POLITECNICO DI TORINO

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Lean Manufacturing tools and stock allocation approaches for Remo Importador warehouse.

Tutor:

Prof.ssa Anna Corinna Cagliano

Candidate:

Daniela Martinez Ortega

Company co-tutor:

Dr. Carlos E. Pulgarín

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INTRODUCTION

Nowadays, the current business environment represents a great challenge for companies, in which every day they must gain competitive advantage against their competitors in order to be able to have highest competitiveness and in this way reaching day by day a higher customer satisfaction and business growth. To do this, companies must question their current processes, verify if they are being carried out in the most efficient way, and identify the activities that are susceptible to being improved, therefore remain in constant change.

This thesis work was developed in "Remo Importador" company, a family business located in the city of Popayan in Colombia, this is responsible of commercialize spare parts of different references of motorcycles that are in the Colombian market, supplying all their customers which are localized through all over the national territory. This company makes part of the competition that all companies in their sector face, and always seeks excellence to obtain the best feedback from their customers, allowing them to grow day a day.

For this purpose, the present thesis work was developed taking into account the concerns presented by the company's contact regarding the current picking activity developed in the process of the warehouse. For this, the first requirement was the evaluation of this activity, so that they, who are a company that has grown empirically, will be able to obtain some efficiency indicators of their current operation.

In this way, the main objective of this work is to carry out an analysis in the company's warehouse by lean manufacturing methods and approaches of allocation of the stock in the picking area, which allowed finding the main errors and opportunities for improvement.

Taking this into account, field visits were made in the company in the months between November and December 2019 and January 2020, which allowed to know and understand all the activities that are daily carried out in the warehouse and perform the data collection in order to be able to obtain a real state of the current situation of the activities, which subsequently helped to provide the improvement proposals to each of the problems founded.

Considering these objective, it was proposed that the main aim of this thesis work is to carry out an in-depth analysis of the current situation of the Remo warehouse to understand if the allocation of the stock method currently used in the picking area is the most efficient, and in the same way, through lean manufacturing tools, map the entire value chain, identifying points that can be susceptible to change, using the tools of this philosophy.

This work consists of five chapters, the first one is intended to provide the reader a theoretical approach to the topics that will be developed through the thesis, the second, specifically, explains the characteristics of what type of company it is, how it is composed, how has been its evolution, main suppliers and customers and its current supply chain management. Moving forward, the third and the fourth chapter contains the core part of the thesis. The former allows to observe the development of this thesis through the analysis of the warehouse, knowing the current distribution in terms of layout and allocation of the stock, the main activities that are developed on it, and the methodology used for the current organization of the stock in the picking area. Following this, the diagnostic of the current situation was made: first, the evaluation of the current methodology of allocation of the stock and comparing it with the proposed approach was carried out using two different KPIs: time and distance. Second, the other main problems founded through observation and interviews made, are also mentioned on this section.

The chapter fourth, presents the opportunities for improvement for this company, through a lean manufacturing analysis, in which the entire Value Stream Map was graphed to know the activities that needs to be improved in order to reduce the lead time and wastes. Finally this diagnostic ends with the identification of the criticalities by means of the 5 why's analysis. In the same way, later in this chapter, the 5's methodology and the future VSM were used to propose the improvement proposals for each of the criticalities, achieving with it, a reduction in times, distances and waste.

Finally, chapter five shows the conclusions, limitations and future steps that could be performed in the company, taking into account the recommendations.

What was intended to have at the end of this thesis are some proposals designed for each criticality found, which can help to create the efficient management of the warehouse, evaluating the quantitative implications that these proposals may have.

As a final conclusion, it can be said that all of the aims proposed in the beginning of this thesis work were achieved, providing to the company some tools which will help them to increase their competitiveness, by analyzing their current situation, finding the main issues of their processes, and proposing solutions to them

CHAPTER 1: Warehousing, storage allocation and Lean manufacturing literature

The main aim of this chapter is to provide to the reader a theoretical description of the tools that are used in the following sections of this thesis work. First there would be explained the concepts and the importance of warehousing, the main activities that are carried out on it, subsequently, the storage allocation methods, followed by the main methodologies that can be applied taking into account the type or organization and the products they manage and finally the main tools of lean manufacturing that can be applied in a warehouse.

1.1. Warehousing definition and its importance

The supply chain is the process that is generated from the moment the customer makes an order until the product or service has been delivered and charged. Therefore, the supply chain includes the planning, execution and control of all activities related to the flow of materials and information from the purchase of raw materials to the final delivery of the product to the customer, through its intermediate transformation.
Consequently, we can define the supply chain as the set of steps and networks that are intertwined from the origin of the product to the final customer. (Mecalux, 2019). Today, the warehouse plays a role of strategic importance within the business processes giving the capacity to success or failure, As a consequence, managing complex warehouses effectively and efficiently has become a challenging task. An important question therefore is how warehouse management, as a cluster of planning and control decisions and procedures, is organized in order to meet today's challenges. This is why Warehouse Management (WM) is becoming a critical activity in the supply chain in the level of service provided to the customer in terms of delivery times and costs (Faber *et al*., 2002). Within a company's supply chain, storage logistics covers the activities of the warehouse related to storing, protecting and conserving the goods for the period of time that is necessary. Likewise, it also deals with the management, transport, location, identification and conditioning of the same from its reception to its issue. The warehouse is the key piece that allows the regular flow of goods between supply and demand. It concentrates the management of the materials that the company moves, saves and manipulates to respond to its commercial and productive needs. The warehouse is, therefore, the central axis of storage logistics or warehousing. (Mecalux, 2019)

The main goal of warehousing is to minimize operating costs, maximizing quality service. In this way, look for the best combination between: maximize the use of storage space, ensure the optimal organization of the workforce, make the most of the maintenance equipment, guarantees access to the goods when requested, maintain the necessary security measures to preserve the integrity of the goods. The aim of logistics managers is to manage each field of storage logistics in order to meet these objectives.

1.1.1. Main activities performed within a warehouse

The core of the warehousing is, as the word itself mentions, the warehouse and the main activities that are developed in it which are: the reception, the storage, the preparation of orders (Picking process) and the shipment of merchandise. (Mecalux, 2019)

Reception: is first phase that determines the beginning of the process that governs the incoming flow of goods and information within the warehouse area is that of receiving, unloading and checking the state of the products, in order to guarantee the correct quality and quantity of orders delivered to the warehouse. Reception begins with the arrival of a vehicle at the reception area where the units to be moved are unloaded for later checking. In this phase the goods are compared with the order of the delivery and with what was declared by the carrier in order to avoid differences in the inventory of the goods in the warehouse, and that there is no subsequent incorrect invoicing in the case of sales transfers of goods between two subjects. (Cristiano,2019)
This phase also includes all the operations of subdivision (prepackaging) of the goods based on the logics of allocation for storage (Frazelle, 2002). In particular, when the goods are delivered an masse by a supplier, this is subsequently divided in order to make the picking more effective and efficient, or to create product combinations to form kits or assortments of goods that must necessarily be handled together.

Storage: in this activity all the operations concerned to the movement of the products from the reception area and storage in a suitable position for future order collection are performed (Cristiano,2019). Therefore it includes material handling, position verification and placement of the handling unit. As for the strategy for allocating the goods, this depends on the size and quantities, as well as on the characteristics of the handling and the containers of the goods (Frazelle, 2002). By storage policy is meant a set of rules that govern the allocation if incoming materials, those have as main objective and decisive implications in optimizing warehouse operations and maximize the exploitation of used space. There are three types of storage policy that will be explain in detailed in section 1.4.

Picking process : once an order of a client has been received at the warehouse, the picking process can be executed, that is, the process dedicated to the collection of the handling units from their storage positions to be subsequently packed and delivered to the customer (Cristiano,2019). The main goal that is sought in the picking process is to reduce the time spent preparing orders in order to offer a better service (shortening delivery times) and at the same time reduce its weight in the operating costs of the warehouse where time is money.

The process of collecting merchandise (picking) and its conditioning for the expedition constitute one of the operations that require more time and efforts in the warehouse. There are different methods of order preparation:(Mecalux, 2019)

- Order picking: n a route collection system, the operator selects the various items to be sent to a customer, this is the basic picking procedure. This method is usually used for orders that include large volumes of the same merchandise.(Krajewsky *et al*, 2007)
- Batch picking: in this case, the picking process is divided into two phases. The first phase the products are picked in a batch collection system, the employee collects the necessary amount of an item to meet a group of customer orders that will be sent in the same truck or railcar (Krajewsky *et al*, 2007). in a second stage, the orders are already packed and conditioned individually. In this way, it is possible to combine the preparation of several orders. It is the most frequent method when handling many references and each of them carries little

merchandise and is one of the methods that is normally recommended as a general strategy of picking improvement.

- Picking by zones: it is an order preparation method that organizes picking orders based on their location in the warehouse. As in the previous case, several orders are processed at the same time.

Packing and shipping: finally, when all the orders have been picked, the process of packing and shipping are carried out. First, all the products are packed to the customer in order to avoid damages of the merchandise, sometimes, the boxes need to be weighed before the shipping, according to the policies of the shipping companies. Then the products are charged to the transportation cars including all the shipping information, with the address.

1.2. Storage systems and material handling system

Nowadays all the elements that represent logistics are a competitive advantage for companies, and they always seek to have the most efficient ways that allow them to increase competitiveness. To do this, one of the examples is when choosing the storage system that helps them to be more efficient. This decision will depend mainly on the size of the warehouse and the type of merchandise to be handled.
The main storage systems in logistics can well be classified as shown below: conventional, compact, dynamic, mobile, semi-automatic and automatic and self-supporting system. (https://kanvel.com/sistemas-de-almacenamiento-logistica/)

Conventional storage system

It is the most used and stores the individual units combined with goods on pallets. The product is accessed and adapts to any load in volume and weight. The high levels are used for complete pallets and the low levels for manual preparation or picking. (Figure 1.1.)

}

Figure 1.1. Conventional storage system
Source: http://www.atoxgrupo.com/

Compact storage system

This system takes full advantage of the space, both in height and surface. It is indicated to store large number of pallets by reference with homogeneous units. (see figure 1.2.)

Figure 1.2. Compact storage system
Source: http://www.demeifurnituregroup.com/

Dynamic storage system

Among the logistics storage systems, it is ideal when perfect rotation units are available. It is based on a system of shelves with rollers that create a slightly inclined slope, through which the different palletized goods run (Fig. 1.3.). It can also be found a variant for this logistics storage system, where a gravitational mechanism replaces the rollers.

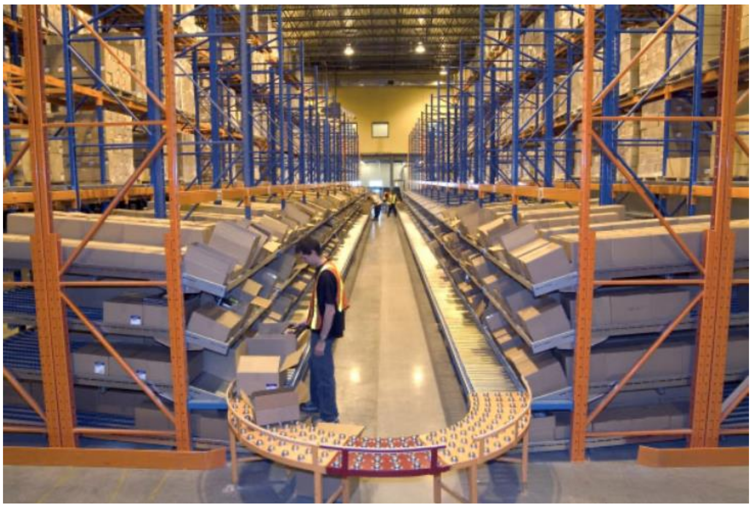


Figure 1.3. Dynamic storage system
Source: https://www.cresswellindustries.com

Mobile storage system

The mobile storage system is the same as the conventional one, with the difference of having a structure on rails instead of anchored to the ground. The shelves move to join or separate them depending on the position to which it is want to accessed. (Figure 1.4)

Figure 1.4. Mobile storage system
Source: https://www.southwestsolutions.com/

Automated storage system

The automatic storage system bases its operation on robotic equipment that carries out operations through pallet stacker cranes (Fig. 1.5.). Within the logistics storage systems, it contains its own warehouse management software that allows the control and identification of the goods.

Figure 1.5. Automated storage system
Source: https://www.interlakemecalux.com

Self-supporting storage system

The self-supporting storage system is designed for maximum utilization of the storage space, in which the shelves are those that support the facilities, eliminating the need for beams or pillars and avoiding the development of an industrial warehouse, is also done through stacker cranes. (Fig.1.6)

Figure 1.6. Self-supporting automated storage and retrieval system
Source: https://www.mecalux.com.mx

Material handling systems:

Material handling systems are tools that helps managing products or materials as its name says. These can be divided in five major equipment categories following Kay's definition: (Kay,2012)

Transport Equipment. Tools used to move material from one location to another e.g. conveyors, cranes, and industrial trucks (Fig.1.7.). Material can also be transported manually.

Figure 1.7. Transportation equipment
Source: https://bloggingkits.org

Positioning Equipment. Tools used to manipulate materials in order to locate them in the right position. This can be also made manually. (e.g. Conveyors)

Unit Load Formation Equipment. Helps to transport or storage huge quantities of materials in order to maintain their order and avoid damages in the material. (e.g. Pallets)

Importance of storage allocation

How to allocate the inventory efficiently when it arrives to the warehouse has always been a fundamental decision for the supply chain, that affects the performance of the picking process. (Krajewsky *et al*, 2007) The objective of the physical distribution of warehouses is to find the optimal point between the costs of material handling and the costs associated with the warehouse space. Consequently, the administration's task is to maximize the utilization of the entire warehouse, that is, to use its entire volume while keeping material handling costs at a low level. The material handling cost is defined as the costs related to the transport of the products that enter, their storage and the transport of the products that leave. These costs include equipment, personnel, material, supervision, insurance and depreciation. Of course, an effective warehouse distribution also minimizes material damage and waste within the warehouse. (Heizer and Render, 2004)

Storage and inventory management are activities that can be very important because they affect the time it takes to process customer orders. These are activities that, due to the fact that they can generate large costs (they are responsible for generating a quarter of logistics expenses) (Ballou, 2014), it is better to have a careful administration on them in order to economize costs and improve service to the client.

The use of a warehouse and its design will always depend on the type of products to be stored in it and its specifications, the facilities vary from long-term and specialized storage (for example, maturation of liquors), to those of storage of general merchandise.

A Careful planning of the distribution and design of a warehouse can ensure years of efficient storage operation; times, distances and reworks can be reduce with a efficient distribution. However, it is a complex process in which a large number of variables that allows to generate the best distribution system must be taken into account depending on the type of product and business methodology.

1.3. Storage allocation methods

As previously stated, the storage allocation methods solve the questions of how to distribute the stock in the warehouse in the more efficient way depending on the products that will be stored in it. There are numerous of methodologies that helps on this problem, but all of them relies on the basis of three of them; which will be later explain in section 1.2.1, 1.2.2 and 1.2.3.

First of all the intuitive methods will be introduced; this are attractive in most cases, as they provide some useful guidelines for the disposition without the need to incur complex processes and studies and can often become more efficient since they are created taking into account all the needs that are perceived by the operators and the managers of the warehouse in order to be able to supply them. The arrangement is often intuitive and based on four criteria: complementarity, compatibility, popularity or rotation previously mentioned and product size. (Ballou, 2014)

Complementarity: The products with affinity needs to be allocated closer to each other, this speeds up the picking operation.

Compatibility: Refers to the evaluation of the relationship of the products and decide whether they can be placed in a practical way next to each other either because of their similarity or similar use.

Popularity: Recognize the turnover index and the costs that are associated to the distance traveled to locate and pick up the stock.

Size: The last point to take into account, would be the size, when placing smaller items near the packing point, but this doesn't guarantee the reduce of the handling costs.

As will be seen in Section 3.6, in which the choice of a model for the business case will be motivated, it is appropriate to briefly describe the differences between the three main allocation models: Random storage, Class-based Storage and Dedicated Storage.

1.3.1 Random storage

In this case, to each product that arrives at the warehouse is randomly assigned a specific position in which the same slot may be assigned to diverse SKUs at different periods which do not necessarily share any similarity.

This concept takes part of the main idea of the closest free space rule that works as its name mentions, distributing merchandise that barely arrives in the spaces closest to the point of entry / exit that are empty (Fig 1.8). Then, the merchandise is stored at this point regardless of turnover. Therefore, the system will behave in the same manner as if the random storage rule were being used. (Hausman *et al*, 1976).

When the picking is made, a computerized system keeps track of the location of each item, prints its location on the bill of lading and shows the shortest route to the person in charge of picking it up. (Krajewsky *et al*, 2007)

This type of allocation approach works really well when taking about automated identification systems (AIS), that almost always coms in the form of a barcode and allow quick and accurate identification of items. When automated identification systems are combined with effective administrative information systems, operations managers know the quantity and location of each unit. This information is used with human operators or with automated storage and recovery systems, with the aim of loading units anywhere in the warehouse, that is, randomly. The precise quantities and locations of inventories mean the potential use of the entire facility because the space does not need to be reserved for certain units in storage (SKU) or families of parts. (Heizer and Render, 2004). On the other hand, when managing not computerized systems, this allocation can turn quite difficult, since operators will not find the products easily and this can make increase the time that takes for picking an order.

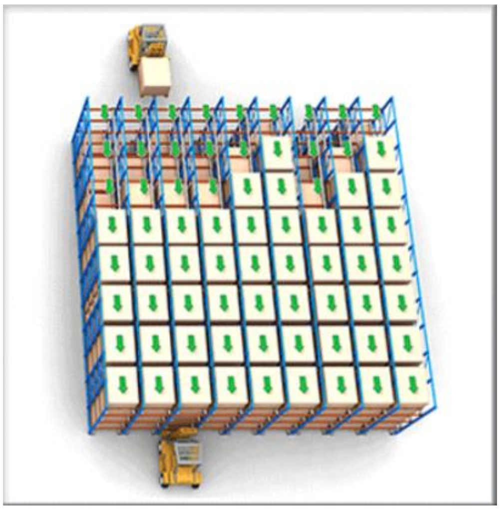


Figure 1.8. Random storage allocation
Source: https:// https://www.atlanticrack.com

1.3.2 Dedicated storage

It is always expected that the warehouses store has few units as possible for the shortest possible time, reducing in this way handling costs, but also is important to customize the allocation of the products, depending on the needs of the products that are being stored. Warehouses are places where value is added to the product through customization. Customization in warehouses is an especially useful way to generate a competitive advantage in markets where products change rapidly. (Heizer and Render, 2004).

Dedicated storage is a useful tool to customize the inventory. Consists in placing each product in a fixed location, an example of it can be seen in Figure 1.9. This type of allocation approach can be useful in cases where the products to be stored have different weights the heaviest ones are located at the bottom of the shelf and the lighter on top and one of its advantages is that employees get used to the fixed location of the different products reducing the time used to pick up, and avoiding them problems with finding the stock. The main disadvantage of this method is that space is reserved for products that could not have available stock, losing the opportunity to place one reference with stock, in this way, needing more free space to storage all the products. One way to improve this storage policy is to apply it exclusively in the picking area, using another type of policy in the low turnover area. With this, getting the advantages of dedicated storage when preparing orders, while reducing its disadvantages, since it is applied over a smaller space.

Figure 1.9. Dedicated storage allocation
Source: https://www.beaverswood.co.uk

1.3.3 Class-based storage

The class-based storage policy, which was first introduced by Hausman *et al*. (1976), assigns items between the number of classes and maintains an area for each class within the storage space. (for example, turnover index, value of the inventory, volume, etc.), for this it is necessary to rely on some criteria. One of the best known is the Pareto law or ABC analysis in which the identification of the critical elements of the inventory are made. A typical organization keeps miles of items in inventory, but only a small percentage they deserve the most careful attention and the highest degree of management control. The ABC analysis is the process of dividing the articles into three classes (Fig. 1.10.), according to the value of their consumption, so that managers can focus their attention on those who have the highest monetary value. This method is the equivalent of creating a Pareto chart, except that it applies to inventories instead of process errors. (Krajewsky *et al,* 2007). Articles present in the warehouse are classified as follows (Ballou, 2004):

- Class A: most important (approximately 20% of the items that represent around 80% of the inventory value).
- Class B: intermediate importance (approximately that 30% of the items that represent 12% of the inventory value).
- Class C: less important (approximately 50% of the items representing around 8% of the value of the inventory).

This analysis guarantees an initial management criterion for goods based on the importance that these have on the selected indicator. One of the most used criteria is the rotation of turnover approach. In this policy, products are distributed taking into account their rotation, i.e. products that have a higher sales rate will be located in the most accessible positions, while products with a lower sales rate will be located in the most remote areas within from the warehouse. The main disadvantage of this method is the continuous variation of the demand for the products, which generates the need to make new product orders within the warehouse.

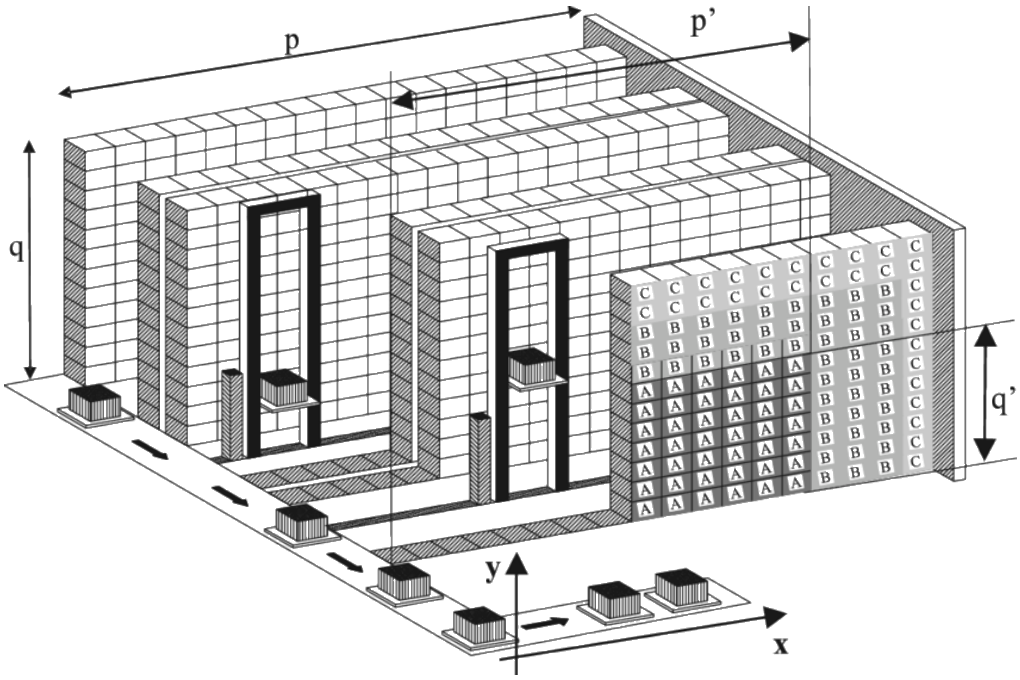


Figure 1.10. Class based storage allocation
Source: Manzini *et al,* 2005

1.4. Lean Manufacturing fundamentals and tools

The Toyota Production System (TPS) is an excellent example of a method for designing value chains known as Lean systems, which are operating systems that maximize the added value of each of a company's activities, by reducing unnecessary resources and the suppression of delays in operations. The Lean systems cover the strategy of operations, process design, quality management, restriction management, physical distribution design, supply chain design and technology management and inventories of a company, and can be used in both service companies as manufacturers. (Krajewsky *et al*, 2007)
In this section, the following concepts of Lean systems will be analyzed: Five S method (5S), Value Stream Map (VSM) and the *Muda* which are the classified waste in warehouse operations.

1.4.1. The 7 wastes

The concept of "Muda" or waste is part of Japanese culture and they are classified into seven types (Ohno, 1978).

- **Transport:** To transport a product means this can have a bad handled so get damaged, also the transportation can represent delays for the end product which is traduced in costs without benefit to the customer
- **Inventory:** These are raw material, or finish products that are stopped in a warehouse, thus, non-creating value to the customer
- **Motion or movement:** This type of waste works similar with the transport one, the fact of moving a product, can generate risks of damaging it, without creating added value to the final customer.
- **Waiting:** This type of waste can be classified to all activities that doesn't allow the process to pass by fluidly, thus, causing unnecessary stops of the merchandise, traduced in long times to deliver the final product to the customer.
- **Over processing:** It happens when an operation is made numbers of times, this spending and losing time on processes that have been made previously
- **Defects:** Each mistake in the process of making a product would generate a rework, which will end in a worker wear and consequently a delay to deliver the final product.

- **Overproduction:** It occurs by manufacturing more than necessary. Or, in a warehouse, having increased levels of stock which are traduced in costs of handling the materials that does not represent any value added to the client.

1.4.2. Value Stream Map (VSM)

A value stream mapping (VSM) is a qualitative tool that is widely used in lean systems to eliminate waste or “Muda”. The waste in many processes becomes up to 60%. The value stream map is useful because it creates a visual "map" of all the processes involved in the flow of materials and information in the value chain of a product. These maps consist of a diagram of the current state, a diagram of the future state and an implementation plan. The value flow maps cover the entire value chain, from when the company receives the raw materials until it delivers the finished product to the customer. Thus, they tend to be broader in scope and show much more information than a typical process map or flow chart used with the Six Sigma process improvement efforts. Creating a representation of the big picture helps managers identify the origin of the costly activities that do not add value. (Krajewsky *et al*, 2007).
To draw a value flow map, follow the steps illustrated in Figure 1.11. The first step is to focus on a family of products for which the map will be drawn. Then it draws a map of the current state of the existing production situation: analysts start from the end of the customer and move upstream to draw the map by hand and record the actual times of the processes instead of relying on information not obtained through direct observation. The important data related to each process are: cycle time (C / T), preparation or setup time (C / O), useful time (machine time available on demand, expressed as a percentage) , size of the production lots, number of people required to operate the process, number of product variations, packaging size (to move the product to the next stage), working time (less breaks) and waste rate. (Krajewsky *et al*, 2007).

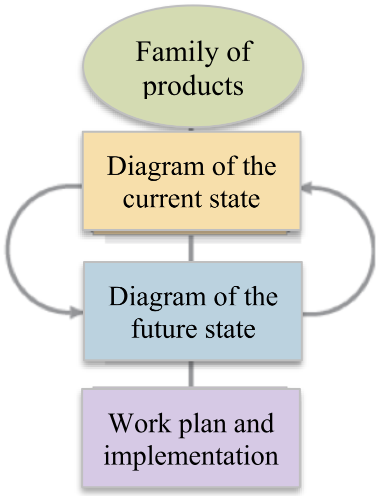


Figure 1.11. Steps to draw a Value Stream Map

Source: Rother and Shook, 2009

Once the current state map is finished, it can be used lean systems principles, such as workload leveling, pull method programming, Kanban cards and other related techniques, to create a map of the future state with more optimized and efficient product flow.

One example of a value stream map of the current state can be seen in the figure 1.12, is it can be seen in a value flow map, a standard set of icons is used to represent the flow of materials, the flow of information and general information (to denote operators, safety inventories, etc.)

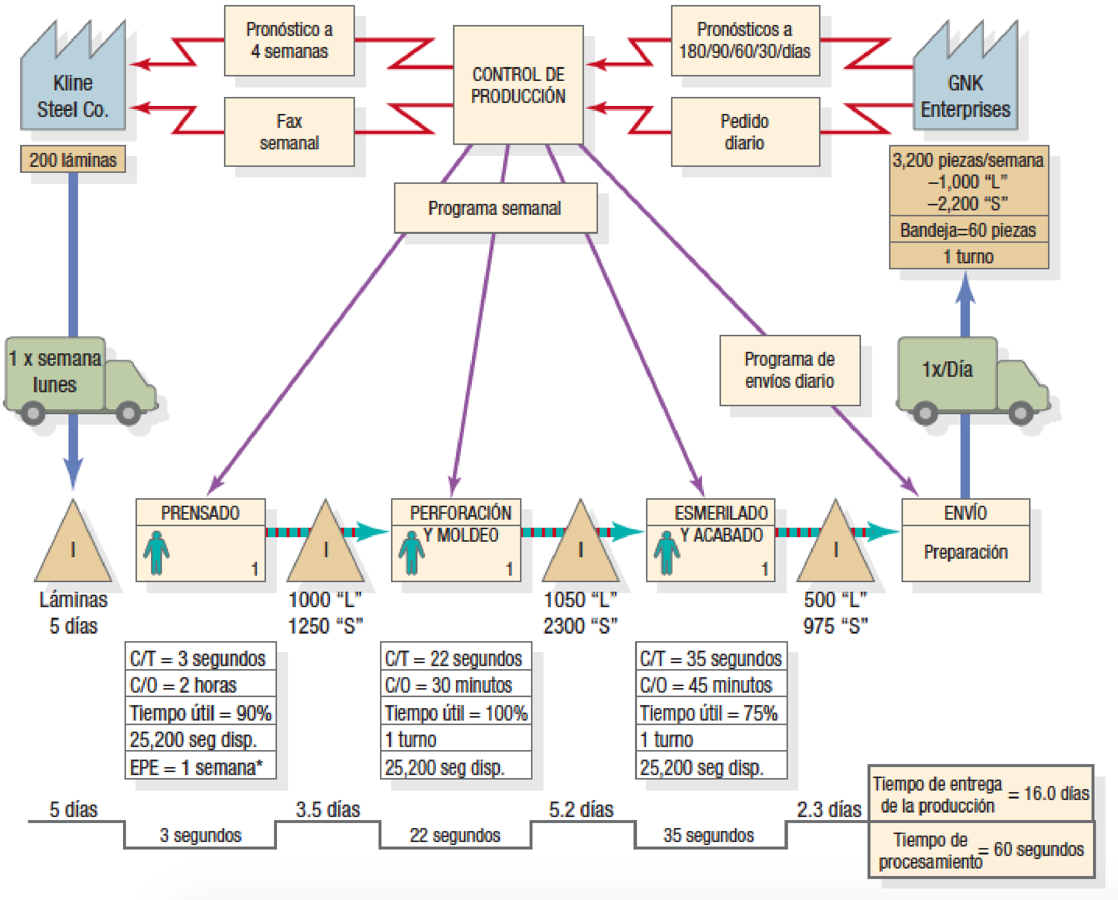


Figure 1.12. Steps to draw a Value Stream Map
Source: Krajewsky *et al*, 2007

1.4.3. The 5W

The 5w technique was conceived by Sakichi Toyoda, developed by Taiichi Ohno and used in TPS (Hukai *et al*., 2018). It is an technique used for problems solving in order to find the root cause of the problem by asking to each criticality found in the process the 5'w. These are represented by the questions: Who? What?, Where ?, When ?, and Why?. This tool is really useful if the end is to understand all the causes that are creating the problem, where is this problem taking place and who can be in charged to solve it. An example of this framework can be seen in the following table (Table 1.1), in which, is combined the wastes classifications and the five why's allowed to organize and structure this wastes and search what type are, where is it found, when, why and who is doing it.

Operation	7 Wastes " muda "	5 Ws Analysis				
		What (Deascription of waste)	When	Where	Why	Who
Receiving (Unloading, unpacking, sorting)	Transport	Long turnaround time for vehicles/ trucks	After completion of receiving operations	Warehouse dockyard	Poor yard control , not optimized strategy for unloading vehicles	
	Inventory	Bottlenecks in the flow of goods / unnecessary stock	During the receiving / unloading process	In the area of the warehouse between receiving and storage	Poor layout planning Inadequate working methods Poor line balancing	
	Motion	Walking around by the warehouse staff to search and find the equipment and tools used in the receiving process. Walking around by workers to find empty spaces for placing the unloaded items	At the beginning and during the receiving process.	In the receiving / unloading area	Lack of straitening (setting in order) principles for tool placement Bottlenecks in the material flow Oversized inventory in the receiving area, information errors, human errors	
	Waiting	Vehicles have to wait a long time before starting the unloading process	On vehicle arrival at the warehouse	In or outside the dock area	Already occupied dock positions, poor scheduling, poor dockyard control. Arrivals of vehicles earlier or later than scheduled	Planning and scheduling department
	Defects	Placement of goods in the wrong order and area after receiving Items received but not appearing in the warehouse information system	During the receiving/ unloading process	In the receiving/ unloading area During the material handling process	Poor record keeping, information errors, delayed data entry	Multiple departments
	Over Processing	Unnecessary repeated checks for product quantity and quality	During the sorting and quality assurance processes	In the receiving area	Information errors Human errors	
	Over Production	Not Applied				

Table 1.1 5 why analysis for the 7 wastes classification
Source: Mustafa *et. al*,2013

1.4.4. The 5'S

Five S (5S) is a methodology to organize, clean, develop and sustain a productive work environment. It represents five related terms, which in English and Japanese begin with S. These terms describe practices in the workplace that promote visual controls and slender production. These five practices of separating, ordering, cleaning, standardizing and sustaining; they are systematically applied to achieve slender systems. They are not something that can be done as a program autonomous. As such, they represent the foundation essential lean systems. (Krajewsky *et al*, 2007). the table 1.2. shows
the terms that represent the 5S and what they imply.

Term	Definition
1. Separate	Separate the necessary elements from those that are not (including tools, parts, materials and paperwork) and discard the unnecessary
2. Order	Organize carefully what is left, with a place for everything and everything in its place. Organize the work area so that It is easy to find what is needed.
3. Clean	Clean and wash the work area so that they are always shiny.
4. Standardize	Establish programs and methods for cleaning and sorting. Formalize the cleaning that results from performing with Regularly the first three practices S in order to maintain a permanent state of cleanliness and preparation.
5. Hold	Create discipline to perform the first four S practices, so that everyone understands, abides by and practices the rules when find on the floor Implement mechanisms to sustain earnings through employee participation and providing them recognition through a performance measurement system.

Table 1.2 The 5s definitions
Source: Krajewsky *et al*, 2007

The continuous implementation of 5S Method in various companies has revealed several advantages, such us: improved quality of products and services, clean and productive work environment, improved maintenance and safety, cost reduction, increasing of effectiveness and efficiency in the processes, discipline and better engagement (Veres *et al,* 2017). An example of this methodology can be seen in the following Figure 1.13

Figure 1.13. Applied 5's methodology
Source*: www.leanproducts.eu*

CHAPTER 2: REMO

In this chapter will be introduced the history of Remo in order to provide an approach to know the reasons that lead to this thesis work, taking into account different points of view of the operating process of the company, it's different businesses lines, products, customers and supply chain.

2.1 History and evolution

Remo is a family business located in Popayan, at the southwestern of Colombia. Was born more than 40 years ago and since its inception has had two business lines, the first one is a representation of a recognized brand of motorcycles (Yamaha). Moreover, the second business line is the imports of spare parts and accessories for motorcycles of all brands, which are distributed wholesale throughout the Colombian territory, and this is the line on which this thesis will be carried out.

In the 70s, the motorcycle was the more efficient way of transportation in Colombia, more and more households had one, this left to an increase in the need of spare parts for replacement of the damaged parts of the motorcycles. The factories at that time did not offered this type of service, thus Remo’s owner saw an opportunity to cover this niche of market. The business started with the owner as the unique employee selling a few references of the parts of this mean of transportation, he started buying to the few existing importers in the country but, through the past of the time the needs of variety of reference was increasing, this is where he decided to import in small quantities covering the missing references in the market, thus achieving significant growth leading the business now a day with more than 40 employees in all lines of business.

The incursion in the motorcycle industry, lead him to make the decision to assume the representation of one of the most important motorcycle brands in the world, Yamaha, and bring it to the city of Popayán, becoming today one of the oldest distributors in the country. This incursion focuses all the business lines in the automotive sector, allowing to grow in parallel.

On its beginnings, Remo started importing approximately 10 references of products only, of which there was no control in terms of stock or sales. The supply of the products was made taking into account the visual need of the market, leading in out of stock of some references and excess in others, in this way the need for controlling the inventory situation was even more noticeable in order to maximize profits, and not to handle obsolete inventory.

As a result of the great growth and development that it has had through the years, today they have a portfolio of more than 3500 product references represented by diverse products and brands, with different origin, like China, Japan, Thailand, India, Taiwan, etc. This evolution has forced themselves to implement gradually inventory systems in order to have greater control of their stock.

Nowadays is being performed a project of construction of a warehouse, on which the stock will be organized in shelves and racks in order to have a better control of management of the inventory, but which is the best way of allocation of the stock in this warehouse? This is where the proposal of this thesis is going to be develop.

2.2. Suppliers, products and customers

2.2.1 Suppliers

The main suppliers of motorcycle spare parts are from China, Taiwan, Korea, Thailand, Japan and India. These products are produced by big companies that have international recognition. Below in the table 2.1 are shown the main suppliers, the products that are bought and the country of origin.

Brand	Supplier	Products	Origin
KEYMAN	Keyman	Motorcycle parts	Taiwan
Nittan	Nittan	Motorcycle parts	China
ENDURIX MOTORCYCLE PARTS	Endurix	Motorcycle parts	India
TANAKA	Tanaka	Motorcycle parts	China
FB	FB	Motorcycle parts / Motor gaskets	China
D.B.C DONGBO	DONGBO	Motorcycle drive chain	Korea
INDEX	Index	Helmets	Thailand
msl	MSL	Motorcycle Kits	
NACHI	Nachi	Bearings	Made in Japan – distributed by USA

Table 2.1 Remo's Main Suppliers
Source: Remo Company

2.2.2 Products

In figures 2.1 to 2.8 are shown some of the products that Remo imports from their suppliers and then are sold to their customers:

Fig. 2.1 On/off Switch

Fig. 2.2 Motorcycle Drive Chain

Fig. 2.3 Streetlight

Fig. 2.4 Lever Clutch

Fig. 2.5 Light Bulb

Fig. 2.6 Motorcycle Horn

Fig. 2.7 Piston Kit

Fig. 2.8 Front Fender

2.2.3 Customers

Remo Importador is specialized in wholesales through the Colombian territory, this means they have customers of their brands in more than 60% of the country in different regions and cities. As it is shown in the Fig. 2.9 the sellers of the company cover different areas, they go directly to the distributors shops and offers Remo’s portfolio of products.

Fig. 2.9 Distribution of the sellers through the Colombian territory.

Source: Remo Company

Remo’s main customers are shown in the table No 2.2, with an approximate value invoiced along 2019. They are located in different parts of the country as it can be seen.

	CUSTOMER	EUR	LOCATION
1	KYOTOMOTO J-C	22.022,21 €	ARMENIA
2	DELIZCA	20.576,69 €	ARMENIA
3	ADRIANA JIMENEZ	19.376,14 €	POPAYAN
4	MOTO PARTES DE LA PENINSULA	17.621,81 €	RIOHACHA
5	MOTO POWER SM S.A.S.	17.365,58 €	SANTA MARTA

Table 2.2 Remo’s Main Customers

Source: Remo Company, the conversion of the currency was made taking into account the actual exchange rate 1 EUR = 3600 COP

2.3. Structure of the company

The organizational structure of Remo Importador (Fig. 2.10) is composed of the executive director (CEO), who is responsible for making strategic decisions for the proper functioning of the company, under the CEO are the Chief Financial Officer (CFO) who is responsible for functions such as: authorization and signature of orders, bank review, accounts receivable, confirmation and download payments and the Director of Operations (COO) that makes daily tactical decisions in all areas of the company.

The organization chart of the company is made up of the departments: ***Administrative*** that handles imports, claims, accounting, human resources. ***Commercial Department*** in charge of sales management, marketing, order shipping, preparation of payment letters and billing. ***Logistic department*** separate and pack orders, supply merchandise on shelves, review, inspection and destruction of returns, download and review of new merchandise and shipping of goods. Finally, the ***supply chain department*** in charge of the purchasing and out of stock management

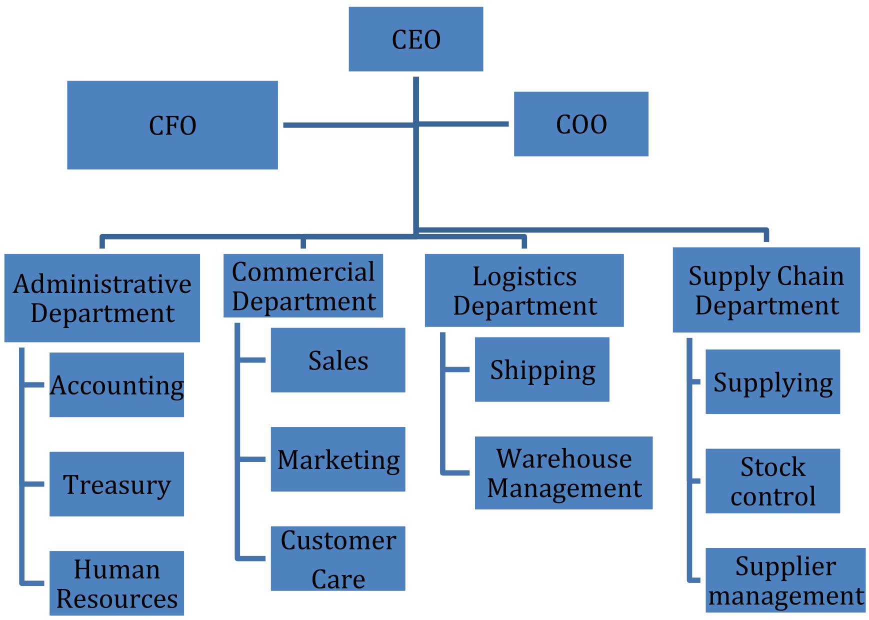


Fig. 2.10 Organization Chart by functions

Source: Remo Company

2.4. Supplying process of Remo

The supplying system of Remo is tied to its sales statistics. The person in charge of the purchases takes into account the average sales for every reference and based on it makes a sales forecast for the following months, if the reference is going to be out of stock before the following container arrives they ask for the product in order to be sent in the first container, if the stock that they have lasts until the second container they purchase the product and deliver it on the second container.

The purchase process of the new references works differently given that they do not have sales data, they base their forecast on a market analysis like how many motorcycles are in the country, if there are or not competitors of the new reference. In every container of motorcycle products they try to include approximately 15% of the total 40 ft container, in new references, in this way they try to expand the portfolio and be more suitable to new models in the market.

Most of the suppliers are in the Asian continent, the lead time of the container is around 2 months since the motorcycle parts and accessories are produced and shipped, time which is also taken into account in the moment of establishing the date of order and shipment. Additionally, the geographical position of the warehouse is 8 hours away from the international port, that is located in Buenaventura, at the east coast of Colombia. The figure 2.11 shows the physical flow of Remo.

Fig 2.11 Remo supply chain

Source: Remo Company

The supplying process has the following steps:

1. **Stock control:** Through the inventory system, a stock control is carried out, in order to analyze the sales since the arrival date of the product to the warehouse in

order to be able to classify its sales speed and to establish the most adequate replenishment time.

2. **Contact Suppliers:** A first "suggested order" is made to the supplier in China, Taiwan or Thailand. The supplier evaluates the quantities and the time needed for the shipment. In this part of the process of confirming the product, if it is necessary, some samples are sent to confirm measurements and specifications.

3. **Management of suppliers:** Depending on the supplier different order conditions are handled, those are: container measure, shipment address, payment conditions and type of product by origin.

4. **Request to be made:** We find the order confirmation and the suggested minimum units, here are the last adjustments and product confirmation

5. **Supervision and revision of the order:** The price of the product given by the producer is confirmed.

6. **Monetary Advancement:** Depending on the supplier, an advance of 30% or 50% of the value of the invoice is made, the rest is paid at the moment the merch arrives at the Colombian port

7. **Reception of merchandise at port:** From the arrival to the port, the departure process can take about 8 days, depending on the customs check and internal traffic.

8. **Total payment:** In this part of the process the payment of the excess is made.

9. **Reception of merchandise at facilities:** The merchandise arrives at the warehouse, its inspection and counting is carried out, the inventory is entered and is located depending on the brand and alphabetically.

CHAPTER 3: Warehouse and storage allocation analysis

Since Remo Importador beginning, it has had a very empirical management, from the acquisition of the products which is made based on the practical knowledge of CEO about the Motorcycle's market, to the organization of the stock in the warehouse. This was possible since small quantities of references were handled and the experience of the workers had allowed to create the processes within the warehouses in the way that best suited them. Recently the company has built a new warehouse in which more than 3500 product references and more than 8 different suppliers are being handled, further is 3 times larger in size than the last they were using for almost 15 years. From this fact, needs of building the new processes of storage and accommodation of the stock are being created so that it is carried out in the most efficient way possible.

In this chapter the goals of this thesis will be achieved, firstly making a detailed description of the warehouse layout and an appropriate analysis of each of the areas that were subdivided including a description of the resources involved in the processes. Secondly, an analysis of the warehouse will be carried out, observing in detail the activities that are executed both in the process of acquiring the merchandise and in the process of sending products to customers. Subsequently, it will be explained how the storage method currently works and finally a diagnosis will be made of all the situations found in the evaluation of this company allowing to offer some proposals for improvement in the critical points found

3.1. Remo's warehouse

Remo's warehouse covers a total area of 750 m^2, and is divided into 2 big spaces: a picking area and another dedicated to the stock of references. The total number of places available is 7680 baskets, of which 3840 are currently being used for the picking process, the others are reserved for the arrival of future references.

The assignments destined for the collection are configured in racks and within them, as mentioned above, the baskets containing the products are positioned. The assignments destined to inventory the references, are generally located in the upper level of the shelves until the available products of the picking baskets are run out of stock, and then these are assorted again.

As mentioned above, the warehouse has two floors, and the layout can be divided into six zones as it is shown in the Fig. 3.1.

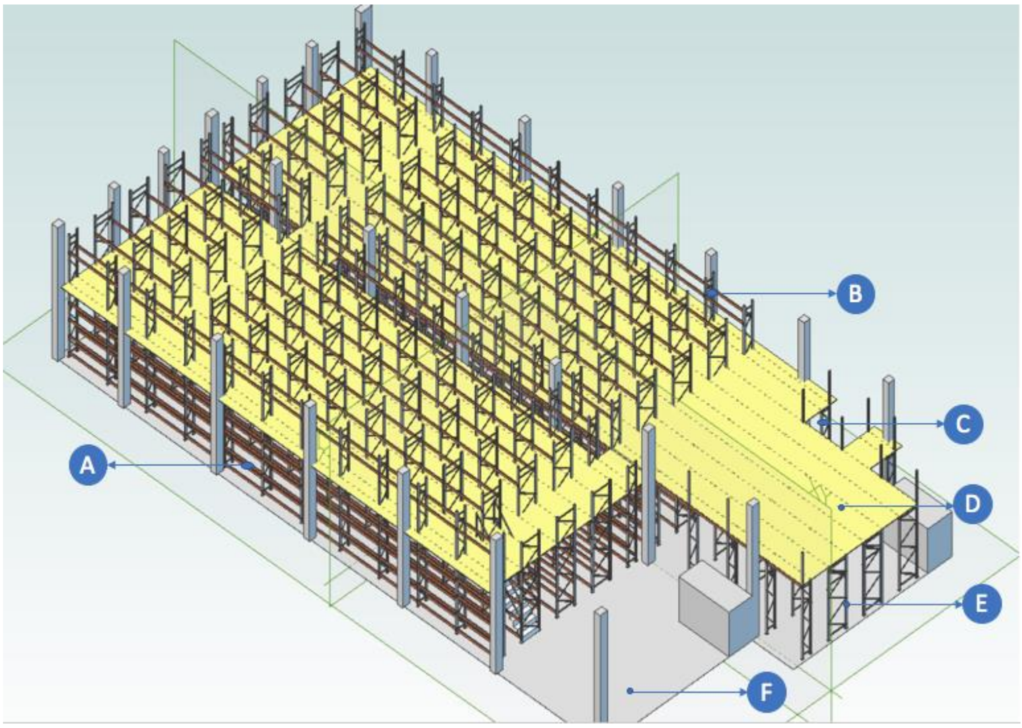


Fig. 3.1 Remo Importador warehouse

Zone A: it's the first floor of high turnover cellar, is distributed as a picking system and has 8 rows, 16 racks of 6 levels each, where the products are stored in baskets for easy access of the staff to the references. The rest of the products that cannot be exhibit on the first floor because of the size of the baskets, are sent to the second (Zone B).

Zone B: It is the second floor of the warehouse, is distributed as a racking system with 8 rows, 16 racks of 3 levels each, here it can be find the boxes containing all the products that will later be supplied to the baskets.

Zone C: Is the charge elevator that facilitates the transportation of the boxes and the heavy stock from one level to the other.

Zone D: Storage of big volume products.

Zone E: Order preparation and packaging area.

Zone F: Reception and delivery of goods.

3.2 Analysis of the warehouse

3.2.1. Description of the zones

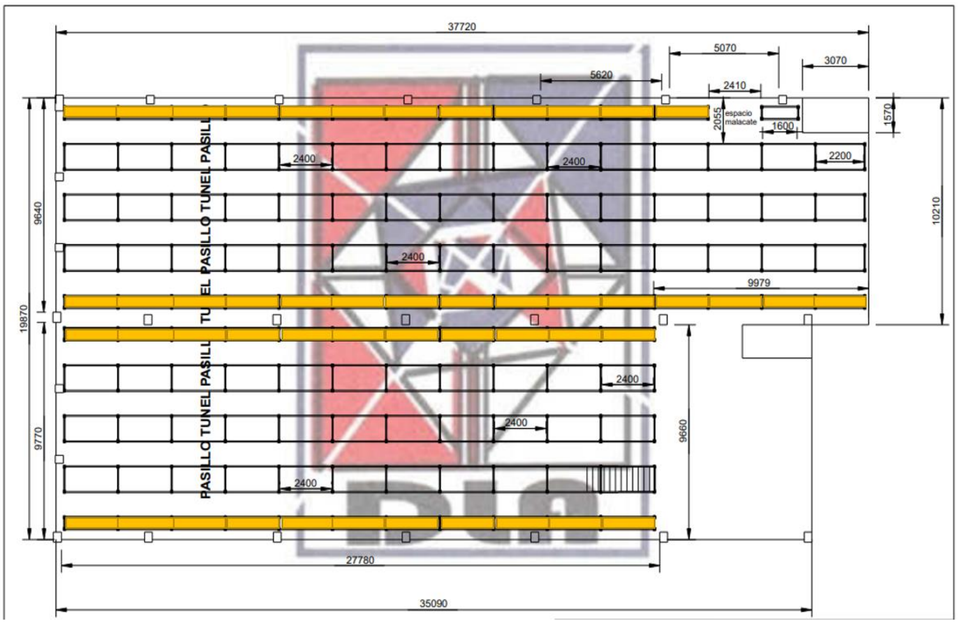
As previously stated in section 3.1 Remo's warehouse layout could be divided into sections which different processes are carried out. The following subsection will help the reader to understand what is each zone made for and the main activities that are developed on them.

Zone A: The first floor of the warehouse has a height of 3.36 meters in total, is divided into 4 shelving levels of 64 cm high each (Fig. 3.2). in which 2 baskets of 24cm high, 60cm long and 38cm wide fits on each level, and horizontally is divided by modules[1] that have 6 baskets. These baskets contain the stock of references and were designed with the front opened in order to achieve efficiency when picking the products. (Fig. 3.3).
On the first floor there are 16 rows of baskets, of these there are only 4 (highlighted in the left-hand side of Fig. 3.4, a) of 60 cm, in which only one basket can be arranged as right hand side of (Fig. 3.4, a). While the rest of the rows have shelves of baskets on both sides of the aisle. (Fig. 3.4, b).

[1] The modules are the divisions that the shelves have every time there is a different column

Fig. 3.2 Measures of the first shelves floor

Fig. 3.3 Baskets used to save the stock for picking



(a)

(b)

Fig. 3.4. Arrangement of the baskets on the shelves

Zone B: Different from the first floor, in the second, the shelf has a height of 2.80 meters, in this the slow rotation boxes are organized containing all the inventory that will then be supplied to the picking area (Baskets of First floor), here there are only two levels of shelf as the reader can see in figure Fig. 3.5.

Fig. 3.5. Arrangement of the second floor

Zone C: Additionally, the structure of the warehouse has a charge elevator (Fig. 3.6) that facilitates the movement of heavy products from one floor to another, this supports 2 tons and measures 1.60 meters wide and 2 meters long.

Fig. 3.6. Charge Elevator

Zone D: This space is the highest in the warehouse, so it is used to store all large volume products that cannot be stored elsewhere (Fig. 3.7), for example, helmet boxes. These are not put in pallets since they are located on the second floor of the structure.

Fig. 3.7. Big volume products

Zone E: It is the area corresponding to the process of packaging products to customers. In this area there are two tables in which the operators check that the purchase order is correct according to the products previously picked and the purchasing order, and then, they pack and seal the orders than will be sent later to every customer. (Fig. 3.8.)

Fig. 3.8. Packing area

Zone F: The area corresponds to the dock where materials are received and the finished product are disposed to deliver to the customers. (Fig 3.9.). The containers are located here when the products arrive from the supplier and then the workers allocate all the stock in the different positions along the warehouse. Also, the boxes of products are disposed here ready to be delivered to the different transport companies that cover the whole country.

Fig. 3.9. Delivery area

3.2.2. Resources

Machines, equipment and tools

The "Shopping cart" or picking cart which was mentioned in the chapter 2 is tailored to the measure of the aisles and the average of orders per client, so it is able to collect up to 4 baskets (Fig. 3.10) its measures are: 1 meters high, 40 cm long, 60 cm wide. Contains a roll of plastic bags that will help the operator to pick up the stock needed and a table that helps to support the purchasing order.

Fig. 3.10. Picking cart

In order the warehouse workers can collect all the stock that is in the highest level of the shelves, they use the following stairs (Fig. 3.11), which are 1,80 meters high.

Fig. 3.11. Stairs used to pick up the stock

During the process of packing the merchandise and dispatch to the final customer the following machines are used (fig. 3.12), from left to right, the goods are first weighed to meet the weight allowed by the transport company, then the baler is used to seal the box, and in this way the box is ready for delivery. In some cases, the sealer is used to pack small products in bags.

Fig. 3.12. Tools that help in the packing process

In addition, it is important to mention that the warehouse has all the regulations that exist in the law in Colombia, in terms of security, signals, lighting, fire extinguishers, smoke detectors and emergency exits.

Human and information resources

For the development of the activities of the warehouse there are 11 people distributed as follows:

Workforce	Quantity
Warehouse Supervisor	1
Office Supervisor	1
Receive and delivery assistants	6
Commercial manager	1
Billing office	2
Total	**11**

Table 3.1. Workforce in the warehouse

On the other hand, SIIGO is a CMMS (Computerized Maintenance Management System) computing solution used in Remo Importador for maintenance operations management, inventory management and accounting system. This program allows to have a large amount of organized and easy to extract information like financial and inventory reports such as income statements, monthly sales, budget compliance, payroll payment form, payments, debts to pay, accounts receivable, merchandise costs, movements of the stock (check in- check out), returns, among other things.

SIIGO provides a mechanism to control inventory levels, informing when materials should be ordered and in what quantity, supporting receipts, supplier management. It allows the visibility of the materials, while they are in stock and after their delivery, in addition to a complete history of their movements, facilitates accounting and control of all items in inventory.

Description of the warehouse operations

In the previous section was described the physical structure of the warehouse and the functions of each zone, but in order to complete the warehouse analysis is also important to describe the activities that take place in the warehouse. In the following flow charts (Fig 3.13 and 3.17.) are presented and summarized the main activities carried out in both important processes: inbound and dispatch outbound flow of materials.

3.2.3. Inbound process activities

The flows of materials and information related to the inbound process are linked to the supplying process of the warehouse. This process starts with sending the orders to the suppliers by the warehouse manager and ends with the positioning of the products at the picking place or inventory racks, in relation to the needs of the moment, this will be explained below. In the figure 3.13. the activities carried out in the inbound process can be seen.

Reception of the merchandise

As a first step the merchandise arrives in a container that will be located in the dock of the warehouse. A number of verifications needs to be done before the staff starts putting out the boxes some of them are:

- Check if the sending subject (company that sends the goods) is right one.
- Check if the addressee subject is Remo
- Verify the place of destination
- Verify the nature and quantity of the goods
- Person who takes care of the transport (sender)

Once the documents have been verified, the merchandise is unloaded, this is done manually. The workers proceed to make a clustering the boxes that contains the same products in order that this facilitates the accommodation operation that will be performed after. Once all the boxes were counted, they give a check to the shipper company. With all these previous steps, they have to verify the content of every box, look over manually if the quantities and the product status are right. The step constitutes a fundamental filter because it is in this phase that it is necessary to identify any type of error. The errors that can take place at this stage are mainly related to a discrepancy between the data listed in document and the actual orders done, and the damaged in the products since they make a trip of many days by seaway and this can make some metal products arrive rusty, wet electronic items, therefore they cannot be used. At the end of this activity, the boxes received are identified by labels that indicate the product code that is contained in them. While the verification of the content of the boxes is done, a worker makes the check-in of the products in the information system.

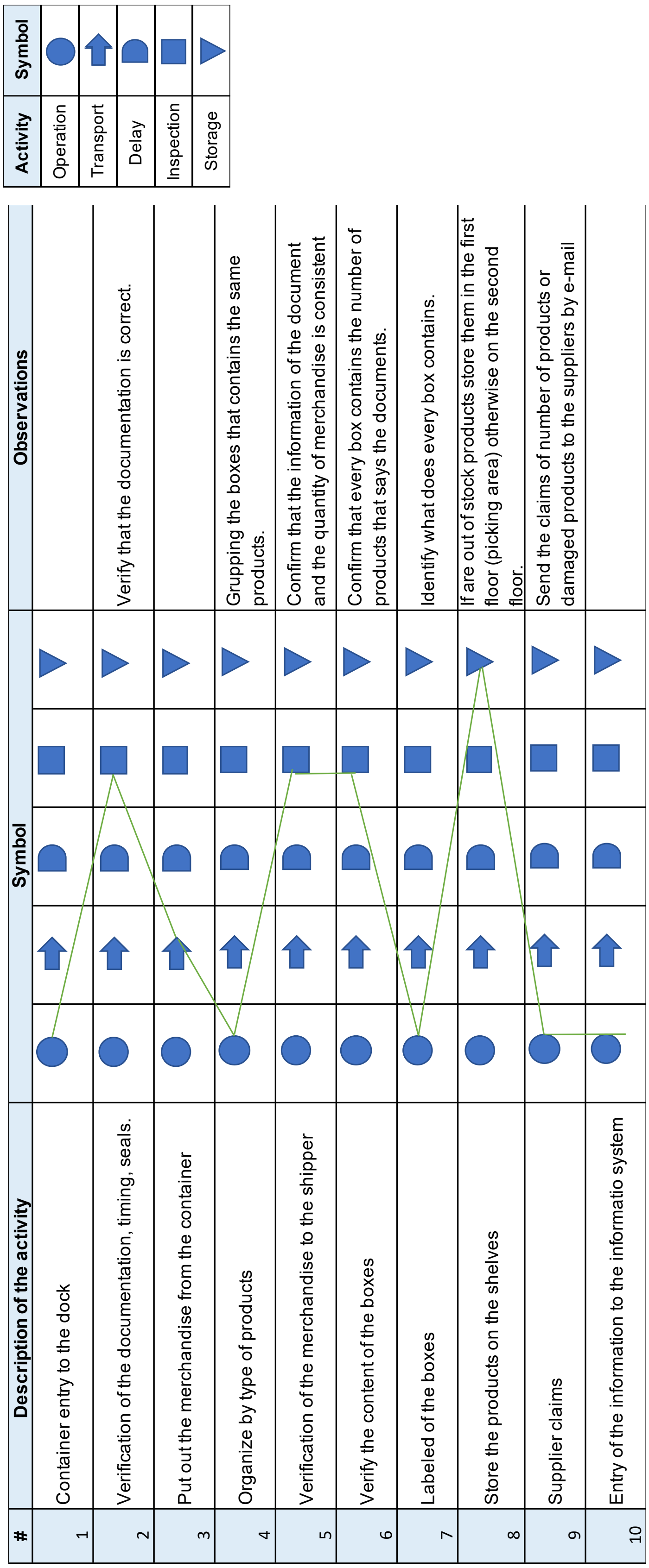


Fig. 3.13. Process flow diagram of the inbound flow of the merchandise

Storage

In this step the start of the allocation and storage of the products is made. They know previously which are the products that are out of stock (if the quantity is 0) so this one is positioned in the first floor, in the picking area, on the baskets. For the other products which they already have inventory, they put them on the second floor. The storage allocation method they are currently using, will be explained in section 3.2.4.

3.2.4. Outbound process activities.

Following with the activities performed in the warehouse, another main moment is identified in the outbound process of products to the customers. The Figure 3.14. describes in detail the operations executed to deliver the products required by the clients. The process begins with the arrival of the order in the warehouse and ends with the loading of the goods on the vehicle that will transport it to the customer.

As stated in the figure 3.14, the process of delivering the product to the customer starts with the updated list that is given by the sales force directly to the client. An example of it can be found in the appendix 1. Followed to this step, they obtain the customer's shopping list by asking the customer how many products of each reference want, and then they send a purchase order by e-mail, this is received by the sales manager which check with the financial department all the actual account statement of the client: the purchase history of the customer, the continuity on which he buys products and what type of customer is, in order to understand what type of discount is he suitable. Then the purchasing order is given to the warehouse manager in order to confirm the quantities asked.

Activity	Symbol
Operation	
Transport	
Delay	
Inspection	
Storage	

#	Description of the activity	Symbol					Observations
1	Update of the selling list						Once a month is made the selling list with all the products available
2	Sending selling lists to all sales force						Sellers perform a door to door sale with the list sent by the warehouse, and by mail, send back the purchasing orders of customers
3	Print purchasing orders						
4	Check account statement of the client						Review the history of orders, if they are still in debt with Remo.
5	Authorization by the Chief Financial Officer (CFO)						Confirm that the information of the document and the quantity of merchandise is consistent
6	Purchasing order verified by the warehouse manager						Check if the products required by the customer are in the quantities wished.
7	Send to the workers the purchasing orders						
8	Picking of the products by the workers						The picking process is carried out in the mornings because in the afternoon the transportation companies arrives for the orders.
9	Verification of the products required by the customer						The verification process is made by another worker in order to avoid mistakes.
9	Packing						Send the claims of number of products or damaged products to the suppliers by e-mail
10	Weight the packs						The transportation companies have their policies about the weights.
11	Seal the pack						Seal the pack that contains the products in order to give security to the customer.
12	Print transportation guide						Document where all the specifications of the delivery are meet.
13	Position the pack in the delivery dock						
14	Deliver the packs to the transportation company						

Fig. 3.14. Process flow diagram of the outbound of the products

Picking process

This process starts when the warehouse manager gives the customer list to the worker who then will pick up all the products needed by the customer with the "shopping cart" [2] shown below in the Figure 3.15.

Is important to mention that this picking is done by in order picking, defined previously in section 1.2, and is only done in the mornings because the transportation companies goes every day in the afternoon to pick up the packs that then will be shipped to clients.

Figure 3.15. "Shopping Cart"

With the shopping list, they search the pallets that are organized depending on the supplier and alphanumerically, this storage approach will be explain carefully in section 3.2.4. Then they pick up the merchandise they need in the baskets (Fig. 3.16) and pass the final purchase order to billing. This last could be modified if they are out of stock in some references. While the billing process is being carried out, the merchandise remains on hold until the payment is confirmed with the customer. When this last process is confirmed, the workers are responsible to pass to the next step, the packaging.

[2] Element used to search all the stock required by the customers. This idea was born by the concept of shopping in a supermarket. Remo's director adapted the shopping car to the needs of the warehouse and made this shopping cart with baskets by which the workers can easily find and move the stock to the packing stage.

Fig. 3.16. Picking process

Verification process

Once the picking is completed, all the orders are grouped in the packing area. The meeting of the customer needs will be later verified taking into account the first order they have done, with the products that where picked. The operators responsible for this activity is different from the ones that made the picking, in order to avoid mistakes in the quantities and products picked. The operator checks by comparing the first order the customer sent with the products available after picking.

Packing and shipping

After verifying the content of each order that will be sent to the customers, the next step is to proceed to pack the products; here several variables are taken into account, first, depending on the transport entity, the boxes cannot exceed 20-23 kg, the delicate products they have to be packed apart from the rest of the products and with shock absorbing content, and when there are products of large volumes different boxes are needed, which adapt to the measures of this. In figure 3.17 an operator can be observed performing the packing operation.

Fig. 3.17. Warehouse worker in the process of packaging

Once the packaging process is completed, the shipping process is carried out and the workers will be responsible for putting security tape on each box to prevent theft, and compile a transport document where they are verified:

• The receiver addresses
• The contents of the boxes
• The weight of these

It is very important the correct handling of the information to achieve good customer service, avoiding product damage, theft, discrepancy in the quantity or type of products. In figure 3.18 are the products positioned in the dock that will soon be sent to different customers throughout the country.

Fig. 3.18. Goods ready to be sent to different parts of the country

With this last process, the warehouse activities are completed and the entire logistic process that takes place in the structure ends. It must be said that this are not the only activities performed in the warehouse, for the proper management of it, other activities are carried out, not directly related to the interest of this thesis work, such as inventories, cleaning activities.

3.2.5. Description of the current stock management

In Colombia, there are approximately 10 motorcycle brands. Each brand handles on average 20 references. Remo Importador has always sought to supply the largest number of spare parts to meet all the needs of the different types of motorcycles that exist in the country. This leads them to have several references of the same product. (e.g., Air filter / Honda, Yamaha, Kawasaki, Suzuki, etc., Bolt / Honda, Yamaha, Kawasaki, Suzuki, etc., Chain / Honda, Yamaha, Kawasaki, Suzuki, etc.,).

When a new product arrives, it is identified by an alphanumeric [3]code consisting of 6 digits as can be seen in the Figure 3.19.

[3] Code which consists of using both letters and numbers

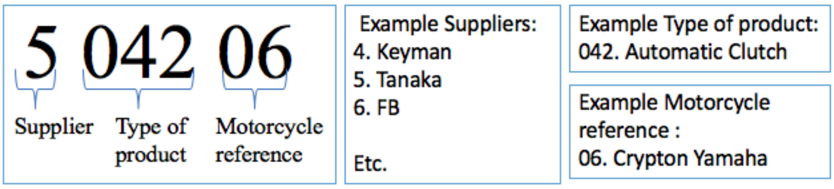


Fig. 3.19. Codes identifying the products

In the system of codes that they handle, it is taken into account that in future, new motorcycle references will arrive of the same type of product; that is why the company leaves some free codes, thinking about the new references coming, in order to be able to add them without altering the order. An example of this can be seen in Table 3.2, in which there are free spaces where new products can be added (that probably will arrive in the future), for example the speedometer: the oldest version is the 5-425-04- (2005 model) and they have left the codes finishing in 05 and 06 vacant in case a new reference of speedometer (e.g. 5-425-05- Speedometer xtz125 2019 model) arrives. This is also reflected in the allocation of the baskets as will be shown later in Figure 3.20.

Code	Reference
5-425-04	Speedometer xtz125 model 2005
5-425-05	free
5-425-06	free
5-425-07	Speedometer yd-110 libero

Table 3.20. Example Blank spaces for new codes

The aisles of the warehouse described above in section 3.3.1. are divided by suppliers. In each aisle the products are organized in alphanumeric order (fig. 3.21.). In the figure, each color represents a supplier (e.g. Keyman- brown aisle in the front of the packing area, Tanaka- yellow aisle below this last, Endurix- green aisle, in others are organized 9 suppliers with the pink color in the bottom of the figure, all of these can be clustered in Others because this suppliers do not have a high representation in quantity of references). It is important to mention that in this current stock approach, only half of the entire picking area is being used because the other part is inactive at the moment, and waiting to be used by future new references, therefore, the other ½ is empty.

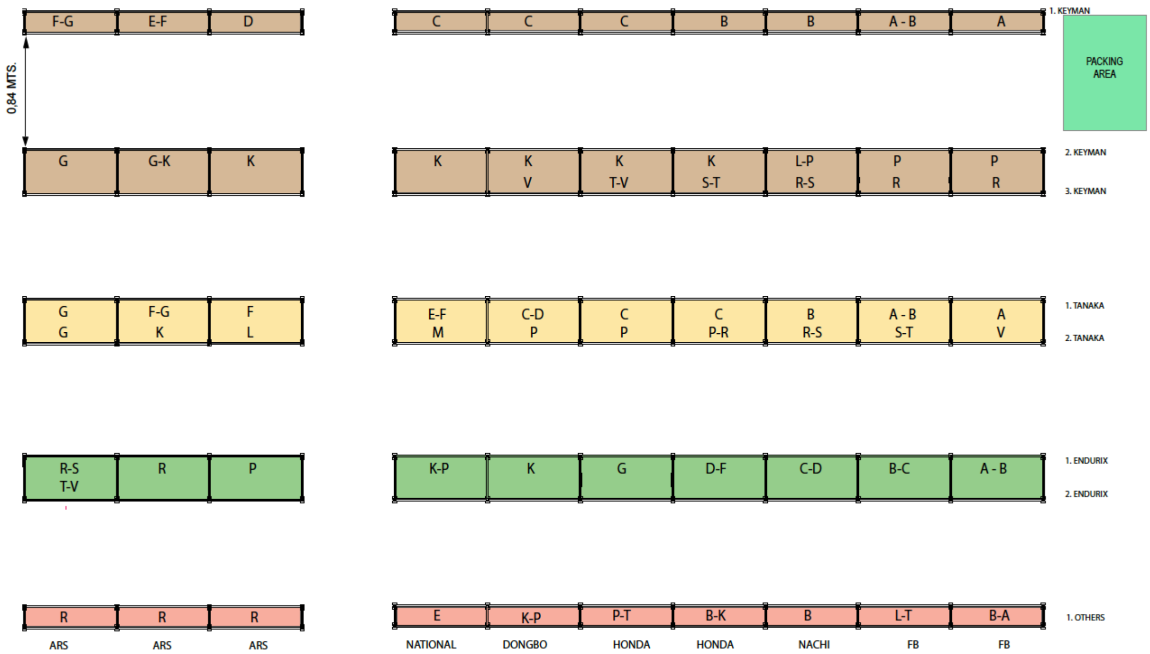


Fig. 3.21. Actual allocation method

The current distribution of the baskets is the following: starting from the lower level (level 1) to the upper level (level 4), and at each level it starts from left to right (Fig. 3.22.).

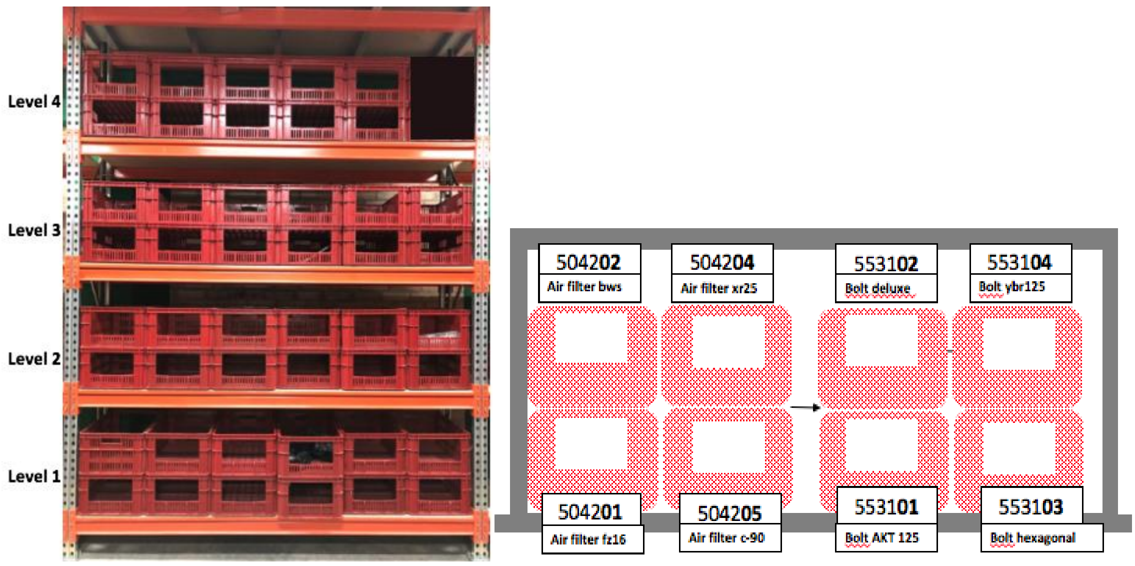


Fig. 3.22. Actual allocation method example

As stated earlier, the blanks are also left intentionally in the organization of the baskets at the end of each module in order that, when introducing a new product, the alphanumerical organization is not disrespected. (Fig.3.23.)

Fig. 3.23. Blanks in order to respect the alphabet distribution

3.3.Diagnostic of the current situation of the warehouse

3.3.1. Information and data collection

In order to make the correct diagnostic of the current situation and the mapping of the processes, activities and flows that are carried out in Remo, the methodologies used were mainly three: field visits carried out in the months of November and December of 2019 and January 2020 , in which the processes that are performed in the warehouse were observed in detail and data of distances, times, among others were taken. On the other hand, the company was also very supportive in providing any type of information that were needed, and finally the interviews with different workers who perform the operations of receipt of the merchandise, picking, packing and shipping and also the warehouse manager, were fundamental to be able to understand the processes well, and to know personally the opinions of the current storage method and the other activities and what difficulties they founded in it.

In the three months in which the field visits were made, the data of the distances traveled by the operators at the picking were taken, these data were taken taking into account one of the orders made in one day, and this process was done 3 of a total 6 labor days a week, of which 12 orders were obtained on average monthly. The times taken by workers in the different operations were provided by the company.

3.3.2. Evaluation of the current storage method

From the beginning of this thesis work what the company always sought to know was whether the current process of the allocation of the stock was the right and efficient one they could get, in terms of time spent in the picking process, distances traveled by the operator in order to avoid waste of these two and increase the service level by reducing the time that an order takes to be prepared and sent to the customer. Then, taking into account this objective, time and distances become a Key Performance Indicator (KPI) which later will allow to evaluate the current situation of the storage method, and the proposed situation and thus be able to observe whether these indicators tend to increase or decrease with the changes.

Distances

For this purpose, the first thing that was done was the route diagram, which, as mentioned in Chapter 1, is a scale diagram that allows to determine the distances that operators travel to pick an order and, by the fact of being a graphical tool, enable to observe if the movements performing this function, are susceptible to change. To carry out this diagram it was necessary to use the warehouse layout, in which the routes taken by the operators were graphed. As stated earlier in section 3.2.4. the current usage of the space is only the half of the total picking area, so, also this was taking into account when the route diagram was graphed.

In order to proceed with the evaluation, a total of 36 samples of the routes were taken, which included the observation of, 3 orders per week and 12 per month for 3 months of observation, as previously mentioned in detail in section 3.2.1.

To achieve the result of the analysis of the distance measurement are shown the figures 3.16. and 3.17, in which 5 orders from 5 different customers were plotted in each one, this differentiation can be seen in the different colors that each order takes, as will be explained later. These are 10 of the 36 graphed samples, which represent the customers that place more orders per year. The other 26 travel charts are in the appendix 3 with their respective distances and averages.

The route of the operators performing the picking activity , always starts from the first bay of the map, in front of the packing area, through the supplier aisle of "Keyman" at the "Start" point, and it and usually ends in the suppliers aisle of "Endurix" or "Others" in which stock of diverse brands like (Nacional, Dongbo, Honda, Nachi, Fb, and ARS) are arranged, as shown in the las modules.

Normally, during a picking mission, the picker makes different stops along the aisles to collect the articles, these stops are indicated in the graphs as points. Once the items of the entire order have been picked, they return to their positions in the picking area to take a new order and begin a new mission. This can happen several times, depending on the number of orders that arrive per day. This last movement described was neglected in the diagram since what is really sought to know is how much distance an operator takes to collect all the products requested by the customer.

Each color line refers to a different customer order, for example, in Figure 3.24. the pink line belongs to the Multimarcas client in which, the operator travels 171.96 mt throughout the picking operation, so on are the Rectimotos customers with blue color, Peralmotos with orange color, Motopartes with green color, and Honda motorcycles with yellow color , which run 137.42, 126.24, 142.42, and 211.71 meters respectively, having a final average of these 5 orders of 157.95 mt.

The same was done with the orders plotted in Figure 3. in which, as it can be seen, the Motobans customer indicated with purple, Ma. Angelica Galeano in green, Terremotos in red, Kyotomoto in light blue and Imporik dark blue travel 119.76, 127.42, 122.42, 26.2 and 76.62 mt respectively, leading to an average of 93.88 mt at the end.

All this information is provided in summary in the following table:

Customer	Color	Distance (mt)
Multimarcas	Pink	171,96
Rectimotos	Light Blue	137,42
Peralmotos	Orange	126,24
Motopartes	Dark green	142,42
Honda motos	Yellow	211,71
Motobans	Purple	119,76
Ma. Angelica Galeano	Light green	127,42
Terremotos	Red	122,42
Kyotomoto	Light Blue	26,2
Imporik	Dark blue	73,62
Average		125,917

Table 3.2. Meters traveled by each customer's order

From the graphical route tool, it was possible to subtract the average distance traveled when picking an order, taking into account the average distance traveled of 36 graphed orders, this is: 136.16 mt, as can be seen in Table 3.3 In pink color are highlighted the orders graphed in figure 3.24 and 3.25.

Similarly, it can be observed that most of the orders carry out the same route due to the alphanumeric organization of the stock they currently have. In addition, it is important to mention that the orders that arrive at the warehouse, have already been previously organized alphabetically and by supplier so that the operator who will be in charge of the picking function can have a sequence when going through the products and avoid unnecessarily movements.

CUSTOMER	DISTANCE (mt)
HONDA MOTOS	211,70
MOTO JAPON LA DORADA	160,44
MOTOBANS	119,76
YAKIMOTOS	232,54
PRIMOTOS	153,33
MULTIMARCAS	171,96
ALMACEN MOTOS OBANDO	53,82
TERREMOTOS	122,42
IMPORIK	73,62
JEIMY BRAHAYAN DORADO	179,73
ANGIE PAOLA RENGIFO	13,20
KYOTOMOTO	26,20
COMERCIALIZADORA DE REPUESTOS PEREZ	194,97
CROSSMOTOS ROAD / SEBASTIAN RODRIGUEZ	76,16
MOTOPARTES	142,42
ORIGINAL MOTOS	50,77
HUBER ARON HURTADO	174,66
ALMACEN Y TALLER MOTOS NEIVA	45,70
MEGA MOTOS PASTO	52,80
JUAN PABLO GUACA	157,40
ALMACEN QUE BUENISIMA ONDA	35,54
ALMACEN Y TALLER CEB SUCURSAL	220,35
ALMACEN Y TALLER CEB PRINCIPAL	182,78
MAXI REPUESTOS	87,33
Ma. ANGELICA GALEANO	127,42
RECTIMOTOS	137,42
JOSE DE LA CRUZ	228,48
FERMOTOS	207,15
OLIMOTOS	146,23
MOTORA	203,09
PERALMOTOS	126,24
PASTO MOTOS	190,90
DIOMOTOS	139,12
MOTO VELOZ	60,93
SURTIMOTOS PASTO	258,94
	136,15mt
	AVERAGE DISTANCE

Table 3.3. Meters traveled by each customer's order

However, as can be seen in Figures 3.24 and 3.25, there are modules in which more stops are made to collect the inventory than in others, an example of this can be seen in Figure 3.24. in the aisle of the supplier Keyman in the module where the products that start with the letters A-B are located, in which, the 5 orders of the 5 customers made the picking of one or more products in this. The same case can be seen in the module of the products that start with the letter C and the letters E-F from the same supplier. Something similar happens in Figure 3.25. when 4 out of 5 customers order products with the letter K from the supplier Tanaka

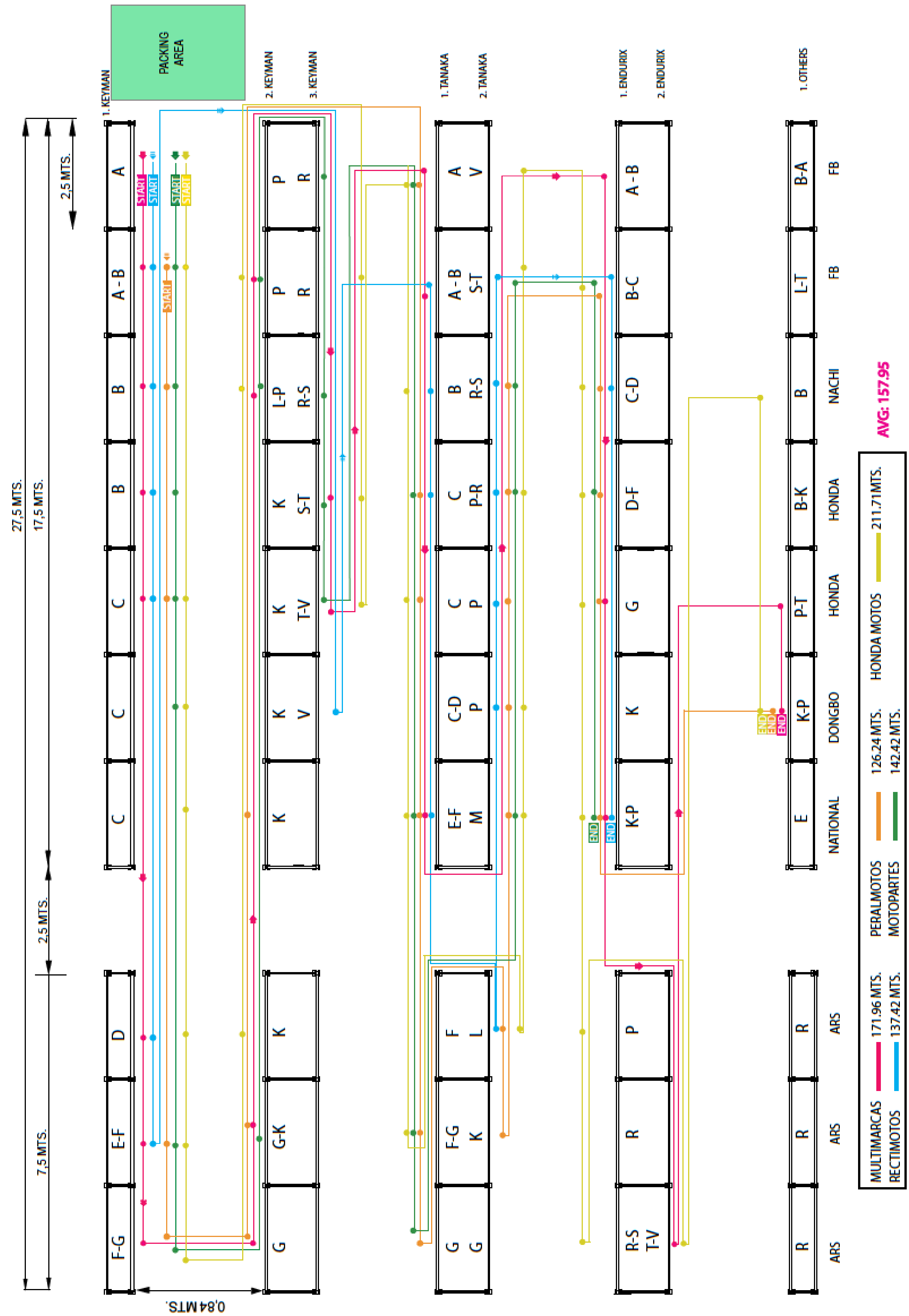


Figure 3.24. Picking route made by 5 different orders

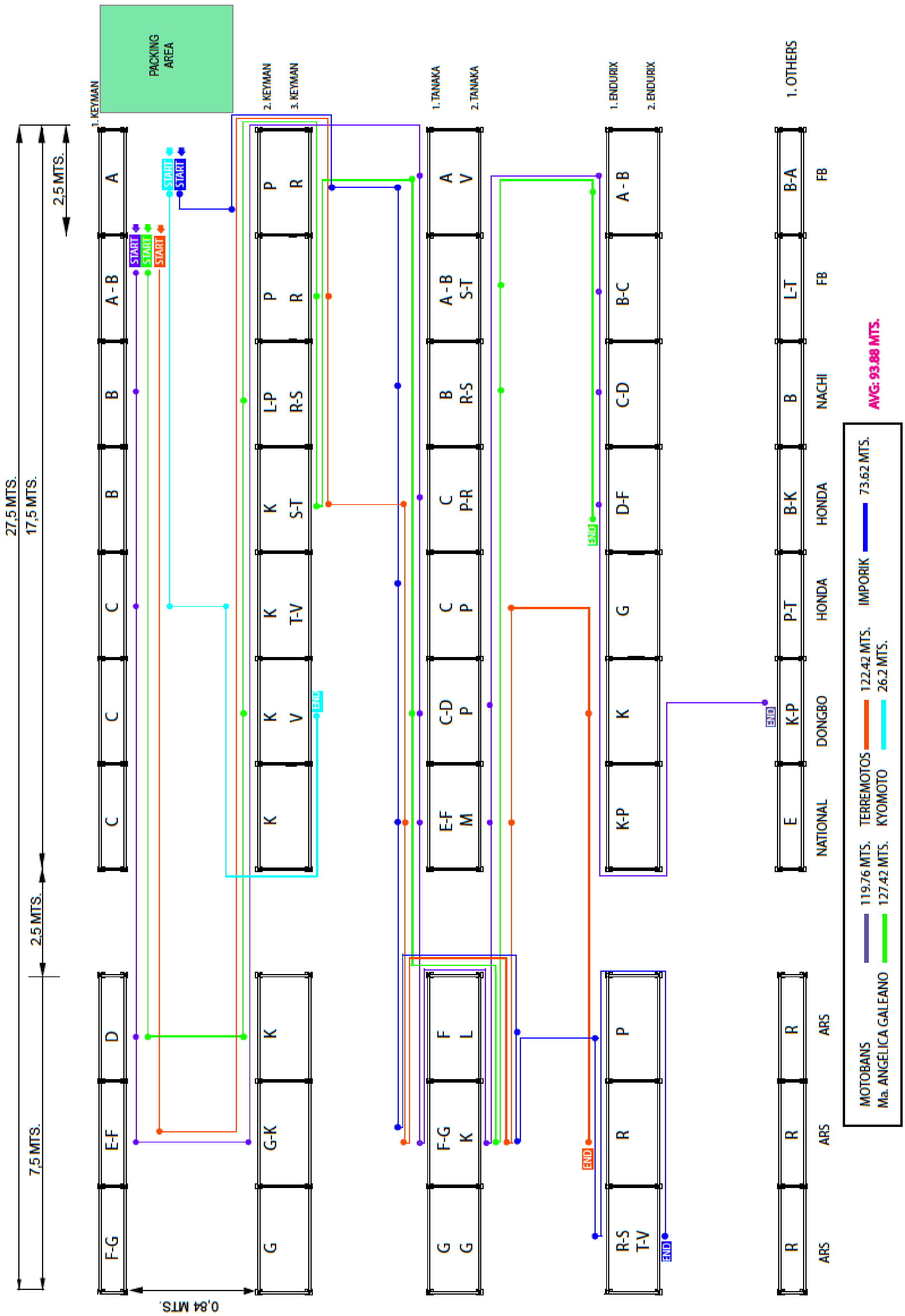


Figure 3.25. Picking route made by 5 different orders

Times

On the other hand, times are also an important indicator. In order to obtain them, it was asked to the company to provide them since they always have a trace of this data. The warehouse manager indicates the exact time when the customer's order is passed to the operator so that he begins his picking process, and at the end of this activity, the exact time at which it ends is also indicated.

Therefore, was investigated the time the operators took to carry out the 36 orders from which the distances were taken. In blue color are highlighted the orders graphed in figure 3.24 and 3.25. This resulted in the following table:

CUSTOMER	STARTING TIME	ENDING TIME	DURATION (hours)	DURATION (minutes)
HONDA MOTOS	15:00:00	17:20:00	2:20:00	145,83
MOTO JAPON LA DORADA	8:30:00	11:08:00	2:38:00	164,58
MOTOBANS	10:45:00	12:00:00	1:15:00	78,13
YAKIMOTOS	11:34:00	15:23:00	3:49:00	238,54
PRIMOTOS	11:34:00	14:05:00	2:31:00	157,29
MULTIMARCAS	9:00:00	11:50:00	2:50:00	177,08
ALMACEN MOTOS OBANDO	10:27:00	11:20:00	0:53:00	55,21
TERREMOTOS	10:27:00	12:10:00	1:43:00	107,29
IMPORIK	8:00:00	9:20:00	1:20:00	83,33
JEIMY BRAHAYAN DORADO	14:00:00	16:57:00	2:57:00	184,38
ANGIE PAOLA RENGIFO	11:00:00	11:13:00	0:13:00	13,54
KYOTOMOTO	10:51:00	11:11:00	0:20:00	20,83
COMERCIALIZADORA DE REPUESTOS PEREZ	11:08:00	14:20:00	3:12:00	200,00
CROSSMOTOS ROAD / SEBASTIAN RODRIGUEZ	8:45:00	10:00:00	1:15:00	78,13
MOTOPARTES	14:00:00	15:35:00	1:35:00	98,96
ORIGINAL MOTOS	14:25:00	15:15:00	0:50:00	52,08
HUBER ARON HURTADO	9:18:00	12:10:00	2:52:00	179,17
ALMACEN Y TALLER MOTOS NEIVA	10:35:00	11:20:00	0:45:00	46,88
MEGA MOTOS PASTO	9:43:00	10:35:00	0:52:00	54,17
JUAN PABLO GUACA	14:10:00	16:45:00	2:35:00	161,46
ALMACEN QUE BUENISIMA ONDA	9:25:00	10:00:00	0:35:00	36,46
ALMACEN Y TALLER CEB SUCURSAL	8:00:00	11:37:00	3:37:00	226,04
ALMACEN Y TALLER CEB PRINCIPAL	9:10:00	12:10:00	3:00:00	187,50
MAXI REPUESTOS	14:15:00	15:41:00	1:26:00	89,58
Ma. ANGELICA GALEANO	14:15:00	16:00:00	1:45:00	109,38
RECTIMOTOS	14:15:00	16:20:00	2:05:00	130,21
JOSE DE LA CRUZ	14:15:00	18:00:00	3:45:00	234,38
FERMOTOS	11:45:00	15:09:00	3:24:00	212,50
OLIMOTOS	9:00:00	11:24:00	2:24:00	150,00
MOTORA	9:00:00	12:20:00	3:20:00	208,33
PERALMOTOS	14:47:00	17:00:00	2:13:00	138,54
PASTO MOTOS	14:00:00	17:08:00	3:08:00	195,83
DIOMOTOS	8:49:00	11:06:00	2:17:00	142,71
MOTO VELOZ	14:45:00	15:45:00	1:00:00	62,50
SURTIMOTOS PASTO	10:00:00	14:15:00	4:15:00	265,63
			2:08:33	133,90
			AVERAGE TIME	

Table 3.4. Average time in preparing one order

As can be deduced from table 3.4, the average time that the operators take to make one order is 133,90 minutes.

Obtaining data on how long it takes on average for an operator to carry out the picking activity and how much distance he travels to obtain all the products required by a client, it is possible to conclude that the following are the Key Performance Indicators:

KPI	Units	Value
Distance	meters	136,15
Time	minutes	133,9

Table 3.5. Key Performance Indicators.

Having these two variables, the next step was obtaining the average speed that it takes to an operator of Remo's warehouse to travel a meter. For this it will be take in to account the formula (1):

$$s = \frac{d}{t} \qquad (1)$$

Where the speed (s) is given by the average distance (d) traveled in an order over the average time (t) it takes to pick an order. With this it will be obtain the formula (2):

$$s = \frac{136.15\ m}{133{,}90\ min} = 1{,}02\,\frac{m}{min} \qquad (2)$$

The picking speed of an operator in Remo is: 1.02 meters per minute. This value will help in order to find the proposed KPI'S in section 3.4.1.

3.3.3. Returns

In the company, the return process has two axes, initially the returns or claims that the company presents to the supplier, in cases where the merchandise presents failures or the product is not correct, in this case the claim is made with the respective photographic and physical evidence, at the time the supplier approves the claim, the damaged merchandise money is returned to the company, and undertakes to destroy the product, since the costs of returning the merchandise to the supplier would be excessively high. It is important to mention that that this type of situations does not occur very frequently.

On the other hand, there are claims received by the end customer, and for handling the claims, the company has a process, which allows filtering returns and having clear causes. For this, the customer is requested to compile a format in which determines the causes of the returns (Appendix 2) the number of articles, de date and the price that is competent to this product.

Analyzing the conversations held with the personnel participating in the returns process, the following are the main causes of returns from the customer to the company:

- Billed products different from the shipped to the customer
- Products dispatched that were not requested by the customer
- Errors in the amount received
- Mistakes in the negotiated prices- order does not correspond to the actual value for which it was sold, due to communication errors between the sellers and the billing manager.
- By warranty- manufacturing defects not detected at the time of dispatch
- Deterioration of the product due to errors in the dispatch process or improper handling by the transportation company

To be able to make the process effective, the company requires that the product is in perfect condition and unused, they must also comply with the established time terms.

The client must inform the company within ten (10) days following except for guarantee that they will be within sixty (60) days after the merchandise is received.

After completing this process, the product returns to the warehouse and is included again in the inventory system, those that are in good condition and correct operation are re-marketed.

Products that have failures or malfunctions do not have an established disposal process, which could lead to a considerable increase in the company's inventory and in turn could arrive to overstock space, the following operations diagram (Fig. 3.26.) shows in summary all the activities described before that needs to be carried out when a return arrives to the company.

Activity	Symbol
Operation	
Transport	
Delay	
Inspection	
Storage	

#	Description of the activity	Symbol					Observations
1	Receipt of document in relation to non-conforming product						Document sent by the customers
2	Physical reception of the damaged product						
3	Inbound of the products to the information resource						They are charged into the inventory of the warehouse again
4	Re-organize the products in good conditions						Select those products that are not damaged and re-sell them
5	Accumulate damaged products						Absence or process in this step, accumulation of unusefull stock

Fig. 3.26. Process flow diagram of the returns process.

In order to quantify the analysis of returns and understand if this number is actually important to pay attention to it was asked to following analysis was done.

Taking into account the information provided by the company, in 2019 a total of 2,092 orders were billed, which contained a total of 555,378 units of products. Moreover, analyzing the total number of days worked in the year, which was 296, it was found the average of orders billed per day which is 7.1. This can be seen in Table 3.6.

Month	Quantity of invoiced orders (Month)	Quantity of invoiced orders (Day)	Quantity of invoiced units (Month)
January	193	7,7	53.879
February	181	7,2	51.441
March	199	8,0	48.959
April	163	6,8	45.069
May	205	8,5	50.077
June	178	7,7	42.027
July	218	8,4	59.274
August	148	6,2	39.153
September	183	7,0	49.911
October	149	5,7	38.165
November	178	7,7	51.062
December	97	3,9	26.361
TOTAL	**2.092**	**7,1**	**546,886**

Table 3.6. Quantities invoiced by month and day

Below is the Table 3.7, which present the detailed information for the year 2019, of the quantities of returns made per month, in average, the number of returns per day and the total quantities of returned units.

Month	Quantity of returns made (Month)	Total quantity of returned units
January	-	-
February	17	376
March	67	1.371
April	87	753
May	97	1.475
June	38	401
July	53	873
August	21	197
September	-	-
October	-	-
November	45	568
December	50	430
TOTAL	**475**	**6.444**

Table 3.7. Quantities of returns made by month and total returned quantities

As can be seen from Table 3.8, although the total number of references returned per year does not represent a really significant percentage based on all orders issued per year (1.16% of the orders invoiced were returned), 6444 units are a representative amount that should be paid attention to, because, the company currently does not carry out a complete return process, that is, once the returns arrive from the customers, many times they stay accumulated in one place, creating overstock of references. Therefore, the absence of a process of returns was a problem found by analyzing the current situation of the company, to which, in the next section, a possible solution will be proposed.

3.3.4. Heavy products at the last shelve

The heavy products that remain at the last shelve was a problem that was mentioned by the operators numbered of times during the set of interviews that was made. Analyzing deeply the situation, this issue is due to the fact that the products are organized alphabetically, and, respecting this order, many times, very heavy products remain at the top (last shelf level) and for workers it becomes a problem to maneuver with this type of objects, since they have to climb a ladder to get them. This is actually an ergonomic problem that if it is done repetitive times a day, can affect the performance of the operators. In order to magnify the quantity of times they have to handle with these products the following analysis was done:

Firstly, it was sought the weight capacity that an operator can carry in the functions, for this, it was took into account the decree 487 of 1997 and Law 31/1995 of the Colombian law, which regulates the health and safety provisions related to load handling, and it is under this rule that companies must be governed to avoid occupational risks.

Taking into account the regulations mentioned, which establishes that all merchandise that exceeds the 3kg that must be loaded up to 30 cm above the shoulder and 30 to 60 cm away from the body, is considered as a risk. We proceeded to quantify products that have been sold that exceed the limits allowed.

Based on the information on the characteristics of the merchandise obtained in the company's computer system (Siigo), the comparison was made on the 2,707 references that were sold in 2019, from which it was concluded that 333 references have a difficult weight to handle, taking into account the type of movement, and the distance that must be traveled to move the merchandise.

These 333 references mentioned, represent 61,115 units of the 555,378 sold during the mentioned period, thus having a participation of 11.00% of the total sold during the year. From this, the products sold in table 3.8 were grouped taking into account their weights.

KILOGRAMS	QUANTITY OF REFERENCES
More than 6 kg.	8
5 kg to 6 kg	47
4 kg to 5 kg	143
3 kg to 4 kg	135
2 kg to 3 kg	924
1 kg to 2 kg.	596
Less than 1 kg.	1023

Table 3.8. Quantities of products clustered by intervals of kilograms

From this table, it is possible to conclude that heavy items really represent a labor risk problem that must be treated, since this can reduce the productivity of the operator at the time of picking and in the worst case, finish in a work accident. Therefore, it will be proposed in the next chapter, that the optimal distribution (either the current one or the allocation class based) include in itself, that the products categorized as heavy and difficult to access are placed on the first level of the shelf.

3.4. Design of the improvement proposals

In this chapter will be presented the proposal solutions to all the problems found. In the first part it will be proposed the class-based storage approach analysis for the inventory storage management, followed by the solutions for the issue with the return's orders. Subsequently there will be presented the 5's analysis for the criticalities found with the 5'w.

3.4.1. Evaluation of the class-based storage approach

In order to find the main aim of this thesis work, which is to evaluate if the current storage policy is the more effective, the KPI's found in section 3.3.2 will be compared with the ones that will be obtained with the ABC approach. To this end, the first thing done was to identify which class was going to be evaluated, for that, the types of classes most used in the ABC evaluation were taken into account and those that could be important were filtered out of those that were not. For example, a type of class that is generally very used but that in the case of Remo Importador would not very useful, taking into account the criteria of the contact of the company, it would be the value of the inventory, since for them it is not really important to be able to have a better control over them, different from what they thought about the products with greater rotation, since this could bring them a benefit by reducing times and distances at the time of picking process. Therefore, the class chosen was inventory turnover.

Taking into account the choice of classes, the next step is proceeded to obtain the information needed, in this case, it was asked to the company to provide the sales data for the year 2019, with the quantities sold for each reference. Once these data were obtained, the Pareto analysis was performed, which can be seen in Figure 3.27.

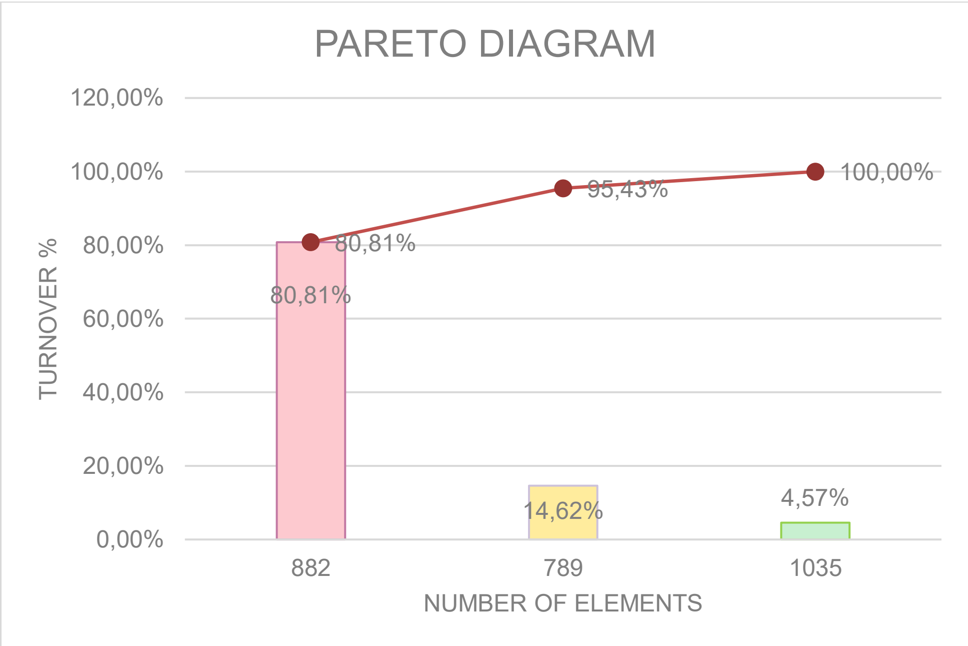


Figure 3.27. Pareto analysis for the turnover percentage

	# ELEMENTS	% ARTICLES	% REAL QTY
A	882	32,59%	80,81%
B	789	29,16%	14,62%
C	1035	38,25%	4,57%

Table 3.11. Pareto analysis summary

In the same way, in table 3.11 it is possible to observe a summary of the analysis obtained with the Pareto chart, from which it can be concluded that: from a total of 546,886 units sold in 2019, 882 products from a total of 2,707 are located in class A, this corresponds to 32.59% of the total products and are responsible for 80.81% of the total items sold in that year. Similarly, there are products classified in class B, which correspond to 789 products, are 29.16% of the total products, and are responsible for 14.62% of the turnover. On the other hand, type C products are 1035 elements, representing 38.25% of the articles and 4.57% of the turnover.

From this it is possible to conclude that type A products are those that generate the highest sales quantities per year, specifically, more than 80% but these sales are represented only by 32.69% of the total products. The products classified in categories B and C are those with the lowest sales per year and between the two represent 67.41% of the turnover.

Once these values have been calculated, it is possible to continue with the ABC analysis, which says that, products A are the ones that should be given the most attention, in this case, what was done was, organize all products A in places more accessible from the picking area for the operators, taking into account that their jobs are located in the packing area, the product area A was located in front of this area. Products classified in the class B could go a little bit far and products class C, given the fact that are the ones with the lowest turnover, can go in the places with more difficult access, because in theory, the orders of the clients will not contain them regularly.

In order to figure out if this proposed allocation was really useful for Remo's warehouse needs, a preliminary evaluation was done, taking into account again the layout of the space as can be seen in figure 3.18. In this case was also despised the other part of the picking area that is currently empty. With que current space they have the first thing that was analyzed was the quantity of modules that each letter needed, to this end it was used the following analysis showed in table 3.12. Each module has the capacity to accommodate 48 references, for the 48 baskets; so, the result was that for class A there are needed 18.4 modules in order to accommodate 883 references, this number was rounded to 19. B needs approximately 17 modules and C 22.

Class	Quantity of products contained in the class	Modules needed
A	882	18,4
B	789	16,4
C	1035	21,6

Table 3.12. Modules needed by class

In this way the stock was, once again organized, first by class, second by supplier and third alphabetically, in order the workers can easily find the products. (Fig 3.28.). The second analysis carried out was to understand how many letters of the alphabet were included by each class and by each supplier, and in that way, determine how many modules per letter had to be left. One example of this can be seen in the following table.

Class	First letter	Supplier	Quantity of Products with the letter	Modules
A	A	KEYMAN	44	0,9
A	B	KEYMAN	36	0,8
A	C	KEYMAN	51	1,1
A	D	KEYMAN	25	0,5
A	E	KEYMAN	19	0,4
A	F	KEYMAN	16	0,3
A	G	KEYMAN	14	0,3
A	H	KEYMAN	2	0,0
A	K	KEYMAN	57	1,2
A	L	KEYMAN	10	0,2
A	P	KEYMAN	35	0,7
A	R	KEYMAN	16	0,3
A	S	KEYMAN	12	0,3
A	T	KEYMAN	41	0,9
A	V	KEYMAN	16	0,3

Table 3.13. Modules needed by class

As the table 3.13 shows, this is an example of the quantity of products that starts by those letters of the supplier Keyman, that are in the category A. (e.g. There are 44 products of the supplier Keyman that starts with the letter A in the class A, this quantity of products, would need 0,9 modules to be allocated taking into account that 48 products can be allocated in one module). This logic was followed for all the suppliers and all the classes obtaining the distribution showed in figure 3.28.

Distances

Follow to this whole process, came the analysis of the distances traveled by the operator. To make this, it was taking into account the same sample of orders that was previously evaluated with the current stock allocation approach in the section 3.2.2. Continued to this step it was necessary to re-accommodate the orders, that were first listed alphabetically and by brand of supplier, in this case were accommodated also with these variables but aggregating the class.

Finally, the distances were obtained making the same picking route of the same customer orders previously graphed in order to obtain the real difference between the two allocation methods. The figures 3.28. and 3.29. present the same 10 customers' orders that the graphs 3.24. and 3.25.

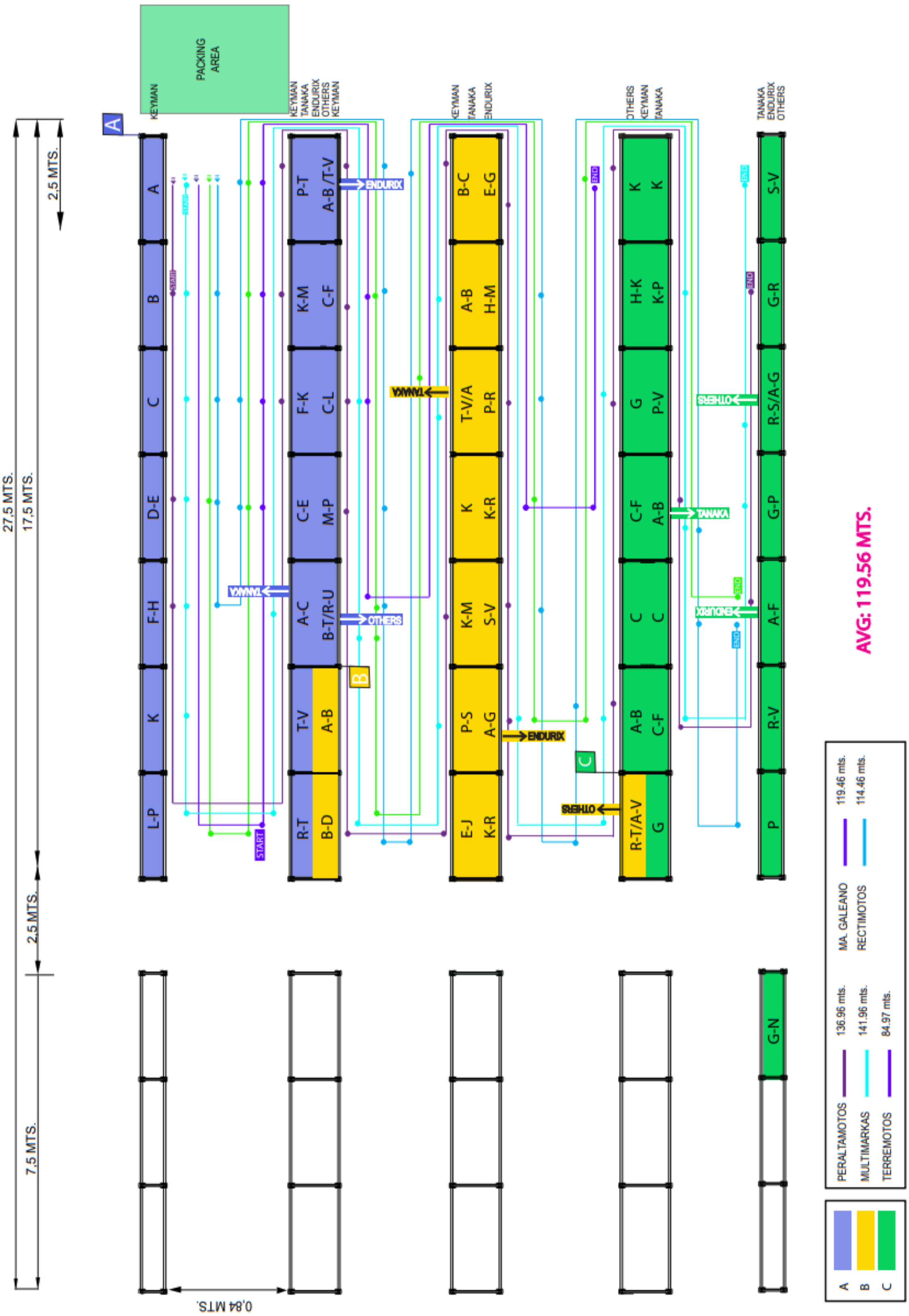


Figure 3.28. Picking route made by 5 different orders

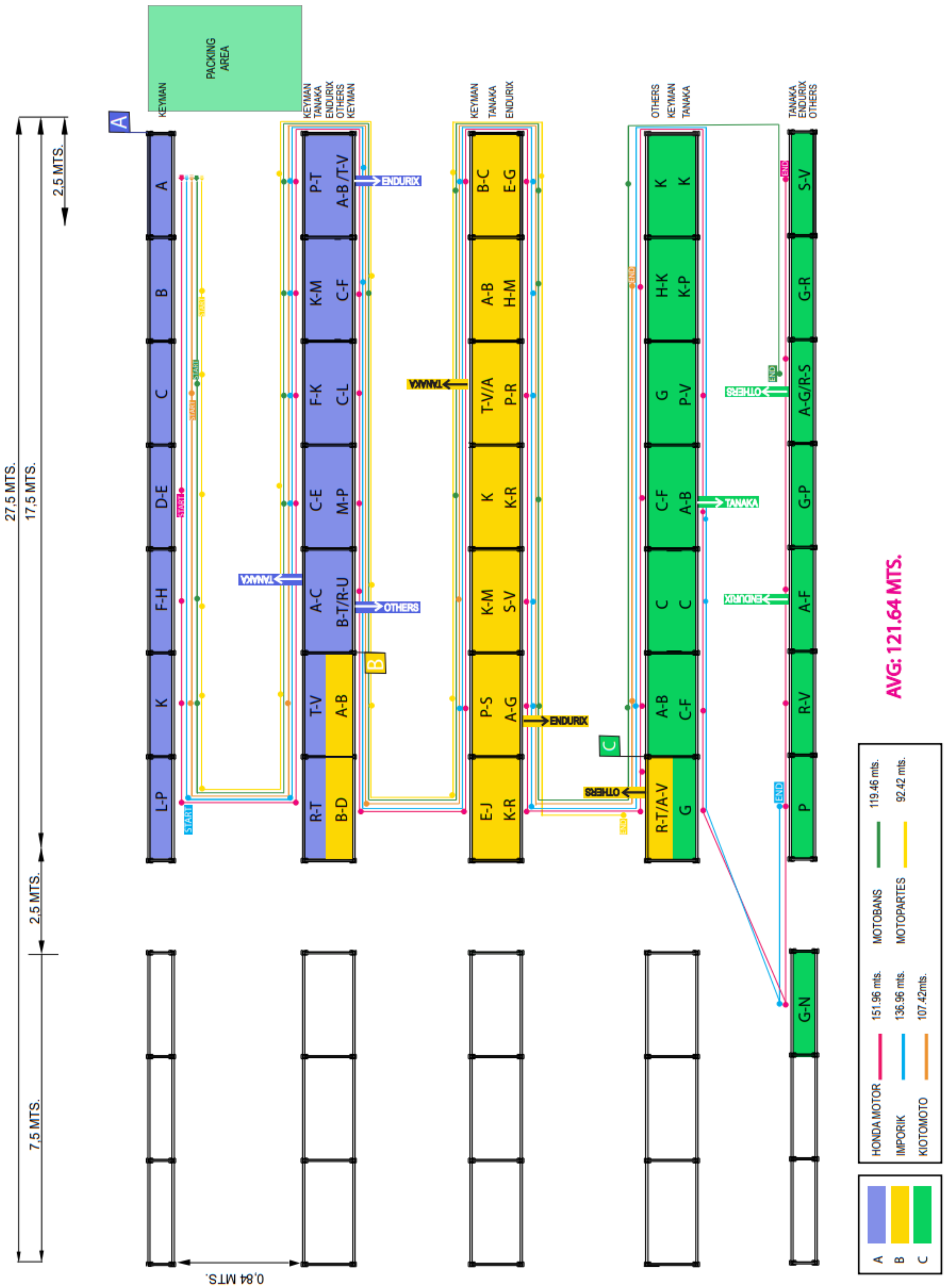


Figure 3.29. Picking route made by 5 different orders

In the previous figures are shown the distribution of the ABC analysis marked with purple color the Class A products, with yellow color the class B products and with green color the class C products. Plus, every flag indicates where a new brand of supplier starts. In this proposed distribution are used only the nearest and most accessible parts in order to avoid long distances traveled and reduce times.

Moreover, despite the average distance seems to have decreased (what will be subsequently checked) most of the orders make almost all the route (e.g. start with the products in the first aisle of Keyman in the Class A and end with the last aisle of category C). On the other hand, what can be actually confirmed is that the operators stop almost always in the same points to pick up the products, for example in figure 3.28. all the orders stopped in points D-E of keyman, 3 orders of 4 stopped in points K-M and P-T of Keyman, C-F, C-L and A-G of endurix. The same case is presented in figure 3.29. This could be explained by the fact the products are organized by turnover, so, in many cases it will be found that the customers ask for the same products.

The table 3.14. shown above will allow to made the comparison between the current method that is being carried out and the proposed one with the class-based storage approach.

CUSTOMER	*DISTANCE CURRENT METHOD (m)*	*DISTANCE METHOD ABC (m)*	*DISTANCE REDUCED (m)*
Multimarcas	171,96	141,96	30
Rectimotos	137,42	114,46	22,96
Peralmotos	126,24	136,96	-10,72
Motopartes	142,42	92,42	50
Honda motos	211,71	151,96	59,75
Motobans	119,76	119,45	0,31
Ma. Angelica Galeano	127,42	119,46	7,96
Terremotos	122,42	84,97	37,45
Kyotomoto	26,2	107,42	-81,22
Imporik	73,62	136,96	-63,34
Average distance	**125,917**	**120,602**	

Table 3.14. Comparison between the current method of allocation and the class-based method for 10 customer's orders

As it can be deduced from the table 3.14. the average distance traveled by each customer order has been reduced, from 125,917 mts to 120,602 mts. In the column distance reduced, it can be proved that almost all the routes have had a distance reduction except the orders for the customers Peralmotos, Kyotomoto and Imporik, which instead of having a distance reduction, the distances has increased in 10,72 , 81,22 and 63,34 meters respectively.

In order to have a deeper understanding of the reduction of distances and times the analysis was made with the same 36 sample of orders that were evaluated in the case of the actual distribution in section 3.3.2, obtaining after being graphed the following reduction in the average distances:

AVERAGE DISTANCE	
DISTANCE CURRENT METHOD (m)	***DISTANCE METHOD ABC (m)***
136,16	**132,008**

Table 3.15. Comparison of the average distance traveled by an operator in the sample of 36 customer orders

As expected, the table 3.15. show us that effectively, there was a reduction in the distance traveled by the operators with the ABC method, this first was 136,16 m/ order and with the class-based method, despite is not a huge reduction, this distance would be 132 m/order. The complete table with the distances traveled by each of the 36 customer's orders and the reduction of each one can be seen in appendix 4.

Times

In order to find the reduction of the times, the average speed found in section 3.2.2 was used. Taking into account again the formula 1:

$$t = \frac{d}{s} \qquad (1)$$

We already have the distance the operators need to travel in order to make the 36 routes of the orders of each customer, and we have the average speed one that one worker of the company Remo take in order to travel one meter which is 1.02 per minute. Following the formula of the time, the next step done was to calculate the time that take an operator to pick up each one of the 36 orders with the proposed distribution of the class-based allocation method, as it is shown in the following table:

CUSTOMER	CURRENT DURATION (minutes)	ABC DURATION (minutes)
HONDA MOTOS	145,83	148,98
MOTO JAPON LA DORADA	164,58	128,10
MOTOBANS	78,13	117,11
YAKIMOTOS	238,54	198,79
PRIMOTOS	157,29	121,13
MULTIMARCAS	177,08	139,18
ALMACEN MOTOS OBANDO	55,21	103,51
TERREMOTOS	107,29	83,30
IMPORIK	83,33	134,27
JEIMY BRAHAYAN DORADO	184,38	147,02
ANGIE PAOLA RENGIFO	13,54	63,69
KYOTOMOTO	20,83	105,31
COMERCIALIZADORA DE REPUESTOS PEREZ	200,00	161,95
CROSSMOTOS ROAD / SEBASTIAN RODRIGUE	78,13	45,47
MOTOPARTES	98,96	90,61
ORIGINAL MOTOS	52,08	100,52
HUBER ARON HURTADO	179,17	142,04
ALMACEN Y TALLER MOTOS NEIVA	46,88	95,54
MEGA MOTOS PASTO	54,17	102,51
JUAN PABLO GUACA	161,46	125,12
ALMACEN QUE BUENISIMA ONDA	36,46	5,65
ALMACEN Y TALLER CEB SUCURSAL	226,04	186,84
ALMACEN Y TALLER CEB PRINCIPAL	187,50	150,01
MAXI REPUESTOS	89,58	136,36
Ma. ANGELICA GALEANO	109,38	117,12
RECTIMOTOS	130,21	112,22
JOSE DE LA CRUZ	234,38	194,80
FERMOTOS	212,50	173,90
OLIMOTOS	150,00	114,17
MOTORA	208,33	169,92
PERALMOTOS	138,54	134,27
PASTO MOTOS	195,83	157,97
DIOMOTOS	142,71	187,13
MOTO VELOZ	62,50	110,48
SURTIMOTOS PASTO	265,63	224,67
	133,90	129,42
	AVERAGE TIME	

Table 3.16. Difference in times spent in the picking operation between the current operation and the ABC distribution

From the table 3.16 it is possible to conclude that, as expected, the average duration of the picking process in the current distribution is higher than the class based one, which is 129,42 min/ order. This is equivalent to say that the picking process with the ABC distribution would take in average 2,15 hours in order to prepare an order.

Thus, comparing both results obtained of the changes in the distance and the time we can get the following conclusion:

KPI	Units	Values for the current situation	Values for the class-based situation	% of variation
Distance	meters	136,15	132,008	3,04%
Time	minutes	133,9	129,42	3,35%

Table 3.17. KPI's for the current and the class-based allocation methods

The table 3.17. allow us to conclude that the class-based allocation approach can improve the current one in terms of distance and time, the former one would be reduced in a 3,04% and the time could be reduced in a 3,35%. To understand the impact of this reduction, the following economic evaluation will be done: it will be calculated the salary taking into account that, a workforce day costs more or less 10€ (30,000$ Colombian pesos) in 8 hours work day would be 1,25€/hour. With the current situation, the picking operation costs 2,78€/ order (2,23 hours/order of the current situation * 1,25€), and the proposed situation will cost 2,69 €/order.

The savings in money taking into account that in average there are made 7 orders/ day would be 0,63€/day, 18,9€/month and 226,8€/year only changing the disposition of the products in the picking operation. Later on, in section 4,2,2 it will be shown which will be the impact if the company change all the problems found in the next chapter

With this validation, and knowing that the KPI's proposed have increased, it is possible to say that the most efficient distribution would be the turnover one, which would be based on the ABC analysis.

3.4.2. Proposed solution to the absence of a process in the returns of stock.

For this point, what is proposed is to create a procedure that manages to be used with an established periodicity to be able to destroy the defective goods, which will no longer be used.

As is known, these things are only causing unnecessary costs of handling the inventory, and taking up space that could be occupied by merchandise that really does generate value for the company. From this it is recommended to continue with the compilation of this process to achieve a complete return process.

The following figure (Figure 3.30.) presents the procedure design in which the product needs to be categorized by the defect it has, the quantity of products that presents this kind of problem, the units of the product (set, packs, pieces), the material of which is composed, in order to understand what kind of disposal needs to be done, subsequently, if a test was performed to it, to understand if it is a damaged without solution.

REMO IMPORTADOR

DISPOSAL OF GOODS

DATE: ______________

THE DOWN SIGNATORS PROCEDURE TO PERFORM THE DESTRUCTION AND/OR RECYCLING OF THE FOLLOWING PRODUCTS, FOR THE REASONS BELOW DESCRIBED ACCORDING TO THE PARAMETERS ESTABLISHED BY THE COMPANY FOR THE MANAGEMENT OF DEFECTIVE GOODS.

CODE	NO. INVOICE	DESCRIPTION	QUANTITY	UNITS	MATERIAL	REASON OF RETURN	TEST PERFORMED	PROCEDURE TO BE USED	RESULT OR VALUE OBTAINED

PLACE AND DATE OF DESTRUCTION AND / OR RECYCLING

NOTE: The destruction and / or recycling of the goods can only be carried out in the days and hours enabled.

OBSERVATIONS

RESPONSIBLE

AUTHORIZED BY:	MADE BY:	WITNESS:
SIGN	SIGN	SIGN

Figure 3.30. Disposal of goods procedure proposed

CHAPTER 4: Lean manufacturing application

4.1. Lean Production analysis

4.1.1. Value Steam Map (VSM) analysis

To go further with the analysis of the current situation of Remo's warehouse that allows to know all the activities related to the processes that are carried out and look for possible criticalities and improvements in this, was opted for the analysis of the supply chain with the help of the tool of the Value Stream Map (VSM), as defined in Chapter 1, is a graphical tool that allows to analyze the entire supply chain, from when the purchase order goes to the suppliers until, when the products are delivered to the customer. The main objective is to have a broader vision of all the processes that are incurred to satisfy customers, in order to reduce the Lead Time which is the sum of all the times of the operations carried out in the warehouse, thus finding all the activities that do not represent value to consumers and are therefore classified as a waste. To achieve this objective, all activities will be analyzed in detail and which of them will generate added value, and those that do not, should be reduced the time or try to delete them from the process.
It should be clarified that due to the fact that it is a warehouse of finished product and commercialization, and not a manufacturing process, the processes carried out in it do not generate value directly to the product, however, they are necessary processes to achieve the satisfaction of the client.
To map the value chain of Remo Importador, the first step that needs to be done in order to have a broader view is to restrict the analysis to a family of products. This is a step that is not mandatory to do in the context of this warehouse, because all the products carry out the same steps without variation but, what was actually done, was restricting the analysis to all the products obtained by one single supplier, which can be seen as a family of products since they perform the same activities. In this case, this will be carried out taking into account the merchandise that arrives from Keyman, because that is the one that handles more references in the warehouse and that arrives more consecutively.

This supplier ships different types of containers from China, with different capacities as shown in table 3.9.

Measure (Feet)	Boxes	Quantity of products
STANDARD 20"	420	28,000 pcs/sets/kits
STANDARD 20"	511	76,250 pcs/sets/kits
STANDARD 20"	384	50,000 pcs/sets/kits
HIGH CUBE 40"	1148	80,737 pcs/sets/kits
STANDARD 40"	894	76,748 pcs/sets/kits
HIGH CUBE 40"	1420	167,500 pcs/sets/kits

Table 3.9. Measures and quantities of products of the different containers

For the analysis of this map, the standard 20-foot container that carries 384 boxes and a total of 50,000 pcs / sets / kits highlighted in the table 3.9 will be taken into account. because this is the container that arrives most frequently at the warehouse.

With this, the chain mapping was carried out. This graph is composed of two parts, the first one, which is located at the top refers to the flow of information that is made between the purchasing department and the supplier and also with the customer, this last will be explain then. In the former case, the purchase orders are always made via e-mail, so the relationship between this department and the supplier was indicated with that zigzag of arrow.

Continuing with this order, the flow of merchandise is reached at the bottom of the graph, where it is indicated that Keyman makes large shipments to the warehouse every two months, in which they contain 50,000 units of products, which reach the warehouse through containers once every two months, so the frequency of arrival is bimonthly.

The receipt of the merchandise is the first process that takes place after the vehicle is placed in the dock. 4 operators proceed with the unloading of the boxes while 2 verify the documents and perform the respective count, for a total of 6 workers in this activity, as shown in this box.

Subsequently, storage, picking, packing and shipping activities are carried out, which include 4, 6, 6 and 6 operators respectively. The flow between the receipt of the merchandise and the storage is push type, that is, at the end of the first one, this “push” the merchandise to the next process regardless of the needs of the next process. Unlike the relationships between the following activities which were marked pull arrows.

Another important thing to mention is the content of each of the boxes that contain the information of each activity, in this case the cycle time C / T for each of the operations is indicated. On the other hand, the preparation time or set up C / O, is taken as 0 as this is not a production process. The useful time is also not considered in this graph since this corresponds to the time of available machines, and in this case, it is despised as it is not a process that is carried out with machines.

In the lower part of the graph both the sum of the processing times corresponding to the lowest peaks of the line, and the delivery time of an order that would be the sum of the highest peaks of the line are shown , it is here where the activities that do not add value for the client are located, therefore, it is these that are susceptible to changes to reduce waste.

It is important to highlight that the activities were graphed with different color intentionally, the pink ones correspond to the inbound process activities, the orange ones correspond to the outbound process activities.

In consequence, the steps made in order to find the value added and no value-added time will be shown after the following graph.

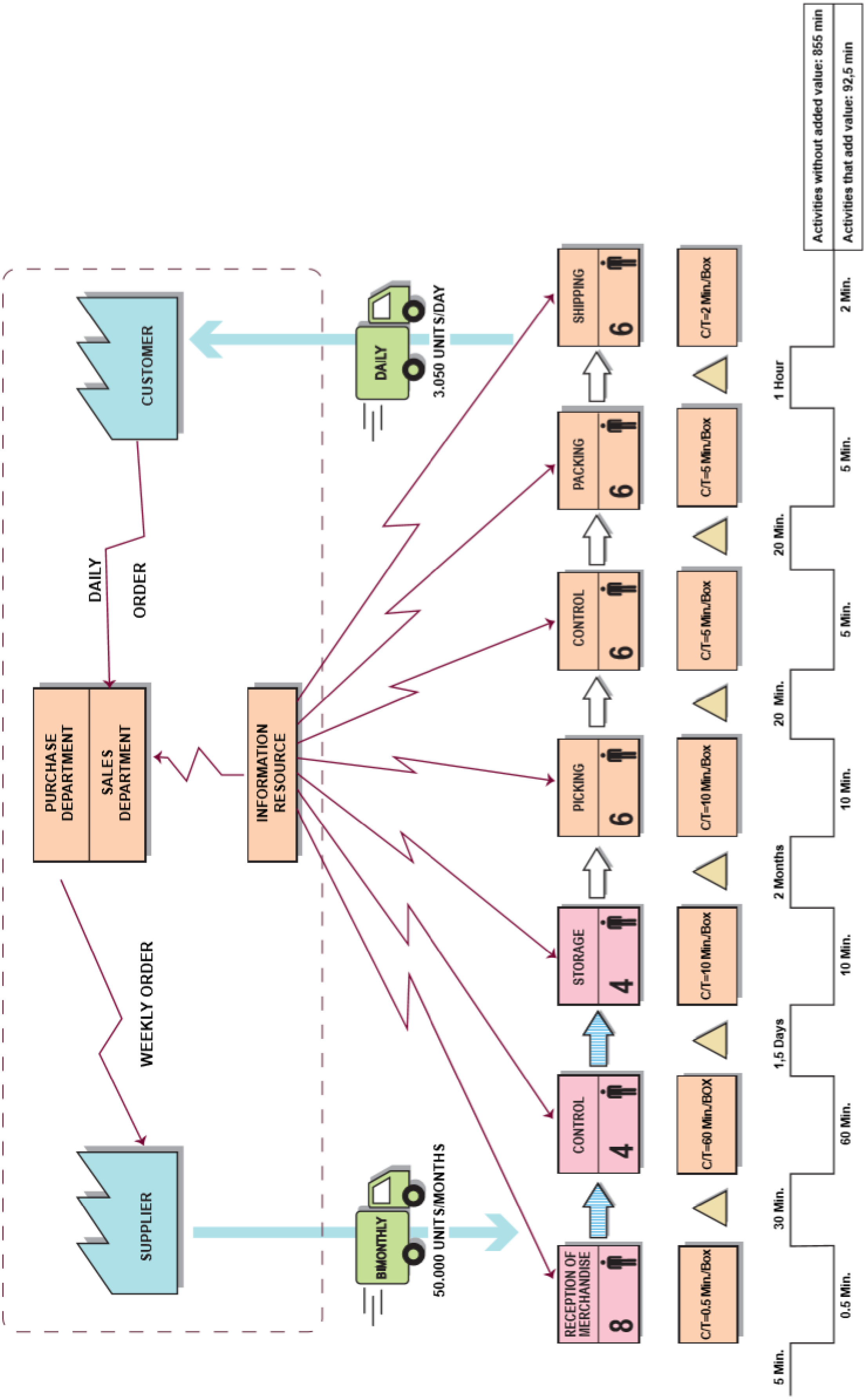


Figure 3.27. VSM for the current situation of the warehouse

This analysis was initially done in order understand how does all the process in Remo's warehouse works. Moreover, in order to identify all the activities that are susceptible to change taking into account the long times that are necessary to be developed.
In this order, for the calculations of this times, it was taking into account the time to carry out these operations for 384 boxes, in this sense, the units that will be take into account for the analysis will be boxes. As a first step were individualized the times to make every operation, so the reception of the merchandise take half a minute to each operator to unload one box of the container and take it to the dock, consequently, the control of each box take in average 1 hour by operator, given that there are some boxes that contains more than 1,000 units, and the quantities have to be verified manually by each operator.
In this sense, once the verification was done, the storage process takes 10 minutes in average to identify the place where the products will be stored, if they are out of stock in the picking part, they baskets will be assorted, otherwise, the products will be stored in the second floor.
For the picking process, the operators take 10 minutes to fill one box of products required for the customer. Continued to this, a previous verification before sending the products is done, in order to avoid discrepancies of the quantities needed by customers and the products required. The packing process takes in average 5 minutes and the shipping, which was characterized as the time that take to the workers to give the box to the transport company (including all the documents signed, explained in section 3.2.4) is 2 minutes per box.
On the other hand, the times that doesn't add value were also individualized as following: 5 minutes take to the container to park in the dock and prepare to be unloaded, 30 minutes meanwhile the operators unload all the boxes and simultaneously they count the number of boxes.
Following to this step is done the assignment of the spaces that will be occupied by the products that just arrived, to this end, the merchandise remines stopped and lay down all thought the warehouse for 1 day and a half, given that, the control operation takes a lot of time.
The inventory that remind stopped between the storage and picking process is 2 months, given that this is the time that more or less take into account to the company to turnover their stock and being supplied again; this time would not be take into account to get the final value of the activities that does not add value because although it's a time that the

products are waiting, it is a necessary step given the nature of this company, so, no modifications to this could be done.
In other way, the time that the boxes remain waiting to be verified are 20 minutes, which is the time that the operator takes in average to complete the other part of the order, which means, to fill other boxes in order to control the complete order of the client, taking into account all the boxes that will be then sent to him.
The same time was found to the wait the products have to be hold meanwhile the worker complete the verification process of the products of an entire order, which can contain diverse number of boxes.
As a finally non added value time, was found that, the products ready to be sent remain waiting since the moment they were packed until the transportation company arrives.
The next step done was to find the total times of added and not added values. For the former it was summed the all the times which are located in the downstream part of the lines, in conclusion this time was: 92,5 minutes. In case of not added values were summed the upstream parts of the lines of time, and the total time is 855 minutes.
As a conclusion to this framework, although the total processing time of each box is only 92,5 minutes, there are needed 855 minutes for the cumulative delivery time, so the total lead time for the operations in the warehouse will be the sum of this two, 947,5 minutes. For that reason, there are many opportunities to reconfigure processes and eliminate or reduced the time wasted in order to have a lower lead time of the complete process. To this end, the following framework will help to understand and identify the criticalities that can lead these times to increase that much, or even, to clarify, why are this happening.

4.1.2. 5 why's analysis to identify criticalities

At this point, an analysis of the 5 whys will be carried out in order to find the criticalities in the process that make activities that do not generate value exist, but for this, they will first be identified and cataloged through an analysis, classifying these activities with the 7 wastes mentioned in chapter 1.
To identify the activities, the process was observed in detail and activities that do not generate value per operation were separated:

Activities that does not add value in the inbound process

In the middle of the operations of reception of the merchandise, the control of these and the storage two critical points were found:

The first issue is merchandise that is identified as damaged in the control process, since these are material resources and money lost depending on the type of defect it has. Therefore, this problem is classified as defects, taking into account the 7 wastes of lean manufacturing.

The other issue found is that the boxes that were received by the supplier are accommodated throughout the warehouse, generating disorder and possible confusion at the time of storage, or it can obstruct the pass of the people or the process of picking, because of the amount of boxes that are arranged on the floor. This problem is given because the operators must work for a long time to be able to control all the merchandise that arrives, (e.g. there are boxes that can contain 1000 products, and they have to make the verification manually that actually, this box contain that number of products), this issue is classified as a transport waste.

Activities that does not add value in the outbound process

A problem found in the picking process is the movement that the operator must make with the boxes of the heavy products. This creates a risk of damage to the product without adding value for the customer. This was classified as movement.

After the picking operation, the order already picked must wait until it is billed, this generates a delay (classified as waste), which does not allow the process to flow consecutively, therefore does not generate added value to the customer.

Subsequently, when the packing process is finished, the operators leave the packages ready to be sent in the shipping dock, but these will not be collected until the carrier arrives. This generates an unnecessary wait for the customer's order, which does not generate added value.

Once the problems that do not generate any value to the customer have been identified, and that have been classified as waste, the reasons why they occur by means of the 5 whys method will be found as presented in table 3.10.:

What	When	Where	Why	Who
Defective merchandise	At the control stage, after receiving the merchandise	In front of the dock, in the area where the unload of the merchandise was done	Negligence when the supplier packed the products Manufacturing defects	Supplier
Boxes placed throughout the warehouse	At the control stage, after the storage operation	In the transit space through the warehouse	The control operation can take large amount of time, avoiding letting the storage process begin quickly	Warehouse operators
Movement of heavy products	In the picking process	At the last level of the shelves	The actual storage allocation approach	Warehouse manager
Delay in bill the order	Before the picking process	Billing office	Lack of stock verification before picking	Warehouse manager
Delay of the order ready to be shipped	In the shipping process	At the outbound dock.	The transportation company only comes once a day	Logistic office

Table 3.10. 5’W analysis

The 5’w method allowed to identify the causes of each of the problems found, knowing in this way in detail what kind of problem it is, when it occurs, where it is presented why and who could take care of this problem. This process makes it easy to find solutions for each of these problems, which will be shown in the next subsection.

4.2. Solution to criticalities found in the VSM

4.2.1. 5'S Analysis

In this point, the solutions to the criticalities found in the VSM and individualized with the 5'w framework are going to be presented. To this end, the lean tool of the 5's will be used. As stated in section 1, this tool will help to identify the solutions based on reducing the waste and increasing the productivity by deleting everything unnecessary to perform an activity, having everything in the work place, clear, clean and organized.
Then in the following table (Table 3.18.), The first column presents each of the criticisms found by the 5 why's and in the rows are the 5's with which the solutions of these criticalities will be individualized.

	Description of the waste by 5's				
Criticality	**Sort (Seiri)**	**Set in order (Seiton)**	**Shine (Seiso)**	**Standardize (Seiketsu)**	**Sustain (Shitsuke)**
Defective merchandise	Classify the type of defective product, according to the product family	Separate defective material from the work area so that it does not interfere with warehouse operations	Apply the format to unsubscribe of disposal of goods	Apply when necessary the process of destruction of products to avoid the accumulation of unnecessary material	Establish an appropriate periodicity for the process of disposal of goods
Boxes placed throughout the warehouse	Sort by product family and supplier brand the products to be organized in alphabetical order as soon as the merchandise arrive to the warehouse	Have a free space in the racks to organize the boxes that have just arrived from the supplier avoiding obstructing the passage or improper storage of the products	Clean the entrance dock after the process of organizing the boxes in a space where the passage does not be interfere.	Previously identify the items of the picking that are out of stock to be these the first ones to be supplied and the rest of the boxes to raise them to the second level where they do not interfere with the step of the picking process, while the verification can be carried out.	Prepare before each arrival of the merchandise, to know the missing items and avoid spending so much time in the storage process
Movement of heavy products	Classify heavy products taking into account the Colombian laws of the occupational health and safety system	Organize heavy products in places with easier access for operators, reducing the risk of damage to both the product and the operator	-	Apply the most effective allocation of the stock methodology, but taking into account that the heaviest products will go to the first shelf levels	Train operators with the new distribution policy of stock accommodation.
Delay in bill the order	Separate the products that have stock from those who do not have in the orders of the clients using the inventory of the information system, avoiding the operator to have to carry out this work manually, in order to reduce the times.	Organize the customer's order list in the order in which the products appear in the warehouse from the beginning of the tour, and mark previously the existence or non-existence of stock	Polish the client's orders before the product collection process avoiding unnecessary operator movements to places where product availability will not be found.	Always carry out the inventory availability check before the picking operation	Maintain the steps described over time in order to reduce unnecessary waiting for orders ready to be sent
Delay of the order ready to be shipped	Schedule the collection of ready goods at different times in the day	Organize a calendar of hours in which different transport companies go at different times to avoid having a lot of ready material stopped at the end of the day	-	Establish a calendar with dates, times and transport company that allows operators to know what orders they should have ready first	Socialize all the operators involved in the process of the new policies of sending finished products to the client and organize the operators in the different time phases so that they can meet the delivery hours

Table 3.18. Solutions to the criticalities found by the 5's framework

Criticality of the defective merchandise.

Defects in the case of the Remo's warehouse can be found both in defective material when it arrives from the supplier and products with defects that will reach the customer. Both types are classified as waste. Using the 5's method, it was possible to find a solution to this problem, suggesting a classification of these, separating them from the area of the warehouse in order to avoid interferences with the operations, and applying a format that has also been created as part of this thesis work to perform the disposal of goods and not accumulate so many useless products. In order to sustain this policy over time, it is suggested to establish a periodicity to remove these products that will no longer serve.

Criticality of boxes placed through the warehouse

For this problem found, it is proposed, as soon as the container arrives and the merchandise is unloaded, to classify the boxes by supplier and by type of product, in this way, times in the storage activity can be reduced since the previously organized products would be and ready to be put on the racks.
To make everything more order in the warehouse, it is proposed to have free the spaces in the racks that can locate the boxes that demand more time in the verifications, in that way avoiding to obstruct the passage and the confusion of the storage of the products.
For "Seiso" it is suggested to clean the entrance dock after organizing all the boxes in a place where it does not interfere with the passage of people.
To standardize and sustain, it is suggested, respectively, to identify, prior to the arrival of the container, the items that are out of stock in the picking section so that they are the first to be supplied, and the rest of the boxes move them to the second floor where they do not interfere with no operation or obstruct the passage while the verification operation is performed.

Criticality of the movement of heavy products

As mentioned before in section 3.3.4 the heavy products represent a problem not only for the risk of damaging a product but also to the worker that needs to handle with it. For this problem, the solutions proposed were:
To classify every heavy product taking into account the Colombians law of occupational health and safety system in order that Remo Importador can accomplish all the requisites of these, avoiding the risks of damage. Organize all these products in places with easier access for operators. Standardize the new allocation method of the stock, applying the most effective one, but taking into account that the heaviest products will go to the first shelf levels. Finally sustain this new process by training the operators with the new distribution policy of stock accommodation.

Criticality of the delay in billing the order

In order to reduce the waiting of the products meanwhile they are being billed, it is proposed to make the verification by using the information system available which can clearly show the state of the quantities of products instead of making this operation manually, which can significative reduce the waiting time. Organize the customer's order list in the order in which the products appear in the warehouse in order to avoid to the worker to make a travel two times, and mark previously the existence or non-existence of stock. To standardize this, it is suggested to always carry out the inventory availability check before the picking operation and maintain the steps described over time in order to reduce unnecessary waiting for orders ready to be sent.

Criticality of the delay in the order ready to be shipped

To this end is proposed a calendar with different hours of the shipping companies, in this way: schedule the recollection of ready goods by the different shipping companies at different times in the day avoiding the waiting of the boxes that are ready to be sent. Organize a calendar of hours in which different transport companies go at different times to avoid having a lot of ready material stopped at the end of the day. Standardize this process by establishing a calendar with dates, times and transport company that allows operators to know what orders they should have ready first and in order to sustain this new propose, socialize all the operators involved in the process of the new policies of sending finished products to the client and organize the operators in the different time phases so that they can meet the delivery hours.

In summary, this methodology has allowed to find the following solutions to the problems:

Criticality	Solution
Defective merchandise	Apply the format of disposal of goods presented in section 3.4.2.
Boxes placed throughout the warehouse	1. Prepare before each arrival of the container the merchandise to know the missing items avoiding spending lots of time in storage 2. Sort by product family the products as soon as the merchandise arrive to the warehouse
Movement of heavy products	Classify heavy products taking into account the Colombian law and allocate them in the 1st shelve taking into account the most efficient allocation method
Delay in bill the order	Make the verification of existence of stock by the information system
Delay of the order ready to be shipped	Schedule the collection of finished orders at different times in the day, organizing a calendar with the different shipping transportation companies

Table 3.19. Solutions to the criticalities

4.2.2. Proposed VSM

In this subchapter what will be done is to apply the proposed conditions to the new VSM taking into account the solutions found in table 3.19. It is important to clarify that with this methodology the aim is to reduce the total lead time taking into account the not added value times, graphically, will be shown the reduction of the times in the proposed VSM (Figure 3.28). To this, it is important to mention that the new times proposed are based on hypothetic times because it was not possible to apply the measures given the short period of analysis.

In this order, not all the criticalities mentioned in figure 3.28 are subjected to immediate changes in the time, for example, the defective merchandise procedure, will make reduce the overstock of defective items in the warehouse, coming with this to a reduction of this problematic but this is not directly linked with the reduction in times.

For the criticality of the boxes placed throughout the warehouse after the reception of the merchandise, it is expected that the solution helps both, the time of storage, and the time that is stopped the merchandise between the control and storage. With the former, being actually 10 minutes/box and being reduced to 5 minutes/box, since they previously know which products needs to be supplied in the picking area, and the rest will be located on the second floor. On the other hand, the time between control and storage will be reduced since, if they have previously sort by type of product, and they organize this, this can be a more efficient operation, letting the 1,5 days being 1 day.

The solution to the movement of heavy products is another criticality that will contribute to the reduction of the time, in this case, the picking time would be reduced by introducing the new allocation of stock distribution, saying that, this reduction could be of a 30% arriving from 10min/box to 7 min/box.

The delay in billing the order Is expected to be reduced from 20 min to 3 min given that even the verification of available stock will not be made physically but by the information system it cannot be 0 because they need to take the time to make the respective verification.

The delay of the order ready to be shipped is expected to be 0 since every packed order will be ready just in time to be picked.

Having with all these reductions the following figure 3.28.

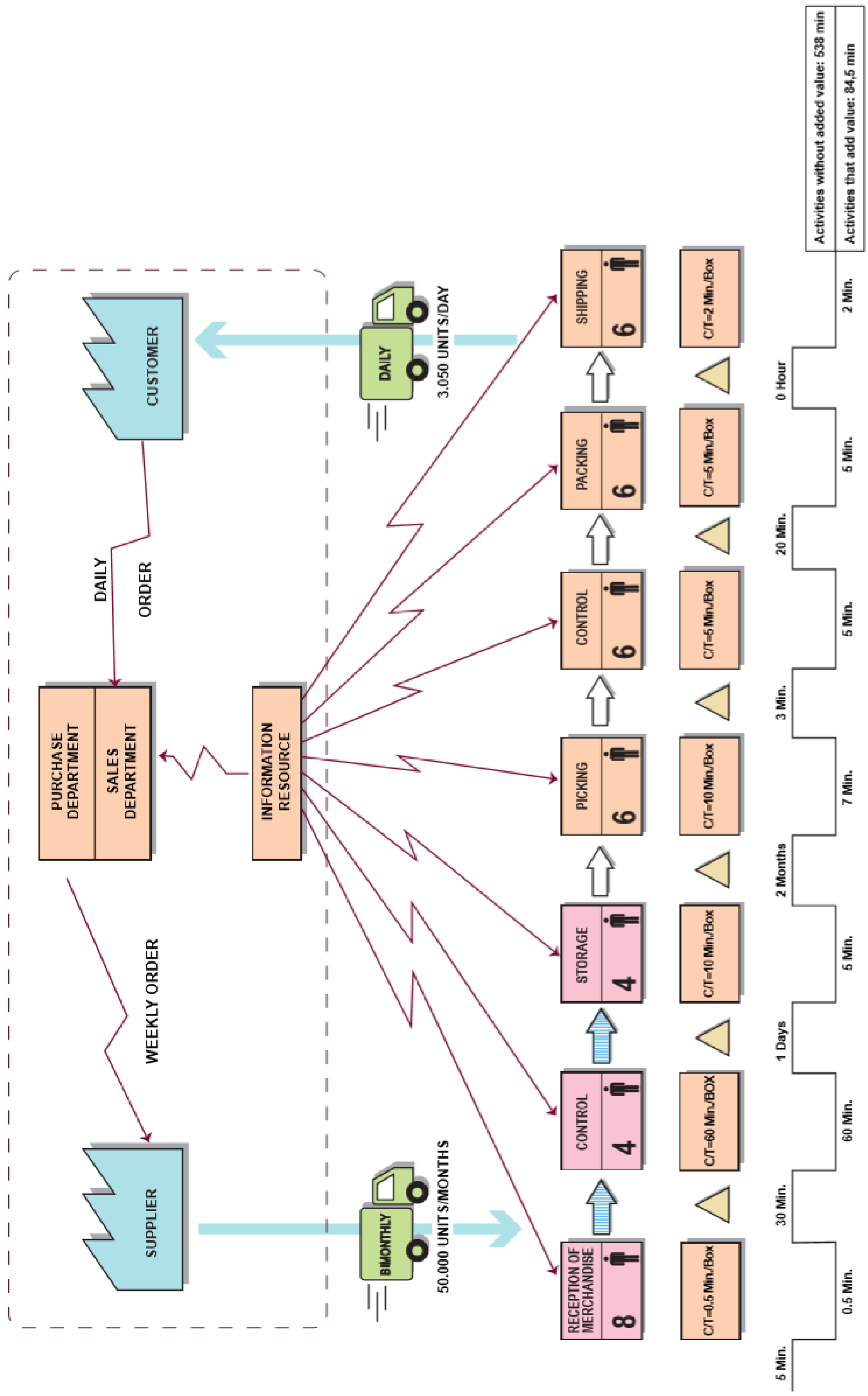


Figure 3.28. VSM for the proposed situation of the warehouse

After graphing the proposed situation it was found the total lead time it can be conclude that, the total processing time of each box is only 84,5 minutes(8 less than the current situation), and there are needed 538 minutes for the cumulative delivery time (317 minutes less than the current situation, so the total lead time which is the sum of the non-value added activities plus the value added will be: 622.5 minutes

As a conclusion to this methodology it can be said that these tools are actually a huge help in order to understand every step of a company and look further every detail that composes its processes in order to evaluate them and find solutions to problems. In this case, even if the modifications were not extreme, a reduction of all the operation into 5,28 hours (317 min) can make a big change speaking in the economic impact, as it will be lately shown.

Besides, all this complete evaluation with Lean Manufacturing tools helps, not only in the reduction of times, because some of them cannot be measured in terms of times, but in order to understand clearly the difficulties that maybe are being present in every activity, facilitating to reduce significantly the defects, creating a continuous improvement.

4.2.3. Economic impact with the proposals

To estimate how much all this proposals will probably impact the current situation, an economic evaluation will be done taking into account the changes in times, the ones that brings improvements but cannot be numerically measured will be let aside (e.g. the fact that, by changing the current methodology of picking the stock by moving the heavy products at the last shelve will brings health benefits to the workers but also the products being managed will encounter less risks), without forgetting that, all of this changes can generate big impacts also. To this end, it will be calculated the salary taking into account what was previously mentioned in the section 3,4,1 about the labor cost 1,25€/hour.

The reduction of the lead time in the warehouse would be will be 325 minutes which comes from the subtraction of the current time (947,5 minutes) minus the proposed lead time 622,5 minutes.

This reduction in terms of money would be 5,41 hours *1,25€/hour = 6,76 €/order and taking into account an average order per day of 7, the company will save 47€/ day. This value will account 1410€/ month and 16920€/year.

CHAPTER 5: Conclusions

5.1. Benefits of the thesis work

After all these analysis done with the current situation of the company, in terms of allocation of the stock and the Lean Manufacturing framework, it can be proved that have been powerful tools that have allowed to identify and understand the strength and weakness points and find the solutions to this last ones.

Moreover, the first work given by the company contact which was to give them a reason if their current stock allocation method was the correct one or not, was successfully completed, arriving to the conclusion that, they can improve this allocation by using the class-based one, by saving time, distance travel by the operators that will be traduced in saving money too.

Adding a deeper evaluation to the current situation, the lean approach applied gave the opportunity to see another important point to improve in the company. Furthermore, the graphic tool of the Value Stream Map proved to be very useful for defining the logistic process and for making critical issues emerge by differentiating the times that do not create value for the customer from those that does. On the other hand, the 5W and 5S tools showed the effectiveness in identifying the causes of the problems and subsequently an easiness resolution proposal. An important thing to highlight is that this tools not only provide numerical changes, but also, by means of identifying the wastes in a company, it can be identified lots of problems that probably will be not directly linked with the economic or time impact but, with the physical or mental health of a worker, and this, will in some way have an important impact in the numbers as well.

On the other hand, it is important to mention that not only a reasoning of all the activities performed in the warehouse was made, but also, it was measured the impact of a problem such as the one they currently have with the heavy articles which are located at the top of the shelves, giving them the opportunity to understand that this is an issue in which they need to work on, not only for the health of the workers but to accomplish all the requisites of the Colombian law.

Besides, another point to take into account of this thesis is the solution that was given to the current problem with the absence of the process of returns, for which, a disposal of goods format was created in order they can follow this process and in a future, they can avoid having problems with overstock, eliminating all this defects that does not serve at all.

So, in conclusion it can be said that all of the aims proposed in the top of this thesis work were achieved, giving to the company a big advantage by analyzing all their processes and providing them tools which will help them to increase their competitiveness by knowing that small changes can make big differences, and by analyzing the impact of this changes, they worth it to make them.

5.2. Limitations

The biggest limitation of this thesis work relies on the application of the proposals done to the company in a real framework, because of the absence of enough time, in order to be able to conclude all this thesis with real data and not by hypothesis of the reduction of the times. This restriction was also due to the fact that this company was not located in the country of the development of the thesis (Italy) , and also, if some changes wanted to be proved, could not be done in an reduced period.

5.3. Future steps

By analyzing all the types of current methodologies of allocation of the stock in the picking process, was found that there are some frameworks actually used in some Remo's competitors which are based on the seasonal demand and the correlation demands of the customers, which will be an interesting work to do in the company. All the proposals made to the company that couldn't be proved because of the lack of time are also another future step to evaluate.

On the other hand, an analysis of the current level of the stock in Remo's warehouse could be attractive to be done, because, taking into account the fact that the company has had an empirical growth over the time, it's interesting to see that they do not have problems with the available space in the warehouse, so, to understand if this level is working correctly is a work that could be done also.

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APPENDIX

APPENDIX 1: ORDERS SHEET

REMO
IMPORTADOR

Febrero 2020

NIT. 10.532.119-7
CRA 17 No. 7A-35
TEL. (2) 8213064- (2) 8226835 FAX 8211134
EMAIL: remoimportador@gmail.com
POPAYAN - CAUCA

CIUDAD		FECHA	
CLIENTE		NIT	
DIRECCION		TEL:	

CONDICIONES DE PAGO	
	VENDEDOR

CODIGO	CANT.	DESCRIPCION	VALOR UNIT.	TOTAL

OBSERVACIONES	FIRMA Y SELLO

DESPRENDA ESTA HOJA Y REALICE AQUÍ SU PEDIDO AL FAX (2) 8211134 POPAYAN

PEDIDOS

remoimportador@gmail.com

APPENDIX 2: RETURNS SHEET

REMO
IMPORTADOR

Febrero 2020

FORMATO DEVOLUCIONES

NIT		FECHA	
CLIENTE			
ALMACEN			
DIRECCION		TEL	
CIUDAD		VENDEDOR	

CODIGO	No. FACT.	ARTICULO	CANT	VALOR UNITARIO	MOTIVO DEVOLUCION

SUBTOTAL	
DCTO	
IVA	
TOTAL $	

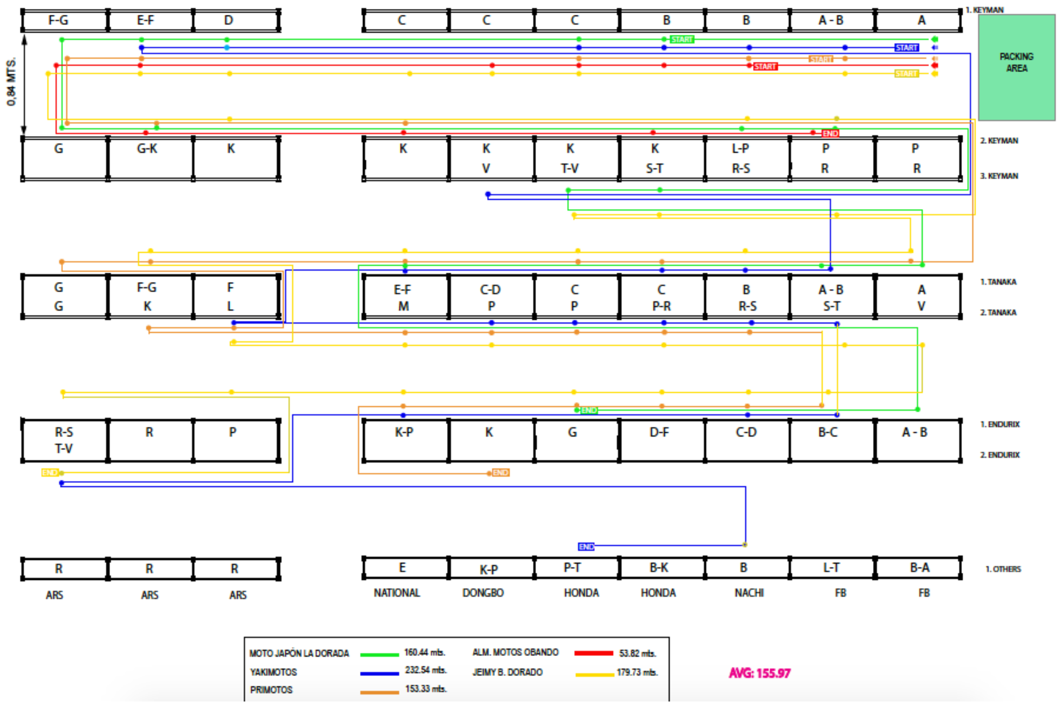
OBSERVACIONES		
AUTORIZADO POR :	RECIBIDO POR:	
FECHA DE ENVIO	FECHA LLEGADA	

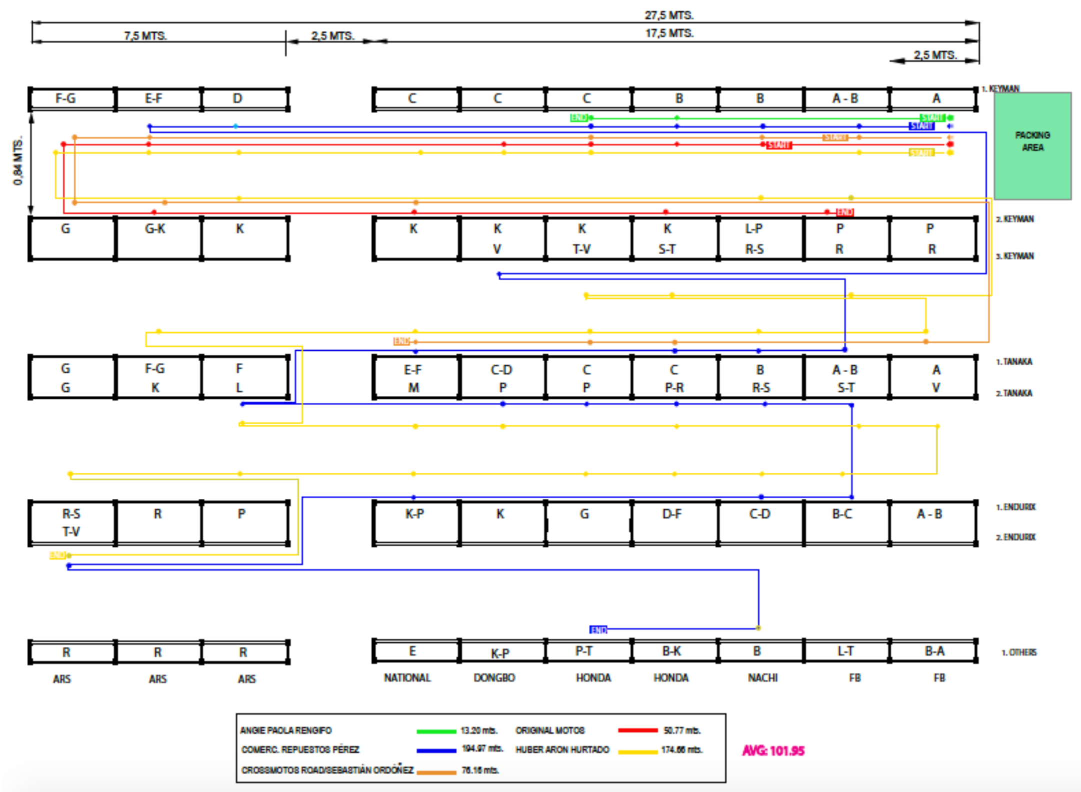
FORMATO DEVOLUCIONES

FAVOR ANEXAR COPIA DE FACTURA

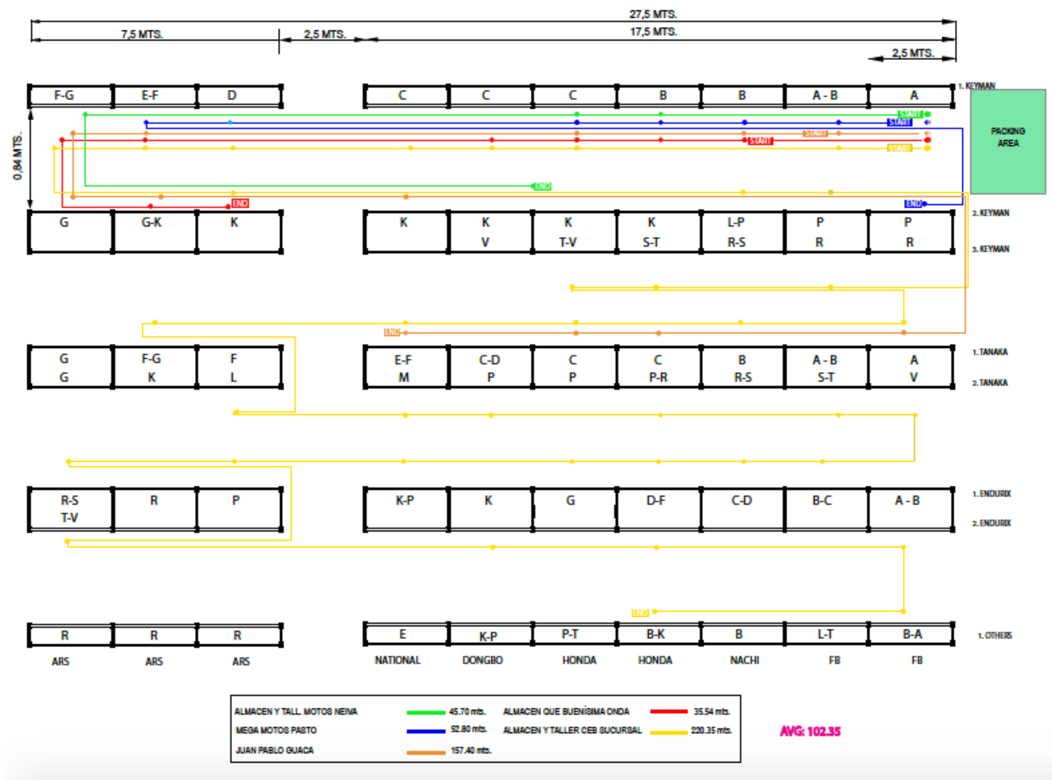
remoimportador@gmail.com

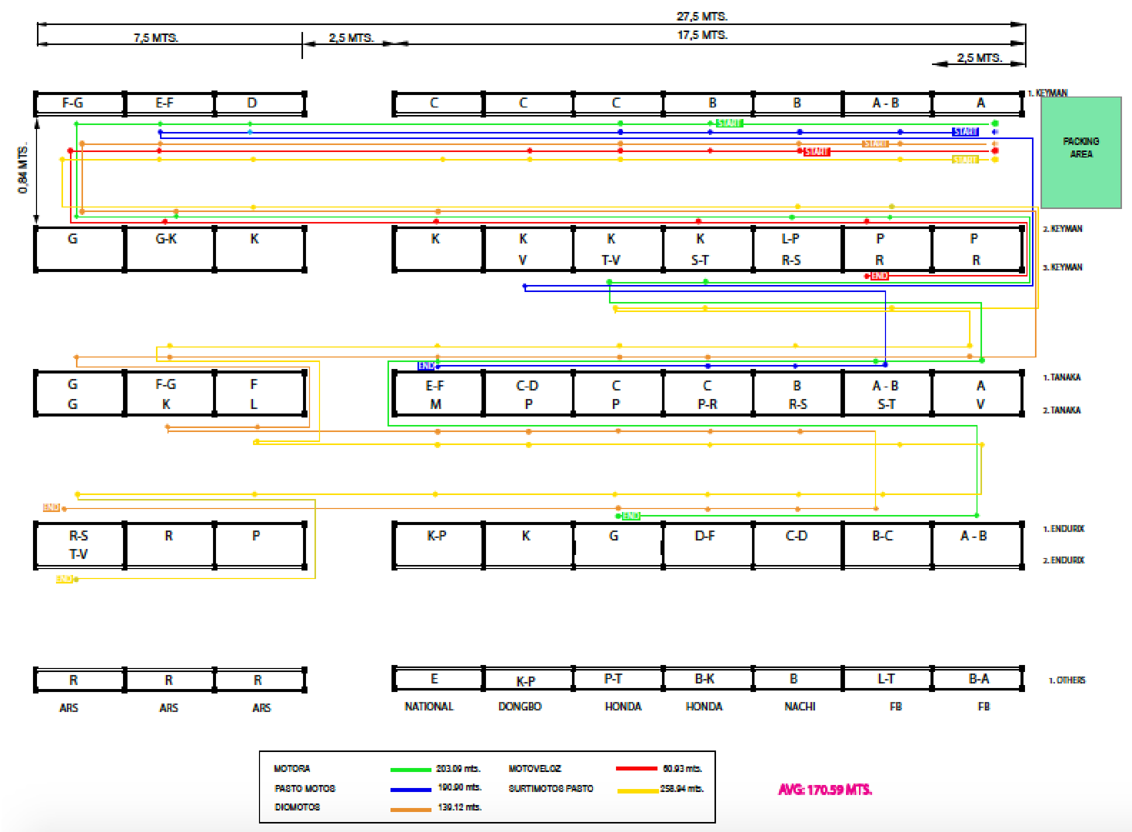
APPENDIX 3: DISTANCES TRAVELED BY THE WORKERS TO PICK THE CUSTOMERS ORDERS






27,5 MTS.
7,5 MTS.
2,5 MTS.
17,5 MTS.
2,5 MTS.
0,84 MTS.
PACKING AREA
1. KEYMAN
2. KEYMAN
3. KEYMAN
1. TANAKA
2. TANAKA
1. ENDURIX
2. ENDURIX
1. OTHERS
ARS
NATIONAL
DONGBO
HONDA
NACHI
FB
ALMACEN Y TALL. CEB PPAL. 182.78 mts.
MAXI REPUESTOS 87.33 mts.
JOSÉ DE LA CRUZ 228.48 mts.
FERMOTOS 207.15 mts.
OLIMOTOS 146.23 mts.
AVG: 170.39 MTS.


27,5 MTS.
7,5 MTS.
2,5 MTS.
17,5 MTS.
2,5 MTS.
0,84 MTS.
PACKING AREA
1. KEYMAN
2. KEYMAN
3. KEYMAN
1. TANAKA
2. TANAKA
1. ENDURIX
2. ENDURIX
1. OTHERS
ARS
NATIONAL
DONGBO
HONDA
NACHI
FB
ALMACEN Y TALL. MOTOS NEIVA 45.70 mts.
MEGA MOTOS PASTO 52.80 mts.
JUAN PABLO GUACA 157.40 mts.
ALMACEN QUE BUENÍSIMA ONDA 35.54 mts.
ALMACEN Y TALLER CEB SUCURSAL 220.35 mts.
AVG: 102.35


27,5 MTS.
7,5 MTS.
2,5 MTS.
17,5 MTS.
2,5 MTS.
0,84 MTS.
PACKING AREA
1. KEYMAN
2. KEYMAN
3. KEYMAN
1. TANAKA
2. TANAKA
1. ENDURIX
2. ENDURIX
1. OTHERS
ARS
NATIONAL
DONGBO
HONDA
NACHI
FB
MOTORA 203.09 mts.
PASTO MOTOS 190.90 mts.
DIOMOTOS 139.12 mts.
MOTOVELOZ 60.93 mts.
SURTIMOTOS PASTO 258.94 mts.
AVG: 170.59 MTS.

APPENDIX 4: DISTANCES COMPARED BY BOTH METHODS, THE CURRENT ONE AND THE CLASS-BASED

CUSTOMER	DISTANCE CURRENT METHOD (mts)	DISTANCE METHOD ABC (mts)	DISTANCE REDUCED (mts)
HONDA MOTOS	211,70	151,960	59,74
MOTO JAPON LA DORADA	160,44	130,666	29,78
MOTOBANS	119,76	119,450	0,31
YAKIMOTOS	232,54	202,763	29,78
PRIMOTOS	153,33	123,557	29,78
MULTIMARCAS	171,96	141,960	30,00
ALMACEN MOTOS OBANDO	53,82	105,579	-51,76
TERREMOTOS	122,42	84,970	37,45
IMPORIK	73,62	136,960	-63,34
JEIMY BRAHAYAN DORADO	179,73	149,959	29,78
ANGIE PAOLA RENGIFO	13,20	64,961	-51,76
KYOTOMOTO	26,20	107,420	-81,22
COMERCIALIZADORA DE REPUESTOS PEREZ	194,97	165,191	29,78
CROSSMOTOS ROAD / SEBASTIAN RODRIGUEZ	76,16	46,383	29,78
MOTOPARTES	142,42	92,420	50,00
ORIGINAL MOTOS	50,77	102,533	-51,76
HUBER ARON HURTADO	174,66	144,882	29,78
ALMACEN Y TALLER MOTOS NEIVA	45,70	97,455	-51,76
MEGA MOTOS PASTO	52,80	104,563	-51,76
JUAN PABLO GUACA	157,40	127,619	29,78
ALMACEN QUE BUENISIMA ONDA	35,54	5,765	29,78
ALMACEN Y TALLER CEB SUCURSAL	220,35	190,577	29,78
ALMACEN Y TALLER CEB PRINCIPAL	182,78	153,006	29,78
MAXI REPUESTOS	87,33	139,089	-51,76
Ma. ANGELICA GALEANO	127,42	119,460	7,96
RECTIMOTOS	137,42	114,460	22,96
JOSE DE LA CRUZ	228,48	198,701	29,78
FERMOTOS	207,15	177,376	29,78
OLIMOTOS	146,23	116,449	29,78

MOTORA	203,09	173,315	29,78
PERALMOTOS	126,24	136,960	-10,72
PASTO MOTOS	190,90	161,129	29,78
DIOMOTOS	139,12	190,877	-51,76
MOTO VELOZ	60,93	112,687	-51,76
SURTIMOTOS PASTO	258,94	229,164	29,78
	136,16	**132,008**	
	AVERAGE DISTANCE		