objectives to be met by those involved in the logistics area, establish planning controls to ensure the assignment of tasks to staff, records that prevent loss and waste of requirements. All this, in order to maintain the proposal and avoid deviating from the objectives set.

Closing

This last step refers to the final evaluation of the indicators that were established in the planning. In this case, the evaluation of the indicators will be done at the end of the validation, where we will obtain the results of the current situation regarding the proposal. The indicators to consider are 4, which are defined in Table V.

TABLE V
INDICATORS OF THE PROPOSAL

INDICATOR	DESCRIPTION
Productivity picking process (PP)	It refers to the total time of the picking process, which includes each of the activities with their respective times and variants. The value of the duration of the process is obtained directly from the simulation that is divided by the takt time per order.
% Staff utilization (UP)	The time of the normal day that the manager allocates to the picking process. This indicator should be less than 85% according to WHO [28]. This value is obtained directly from the simulation.
Waiting Orders (PE)	Are those orders that do not come out perfect system, this can be in quantity, time and place. Imperfect requirements is a value obtained from the system and is related to the total requirements that are entered.
% Orders Served (PA)	It is obtained in relation to the perfect orders that leave the system and those that enter. This, according to the time interval.

Where, the formula of the indicators is the following P_p in (4), P_E in (5) and P_A in (6); except for staff utilization obtained directly from the system.

$$P_P = \frac{Process\ duration\ (min)}{T_{time}\ per\ requirement(min)} \tag{4}$$

$$P_E = \frac{WIP\ Orders}{Orders\ entering\ the\ system} \tag{5}$$

$$P_A = \frac{Orders\ leaving\ the\ system}{Orders\ entering\ the\ system} \tag{6}$$

IV. VALIDATION

The validation of the picking operation improvement model in the organization will be carried out by simulating systems for discrete events. What is expected is to eliminate the problem of delays in the preparation of orders by reducing time by 20% during the first year of model implementation. To develop this validation, the criteria described in the following lines will be considered.

A. Factors and aspects involved in the system

The factors to take into account for the simulation model are: number of people involved in the picking process, number of orders per project, distribution of times, speed of people in the picking process and times of activities (plan, collect, package, verify, transfer and order)

B. Describe the problem solution model

With the proposed solution, waste processes will be eliminated, queues will be reduced and an increase in perfect orders will be obtained, which will be seen in a good way, since it will be taken as an improvement in the service. The resources to be used in the improvement are a collector and a requirement transfer cart; which, will not be shown in the system, but will allow transfers to be made in less time.

The scope of the investigation includes: the investigation focused on reducing the tail of the requirement packaging, working with the data from July to September 2019 within 10:00 am to 7:00 pm on Thursdays and Fridays.

The activities are grouped into discrete events to perform the current simulation in Fig. 6, among the events it is considered: planning, sorting, collecting, packaging, verifying, moving and ordering; with their respective service times.

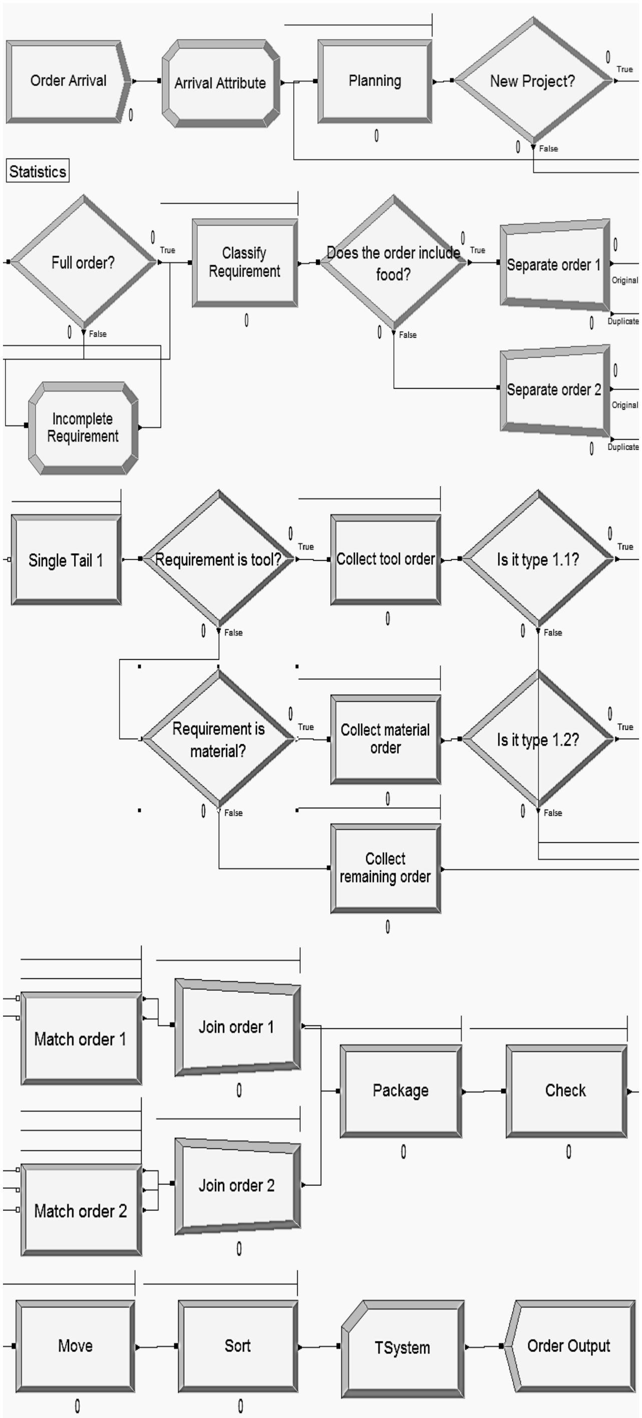

Fig. 6 Current simulator of picking operation

The results shown in Table VI were obtained from the simulation.

TABLE VI
CURRENT ACTIVITIES OF THE PICKING OPERATION

Outputs	Current system	Outputs	Current system
TSystem	70.367	TamTailRPM	-
TamTailE	0.0036	TamTailMatchOrder1	1.8908
TamTailUP1	-	TamTailMatchOrder2	0.5133
TamTailCR	0.0139	TamTailP	-
TamTailVP	0.0030	TamTailRPR	-
TamSingleTail	0.5039	TamTailOP	0.0063
TamTailRPH	-	TamTailT	0.0033
TamTailJU1	2.5350	AssistantUtilization	74.63%
TamTailUP2	-	CoordinatorUtilization	13.47%
TamTailJU2	1.3392	Order.WIP	9.021
TamTailJU3	0.8179	% orders served	60.34%

Subsequently, the improvement model is carried out in Fig. 7 of the order preparation and assess the differences with respect to the current situation. The simulation model that has been developed in the Arena software is not considered planning, sorting and sorting activities; since, through the proposal they are not part of the picking process.

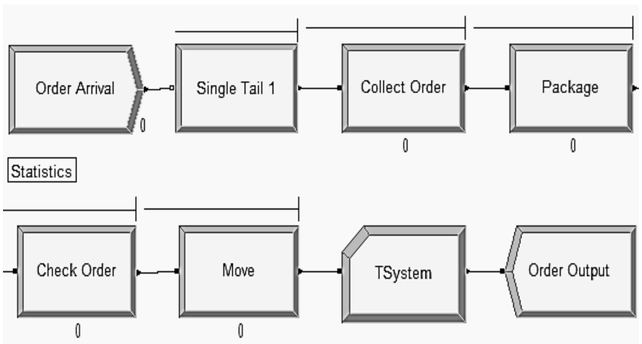

Fig. 7 Proposed picking operation simulator

From the simulation proposed, the results are obtained in Table VII.

TABLE VII
PROPOSED ACTIVITIES OF THE PICKING OPERATION

Outputs	**Proposed system**
TSystem	240.05
TamTailE	-
TamTailV	-
TamTailCU1	-
TamTailR	-
TamTailT	-
AssistantUtilization	18.34%
Order.WIP	0.183
% orders served	0.99%

V. DISCUSSION

From both simulations, a comparison is made of the current situation and the proposal to identify the improvements according to the indicators proposed in (4), (5) and (6).

It is observed in Table VIII that the indicators obtained directly from the simulator are favorable, where the orders served increase by approximately 40% and the use of personnel decreased by 56%.

TABLE VIII
RESULTS OF SIMULATION STATES

Outcome	Current situation	Simulation
Duration of operation	70.367 min	240.05 min
Staff use	74.63%	18.34%
Orders in processes	9 orders	0 orders
Orders Served	60%	99%

Regarding the productivity of the operation and the waiting orders, the calculations are obtained, obtaining the results in Table IX.

From the indicators in Table IX there is an increase in productivity of approximately 27%; since, previously time was not used efficiently. This translates into a directly proportional relationship between the duration of the process and productivity. As to (7) a notable improvement is observed; since, with the proposal, orders waiting 100% are eliminated.

TABLE IX
RESULTS OF SIMULATION STATES

Outcome	Current Situation	Simulation
Productivity of the process	13.18%	47.07%
Waiting Orders	3.52%	0%

Achievements in solving the problem

- Increasing the time of the picking operation has increased productivity, because time is better used by eliminating waste in the system. And in turn, the increase in orders served. In case, it is desired to reduce the operating time, it is suggested to increase the number of collectors, but during the high peaks of entry requirements; since, otherwise, additional costs may be incurred. in the system. In addition, this would not be reflected in the orders served because with the proposal they would be being attended to 100%.
- Also, the queues in the activities have been eliminated, including the packaging, the orders in process have been eliminated and therefore in waiting, the use of the collector is reduced according to ILO regulations regarding the loading of people (Scheduled Utilization).
- When solving the problem found in the warehouse, the fluidity in the collection of the requirements would be obtained and having the perfect orders can be delivered at the project site within the agreed time frame, avoiding customer dissatisfaction.

It should be noted that of the articles consulted in the state of the art has not been considered in control of the time of the activities in the picking process; Therefore, it has been considered to include it in the Heijunka board.

VI. CONCLUSION

As part of a process of continuous improvement to enhance the key processes of the organization, attempts were made to improve the efficiency of the picking operation in the construction sector using Lean principles. Where, from the initial mapping to determine the waste, there are significant results such as an increase in the productivity of the process to 47%, an increase in the orders served to 99%, a decrease in the staff load to 18.34% and a total elimination of orders. In process or waiting. This was achieved with the Lean Picking Model that eliminates waste activities, implements ergonomic equipment, improves the process and includes the Heijunka planning and control board. This document shows that Lean principles can be applied successfully in the picking operation of a warehouse of materials and construction tools.

In addition, it is considered that the Heijunka board additionally to level the diversity of the requirements of the orders, contributes to the planning of the inputs of the process and controls the times in each activity that will favor in identifying the occurrence of delays to take preventive measures. Therefore, this document contributes to research in this modification of the technique to seek improvements in order to control the process and identify delays.

Finally, the proposed solution can be applied in emergency situations for the rapid response in the transfer of the requirements to the emergency zone; since, the organization under study carries out the deployment with a lead time of 01 week for the construction of the housing modules. Together with the proposal, the previous planning of the resources is added, checking that the times are met, delivery of correct amounts and quick response to guarantee the timely arrival of the aid.

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