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Localization System for Optimization of Picking in a Manual Warehouse

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Abstract

Inbound logistics assumes increasing importance in retail operations, because there are usually hidden inefficiencies that contribute to higher labour costs and more time spent in the usual procedures in warehouses.
The work developed was carried out in a manual warehouse of a retail company, with the main goal being the optimization of picking tasks and the improvement of the warehouse operations, as well as stock management. The solution is based on the development and implementation of a localization system, to reduce one of the most time-consuming components of picking, the search time for products in the warehouse. This application led to a reduction of this unproductive time by 93% to 100%, meaning the complete elimination of this component, which led to an optimization of the picking activity, by increasing the warehouse preparation capacity by 63%. Apart from the software upgrade, the operators now use Personal Digital Assistants to perform and validate the picking of items, increasing the accuracy of picking and the traceability of stock.

Keywords: *Logistics, Supply Chain Management, Stock Management, Continuous Improvement, Performance Monitoring..*

1. Introduction

Currently, the retail industry is considered a high competition environment, where gaining and maintaining an advantage over other companies is of paramount importance. This fact, coupled with the constant evolution of information technology (IT), the current economic environment and global markets, forces companies to rethink their management policies and adopt new strategies to survive in competitive markets [1].

Especially in the retail industry where, according to [2], many of the products "have become homogeneous and indistinguishable to the customer", therefore, changes in these, whether in terms of prices or marketing, are easily replicated by competing companies. Mentzer and Williams [2] conclude that "the way to sustainable competitive

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advantage may not lie in changes in the product, promotion, or pricing strategies of the company, but rather in improving ancillary services, such as logistics", i.e. that the way for a company to maintain its competitiveness in the retail distribution sector is in improving the efficiency of logistics activity, rather than acting on the competitive dimensions associated with the product and its promotion. Other works such as [3] reinforce this idea, claiming that logistics had and have a secondary role in strategic business planning, meeting the demands of suppliers and the marketing team. It has become the target of top management attention, as it is an important source of competitive advantage, with the objective of finding possible improvements to be implemented. These would aim at reducing logistics costs and improving customer responsiveness, thus allowing them to be satisfied [2, 4, 5].

In the last decade, the company Abílio Rodrigues Peixoto & Filhos, S.A., a retailer of construction products, where the presented work was developed, has focused mainly on commercial expansion, keeping its logistics processes unchanged. With the opening of new stores and the modernization of existing ones, the need arises to analyze and improve the entire logistic procedure, which is centralized in a single warehouse. One of the biggest difficulties of the logistics centre was the high unproductive time in picking, devoted to search for products in the manual warehouse, which translated into high waiting times for customers and unproductive times of the warehouse workforce, compromising the quality standard desired by the company.

The present work focuses on the development and implementation of a product localization system in the warehouse, in order to optimize picking times and increase the efficiency and productivity of the logistics centre workers.

In the early stages of the system development, several Key Performance Indicators (KPI) were defined and analyzed to corroborate and verify the potential advantages and disadvantages of such an optimization, since it has an impact on all logistic procedures of the warehouse. After the implementation of the application, the results of the previous analysis were reviewed and re-studied, to verify the positive and negative results and to prove if the solution developed was able to solve the main difficulty of the logistics centre.

The article's structure is divided into five sections: the first corresponds to this Introduction; Section 2 mentions the theoretical research regarding the article's issues; Section 3 refers to the methodology used in this study; Section 4 describes the work developed according to the adopted methodology and, finally, Section 5 contains the discussion of the general results and conclusions of this work.

2. Literature review

The elements of logistics and the supply chain have always been fundamental for the manufacture, storage and movement of goods and products. However, it is only until recently that they have begun to be recognized as vital functions in the commercial, business and economic environments. Managers surpass the idea that logistics played a secondary role in companies, now considering that it plays an important role in the success of organizations as an essential source of competitive advantage [6]. Logistics is considered by Carvalho [7] "[...] as a way of survival and maintenance of competitiveness for the company of the future". This is because customer service and its consequent satisfaction are increasingly relevant and are intrinsically linked to the success of a corporation, as stated in [8].

The logistic system of any company has as main objective the creation of value for the client. By analyzing the pure storage activity, it does not add value to the product, which remains constant or may even decrease, due to obsolescence, breaks or other reasons, until it reaches the destination. Although the storage process alone does not add value, it helps the entire logistics system to do so, essentially by making the product available to the customer, achieved by synchronizing the various links involved in the chain. The main purpose of the storage operation is to facilitate the flow of material, along the supply chain, to its end consumer. Recently and due to developments in Supply Chain Management (SCM), top management of enterprises has required this operation to add value to the supply chain. This is reflected in the importance of increasingly improving the quality of service and reaching the level of customer demand, so optimizing storage management will result in an improvement in the company's performance in this regard [9]. The warehouse functions as an inventory buffer, between the points of origin and the points of consumption, allowing the consumption process to be independent of the supply process [10]. In addition to making these two processes independent, the storage process functions as a safety net against market variability, protection against the uncertainty of demand and waiting time, and assists in providing a wide range of products to customers, consolidation of orders, the obtaining of quantity discounts and a greater customization of the product and the service.

Storage operations obviously contribute to the total cost of SCM. When storage management is optimized for cost reduction and for increased productivity, flexibility and responsiveness, only then can warehouses become valuable to the organization and the supply chain, rather than being considered a "dead end" [11]. Order-picking is considered the main activity in most warehouses. It refers to the transport of the correct material, in the right amount, from its storage area, in response to an order from a customer. Picking is a crucial function, mainly due to the associated costs and productivity loss in case of failures, and because it is a critical factor in maintaining the level of customer service. In the work presented by Tompkins et al. [12], the time spent by the workers in the order picking operation was studied, categorizing several sub-activities inherent to the main operation. This paper focuses on the travel component, which presents the highest amount of time spent (50%). According to Bartholdi and Hackman [13], "[...] travel time is waste: It costs labour hours but does not add value". Another relevant variable is the search component, which represents a value of 20% of the total work time. This percentage counts as unproductive time. These factors and consequently all the order picking activity, are intrinsically linked to the warehouse storage strategy. According to Emmett [14] and Çelik, M. & Süral [15] one of the most relevant factors in the picking operation is the localization of products, noting that the closer the articles are stored, the shorter is the travel time; it is recalled that according to Tompkins et al. [12], the search time is 50% of the total picking time, a time considered as unproductive.

The order picking operation involves obtaining products from specific storage locations, according to consumer orders. In general, this process is the most intensive labour activity in manual warehouses, and the most expensive in the implementation of robotic systems. The overall objective of its optimization is to maximize the level of service, subject to constraints of resources such as labour, equipment and capital. As a crucial operation, poor performance can lead to unsatisfactory customer service and increased operating costs for the warehouse and, therefore, the entire supply chain [7]. Increasingly, warehouses have less time to process an order, less room for errors, and less skilled labour. Nowadays, it is critical for a company that its warehouses work efficiently, quickly and without errors, and therefore the optimization of the order picking operation is necessary. To do so, these facilities are very often supported by Warehouse Management Systems (WMS), that help to track information like products or equipment and, by providing algorithms for storage location assignment, for example, coordinate logistic operations. Caridade et al. [16] carried out similar work, with the implementation of a Warehouse Management System (WMS) in order to improve the warehouse responsiveness to production by controlling stock inventory and storage locations.

3. Methodology

The present work focuses on the development and implementation of a product localization system in the warehouse, in order to optimize picking times and increase the efficiency and productivity of the logistics centre workforce.

A literature review was done first, to emphasize the importance of logistics and present the main problem this work intends to solve and its relevance. Following the validation and planning of this project, the A3 model developed originally by Toyota Motor Corporation was used. This model consists of different sections, according to the Plan-Do-Check-Act (PDCA) cycle [17]. Also, a Gantt chart was used to visualize and control the various activities in this development.

The Plan phase was constituted in studying the interconnection between the software, the hardware and the logistics operations. Furthermore, in order to corroborate and verify the potential advantages and disadvantages of such an optimization, various KPI were defined.

The Do phase featured the benefit evaluation, requirement gathering and active programming of the software. In addition, the training and familiarization of the warehouse workers with the visual management tools was implemented.

In the Check phase, the software was submitted to a series of tests and a re-evaluation of the KPIs was done, in order to verify the positive and negative results, proving that the solution developed is able to fulfil the main difficulty of the logistics centre.

Finally, in the last phase, the continuous improvement of the software with the addition of other functionalities, reinforces the positive impact of this optimization, as in all logistics operations.

4. Project development

For the development of this project, a requirement survey phase was done. This consisted of the study and evaluation of necessary prerequisites and other improvements that would support and facilitate the implementation of the localization system but also benefit the warehouse on their own. The requirements were related to two areas: layout and operations. Layout requirements consisted of the mapping of storage locations of the warehouse, the application of visual management tools and an ABC analysis based on product turnover. The operations prerequisites are linked to the interface man-machine, with the implementation of Personal Digital Assistants (PDA) in multiple warehouse activities.

Throughout the development of this work, performance monitoring was a crucial part, to verify and prove if the solution elaborated was, or not, appropriate to the scenario in question. Moreover, in the early phases of project development, four KPIs have been defined: the ratio between daily needs met and total daily needs, inventory accuracy, search time and preparation capacity.

4.1 Benefit Evaluation

The first step in the system, planning was the evaluation of its potential gains. Through field experience, it was known that the search time was high, but this value was not quantified, therefore warehouse employees were timed in their daily picking activities to provide such measurements.

The order picking activity was divided into three operations: travel, search and preparation. The travel component refers to the travel time of the operator to the product to pick rack. The search time starts on this shelf until the article is identified. The preparation activity encompasses all the activities required until the product is ready for check-out. Three workers were timed in the course of two weeks. From direct observation during the timing process, a correlation between the storage experience of the worker and the time spent in the search was evident, as well as the level of experience held by those performing the service was decisive for its quality. This dependence becomes problematic when these operators are not available to perform the picking, resulting in even higher unproductive times. Promoting standardization of picking by implementing the location system would be an advantage, as there will be no more reliance on experience to maintain a high quality of service.

Time measurement was performed by the expedition list line. Each line refers to an item, in a certain quantity, so that for each line there is a travel, search and preparation time. In total, 366 lines were timed, and the results of the measurement can be visualized in Table 1.

Table 1. Timing of picking workers results.

Picking Components	**Average Time/Line (min)**	**Component/Line (%)**
Travel	0,20	3,55
Search	2,34	41,49
Preparation	3,10	54,96
Total	5,64	100

From these results it is concluded that 41% of the daily time of a picker was wasted in the search for articles, being the highest search time registered of 28 minutes on a single line. This is due to the high stock disorganization throughout all logistics operations. The reception dock is highly cluttered since there is not much time to organize pallets when suppliers have such a tight delivery window, which has negative effects on the put-away activity. Therefore, the following operation, picking, is immensely affected, especially because many products may haven't been stored yet. This is a clear evidence something had to be done in order to improve the logistics processes in the warehouse.

In this scenario, the travel time has little relevance, because this component was kept constant and low (0.2 minutes per line). Although in the literature presented, travel time represents a much higher worker time percentage, this is not the case since the warehouse is rather small and all racks are very close to each other.

Financially, unproductive times bring significant expense to the company. With two picking operators working 8 hours a day, each having a cost to the company of 9.32 euros per hour (including salary and insurance, depending on the company and activity), it is possible to calculate the annual waste of unproductive paid hours (See Equation 1)

$$2\ Op * 8h * 9.32\ €/h * 322\ days * 0.41\ (\%\ Search) = 19\ 686.82\ €/year \quad (1)$$

Only in human resources, more than 19.600 euros are paid annually in completely unproductive work. The high waste of time in the search for material does not generate value for the customer, and obviously damages the productivity of the warehouse operators.

4.2 Warehouse Operations and Software Engagement

With the unproductive times and associated monetary expenditures quantified, the requirement gathering mentioned was carried out. Focusing solely on warehouse operations, it was necessary to implement picking by PDA because the software works based on sequential barcode reading of locations and articles. This method requires specific steps to follow through a certain activity, therefore, flowcharts were developed to represent this sequence of activities, in order to perform the four main warehouse operations: receiving, put-away, picking and check-out.

In addition, the information flow in the warehouse wasn’t properly transmitted. This would lead the workers to often stop for lack of task assignment. The change to computerized processes through PDA picking will simplify all information flow inside the warehouse. The change to this picking method has advantages in increasing the productivity of all workers but also in the area of environmental sustainability because the order documents will be in digital format, instead of paper.

Visual management tools were also implemented. In order to validate picking in the correct locations, these were mapped and identified with a tag (see Figure 1), so that they can be scanned during operations.

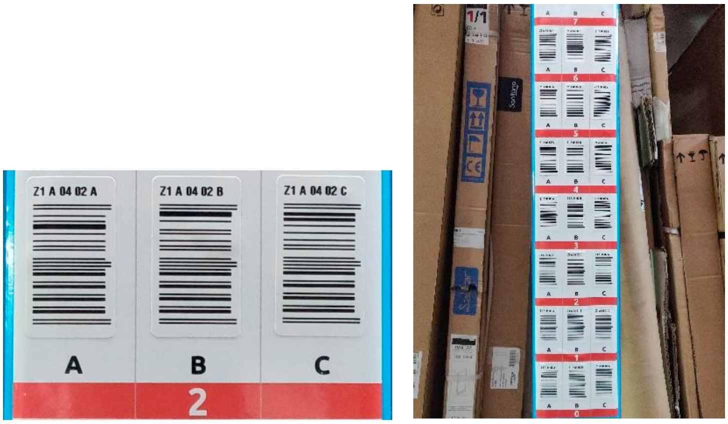

Fig. 1 – *Location Tag Board*

The localization system works as follows. Firstly, pallets are identified with a tag when checked-in and are stored in a put-away dock. When performing that task, the operator first validates its location by reading the put-away dock tag and afterwards scans a pallet tag. Based on the turnover of its products, the system calculates the best available location to store them. The operator then transports the pallet to that location, where he scans the storage location tag. The software automatically transfers the stock from the put-away dock to the operator, to the storage location with each tag scan.

The hardware utilized in the warehouse is the Zebra MC3300 Mobile Computer as shown in Figure 2, as is the main menu of the PDA interface. This menu can be read from top to bottom as follow: date, storage unit, put-away, picking, stock transfer, unit movement, product status and my user. This allows the operator to perform all operations in a quick and efficient way.

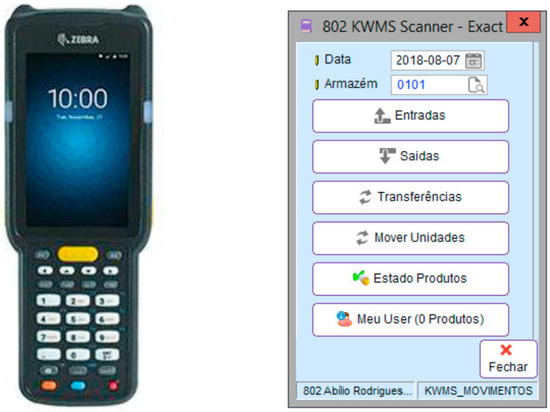

Fig. 2 – *Left: Zebra MC3300 Mobile Computer, right: localization system main menu.*

The picking activity is no longer by order but by article, in a way to eliminate repetitive movements when picking the same article for different orders. This way, the operator picks the total quantity needed of a certain article, considering all daily orders. This operation starts with a scan of the product to pick a location tag. Even though an article may be stored in multiple locations, the system always shows the location that has the lowest picking time. Then, the article is scanned and the quantity to pick is validated. Afterwards, the operator transports the pallet to the check-out dock, scanning that location tag and ending the task.

Check-out operators can only perform their task when all products of an order are in the check-out dock. When an order is fulfilled, these operators perform storing, clustering the products by order. Firstly, the check-out tag is scanned, following the products and confirming their quantities.

One of the most important advantages of the system is the traceability of stock, because every stock movement is recorded and can be analyzed, in order to verify stock errors and inconsistencies. The existence of a movement register associated with the workers, due to the attribution of tasks, increases the level of traceability of the articles in the manual interior. By knowing who has performed a certain operation, it is easier to inquire and solve any stock error.

4.3 Results Analysis

In order to minimize the impact and possible errors in the project implementation, it was decided that it would be implemented in phases. Initially, the warehouse was inventoried informatically and physically. Subsequently, a test phase was initiated. This allowed a period of familiarization of warehouse employees with the concept, the PDA operations, the syntax of the system and the visual management tools implemented. In this phase, the system gains were also verified, by studying the KPIs previously defined.

Starting with the analysis of the search time, through a new timing of this component, it was concluded that the application complied with the main objective of total or substantial reduction of this unproductive time. During the test phase, 103 lines were timed, and no measurement exceeded 10 seconds (0.17 minutes). The results are shown in Table 2. Considering the worst-case scenario, there is a reduction of 92,74%, when compared to the previously measured value of 2.34 minutes per line. In many storage locations, the complete elimination of the search time was achieved. Because of the reduction of downtime from more than 41% of a worker's daily time to only 4.9%, the overall order picking activity was also optimized, with a reduction of 5.64 minutes per line to 3.47 minutes per line. The total available picking time can be calculated (see Equation 2).

$$2 \text{ Op} * 60 \text{ min} * 8\text{h} = 960 \text{ min of order picking/day} \quad (2)$$

Thus, it is possible to calculate the average capacity of the warehouse to prepare articles per day, as shown in Table 3.

Table 2. Timing of picking workers results, after system implementation.

Picking Components	New Average Time/Line (min)	New Component/Line (%)
Travel	0,20	5,76
Search	**0,17**	**4,90**
Preparation	3,10	89,34
Total	3,47	100

Table 3. Timing of picking workers results, after system implementation.

Before	960/5,64 = 170 maximum lines prepared/day
After	960/3,47 = 277 maximum lines prepared/day

This represents an increase in the warehouse picking capacity of 63%, meaning more products can be daily checked-out, due to the reduction/elimination of the search component.

Considering the ratio between daily orders completed and total daily orders, the warehouse has always completed 100% of its needs. The difference with the implementation of the system lies in the non-use of overtime; with the significant reduction of the search time, it is possible to perform secondary tasks, such as cleaning and organizing the warehouse, instead of working overtime to complete daily orders. Thus, the annual payment of more than 19.600 euros in unproductive work, becomes an investment in productivity.

Lastly, in terms of inventory accuracy, the disappearance of material and the inconsistencies between informatics and physical stock were very common. Due to the computer application, during the testing phase, there were no errors detected, meaning the location and quantity of the computer and physical stock coincided for every line timed.

5. Discussion and Conclusions

Due to the highly competitive retail environment as well as the wide variety of products on the market and growing demand for quality services from consumers, greater emphasis is placed on the ability of companies to establish efficient logistics operations to obtain competitive advantages over the competition. Thus, warehouses play a vital role, especially in non-optimized supply chains, serving as inventory buffers to fill the space and time gaps between suppliers and end consumers. Storage influences the performance of the entire supply chain, as it provides guarantees of meeting customer requirements and therefore ensures the corresponding monetary return. In this way, it is necessary more research and investment in the continuous improvement of logistics processes.

The main objective of this project was successfully achieved, reducing the search time of the articles by 92.74% (in the worst cases), with most improvements being made in the order of 100%. This, coupled with the absence of inventory errors during the testing phase, reveals that the computer application for mapping storage in the warehouse is undoubtedly a unique tool adapted to the company's reality.

With the implementation of this application in the warehouse, the system has multiple advantages, such as operational and financial waste minimization, shorter preparation time and distances, greater accuracy and inventory traceability, greater organization and systematization of the warehouse, Standard Work in order picking, visual management tools and automatic task assignment. Stock management has also been simplified, by the simple fact that there is a record of stock movement, thus allowing greater traceability and control in case of errors and disappearance of material.

The evolution of the level of computerization in order picking also has the advantage of meeting the concept of Green Warehousing, since ecological concern and environmental awareness are increasingly important and necessary. The exchange of the paper format for the digital format proves to be an asset in this regard.

However, the system also has its drawbacks. The substantial initial financial investment and the fact that this computerization has an influence on all other logistics processes, the need for training of workers, the deficient use of space, in terms of the volume occupied by location, a delay in stock availability and the use of bar codes, and not RFID tags.

Performance monitoring was crucial for the evaluation of the implemented solution. In this way, it was possible to evaluate the project through multiple parameters such as inventory accuracy, distance travelled and picking time, warehouse capacity and the ratio of daily needs to total daily needs.

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