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# Internal Logistics System Selection with Total Cost of Ownership Analysis

**Inês Araújo[1], Carina Pimentel[2], Radu Godina[3], João C. O. Matias[2,3]**

[1]Department of Economics Management, Industrial Engineering and Tourism, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro (Portugal).

[2]GOVCOPP& Department of Economics Management, Industrial Engineering and Tourism, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro (Portugal).

[3]C-MAST, Department of Electromechanical Engineering, University of Beira Interior. Edifício I das Engenharias. Calçada Fonte do Lameiro, 1. P-6200-001 Covilhã (Portugal).

ines.araujo@ua.pt; carina.pimentel@ua.pt;rd@ubi.pt ; jmatias@ua.pt

**Abstract**. In this paper a methodology was followed in order to support the decision-making of one industrial unit regarding its internal logistics system. The addressed factory was facing issues with their internal logistics approach.Some alternatives were pointed out and a proper total cost of ownership (TCO) analysis was developed. This analysis was taken in order to demonstrate the more cost-effective solution for the internal logistics system. This tool is more and more valued by the companies, due to their willing to reduce the costs that are associated with the way of doing business. Despite the proposal of the best choice for the internal logistics system of the enterprise, this study also intends to present some conclusions about the match between the nature of the industrial unit and the logistics systems that best fit the requirements of those.

## 1. Introduction

Nowadays companies are facing several demanding challenges, mostly due to the globalization and the instability lived in the marketplace. In order to maintain a strong position in the market, enterprises are compelled to develop goods with higher quality at the best possible price for the consumer [1]. Thus, all enterprises share the concern of being effective in the way they do business. Therefore, cost associated with the business is a well-knowntopicto managers[2].

It has beenwell established that the enterprises can get to know which activities add value and witch do not, by developing a proper TCO analysis. By doing so, enterprises can find the processes that can be improved and ultimatelyimprove the manner the factory does business[3]. Although the TCO approach can be applied in all stages of the business, it is more desirable, to be used in the early stage of the business or project. By doing so, it is likely that the TCO will be minimized [4]. Also, it is easier at this stage to propose alternatives, if the project design exceeds the budget. In [5] is argued that the TCO concept assumes a huge role in high-tech decision-making process. The same authors also defend that the TCO is a tool that improves the quality of decisions and communication.

This paper presents an investigation carried out in an industrial company that was facing a few challenges on its internal logistics system. The company was considering two alternative solutions to its current material handling system so as to improve its internal material flows. Such solutions were considered in order to suit the company needs and were evaluated through a TCO analysis.The main objective of this study is to reach an alternative system that suits the needs of this type of industrial company, without compromising the target budget to spend in the internal logistics process with the needed resources (capital and human).

For the accomplishment of this study, a deep knowledge about the company and of its internal logistics process was needed. Thus, the researcher spent a considerable period of time in the facilities of the company. This period of time was fundamental to the identification of the constraints and specifications of the current internal logistics system.Also, it was necessary to create some connections with the company, in order to get access to data for the TCO analysis. During the study, it was imperative to know which solutions were available in the marketplace. Thus, the researcher conducted some meetings with suppliers of conveyor systems and milk run systems, in order to understand and gain the required knowledge about the alternative systems.

The paper is organized as follows. The logistics systems are described in Section 2. In section 3 the enterprise and the core business are briefly described. In Section 4 the applied methodology is discussed. Finally, conclusions are summarized in Section 5.

## 2. The logistics systems

The current material handling system is characterized by the traditional method. The materials are conducted from the company warehouses or from the workstations to the place where they are required, typically a workstation in the production area or a warehouse near the production space, by a stacker or a forklift. Using this method the unit load for the supply of goods (raw materials, work in progress or end items) is the pallet, resulting in several major drawbacks for the materials flows function: (1) the supplied quantities are much higher than the ones needed in the production area in a given instant time, resulting in an excess of work in process since the materials in excess remain near the workstation after the production finishing, until their fully consumption in future productions; (2) there is a lack of efficiency of the process and at the end the productivity is compromised, since the production workers are also involved in the movement of the materials, leaving for some periods of time their workstation; and (3) the principle of work design is compromised since the safety conditions offered to the workers are not, by far, the best ones due to the lack of space to perform their tasks using free body movements (the space near the workers is in general occupied by the goods supplied or to be collected after the production process).

The two alternative solutions under study are: a conveyor system and a milk run system. These solutions are more sophisticated than the materials handling method used currently by the factory unit, representing a different logistics flow philosophy. Therefore, the purpose of this study was to design the two alternative systems and to make a comparison between each other and with the current materials handling system. The comparison was performed through a TCO analysis.

### *2.1. The conveyors system*

This solution is characterized by a combination of a belt conveyor and an overhead conveyor. On one hand, the belt conveyor is the most requested element of the family of conveyors. This occurs probably by its more attractive cost of acquisition and also by its large spectrum of applicability[6]. This equipment is ideal for transporting material in long distances and it is designed for continuous flow of material[7]. On the other hand, there is the overhead conveyor. Several different solutions are available of this type of equipment. Everysolution serves the same purpose that is transporting material overhead across the facilities, creating available area on the plant layout[6].

Since the objective of this equipment is to create the conditions for the integral dedication of the production operator to the production activities, the choice for the free conveyor is not wise. This free overhead conveyor requires the products to be moved by the action of the operator by pushing the product or in some cases by the action of gravity. Likewise, this equipment is more common in plants

that have a low volume of production or have a high level of activities performed manually[6]. The solution gave by power and free is very sophisticated and requires a higher acquisition cost that is not justified for this application. Thus, the solution thought for the overhead conveyor is the powered one. This type of solution is suited to production systems with a medium to high volume of products. This equipment will also be transporting the material in a continuous movement[8] which is very fitting.

### *2.2. Milk Run*

The philosophy that supports the principle of the milk run is a novelty that the companies are applying in order to improve their productive systems, by reducing the work in process (WIP) at the lowest level[9]. The milk run is supported by the Just-In-Time (JIT) philosophy, since the material is only transferred to the workstation when it is needed [10].This equipment is the result of the tow in combination with the carriages. Since the milk run is manually operated, there is a requirement for the allocation of a human resource to drive the equipment[11].For the accomplishment of the principle of work of this equipment, there are some key issues that must be addressed, like the design of proper routes and time periods for each route[12].Another topic is the renewal of the kind of containers that are applied for the transportation of material. For the implementation of the milk run, the containers must be smaller and the quantity of product in movement on those must also be standardized[13].

## 3. The enterprise and the core business

The enterprise where the study was taken on is a manufacturing company belonging to the automotive industry. The enterprise is in an initial position on the supply chain where it is inserted. As so, the products that the company offers will be transformed in the next partners of the supply chain.

Thisfactory has two major clients. On one hand there is the first tier client system representing 84% of the clients. On the other hand, there are the Original Equipment Manufacturer (OEM) clients which represent 10% of the clients. The rest (6%) are considered as other clients.

The core business of the company in study is stated as manufacturing metallic components for the automotive industry. As so, the raw materials used in the facilities are giving by sheet, tube or wire of metal. Since the company is divided in several production processes (stamping, welding, wire and tube forming), it can offer a large number of different products. The total number of different final products producedby the industrial unit is around five hundred. The plant layout is shown in Figure1. In yellow is highlighted the robot welding sector, in blue the elements warehouse, and in green the final product warehouse - areas that are elements under analysis in the internal logistics system.

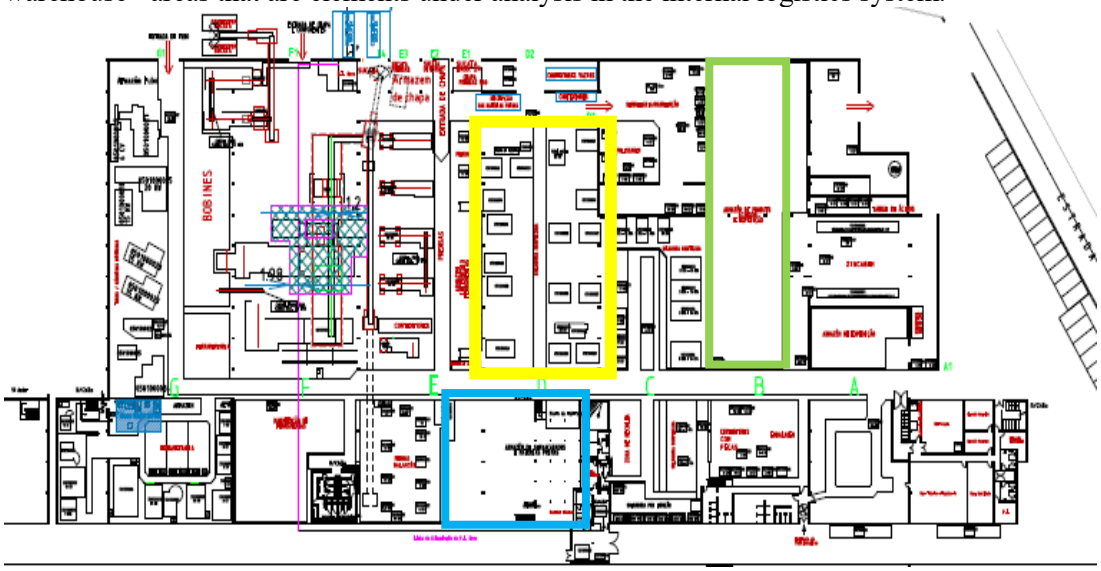


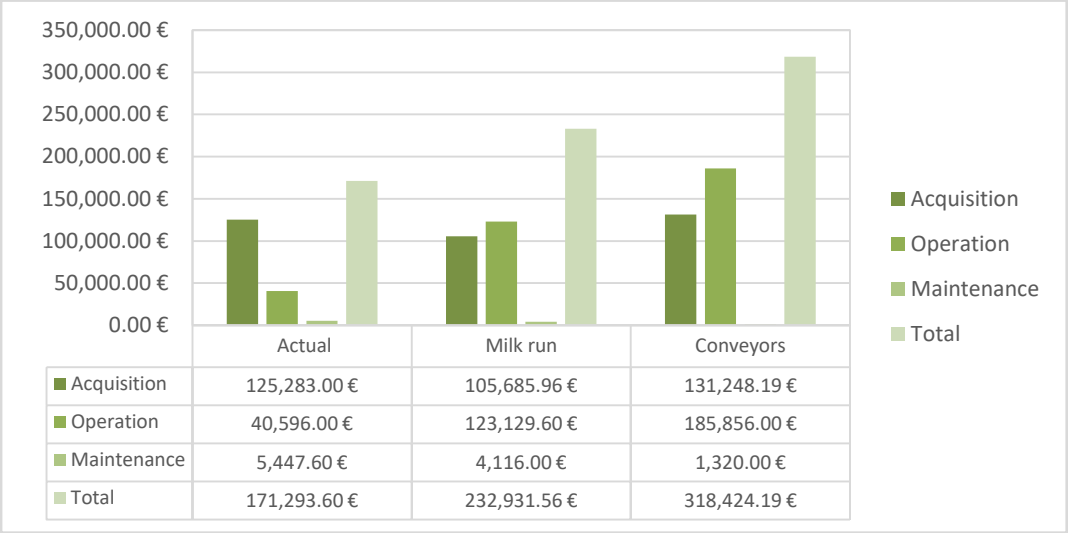

**Figure 1.**Layout of the factory and the highlighted areas analyzed in this study.

## 4. The applied methodology

The TCO analysis was developed in order to provide the more cost-efficient solution to the company. This analysis was made for a four years' period, in order to compare all the three systems (current, conveyors and milk run) in the same base. Also, it was considered that the traditional method was not implemented. As so it was necessary to purchase all the items in the three scenarios, as if it was the opening of the business.The Cost Breakdown Structure (CBS) for minor purchase was the approach followed, where the total cost is giving by acquisition, operation and maintenance costs [14]. Therefore, in each of the threecategories different costs were taken in account.

The acquisition costs were given by potential suppliers of the systems. So those values are the most accurate ones in a long-term period. The operation costs were estimated based on cost estimating relationships. Therefore, the cost associated with the non-value activities that the production operators take when they perform this logistic activity were estimated based on the man hour cost. The fuel was also estimated based on the total consumption of the forklift over a year. Specifically, it was estimated based on the distance that the forklift will do in a year, only for the pick-up of the final products of the family of products.Regarding the costs associated with maintenance, such cost was also found by cost estimating relationship. The cost of outsourcing was considered based on historical data, as well as the maintenance taken on the facilities. So the operation and maintenance cost could be less accurate in a long-term period.

It is also important to clarify that costs related to the stock were not taken into account. This assumption was made by two main reasons. In one hand, the information about the cost impact of the material stock of this family of productswas not available. In this case the consideration of cost could be completely inaccurate. On the other hand, the family of products is highly requested by the clients of the company. So the volume of production is high, and the stock of final products only occur during the week, since every Friday the product is always delivered. At the end of the week (Friday afternoon) the stock of final products is only made of the production of Friday. Nevertheless, the stock of the parts to be weld does not assume the same behavior as verified with the final products. Such parts are produced in the other plants of the company with a huge volume of production. So, these pieces parts are stored in the parts warehouse, where they are waiting to be consumed. The stock was very difficult to account, since it isn't only the plant of the warehouse that is occupied that should be addressed. There is also the cost associated with setup in the plants that produce those parts, namely the stamping sector. This is the only cost that was not taken into account. Also, as already stated in this analysis, it occurredafter the CBS for a minor purchase. On a more rigorous approach, it will be necessary to have moredetailed costs. The result of the TCO analysis is presented in the Figure 2.




| | Actual | Milk run | Conveyors |
|---|---|---|---|
| Acquisition | 125,283.00 € | 105,685.96 € | 131,248.19 € |
| Operation | 40,596.00 € | 123,129.60 € | 185,856.00 € |
| Maintenance | 5,447.60 € | 4,116.00 € | 1,320.00 € |
| Total | 171,293.60 € | 232,931.56 € | 318,424.19 € |

**Figure 2.**Result of TCOanalysis.

## 5. Conclusion

Remarkably, the conveyors system demonstrated to be the most expensive solution in all the categories, besides the maintenance. The cost of maintenance was estimated based on the number of hours that the enterprise actually spentin maintenance of each lubrication tunnel. So this value can be underestimated, since the breakdowns are not considered. Despite the lesser cost being associated with the maintenance activities the total cost of this solution is remarkably higher than the other ones. And because of that, it won't be presented to the factory as the best solution.

The milk run has shown two categories (acquisition and maintenance) that are less expensive than the traditional method. Yet, the total cost is higher than the current method. Here is a good example that taking only the acquisition cost can lead to hasty decisions. In this context, the limitation of the milk run is in the operation cost, becausethe logistics operator is more dedicated to the activity of supply and pick-up of workstations (40 minutes each hour) than in the current system. In the current system the warehouse staff goes only once a day to the workstations, in order to supply them with the parts for the welding process.With such results, the best choice is to maintain the current system, although the factory unit must be aware that also other criteria exist besides the cost.

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