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Assessment of the implementation of a Warehouse Management System in a multinational company of industrial gears and drives

Avaliação da implantação do Sistema de Gestão de Armazém em uma empresa multinacional do ramo de acionamentos

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Abstract: The companies may gain competitive advantage when they have an efficient logistics. In this aspect, the use of tools for the management and control of material handling and storage are essential for a fast and efficient logistics. The Warehouse Management System (WMS) is one available alternative for the automation of the logistic operations. In this context, this study has the central objective of analyzing the results of the implementation of a WMS system in a manufacturer of mechanical parts, in terms of operational efficiency and quality. The results of this study are focused on the satisfaction of the workers involved with the logistic operations, evaluated by means of interviews, and on the operational results, evaluated by means of a comparative analysis of the logistic performance indicators at two different times, the time before and the time after the implementation of the WMS. The analysis of the performance indicators demonstrated that the logistic operations have become more agile, what has reflected on financial gains. In addition, the workers involved with the change have reported a decrease in the functional conflicts and an increase in the reliability and credibility of information available to internal and external customers.

Keywords: Warehouse Management System; WMS; Logistic; Supply chain management.

Resumo: *A eficiência nas operações logísticas torna as empresas mais competitivas. Nesse aspecto, o uso de ferramentas para o gerenciamento e controle dessas operações é essencial para uma logística ágil e eficiente. O Sistema de Gestão de Armazém (Warehouse Management System, WMS) é uma das alternativas disponíveis no mercado capaz de automatizar as operações logísticas, buscando maior eficiência. A partir desse contexto, este estudo tem como objetivo central observar o processo de implantação de um Sistema de Gestão de Armazém em uma empresa de componentes mecânicos e analisar os impactos nas operações logísticas em termos de eficiência e qualidade de trabalho. Os resultados deste estudo estão focados na satisfação dos envolvidos, avaliada por meio de entrevistas, e nos resultados operacionais, fazendo-se um comparativo dos indicadores de desempenho logísticos em dois momentos distintos: o período anterior e o posterior à implantação do WMS. A partir da análise dos indicadores, foi possível observar um ganho de agilidade nas operações logísticas que, consequentemente, reflete-se em ganhos financeiros. Além disso, os relatos dos colaboradores envolvidos na mudança revelaram diminuição de atritos e aumento expressivo da confiabilidade e da credibilidade depositada nas informações por parte de clientes internos e externos.*

Palavras-chave: *Sistema de Gestão de Armazém; WMS; Logística; Gestão da cadeia de suprimentos.*

1 Introduction

Logistics is a very important activity that has been taking place for a long time in institutions - the ancient civilizations already had the necessity of transportation and storage of the produced and commercialized goods (Soriano, 2013). Over time, the logistics has been developed with new technologies and new methods, and is currently a part of the process with high responsibility within the entire production chain.

The industrial environment suffers recurrent pressure for improvements. This means that the companies are increasingly seeking to improve their services to satisfy their customers, entering into fiercer competition with other companies in the industry that can offer better services in a shorter period of time. Guarnieri et al. (2006) assert that the development of business logistics has been exponential in recent years, since it is an essential factor for the competitivity of companies.

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A warehouse management system (WMS) has the basic function of improving logistics management. Banzato (2005) states that the WMS provides enhancement in operational and administrative activities, including all sectors and activities related to the movement of materials within maufacturing and commerce. Poon et al. (2009) and Jin et al. (2013) complement that, with the development of modern logistics, the WMS becomes important in the supply chain, in which the level of information becomes ever greater. Poon et al. (2009) emphasizes that warehouse management systems (WMSs) have been developed to deal with warehouse resources and operations control.

The studied company is a German multinational manufacturer of electromechanical products located in the state of São Paulo. In 2013, the major plant of the existing group in Brazil was deactivated and, due to this change, the plant under analysis had an increase of more than 150% in production, in order to attend the demand of the closed plant. With this increase came the difficulty of managing the manufacturing processes, caused by the increase of manpower, increase of shifts, pressure for productivity, among others. In terms of built area and facilities, there was no increase. Many challenges related to process and production volume were overcome with the opening of a second shift and the training of manpower, but the biggest challenge was tracking the inventories in the plant. Due to the mentioned change, this became a problem.

Among the problems encountered with the new scenario was the high level of divergence in inventories, the difficulty of managing empty spaces, the limitation of the item location system, the loss of orders due to the lead time increase for logistic operations, poor traceability, interdepartmental friction and incorrect storage of material. These problems were aggravated by the fact that the company manufactures customized products on a MTO basis, that is, products that already have longer lead times.

Given this scenario and already predicting this type of problem, the company looked for an automated solution to obtain greater productivity and, mainly, reliability in the operations related to logistics. A software capable of supporting the management and automation of logistic processes encompasses many factors that seek to attend this demand; however, its implementation involves procedural and structural concepts and changes.

In this context, the main objective of the research is to observe the process of implementation of a Warehouse Management System and analyze the obtained results based on the vision of different departments of the company, evaluating the results obtained in terms of efficiency and quality of work associated to logistic operations.

This study also provides guidelines for other companies that face problems in logistics, exemplifying the functionalities of this system and contributing to the existing literature, with a view of the effects of this implementation in a multinational company.

2 Theoretical review

A Warehouse Management System (WMS) seeks to optimize, control and record the flow of material and information, reducing routines and maximizing the use of available space and the performance of tasks associated to logistics. The system helps to manage all the tasks involved with logistics (Banzato, 2005; Moura, 2010), with hardware and software components aimed at coordinating the material and information flows. This coordination, in turn, directly affects the manpower, as it generates changes in work procedures and routine. Basically, every WMS system has computers, barcode readers, zebra printers, some peripheral equipment and, in some cases, radio frequency equipment (Moura, 2010). According to Banzato (2005), there are two main objectives associated to logistic processes, namely the maximization of resources use such as space, equipment and manpower, and the satisfaction of the customers' needs.

Moura (2010) and Costa & Gobbo (2008) also mention that the WMS accomplishes these objectives by reducing error rates, improving inbound logistics, optimizing storage space, improving customer service, improving labor productivity, improving the equipment use and ensuring greater precision in the inventory. According to Jin et al. (2013), WMS reduces management costs, improves team and equipment usage rates, and shortens workflow. Klabusayová (2013) describes the advantages of the system as administration and definition of the order of operations, storage location determination, reliability of inbound and outbound flows and monitoring operations. According to Zhou & Fei (2016), the automated warehouse is an important part of the development of the modern logistics system because it generates economy of space and work. The WMS has the ability to allocate operators and plan daily activities automatically (Banzato, 2005) and does it so much more accurately than humans because of the equipment and technology applied in the system (Moura, 2010). Moura (2010) also points out that identification and traceability are the basis for efficient and accurate operations.

Some ERP systems include logistic modules, however, in many cases, it is necessary to have a sophisticated, dedicated and specialized system (Costa & Gobbo, 2008). WMS has been developed to fill these shortcomings. Klabusayová (2013) emphasizes that WMS is a system that may be integrated with other systems, mainly the ERP systems.

The use of a WMS also brings benefits to managers, since it records the time that the employee spends for a given task, shows what has been separated and helps determining the volume of manpower to be used (Banzato, 2005; Moura, 2010). Although it is a system with enough technology for warehouse management, it is still configurable and managed by the employees. For this reason, the system requires qualified personnel to operate it. Harb et al. (2016) cite the importance of employee training and education for its success in the implementation and usage of WMS.

As the WMS is customizable, it may be adapted to fit different business segments. In this work, a comparative chart of functionalities of the Warehouse Management System was elaborated based on the revision of the works of Banzato (2005), Moura (2010), Costa & Gobbo (2008) and Klabusayová (2013). For such comparison, classification categories of the different functionalities or system characteristics were proposed, as shown in Chart 1.

According to the reviewed literature, the WMS must have tools and functions to support the main steps and logistic processes of inbound, production and outbound, such as: pre-receiving of materials, concierge management, receiving, inbound quality control, storage, transfer, picking, cyclic counting and shipping. Such macro processes were adopted as categories for the classification of the system functionalities and characteristics. Other considered relevant categories such as management support, possibility of integration and customization were also proposed. Although they are not macro logistic processes, these categories cluster important WMS functionalities.

To give greater agility and reliability to logistics processes, the WMS counts on the support of some technologies as already mentioned. The bar code reading came as an important ally as it assigns a reference to a particular item, defines its identity and relevant information. However, this technology only gains agility if it is tied to a radio frequency system (Moura, 2010) which allows real-time updates. In addition, Moura (2010) and Soriano (2013) explain that for an efficient radio frequency system it is necessary to have antennas to send radio waves to all interconnected equipment in the network and, when the use of collectors and bar codes is also necessary, there should be printers available for issuing labels, computers and a server.

Another possible WMS integration technology is RFID, Radio Frequency Identification. According to Banzato (2005) and Klabusayová (2013), RFID has been created to overcome the imperfections of the bar code. Among them, we can cite information restrictions, errors of readings, duplicate readings, torn labels, among others. Poon et al. (2009) still mentions that RFID is more effective than barcode scanning technology. Banzato (2005) and Moura (2010) emphasize that reading RFID is much simpler and faster, since it is not necessary to turn the packaging in search for the bar code. Besides, it is possible to several readings at the same time.

3 Methodological procedures

3.1 Company description

The present work introduces a case study carried out in a German multinational company that was founded in 1931 and manufactures a wide line of products for complex drives. The company has a strong strategy of vertical integration, producing approximately 85% of all the items that make up its electromechanical products. The unity of analysis is an ATO assembly plant located in Brazil and supplied by a company from the same group.

3.2 Research variables and steps

According to Miguel (2010), the general structure for conducting case study research comprises the definition of the research objectives and variables, construction of theoretical framework, technical visit, data collection, transcription and compilation, data analysis and writting.

The variables taken into account for this study are linked to the level of bureaucracy, the performance, credibility, accuracy and quality of the logistic processes, the satisfaction of those involved with the process, as well as interdepartmental and end customer relationships. The definitions of such variables are shown in Chart 2.

As the objective of this study is to observe the implementation of the Warehouse Management System and analyze the results obtained from different perspectives within the company, the data collection was done through direct observation, analysis of documents and, indicators and interviews with employees from different sectors of the company. Several hierarchical levels were considered, including operators, analysts and managers. Based on this data set, it was sought to obtain a comparative picture of the existing situations before and after the system implementation. Figure 1 expresses the steps for collecting and analyzing the data.

Since the proposal of this study is to evaluate the impact of the implementation of the WMS system, the pertinent questions to the interviews were divided in two phases, before and after WMS implementation. The objective was to formulate questions that extracted from the interviewees their perception about the impacts of the implantation on logistic operations quality. A semi-structured interview script with 15 questions and more 6 closed questions was drawn up and applied to all 19 interviewees, which represented 10% of the staff.

Chart 1. WMS functionalities.

	Features	Banzato (2005)	Moura (2010)	Costa & Gobbo (2008)	Klabusayová (2013)
Possibility of integration and customization	Enables integration with radio-frequency system	X	X		X
	Enables integration with barcode system	X			X
	Enables integration with RFID	X			X
	Enables integration with automated storage systems	X			
	Enables interface with costumers and suppliers			X	
	Enables customization	X			
	Enables parameterization	X			X
	Possess its own register	X			X
	Accepts different rules/policies for items	X			X
Receiving and inspection	Manages receiving/staging area	X	X		
	Manages scheduling and order entry	X			
	Controls concierge	X			
	Executes “blind” conference on the receiving	X			
	Controls batches	X		X	
	Checks each item in the order	X	X	X	
	Designates automatically storage locations		X		X
	Generates labels		X		
	Supports systematic classification of items			X	
	Controls quantities	X		X	
Storage processes	Controls FIFO	X			X
	Updates records in real time	X			
	Assigns the addresses automatically	X			X
	Recognizes the physical storage limitation of each address	X			
	Checks storage at the correct addresses	X			
	Supports resources’ allocation	X			
	Defines usage characteristics for each storage location			X	
	Stores accurately		X		
	Confirms transfer and replenishment	X			
Order separation	Drives picking activities		X		X
	Controls routes	X		X	X
	Generates picking list		X	X	
Cyclic counting	Manages cyclic counting	X	X	X	
	Identifies and records inventory receipts based on storage		X		
	Tracks all inventory by location		X		
Shipment	Generates shipping sequence/ schedule		X	X	
	Calculates the needs for packaging		X		
	Generates shipping documents	X	X		
	Updates system for issuing invoice		X		
	Calculates dimensions of packages		X		

Source: author.

Chart 1. Continued...

	Features	Banzato (2005)	Moura (2010)	Costa & Gobbo (2008)	Klabusayová (2013)
Management support	Plans and controls capabilities	X	X	X	
	Manages backorders	X			
	Monitors performance of activities	X			X
	Allocates human resources for the activities	X			X
	Supports productivity measurement	X			X
	Supports the whole inventory management process	X			X
	Tracks all operations		X	X	

Source: author.

Chart 2. Research variables.

VARIABLES	DESCRIPTION
Level of bureaucracy	Related to the volume of indirect activities associated to the recording/ processing of information, the amount of documents needed, and the time spent with these activities
Performance of logistics operation	It is measured by the historical monitoring of logistic indicators
Satisfaction and credibility	Considers the level of satisfaction of the stakeholders regarding the performance of the logistics operations and the credibility in the information related to these operations
Accuracy	It is defined as the level of correspondence between the physical stock of the item and the data recorded the system (quantity and type)
Quality	Considers the improvement in the logistics processes regarding agility, operational errors, storage, identification and traceability
Cross-functional and customer relationships	Evaluated by means of he frequency and intensity of complaints from internal and external customers in relation to the logistics sector

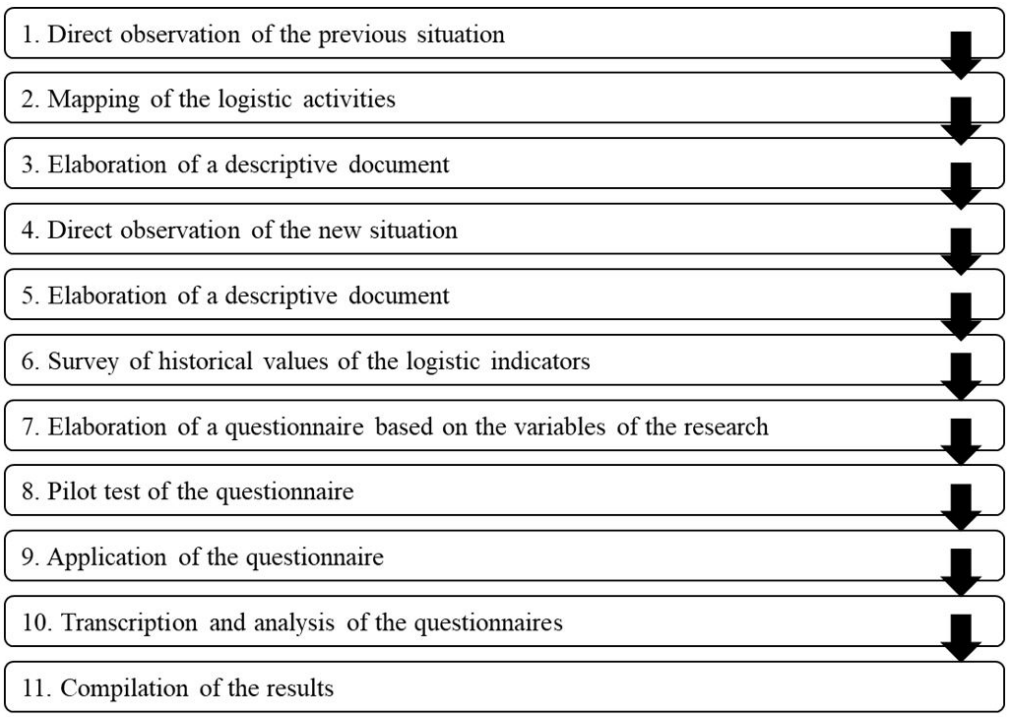

Figure 1. Research steps.

More specifically, the interviewees were: 3 coordinators from logistics, assembly and commercial sectors; 2 planning analysts; 2 salespersons; and 12 logistics operators from receiving, shipping, separation and inventory sectors. Employees with different positions and functions were chosen in order to obtain several points of view on the logistics operations. The interviews were recorded and took place at the company itself; they addressed questions about difficulties in performing the operations, potential for financial loss, friction between departments, operation delays, overtime and impacts for the final customer. The closed questions were inserted with the objective of obtaining a grade for the logistic operations efficiency before and after the implementation of WMS and indicate the degree of satisfaction of the interviewees in relation to the logistic operations.

4 Case study

4.1 Materials and information general flow

The flow of materials and information, including input, production and output is shown in Figure 2.

The flow is initiated by the supplier, which belongs to the same group. This factory is responsible for supplying all the assembly plants, not only in Brazil but also in Latin America.

Besides manufacturing parts, this supplier also centralizes the purchase of non-manufactured items. For this reason, the assembly plant has only this factory of the group as a supplier. For this reason there is no quality inspection department in the assembly plant, since this process is done in the supplier (assured quality). The assembly plant receives daily around 13 tons of parts transported by trucks, and this material is received, checked and stored. The logistics sector is also responsible for the picking of parts that will be used in the assembly, performed according to the schedule issued by the Production Planning and Control (PPC) department. The pincking and manufacturing is accomplished in accordance to the guidelines of the PPC, which evaluates the quantity of raw material needed to comply with the requests within the established deadlines. After assembly, the drives are tested, painted and packaged to wait for shipment. The figure also shows the exchanges of information between the PPC, Sales and Purchasing departments that make interface with the Finance sector.

4.2 Logistcs before WMS

In the studied case, it was observed that the main factors contributing to logistic problems were related to the reliability of logistic information and the efficiency of handling operations. In the next paragraphs, the receiving, storage and picking operations (Figure 2) that were performed before the implementation of the WMS, are described. The detailed flowcharts of these operations are presented in Figure 3.

Daily shipments of parts were sent to the assembly plant by road. After the invoice was registered in the system, the received itens and quantities were checked by the operators according to the packing list. If the information was correct, the material was made available for storage. Each item had a main address registered in the system; if the amount of material exceeded the space, the surplus of material was allocated in alternative addresses managed with the aid of electronic spreadsheets.

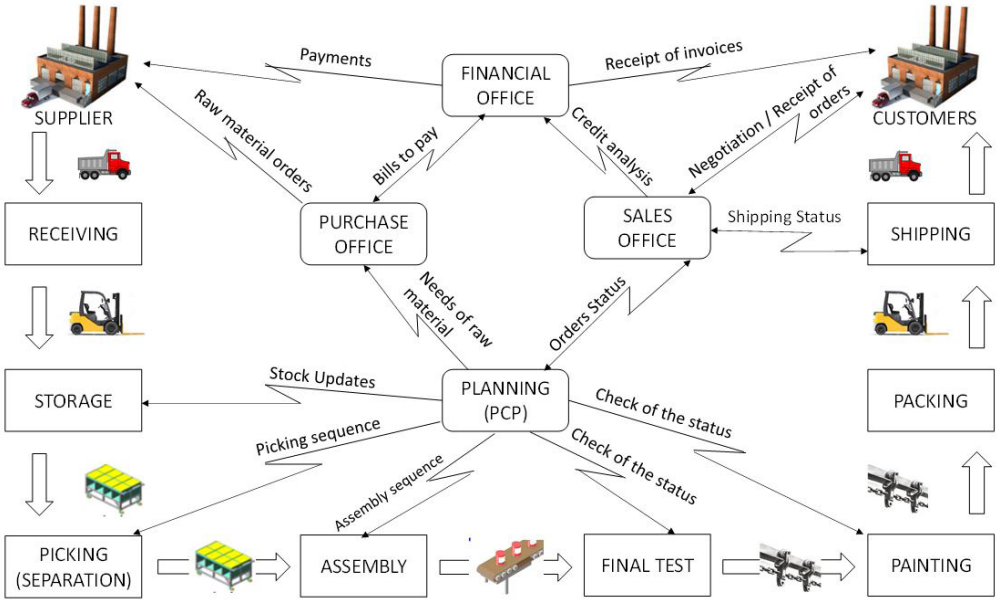

Figure 2. Material and information flow.

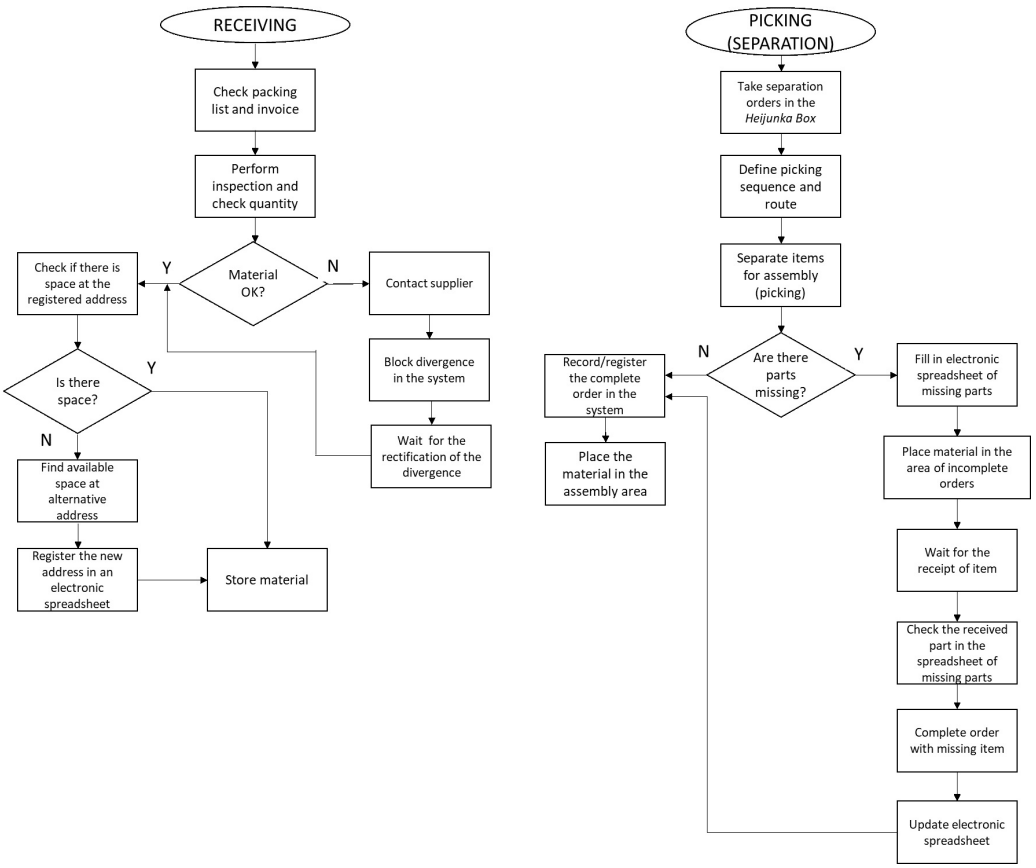

Figure 3. Receiving and material separation flowcharts.

Figure 3 also shows the flowchart of picking (of raw material and parts) for the assembly orders. This operation is a step of the logistic processes managed by the PPC department. Twenty assembly stations are supplied by this operation; they are split into five clusters, according to the type and size of product.

The scheduling was performed by the PPC with the aid of a *heijunka* box and the orders were strategically positioned according to priority. The operability of the picking tasks was extremely impaired by the parallel control of quantities and addresses of the itens, using electronic spreadsheets (instead of the ERP system). This data not updated in the right time, increasing the time for searching parts.

To make matters even more complicated, the plant used backflushing, in the accounting of consumed items occured only when the assembly order was complete. Consequently, orders containing divergences were left in an area of incomplete orders. The management of missing items and separate items awaiting disposal was controlled by means of electronic spreadsheets. These worksheets started to be as important as the ERP, but the fact is that, with time becoming increasingly scarce, the loss of time with parts searching and the daily pressure for productivity caused failures on updating these spreadsheets. Considering that there were more than 7 thousand storage locations in the warehouse, it became almost impossible to find a given item stored in an alternative address when this information was not accurately recorded. The described receiving and picking flow are shown in Figure 3.

In this scenario, the company faced a number of problems derived from the low accuracy of inventory records, such as: delays, rework and waste of time to find parts, production of unnecessary items to replenish inventory, excess of orders separated incompletely waiting for items, lack of space to allocate these requests, lack of space to allocate received items, excessive overtime and loss of orders. The result of this set of problems reflected on the dissatisfaction of the customers, which no longer relied on the delivery performance and quality of operations executed by the company. Certain frictions between company and customer had to be mitigated by free shippings. Another rather unusual practice that began to emerge was the physical checking of items before selling. Such practice contributed even more to unproductiveness.

From this moment on, the company made efforts to find a solution to solve problems related to logistic processes. This solution included the deployment of a Warehouse Management System (WMS).

4.3 Logistic dynamics after WMS

For the implementation process, a restructuring in the logistic chain was necessary, starting with the organization and item allocation strategy.

It was necessary to map all the stock positions taking the consumption and the location of the workstations into account. Items that are destined to a certain workstation should be in the same corridor and items with greater turnover should be in positions that are within the reach of the logistic operator without the use of forklifts and pallet trucks. In addition to this mapping, the unitary volume of all materials and the available volume of the stock positions were measured, and the reorder points were determined. All this information, combined with the information already existing in the ERP system, such as prices and ABC curve, served as parameters for the configuration of the WMS system.

For greater efficiency, it was necessary to delimit fixed positions for the most consumed itens. These positions would drive the operator during the picking; the surplus of a certain item stored in a fixed position or lower consumption items would be stored in variable positions. These variable positions were denominated this way because, depending on the need and quantity, the system determines where, among all the free positions of the stock, the item should be located. Automatically, when an item stored in a fixed position enters the reorder point, the system generates a relocation order, so that a certain amount is moved from the variable position to the fixed position.

Bar code lables were created for each item and each position, generating a unique identity for the purpose of performing updates in real time. Another investment was required in the radio frequency structure which included the installation of antennas for remote communication, the acquisition of zebra printers to create labels and remote collectors, so that each logistic operator had his own collector.

The ERP system is broad and contains numerous modules, such as modules to support commercial, tax and production tasks. A WMS system that could be integrated to the ERP was chosen due to the fact that the company already had a complex ERP. Several adaptations were developed. Automatic and periodic transactions update both systems every 2 minutes, establishing the interface between them. In these updates, the WMS information, such as inventory levels, movements and operation status, is exported to the ERP. The MRP module of the ERP system, for example, uses this information to calculate the inventory in hand and to plan the release of purchase orders for components; likewise, the MRP module updates the sales module, giving the sellers the correct commercial forecasts of a particular product. So, all the movement performed in the WMS is updated in the other modules of the ERP system, not compromising the information accuracy and saving some transactions. The systematic movements of the itens were mapped, in order to show their availability in real time and improve traceability. In this mapping, virtual zones referring or not to the physical spaces within the company were created, as shown in Figure 4.

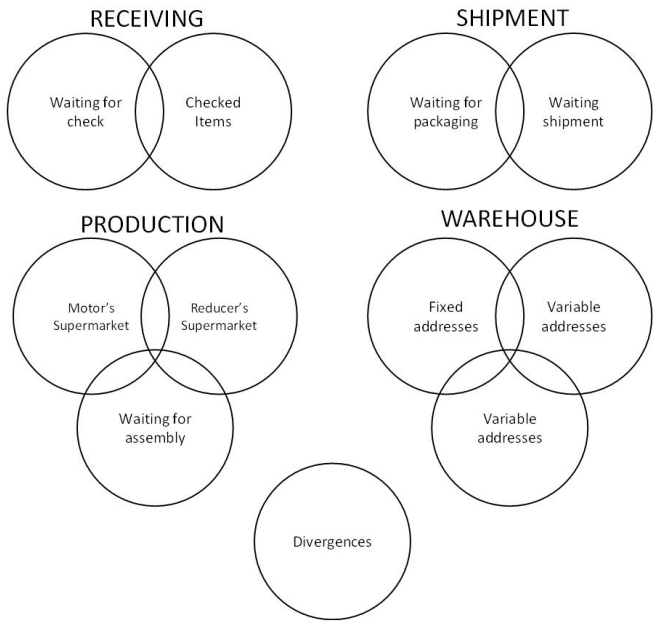

Figure 4. WMS mapping: creation of virtual zones.

Within each zone it is possible to also monitor the item status. The WMS provides complete information on the transit of materials in the virtual zones, allowing a broad and concise view of where the materials are, to which work orders they are attached to, which operations have already been performed and who has performed them, and which operations are pending. Traceability is improved and paper becomes unnecessary. With the new system, the outward movements of stock were immediately recorded, istead of being recorded by means of backflushing. Usually, backflushing is recommended when the volume of itens is not so big and the lead times of assembly are not so long, which is not the case of the system under analysis.

The biggest challenge of the implementation process was to predict the cultural shock that would surely occur and to cope with it. The WMS system is complex because it requires the standardization and formalization of processes, limits the existence of informal and alternative records, monitors and tracks the entire movement of parts and points out the productivity of those involved, directs the tasks and does not allow much decision autonomy for standard operations. These new work practices, compared to previous ones, have greatly changed the routine of logistic operators.

Two very important custom features, called "picking monitor" and "RF monitor", have also been inserted in this context. The picking monitor has been designed to aid production planning and control. This feature allowed grouping multiple assembly orders and performing availability analysis at once, in a visual way, signaling this availability with traffic lights.

With the picking monitor it is possible to generate the work order, which is the trigger for the picking. At the time of the work order generation, stored items are automatically reserved and no other order can use these items even if the picker has not performed the physical sorting operation yet. WMS provides resources that allow visualizing the dynamics of an item, including allocation, transportation, divergence, process and availability. If any detours happen on the route, the tracking is efficient and fast.

The RF monitor is another customized tool, which can be compared to a control room. Inside it is possible to see all the movements, the work to be done and the available human resources. In this way, the logistic operations manager allocates the human resources to attend the pending work orders. With simple drags on the system interface screen it is possible to allocate two or more operators to the most congested areas and to change the sequence of work orders. Once reallocated, the operator knows his/her next task, and the system restricts the execution of a different task, since it does not provide the necessary information and tools.

After the implementation, it was possible to observe in the flowcharts how the logistic operations became leaner. Figure 5 shows the receiving and picking/separation processes after the changes, and may be compared to Figure 3.

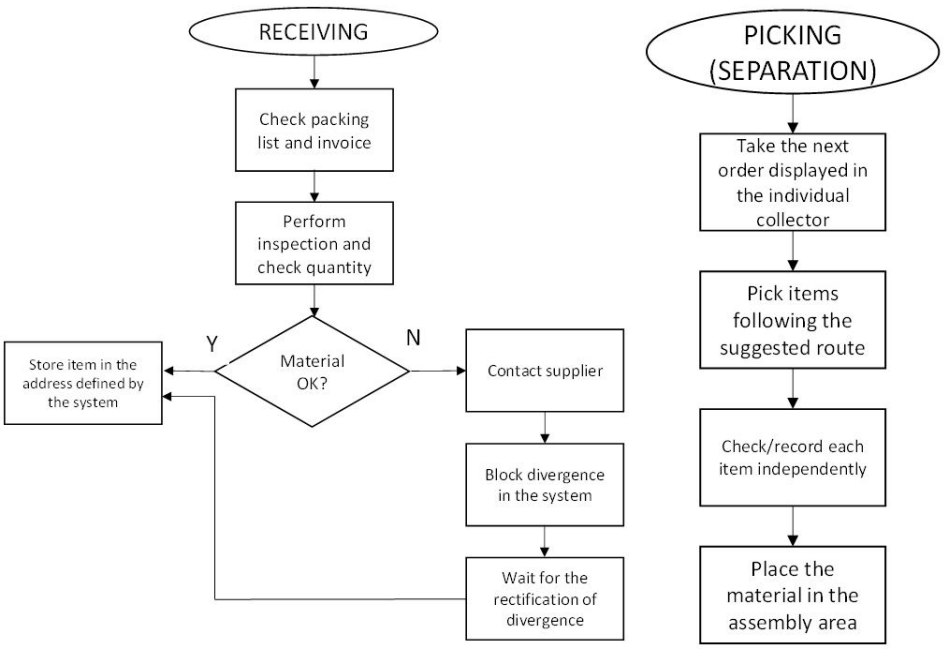

Figure 5. Receiving and separation flowchart after WMS implementation.

5 Results and discussions

Even with the preparatory actions described in item 4.3, the migration to the new system was very troubled; many problems were not previewed and some WMS tools were not performing functions as expected. Many adjustments had to be made, mainly those related to the recordings of inward/outward movements of stock, to the culture of logistic operators and to the company own strategy regarding to fixed storage locations. According to the involved people, this phase was as disturbing as the previous scenario; for a period of time, the WMS effectiveness was questioned. However, after this transition, the system showed its efficiency and the employees adapted to the new way of working.

There was a significant improvement in the picking process due to the WMS system tools, which, together with the use of a supermarket (stock area closed to the assembly stations), allowed the separation/picking time to be reduced by almost half. Table 1 presents the average values of some indicators related to order separation. The data shows a decrease of the operation average time, the reduction of people engaged in the process and the increase of productivity.

The practice of using fixed addresses and supermarkets, linked to the new warehousing policy considering the proximity to the assembly stations and the turnover of the items reduced the time of forklift use. The delimitation of the routes by the system optimizes the use of time, and the radio frequency system guarantees the reliability of the operations. The high stock accuracy guarantees the speed in the process.

In the previous inbound process, it took approximately 20 hours for all daily material loading to be checked and stored (but this value could be higher depending on the problems encountered during the conference); after consolidating the WMS system, this time has dropped to approximately 8 hours. For this reason, there is currently only one logistic operator responsible for the reception and storage in the second shift.

The outbound process presented an improvement in the information reliability and waiting time for shipment of the final product. Mainly, there was a decrease in the complaints of internal customers. The number of operators in this sector remains the same because there was no reduction of the process steps and the WMS was not deployed with 100% of the resources in the shipment sector. The improvement observed in this sector occured mainly due to the impacts of the increased reliability of the operations prior to packaging and shipment.

The accuracy of inventory information was the most significant result. The high variety of items and addresses brings greater complexity to the management of the the warehouse. The WMS brought tools that enabled better traceability and the possibility of performing the cyclic counting with the company still in operation. To maximize efficiency, a logistic operator has been dedicated to full-time cyclic counting. The result was reduction of divergences by more than 96%, and an accuracy of 98% of the total stock value, at the time this study was closed. The main change that resulted from the application of the WMS and caused these achievements was the restriction of the operator's decisions decisions regarding relocation within the warehouse, along with the extinction of electronic spreadsheets to control items in variable positions. Figure 6 shows the evolution of inventory accuracy indicators and the punctuality of the picking of customer orders and assembly orders. Considering the period from

Table 1. Logistic indicators.

Indicator	2013	2014	2015
Quantity of operators	16	14	10
Average picking time (minutes/equipment)	8	7	5
Picking performance (orders/day/operator)	60	68	95

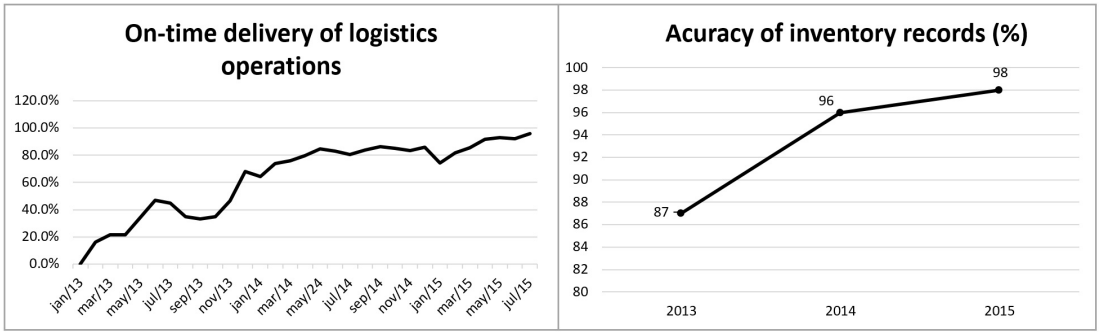

Figure 6. On-time delivery and accuracy of inventory records. Source: author.

January 2013 to July 2015, it is possible to observe that punctuality reached values above 95%. The worst mark was 0.1% in January 2013 due to accumulated delays per weeks.

As mentioned before, to evaluate the impacts of WMS from other perspectives, a perception survey was applied to the employees of the main areas involved in the process of change. The interviewed collaborators belonged to different hierarchical levels aiming that all the involved population were represented. The research was designed to cover the research variables defined in the methodology section.

The interviews were transcribed and the answers were grouped into categories, based on content similarity and similarity of the terms used by the respondents. Prior to the WMS period, the following difficulties were mentioned:

- lack of inventory accuracy (53%);
- slow and confusing process due to the lack of update of parallel spreadsheets, lack of standardization to perform operations and lack of knowledge about the status of the orders (23%);
- lack of traceability of stock items (18%);
- operator's autonomy in decision making regarding the operations scheduling (6%).

All of the above factors potentiated the delays. The percentages indicated in each item represent the percentage of respondents who mentioned each of the listed factors.

For the commercial department, the difficulties were originated from the lack of information regarding the incomplete orders, which generated lack of punctuality of the assembly orders and customer dissatisfaction. This aspect was cited by 100% of respondents in the commercial area. The interviewees realized the potential financial impacts generated by this situation. These financial aspects were associated to the following points: manufacturing of items that were not found, mentioned by 38% of the interviewees; loss of customers due to missed deadlines, indicated by 17% of the interviewees and even mentioned by logistic operators who do not have direct contact with the final customer; payment of freights as a courtesy to customers due to delays, mentioned by 16% of the interviewees (logistic operators in the shipping area, salespersons and PPC analysts); and labor allocation for rework and search for parts, present in the answer of 29% of the interviewees. It was not possible to measure some financial values because they were not provided by the company. Thus, these evidences of financial impacts are based on the perceptions of the respondents. The degree of satisfaction regarding to logistic operations and inventory accuracy were also evaluated by the interviewees. Figures 7 and 8 express the results of this evaluation.

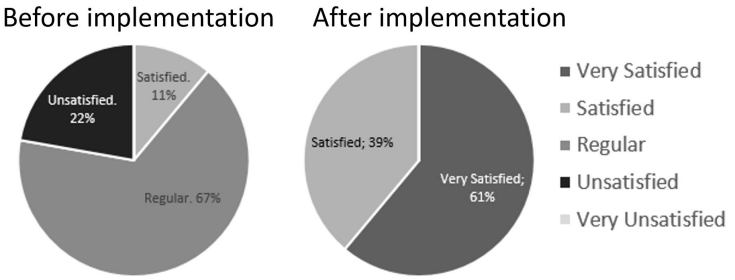

Figure 7. Employee and internal customer satisfaction with the logistics function.

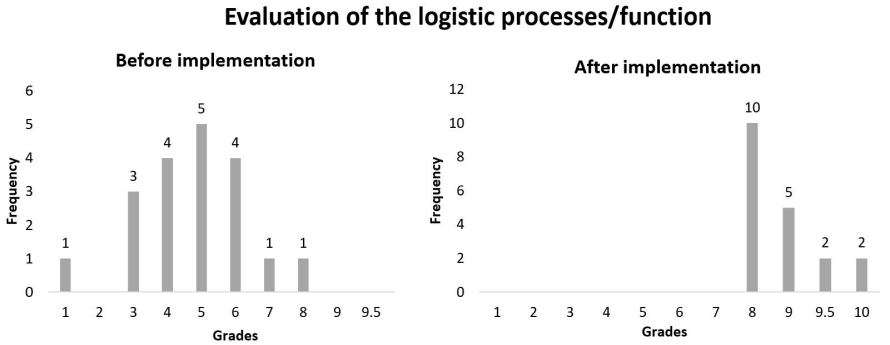

Figure 8. Grades given by internal customers for the accuracy of inventory records.

Most respondents cited as key enhancements reliability, traceability, and effective management of logistic operations after the WMS implementation. The impacts of this evolution on the efficiency of logistics operations were noticed by all manufacturing sectors, including the commercial department and the final customer. Parallel papers and spreadsheets were all extinguished, so there was a decrease in the level of bureaucracy and an integration of information. The report of one of the interviewees showed a punctual increase of bureaucracy in the tasks needed to reverse some operations in the WMS system, however, the opinion of the same interviewee, shared with all logistic operators, is that reliability and simplicity in the execution of the other tasks were more important than this punctual drawback. Redundant and unnecessary steps are no longer part of the new logistics scenario. The study and the mapping of the logistic flow, as well as the performance measurement of the logistic operations provided by the company, confirm the perception of the interviewees.

It was observed that the success in the implementation of the WMS system required the commitment of all the staff involved, mainly because a new routine and work philosophy had to be assimilated. In this course, the company board of directors was involved with the employees, participating directly in problem solving and showing the importance of the new work philosophy.

Chart 3 summarizes the results achieved. These results were obtained from three data sources: direct observation of the researchers, documentary/measurement evidences and perceptual interviews. The material and information traceability and the factor related to financial impact were significantly cited in the

Chart 3. Summary of the results.

Evaluated factors	Situation prior to the deployment of WMS	Situation posterior to the deployment of WMS
Traceability of materials and information	Low traceability and low inventory accuracy	Total traceability of the logistic operations
Inventory accuracy	Reliability of 87%	Reliability of 98% with a projection of 99% for the next year
Picking route	Random. The operator chooses the route, leading to exessive and repeated displacements/movements	Route planned by the system according to the location of the itens, optimizing the displacements and movements
Bureaucracy level	High. Very manual process, many parallel electronic worksheets and papers	Low, without the use of papers; transactions automatically recorded
Delivery performance	Delayed deliveries, caused by failures in the process and lack of inventory accuracy	On time in full deliveries
Quality of the logistics operations	Low; avarage grade of 4.76 out of 10	High, average grade of 8.63 out of 10
Main financial impact potentials	Rework, overtime, loss of orders and freight courtesies	Reduction of picking time, reduction of overtime and increase of productivity
Degree of employee satisfaction with the logistics system	Regular	Very satisfied
Picking performance	On average 8 min/order	On average 5 min/order
Lead time of the receiving operations	20 hours per day	8 hours per day
Organization and standardization	Low	High
Evaluated factors	**Disadvantages and difficulties**	
Reversing operations	In the WMS, requires several transactions	
Dependence on the radio frequency system	All operations stop without radio frequency	
Investment	High investment of hardware e software	
Difficulties of implantation	Cultural change	
	Organization and standardization	
	Infrastructure	
	Interface with ERP	
	Recording itens (for the first time)	
	Labelling	

interviews; the aspects related to inventory accuracy, level of bureaucracy and fulfillment of due dates were both mentioned in the interviews and evaluated through documents and indicators; the factors related to picking route, organization and standardization were perceived through direct observation but were also mentioned in the interviews; the quality of the logistic operations and the degree of operators' satisfaction were evaluated by means of closed questions; the productivity indicators were evaluated through documents provided by the company.

6 Conclusion

The focus of this study was to evaluate the WMS system implmentation in a multinational company based on concrete evidences (indicators) and based on the view of different departments of the company. In this evaluation, data regarding the previous situation and the situation after the implantation was analyzed through direct observation, documentary analysis and interviews. Due to a significant increase in workload in the studied plant, caused by the deactivation of another unit, the studied company faced several problems in logistic operations which affected the final customer and compromised the quality of operations. The solution found was to implement a WMS software to support the management of logistic operations.

One of the important factors for the implementation success was the reformulation of work methodology together with standardization and organization practices. Only then could the WMS system benefits be noticed.

From the analysis of relevant indicators it was possible to observe a gain in agility in the logistic operations, which consequently results in financial gains. Besides, the reports from the employees involved in the change revealed a decrease in conflicts and a significant increase in the reliability and credibility of internal and external clients. These factors have demonstrated an improvement in efficiency and service level.

Some benefits obtained with the system implementation are concrete, as expressed by the indicators monitored. On the other hand, some improvements are intangible and more difficult to measure, such as the potential of increase in competitiveness. According to reports and direct observation, some customers have already praised the company's new stance regarding deadlines, and placed new orders. Most of the employees declared themselves very satisfied about logistic operations performance and the average grade for logistic operations quality after implementation was 8.63. This number represents an improvement of approximately 80% when compared to the evaluation of the same employees referring to the period prior to the implementatiotn of the system.

The WMS system requires a high investment which has shown to bring advantages, but there are also some disadvantages. The main negative points mentioned were the disorder and various adjustments needed during the implantation and transition phase. The adaptation by the stakeholders until the complete understanding of the system was gradual. This was a troubled period and generated disbelief in the system efficiency; even though, this phase was overcome without major impacts. Some tasks that are not very common have become more complex such as charge-backs, but not to the point of interfering with the efficiency and operation quality.

According to the stakeholders, the results with the implementation of the system were satisfactory. There is a perception on the part of those involved in the research that the financial results and strategic gains offset the investment made.

This study also has sought to contribute to the existing literature with the report of an implantation case in a multinational company, aiming to bring guidelines to other companies that face similar problems in the logistics and exemplifying the functionalities of the implemented system. A suggestion for future work would be to conduct a larger survey-type reasearch involving a larger sample of companies that have implemented the WMS system. In this way, it would be possible to compare the functionalities present in the system of each company, as well as to verify the relationship between the implementation of the system and the logistic performance of the companies in a more general manner.

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