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Lean Procurement Strategy at Cotecmar

December 2019

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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ABSTRACT

Cotecmar, the Science and Technology Corporation for the Development of the Maritime, Naval and River Industry, is a non-profit organization established in 2000. It serves to satisfy Colombian Navy needs and to lead industry growth through research, development, and innovation. The main services offered by Cotecmar are in the shipyard industry and include services such as shipbuilding, repair and maintenance, and design. Nowadays, Cotecmar leads the shipyard industry in Colombia and is one of the main options to provide goods and services in Central and South America.

The supply chain for the shipyard industry needs to be flexible and efficient to face unpredictable demands from maintenance and repair projects. This project seeks to provide recommendations to implement a lean procurement strategy in Cotecmar, for the maintenance and repair projects done by the Bocagrande complex, and to set up an example to further applications that help create a lean supply chain. With the data collected from different sources such as Enterprise Resource Planning, the Quality Management System, and internal regulations and databases, the research identifies all the non-value-added activities to determine those that are a waste. After identifying the most common waste within the requirements' Value Stream Map, further analysis provides recommended actions to reduce that waste and achieve an efficient procurement process.

Keywords: Lean Six Sigma, lean supply chain, lean procurement

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ABOUT THE AUTHOR

Jose Abel Carrasco Mora (March 26th, 1987). Born in Ubaté - Cundinamarca. A municipality located in Colombia's Andean region. Moved by his vocation of service, in 2005 Jose joined the navy as part of the 119th contingent of the "Almirante Padilla" Naval Academy for Cadets, the alma mater of Colombia's National Navy officers, acquiring the professional degree in naval sciences, and the rank of Ensign in 2008. His first assignment as Logistic Officer was at the ARC Leguizamo Naval Base, located in the Puerto Leguizamo municipality, as Chief of Logistics Department. In 2012 he was assigned to the 4th Marine Infantry Command and Support Battalion, based out of the Municipality of Tumaco. There, he held the position of Commander of the Management and Logistics Company. By 2014, he was designated as Head of the Logistics Department aboard the ARC "Caldas" Frigate. During 2015, Jose returned to the "Almirante Padilla" Naval Academy for Cadets to complete his studies and acquire his second professional degree as Maritime Administrator. In 2016 he was appointed as a commissioned officer at the Science and Technology Corporation for Innovation and Development of the Naval, Maritime and Fluvial Industries – COTECMAR as Head of the Logistics Management.

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LIST OF ACRONYMS AND ABBREVIATIONS

DMAIC	Define, Measure, Analyze, Improve and Control
ERP	Enterprise Resource Planning from SAP®
FCE	Force Chief Engineer
LSS	Lean Six Sigma
OPV	Offshore patrol vessel
PO	Purchase order
PR	Purchase request
QMS	Quality Management System
QR	Quote requirement
SIPOC	Supplier, Input, Process, Output, Customer
VMI	Vendor managed inventory
VSM	Value stream mapping

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I. INTRODUCTION

This project pertains to procurement activities in Cotecmar, the largest and most important shipyard in Colombia, starting from identifying the customer's needs to the delivery of goods or services. Since it was established in 2000 to provide repairs and maintenance for the Colombian Navy's ships, Cotecmar has grown in capabilities and structure to provide services to both military and civilian customers, including design, construction, maintenance, and repairs. Even with Cotecmar's expansion, the Colombian Navy remains its most important customer for shipbuilding, repair, and maintenance; in 2018, the Colombian Navy represented more than 50% of the company's total sales for repair and maintenance projects (Cotecmar 2019).

Cotecmar has two operational complexes in Cartagena, Colombia. Each complex focuses on different activities and customers. In addition to shipbuilding facilities, the Mamonal complex includes administrative areas such as human resources, administration, and information technologies. The other, located within the Colombian naval base in Bocagrande, includes workshops, warehouses, and the complex's management offices. This project studies the procurement process for the complex located in Bocagrande and focuses on the Colombian Navy's requirements.

Repair, maintenance, and shipbuilding projects have essential differences and requirements. Shipbuilding projects have more planning time, which allows for searching for better purchasing conditions (such as lower prices, higher quality, or shorter delivery time). The short planning times for repair and maintenance projects, however, affect negotiation opportunities; additionally, due to operational needs, customers expect rapid response times.

To satisfy the Colombian Navy's needs for repair and maintenance, Cotecmar designated the Bocagrande complex and organization for performing operational activities; the complex receives logistical support from the Administration Department, which operates from a different location in the city. The Bocagrande complex coordinates the services for every location where the Colombian Navy needs support, including international support. These locations include areas with low supply capabilities and low transportation infrastructure, which affect the supply chain performance.

It is important to note that, as a corporation, Cotecmar faces purchase regulations that differ from other governmental entities. Current procedures and regulations are similar to those applied by the private sector.

A. BACKGROUND

Since 2000, Cotecmar has been growing in experience, capabilities, and leadership in the shipyard industry. Some of the most significant achievements are as follows: riverine ship design and construction (2007), Colombian Navy frigate overhauling (2011), offshore patrol vessel (OPV) design and construction (2012), Colombian Navy submarine overhauling (2013), and the Logistic Support Ship sale to Honduras (2017) (Cotecmar 2018). Although these achievements represented challenges for engineers and designers, Cotecmar's growth also represented challenges for its supply chain.

Traditional logistical support evolved along with capabilities and available resources. The main improvements related to the procurement process are as follows: INFOR system implementation (2006), in-house implementation (2010), tariffs contracts for external services (2010), enterprise resource planning (ERP) system implementation (2014), and vendor managed inventory (VMI) implementation (2017) (Cotecmar 2018). The INFOR system facilitates the procurement process and improves traceability for expenditures. In-house implementation reduced the delivery to identified elements; this methodology allows suppliers to have a stock of elements to sell within the Cotecmar facilities. Setting tariffs and utilizing external service suppliers reduces search time, and as all the suppliers agree on the same price quotes, the only aspect that varies is the quantity. The ERP from SAP® (ERP) system implementation is one of the most significant improvements to the supply chain. Initially, the ERP meant a transition from the previous system and added more capabilities to the supply chain (such as supplier license to access the system) to identify the elements that supplier can provide, automatic authorization flow, improved project management, and traceability. It is essential to highlight that one of the ERP considerations is its constant evolution. For example, Cotecmar recently started to integrate human resources activities to the ERP modules. During 2017, the ERP system was integrated with the VMI strategy, representing the evolution of the in-house strategy, as the supplier has control of the inventory and the ERP system automatically generates the purchase order (PO) for the supplier.

In the near future, Cotecmar expects to face more challenges such as frigate design and construction, government projects for increasing and optimizing riverine infrastructure, increasing lifting capacity, and more sales to foreign navies. In addition to cost-reduction objectives, those challenges require further supply chain optimization and integration along both sides of the chain.

In general terms, Cotecmar's procurement process integrates activities from two management areas: Complex Management and Financial and Administrative Management. Within those areas, the departments that interact during the procurement process are Sales, Estimation, Project Management, and Production and Administration. This structure makes data collection and analysis during the process more difficult.

An initial approach for optimizing the supply chain is eliminating waste in its processes; the lean supply chain methodology provides the tools necessary to identify and propose strategies for eliminating waste in all stages of the process. Nevertheless, most of the literature on this topic focuses on production cases and analysis, while few cases focus on supply chain focus on inventory management. Literature about procurement activities is limited, which provides an opportunity for this project to apply lean supply chain tools in a new environment.

B. PROBLEM/OPPORTUNITY

Despite the evolution of the procurement process and previously mentioned improvements to the supply chain, Cotecmar management considers that the current process is not efficient enough, in that it takes more time and demands more resources than it should. In a previous report, the Administration Department identified some weaknesses within the general supply chain activities, such as lack of forecasting systems, over-processing looking for quotes, lack of communication, and too many authorization levels, according to internal reports.

Efficiency and cost reduction are permanent objectives for the organization. This project applies lean tools to identify waste along the process. After identification, the project proposes a mitigation strategy to eliminate waste within the procurement process for the Bocagrande complex, thus increasing efficiency and reducing costs. Further activities might

include the application of the same or similar analysis to reduce waste along the organization's supply chain.

C. OBJECTIVE

The objective of this project is to provide a lean approach to the procurement process that logistically supports the Bocagrande complex and subsequently provides services to the Colombian Navy as a strategic client. Improving support for this complex requires determination of a scope beyond the Acquisition Department in charge of the procurement activities, going from the customer's requirements to PO creation and delivery to the supplier.

The principal question that this project seeks to answer is: What strategy should be used to implement a lean procurement methodology in Cotecmar's procurement process?

Along with the main question, the project answers these additional questions, leading to conclusions and recommendations:

- What are the predominant causes of waste in the current procurement process?
- What is the impact of waste on the requirement life cycle?
- What should be done to reduce waste and promote a lean supply chain culture?

Answering these questions will provide an initial approach for implementing a lean procurement strategy for the entire process and extend its application to the whole supply chain.

D. METHODOLOGY

Lean procurement methodology focuses on identifying and eliminating waste in the process and activities. This project applies the Define, Measure, Analyze, Improve, Control (DMAIC) model along the procurement process. The define step of the project is the identification of the current procurement process and the main areas involved. For the measure and analyze steps, Lean methodology uses tools such as flowcharts, value stream mapping (VSM), and swim-lane flowcharts. These tools facilitate understanding and further analysis of the process. In-depth analysis for each area could provide more information about waste and any impact on the process.

Data collection from internal sources such as the Quality Management System (QMS) and the IT system allows for tracking times and flows. Yet, it is essential to collect information from additional sources such as internal reports, management files, and internal procedures, especially for the areas that do not work with ERP. Data collection focuses on information from 2018 and is analyzed with tools such as Supplier, Input, Process, Output, and Customer (SIPOC) and cause-and-effect analysis.

Finally, the project includes recommendations to improve and control the supply chain, and proposes strategies to adapt in the short and medium-term to increase the procurement process efficiency.

E. SCOPE

The current project's focus is on the Colombian Navy's requirements that the Bocagrande complex manages, along with the logistical support of the Administrative Department. Purchases for the Mamonal complex, shipbuilding projects, and other administrative functions are not included in this project. Data included in the analysis is information from 2018. The process framework starts with the customer contact and concludes when the supplier receives the PO.

F. OUTLINE

This chapter introduces the project; it includes the objective and the questions to answer once the project is completed.

Chapter II includes a review of the available literature that is applicable to the project and related to Lean methodology. The chapter presents a background of the methodology, and then focuses on the Lean tools to apply. These sections also review cases from manufacturing and supply processes.

Chapter III describes the current procurement process, starting with a SIPOC analysis to explain the interaction between the areas and to detail the general process. The chapter also includes a description of the activities from each area, including data available and variations in the process.

Chapter IV includes an analysis of applying Lean tools such as cause-and-effect diagram and the five "whys" to the Cotecmar case. Additional data analysis supports conclusions about the information flow that transforms a customer requirement into a PO.

Chapter V presents the conclusions and a proposal for a strategy to implement a Lean procurement methodology for the Bocagrande complex. Finally, it includes recommendations for further research and projects to achieve a Lean supply chain.

II. LITERATURE REVIEW

This chapter provides background about Lean methodology, including examples of how this methodology improves organizations. First, there is a selection of the most relevant sources about Lean methodology, its applications, its relationship with Six Sigma methodology, and references about application cases proving its benefits for the manufacturing sector. Second, this chapter includes information about how Lean thinking came from manufacturing activities through the supply chain environment and, ultimately, to the Lean procurement concept. The final part of the chapter presents information about the tools to be used in the research, including cases in manufacturing for guiding further application. This information facilitates the analysis and presentation of the Lean procurement strategy to Cotecmar.

A. LEAN THINKING

Lean thinking is the evolution of previous strategies, ideas, and concepts to improve industry. *The Machine that Changed the World: How Japan's Secret Weapon in the Global Auto Wars Will Revolutionize Western Industry* (Womack, Jones, & Roos, 1992) presented Lean production as the evolution of the Toyota Production System established by Ohno (1988). The authors also described the different tools applied to improve the Japanese car industry and how those tools could improve more industries.

Among many Lean descriptions, one of the most practical is the definition presented by Womack and Jones (1996): "In short, lean thinking is lean because it provides a way to do more and more with less and less—less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want" (p. 15).

This description is closely related to the ideas that created Lean methodology, challenging the old paradigm that high quality was expensive: "In the 1980s when most companies believed that producing quality products was too costly, Motorola believed the opposite: the better, the cheaper. It realized that by producing a higher-quality product, the cost of producing goes down" (Taghizadegan, 2006, p. 1). Motorola became the Lean manufacturing pioneer; soon, its methodology was adopted by other firms to improve their

manufacturing processes. Nowadays, Lean is a well-known concept thanks to the benefits that its implementation gives to any organization looking for greater efficiency in its operations.

Consequently, as with previous authors, Myerson (2012) described Lean application as a philosophy: "Lean, in a nutshell, is a team-based form of continuous improvement that focuses on identifying and eliminating 'waste.'" (p. 2). This description includes another essential term: *waste*. Waste can be described as "any human activity which absorbs resources but creates no value" (Womack & Jones, 1996, p. 15).

Lean methodology focuses on the identification and elimination of every element that could be considered waste according to the classification from Ohno (1988), one of the most important authors on the topic. Ohno (1988) presented the Toyota Production System as an example of an effective system to reduce waste. According to this author, waste can be classified into the following categories:

1. Transportation or movement
2. Inventory
3. Motion
4. Waiting
5. Overproduction
6. Over-processing
7. Defects

Recently, some authors proposed another kind of waste: "You can also add the eighth waste of behavior (or underutilized employees) to this as it can sometimes be the biggest waste of all" (Myerson, 2012, p. 19). The additional category includes situations in which the organization invests in selection and formation to carry on determined activities, but due to administrative labor, the time employed by specialists is wasted on other activities.

To complete this research, it is essential to understand the Lean concept and how it focuses on waste identification and reduction. This research identifies waste in Cotecmar's procurement process (based on the previous definition and the current status); additional analysis compares the process with cases from manufacturing and other organizations.

One of the benefits of Lean methodology is how well it integrates with other methodologies. One of the main methodologies applied in conjunction with Lean methodology

is Six Sigma. As presented by Taghizadegan (2006), "the methodology of Six Sigma uses the statistical theory and thus assumes that every process factor can be characterized by a statistical distribution curve. The objective is to free all the defects from every process, product, and transaction" (p. 4). The integration of both methodologies created Lean Six Sigma (LSS) as a new strategy to improve organization from different perspectives.

LSS is a widely applied methodology that reduces costs and increases profits by combining "Lean manufacturing, which aims at reducing waste, and Six Sigma, which helps companies reduce errors. Together they can help companies reap the benefits of faster processes with lower cost and higher quality" (Myerson, 2012, p. 15).

Complementing the previous definitions, George (2003) remarked that Six Sigma does not have the process speed tools of Lean, but Lean lacks tools for statistical control. Therefore, both methodologies complement each other. In *Lean Six Sigma for Service*, George (2003) presented application cases with metrics, which are important considering the cases their focus on the principles rather than manufacturing itself.

In the same way, more authors have indicated the benefits of LSS. For example, Taghizadegan (2006) cited LSS contributions from different cases in other types of manufacturing companies around the world as follows:

- eliminating all the wasted time that can slow down the project
- maintaining customer satisfaction with the speed in delivery
- completing the project ahead of deadlines and possibly under budget
- continuously improving profitability e.g., in a shorter period than planned

The success of LSS projects, however, requires the application of appropriate tools and techniques. Tools such as Sort, Shine, Straighten, Standardize, and Sustain (5S), VSM, Kaizen event, cycle-time reduction, inventory reduction, setup time reduction, and mistake-proofing are the most known and applied to the manufacturing process. Even so, there are more suitable tools depending on company needs and objectives. Tools differ in complexity, time frames, resources, objectives, organization levels, and company structures; for instance, 5S focuses on the organization of the workplace and tools to reduce movements or waiting times caused by employees trying to find tools. VSM focuses on the knowledge of the process and its path to identify waste.

In *Essentials of Lean Six Sigma*, Taghizadegan (2006) compiled the main tools and described how to apply them through the different steps of the LSS project for improvement:

1. Define
2. Measure
3. Analyze
4. Improve
5. Control

The three cases presented by Taghizadegan (2006) contain detailed information about the application of the LSS steps in real-world situations for production systems and include benefits and recommendations for improvements based on expected results. The first case is "Methodology for Machine Downtime Reduction—A Green Belt Methodology," in which the author presented a real-world situation and the application of diverse LSS tools, such as SIPOC and the process flowchart, to understand the situation. Statistical tools help to identify the standard production for the process, and the author then presents the application of additional tools (such as a cause-and-effect diagram) as well as some tools to control and maintain the improvements.[1]

LSS benefits apply easily to other fields. In *Lean Six Sigma Implementation for Military Logistics to Improve Readiness*, Apte and Kang (2007) presented LSS implementation results within the U.S. military, including $11.9 million savings for the Army, $177,900 annual savings for the Navy, and $2.4 million savings for the Air Force. Although those benefits came from different projects, the authors remarked on the importance of LSS as a culture to achieve long-term benefits.

The previous cases are relevant information sources for clearly understanding the Lean methodology and its principles and to obtain reference points to compare applications. Previous sources provide insight into the process that this project follows to improve Cotecmar's procurement process for repair and maintenance projects.

[1] Some of the tools are 5S and poka-yoke

B. LEAN SUPPLY CHAIN

After Lean methodology's success in the production process, further application in additional areas within organizations started to gain interest. Two of the areas that started the implementation of Lean tools is logistics and supply chains. To understand why this happened, it is important to understand the importance of the supply chain for any organization: "Supply chain effectiveness is critical to profitability since manufacturing and distribution costs represent 50% to 70% of an organization's budget" (Martin, 2007, p. 71). Any waste in supple chain activities has significant consequences in an organization, most notably its finances and stability.

Lean Six Sigma for Supply Chain Management: The 10-Step Solution Process (Martin, 2007) presented more information about the impact of Lean implementation in the supply chain: "If integrated properly, successfully executed Lean Six Sigma projects will build momentum and effectively change an organizational culture over time. This will create a truly Lean supply chain" (p. 49). Lean also helps to increase customer satisfaction with differentiating competencies: "Organizations should also develop internal competencies that competitors cannot easily emulate to remain competitive over time" (Martin, 2007, p. 182). Martin concluded that improvements in Lean methodology in the supply chain "achieve the lowest total system cost by shortening the length of the supply chain and reducing the number of suppliers in the system (reducing complexity)" (Martin, 2007, p. 184).

In the same way, complementary information about how Lean methodology benefits the supply chain is described in *Lean Supply Chain and Logistics Management* (Myerson, 2012), which provided a complete framework for Lean application within the supply chain. The book includes waste classification, basic Lean tools, advanced Lean tools, case analyses, Lean thinking, and more information that serves as a guide to develop the project.

One of the highlighted cases is a Lean case for the office: "The experience of a European life insurance provider highlights the lessons learned from transferring Lean from the shop floor to the office, as well as providing a deployment model that integrates Lean, Six Sigma, and process management" (Myerson, 2012, p. 188). In this case, the primary technique applied is Kaizen workshops to address cost reduction. Yet, its implementation faced challenges such as difficult-to-implement tools, managers vetting team ideas, and cost savings

estimation being too high. Those challenges are similar to what Cotecmar could face during the analysis stage or further implementation. One relevant aspect that Cotecmar could share with the aforementioned case is how critical the information flow is. In both cases, the process focuses on managing the requirement information. In the same way, knowing how the cases overcome or adapt to the situations is essential in order to determine recommendations for reaching the objective.

Supplementing the previous information, Afonso and Cabrita (2015) proposed a performance framework to measure the Lean supply chain based on empirical cases:

> There are a number of conceptual frameworks and discussions on supply chain performance measurements in the literature. However, there is a lack of empirical analysis and case studies on performance metrics and measurements in the supply chain environment of Small and Medium-Sized Enterprises (SMEs). Their research aims to develop a conceptual framework for managing LSC, integrating both financial and non-financial performance dimensions, and so it expands the existent knowledge and provides an indication of how LSC performance can be assessed and improved in this and other kinds of organizations. (p. 1)

Previous Lean cases and literature presented the ways organizations adopted methodologies initially designed for production-related activities and incorporated those methodologies into a method applied to supply chain activities, such as inventory and transportation. Nevertheless, adapting the methodology has its own challenges depending on each organization and its internal conditions (mindset, resources, and time, for instance). It is important to learn the lessons from the presented case to adapt them to Cotecmar's procurement process. Lessons learned about this case are IT optimization and applicability to eliminate waste, cross-train teams, and finally, identify waiting time in the services process.

C. LEAN PROCUREMENT

Taking information from different sources provides different perspectives about how to analyze the procurement process to achieve results that improve the process within the organization and to set up a starting point to implement a complete Lean methodology in Cotecmar. Most of the Lean supply chain literature focuses on two activities: transportation and inventory. This is probably because transportation and inventory are activities that not only tend to have more waste, but also are easier to identify and adjust—mainly because most of

the responsibility for the process includes only a few areas. Lean procurement is a recently developed concept that focuses on how to improve this process. Myerson (2012) wrote, "Lean sourcing or procurement is a different way of looking at and working with suppliers. There is greater use of partnerships and alliances as well as a greater need for coordination and collaboration" (p. 31).

Research and application of internal processes within the organization, such as procurement activities, are limited. Therefore, most of the literature about Lean application to the procurement process is described in theses such as *Implementing Lean Procurement: Opportunities, Methods and Hinders for Medium-Sized Enterprises—A Case Study* (Hagström & Wollner, 2011). In this thesis, Hagström and Wollner described a Lean procurement implementation for a medium-sized enterprise. This work includes essential considerations for determining activities within projects and contrasting some of the procurement aspects of the process analyzed in this project.

In the same direction, George (2003) presented an example of Lockheed Martin's systems and how the procurement process was affected by waste. The data about the process allowed the organization to determine waste elimination measures.

Another source to consider is "*Enabling Lean Procurement: A Consolidation Model for Small and Medium-Sized Enterprises*" (Wilson & Roy, 2009). Wilson and Roy (2009) discussed a method to implement Lean procurement methodologies in small and medium-sized enterprises. The information presented serves as a guide and reference point to give an independent strategy that fits Cotecmar conditions (structure, resources, and policies).

Lean Procurement in Global Shipbuilding of High-End Specialized Vessels (Oterhals & Salte, 2015) presented a case more closely related to the shipbuilding industry to answer the formulated problem: "To what extent will lean procurement be applicable for a global shipbuilder, building high-end specialized vessels in a low-cost country?" (p. 5). The conclusions of this work provide an important reference to include as a comparative point, as it has elements in common from two different shipyards implementing Lean procurement methodology.

Finally, by focusing on a particular company to analyze Lean thinking and the procurement change processes within an organization, Haugland (2015) provided a framework to understand some of the challenges to Lean procurement from a social perspective.

D. LEAN TOOLS

Previous literature serves as a guide and reference point to the analysis and application of Lean methodology from a general to a more specific perspective using the definitions, procedures, and cases to compare the application of the methodology in Cotecmar's procurement activities. The following literature contains detailed examples to understand how to apply the tool, what information to collect, and what the expectations are for the project in the improvement of the procurement process.

As mentioned, different tools are used in Lean projects, and each one has unique conditions to its application. Some of the tools are cause-and-effect diagrams, 5S, Kaizen event, cycle-time reduction, and SIPOC analysis. The selection of the tools differs according to each stage and each organization's conditions. Furthermore, no tool is useful without the commitment of personnel.

One of the most suitable tools for analyzing Cotecmar procurement process is VSM because this tool provides a general framework of the process and how the areas interact. As Myerson (2012) explained,

> VSM is a mapping tool that is a 10,000-foot-level view of a process. Typically, it is for a family of goods or services from the customer working its way upstream all the way to key suppliers. A VSM is similar to a flowchart or process flow map, but one of the key differences in the current State map identifies value-added and non-value-added activities. (p. 41)

In the book *Lean Systems* (Cudney, 2014) presents a complete guide about VSM as one of the most applied tools; it is easy to apply and explain the interactions graphically during any process. It states, "VSM is a flowcharting method originally created in the Toyota Production System (TPS) to document the entire process (of a company or a department) on a single sheet of paper to encourage dialogue and understand the process better" (p. 63). VSM is the most convenient tool to use in research considering the length of the process and the different areas that have added value to the requirements; VSM also displays both the requirements and information flows. However, to increase the impact of Lean strategies, it is essential to

complement VSM with other tools. Cudney (2014) wrote, "VSM also provides a common platform to apply various Lean principles and tools and allows an organization to create an integrated plan to follow for implementation" (p. 65). Cause–effect analysis and the five "whys" are complementary tools to be used with the VSM to identify and classify activities according to the value in each stage. The author also included case studies of VSMs for manufacturing, service, and healthcare applications, serving as a guide for applying this tool in an analysis of the procurement process.

Another tool to be used is the SIPOC analysis. Unlike VSM, SIPOC analysis presents only the input/output relationships without graphing the process, providing more information to analyze interactions. "The SIPOC is a high-level, quantified system map that shows process input/output relationships" (Martin, 2007, p. 34). Some examples of SIPOC applications are presented by other authors like Taghizadegan (2006) and Mishra and Kumar Sharma (2014), who presented an application example of SIPOC in addition to Six Sigma stages for the paint industry.

Considering the size and complexity of the procurement process within Cotecmar, it is necessary to present the general process and the area's relationship without additional data or specifications. The best tool to show the process with previous considerations is the swim lane flowchart (Apte, 2018). This chart presents the activities in charge of each area and how the flow comes back to certain points.

E. COTECMAR QUALITY MANAGEMENT SYSTEM

Finally, Cotecmar has relevant information about its process, thanks to the QMS implemented and certified more than five years ago. One of the principal requirements of the QMS is the standardization of processes; therefore, every process that Cotecmar performs has an associated document that describes all activities within that process that should be applied by all employees (Cotecmar, "Sistema de Gestión de Calidad" [Quality Management Systems], corporate policy, 2018). Those documents are an important source to identify and help describe the current process and integration between areas.

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III. PROCUREMENT PROCESS

This chapter presents Cotecmar's current procurement process for the Bocagrande complex, starting with customer need(s) through PO reception by the supplier. The first section provides a general overview of the process for identifying the main areas involved and how the information flows between them. The swim lane flowchart best displays the information described in this chapter, dividing the process between the areas involved in the procurement process. After the swim lane flowchart, a SIPOC analysis adds more details for understanding the general process. The following sections present more detailed descriptions and analyses of the activities done by each area using the VSM.

A. CURRENT PROCUREMENT MACRO-PROCESS

The Cotecmar–Bocagrande complex focuses on repair and maintenance projects for the Colombian Navy, which represents additional commitments considering the bond between the two entities. Because of that relationship, Cotecmar–Bocagrande established a structure to make the process more dynamic and effective than other facilities. This section describes the swim lane flowchart from Figure 1 for the current procurement macro-process.

The process begins with the customer presenting a requirement(s)[2] to Cotecmar using an information system or by email. After the sales office receives the requirement and proceeds to generate the Quote Requirement (QR) document, it sends the QR to the estimation division, which then defines the costs of the project and the adequate budget for it. Once the budget and quote are set, the sales office emails the quote to the customer for approval. If approved, the sales office creates a sales project and sends it to the Project Management Department, which assigns a project manager. Up to this stage, the project does not exist within the ERP system.

[2] Including project specifications and assigning a priority according to customer needs and resources

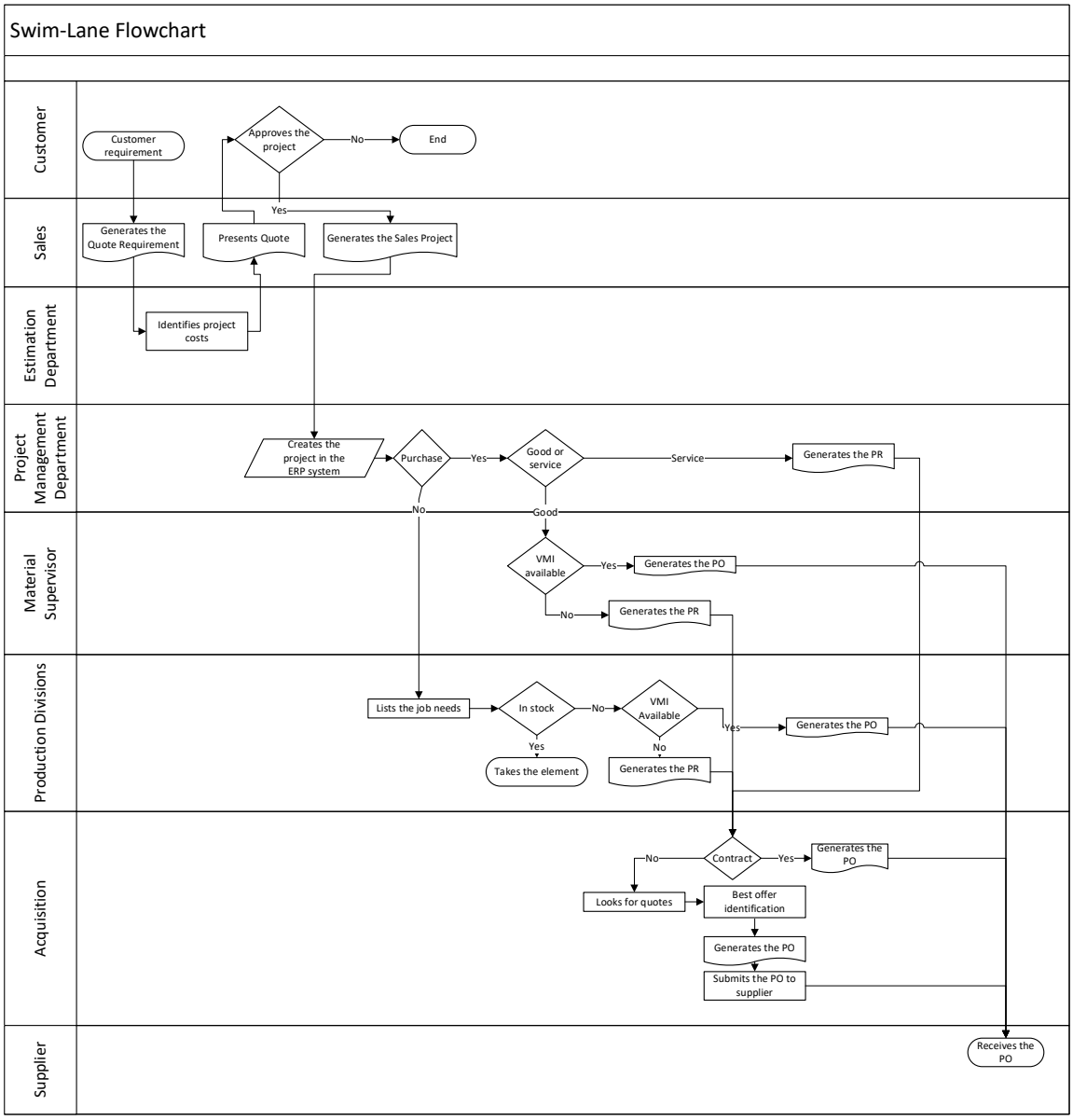


Figure 1. Cotecmar Procurement Macro-Process

Once the project has a project manager, that person creates the project in the ERP system. This is the starting point for most of the budget-related activities, among other project management activities. The project manager identifies and assigns the project's purchasing needs with respect to available resources. The needs could take one of three alternatives: first, services that the production divisions can provide; second, services that the production

divisions cannot provide;[3] and third, the goods needed for the project. Each alternative goes to different areas such as production divisions, acquisition, and the material supervisor, respectively.

For the first alternative, production divisions receive the job requirement(s) and identify the materials needed for completion. If they do not have the stock or a VMI contract, they create the purchase requirement (PR) in the ERP system. The system automatically sends the PR to the acquisition division. For the second alternative, which corresponds to the services that depend on contractors to provide, the project manager creates the PR in the ERP system and sends it to the acquisition division. Finally, the third alternative corresponds to the goods needed for the project. For these cases, the project manager sends the requirement to the material supervisor, who verifies that the element needed is included within a VMI contract to generate the PO; otherwise, the material supervisor must generate a PR, which automatically starts the approbation flow up to the acquisition analyst.

The acquisition division receives the PR and verifies whether the good or service needed is within a contract other than the VMI. It then proceeds to generate and send the PO to the selected supplier. Otherwise, the acquisition analyst looks for quotes of the good or service that the project needs. Once the analyst has the quotes, he or she generates and sends the PO to the selected supplier.

These are the general stages in the process. Although the process generally follows these steps, each stage has particular inputs, activities, conditions, outputs, and resources to fulfill the requirements and deliver the product to the next stage. The next step in this research is to make a SIPOC analysis and a more detailed flowchart for each subprocess.

B. SUPPLIER, INPUT, PROCESS, OUTPUT, CUSTOMER ANALYSIS

Providing more details about the current procurement process, the SIPOC analysis in Table 1 synthesizes the previous activities in terms of what the areas receive, what the process is, and what they deliver.

[3] Therefore, contractors will execute with a corresponding PO.

Table 1. SIPOC Analysis

Supplier	Input	Process	Output	Customer
Customer	Requirement	Verification	Quote Requirement	Estimation Department
Sales Office	Quote Requirement	Cost identification Quotes	Quote to be signed	Sales Office
Estimation Department	Quote to be signed	Signature and customer approbation	Sales project	Project Management Department
Sales Office	Sales project	Needs identification and prioritization	1. Internal Services: Job requirement 2. External Services: Services PR 3. Goods: PR elaboration requirement	1. Division Head 2. Acquisition Analyst 3. Material Supervisor
Project Manager	Job requirement	Identification of needs to purchase Code assignation VMI verification	PR	Acquisition Analyst
Project Manager	PR elaboration requirement	Code assignation PR elaboration VMI verification	PR	Acquisition Analyst
1. Division Head 2. Project Manager 3. Material Supervisor	PR	Supply strategy identification Quote request Supplier selection PO elaboration and submit	PO	Supplier

C. AREA PROCESSES

The following information describes the activities each area must perform.

a. Sales Office

The present research considers the beginning of the procurement process to be when a customer request is submitted to the sales office. In Cotecmar's hierarchical organization, the sales office is directly under the sales coordinator. According to the QMS, the sales office framework activities include customer searching, contract suggestions and signing, and sales documentation (Cotecmar, "Gestión De Ventas para Proyectos de Reparación y Mantenimiento" [Sales Management for Repair and Maintenance Projects], corporate policy 2019). Currently, the sales office has three personnel positions in charge of these previous tasks, as well as administrative activities such as meetings and training.

To describe the activities related to the procurement process, Figure 2 displays the general flow of actions.

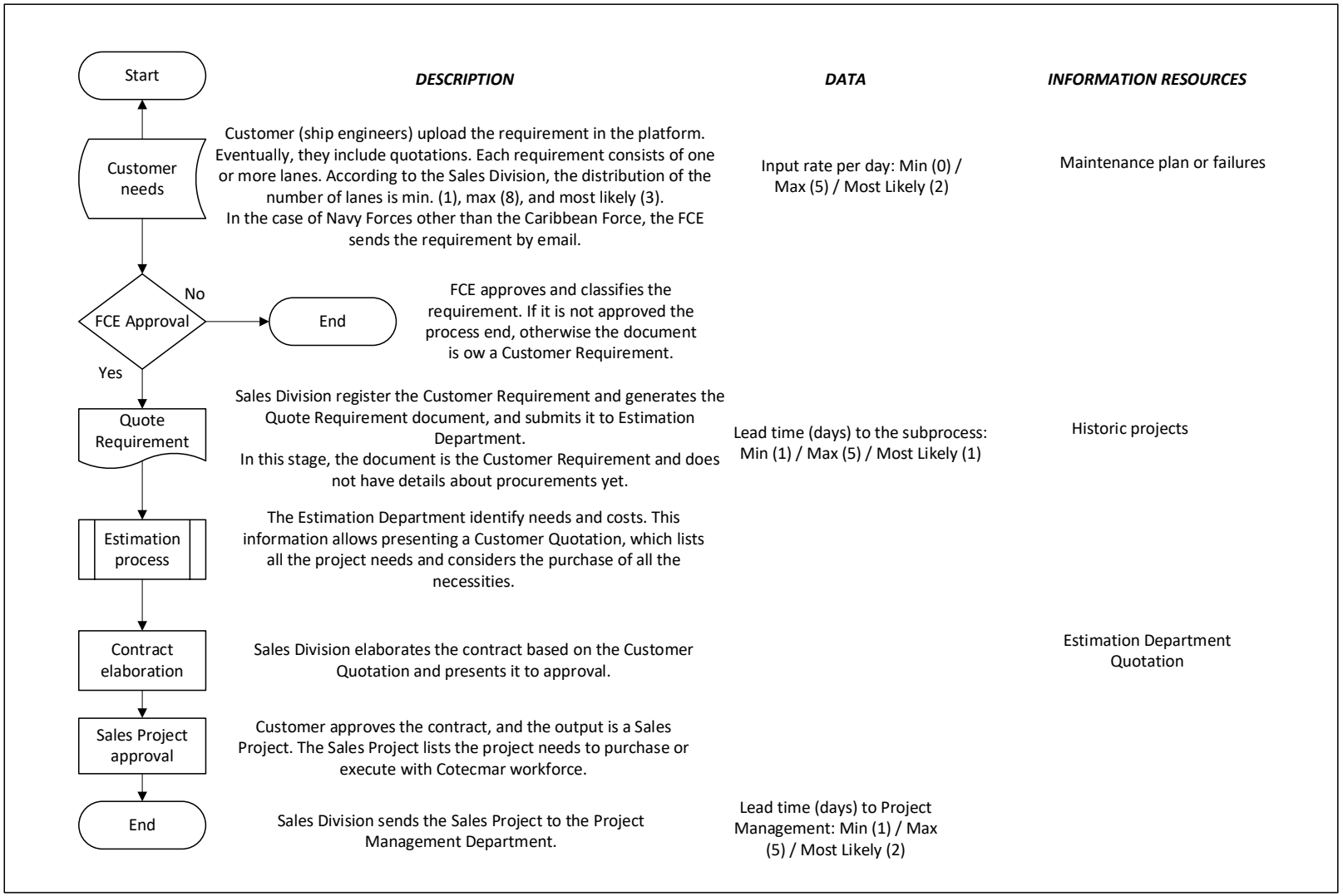


Figure 2. Cotecmar's Sales Office Activities

The first stage results in customer needs from two different sources: The Caribbean naval force engineers (FCEs) uploading their needs using software that Cotecmar provides, and other regions and units emailing their requirements. The Cotecmar software facilitates customer procedures and authorizations, also allowing the customer to include quotes in the requirement(s). The system automatically sends the requirement for approbation by the FCE of each naval force. If approved, the requirement is classified according to the priorities of vital, important, or accessory (see Figure 3 for an example of the customer requirements). Then, the FCE submits the approved customer requirement(s) to the sales office. For naval forces outside Cartagena, the FCE emails the customer requirement. The sales office reviews the customer requirement and then generates the QR document to submit to the Estimation Department, where the requirement gets a budget and returns to the sales office. With the budget assigned, the sales office generates a formal quote and presents it to the facility manager for signature. Once the quote is signed, it goes to the customer for approval. Finally, the sales office sends the information to the Project Management Department.

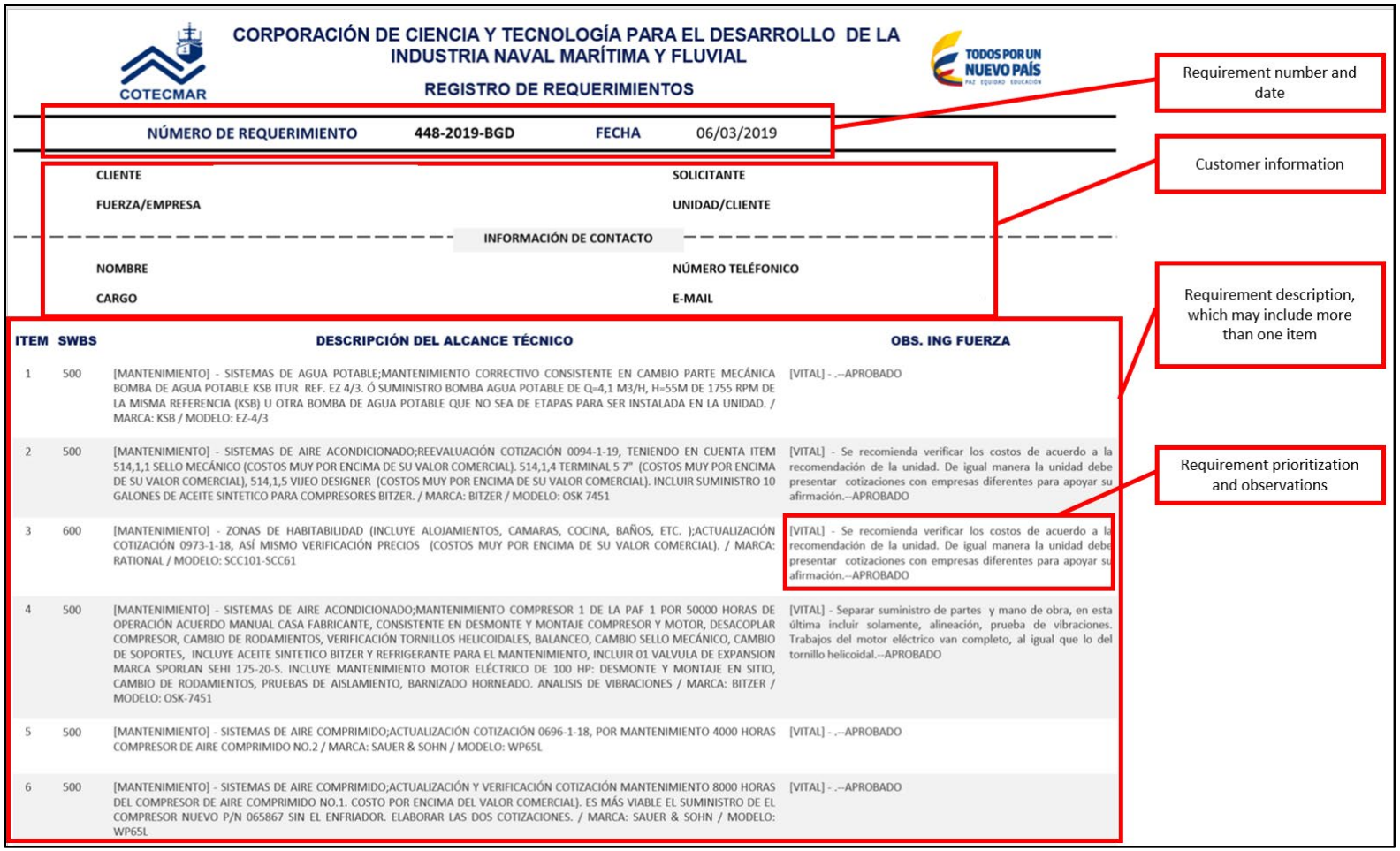


Figure 3. Customer Requirement Example. Source: Cotecmar (2019).

b. Estimation Department

The Estimation Department is under the authority of the facility manager. The department is in charge of estimating the costs for all the projects that the customer presents. The scope of work is diverse, considering that one requirement might end up with more than 10 elements needing quotes. The current workforce includes seven personnel working on identifying requirement costs. Figure 4 displays the process in which the starting input is the QR from the sales office. The estimator is assigned through availability, experience, and work load, once the department head receives the QR.

Using diverse sources, the estimator proceeds to look for information to determine the requirement's budget. The first information source is the customer requirement, which eventually includes quotes. Additional sources are the shared folder with historical quotes, previous ERP purchases, or looking on the market for new quotes. For activities that Cotecmar can perform within its workforce, the estimator looks for cost information in the Production Department.[4] Once the cost information is complete, the estimator proceeds to build a project budget, sending it to the department head for signing before sending it on to the sales office.

This stage of the process can appear quite simple; however, it requires a significant amount of information to complete the process for submitting to the next stage. One important aspect is that the Estimation Department typically finishes its portion of the procurement process once the project budget is with the sales office. Additionally, its interaction with ERP is for consulting on information; the project is not yet created within the system.

[4] This activity, however, has no relation to the procurement process.

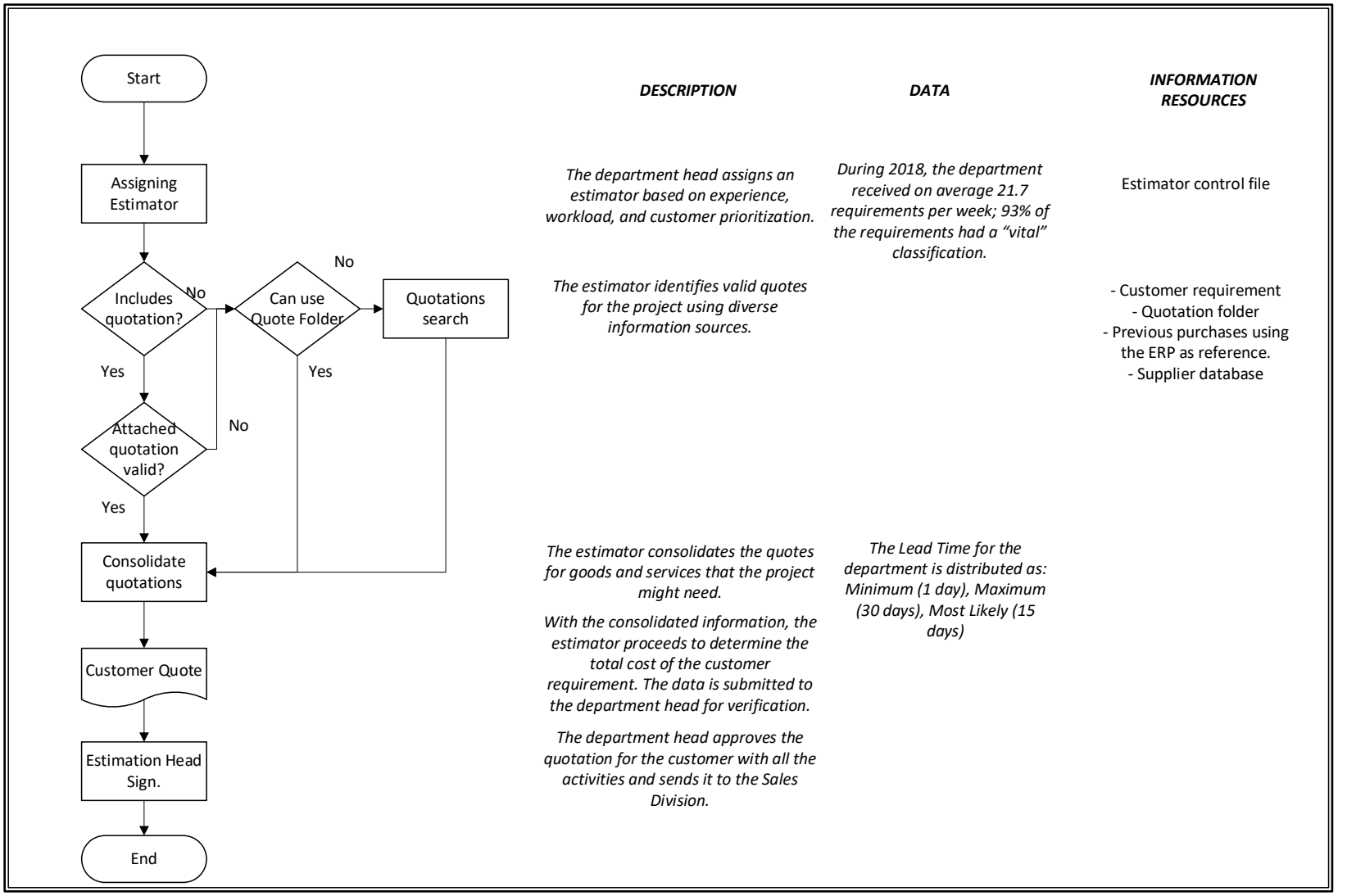
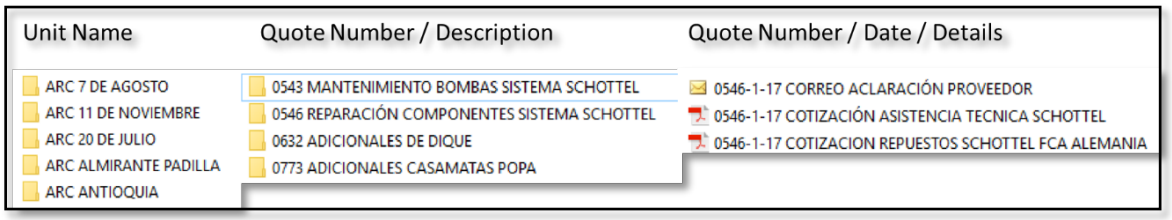


Figure 4. Cotecmar Estimation Department Activities

All the quote data is stored in a shared folder managed and shared by the Estimation Department. Figure 5 displays the general structure for this shared folder.



Source: Cotecmar, "Instructivo para Organización de la Información Digital en el Servidor Afrodita" [Instruction for the Organization of Digital Information within Afrodite Server], Corporate Policy (2018).

Figure 5. Shared Folder Organization

c. Project Management Department

The Project Management Department is under the authority of the facility manager. The current department structure has six project managers, with one additional person to execute projects in the Pacific naval force. The QMS describes the "project management" procedure, which includes specifications about the requirements, definitions, and procedure, which is described in four steps: planning, risk management, control, and delivery (Cotecmar, "Administración de Proyectos" [Project Management], corporate policy, 2016).

Once the sales office receives customer approval, the division sends the sales project to the Project Management Department head to start execution. The project is created in the ERP system after the department head assigns a project manager. The assignment of the project manager is based on the number of active projects, experience, and availability. From this step onward, costs, budget, purchases, and financial activities are linked to the project number, allowing easier management and tracking of changes. Once the project manager identifies the purchase requirements, the process splits in three directions: first, services that Cotecmar's workforce can provide; second, services requiring a contractor if Cotecmar does not have enough personnel available; and third, goods included in the project (such as spare parts or new components).

Each variable has different processes, outputs, and receiving areas. In the case of services that Cotecmar can execute within its workforce, the project manager emails the

requirements to the corresponding division head. The requirement includes specifications such as scope, deadline, and shipping information. Sending that requirement finishes the activities for the first alternative. The second direction corresponds to goods provided, such as spare parts or new components included in the sales project. For those goods, the project manager identifies the items needed and emails the information to the material supervisor, who continues the process. Most of the time, the quote from the estimation phase is included in the email. Finally, the third direction corresponds to external services that contractors provide. The process for external services continues when the project manager creates the PRs in the ERP system, which automatically sends them to the project manager for approval and then to the acquisition analyst to continue the process. Figure 6 displays the process and how the three alternatives differ. Nonetheless, as the process continues, all the alternatives go to the acquisition analyst at some point.

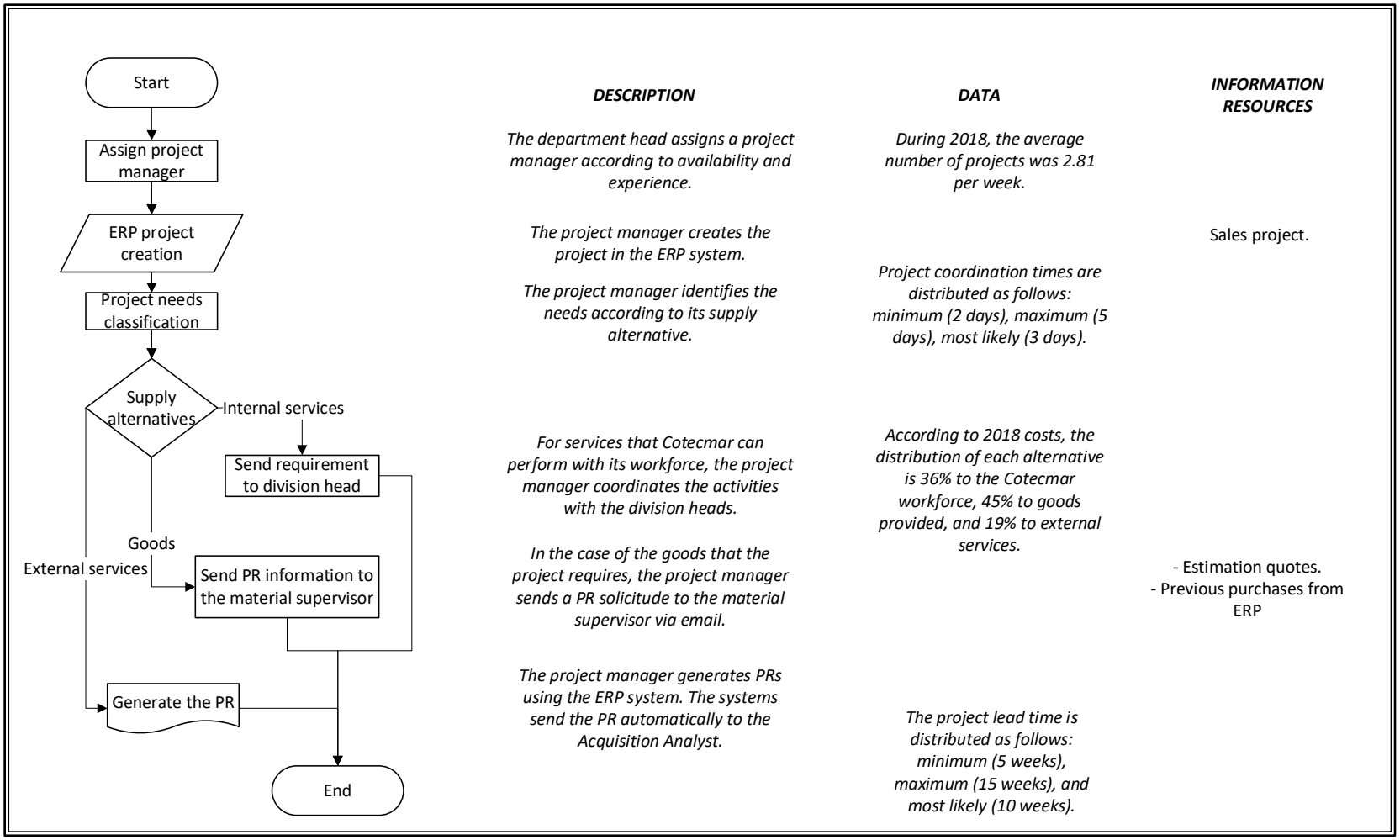


Figure 6. Cotecmar Project Management Activities

The Project Management Department receives sales projects and assigns them to the project manager. The project manager creates the project within the ERP system, which helps the department manage the project. The ERP system then assigns a code for the project, which then becomes the center of all the digital activities, including the series of requirements that will be done via the various alternatives. After identifying the purchase requirements, the project manager distributes needs according to capacities. First, the services Cotecmar provides are submitted to the division head; second, services from external contractors are submitted; and third, the elements for the project are submitted.

d. Division Heads

Cotecmar's Production Department has divisions in charge of executing production activities: welding, painting, electricity, and engines. It is essential to highlight that Cotecmar's workforce is usually smaller than the capacity required, as the organization wants to keep fixed costs low when there are few projects. Additionally, using contractors improves the local economy and growth of the industry.

Figure 7 displays the activities within the divisions that have an impact on the procurement process.[5]

[5] The process is the same for all divisions.

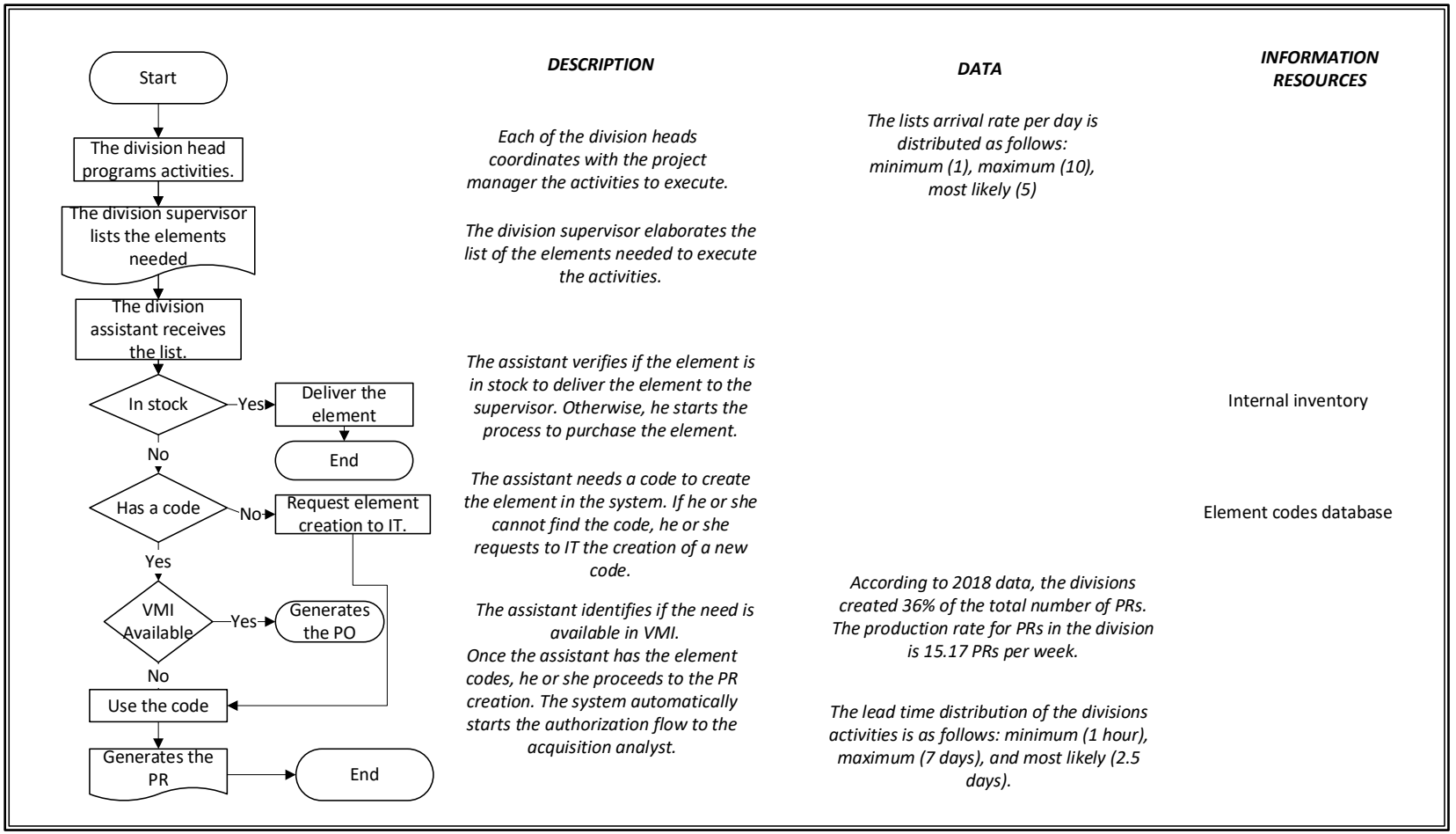


Figure 7. Cotecmar Division Head Activities

The starting point is when the division receives the requirements from the project managers to assign manpower and resources for specific jobs.[6] First, the supervisor lists the elements that the job needs and presents the list to a division assistant, whose first determination is whether the element is in stock. If it is, the procurement process ends; if not, the division assistant proceeds to identify if the element is in the ERP system or not. If the element is already in the system and has a code, the division assistant uses it. If not, the division assistant emails a request for the creation of the new element to the ERP specialist.[7] Once the element is created and has a code, the division assistant requests that the material supervisor create the PR, which starts the flow to the project manager for approbation and then submission to the acquisition analyst for purchase.

e. Material Supervisor

The material supervisor is in charge of gathering the project managers' requirements and ensuring that projects receive elements according to their needs. There is currently only one material supervisor position, which falls under the Project Management Department. Figure 8 displays the activities that the material supervisor performs in order to facilitate the procurement process.

[6] However, to complete the jobs, the division might need additional elements.

[7] Including the quote is obligatory for creating the element.

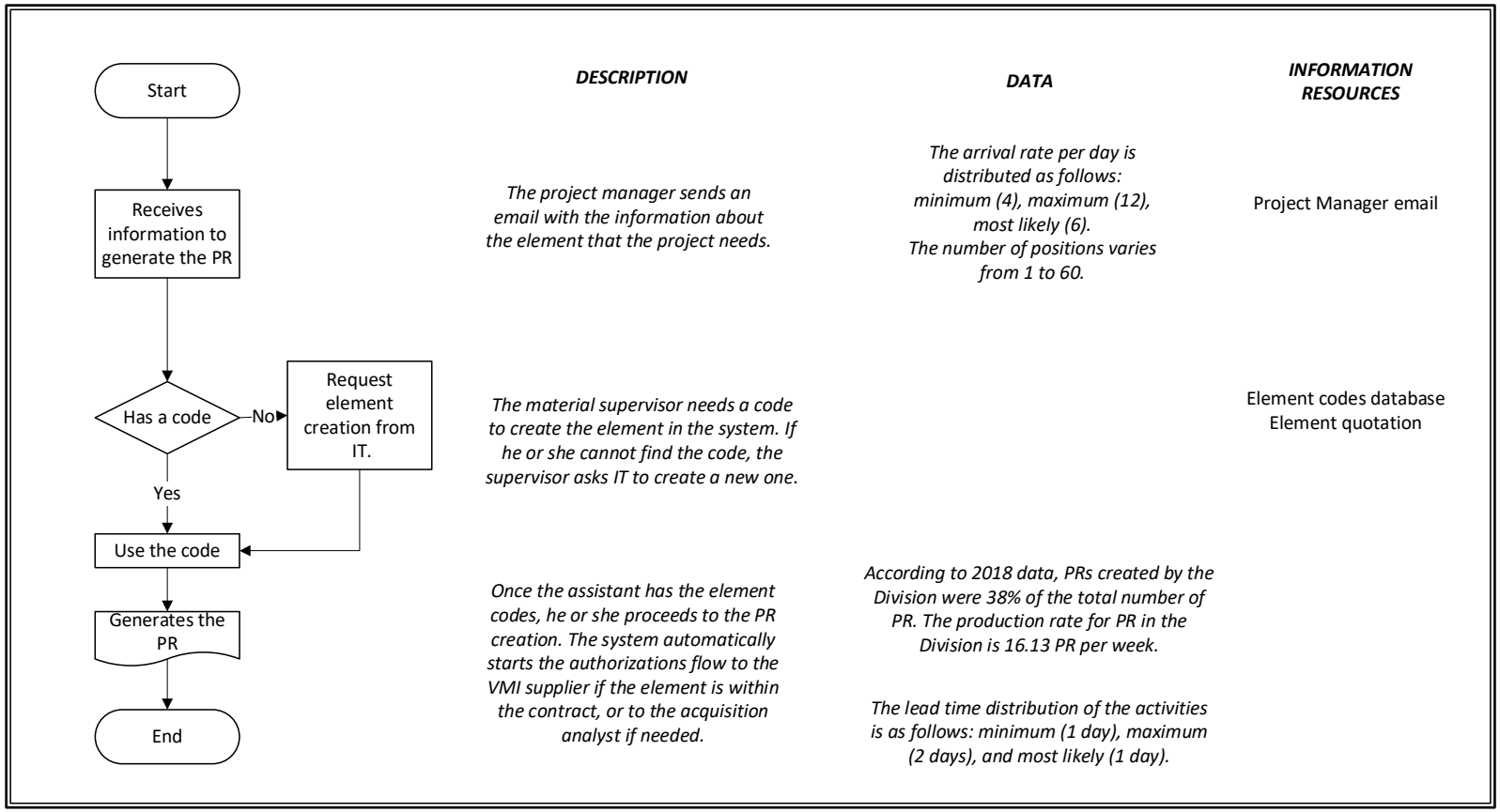


Figure 8. Cotecmar Material Supervisor Activities

This stage starts with the project manager emailing a request for the elements necessary for the project and including information about the element such as a basic description, measures, brand, and sometimes a price quote. The material supervisor proceeds to check in the ERP system for the element's code; if present, the material supervisor can proceed to creating the PR. If not, a request for the element's codification is sent to the ERP specialist. After the code is established and the PR created, the material supervisor passes it on the project manager for approval. If the PR does not correspond to VMI or any supply strategy, the PR is submitted automatically to the acquisition analyst. Figure 9 displays an example of how the PR looks in the ERP system and the information it contains.

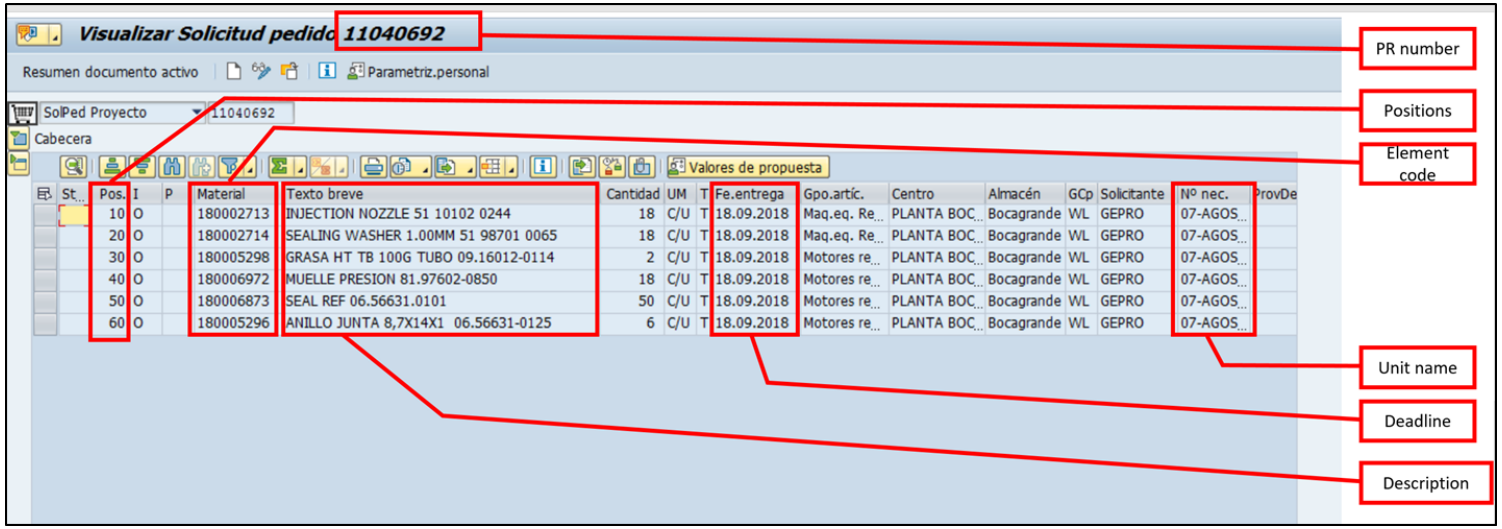


Figure 9. Purchase Requirement Example. Source: Cotecmar ERP (2019).

f. Acquisition Analyst Activities

Within the Acquisition Department, the acquisition analyst's functions are exclusively limited to purchasing goods and services for the organization (Cotecmar, "Consecución de Bienes y Servicios" [Goods and Services Acquisition], corporate policy, 2018). Although this is done from a different facility, weekly meetings keep the information flowing to the project managers. Currently, the division has one person responsible for all of the Bocagrande facility's purchasing needs, and this employee is the only one who can submit a PO to suppliers that do not have a supply strategy.

For this stage, the acquisition analyst receives input from two different sources: the PR from the material supervisor for elements and the PR from the project manager for external services. The flow for both alternatives is very similar thanks to the purchasing strategies and contracts within the organization. Figure 10 displays the activities that the acquisition analyst performs during the procurement process.

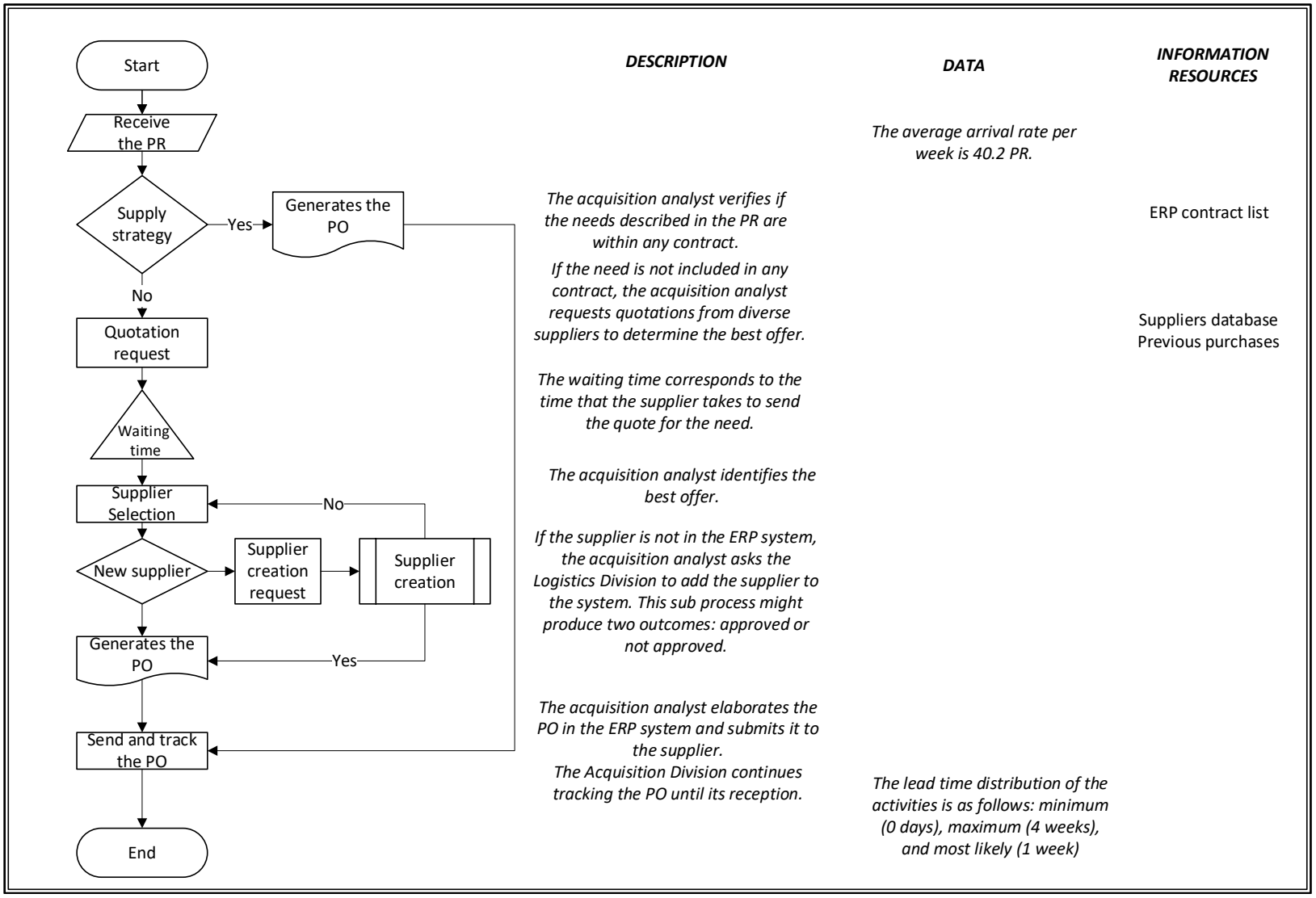


Figure 10. Cotecmar Acquisition Analyst Activities

A PR is the input that the acquisition analyst needs to start the process. Once in receipt of the PR, the first decision point appears: Is the good or service within any supply strategy? If so, then the PO can be generated and sent to the corresponding supplier in accordance with the established strategy. Figure 11 details an example of the PO from the ERP system and the general information included. If the good or service is not under purchasing strategies, the acquisition analyst asks for price quotes from sources such as the Estimation Department, supplier database, historic purchases, and previous suppliers. If none of these alternatives work, the analyst asks for quotes from new suppliers. If the best alternative for supplying the good or service is a new supplier, the supplier needs to be included in the ERP system. Then the acquisition analyst can proceed to send the PO to the selected supplier.

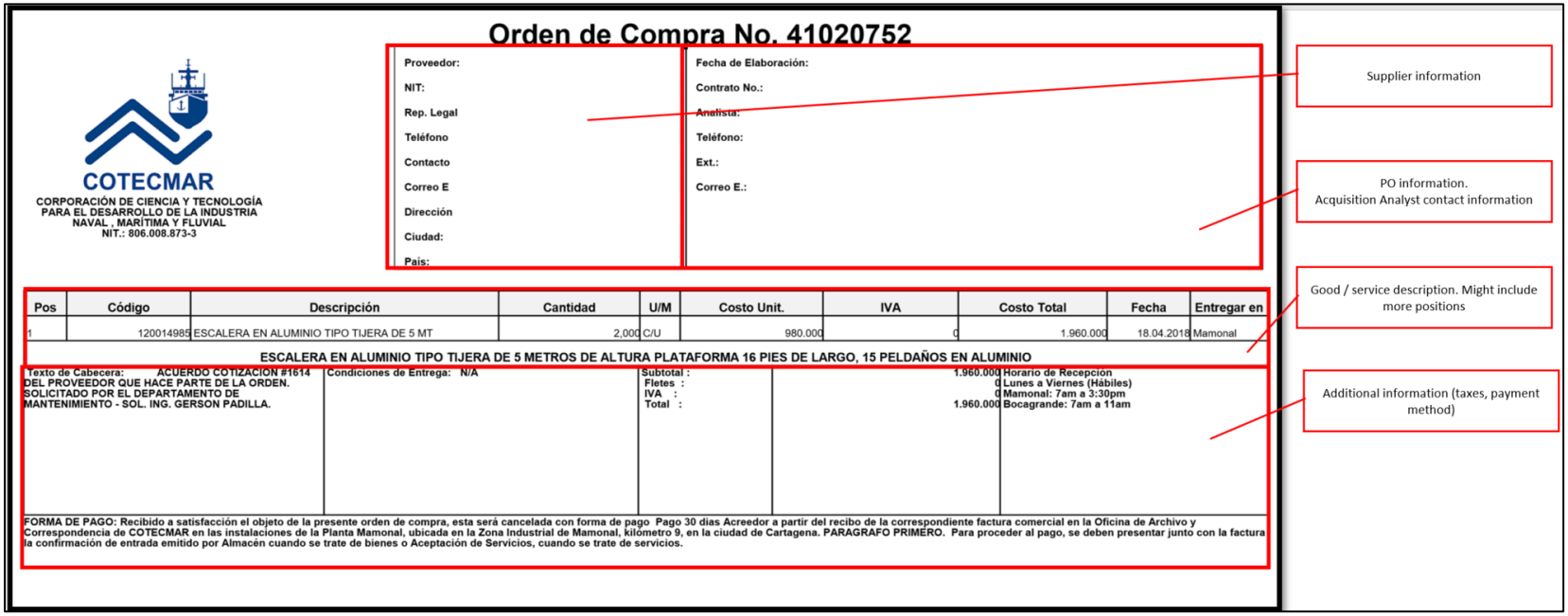


Figure 11. Purchase Order Example. Source: Cotecmar (2019).

g. Reception Activities

The final activities correspond to the delivery and receipt of the goods or services that the supplier provides. The warehouse division physically receives the goods and enters them into the system immediately upon delivery. The project manager enters services into the system throughout the process as they are completed. Further activities, such as quality problems and billing, are not in the scope of this project.

IV. PROCESS ANALYSIS

This chapter presents the application of the Measure and Analyze phases of the LSS DMAIC process to the procurement process at Bocagrande complex based on 2018 data and reports. The Measure phase presents the relevant data and explains its relationship to the problems analyzed in this report. The Analyze phase applies such Lean tools as the cause-and-effect analysis and the value stream analysis. The Implement and Control phases of the LSS DMAIC process are presented as conclusions and recommendations in Chapter V. The final section of this chapter answers two secondary questions of this project by analyzing and assessing waste during the procurement process and its impact on the process.

This chapter is organized along the lines of Chapter III and describes the findings for each area and the data that support the analysis. As mentioned previously, though, it should be noted that one of the limitations of the project is the lack of data in some areas.

A. MEASURE

ERP provides most of the data for the procurement process. It is important, however, to make the following considerations. First, the ERP does not cover all of the procurement processes; it is limited to the steps from the project manager to the acquisition analyst. Second, data might have imprecisions because it relies on many users to upload information.

1. Estimation Department

The first data available correspond to Excel-based control within the Estimation Department. This document registers the following information: consecutive number, quotation number, ship name, priority, customer, week, and estimator name. The objective is to identify and facilitate the work distribution and control. The first step is to determine the importance of the Colombian Navy as a customer to the Bocagrande complex. Figure 12 displays the total number of quotations that the Estimation Department provided during 2018. With 1,019 requirements out of a total of 1,130 requirements, the Colombian Navy represented about 90% of the total workload of the Estimation Department.

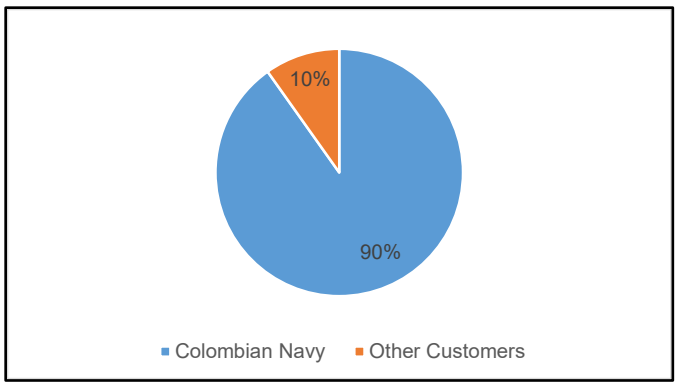


Figure 12. Requirements by Customer

An additional aspect of the data is how the Colombian Navy prioritizes its requirements. The prioritization classification system designates the requirements as Accessory, Important, or Vital. This classification allows the Estimation Department to focus its resources on solving vital requirements as soon as possible. The analysis of the information presented in Figure 13, however, indicates that most of the requirements are classified as vital for the Colombian Navy. Having the majority of the requirements classified as vital makes it more difficult for the Estimation Department to respond adequately according to the Colombian Navy's priorities.

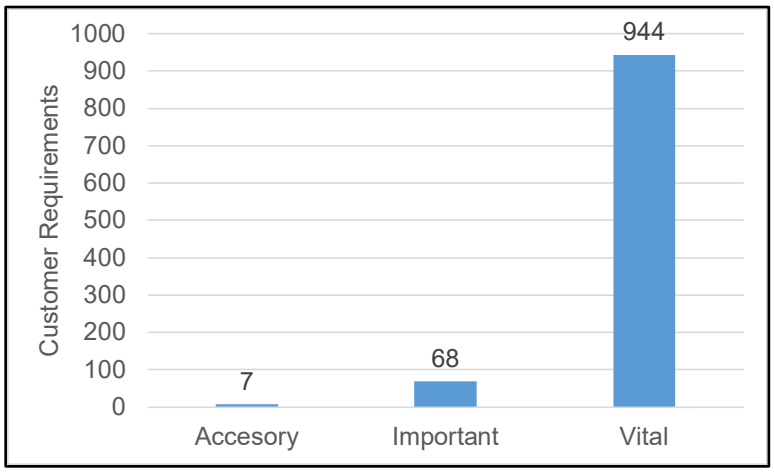


Figure 13. Colombian Navy Quote Prioritization

The Excel control also allows identifying the input rate during each month. Figure 14 displays the number of quote requirements that the Estimation Department received monthly.

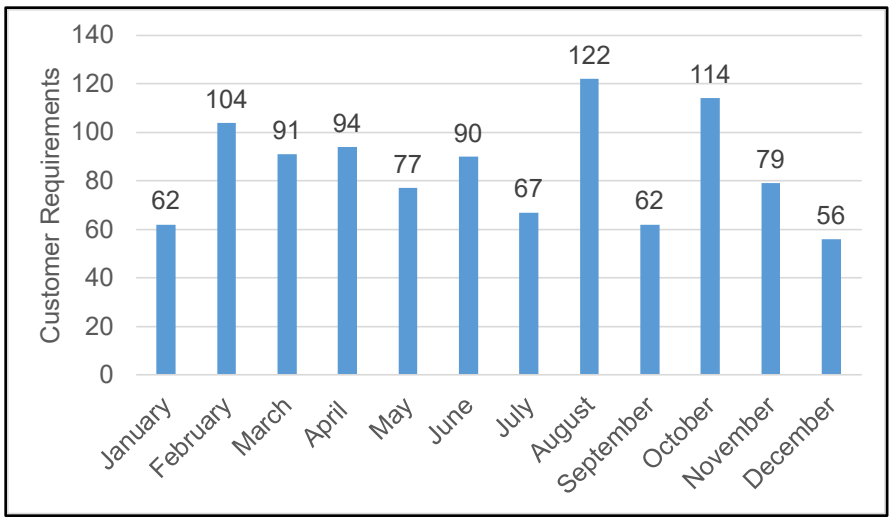


Figure 14. Quote Requirement Arrival per Month

The last figure illustrates the low number of requirements during the end and the beginning of the fiscal year. The Colombian Navy budget process causes this behavior. The figure also indicates that there are no peaks during the first half of the year and more variation during the second semester. Comparing this information with more years would allow for the identification of patterns in customer requirements separate from and in addition to those related to points within fiscal years. Table 2 reflects the arrival rate per month including the standard deviation. Those statistics provide a clearer picture of the input rate for the sales office.

Table 2. Quote Requirements Data per Month. Source: Cotecmar (2019).

Statistics	Quote Requirements
Standard Dev.	20.5
Mean	84.8
Median	84.5

Identifying individual performance based on the data provides a more precise base from which to measure production in the Estimation Department. During 2018, the information reports 10 estimators; however, not everyone worked the whole year. Only seven estimators worked in QR processing during all of 2018. The other three team members worked for eight, three, and two months, respectively. Table 3 displays the data and distribution of the QR arrival

rate per month based on the seven employees who worked the whole year. This data provides a foundation for the current production rate and measures to improve using the Lean strategy.

Eventually, customer requirements include price quotes. When the customer includes a valid quote, the Estimation Department is able to reduce the time it spends looking for that information in the system or from potential suppliers. Yet, there is no data available about how often the customer includes quotes.

Table 3. Quote Requirements Data per Employee.
Source: Cotecmar (2019).

Statistics	Quote Requirements (Monthly)
Standard Dev.	6.4
Mean	10.8
Median	10.0
Mode	9

2. Project Manager

The next available data relate to the Project Management Department Report. This report is an Excel file that the department uses to present financial information about each project. The report includes classified information about margins and revenues per project as well as cost discrimination. On the other hand, it could also be used to identify the number of projects and QRs that the Colombian Navy approved. From the 1,019 QRs processed by the Estimation Department, only 156 became approved projects. Nevertheless, the organization does not record the non-approved projects as waste because the QRs correspond to the Colombian Navy requirements.

Further analysis expands those projects into PRs based on information generated by the ERP.

3. Project Managers, Division Heads, and Material Supervisors

Once the project manager is assigned to a project, he or she continues the procurement process using the ERP. This system allows for generating a report to identify and measure the

PR process. This report includes information such as PR number, position, description, project, generator name, PO, and date.

At this point, it is important to determine the best way to measure and analyze the information described in the report. One way is using PR as a measuring unit; however, as mentioned in Chapter III, the PRs might include one or more positions. Each position corresponds to the description of one good or service to purchase, as shown in Figure 9. The time needed for a PR with one position to be processed is different from the time needed for a PR with more positions. Another way to analyze the process is by using positions as a measuring unit. This method measures the processing time for all of the positions until PO generation. Also, it is important to consider that not every PR is transformed into a PO; this is discussed in greater detail later in this chapter.

The first step in the Measure phase for this section is to identify the total number of PRs and positions corresponding to each generator. Figure 15 presents the percentage of PRs and positions by generators. The generator also indicates the type of PR. Division heads originate PRs for materials needed to complete a determined job. Project managers originate PRs for services that the Cotecmar workforce cannot complete. Furthermore, the material supervisor creates the PRs for goods and equipment needed for the project.

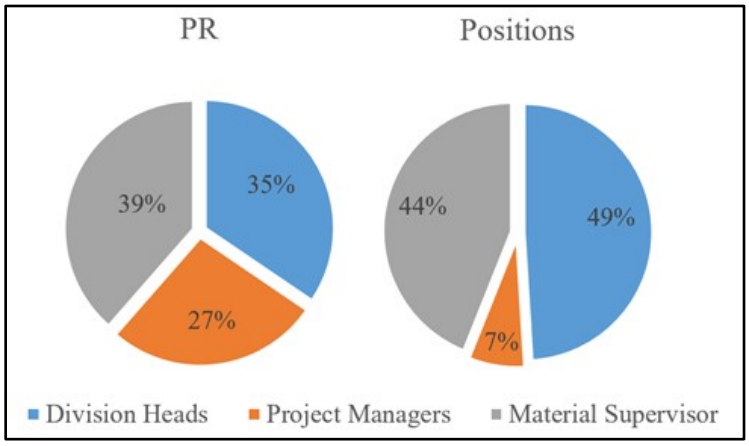


Figure 15. Measure of PRs and Positions by Generator

The output of each area varies according to the measuring unit selected. If the measure considers only the PR as the output unit, all three generators will have a work balance in the

procurement process. On the other hand, if the analysis takes the number of positions as a measuring unit, the procurement-related workload on the material supervisor and division heads is higher. Therefore, it is easier to identify the areas to work on in order to have a higher impact on process efficiency.

According to the ERP report, in 2018, the total amount of output was 9,148 positions in 2,142 PRs. Figure 16 displays the concentration of positions in the PRs. The distribution is right-skewed, with most of the PRs with one and six positions.

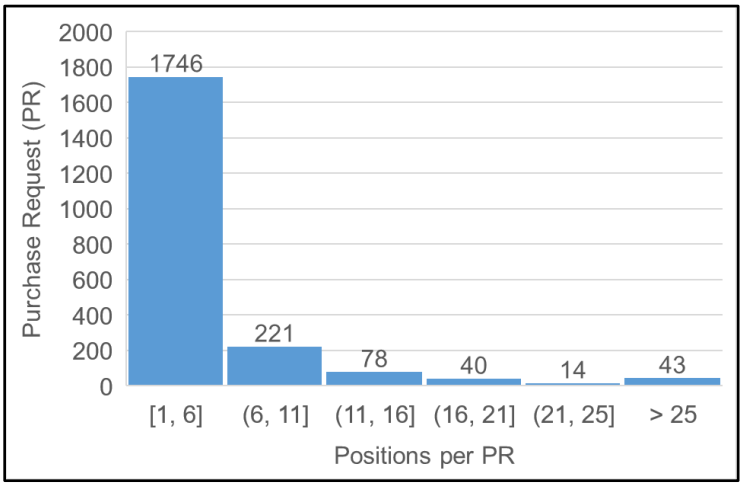


Figure 16. Number of Positions per PR

The report additionally allows for identifying the number of deleted PRs, which corresponds to the first identifiable measure of waste: over-processing. Figure 17 displays the over-processing waste percentage in terms of PRs and positions. The results are not equal, and as mentioned earlier in the section, accounting only for PRs might lead to a misunderstanding of the situation. While the PR analysis shows 11% waste, the analysis of the positions has only 4% waste. The main reason for this discrepancy is that users can delete one position but keep the PR in the process to procure the other positions. This aspect supports the positions analysis instead of a PR analysis.

After identifying the over-processing waste in the process, it is important to identify the origin of that waste in order to focus Lean actions on critical groups. Figure 18 displays the

waste percentage from each origin. In this case, division heads have twice the waste percentage of the other two generators.

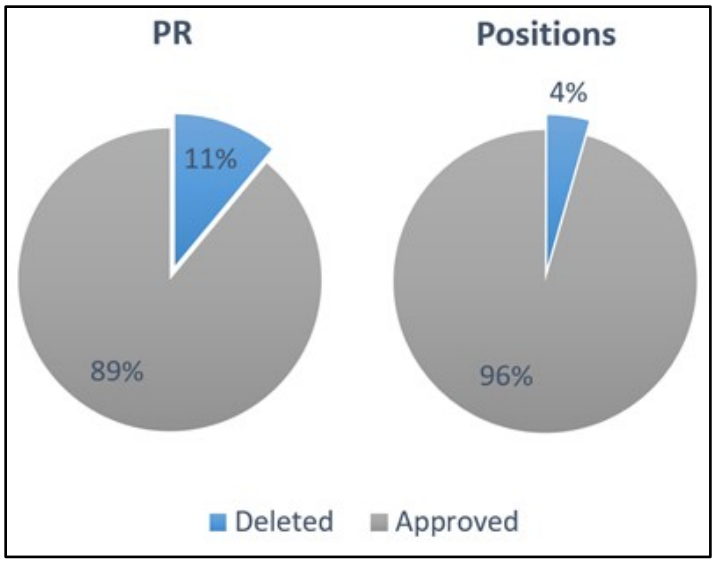


Figure 17. Over-Processing Waste as a Result of Deleted PR

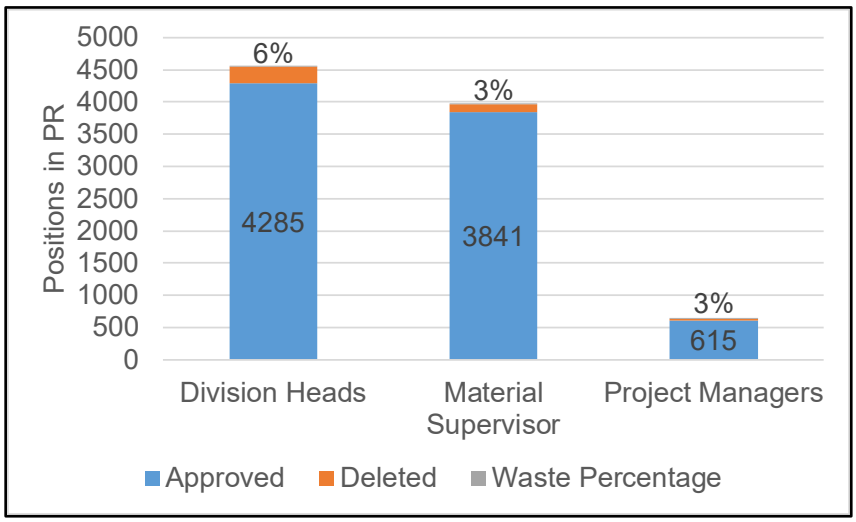


Figure 18. Waste Analysis by Generator

This information identifies the focus group that is analyzed in an attempt to reduce over-processing waste.

4. Material Supervisor and Acquisition Analyst

Transforming the PRs into POs requires activities from the material supervisor and acquisition analyst. As Chapter III described, the PRs have three alternatives to become a PO: first, the PR is turned into a VMI strategy; second, the PR is included within the supply strategy; and third, the PR is not included in previous requests and requires a new quote. This transformation does not include supplier activities or reception activities.

The first alternative involves the material supervisor and division heads. The system registers those purchases as a VMI that corresponds to goods that suppliers keep available within the Bocagrande complex. Some of the most relevant aspects of VMI are the fact that it reduces the steps to purchase elements, reduces the supplier's lead time, and minimizes the holding costs to the organization. To guarantee the sustainability of VMI, however, it is crucial to have good supervision and control of the Bocagrande supply and commitment from suppliers.

The second alternative corresponds to goods or services within additional supply strategies. Those strategies are contracts that include prearranged tariffs, delivery conditions, or ERP licenses. This alternative involves the acquisition analyst and is registered as a supply strategy in the report. One benefit of this option is an overall lead time reduction of the procurement process because the analyst does not need to look for quotes or offers.

Finally, the third alternative corresponds to the goods or services that are not included in any of the previous alternatives. Those goods and services follow the longest path in the process. The acquisition analyst has to look for quotes in the market in order to identify the best supplier according to the PR conditions (price, delivery time and place, and technical specifications).

Each of these alternatives has specific conditions, benefits, and problems. Yet, all three share internal and external customers. The external customer is the supplier who receives the PO, and the internal customer is the one that will receive the good or service.

To measure this stage's performance, it is necessary to download the ERP report and consolidate a single document with the necessary information based on that report. The original report includes PR number, position number, description, project, created by, selected

alternative, PR date, project manager approval date, PO date, and lead time. Table 4 summarizes the original report and consolidates information based on data from 2018.

Table 4. Consolidated Purchases File. Source: Cotecmar (2019).

Measure	Quantity
Total PR	2,072
Total Positions (PR)	9,148
Total PO	2,815
Total Positions (PO)	8,469

Before measuring the consolidated information, it is necessary to explain an important aspect of the PR processing into a PO: multiple positions and POs under the same PR. For example, the single PR in Table 5 has four positions; however, each position was processed into a different PO and used different alternatives. This aspect generates some differences in the balance between PRs and POs. Therefore, measuring has to include individual analysis from the input (PR) and the output (PO) perspective.

Table 5. PR Example Case with Multiple Positions and POs. Source: Cotecmar (2019).

PR	Description (in Spanish)	Origin	PO	Supply Alterative
11035036	Abrazadera plastica negra 28″	Material. Supervisor	41019705	Gen. Purchase
11035036	Loctite 406	Material. Supervisor	41019951	Gen. Purchase
11035036	Primer epoxi poliamida verde 110046	Material. Supervisor	46011614	VMI
11035036	Guantes vaqueta refor t/ingeniero cortos	Material. Supervisor	46011676	VMI

The first element to measure in this section is the lead time required to process a PR into a PO. That time is the difference in days between the PR elaboration and the PO

elaboration. This measure assumes the Acquisition Analyst submits the PO on the same day. Table 6 represents the information obtained, with a mean of 3.1 days, a mode of one day, and a standard deviation of 2.55 days, the distribution is right-side skewed.

Table 6. Lead-Time Statistics. Source: Cotecmar (2019).

Statistic	Days
Standard Deviation	2.55
Mean	3.10
Mode	1

Table 6 also allows for measuring the lead time according to each PR generator. Table 7 displays the statistics of the lead time for each generator. That information helps to set up the goals for the Lean strategy.

Table 7. Lead-Time Statistics per Generator. Source: Cotecmar (2019).

Generator	Total positions	Mean (Days)	Median (Days)	Std. Deviation
Division Heads	4,285	2.73	2	2.17
Project Managers	615	4.37	3	3.84
Material Supervisor	3,841	3.32	2	2.78

The analysis focuses on events with higher lead times and higher deviation from the median. At first sight, the services have a higher lead time considering the detail and communication that occurs to guarantee adequate supplier selection and service execution.

Another aspect to measure, as mentioned in the beginning of the section, is the lead time for each supply alternative:

- Using a VMI supplier,
- Using another supply strategy, and
- Seeking quotes to find the best supplier for a general purchase.

Figure 19 represents the percentage of usage for each alternative. Internal activities and projects focus on increasing procurement using the first two strategies, as a way to reduce lead times and increase effectiveness.

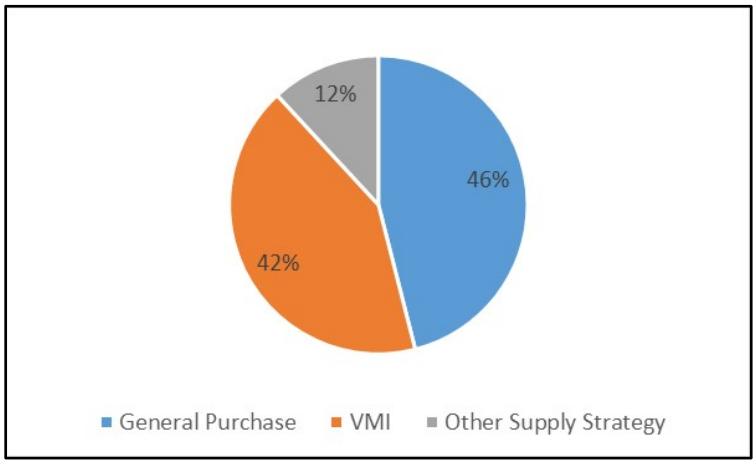


Figure 19. Supply Alternative Participation

Figure 20 displays the lead-time distribution for the PR processed using VMI strategies. The main objective of VMI strategies is to reduce the lead time to one day or less. The available information shows that the strategies are not as effective as they could be. The analysis must help to determine the causes of higher lead times and incorporate the internal customer in the strategies.

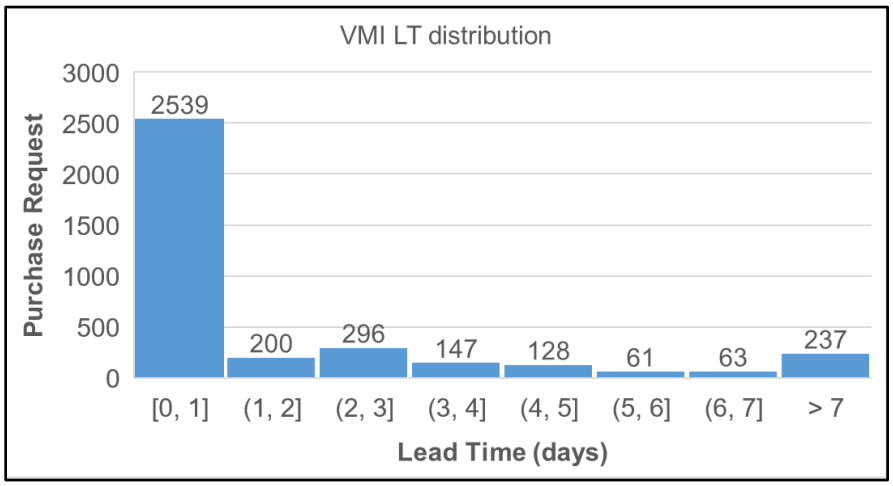


Figure 20. VMI Lead-Time Distribution

The next supply alternative is using a pre-arranged agreement. The expected lead time for this alternative is between zero and three days. Nevertheless, according to Figure 21, the alternative took more time in certain situations in 2018; this requires further analysis.

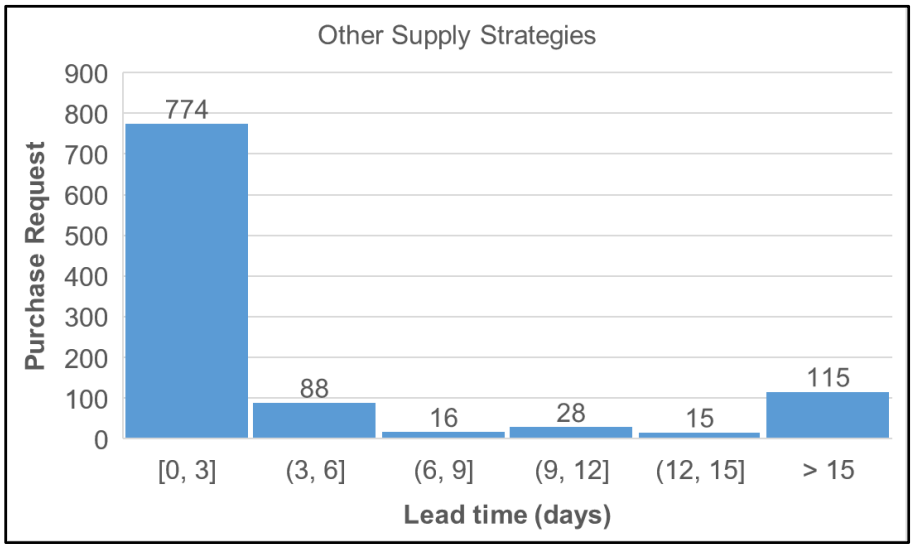


Figure 21. Lead-Time Distribution for Other Supply Strategies

Finally, the third alternative corresponds to goods or services listed as general purchases. Figure 22 displays the lead-time distribution during 2018.

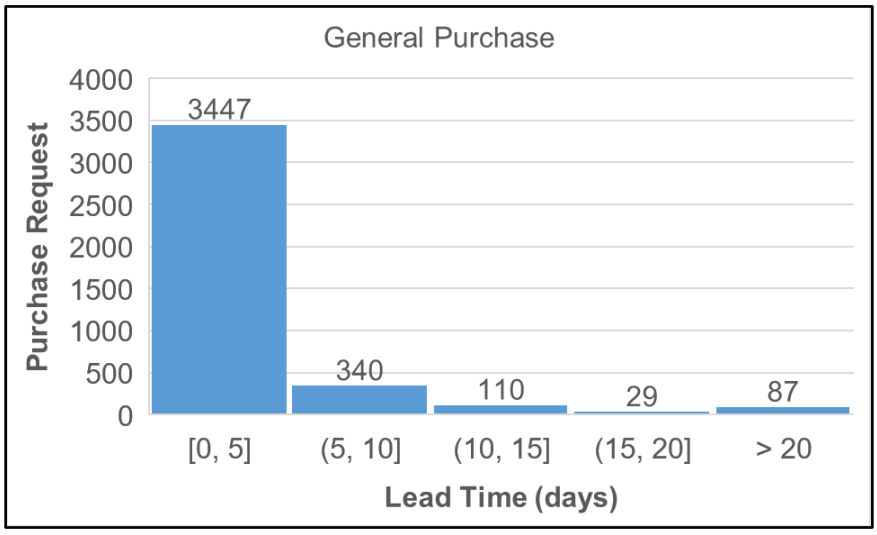


Figure 22. General Purchases Lead-Time Distribution

The last aspect for which the report allows identification is over-processing waste. In this stage, the report includes deleted POs. Figure 23 displays the percentage of deleted POs, which sets up a reduction goal for the Lean strategy.

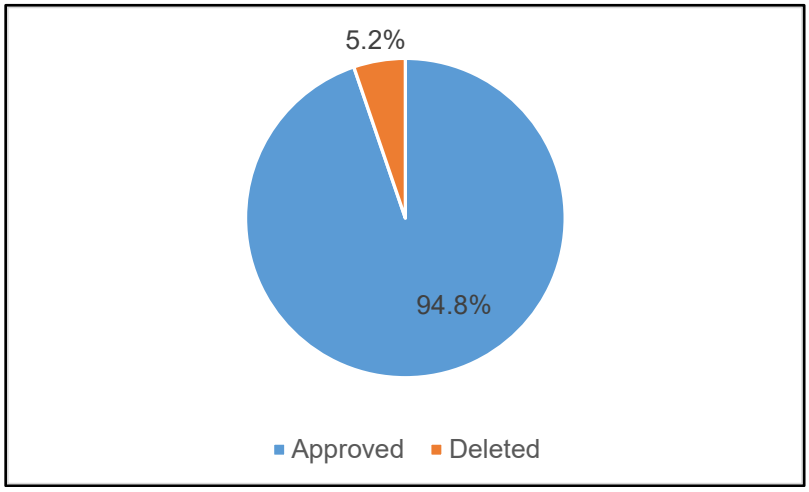


Figure 23. Percentages of Over-Processing Waste

B. ANALYSIS

This section presents the analysis of the obtained information, and applies Lean tools to determine relevant aspects to consider in the Lean strategy. The analysis follows the same structure as the Measure phase.

1. Sales Office and Estimation Department

One of the first elements to analyze is the effectiveness of the prioritization given by the customer. As mentioned earlier in this chapter, the Colombian Navy required 1,019 quotes, 92% of those quotes correspond to vital requirements. Other categories (accessory and important) compose just 8% of the total number of requirements. Even though prioritization is an excellent trait to offer, the previous number of vital requirements makes it difficult to optimize this classification. The objective of any prioritization is to determine resource allocation in order to solve the most urgent needs first—in this case, the vital requirements. Important and accessory classifications can wait until the resources used to solve vital requirements are available.

Failing to prioritize has three adverse effects. First, all of the vital requirements saturate the available resources; therefore, they are processed as regular requirements. Second, the customer does not perceive a sense of urgency to solve vital requirements. Third, important and accessory requirements have to wait until the estimators can process them; eventually, after a considerable waiting time, those requirements become vital as well. Figure 24 displays the classification behavior during 2018.

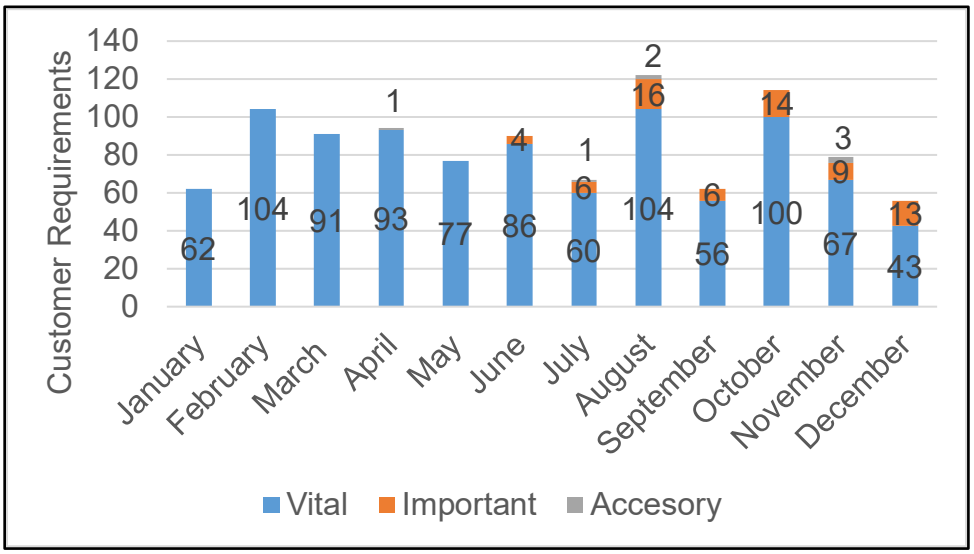


Figure 24. Requirement Prioritization in 2018

According to the data, during the first five months, every requirement was vital. Furthermore, after the sixth month, important and accessory requirements started arriving. This situation emphasizes the importance of adequate communication with the customer.

The Lean strategy must focus on the customer in order to optimize the tools provided to satisfy customer requirements as expected. One proposal is working on customer expectations and achieving a high understanding of the available resources to fulfill vital requirements. It is probably necessary to implement a more detailed classification system that helps to improve resource allocations.

2. Division Heads and Material Supervisor

Division heads and the material supervisor face a decision point in the process. This decision point is whether to use a VMI strategy or not. This decision point can reduce the lead time and the overall procurement process time. According to previous information, VMI represents 42% of the total number of requirements. Figure 25 displays the percentage of PRs generated by each area through the VMI alternative. The ERP enables the information to be identified for both PR and position amounts.

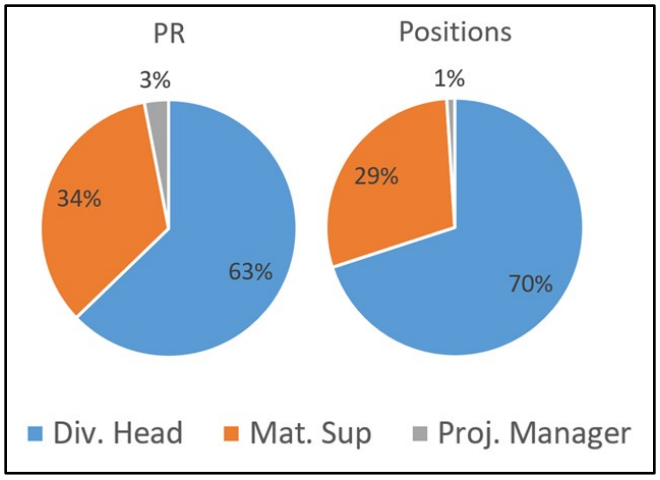


Figure 25. VMI Participation by Area

The information correlates with the nature of the standard requirements. Also, it demonstrates that any VMI improvement action must take into account the voice of the division heads, who are the primary users of this alternative.

Another aspect of the analysis is to identify situations where the goods were purchased using more than one alternative (VMI does not include services suppliers). It is essential to identify those situations because they represent waste in the process. The use of alternatives other than VMI cause the organization to over-process the requirements through a longer process. The first step to identify the mentioned situations is listing the total positions in the report. According to the ERP, in 2018, the complex purchased 3,956 specifications of goods or services. Of those, 225 elements were purchased using VMI and one or two of the other

strategies. The Lean strategy must focus on partnering with the division heads and material supervisor to reduce those events.

After identifying the specifications, the analysis locates and quantifies the number of positions that represent waste in the procurement process because the process those requirements followed was not necessary. Table 8 displays the results of the waste analysis. Reducing this waste requires activities such as strict contract supervision, training, and standardized processes.

Table 8. Waste Identification. Source: Cotecmar (2019).

Description	Positions
Total number of positions	1,689
Positions assigned to another alternative than VMI	421
Waste percentage	25%

3. Acquisition Analyst

At this stage, the analysis focuses on the purchases ERP reports. One crucial aspect, in addition to the waste identified in the previous section, is the high lead time for some of the waste mentioned in Table 7. Of the 421 positions that did not proceed through the VMI alternative, 68 positions took more than five days to be included in a PO. This aspect is relevant for the acquisition analyst because reducing that waste will reduce the acquisition analyst lead-time indicator.

As mentioned in the Measure section, the ERP report also includes the deleted POs, which also are an over-processing waste. The over-processing causes are related to a lack of communication between the areas. More in-depth analysis allows classification of the deleted POs according to the generators. Figure 26 displays the results of the analysis and identifies the areas to optimize information flow.

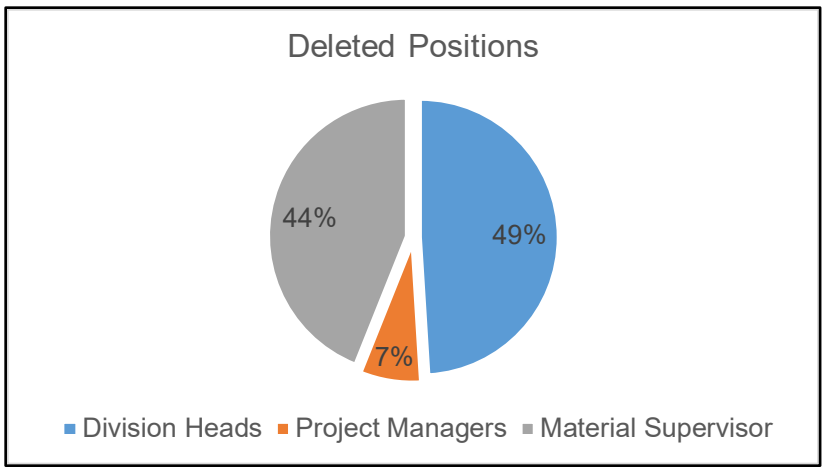


Figure 26. Deleted Positions in the PO Report by Generator

Activities to improve communication must focus on the areas with higher percentages of deleted POs. Further measures and controls are necessary to reduce the number of these events and allow for tracking if the reasons for deleted POs include quality defects in the PR before submission to the acquisition analyst.

C. WASTE CLASSIFICATION

This section presents the findings for two of the project's secondary questions regarding waste in the procurement process. Waste classification follows the original seven wastes according to Ohno (1988):

- Overproduction
- Time on hand (waiting)
- Transportation
- Processing itself
- Inventory
- Movement
- Making defective products

Even more, some authors include an additional eighth waste: "You can also add the eighth waste of *behavior* (or underutilized employees) to this as it can sometimes be the biggest waste of all" (Myerson, 2012, p. 19). However, not every kind of waste is identifiable in the procurement process; this chapter focuses only on the most relevant types of waste.

This section summarizes the findings and classifies the most relevant waste in four out of the mentioned eight categories.

1. Waiting Times

The first category identified in the procurement process is waiting time. According to Myerson (2012), "The waste of waiting is simply time spent waiting on materials, supplies, information, and people that are needed to finish a task" (p. 23).

In this case, the waiting time occurs because the areas do not have the information to continue the process. Yet, along the procurement process, only one waiting time stage is identified. This waste is the time that the acquisition analyst has to wait for the supplier's quote. This waiting time applies when the procurement process follows the path without VMI or any supply strategy. Nevertheless, according to the employees, more waiting time occurs due to defects; that waste is described further in the Defects section.

The waiting time, in this case, starts when the acquisition analyst requests a quotation for a particular good or service from the suppliers. The supplier's response time is based on factors such as workload, sale probability, potential revenue, and Cotecmar priority. Data about those factors is unavailable. Moreover, if the communication between the areas asking for quotes is not effective, this might lead to asking the same supplier for the same quotation multiple times. This event negatively affects Cotecmar priority and sale probability for the suppliers.

2. Over-Processing

The second waste group corresponds to over-processing: "Overprocessing happens when too much time or effort is put into processing material or information that is not viewed as adding value to the customer" (Myerson, 2012, p. 24). In the office environment, over-processing is represented by too many authorization levels, the use of different systems to include the same information, and other redundant activities.

Analyzing the Cotecmar procurement process, one activity represents the most significant over-processing: finding a quotation. All the areas perform this activity at least one time during the process. The frequency is not identifiable because of the lack of data and how

the employees solve the problem to make the process faster every time. At a stricter level, every order that does not follow the VMI or any supply strategy means over-processing.

As mentioned earlier in this chapter, another over-processing waste is the number of deleted POs. This indicator means that the acquisition analyst executed all the activities required to generate the PO, but the requirement changed or was canceled.

It is essential to highlight Cotecmar's effort to reduce over-processing waste with VMI strategies. Internal logistical indicators measure the utilization of supply strategies, and there is a division in charge of optimizing and increasing those strategies' capabilities. These efforts are helping the organization reduce not just over-processing, but delivery times as well. Furthermore, those strategies need to ensure adequate surveillance over the suppliers and involve areas beyond the Administration Department to guarantee positive outcomes from and sustainability of suppliers in a win-win relationship.

3. Defects

The third waste group is related to quality, such as when the input does not have the information needed to continue the process. "In the office and warehouse, this can be errors such as those made during data entry, receiving, and picking and shipping the wrong product" (Myerson, 2012, p. 25). The author describes the main causes as too many variations in the process, a lack of standardization, and insufficient or improper training.

The current procurement process and organizational culture make it difficult to measure the impact of defects during the stages. On the one hand, employees look for solutions at every level even without complete information due to pressure to complete the project on time. This eventually solves some problems but later makes it difficult to identify and prevent more challenging situations. On the other hand, all the areas reported failure to internal suppliers during the procurement process because of quality problems. The most common cause is a lack of specifications, such as missing reference numbers, delivery address, deadlines, authorizations, and wrong quotations; however, there is no available data to identify this kind of waste.

Defects in the current conditions have hidden impacts on the procurement process's effectiveness. The first step to mitigate waste related to lack of quality is establishing activities

to register waste-related events at every level. This task will need IT participation to make registration more manageable in the ERP and employees' participation in understanding and implementing a sustainable culture related to waste identification. That data will provide clearer information about the hidden elements that affect quality in the procurement process and as well as potential actions to mitigate its impact.

4. Skills

Finally, the fourth waste group refers to underutilized employees: "Other unutilized talents are employee lost time, unused skills, employee ideas, and recommendations in simplifying the process" (Taghizadegan, 2006, p. 65). This waste is the most difficult to identify and is also probably one of the most critical to any organization. It is difficult to identify because organizations do not know what they do not get. For example, the idea someone did not share or the improvement someone did not implement is unidentifiable. This information is critical because human capital is the key resource for any successful project. As Myerson (2012) stated, "You must fully utilize and leverage employee knowledge and skills, and offer proper training and opportunities for advancement to guarantee success" (p. 25).

The analysis identified two main areas with this type of waste: project managers and acquisition analysts. Their considerations are different because each area has different objectives and impacts. Project managers' primary objective is not directly related to completing the procurement activities. Their main objective and responsibility is completing the project; procurement activities are secondary. On the other hand, the main objective of the acquisition analyst is procurement activities. That difference makes it important to analyze each waste independently.

The project managers' situation is related to the opportunity cost that they must incur to solve procurement-related activities. Eventually, they assume more functions than they have to in order to complete the project on time. Those functions demand time that could be invested in the project managers' main objective. As mentioned earlier in this chapter, data about those activities and impacts are not available, but these situations do occur within the organization.

To the acquisition analysts, the situation is different because they focus on the procurement process and their outputs are easier to measure. According to Cotecmar (2018)

Quality Management System, acquisition analysts negotiate with the supplier for better purchasing conditions such as lower prices or delivery time. However, the human capital and the number of inputs needed for the Acquisition Division reduces the analysts' available time to negotiate. Therefore, any improvement which increases available time for the acquisition analyst would provide better supply conditions.

To fully utilize employees' knowledge and skills, the Lean strategy needs to include activities to standardize some of the most frequent activities and focus on the main objective of each area.

D. FISHBONE DIAGRAM

The fishbone diagram in Figure 27 displays an analysis of the main problem identified by this project: an inefficient procurement process. The diagram clusters causes according to the areas; however, some areas have similar causes. The diagram also summarizes the information presented on the chapter, and its relationship with this problem.

The diagram indicates that one of the most common causes of an inefficient procurement process is information errors. This situation affects all of the areas, and even if one area fixes the information problem, it does not guarantee that the event will not occur again. The information errors force the areas to look for the incorrect information, which affects the process flow. For example, information defects may cause an acquisition analyst to purchase elements that are not required or beyond the budget. These defects may also cause the material supervisor to find quotes from different sources when generating the PRs for new descriptions. These activities might produce differences between the element quoted to the customer and the element purchased.

The most relevant aspect of the fishbone diagram is the finding of common causes in different stages. The recommended Lean strategy prioritizes the common aspects over the particular causes. In this case, the diagram indicates that the most important aspects to focus on are information errors and over-processing.

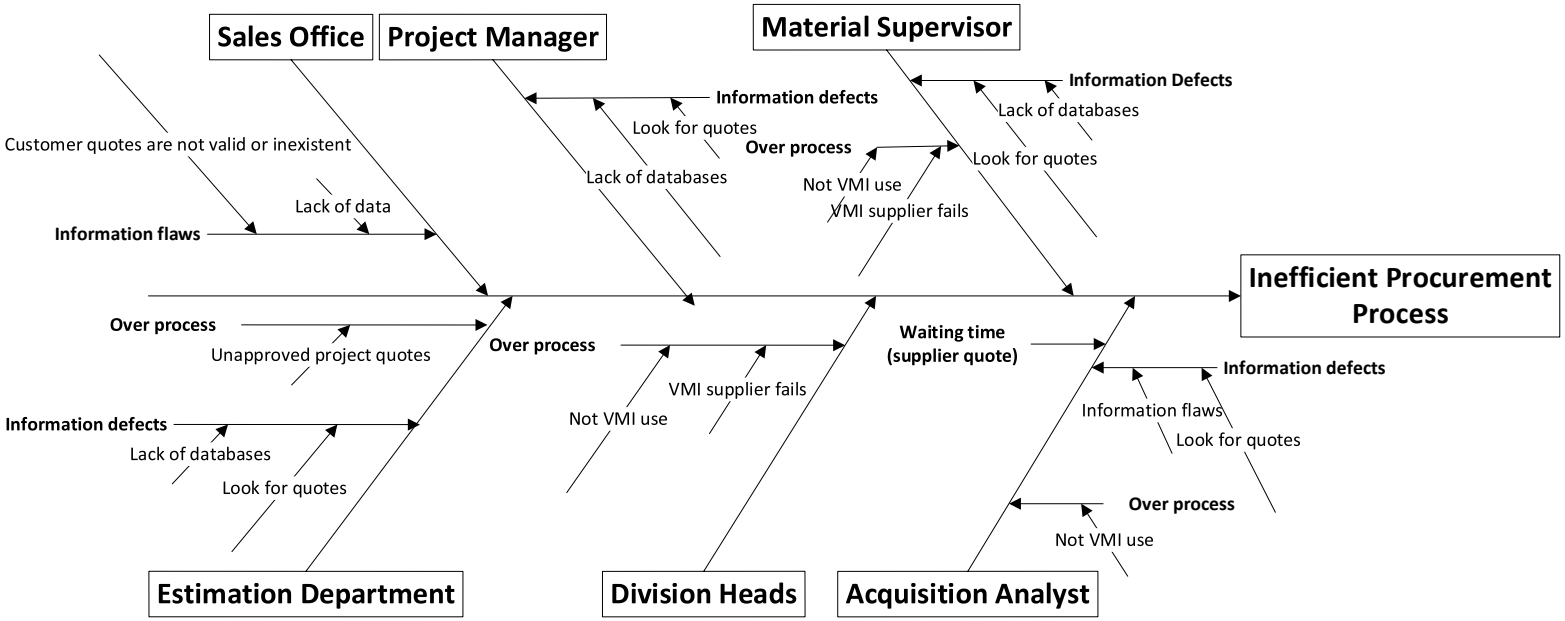


Figure 27. Cause and Effect of the Inefficient Procurement Process

E. SUMMARY

The analysis allowed for the identification of waste in the current procurement process. Despite the number of areas involved in the process, waste-related causes such as lack of information and communication failures are common factors. The analysis considered information related to the product that goes through the areas until becoming a PO.

The first stage of the analysis focused on the customer and its importance to the procurement process. Customer-provided information such as prioritization levels and detailed requirements impact the process. The prioritization levels allow Cotecmar to optimize resource allocation and improve customer satisfaction. Additionally, if the customer includes a valid quote and detailed information, the areas can reduce time spent looking for additional information. The data about this stage, however, is limited and does not include ERP activities.

The ERP report is essential to complete the second stage of the analysis. The ERP report allows the identification of the VMI utilization, most frequent users, benefits, lead times, and waste in over-processing associated with the use of different alternatives. Additionally, the analysis provides information about over-processing. Over-processing is evidenced by the deleted PRs and deleted POs.

The waste classification summarized the main findings within the waste groups. Grouping waste facilitated the recommendation process for mitigating common waste causes. Finally, the cause and effect diagram integrated the analysis and served as the foundation for the Lean strategy recommended in the next chapter.

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V. RECOMMENDATIONS

Following the DMAIC process from the previous chapters, this chapter includes the Improve and Control phases. The first part of the chapter presents the recommendations for each area and general recommendations. The second part proposes a Lean procurement strategy as the main output of the project.

A. IMPROVEMENT RECOMMENDATIONS

This section presents the improvement recommendations clustering the work areas in the procurement process. Lean focus on continuous improvement, and the following are initial recommendations to include within the Lean strategy.

1. Sales Office and Estimation Department

According to the analysis, in the sales office and Estimation Department, it is essential to focus on improving customer communication. One aspect of implementing the Lean procurement strategy is providing the customer access to valid sources for preparing a quote. Customer requirements that include valid quotes save time for the areas involved in the procurement process and improve the probability of customer satisfaction. One way this could be implemented is guaranteeing customers access to the supplier database. This database includes contact information from authorized suppliers; however, the sales office would have to review critical supplier listings for potentially restricted information.

The next aspect is the implementation of activities to increase prioritization benefits. As mentioned in the previous chapter, the prioritization objective is identifying the most urgent requirements to assign more resources to those requirements in order to guarantee customer satisfaction. However, the analysis indicates that the customer classifies most of its requirements as "vital" (the highest priority). This classification saturates the Estimation Department, which starts solving the requirements as they arrive, making the "vital" prioritization label irrelevant.

The analysis section presented the three adverse effects that a failed prioritization classification created. The mitigation of the undesired effect requires redesigning the prioritization policies with the customer. The section also presents the results of the

implemented policies to new customer representatives, reducing the time it takes for personnel to adopt the policies.

This is also the first stage that has to look for a quote to determine project costs. The improvement proposed in this stage will impact all of the processes; therefore, the General Improvements section later in this chapter explains that improvement and further impact.

2. Division Heads and Material Supervisor

In the case of the division heads and the material supervisor, the improvements must focus on increasing VMI utilization and eliminating or reducing the time spent looking for a quote. The analysis indicates that the division heads have higher participation in the VMI purchases; however, adequate feedback to the Administration Department, which leads the VMI strategies, is limited.

Increasing VMI participation in purchases is an objective for the Administration Department. Each quarter, the team measures the VMI purchases and presents the information and strategies to the managers. The supervisor keeps the identification of new elements to include into this supply strategy. Furthermore, the VMI suppliers keep doing in-field research to identify more elements to include in the agreement.

Chapter III indicates that the waste at this stage, which is about 25% of the total VMI purchases, corresponds to elements included in the VMI agreement but purchased with other alternatives. Therefore, those purchases constitute over-processing.

The proposed Lean strategy target is reducing that percentage progressively and attacking the root causes with joint contract surveillance. That way, the division heads will be able to inform the suppliers' non-observance of the agreement.

3. Acquisition Analysts

To reduce waste created by the acquisition analysts, there are two areas to focus on: increasing the elements in supply strategies and reducing the time spent looking for quotes and waiting for the suppliers' quotes. Both aspects are considered waste in the procurement process.

For the first objective, the Administration Department has indicators to measure the performance of those strategies. Those measures are reported and allow for taking action to improve their performance. Despite some particular events and IT-related problems, the strategies seem adequate, and the analysis did not uncover a significant amount of improvement. The recommendation is to maintain control and keep frequent communication with suppliers.

For the second objective, the main improvement recommendation aims to reduce the amount of time the acquisition analysts waste looking for quotes and waiting for suppliers' responses. To achieve the mentioned objective, it is essential to improve information systems. The general improvements presented in the next section provide an optimal solution to achieve that goal.

4. General Improvements

As mentioned in Chapter IV, there are common causes that affect the procurement process negatively. The most common cause is information management. The process described in Chapter III indicates that different areas use the same information during the procurement process. Yet, not all areas have access to the same sources and information, and eventually, the information does not have the quality that the internal customers expect.

The base of the proposed improvement lies in the Estimation Department process. In this department, the process includes storing the information in a shared file. As Chapter III mentions, the objective of this storage system is guaranteeing traceability and access to the quotes that support the project costs. The storage system, however, requires time to find the desired quotes and does not incorporate feedback from the other stages.

The size of the folder and subsequent subfolders make it difficult to locate the desired quotes and information. While adding feedback to these already large folders would further complicate matters, the feedback from other stages is most important in achieving the expected improvement. For example, if the quote selected in the Estimation Department to support the sales project is not used during the subsequent stages of the procurement process (failed specifications), the Estimation Department assumes that the quote is valid and useful for future projects. Feedback to the Estimation Department is key to

continuous improvement because it helps to identify failures and prevent repeating those failures in other projects. Some of the failures in the information are invalid quotes, wrong specifications (such as reference number, delivery place, and additional costs), and expired quotes.

The proposed improvement is using the information storage that the Estimation Department implemented to develop a quote database. The shared database would reduce the time estimators take to navigate through the folders to find a quote. It would also reduce the time spent looking for a quote in other areas. Finally, it would provide feedback to the areas about the quote used in the project.

The database to implement feedback must include the following features.

a. Implementation

Estimation efficiency plays an essential role for the customer; that is the reason why the development and implementation of the database need to mitigate the impact on these activities.

b. Roles

The database must include the following roles: administrator, editor, and consultant. The administrator is the person who manages the database and assigns roles. The editors are the ones who can upload quotes; in this case, those roles pertain to the estimators and the acquisition analysts. Finally, the consultants are all of the other areas involved in the procurement process that, along the process, might need the quotes.

c. Basic Inputs

Starting inputs have to include the current storage folder that the Estimation Department is using for that input, the goods and services elements within the VMI, and other supply strategies.

d. ERP Integration

Cotecmar implemented the ERP system to cover most of the activities in the organization. The system extended to other departments and developed new capabilities such

as VMI and supply strategies. This aspect makes the ERP a central point in any system implementation. The database must fully integrate with the system to achieve more automation in the process.

e. Basic Outputs

The database has to be easy to consult (by element, navy unit name, or date) and display the desired quote(s) without looking into the folders or other sources. The database needs to indicate whether the quote was final purchase.

f. Control

The database should be updated by the estimators and the acquisition analysts. That way, it will provide feedback to the Estimation Department about the utilization of the quote or the need for additional quotes because of incorrect information.

g. General Considerations

Nowadays, there are several available solutions for data management, with a wide range of costs and specifications. The recommended database has an important drawback; the format of the quote is not standard. Suppliers present their quotes in different formats and structures. The files could be .pdf, Microsoft Word or Excel document, or even image files. The structure is also different; some prices include taxes and fees, while other suppliers do not include taxes in the total price, and the conditions differ. This situation forces staff to manually upload the information to the database.

Based on aspects such as information size, the mentioned drawback, and the number of areas, the recommendation is to outsource the development of a solution. The objective is to implement a customized database. Further investigation could focus on determining the return on investment from different alternatives.

B. RECOMMENDATIONS SUMMARY

Table 9 classifies the recommendations based on the expected impact and implementation costs. Any of the recommendations estimates a high cost and low impact. Nevertheless, some activities with low cost might have higher impact, such as the quote

database implementation. Other activities are more expensive, but the expected outcome will improve the process.

Table 9. Recommendation Summary

		Impact Expected	
		Low	***High***
Implementation cost	***Low***	• Prioritization update • Increase division heads' participation in VMI agreements	• Provide customer with the supplier's database • Periodic data revisions • Adopt a quotes database
	High		• Include estimation activities into ERP • Implement Lean strategy

C. LEAN STRATEGY

This section provides an answer to the project's central question considering the DMAIC process from previous chapters. The chapter presents a general structure of the Lean strategy, and then it explains each component, including aspects such as relevance and activities.

Figure 28 displays the components and the relationship between them. The process to propose a Lean strategy for the Cotecmar procurement process has at its base the adoption of a Lean culture within the areas related to the process. Otherwise, any attempt to implement any activity or improvement will fail.

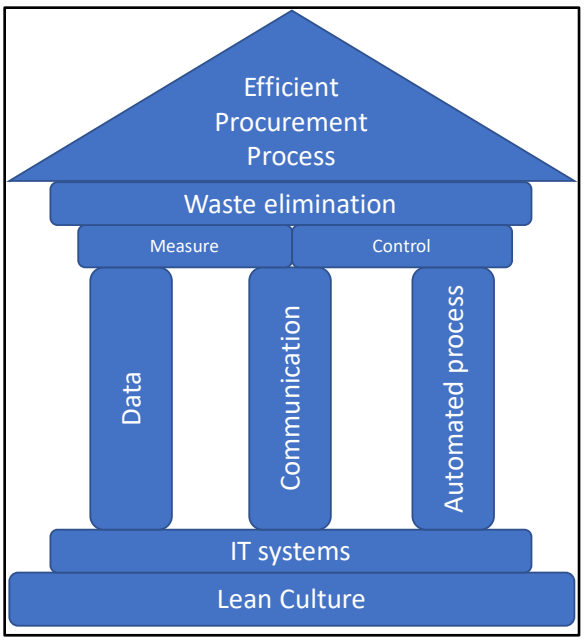

Figure 28. Lean Procurement Strategy

The first two stages constitute the foundation of the Lean procurement strategy: Lean culture, and IT systems. The next element in the strategy is the pillars; those represent the activities at a lower level and are deeply related to the success of the foundation. The third section of the strategy corresponds to the blocks; in this case, it is the tactical use of the information to continuously measure and control waste elimination. Finally, the adequate integration of those elements will guarantee an efficient procurement process.

1. Lean Culture

Lean culture is the base of any Lean strategy. The success of the strategy lies in its foundation. In this case, the foundation of the Lean strategy is ensuring everyone in the organization is involved in the process of adopting a Lean culture; otherwise, the Lean strategy implementation will become a waste of valuable resources to the organization.

a. Definition

Adopting a Lean culture translates into everyone committing to identifying and eliminating waste in the process. Every manager will assign value to the activities and control the waste in their corresponding process. To achieve that level of Lean culture, as

Taghizadegan (2006) described, it is necessary for commitment to start at the highest levels of management:

> The CEO and the highest management of a corporation should be committed and engaged with full support of the Lean Six Sigma initiative throughout the program. The cultural and infrastructure changes must be accepted by senior and top management for the future vision of the company, which include Lean operations, customer satisfaction, and bottom-line awareness. Furthermore, all the managers should be trained and educated in the program. (Taghizadegan, 2006, p. 80)

Once the strategy gets the commitment from the highest direction, it is necessary to convey the message and the cultural shift to the employees and mid-level managers. To do so, training programs are the best alternative.

b. Importance

It is important to instill a strong Lean culture because only the will of the people who perform daily activities is capable of achieving strategic objectives. If people are aware of the benefits of Lean data to measure and control the processes, they will work to keep data clean and updated. Lean culture promotes the general understanding that communication with the next area in the process is necessary to reduce over-processing and helps to identify the activities within the process that can be automated.

Training is fundamental to guarantee Lean culture and the success of a Lean strategy, Myerson (2012) indicated, "First of all, it is important to train the entire organization to ensure that everyone understands the Lean philosophy, as well as has an understanding of all the concepts and tools" (p. 105). The benefits of adequate training are the increased participation of the workers and full commitment to the Lean strategy.

c. Activities

Lean culture activities might include:

- Training programs for managers and workers,
- Improvements in socialization and results,
- Lessons learned cases, and
- Lean team creation.

2. IT Systems

The next Lean foundation is the IT systems. Once the Lean culture starts working, IT systems are the main resource to achieve Lean objectives.

a. Definition

IT systems include all the technological resources that the organization currently has or will implement during the project. In this aspect, the IT systems refer to systems such as the ERP and further developments.

b. Importance

Most of the waste in the process is caused by the repetition of simple tasks or information flow breakdown. The IT systems is one of the strategic foundations because they are the best alternative to achieve an automated process and improve data management and process control.

The IT systems must cover the entire process and be accessible by all the areas involved in the process.

c. Activities

The activities in the Lean strategy related to the IT systems include:

- Database implementation,
- Estimation Department expansion into ERP or compatible systems, and
- Supply strategies expansion and sustainability.

3. Data

Carly Fiorina (2004), former executive, president, and chair of Hewlett-Packard summarized data relevance in any organization by stating, “The goal is to turn data into information, and information into insight.” That insight is the reason to define data as one of the pillars of the Lean procurement strategy.

Complementing the previous affirmation, “every improvement project must be driven by data” (George, 2003, p. 257). Companies make a common mistake when they base their actions on assumptions, but data provides a clearer picture of the problem.

a. Definition

In the Lean procurement strategy, data is related to process information and how accessible it is to the Lean team. Once the IT systems work properly, the data provided must include lead times, input and output rate, defects, and initial and final prices.

b. Importance

Decision-making within the Lean strategy is driven by data. Accurate data provides management with a process description and allows it to put red flags into a critical situation. Data is also relevant because it provides improvement results to the Lean team.

c. Activities

Having optimal data is a permanent activity and is part of the Lean strategy. It must include the following activities:

- Determine the data required to measure and control the process,
- Identify the IT systems that will provide data,
- Stratify the data,
- Determine who is responsible for data management, and
- Periodically revise the data quality.

4. Communication

Communication is one of the Lean strategy pillars because every process with more than one person involved requires excellent communication. As Chapter III presented, the current procurement process is that permanent information flows between different areas; this makes the process susceptible to communication flaws.

a. Definition

Communication refers to the information flow along the process, or how information arrives at the sales office and how it interacts with the areas until becoming a submitted PO.

b. Importance

In the procurement process, the work-in-process refers to documents with specific information about customer requirements. The Lean procurement strategy has to promote

communication between the areas. The current procurement process includes many steps and involves many actors. If those areas start assuming information that has not been received, the process will incur waste through over-processing. This waste will have a greater effect as the assumptions fill communication gaps later in the process.

c. Activities

In addition to the IT systems and Lean culture activities that facilitate communication along the procurement process, some activities included in the Lean strategy are:

- Determining clarity on the information required by the internal customers,
- Replacing emails with IT solutions, and
- Promoting the feedback on the quote utilization to the Estimation Department.

5. Automated Process

The automated process reduces quality waste. With reliable and practical IT systems, automation of the process can reduce waste at every stage. Yet, it is important to consider that the objective is to allow human capabilities to add more value in the process instead of doing activities with no value, such as transcribing numbers or writing emails that the system can do.

a. Definition

In this case, the automated process means the identification of activities in the current process that require human interaction. For example, price designation, sending emails, or requesting quotes from suppliers can be automated. A good example of this is the work that the Administration Department does with the VMI strategy, which reduces human interactions with the requirements through the ERP system.

b. Importance

The automated process takes advantage of the IT systems, thereby reducing the time spent by workers to perform everyday activities and increasing time available to add value along the process. Automation must focus on reducing the complexity of the process because "Remember, the greater the complexity of the tasks performed, the lower the frequency of performing any single task, which leads to a continuous loss in productivity due to learning curve issues" (George, 2003, p. 297).

An additional benefit from the automated process is the reduction of time that new employees need to adapt to the process. This makes the process less dependent on a few workers.

c. Activities

Implementing an automated process requires the following activities:

- Brainstorming sessions,
- IT consultants, and
- Simulations.

6. Measure and Control

The measure and control components of the strategy reflect the expectation of implementing the previous elements. Data, communication, and the automated process must provide Cotecmar the tools to measure and control the procurement process.

a. Definition

Measure and control in the strategy mean to set up a baseline and keep tracking the benefits of the strategy as well as measuring further decisions or improvements.

b. Importance

Without results, it is impossible to know whether the strategy is successful. Having the first measures and periodic reviews of the improvements based on data allows for the identification of the goals and the areas on which to focus. It will also show the results to the team and sustain the strategy over time.

The Lean practical cases presented by George (2003) and Myerson (2012) include all kinds of measures, such as cost savings, improved delivery time, sales increase, error rates, and more. Those indicators are the results of the improvements, and only by measuring and controlling the process were the strategies able to demonstrate those results.

c. Activities

Measuring and controlling activities after an adequate Lean implementation include periodic reports with and control over the areas that implemented waste elimination strategies. Following the current policies, quarterly reports from the Lean team will provide management with the diagnosis of the strategy and corresponding results and recommended actions in the areas with the lowest results.

7. Efficient Procurement Process

With the integration of the previously mentioned elements, the Lean procurement strategy will achieve its final objective and will provide enough evidence to apply the Lean methodology to other processes and, eventually, to the entire organization.

8. Roles

Defining the roles within the organization is an essential part of the strategy. In this case, the roles include internal and external participation. As George (2003, p. 213) mentioned, two pitfalls in terms of how the teams affect Lean programs are having a team without connection to real work in the company and expecting that people with full-time jobs and responsibilities will implement the Lean strategy well.

In the same way, Myerson (2012) highlighted the relevance of a mixed team by stating, "The actual team members should be a blend of people from inside and outside of the area, as mentioned previously, and they should understand the target area (may work in it or can learn about it) and be open to thinking about doing things differently" (p. 130).

Following the infrastructure proposed by George (2003), the roles in the Lean procurement strategy are as follows.

a. Vice President

The Lean procurement strategy requires the participation of a higher manager. Considering that the strategy does not involve the entire organization so far, though, the vice president level is adequate to lead the implementation team. This person will monitor the evolution of the project and will generate the instructions to lower echelons in order to facilitate

the project initiatives. This person will approve the improvements and activities related to the project.

b. Department Heads/Sponsors

Department heads will work with external consultants to articulate strategies into operational improvements. They will provide and facilitate data collection and measure indicators about the process and current capabilities. They will also determine the value in the inputs their respective area receives to help the VSM. Additionally, they will determine, in coordination with the external consultant, which activities to present for implementation to the vice president.

c. Team Members

The team member level includes the current executors of the activities, such as a project manager who submits the services PR and the acquisition analyst who receives it. They have a detailed description of the process and might provide valuable improvement recommendations. They will also provide the available reports and indicate the quality defects that the process faces and how they are solved.

d. Champion Consultant

The role of champion consultant will be filled by an external expert because of the expertise level and qualities that the Lean strategy requires in the leadership team. This full-time consultant will lead the team, the training, and the meetings and will report directly to the vice president about the project. The consultant's knowledge will help the organization identify value along the process and convey the importance of Lean culture to all the stakeholders.

e. Black Belt Consultant

The black belt consultant is an external consultant who helps the champion consultant in the Lean strategy implementation. This person has a full-time commitment to the Lean project. The black belt consultant focuses on conveying Lean knowledge and experience to the sponsors and team members. The consultant leads the improvement implementation side-by-side with the team members, and this person's direct results are the implementation results.

D. RECOMMENDATIONS

In the supply chain environment, further improvement and research might focus on achieving a fully automated acquisition plan.

1. Once the estimator receives the QR, the ERP system automatically processes the information and produces a recommended purchase list based on the information from the quotes database. To do so, it is necessary to include the estimation process in the ERP or any compatible software; this feature will improve the data available for measuring and analysis later.

2. Once the customer approves the sales project, the recommended purchase list is attached to the project and submitted.

3. The project manager validates the recommended purchase list and submits the PR to the acquisition analyst. The material supervisor and division heads receive a copy of the purchase list.

4. Division heads include their requirements in the list and generate the PR according to the available alternatives.

5. The material supervisor receives the list and generates the PR according to available alternatives.

6. The acquisition analyst receives only the general purchases that are not included in any supply strategy but already have quotes attached. The acquisition analyst also performs a supply alternatives analysis and selects the supplier.

The presented Lean strategy might extend to the Mamonal complex and eventually, to the shipbuilding complex. Furthermore, by including the information from the ships built by Cotecmar, the repair and maintenance process will reduce the lead time for the procurement process. That extension would increase the available information in the database and reduce over-processing for more areas.

Lean is not only a methodology for one process. If the results of adopting a Lean procurement process are convincing enough, Cotecmar might start a complete Lean program in the entire organization. This process would require external resources and a long-term commitment from every level; however, if it is implemented correctly, it would reduce costs and increase customer satisfaction.

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