KEYWORDS SLA – service level agreement telecomunications
spare parts project closed-loop supply chain

Lebhon Régis Guimarães
Siemens Enterprise Communication, Curitiba, Brazil
lebhon@siemens-enterprise.com

José Eduardo Pécora Jr., Ph.D.
Professor at Federal University of Paraná (UFPR), Curitiba, Brazil
pecora@ufpr.br

Darli Rodrigues Vieira, Ph.D.
Professor at Université du Québec à Trois-Rivières – UQTR, Canada
darli.vieira@uqtr.ca

Effectiveness of SLA PROJECT with spare parts MANAGEMENT: The case of a telecom equipment industry

ABSTRACT

Managing a portfolio of customers of telecommunications equipment has several challenges, including the sales of the equipment itself, winning the contract for maintenance, but it is also to maintain the agreed level of service for this contract and give the customer required value to post-sale management. The primary objective of this paper is twofold: 1. Characterize the structure of the logistic cycle of spare parts for telecommunication equipment, underlining the importance of each process and the reasons, which require discipline in the control of every item in stock; 2. Verify the alignment between the decision makers concerning the choice of relevant criteria to assist the decision making on whether or not to acquire certain inventory items.

INTRODUCTION

Managing a portfolio of customers of telecommunications equipment has several challenges, including: the sales of the equipment itself, winning the contract for maintenance, but also to maintain the agreed service level for each contract and to provide the customer the required value for post-sale management.

In the telecommunications equipment industry, due to the increasing reliance on technology, customers require a fast response in case of an emergency, either maintenance or replacement of their equipment, through an aggressive Service Level Agreement *(SLA)*. Examples of this reliance are: *(1)* banks that require constant availability on their websites for consultation and/or operations of their clients in the comfort of their home *(competitive advantage)*, *(2)* cable TV operators that require the transmission availability to thousands of subscribers, *(3)* oil companies that have pipelines monitored throughout the country to avoid leaks or pressure loss in the transmission of their products, amongst others.

The resulting loss for companies that depend on reliable telecommunications equipment is not only restricted to costs, it also includes client satisfaction and their level of service. Therefore, a rupture in their production systems due to malfunction of the telecommunication equipment which is not repaired in the agreed time span, translates into fines, often exorbitant. This practice mandates suppliers of the telecom equipment to keep an adequate quantity of spare equipment as close as possible to their clients. Actually, this decision is linked to the tradeoff: maintenance cost of spare parts versus clients' level of satisfaction.

In the context of Supply Chain Management operations, the logistics of spare parts has many peculiarities, such as the reverse logistics of the defective part to repair the malfunctioning component. After it has been repaired, the equipment is sent to the nearest warehouse, or if it cannot be repaired, it is sent for disposal or recycling. This effort, which is focused on the management of spare parts, ensures that the process of an eventual recovery, disposal or recycling can be done as cheaply and efficiently as possible.

Therefore, improving spare parts management in the supply chain to guarantee the SLA is a priority for many sectors and companies. It is the spare parts logistics cycle that management action should focus on to optimize its flow. It is this managerial action that defines the efficiency of the stock parts policy focusing on the agreed level of service warranty. In this context, is very important to design an agile logistic network, forward and reverse, for spare parts, considering all the interested parties: the client, the domestic inventory and the repairer, thereby constituting a closed loop logistics network. It is the quick action of the reverse logistics network that will help to keep the inventory at adequate levels to meet the SLA at affordable costs. These set of actions have been termed Logistic Cycle of Replacement Spare Parts.

The project management of spare parts is characterized as project management with some specifics. Often, about 80% of the items in stock are little used over the years and nearly half *(50%)* of the stock will be obsolete in no more than 4 years. There is a variety of factors, including agreed service level and technological innovation, which affect the nature of the decisions made in projects. The definition of spare parts for new equipment does not use the same approach for projects of 4 or 5 year-old spare equipment or end-of-life equipment. Therefore, among other things, the success of the project requires in depth understanding of the product lifecycle management methodology *(Vieira, et al., 2013)*, excellent know-how of contract management and realistic information about the failure rate of products and processes. The project is not always developed under these conditions, which often increases the complexity and uncertainty concerning its management. In a recent study, Thamhain *(2013)* highlighted the importance of the degree of uncertainty and complexity such as variables affecting risk management. To minimize the risk and consequently the critical factors of success in the spare parts projects, a heavy involvement of stakeholders is necessary, and all of that within the perspective of the customer and the service provider *(Bryde & Robinson, 2005)*.

The main objective of this paper is twofold:

- 1. Characterize the structure of the closed-loop logistic cycle of spare parts for telecommunication equipment, underline the importance of each process and the reasons that require discipline in the control of every item in stock;
- 2. Verify the alignment between decision makers concerning the choice of relevant criteria to assist decision-making on whether or not to acquire certain inventory items.

This article is structured as follows: section 1 presents a literature review of the topics concerning closed-loop supply chain and spare parts inventory policies. Section 2 describes the case study detailing the logistic network, inventory policies, the main aspects of the project management of spare parts and also, a brief discussion about the decision-making regarding the level of stock of each spare part. Finally, Section 3 concludes the paper.

1. Literature review

The literature review is divided into two parts, the first focuses on the closed-loop supply chain, the second in spare parts management; both subjects are quite broad, therefore, only selected papers concerning the main focus of our work are presented here.

1.1 Closed-Loop Supply Chains

A Supply chain management is practiced by organizations that purchase, transform, and/or distribute physical products *(Shapiro, 2007)*. In essence, every company that buys raw materials to transform them into goods with more aggregated value is dealing with a supply chain. In this paper we focused on a special class of supply chain, called closed-loop supply chain. The classical supply-chain has physical products going from the producer to the customer, on the other hand, the closed-loop supply chain has physical products, which may be, but not necessarily, the same product produced and distributed by the forward supply-chain, traveling in reverse direction, from the customer to the producer.

Contrary to common knowledge, the closed-loop supply chains are not only about recycling and sustainability, although these play an important role in the enterprise and literature. Closed-loops supply chains are about returning physical goods in reverse flow. Managers usually see the return of a product as an undesirable problem, which, as a matter of fact, it is. But this common sense has a major implication on the design of the reverse supply-chain which is usually done to be as cost efficient as possible.

Fisher *(1997)* classifies the forward supply chains in two parts: responsive and efficient supply-chains, the main difference between them is that the responsive is faster and has a higher cost, while efficient ones are slower but minimize the total cost of operation.

Flapper et al. *(2005)* classifies these supply chains according to the types of returns: commercial, repair and replacement, end-of-use, end-of-life, production return flows and, finally, distribution returns.

Blackburn et al. *(2004)* present a classification for closed-loop supply chains and discuss their design. They state that the project of the reverse supply-chain should depend on the type of material to be returned. They classify the materials introducing the concept of the Marginal Value of Time for Returns *(MVT)*. Products that lose value rapidly are called time sensitive products and have a high MVT, while products that lose value slowly are called time insensitive products and have a low MVT. Examples of time sensitive products are generally electronics and time insensitive products may be power tools.

Using Fisher's *(1997)* classification and the concept of MVT, one can conclude that a cost efficient supply-chain should be used by companies that deal with the return of low MVT products, and responsive supply-chains may be used to transport products with high MVT. The study of Blackburn, et al. *(2004)* reports that the reverse supply-chain for both types of industries are very similar, leading to a value loss for the whole supply-chain.

The decision to close the supply chain is a strategic one; several aspects should be considered: where, when and why to close the loop, how to design the logistic network; certain organizational aspects as who to involve in the recovery process, the information system to be used, if or not the company wants to sell a green image and, of course, the profit associated. The profit is not always easily measurable, especially when the image of the company and the agreed level of service play an important role in the business drivers.

There are several reasons that a company may choose or be forced to close its supply chain. According to Flapper et al. *(2005)*, and also with the sustainability theory, all these reasons may be classified into Profit, People and Planet.

Profit has always been the main business driver for almost every industry. When a company faces the decision of closing the loop of its supply chain, this is no different. There are a number of reasons that a closed-loop supply chain will positively impact the economic performance. It may reduce the cost of raw materials, to optimize the distribution using empty trucks to perform the reverse loop transportation, to become less dependent on suppliers; closing the loop may also be used to protect the market share and open potential new markets. *(Flapper, et al. 2005)*

Good examples of companies putting an effort to close their supply chain are those that are switching their core business from production to service, such as copier manufacturers, who a couple of years ago used to sell their machines, thus making the client responsible for the good at the end-of-life. Today, they rent or lease the copy machines, changing their core business and creating the need for a reverse channel, once the producer is now responsible for the end-of-use machine. This implies a well-designed reverse logistic network.

The second and third business drive, people and planet, are closely linked to a company's image; usually the company will implement a closed-loop supply chain in order to meet clients' requirements or legal impositions. In several countries, companies are legally responsible to take back their products in their final lifecycle stage. In Brazil, the state of São Paulo now requires the white-line industries to be responsible for their products in the end of life-cycle. For a comprehensive review and the evolution of the closed-loop supply chains, refer to Guide and Van Wassenhove *(2009)*.

1.2 Spare Parts Management

Gelders and Van Looy *(1978)* presented different inventory policies for high and low turnover items in a petrochemical plant with 22 500 SKUs. Vereecke and Verstraeten *(1994)* implemented an algorithm for a computerized inventory management system of spare parts in a large chemical plant: the supply of spare parts studied here were about 34 000 different SKU, where 90% had a turnover of less than 4 times a year. Kukreja and Schmidt *(2005)* studied the case of a large utility company with 29 power generating plants in five southeastern states. They obtained interesting results, analyzing a small number of high-value items with an irregular demand. They also developed and proposed a control through continuous inventory. Porras and Dekker *(2008)* compared different methods of inventory control in a large oil refinery in the Netherlands. They noted that it is difficult to develop strategies for managing spare parts because they typically have a low and irregular demand with high volume storage.

Deckker et al. *(2013)* states that the research on spare parts management has been neglected over the past years. As a result, the methods used to compute the inventory level have been the same used for finished or in-process products *(Bacchetti, et al. 2013)*. Reinforcing Deckker, et al.'s *(2013)* analysis, neglecting the area of spare parts directly affects the leadtime, which is a measurable performance indicator defined as the time-span between the moment the order for the spare part is placed and the moment it arrives at the customer. Increasing this lead time is not advantageous to the client, manufacturer or the dealer.

Deckker et al. *(2013)* define four main issues in spare parts logistics management:

- Lead times: Here, we must distinguish manufacturing and transport lead times; the latter is the time it takes to bring a part from a warehouse to a client, and the former is the time it takes for the spare part to become available. Hence, the forecast of the spare part demand within its lead time is needed.
- Demand Characteristics: The demand for spare parts is usually intermittent, erratic and slow moving, thus, the forecast comes with a substantial level of uncertainty.
- Information sharing: Although there are inventory optimization possibilities between different services and providers, they refrain from sharing information, mostly because this is sensitive and strategic information and competition.
- Product lifecycle phase: The product lifecycle phase directly affects the management of the spare parts, as a product in its mature phase has much more need of spare parts than an end-of-life product. The Product Lifecycle Management (PML) is increasingly incorporating concern for spare parts, favoring the reduction of its costs.

Deckker et al. *(2013)* describe the demand for spare parts as erratic and intermittent, resulting in high inventory levels. Despite numerous authors who theorize about the forecast of spare parts, many of them do not generate good results. Deckker et al. *(2013)* have observed that the base installed over the entire lifecycle closely follows the product lifecycle. Therefore, there are significant advantages when making forecasts based on each phase of the product lifecycle *(initial phase, maturity phase and end-of-life phase)*. The following may be added to Deckker et al.'s *(2013)*: the environment in which the equipment is installed, the versions of the operating system of telecommunication solutions in each region and the diversity of the installed equipment.

2. The spare parts service Project: a case study in telecom

Yin *(2009)* defines the case study methodology as an empirical inquiry with a twofold characteristic: "1) a contemporary phenomenon in depth and within its real-life context, 2) especially when the boundaries between phenomenon and context are not clearly evident."

This case study focuses on the operations of a large telecommunications industry, aiming at describing and understanding the project of spare parts to guarantee the SLA. Spare Parts Management is not only a contemporary phenomenon but an extremely relevant phenomenon in certain high-tech industries, where they permanently accelerate the reduction of the product lifecycle as a competitive advantage. The project management of Spare parts to guarantee SLA is a very complex problem, mostly due to the intrinsic demand uncertainty and the different client profiles.

The telecommunications industry studied in this paper, named Enterprise X for the sake of simplicity, has several clients, each of them with a different SLA. Its main business is to provide the telecommunication structure, including hardware, at a given service level. Examples of clients are: banks, TV channels, hospitals, etc. and several other companies which strongly depend on the telecommunications structure.

Contracts between Enterprise X and its customers imply that their systems operate continuously or at the agreed service level, measured in non-operational time. If this SLA is not met, Enterprise X may incur high-level fees. Therefore, it is vital that these telecom structures run as smoothly as possible. In case of a problem, Enterprise X does not have time to produce the components in order to repair the equipment installed at its clients' facilities. What usually happens is that the technician simply replaces the faulty component with a new or remanufactured one, assuring the minimal non-operational time possible. That is why inventory of spare parts should be as high as possible; however, telecommunication equipment has a very short lifecycle and a high aggregated value, implying elevated costs. Thus, the company wants to meet all the SLA but at the minimum possible cost, to do this a very efficient spare part inventory policy is a must.

2.1 Logistic Cycle

Figure 1 presents an overview of the logistic cycle of Enterprise X with regard to replacement parts. One can observe the physical flow from its departure until its return to the shelf or recycling. The logistic cycle can be divided into three parts: the information system, the forward supply-chain and the reverse supply chain.

The logistical cycle starts with the planning of the spare parts policies. When a maintenance requisition arrives at the Enterprise Resource Planning *(ERP)*, it checks the availability of the spare part *(SKU)* in stock; if it is available, it is sorted to be shipped to the client, if it is not available, the

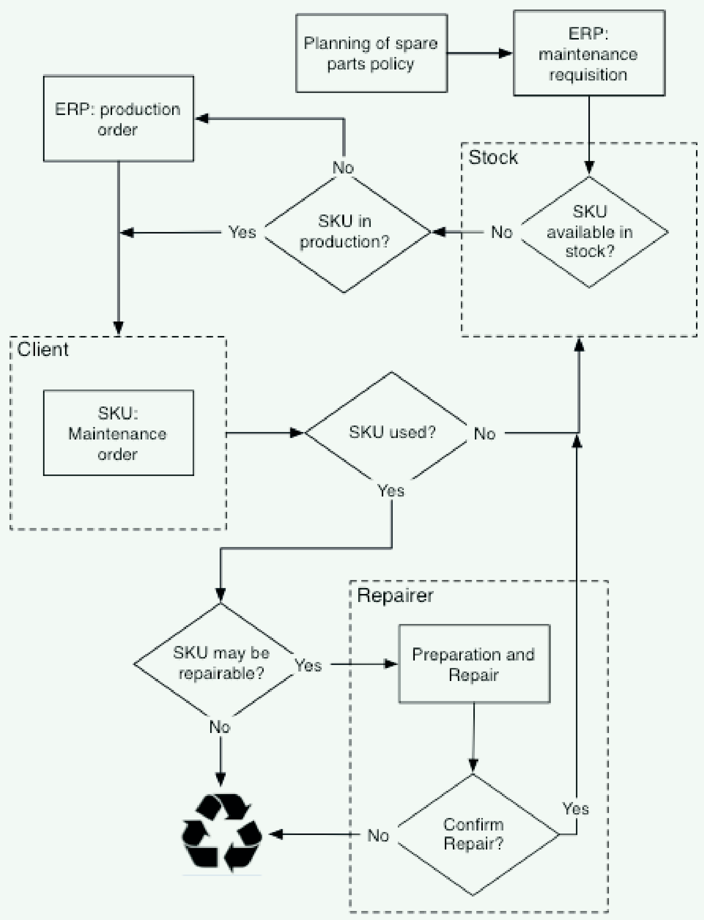

FIGURE 1. *Closed-Loop Supply Chain.*

system checks if the SKU is in production. If it is not in production, a production order is placed and the SKU is shipped directly to the client.

At this point, a forward supply to fulfill the maintenance order is begun. The components are then sent to the customer via a multi-modal logistic network from the closest warehouse. After the maintenance, the third phase, the reverse logistic, begins; if the SKU is not used in the repair, it is shipped back to the nearest stock. If the SKU was used, a technician evaluates the faulty component and decides if it may be repaired or if it goes directly to the recycling process. The repair process takes around 15 days, if the component *(SKU)* is successfully repaired, it is shipped back to the stock, if not, it goes to recycling.

2.1.1 Inventory Location

Another important issue concerning the logistic cycle is where to allocate the stocks. In this problem we have the classical trade-off depicted by Fisher *(1997)*; having one central stock is cheaper, but the service level is worse, having one stock at each customer ensures the service level, but the cost is very high. To tackle this problem, a model of multi-echelon inventory is used. In this model, the stocking-distribution structure is composed of main, secondary and tertiary inventories.

All the information necessary to manage the inventory, the demand and the cost of each SKU, their behavior by region, etc. are sent to the main warehouse, which receives information from other warehouses in the form of daily demand reports. The secondary and tertiary warehouses may be configured in size depending on the importance of the customer and/or the value of the equipment. Geography also plays an important role, especially when the territory is as vast as Brazil.

The main inventory is used for items with low demand, high value that does not have spare parts contract with the supplier. The secondary inventory is for items with high demand and replacement items that have high vitality in customer equipment. The amount and types of SKU are determined by the amount of equipment *(installed base)* for clients per region and their SLA. The tertiary inventory holds smaller amounts of SKU and is installed in the client's facility. It serves only customers who have an extremely aggressive service level agreement *(SLA)*, customers classified as "A" in the sales portfolio. These items are of high vitality, because if they fail, the customer's solution can be completely or largely paralyzed, causing damage in their operations or their own customers.

Figure 2 illustrates the three echelon inventory configuration.

- **The main warehouse (primary):** Its location should be where the client installed base is larger and where low demand and high value added materials do not have a spare parts contract with any client.
- **Regional warehouse (secondary):** High demand materials and also replacement items that are of great importance to the customer equipment can be concentrated here. The quantity of each SKU is determined by the amount of equipment (installed base) and their customer's SLA. By definition, the size of the regional warehouse is smaller than the main one.
- **Kit (tertiary):** These are smaller quantities of equipment that are stocked inside the client's building. These items are vitally important for the maintenance of the client's equipment. Note that only very important clients with a very aggressive SLA, classified as client type A, should have a spare parts kit. To assure information flow runs smoothly, every tertiary warehouse is connected to one and only one secondary warehouse is linked to the primary one.

2.1.2 Technical expertise

One way to minimize costs is through the efficiency of the technical team. The technical expertise to identify what is the real cause of the problem in the equipment is critical to control logistics costs. The physical transportation of the wrong SKU from the warehouse to the customer increases the shipping cost in sending and returning the component, and also causes the unavailability of the item on the shelves for a possible service to another customer. The training of technicians generates an economy generally not measured and, above all, reduces the probability of the client experiencing problems with technical competence.

When dealing with a client who has an SLA that is not very aggressive, the components to be used in maintenance are shipped from the main or the secondary warehouses. In order to be sure whether the components are really needed, Enterprise X has a process of confirmation of the SKU to be used. The SKU is sent only after the technician's confirmation.

2.1.3 Transportation

To ensure the agility and the responsiveness of this logistic cycle, and consequently, the fulfillment of the SLA, Enterprise X also has several transportation modes, from aerial, for the SKU with the most aggregated value, to road transportation for the recycling items going by motorcycle transportation to clients around 70 km from a distribution center or an airport.

Which mode will be used depends on the distance and the urgency of the order. Air transportation, the most expensive, is used when the equipment required is urgent. Enterprise X uses the multi-echelon inventory structure as a buffer to avoid the use of aerial modal. They also use rented vehicles to transport their equipment, also an expensive mode, but it may be used depending on the noncompliance penalty of the SLA.

The most common operation is road transportation to replenish the inventory of the secondary or tertiary warehouses and also for the reverse flow of components to be recycled or remanufactured. This mode cannot be used in emergency situations. If the client is in a radius of at most 70 km, motorcycle transportation is the most efficient one considering cost and velocity. Motorcycles are generally used to transport from the main warehouse and from the airports to the clients. This mode may also be used to return the parts with high aggregated value to remanufacture.

The use of different transportation modes and even multimodal transport increases the responsiveness of the closed-loop supply chain and helps to decrease the costs.

2.1.4 The "preponement"

Preponement is a term defined by Blackburn et al. *(2004)* as:

> *"A modification of this concept (postponement) can be very useful in a reverse supply chain: managers should make a disposition as early as possible to avoid processing returns with no recoverable value. We call this concept "preponement" and posit that it can greatly benefit the profitability of a firm by avoiding unnecessary processing expenses, while at the same time providing faster recovery of products with significant value."*

After maintenance service, the technician faces two situations: first, the spare component was not used and should be returned to the closest warehouse and second, the component was changed and thus, the used component needs a destination.

The former case also has two situations: the package seal may or may not have been broken. If it was necessary to remove the item from its original packaging, the technician will be required to certify that the item was not used.

In the latter case, where the items originated from the client and were definitely faulty, and depending on the physical situation of the item, the technician can immediately verify if there was an irreparable situation, for example, a burning where the components were on a short circuit or that overloaded the system. When the technician cannot verify it immediately, the fault item is sent to repair. Thus, the faulty item is classified as recycle or repair and sent to the appropriate destination. Needless to say, the items classified as "repair" have a priority in transportation to the "recycle" items.

2.1.5 The reverse logistic – closing the loop

This is the procedure of sending the defective material for repair or disposal. It is one of the most important procedures in order to maintain an adequate stock level. Because the delay in the return of defective items implies the use of new items to meet customer requests, the opportunity to use a material that is already in the spare-parts logistics cycle is lost.

2.2 Issues affecting the inventory level

The dynamics of the logistic cycle for spare parts is strongly linked to the part's lifecycle in a context where the lifecycle is very short, as with telecommunications equipment; usually, the equipment has an end-of-life determined by obsolescence or uselessness. This logistic

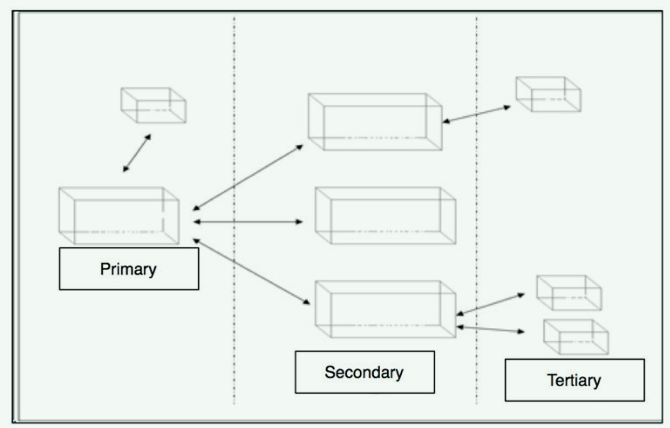

FIGURE 2. *Warehouses' configuration (Client x SLA x Geography).*

cycle is driven by demand, having more or less stock depending on the qualitative and quantitative characteristics of the installed base. This results in a level of storage that is a function of the demand. Demand may be computed using forecasting or fault history. As the demand of spare parts is erratic, even using a method to compute demand forecast, which theoretically makes the result more reliable, the level of uncertainty is still substantial.

Another determining factor impacting the level of inventory is the amount of equipment that returns from the client in irreparable conditions, equipment that in another context would demand only maintenance, should be replaced. Thus, the inventory level will oscillate until new items replace the irreparable materials. Rapid managerial action to level the inventory should be made in order to mitigate this oscillation.

This oscillation relies on the hierarchical level of the equipment being kept as spare parts. Below we show some of the elements that cause this variation and have an impact on the difficulty of controlling and regulating the operation cost of logistics to maintain the SLA. The focus will be on switchboards for private calls, which are divided into small, medium and large switchboards. We will also discuss how these switchboards have become modern communications solutions integrated with the advent of digitization. *(see* **Figure 3**).

The forces that act against or in favor of an appropriate inventory level happen all the time. The spare parts manager must calculate how strong each force is in order to balance the results to attain the best inventory level. For instance, if a manager is not looking for an equipment provider who offers a replacement of spare parts agreement in advance, he must have his own spare parts, increasing the cost and inventory level.

2.2.1 Technological innovation and new strategies for project spare parts

Twenty years ago, telephone exchanges were called private branching exchange and its operation was basically performed by relays. At that time, the volume of hardware was large and the technology enabled a very small quantity of users as compared to today. With the advent of digitization, volumes of hardware decreased while the quantity of users significantly increased, allowing lower manufacturing costs, logistical operations, physical space for installation of these plants and consequently, reducing inventory levels of spare parts to support the aftermarket.

Telephone exchanges after digitalization won a broader format when talking about the exchange of information. They became communication's solutions and their working platforms, which were previously based on the physical component *(hardware)*, becoming more logical. Actually, they became a hybrid component where hardware and software work together. In the near future, the software component will gain more strength and the logic will make the hardware gradually lose space in the solutions. This advent, where communication is replaced by logic, will cause the logistics of Spare Parts for these technologies to lose substantial strength. Thus, this will require the design of new strategies for the business of spare parts. This means that companies that make money with spare parts should seek other solutions to continue profiting with spare parts, for example, negotiating the sale of a particular spare part solution as a requirement *(e.g., mandatory exchange of components for each "x" hour of use)*.

This new solution-oriented communication between businesses, individuals and even machine-machine begins to add equipment with different functions associated with electronic switching *(EPABX)*. Thus, it becomes an information provider with the ability to generate complete reports with important data such as call volume, peak times of greatest demand calls, spending with external links *(national and international)*, volume of internal links, digital recorders, electronic ticketing, etc.

2.2.2 Technological device provider: What changes in the project of spare parts?

These peripherals that came to increase the operational capacity of the traditional PBX in digital era, brought with them a model of spare parts management of partnership between the solution provider and manufacturer of equipment aggregating value in the logistic chain.

The main factor leading reseller companies to sign a service contract logistics spare parts is the total cost of the product, cost of the physical product and a license to use, which is often 60% of the hardware. The storage of these products as spare parts by the dealers is not economically advantageous, since the MTBF *(Mean Time between Failures)* may be high and consequently, the frequency of failures may be very low.

Investment in an asset of this sum causes the reduction of the profit margins on contracts with the final customer. On the other hand, the contract with the manufacturer of these products usually offers replacement of parts with SLA in accordance with the SLA between the dealers and their customers. This contract does not provide just the equipment, but also the services and software update designed by high-level technicians from the manufacturer. Depending on the SLA agreement with the end customer, the retailer needs to decide which model of spare parts management will be applied: a) investment in equipment or b) maintenance contract with the manufacturer.

In the first case *(a)*, investment in spare parts requires the reseller to maintain its own storage, control, transportation and also a technical team to diagnose the problem and perform the exchange of the faulty equipment using the correct spare part. Thereafter, the reverse logistics of a company is triggered, to collect the faulty equipment and send it to the manufacturer to repair. In the latter case *(b)*, the maintenance contract should contain clear rules of service, SLAs in accordance with the commitment made with the end customer. Since there is no investment in spare parts, there is no need for storage, nor handling, neither reverse logistics. There is only a need for the periodic payment *(monthly or yearly)* to the manufacturer to maintain spare parts. The decision between models *(a)* and *(b)* depends on demand, distance between the client and storage, and especially the agreed SLA with the end customer.

The decision making between models *(a)* and *(b)* is not an easy task. If the choice is acquisition of spare parts, the planner must answer the following questions: a) How many parts? b) How much is the frequency of failures of each part *(MTBF)*? c) What levels of SLA contracts do you have with customers?

2.2.3 The importance of the environment to the project of spare parts

The environment is one of the elements that most contributes to the uncertainty of the stock of spare parts in the telecommunications industry. The lightning mapping in Brazil shows that regions where this phenomenon occurs in higher concentration, around 80%, are the Mid-West and Southwest. It is well-known that electronic devices are very sensitive to electrical disturbances such as lightning. Thus, managing inventory levels of spare parts for telecommunications equipment is a mission hindered by this random and unpredictable factor. The project of spare parts SLA should anticipate the incidence of lightning and if the buildings where the equipment is installed include a system for proper grounding to mitigate the effects of atmospheric electrical discharges. This analysis will directly affect the decision of how much stock level of spare parts *(spare parts)* will be retained or hired.

2.2.4 Installed Base: A reference in spare parts project

Longman *(2007)* defines Installed base as: "all the pieces of equipment of a particular kind that have been sold and are being used". This definition suggests that the manager of spare parts stock needs to have the correct information about quantity and time of the equipment that was, is, and will be installed. The information must be "on time" so there will be enough time to plan the appropriate amount of spare parts, usually a decision to purchase or maintain the level of inventory. But who generates the information of the installed base?

Major manufacturers of advanced technology products, such as IBM, DELL, Siemens, Enterasys, have Enterprise Resource Planning *(ERP)* that records each equipment sold as well as its client. These records of the date of sale, models and product configurations in ERP guarantee the information of the installed base in each region of the country. Thus, the calculation of spare parts inventory level can be determined for each region when it comes to a multi-echelon stock.

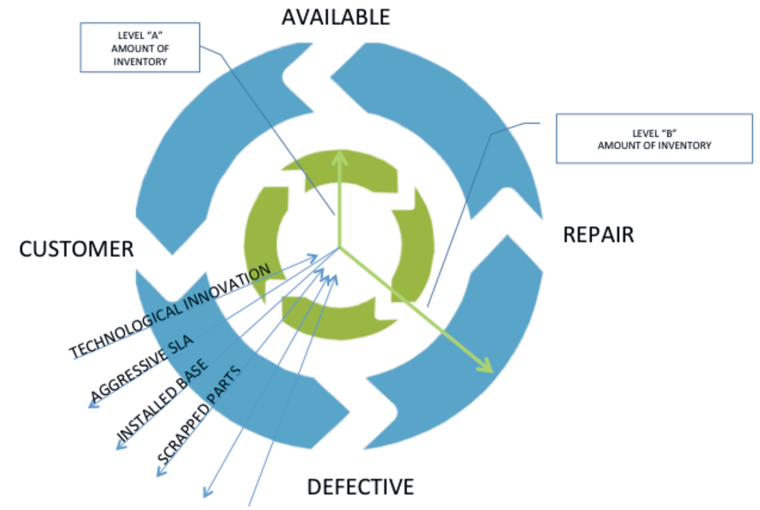

FIGURE 3. *Forces acting on the balance of inventory level.*

The ERP may generate reports of sales volume by product type and by region or equipment. Having a good and functional ERP to organize the sales records is an economic competitive advantage, especially in the case of telecommunication companies that manufacture or resell electronics – products with a low lifecycle – all parts that form a central exchange and/or their peripheral equipment have high technological and financial value.

We should emphasize that there are different types of installed base; customers that purchase the hardware also hire the replacement services of different spare parts with different SLAs, these services make up a valuable portion of the company's revenues. The classification of these customers must be meticulously done from the point of view of spare parts, since there are very aggressive SLAs, typically measured in hours, such as 2, 4, 6, 8 hours, NBD *(Next Business Day)*; 2NBD *(Two Next Business Days)*, etc. The importance of the installed base information is due to the fact that it is very common in contracts of this nature to fine the manufacturer or reseller that does not meet the SLA. Thus, from an economic standpoint, the investment in data analysis of the installed base is very profitable to the manufacturer.

One of the subtlest aspects when using the product's lifecycle to forecast the spare parts is its end-of-life phase. This is where it becomes crucial for the information of the installed base to correctly predict the remaining amount of spare parts, in order to serve customers that, even after the product's end-of-life, will still be connected to the manufacturer or dealer through contracts of replacement parts. In this context, manufacturing of the parts will cease, thus, only the stock of spare parts *(without factory support)* will provide their maintenance. This will require an alignment between the installed base, the life logbook of the spare parts in remaining contracts and the installed base covered by maintenance contracts. It is worth noting that many countries have laws that protect consumers, even in cases where the vendor has no maintenance contract, where the manufacturer is obligated to keep up the post sales maintenance. For example, up to five years after the end-of-life of the product. Therefore, in this case, the entire installed base must be considered and not just the one with a maintenance contract and the SLA.

Another aspect of the installed base is that many manufacturers or dealers rent equipment or complete telecom solutions. The parts returned at the end of the lease may be utilized as spare parts. This is a practice that reduces the overall cost of spare parts because these parts, besides being used, are still operational. Therefore, projects and projections of inventory level should take into account the rate of return of materials whose leases are ending. Complete telecom solutions, leased previously, may be dismantled into pieces and used as spare parts. The savings compared to the purchase of a new item may be of up to 50%.

The uncertainty in project management tends to decrease as it moves up the stages of development and product launch toward obsolescence. In part, this is because the requirement for the product services level becomes lower and because it creates a historical failure data.

2.2.5 The danger of the scrapped parts: Temporarily reducing stock of spare parts

A factor that temporarily reduces the stock level when there is a spare part that becomes scrap. This happens when the replacement part has irreversible defects, such as: components no longer on in the market; carbonization of the integrated board, *(e.g., effects of atmospheric electrical discharge)*. In the process of reverse logistics, defective equipment functionality is sent to the source repository to be analyzed. The decision to send or to not repair, depends on many factors, including:

- a) Repair costs compared to the cost of a new part;
- b) If the visual test demonstrates that the damage was irreversible, such as an electrical discharge that has undermined the structure of the base components of the electronic equipment;
- c) If there is termination of this kind of equipment by having it entirely replaced by an updated version.

2.2.6 Aggressive SLA: A restriction on the success of projects

One of the necessary evils caused by the dealer or the manufacturer are the contracts with customers whose SLAs are aggressive, but with limited geographic delivery, i.e., there is a promise of delivering spare parts to remote locations depending on the current geographic and logistic structures. Regions far from major deposits often fail to deliver as agreed.

Usually, this happens due to a lack of communication between operations and sales, or simply because the requirement is to satisfy an "A" customer. Usual delivery times for replacement contracts are 2h, 4h, 6h, 8h and NBD.

The more aggressive the delivery timespan, the broader the inventory structure should be, i.e., it will require parts assembled in more remote locations, increasing the overall level of inventories of spare parts. This increases the cost of inventory because it requires a control structure, organization and personnel in remote locations. One way to perform this operation at lower costs is to outsource the logistics of spare parts using a 3PL.

2.3 The decision making of the spare parts policy

In this model, the planning of the spare parts policy is the process of computing the volume needed for each spare part in order to maintain each echelon of inventory. High-level planning promotes a minimum of inventory obsolescence. Theoretically, the number of failures inside a given timespan may be modeled using the Poisson Process; in this case, we have tried to use the Poisson Process without any valid results. The most appropriate model for spare parts, according to the literature, is to use the Mean Time Between Failures *(MTBF)*. Again, the practice says that a model based only on the MTBF is not appropriate to this case.

We identified five factors that will affect the decision maker in choosing the level of inventory for each spare part:

- **Lifetime** – how long this part will be productive;
- **Demand** – Despite not being able to forecast the demand, the decision maker has a qualitative knowledge about the behavior of each spare part, or at least for the most important ones;
- **MTBF** – Mean Time Between Failures;
- **Lead time** – how long until production (or repair);
- **Cost.**

It is clear that these five factors compete against each other, thus, there is a trade off amongst them. In order to identify the most important factor in the decision-making, four specialists were interviewed. Our interviewees consider the lifetime as the most important factor, followed by Demand Behavior, Cost, Lead Time and MTBF. As this case study is about the telecommunication equipment industry, lifetime as the most important was not a surprise at all. In this sector, the lifetime of each component is very short, a wrong decision about a single part may lead to very high inventories due to obsolescence. This is also in agreement with the theory of MVT developed by Blackburn, et al. *(2004)*, which says that in this fast-changing industry the components lose value very rapidly.

3. Conclusions

The company studied in this paper has as a daily challenge to meet the requirements imposed by the clients through the Service Level Agreement in a very complex and changing environment: telecommunications equipment. The closed-loop supply chain developed by this company goes from the use of multi-echelon inventory to the utilization of several transportation modes, to the development of a supply chain as responsive as possible. The location of the spare parts and the logistic network used by the maintenance service and the decision of which and how many of each spare parts to keep in stock, is vital to keep the service level as high as possible.

Furthermore, it is necessary that the company maintains a high quality management system for spare parts. This system must be able to manage exceptions given that the forecast of the demand for maintenance is very poor. Also, the decision maker must consider that the telecommunications equipment is used by very different types of enterprises, some might have a higher level of service *(e.g., hospitals, banks)*, while others do not require such a level of service. The differentiation of the clients was also taken into consideration when this logistic network was projected.

Finally, the results obtained in this case study highlight several factors that should be part of an inventory design for spare parts to keep the SLA: from the definition of the most important factors for planning the spare parts policy, using the closed-loop logistic cycle, to operational issues such as, whether the technician will send the SKU to repair or not, and also the aspects regarding internal and external factors that affect the spare parts stock level. Thus, it is possible to see how complex it is to predict a correct level of spare parts inventory.

authors

Lebhon Guimarães Logistics Coordinator from Siemens Enterprise Communication Ltda. Has MBA in Logistics System from Universidade Federal do Paraná (UFPR). Logistics Coordinator from Siemens Enterprise Communication Ltda. Has MBA in Logistics System and Administration degree at Federal University of Paraná (UFPR).

José Eduardo Pécora Jr. Ph.D., Professor in the Department of General and Applied Management and Coordinator of MBA in Logistics Management Systems both at Federal University of Paraná. Has Ph.D. degree in Logistics, Operations and Decision Systems at Université Laval in Canada (2008), Master in Science (M.Sc.) and Bachelor of Applied and Computational Mathematics from the State University of Campinas (UNICAMP). Visiting Professor at several universities in France and Canada. Served as a consultant in several companies such as Sadia, Parmalat, CST, CSN and Aracruz, where he developed projects in the areas of supply chain strategic planning, methods for solving transport and production problems and decision analysis in logistics.

Darli Rodrigues Vieira Ph.D. Professor in Project Management. Holds the research chair in Management of Aeronautical Projects – Université du Québec à Trois-Rivières (UQTR), Canada.

BIBLIOGRAPHIC references

Bacchetti A., Plebani F., Saccani N., & Syntetos A.A. *(2013)*. Empirically-driven hierarchical classification of stock keeping units, International Journal of Production Economics, 143: 263-274.

Blackburn, J.D., Guide, Jr. V.D.R., Souza, G.C., & Van Wassenhove, L.N. *(2004)*. Reverse Supply Chains for Commercial Returns, California Management Review, 46*(2)*.

Bryde D.J., & Robinson *(2005)*. Client versus contractor perspectives on project success criteria, International Journal of Project Management, 23.

Dekker, R., Cerag P., Rob, Z., & Muhammad N.J. *(2013)*. On the use of installed base information for spare parts logistics: A review of ideas and industry practice, International Journal of Production Economics, 143: 536-545.

Fisher, M. *(1997, March-April)*. What is the right supply chain for your product? Harvard Business Review – 75*(2)*: 83-93.

Flapper, S.D.P, van Nunen, J.A.E.E., & Van Wassenhove L.N. *(Editors) (2005)*. Managing Closed-Loop Supply Chains – Springer.

Gelders, L.F., van Looy, P.M., *(1978)*. An inventory policy for slow and fast movers in a petrochemical plant: A case study. Journal of the Operational Research Society 29*(9)*: 867–874.

Guide, V.D.R. Jr., Van Wassenhove L.N. *(2009, January-February)*. The evolution of closed-loop supply chain research, Operations Research, 57*(1)*: 10–18.

Kukreja, A., Schmidt, C.P. *(2005, August)*. A model for lumpy demand parts in a multi-location inventory system with transshipments, Computers & Operations Research, 32*(8)*: 2059-2075.

Porras, E., Dekker, R. *(2008, January 1)*. An inventory control system for spare parts at a refinery: An empirical comparison of different re-order point methods, European Journal of Operational Research, 184*(1)*: 101-132.

Shapiro, J.F. *(2007)*. Modeling the supply-chain, Thompson Higher Education.

Thamsain H. *(2013)*. Managing risks in complex projects, Project Management Journal, April.

Vereecke, A., Verstraeten, P. *(1994, June)*. An inventory management model for an inventory consisting of lumpy items, slow movers and fast movers, International Journal of Production Economics, 35*(1-3)*: 379-389.

Vieira D.R., Bouras A., e Debaecker D. *(2013)*. Gestão de projeto do produto. Baseada na metodologia Product Lifecycle Management *(PLM)*, Ed. Elsevier, SP.

Yin, R.K. *(2009)*. Case study research: design and methods, 4th Edition, Sage Publications.