# Implementation of an RFID tracking system for returnable container control in the distribution of pharmaceuticals - Case Study

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**Abstract**

Nowadays, companies are increasingly more aware of their practices due to social responsibility, logistic, economic and ecological benefits. One of the strongest concerns in logistic operations is the use of returnable containers instead of the common disposable packaging. However, an inefficient management of the containers pool leads to an increase in the costs of loss and replacement.

In this article, a new procedure was developed to control the returnable containers of Company X, a Portuguese pharmaceutical distributor that spends an average of €100k in new containers every year. The current barcode based tracking system is outdated and flawed, easing up to the shrinkage of the containers' pool by misplacement or theft. It's necessary to perform a redesign of the process paired with the introduction of a more advanced auto-identification technology such as RFID (Radio-Frequency IDentification) that allows wireless data transmission between a tag and a reader through radio-frequency waves, without requiring line of sight and with the ability to read multiple tags simultaneously.

As a result, a solution was conceived including RFID reading modules in the warehouse, in the transport vehicles and the tagging of about 100k containers with passive RFID tags. The execution plan was developed along with suggestions for change management. The new solution brings many benefits, especially major time gains, reduction in the number of tasks performed by operators and Company X is predicted to save about €75k per year.

**Keywords:** Reverse Logistics, Control of Reusable Containers, Auto-identification Technologies, Barcode, RFID, tags.

**Abbreviations:** RFID – Radio-Frequency Identification; RL – Reverse Logistics; CLSC - Closed-Loop Supply Chain; RTI – Returnable Transport Items; ERP – Enterprise Resource Planning; TMS – Transportation Management System.

## 1. Introduction

Nowadays, globalization and the craving for competitive advantage motivates companies to expand their internal operations to complex supply chain networks even across other countries [1]. The direct supply chain refers to the downstream movement of products from the manufacturer to the retailer and when a client returns a product, an upstream movement is originated from the retailer to the manufacturer. This upstream movement is called reverse supply chain or Reverse Logistics (RL) and the integration of both downstream and upstream movements is called a Closed-Loop Supply Chain (CLSC). CLSC are key factors in sustainable business operations and have received increasing attention due to environmental regulations and economic reasons [2]. As a result of CLSC management, Returnable Transport Items (RTI) have increasingly been introduced in various industries and may offer significant benefits over traditional disposable packaging. RTI include for example, reusable pallets, containers, trays, boxes, barrels, etc. RTI are often adopted by companies to reduce packaging waste, improve working environments, improve protection and security of products, to have a more efficient handling and to meet waste reduction levels demanded by governmental regulations. There are numerous costs associated with adopting RTI but the list doesn't include shrinkage (theft or misplacement) [3]. In many industries, the loss of RTIs poses a severe problem to companies. For instance, it was reported that the annual loss of cylinders in the packaged gas industry is between 10% and 15% and the annual loss rate for pallets of about 10%. Another study showed that a lack of customer compliance in returning reusable packaging material causes an annual loss of up to £140 million just in the UK [4]. The cost of a single RTI can go from a few euros to thousands of euros and it's common that the value of the RTI exceeds the goods that it holds. Hence, a RTI pool often represents a significant initial capital investment, and shrinkage may represent a considerable operating cost [3]. For Company X, this cost is about €100k every year in container replacement.

If not managed properly, the use of returnable containers can significantly raise logistic costs. Containers are routinely misdirected or lost, and they are rarely tracked in system-wide information systems. As a result, companies need to increase the number of containers due to longer stockholding or reuse by the receiver, the receiver giving the RTI to another user, failure to collect the empties and get them ready for reuse [5]. The problems and inefficiencies outlined also characterize the state of returnable container management problems experienced at Company X. Most of the reviewed literature, including case studies, identified lack of visibility as the major contributor to ineffective returnable containers management. In short, this visibility translates into information that allows managers to make decisions to improve the supply chain's performance [6, p. 500]. One key ingredient for improving the visibility of containers throughout the supply chain is the use of Automatic Identification (AutoID) technology. Using AutoID systems to track returnable containers can improve the return on investment by lowering operating expenses including transportation costs. However, to exploit the full benefits of an AutoID technology, it is essential that the physical flow of the containers as well as the information flow is thoroughly understood, characterized, and analyzed [7]. Such analysis can then lead to proposals, including the proper AutoID technology, which can address the logistics difficulties experienced by Company X. Before implementing a new AutoID technology the information flow must be improved and new abilities must be added to the information systems. It is also of major importance to implement liability contracts that bind the parties and ensure responsibility for the Company X-owned returnable containers.

An extensive review of the literature provided that several AutoID technologies allow the control of the RTI, such as the bar code, RFID (Radio-Frequency Identification), Wi-Fi, GPS and the Internet of Things, technologies used to increase productivity and reducing human error by automating some of the information processing tasks [7,8]. Logistics and supply chain management are heavily influenced by the rapid development of new technology. However, the development of technologies and systems for logistics information is ongoing, and the interest in advanced automated data capture and identification (Auto-ID) technologies, particularly radio frequency identification (RFID), has increased greatly. RFID technology has been a 'hot' topic during the last couple of years and uses radio waves to transfer the data between a reader and a tag attached to an item to be identified. Compared with bar codes, the main strengths of RFID are that multiple RFID tags can be read simultaneously and through non-metallic obstructions not requiring line-of-sight. Hence, RFID technology can potentially provide real-time information to manage operations and enable supply chain visibility [9].

## 2. Company X – Case Study

### 2.1. Overview

Company X is a Portuguese pharmaceutical distributor that delivers healthcare products to over 2000 clients across the country, with about 500 employees and 5 warehouses. Motivated by having a more efficient and environmentally friendly operation, Company X uses returnable containers to carry out its operations. The very dynamics of the operation make them a convenient solution since the turnover of the business is very high and most clients receive orders every day or even more than once a day, allowing them to be collected upon a new delivery. The typical delivery process goes as follows: the container is shipped, the carrier delivers it to the client, collects the empty containers from previous deliveries and returns them to the warehouse. In addition, the containers serve as a vehicle for transporting the products within the warehouse, along the automatic conveyor system. An order from a client results in the assignment of a container where all products of the order will be placed as it goes through conveyor system along the necessary areas of the warehouse until it's ready for shipping. The container is the same from the beginning (moment of client assignment), to the end of the process (delivery to the client). Plastic containers are not only a convenient and efficient method of transporting the products to the company's clients but also a safe method. They are made of sturdy plastic and when the order is complete they are closed and sealed, making them virtually tamperproof. In addition, containers are stackable, simplifying logistic processes. Figure 1 shows a container used by Company X.

Figure 1 – Container used by Company X.

Every day, about 15k containers are shipped, of which 7k are shipped from the Lisbon warehouse alone. The total container pool is about 100k, including containers in storage, emergency stocks and those out in regular operations. Company X is faced with the need to invest large annual amounts in the acquisition of new containers. To be exact, €230k in the last two years. Nowadays, containers are tracked through a barcode system along the entire conveyor system and the delivery operations. The direct flow (warehouse-client) is tightly controlled and has high visibility. The problem occurs in the return process, the reverse flow (client-warehouse), that currently has little control and poor visibility, reflecting an inefficient RL management. The fact that they are empty and apparently have no value and the interest in simplifying the work of the carrier for faster deliveries, led Company X to adopt this ineffective control. Furthermore, it's possible that containers have significant value in parallel markets and that this may be one of the reasons behind the disappearances. Company X believes that the main causes are directly related with two players in the process: carriers and/or clients.

### 2.2. Analysis of Current Process

It's relevant to fully understand the whole process from the moment a product is received from a laboratory, goes through all different warehouse stations and is shipped to the client. Figure 2 illustrates Company X's current process from a container point of view. When the order is complete, containers are then sent to the successive labeling, billing, closing and sealing stations, to be finally shipped. In the Shipping section, the containers are sorted by routes, loaded onto the vehicles by their carriers and delivered to clients. Upon returning to the warehouse, the carriers bring the empty containers collected in the clients along the routes, as well as any products for exchange or return. The latter go to the Exchanges and Returns section for processing. The empty containers are stacked in the Shipping section near the feeding lines of the conveyor system to re-enter the lines and restart the process.

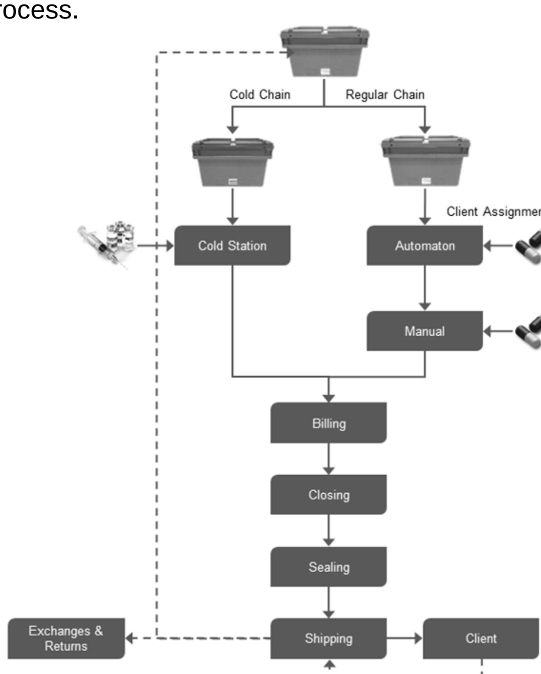



Figure 2 - Simplified representation of Company X's process.

### 2.3. Monitoring of carriers and clients

The main causes of the disappearance of containers may be directly related to their handling by clients and carriers. Thus, it was relevant to monitor both for statistical data collection. Regarding the carriers, most of their protocol is mandatory by the TMS (Transportation Management System) on their PDA, that is, the carrier can only proceed to the next task when the previous one is finished. The monitoring was done along 6 routes with 5 carriers, with a total of 77 stops. It was stated that most of the tasks were performed correctly and according to the protocol in 100% of the stops. The irregularities found were: in 13% of the stops the client didn't sign the carrier's PDA solely due to the fact that the delivery was made behind closed doors, i.e. before the opening hours of the establishment; in 12% of the stops the carrier did not collect the empty containers or products for return and of these 12%, 78% are due to the non-existence of containers to collect and the remaining 22% to the fact that the delivery took place behind closed doors. Clients monitoring was done simultaneously with the carriers, escorting them at all stops, entering the pharmacies and even in their storages and back offices. These spaces were observed discreetly, in order to identify retained containers. Of the clients monitored, 19% had withheld containers for their own use. Clients were seen with 1 to 15 retained containers, with an average of 4.1 retained containers per client. Figure 3 shows one of the cases identified in the monitoring, in which the client had retained about 15 containers to perform KAIZEN techniques. It should be noted that only the visible retained containers were identified, being impossible to know the actual quantity of containers previously retained by the client, that are most likely irretrievable.

Figure 3 – A pharmacy with containers for own use.

There was a need to conduct a small inquiry to the carriers, regarding the procedure of returning the containers to the warehouse. Company X has about 80 outsourced carriers in the Lisbon location, and a sample of 20 was inquired. Of the inquired carriers: 100% always scans empties; 20% never scans the containers that carry the returns; 25% of the carriers scan containers at the end of the route, wherever they are. That is, only 75% scans in the warehouse. It should be noted that this is part of normal procedures, because not all carriers return to the warehouse at the end of their shifts. The reason why 20% of the carriers do not scan the containers with returns is because they think they will be scanned in the Exchanges and Returns section, reflecting a lack of proper communication and training.

### 2.4. Weakness Analysis and Suggestions

After process mapping, monitoring, inquiries and meetings with section managers, several weaknesses were identified in the system, related to the softwares used, the clients and the carriers.

#### 2.4.1. TMS software

TMS (Transportation Management System) is the professional fleet and delivery management tool used by Company X and featured in the carrier's PDA, with barcode reading ability.

***Unidirectional information flow*** – The TMS doesn't cross information completely with the ERP (Enterprise Resource Planning). The information flow is unidirectional, the TMS receives information from the ERP regarding the routes, the assignment of containers to clients, deliveries, etc., but does not send any information back to the ERP, because it doesn't allow it. For example, it would be beneficial if the scans of empty containers upon arrival at the warehouse were forwarded to the ERP system.

***Incomplete registration of key moments*** - There are 4 key moments in the life cycle of a container that must be recorded to obtain efficient container control.

a. **Warehouse exit** - Registered both in the ERP and in the TMS by the carrier before being able to start his route. All containers are individually scanned with the PDA (TMS);
b. **Arrival at the client** - Registered only in the TMS. All containers to deliver are individually scanned with the PDA (TMS);
c. **Collect empties at the client** - Not registered at the level of ideal specificity. The containers are counted manually and the number is entered in the carrier's PDA (TMS);
d. **Warehouse entry** - Registered in the PDA (TMS). It should also be registered in the ERP and there is a dedicated portable scanner for this. Carriers don't use it because they think they are duplicating information and find it to be a waste of time since they have already scanned them with the TMS. In fact, the goal is to have a simple procedure and this problem would not exist if the two softwares would cross information efficiently.

***Containers scanned more than once*** - a carrier can reach the warehouse and read the containers stacked in storage and the same container can be read several times by the TMS without issuing any error. This allows that the possible theft of containers is untraceable. The solution would be to prevent the storage containers from being scanned again, which would only be possible in two ways: using the ERP scanner or the PDA to issue an error. The reason why the first solution does not apply is explained in the previous paragraph, and the second solution would imply that the PDA had stored the information of all the stacked containers and connected in network, which at this moment is impossible, due to limitations of the own hardware. A solution is needed to avoid this situation and to allow the visibility and traceability of the containers from the moment they are delivered to the client.

***The number of containers held by the client is not accounted*** - currently the ERP system accounts the number of containers in each client, in theory. But there is no control of the ratio of number of containers delivered versus containers collected. That is, the carrier collects the containers that are available for collection, without having any information on how many containers the client has, theoretically, in his possession. Ideally, empty containers should be scanned individually with the PDA, but Company X has decided not to carry out this operation in order to simplify the work of the carrier for faster delivery and collection. For example, the ERP system can declare that a particular client has 300 containers and when confronting this client, they can say that they don't have them. In this situation, the carrier himself can say that he has collected them and Company X has no way of proving or refuting this. The solution would involve the accountability of the client with the possible debit of lost containers. But for this it's necessary to have a well-structured and precise information support.

#### 2.4.2. ERP system

Company X's ERP system is responsible for all operational management of the warehouse, namely: orders, suppliers, clients, sales, etc.

***Cleaning and repair of containers*** - When the containers are dirty or damaged, they are sent to the Oporto warehouse for cleaning, repair or disposal. Currently, in the ERP system, when entering a code for a certain container that has gone for cleaning and repair, the information returned is that it is in the warehouse from which it was sent and not in the Oporto warehouse, because the containers are not scanned upon arrival there. There should be a cleaning/repair field in the ERP interface so that the location of the containers is always known and should also be scanned upon arrival at Oporto.

***Communication between warehouses*** – the ERP system of the 5 warehouses does not communicate efficiently. When searching for a certain container, the ERP system can return that it is in the street (in a certain client) but when searching for this same container in the TMS it can return movements referring to other warehouses. It's part of Company X's procedures to transfer containers between the various warehouses for reasons of inventory management of both containers and pharmaceuticals. These transfers should be immediately detectable by the ERP system of any warehouse, but for this to happen it's necessary that the information flows efficiently between them. Today, the only way to get a global sense of the containers on the street is to extract an Excel through an ERP script. This file is useful for statistical analysis but it's not an efficient tool in the daily control of containers.

#### 2.4.3. Clients

***Containers for own use*** - In 77 stops, 19% of the clients visited had retained containers for their own use. This reflects the fact that there is no control by Company X or any pressure on the carriers and on the clients to encourage the return and collection of the empty containers. There are several possible solutions to make clients accountable, such as making known the "Balance of containers" of each one, making surprise audits/inspections with collection of containers, implementing color coding to identify the level of containers of each client (Green - OK; Yellow - Attention; Red - Check and collect), etc.

#### 2.4.4. Carriers

***Containers with returns*** - 20% of carriers never scan the containers that carry the returns. This can be easily solved by appropriate training and surprise audits/inspections to the carriers. This flaw is significant because it's common that some containers are held in the section of Exchanges and Returns for an undetermined time, due to expiration periods, for example. And during this time, the containers are given as lost because they weren't scanned upon entering the warehouse.

## 3. Development and Evaluation of Solutions

Considering the problem presented and the technologies available, it was verified that RFID technology is the best alternative to control the empty containers of Company X. Other technologies such as Wi-Fi, GPS and Internet of Things, demand much higher costs due to the higher price of the tag. A new solution with RFID was designed.

### 3.1. Proposed Solution

The preliminary solutions proposed in the previous chapter are related to the current process. Company X can implemented them to solve the problem but with higher complexity. Scenarios where client signs the PDA also in the act of collecting the empties, or the carrier scans each empty container at the client are solutions that would allow closing the existing gaps in the current process. However, these highly complex solutions would not be beneficial to client relations or process efficiency, since the carrier would take longer at each stop. The solution to this problem has to be simple and effective, without causing inconvenience and the need for additional tasks. Thus, it was confirmed that the best way would be to implement RFID technology to complement the existing barcode system. After much research and discussion with interested parties, it was concluded that the solution to the problem of the disappearance of containers requires essentially the registration of two new key moments with RFID: entry in the vehicle and entry in the warehouse. This solution requires the upgrade of Company X's vehicles with RFID portals to automatically scan all the empty containers loaded by the carrier during the route and an RFID gateway in the warehouse that will scan all empty containers the moment the carrier crosses the gateway. Therefore solving existing gaps and closing the container cycle, allowing a subsequent and much needed accountability of the parties.

#### 3.1.1. Choosing the Tag

Despite the superior characteristics of active and semi-passive RFID tags, passive tags were chosen because they satisfy the minimum requirements of the new system. For example, the average price of an active tag is around €15, the placement of active tags to all 100k containers would total an investment of €1.5 million, much higher than the expected investment in equipment. Moreover, a €15 tag in a container of around €6 is not reasonable when the passive tag is a cheaper alternative and equally solves the problem. On the other hand, active and semi-passive tags can have environment sensors installed, which is unnecessary for the company's daily operations. Besides the economic advantages of the passive tag, its small dimensions and 2D structure, allow it to be more easily applied in the containers, since they can be placed under a common barcode label, becoming virtually unnoticeable.

#### 3.1.2.The solution

RFID and the new process add value to two actions that the carrier is already doing: loading the empty containers into the vehicle and unloading them into the warehouse. With passive RFID tags placed on the containers, the carrier is able to perform these two actions and, at the same time, the containers are automatically scanned. In Table 1 it can be observed that each new RFID task has the ability to replace two current tasks without adding new responsibilities to the carrier. With the new solution, there's a simple method for assessing the responsibility in case of a lost container. If a container is missing, it means that it left the warehouse, but did not return. This happens only in one of two situations: it entered the vehicle and didn't enter the warehouse, and it's the carrier's responsibility; or it didn't enter the vehicle at all, and it's the client's responsibility.

The solution comprises the execution of the three tasks represented in Figure 4: Collection, Scanning and Confirmation. Collection of empty containers by the carrier at the client; Scanning of the same containers by the vehicle's RFID portal; Confirmation by scannig the containers when going through the RFID gateway in the warehouse.

Table 1 - Reduction of the number of tasks performed by the carrier, with RFID.

| Site | Current Actions | New Actions w/ RFID |
| --- | --- | --- |
| Client | • Manual counting of empty containers.<br>• Introduction of the number of empty containers in the PDA. | • Vehicle scans empty containers automatically. |
| Warehouse | • Empty containers are scanned individually with the PDA.<br>• Stack containers and store them. | • RFID portal scans containers automatically. |

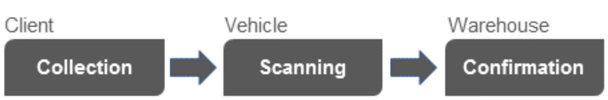



Figure 4 - Schematic of the three main actions with the new RFID procedure.

It's necessary to take into account that the solution also covers the direct process (warehouse-client), although for purposes of this article, the main focus is on the reverse process (client-warehouse). With the new solution, carriers will no longer need to scan each container while loading the vehicle, in the warehouse. As in the case of empty containers, the full containers only need to be loaded in the vehicle before the start of the route and then the authorization for departure given.

### 3.1.3. Modules

***Warehouse Module***

The Warehouse Module must be an RFID gateway that allows the mass scanning of containers to be stored the Shipping section. Figure 5 illustrates an example of an RFID gateway scanning a pallet of empty containers. The gateway must be able to scan all containers as they are carried, without stopping. In addition, to solve some weaknesses referred in item 2.3 and the necessities to the matter of Cleaning/Repair, Returns and Transfers between warehouses, the gateway must have a display that allows the choosing of these operations according to the needs.

Figure 5 – Warehouse module: RFID gateway.

***Vehicle Module***

The Vehicle Module must consist of an RFID reader and the necessary number of antennas for scanning all containers loaded. Figure 6 shows an example of an RFID system reading containers inside the load compartment. The RFID system must be able to scan all empty and full containers at scanning events defined by Company X. These events can be periodic or triggered by certain actions, such as stoppages or opening/closing of doors.

Figure 6 - Vehicle Module.

***Container Module***

The Container Module is consists of a passive RFID tag that allows its detection by the RFID readers. The code of the container must be recorded in the tag, to safeguard its history. Nowadays, a passive RFID chip has a thickness of less than 0.5 mm, which becomes virtually imperceptible when placed underneath a label. In Figure 7 c, an example of a passive RFID tag can be observed.

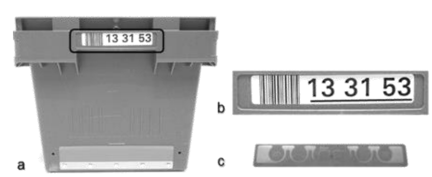



Figure 7 - Container Module.

Currently, a container has 6 labels. To avoid placing yet another label, it was thought to substituting one of the 6. The technology allows personalized printing on the tags to put the same information as before (Figure 7 b). Thus, the tag will allow a visual scanning of the barcode and transmit the same information to the RFID reader. In addition, RFID tags allow the recording of information, like the location/date/time of every scan, for example.

***Management and Maintenance Module***

Consisting of a computer with the control software of all the RFID systems implemented and that allows its maintenance. The computer is connected to an RFID reader and a printer, for reading, recording and printing these tags.

### 3.2. Budgeting

After online research of the RFID Portuguese market, supplier companies were contacted. Due to the sensitivity of the case study and the problem highlighted it is necessary that the information obtained through the RFID modules is accurate and above all reliable. Therefore, it was necessary to perform reading tests. The tests were conducted with supplier Z to serve as an illustration of the proposed solution and also of its validation method. The information gathered in the tests proved that the proposed RFID solution is appropriate to control the containers of Company X and ideal for its operations, since it allows the scanning of multiple containers in loaded vehicles and stacked containers going through an RFID gateway. As a result, all situations tested demonstrated 100% accuracy (all containers were read), and with the right polarization, at a very high speed (almost immediately).

The budgets were requested considering the following requirements:

a) **RFID gateway** - 5 warehouses
b) **Vehicle RFID system** – 170 vehicles.
c) **Passive RFID tags** – 100k containers.

Budgets were obtained from 3 suppliers (Z, O and T) and Table 2 compares the respective costs. The offer of supplier T proved to be several times cheaper than that of others. Meanwhile, the values proposed by supplier O are not reasonable when compared with the others. So, after discussing with the Company X's COO (Chief Operational Officer), it was decided not to proceed with supplier O. Although supplier T is the most inexpensive overall, supplier Z is the one with the cheapest tags (€0.16 each). It is necessary to understand why supplier T's tags (€0.67) are about 4.2 times more expensive than those of supplier Z and use this information as a basis for negotiation.

Table 2 - Comparison of the costs of the solutions proposed by the suppliers (without taxes).

| Supplier | Z | O | T |
|---|---|---|---|
| Equipments | €307,614 | €1,043,015 | €87,088 |
| RFID tags | €15,802 | €69,000 | €67,000 |
| Implementation Services | €86,785 | €189,500 | €25,400 |
| Total | €410,201 | €1,301,514 | €179,488 |

These budgets serve to illustrate the costs of implementing a large RFID solution and to assist Company X in the choosing of a supplier and in negotiating the offer. Based on the information obtained, it's suggested that Company X hires supplier T, not only because it's the most economical but also because it's acquainted with the company's operations and current issues. The fact that supplier T is responsible for providing the TMS, makes it able to offer a simple and integrated solution. It is believed that supplier T is the best option at all levels, mainly economical and logistical.

### 3.3. Benefit Analysis

This project is a case study on the application of RFID to control the containers of Company X. It was pertinent to carry out a benefit analysis of time and quality in logistics operations, economics and company image, resulting of the implementation, for purposes of this study and to justify the future investment.

**Benefits of time and quality in logistics operations**

As already mentioned in item 3.1.2, the proposed solution will eliminate a series of tasks performed currently, simplifying the process. These types of benefits are valuable for both Company X and the carriers, contributing to the rise of the satisfaction level and consequently a better workplace environment. It's proven that employees satisfaction is significantly correlated with their productivity and subsequent company profitability [10]. In the client, the act of counting the containers to collect and entering the number in the PDA will be eliminated. With the new RFID process, the carrier will only have to load the containers in the vehicle. In the warehouse, the new solution won't require the carrier to scan all containers individually. In the loading process of full containers, the vehicle module will scan them automatically, and in the returning of empty containers to the warehouse the RFID gateway will do the same, even if they are stacked. These procedure simplifications result in considerable time savings.

Time gains at the client were determined based on the following assumptions (average values): the carrier stays at the client for 2 minutes; collects 10 empty containers per stop; it takes 20 seconds to count the containers and inserting the value on the PDA; 20 stops per route. The same route can be done more than once a day so the calculations were made based on the number of rides, that is, when a carrier leaves the warehouse to make deliveries. Around 1973 rides occur every week, nationwide. So, with the RFID solution it is expected to save about 220h per week, nationwide. Per ride, the saving is approximately 7 minutes, allowing the execution of one or two more stops, depending on their locations. Considering that the carriers operate on average 8 hours per day (40 hours per week), a weekly saving of 220 hours means that it is possible to reduce 5.5 operators. This estimation is based on average values and helps to illustrate the significance of the time savings achieved with the proposed solution. It is foreseeable that due to the specificities of the business and its operations it's not possible to reduce 5.5 operators. However, such time savings can serve as a basis for renegotiating contracts with the outsourced transport companies to reduce costs.

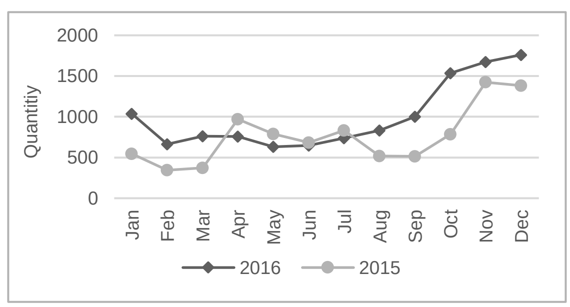
At the warehouse, simplifying the process will allow carriers to save time when loading and unloading the vehicles. On average, a carrier takes 12 seconds to scan 10 large containers and 14 seconds to scan 10 small containers, because small ones, when stacked, have the bar codes covered. Considering that a full container, has the same reading time as a non-stacked large container (12 s), and knowing that at the beginning of each route an average of 50 containers is loaded, the scanning of these containers takes 1 min. And regarding the empties, it would take about 4.7 minutes to scan the average of 200 small containers unloaded, the worst scenario. With the proposed solution, these times will be totally saved.

### *Economic Benefits*

In the last two years, approximately €230k were spent in new containers, with an average of about €115k per year. However, 2016 wasn't a typical year with the opening of the new Lisbon warehouse, which required the acquisition of more containers and cold chain components. Thus, the real average is about €100k per year in containers. Translating this in quantities, in these two years were bought about 13k large containers, 4k small and 19k lids.

The ERP system issues a report called "Containers Out" that lists all the containers that have left warehouses and didn't re-enter. The report states that the number of containers lost in 2015 is 9,161 and 12,041 in 2016, which totals 21,202 in the two years. Company X assumes a container is lost when it does not return to the warehouse one month after it leaves, so it's safe to consider these containers undoubtedly lost. Graph 1 shows that the number of containers lost tends to increase since the line for the year 2016 is higher in all periods except for 4 months (April-July).

Knowing that the average cost of a container is €6 and that the number of containers lost is 21,202, then the value of capital lost in containers in the last two years is around €127,212, of which €54,966 and €72,246 correspond to the years 2015 and 2016 respectively. These figures appear to be small when compared to effective purchases of new containers of €93,202 in 2015 and €133,880 in 2016. Looking at quantities, the values seem to be more coherent: in 2015, 9,161 containers were lost and 8,617 new ones were bought and in 2016, 12,041 were lost and 8,034 were bought. The apparent discrepancy comparing to the financial values is because we are comparing an estimated value with the actual value of vendor invoices. In this case the value of invoices is greater because the purchase of new containers implies the acquisition of all its components (labels, reinforcing strips, address kit, etc.). If we compare only the values of the container itself, large and small, excluding all other components, the values become more consistent. In 2015, for a loss of €54,966, the company purchased €55,407 in containers and in 2016 a loss of €72 246 resulted in the acquisition of €48 660. The fact that the 2016 figures are relatively higher than in 2015 may come from the assumption that the report considered as lost in 2016, containers that could still be brought in later in 2017.




Graph 1 - Quantities of containers on the street in the years 2015 and 2016, from the ERP report "Containers Out".

For the previous calculations, it was assumed that €6 was the average cost per container, but when a container is lost, all of its components are also lost (lid, address kits and bar codes, cold chain components, etc.). Hence, it's pertinent to determine the real value in lost containers. A normal chain large container costs €10.92 while a cold chain container costs €18.73 (with a polystyrene thermobox, icepack holders and icepacks). Knowing that about 10% of containers are from cold chain we can assume that 10% of the lost containers are also cold chain. Thus, the actual value for the loss of

21,202 containers in the last two years totals €248,082 in reality, a figure much higher than that of €127,212, calculated assuming the average value of €6 per container, and much more in agreement with the total value of vendor invoices of €227,082. Knowing that there is an average annual expense of about €100k, the ideal would be to save this amount in full. However, there are always costs associated with container operations, including recovery and replacement. According to Company X, the number of containers decommissioned is residual, therefore, this parcel will be discarded. To recover (clean and repair), there are currently about 6k containers stored in the warehouse of Oporto, resulting from one year of operations. These containers represent a cost of approximately €37k if replaced by new ones. However, Company X has studied the possibility of hiring an employee to perform full-time container recovery that would cost €939 per month. Working 22 days a month, with a recovery rate of 90 containers/day, the employee will take approximately 3 months to complete, with a cost of only €2,818 plus the cost of consumables (barcode kit and address kit) of €6,050, totaling €8,868. Hiring this operator is much more viable than buying new containers, with a saving of about €28k a year. Based on the previous information, it's safe to assume that 6k containers are damaged every year (500 per month). It should be noted that the annual €100k spent on new containers considers the replacement of the damaged containers instead of their recovery. But, after the implementation of this project, Company X will do this recovery, allowing the saving of this value. The new RFID solution will reduce but not eliminate the losses of containers completely. The losses can still occur due to a variety of reasons, and if proven to be the responsibility of the carriers/clients, the activation of the debits will be a decision ultimately taken by Company X. It's estimated that the future losses will be €25k per year, approximately 2,500 containers. It's possible that the losses are lower and the savings greater, in reality, but for the purposes of this article, it is advisable to use this as a safety margin. Therefore, an annual saving of €75k is foreseen. If the debits are approved, the potential savings can be greater. In addition, the loss of 2,500 containers per year translates into about 210 containers per month, which is 87% lower than 1,631 which is the average number of containers currently lost per month. Thus, the implemented solution allows a saving of approximately 75% of the current expense, that is, €75k per year. Considering the offer of supplier T with a total investment of €180k, and with an annual saving of €75k, it is expected that the payback time of the investment will be in 2.4 years (approximately 2 years and 5 months). It should be noted that these values are only estimations calculated to illustrate the potential benefits of implementing the designed RFID solution.

***Image Benefits***

With the implementation of the proposed solution, Company X presents itself as an avant-garde technology partner, inspiring confidence in its current and future clients. The fact that the company wants to control its reusable containers also shows that it's concerned not only with its economy but also with environmental protection and sustainability. Furthermore, the designed solution reflects the concern for quality control in the service, an important factor in the pharmaceutical industry.

### 3.4. Change Management

Change management is the process of continually renewing the organization's direction, structure and resources to meet the changing needs of external and internal customers and to achieve greater efficiency. Change management helps new initiatives to be more likely to succeed, being accepted more naturally and quickly by the impacted employees. For this, it is necessary to involve the employees so that they can fully understand the proposed changes and believe in their objectives. The proposed solution requires the reengineering of the process and therefore will impact several areas of the company and its business. It will have to be implemented in a phased and well-structured way [11,12]. The project was designed based on the warehouse of Lisbon that will function as pilot.

Tagging all 100k containers with RFID tags is a process that must planned so as not to disrupt the normal operations of the company and can be done by Company X or by the supplier. The new procedure should be notified in a timely manner to all employees subject to the change, from carriers, shippers, call-center operators, sales representatives, etc. Training sessions of 2 days per warehouse are advisable. Carriers must be trained in groups, so that operations don't stop. Due to sensitive nature of the new procedure for debit of lost containers, the announcement must be done tactfully so that employees don't feel like they can't be trusted. It must be done in a way that reflects the natural result of the technological evolution of the company with the ultimate goal of achieving higher levels of efficiency. The RFID installation in vehicles is expected to take place in 6 weeks, with 2 weeks for the Lisbon warehouse alone due to its larger fleet, and one week for each of the remaining warehouses. Notifying the clients about the change is the most delicate task of this procedure.

Presently, clients don't feel any control by Company X regarding the containers, excluding extreme situations. Starting to enforce this control in order to execute the possible debit of lost containers will be seen as a drastic change and therefore has to be done in a thoughtful way so as not to damage client relations irreversibly. The company's ERP system has to be improved to receive information from the RFID modules and the company's billing system has to integrate a new management tool for container balances and allow the execution of debits. Full implementation of the process is expected to take about 4 months.

## 4. Conclusions

The goal of this project was to develop a new process for controlling the reusable containers of Company X implementing RFID technology. This company uses returnable containers to deliver pharmaceutical products, but its high rate of disappearance facilitated by poor management of its reverse logistics, leads to high loss and replacement costs. Currently, the automatic identification system used by Company X is the barcode that provides low visibility in the return process of empty containers. RFID (Radio Frequency Identification) technology with its mass reading abilities and without requiring a line of sight, proved to be a better solution to increase the visibility and reduce losses. This control must be done through RFID gateways in the warehouses and reading modules in the vehicles that allow the detection of passive RFID tags attached to containers. This technological solution combined with the reengineering of the process, allows the assessment of responsibility in case of lost containers, and the debit of their value to carriers and/or clients. Scanning tests proved that the proposed RFID solution is appropriate to control the containers of Company X and ideal for the type of operations performed. All situations tested demonstrated a 100% accuracy (all containers were read), and with the right polarization, at a very high speed. The budgets obtained for the solutions were quite different: €179,488 from supplier T, €410,201 from supplier Z and €1,301,515 from supplier O. It is suggested that Company X hires supplier T, not only because of its low cost but because it is already responsible for facilitating Company X's delivery and fleet management solutions (TMS), making supplier T capable of offering a simple and integrated solution.

As expected the new RFID solution brings several benefits. The solution will eliminate a series of tasks performed by carriers, allowing the simplification of the process and the saving of time. The elimination of tasks in the client and warehouse is expected to save up to 220 hours of labour per week, nationwide, being able to reduce the number of operators by 5.5. The new solution will allow a potential annual saving of 75k €. This project was presented to the Company X's COO who decided to take it to the Executive Committee for approval.

For future studies, it would be interesting to tag about 1% of the containers pool with a more complete technology like the Internet of Things, for example [8]. These tags allow the real-time tracking of the containers and don't require the presence of a reader to transmit their signal, since they communicate through a wireless network that covers about 75% of the national territory [13]. This sampling test would be interesting to determine loss patterns in the routes and therefore complement the designed solution for container control with RFID.

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