Continuous Improvement to Create Value: Warehouse Management in a Telecommunications Company

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Abstract

The telecommunications market is characterized by high unpredictability and volatility of demand as well as a great instability due to the existing strong competitive environment. Thus, it has become imperative for companies to invest on several continuous improvement tools, with a view to enhancement and stabilization of processes, standardization of labor and elimination of waste along the value chain. The work described in this paper was carried out in the warehouses of a well-known Portuguese telecommunications company that is characterized by a considerable innovative dimension and, due to its recent growth in the market, presents several problems in its logistics sector, which was not able to keep up with this expansion. The main objective was to eliminate/reduce the waste in the warehouse processes reducing logistics cost and therefore, creating value for the company. The implementation of a set of continuous improvement (lean) tools such as ABC analysis, spaghetti diagrams, and layout redesign allowed the looked-for value adding to the inner processes.

Keywords
Continuous improvement, Layout, Logistics, Telecommunications, Warehouse management.

1. Introduction

In the modern competitive setting, boosted by the great phenomenon of globalization, companies are increasingly looking to respond in a quick and agile manner to their customers and differentiate themselves from the competition. Consumers are increasingly informed and challenging, which has contributed to changes in demand patterns. On the other hand, markets are quite saturated and, to survive, a company needs to understand these new challenges and be adaptive.

Accompanying this development, logistics operations have become increasingly complex and comprehensive, pushing the organizational boundaries and assuming stronger links along the supply chain.

In this study, the company in analysis belongs to the telecommunications market, which is a very unstable and volatile market whose products have increasingly shorter life cycles. Due to the high growth of the company and increased sales volume, the number of product references in warehouse increased significantly. Thus, it is extremely important for the company to create appropriate storage infrastructure and apply a continuous improvement philosophy to impel a sustainable progress.

It this context the work focuses the logistics function performance, and, in particular, the warehouse management in order to improve the operations, recognizing that it is from this internal value creation that the company can respond quickly to customer needs and requirements.

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The implementation of a series of continuous improvement tools such as process mapping, ABC analysis, layout redesign and spaghetti diagrams resulted in more efficient and effective processes carried out in the warehouses of the company, taking advantage of the available resources.
The following sections provide, by this order: a brief theoretical framework on warehouse management as well as on continuous improvement philosophy (lean manufacturing); the description of the system-in-analysis considering the existing situation and the major problems found; the presentation of the continuous improvement tools utilized and the attained results; and some major conclusions about this study.

2. Warehouse Management

2.1 Warehousing

Logistics plays a fundamental role in supporting companies to manage, efficiently, their warehouse operations and infrastructure. Tompkins and Smith (1998) identified ten basic activities that occur in the warehouse: receiving, inspecting, stock controlling, storage, replenishment, picking, verification, packaging and referencing, consolidation, and expedition.
The key problems reported in the literature concerning warehouse operations are, according to Gu et al. (2007): truck-dock assignment, assignment of Stock Keeping Units (SKUs) and space allocation, batch size, assignment of pickers, routing and sequencing of picking tours, dwell point selection, and order-lane assignment. The modern information technologies such as RFID, GPS or AS/RS bring new challenges and opportunities into warehouse design and operations.
The evolution of warehousing activity has been driven by high competition in the market and the continuous improvements implemented at the level of design and operation of distribution networks. Nevertheless, and as reported by Gu et al. (2007), the adoption of new philosophies such as Just-in-Time (JIT) or Lean Manufacturing (LM) has also brought new challenges for storage systems.
Many companies do not recognize value in storage activities and material handling; however, these are important elements in a supply chain and play a crucial role in allowing increased efficiency or to ensure customer satisfaction (Bartholdi and Hackman 2016). Thus it is extremely important to understand the real benefits for a company to have its own warehouse/storage space as well as the various activities that take place in this space, which is a topic widely discussed by several authors.
In a supply chain, the warehouse is a central element, which can be enclosed into several categories (Frazelle 2002): i) warehouse of raw materials and components; ii) warehouse of work-in-process; iii) warehouse of finished product; iv) warehouse of distribution or distribution centers; v) warehouse of service or call centers; and vi) local warehouse.
According to Bartholdi and Hackman (2016), despite the high costs, a company should have a warehouse for balancing supply with consumer demand (allowing to quickly respond to changes in demand) and to consolidate the product (reducing transportation costs and providing customer service). They also refer that a warehouse enables opportunities to delay product differentiation (postponement strategies), allowing the basic product to be customized near to the customer, something highly valued in the industry of electronic components.
The location and design of a warehouse are strategic issues that must be addressed in the early stage of the project of supply chains as it becomes important to determine the storage size and the maximum capacity. Thus, the design of a warehouse is a complex problem involving five primary decisions (Gu et al. 2007): general structure, layout, size and dimension, equipment and operational strategy.

2.2 Continuous Improvement

In general terms, the main objective of lean manufacturing focuses on eliminating waste (e.g., overproduction, transportation, defects) and add value to the product (that must be perceived by the client). Based on this philosophy many other concepts have emerged, highlighting continuous improvement (kaizen) as a daily culture. Lean manufacturing principles and tools are proving to be a good practice for companies who want to become more competitive through waste reduction and value-added creation. Despite some criticism of the leanness approach particularly when demand is lumpy and highly varying (Pool et al. 2011), the utilization of lean tools such as, Kanban, one-piece flow, leveling, line balancing, layout redesign, and value stream mapping is, nowadays, widespread and goes beyond the concept of lean (Mehrsai et al. 2014).
Implementing and maintaining continuous improvement practices in an organization is an arduous task that requires the presence of methodologies based on the famous PDCA (Plan-Do-Check-Act) cycle, considered as one of the main

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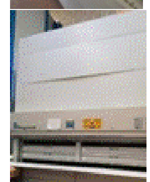
drivers of continuous improvement. Therefore, according to Pinto (2009), continuous improvement is a method by which people work together to improve the performance of their processes, bring the performance to benchmarks and continuously meet the needs and requirements of customers.
The operational tools available to put into practice the continuous improvement culture are numerous and diverse such as, ABC analysis, Value Stream Mapping (VSM), 5S, line balancing, Kanban, spaghetti diagrams, cause-effect diagrams, etc. The following sections describe the application of some of these tools to enhance the operations of the company's warehouse creating value in the related processes.

3. System-In-Analysis

3.1 Company and its Warehouses

The company where this study took place is a reference in the Portuguese telecommunications market. A multinational group has acquired the enterprise, recently. It is the structure in charge of Innovation, Research & Development ensuring that the group transforms knowledge into technological innovation creating differentiation in the markets.
The logistics sector, as well as the area of Production Planning, belongs to the Department DSR6 (Production, Implementation and Support), which in turn is part of the direction DSR (Development and Implementation of Network Systems). The logistics sector ensures the realization of various activities such as: receiving, identification and storage, supply for internal and subcontracted production, and shipment of finished product for domestic and international markets.
In order to allow all these processes to occur in the best possible way, it is indeed important to perform a correct physical management of materials and warehouse space, which has not occurred in the company much due to the high number of references-at-hand and the scarcity of resources allocated to this area.
The company has two independent warehouses. Jointly, this is the only storage space that the company holds, ensuring the supply of material for domestic production and subcontractors, and allowing the production flow. This storage space constitutes an important link between the company and consumers.
The logistics team consists of only five people, which try to ensure that all logistics processes occur efficiently, performing, all of them, administrative and operational tasks. However, the human resources and facilities are scarce to perform all activities in the warehouse, and important tasks such as materials management and warehouse space management, which often compromise the quality of electronic items stored, are being neglected.
The main warehouse (warehouse 1) is responsible for receiving all the necessary components for the production of all types of finished product belonging to the company's portfolio. The material is received on pallets or in volumes, a process that occurs daily from various carriers or transport providers.
The warehouse 2, near warehouse 1, was purchased recently and, until a year ago, it did not have any storage system, being all the material on the ground. Today there are four racks where it is placed the material without any specific order. This space only supports the main warehouse and it is not being used and explored adequately.
According to the flow type, either warehouses have the U-flow configuration wherein the receiving and shipping areas are in the same place. Regarding the existing storage systems, there are several types ranging from manual systems to automated systems. The main storage system corresponds to racks that allow palletization of larger materials. The storage capacity of these systems corresponds to 804 Euro-pallets in both warehouses. The various systems used are presented in table 1.

Table 1. Storage systems in the warehouses of the company

Storage System	Main function	Example
Conventional rack system	Allows storing larger material and are generally with 3 to 4 levels, enabling time-based storage policies. The key storage system in both warehouses of the company.	
Kardex system	Dynamic shelves that correspond to an automatic cabinet for storing electronic components of small dimensions.	
Megamat system	Rotational system corresponding to an automatic cabinet for storing electronic components of very small dimensions.	
Double-Deck	Two-level structure for storing raw materials of small dimension.	

The next subsection describes the main problems of the logistics system of the company that, in turn, correspond to major opportunities for continuous improvement activities.

3.2 Major Problems and Opportunities

The logistics processes are somehow inefficient, which results in large part from the fact that both warehouses are physically separated and there is no internal integration between them. Another problem found lies in the lack of clear and well-defined working areas.

The storage systems and the corridors are well defined facilitating the picking tasks but the high volume of material on the ground (very high percentage of obsolete materials stored in the racks) makes this process very time consuming. The Double-Deck system at the entrance allows employees to ensure prompt receipt and shipment of material and the Megamat and Kardex automatic systems, located in the warehouse 1 entrance, are easily accessible by operators, however, all these storage systems restrict the entry space and hence the receiving and shipping areas.

The floor area for the circulation of the various handling systems and workers (which should be free), serves currently as storage area. In warehouse 1, the average area occupied is equivalent to 80 m^2, or about 84 Euro-pallets obstructing the pathway. For warehouse 2, the average is 96 Euro-pallets blocking the pathway, which corresponds to an occupied area of 94 m^2.

In addition, the company has a high diversity of material in inventory (about 9700 references of raw materials and 530 references of finished product) and, despite the available storage systems, it is observed: small dimension components stored near large dimension materials; lack of well-defined storage/working areas leading to a high volume of pallets on the floor; pallets of material at elevated positions without being properly packed, compromising the safety of employees; and electronic materials without any protection compromising their integrity.

An ABC analysis performed for the annual consumption of items in stock allowed the company to found that 80% of the value focuses on 68 items (A items), i.e., a small percentage of references is responsible for a large percentage of the annual (2017) consumption value. The ABC analysis allowed the classification of items, according to the 80/20

Pareto law, and the selection, for analysis, of items belonging to class A (most important items regarding high levels of consumption and/or high monetary value).
In synthesis, the major problems found in the warehouses of the company, and in the related logistics processes, are the following:

i) Human Resources: insufficient number of human resources allocated to the logistics sector, lack of training, and lack of involvement of managers.
ii) Materials: high volume of obsolete material occupying almost the entire available storage area.
iii) Methods and Security: lack of working methods for referencing and storage, and improper packaging of electronic equipment.
iv) Layout: inexistence of well-defined working areas, considerable times in transportation tasks, and bad space management.
v) Continuous Improvement: lack of a continuous improvement plan to guide the daily operations and improve the performance of the logistics sector.

The next section presents the major actions taken to solve the problems encountered.

4. Continuous Improvement Actions and Results

After an exhaustive diagnosis analysis, the team concluded that the company's organizational structure is limiting the warehouse productivity gains and the various activities carried out in these spaces. Given the high volume of work, and the lack of a responsible worker for managing the warehouses, there is a considerable level of disorganization and a significant time spent on warehouse activities. The lack of training is evident and has a very negative impact on the daily tasks.

4.1 Materials

As discussed previously, much of the existing material on the shelves is not used for several years being the storage systems filled with obsolete materials. Thus, one of the most important improvements was the definition of an "Obsolete Material Plan" and the cleaning of the shelves, essential for increasing the performance of logistic activities. The proposed life cycle model considers the time that a given reference is not in use. If a given reference is no longer used for over a year, this is regarded as pre-obsolete. From the moment that is not consumed for more than two years it is considered obsolete, so it proceeds to its separation and subsequent disposal.
Until this document, there was a disposal of about 6079 references of raw materials and 107 different product references were classified as obsolete, which resulted in a release of about 58% of the total storage space.

4.2 Layout

There was an obvious need to redesign the layout of the warehouses in order to create an integrated and efficient solution in terms of space utilization and flow of operations. The major areas of the warehouse were defined based on the fundamental processes carried out in this space such as reception, inspection and identification of materials.
Fig.1 depicts the new layout, which took into account several different requirements.

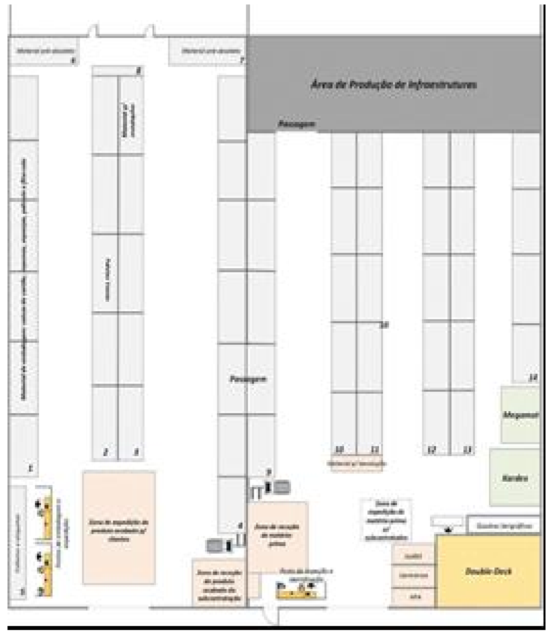


Figure 1. New layout of the warehouses of the company

The new layout joins warehouse 1 and warehouse 2 in an integrated way being the first one (right side of Fig.1) devoted to raw materials and embracing the relocated Megamat, Kardex and Double-Deck storage areas, and the second one (left side of Fig.1) dedicated to reception and expedition of finished product. The working areas are now well defined and delimitated and the resizing of the corridors (and the racks) allow the proper circulation of material handling equipment and picking activities. There are products where it is observed a reduction in picking time of about 30 minutes.
The criteria for allocation of materials to the shelves was based on an ABC analysis of materials' movements (inbound and outbound).
Analyzing the daily movements of a typical warehouse worker, it is evident the biggest improvement in their reduction (Fig.2). To complete the same tasks, the worker walks, in the new solution, less 500 meters.

Figure 2. Spaghetti diagram for movements of a typical warehouse worker (before and after improvements)

In order to normalize the various working methods and processes carried out in the warehouses it was also implemented a Daily Kaizen divided into four levels of intervention: organization of the working team (level 1), organization of the workplace (level 2), standards (level 3) and problem solving (level 4).

5. Conclusion

The main objective of the project was to eliminate/reduce the waste in the warehouse processes reducing logistics cost and therefore, creating value for the company.

The implementation of a set of continuous improvements measures such as human resources management, definition of a new obsolete material policy through the creation of a new life cycle for the various items of the company, definition of a new layout, and creation of new methods to allocate materials to the shelves was very relevant being obvious the good operational results.
The involvement of top management was critical in this process. Nevertheless, a cultural change across the organization is steel needed. There was a "natural" resistance to change the procedures and "ways of doing" but the greater involvement of top management and the workers' training plan was encouraging. The culture of the company and the dedication of the management influences positively the commitment of workers in the continuous improvement process and, obviously, the results.
An audit system was also implemented because it has been proven to work as an important incentive, motivation and control tool.
The company still has a long way to go to reach the so desired efficiency of the logistics system. It should follow up the sector innovations investing efforts towards continuous improvement.
In a near future it is needed an intervention on suppliers management. It will be essential to carry out various negotiations with suppliers in order to level their deliveries.

References

Tompkins, J. and Smith, J., *The warehouse management handbook*, Tompkins Press, 1998.
Gu, J., Goetschalckx, M. and McGinnis, L., Research on warehouse operation: A comprehensive review, *European Journal of Operational Research*, vol. 177, no. 1, pp. 1-21, 2007.
Bartholdi, J. and Hackman, S., *Warehouse & Distribution Science*, Georgia Institute of Technology, 2016.
Frazelle, E., *Supply chain strategy: the logistics of supply chain management*, McGraw-Hill, 2002
Pool, A., Wijngaard, J. and van der Zee, d.-j., Lean planning in the semi-process industry, *International Journal of Production Economics*, vol. 131, no. 1, pp. 194-203, 2011.
Mehrsai, A., Thoben, K-D. and Scholz-Reiter, B., Bridging lean to agile production logistics using autonomous carriers in pull flow, *International Journal of Production Research*, vol. 52, no. 16, pp. 4711-4730, 2014.
Pinto, J., *Pensamento Lean – A filosofia das organizações vencedoras*, Lidel, 2009.

Biographies

José Vasconcelos Ferreira was born in Portugal in 1960. He received the M.Sc. degree in operational research and systems engineering from the Technical University of Lisboa, Lisboa, Portugal, in 1989, and the Ph.D. degree in engineering sciences from the University of Porto, Porto, Portugal, in 2005. He is an Associate Professor of Industrial Engineering and Management (IEM) with the University of Aveiro, since 2013, where he teaches since 1997 (Statistics, Logistics, Multivariate Data Analysis). He was Director of the IEM doctoral program, IEM graduate program, Member of the Department of Economics, Management and Industrial Engineering Council and Member of the Industrial Engineering Doctoral Program Council. He was Assistant Lecturer with the University of Porto. He is a member of the research unit on Governance, Competitiveness and Public Policies (GOVCOPP) working in the Decision-Support Systems' group. His research work focuses on systems engineering, logistics, multivariate data analysis, and operational planning at mass transit companies. He is co-author of several papers published in peer-reviewed publications and has more than twenty years of experience collaborating with the main urban mass transit companies in Portugal. He works in partnership with a spin-off company dedicated to Transportation Planning and Optimization.

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